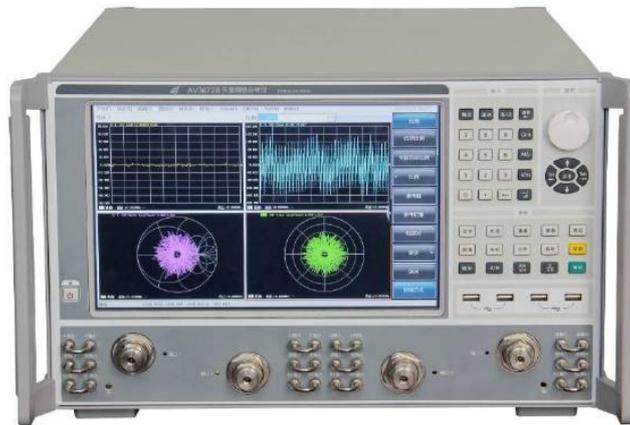




# AV3672 Series Vector Network Analyzer User Manual



**The 41st Institute of China Electronics Technology Group Corporation**

The manual applies to vector network analyzers of the following models.

- AV3672 series vector network analyzer

Options in addition to standard accessories:

- Two-port program-controlled step attenuator
- Four-port measuring device
- Four-port program-controlled step attenuator
- Active intermodulation measuring device
- Pulse measuring device
- Time domain measuring device
- Frequency offset measuring device
- Mixer scalar measuring device
- Mixer vector measuring device
- Embedded local oscillator converter measuring device
- Gain compression and two-dimensional scanning measuring device

Version: A.1 November 2014 The 41st Institute of China Electronics Technology Group Corporation

Address: 98 Xiangjiang Road, Economic and Technological Development Zone, Qingdao, Shandong, China

Toll Free Customer Service Phone: 800-868-7041

Technical support: 0532-86889847 86897262

Fax: 0532-86889056 86897258

Website: [www.ei41.com](http://www.ei41.com)

Email: [eiqd@ei41.com](mailto:eiqd@ei41.com)

Postcode: 266555

## Preface

Thanks for choosing the AV3672 series vector network analyzer produced by The 41st Institute of China Electronics Technology Group Corporation. Please read this User Manual carefully for your convenience.

We devote ourselves to meeting your demands, providing you high-quality measuring instrument and the best after-sales service. We persist with “superior quality and considerate service”, and are committed to offering satisfactory products and service for our clients.

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A.2 2015.09

The 41st Institute of China Electronics Technology Group Corporation

### Manual Authorization

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### Product Quality Assurance

The warranty period of the product is 18 months from the date of delivery. The instrument manufacturer will repair or replace damaged parts according to the actual situation within the warranty period. The user should return the product to the manufacturer and prepay mailing costs. The manufacturer will return the product and such costs to the user after maintenance.

### Product Quality Certificate

The product meets the indicator requirements of the manual at the time of delivery. Calibration and measurement are completed by the measuring organization with qualifications specified by the state, and relevant data are provided for reference.

### Quality/Environment Management

Research, development, manufacturing and testing of the product comply with the requirements of the quality and environmental management system. The 41st Institute has the qualifications and has been certified by the ISO9001 and ISO14001 management system.

### Precautions



“Warning” indicates danger. It reminds the user to pay attention to a certain operation process, operation method or similar situations. Noncompliance with the rules or improper operation may result in personal injuries. You must fully understand the warning and all the conditions in it shall be met before the next step.



“Attention” indicates important prompts and no danger. It reminds the user to pay attention to a certain operation process, operation method or similar situations. Noncompliance with the rules or improper operation may result in damage to the instrument or loss of important data. You must fully understand the caution and all the conditions in it shall be met before the next step.

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## 1. Manual Guide

This chapter summarizes the functions, structure and main contents of the user manual of AV3672 vector network analyzers, and the related documents for the user.

- [About manual](#) .....15
- [Related documents](#) .....16

### 1.1 About the Manual

The manual describes the purposes, performance indicators, basic operating theory, operating method, operation precautions, etc. of AV3672 vector network analyzers produced by The 41st Institute of China Electronics Technology Group Corporation, to help you rapidly get familiar with and understand key points of the instrument operation and use. Please read this User Manual carefully and follow its guidance.

Due to the limit of time and knowledge of the writer, there may be some omission or error, and you are welcome to correct any such error. We are sorry for the flaws which may cause your inconvenience.

The user manual includes the following chapters.

- **Overview**

The chapter provides an overview of the characteristics and operation precautions of AV3672 vector network analyzers, mainly including a product overview and a safe operation guide.

- **Introduction**

This chapter describes the preparations before operation of AV3672 vector network analyzers, routine maintenance of the system and instrument, overview of the front panel and the rear panel, operation interface, analyzer menus, tracks, channels, windows, and analysis and saving of measurement data.

- **Measurement setting**

This chapter describes various settings of the network analyzer in operation, including resetting of the analyzer, selection of measurement parameters, setting of the frequency range, setting of the signal power level, setting of scanning, selection of the trigger mode, selection of the data format and scale, viewing of several tracks, opening of several channels, and setting of the analyzer display.

- **Menu**

This chapter describes the menu structure and items according to functional categories to facilitate query and reference.

- **Measurement optimization**

This chapter describes how to optimize the measurement accuracy by means of proper settings, including reduction of accessory impacts, improvement of the reflection accuracy of the low-loss double-port device, increase of the dynamic range, improvement of the measurement results of the electrical length and the measurement accuracy of the phase, reduction of the track noise and receiver crosstalk, increase of data points, improvement of the measurement stability, scanning speed, multi-status measurement efficiency and rapid data transmission, use of macros, etc.

- **Calibration**

This chapter introduces the calibration type and method of AV3672 vector network analyzers to improve the accuracy of measurement.

- **Network measurement basics**

This chapter describes the basic concepts and related theories of senior network parameter measurement.

- **Remote control**

This section outlines the remote control of the instrument, so that the user can rapidly get to know how to remotely control the instrument. It is divided into four sections: the program control basics describe the concepts related to program control, software configuration, program-controlled port, SCPI commands, etc.; instrument port

configuration describes the connection and software configuration of the program-controlled port of AV3672 vector network analyzers; basic programming of VISA interface provides an example of basic programming with text illustration and example codes, so that the user can rapidly get to know the programming method; and I/O function library describes the basic concepts of the instrument drive and the basic installation and configuration requirements of the IVI-COM/IVI-C drive.

- **Fault diagnosis and repair**

This section describes the overall operating theory, fault diagnosis and troubleshooting, and errors and repair.

- **Technical indicators and test methods**

This section describes the main technical indicators of AV3672 analyzers and the recommended test instructions for the user.

- **Appendix**

This section lists the instructions on software accessories of AV3672 vector network analyzers.

## 1.2 Related Documents

The documents related to AV3672 series vector network analyzer include:

- User Manual
- Program control document
- Quick Start Guide
- Online help

### User Manual

This manual introduces the functions and operation methods of the instrument in details, including configuration, measurement, program control, maintenance, etc. It aims to guide the user to comprehensively understand the functional characteristics and common test methods of the instrument. It mainly includes the following chapters:

- Manual Navigation
- Overview
- Introduction
- Measurement setting
- Menu
- Measurement optimization
- Calibration
- Network measurement basics
- Remote control
- Fault diagnosis and repair
- Technical indicators and measurement method
- Appendix

### Program control document

This manual introduces the remote programming basis, SCPI basis, SCPI commands, programming examples, I/O drive function library, etc. It aims to guide the user to rapidly and comprehensively know the program control commands and methods of the instrument. It mainly includes the following chapters:

- Remote control
- Program control commands
- Programming examples

- Error illustration
- Appendix

### **Quick Start Guide**

This manual introduces the basic operations of configuration, start-up and measurement of the instrument, aiming to help the user rapidly know the characteristics of the instrument and understand basic settings and operations. It mainly includes the following chapters:

- Preparation for use
- Typical application
- Help

### **Online help**

Online help is integrated in the instrument to provide rapid text navigation help and facilitate local and remote operation. Hard keys on the front panel of the instrument and tool bars of the user interface can be activated with corresponding shortcut keys. Main chapters are the same as those in the user manual.

## 2 Overview

This chapter describes the main performance characteristics, purposes and technical indicators of AV3672 analyzers. It also includes the precautions for proper operation, electrical safety, etc.

- [Product overview](#) .....19
- [Safe operation guide](#) .....24

### 2.1 Product Overview

AV3672 series vector network analyzers are a new generation of vector network analyzer, launched by the 41st Institute of China Electronics Technology Group Corporation. In the hardware, new design concept and technical schemes are adopted, thus significantly improving key technical performance indicators such as the overall scanning speed and dynamic range. In the software, the embedded computer with high-performance microprocessor chip and platform environment based on Windows7 operating system are applied, thus greatly improving the overall interconnection and usability.

AV3672 series vector network analyzers have multiple calibration modes such as frequency response, single port, response isolation, enhanced response, double ports and electrical calibration, and multiple display modes such as the logarithmic amplitude, linearity amplitude, standing wave, phase, group delay and Smith chart. It is equipped with various standard interfaces, such as USB, LAN, GPIB and VGA. In addition to all measurement functions of the traditional vector network analyzer, the instrument can be used to test comprehensive parameters of multiple functions such as the mixer/converter, active intermodulation distortion and harmonic distortion, gain compression and two-dimensional scanning and S-parameter of the pulse network, and accurately measure the amplitude frequency characteristics, phase frequency characteristics and group delay characteristics of the microwave network.

The instrument can be widely applied in measurement of the transmission/reception (T/R) module, dielectric material properties, microwave pulse characteristics and photoelectric properties. It is an indispensable tester in research and production of the phased array radar, communication, RF microwave device and other systems.

#### Product Features:

- 12.1-inch high-resolution touch screen;
- Windows operating system and Chinese menu, with optional English menu;
- Multiple calibration modes such as the frequency response, single port, frequency isolation, double ports, TRL and electrical calibration;
- 16 display windows capable of displaying 8 tracks at the same time, and 64 independent measurement channels to rapidly implement complex test solutions;
- Record/run (one-button operation), greatly simplifying the measurement setting steps and improving the working efficiency;
- Multiple display formats such as the logarithmic amplitude, linearity amplitude, standing wave, phase, group delay, Smith chart and polar coordinates;
- USB, GPIB, LAN and VGA interface;
- Two options: single-source excitation type double-port vector network analyzer and double-source excitation type four-port vector network analyzer;
- Multiple functions such as the pulse measurement, time domain measurement, mixer measurement, active intermodulation distortion measurement, gain compression and two-dimensional scanning measurement, millimeter wave spreading, antenna and RCS measurement reception.

#### 1) Simple and intuitive humane user interface, facilitating operation and improving the test efficiency.

The touch screen, panel keys and mouse can be used to effectively guide the user to properly operate the instrument. The operation can be made quick and intuitive in the Windows system, thus greatly improving the test efficiency.

AV3672 series vector network analyzers are equipped with a 12.1-inch 1280\*800 touch screen, as shown in Fig. 2.1, to facilitate operation.



Fig. 2.1 12.1-inch 1280\*800 Touch Screen

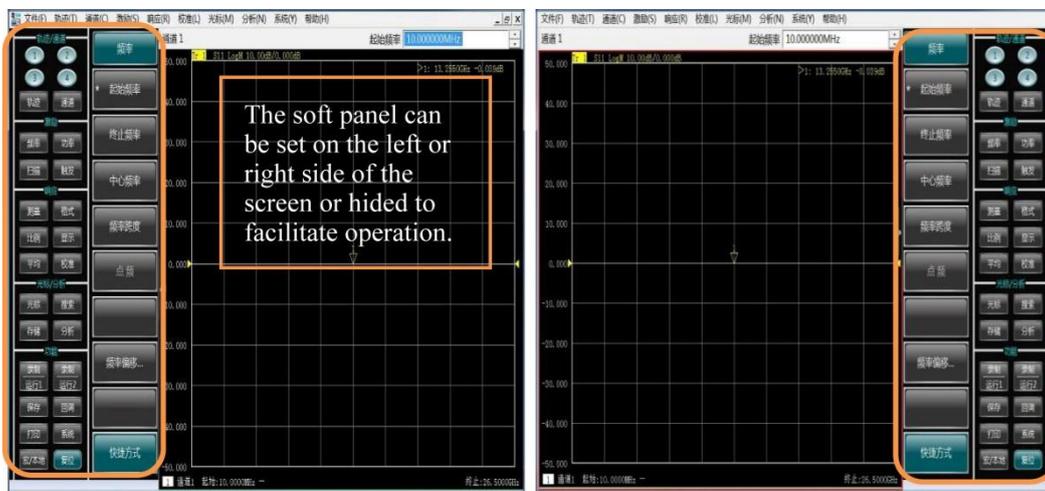


Fig. 2.2 Soft Panel Interface

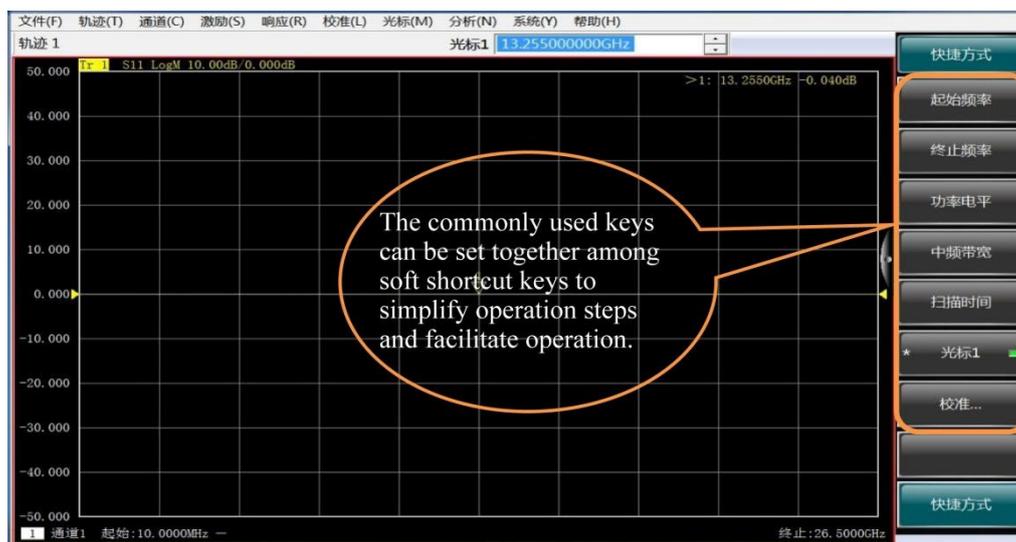


Fig. 2.3 Soft Shortcut Keys

## 2) Multi-window multi-channel measurement display

AV3672 series vector network analyzers support up to 64 channels, and as many as 16 measurement windows can be displayed at the same time. Up to 8 test tracks can be displayed in each window, and frequent status calling is not required to measure several parameters of the tested device, thus simplifying the test process.

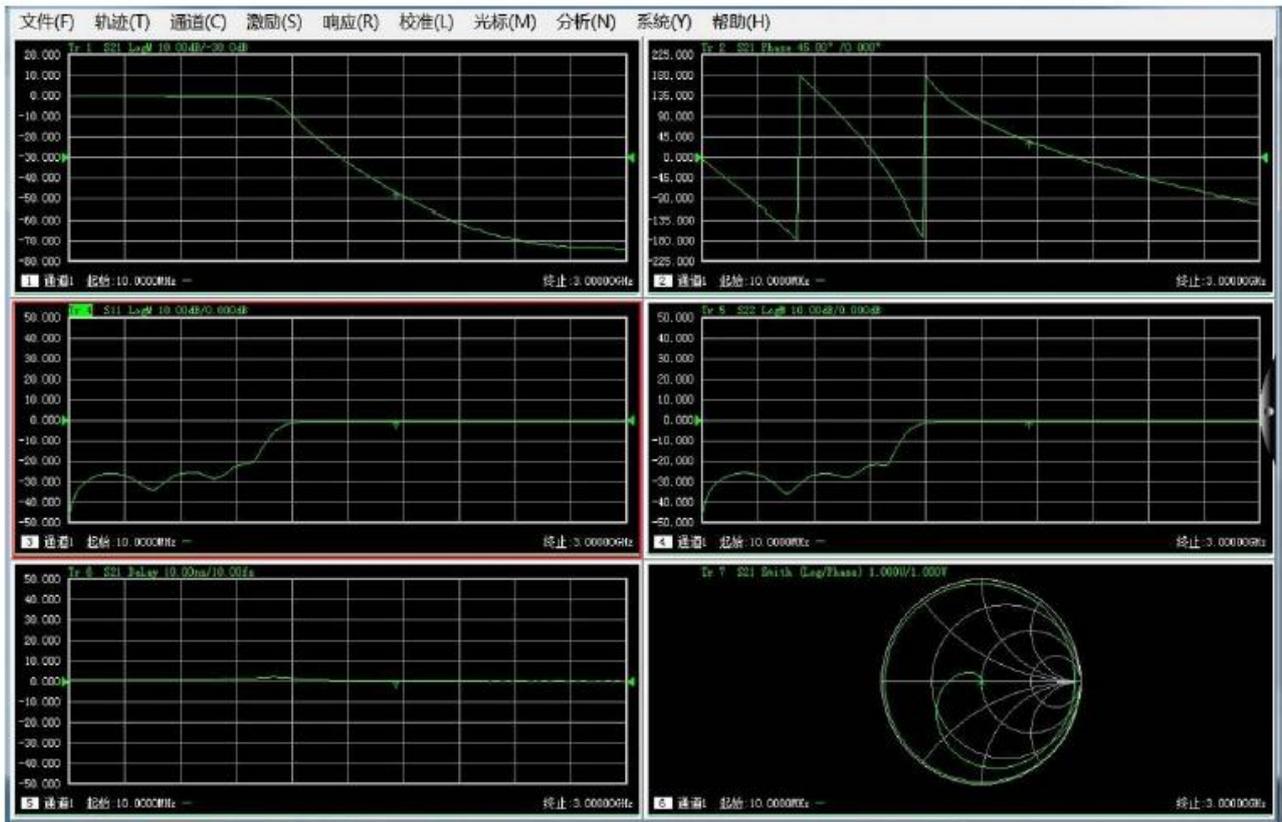


Fig. 2.4 Multi-window Multi-channel Measurement Display

### 3) Wide dynamic range

AV3672 series vector network analyzers are designed based on fundamental wave mixed reception, thus effectively expanding the dynamic range of the overall test and meeting increasing test demands for the wide dynamic range.

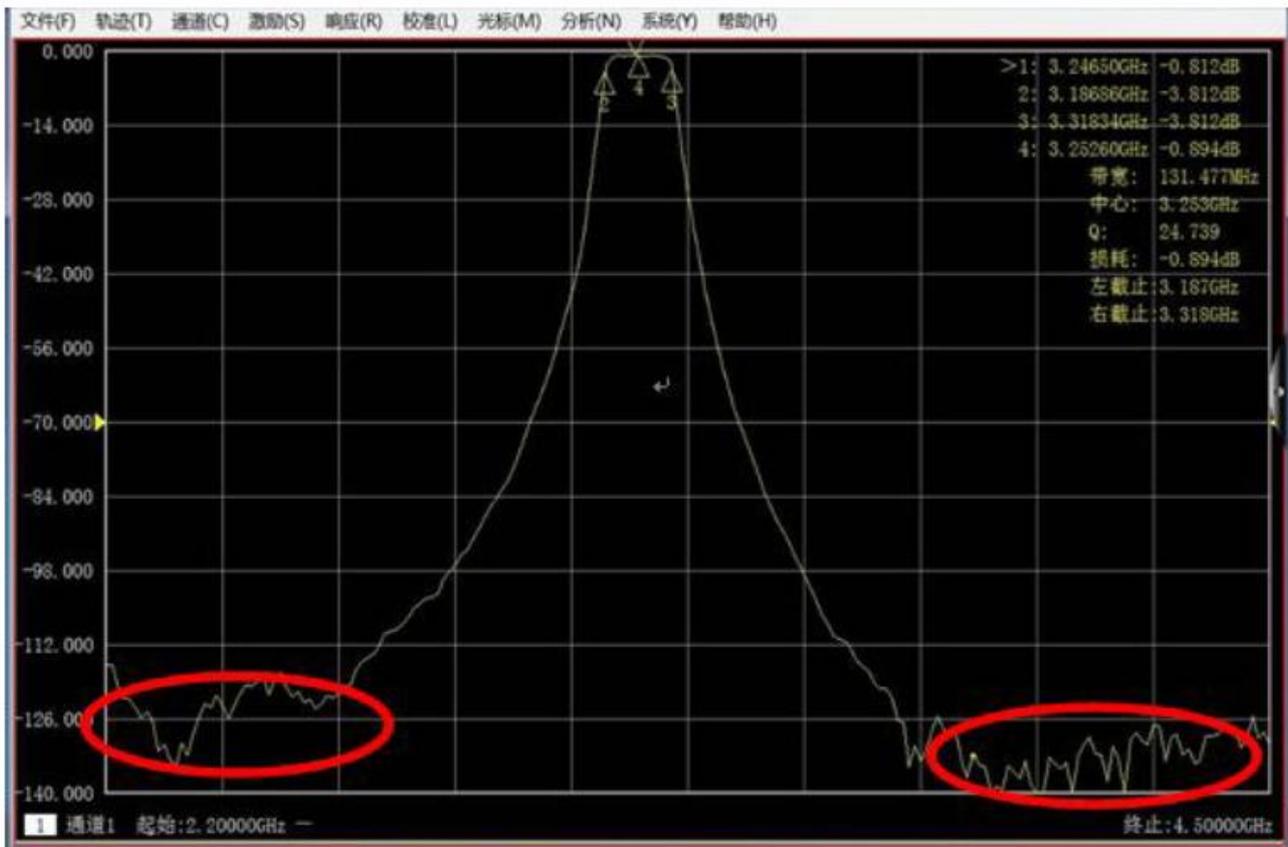


Fig. 2.5 Filter Measurement Results

#### 4) Automatic test

The automatic test can help to save a lot of time and effectively reduce the test cost in a flexible automation environment.

- 1) The vector network analyzer is controlled with SCPI commands to complete automatic tests.
- 2) Codes are directly executed from the vector network analyzer or external PC through a LAN or GPIB interface.
- 3) The application program can be directly run in the instrument, with no external PC.

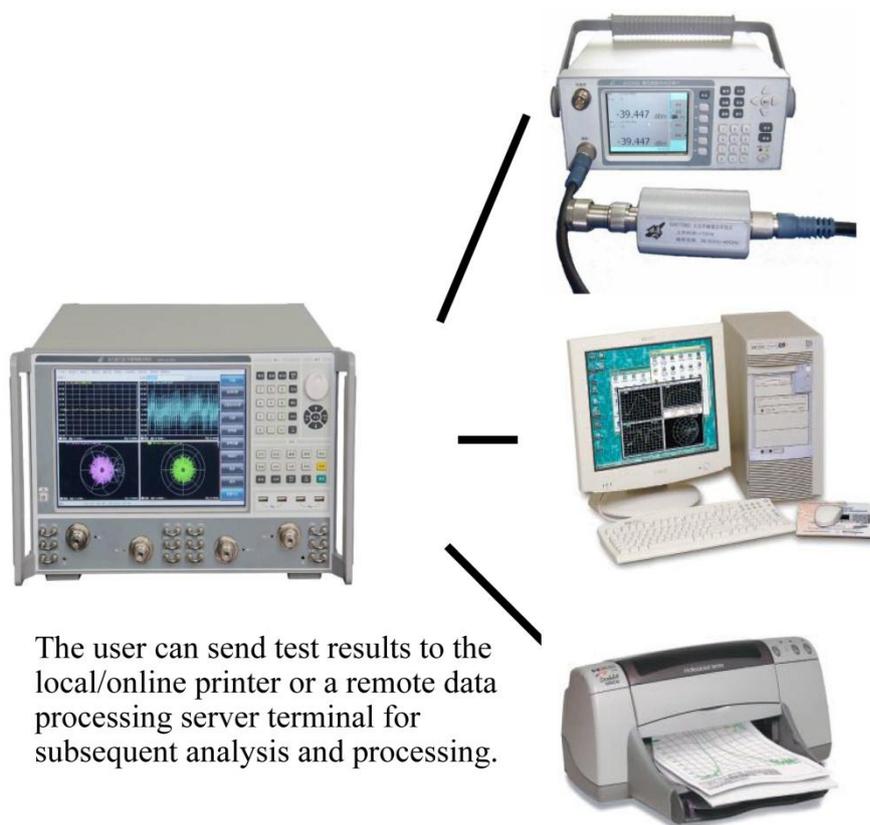


Fig. 2.6 Automatic Test

### 5) GPIB interface

AV3672 series vector network analyzers are equipped with a 24-pin D-type female GPIB connector, which conforms to the IEEE-488 standard and is used to send and receive GPIB/SCPI commands.

### 6) USB Interface

AV3672 series vector network analyzers are equipped with nine high-speed USB interfaces (eight A-type interfaces and one B-type interface) to facilitate the connection to the keyboard, mouse, printer, electronic calibrator and other peripherals with USB interfaces.

### 7) Printing function

AV3672 series vector network analyzers have a powerful printing function, and are able to output or print the contents of the measurement display into a specified file through a printer. A local or network printer with a LAN or USB interface can be used. Measurement results can be printed after the printer is added to the Windows 7 operating system.

## 2.2 Safety Guide

Please carefully read and strictly follow the notes for attention below!

We will spare no effort to ensure that all production stages conform to the latest safety standards to guarantee the highest safety for users. The design and test of our product and ancillary equipment thereof have been up to relevant standards of security; quality assurance system has been established to monitor the product quality to ensure the consistency with such standards. Precautions proposed in this User Manual should be followed to keep equipment intact and operations safe. Please do not hesitate to consult us if you have any questions.

However, it is your responsibility to operate the product in a correct way. Please read and follow the safety instructions carefully before operating the instrument. The instrument is applicable to the industrial and laboratory environment or field measurement. Pay attention to the limitations for proper operation to avoid personal injury or property damage. We will not take any responsibility for any misuse or inconsistency as required, and you are liable for any risks incurred by. **Therefore follow the safety instructions to prevent from personal injury or**

**property damage.** Please keep the basic safety instructions and product documentation safe and submit them to end users.

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## 2.2.1 Safety Signs

### 2.2.1.1 Product-related Signs

The safety signs of the instrument are as follows (Table 2.1).

Table 2.1 Instrument Safety Signs

Symbol	Meaning	Symbol	Meaning
	Caution: the user should pay attention to the information. The user should pay attention to the operation information or instructions.		Power on/off
	Caution: handle heavy equipment.		Standby indication
	Danger! Be careful of electric shock!		Direct-current (DC) power
	Warning! Be careful of surface heat.		Alternating-current (AC) power
	Protect the conductive terminal.		Direct-current/alternating-current power (DC/AC)
	Grounding		Instrument reinforcement and insulation protection.
	Earthing Terminal		EU mark of battery and accumulator. For details, refer to 1 of “2.2.8 Waste disposal/environment protection”.
	Caution: electrostatic sensitive device. Be careful.		EU mark for electronic parts to be collected separately For details, refer to 2 of “2.2.8 Waste disposal/environment protection”.
	Warning! Radiation. For details, refer to 7 of 2.2.4 “Operation Precautions” of this section.		

### 2.2.1.2 Manual-related Signs

The following safety warning signs are used in the product manual to remind the user to operate the instrument

safely and pay attention to relevant information.



Danger sign: personal injury and equipment damage may be caused if no attention is paid.

Warning sign: personal injury and equipment damage may be caused if no attention is paid.

Caution sign: minor or moderate personal injury and equipment damage may be caused if no attention is paid.

Attention sign: it indicates important prompts but no danger.

Prompt sign: information of the instruction and operation.

### 2.2.2 Operation Status and Location

Pay attention to the following items before operation:

- 1) Unless otherwise stated, AV3672 series vector network analyzers should be placed steadily and operated indoor with protection of IP 2X. The maximum altitude must not exceed 2,000m in operation and 4,500m in transportation. The actual power supply voltage may be the indicated voltage  $\pm 10\%$ , and the power supply frequency may be the indicated frequency  $\pm 5\%$ . Both the overvoltage protection and the pollution intensity are Class 2.
- 2) Do not place the instrument on a wet surface, vehicle, cabinet, table and other objects which are not fixed and do not conform to the load conditions. Place the instrument steadily and fix it on the solid object surface (such as the anti-static workbench).
- 3) Do not place the instrument on a heat dissipating surface (such as a radiator). The operating temperature must not exceed the specified range of relevant indicators of the instrument. Overheating may result in electric shock, fire, etc.

### 2.2.3 Power Safety

Precautions for the power supply of the instrument:

- 1) Ensure that the actual power supply voltage is the same as that marked on the instrument before powering-on. If the power supply voltage is changed, replace the fuse of the instrument.
- 2) Refer to the power supply requirements on the rear panel of the instrument. Use three-core power cords. Ensure that the power cord is grounded reliably. Floating or improper grounding may result in damage to the instrument and even operator injuries.
- 3) Do not damage the power cord; otherwise, electrical leakage may be caused, resulting in instrument damage and even operator injuries. If any, check the external power cord or terminal block before operation to ensure the power safety.
- 4) If the power socket is not equipped with any ON/OFF switch, the power plug can be directly pulled off to power off the instrument. In this case, ensure it is easy to plug and unplug the power line.
- 5) Do not use any damaged power cord. Before connecting the power cord to the instrument, check the power cord for integrity and safety. Reasonably place the power cord to avoid the impact from human activities. For example, the operator may fall over if the power cord extends over long distances.
- 6) The TN/TT power network is required. The maximum rated current of the fuse should be 16A (contact the manufacturer if a fuse of higher current is required).
- 7) Keep the socket clean and the plug and the socket in good and firm contact.
- 8) The socket and power cord must not be overloaded; otherwise, fire or electric shock may be caused.
- 9) If the voltage  $V_{rms}$  is higher than 30V in the test, take appropriate protective measures (such as use of the appropriate test instrument and fuse, limitation of the current, electrical isolation and insulation, etc.) to avoid damage to the instrument.
- 10) The instrument shall conform to IEC60950-1/EN60950-1 or IEC61010-1/EN61010-1 so as to realize the connection to a PC or industrial personal computer.

- 11) Unless specially permitted, the instrument shell must not be opened; otherwise, internal circuits and parts may be exposed, resulting in unnecessary damage.
- 12) If the instrument needs to be fixed in a test place, the protective ground wire should be installed between the test place and instrument by the electrician with qualifications.
- 13) Take appropriate overload protection measures to avoid instrument damages or personal injuries caused by overload voltage (arising from lightning, etc.).
- 14) If the instrument shell is opened, unnecessary parts must not be placed into the shell; otherwise, short circuiting, instrument damages and even personal injuries may be caused.
- 15) Unless otherwise stated, the instrument is not subject to waterproof protection. Therefore, the instrument must not contact with liquid to prevent damages and even personal injuries.
- 16) The instrument must not be placed in a place where mist can be easily produced. For example, if the instrument is handled in an environment with temperature fluctuation, hazards such as electric shock may be caused by water drops produced on the instrument.

### 2.2.4 Operation Precautions

- 1) The instrument operator must have certain professional and technological knowledge, good psychological quality and emergency response capability.
- 2) Refer to relevant requirements in “[2.2.7 Transportation](#)” before handling or transporting the instrument.
- 3) Allergic substances (such as nickel) are produced inevitably during instrument production. If the operator shows any allergic symptom (such as rash, frequent sneezing, red eye, breathing difficulty, etc.), immediately seek medical help to eliminate the symptoms.
- 4) Refer to relevant requirements in “[2.2.8 Waste disposal/environmental protection](#)” of this section before removing and disposal of the instrument.
- 5) RF instruments may result in high-intensity electromagnetic radiation. The pregnant women and operators with heart pacemaker must be protected particularly. If the degree of radiation is high, take appropriate measures to remove the radiation source so as to prevent personal injury.
- 6) If a fire occurs, toxic substances will be released by the damaged instrument. In this case, the operator should wear appropriate protective equipment (such as the protective mask and clothing) for protection.
- 7) The laser product should be marked with warnings according to the laser category, as personal injuries may be caused as a result of laser radiation and high electromagnetic power of such products. 8) If the instrument is integrated with any laser product (such as a CD/DVD drive), no additional function should be added, except the settings and functions described in the manual, in order to prevent personal injuries caused by laser beams.
- 8) The electromagnetic compatibility should conform to the EN55011/CISPR11, EN55022/CISPR22 and EN55032/CISPR32 standards.

- Class A equipment:

applicable to any place except in residential areas and a low-voltage power supply environment.

Note: Class A equipment is suitable for the industrial operating environment. As wireless communication disturbance may be caused to residential areas, the operator should take appropriate measures to reduce disturbance.

- Class B equipment:

It is applicable to the residential area and low-voltage power supply environment.

### 2.2.5 Maintenance

- 1) The instrument chassis must be opened by an authorized operator who has received special technical training. The power cord should be disconnected before operation, so as to avoid instrument damages and even personal injuries.
- 2) The instrument should be repaired, replaced and maintained by special electronic engineers of the manufacturer, and the replaced or maintained parts must be subject to safety tests to ensure the safety of subsequent operation.

### 2.2.6 Battery and Power Supply Module

Carefully read relevant information before using the battery and power supply module, so as to avoid explosion, fire and even personal injuries. In some cases, waste alkaline batteries (such as lithium batteries) should be disposed in accordance with the EN62133 standard. Precautions for battery use:

- 1) Do not damage the battery.
- 2) The battery and power supply module must not be exposed to flame and other heat sources. They must be prevented from direct sunlight and should be kept clean and dry in storage. Clean the connection port of the battery or power supply module with clean and dry soft cloth.
- 3) Do not make the battery or power supply module short-circuited. As the short circuit may be easily caused by mutual contact or contact with other conductors, several batteries or power supply modules must not be stored in the same carton or drawer. Do not remove the original package until the battery and power supply module are required.
- 4) The battery and power supply module must be prevented from mechanical impact.
- 5) The leaky battery must not contact with the skin or eyes. In case of contact, rinse with plenty of clean water and immediately seek medical help.
- 6) Use the standard battery and power supply module provided by the manufacturer. Any improper replacement or charging of alkaline batteries (such as lithium batteries) may easily result in explosion.
- 7) The waste battery and power supply module should be recovered and disposed separately with other wastes. The battery contains toxic substances. It must be discarded or recycled according to the local provisions.

### 2.2.7 Transportation

- 1) The heavy instrument must be handled carefully. If necessary, use tools (such as the crane) to move the instrument to prevent damage to the body.
- 2) The instrument handle is applicable to handling by individuals. The instrument must not be fixed on the transport equipment during transportation. In order to prevent damage to the property and body, observe the manufacturer's safety provisions on instrument transportation.
- 3) If the instrument is operated on the transport vehicle, the driver should drive carefully to ensure the transportation safety. The manufacturer will not be responsible for emergencies in transportation. Do not operate the machine during transportation. Take reinforcement and protection measures to ensure the safety of transportation.

### 2.2.8 Waste Disposal/Environmental Protection

- 1) Do not dispose the equipment with the battery or accumulator mark along with other unclassified wastes. Instead, such equipment should be collected separately and discarded or disposed in the appropriate collection place or by the customer service center of the manufacturer.
- 2) Do not dispose the discarded electronic equipment with other unclassified wastes. Such electronic equipment should be collected separately. The manufacturer has the right and responsibility to help end users to dispose waste products. If necessary, contact the customer service center of the manufacturer for corresponding disposal to avoid damage to the environment.
- 3) Toxic substances (heavy dust such as lead, beryllium, nickel, etc.) may be released in machining or thermal reprocessing of the instrument or internal parts. In this case, the instrument or internal parts must be removed by technical personnel who have received special training and relevant experience, so as to avoid personal injuries.
- 4) Toxic substances or fuel released by the instrument in reprocessing should be disposed in the specified method, with reference to the safety operation rules put forward by the manufacturer, so as to avoid personal injuries.

## 3 Introduction to Use

This chapter introduces the operation precautions, front and rear panel browsing, commonly used basic measurement methods, data file management, etc. of AV3672 series vector network analyzers, so that the user has a preliminary understanding of the instrument and measurement process.

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## 3.1 Preparation before Use

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### 3.1.1 Pre-operation Preparation

This chapter introduces the precautions for initial setting and operation of AV3672 series vector network analyzer.



#### Warning

##### Prevent damage to the instrument.

In order to avoid electric shock, fire and personal injury:

- Do not open the casing without permission.
- Do not disassemble or modify any part which is not described in this manual. Disassembly may result in declining of the electromagnetic shielding performance, damage to parts in the instrument, etc., thus affecting the product reliability. In this case, we will not provide free maintenance services even within the warranty period.
- Carefully read the relevant contents in “2.2 Safe Operation Guide” of this manual, and the safety precautions listed below. At the same time, pay attention to the specific operating environment requirements on the page of data.

#### Attention

##### Electrostatic protection

Pay attention to anti-static measures in the workplace to prevent damage to the instrument. For details, refer to the relevant contents of “2.2 Safe Operation Guide” of this manual.

#### Attention

##### Pay attention to the following requirements before operation:

The improper operation location or measurement setting may result in damage to the instrument or the connected instrument. Pay attention to the following requirements before powering on the instrument:

- The fan blades and ventilation holes are not blocked, and the instrument is at least 10cm away from the wall.
- Keep the instrument dry.
- Horizontally and reasonably arrange the instrument.
- The ambient temperature meets the requirements on the page of data.
- The input signal power of the port is within the specified range.
- The signal output port is properly connected and not overloaded.

#### Prompt

**Influence of electromagnetic interference (EMI):**

Electromagnetic interference will affect measurement results, therefore:

- Select the appropriate shielded cable. Example: use the dual-shielded radio-frequency/network connection cable.
- Please promptly close the cable connection port which is open and not used temporarily or the connection port connected to the matching load.
- Refer to the electromagnetic compatibility (EMC) level on the data page.

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**3.1.1.1 Unpacking**

1) Appearance inspection

**Step 1:** check whether the outer packing box and shockproof package are damaged. In case of any damage, keep the outer package for future use. Continue inspection according to the following steps.

**Step 2:** unpack the box and check whether the host and accompanying articles are damaged.

**Step 3:** carefully check the above articles according to Table 3.1.

**Step 4:** Do not turn on the power supply of the instrument if the outer package, instrument and accompanying article is damaged or any error exists. Contact our service consultation center at the service consultation hotline on the cover. We will rapidly repair or replace the instrument, depending on the actual situation.

**Attention**

**Handling:** the heavy instrument and packing box must be handled by two persons and placed carefully.

**2) Model confirmation**

Table 3.1 List of Accompanying Articles of AV3672

Name	Quantity	Function
<b>Host computer:</b>		
◇ AV3672 Series	1	—
<b>Standard:</b>		
◇ Three-core power cord	1	—
◇ USB mouse	1	—
◇ USB keyboard	1	—
◇ User Manual	1	—
◇ Packing list	1	—
◇ Quality Certificate	1	—
<b>Options:</b>		
◇ 201 two-port program-controlled step attenuator	1	Expand the output power range and receiving power range of the receiver.
◇ 400 four-port measuring device	1	Expanded to the four-port vector network analyzer.
◇ 401 four-port program-controlled step attenuator	1	Expand the output power range and receiving power range of the receiver.

✧ 008 pulse measurement	1	Used for measuring the RF S-parameter of pulse.
✧ S10 time domain measuring device	1	Used for measuring the time domain, and determining and analyzing the discontinuous locations of appliances, clamps or cables.
✧ S80 frequency offset measuring device	1	Used for measuring the frequency offset, in millimeter wave THz, expandable.
✧ S82 mixer scalar measuring device	1	Used for measuring the mixer scalar parameter.
✧ S83 mixer vector measuring device	1	Used for measuring the mixer vector parameter.
✧ S84 embedded local oscillator converter measuring device	1	Used for measuring the embedded local oscillator converter.
✧ S86 gain compression and two-dimensional scanning measuring device	1	Used for gain compression and two-dimensional scanning measurement.
✧ S87 active intermodulation distortion measuring device	1	Used for measuring the active intermodulation distortion signal.
<b>AV3672A/B accessory:</b>		
✧ AV31121 calibrating device	1	Used for overall calibration.
✧ FB0HA0HB025.0	1	3.5mm amplitude-stabilized phase-compensated cable, used for overall measurement.
✧ B0HA0HC025.0	1	3.5mm amplitude-stabilized phase-compensated cable, used for overall measurement.
<b>AV3672C accessory:</b>		
✧ AV31123 calibrator	1	Used for overall calibration.
✧ FE0BN0BM025.0	1	2.4mm amplitude-stabilized phase-compensated cable, used for overall measurement.
✧ FE0BN0BL025.0	1	2.4mm amplitude-stabilized phase-compensated cable, used for overall measurement.
<b>AV3672D accessory:</b>		
✧ AV31123A calibrator	1	Used for overall calibration.
✧ FE0BN0BM025.0	1	2.4mm amplitude-stabilized phase-compensated cable, used for overall measurement.
✧ FE0BN0BL025.0	1	2.4mm amplitude-stabilized phase-compensated cable, used for overall measurement.

### 3.1.1.2 Environmental Requirements

The operation place of AV3672 series vector network analyzers should conform to the following environmental requirements.

#### 1) Operating environment

The operating environment should conform to the following requirements.

Table 3.2 Operating Environment Requirements of AV3672

<b>Temperature</b>	0°C-40°C
<b>Temperature range of error adjustment</b>	23°C±5°C (allowable temperature deviation in error adjustment: <1°C)
<b>Humidity</b>	If the temperature is lower than +29°C, the measurement range of the humidity meter should be 20% to 80%, without condensation.
<b>Altitude</b>	0-2,000m (0-6,561 feet)
<b>Vibration</b>	Max. 0.21G, 5-500Hz

**Attention**

The above requirements are for the operating environment of the instrument and not the range of technical indicators.

## 2) Heat dissipation requirements

In order to keep the operating temperature of the instrument within the specified temperature range, the heat dissipation space of the instrument should conform to the following requirements.

Table 3.3 Heat Dissipation Requirements of AV3672

Instrument Part	Heat Dissipation Distance
Rear side	≥ 180mm
Left and right side	≥ 60mm

## 3) Electrostatic protection

Static electricity is destructive to electronic components and devices. Generally, two anti-static measures can be taken: combination of conductive table mat and wrist strap; and combination of conductive floor mat and ankle strap. Anti-static effect will be better when two measures are used at the same time. If used independently, only the former can make sure the safety. In order to ensure the user safety, the ground isolation resistance of anti-static components must be 1MΩ at least.

The follow anti-static measures should be taken to reduce static damage:

- All instruments must be properly grounded to prevent static electricity.
- The internal and external conductor of the cable should respectively contact with the ground temporarily before the coaxial cable and instrument are connected.
- Workers must wear the anti-static wrist strap or take other anti-static measures before contact with the connector or wire or any assembly.



### Voltage range

The above anti-static measures are not suitable for the places with the voltage higher than 500V.

### 3.1.1.3 On/Off

#### 1) Precautions before powering-on

Check the following items before powering on the instrument.

##### a) Confirm the power supply parameters.

AV3672 series vector network analyzers are equipped with a three-core power line interface and conform to the international safety standards. Confirm that the protective ground wire of the power supply socket is grounded reliably before inserting the power line into the standard three-core socket to power on the instrument. Floating or improper grounding may result in damage to the instrument and even personal injuries. Do not use the power line with no protective measure. Table 3.4 lists the requirements of the external power supply for normal operation of the network analyzer.

Table 3.4 Parameters of Working Power Supply of AV3672

Power supply parameter	Applicable range
Voltage, frequency	220V±10% and 50-60Hz
Rated output current	>3A
Power consumption	>600W

## Prompt

### Prevent mutual interference of various power supplies.

In order to prevent mutual interference of power supplies of various devices, especially the instrument hardware damage caused by peak pulse interference of high-power equipment, it is recommended to use the 220V AC voltage-regulated power supply to power on the network analyzer.

### b) Confirm and connect the power line.

AV3672 series vector network analyzers are equipped with the three-core power line interface and conform to national safety standards. Confirm that **the protective ground wire of the power line of the network analyzer is reliably grounded** before powering on the network analyzer. Floating or improper grounding may result in instrument damage and even operator injuries. Do not use the power line with no protective ground wire. When the appropriate power socket is connected, the instrument shell will be grounded through the power line. The rated voltage of the power line should be no less than 250V, and the rated current should be no less than 6A.

Connection of the power line to the instrument:

**Step 1:** confirm that the power line is not damaged.

**Step 2:** connect the power socket on the rear panel of the instrument to the well grounded three-core power socket through the power line.



## Warning

### Grounding

Improper/wrong ground might lead to instrument destroy or even personal injury. Ensure that the protective ground wire and the ground wire of the power supply are in good contact before powering-on to start the network analyzer.

Use the power socket with protective ground wire. Do not use the external cable, power line or autotransformer subject to no grounding protection instead of the protective ground wire. If required, connect the common end of the autotransformer to the protective ground wire of the power connector.

### 2) Initial power-on

The method and precautions of initial power-on are as follows.

#### a) Connection of power supply

Check the power supply parameters and power cord before initial powering-on. For details, refer to the precautions before powering-on in 3.1.1.3 of the user manual.

**Step 1: connect the power line.** Connect one end of the supporting power line of the network analyzer or the three-core power line conforming to the requirements in the packing box to the power socket (as shown in Fig. 3.1) on the rear panel of the network analyzer. The voltage indicator of the network analyzer is marked beside the power socket to remind the user that the applied voltage should conform to the requirements. Connect the other end of the power cord to the required AC power supply.

**Step 2: turn on the power switch on the rear panel.** As shown in Fig. 3.2, check whether the standby indicator above the power switch on the front panel (as shown in Fig. 3.3) is ON and yellow.

**Step 3: turn on the power switch on the front panel,** as shown in Fig. 3.3. Do not connect any device to the network analyzer before start-up. Start the instrument under normal conditions. After start-up, the indicator above the power switch on the front panel will turn green.



Fig. 3.1 AV3672 Power Socket



Fig. 3.2 Switch on Rear Panel of AV3672



Fig. 3.3 Power Switch on Front Panel of AV3672

## b) Start-up/shutdown

### i. Start-up

**Step 1:** turn on the power switch (“I”) on the rear panel.

**Step 2:** turn on the power switch in the lower left corner of the front panel. Check whether it is pressed (  ). In this case, the power indicator above the power switch will turn green from yellow.

**Step 3:** about one minute is required for the network analyzer to start the Windows 7 system. After a series of self-inspection and adjustment procedures, the main measurement program will be run.

**Then the instrument can be operated.**

---

### Prompt

#### Preheating for cold start of the instrument

In order to meet the performance indicators of AV3672 series vector network analyzer in cold start, preheat it more than 30 minutes before measurement.

### Prompt

#### Run the analyzer application program.

The application program will be automatically run after the network analyzer is started. After exiting the application program, you can run the measurement program again according to the following method.

**Method 1:** click [Start] of the task bar in the lower left corner of the screen. Point to [Program] in the Start menu and then [Vector network analyzer] in the program sub-menu. Click [Vector network analyzer] in the pop-up sub-menu. Then the measurement application program will be run in the analyzer. You can also double-click the shortcut key on the desktop to run the program.

**Method 2:** press [Reset] in the functional key zone. Then the application program of the AV3672 series vector network analyzer will be run.

---

### ii. Shutdown

**Step 1:** turn off the power switch in the lower left corner of the front panel (as shown in Fig. 3.3). In this case, the shutdown process is started (the power supply will be shut down after processing of software and hardware). After dozens of seconds, the instrument will be powered off. The power indicator above the power switch will turn yellow from green.

**Step 2:** turn off the power switch (“O”) on the rear panel, or disconnect the power supply of the instrument.

**Thus the instrument is shut down.**

---

### Attention

#### Shutdown of Instrument

The instrument in normal operation must be shut down by operating the power switch of the front panel. **Do not directly operate the power switch of the rear panel or directly cut off the power supply of the instrument;**

---

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otherwise, the instrument cannot be shut down normally and may be damaged, or the current status/measurement data may be lost. **Shut down the instrument properly.** In case of failure of normal shutdown caused by the anomaly of the operating system or application program, press **[Power/Standby]** key four seconds at least to shut down the analyzer.

---

### c) Cutoff of power supply

In order to prevent personal injury under abnormal conditions, the power supply of the network analyzer requires emergency cutoff. In this case, pull off the power cord (from the AC power socket or the power socket of the rear panel of the instrument). Therefore, sufficient operating space should be reserved for direct cutoff of the power supply if necessary.

#### 3.1.1.4 Proper Use of Connector

The connector is always required in various tests of the network analyzer. Although the connectors of the calibrator, test cable and analyzer measurement port are designed and manufactured according to the highest standards, the service life is limited. Inevitable wear in normal operation may result in declining of performance indicators of the connector and failure to meet measurement requirements. Proper connection of the connector in maintenance and measurement can help to obtain accurate and repeatable results, prolong the service life of the connector, and reduce the measurement cost. Pay attention to the following items in actual operation.

##### 1) Inspection of connector

Wear the anti-static wristband in connector inspection. It is recommended to use the magnifying lens to check the following items.

- 1) Check whether the plating surface is worn or deeply scratched.
- 2) Check whether threads are deformed.
- 3) Check whether there are metal particles on the connector threads and joint surfaces.
- 4) Check whether the internal conductor is bent or cracking.
- 5) Check whether the connector screw is tightened properly.



##### Prevent damage to the instrument port in connector inspection.

Any damaged connector may result in damage to the connector in good conditions even in the first measurement connection. In order to protect each interface of the network analyzer, the connector must be checked before connection.

---

##### 2) Cleaning of connector

Wear the anti-static wrist strap before cleaning the connector. Clean the connector according to the following steps.

- 1) Remove loose particles on the connector threads and joint plane with clean low-pressure air. Thoroughly check the connector. If required, further clean the connector according to the following steps.
- 2) Soak the lint-free cotton swab with isopropyl alcohol (not thoroughly soaked).
- 3) Clean the dirt and debris on the joint plane and threads of the connector with the swab. Do not apply force on the internal conductor at the center during cleaning of the internal surface. Do not leave the swab fibers on the central conductor of the connector.
- 4) Evaporate alcohol and purge the surface with compressed air.
- 5) Check the connector for particles and residues.
- 6) If the connector defect is still visible after cleaning, it indicates that the connector may be damaged and must not be used. Find the causes of damage before measurement connection.

##### 3) Connection method

Check and clean the connector before measurement connection. Ensure that the connector is clean and intact. Wear

the anti-static wristband in connection. The correct connection method and steps are as follows.

**Step 1:** as shown in Fig. 3.4, align the axes of two connectors to be interconnected, and ensure that the pin of the male connector can concentrically slide into the jack of the female connector.



Fig. 3.4 Alignment of Axes of Interconnected Connectors

**Step 2:** as shown in Fig. 3.5, horizontally move two connectors to make them connected smoothly. Tighten the connector nut by means of rotation (do not rotate the connector). Avoid relative rotation of connectors during connection.

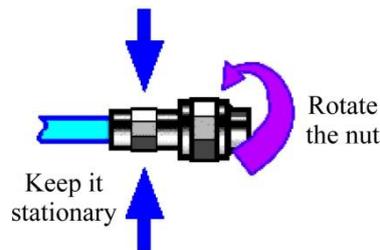


Fig. 3.5 Connection Method

**Step 3:** as shown in Fig. 3.6, complete the final connection by tightening with the torque wrench. Note that the torque wrench must not be beyond the initial break point. Use the auxiliary wrench to prevent the connectors from rotation.

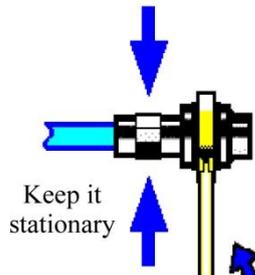


Fig. 3.6 Final Connection with Torque Wrench

#### 4) Disconnection method

**Step 1:** support the connectors to prevent any kind of force which may result in distortion, shaking or bending.

**Step 2:** use the open-end wrench to prevent the connector body from rotation.

**Step 3:** use another wrench to loosen the connector nut.

**Step 4:** rotate the connector nut by hand to complete final disconnection.

**Step 5:** horizontally separate two connectors.

#### 5) Use of torque wrench

The use of the torque wrench is shown in Fig. 3.7. Pay attention to the following items.

- Check whether the torque of the torque wrench is set properly before use.
- Ensure that the angle between the torque wrench and the other wrench (used to support the connector or cable) is less than  $90^\circ$  before applying force.
- Carefully grip the handle end of the torque wrench, and apply force in the direction vertical to the handle to reach the break point of the wrench.

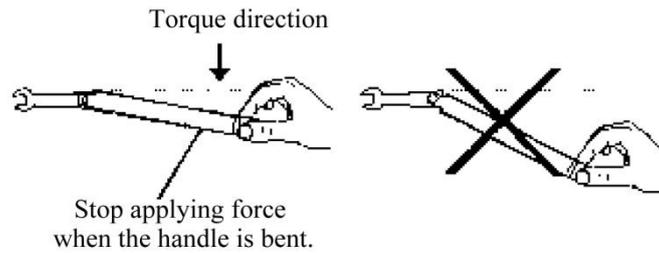


Fig. 3.7 Use of Torque Wrench

## 6) Operation and storage of connectors

- 1) Connectors should be protected with covers if not in use.
- 2) Do not place various connectors, air lines and standard calibrators in one box in a messy manner. This is one of common causes of connector damage.
- 3) Keep the connectors and analyzer at the same temperature. Hold and clean connectors with compressed air to greatly increase the temperature. Do not calibrate the connectors until the temperature is stable.
- 4) Do not connect the joint planes of connectors. The skin oil and dust particles cannot be easily removed from joint planes.
- 5) Do not place the contact surfaces of connectors down to the hard table. Any contact with solid surfaces may cause damage to the electric plating and joint planes of connectors.
- 6) Wear the anti-static wrist band and operate the instrument on the grounded conductive workbench mat to protect the analyzer and connectors from the influence of static release.

## 7) Use of adapter

If the type of the measurement port of the analyzer is not applicable to the applied connector, use the adapter in measurement connection. In addition, it is a good choice to use an adapter even if the connector type of the measurement port of the analyzer is the same as that of the port of the tested device. The measurement port can be protected in these two cases, to prolong the service life and reduce the maintenance costs. Carefully check and clean the adapter before connection to the measurement port of the analyzer. Use the high-quality adapter to reduce the influence of mismatch on the measurement accuracy.

## 8) Joint plane of connector

One important concept of microwave measurement is a reference surface, which is the benchmark surface for all measurements of the analyzer. The reference plane is defined as a joint plane of the measurement port and standard calibrator in the calibration process. Good connection and calibration depends on the complete and smooth contact at all points of the joint planes of connectors.

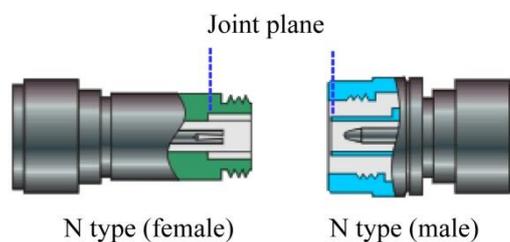


Fig. 3.8 Calibration Plane

## 3.1.2 System Recovery and Installation Program of Analyzer

### 3.1.2.1 System Recovery of Network Analyzer

Abnormal shutdown of software, infection of viruses or use of other kinds of software in the analyzer may result in anomaly of the operating system of the analyzer. In this case, system recovery is recovered. Recover default settings of the analyzer according to the following steps:

- 1) Shut down the analyzer and connect the keyboard to the USB interface.
- 2) Press the [Power/Standby] key in the lower left corner of the front panel of the analyzer. When the indicator of the external keyboard is ON and the screen shown in Fig. 3.9 appears, immediately press [↑] and [↓], select “System Recovery”, and press [Enter] of the keyboard to automatically recover the system.

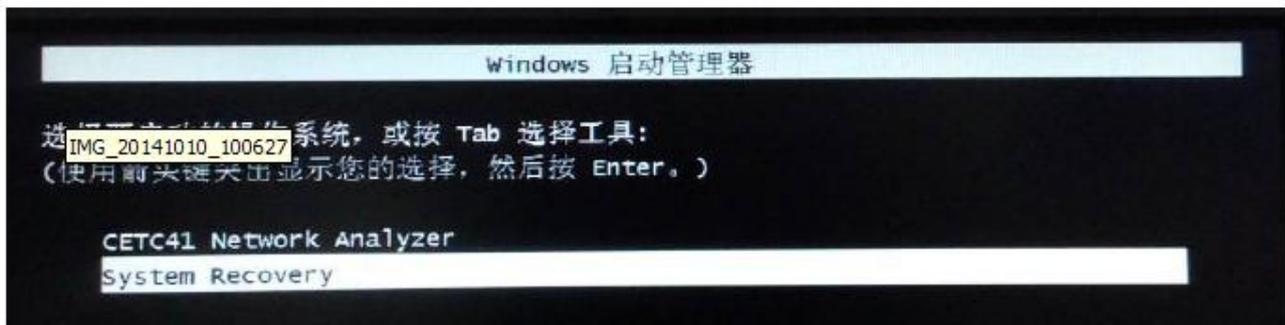


Fig. 3.9 Start-up Screen

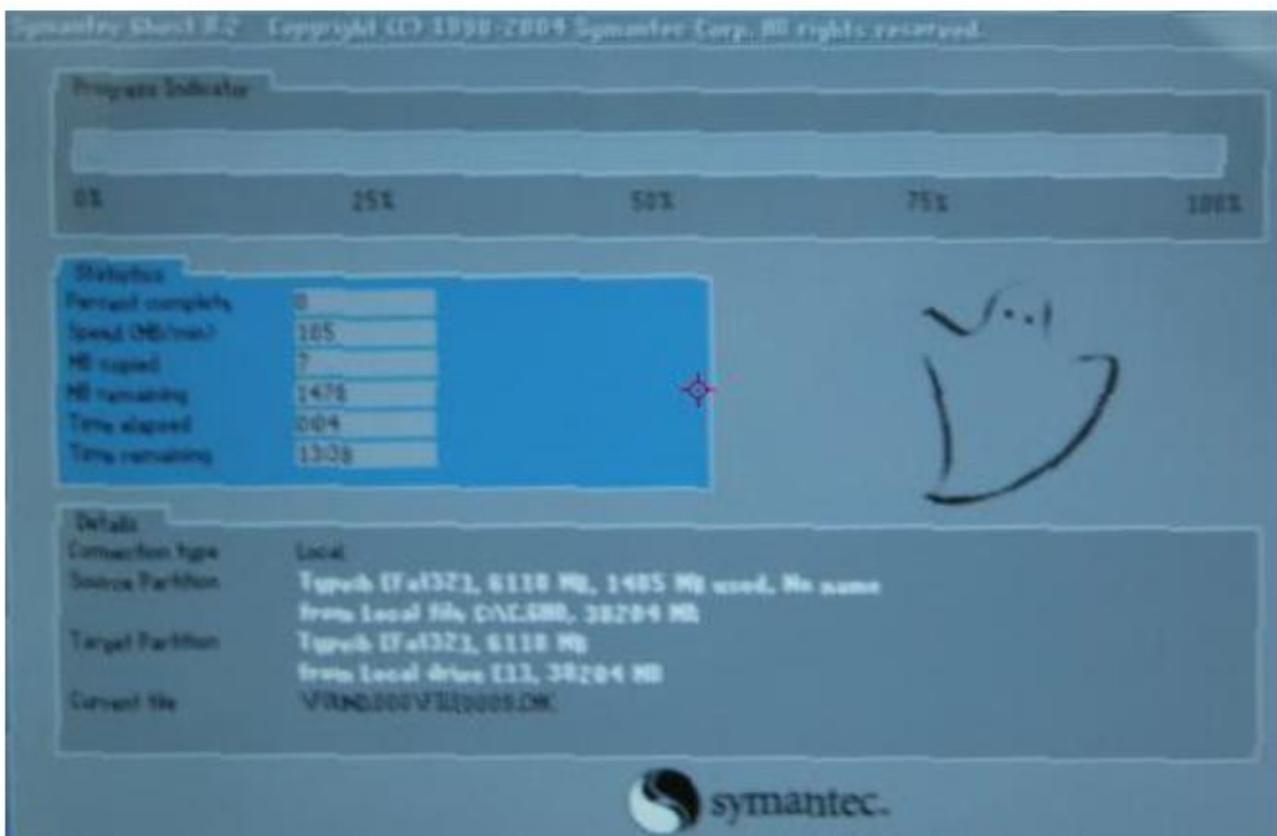


Fig. 3.10 System Recovery Screen

- 3) If the screen shown in Fig. 3.10 appears, system recovery is started. About 10min is required in the whole process of system recovery. Restart the analyzer after recovery.

### 3.1.2.2 Updating of Network Analyzer Program

To update program files or install a new program in an AV3672 series vector network analyzer, **double-click** “D:\AV3672 program installation”. According to the guidance of the menu [Program installation of AV3672 series vector network analyzer], directly press [Next]. When [Select installation type] appears, select [Complete]. If any other menu appears, directly click [Cancel]. Then double-click the icon of AV3672 series vector network analyzer on the desktop or press [Reset] to start the program.

Specific steps are shown in Fig. 3.11 to 3.17.



Fig. 3.11 Start Interface of Installation Program

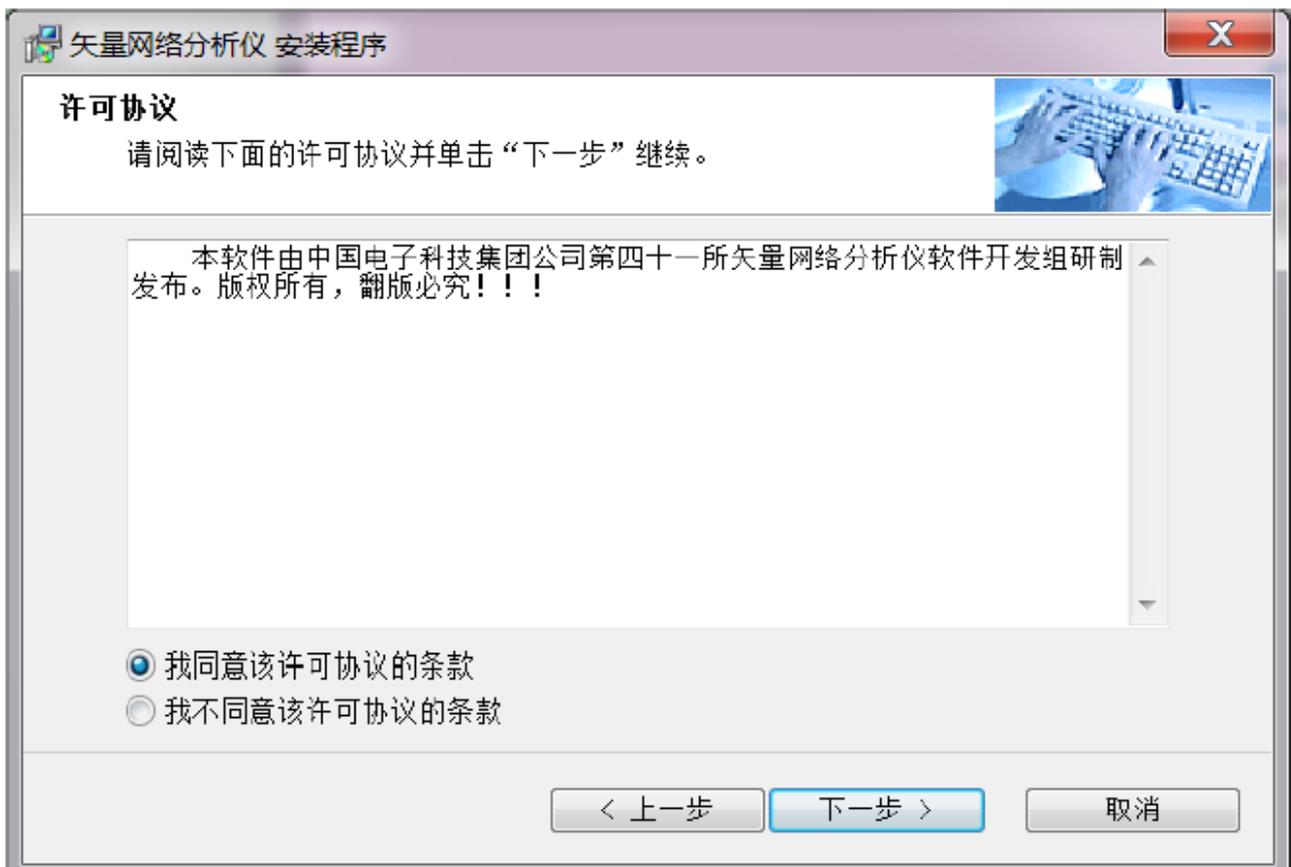


Fig. 3.12 License Protocol Interface

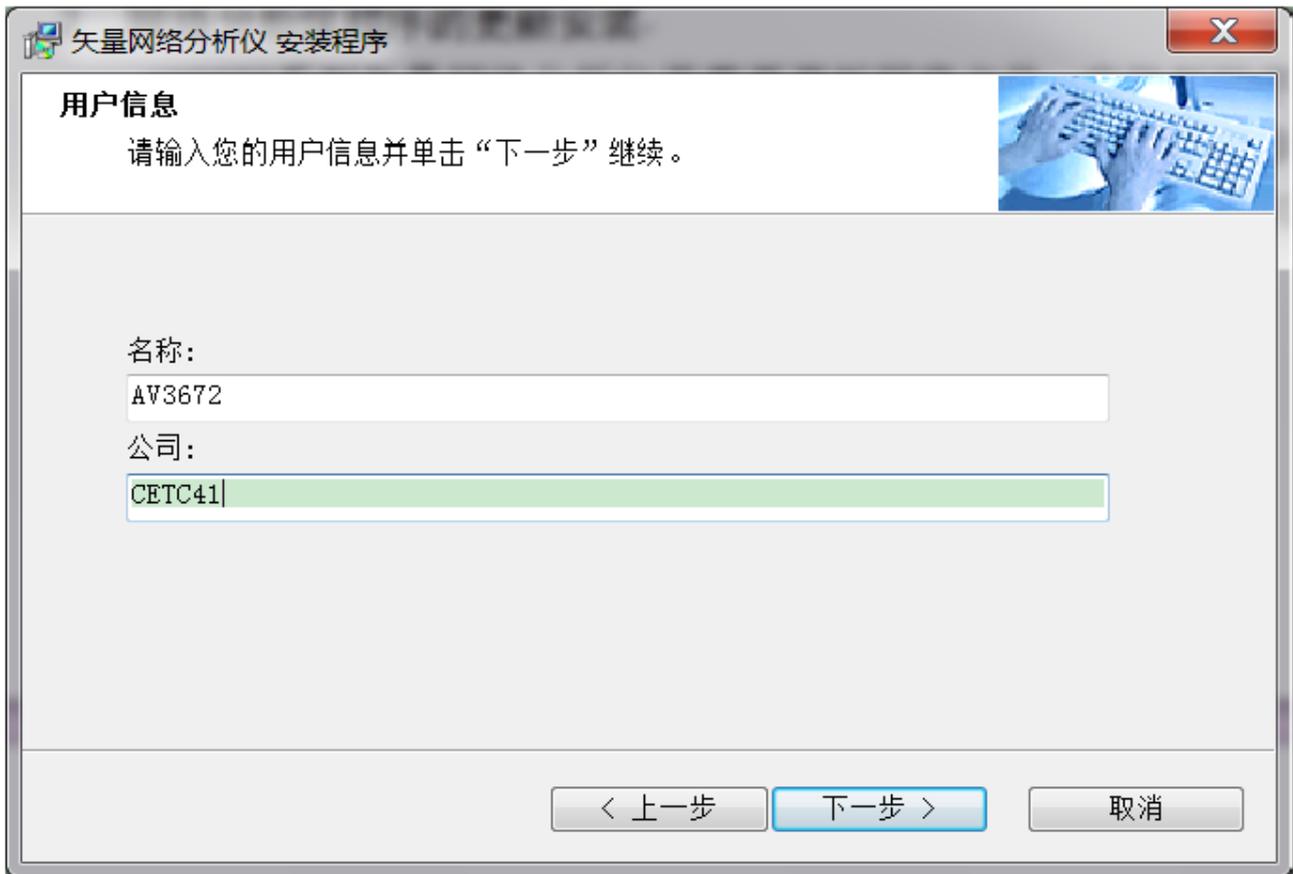


Fig. 3.13 User Information Input Interface

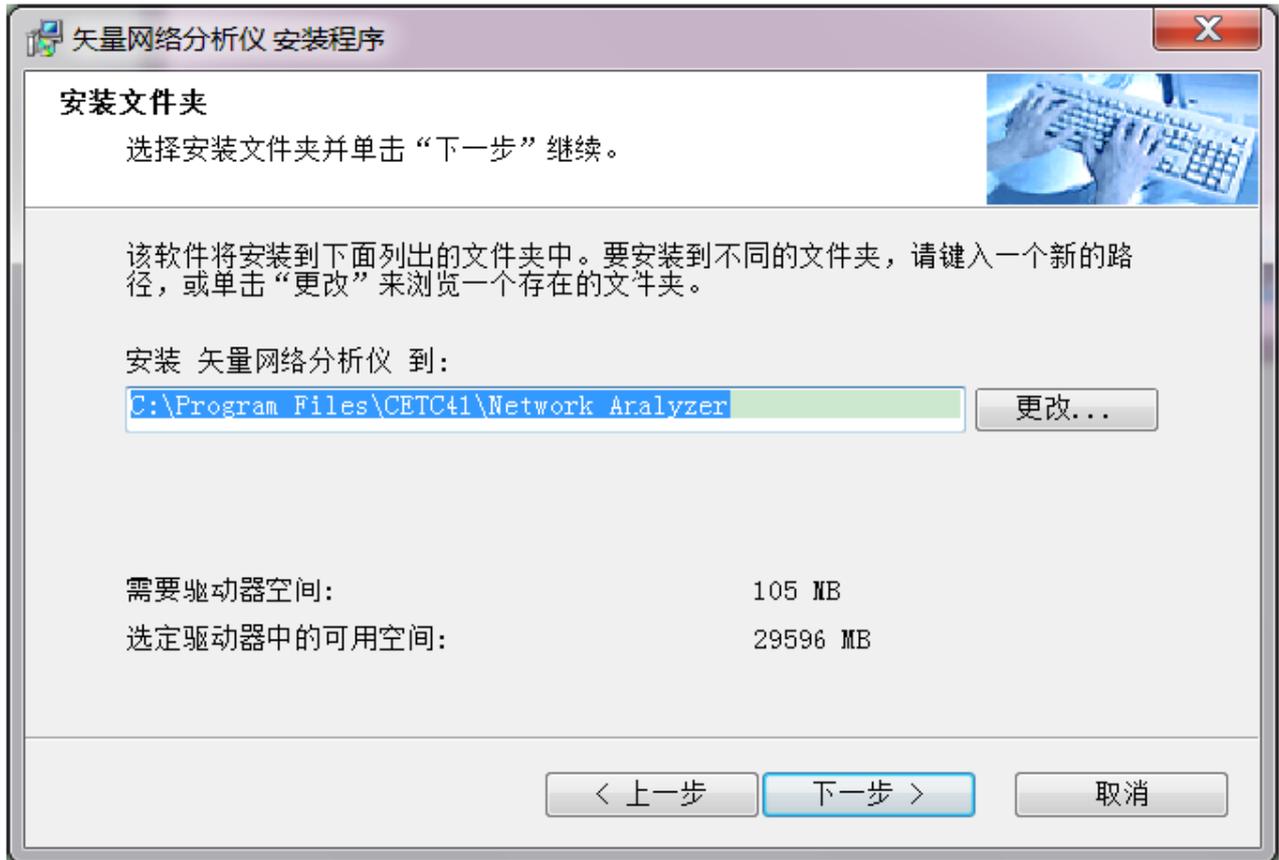


Fig. 3.14 Interface of Installation Directory Selection

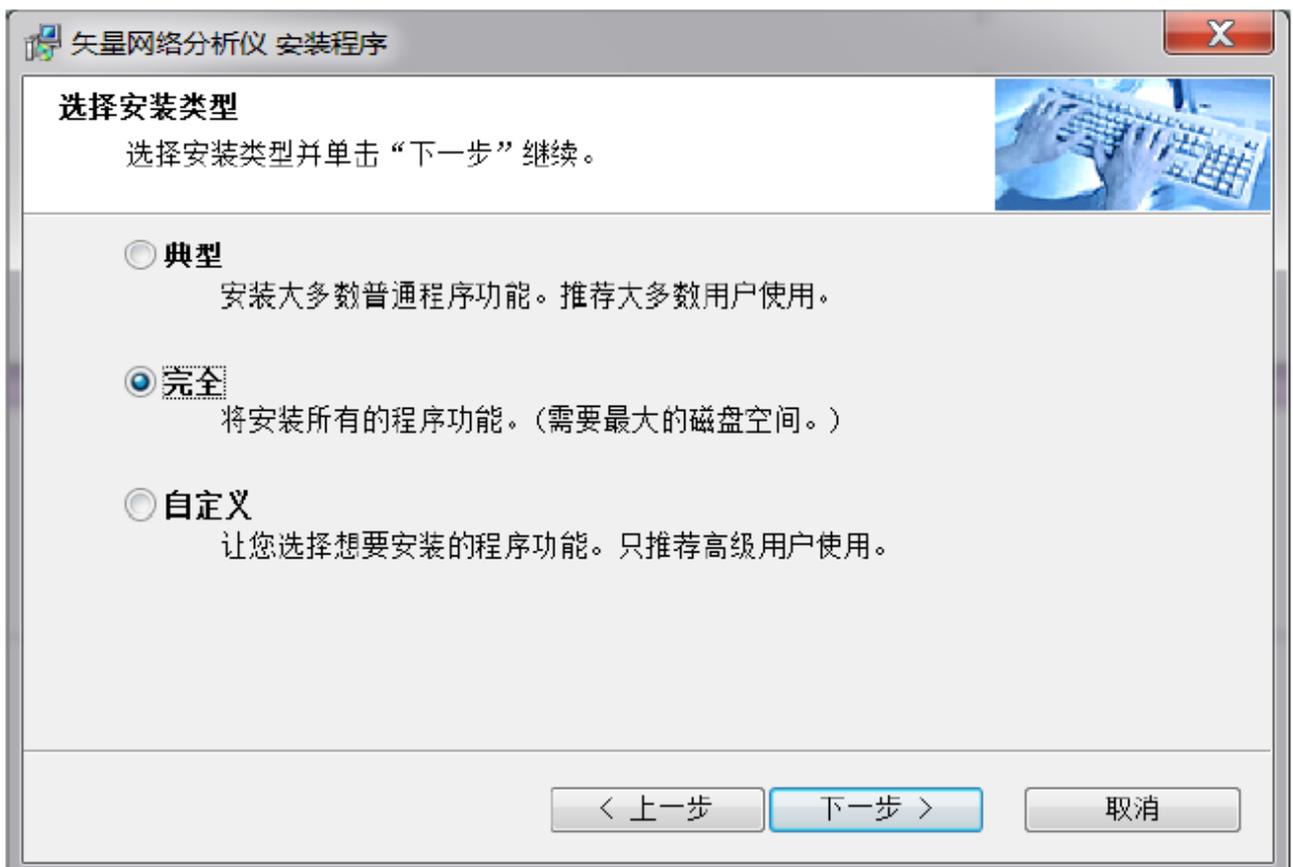


Fig. 3.15 Interface of Installation Type Selection

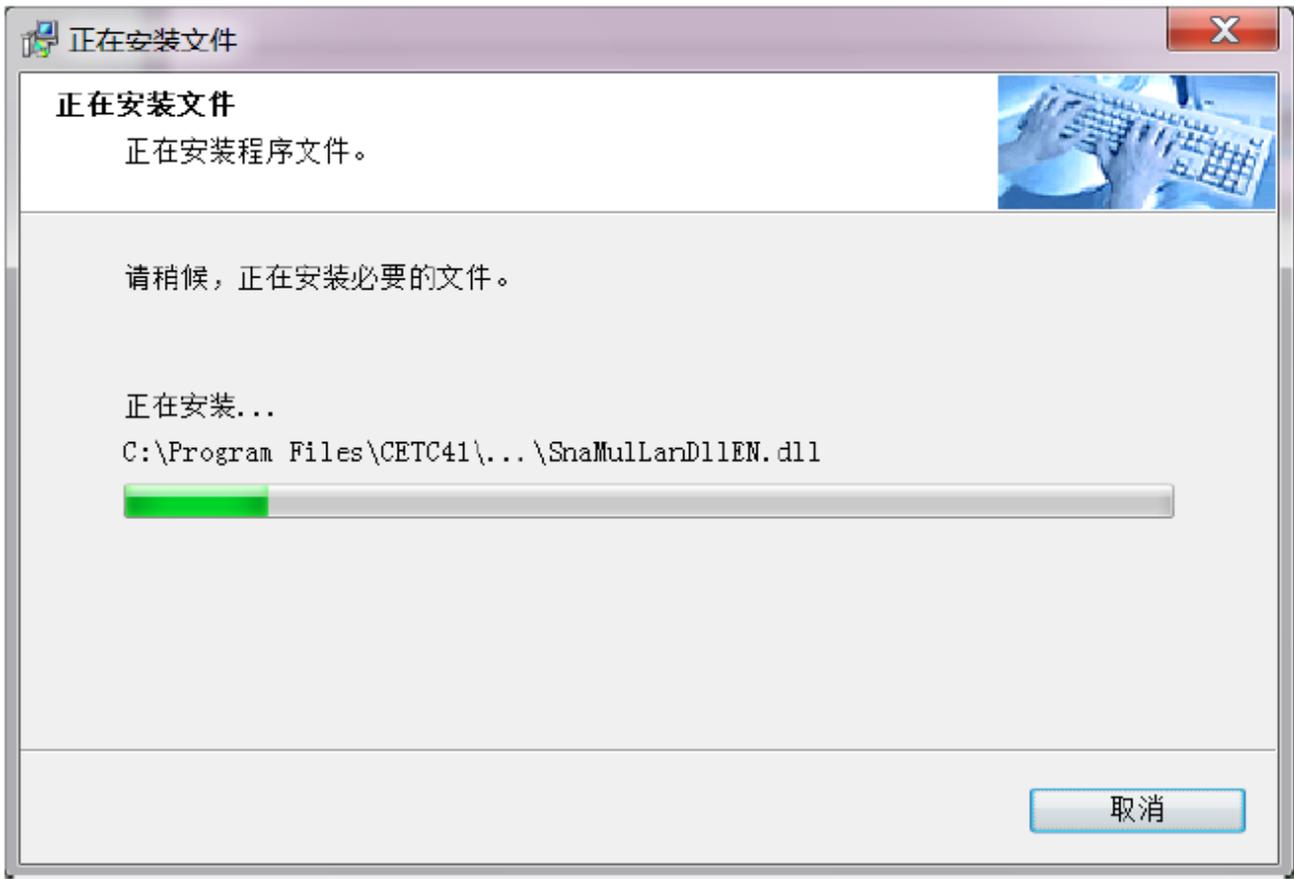


Fig. 3.16 Installation Waiting Interface



Fig. 3.17 Interface of Installation Completion

### 3.1.3 Routine Maintenance

This section describes the routine maintenance of AV3672 series vector network analyzers.

#### 3.1.4.1 Cleaning

##### 1) Cleaning of instrument surface

Clean the instrument surface according to the following steps:

**Step 1:** turn off the instrument by disconnecting the power line connected to the instrument.

**Step 2:** carefully wipe the surface with dry or slightly wet soft cloth. Do not wipe the inside of the instrument.

**Step 3:** do not use any chemical cleaner, such as alcohol, acetone or any cleaner which may be diluted.

##### 2) Cleaning of display

Clean the display after a certain period of use. Follow the steps below:

**Step 1:** turn off the instrument by disconnecting the power line connected to the instrument.

**Step 2:** soak clean soft cloth with cleaner, and carefully wipe the display panel.

**Step 3:** dry the display with clean and soft cotton cloth.

**Step 4:** Connect the power line after the cleaner is thoroughly dry.

### Attention

#### Clean the display.

There is anti-static coating on display surface, do not use fluoride-bearing detergent or acidic/alkaline detergent. Do not spray detergent on display panel directly, otherwise it may penetrate into and damage the instrument.

## 3.2 Front Panel & Rear Panel

This chapter introduces the elements and functions of the front panel, rear panel and operation interface of AV3672 series vector network analyzer.

- Front panel .....44
- Rear panel .....49

### 3.2.1 Front Panel

This section describes the structure and functions of the front panel of AV3672 series vector network analyzers. The front panel is shown in Fig. 3.18.

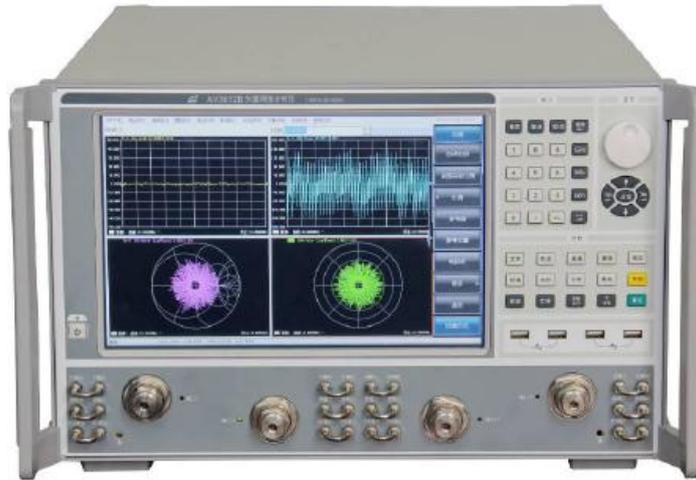


Fig. 3.18 Front Panel of AV3672

#### 1) Input key zone

The keys are used to enter measurement settings, as shown in Fig. 3.19.



Fig. 3.19 Input Key Zone of AV3672

##### a) [OK] key

Confirm the settings and input values in the dialog box and close the dialog box, equivalent to the “OK” button in the dialog box.

##### b) [Cancel] key

Ignore the settings and input in the dialog box and close the dialog box, equivalent to the “Cancel” button in the dialog box.

##### c) [Input method] key

Call the soft keyboard of the Windows 7 system.

**d) [Backspace/←] key**

Move the cursor back and delete the original input after entering.

**e) Number keys**

Include 0-9. Enter the numbers in measurement setting and press the corresponding unit keys to complete input.

**f) Unit keys**

End the number input and distribute a unit to each input value. The unit corresponding to each key is as follows:

[G/n] G/ns (109/10-9)

[M/μ] M/μs (106/10-6)

[k/m] k/ms (103/10-3)

**【↵】** Basic units include dB, dBm, degree, second, Hz or dB/GHz. The keys can also be used to input values with no unit and have the functions of the “Enter” key.

**2) Adjustment key zone**

Include navigation keys and knobs, as shown in Fig. 3.20.



Fig. 3.20 Adjustment Key Zone of AV3672

**a) Knob**

Rotate the knob to adjust the set value in the current active input box.

**b) [←Tab] and [→Tab] key**

- Move left or right to select the menu.
- Switch the active options in the dialog box.

**c) [↑] and [↓] key**

Move up and down in the menu to select the menu item. They also have the following functions in the dialog box: changing the value, selecting the item of the drop-down list, and selecting the desired option in a group of option buttons.

**d) [Click] key**

Have the same functions as the mouse.

**3) Functional key zone**

Functional keys include 10 main menu keys and 5 shortcut keys, as shown in Fig. 3.21.



Fig. 3.21 Functional Key Zone of AV3672

**a) [File] key**

Open the main file menu. The primary menu will be displayed in the auxiliary menu bar: “Save”, “Call”, “Print”, “Minimize application program” and “Exit”.

**b) [Track] key**

Open the main track menu. The primary menu will be displayed in the auxiliary menu bar: “New track”, “Delete track”, “Select track”, “Move track”, “Track title” and “Maximize track”.

**c) [Channel] key**

Open the main channel menu and the current channel will be selected automatically. The primary menu will be displayed in the auxiliary menu bar: “Channel 1/2/3/4”, “Open channel”, “Close channel”, “Select channel”, “Copy channel” and “Hardware setting”.

**d) [Excitation] key**

Open the main excitation menu. The primary menu will be displayed in the auxiliary menu bar: “Frequency”, “Power”, “Scan” and “Trigger”.

**e) [Response] key**

Open the main response menu. The primary menu will be displayed in the auxiliary menu bar: “Measurement”, “Format”, “Scale”, “Display” and “Average”.

**f) [Calibration] key**

Open the main calibration menu. The primary menu will be displayed in the auxiliary menu bar: “Calibration”, “Correction ON/OFF”, “Interpolation ON/OFF”, “Port extension”, “Fixture”, “Edit calibrator”, “Attribute” and “Power calibration”.

**g) [Cursor] key**

Open the main cursor menu. The primary menu will be displayed in the auxiliary menu bar: “Cursor”, “Cursor function”, “Cursor search”, “Cursor attribute” and “Cursor display”. If no cursor is enabled at present, the cursor 1 will be enabled automatically in the default mode. If a cursor is enabled, the current cursor will be selected automatically.

**h) [Analysis] key**

Open the main analysis menu. The primary menu will be displayed in the auxiliary menu bar: “Save”, “Test”, “Track statistics”, “Gate”, “Window”, “Time domain”, “Structural return loss” and “Formula editor”.

**i) [System] key**

Open the main system menu. The primary menu will be displayed in the auxiliary menu bar: “Configuration”, “Record/Run”, “Spread spectrum”, “Windows task bar”, “Reset”, “Custom user reset state” and “Language”.

**j) [Help] key**

Open the main help menu. The primary menu will be displayed in the auxiliary menu bar: “User manual”, “Programming manual”, “Technical support”, “Error information” and “About”.

#### k) [Frequency] key

It is shortcut key to set the frequency. The starting frequency, ending frequency, center frequency, frequency span and frequency offset can be set in the normal mode. The frequency corresponding to measurement can be set in the multi-function option measurement.

#### l) [Power] key

It is a shortcut key to set the power. The power level, power status ON/OFF, power, power attenuation and power slope can be set in the normal mode. The power corresponding to measurement can be set in the multi-function option measurement.

#### m) [Record/run] key

It is a shortcut key to enable the recording/running function of the analyzer. Press the key to automatically start recording. If recording is completed, press this key to automatically start running. This key is only effective for Record/Run 1, and cannot be used to control Record/Run 2.

#### n) [Macro/local] key

If the analyzer is programmed, press this key to switch to the macro state. If the analyzer is not programmed, press this key to open the macro menu.

#### o) [Reset] key

It is a shortcut key to reset the analyzer. If the user has saved the reset state and tick the item “Enable user reset state”, press this key to recover the state saved by the user; otherwise, the system reset state will be recovered.

### 4) USB Interface

The USB interface can be connected with the keyboard, mouse and other USB devices. The front panel is equipped with four USB interfaces in total and conforms to the USB2.0 specifications. The interface jack is of A type (four embedded contacts; Contact 1 on the left side). The features of each interface are as follows:

- Contact 1: Vcc, 4.75V-5.25V; maximum output current: 500mA.
- Contact 2: data -.
- Contact 3: data +.
- Contact 4: ground.



Fig. 3.22 USB Interface

### 5) Display screen

As shown in Fig. 3.23, the display screen of the analyzer is a TFT LCD screen. Technical indicators are as follows:

- 12.1-inch touch screen
- Resolution: 1280×800
- Vertical refresh rate: 60Hz
- Horizontal refresh rate: 48.4Hz

For the function and setting details of each display element of the screen, refer to “4.9 Setting of analyzer display”.

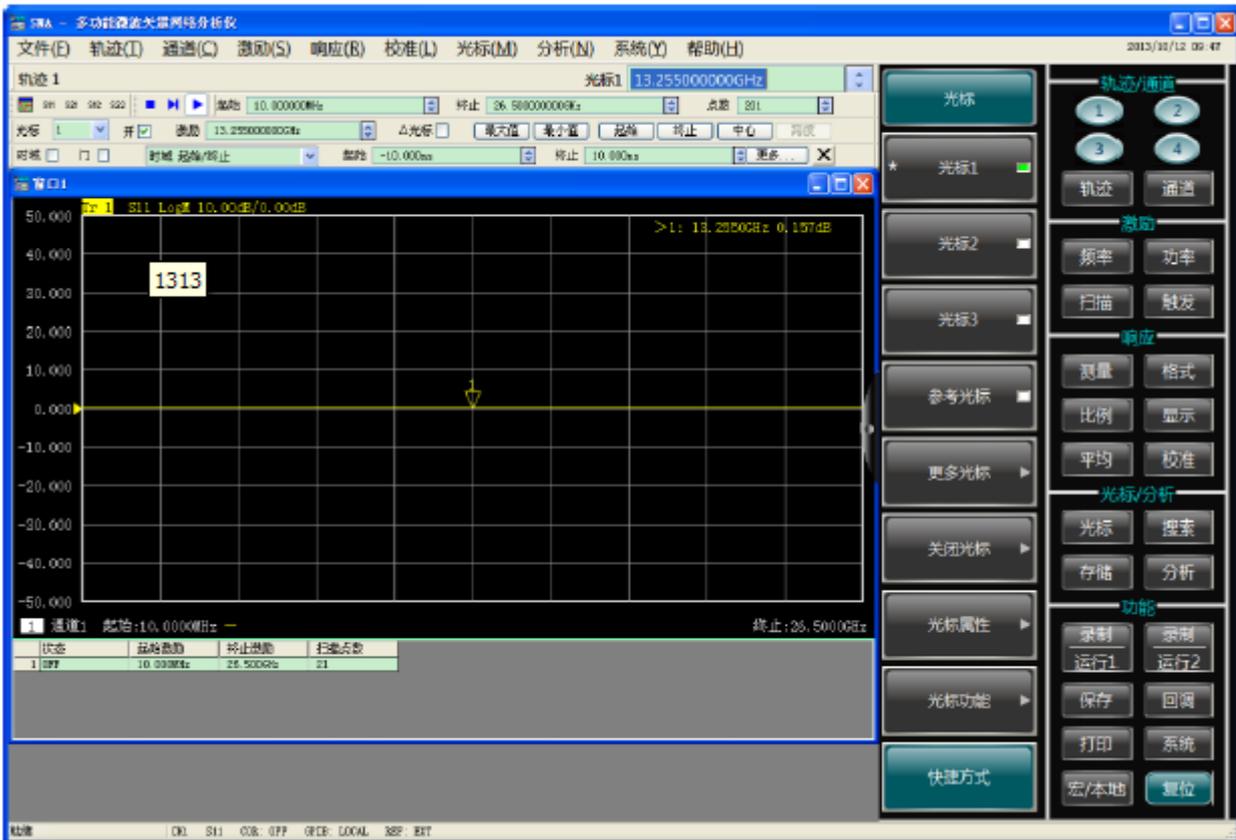


Fig. 3.23 Display Screen of Analyzer

#### 6) [Start/Standby] key and indicator

The [Start/Standby] key and indicator are shown in Fig. 3.24. The power switch is used to start the analyzer or enable the standby state of the analyzer.

- The indicator is green when the analyzer is started.
- The indicator is orange when the analyzer is in the standby state.
- Press the power button to start the analyzer. Then the Windows 7 operating system will be run automatically and the measurement application program will be loaded.
- When the power button is pressed in the standby state, the analyzer will automatically exit the application program. When the power supply will be turned off, the standby state will be enabled.
- This is only a standby switch. It cannot be directly connected with the external power supply or used to cut off the connection between the instrument and external power supply. The external power supply of the analyzer can be shut down by the power switch on the rear panel. The connection between the analyzer and external power supply can be fully cut off by removing the power line.



Fig. 3.24 [Start/Standby] Key and Indicator

#### 7) Test port

As shown in Fig. 3.25, the test is equipped with two 50Ω and 3.5mm (male) test ports for switching between the RF source and receiver, so as to measure the tested device in two directions. The yellow light is used to indicate the source output port.



Fig. 3.25 Test Ports of Analyzer

### 3.2.2 Rear panel

This section describes the structure and functions of the rear panel of AV3672 series vector network analyzers. The rear panel is shown in Fig. 3.26.



Fig. 3.26 Rear Panel of Network Analyzer

#### 1) 10MHz reference connector



Fig. 3.27 10MHz Reference Connector

##### a) 10MHz reference input

As shown in Fig. 3.27, the BNC (female) connector can be used for connection between the analyzer and external reference signal. The 10MHz external reference signal detected by the port will be used as the reference frequency of the instrument, instead of the internal reference frequency. The 10MHz reference input port has the following features:

- Input frequency: 10MHz±1ppm
- Input level: -15dBm to +20dBm
- Input impedance: 200Ω

### b) 10MHZ reference output

The reference signal with the following features can be provided for the outside through the BNC (female) connector.

- Output frequency:  $10\text{MHz} \pm 1\text{ppm}$
- Signal type: sine wave
- Output level:  $13\text{dBm} \pm 4\text{dB}$  into  $50\Omega$
- Output impedance:  $50\Omega$

### 2) General-interface bus connector

As shown in Fig. 3.28, this is a 24-pin D-type female connector, meeting the IEEE-488 standards. It is used to transmit and receive GPIB/SCPI commands.

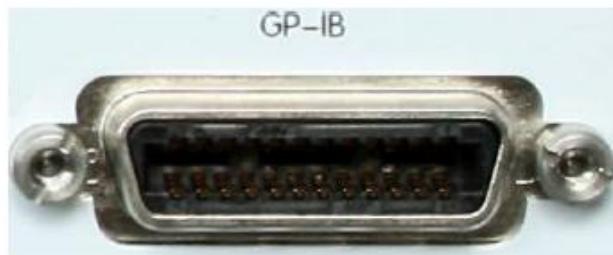


Fig. 3.28 General-interface Bus Connector

### 3) LAN connector

As shown in Fig. 3.29, this is a 10/100/1000BaseT Ethernet connector of standard 8-pin structure, and three data rates can be selected.



Fig. 3.29 LAN Connector

### 4) USB connector

As shown in Fig. 3.30, the connector jack is of Type A (four embedded contacts; with Contact 1 on the left side) and Type B. Type A connector can be connected to the USB mouse, keyboard or other USB interface devices. The rear panel is equipped with four interfaces in total. The interface features are as follows:

- Contact 1: Vcc, 4.75V-5.25V, max. 500mA
- Contact 2: data -
- Contact 3: data +
- Contact 4: ground

Type B connector is mainly used for control. The network analyzer can be connected to the external computer or remote device through SCPI control. The rear panel is equipped with one interface.



Fig. 3.30 USB Connector (B-type on the left and A-type on the right)

### 5) Video graphic adapter (VGA) output connector

As shown in Fig. 3.31, this is a 15-pin D-sub female connector to be connected with the external VGA display of corresponding resolution. In this case, the user can observe the internal and external display at the same time.



Fig. 3.31 Output Connector of Video Graphic Adapter (VGA)

Right-click the mouse on the Windows desktop. Confirm the multi-display mode by the right-click menu, as shown in Fig. 3.32.



Fig. 3.32 Configuration of Multi-display Mode

- If **[Monitor]** is ticked, only the external VGA display to observe the measurement results, and the internal LCD display of the analyzer will be ineffective.
- If **[Laptop]** is ticked, only the internal LCD display of the analyzer is used to observe the measurement results, and the external VGA display will be ineffective.
- If **[Monitor + Laptop]** is ticked, the internal LCD display and external VGA display can be used as the same time to observe the measurement results.

### 6) LO and RF output connector

As shown in Fig. 3.33, the 3.5mm female interface is used for LO output and RF output. The LO interface is used for internal LO signal output, and RF interface for RF source signal output. The connector can be used for fault detection and millimeter wave spreading. The interface features are as follows:

- Frequency range of LO output signal:  
12.535MHz-13.507606GHz/26.507606GHz/43.507606GHz/50.007606GHz/67.007606GHz
- Power range of LO output signal: -4dBm to 6dBm
- Frequency range of RF output signal: 3.2GHz-13.5GHz/26.5GHz/43.5GHz/50GHz/67GHz
- RF output signal power: -3dBm±2dB



Fig. 3.33 LO and RF Output Connector

### 7) Pulse input/output connector

As shown in Fig. 3.34, this is a 15-pin D-type female connector. The working status of the internal pulse generator can be monitored synchronously through this interface. In addition,

Electrical features are as follows:

- Pulse width range: 33ns to 60s
- Pulse transition time: 30ns
- Input impedance: 1KOhm
- DC input: <5.5V
- Drive voltage: 0V (off)+3.3V (on)



Fig. 3.34 Pulse Input/Output Connector

The pin definition and description are as follows.

Table 3.5 Pin Specifications of Pulse Input/Output Connector

Pin	Function description
1~5	intermediate-frequency pulse gate input A/B/C/D/R (TTL)
6, 9, 15	Reference ground
7	Input of pulse synchronization trigger
8	Input of source pulse modulation drive
10~13	Pulse output 1-4 (TTL)
14	Vacancy

### 8) External medium-frequency input connector

As shown in Fig. 3.35, five SMA interfaces are used for external medium-frequency input of the vector network. The two-port model is marked with A, B, R1 and R2, and the four-port with A, B, C, D and R. Features are as follows:

- Input impedance: 50Ω
- RF input: <23dBm
- DC input: <5.5V
- 0.1dB compression point: -9dBm



Fig. 3.35 External Medium-frequency Input Connector

### 9) Automatic test interface connector

As shown in Fig. 3.36, this interface is a 36-pin female connector. The network analyzer and material handler can exchange signals through this interface to provide a stable and reliable automatic test environment for the user.

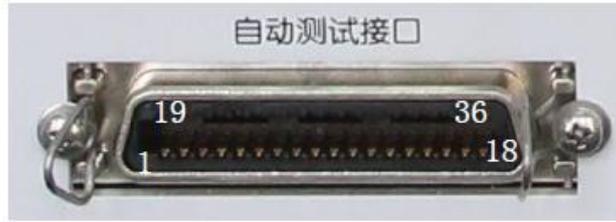


Fig. 3.36 Automatic Test Interface Connector

The port is composed of TTL array and has the following electrical features:

a) Input voltage range: -0.5V to 5.5V

High level of TTL: 2.0V to 5.0V

Low level of TTL: 0V to 0.5V

b) Output current/voltage range: -10mA to 10mA

Output current

High level of TTL: -5mA

Low level of TTL: 3mA

Output voltage:

High level of TTL: 2.0V to 3.3V

Low level of TTL: 0V to 0.8V

The pin definition and description are as follows.

Table 3.6 Pin Specifications of Automatic Test Interface Connector

Pin	Function description
1 (lower left corner)	ground
2	Input 1
3, 4	Input 1 and 2
5~12	Output port A0-A7
13~17, 19	Output port B0-B5
22~25	Input/output port C0-C3
26~29	Input/output port D0-D3
18	external triggering
20	Output port B6/Index signal
21	Output port B7/Trigger Ready
30, 31	Port C/D State
32	Output port OK
33	Pass/Fail status information
34	End of scanning
35, 36	+5V and Pass/Fail status information confirmation

#### 10) Extension interface connector

As shown in Fig. 3.37, this interface is a 9-pin D-type female connector.



Fig. 3.37 Extension Interface Connector

The pin definition and description are as follows.

Table 3.7 Pin Specifications of Extension Interface Connector

Pin	Name	Function description
1 and 2 (lower left corner)	+15V, -15V	15V@400mA
3, 4	Analog output port 1 and 2	The +/-10V@100mA output resolution can be controlled to be 2.44mV by means of internal setting.
5	ACOM	Ground wire of system
6	GndSence	Ground wire of analog input/output detector
7, 8	Analog input port 1 and 2	Analog input +/-10V@1.22mV resolution
9	Power switch	Power switch input

### 11) External tester interface connector

As shown in Fig. 3.38, this tester interface is a DB-25 female interface, including 13 addresses and data multiplexing lines, three control lines and one interruption control line, and is used to control the external tester (such as the external spread spectrum controller).



Fig. 3.38 External Tester Interface Connector

Table 3.8 Pin Specifications of Interface Connector of External Test Instrument

Pin	Name	Function description
1, 15, 16 and 18 (with Pin 1 in the lower left corner)	Address selection bit of test device	The initial bit of grounding is the lowest. Once an external device is connected successfully, the bit will be increased by 1.
2	Waiting for scanning	Use the program-controlled scanning switch to trigger and introduce the time delay mode.
3~6, 9~11, 17, 19~23	Address bit AD0-AD12	Used to output the data address or receive/send data information.
7, 12	ground	Reference ground wire
8	Address switch LAS	The low level means that the address information is transmitted at present.
24	Data switch LDS	The low level means that the data information is transmitted at present.
25	Reading and writing prompt RLW	The low level indicates output, while high level indicates data input.
13	Input interruption	Read the TTL input status according to the program.
14	Unconnected	Maximum range: +22V100mA

### 12) Trigger input/output interface connector

As shown in Fig. 3.39, this interface is an external and auxiliary trigger input/output interface. Specific functions are as follows:

- External trigger input - if it is enabled, the vector network analyzer will be triggered according to the connector signal.
- External trigger ready - if it is enabled, the vector network analyzer will send a “Ready” signal to the external device through this interface.

- Auxiliary trigger input 1/2 - if it is enabled, the external device will send an “OK” signal (meaning the external device is ready to receive trigger signal) to the vector network analyzer through this interface.
- Auxiliary trigger output 1/2 - if it is enabled, the vector network analyzer will send an “OK” signal through this interface before (or after) one measurement.



Fig. 3.39 Trigger Input/Output Interface Connector

### 13) 28V (BNC) interface connector

As shown in Fig. 3.40, this BNC (female) connector can be used to drive a noise source.



Fig. 3.40 28V (BNC) Interface Connector

## 3.3 Analyzer Interface

The analyzer interface is used to guide the user to use and set the analyzer, and includes the front panel interface and user interface.

- Front panel interface .....55
- Mouse interface .....56

### 3.3.1 Front Panel Interface

As shown in Fig. 3.41, the user can use the keys of the front panel to set and operate the analyzer according to the above two methods. The analyzer can be rapidly set by the following steps.

- Press the corresponding front panel key to activate the auxiliary menu bar.
- Observe the functional items of the auxiliary menu bar.
- Press the corresponding panel for required function.
- Enter the value (if required).

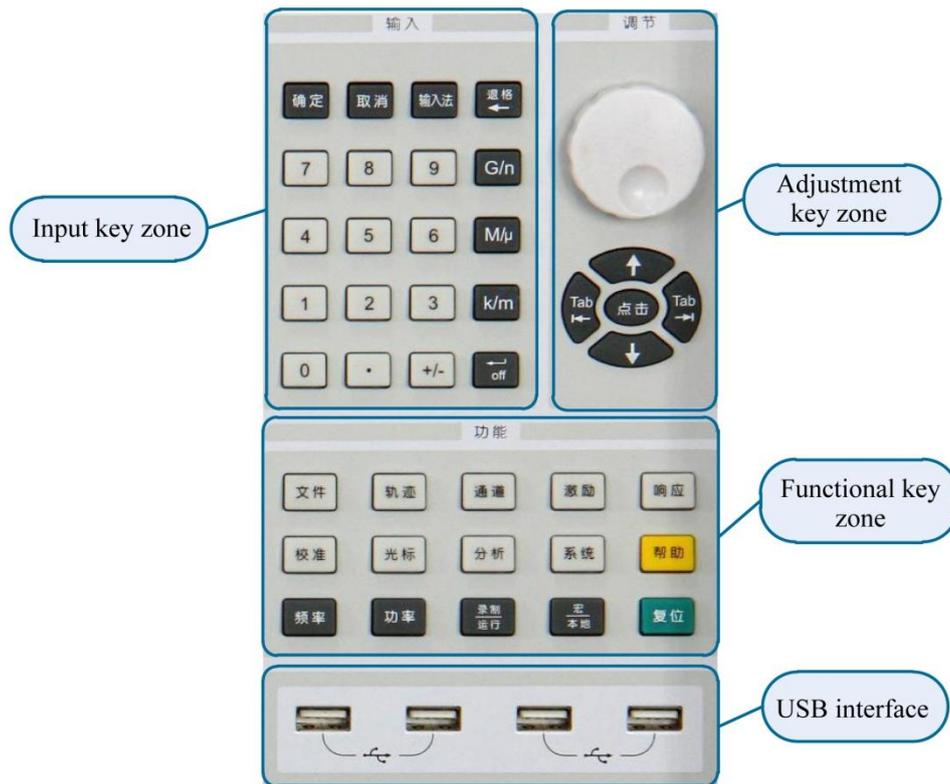


Fig. 3.41 Front Panel Interface

### 3.3.2 Mouse Interface

As shown in Fig. 3.42, the mouse can be used to realize the following operations.

- Click the **menu bar** to display the drop-down menu.
- Click the **input** toolbar to adjust the entered number.
- Click the **cursor** toolbar to use the cursor.
- Click the **measurement** toolbar to add the measurement track.
- Click the **scanning** toolbar to control scanning of the analyzer.
- Click the **excitation** toolbar to set scanning excitation.
- Click the **time domain** toolbar to set time domain settings.
- Right-click the mouse on the screen to display the right-click menu.
- Click the track bar to select the current activation track.
- Right-click the mouse on the track bar to set the current activation track in the right-click menu.
- Click the auxiliary menu bar and shortcut toolbar to perform corresponding settings.

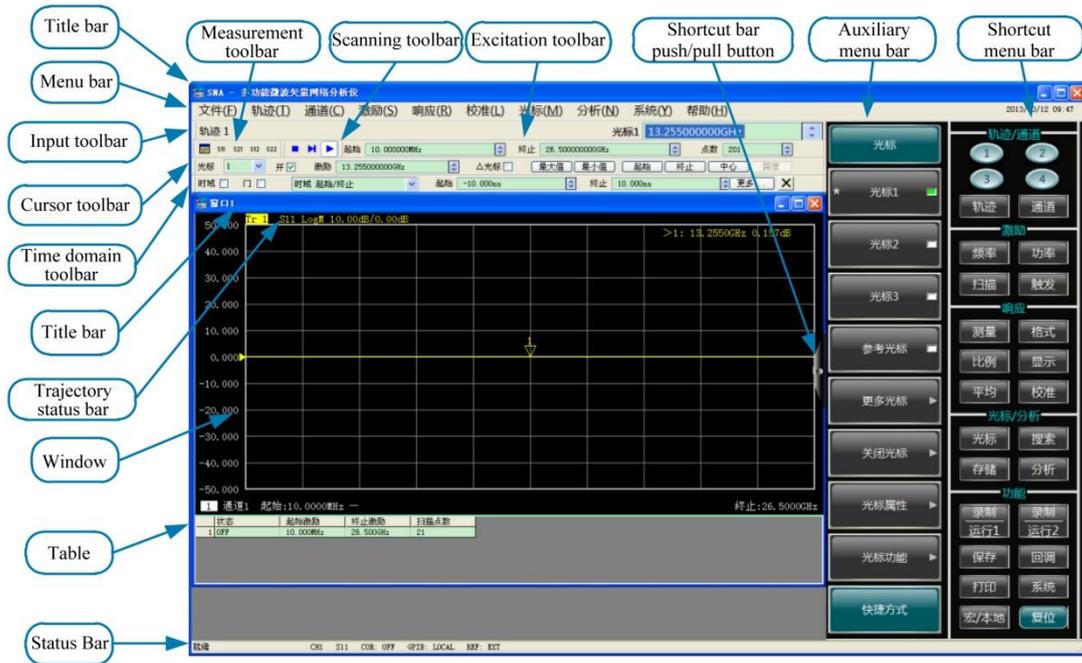


Fig. 3.42 Display Screen of Analyzer

### 3.4 Track, Channel and Window of Analyzer

- Track .....57
- Channel .....57
- Window .....58

#### 3.4.1 Track

The track is a series of measurement data points. Track settings will affect the mathematical operation and display of measurement data. Only the settings of the active track can be changed. Click the corresponding track status button to activate the track. For detailed setting, refer to “Change track activation status” of “4.2 Selection of Measurement Parameter”. Track settings include:

- Measured parameters
- Display format
- Scale
- Track operation
- Cursor
- Electrical delay
- Phase deviation
- Smoothing
- Time domain transformation

#### 3.4.2 Channel

The channel includes the track. The analyzer supports 64 channels in total. Channel settings are associated with measurement of the track in the channel. The same channel settings are applicable to tracks in the same channel. Only the settings of the active channel can be changed. Once the track in the channel is activated, the channel will also be activated. For detailed settings of the active track, refer to “Change track activation status” of “4.2 Selection of Measurement Parameter”. Channel settings include:

- Frequency span

- Power
- Standard data
- Intermediate-frequency bandwidth
- Number of scanning points
- Scanning setting
- Average
- Trigger (for some settings)

### 3.4.3 Window

The window is used to observe the measurement track. The analyzer supports 32 windows at most, and eight tracks can be displayed at most in each window. Set the window display by the [View] menu. For details, refer to “4.9 Setting of Analyzer Display”.

#### 1) Create a new window.

Menu path: [Response] > [Display] > [Window] > [New window]. Then a new window will be created. The default setting of the track in the window is S<sub>11</sub>, indicating Channel 1.



Fig. 3.43 Creation of New Window

#### 2) Use the full screen window.

If several windows are opened at the same time, the track will be unclear as a result of too small window size. In this case, one window can be displayed in the full screen so as to better observe the track in the window.

Use the mouse to display one window in the full screen according to the following three methods.

- If the title bar is opened, click the “**Maximize**” button in the title bar of the window.
- If the title bar is closed, double-click the mouse in the window to be maximized.
- Menu path: [Display] > [Window] > [Maximize].

## 3.5 Data Analysis

- Cursor .....59
- Track operation and statistics .....69

- Limit test .....71
- Ripple test .....73
- Bandwidth test .....76
- Formula editor .....78

### 3.5.1 Cursor

Use the cursor to read the measurement data, search the values of specific type or change the excitation settings. Nine normal cursors and one reference cursor can be used at most for each track.

- Formula editor .....59
- Move cursor .....61
- Cursor search .....62
- Cursor function .....66
- Advanced cursor option setting .....67
- Cursor list .....68

#### 3.5.1.1 Create cursor

##### 1) Use of cursor functions

##### a) Cursor toolbar

Menu path: [Response] > [Display] > [Toolbar]. Click [Cursor] in the toolbar sub-menu to display the cursor toolbar.

Select the cursor to be opened in the [Cursor] box.

Set the cursor excitation value in the [Excitation] box.

Click the [Open] check box.



Fig. 3.44 Creation of Cursor by Cursor Toolbar

**b) Cursor menu**

Menu path: [Cursor] > [Cursor]. The **cursor** sub-menu will be displayed.

Click the cursor to be opened in the sub-menu.



Fig. 3.45 Creation of Cursor by Cursor Menu

**c) Cursor dialog box**

Menu path: [Cursor] > [Cursor] > [Cursor...]. The cursor dialog box will be displayed.

Select the cursor to be opened in the [Cursor] box.

Set the cursor excitation value in the [Excitation] box.

Click the [Open] check box.



Fig. 3.46 Creation of Cursor by Cursor Dialog Box

**2) Cursor dialog box**

**a) [Cursor] box**

Select the cursor to be defined.

**b) [Excitation] box**

Define the excitation value of X-axis of the selected cursor.

**c) [Open] check box**

Select it to open the cursor in the cursor dialog box and clear it to close the cursor in the cursor dialog box.

**d) [ $\Delta$  Cursor] check box**

Select it to display the relative values of the selected cursor and **reference R** cursor. If the cursor R is not opened, select the check box to automatically open the reference **R cursor**.

**e) [Advanced cursor...] button**

Click it to display the advanced cursor dialog box.

**f) [Close all cursors] button**

Click it to close all the opened cursors.

**3.5.1.2 Move cursor**

1) Activate the cursor to be moved in one of the above three methods.

2) Move the cursor in one of the following methods.

a) Click the [**Excitation**] box in the cursor dialog box and move the **cursor** in the following method.

i. Directly enter the cursor excitation value.

ii. Rotate the knob to move the cursor.

iii. Click the [ $\uparrow$ ] or [ $\downarrow$ ] in the [**Excitation**] box to change the cursor excitation value.

iv. Press [ $\uparrow$ ] or [ $\downarrow$ ] in the **adjustment key zone** to change the cursor excitation value.

b) Click the [Excitation] box in the cursor toolbar and move the cursor in the following method.

i. Directly enter the excitation value.

ii. Rotate the knob to move the cursor.

iii. Click the [ $\uparrow$ ] or [ $\downarrow$ ] in the [**Excitation**] box to change the cursor excitation value.

iv. Press [ $\uparrow$ ] or [ $\downarrow$ ] in the **adjustment key zone** to change the cursor excitation value.

c) Move the cursor in the input toolbar in the following method.

i. Directly enter the excitation value.

ii. Rotate the knob to change the excitation value.

iii. Press [ $\uparrow$ ] or [ $\downarrow$ ] in the **adjustment key zone** to change the cursor excitation value.

iv. Click the Up and Down arrow in the input box to change the cursor excitation value.

**3.5.1.3 Cursor search**

Search the specific measured value with the cursor searching function. If no matching measurement data are found, the cursor will remain unchanged in the current position.

**1) Cursor search method:**

Menu path: [**Cursor**] > [**Cursor search**].

Set the cursor search in the dialog box. Click [**Execute**] to execute cursor search and [**OK**] to close the dialog box.

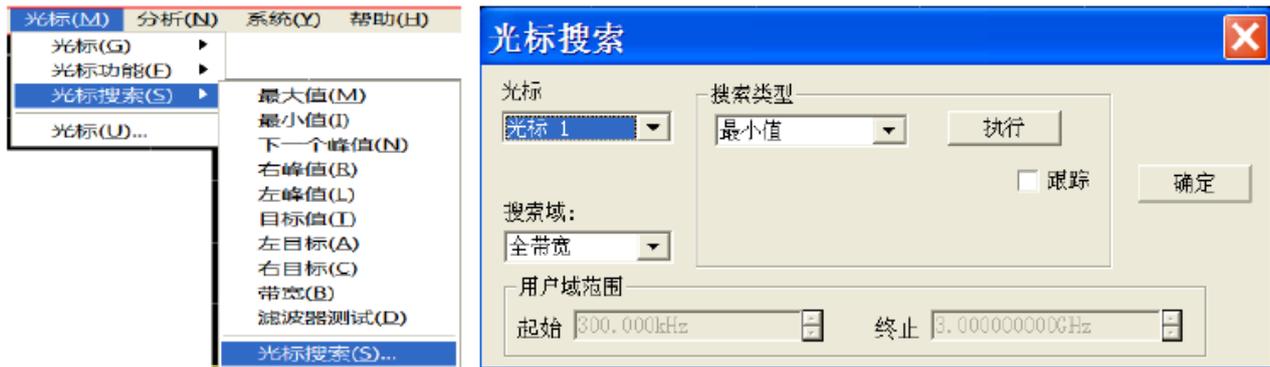


Fig. 3.47 Cursor Search

## 2) Cursor search dialog box

### a) Cursor zone

Select the cursor to be defined for search.

### b) Search domain zone

Define the range of cursor search. The default search domain is the **full bandwidth**. In addition, the instrument supports the search of **nine user settings**. The **user setting** to be selected must be defined in the **user domain range**. The ranges of search domains **set by users** are allowed to be overlapping. Various cursors can be applied in one search domain. Fig. 3.48 shows a group of search domains set by users.

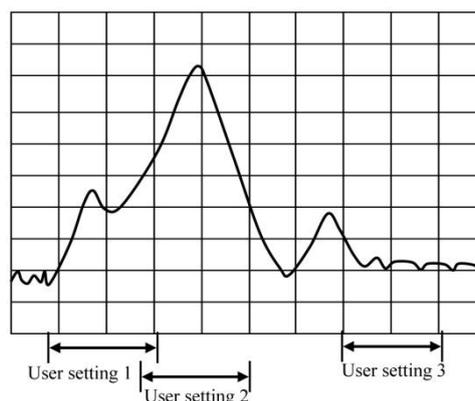


Fig. 3.48 Schematic Diagram of Search Domains Set by Cursor Users

### c) User domain range zone

The **[Start]** box and **[End]** box within the **user domain range** zone are used to define the search domain set by the user.

### d) Search type zone

Define the type of cursor search. The analyzer supports the following 10 search types:

- **Minimum value:** search the minimum measurement data point.
- **Maximum value:** search the maximum measurement data point.
- **Right peak value:** search next effective peak value on the right side of the cursor. The peak must be defined at first.

The peak is defined according to **[Threshold]** and **[Offset]**. The minimum peak point is defined in the **[Threshold]** box. The effective peak point must be above the threshold value, and the valley points on both sides may be less than the threshold value. The minimum vertical distance between the peak value and valley value is defined in the **[Offset]** box. The vertical distance between the effective peak value and valley values on both sides must be more than the offset value. The analyzer settings in Fig. 3.49 are as follows:

Threshold: -50dB  
Offset: 10dB  
Scale: 10dB/grid

- i. Peak A is effective, and the threshold and peak value conform to the requirements.
- ii. Peak B is not effective, and the offset does not conform to the requirements.
- iii. Peak C is not effective, and the threshold does not conform to the requirements.

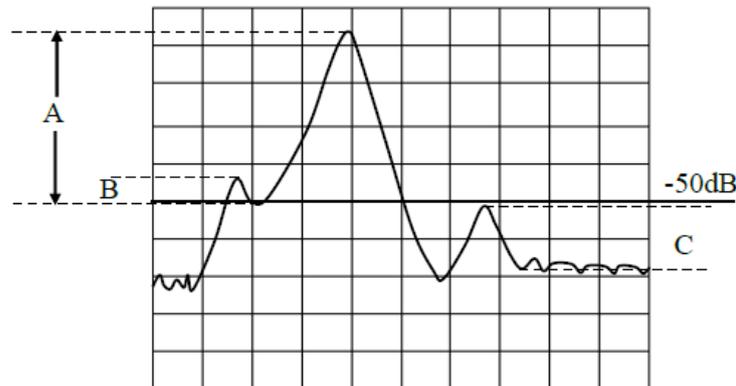


Fig. 3.49 Schematic Diagram of Peak in Cursor Domain

- **Left peak:** search next effective peak value on the left side of the cursor. The peak must be defined at first.
  - **Next peak:** search next peak lower than the current cursor amplitude. The peak must be defined at first.
  - **Target:** enter the search target value in the **[Log]** box and click **[Execute]**. The cursor will move to the first target value on the right side of the current cursor location. Then continuously click **[Execute]**, and the cursor will move to next target value on the right side until it reaches the maximum excitation value. In this case, the cursor will return to the lowest excitation value to search the target value.
- ① If the **[Discrete cursor]** is selected in the **[Advanced cursor]** dialog box, the cursor will move to the discrete data point corresponding to the target value.
  - ② If the **[Discrete cursor]** is cleared in the **[Advanced cursor]** dialog box, the cursor will move to the interpolation data point corresponding to the target value.
- **Left target:** only search the target value on the left side of the current cursor.
  - **Right target:** only search the target value on the right side of the current cursor.
  - **Bandwidth:** if the **bandwidth** searching function is selected, set the **level** (default: -3dB) below the peak in the level box and measure the bandwidth at the set level, as shown in Fig. 3.50. Use Cursor 1-4 for measurement. Cursor 1 is used to search the maximum peak value, Cursor 2 to search the point of specified level on the left side of the peak, Cursor 3 to search the point of specified level on the right side of the peak, and Cursor 4 to search the center of the bandwidth. The following information will be displayed after measurement.
- Bandwidth: frequency difference between the right and left cutoff frequency point.
- Center: frequency of the middle point between the right and left cutoff frequency point.
- Q: value calculated by dividing the center frequency by the bandwidth.
- Loss: value measured at the center frequency point of the bandwidth.
- Left cutoff: minimum frequency of two points below the specific bandwidth level of the signal peak.
- Right cutoff: maximum frequency of two points below the specific bandwidth level of the signal peak.

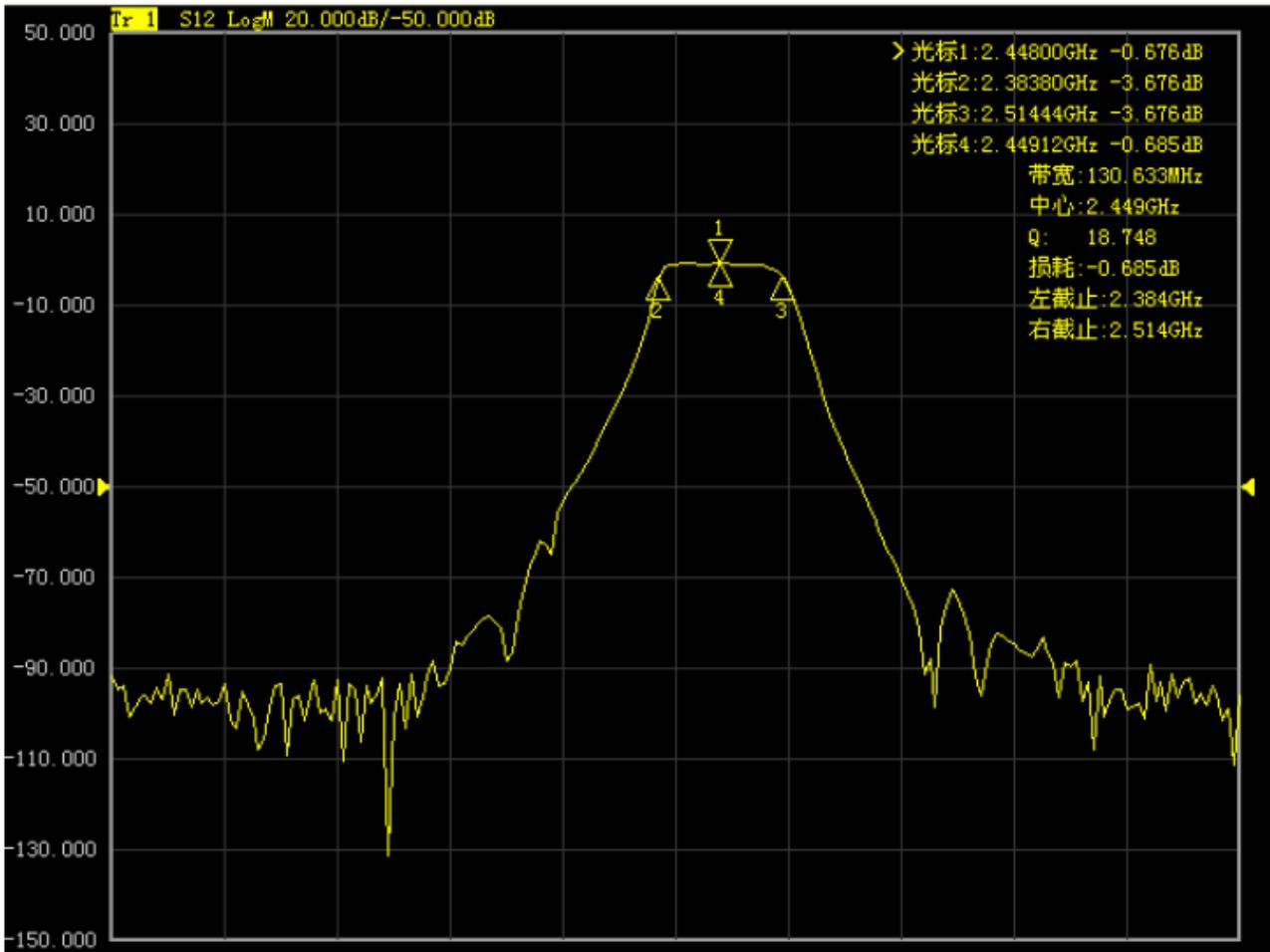


Fig. 3.50 Bandwidth Search

- **Filter test:** the analyzer has a special shortcut function to test the filter, and all test parameters will be automatically displayed on the screen so that the user can directly observe measurement results. As manual setting in the test is eliminated, the speed of filter test is greatly increased. As shown in Fig. 3.51.

Eight parameters of the filter test are displayed in the upper left corner of the track. When the **filter test** is started, **bandwidth search** will be automatically enabled, and six parameters of the bandwidth test will be displayed in the upper right corner at the same time.

Level of Bandwidth 1: set the level of Bandwidth 1 in the input box.

Level of Bandwidth 2: set the level of Bandwidth 2 in the input box.

Percentage frequency offset: set the percentage of frequency offset in the input box.

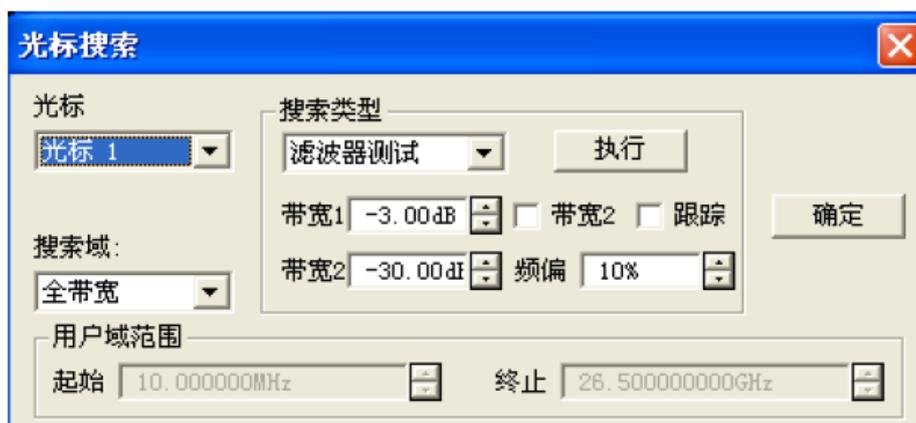


Fig. 3.51 Filter Test

**e) [Execute] button**

Click the [Execute] button to execute one cursor search of specified type.

**f) [Track] check box**

If [Track] is selected, the search function will be executed after each scanning according to the current search type and domain setting. In this case, the cursor will be in the desired position after each scanning.

**3.5.1.4 Cursor function**

**1) Use of cursor functions**

Some settings of the instrument can be changed according to the cursor activation position, such as the starting frequency, ending frequency, etc. The setting method is as follows.

Menu path: [Cursor] > [Cursor function].



Fig. 3.52 Measurement Setting by Cursor Function Dialog Box

**Prompt**

**Soft key toolbar of cursor function**

The soft key toolbar of the cursor function can be used to set the starting value, ending value, center value, reference value and delay.

**2) Cursor function dialog box**

**a) [Cursor > Start] button**

Click it to set the scanning start value to be equal to the excitation value of the active cursor.

**b) [Cursor > End] button**

Click it to set the scanning end value to be equal to the excitation value of the active cursor.

**c) [Cursor > Center] button**

Click it to set the scanning center value to be equal to the excitation value of the active cursor.

**d) [Cursor > Reference] button**

Click it to set the scanning reference value to be equal to the excitation value of the active cursor.

**e) [Cursor > Delay] button**

Click it and the electrical delay of the reception path will be adjusted according to the phase slope of the active cursor. In this case, the phase track near the active cursor will be flattened. This function can be used to measure the electrical length and phase offset. It is only applicable to ratio measurement.

**f) [Cursor > Span] button**

Click it to set the scanning span value to be equal to the excitation difference ( $\Delta$ cursor) between the active cursor and reference cursor. This button is effective only when the  $\Delta$ cursor function of the active cursor is enabled.

**3.5.1.5 Advanced cursor option setting**

**1) Use of advanced cursor option function**

Menu path: [Cursor] > [Cursor] > [Cursor...]. The **cursor** dialog box will be displayed.

Click the [Advanced cursor...] button. The **advanced cursor** dialog box will appear.

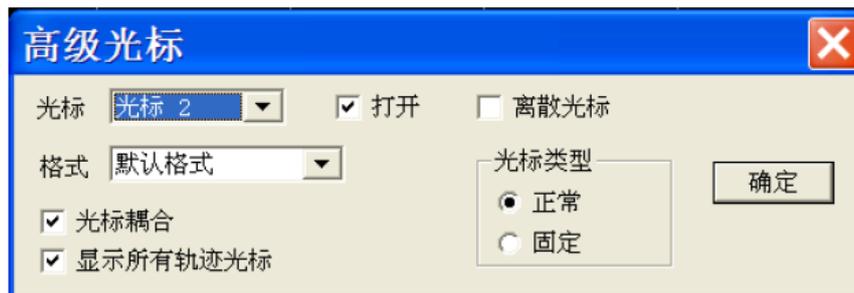


Fig. 3.53 Advanced Cursor Dialog Box

**2) Advanced cursor option dialog box**

**a) [Cursor] box**

Select the cursor to be set.

**b) [Open] check box**

If this check box is selected, the corresponding cursor will be displayed on the screen. If this check box is cleared, the cursor display will be shut down.

**c) [Discrete] check box**

If this check box is selected, the data of the actual measurement point will be displayed. If this check box is cleared, the interpolation data point between measurement points is still displayed.

**d) [Format] box**

Select the cursor data format. The cursor data format may be different from the format of track data on the screen. The above formats are identical in the default mode.

**e) Cursor type zone**

**i. [Normal] option box**

The X-axis location of the standard cursor is fixed, while the Y-axis location changes with the track data amplitude. The cursor can be moved right and left on the X-axis by changing the excitation value.

**ii. [Fixed] option box**

The X-axis and Y-axis coordinates of the cursor set to be of **fixed** type remain fixed on the track and do not change with the track data amplitude. The cursor can be moved on the X-axis by changing the excitation value, however, the Y-axis coordinate remains unchanged. This kind of cursor is mainly used to observe changes of track data. For example, the fix cursor can be used to compare insertion loss changes before and after filter tuning.

**3.5.1.6 Cursor list**

**1) Cursor list**

All cursor data of the active data can be displayed by opening the cursor list, in the format specified for the corresponding data. The cursor list will be opened and closed in the following method.

## 2) Open/Close method

Menu path 1: [**Cursor**] > [**Cursor**] > [**Display cursor list**] to open the cursor list or [**Hide cursor list**] to close the cursor list.



Fig. 3.54 Cursor List Setting by Cursor Menu

Menu path 2: [**Response**] > [**Display**] > [**List**] > [**Cursor list**].

If “√” is marked, the cursor list will be opened; otherwise, the cursor list will be closed.



Fig. 3.55 Cursor List Setting by “View” Menu

## 3.5.2 Track Operation and Statistics

The analyzer supports four kinds of mathematical operation of the current active track and the track in the memory. In addition, the analyzer has three functions of track statistics: average, offset and peak-peak value.

- [Track operation](#) .....69
- [Track statistics](#) .....70

### 3.5.2.1 Track Operation

#### 1) Setting the method of track operation

One track must be stored in the memory before setting the method of track operation or performing any kind of track operation. Track operation is a kind of vector operation based on plural data before display formatting. It is set in the following method.

Menu path: [Analysis] > [Save] > [Operate/save...]. Then the operation/storage dialog box will appear.

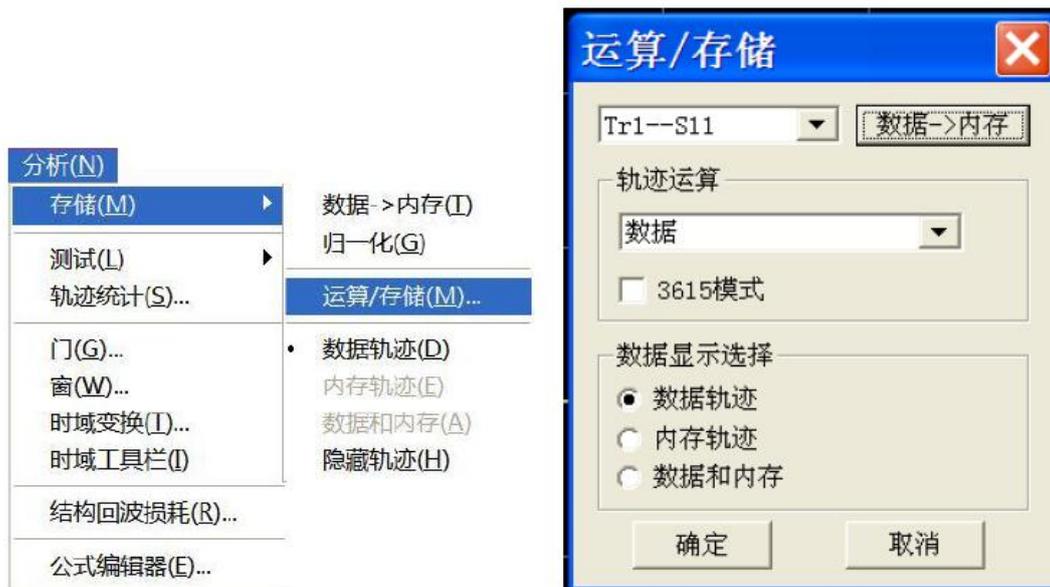


Fig. 3.56 Setting of Track Operation

#### 2) Operation/storage dialog box

##### a) [Data > Memory] button

Save the current measurement data into the memory.

##### b) [Track operation] box

The [Track operation] box is used to select the type of track operation. The analyzer supports the following operations.

##### i. Data

No mathematical operation.

##### ii. Data+storage

The displayed track data are the measured data plus stored track data.

##### iii. Data-storage

The displayed track data are the measured data minus stored track data. This function can be used for simple correction of errors. At first, store the measured vector error into the memory, and then reduce the measurement data of the tested device by the measured error.

##### iv. Data \* storage

The displayed track data are the measured data multiplied by the stored track data.

v. Data/storage

The displayed track data are the measured data divided by the stored track data. This function is mainly used to measure the ratio, such as the gain and attenuation.

**c) Data display selection zone**

i. **[Data track]** option box

Only display the data track.

ii. **[Memory track]** option box

Only display the memory track.

iii. **[Data and memory]** option box

Display the data track and memory track at the same time.

**3.5.2.2 Track Statistics**

The analyzer has three functions of track statistics: average, offset and peak-peak value. The statistical values can be calculated within the whole excitation bandwidth or user-defined bandwidth. Each channel supports nine user setting ranges, which are the same as the search domains set by user in the function of cursor search. The same memory address is applied, so the same excitation settings are shared. If the search domain to be set by the channel user is defined by cursor search, the same excitation settings can be called by selecting the corresponding user settings in track statistics. The ranges of user settings are allowed to be overlapping.

It is not required to search the maximum and minimum value in the function of track statistics, and the peak-peak value of passband ripple can be measured easily. The statistical values of track are calculated according to the data display format.

- **Rectangular coordinate format:** the statistical values of track are calculated according to the displayed scalar data.
- **Polar coordinate and Smith chart format:** the statistical values of track are calculated according to the value displayed in the log magnitude format.

**1) Activation of track statistics**

Menu path: **[Analysis] > [Track statistics]**. The dialog box of **track statistics** will appear.



Fig. 3.56 Dialog Box of Track Statistics

**2) Dialog box of track statistics**

**a) [Statistics > Average, offset and peak-to-peak value] check box**

If this check box is selected, the function of track statistics will be enabled. If this check box is cleared, the function of track statistics will be disabled.

**b) [Span] box**

Set the span of track statistics. Nine user settings can be selected within the whole bandwidth or customized, or the user settings can be customized through the **cursor search** dialog box.

**c) User domain definition zone**

i. **[Start]** box

Customize the starting value of the user setting span.

ii. **[End]** box

Customize the ending value of the user setting span.

**3.5.3 Limit Test**

The limit test function is used to compare the measured data and defined constraints (limits). The limits defined by the user are intuitively displayed on the screen in the limit line form. The limit lines have the following advantages:

- Provide intuitive indicators for the device commissioning personnel.
- Provide the standards of characteristic indicators of the device.
- Provide the intuitive comparison between the measured data and indicators of the device.

The limit test function is used to compare the measured data and defined limits, and provide PASS and FAIL information. Each track supports up to 100 separate limit segments for accurate definition.

- [Create and edit limit line](#) .....71
- [Limit table](#) .....72
- [Set limit test](#) .....72

**3.5.3.1 Creating and Editing of Limit Line**

The analyzer supports creating of limit lines for all measured tracks. The limit line is composed of several separate segments which are respectively determined by four coordinate values: X-axis starting and ending excitation value and Y-axis starting and ending response value. It is created and edited according to the limit table.

- 1) Menu path: **[Analysis]** > **[Test]** > **[Limit test]**. The **test** dialog box will appear.
- 2) Click **[Display list]** in the dialog box to display the limit table.
- 3) Click **[OK]** to close the dialog box.
- 4) Click **[Limit type]** in the **limit test** dialog box and select the limit test type in the drop-down box.

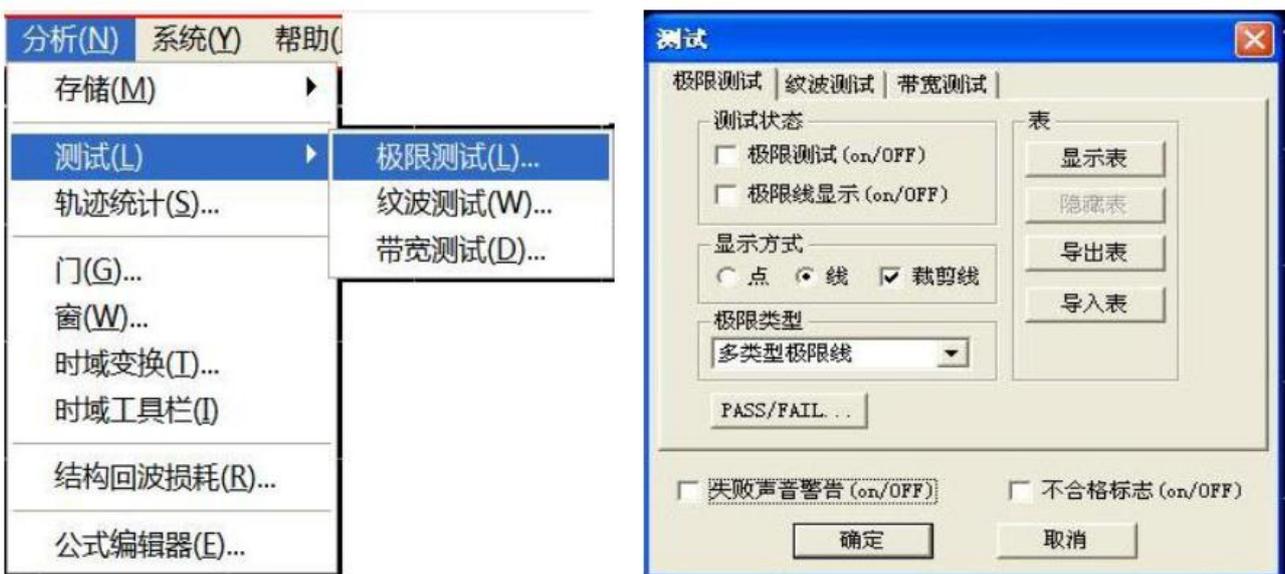


Fig. 3.58 Limit Test

### 3.5.3.2 Limit Table

	Type	Starting excitation	Ending excitation	Starting response	Ending response	Limit type
1	MAX	100.000kHz	100.000kHz	-100.000dB	-100.000dB	SLOP
2	MIN	100.000kHz	3.000GHz	-100.000dB	-100.000dB	FLAT
3	OFF	100.000kHz	3.000GHz	-100.000dB	100.000dB	SLOP

Fig. 3.59 Limit Table

#### “Type” box

The “Type” box is used to set the limit test type:

- MAX: the limit test fails if the track is above the limit segment.
- MIN: the limit test fails if the track is below the limit segment.
- OFF: disable the test of the limit segment.

#### “Starting excitation” box and “Ending excitation” box

Set the starting and ending excitation value of the limit segment (i.e. X-axis starting and ending coordinate of the limit segment).

#### “Starting response” box and “Ending response” box

Set the starting and ending response value of the limit segment (i.e. Y-axis starting and ending coordinate of the limit segment).

#### “Limit type” box

Set the limit line display mode of the limit test:

- SLOP: display the slope limit line.
- FLAT: display the flat limit line.
- POINT: display the point limit line.

### 3.5.3.3 Setting of Limit Test

After creating the limit line, select the mode of displaying or hiding the limit line of one track. Even if the limit line is hidden, the corresponding limit test is still effective. The limit test is not applicable to the stored track. You can select to send the warning sound and display the failure sign (FAIL) in case of the failure of limit test. When the limit test function is enabled, the track of the failure part is red in the default mode. You can change the **limit failure color** in the “Color setting” of the right-click menu of the mouse, and the track color of the passing part remains unchanged.

#### 1) Setting method

- a) Menu path: [Analysis] > [Test] - [Limit test]. The test dialog box will appear.
- b) Set the limit test in the dialog box.
- c) Click [OK] to close the dialog box.

The limit test can only be done at the actual scanning measurement point. The instrument can still pass the limit test if only a few scanning points are applied and the performance indicators of the tested device may not conform to the requirements. Therefore, sufficient scanning points should be applied in actual measurement of the limit test.

#### 2) Limit test dialog box

##### [Limit test ON/OFF] check box

If this check box is selected, the limit test of the active track will be enabled. If this check box is cleared, the limit test of the active track will be disabled.

##### [Limit line display ON/OFF] check box

If this check box is selected, the limit line of the active track will be displayed on the screen. If this check box is

cleared, the limit line display of the active track will be turned off, however, the limit test function will not be affected.

**[Failure sound warning] check box**

If this check box is selected, the buzzer will send the warning sound in case of failure of the track data point test.

**[FAIL ON/OFF] check box**

If this check box is selected, the FAIL sign will be displayed on the screen in case of failure of the track data point test.

**[Point] option box**

If this box is selected, the discrete limit value corresponding to the measurement data point will be indicated with the symbol “v” (measurement type: MAX) and “^” (measurement type: MIN).

**[Line] option box**

If this box is selected, all the discrete limit setting points will be connected through a line.

**[Display table] button**

Click it to display and edit the limit table. If the limit table is opened, this button will be disabled.

**[Hide table] button**

Click it to close the limit table display. If the limit table is closed, this button will be disabled.

**[Export table] button**

Click it and the storage dialog box will pop up. You can select the storage path, and the file will be saved in the “\*.csv” format.

**[Import table] button**

Click it and the storage dialog box will pop up. Select the storage path of the file to be opened, and the file will be opened in the “\*.csv” format.

**[Limit test type] drop-down option box**

Click this drop-down option box to select the limit test type. Four types are provided in total: multi-type limit line, slope limit line, single-point limit line and flat limit line.

### 3.5.4 Ripple Test

The conformity of test results can be evaluated by setting the ripple limit of the ripple test. The measured data and defined ripple limit are compared in the test. The PASS and FAIL information will be provided, and the measurement results will be intuitively displayed on the screen. Each track supports 12 separate limit segments at most. You can set the starting excitation, ending excitation and maximum fluctuation of each limit segment. The excitation settings of different segments may be overlapping.

#### 3.5.4.1 Creating and Editing of Ripple Limit Line

The ripple limit test can be done to several tracks at the same time. The ripple limit can be set after the track is activated.

##### 1) Setting method

- a) Menu path: [Analysis] > [Test] > [Ripple test]. The test dialog box will appear.
- b) Click the [Display table] button in the dialog box to open the ripple limit table.

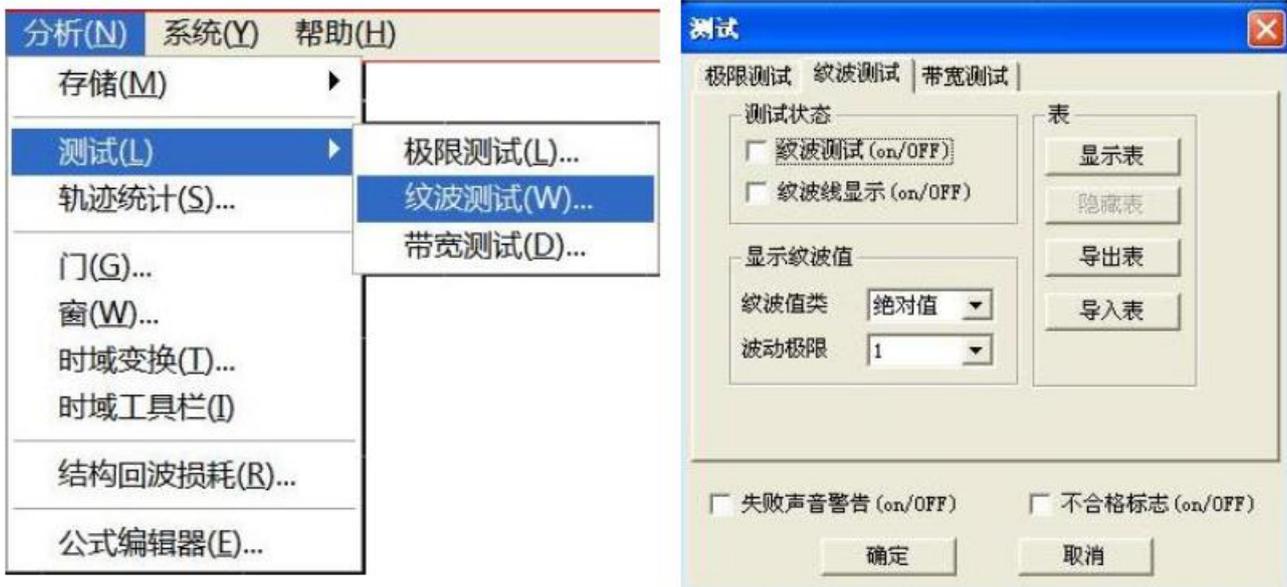


Fig. 3.60 Ripple Test Dialog Box

## 2) Ripple limit table

	Type	Starting excitation	Ending excitation	Maximum fluctuation
1	ON	100.000kHz	2.000GHz	5.000dB
2	ON	2.000GHz	3.000GHz	10.000dB
3	OFF	100.000kHz	3.000GHz	100.000dB

Fig. 3.61 Ripple Limit Table

### “Type” box

The “Type” box is used to set the limit test type:

ON: enable the test of the limit segment.

OFF: disable the test of the limit segment.

### “Starting excitation” box and “Ending excitation” box

Set the starting and ending excitation value of the ripple limit segment.

### “Maximum fluctuation” box

Set the maximum fluctuation of the test line of the ripple limit segment test.

### 3.5.4.2 Setting of Ripple Test

After creating the ripple limit line, select the mode of displaying or hiding the ripple limit line of one track. Even if the limit line is hided, the corresponding ripple test is still effective. You can select to send the warning sound and display the failure sign (FAIL) in case of the failure of ripple test. When the ripple test function is enabled, the track of the failure part is red in the default mode. You can change the **limit failure color** in the “Color setting” of the right-click menu of the mouse, and the track color of the passing part remains unchanged.

Menu path: [Analysis] > [Test] - [Ripple test]. The test dialog box will appear.

The ripple test can only be done at the actual scanning measurement point. The instrument can still pass the ripple test if only a few scanning points are applied and the performance indicators of the tested device may not conform to the requirements. Therefore, sufficient scanning points should be applied in actual measurement of the limit test.

### Ripple test dialog box

#### [Ripple test on/OFF] check box

If this check box is selected, the ripple test of the active track will be enabled. If this check box is cleared, the ripple test of the active track will be disabled.

**[Ripple line display on/OFF] check box**

If this check box is selected, the ripple line of the active track will be displayed on the screen. If this check box is cleared, the ripple line display of the active track will be turned off, however, the ripple test function will not be affected.

**[Failure sound warning on/OFF] check box**

If this check box is selected, the buzzer will send the warning sound in case of failure of the track data point test.

**[FAIL sign on/OFF] check box**

If this check box is selected, the **FAIL** sign will be displayed on the screen in case of failure of the track data point test.

**[Display table] button**

Click it to display and edit the ripple table. If the ripple table is opened, this button will be disabled.

**[Hide table] button**

Click it to close the ripple table display. If the ripple table is closed, this button will be disabled.

**[Export table] button**

Click it and the storage dialog box will pop up. You can select the storage path, and the file will be saved in the “\*.csv” format.

**[Import table] button**

Click it and the storage dialog box will pop up. Select the storage path of the file to be opened, and the file will be opened in the “\*.csv” format.

**[Ripple value type] drop-down option box**

Click this drop-down option box to select the limit test type: **none**, **absolute value and allowance**. The default value is the **absolute** value after start-up of the instrument.

**[Ripple limit segment] drop-down option box**

Click the drop-down option box to select the number of ripple limit segments to be opened. At most 12 segments can be opened.

**3.5.4.3 Display of Ripple Test Results**

If the measurement results of ripple test conform to the requirements, “PASS” will be displayed in the upper left corner of the screen; otherwise, “FAIL” will be displayed. “PASS” and “FAIL” of each track will be respectively displayed if several tracks are tested at the same time. The excitation ranges of different ripple limit segments are allowed to be overlapping, and various ripple limits can be set.

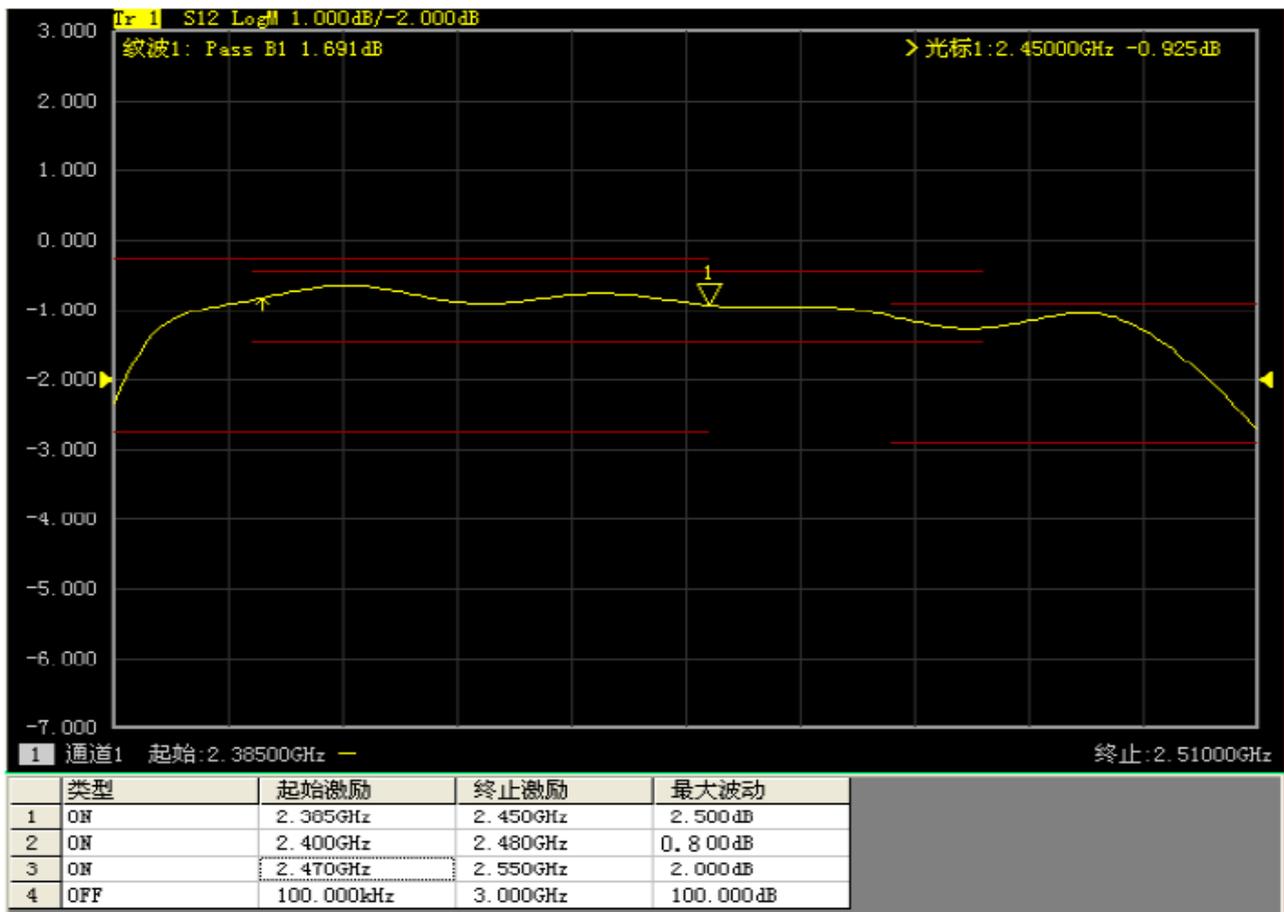


Fig. 3.62 Ripple Test Results

### 3.5.5 Bandwidth Test

The bandwidth test function is mainly used to test the bandwidth of the bandpass filter.

The signal peak within the passband can be found in the bandwidth test. Two points are respectively located at the specific amplitude on both side of the passband. The amplitude is lower than the signal peak and can be adjusted by setting the **NdB** point (default setting: 3dB). The frequency range between the two points is the bandwidth of the tested filter.

The **minimum bandwidth** and **maximum bandwidth** allowed by the user can be set before the bandwidth test. The actual bandwidth will be automatically compared with the above two values. In case of nonconformity, the **FAIL** information will be provided on the screen or the sound will be uttered, so that the user can intuitively check whether the properties of the tested device conforms to the requirements.

#### 3.5.5.1 Enabling and Setting of Bandwidth Test

Set the bandwidth threshold (NdB point), maximum bandwidth and minimum bandwidth before the bandwidth test. Several tracks can be set.

- 1) Menu path: [Analysis] > [Test] > [Bandwidth test]. The **test** dialog box will appear.
- 2) Tick the [Bandwidth test on/OFF] check box in the dialog box to enable the bandwidth test.
- 3) Tick the [Bandwidth display on/OFF] check box in the dialog box to display the tested bandwidth on the screen.
- 4) Tick the [Bandwidth mark display on/OFF] check box in the dialog box. The bandwidth location mark will be displayed on the screen.
- 5) Click the [NdB point] box to set the bandwidth threshold.

- 6) Click the **[Minimum bandwidth]** box to set the minimum bandwidth.
- 7) Click the **[Maximum bandwidth]** box to set the maximum bandwidth.
- 8) Tick the **[FAIL sound on/OFF]** check box in the dialog box. The sound prompt will be provided in case of failure of the bandwidth test.
- 9) Tick the **[FAIL sign on/OFF]** check box in the dialog box. The **FAIL** prompt will be provided in case of failure of the bandwidth test.
- 10) Click **[OK]**. Thus the bandwidth test setting is completed.

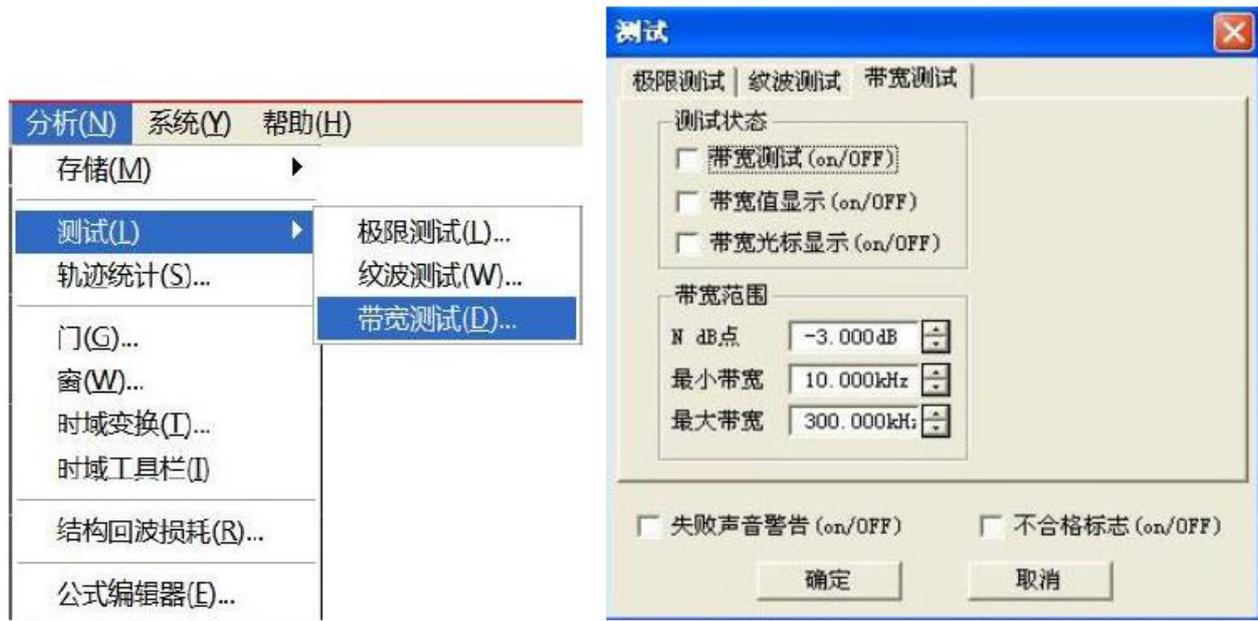


Fig. 3.63 Dialog Box of Bandwidth Test

### 3.5.5.2 Display of Bandwidth Test Results

Bandwidth test results will be displayed in the upper left corner of the track. If the test results are acceptable, "PASS" will be displayed. The red T-type bandwidth marks will appear on both sides of the bandwidth.

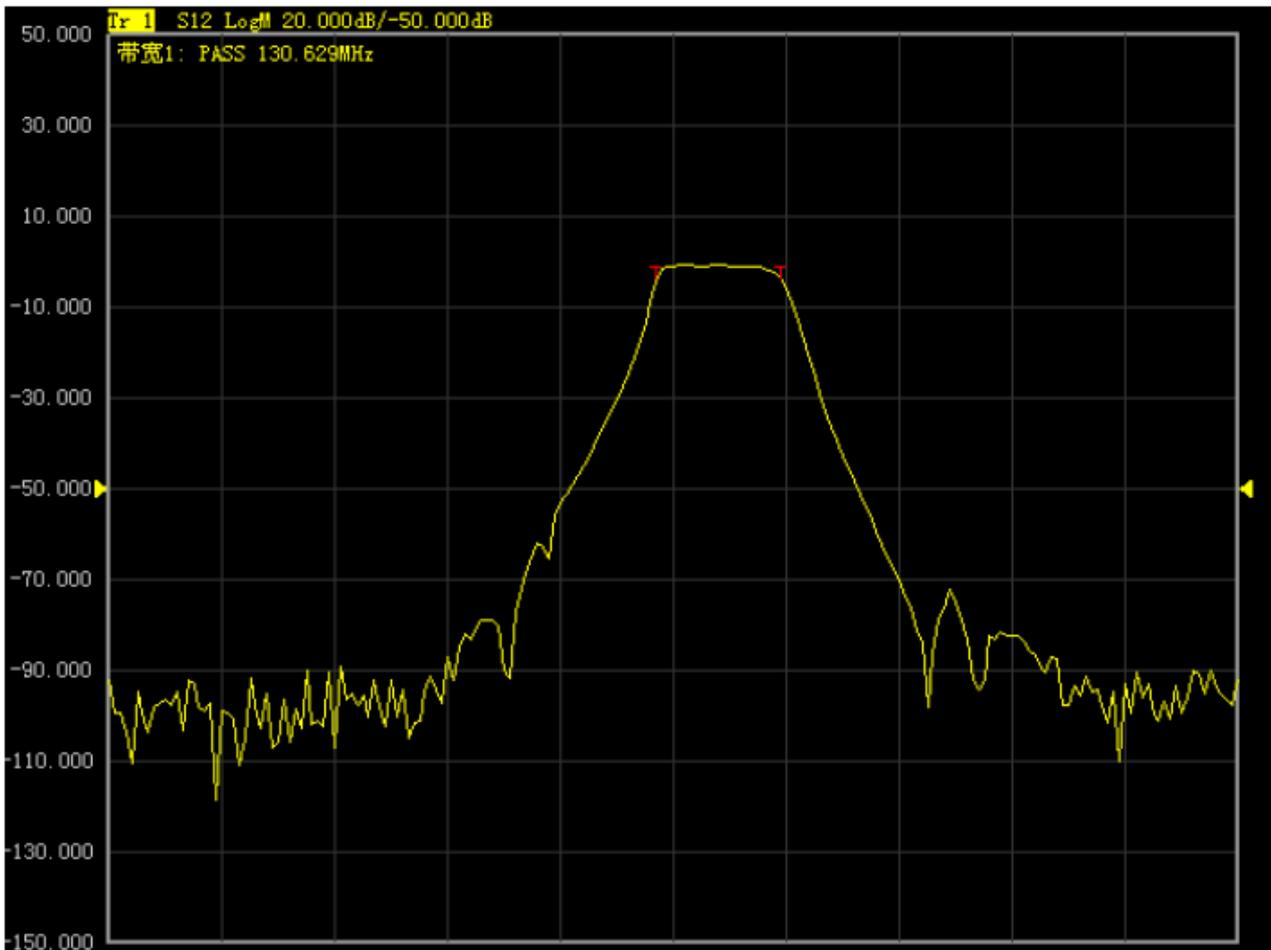


Fig. 3.64 Display of Bandwidth Test Results

### 3.5.5.3 Shutdown of Bandwidth Test

- 1) Click [Analysis] > [Test] > [Bandwidth test]. The test dialog box will appear.
- 2) Click the [Bandwidth test on/OFF] check box and remove the tick to shut down the bandwidth test.
- 3) Click the [Bandwidth value display on/OFF] check box and remove the tick to shut down the test bandwidth value display.
- 4) Click the [Bandwidth mark display on/OFF] check box and remove the tick to shut down the bandwidth position mark display.
- 5) Click [OK] to shut down the bandwidth test.

### 3.5.6 Formula Editor

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#### 3.5.6.1 Overview

In order to facilitate illustration, the following two terms should be defined at first.

**Reference track:** a track used as data in the formula.

**Formula track:** a current active track after formula operation.

The user is allowed to enter an algebraic expression in the formula editor. The algebraic expression can be used for mathematical operation of measurement data. Operation results can be displayed in the data track form. Measurement data of the formula track are the data of one or more channel(s). The mathematical expression entered by the user is composed of the basic operator, built-in function and parameters. Measurement parameters or track data used in the formula are provided by the vector network analyzer. If a calculation formula is entered into the formula input box and the activation box is ticked, the current active track will become a formula track. The formula track data are the data after operation, and the formula track curve can be updated with data changes in a real-time manner. Take the input formula  $S_{21}/(1-S_{11})$  as an example. The value of each point on the formula track is calculated by  $S_{21}/(1-S_{11})$  of the corresponding point. If the track includes 201 points, the operation will be done 201 times by the expression, that is, once for each point.

Measurement of a three-port device is not conventional for the analyzer, but can be done through the formula editor. If the user expects to obtain a logarithmic formula track, the following expression can be used:  $S_{21}+S_{23}-S_{13}$ . However, the data used in the formula editor are plural data with no format requirements. The user needs to enter the following formula:  $S_{21}*S_{23}/S_{13}$ . After the formula is entered,  $Eq=S_{21}*S_{23}/S_{13}$  will be displayed on the current active track of the vector network analyzer, as shown in Fig. 3.66.



Fig. 3.65 Dialog Box of Formula Editor

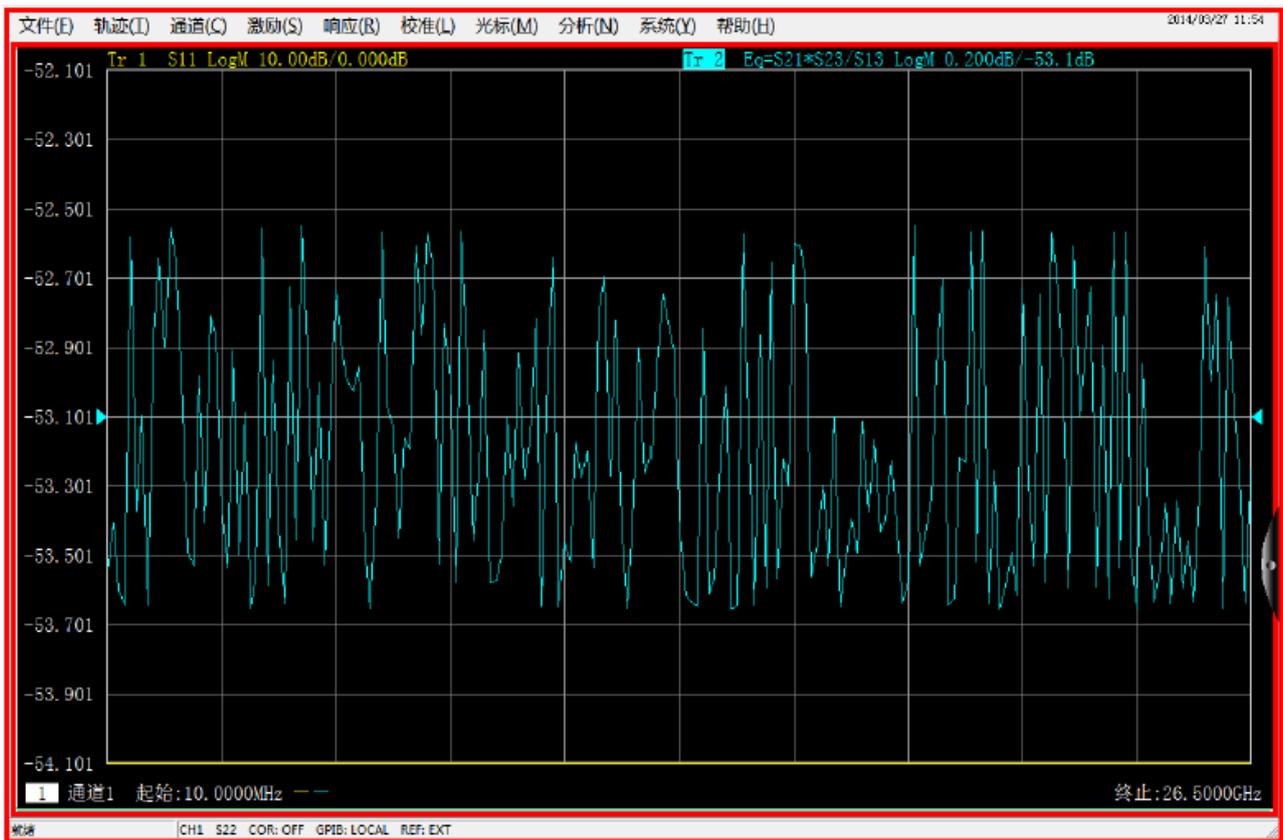


Fig. 3.66 Display of Formula Track

### 3.5.6.2 Use of Formula Editor

#### 1) Open the formula editor dialog box.

Click the [Analysis] > [Formula editor] in the menu of the vector network analyzer to open the formula editor dialog box, as shown in Fig. 3.67.



Fig. 3.67 Formula Editor Menu

#### 2) How to enter the formula in the formula editor dialog box

##### a) Function input

Click the function list under [Function and constants] in Fig. 3.65 and enter the function in the formula input box, or directly enter the function through the keyboard.

##### b) Operator input

Click the operator list under [Operator] and enter the operator in the formula input box, or enter the operator through the keyboard.

### c) Track and channel input

Click the mouse to enter the track and channel parameters among the options in the drop-down list of [Track] or [Channel parameters], as the formula parameters or variables, or enter the operator through the keyboard.

### d) Data input

Enter the numbers through the number keys on the right side, or enter the operator through the keyboard.

### 2) “Activation” check box

The “Activation” check box is ticked in the default mode. The formula entered by the user will be judged only when this check box is ticked. If the formula is applicable to calculation, operation will be started. The expression Eq=XXX of the current formula will be displayed on the active track of the current active window of the vector network analyzer. If this check box is not ticked, operation will not be started no matter whether the entered expression is applicable to calculation. In addition, if this check box is ticked but the entered formula is not applicable to calculation (such as the case of “2+1+”), the check box will be gray.

### 4) Formula saving and deleting

Click [Save formula] to save any expression entered by the user in the formula input box, the formula will be saved in the drop-down menu of the formula input box. Click the right drop-down arrow of the formula input box and select the formula in the drop-down list.

In addition, the user can click [Delete formula] to delete the formula in the formula input box.

### 5) Backspace button

[<-Backspace]: used to delete one character in front of the cursor. If there is no character on the left side, the cursor position will remain unchanged.

### 6) Leftward and rightward movement of cursor

[<-]: used to move the current cursor left for one character but not to delete the left character. If there is no character on the left side, the cursor position will remain unchanged.

[->]: used to move the current cursor right for one character but not to delete the right character. If there is no character on the right side, the cursor position will remain unchanged.

### 7) Selection of functions and variables

The built-in function library is set in the default mode, including the commonly used formulas and constants to be selected by clicking. The functions/constants are shown in Table 3.10. If the parameter of one function is of plural type, the scalar can be used as the parameter. The scalar is a plural, with 0 as the imaginary part.

Table 3.10 List of Functions/Constants

acos(scalara)	Return to the ACOS value of the parameter a in radian. The parameter a is a scalar.
asin(scalara)	Return to the ASIN value of the parameter a in radian. The parameter a is a scalar.
atan(scalara)	Return to the Atan value of the parameter a in radian. The parameter a is a scalar.
atan2	Return to the phase of the plural a in radian. Two parameter types can be applied: atan2 (complexa): return to the phase in radian. The parameter a is a scalar. atan2 (scalara and scalarb): return to the phase in radian. The parameter a and b are scalars.
conj(complexa)	Return to the conjugate complex of the plural a.
cos(complexa)	Calculate the cosine value of the plural a. The real part and imaginary part of a are in radian.
cpx(scalara,scalarb)	Return to a plural (a+jb). The parameter a and b are scalars.
getNumPoints()	Return to the number of the current scanning points.
im(complexa)	Return to the imaginary part of the parameter a.
kfac(rComplexa, rComplexb,	Return value $k = (1- a ^2- d ^2+ a*d-b*c ^2)/(2* b*c )$ . The parameter a, b, c and d are plurals.

rComplexc, rComplexd)	
ln(complexa)	Return to the natural logarithm of the plural a.
log10(complexa)	Return to the logarithm of 10 corresponding to the plural a.
mag(complexa)	Return to the modulus of the plural a. The parameter a is a plural.
mu1(complexa,com plexb, complexc,complexd)	Return value $\mu_1 = (1- a ^2)/( d-\text{conj}(a)*(a*d-b*c) + b*c )$ . The parameter a, b, c and d are plurals.
mu2(complexa,com plexb, complexc,complexd)	Return value $\mu_2 = (1- d ^2)/( a-\text{conj}(d)*(a*d-b*c) + b*c )$ . The parameter a, b, c and d are plurals.
phase(complexa)	Return to atan2 (a), i.e. calculation phase, in radian. The parameter is a plural.
PI	Constant Pi, 3.141592.
re(complexa)	Return to the real part of the plural a. The plural a is a plural.
sin(complexa)	Return to the sine value of the plural a. The parameter a is a plural, in radian.
sqrt(complexa)	Return to the square root of the modulus of the plural a. The parameter a is a plural.
tan(complexa)	Return to the tangent value of the plural a. The parameter a is a plural, in radian.

### 8) Operator selection

Operations are shown in Table 3.11. The user can click the mouse to select the required operator, such as four basic operators, i.e. “+”, “-”, “\*” and “/”, as well as the left bracket and right bracket. In addition, the formula editor also supports direct input of plural data for operation. To enter the plural constant 2+j3, the user should enter <2:3> into the formula editor to indicate the plural constant 2+j3. To enter the (2+j3)\*S11, the user should enter the expression <2:3>\*S11 for operation.

Table 3.11 List of Operators

+	Addition operator
-	Subtraction operator
*	Multiplication operator
/	Division operator
(	Left bracket
)	Right bracket
,	Comma, used to separate several parameters.
<	Start symbol to enter the plural.
:	Used to separate the real part and imaginary part of the plural.
>	Ending symbol to enter the plural.

### 9) Track data

The user can select the track or track data in the list below, but the current active track cannot be selected.

### 10) Channel parameter data

The user can only select the S-parameter of the current active channel as the parameter data of the entered expression.

### 11) Number key zone

The user can enter numbers by clicking number keys in the number key zone, the positive and negative symbol by clicking [+/-] and the decimal point by clicking [•].

### 3.5.6.3 Data and Precautions of Use of Formula Editor

The data of each point of the formula track can be calculated according to the data of the corresponding point on the reference track. If the track includes 201 points, the calculation will be done 201 times by the formula, i.e. once

for each data point. If the current track is Tr4 and the formula is Tr2+S11, Tr4 will be the formula track. Tr1 and S11 are the reference tracks of the formula track. In addition, the current active track Tr4 in the display window of the vector network analyzer will be displayed as Tr4Eq=Tr2+S11. As shown in Fig. 3.68.

## Attention

### Precautions for use of formula vector

- 1) If the formula is active and can be used for calculation, the original parameter will not be displayed on the current active track. Instead, the formula track will be displayed. For example, if the current active track is Tr4 S22 and the formula Tr2+S11 is entered, the formula track Tr4 Eq=Tr2+S11 will be displayed. However, if the entered formula cannot be used for calculation, the original track name will be displayed. For example, if “Tr2+S11+” is entered, the original Tr4 S22 will be displayed on the current active track.
- 2) The current active track cannot be used as the reference track of the formula track. For example, the current active track is Tr4, Tr4 cannot be used as a parameter of the formula.
- 3) The reference track can be selected from the S-parameter and memory tracks. Ensure that the memory track exists before using it as a parameter; otherwise, the formula cannot be used for calculation.
- 4) The reference track must be the displayed track if the track of another channel is used as the reference track. The track must be used in the Trx form. The numbers of data points of the reference track and formula track should be identical. For example, if the number of data points of the reference track is 201, the number of data points of the formula track should also be 201.



Fig. 3.68 Formula Track Display Window

### 3.5.6.4 Saving of Formula Editor Data

Formula data can be saved in the “.cti”, “\*.prn” and “\*.dat” format. However, the original names of measurement parameters are kept in the saved file. For example, if the original name of Tr2 is S22 and the entered formula is 10+S22, the saved measurement parameter name will remain unchanged, i.e. S22. The data will become the value of 10+S22. The equation track cannot be saved as a data file in the “\*.snp” format.

## 3.6. Data output

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### 3.6.1 Saving and Calling of File

AV3672 series vector network analyzer supports the saving and calling of files in various formats.

#### 3.6.1.1 Saving of File

##### 1) Saving method

Menu path: [**File**] > [**Save**] > [**Save**]/[**Save as...**].



Fig 3.69 Saving of File

##### 2) File menu item: [Save]

Click [**Save**] to save the instrument status and calibration data into the default file (default.cst) of the specified directory. If the default file exists, the dialog box to confirm whether to cover will appear.

##### 3) File menu item: [Save as...]

Click [Save as...] to save the file in the dialog box.

##### a) [Save in] drop-down box

Display and set the saving path.

##### b) [File list] box

Display the holder under the current path and all files matching with the saving type. Click one file to set its name. Click the holder to change the current path.

##### c) [File name] box

Display the entered file name or the file name clicked in the file list box.

##### d) [Saving type] box

Select the saving type. The analyzer supports the following file types:

i. cst file

Save the instrument status and calibration data.

ii. sta file

Only save the instrument status data.

iii. cal file

Only save the instrument calibration data.

iv. dat file

In this mode, the **[Data save setting]** dialog box will be opened, and the track data file will be saved according to the user's requirements.

v. Prn

Only save the current active track data.

vi. bmp file

Save the screen display information in the bitmap form.

### 3.6.1.2 Calling of File

#### 1) Call status and calibration data:

##### a) sta file

The status data of the instrument are saved in the sta file, including the settings, track data, limit line and cursor.

##### b) cal file

Calibration data are saved in the cal file, excluding status data. The correction accuracy of calibration data is associated with the status setting. To realize the highest accuracy of measurement, the instrument settings should be identical in file calling and calibration; otherwise, the accuracy of calibration will not be guaranteed.

##### c) cst file

All measurement status and calibration data of the instrument are saved in the cst file, therefore, the cst file can be called to save time.

#### 2) File calling:

Menu path: **[File]** > **[Call...]**. The dialog box will appear.

Select the load file type in the **[File type]** box.

Set the call file directory through the **[Search range]** box and the **[File list]** below.

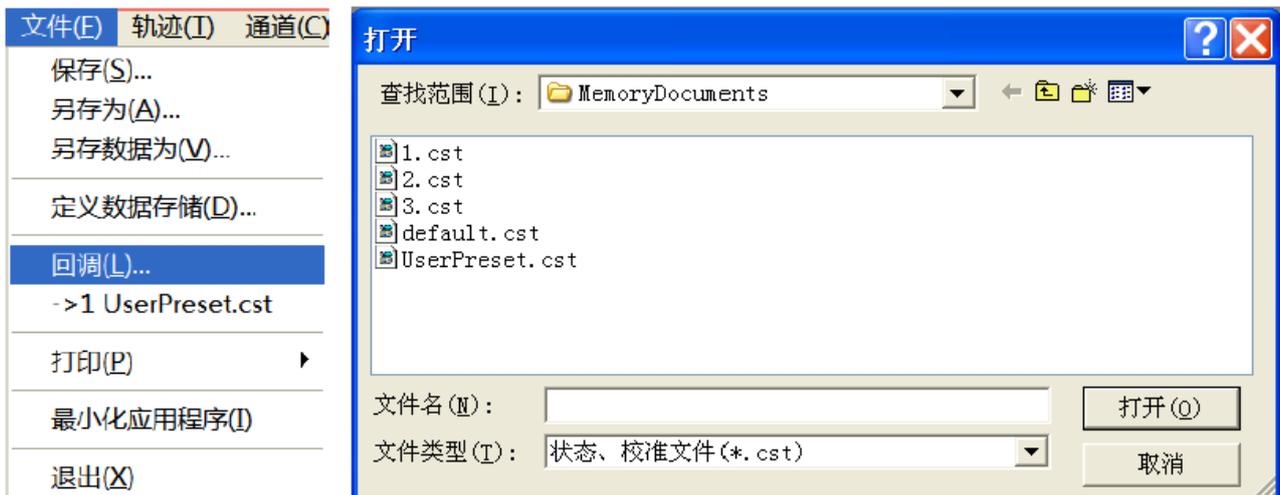


Fig. 3.70 File Calling

The file is called by the following methods:

- i. Double-click the file to be called in the **[File list]** box.
- ii. Click the file to be called in the **[File list]** box and then click **[Open]**.
- iii. Enter the name of the file to be called in the **[File name]** box and then click **[Open]**.

#### 3.6.1.3 Data File

Measurement results are saved in the ASCII format in data files. Data files can be edited with the text editing software and spreadsheet software, but cannot be called by the analyzer. Three types of data files can be saved in the analyzer:

### 1) dat file

The “dat” file is used for saving measurement data of the active track or all tracks in the formatted or unformatted form. Define the data saving mode in the **[Data save setting]** dialog box.

The “dat” file is saved by the following methods:

- Menu path: **[File] > [Save as...]**. The **[Save as...]** dialog box will appear.
- Set the file saving type as the **data file (\*.dat)** in the **[Saving type]** box.
- Set the saving directory in the **[Save in]** box and **[File list]** box.
- Set the name of the file to be saved in the **[File name]** box.
- Click **[Save]**. The **[Data save setting]** dialog box will appear.
- Set the contents and format of the file to be saved. Click **[Formatted data]** or **[Unformatted]** to save the data file. Close the dialog box.

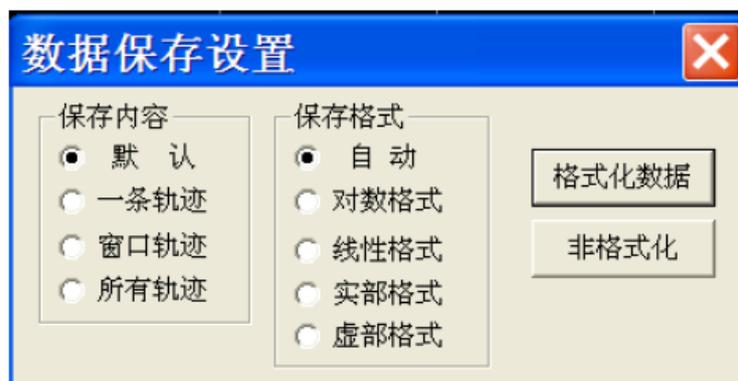


Fig. 3.71 [Data save setting] Dialog Box

#### **[Save contents] zone**

Define the track data to be saved into the file.

##### **a) [Default] radio box**

Save the data of active tracks in all windows.

##### **b) [One track] radio box**

Save the data of the current active track.

##### **c) [Window track] radio box**

Save the data of all tracks in the current active window.

##### **d) [All tracks] radio box**

Save the data of all tracks.

#### **[Saving format] zone**

##### **a) [Auto] radio box**

Save the track data according to the actual display format.

##### **b) [Log] radio box**

Save the track data in the logarithmic amplitude format.

##### **c) [Linear format] radio box**

Save the track data in the linear amplitude format.

**d) [Real part format] radio box**

Save the track data in the real part format.

**e) [Imaginary part format] radio box**

Save the track data in the imaginary part format.

**[Formatted data] button**

Save the track data in the format set in the [Saving format] zone.

**[Unformatted] button**

Save the track data in the real/imaginary part format.

**2) snp (s1p and s2p) file**

The “snp” file is a kind of data output file. It can be called by the CAE (computer aided engineering) software (such as ADS of Agilent), but cannot be called by the analyzer. The “s1p” file is used to save the characteristics of single-port devices, only including one S parameter ( $S_{11}$  or  $S_{22}$ ). The “s2p” file is used to save the characteristics of double-port devices, including four S parameters. If the full double-port correction is started, four S parameters will be saved in the “s2p” file. If the full double-port correction is shut down, measurement data will be saved in the “s2p” file as much as possible. Example: if the full double-port correction is shut down, the current active track is  $S_{11}$ , but  $S_{21}$  is still measured in the channel, measurement results of  $S_{11}$  and  $S_{21}$  will be saved in the “s2p” file. As no effective measurement data of  $S_{22}$  and  $S_{12}$  are provided, the corresponding data in the “s2p” file are 0.

The “snp” file is saved by the following method:

- a) Menu path: [File] > [Save] > [Save as...]. The [Save as] dialog box will appear.
- b) Set the saving type as the **data file (\*.s1p or \*.s2p)** in the [Saving type] box.
- c) Set the saving directory in the [Save in] box and [File list] box.
- d) Set the file name in the [File name] box.
- e) Click [Save] to save data.

**3) prn file**

The prn file is used to save the measurement data of the active track in lines and rows. Each line corresponds to one measurement point. The first row corresponds to the excitation value, while the second row corresponds to the response value. The rows are separated by the comma (.). The format is as follows:

$S_{11}$	LogMag
LIN_SWEEP (Hz), LOG_FORMAT (dB)	
3.000000e+005,	-9.232986e+000
7.502250e+008,	-3.219671e-001
1.500150e+009,	-6.892332e+000
2.250075e+009,	-1.146303e+000
3.000000e+009,	-1.245240e+001

The “prn” file is saved in the following method:

**Menu path: [File] > [Save] > [Save as...]. The [Save as...] dialog box will appear.**

**Set the saving type as the list file (\*.prn) in the [Saving type] box.**

**Set the saving directory in the [Save in] box and [File list] box.**

**Set the file name in the [File name] box. Click [Save] to save the file. Close the dialog box.**

**3.6.2 Printing of Measurement Contents**

The analyzer supports the output of measurement contents through the printer or printing into the specified file. The local or network printer can be used. The printer can be of parallel, serial or USB interface type. Add the printer in the WINDOWS operating system.

### 3.6.2.1 Print Setting

#### Method of print setting

Menu path: **[File] > [Print] > [Page setting]**. Then the **page setting** dialog box will appear.

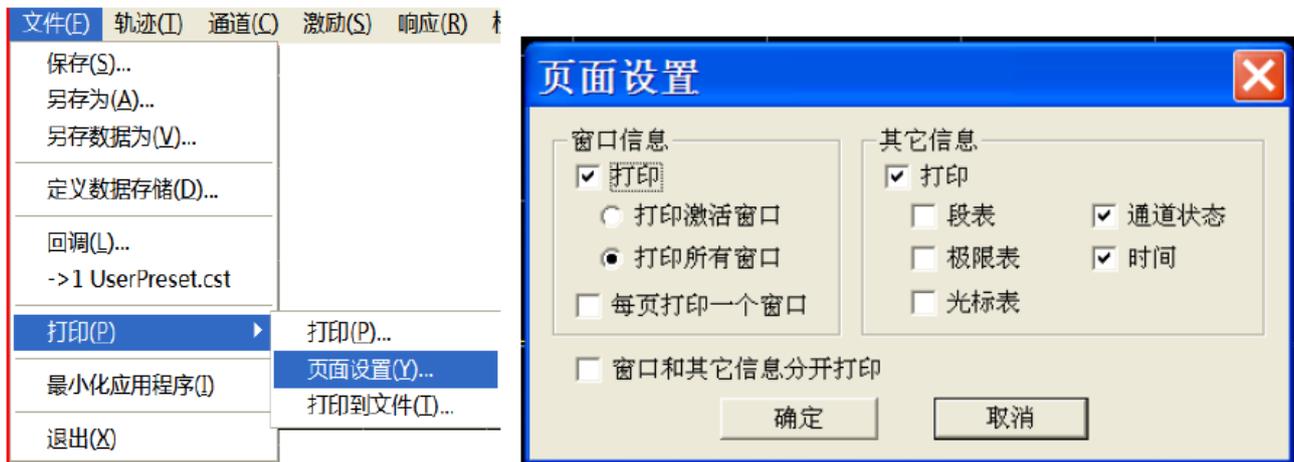


Fig. 3.72 Print Setting

#### [Page setting] dialog box

##### 1) [Window information] zone

###### a) [Print] check box

If this check box is selected, the window track information will be printed. If this check box is cleared, the window track information will not be printed. The following two check boxes are effectively only when the above check box is selected.

###### b) [Print one window on each page] check box

If this check box is selected, only the information of one window will be printed. If this check box is cleared, the information of all windows will be printed continuously, with no page breaks.

###### c) [Print active window] radio box

If this box is selected, only the information of the current active window will be printed.

###### d) [Print all windows] radio box

If this box is selected, only the information of the current active window will be printed.

##### 2) [Other information] zone

###### a) [Print] check box

If this check box is selected, the channel setting information will be printed. The following check boxes are effectively only when this check box is selected.

###### b) [Segment table], [Limit table], [Cursor table], [Channel statue] and [Time] check box

Select to print the corresponding information.

###### 3) [Separately print window and other information] check box

If this check box is selected, the window and other information will be printed separately. If this check box is cleared, the above information will be printed together.

### 3.6.2.2 Printing

After the printer is added and the print contents are set, measurement information can be output through the printer, as shown below:

Menu path: **[File] > [Print] > [Print...]**. The **print setting** dialog box will appear.



Fig. 3.73 Printing of Measurement Information

### 3.6.2.3 Printing into File

The analyzer supports the output of print contents into the bitmap (bmp) file. To print several pages, various BMP files will be created automatically, respectively corresponding to each page. The other files are identified in the “file name (number).bmp” format, such as amp.bmp, amp(1).bmp and amp(2).bmp. The printing method is as follows:

Menu path: **[File] > [Print] > [Print to file...]**.

Set the file directory and name in the dialog box.

Click **[Save]** to save the file.

## 4 Measurement Setting

This chapter mainly describes the operation of AV3672 series network analyzers in measurement, creation of the measurement of the known status by analyzer resetting, selection of measurement setting, adjustment of the analyzer display so as to better observe measurement results, specifically including:

- [Resetting of analyzer](#) .....91
- [Selection of measurement parameter](#) .....95
- [Setting of frequency range](#) .....99
- [Setting of signal power level](#) .....100
- [Setting of scanning](#) .....103
- [Trigger mode](#) .....107
- [Setting of data format and scale](#) .....113
- [Observation of multiple tracks and opening of multiple channels](#) .....118
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### 4.1 Resetting of Analyzer

- [Default reset state](#) .....91
- [User reset state](#) .....94
- [Resetting of analyzer](#) .....94

#### 4.1.1 Default Reset State

Press the **[Reset]** on the front panel to return to the known default state, i.e. reset state. The reset state is set as follows:

**1) Measurement parameter:** S11

**2) Frequency setting:**

- a) Starting frequency: 10MHz
- b) Ending frequency: 13.5GHz/26.5GHz/43.5GHz/50GHz/67GHz
- c) CW frequency: 2GHz

**3) Power setting:**

- a) Test port power: -5dBm
- b) Coupling port power: open
- c) Attenuation: automatic
- d) Attenuation values: 0dB
- e) Power slope: closed
- f) Slope: 0dB/GHz

**4) Scanning setting:**

- a) Scanning type: linear frequency
- b) Scanning time: automatic
- c) Number of scanning points: 201

**5) Segment scanning setting:**

- a) Number of open segments: 1
- b) Starting frequency: 10MHz

- c) Ending frequency: 13.5GHz/26.5GHz/43.5GHz/50GHz/67GHz
- d) Number of points: 21
- e) Power: -5dBm
- f) Intermediate frequency bandwidth: 1kHz

**6) Trigger setting:**

- a) Trigger source: internal
- b) Trigger type: continuous scanning

**7) Display format:**

Format: logarithmic amplitude

The details of various formats are shown in Table 4.1.

Table 4.1 Default Format Setting of AV3672 Series Vector Network Analyzers

Format	Scale	Reference position	Reference value
Logarithmic amplitude	≤10 dB	5	0dB
phase	45o	5	0o
Group delay	10ns	5	10fs
Linear amplitude	100mU	5	500mU
Standing wave ratio	1U	5	6U
Real part	2U	5	0U
Imaginary part	2U	5	0U
Polar coordinate	1U	None	1U
Smith chart	1U	None	1U

**8) Response setting:**

- a) Number of channels: 1
- b) Intermediate frequency bandwidth: 1kHz
- c) Average: closed
- d) Average factor: 1
- e) Smoothing: closed
- f) Smoothing factor: 2.49% of the value range
- g) Electrical delay: 0s
- h) Speed factor: 1
- i) Phase shift: 0°
- j) Track display: data

**9) Calibration setting:**

- a) Correction: closed
- b) Interpolation: open
- c) Calibration type: none
- d) Calibration kit number: current calibration kit number
- e) System impedance: 50Ω
- f) Port extension: closed
- g) Port extension value: 0s

**10) Cursor setting:**

- a) Initial frequency: full range of center frequency
- b) Reference cursor R: closed
- c) Discrete cursor: closed
- d) Format: track format
- e) Type: standard
- f) Cursor search type: minimum
- g) Search domain: full bandwidth
- h) Cursor table: empty

**11) Limit test setting:**

- a) Limit test: closed
- b) Limit line display: closed
- c) FAIL sound warning: closed

**12) Limit table setting:**

- a) Type: OFF
- b) Initial excitation: 10MHZ
- c) Ending excitation: 13.5GHz/26.5GHz/43.5GHz/50GHz/67GHz
- d) Initial response: -100dB
- e) Ending response: 100dB

**13) Time domain transformation setting (optional):**

- a) Time domain transformation: closed
- b) Transformation mode: bandpass
- c) Transformation start: -5ns
- d) Transformation end: 5ns
- e) Kaiser window  $\beta$  factor: 6.0
- f) Gate state: closed
- g) Gate starting value: -5ns
- h) Gate ending value: 5ns
- i) Gate shape: standard
- j) Gate type: bandpass

**14) Full display setting:**

- a) Track state: open
- b) Frequency/excitation: open
- c) Cursor reading: open
- d) Status bar: closed

**4.1.2 User Reset State**

The analyzer can be reset into the known default status or user-defined status. In the default mode, the analyzer is reset into the default status. It can be reset into the user-defined status by means of setting. Specific steps of setting the user reset status are as follows.

1) Menu path: [System] > [Define user status...]. Then the [Define user reset status...] dialog box will appear.

2) Click [Enable user reset status] and tick the check box.

**Notes:** a) If you tick [Save final status as user reset state], the final status before exiting the program will be saved as the user reset state.

b) Click [Save current status as user reset status]. Then the current settings of the analyzer will be saved as the user reset status.

c) To use the known status, click [Load the known file as user reset status]. Select the status in the dialog box, and open the file. Then the selected file will be used as the user reset status file of the analyzer.

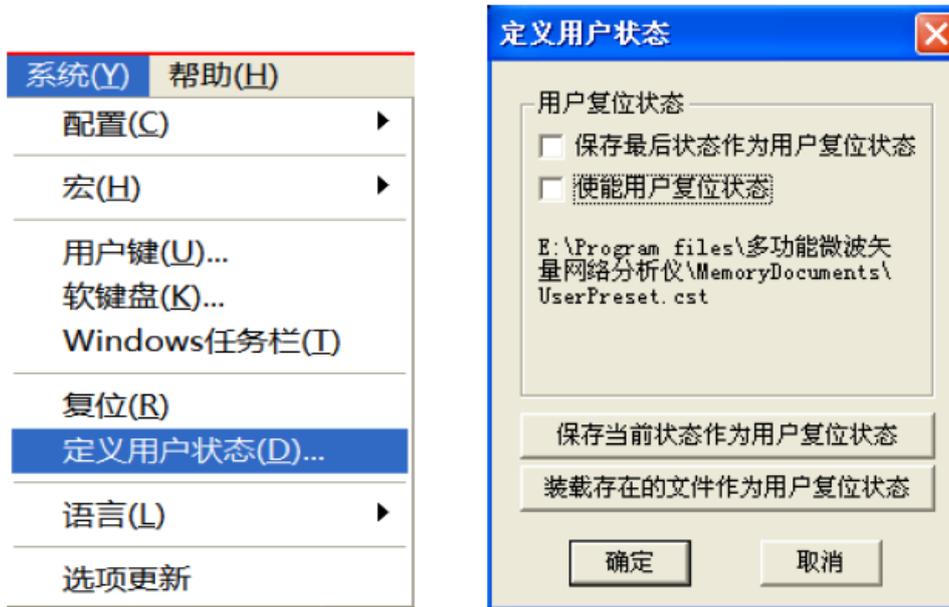


Fig. 4.1 Definition of User Reset Status

### 4.1.3 Resetting of Analyzer

Menu path: [System] > [Reset]

If the user reset state has been set, click [User reset].



Fig. 4.2 Resetting of Analyzer

Prompt

**[Reset] shortcut key**

The **[Reset]** shortcut key is set in the **functional** key zone and shortcut menu bar.

**4.2 Selection of Measurement Parameter**

The following parameters can be set in an AV3672 series vector network analyzer to measure the electrical characteristics of devices.

- S parameter (fixed ratio)
- Any ratio (custom ratio for measurement)
- Non-ratio power measurement (absolute power measurement)
- S parameter .....95
- Any ratio .....97
- Non-ratio power measurement .....98
- Change of track measurement type .....99

**4.2.1 Parameter S**

**1) Overview of Parameter S**

The parameter S (scattering parameter) is used to describe the change of input signal and the reflection and transmission characteristics of the tested device. The S-parameter is shown in the prescribed digit row, and indicates the proportion of two complex vectors, i.e.  $S_{\text{output/input}}$ , including the amplitude and phase information. The output refers to the output signal port number of the tested device, and the input refers to the input signal port number of the tested device. The analyzer is equipped with four test ports to test single-port, double-port, three-port and four-port devices.

For example, when one double-port device is connected to Port 1 and 2, four parameters (S) can be measured at the same time.

In this case, the four parameters (S) of the double-port device are respectively S11, S12, S21 and S22. Fig. 4.3 further shows the parameter S, where:

- a refers to the excitation signal from the input to tested device.
- b refers to the reflection and transmission signal (response signal) of the tested device.

The parameter S is a plural linear value. The measurement accuracy depends on the indicators of the calibrator and the adopted technology of measurement connection, and is also associated with the connection of the non-measurement port (non-excited port).

**2) Application of parameter S**

The following parameters can be measured with S.

- a) Reflection measurement: SXX (X=1, 2, 3, 4)
  - i. Return loss
  - ii. Standing wave ratio (SWR)
  - iii. Reflection coefficient
  - iv. Impedance
  - v. S11, S22, S33 and S44
- b) Transmission measurement: SXY (X=1, 2, 3, 4; Y=1, 2, 3, 4; X≠Y)
  - i. Insertion loss
  - ii. Transmission coefficient
  - iii. Gain

iv. Group delay

v. SXY

The measurement of the double-port device with Port 1 and 2 is taken as an example below to introduce the parameter S.

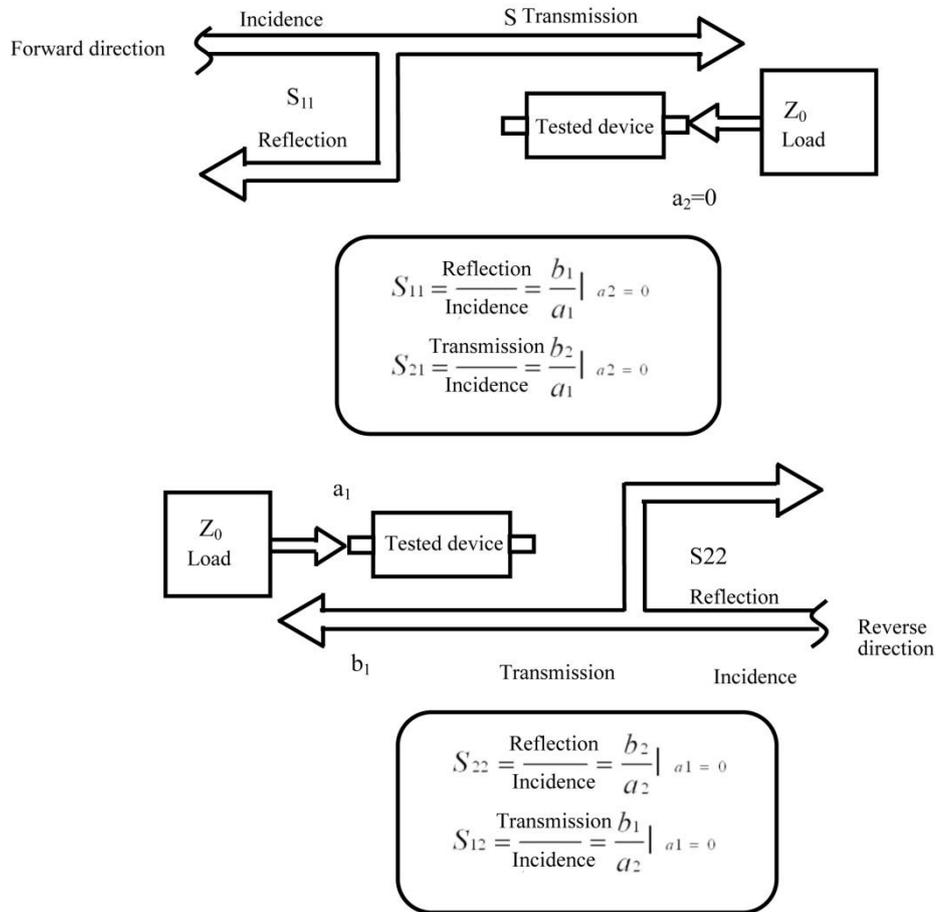


Fig. 4.3 Definition of Parameter S

### 3) New S measurement track

Menu path: [Track] > [New track]. Click the **S-parameter** in the dialog box.

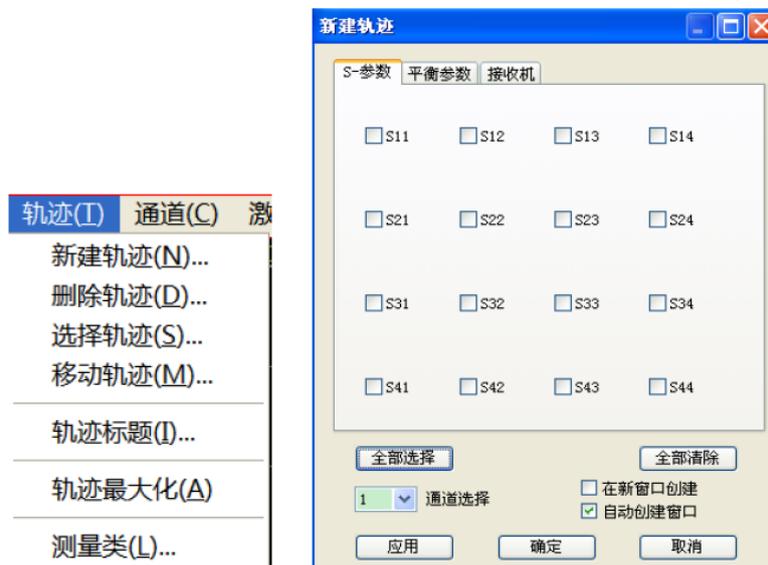


Fig. 4.4 Definition of Parameter S

**4) [New track] dialog box**

**a) [Parameter selection] zone**

Select the S parameter measurement track to be created.

**b) [Receiver] button**

Open the dialog box to create any ratio or non-ratio power measurement track.

**c) [Balance parameter] button**

Open the dialog box to create the balance parameter measurement track.

**d) [Channel selection] box**

Select the channel where the new track is located.

**e) [Create in new window] check box**

If this check box is selected, a track will be created in the new window. If this check box is cleared, a track will be created in the current active window.

**4.2.2 Any Ratio**

The input signal and reference signal are selected from the receiver A, B, C, D, R1, R2, R3 or R4 for ratio measurement.

**1) Create measurement track of any ratio**

Menu path: [Track] > [New track]. Click “Receiver” in the dialog box.



Fig. 4.5 Definition of Parameter S

**4.2.3 Non-ratio Power Measurement**

The absolute power of the receiver A, B, C, D, R1, R2, R3 and R4 can be measured in the non-ratio power

measurement mode, however, the phase, group delay and other items under the “average” function cannot be measured.

**1) New non-ratio power measurement track**

Menu path: [Track] > [New track]. Click “Receiver” in the dialog box.

**2) [New track] dialog box (any ratio and non-ratio power measurement)**

a) [Activation] check box

Tick it to create a new track.

b) [Numerator] zone

Select the numerator of any ratio measurement or the receiver for non-ratio power measurement.

c) [Denominator] zone

Select the denominator of any ratio measurement. The value is 1 in non-ratio power measurement.

d) [Source port] box

Select the source signal output port of the analyzer.

e) [Channel selection] box

Select the channel for the new track.

f) [Create in new window] check box

If this check box is selected, a track will be created in the new window. If this check box is cleared, a track will be created in the current active window.

g) [Automatically create window] check box

If this check box is ticked and the number of tracks in the window exceeds 8, excessive tracks will be automatically created in a new window.

If this check box is cleared and the number of tracks in the window exceeds 8, excessive tracks will not be created.

#### 4.2.4 Measurement mode of track change

The track must be activated before setting and modification.

**1) Change the track activation status**

Click the [Track status] button in the window. The corresponding track will be activated.



Fig. 4.6 Change of Track Activation Status

**2) Change the measurement parameter of the activated track**

Menu path: [Response] > [Measurement]. The **measurement** sub-menu will appear. Or, right-click the track title bar, and click [Measurement] in the menu, as shown in Fig. 4.7.



Fig. 4.7 Setting of Parameter S Measurement Mode of Activated Track

### 4.3 Setting of Frequency Range

Frequency range: 10MHz-13.5GHz/26.5GHz/43.5GHz/50GHz/67GHz

Frequency resolution: 1Hz

#### 1) Two ways of frequency range setting

- a) Specify the starting and ending frequency.
- b) Specify the center frequency and frequency span.

#### 2) Setting of starting and ending frequency

Menu path: [Excitation] > [Frequency]

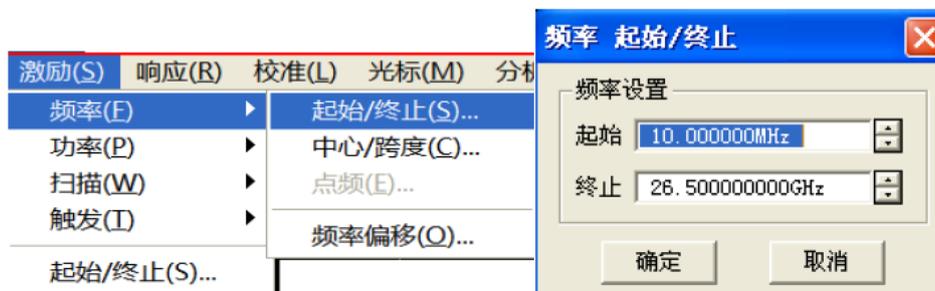


Fig. 4.8 Setting of Starting and Ending Frequency

#### 3) Setting of center frequency and frequency span

Menu path: [Excitation] > [Frequency]

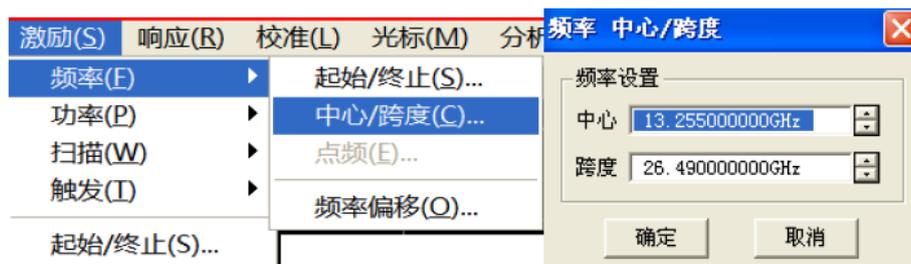


Fig. 4.9 Setting of Center Frequency and Frequency Span

**Prompt**

**[Frequency] shortcut key**

The frequency can be rapidly set with the **[Frequency]** shortcut key in the functional key zone of the front panel.

**4.4 Setting of Signal Power Level**

The power level refers to the power level of the output signal of the test port. The power level indicators of the port of AV3672 series vector network analyzer are as follows.

Table 4.2 Power Level Indicators of Source Output Signal

Frequency range	Source frequency range (dBm)	Configuration
10MHz-13.5GHz/26.5GHz/43.5GHz/50GHz/67GHz	-30~+20	Standard configuration
10MHz~13.5GHz/26.5GHz	-100~+20	Option: program-controlled step attenuator
10MHz~43.5GHz/50GHz	-90~+20	Option: program-controlled step attenuator

**1) Setting of power level**

Menu path: **[Excitation]** > **[Power]**. Also, the **[Power]** shortcut key is set in the **functional** key zone of the front panel and the shortcut menu bar.



Fig. 4.10 Setting of Power Level

## 2) Cutoff of port power

Menu path: **[Excitation]** > **[Power]** > **[Power state ON/off]**. Or, switch the power by changing the setting of the **[Power ON/off]** check box in the [Power setting] dialog box.

## 3) Manual setting of attenuation

Menu path: **[Excitation]** > **[Power]** > **[Power and attenuation...]**. The **[Power and attenuation]** will appear. Click to clear the **[Auto attenuation]** zone check box. Click the **[Attenuation]** input box and enter the attenuation value.

## 4) Setting of power slope

Menu path: **[Excitation]** > **[Power]** > **[Power...]**. The [Power] dialog box will appear. Click **[Slope]** check box. Click the **[Slope]** input box and enter the power slope.

## 5) [Power] dialog box

### a) [Power ON/off] check box

If this check box is ticked, the port will normally output the power. If this check box is cleared, the port output power will be cut off.

### b) [Power-port 1]

Set the power level of the port 1.

### c) [Power slope] check box

Tick the **[Power slope]** check box and enter the slope value in the **[Slope]** input box to enable the power slope function.

The power slope is used to compensate the power loss of the cable and test fixture as a result of frequency increase.

- If the power slope function is enabled, the output power of the test port will increase (or decrease) with the increase of scanning frequency.
- Unit of power slope: dB/GHz.
- Power slope setting range: -2 to +2.

## 6) [Power and attenuation] dialog box

### a) [Power ON/off] check box

If this check box is ticked, the port will normally output the power. If this check box is cleared, the port output power will be cut off.

### b) [Coupling port power] check box

If the **[Coupling port power]** check box is ticked in the default mode, the power level settings of two ports of the analyzer will be identical. However, different power levels are required for ports in some measurement applications. For example, the power of each port must be set separately to measure the gain and reverse isolation of one high-gain amplifier, as the power of the input port of the amplifier is lower than that of the output port. If the **[Coupling port power]** check box is cleared, the power level of each port can be set separately in the analyzer.

### c) [State] bar

It is **[Auto]** in the default mode. In this case, the power ON/OFF state can be switched according to the measurement needs. **[ON]** indicates the port power is always ON, while **[OFF]** indicates the port power is always OFF.

### d) [Port power] bar

Set the port power.

### e) [Automatic attenuation] bar

If this check box is ticked, any power level can be set within the allowable range of the instrument. If this check box is cleared, the source power and attenuation can be set manually for certain measurement, such as the reflection amplifier (oscillator or unsteady-state amplifier) measurement. In this case, the matching source impedance (better

than the return loss of 20dB) should be set within a wide frequency range.

**f) [Attenuation] bar**

Set the attenuation.

**g) [Fixed amplitude mode] bar**

Set the fixed amplitude mode, including [Internal fixed amplitude], [Receiver] and [Open loop]. The amplitude is not fixed in the [Open loop] mode.

**h) [Power slope] check box**

Tick the [Slope] check box and enter the slope value in the [Slope] input box to enable the power slope function. The power slope is used to compensate the power loss of the cable and test fixture as a result of frequency increase.

- If the power slope function is enabled, the output power of the test port will increase (or decrease) with the increase of scanning frequency.
- Unit of power slope: dB/GHz.
- Power slope setting range: -2 to +2.

**i) Attenuator Settings and power range**

The programmable attenuator is used to cover the whole power range. It can adjust the power level of the tested device while the power level of the reference path of the analyzer remains unchanged. Thus, higher accuracy and characteristic indicates and more accurate matching of source output signals can be realized.

The fully accurate error correction can be done at the power point for measurement calibration. If the power level is changed in the same attenuator settings as those of measurement calibration, the accuracy of error correction is higher in ratio measurement but poorer in non-ratio measurement.

## 4.5 Setting of Scanning

Scanning refers to the process of continuously measuring data points according to the excitation values in the specified sequence.

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- Scanning time .....106
- Scanning setting .....106

### 4.5.1 Overview of Scanning Types

The network analyzer supports six scanning types shown below.

**1) Linear frequency**

This is the default scanning type of the instrument. The whole frequency range is covered continuously by the frequency linearity.

**2) Logarithmic frequency**

In the logarithmic frequency mode, the source frequency increases in logarithmic steps, and the frequency ratio of every two adjacent frequency points is identical.

**3) Power scanning**

The power is scanned at the point frequency. The maximum scanning range is 50dB. The default frequency scanning range is -30dBm to +20dBm.

**4) Point frequency**

In the point frequency scanning mode, a single scanning frequency is set in the analyzer, measurement data are accurately and continuously samples at the intervals determined according to the scanning time and the number of measurement points, and changes of measurement data with time are displayed.

### 5) Segment scanning

Segment scanning aims to start scanning of several segments. The power level, intermediate frequency bandwidth and scanning time of each segment can be set independently. After calibration of all segments, one or several segment(s) can be measured according to the calibrations. Segments are defined according to the frequency increase sequence, and the frequency range must be prevented from overlapping. The attenuator settings of the power levels of all segments must be identical to prevent damage caused by frequent switching of the attenuator. If the attenuator settings of the current segment and defined segment are different, the analyzer will automatically change the power level and attenuator settings of the defined segment.

### 6) Phase scanning

Scan the phase of one or several source(s) relative to another source. The measured value is  $-360^\circ$  to  $+360^\circ$ .

## 4.5.2 Setting of Scanning Type

### 1) Setting of scanning type

Menu path: [Excitation] > [Scan] > [Scanning type].

Select the corresponding scanning type in the auxiliary menu bar or in the [Setting of scanning type] dialog box.

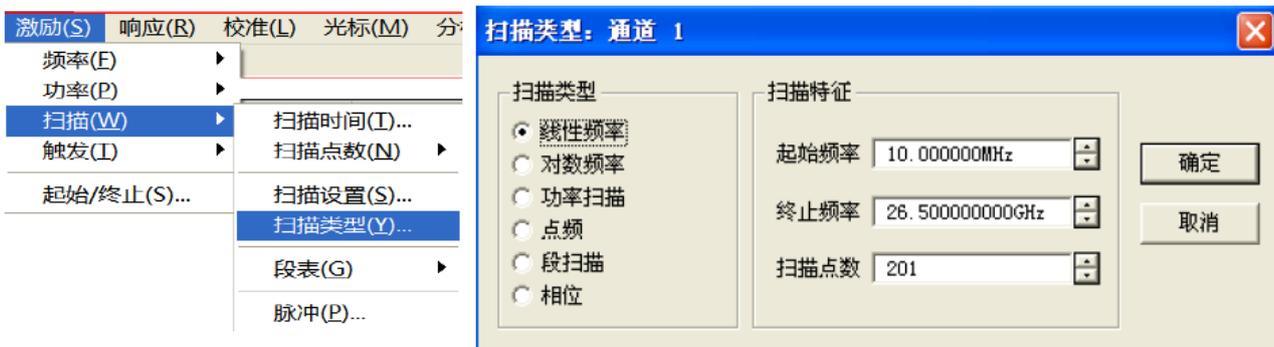


Fig. 4.11 Setting of Linear Frequency Scanning Type

### 2) Setting of segment scanning type

Menu path: [Excitation] > [Scan] > [Scanning type].

Auxiliary menu bar: click [Segment scanning] or select [Segment scanning] in the [Setting type] dialog box.

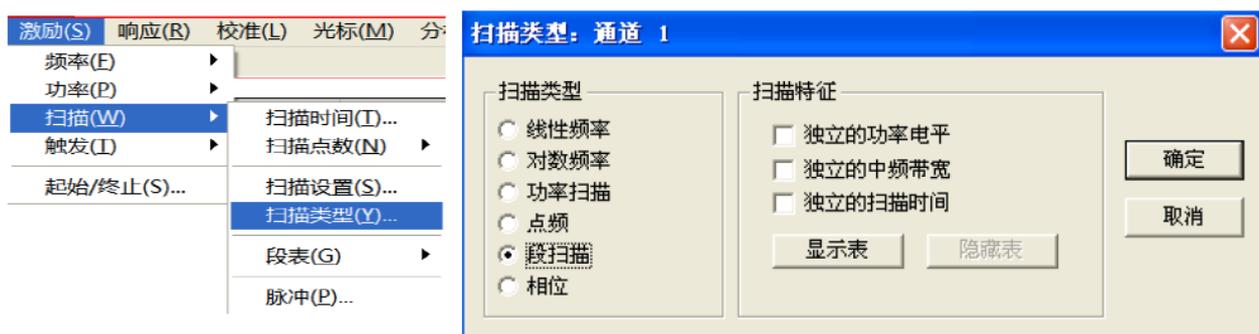


Fig. 4.12 Setting of Segment Scanning Type

Dialog box setting instructions:

- [Independent power level] check box: tick it to set the independent power level of each segment. In this case, the attenuator settings must be identical.
- [Independent intermediate frequency bandwidth] check box: tick it to set the independent intermediate frequency bandwidth of each segment.
- [Independent scanning time] check box: tick it to set the independent scanning time of each segment.

- d) **[Display table]** button: click it to create and edit the scanning table.
- e) **[Hide table]** button: click it to hide the segment scanning table.

### 3) Segment insertion and deletion

Only the displayed segment table can be edited.

Menu path: **[Excitation]** > **[Scan]** > **[Segment table]** > **[Display segment table]**. The **segment table** sub-menu will appear.

Tick **[Display segment table]** in the **segment table** sub-menu. Click **[Insert segment]** in the **segment table** sub-menu to add a new segment in front of the selected segment. Click **[Delete segment]** in the **segment table** sub-menu to delete the selected segment. Click **[Delete all]** to delete the whole segment table.

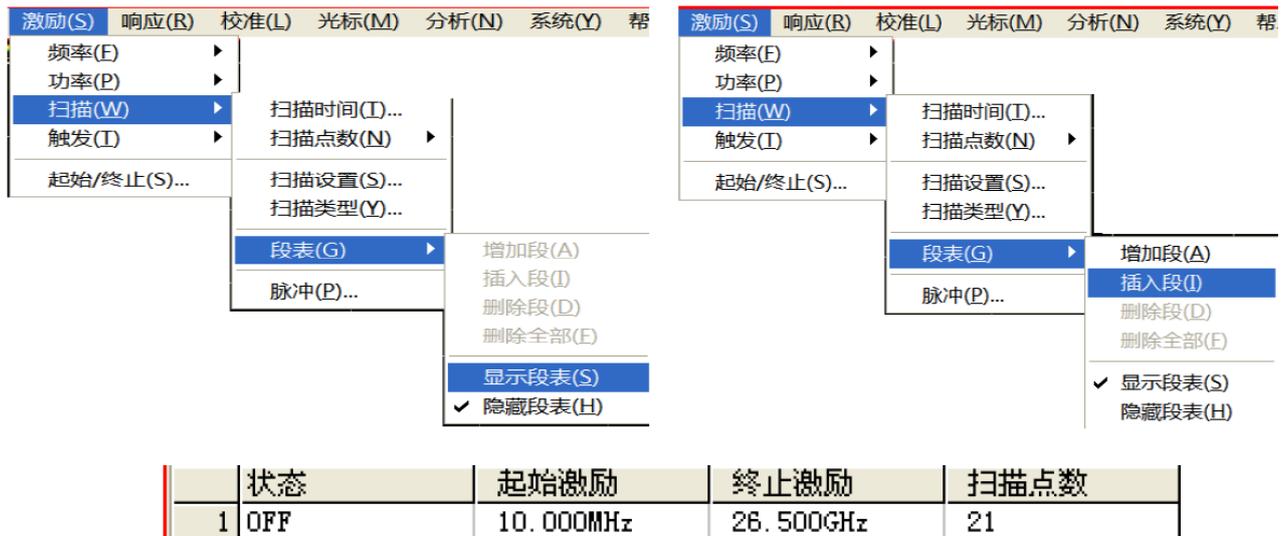


Fig. 4.13 Segment Insertion and Deletion

### 4) Editing of segment table

- a) Double-click the [State] box of the segment and select “ON” or “OFF” to open or close the segment.
- b) Double-click the [Starting excitation] box of the segment and enter the starting frequency of the segment.
- c) Double-click the [Ending excitation] box of the segment and enter the ending frequency of the segment.
- d) Double-click the [Number of scanning points] box of the segment and enter the number of scanning points of the segment.
- e) Double-click the [Power level] box of the segment and enter the power level of the segment (the independent power level option is opened).
- f) Double-click the [Intermediate frequency bandwidth] box of the segment and enter the intermediate frequency bandwidth of the segment (the intermediate frequency bandwidth option is opened).
- g) Double-click the [Scanning time] box of the segment and set the scanning time (the independent scanning time option is opened).

### 5) Setting of phase scanning type

Menu path: **[Excitation]** > **[Scan]** > **[Scanning type]**. The **scanning type** sub-menu will appear.

Click the **phase scanning** in the auxiliary menu bar, or select **phase scanning** in the [Scanning type setting] dialog box.



Fig. 4.14 Setting of Phase Scanning Type

### 4.5.3 Scanning Time

After setting of measurement, the minimum scanning time will be adopted by the analyzer. The scanning time can be increased to meet certain requirements of measurement. If the scanning time is set as 0, the minimum scanning time will be adopted automatically by the analyzer. If the scanning is no less than 300ms, a scanning indicator will be displayed on the analyzer, indicating the point-to-point measurement scanning. The measurement indicator is a small upward arrow, showing the point at which measurement is just completed on the track.

#### 1) Setting of scanning time

Menu path: [Excitation] > [Scan] > [Scanning time...]. The dialog box of **scanning time** will appear.

Enter the scanning time directly in the [Scanning time] box. For setting of the scanning time with the keys and auxiliary menu bar, directly enter the scanning time in the input toolbar.

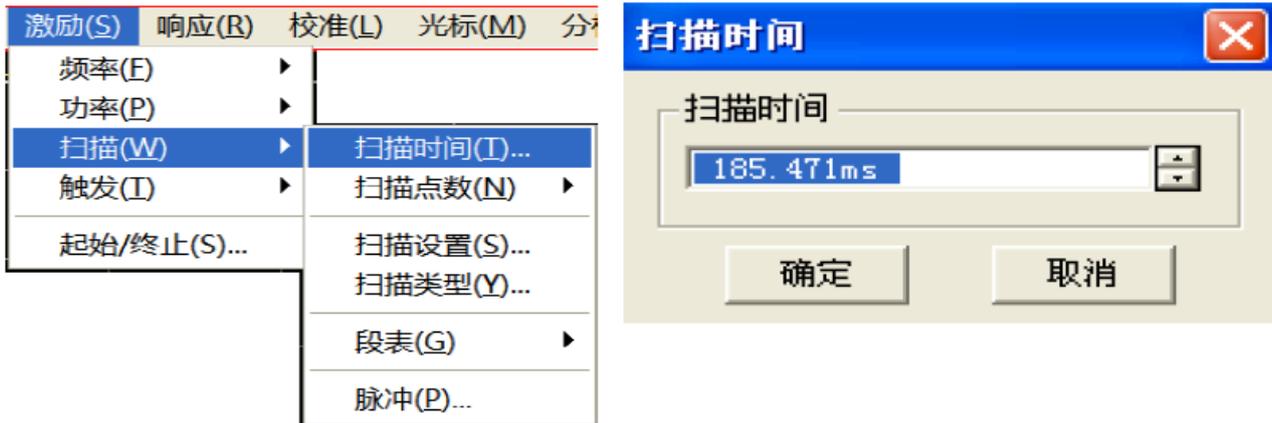


Fig. 4.15 Setting of Scanning Time

#### 4.5.4 Setting of Scanning

##### 1) Scanning setting

Menu path: [Excitation] > [Scan] > [Scanning setting...]. The [Scanning setting] dialog box will appear.

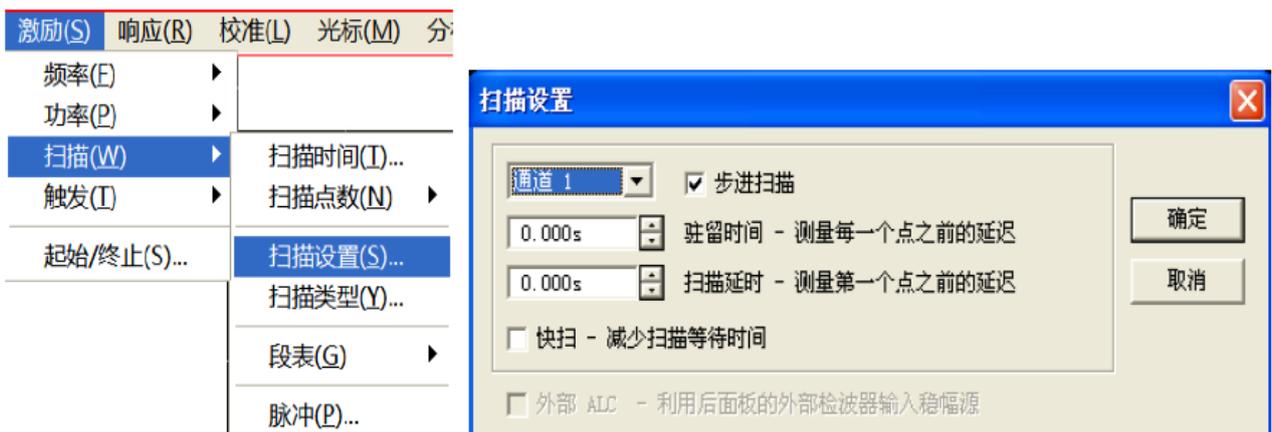


Fig. 4.16 Scanning Setting

##### 2) [Scanning setting] dialog box

###### a) [Channel] box

Select the channel applicable to scanning setting.

###### b) [Step scanning] check box

In the **step scanning** mode, the source is tuned to a frequency point and the frequency point is measured after the specified residence time. Then the source is tuned to next frequency point. A device of long electrical delay can be accurately measured. If this check box is cleared, the analyzer may work in the **analog scanning** or **step scanning** mode, depending on the setting of the scanning time and intermediate frequency bandwidth.

###### c) [Residence time] input box

Set the residence time at each point before obtaining the measurement data. This is only applicable to the **step scanning** mode.

###### d) [Scanning delay] input box

Set the waiting time of the analyzer before obtaining the measurement data. It refers to the delay before measurement of the first point.

###### e) [Quick scan] check box

If the **[Quick scan]** check box is selected, analog scanning will be started. Data are collected in the scanning process, thus reducing the waiting time of scanning.

## 4.6 Trigger Mode

The trigger signal is used to enable measurement scanning of the analyzer. The scanning mode and time to stop scanning and return to the holding state are determined by trigger settings. The vector network analyzer has high flexibility in trigger setting.

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- [Trigger] dialog box .....109

### 4.6.1 Simple Trigger Setting

Only the trigger mode of the current active channel can be set by simple trigger setting.

Menu path: **[Excitation]** > **[Trigger]**. The **trigger** sub-menu will appear.

Click **[Continuous]**, **[Once]** or **[Hold]** in the sub-menu and select the trigger mode.



Fig. 4.17 Simple Trigger Setting

### 4.6.2 Detailed Trigger Setting

Menu path: **[Excitation]** > **[Trigger]** > **[Trigger...]**. The **trigger** dialog box will appear.



Fig. 4.18 Trigger Sub-menu

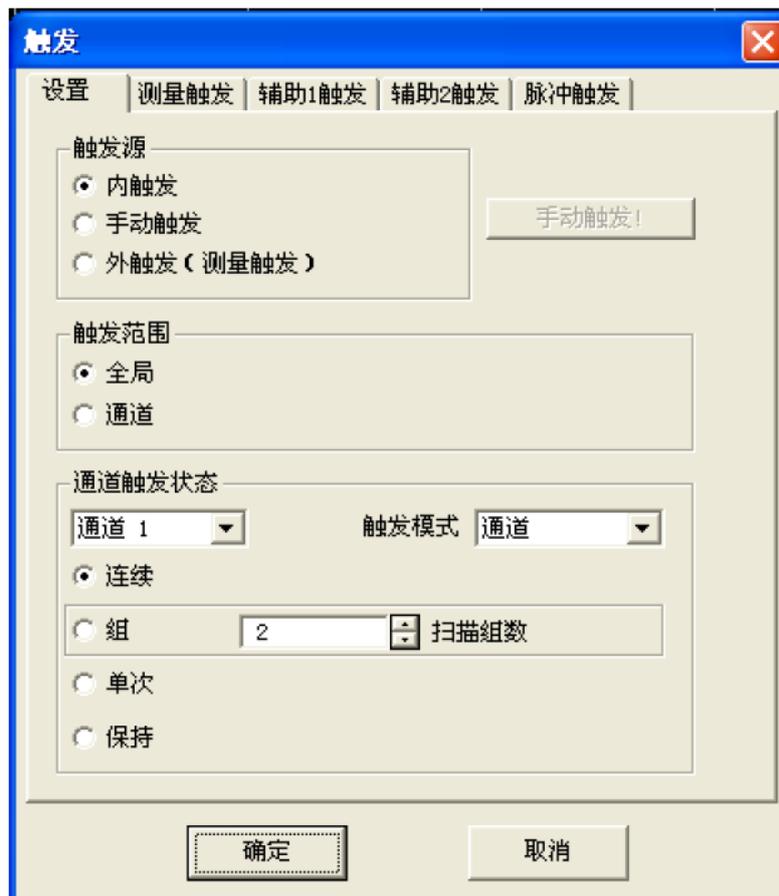


Fig. 4.19 Trigger Setting Dialog Box

### 4.6.3 [Trigger] Dialog Box

#### 1) Trigger setting options

##### a) Trigger source zone

The source of the channel trigger signal is determined by trigger source setting of the trigger source zone. The effective trigger signal is generated when scanning is not done by the vector network analyzer. Three trigger sources can be selected: **internal**, **manual** and **external**. The set trigger source will be used as the trigger source of all channels.

##### ➤ [Internal] (default)

- 1) Trigger signal generation is controlled automatically by the analyzer.
- 2) One trigger signal is generated immediately after one measurement.

##### ➤ [Manual]

The manual trigger signal is generated in the following methods.

- 1) Click the [Manual trigger] button in the [Trigger] dialog box.
- 2) Click the [Manual trigger] item in the [Trigger] sub-menu under the [Excitation] menu of the menu bar.

##### ➤ [External]

- 1) The trigger signal is input by [External trigger input] of the BNC connector on the rear panel.
- 2) The signal is TTL level.
- 3) Level trigger: the high or low level can be set in the [External trigger] dialog box.
- 4) The pulse width is 1 $\mu$ s at and must not be longer than the scanning time (otherwise, the trigger may be enabled

several times).

b) Range zone

The measurement channel receiving the trigger signal is determined by trigger range setting. Two types of trigger range can be set: **global** and **channel**.

➤ **[Global]**

This is the default setting of the analyzer. Except the channel in the **holding** mode, all channels can receive the trigger signal.

➤ **[Channel]**

Next channel which is not in the **holding** mode will receive the trigger signal. After the current channel is measured, next channel will be selected automatically. Except the channel in the **holding** mode, all channels will be selected in sequence. The **trigger source** should be set in the **manual** mode to make the above setting effective. Set the **[Channel]** to enable the **spot scanning** function.

c) Trigger setting zone

The number of trigger signals to be received by one channel is determined by trigger setting. Four channel triggering states are provided:

➤ **[Continuous]**

The channel will receive a number of trigger signals. Scanning will be done continuously.

➤ **[Group]**

The channel will only receive the trigger signals, the number of which is set in the **[Group]** input box. Scanning will be done for the set times, and then the channel will enter the **holding** mode.

➤ **[Once]**

The channel will receive one trigger signal. Scanning will be done once, and then the channel will enter the **holding** mode.

➤ **[Hold]**

The channel will not receive the trigger signal, and scanning will be stopped.

➤ **[Spot] ([Trigger mode] check box)**

The **spot scanning** mode can be selected only when the **trigger source** is **manual** or **external** and the **trigger range** is the **channel**. In the **spot scanning** mode, next data point will be measured in scanning after the channel receives the trigger signal. The channel will continuously receive the trigger signal until all measurements in the channel are done. Then next channel which is not in the **holding** mode will be triggered.

➤ **[Channel] ([Trigger mode] check box)**

All tracks in the channel will be triggered.

➤ **[Scan] ([Trigger mode] check box)**

The **scanning trigger** mode can be selected only when the **trigger source** is **manual** or **external** and the **trigger range** is the **channel**. The tracks sharing one source port in the channel will be triggered.

## 2) Measurement trigger options

a) Main trigger input zone

Set the nature of the external trigger signal to be received in the trigger input zone.

➤ **[Global/channel trigger delay]**

**[Delay]:** Enter the delay time in the delay input box. When the instrument receives the external trigger signal, scanning will be started after the delay time.

➤ **[Trigger source]**

Set the external trigger signal input interface, including the BNC interface and automatic test interface (18-pin).

➤ **[Level/edge]**

Set the trigger mode of the external trigger signal, including high level, low level, rising edge and falling edge.

➤ **[Ready to enable trigger signal received before triggering]**

If this item is ticked, corresponding scanning will be executed immediately after the vector network analyzer receives the trigger signal; otherwise, all the received trigger signals will be ignored.

➤ **[Ready to receive trigger prompt]**

The trigger READY signal is sent by the BNC interface and automatic test interface (21-pin). High level and low level of the signal are optional.

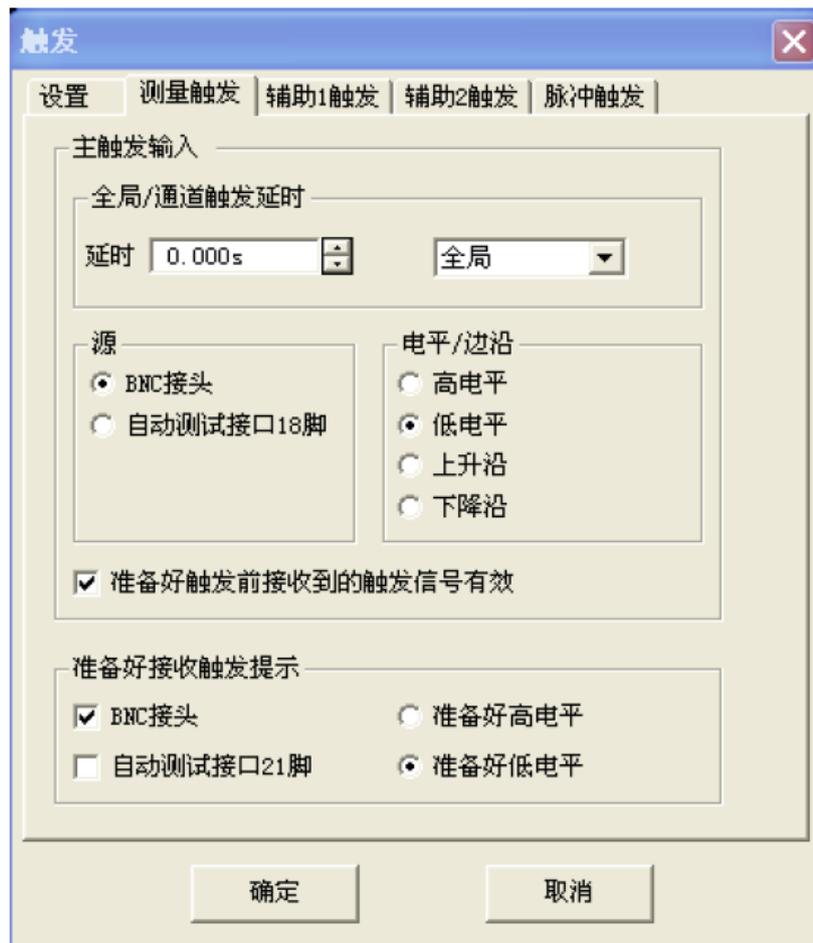


Fig. 4.20 Measurement Trigger Dialog Box

**3) Auxiliary 1/2 trigger option**

a) Auxiliary trigger output zone

➤ **[Enabled]**

Tick the check box to open the external trigger output of the corresponding channel; otherwise, the external trigger output will be closed.

➤ **[Polarity]**

Set the polarity of the trigger output signal in the radio box: **[Positive pulse]** or **[Negative pulse]**.

➤ **[Position]**

Set the time to send the trigger output signal in the radio box: **[Before data capturing]** or **[After data capturing]**.

➤ **[Pulse width]**

Input the pulse width of the trigger output signal in the input box.

➤ **[Enable the waiting for external equipment holding signal]**

If this check box is ticked, data will not be captured until the vector network analyzer receives the specific level from the **auxiliary trigger input (1&2) connector** of the rear panel. This signal indicates that the external device is ready and the network analyzer is allowed to capture data. Otherwise, the network analyzer will not wait. However, a trigger signal will be sent when the network analyzer is ready. This signal cannot be used to trigger the network analyzer. It is generated by the internal, manual or external source.

➤ **[Auxiliary trigger input]**

When the network analyzer is ready, a confirmation signal will be sent to the auxiliary 1 & 2 connection port. The signal can be in the rising edge, falling edge, high level or low level form.

➤ **[Delay]**

When the network analyzer receives the holding signal, data will be captured after the corresponding delay time.

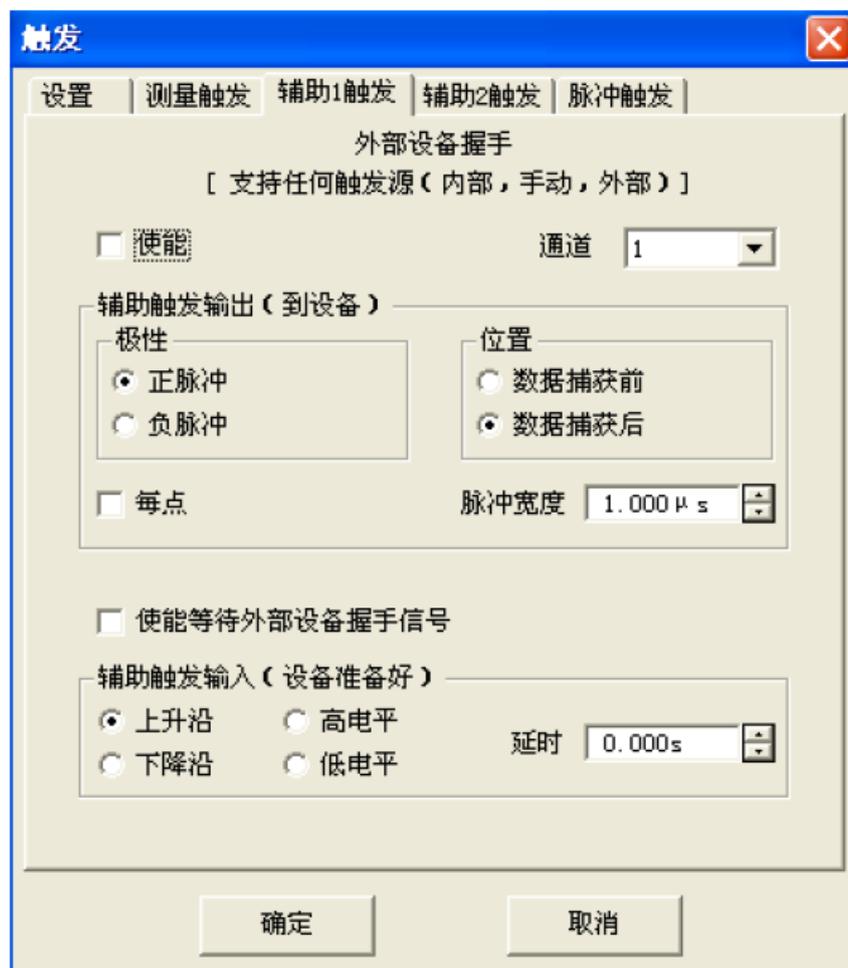


Fig. 4.21 Auxiliary 1/2 Trigger Dialog Box

**4) Pulse trigger options**

a) Synchronous pulse input zone

Select the internal or external source to synchronize the internal pulse generator of the analyzer.

➤ **[Synchronization]**

1) **Internal:** the pulse generator is synchronized according to the periodic signal generated in the analyzer, and the output pulse train period is determined according to the pulse repetition period in the pulse measurement interface.

2) **External**: the pulse repetition period specified by the user is ignored. One pulse train will be output once an effective external pulse synchronization signal is detected by the analyzer. The delay and width of the pulse generator can be set respectively in the pulse measurement interface. The external pulse synchronization input signal will be input through the **pulse input/output interface** of the rear panel of the analyzer. The configurable synchronization trigger signal can be input to the analyzer according to the pulse synchronization input signal. If the level is trigger, the analyzer will output a pulse train. If the level is continuously effective, the analyzer will continue to output another pulse train. If the edge is triggered, the analyzer will be triggered by one effective edge signal to output a pulse train. The pulse train length is the maximum value (delay + width) in all the enabled pulse generators.

➤ **[Level/edge]**

Set the characteristics of the effective external pulse synchronization input signal to be received by the analyzer: high level, low level, rising edge or falling edge.

b) Receiver output zone

➤ **[Synchronization of receiver and pulse generator 0]**

It is used to measure the broadband synchronization pulse. When this function is enabled, the pulse generator output and data collection are allowed to be synchronized.

➤ **[Delay]**

Set the delay time before collection of AD data.

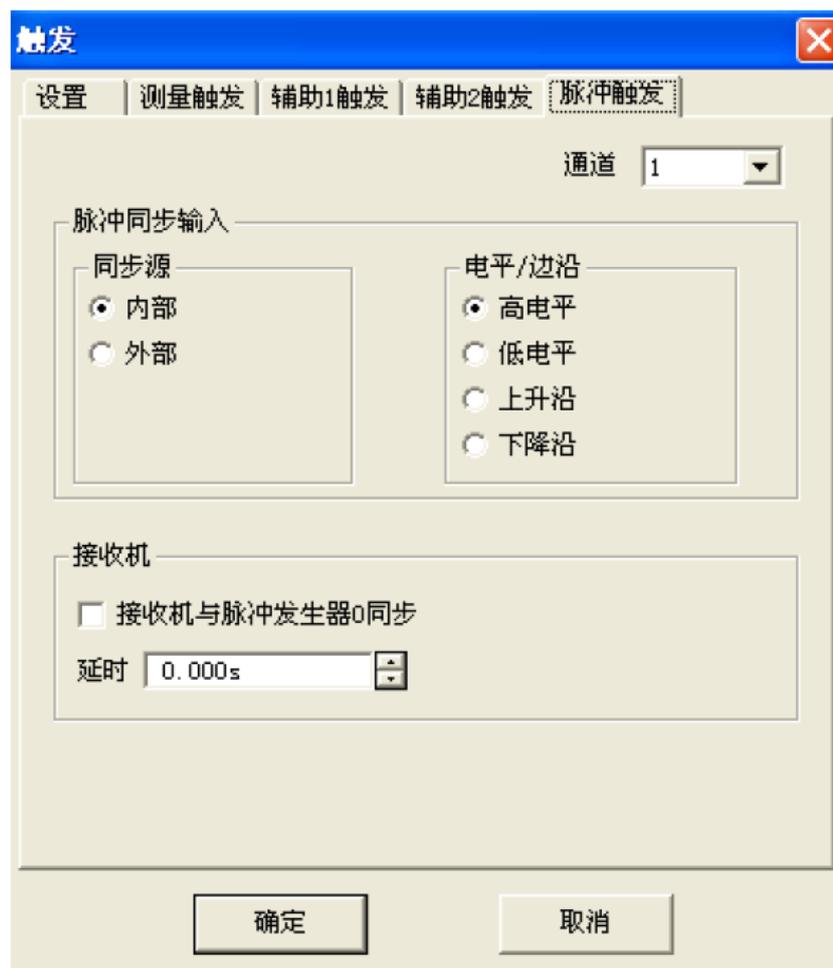


Fig. 4.22 Pulse Trigger Dialog Box

## 4.7 Setting of Data Format and Scale

The data format refers to the display of measurement data in the graphical form. Select the data format which is the

most favorable to understand the characteristics of the tested device. This section introduces nine data formats and the method of scale setting so as to better display the measurement information.

- [Data format](#) .....113
- [Data format setting](#) .....116
- [Scale](#) .....116

### 4.7.1 Data Format

#### 1) Rectangular coordinate format

Seven of nine formats of measurement data are in the rectangular coordinate form. This format is also known as the Cartesian format, X/Y format or linear format and is suitable to display the frequency response information of the tested device. For example, the rectangular coordinates in Fig. 4.23 show the following information.

- Excitation value (frequency, power or time) in the linear scale form on the X-axis in the default mode.
- Response value corresponding to the excitation value on the Y-axis.

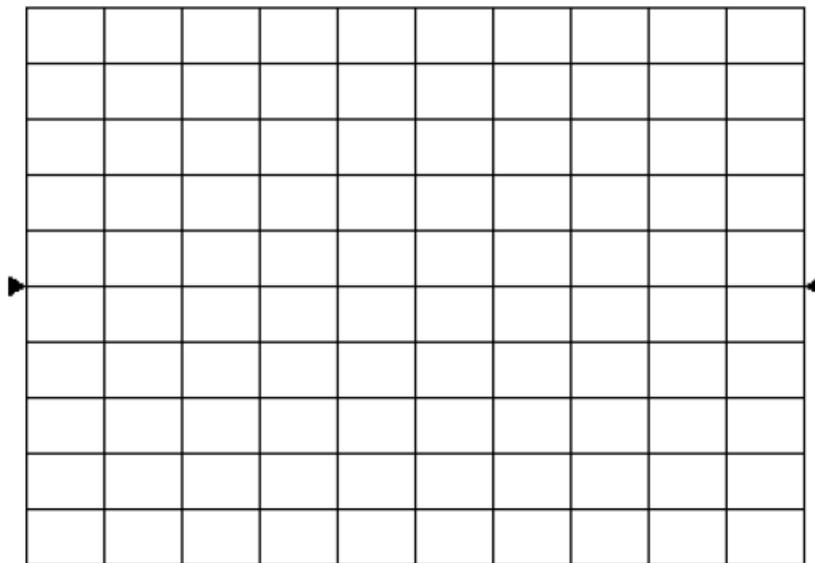


Fig. 4.23 Rectangular Coordinate Format

#### a) Logarithmic amplitude format

- Display the amplitude information (no phase information).
- Y-axis unit: dB
- Applicable typical measurement: return loss, insertion loss and gain.

#### b) Phase format

- Display the phase information (no amplitude information).
- Y-axis unit: phase (degree)
- Applicable typical measurement: linear phase deviation.

#### c) Group delay format

- Display the signal transmission time through the tested device.
- Y-axis unit: time (second)
- Applicable typical measurement: group delay.

#### d) Linear amplitude format

- Only display the positive value.

- Y-axis: no unit (U) in ratio measurement and milliwatt (mW) in non-ratio measurement.
  - Applicable typical measurement: reflection and transmission coefficient (amplitude) value and time domain transformation
- e) Standing wave ratio format
- Display the reflection measurement data calculated by the formula  $(1+\rho)/(1-\rho)$ , where  $\rho$  is the reflection coefficient.
  - Effective in reflection measurement.
  - Y-axis: no unit.
  - Applicable typical measurement: standing wave ratio.
- f) Real part format
- Display the real part of the measurement complex.
  - It is similar to the linear amplitude format, but both the positive value and negative value can be displayed.
  - Y-axis: no unit.
  - Applicable typical measurement: time domain and auxiliary input voltage for maintenance purposes.
- g) Imaginary part format
- Only display the imaginary part of measurement data.
  - Y-axis: no unit.
  - Applicable typical measurement: impedance measurement in design of matching network.

## 2) Polar coordinate format

The polar coordinate format shown in Fig. 4.24 includes the amplitude and phase information. The vector value can be read in the following method.

- a) The amplitude of any point is determined by the displacement of this point relative to the central point (or zero point). In the default mode, the amplitude is a linear scale, and the excircle scale is set as 1.
- b) The phase of any point is determined by the angle relative to the X-axis.
- c) The frequency information can only be read through the cursor. The default cursor format includes the real part and imaginary part. The **cursor** dialog box can be opened in the **cursor/analysis** menu. Other formats can be selected in the **advanced cursor** menu.

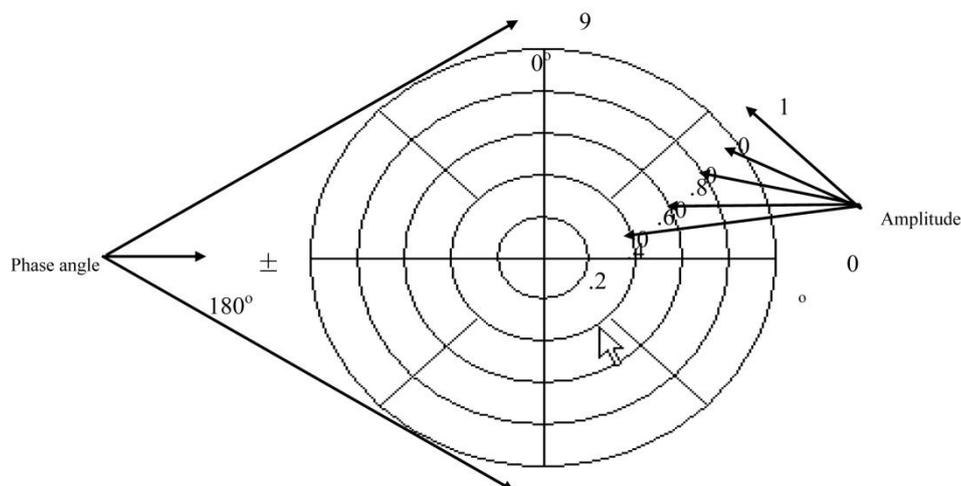


Fig. 4.24 Polar Coordinate Format

## 3) Smith chart format

Smith chart shown in Fig. 4.25 is a tool to map the reflection measurement data of the tested device into impedance.

Each point of the chart represents a complex impedance composed of the real resistance (R) and virtual reactance ( $\pm jX$ ). The resistance, reactance, equivalent capacitance and inductance can be read through the cursor.

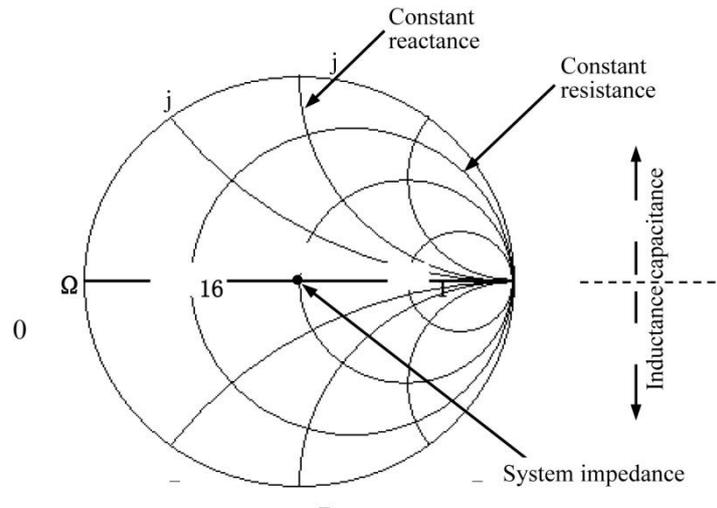


Fig. 4.25 Smith Chart Format

- a) The horizontal axis of the center of Smith chart represents the pure resistance, and the center of the horizontal axis represents the system impedance. The leftmost resistance on the horizontal axis is zero, indicating a short circuit. The rightmost resistance of the horizontal axis is infinite, indicating an open circuit.
- b) The points on the intersecting circle of Smith chart and horizontal axis have the same resistance.
- c) The points on the tangent of Smith chart and horizontal axis have the same reactance.
- d) The reactance of the upper part of Smith chart is positive. Therefore, the upper part is the sensitive zone.
- e) The reactance of the lower part of Smith chart is negative. Therefore, the lower part is the capacitive zone.

### 4.7.2 Data Format Setting

Menu path: [Response] > [Format]. The **format** sub-menu will pop up.

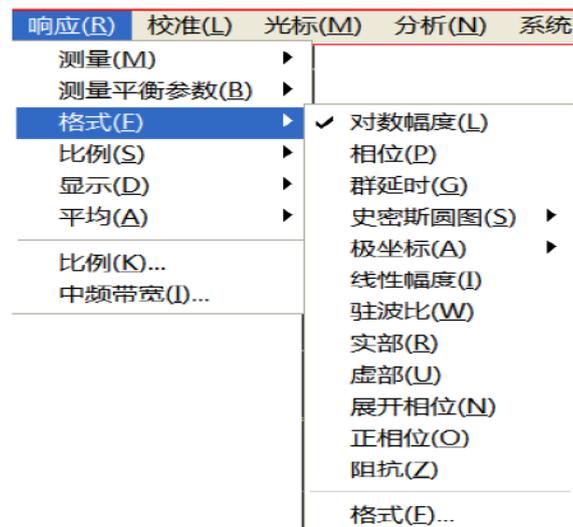


Fig. 4.26 Setting of Data Format

### 4.7.3 Scale

The scale refers to the scale of the vertical part of the display grid. In the polar coordinate and Smith chart format, the scale refers to the full scale of the excircle. The display mode of measurement data on the screen are determined

by scale and format settings. In the log format, the scale setting range is 0.001dB/grid to 500dB/grid.

### 1) Scale setting

Menu path: [**Response**] > [**Scale**]. The **scale** sub-menu will pop up.

Set the appropriate scale, reference location and reference level by clicking the corresponding input zone or keys.

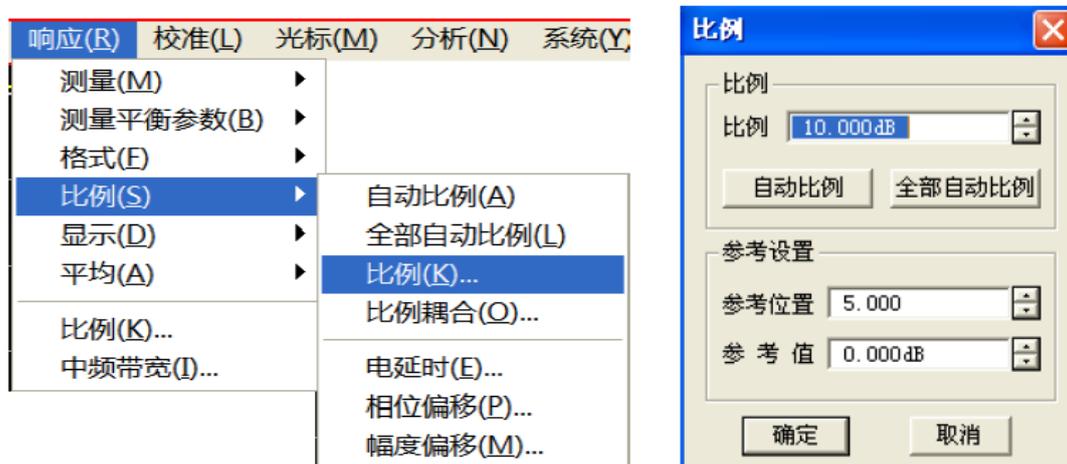


Fig. 4.27 Setting of Scale

### 2) Scale setting dialog box

#### a) Scale zone

##### ➤ [**Scale**] box

Enter the set scale value.

##### ➤ [**Automatic scale**] button

Click the [**Automatic scale**] button. The analyzer will automatically select the vertical scale to better display the active track in the vertical grid of the screen. The excitation value will not be affected, and only the scale value and reference value are changed.

i. An appropriate scale factor will be selected so that data are displayed in 80% of the screen.

ii. The center value of the track on the screen will be selected as the reference value.

##### ➤ [**All automatic scales**] button

Click the [**All automatic scales**] button. The analyzer will select appropriate scales of all tracks in the window so that the tracks are better displayed in vertical grids of the window.

#### b) Reference setting zone

##### ➤ [**Reference position**] button

The reference position refers to the position of the reference line in the rectangular coordinate figure. The position of the bottom line in the figure is 0, the position of the top line is 10, and the default value of the reference position is 5.

##### ➤ [**Reference value**] button

The reference value refers to the value of the reference line in the rectangular coordinate format, and the value of the excircle in the polar coordinate and Smith chart format. The setting range is -500dB to +500dB in the logarithmic amplitude format.

## 4.8 Observation of Multiple Tracks and Opening of Multiple Channels

A convenient method is provided in the preconfiguration function of the analyzer for multi-track, multi-channel and multi-window measurement. The analyzer has four preconfigured measurement settings. If one kind of setting is selected, the current track and window will be closed, and a new track and window will be created. The window

arrangement of four presets is as follows.

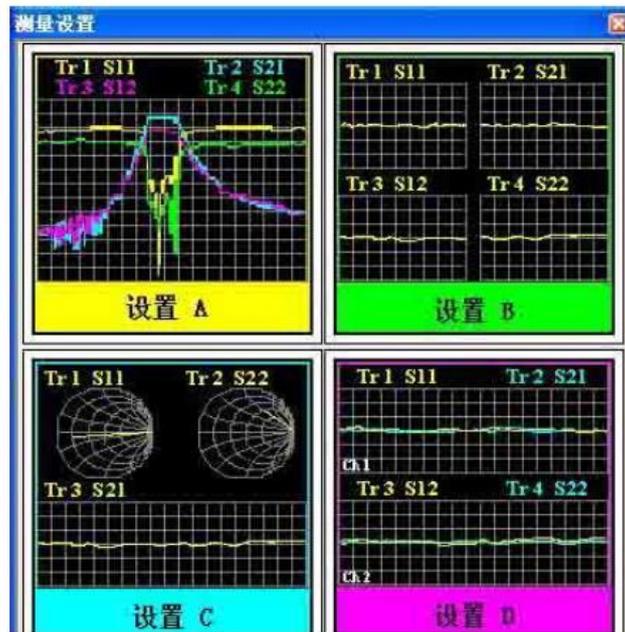


Fig. 4.28 Preconfigured Window Arrangement

➤ **Setting A**

Four tracks will be created in Window 1: S11, S21, S12 and S22, in the logarithmic format in Channel 1.

➤ **Setting B**

Four tracks will be created in four windows, in the logarithmic format in Channel 1. S11 will be displayed in Window 1, S21 in Window 2, S12 in Window 3 and S22 in Window 4.

➤ **Setting C**

Three tracks will be created in three windows of Channel 1. S11 will be displayed in the Smith chart format in Window 1, S22 in the Smith chart format in Window 2 and S21 in the logarithmic format in Window 3.

➤ **Setting D**

Four tracks will be displayed in two windows, in the logarithmic format in two channels. S11 and S21 will be displayed in Window 1 of Channel 1, and S12 and S22 in Window 2 of Channel 2.

**1) Preconfigured measurement setting**

Menu path: **[Response] > [Display] > [Measurement setting...]**. The **measurement setting** dialog box will appear.

Select the preconfigured measurement setting in the dialog box.

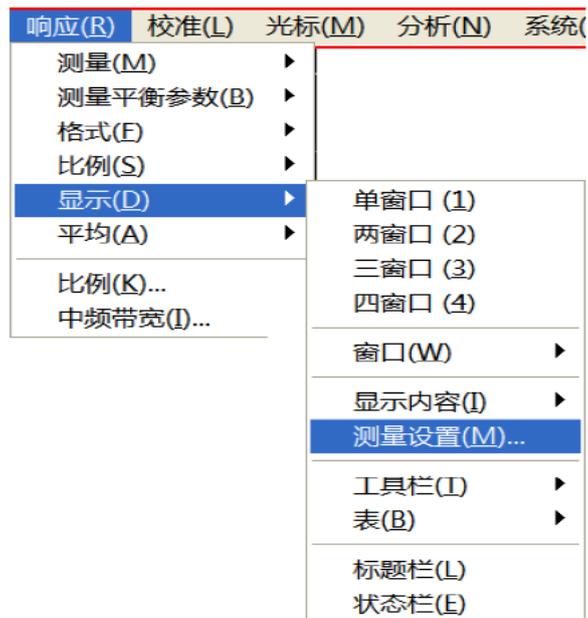


Fig. 4.29 Preconfigured Measurement Setting

## 2) Window arrangement

a) Several methods of window adjustment are provided in the analyzer.

- Use the mouse to move and adjust the window.
- Arrange the windows of the analyzer by the [Tile], [Cascade], [Maximize] and [Minimize] items of the **window** menu.
- Arrange the windows by the [One-window], [Two-window], [Three-window] and [Four-window] items of the **display** menu.
- Use the [Minimize], [Maximize/reduce down] and [Close] button in the top right corner of the window to adjust or hide the window.

b) The display menu of the analyzer provides four kinds of window arrangement. The existing tracks are distributed into different windows according to a certain algorithm.

- One-window arrangement

All tracks are displayed in one window in a cascading manner.

- Two-window arrangement

All tracks are displayed in two windows which are vertically overlapped.

- Three-window arrangement

All tracks are displayed in three windows. Two of the three windows are arranged in the upper part, and the other in the lower part.

- Four-window arrangement

All tracks are displayed in four windows which respectively cover one fourth of the screen.

c) Setting of window arrangement

Menu path: [Response] > [Display]. The display sub-menu will pop up. Select the window arrangement mode in the **display** sub-menu.



Fig. 4.30 Setting of Window Arrangement

## 4.9 Setting of Analyzer Display

You can use the display menu of the analyzer to display or hide the display elements and customize the screen. These display elements are usable for measurement observation, setting and modification, including the status bar, toolbar, list, measurement display, data track, memory track and title bar.

●	Status bar .....	120
●	Toolbar .....	121
●	Table .....	123
●	Display contents .....	124
●	Title bar .....	126

### 4.9.1 Status Bar



1) The opened status bar will be displayed at the bottom of the screen, including the following contents:

- Current active channel
- Measurement parameter of active track
- Mathematical operation of active track
- Error correction status of active track
- If the average function is enabled, the average factor of the current active channel and the average times will be displayed.
- If the smoothing function is enabled, the number of smoothing points will be displayed.
- If the function of time domain transformation is enabled, “TRANSFORM: ON” will be displayed.
- If the gate setting function is enabled, “GATE: ON” will be displayed.
- GPIB status: LOCAL or REMOTE.
- Reference (REF) signal status: INT or EXT

## 2) Display of trigger status bar

Menu path: **[Response]** > **[Display]**. Tick **[Status bar]** in the display sub-menu to open the status bar display and clear **[Status bar]** to close the status bar display. Or, press the **status bar opening/closing** item of the auxiliary menu bar to open or close the status bar.



Fig. 4.31 Display of Trigger Status Bar

## 4.9.2 Tool bar

1) Six different toolbars can be displayed at the same time. Measurement can be easily set through the toolbar.

### a) Input toolbar



Input the value through the input toolbar to set the measurement parameter.

### b) Cursor toolbar

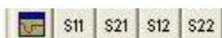


Set and modify the cursor, including:

- Cursor number
- Cursor ON/OFF check box
- Excitation value
- Cursor function:  $\Delta$  cursor, maximum/minimum value, starting/ending value and center/span value.

Click the [Excitation] value of the cursor toolbar and rotate the knob on the front panel to change the cursor position.

### c) Measurement toolbar



The measurement toolbar is used to create the S parameter track in the current active window or new window. If the left button of the measurement toolbar is lifted (  ), the S parameter track will be created in the current active window. If this button is pressed (  ), the S parameter track will be created in a new window.

### d) Scanning control toolbar



The buttons of the scanning control toolbar are respectively used to set the following modes of the active channel in sequence:

- **Holding mode**
- **Single scanning**
- **Continuous scanning**

e) Excitation toolbar



f) The excitation toolbar is used to observe, set and modify the scanning excitation, including:

- **Starting excitation value (CW frequency in the CW mode)**
- **Ending excitation value (time in the CW mode)**
- **Number of scanning points**

g) Time domain toolbar

- **Time domain ON/OFF check box**
- **Gate ON/OFF check box**
- **Scanning setting type**
- **Starting excitation value**
- **Ending excitation value**
- **More**

## 2) Trigger toolbar display

Menu path: **[Response]** > **[Display]**. Point to the toolbar in the display sub-menu.

Click the **toolbar** item to be set in the toolbar sub-menu. Tick the item to open the toolbar display and clear it to close the toolbar display.



Fig. 4.32 Trigger Toolbar Display

### 4.9.3 List

1) Display the cursor, limit and segment table so that the user can observe and modify the settings (except the cursor table). The list is displayed in the lower part of the window. Only one table can be displayed in each window.

a) Cursor table

光标	参考	激励	响应
1		20.023GHz	-6.413dBm
2		25.217GHz	-4.614dBm
3		13.030GHz	-5.823dBm
R		3.042GHz	-4.534dBm

Fig. 4.33 Cursor Table

The cursor table is used to display the cursor parameters, including:

- Cursor number
- Reference cursor (for relative measurement)
- Excitation value
- Response value

b) Limit table

	类型	起始激励	终止激励	起始响应	终止响应
1	MAX	45.000MHz	20.000GHz	10.000dB	10.000dB
2	MIN	45.000MHz	20.000GHz	-10.000dB	-10.000dB
3	OFF	45.000MHz	20.000GHz	-100.000dB	100.000dB

Fig. 4.34 Limit Table

The limit table is used to display, set and modify the limit test parameters, including:

- Type (minimum, maximum or closed)
- Starting and ending excitation value
- Starting and ending response value

c) Segment table

	状态	起始激励	终止激励	扫描点数	功率电平	中频带宽	扫描时间
1	ON	45.000MHz	2.000GHz	5	-5.000dBm	1.000kHz	6.569ms
2	ON	2.000GHz	10.000GHz	21	-5.000dBm	1.000kHz	27.378ms
3	ON	10.000GHz	20.000GHz	21	-5.000dBm	1.000kHz	29.378ms
4	ON	20.000GHz	40.000GHz	21	-5.000dBm	1.000kHz	39.378ms
5	OFF	40.000GHz	40.000GHz	21	-5.000dBm	360.000kHz	49.686 μs

Fig. 4.35 Segment Table

The segment table is used to display, set and modify the segment scanning parameters, including:

- Status (ON/OFF)
- Starting and ending excitation value
- Number of scanning points
- Power level (separately set for each segment)
- Intermediate frequency bandwidth (separately set for each segment)
- Scanning time (separately set for each segment)

## 2) Triggering of table display

Menu path: [**R**esponse] > [**D**isplay]. Point to the [**T**able] in the **display** sub-menu.

Click the table to be triggered in the **sub**-menu. Tick this item to display the table and clear it to hide the table.



Fig. 4.36 Triggering of Table Display

### 4.9.4 Display Contents

1) Six kinds of measurement information can be displayed or hidden so that the user can observe the current measurement state, including:

- Title
- Track state
- Frequency/excitation state
- Cursor display
- Display time state

a) Title

One title can be set for each window. The title will be created through the **title input** dialog box, and the entered title will be displayed in the upper left corner of the window. If required, delete the title through the [**I**nput] box of the **title input** dialog box. Click [**O**K] to close the dialog box.



Fig. 4.37 Title Input Dialog Box

b) Track state

The track state will be displayed in the upper left corner of each window on the screen, including:

- Measured parameters
- Format
- Scale
- Reference value

The track state button can be used to set the corresponding track as the current active track so as to set the track. Point to the button and right-click the mouse. Delete the track or set the track scale, color and line through the right-click menu.

c) Frequency/excitation state

The frequency/excitation information will be displayed under each window on the screen. The display can be hidden for security purposes. The following information will be displayed.

- Channel number
- Starting excitation value
- Ending excitation value

d) Cursor display

The cursor display information includes the cursor reading ON/OFF, track cursor ON/OFF, large font ON/OFF, leftward movement of display position, and downward movement of display position. The cursor reading information is displayed in the upper right corner of each window on the screen. The following information will be displayed:

- Cursor number
- Excitation value
- Response value

e) Display time state

If the display time is ON, the system time will be displayed in the upper right corner of the screen.

## 2) Triggering of display contents

Menu path: [**Response**] > [**Display**]. Point to [**Display contents**] in the **display** sub-menu.

Tick or click the auxiliary menu bar in the drop-down menu of the menu bar to display or hide the corresponding contents.



Fig. 4.38 Triggering of Display Contents

#### 4.9.5 Title bar

The title bar includes the application program title bar and window title bar, including the title name and window control button. Click [Hide title bar] to hide all title bars on the screen. In this case, the display of measurement results on the screen can be maximized.

##### Triggering of title bar display

Menu path: [Response] > [Display]. Click [Title bar] in the **display** sub-menu. Tick this item to display the title bar and clear it to hide the title bar.

## 5 Menu

The menu is used to operate and set the vector network analyzer. AV3672 series vector network analyzers are configured with a complex menu system and setting dialog boxes under the menus at all levels. Be familiar with the menu system of the network analyzer to facilitate operation. The menu system of AV3672 series vector network analyzers is divided into the main menu, primary menu, secondary menu, etc. The analyzer can be directly and partially set and operated through the menus at all levels. The setting and input dialog boxes under the menus at various levels should be opened for some settings and operations.

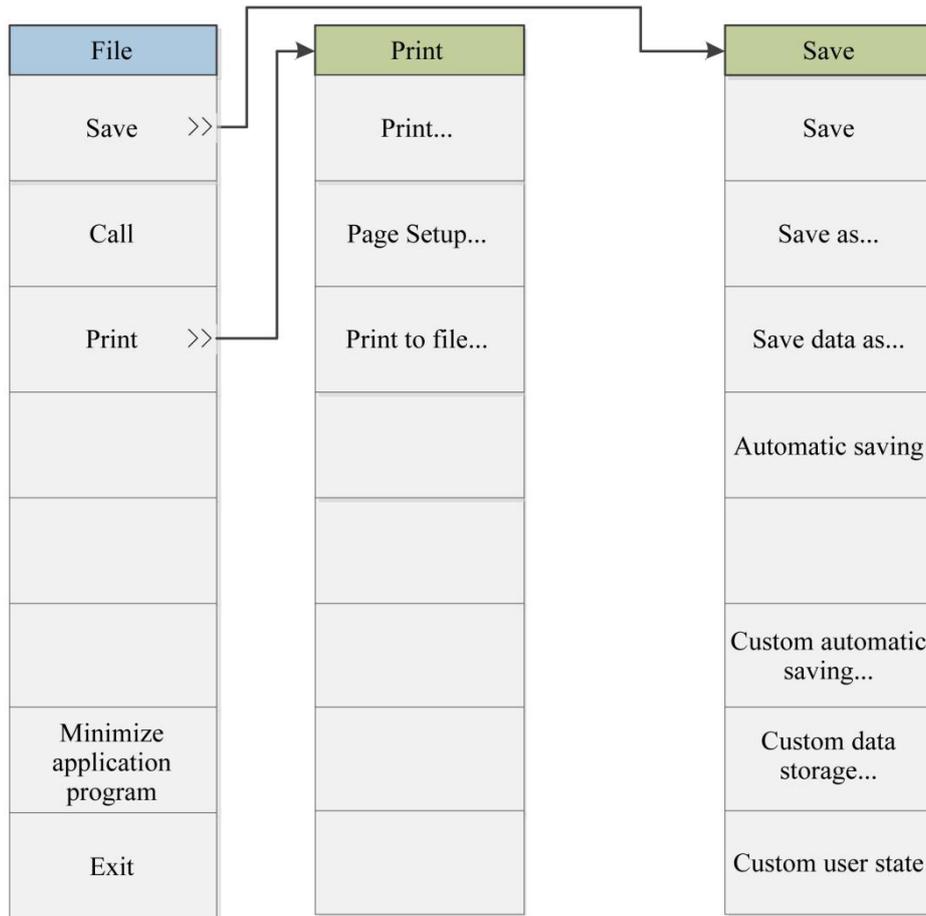
- [Menu structure](#) .....127
- [Menu description](#) .....147

### 5.1 Menu structure

The menus at various levels are as follows:

- [File](#) .....128
- [Track](#) .....129
- [Channel](#) .....130
- [Excitation](#) .....131
- [Response](#) .....134
- [Calibration](#) .....138
- [Cursor](#) .....139
- [Analysis](#) .....142
- [System](#) .....145
- [Help](#) .....146

#### 5.1.1 File



Note: Press the menu with an ellipsis (...) to open the corresponding dialog box, the same below.

Fig. 5.1 File Menu

### 5.1.2 Track

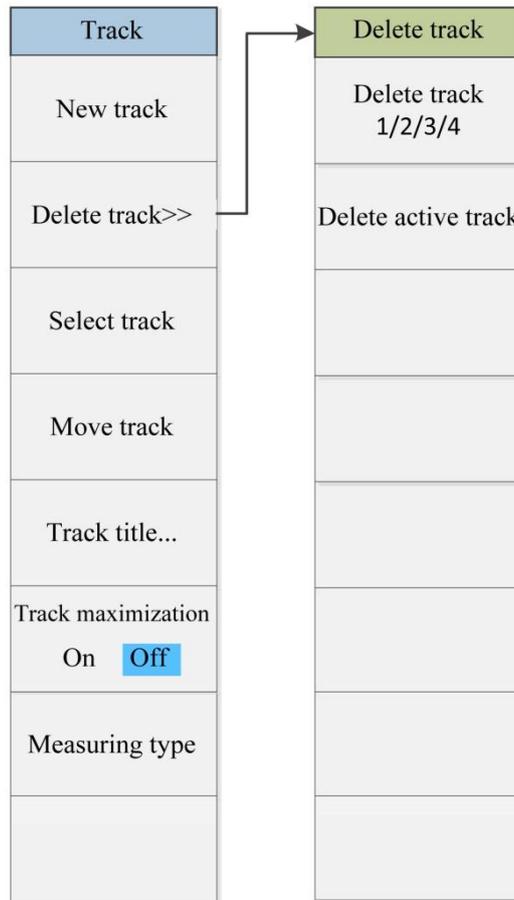


Fig. 5.2 Track Menu

### 5.1.3 Channel

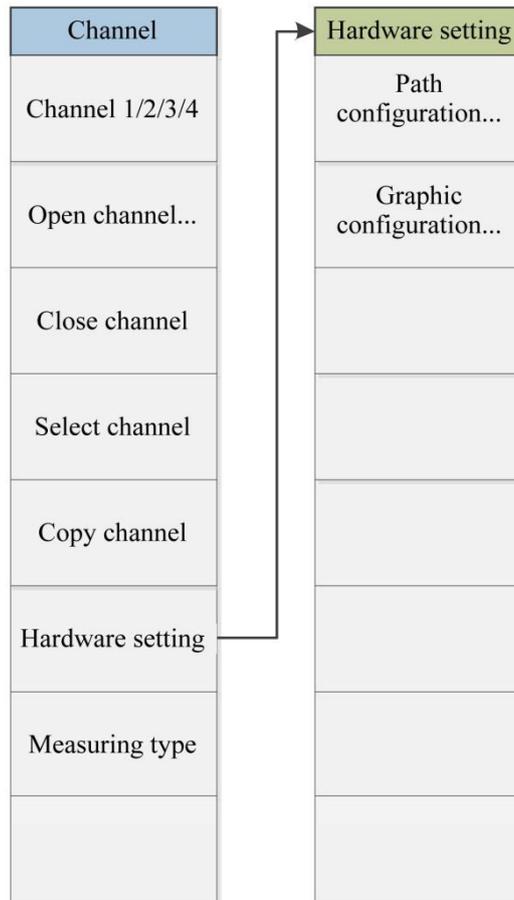
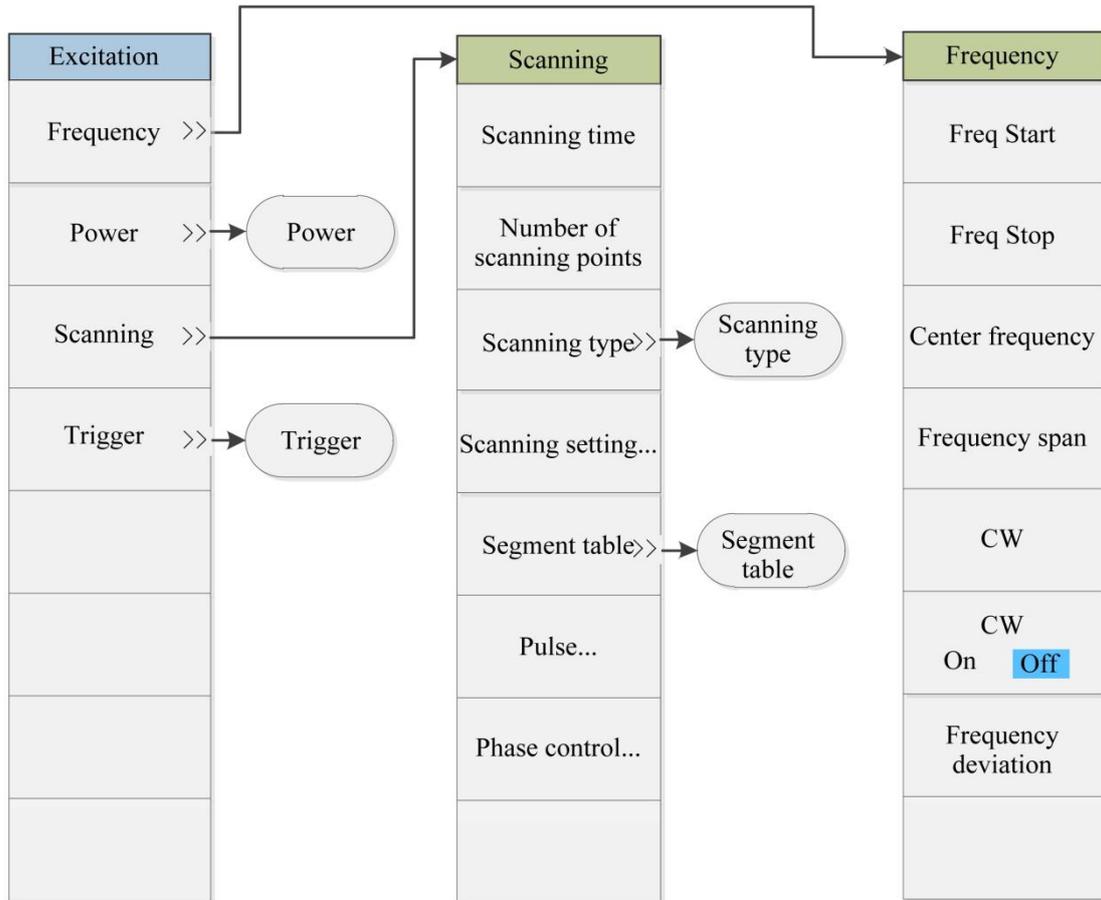
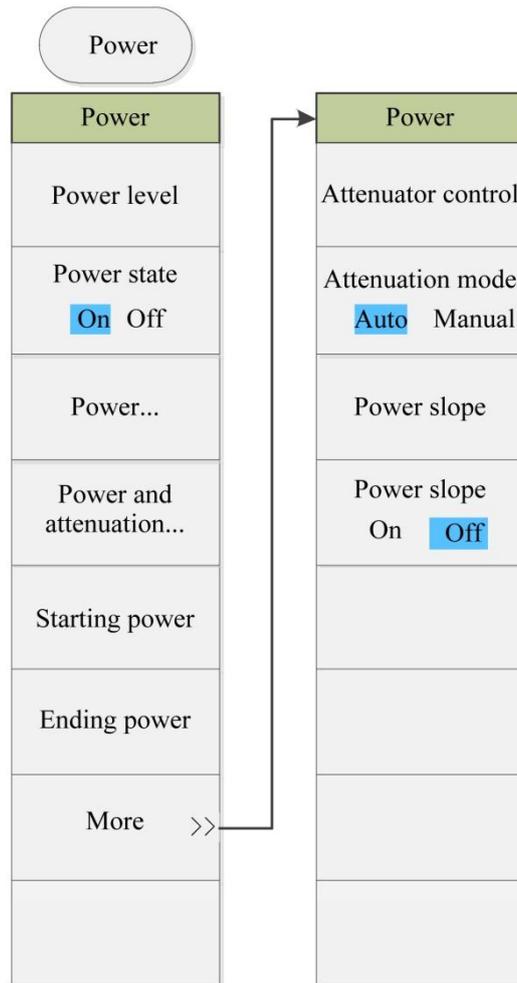


Fig. 5.3 Channel Menu

### 5.1.4 Excitation

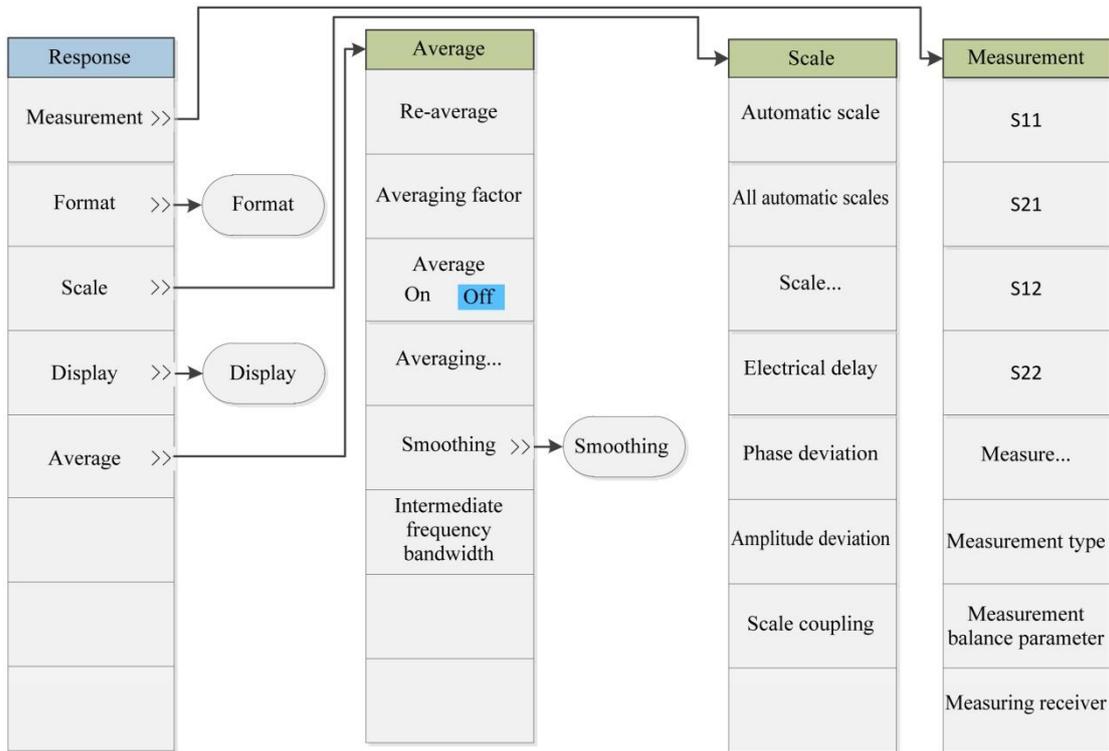




Trigger	Scanning type	Segment table
Trigger	Scanning type	Segment table
Hold	Linear frequency	Segment table On <input type="checkbox"/> Off
Singular	Logarithmic frequency	Add segment
Group scanning	Power sweep	Insert segment
Continuous scanning	CW	Delete segment
Re-scanning	Segment scanning	Independent power level On <input type="checkbox"/> Off
Manual trigger	Phase scanning	Independent intermediate frequency bandwidth On <input type="checkbox"/> Off
Trigger...	Segment table On <input type="checkbox"/> Off	Independent scanning time On <input type="checkbox"/> Off

Fig. 5.4 Excitation Menu

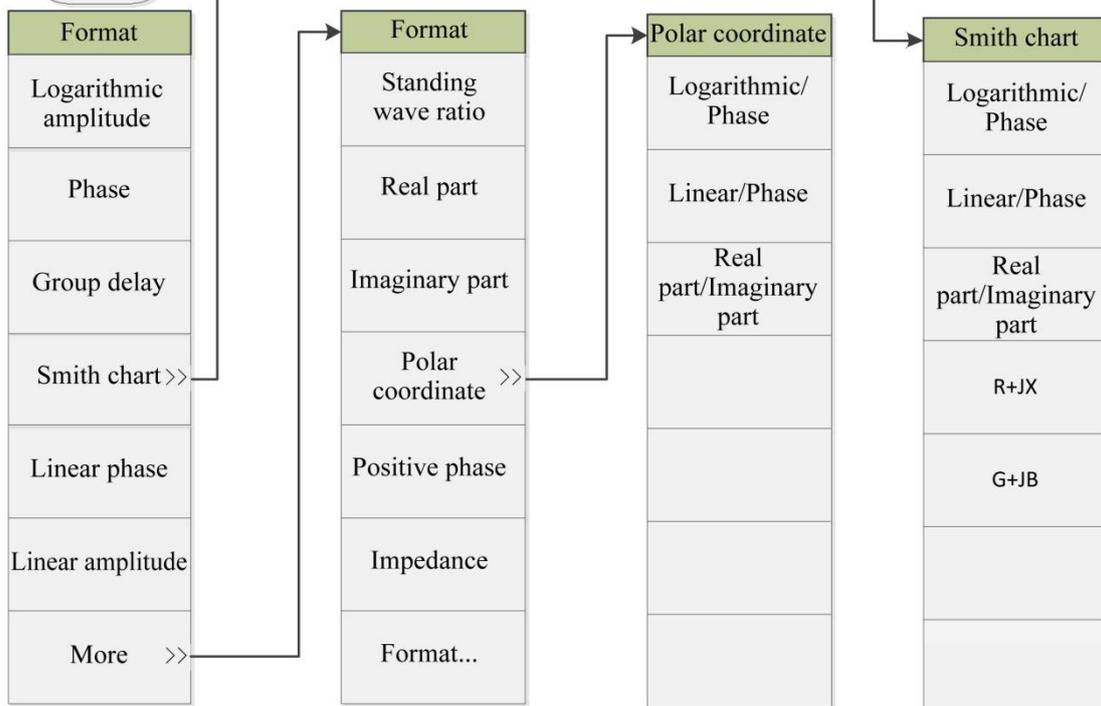
### 5.1.5 Response

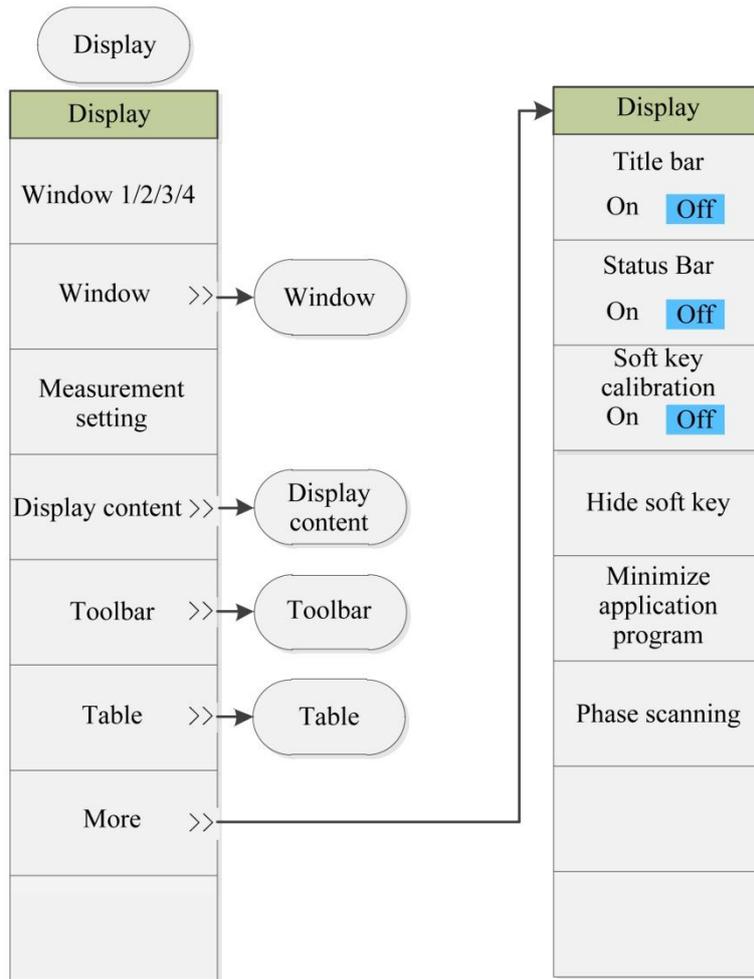


Smoothing

Smoothing
Smoothing On <input type="checkbox"/> Off <input checked="" type="checkbox"/>
Smoothing percentage
Number of smoothing points

Format





Window	Display content	Toolbar	Table
Window	Display content	Toolbar	Table
Window 1/2/3/4	Title	Input toolbar On 关	Segment table
New window	Track state On Off	Cursor toolbar On Off	Cursor table
Close window	Frequency excitation state On Off	Measurement toolbar On Off	Limit table
Select window	Cursor display	Scanning toolbar On Off	Hide table
Tile window	Display time On Off	Excitation toolbar On Off	
Minimization	Screen brightness	Time domain toolbar On Off	
Redo			
Maximization			

Fig. 5.5 Response Menu

### 5.1.6 Calibration

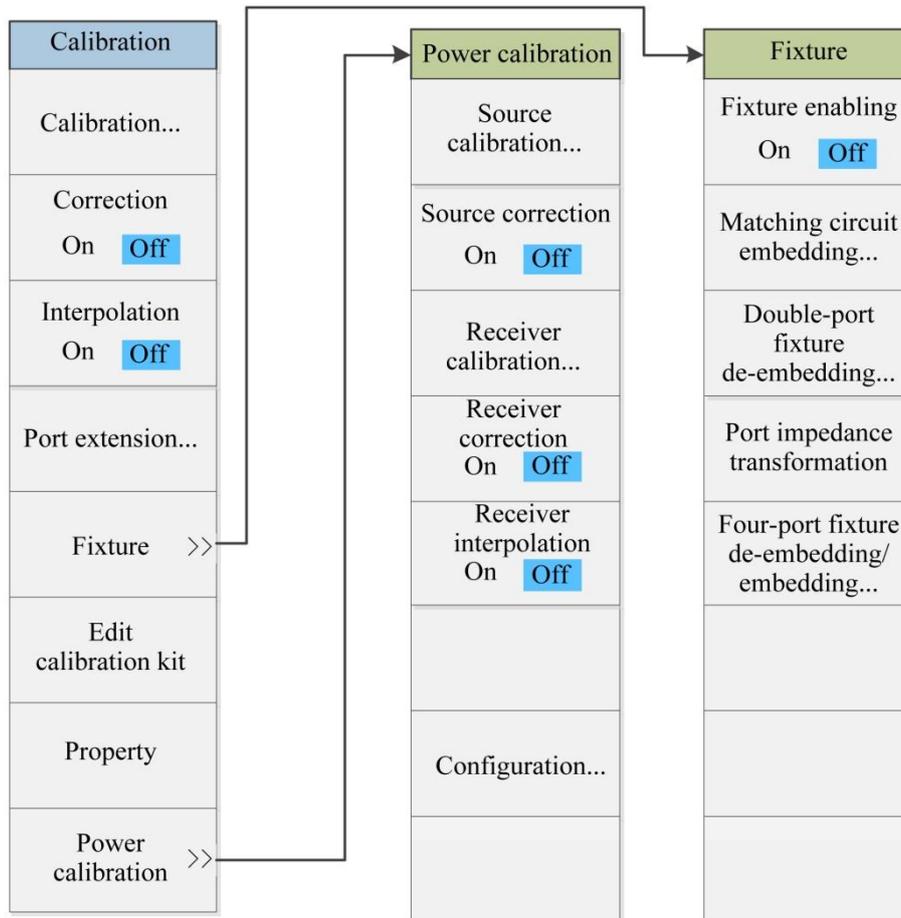
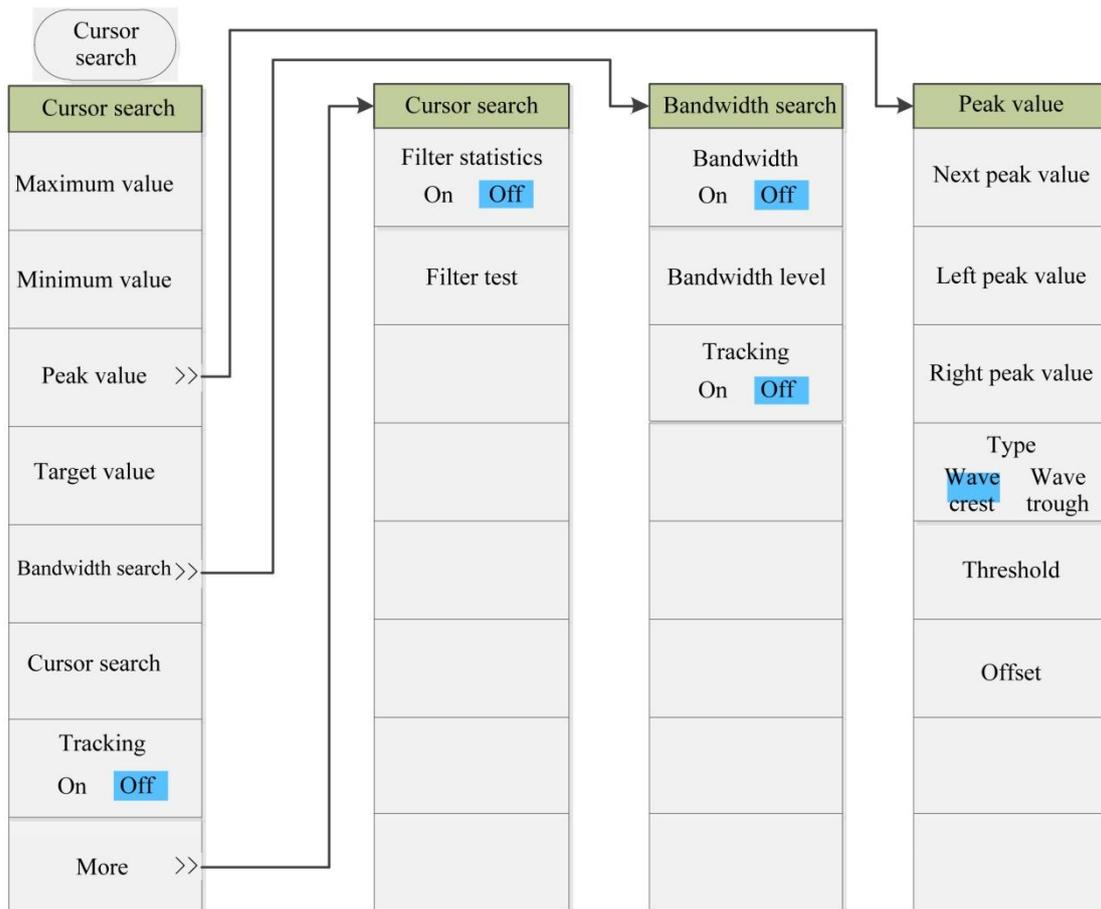
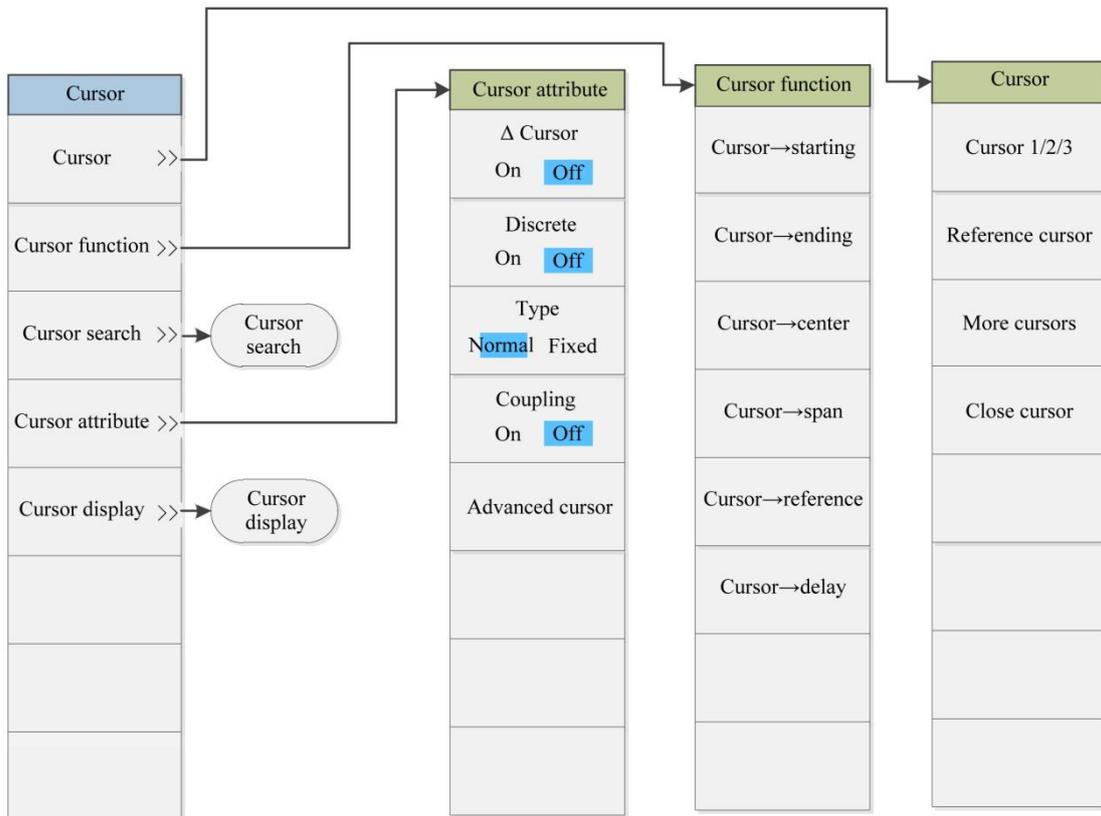


Fig. 5.6 Calibration Menu

### 5.1.7 Cursor



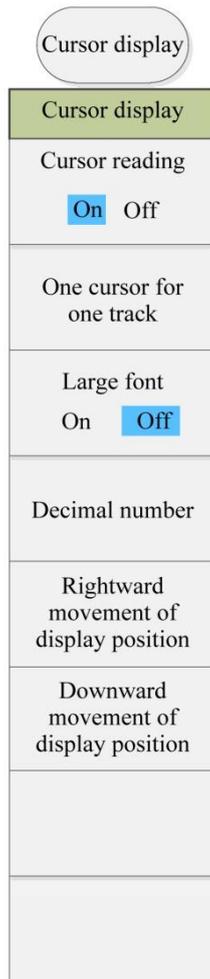
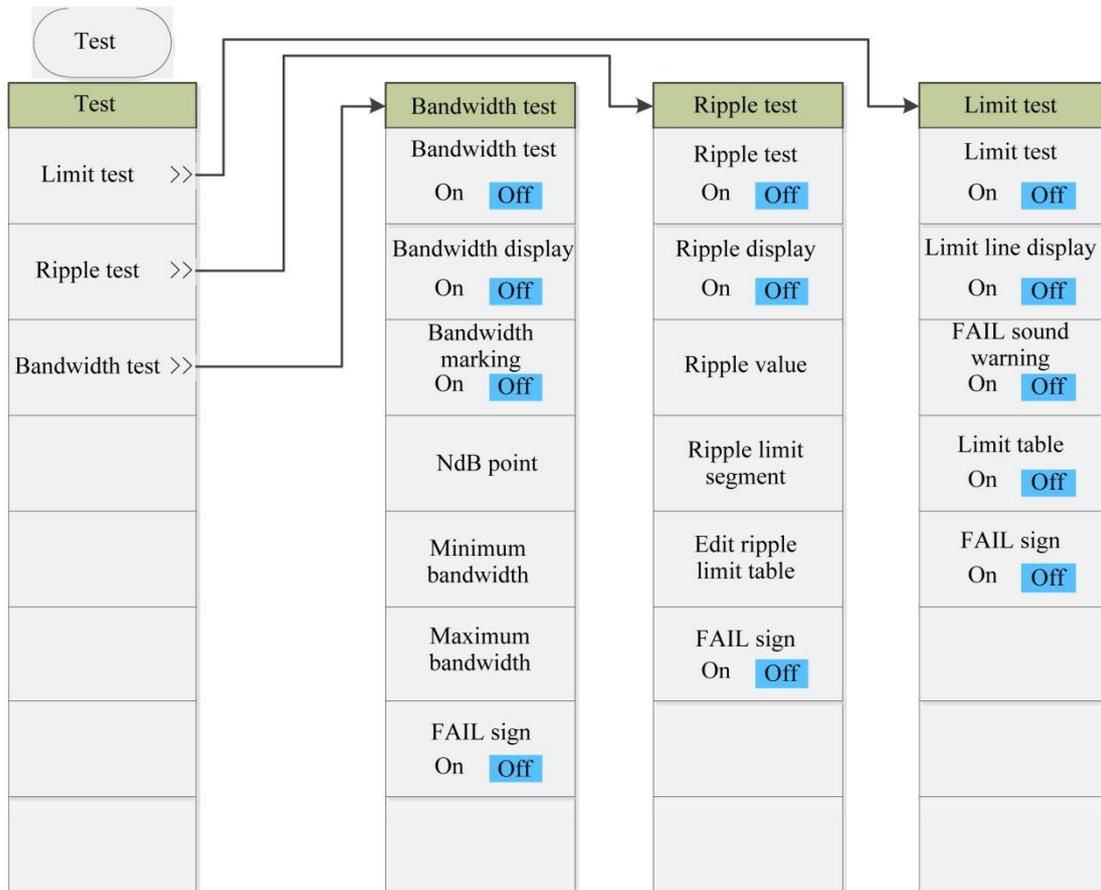
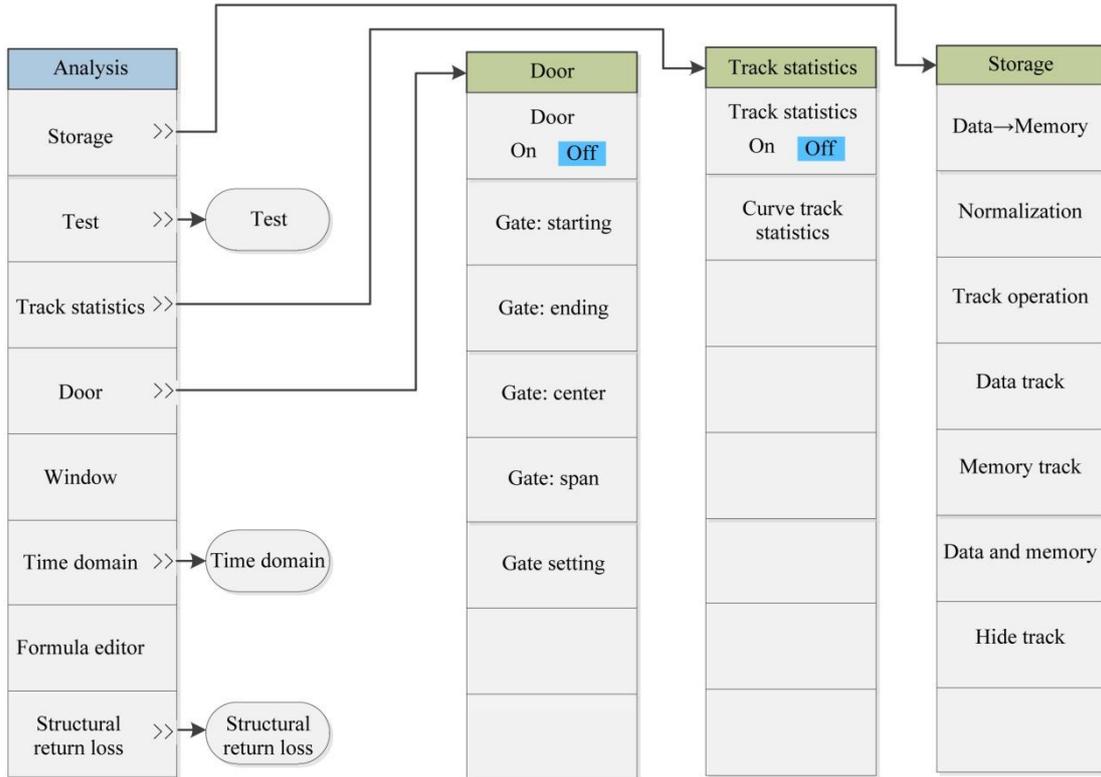


Fig. 5.7 Cursor Menu

### 5.1.8 Analysis



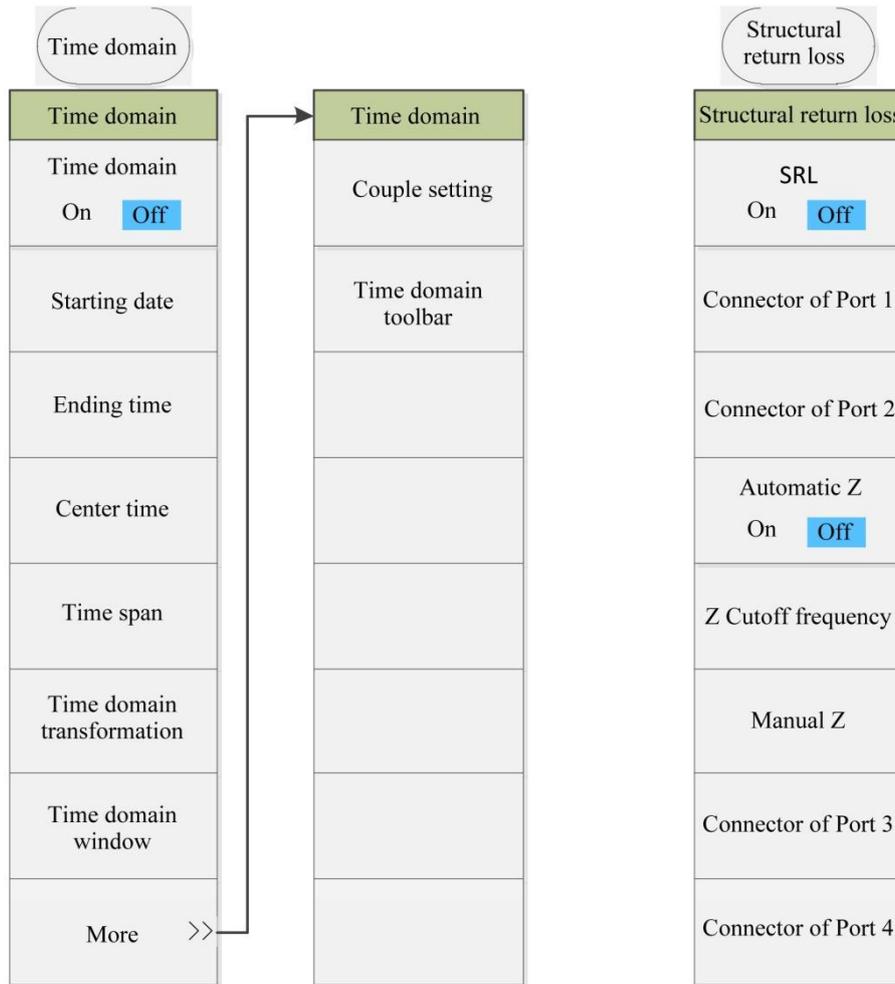


Fig. 5.8 Analysis Menu

### 5.1.9 System

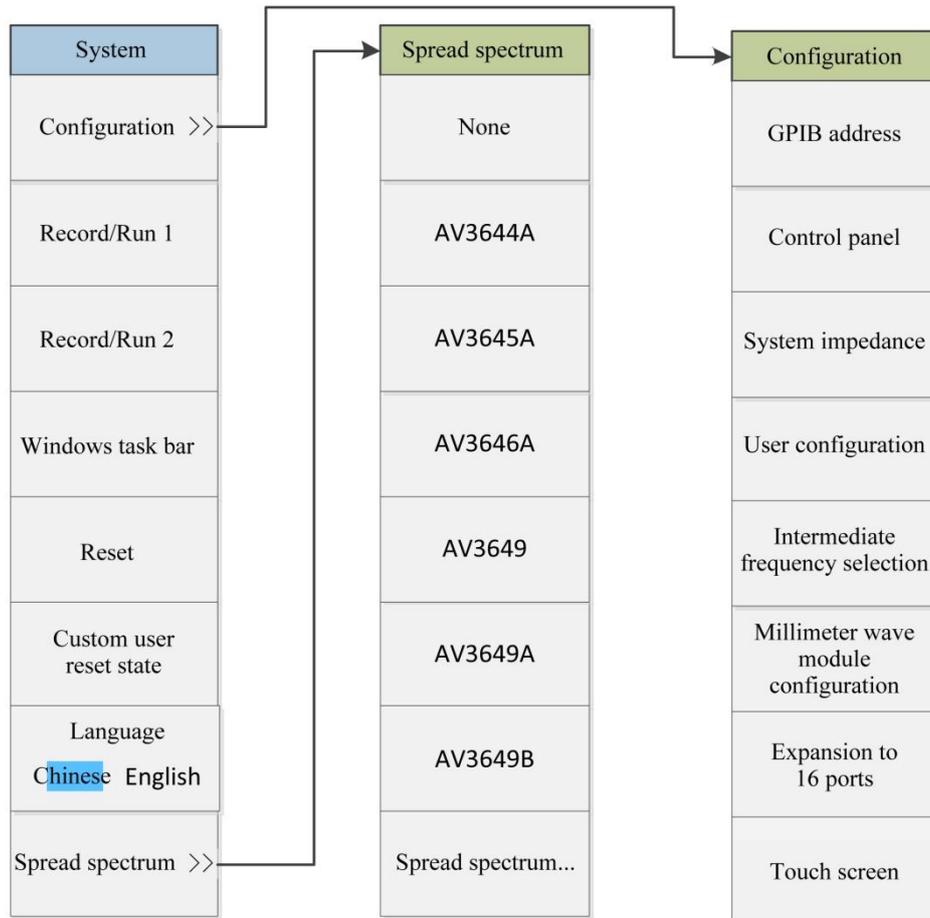


Fig. 5.9 System menu

5.1.10 Help

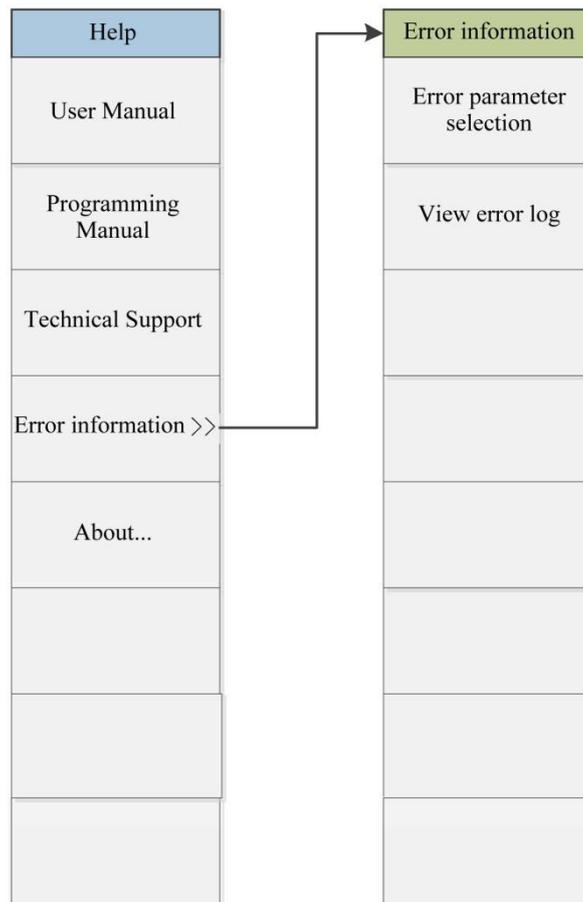


Fig. 5.10 Help Menu

### 1) Main menu

AV3672 series vector network analyzers are configured with 10 main menus.

- **File:** used to save, call and print test data, minimize the window and exit the program.
- **Track:** used for relevant operations of tracks.
- **Channel:** used for relevant operations of channels.
- **Excitation:** used for relevant setting of the excitation signal.
- **Response:** used for signal reception and measurement display setting.
- **Calibration:** used for analyzer calibration and calibration setting.
- **Cursor:** used for relevant operations of the cursor system.
- **Analysis:** used for analysis and statistics of test results and relevant setting of the time domain function.
- **System:** used for relevant configuration setting, macro setting, pulse function setting, language setting, resetting and other settings of the analyzer.
- **Help:** used to call the user manual, program control manual and technical support, and view the error log and software version information.

### 2) Sub-menu

The sub-menu of the main menu is the primary menu, the sub-menu of the primary menu is the secondary menu, and so on. In principle, the menu of higher level should be opened before opening the menu of lower level. For convenience, the commonly used secondary menus are displayed in parallel to the menus of higher level.

### 3) Menu opening

Menus at various levels can be opened in the following three methods.

- By the menu bar: click the main menu, and the primary menu will appear. Click the corresponding menu, and the menu of lower level or corresponding dialog box will appear.
- By keys of the front panel: press the main menu key in the functional key zone of the front panel, and the auxiliary menu bar will pop up, displaying the primary menu. Click the corresponding menu in the auxiliary menu bar, and the menu of lower level or corresponding dialog box will appear.
- For convenience, the shortcut menu bar is set on the right side of the auxiliary menu bar, including the commonly used menus. Drag the shortcut bar push-pull button on the left side of the auxiliary menu bar to display and hide the shortcut menu bar and auxiliary menu bar.

## Prompt

**In order to facilitate introduction, the screenshots used in the manual are for menu opening by the menu bar.**

## 5.2. Description of menu

This section introduces the details of the functions, parameters, etc. of menu items.

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● Track .....	150
● Channel .....	152
● Excitation .....	154
● Response .....	161
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● Cursor .....	173
● Analysis .....	182
● System .....	193
● Help .....	196

### 5.2.1 File

Press the **[File]** key on the front panel or the menu item [File] on the user interface. The file-related menu will pop up, including [Save>>], [Call>>] and [Print>>]. The specific description of menu items is as follows.

#### 5.2.1.1 Save>>

This menu is used to save data. Click it to enter the menu of lower level. The specific menu includes:

Table 5.2 Save

Menu
✧ Save
✧ Save As...
✧ Save data as...
✧ Automatic saving

#### 1) Save

##### Function description:

Save user settings and calibration information in the data (\*.CST) file.

The current user settings and calibration information will be saved in the latest user data file. If this item is clicked,

the [Whether to cover previous data] dialog box will pop up. Click “Yes” to cover previous data and save current data; and click “No” to abandon saving.

**Parameter description:**

None

**2) Save as...**

**Function description:**

Save the data file required by the user.

The data required by the user will be saved in different types of files. The user can set the file name. File types include: state and calibration file (\*.CST), state file (\*.STA), calibration file, (\*.CAL), data file (\*.DAT, \*.CTI and \*.S1P), bitmap file (\*.BMP), etc.

**Parameter description:**

None

**3) Save data as...**

**Function description:**

Save the file required by the user.

The parameters required by the user will be saved in different types of files. The user can set the file name. File types include the data file (\*.DAT, \*.CTI, \*.S1P and \*.S2P) and list file (\*.PRN).

**Parameter description:**

None

**4) Automatic save**

**Function description:**

Save user settings and calibration information in the data (\*.CST) file.

If this item is clicked, a new state and calibration (\*.CST) file will be created, and the current user settings and calibration information will be saved in the file.

**Parameter description:**

None

**5.2.1.2 Call>>**

This menu is used to call the saved data. Click it to enter the menu of lower level. The specific menu includes:

Table 5.3 Call

Menu
✧ Call

**1) Call**

**Function description:**

Call the saved state file or calibration file.

If this item is clicked, a state file or calibration file will be called. File types includes the state and calibration file (\*.CST), state file (\*.STA), calibration file (\*.CAL) and data file (\*.DAT, \*.CTI and \*.S1P).

**Parameter description:**

None

**5.2.1.3 Print>>**

This menu is used to print data. Click it to enter the menu of lower level. The specific menu includes:

Table 5.4 Print

Menu	
◇	Print
◇	Print into file
◇	Page Setup

### 1) Print

#### Function description:

Click this menu to enter the printer setting page.  
Set the printer options, paper and direction according to the prompts.

#### Parameter description:

None

### 2) Print into file

#### Function description:

Click this menu to save the test curve as a figure.  
The test curve can be saved in the figure (\*.BMP and \*.JPG) form according to the prompts.

#### Parameter description:

None

### 3) Page setting

#### Function description:

Click this menu to enter the page setting interface.  
The window information and other information can be set on this page. Window information includes: “Print active window”, “Print all windows” and “Print one window on each page”. Other information includes: printing of the segment table, limit table, cursor table, channel state and time. The user can print the corresponding page information according to the needs.

#### Parameter description:

None

## 5.2.2 Track

Press the [Track] key on the front panel or click the [Track] menu item on the user interface. The track-related menu will pop up. Specific items include: [New track], [Delete track>>], [Select track], [Move track], [Track title] and [Track maximization ON/OFF]. The specific description of menu items is as follows.

### Prompt

#### Track setting

The track refers to a series of measurement data point. Track setting affects the mathematical operation and display of measurement data. Only the active track can be set. Click the corresponding track state button to activate the track.

#### 5.2.2.1 New track

#### Function description:

Click this menu, and the [New track] dialog box will pop up. The user can select different track types, including S-parameter (S11, S12, S22 and S21) and receiver (R1, R2, A and B).

**Parameter description:**

None

**5.2.2.2 Delete track>>**

This menu is used to delete the track. Click it to enter the menu of lower level, as shown in the following table.

Table 5.5 “Delete track”

Menu	
✧	Delete track 1
✧	Delete track 2
✧	Delete track 3
✧	Delete track 4
✧	Delete active track
✧	Delete track...

**1) Delete track 1-Delete track 4**

**Function description:**

Click it to rapidly delete the existing data track (the existing track is highlighted if displayed and dark if deleted).

**Parameter description:**

None

**2) Delete active track**

**Function description:**

Click this menu to delete the current active track (click once to delete one active track, until all active tracks are deleted).

**Parameter description:**

None

**3) Delete track...**

**Function description:**

Click this menu, and the track deletion list will pop up, showing the existing tracks. Select the track to be deleted, click [Apply] to delete the track and continue the above operation. Click [OK] to exit the program.

**Parameter description:**

None

**5.2.2.3 Move track**

**Function description:**

Click this menu, and the track movement list will pop up, showing the existing windows. The user can move the current active track into any window (if [New window] is selected, a new window will be created). Click [Apply] to move the track and continue the above operation. Click [OK] to exit the program.

**Parameter description:**

None

**5.2.2.4 Track title**

**Function description:**

Click this menu to change the default name of the current active curve. Enter the curve title, select the [Enable]

check box and click [OK]. Thus the track title is changed.

**Parameter description:**

None

**5.2.2.1 Track maximization ON/OFF**

**Function description:**

Click this menu to maximize the current active track and hide other track curves. Click once to maximize the track, and [Track maximization ON/OFF] will appear. Click again to recover all tracks, and [Track maximization ON/OFF] will appear.

**Parameter description:**

OFF [OFF|ON].

**5.2.3 Channel**

Press the [Channel] key on the front panel or the [Channel] menu item on the user interface, and the channel-related menu will pop up for setting of channel parameters. Specific items include: [Open channel], [Close channel], [Select channel], [Copy channel] and [Hardware setting]. The specific description of menu items is as follows.

---

**Prompt**

**Channel and track**

The channel includes the track. The analyzer supports 64 channels in total. Tracks in one channel are subject to the same channel settings. Only the settings of the active channel can be changed. Once the track in the channel is activated, the channel will also be activated.

---

**5.2.3.1 Open channel**

**Function description:**

Click this menu, and the [Open channel] list will pop up, showing the closed channels. The user can select the channel to be opened (if [New window] is selected, a new window will be created). Click [Apply] to open the channel and continue the above operation. Click [OK] to exit the program.

**Parameter description:**

None

**5.2.3.2 Close channel**

**Function description:**

Click this menu, and the [Close channel] list will pop up, showing the open channels. The user can select one channel, click [Apply] to close the channel and then click [OK] to exit the program.

**Parameter description:**

None

**5.2.3.3 Select channel**

**Function description:**

Click this menu, and the [Select channel] list will pop up, showing the existing channels. The user can select the channel to be activated, click [Apply] to select the channel and then click [OK] to exit the program.

**Parameter description:**

None

**5.2.3.4 Copy channel**

**Function description:**

Click this menu, and the [Copy channel] list will pop up. The user can select the target channel from the existing

channels in the drop-down menu of [Copy channel], click [Apply] to copy the channel and then click [OK] to exit the program.

**Parameter description:**

None

**5.2.3.5 Hardware setting**

This menu is used for hardware setting. Click it to enter the menu of lower level, as shown in the following table.

Table 5.6 Hardware Setting

Menu
✧ Path configuration
✧ Graphic configuration

**1) Path configuration**

**Function description:**

Click this menu to configure the corresponding RF path.

**Parameter description:**

None

**2) Graphic configuration**

**Function description:**

Click this menu to configure the filter/high power mode of the source and the reference mixer switch.

**Parameter description:**

None

**5.2.4 Excitation**

Press the [Excitation] key on the front panel or the [Excitation] menu item on the user interface, and then excitation-related menu will pop up for setting of excitation parameters. Specific items include: [Frequency], [Power], [Scan] and [Trigger]. The specific description of menu items is as follows.

**5.2.4.1 Frequency**

This menu is used to set the frequency. Click it to enter the menu of lower level. The specific menu includes:

Table 5.7 Frequency

Menu
✧ Freq Start
✧ Freq Stop
✧ center frequency
✧ Frequency span
✧ Frequency deviation
✧ CW
✧ CW ON/OFF

---

### Frequency unit

All the frequency parameters are in Hz. The digital input must be ended with four frequency units (GHz, MHz, kHz or Hz). When input ends, new frequency value is displayed in appropriate unit.

---

### Attention

#### The ending frequency must not exceed the starting frequency.

The sweeper can only sweep upward under stepped sweep mode, so ending frequency must be not less than starting frequency. If starting frequency is more than ending frequency, ending frequency is equal to starting frequency; if ending frequency is less than starting frequency, starting frequency is equal to ending frequency.

---

#### 1) Starting frequency

##### Function description:

Set the starting point of the scanning frequency.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

##### Parameter description:

10MHz [10MHz~26.5GHz].

#### 2) Ending frequency

##### Function description:

Set the ending point of scanning frequency.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

##### Parameter description:

26.5GHz [10MHz~26.5GHz].

#### 3) Center frequency

##### Function description:

Set the center point of scanning frequency.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

##### Parameter description:

13.5GHz [10MHz~26.5GHz].

#### 4) Frequency span

##### Function description:

Set the span of frequency.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

##### Parameter description:

26.49GHz [10MHz~26.5GHz].

#### 5) Frequency deviation

##### Function description:

Set the deviation of frequency.

This menu is used for relevant settings of the frequency deviation. See details in “Appendix 3: Frequency Deviation Measurement”.

**Parameter description:**

None

**6) Point frequency**

**Function description:**

Set the CW frequency.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

2GHz [10MHz~26.5GHz].

**7) CW ON/OFF**

**Function description:**

Activate dot frequency to set frequency of dot frequency.

**Parameter description:**

OFF [OFF|ON].

**5.2.4.2 Power**

This menu is used to set the power. Click it to enter the menu of lower level. The specific menu includes:

Table 5.8 Power

Menu	
◇	Power
◇	Power and attenuation

**Prompt**

**Power unit**

All power parameters are in dBm. Click [OK] on the panel after entering. Thus the power setting is completed.

**1) Power**

**Function description:**

Set the power ON/OFF, power level, scanning starting/ending power and power slope.

**Parameter description:**

None

**2) Power and attenuation**

**Function description:**

Set the power attenuation mode, fixed amplitude mode, etc.

**Parameter description:**

None

**5.2.4.3 Scanning**

This menu is used for scanning setting. Click it to enter the menu of lower level. The specific menu includes:

Table 5.9 Scanning: Segment Table

**Menu**

**Sub-menu**

◇ Scanning time	
◇ Number of scanning points	
◇ Scanning type	
◇ Scanning setting	
◇ Phase control	
◇ Pulse	
◇ Segment table>>	
	Segment table ON/OFF
	Add segment
	Insert segment
	Delete segment
	Independent power level ON/OFF
	Independent intermediate frequency bandwidth ON/OFF
	Independent scanning time ON/OFF

### 1) Scanning time

#### Function description:

Set the total time of scanning from the starting frequency to ending frequency.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

#### Reference note: (201points)

198ms [198ms-86400s].

### 2) Number of scanning points

#### Function description:

Set the total point number of scanning from the starting frequency to ending frequency.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

#### Parameter description:

201[1~32001].

### 3) Scanning type

#### Function description:

Set the scanning type.

Optional scanning types include: linear frequency, logarithmic frequency, power scanning, CW, segment scanning and phase scanning.

#### Parameter description:

None

### 4) Scanning setting

#### Function description:

Set the scanning function.

The scanning functions include the step scanning, quick scanning, residence time and scanning delay.

#### Parameter description:

None

### 5) Phase control

#### Function description:

Set the phase of the test port, including the starting phase, ending phase, phase ON/OFF, etc.

**Parameter description:**

0° [0°-360°]

**6) Pulse**

**Function description:**

Set the pulse measurement function. See details in “Appendix 4: Pulse Measurement”.

**Parameter description:**

Pulse width: 33ns-60s

Pulse rising/falling time: 30ns

**7) Segment table**

This menu is used for relevant setting of the segment table. Click it to enter the menu of lower level. The specific menu includes:

Table 5.10 Segment Table

Menu
✧ Segment table ON/OFF
✧ Add segment
✧ Insert segment
✧ Delete segment
✧ Independent power level ON/ <u>OFF</u>
✧ Independent intermediate frequency bandwidth ON/ <u>OFF</u>
✧ Independent scanning time ON/ <u>OFF</u>

**a) Segment table ON/OFF**

**Function description:**

If this menu is selected, all menu items will be lit, allowing the user to set the segment scanning function.

**Parameter description:**

OFF [OFF|ON].

**b) Add segment**

**Function description:**

Add a new segment behind the existing segment.

**Parameter description:**

None

**c) Insert segment**

**Function description:**

Insert a new segment in front of the selected segment.

**Parameter description:**

None

**d) Delete segment**

**Function description:**

Delete the selected segment.

**Parameter description:**

None

**e) Independent power level ON/OFF**

**Function description:**

Allow to set different power levels for different segments.

**Parameter description:**

OFF [OFF|ON].

**f) Independent intermediate frequency bandwidth ON/OFF**

**Function description:**

Allow to set different intermediate frequency bandwidths for different segments.

**Parameter description:**

OFF [OFF|ON].

**g) Independent scanning time ON/OFF**

**Function description:**

Allow to set different periods of scanning time for different segments.

**Parameter description:**

OFF [OFF|ON].

**5.2.4.4 Trigger**

This menu is used for trigger setting. Click it to enter the menu of lower level. The specific menu includes:

Table 5.11 Trigger

Menu
✧ Hold
✧ Singular
✧ Group scanning
✧ Continuous scanning
✧ Re-scanning
✧ Manual trigger
✧ Trigger

**1) Hold**

**Function description:**

If this menu is selected, the system will stop scanning and be kept at the current CW.

**Parameter description:**

None

**2) Once**

**Function description:**

If this menu is selected, the system will automatically enter the holding mode after scanning once.

**Parameter description:**

None

**3) Group scanning**

**Function description:**

If this menu is selected, the system will automatically enter the holding mode after the set scanning process.

**Parameter description:**

None

**4) Continuous scanning**

**Function description:**

If this menu is selected, the system will restart scanning after scanning once.

**Parameter description:**

None

**5) Re-scanning**

**Function description:**

If this menu is selected, the system will restart scanning from the starting frequency.

**Parameter description:**

None

**6) Manual trigger**

**Function description:**

Set the trigger menu to light up this menu. If this menu is selected, manual triggering will be done once.

**Parameter description:**

None

**7) Trigger**

**Function description:**

Select this menu to enter the trigger function setting interface. See details in “4.6 Trigger Mode”.

**Parameter description:**

None

**5.2.5 Response**

Press the [Response] key on the front panel or the [Response] menu item on the user interface, and the response-related menu will pop up. Specific items include: [Measurement], [Format], [Scale], [Display] and [Average]. The specific description of menu items is as follows.

**5.2.5.1 Measurement**

This menu is used to set measurement. Click it to enter the menu of lower level. The specific menu includes:

Table 5.12 Measurement

Menu
✧ Measurement S-parameter
✧ Measurement balance parameter
✧ Measuring type

◇ measuring receiver

### 1) Measurement S-parameter

**Function description:**

Select this menu to select the S-parameter.

**Parameter description:**

None

### 2) Measurement balance parameter

**Function description:**

Select this menu to select the balance parameter.

**Parameter description:**

None

### 3) Measuring type

**Function description:**

Select this menu to enter the multi-functional measurement option setting interface, such as the mixer measurement. See details in “Appendix 6: Mixer Measurement”.

**Parameter description:**

None

### 4) Measurement receiver

**Function description:**

Select this menu to select the receiver parameter, such as R1, R2, A, B, etc.

**Parameter description:**

None

### 5.2.5.2 Format

This menu is used to set measurement. Click it to enter the menu of lower level. The specific menu includes:

Table 5.13 Format

**Menu**

- ◇ Logarithmic amplitude
- ◇ phase
- ◇ Group delay
- ◇ Smith chart
- ◇ Linear phase
- ◇ Linear amplitude
- ◇ Standing wave ratio
- ◇ Real part
- ◇ Imaginary part
- ◇ Polar coordinate
- ◇ Positive phase

- ✧ Impedance
- ✧ Format

### 1) Logarithm amplitude

**Function description:**

Select this menu to scan in the logarithmic format.

**Parameter description:**

None

### 2) Phase

**Function description:**

Select this menu to display the phase curve.

**Parameter description:**

None

### 3) Group delay

**Function description:**

Select this menu to display the group delay curve.

**Parameter description:**

None

### 4) Smith chart

**Function description:**

Select this menu to display the Smith chart curve.

**Parameter description:**

None

### 5) Linear phase

**Function description:**

Select this menu to display the linear phase curve.

**Parameter description:**

None

### 6) Linear amplitude

**Function description:**

Select this menu to display the linear amplitude curve.

**Parameter description:**

None

### 7) Standing wave ratio

**Function description:**

Select this menu to display the standing wave ratio curve.

**Parameter description:**

None

### 8) Real part

**Function description:**

Select this menu to display the real part curve.

**Parameter description:**

None

**9) Imaginary part**

**Function description:**

Select this menu to display the imaginary part curve.

**Parameter description:**

None

**10) Polar coordinate**

**Function description:**

Select this menu to display the polar coordinate curve.

**Parameter description:**

None

**11) Positive phase**

**Function description:**

Select this menu to display the positive phase curve.

**Parameter description:**

None

**12) Impedance**

**Function description:**

Select this menu to display the impedance curve.

**Parameter description:**

None

**13) Format**

**Function description:**

If this menu is selected, the display format table will pop up. Multiple format curves can be selected.

**Parameter description:**

None

**5.2.5.3 Scale**

This menu is used to set the scale. Click it to enter the menu of lower level. The specific menu includes:

Table 5.14 Format

Menu
✧ Automatic scale
✧ Fully automatic scale
✧ Scale
✧ Electrical delay
✧ Phase deviation

- ✧ Amplitude deviation
- ✧ Scale coupling

### 1) Automatic scale

#### Function description:

If this menu is selected, the vertical scale will be selected automatically so that the active track can be better displayed in the vertical grid of the screen. The excitation is not affected, and only the scale value and reference value are changed.

The appropriate scale factor will be selected so that data can be displayed in 80% of the screen.

Select the center value of the track on the screen according to the reference value.

#### Parameter description:

None

### 2) Fully automatic scale

#### Function description:

If this menu is selected, the appropriate scale will be set for all tracks in the window so that the track can be better displayed in the vertical grids of the window.

#### Parameter description:

None

### 3) Scale

#### Function description:

Select this menu and enter the set scale value.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

#### Parameter description:

10dB[0.001dB-500dB].

### 4) Electrical delay

#### Function description:

Select this menu to set the electrical delay.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

#### Parameter description:

0s[-1000s to 1000s].

### 5) Phase deviation

#### Function description:

Select this menu to set the phase deviation. Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

#### Parameter description:

0° [-1000° to 1000°].

### 6) Amplitude deviation

#### Function description:

Select this menu to set the amplitude deviation.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

0dB[-1000dB~1000dB]。

**7) Scale coupling**

**Function description:**

Select this menu to set scale coupling.

**Parameter description:**

None

**5.2.5.4 Display**

This menu is used to set the scale. Click it to enter the menu of lower level. The specific menu includes:

Table 5.15 Format

Menu	
✧	One-window/two-window/three-window/four-window
✧	Window
✧	Measurement setting
✧	Display content
✧	Soft key calibration ON/OFF
✧	Hide soft key
✧	Minimize application program
✧	Toolbar
✧	Title bar ON/OFF
✧	Status bar ON/OFF
✧	Table

**1) One-window/two-window/three-window/four-window**

**Function description:**

Select this menu for one-window/two-window/three-window/four-window display.

**Parameter description:**

None

**2) Window**

**Function description:**

Select this menu to create more windows and close unnecessary windows.

**Parameter description:**

None

**3) Measurement setting**

**Function description:**

This menu includes various default system settings.

Four tracks will be created in Window 1: S11, S21, S12 and S22, in the logarithmic format in Channel 1.

Four tracks will be created in four windows, in the logarithmic format in Channel 1. S11 will be displayed in

Window 1, S21 in Window 2, S12 in Window 3 and S22 in Window 4.

Three tracks will be created in three windows of Channel 1. S11 will be displayed in the Smith chart format in Window 1, S22 in the Smith chart format in Window 2 and S21 in the logarithmic format in Window 3.

Four tracks will be displayed in two windows, in the logarithmic format in two channels. S11 and S21 will be displayed in Window 1 of Channel 1, and S12 and S22 in Window 2 of Channel 2.

**Parameter description:**

None

**4) Display content**

**Function description:**

Select this menu to control part of display contents, such as the title, track state, frequency/excitation state, cursor display, display time, etc.

**Parameter description:**

None

**5) Soft key calibration ON/OFF**

**Function description:**

Select this menu to calibrate keys in the soft keyboard form to facilitate the user of old users.

**Parameter description:**

OFF [OFF|ON].

**6) Hide soft key**

**Function description:**

Select this menu to hide the soft keyboard on the right side of the display. The curve will be displayed in the whole screen.

**Parameter description:**

None

**7) Minimize application program**

**Function description:**

Select this menu to minimize the soft key in operation in the vector network analyzer.

**Parameter description:**

None

**8) Tool bar**

**Function description:**

Select this menu to control the toolbar display, such as the input toolbar, cursor toolbar, measurement toolbar, scanning toolbar, excitation toolbar and time domain toolbar.

**Parameter description:**

None

**9) Title bar ON/OFF**

**Function description:**

Select this menu to display the title bar.

**Parameter description:**

None

### 10) Status bar ON/OFF

**Function description:**

Select this menu to display the status bar.

**Parameter description:**

None

### 11) Table

**Function description:**

Select this menu to display the cursor table, limit table and segment table.

**Parameter description:**

None

### 5.2.5.5 Average

This menu is used to set the scale. Click it to enter the menu of lower level. The specific menu includes:

Table 5.16 Format

Menu
◇ Re-average
◇ Averaging factor
◇ Average <u>ON/OFF</u>
◇ Smoothing
◇ intermediate-frequency bandwidth

#### 1) Re-average

**Function description:**

Select this menu for a group of new average scanning.

**Parameter description:**

None

#### 2) Averaging factor

**Function description:**

Select this menu to set the average times of curve scanning.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

1 [1~1024].

#### 3) Average ON/OFF

**Function description:**

Select this menu to open the track averaging function.

The more times averaging is done, the more noise will be reduced, and the larger the dynamic range will be.

The noise reduction effect of scanning averaging is the same as that of reduction of the intermediate frequency bandwidth.

**Parameter description:**

OFF [OFF|ON].

#### 4) Smoothing

This menu is used for smoothing setting. Click it to enter the menu of lower level. The specific menu includes:

Table 5.17 Smoothing

Menu	
◇	Smoothing ON/OFF
◇	Smoothing percentage
◇	Number of smoothing points

##### a) Smoothing ON/OFF

**Function description:**

Select this menu to enable the smoothing function.

The smoothing function is used to reduce the peak-peak noise of bandwidth measurement data.

Data averaging is done for part of the displayed track. The number of adjacent data points averaged at the same time is also known as the smoothing aperture. The aperture can be defined as the number of data points or the percentage of X-axis span.

**Parameter description:**

OFF [OFF|ON].

##### b) Smoothing percentage

**Function description:**

Select this menu to set the smoothing percentage.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

0 [0-25%].

##### c) Number of smoothing points

**Function description:**

This menu is used to set the number of smoothing points.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

0 [0~N (total point number)\*25%].

#### 5) Intermediate frequency bandwidth

**Function description:**

Select this menu to set the intermediate frequency bandwidth.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

1kHz [1Hz~5MHz].

### 5.2.6 Calibration

Press the [Calibration] key on the front panel or the [Calibration] menu item on the user interface. The calibration-related menu will pop up. Specific items include: [Calibration], [Correction ON/OFF], [Interpolation ON/OFF], [Port extension], [Fixture>>], [Edit calibration kit], [Attribute] and [Power calibration]. The specific description of menu items is as follows.

### 5.2.6.1 Calibration

**Function description:**

Select this menu to enter the calibration interface, including three calibration types: guided calibration, non-guided calibration and electronic calibration. Select the appropriate calibration method according to the measurement type and accuracy requirements. See details in 6.3 “Calibration Guide”.

**Parameter description:**

None

### 5.2.6.2 Correction ON/OFF

**Function description:**

Select this menu to enable the correction function and add calibration data.

**Parameter description:**

OFF [OFF|ON].

### 5.2.6.3 Interpolation ON/OFF

**Function description:**

Select this menu to enable the interpolation function.

**Parameter description:**

OFF [OFF|ON].

### 5.2.6.4 Port Extension

**Function description:**

Select this menu to move the measurement reference plane in an electrical manner. Thus, other kinds of calibration can be avoided.

Add a cable after calibration. The port extension function is used to “tell” the length of the cable added to the specific port of the analyzer. In case of failure of direct calibration, the delay (phase shift) caused by the clamp can be compensated by port extension. For the method of port extension setting, refer to the section of port extension in 5.5 “Improvement of Phase Measurement Accuracy”.

**Parameter description:**

None

### 5.2.6.5 Fixture>>

This menu is used to set the fixture function. Click it to enter the menu of lower level. The specific menu includes:

Table 5.18 Fixture

Menu
✧ Fixture enabling ON/OFF
✧ Matching circuit embedding
✧ Double-port fixture de-embedding
✧ Port impedance transformation
✧ Four-port fixture de-embedding/embedding

#### 1) Fixture enabling ON/OFF

**Function description:**

Select this menu to enable the fixture simulator function. The functions of the fixture simulator are effective only in this mode.

**Parameter description:**

OFF [OFF|ON].

**2) Matching circuit embedding**

**Function description:**

Select this menu to enable the matching circuit embedding function. For setting of matching circuit embedding, refer to “[7.9.3 Matching circuit embedding](#)” in “[7.9 Fixture Compensation Calibration](#)”.

**Parameter description:**

None

**3) Double-port fixture de-embedding**

**Function description:**

Select this menu to enable the double-port fixture de-embedding function. For setting of double-port fixture de-embedding, refer to “[7.9.4 Double-port fixture de-embedding](#)” in “[7.9 Fixture Compensation Calibration](#)”.

**Parameter description:**

None

**4) Port impedance transformation**

**Function description:**

Select this menu to enable the port impedance transformation function. For setting of port impedance transformation, refer to “[7.9.5 Port impedance transformation](#)” in “[7.9 Fixture Compensation Calibration](#)”.

**Parameter description:**

None

**5) Four-port fixture de-embedding/embedding**

**Function description:**

Select this menu to enable the four-port fixture de-embedding/embedding function. For setting of port impedance transformation, refer to “[7.9.6 Four-port fixture de-embedding/embedding](#)” in “[7.9 Fixture Compensation Calibration](#)”.

**Parameter description:**

None

**5.2.6.6 Editing of Calibration Kit**

**Function description:**

Select this menu to define and edit the calibration kit information. For calibration kit editing, refer to “[7.6.3 Edit calibration kit](#)” in “[7.6 Definition of Calibration Kit Editing](#)”.

**Parameter description:**

None

**5.2.6.7 Attribute**

**Function description:**

This menu is effective after calibration of the instrument. Select this menu to display the current calibration attribute, such as the channel, calibration time, calibration type, frequency, number of scanning points, scanning time, port power, scanning type, etc.

**Parameter description:**

None

**5.2.6.8 Power Calibration**

**Function description:**

Select this menu to set the source power, receiver calibration, etc. For power calibration setting, refer to “Port power calibration” in “6.3 Calibration of scale mixer measurement” of “Appendix 6 Mixer Measurement”.

**Parameter description:**

None

**5.2.7 Cursor**

Press the [Cursor] key on the front panel or click the [Cursor] menu item on the user interface. The cursor-related menu will pop up. Specific items include: [Cursor], [Cursor function], [Cursor search], [Cursor attribute] and [Cursor display]. The specific description of menu items is as follows.

**5.2.7.1 Cursor**

This menu is used to set the cursor. Click it to enter the menu of lower level. The specific menu includes:

Table 5.19 Cursor

Menu	
✧	Cursor 1/2/3
✧	Reference cursor
✧	More cursors
✧	Close cursor

**1) Cursor 1/2/3**

**Function description:**

Select this menu to enable the function of Cursor 1/2/3. Read the measurement data, search the value of specific type or change the excitation setting.

**Parameter description:**

None

**2) Reference cursor**

**Function description:**

Select this menu to enable the reference cursor function for relative measurement.

**Parameter description:**

None

**3) More cursors**

**Function description:**

Select this menu to enter the “More cursors” page. The system is configured with Cursor 4, Cursor 5, Cursor 6, Cursor 7, Cursor 8 and Cursor 9.

**Parameter description:**

None

**4) Close cursor**

**Function description:**

Select this menu to close the corresponding cursor.

**Parameter description:**

None

### 5.2.7.2 Cursor function

This menu is used to set the cursor function. Click it to enter the menu of lower level. The specific menu includes:

Table 5.20 Cursor Function

Menu	
◇	Cursor→starting
◇	Cursor→ending
◇	Cursor→center
◇	Cursor→span
◇	Cursor→reference
◇	Cursor→delay

#### 1) Cursor→starting

**Function description:**

Select this menu to set the frequency of the active cursor as the starting frequency.

**Parameter description:**

None

#### 2) Cursor→ending

**Function description:**

Select this menu to set the frequency of the active cursor as the ending frequency.

**Parameter description:**

None

#### 3) Cursor→center

**Function description:**

Select this menu to set the frequency of the active cursor as the center frequency.

**Parameter description:**

None

#### 4) Cursor→span

**Function description:**

Select this menu to set the active  $\Delta$  cursor frequency as the frequency span.

**Parameter description:**

None

#### 5) Cursor→reference

**Function description:**

Select this menu to set the power of the active cursor as the power reference value.

**Parameter description:**

None

#### 6) Cursor→delay

**Function description:**

Select this menu to normalize the group delay of active cursor points into 0.

**Parameter description:**

None

**5.2.7.3 Cursor search**

This menu is used to set cursor search. Click it to enter the menu of lower level. The specific menu includes:

Table 5.21 Cursor search

Menu	
◇	Maximum value
◇	Minimum value
◇	Peak value
◇	Target value
◇	Bandwidth search
◇	Cursor search
◇	Track ON/OFF
◇	Filter statistics
◇	Filter test

**1) Maximum value**

**Function description:**

Select this menu for cursor search of the maximum measurement data point.

**Parameter description:**

None

**2) Minimum value**

**Function description:**

Select this menu for cursor search of the minimum measurement data point.

**Parameter description:**

None

**3) Peak value**

This menu is used to set the peak search. Click it to enter the menu of lower level. The specific menu includes:

Table 5.22 Peak Value

Menu	
◇	Next peak value
◇	Right peak value
◇	Left peak value
◇	Peak/valley type
◇	Threshold
◇	Offset

**a) Next peak value**

**Function description:**

Select this menu to search next peak value lower than the current cursor amplitude value.

**Parameter description:**

None

**b) Right peak value**

**Function description:**

Select this menu to search next effective peak value on the right side of the cursor position.

**Parameter description:**

None

**c) Left peak value**

**Function description:**

Select this menu to search next effective peak value on the left side of the cursor position.

**Parameter description:**

OFF [OFF|ON].

**d) Peak/valley type**

**Function description:**

Select this menu to select the peak type.

**Parameter description:**

Peak [Valley|Peak].

**e) Threshold**

**Function description:**

Select this menu to define the minimum peak value. The effective peak value must be more than the threshold. The valley values on both sides may be less than the threshold.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

-100dB [-500dB to 500dB].

**f) Deviation**

**Function description:**

Select this menu to define the minimum vertical distance between the peak value and valley value. The vertical distance between the effective peak value and valley values on both sides must be more than the deviation.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

3dB [-500dB~500dB].

**4) Target value**

**Function description:**

Select this menu and enter the search target value. If this menu is clicked once, the cursor will move to the first target value on the right side of the current cursor position. Continue the above operation to reach to the highest excitation value. Then return to the minimum search target value of excitation.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

0dB [-500dB~500dB].

### 5) Bandwidth search

This menu is used to as the bandwidth search. Click it to enter the menu of lower level. The specific menu includes:

Table 5.23 Bandwidth

Menu	
◇	Bandwidth ON/OFF
◇	Bandwidth level
◇	Track ON/OFF

#### a) Bandwidth ON/OFF

**Function description:**

Select this menu to enable the bandwidth search function.

**Parameter description:**

OFF [OFF|ON].

#### b) Bandwidth level

**Function description:**

Select this menu to set the levels of both sides, falling from the peak.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

-3dB [-500dB~500dB].

#### c) Track ON/OFF

**Function description:**

Select this menu to enable the bandwidth search tracking function. The search function will be executed according to the current search type and domain settings after each scanning, so as to ensure that the cursor is in the expected position after each scanning.

**Parameter description:**

OFF [OFF|ON].

### 6) Cursor search

**Function description:**

Select this menu to enter the shortcut menu of cursor search.

**Parameter description:**

None

### 7) Track ON/OFF

**Function description:**

Select this menu to enable the cursor search tracking function.

**Parameter description:**

OFF [OFF|ON].

### 8) Filter statistics ON/OFF

**Function description:**

Select this menu to enable the function of filter statistics.

**Parameter description:**

OFF [OFF|ON].

**9) Filter test**

This menu is used to set the filter test. Click it to enter the menu of lower level. The specific menu includes:

Table 5.24 Filter Test

Menu	
◇	Filter test ON/OFF
◇	Bandwidth level
◇	Frequency difference percentage
◇	Track ON/OFF

**a) Filter test ON/OFF**

**Function description:**

Select this menu to enable the filter test function.

**Parameter description:**

OFF [OFF|ON].

**b) Bandwidth level**

**Function description:**

Select this menu to set the filter bandwidth level.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

-3dB [-500dB~500dB].

**c) Frequency difference percentage**

**Function description:**

Select this menu to set the frequency difference percentage.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

10% [0% to 100%].

**d) Track ON/OFF**

**Function description:**

Select this menu to enable the cursor tracking function for the filter test.

**Parameter description:**

OFF [OFF|ON].

**5.2.7.4 Cursor attribute**

This menu is used to set the cursor attribute. Click it to enter the menu of lower level. The specific menu includes:

Table 5.25 Cursor Attribute

Menu	
------	--

- ✧  $\Delta$  Cursor ON/OFF
- ✧ Discrete ON/OFF
- ✧ Type Normal/Fixed
- ✧ Coupling ON/OFF
- ✧ Advanced cursor

### 1) $\Delta$ Cursor ON/OFF

#### Function description:

Select this menu to enable the  $\Delta$  cursor function.

#### Parameter description:

OFF [OFF|ON].

### 2) Discrete ON/OFF

#### Function description:

Select this menu to enable the discrete cursor function. The cursor will be moved to the discrete data point equivalent to the target value.

#### Parameter description:

OFF [OFF|ON].

### 3) Type Normal/Fixed

#### Function description:

Select this menu to select the cursor type.

Normal: the X-axis position of the standard cursor is fixed, and the Y-axis position changes along with the amplitude of track data. The cursor can be moved right and left on the X-axis by changing the excitation value.

Fixed: the X-axis and Y-axis coordinates of the cursor remain unchanged, no matter whether the amplitude of track data changes. The cursor can be moved on the X-axis by changing the excitation value, but the Y-axis coordinate remains unchanged.

#### Parameter description:

Normal [Normal|Fixed].

### 4) Coupling ON/OFF

#### Function description:

Select this menu to enable the cursor coupling function.

#### Parameter description:

OFF [OFF|ON].

### 5) Advanced cursor

#### Function description:

Select this menu to enter the shortcut menu of advanced cursor.

#### Parameter description:

None

### 5.2.7.5 Cursor display

This menu is used to set the cursor display. Click it to enter the menu of lower level. The specific menu includes:

Table 5.26 Cursor Display

### Menu

- ✧ Cursor reading ON/OFF
- ✧ One cursor for one track ON/OFF
- ✧ Large font ON/OFF
- ✧ Decimal place
- ✧ Rightward movement of display position
- ✧ Downward movement of display position

#### 1) Cursor reading ON/OFF

**Function description:**

Select this menu to enable the cursor reading function.

**Parameter description:**

ON [ON|OFF].

#### 2) One cursor for one track ON/OFF

**Function description:**

Select this menu to enable the function of one cursor for one track.

**Parameter description:**

OFF [OFF|ON].

#### 3) Large font ON/OFF

**Function description:**

Select this menu to enable the function of large font display of the cursor.

**Parameter description:**

OFF [OFF|ON].

#### 4) Decimal place

**Function description:**

Select this menu to set the number of decimal places of cursor display.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

2 [0~4].

#### 5) Rightward movement of display position

**Function description:**

Select this menu to set the horizontal position of the cursor.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

80% [-200% to 200%].

#### 6) Downward movement of display position

**Function description:**

Select this menu to set the vertical position of the cursor.

Set and adjust the parameter by the mouse/keyboard or the knob, number keys and stepping keys on the front panel.

**Parameter description:**

80% [-200% to 200%].

**5.2.8 Analysis**

Press the [Analysis] key on the front panel or the [Analysis] menu item on the user interface. The analysis-related menu will pop up. Specific items include: [Save], [Test], [Track statistics], [Gate], [Window], [Time domain], [Structural return loss] and [Formula editor]. The specific description of menu items is as follows.

**5.2.8.1 Save**

This menu is used to save the settings. Click it to enter the menu of lower level. The specific menu includes:

Table 5.27 Save

Menu
✧ Data→Memory
✧ Normalization
✧ Track operation
✧ Data track
✧ Memory track
✧ Data and memory
✧ Hide track

**1) Data>Memory**

**Function description:**

Select this menu to save the current test curve data into the memory.

**Parameter description:**

None

**2) Normalization**

**Function description:**

Select this menu to save the current test curve data into the memory and perform data/memory operation.

**Parameter description:**

None

**3) Track operation**

**Function description:**

Select this menu to execute four types of mathematical operation of the current active track and memory track, including the data/memory, data\*memory, data+memory and data-memory.

**Parameter description:**

None

**4) Data track**

**Function description:**

Select this menu to display the data track curve.

**Parameter description:**

None

**5) Memory track**

**Function description:**

Select this menu to display the memory track curve.

**Parameter description:**

None

**6) Data and memory**

**Function description:**

Select this menu to display the data track and memory track curve.

**Parameter description:**

None

**7) Hide track**

**Function description:**

Select this menu to hide the data track and memory track.

**Parameter description:**

None

**5.2.8.2 Test**

This menu is used to set the test. Click it to enter the menu of lower level. The specific menu includes:

Table 5.28 Test

Menu	
◇	Limit test
◇	Ripple test
◇	Bandwidth test

**1) Limit test**

This menu is used to set the limit test. Click it to enter the menu of lower level. The specific menu includes:

Table 5.29 Limit Test

Menu	
◇	Limit test <u>ON/OFF</u>
◇	Limit line display <u>ON/OFF</u>
◇	FAIL sound warning <u>ON/OFF</u>
◇	Limit table <u>ON/OFF</u>
◇	FAIL sign <u>ON/OFF</u>

**a) Limit test ON/OFF**

**Function description:**

Select this menu to enable the limit test function. Clear this menu to close the function of limit test of the active track.

**Parameter description:**

OFF [OFF|ON].

**b) Limit line display ON/OFF**

**Function description:**

Select this menu to enable the limit line display function. Clear this menu to close the function of limit line display of the active track.

**Parameter description:**

OFF [OFF|ON].

**c) FAIL sound warning ON/OFF**

**Function description:**

Select this menu to enable the FAIL sound warning function. In case of failure of the track data point test, the buzzer will send the warning sound.

**Parameter description:**

OFF [OFF|ON].

**d) Limit table ON/OFF**

**Function description:**

Select this menu to enable the limit table function.

**Parameter description:**

OFF [OFF|ON].

**e) FAIL sign ON/OFF**

**Function description:**

Select this menu to enable the FAIL sign function. In case of failure of the track data point test, the FAIL sign will appear on the screen.

**Parameter description:**

OFF [OFF|ON].

**2) Ripple test**

This menu is used to set the ripple test. Click it to enter the menu of lower level. The specific menu includes:

Table 5.30 Ripple Test

Menu	
✧	Ripple test ON/ <u>OFF</u>
✧	Ripple display ON/ <u>OFF</u>
✧	Ripple value
✧	Ripple limit segment
✧	Edit ripple limit table
✧	FAIL sign ON/ <u>OFF</u>

**a) Ripple test ON/OFF**

**Function description:**

Select this menu to enable the ripple test function. Clear this menu to close the function of ripple test of the active track.

**Parameter description:**

OFF [OFF|ON].

**b) Ripple display ON/OFF**

**Function description:**

Select this menu to enable the ripple display function. Clear this menu to close the ripple line display of the active track, however, the ripple test function must not be affected.

**Parameter description:**

OFF [OFF|ON].

**c) Ripple value**

**Function description:**

Select this menu to set the ripple type. Optional ripple type: none, absolute value and allowance.

**Parameter description:**

None

**d) Ripple limit segment**

**Function description:**

Select this menu to select the number of ripple limit segments to be opened. Up to 12 segments can be opened.

**Parameter description:**

None

**e) Edit ripple limit table**

**Function description:**

Select this menu to edit the ripple limit table. The ripple limit table can be added, deleted and edited.

**Parameter description:**

None

**f) FAIL sign ON/OFF**

**Function description:**

Select this menu to enable the FAIL sign function. In case of failure of the track data point test, the FAIL sign will appear on the screen.

**Parameter description:**

OFF [OFF|ON].

**3) Bandwidth test**

This menu is used to set the bandwidth test. Click it to enter the menu of lower level. The specific menu includes:

Table 5.31 Bandwidth Test

Menu	
✧	Bandwidth test ON/ <u>OFF</u>
✧	Bandwidth display ON/ <u>OFF</u>
✧	Bandwidth marking ON/ <u>OFF</u>
✧	NdB point
✧	Minimum bandwidth
✧	Maximum bandwidth
✧	FAIL sign ON/ <u>OFF</u>

**a) Bandwidth test ON/OFF**

**Function description:**

Select this menu to enable the bandwidth test function to test the bandwidth of the bandpass filter.

**Parameter description:**

OFF [OFF|ON].

**b) Bandwidth display ON/OFF**

**Function description:**

Select this menu to enable the bandwidth display function. The tested bandwidth will be displayed on the screen.

**Parameter description:**

OFF [OFF|ON].

**c) Bandwidth marking ON/OFF**

**Function description:**

Select this menu to enable the bandwidth marking function. The bandwidth position mark will be displayed on the screen.

**Parameter description:**

OFF [OFF|ON].

**d) NdB point**

**Function description:**

Select this menu to adjust the NdB point and determine the amplitude difference between two frequency points and the signal peak value of the passband.

**Parameter description:**

-3dB [-500dB~500dB].

**e) Minimum bandwidth**

**Function description:**

Select this menu to set the allowable minimum bandwidth. If the test bandwidth is less than the minimum value, the prompt of bandwidth test failure (FAIL) will appear on the screen, or the prompt sound will be sent, so that the user can directly observe whether the characteristics of the tested device meet the requirements.

**Parameter description:**

10kHz [0Hz~300kHz].

**f) Maximum bandwidth**

**Function description:**

Select this menu to set the allowable maximum bandwidth. If the test bandwidth exceeds the maximum value, the prompt of bandwidth test failure (FAIL) will appear on the screen, or the prompt sound will be sent, so that the user can directly observe whether the tested device meet the requirements.

**Parameter description:**

300kHz [300kHz~∞].

**g) FAIL sign ON/OFF**

**Function description:**

Select this menu to enable the FAIL sign function. In case of failure of the track data point test, the FAIL sign will appear on the screen.

**Parameter description:**

OFF [OFF|ON].

### 5.2.8.3 Track Statistics

This menu is used to set track statistics. Click it to enter the menu of lower level. The specific menu includes:

Table 5.32 Track Statistics

Menu	
◇	Track statistics <u>ON/OFF</u>
◇	Curve track statistics

#### 1) Track statistics ON/OFF

##### Function description:

Select this menu to enable the function of track statistics. It is not required to search the maximum value and minimum value so as to easily measure the peak-peak value of passband ripple.

##### Parameter description:

OFF [OFF|ON].

#### 2) Curve track statistics

##### Parameter description:

Select this menu to enter the interface of curve track statistics. Three functions of track statistics are provided: average value, deviation value and peak-peak value, so as to calculate the statistical values within whole excitation bandwidth or user-defined bandwidth.

##### Parameter description:

None

### 5.2.8.4 Gate

This menu is used to set the gate. Click it to enter the menu of lower level. The specific menu includes:

Table 5.33 Gate

Menu	
◇	Gate <u>ON/OFF</u>
◇	Gate: starting
◇	Gate: ending
◇	Gate: center
◇	Gate: span
◇	Gate setting

#### 1) Gate ON/OFF

##### Function description:

Select this menu to enable the gate function. Select or remove one response in the time domain through the gate function, and then change into the frequency domain for observation.

##### Parameter description:

OFF [OFF|ON].

#### 2) Gate: starting

##### Function description:

Select this menu to set the starting value of the gate.

**Parameter description:**

-10ns [-14.825797ns~14.825797ns]

**3) Gate: ending**

**Function description:**

Select this menu to set the ending value of the gate.

**Parameter description:**

10ns [-14.825797ns~14.825797ns]

**4) Gate: center**

**Function description:**

Select this menu to set the center value of the gate.

**Parameter description:**

0ns [-14.825797ns~14.825797ns]

**5) Gate: span**

**Function description:**

Select this menu to set the span value of the gate.

**Parameter description:**

20ns [0ns-29.651594ns].

**6) Gate: setting**

**Function description:**

Select this menu to enter the window of time domain transformation function. The time domain transformation, gate, window and options can be set.

**Parameter description:**

None

**5.2.8.5 Window**

**Function description:**

Select this menu to enter the window of time domain transformation function. The time domain transformation, gate, window and options can be set.

**Parameter description:**

None

**5.2.8.6 Time domain**

This menu is used to set the time domain. Click it to enter the menu of lower level. The specific menu includes:

Table 5.34 Time Domain

Menu	
✧	Time domain ON/OFF
✧	Starting date
✧	Ending time
✧	Center time
✧	Time span

- ◇ Time domain transformation
- ◇ Time domain window
- ◇ Couple setting
- ◇ Time domain toolbar

### 1) Time domain ON/OFF

#### Function description:

Select this menu to enable the time domain function.

#### Parameter description:

OFF [OFF|ON].

### 2) Starting date

#### Function description:

Select this menu to set the starting time.

#### Parameter description:

-10ns [-14.825797ns~14.825797ns]

### 3) Ending time

#### Function description:

Select this menu to set the ending time.

#### Parameter description:

10ns [-14.825797ns~14.825797ns]

### 4) Center time

#### Function description:

Select this menu to set the center time.

#### Parameter description:

0ns [-14.825797ns~14.825797ns]

### 5) Time span

#### Function description:

Select this menu to set the time span.

#### Parameter description:

20ns [0ns-29.651594ns].

### 6) Time domain transformation

#### Function description:

Select this menu to enter the window of time domain transformation function. The time domain transformation, gate, window and options can be set.

#### Parameter description:

None

### 7) Time domain window

#### Function description:

Select this menu to enter the window of time domain transformation function. The time domain transformation, gate, window and options can be set.

**Parameter description:**

None

**8) Coupling setting**

**Function description:**

Select this menu to enter the window of coupling setting function.

**Parameter description:**

None

**9) Time domain toolbar**

**Function description:**

Select this menu to enable the time domain toolbar function so as to clearly observe the influence of setting changes on measurement.

**Parameter description:**

OFF [OFF|ON].

**5.2.8.7 Structural Return Loss**

This menu is used to set the structural return loss. Click it to enter the menu of lower level. The specific menu includes:

Table 5.35 Structural Return Loss

Menu	
◇	SRL ON/ <u>OFF</u>
◇	Port connector 1/2/3/4
◇	Automatic Z ON/ <u>OFF</u>
◇	Z Cutoff frequency
◇	Manual Z

**1) SRL ON/OFF**

**Function description:**

Select this menu to enable the SRL function.

**Parameter description:**

OFF [OFF|ON].

**2) Port connector 1/2/3/4**

**Function description:**

Select this menu to set the length and capacity of the port connector 1/2/3/4.

**Parameter description:**

None

**3) Automatic Z ON/OFF**

**Function description:**

Select this menu to enable the automatic Z function.

**Parameter description:**

OFF [OFF|ON].

#### 4) Z cutoff frequency

**Function description:**

Select this menu to set the Z cutoff frequency.

**Parameter description:**

210MHz [10MHz~26.5GHz].

#### 5) Manual Z

**Function description:**

Select this function to enable the manual Z function.

**Parameter description:**

OFF [OFF|ON].

#### 5.2.8.8 Formula Editor

**Function description:**

Select this menu to enter the formula editor interface. Parameter description:

**Parameter description:**

OFF [OFF|ON].

### 5.2.9 System

Press the [System] key on the front panel or the [System] menu item on the user interface. The system-related menu will pop up. Specific items include: [Configuration], [Record/Run 1], [Record/Run 2], [Windows task bar], [Reset], [Custom user reset state], [Language: CN/EN] and [Spread spectrum]. The specific description of menu items is as follows.

#### 5.2.9.1 Configuration

This menu is used to set the configuration. Click it to enter the menu of lower level. The specific menu includes:

Table 5.36 Configuration

Menu
✧ GPIB address
✧ Control panel
✧ System impedance
✧ User configuration
✧ Intermediate frequency selection
✧ Millimeter wave module configuration
✧ Expansion to 16 ports
✧ Touch screen

#### 1) GPIB address

**Function description:**

Select this menu to configure the GPIB address.

**Parameter description:**

16 [0~30].

#### 2) Control panel

**Function description:**

If this menu is selected, the control panel menu will pop up. The user can set the operating system.

**Parameter description:**

None

**3) System impedance**

**Function description:**

Select this menu to set the system impedance. The system impedance must be changed in measurements of devices except those of 50Ω, such as waveguide devices.

**Parameter description:**

50Ω [0Ω-1kΩ].

**4) User configuration**

**Function description:**

If this menu is selected, the user can configure it. Configurable options include: “Enable touch screen”, “Save calibration file in the current time name”, “Not automatically save after calibration”, “Display cursor on all the existing tracks”, “Display limit test on all the existing tracks”, “Press the UP/DOWN key to change the cursor point by point”, “Install anti-virus software”, “Multi-port calibration” and “Identify port scanning state”.

**Parameter description:**

None

**5) Intermediate frequency selection**

**Function description:**

Select this menu to select the intermediate frequency, including the internal intermediate frequency and external intermediate frequency.

**Parameter description:**

None

**6) Millimeter wave module configuration**

**Function description:**

Select this menu to configure the millimeter wave module, including the model selection, port setting and frequency setting.

**Parameter description:**

None

**7) Expansion to 16 ports**

**Function description:**

Select this menu to expand the instrument to 16 ports.

**Parameter description:**

None

**8) Touch screen**

**Function description:**

Select this menu to enable the touch screen function and calibrate the touch screen.

**Parameter description:**

None

**5.2.9.2 Record/Run 1**

**Function description:**

Select this menu to automatically start recording. If recording has been done, press this key to automatically start running.

**Parameter description:**

None

**5.2.9.3 Record/Run 2**

**Function description:**

Select this menu to automatically start recording. If recording has been done, press this key to automatically start running.

**Parameter description:**

None

**5.2.9.4 Windows Task Bar**

**Function description:**

Select this menu to open the operating system task bar.

**Parameter description:**

None

**5.2.9.5 Reset**

**Function description:**

Select this menu to run the application program of the AV3672 series vector network analyzer.

**Parameter description:**

None

**5.2.9.6 Reset User State**

**Function description:**

Select this menu to customize the user state interface. The user can be customize the user reset state.

**Parameter description:**

None

**5.2.9.7 Language CN/EN**

**Function description:**

Select this menu to select the operating language (CN|EN).

**Parameter description:**

CN [CN|EN].

**5.2.9.8 Spread Spectrum**

**Function description:**

Select this menu to select the spread spectrum function, including AV3644A, AV3645A, AV3646A, AV3649, AV3649A, etc.

**Parameter description:**

None

**5.2.10 Help**

Press the [Help] key on the front panel or the [Help] menu item on the user interface. The help-related menu will pop up. Specific items include: [User manual], [Programming manual], [Technical support], [Error information]

and [About]. The specific description of menu items is as follows.

#### **5.2.10.1 User Manual**

**Function description:**

Select this menu to open the “User Manual of AV3672 Series Vector Network Analyzers”.

**Parameter description:**

None

#### **5.2.10.2 Programming Manual**

**Function description:**

Select this menu to open the “Program Control Manual of AV3672 Series Vector Network Analyzers”.

**Parameter description:**

None

#### **5.2.10.3 Technical Support**

**Function description:**

Select this menu to enter the home page of the 41st Institute of China Electronics Technology Group Corporation.

**Parameter description:**

None

#### **5.2.10.4 Error Information**

**Function description:**

Select this menu to select the error parameter and view the error log.

**Parameter description:**

None

#### **5.2.10.5 About**

**Function description:**

Select this menu to view the basic information of the instrument and the company information.

**Parameter description:**

None

## 6 Measurement Optimization

The following methods can be applied to adjust the setting and optimize the measurement accuracy.

• Reduction of accessory influence .....	199
• Improvement of reflection accuracy of low-loss double-port device .....	200
• Increase of dynamic range .....	202
• Improvement of measurement results of electrical long device .....	204
• Improvement of phase measurement accuracy .....	206
• Reduction of track noise .....	211
• Increase of data point number .....	214
• Improvement of measurement stability .....	216
• Improvement of scanning speed .....	217
• Improvement of efficiency of multi-state measurement .....	220
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### 6.1 Reduction of Accessory Influence

Some accessories may affect the measurement results of the tested device. Select one of two characteristics of the analyzer to reduce the accessory influence. In order to reduce the accessory influence, you can select the most suitable method to test the configuration.

#### 1) Compensate the cable loss with the power slope.

If a long cable or other kind of accessory is used in measurement configuration, the power loss will be generated within the whole band. In this case, the power slope function should be applied. The defined ratio (dB/GHz) can be used in this function to increase the source power of the analyzer. The process of cable loss compensation is as follows.

Menu path: **[Excitation] > [Power...]**.

If the power slope function is not activated, tick the **[Slope]** check box. Input the ratio to be increased in frequency scanning of the source power in the **[dB/GHz]** box.

#### 2) Selectively remove the response gate (only for the time domain).

a) The gate is one of the time domain characteristics. It is used to remove the response mathematically. The gate of reflection response or transmission response can be set, but different results will be obtained.

- **Gate reflection response:** the desired response (such as the return loss of the filter) can be separated from the undesired response (such as the adapter reflection or connector mismatch) by reflection response of the gate.
- **Gate transmission response:** the specific path of large electrical length in the multi-path device can be separated by transmission response of the gate.

In order to apply the gate in the time domain mode, the transformation can be disconnected, and the existing gate pulse can be used in study of the frequency response of the device. The time filter gate pulse have the following shapes and features:

- **Band pass shape:** the response beyond the passband zone can be removed.
- **Trap shape:** unnecessary response in the frequency zone can be removed.

b) Removal of unnecessary response

Menu path: **[Analysis] > [Time domain] > [Time domain transformation...]**.

Click the **[Time domain transformation]** check box in the **[Time domain transformation]** dialog box to activate



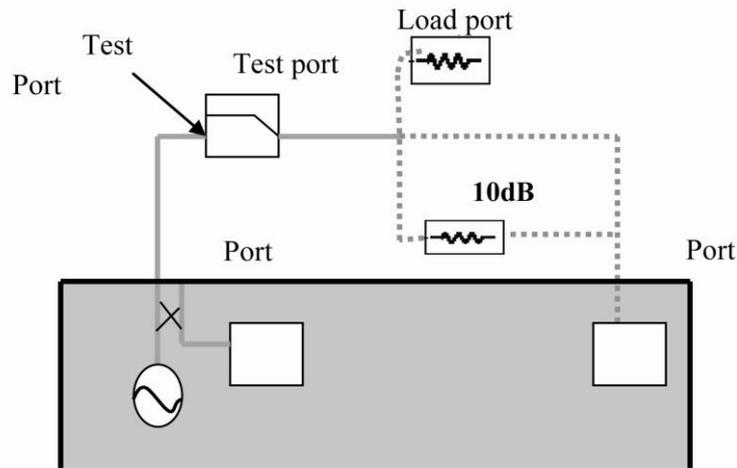


Fig. 6.2 Accurate Reflection Measurement of Double-port Device

### Attention

The corresponding linear values are given in the brackets.

**Analyzer:** Load matching (NALM)=18dB (.126)  
Direction (NAD)=40dB (.010)

**Filter:** Insertion loss (FIL)=1dB (.891)  
Return loss (FRL)=16dB (.158)

**Attenuator:** Insertion loss (AIL)=10dB (.316)  
SWR (ASWR)=1.05 (.024) Return loss: 32.26dB

Calculation: **without attenuator**

$$\begin{aligned} NA &= (F_{IL}) * (NA_{LM}) * (F_{IL}) \\ &= (.891) * (.126) * (.891) \\ &=.100 \end{aligned}$$

**Attenuator** NA

**with attenuator**

$$\begin{aligned} &= (F_{IL}) * (A_{IL}) * (NA_{LM}) * (A_{IL}) * (F_{IL}) \\ &= (.891) * (.316) * (.126) * (.316) * (.891) \\ &=.010 \end{aligned}$$

$$\begin{aligned} &= (F_{IL}) * (A_{SWR}) * (F_{IL}) \\ &= (.891) * (.126) * (.891) \\ &=.019 \end{aligned}$$

**Error in the worst case (EWC) NA**

=.1

=NA+Attn.

=.01+.019

=.029

**Upper limit of instability**  
 $20\log\{(FRL)+(EWC)+(NAD)\}$

$$=-20\log\{(.158)+(.100)+(.010)\}$$

=11.4dB

**instability**  
 $20\log\{(FRL)+(EWC)+(NAD)\}$

$$=-20\log\{(.158)+(.029)+(.010)\}$$

=14.1dB

**Lower limit of instability**  
 $20\log\{(FRL)-(EWC)-(NAD)\}$

$$=-20\log\{(.158)-(.100)-(.010)\}$$

=26.4dB

$20\log\{(FRL)-(EWC)-(NAD)\}$

$$=-20\log\{(.158)-(.029)-(.010)\}$$

=18.5dB

Therefore, one of the following methods can be applied to obtain accurate results in reflection measurement of the low-loss double-port device.

- Connect one high-quality load to the output end of the tested device after one-port calibration.

- Insert one 10dB attenuator between the output of the tested device and the analyzer after one-port calibration.
- Directly connect the output of the tested device to the analyzer after double-port measurement calibration.

### 6.3 Increase of Dynamic Range

The dynamic range refers to the difference between the maximum power allowed to be input into the analyzer and the minimum power (base noise) which can be tested. To make the measurement correct and effective, the input signal must be within the dynamic range. In order to greatly change the signal amplitude of measurement, such as the filter passband and stop-band, it is important to increase the dynamic range. Fig. 6.3 is a typical dynamic range of measurement.

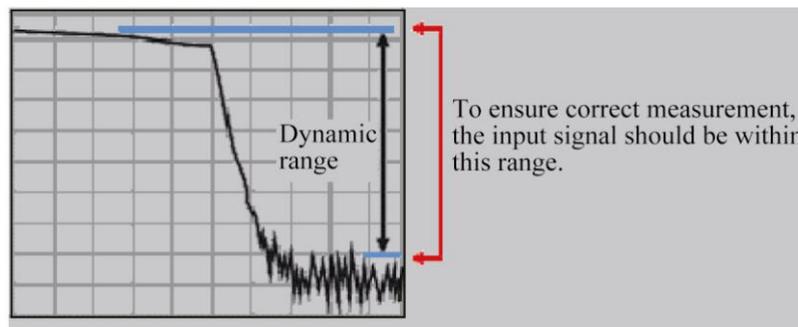


Fig. 6.3 Dynamic Range

In order to reduce the instability of measurement, the dynamic range of the analyzer should be larger than the response of the tested device. For example, the accuracy can be improved if the response of the tested device is at least 10dB more than the base noise. The following methods can help to increase the dynamic range.

#### Attention

##### Dynamic range and measurement time

As some analyzers have the characteristics of alternating scanning, the dynamic range can be increased so as to increase the measurement time.

#### 6.3.1 Increase of Input Power of Device

- 1) The input power of the tested device can be increased so that the output power of the tested device can be accurately tested and measured by the network analyzer.
- 2) If the input of the receiver is too high, compression distortion may be caused. If the input reaches to a certain degree, the receiver may be damaged.



#### Warning

**If the input level reaches +15dBm, the receiver may be damaged.**

#### Attention

##### Do not apply the maximum source output power.

If the test equipment has gain, the maximum source output power cannot be applied; otherwise, the receiver may be damaged.

Menu path: **[Excitation] > [Power]**. The **power** shortcut key is set on the auxiliary menu bar and front panel.

Input the power value directly in the input toolbar, or click **[Power...]** to set the power in the dialog box.

#### 6.3.2 Reduction of Base Noise of Receiver

The following methods can be applied to reduce the base noise and increase the dynamic range of the analyzer.

- a) Reduce the intermediate frequency bandwidth.
- b) Use the scanning average value.

## Prompt

### Reduction of crosstalk between receivers

When the measurement signal is close to the base noise of the analyzer, the crosstalk between receivers should be reduced.

#### 1) Reduction of intermediate frequency bandwidth

As shown in Fig. 6.4, the intermediate frequency bandwidth has influence on measurement results.

- The bandwidth of the intermediate frequency receiver can be reduced so as to reduce the influence of random noise in measurement. Once the intermediate frequency bandwidth is reduced by 10 times, the base noise will be reduced by 10dB. However, the smaller the intermediate frequency bandwidth is, the longer the scanning time is.
- The network analyzer can change the received signal from the RF/microwave frequency into the intermediate frequency (7.606MHz). The bandwidth of the intermediate frequency band pass filter can be reduced from 5MHz to 1Hz (min.).
- The intermediate frequency bandwidth can be independently set for each channel or each segment in segment scanning.

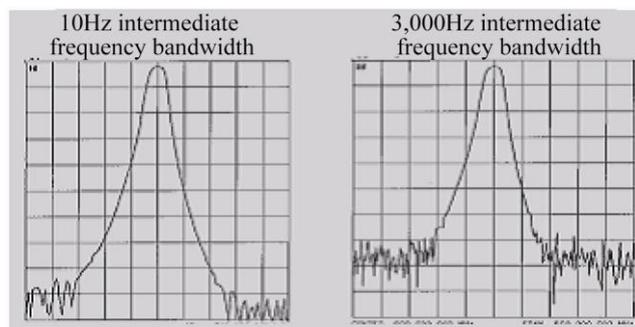


Fig. 6.4 Influence of Intermediate Frequency Bandwidth on Measurement Results

- a) Setting of intermediate frequency bandwidth

Menu path: **[Response]** > **[Average]** > **[Intermediate frequency bandwidth]**.

Input the intermediate frequency bandwidth value in the **input toolbar** or directly input the value in the **[Intermediate frequency bandwidth]** dialog box or select a value with the arrow button.

#### 2) Increase or change of the average value of scanning

- a) Increase or change of the average value of scanning

- Scanning averaging is a method to reduce the influence of random noise in measurement.
- Each data point is calculated based on the average value of several continuous scanning procedures.
- The more times averaging is done, the more noise will be reduced, and the larger the dynamic range will be.

As shown in Fig. 6.5, scanning averaging has influence on measurement results.

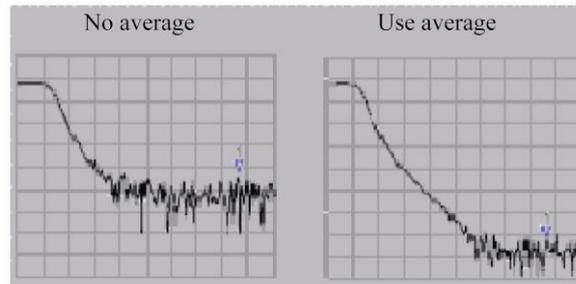


Fig. 6.5 Influence of Scanning Averaging on Measurement Results

## Prompt

### Reduction of random noise

- The average value of measurement can be independently set for each channel.
- The total measurement time increases along with the increase of averaging times.
- General noise can be minimized by setting the average value and intermediate frequency bandwidth.
- In order to minimize the low-frequency noise, measurement averaging is more effective than reduction of the system bandwidth.

### b) Setting of scanning average value

Menu path: **[Response]** > **[Average]**. Set the average value by the **[Average]** key in the auxiliary menu bar or in the **[Average]** dialog box. Enable or disable the averaging function by **[Average on/OFF]**. Directly enter the value or press the arrow button to increase/decrease the averaging times according to the **averaging factor**.

## Attention

Select **[Re-average]** to start a group of new average scanning.

## 6.4 Improvement of Measurement Results of Electrical Long Device

The frequency of the signal from the tested device may be different from the frequency of the signal into the tested device at the given time. This may result in inaccurate measurement results sometimes. The following contents can help to understand why inaccurate measurement results are obtained and how to compensate.

Why are inaccurate results produced as a result of delay?

- The source and receiver can be locked at the same time, and scanning can be done for one frequency interval with the vector network analyzer.
- The signal through the tested device (DUT) represents different colors corresponding to different frequencies.
- If the excitation frequency passes through the tested device and the analyzer is tuned to new frequency before the signal reaches the receiver, inaccurate measurement results will be produced.

As shown in Fig. 6.6, if a long cable is measured by the analyzer, the signal frequency of the cable end will lag behind the source frequency of the analyzer. If the frequency deviation (typically dozens of kHz) is obvious relative to the intermediate frequency test bandwidth of the network analyzer, measurement results may be wrong due to the roll-down characteristics of the intermediate frequency filter.

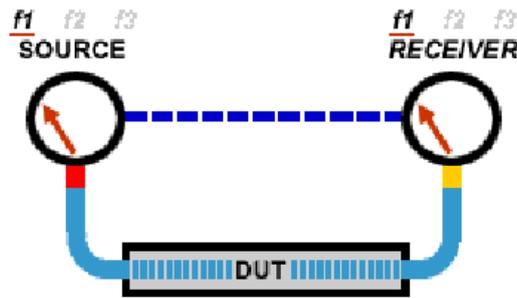


Fig. 6.6 Schematic Diagram of Test of Long Cable

The delay of the electrical long device can be compensated in the following methods.

### 1) Reduction of scanning speed

The scanning speed can be reduced by increasing the scanning time, reducing the intermediate frequency bandwidth or increasing the number of scanning points.

a) Increase the scanning time.

Menu path: **[Excitation] > [Scan] > [Scanning time...]**.

Enter the time or select the time with the arrow.

b) Reduce the intermediate frequency bandwidth.

Menu path: **[Response] > [Average] > [Intermediate frequency bandwidth...]**.

Directly enter the value or select the time with the arrow.

c) Increase the number of scanning points.

Menu path: **[Excitation] > [Scan] > [Number of scanning points]**.

Directly click the required point number in the sub-menu or click **[Custom...]**. Enter the value in the **[Number of scanning points]** dialog box or select the value with the arrow.

### 2) Use of step scanning.

Change analog scanning into step scanning so that the source can step over each test point. In this case, the scanning speed of the analyzer can be reduced. The residence time of each step or test point can also be set.

Menu path: **[Excitation] > [Scan] > [Scanning setting...]**.

Tick the **step scanning**. Directly enter the residence time in the **[Residence time]** box or select the required residence time of each test point.

## 6.5 Improvement of Phase Measurement Accuracy

The following characteristics of the analyzer can be applied to improve the accuracy of phase measurement.

● Electrical delay .....	206
● Port extension .....	206
● Phase deviation .....	208
● Frequency point interval .....	209
● Specific operation .....	210

### 6.5.1 Electrical Delay

- The electrical delay can be applied to compensate the linear phase deviation of the tested device so as to highlight the linear phase deviation of the tested device.
- The electrical delay is a kind of mathematical function. The transmission line of no loss and adjustable length can be simulated.

- The electrical delay which is not associated with each measurement track can be set.

### 6.5.2 Port Extension

1) The measurement reference plane can be moved electrically by means of port extension after calibration. Thus, other kinds of calibration can be avoided. Port extension is introduced in the following two cases.

- a) Decide whether to add one cable in the measurement configuration after calibration. The port extension characteristics can be applied to “tell” the analyzer to increase the cable length to the specific port.
- b) If calibration cannot be done directly on the tested device in the test fixture, port extension can be applied to compensate the delay (phase deviation) arising from the fixture.

2) Use of port extension function

- a) If the electrical length of the tested fixture or added cable is known, enter the value in the **[Time]** box.
- b) If the physical length of the tested fixture or added cable is known, enter the value in the **[Distance]** box.
- c) If the above two items are unknown, the open-circuit device or short-circuit device can be used instead of the tested device on the reference plane after extension. Generally, the new reference plane is regarded in the open-circuit state after removal of the tested device.

3) The appropriate port extension value can be obtained in the following methods.

- a) Select the S11 measurement after calibration and set the phase format as the display format.
- b) Connect the open-circuit device or short-circuit device to the calibration plane and check whether the displayed phase curve is within the measurement frequency range and around 0°.
- c) Connect the fixture or transmission cable and use the open-circuit device or short-circuit device instead of the tested device (the circuit is regarded as an open circuit if the tested device is removed). Adjust the value of the **[Time]** or **[Distance]** box in the [Port extension] dialog box until the phase track is flat.
- d) If the loss characteristics of the extension part are known, compensation can be done in the one-dimensional or two-dimensional manner in the [Loss compensation] part.

---

#### Attention

##### Nonzero delay

The nonzero delay is specified in the majority of short circuit standards and can be applied to adjust the error which is twice that of short-circuit calibration as a result of port extension and further view the definition of the calibration kit so as to determine the appropriate extension value.

---

4) Setting of port extension

Menu path: **[Calibration]** > **[Port extension]**.



Fig. 6.7 Setting of Port Extension

The [Port extension] dialog box will appear. Tick the [Port extension] check box. Then the port extension function will be effective for all ports.

- [Port]: select the current extension port in the drop-down box. The port extension settings are effective for all measurements of active channels on the current port.
- [Display toolbar]: display the port extension toolbar.
- [Time]: set the delay time of port extension.
- [Distance]: set the physical length of the delay time of port extension.
- [Unit]: set the calculation unit of port extension distance: meter, foot or inch.
- [DC loss]: set the deviation of the whole frequency band.
- [Loss][@frequency]: set the loss and frequency. If only [Loss 1] is selected, the compensation formula is as follows:

$$\text{Loss (f)} = \text{Loss 1} * (\text{f} / \text{frequency 1}) ^{0.5}$$

If Loss 1 and 2 are selected, the compensation formula is as follows:

$$\text{Loss (f)} = \text{Loss 1} * (\text{f} / \text{frequency 1}) ^n, \text{ where:}$$

$$n = \log_{10} (\text{Loss 1} / \text{Loss 2}) / \log_{10} (\text{Frequency 1} / \text{Frequency 2})$$

- [Speed factor]: set the speed factor. Note that this speed factor is the same as that of the system.
- [Coaxial]: set the coaxial characteristics of the current port extension.
- [Waveguide] and [Cutoff frequency]: set the waveguide characteristics of the current port extension. In this case, the cutoff frequency of waveguide can be set. Note that the set medium type is the same as that of the system.
- [Reset]: recover the default mode of the system. Note that the port extension state remains unchanged.
- [Automatic port extension]: call the [Automatic port extension] dialog box.

Manual port extension can be done automatically in the automatic port extension mode. If the extension plane is connected with an open-circuit device or short-circuit device, the system will automatically calculate the delay time and loss of port extension, and the measurement end face will be compensated to the extension part.

Steps of automatic port extension:

- 1) Connect the new transmission line or fixture and then connect the open-circuit device or short-circuit device to the new measurement end face. Generally, no connection with the calibration kit is equivalent to the open-circuit

state.

- 2) Click [**Automatic port extension...**] in the port extension toolbar and then click [**Display configuration**] to view more options.
- 3) Click [**Measurement**] to start the port extension calculation. The calculated delay time and loss value will be automatically displayed in the toolbar.

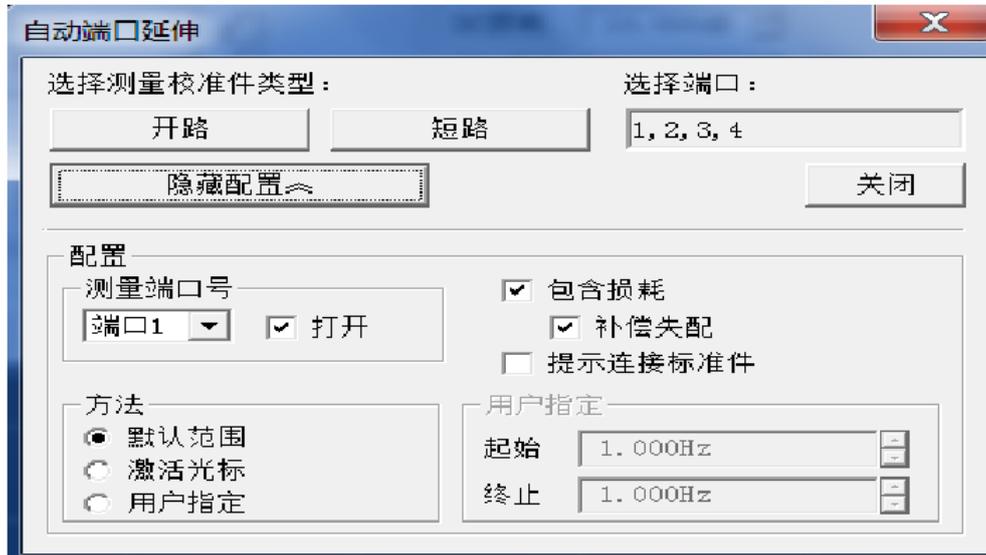


Fig. 6.8 Automatic Port Extension

- [**Open circuit**] and [**Short circuit**]: connect the open-circuit device or short-circuit device to the port requiring automatic extension.
- [**Display configuration**] and [**Hide configuration**]: display and hide the configuration of automatic port extension.
- **Measurement port number**: select the port to be subject to automatic extension calculation.
- **Method**: set the frequency range of the data collected for automatic port extension calculation.

[**Default range**]: the same as the frequency range of current measurement.

[**Activate cursor**]: use the data between the activated cursor and the part of the highest frequency to calculate the automatic port extension.

[**User-defined**]: the user enters the frequency range of calculation.

- [**Include loss**]: select it to automatically calculate the loss arising from the current port extension.
- [**Compensation mismatch**]: select it to automatically compensate the error arising from mismatch.
- [**Prompt of calibration kit connection**]: if this item is selected, the [Calculation kit connection] prompt box will pop up.
- [**Close**]: apply the current calculation results to the active channel and exit the dialog box.

### 6.5.3 Phase Deviation

The phase deviation is a kind of mathematical phase measurement, and the deviation range is 0-360°. Use this characteristic in the following methods:

- **Improve the display of phase measurement results.**

This is similar to the improvement of reference level in amplitude measurement. Change the phase response to make it at the screen center or on the same straight line as the screen.

- **Simulate the phase deviation determined in measurement.**

For example, if it is known to add a cable and the cable length may result in phase deviation of measurement results, the phase deviation can be increased by movement and the measurement of the whole device can be simulated.

### 1) Setting of phase deviation

Menu path: [**Response**] > [**Scale**] > [**Phase deviation...**]. The [**Phase deviation**] dialog box will appear.

Set the phase deviation in the [**Phase deviation**] box.



Fig. 6.9 Automatic Port Extension

## 6.5.4 Frequency Point Interval

- 1) Sample the data of discrete frequency points, connect each sampling point and form a track on the screen.
- 2) If the phase deviation of two adjacent frequency points of the device is more than  $180^\circ$ , the displayed phase slope will look like the reverse phase. This is caused by mixing as a result of insufficient data sampling.

If the group delay is measured but the phase slope is opposite, the symbol will be changed as a result of the group delay. For example, Fig. 6.10 shows the measurement results of the surface acoustic wave (SAW) bandpass filter.

a) The first figure shows the measurement results of 51 points, and the group delay is negative. But this is impossible in the actual situation, as the response will not be below the reference line ( $0s$ ).

b) The second figure shows the measurement results of 201 points, and the group delay is positive, that is, the response is above the reference line ( $0s$ ).

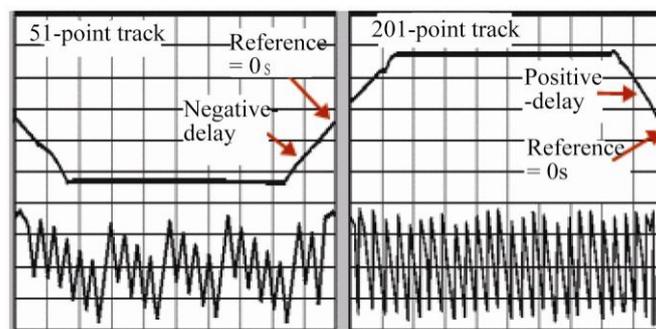


Fig. 6.10 Influence of Frequency Interval on Phase Measurement

## Prompt

### Mixing check

In order to check mixing in measurement, you can check whether the display data change by reducing the frequency interval. You can increase the number of frequency points or reduce the frequency interval to avoid mixing.

## 6.5.5 Specific Operations

### 1) Compensation of linear phase deviation

Menu path: **[Response]** > **[Scale]** > **[Electrical delay...]**.

Enter the required value in the **[Electrical delay]** box or select the value with the arrow.

Enter the value in the **[Speed factor]** box or select the value between 0 and 1.0 with the arrow.

- 1.0 corresponds to the light speed in vacuum.
- 0.66 corresponds to the typical light speed in the polyethylene medium.
- 0.70 corresponds to the typical light speed in the Teflon medium.



Fig. 6.11 Setting of Electrical Delay

### 2) Electrical movement reference plane

Menu path: **[Calibration]** > **[Port extension...]**.

Select the **[Port extension on/OFF]** check box.

Add the port extension value in the reference plane to be extended.

Select a value between 0 and 1.0 in the **[Speed factor]** box as the relative speed of the added cable or medium after calibration. Then click **[OK]**.

- 1.0 corresponds to the light speed in vacuum.
- 0.66 corresponds to the typical light speed in the polyethylene medium.
- 0.70 corresponds to the typical light speed in the Teflon medium.

## Prompt

**You can perform the following operation to check whether the sufficient delay is added:**

- Connect one short-circuit device.
- Adjust the port extension until the phase correspondingly becomes flat.

## Attention

**Determine the deviation delay of the standard short-circuit device.**

The delay time of the majority of short-circuit calibration kits is not zero. Therefore, the delay error caused by this method is twice that of the short-circuit device. Determine the deviation delay of the standard short-circuit device according to the definition of the inspection standards.

### 3) Phase deviation measurement

Menu path: **[Response]** > **[Scale]** > **[Phase deviation...]**.

Enter the value in the **[Phase deviation]** dialog box or select the required value with the arrow.

#### 4) Inspection of mixing

Menu path: **[Excitation]** > **[Scan]** > **[Number of scanning points]**.

Select one value in the list, or click **[Custom...]**, and enter the value smaller than the current value through the number keys of the keyboard or **input zone**.

The problem of changes of the displayed data can be solved by increasing the number of points or reducing the frequency span.

## 6.6 Reduction of Track Noise

Reduce the noise on the measurement track by the network analyzer function. The following functions of the analyzer can help to reduce the influence of track noise.

- **Scanning averaging** .....211
- **Track smoothing** .....212
- **Intermediate frequency bandwidth** .....214

### 6.6.1 Scanning Averaging

#### 1) Scanning averaging

a) Scanning averaging is a function to reduce the influence of random noise on the measurement.

b) Each data point is calculated based on the average value of several continuous scanning operations. The times of continuous scanning are determined according to the setting of the averaging factor.

c) The average value of tracks will be applied on all measurements of one channel, and the average number of each channel will be displayed.

d) The noise reduction and dynamic range can be improved by increasing the averaging times.

e) The noise reduction effect of scanning averaging is the same as that of reduction of the intermediate frequency bandwidth.

#### 2) Influence of scanning averaging

As shown in Fig. 6.12, scanning averaging has influence on measurement results.

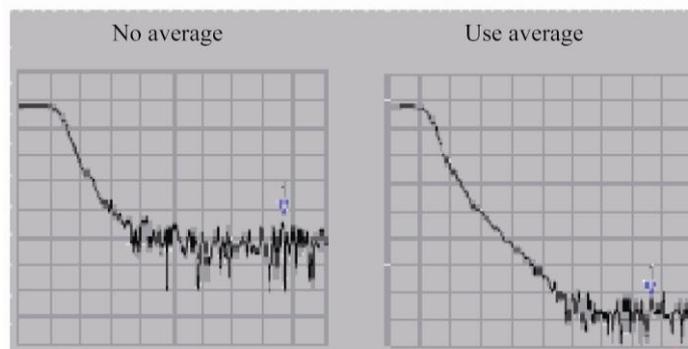


Fig. 6.12 Influence of Scanning Averaging on Measurement Results

#### 3) Setting of scanning averaging

Menu path: **[Response]** > **[Average]** > **[Average...]**.

Select **[Average on/OFF]** to enable the averaging function.

Directly enter the value in the **[Averaging factor]** box or increase/decrease the averaging times of the analyzer with the arrow button.

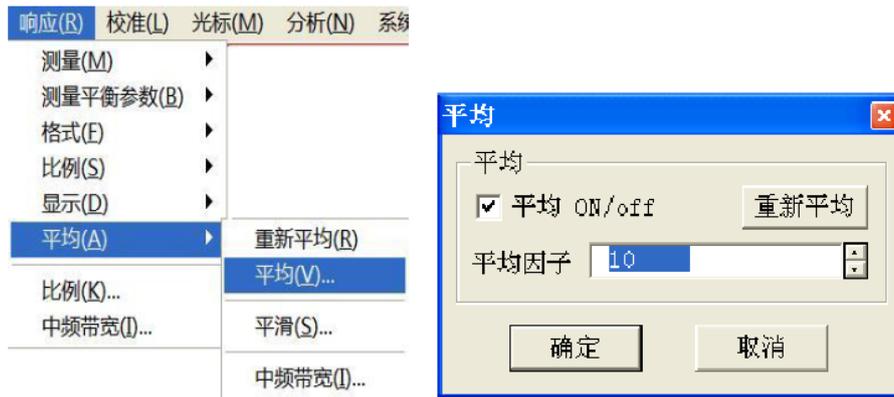


Fig. 6.13 Setting of Scanning Averaging

## Attention

Click [Re-average] in the sub-menu to start a group of new average scanning.

### 6.6.2 Track Smoothing

The smoothing function is used to reduce the peak-peak noise of broadband measurement data. The data of part of the displayed track are averaged by the analyzer. The number of adjacent data points subject to averaging at the same time is also known as the smoothing aperture. The aperture can be defined as the number of data point or the percentage of X-axis span.

## Prompt

### Use of the smoothing function:

- Use sufficient points in the display to avoid misleading results.
- The smoothing function must not be applied to the highly resonant device or the device subject to broad track changes, as measurement errors may be caused.
- The smoothing function can be independently set for each track.

#### 1) Influence of track smoothing

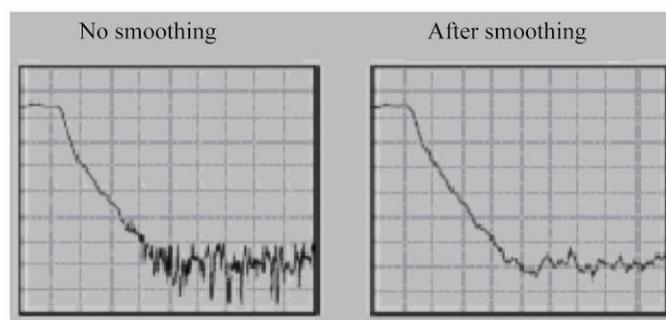


Fig. 6.14 Influence of Track Smoothing on Measurement Results

#### 2) Setting of track smoothing

Menu path: [Response] > [Average] > [Smooth...].

Click [Smooth] to enable the smoothing function.

Select the method to specify the value of the smoothing aperture:

- a) Enter the smoothing percentage in the [Smoothing percentage] box. (Max. 25%)
- b) Enter the number of smoothing points in the [Number of smoothing points] box. (The maximum value is 25%)

of the total number of scanning points of the test.)



Fig. 6.15 Setting of Smoothing

### 6.6.3 Intermediate Frequency Bandwidth

You can reduce the bandwidth of the intermediate frequency receiver so as to reduce the influence of random noise in measurement. Once the intermediate frequency bandwidth is reduced by 10 times, the base noise will be reduced by 10dB. However, if the intermediate frequency bandwidth is small, the scanning time will be long. The signal received by the analyzer will be changed into the intermediate frequency (7.606MHz) from the network analyzer can change the received signal from the RF/microwave frequency into the intermediate frequency (7.606MHz). The bandwidth of the intermediate frequency band pass filter can be reduced from 5MHz to 1Hz (min.). The intermediate frequency bandwidth can be independently set for each channel or in segment scanning.

#### 1) Reduction of influence of intermediate frequency bandwidth

The influence of the intermediate frequency bandwidth on measurement results is shown in Fig. 6.16.

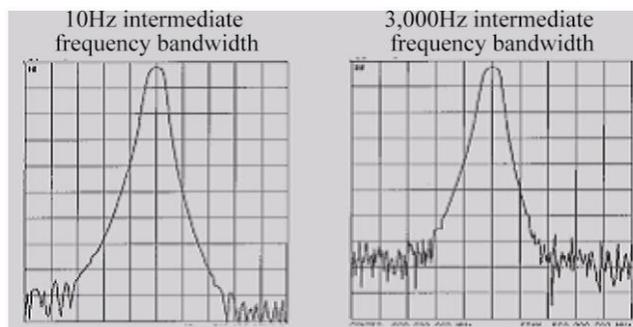


Fig. 6.16 Influence of Intermediate Frequency Bandwidth on Measurement Results

#### 2) Setting of intermediate frequency bandwidth

Menu path: [**R**esponse] > [**A**verage] > [**I**ntermediate frequency bandwidth...].

Directly enter the value in the [**I**ntermediate frequency bandwidth] dialog box or select the value with the arrow button.



Fig. 6.17 Setting of Intermediate Frequency Bandwidth

## 6.7 Increase of Data Point Number

The data point or “point” refers to the sampling results of next value after one excitation. You can define the number of measurement points within one scanning.

- The track can be scanned through a large number of data points so as to better define the device response.
- The majority of data processing is done between adjacent points. One “scanning” refers to the measurement results of a series of continuous data points, corresponding to the excitation value within one sequence.
- The default number of points of each scanning is 201.

The scanning time of the analyzer can be changed according to the number of scanning points and the scale. However, the total measurement period will not change according to the number of scanning points and the scale. Instead, it is affected by other factors, such as the flyback time, data calculation, formation time, etc. Refer to the technical specifications for the influence of the point number and other settings on the scanning time.

### Prompt

#### Use of data points

- In order to obtain the best track resolution, use the maximum number of data points.
- In order to realize rapid throughput, use the minimum number of data points, which can help to achieve the acceptable accuracy.
- In order to find the optimal number of data points, find a value with measurement results subject to no significant difference from the required number of measurement points.
- In order to ensure the accurate measurement calibration, the number of calibration points should be the same as that of measurement points.

#### 1) Specific operations

Menu path: [Excitation] > [Scan] > [Number of scanning points].

Directly click the required point number in the [Number of scanning points] sub-menu, or click [Custom...], enter the value in the [Number of scanning points] dialog box, or select the value with the arrow.

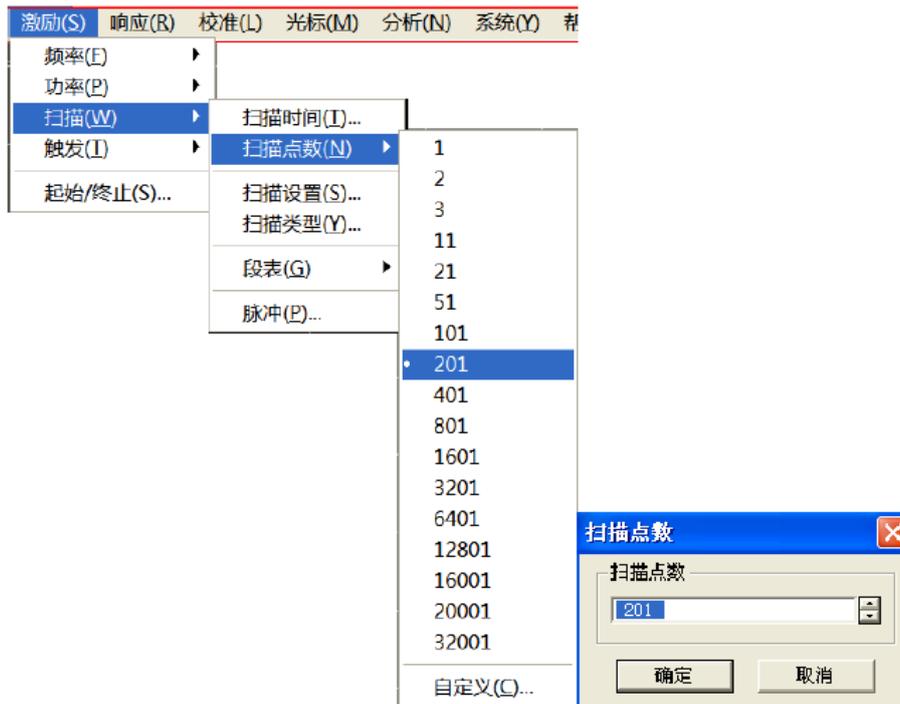


Fig. 6.18 Setting of Number of Scanning Points

## 2) Optimization of measurement results

One measurement includes several interdependent settings. You can modify the settings to achieve the purposes of measurement application: faster throughput or more accurate data. You can balance the settings to optimize measurement.

- Increase the measurement throughput.
- Improve the measurement accuracy.

## 6.8 Improvement of Measurement Stability

Measurement instability is caused under several conditions. For repeated measurement, you can apply several methods to create a stable measurement environment. The following factors have adverse effects on the measurement accuracy.

### 1) Frequency deviation

The frequency precision of the analyzer depends on the accuracy of the internal 10MHz oscillator. If high frequency accuracy and stability are required in the measurement application, no consideration should be given to the internal frequency standard, and a high-stability external frequency source can be created by the 10MHz reference input connector on the rear panel.

### 2) Temperature deviation

a) The electrical characteristics of the following components can be changed as a result of thermal expansion and contraction.

- Internal device of analyzer
- Standard of calibration kit
- Tester
- Cable
- Adapter

b) The temperature deviation in measurement can be reduced in the following methods.

- Apply a temperature-controlled environment.
- Ensure the temperature stability of the calibration kit.
- Avoid unnecessary operation of the calibration kit during calibration.
- Ensure that the difference between the ambient temperature and calibration temperature is  $\pm 1^\circ\text{C}$ .

### 3) Improper measurement calibration

Improper measurement calibration may result in failure to detect the correct response of the tested device. You can apply the following methods to ensure the proper calibration:

- a) Perform the measurement calibration of the connection of the tested device, i.e. reference plane.
- b) If an additional accessory (cable, adapter or attenuator) is inserted into the tested device after one measurement calibration, the additional electrical length and delay time can be compensated by the port extension function.
- c) Apply the calibration standard defined in the calibration process. For more details, see the section about accurate measurement calibration.

### 4) Equipment connector

A good connector is necessary in repeated measurement. Good connection can be realized in the following methods:

- a) Check and clean the connectors of all components in the test equipment.
- b) Apply the correct connection method.
- c) Do not move the cable during measurement.

### 5) Apply the external reference frequency.

Input the external frequency reference signal to the rear panel connector.

- a) Input frequency:  $10\text{MHz} \pm 10\text{ppm}$
- b) Input level:  $-15\text{dBm}$  to  $+20\text{dBm}$
- c) Input impedance:  $200\text{ohms}$

### 6) Control the room temperature.

- a) Run the analyzer for more than 30min before each measurement calibration or equipment measurement.
- b) Measure the equipment in the temperature-controlled environment. All the instructions and characteristics are applied at  $23^\circ\text{C} \pm 3^\circ\text{C}$  (unless otherwise specified).
- c) Ensure that the difference between the ambient temperature and calibration temperature is  $\pm 1^\circ\text{C}$ .

### 7) Stabilize the standard temperature of calibration.

- a) Open the calibration kit box and take out the standard kit out of the protective foam one hour before measurement calibration.
- b) Avoid unnecessary operation of the calibration kit in each measurement calibration.

### 8) Use connectors in good conditions.

- a) Check all connectors with the magnifying glass. Check the following kinds of damage: wear, bending, breakage, deep scratch, dent, rounded shoulder, dirt or metal chippings.
- b) Clean all connectors with isopropyl alcohol and swabs.
  - Evaporate alcohol.
  - Gradually dry connectors with compressed air.
- c) Properly connect the parts.
  - Connect the body and other parts to the ground with anti-static pads and wrist straps.
  - Arrange the connectors in one row.

- Rotate the connection nuts.
- Perform final connection with the torque wrench.

## 6.9 Increase of Scanning Speed

The measurement efficiency can be improved by increasing the scanning speed. The highest scanning speed can be achieved by optimizing the following settings in measurement.

### 1) Scanning setting

Carefully set the following items to achieve the highest scanning speed.

- **Frequency span:** only measure the frequency range of the tested device. See the setting method in “[4.3 Setting of Frequency Range](#)”.
- **Segment scanning:** measure the relevant frequency range by means of segment scanning. See the setting method in the instructions of “[Setting of scanning type](#)” in “[4.5.2 Setting of scanning type](#)” of “[4.5 Setting of Scanning](#)”.
- **Shutdown of step scanning:** the step scanning mode must not be used unless permitted in measurement, so as to minimize the scanning time. See the setting method in “[4.5.3 Setting of scanning](#)” of “[4.5 Setting of Scanning](#)”.
- **Automatic scanning time:** use the default setting time in the current setting to achieve the most rapid scanning. See the setting method in “[4.5.3 Scanning time](#)” of “[4.5 Setting of Scanning](#)”.
- **Number of scanning points:** use the minimum number required in measurement. See the setting method in “[6.7 Increase of Data Point Number](#)”.

### 2) Setting of noise reduction

Reasonably set the following two items to reduce the scanning time but obtain the acceptable measurement results.

- **Intermediate frequency bandwidth:** use the largest intermediate frequency bandwidth to ensure the acceptable track noise and dynamic range. See the setting method in “[6.6.3 Intermediate frequency bandwidth](#)” of “[6.6 Reduction of Track Noise](#)”.
- **Average:** minimize the averaging factor or shut down the averaging function. See the setting method in “[6.6.1 Scanning averaging](#)” of “[6.6 Reduction of Track Noise](#)”.

### 3) Selection of calibration type

Apply the most rapid calibration meeting the measurement requirements. The time of scanning measurement is almost the same without error correction or with response calibration. The measurement parameters of fully double-port calibration should be updated with error correction by forward and reverse scanning, even if only one S-parameter is displayed, so the measurement time is the longest. For calibration type details, see “[6.2 Selection of Calibration Type](#)”.

### 4) Shutdown of unnecessary functions

The information of all active functions must be updated. In order to increase the scanning speed, the following unnecessary functions for measurement should be shut down.

- **Unnecessary track**
- **Unnecessary cursor**
- **Smoothing**
- **Limit test**
- **Track operation**
- **Display**

The scanning speed of the analyzer depends on measurement settings. Therefore, you should try many times to achieve the highest scanning speed and conforming measurement results.

a) Delete the unnecessary track.

Right-click the mouse on the status bar button used to delete the track. The right-click menu will appear.

Click [**Delete track**] in the right-click menu.



Fig. 6.19 Deletion of Unnecessary Track

b) Close the unnecessary cursor.

Menu path: [**Cursor**] > [**Cursor**] > [**Close cursor**].

Select the cursor to be closed.



Fig. 6.20 Closing of Unnecessary Cursor

c) Shutdown of smoothing function

Menu path: [**Response**] > [**Average**] > [**Smooth...**]. The [**Smooth**] dialog box will appear.

Click [**Smooth ON/off**] to shut down the smoothing function.



Fig. 6.21 Shutdown of Smoothing Function

d) Shutdown of limit test

Menu path: [Analysis] > [Limit test...]. The [Limit test] dialog box will appear.

Click [Limit test ON/off] check box to shut down the limit test function.



Fig. 6.22 Shutdown of Limit Test

e) Shutdown of track operation function

Menu path: [Analysis] > [Save] > [Save/Operate].

Select the **data** in the [Track operation] box.

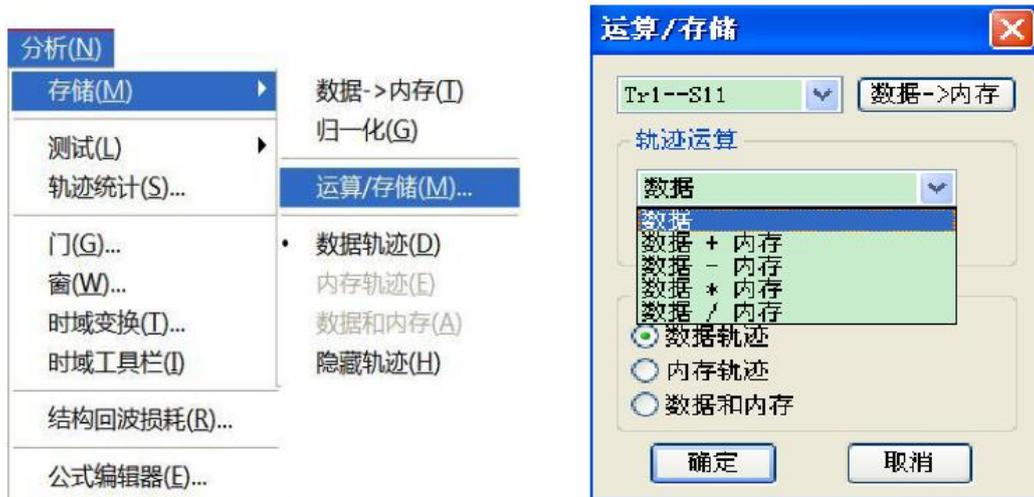


Fig. 6.23 Shutdown of Track Operation Function

## 6.10 Improvement of Efficiency of Multi-state Measurement

If multiple parameter measurements are required to represent the characteristics of one device, various methods can be applied to improve the measurement efficiency. You can try the following methods to find the most suitable application solution.

- [Improvement of measurement efficiency by measurement setting](#) .....221
- [Automatic change of measurement setting](#) .....222
- [Rapid calling of measurement](#) .....222

### 6.10.1 Improvement of Measurement Efficiency by Measurement Setting

In order to improve the measurement efficiency of the tested device requiring various parameter measurements, you should be familiar with the analyzer operation, which can help to create the optimal application solution. See track, channel and window details related to parameter measurements in “3.4 Track, Channel and Window of Analyzer”.

#### 1) Reasonably arrange one group of measurements.

Arrange one group of measurements of the tested device in one instrument state. Save the instrument state so as to perform the previous group of measurements by calling. Or, arrange a group of measurements by the preconfigured measurement setting function of the analyzer. See details in “Setting of preconfigured measurement” of “4.8 Observation of multiple tracks and opening of multiple channels”.

#### 2) Apply the segment scanning function.

Segment scanning can be applied to change the following settings to represent multiple parameter measurements of one device.

- Frequency range
- power level
- intermediate-frequency bandwidth
- Number of scanning point

A group of frequency ranges with respective attributes can be defined in segment scanning. In this case, the tested device with multiple measurement settings can be measured by means of one scanning. See segment scanning details in the “Setting of segment scanning type” of “4.5.2 Setting of scanning type” of “4.5 Setting of scanning”.

#### 3) Selectively trigger the measurement.

Set the measurement as follows by triggering.

- Continuously update the measurement with rapid data changes.
- Occasionally update the measurement with a few data changes.

For example, the tuning measurement of one filter can be set by the following settings:

- One channel is used to measure the passband response of the filter in tuning.
- One channel is used to measure the out-of-band response of the filter.

In this case, the turning measurement of the filter can be observed continuously. If all channels are updated constantly, the response speed of the analyzer will be reduced, and the filter cannot be tuned rapidly. Measurement setting is introduced as follows.

- Measurement data of Channel 1 will be updated continuously.
- Measurement data of Channel 2 will be updated when required.

#### a) Use the mouse.

1) Create the double-channel measurement.

Menu path: **[Response]** > **[Display]** > **[Measurement setting]** > **[Setting D]**.

2) Set the trigger mode of Channel 1: constantly update measurement data.

Menu path: **[Excitation]** > **[Trigger]** > **[Trigger...]**. The **[Trigger]** dialog box will appear.

Select the **[Internal]** radio box in the **trigger source** zone.

Click the **[Channel]** box in the **trigger setting** zone and select **Channel 1**.

Click the **[Constantly]** radio box in the **trigger setting** zone.

3) Set the trigger mode of Channel 2: update measurement data when required.

Click the **[Channel]** box in the **trigger setting** zone and select **Channel 2**.

Click the **[Once]** or **[Group]** radio box in the **trigger setting** zone. If the **group triggering** mode is selected, enter the group number in the **[Group]** input box.

4) Click **[Soft keyboard]** in the **[System]** menu. The **[Soft keyboard]** dialog box will appear. Click **[Excitation]** > **[Trigger]** in the dialog box and the toolbar to trigger the corresponding soft key will appear.

5) Click the window below to set Channel 2 as the current active channel.

6) Update the measurement data of Channel 2.

7) Click the **[Once]**, **[Group scanning]** or **[Re-scanning]** on the **trigger** soft key toolbar. Measurement data of Channel 2 will be updated.

### 6.10.2 Automatic Change of Measurement Setting

Automatically change measurement settings by means of programming to effectively improve the efficiency of multi-parameter measurements.

### 6.10.3 Rapid calling of measurement

The most effective method to call the measurement is to save a group of measurements as one instrument state.

- The time difference of calling the instrument with one or more measurements is little.
- The corresponding time is required in each calling. The calling time can be saved by setting a group of measurements.

## 6.11 Rapid Data Transmission

Rapid data transmission can help to improve the measurement efficiency. You can apply the following methods to increase the data transmission speed.

- **Rapid calling of measurement** .....222
- **Minimization of transmission data** .....223

- Use of real number format .....223
- Use of LAN .....223
- Use of COM program .....223

### 6.11.1 Use of “Once” Trigger Mode

Use the “single” trigger mode to complete measurement before data transmission.

Menu path: **[Excitation]** > **[Trigger]** > **[Trigger...]**. The **[Trigger]** dialog box will appear.

Select the **[Internal]** radio box in the **trigger source** zone.

Select the measurement channel for data transmission by clicking the **[Channel]** box in the **trigger setting** zone.

Click the **[Constantly]** radio box in the **trigger setting** zone and then click **[OK]** to close the dialog box.

Update the measurement results:

- 1) Click the corresponding track state button to set the track and channel to be updated as the active track and channel.
- 2) Click **[Soft keyboard]** in the [System] sub-menu. Then click **[Excitation]** > **[Trigger]** in the **[Soft keyboard]** dialog box.
- 3) Click **[Once]** in the **trigger** soft key toolbar.

### 6.11.2 Minimization of Transmission Data

Apply the segment scanning function to reduce the number of track points, instead of transmission of the whole track with a lot of linear points.

### 6.11.3 Use of Real Number Format

Select the real number format in automatic measurement using SCPI so as to achieve the highest transmission speed.

### 6.11.4 Use of LAN

Use the LAN to increase the data transmission speed in the automatic SCPI measurement application.

### 6.11.5 Use of COM Program

Use COM in the automatic measurement program to achieve the highest speed of data transmission.

## 6.12 Use of Macro

The macro is an executable file installed and run in the analyzer. AV3672 series vector network analyzers support up to 10 macros.

- New macro .....223
- [Macro setting] dialog box .....224
- [Macro setting window] dialog box .....225

### 6.12.1 New macro

Menu path: **[System]** > **[Macro]** > **[Macro setting...]**. The **[Macro setting]** dialog box will appear.



Fig. 6.24 Macro Setting

Click the [Macro setting] dialog box to activate the blank line under the macro settings. Click the [Edit...] button and the [Macro setting window] dialog box will appear.

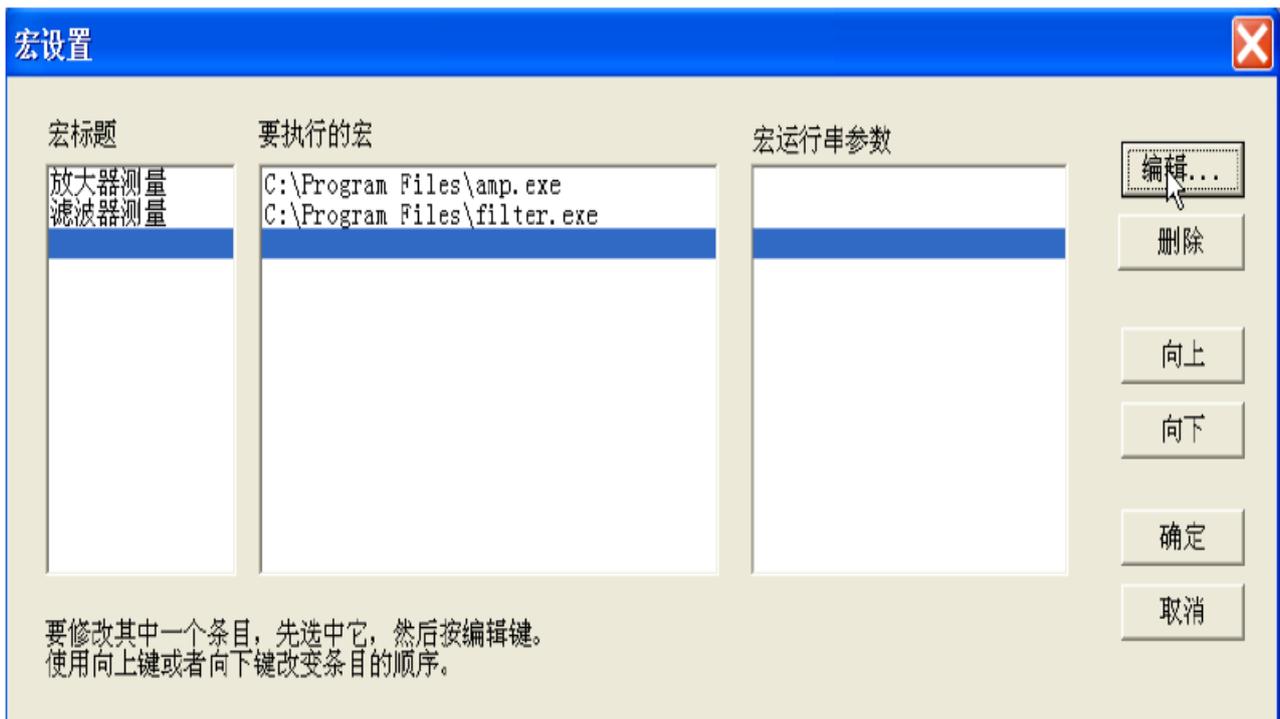


Fig. 6.25 [Macro setting] Dialog Box

- Enter the macro title text in the [Macro name] box.
- Enter the detailed path of the executable file in the [Executable file] box, or click the [Browse...] button to find the executable file.
- Enter the character string parameter of the executable file in the [Parameter] box.

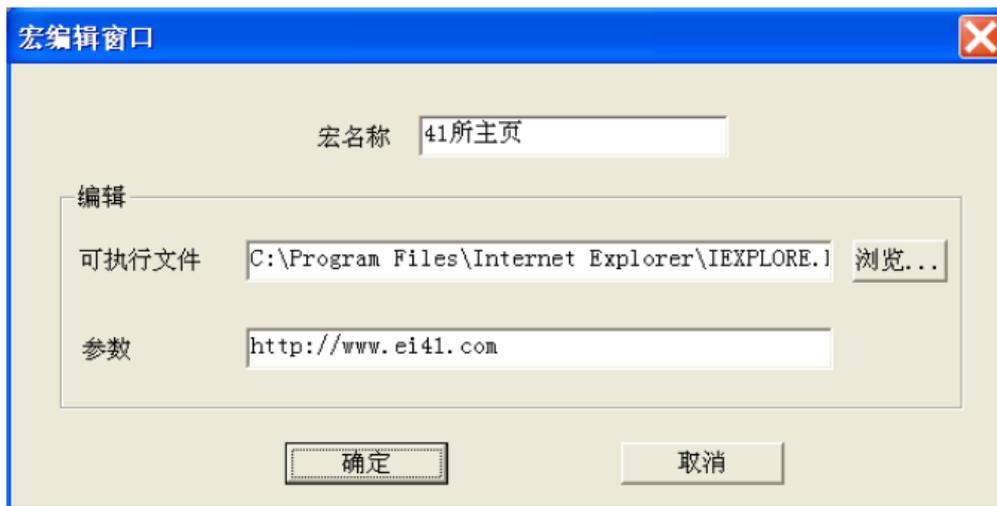


Fig. 6.26 [Macro setting window] Dialog Box

### 6.12.2 [Macro setting] Dialog Box

#### 1) [Macro title] box

Display the macro title. If the **[Macro/local]** key is pressed, the macro title can be displayed in the current toolbar button. Click **[Macro]** in the system menu. The macro title will be displayed in the **macro** sub-menu. To display the complete macro title in the current toolbar button, the number of title characters should not exceed 14. The macro title can be associated with the executable file. It is better to describe the macro function so as to easily distinguish different macros. For example, the title of the macro to visit the home page of the 41st Institute can be named as “41st Institute Home Page”.

#### 2) [Macro to be executed] box

Display the full path of the executable file. Take the macro to visit the home page of the 41st Institute as an example. The path of the executable file is: C:\ProgramFiles\InternetExplorer\IEXPLORE.EXE.

#### 3) [Macro running string parameter] box

Display the parameter to be transmitted to the executable file and used by the executable file. Take the macro to visit the home page of the 41st Institute as an example. The parameter of macro running is: http://www.ei41.com.

#### 4) [Edit] button

Click it to display the **[Macro editing window]** dialog box to set and modify the selected macro.

#### 5) [Delete] button

Click it to delete the selected macro.

#### 6) [UP] button

Click it to move the selected macro **up** for one line. It is used to rearrange the macro sequence. The macro sequence in the dialog box is the same as that in the current toolbar. Four macros will be displayed in the toolbar each time. If **[Macro/local]** is pressed, four macros will be displayed.

#### 7) [DOWN] button

Click it to move the selected macro **down** for one line.

### 6.12.3 [Macro setting window] dialog box

#### 1) [Macro name] box

Set the macro title name.

#### 2) Editing zone

##### a) [Executable file] box

Set the full path of the executable file.

**b) [Browse...] button**

Browse the drive and director, position the executable file and establish the full path of the executable file.

**c) [Parameter] box**

Used to set the character string parameter to be transmitted to the executable file for reference.

## 7 Calibration

Calibration can help to reduce the measurement error. This chapter includes the following contents:

- Calibration overview .....227
- Selection of calibration type .....228
- Calibration guide .....230
- High-accuracy measurement calibration .....233
- Measurement error .....235
- Editing of calibration kit definition .....238
- Calibration standards .....248
- TRL calibration .....250
- Fixture compensation calibration .....251
- Electronic calibration .....251

### 7.1 Calibration Overview

Measurement calibration is a process to determine the system errors according to the standards of the existing measurement characteristics and then eliminate the influence of system errors during measurement of the tested device. It can help to reduce the measurement error and improve the measurement accuracy of the analyzer.

#### 7.1.1 Definition of Calibration

Calibration is a process to eliminate one or more system error(s) with the error model. The error item of the error model is solved by measurement according to high-quality calibration standards (including the open-circuit device, short-circuit device, load and through type part). See system error details in “7.5.3 System Error” of “7.5 Measurement Error” in this chapter.

Select the appropriate calibration method according to the measurement type and accuracy requirements. See details in “7.2 Selection of Calibration Type”.

Various kinds of calibration can be done according to the calibration guide of the calibration. See details in “7.3 Calibration Guide”.

The measurement accuracy after calibration depends on the quality of the calibration standard and the model definition accuracy of the standard calibration kit in the calibration kit definition file. The calibration kit definition file is saved in the analyzer. In order to ensure the measurement accuracy, the actual calibration kit must conform to the requirements of the calibration kit definition file. See accurate calibration details in “7.4 High-accuracy Measurement Calibration”.

The user must correctly define the calibration standard in the calibration kit definition file of the user so as to use the custom calibration kit (e.g. for fixture measurement calibration). See details in “7.6 Editing of Calibration Kit Definition”.

#### 7.1.2 Significance of Calibration

It is impossible to make an ideal analyzer requiring no error correction from the perspective of hardware circuit. Even if error correction can be ignored in good hardware circuits, the costs will be high. In addition, the measurement accuracy of the analyzer is largely influenced by external accessories. The amplitude and phase changes of test components such as the connecting cable and adapter will affect response the real response of the tested device. Therefore, the best method is to balance the hardware performance and cost, make high-quality hardware as practical as possible and improve the measurement accuracy by calibration.

#### 7.1.3 Applications of Calibration

- High measurement accuracy is expected.
- Different types of connector or impedance are used.

- A cable is connected between the tested device and the test port of the analyzer.
- The tested device is measured in a wide frequency range or a device of long electrical delay is measured.
- An attenuator or similar device is connected to the input or output end of the tested device.

### 7.1.4 Simple Calibration Process

- 1) Connect the analyzer according to the measurement requirements.
- 2) Select the appropriate analyzer to optimize measurement.
- 3) Remove the tested device and select the calibration type and kit according to the calibration guide.
- 4) Connect the standard calibration kit of the selected type in measurement according to the calibration guide. The error is calculated by measurement with the standard calibration kit and saved in the memory of the analyzer.
- 5) Reconnect and measure the tested device. If error correction is applied during measurement, the error influence will be eliminated.

## 7.2 Selection of Calibration Type

AV3672 series vector network analyzers support six common calibration types, with details as follows:

### 1) Open-circuit response

- a) Calibration accuracy: low to medium.
- b) Measurement parameter: S11, S22, S33 and S44.
- c) Standard calibration kit: open-circuit device.
- d) System error correction: reflection tracking.
- e) Measurement application: reflection measurement of any port.

### 2) Short-circuit response

- a) Calibration accuracy: low to medium.
- b) Measurement parameter: S11, S22, S33 and S44.
- c) Standard calibration kit: short-circuit device.
- d) System error correction: reflection tracking.
- e) Measurement application: reflection measurement of any port.

### 3) Through type response

- a) Calibration accuracy: medium.
- b) Measurement parameter: S-parameter of transmission measurement.
- c) Standard calibration kit: through type device.
- d) System error correction: transmission tracking.
- e) Measurement transmission measurement in any direction.

---

## Attention

**The adapter is used as the through type device.**

The through type device is of zero length and loss according to the definition in the calibration kit definition file. If the adapter is used as the through type device in calibration, the characteristics of the adapter must be specified in the calibration kit definition file to ensure the accuracy of calibration. See details in “7.4 High-accuracy Measurement Calibration”.

---

### 4) Through type response and isolation

- a) Calibration accuracy: medium.

- b) Measurement parameter: S-parameter of transmission measurement.
- c) Standard calibration kit: through type device and two load (one respectively for each port).
- d) System error correction:
  - Transmission tracking
  - Crosstalk
- e) Measurement application:
  - Transmission measurement in any direction.
  - Improvement of the dynamic range of the system by means of isolation calibration.

---

## Attention

### Isolation calibration

Isolation calibration is not allowed if all the ports are not respectively connected with one load at the same time.

---

### 5) One-port (reflection)

- a) Calibration accuracy: high
- b) Measurement parameter: S11, S22, S33 and S44.
- c) Standard calibration kit: open-circuit device, short-circuit device and load.
- d) System error correction:
  - Direction
  - Source matching
  - Reflection tracking
- e) Measurement application: reflection measurement of any port.

### 6) Full double-port SOLT

- a) Calibration accuracy: high
- b) Measurement parameters: all
- c) Standard calibration kit: open-circuit device, short-circuit device, load and through type device.
- d) System error correction:
  - Direction
  - Source matching
  - Reflection tracking
  - Crosstalk
  - Transmission tracking
- e) Measurement application:
  - Measurement of all S-parameters.
  - Improvement of the measurement accuracy by 12 error corrections.

## 7.3 Calibration Guide

Select the calibration type and perform calibration according to the calibration guide of the analyzer. The through type response and isolation calibration are taken as examples below to demonstrate the calibration process (this kind of calibration is effective only in transmission measurement).

Enable the calibration guide for calibration.

1) Menu path: [**Calibration**] > [**Calibration...**]. The [**Calibration guide**] dialog box will appear.



Fig. 7.1 Enabling of Calibration

2) Click [**Unguided calibration**] and [**Next**].

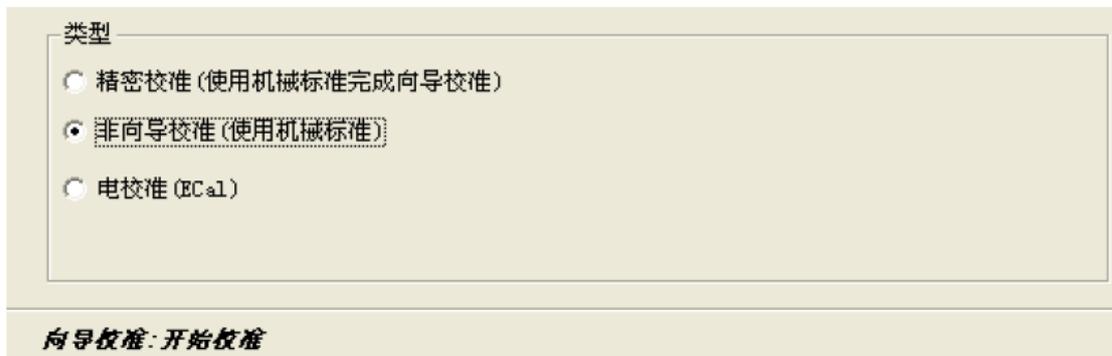


Fig. 7.2 Start of Calibration

3) Click [**Through type response and isolation calibration**] and [**Next**].



Fig. 7.3 Selection of Type of Mechanical Calibration

4) Click [**Select calibration kit**], and the [**Select calibration kit**] dialog box will appear. Select the calibration kit and click [**OK**] to open the dialog box. Thus the calibration kit is changed.

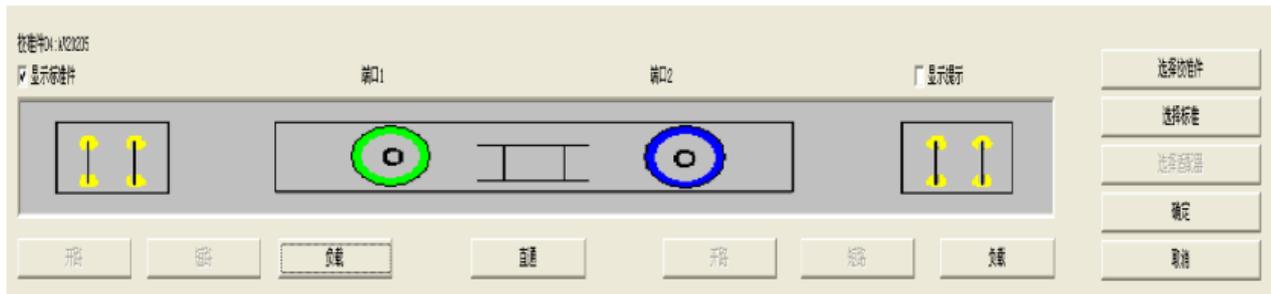


Fig. 7.4 [Through type response and isolation calibration] Dialog Box and [Select calibration kit] Dialog Box

5) Click **[Select standard]**, and the **[Type information]** dialog box will appear. Set the calibration standard and click **[OK]** to close the dialog box.



Fig. 7.5 [Type information] Dialog Box

6) To directly connect Port 1 and 2 through the cable, click **[Through]** and [(THRU)]. After connection, click **[OK]**. The standard calibration kit button in the **[Through type response and isolation calibration]** dialog box will become green after through type calibration. Modify the frequency range of calibration in the **[Minimum frequency]** and **[Maximum frequency]** input box.

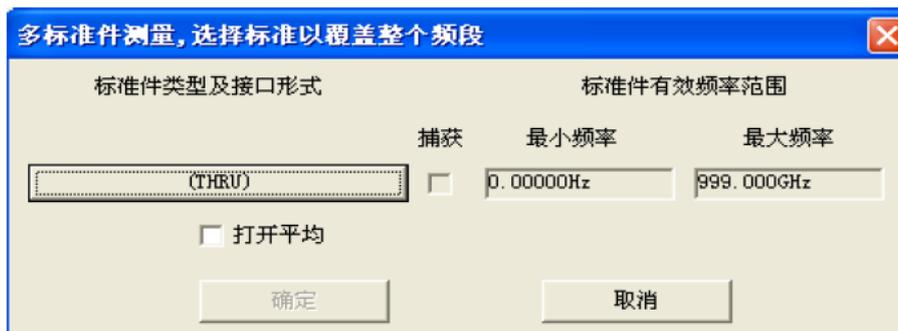


Fig. 7.6 [Measurement of multiple standard kits] Dialog Box

7) Respectively connect Port 1 and 2 to the load calibration kit. Click **[Load]** and the keys of the **standard kit type and interface type** (the display contents vary from calibration types). After selection, click **[OK]**. Modify the frequency range of calibration in the **[Minimum frequency]** and **[Maximum frequency]** input box. The standard calibration kit button in the **[Through type response and isolation calibration]** dialog box will become green after isolation calibration.



Fig. 7.7 [Measurement of multiple standard kits] Dialog Box

8) Click [OK] in the [Through type response and isolation calibration] dialog box after calibration.

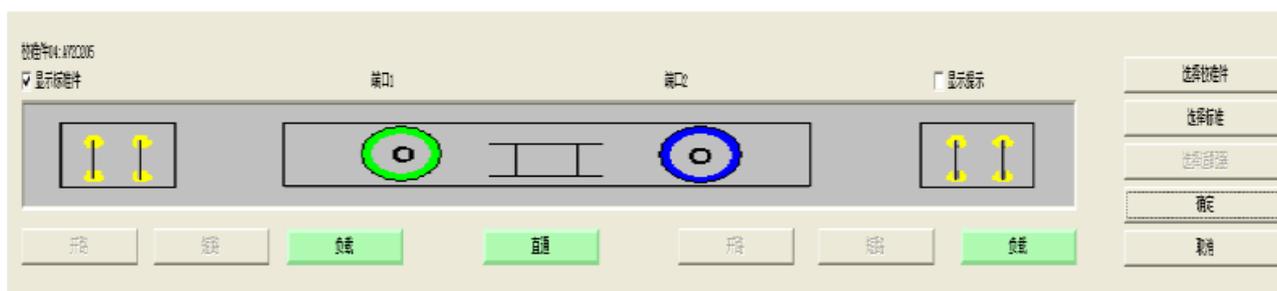


Fig. 7.8 [Through type response and isolation calibration] Dialog Box

Notes: 1. The optional calibration type is associated with the measurement parameters of the current active channel. For example, if the measurement parameter is  $S_{11}$ , the **through type response** mode or the **through type response and isolation calibration** mode cannot be selected.

2. If isolation calibration is not required in the full double-port calibration, tick the [Ignore isolation (2-port type)] check box.

## Attention

**Properly select the calibration standard to realize the highest calibration accuracy.**

The [Measurement of multiple standard kits] dialog box shows the standard connector types, instead of the connector types for non-test ports. In order to realize the highest calibration accuracy, the calibration standard must be selected properly.

## 7.4 High-accuracy Measurement Calibration

The calibration accuracy depends on the selected calibration type, calibration kit quality and calibration process. This section mainly discusses how to perform high-accuracy calibration.

### 1) Measurement reference plane

The tested device is not directly connected to the port of the analyzer in most of measurements. Instead, it is connected through the test fixture or cable. The connection point of the tested device must be calibrated to realize the highest measurement accuracy. This point is called the measurement reference plane. If the measurement reference plane is calibrated, the error related to the measurement composition (such as the cable, test fixture and adapter between the analyzer port and reference plane) can be measured and eliminated.

### 2) Influence of calibration kit

Under normal conditions, the calibration standard of the calibration kit is the same as the connector type standard of the tested device. In some cases, however, the calibration kit corresponding to the connector type of the tested device is not provided. For example, the port size of the tested device is 2.4mm, but the connector size of the

analyzer and calibration kit is 3.5mm. If the 2.4mm calibration kit is used for calibration and the 2.4mm/3.5mm adapter is used in measurement, the measurement error will be obvious, especially in reflection measurement, as the adapter is not calibrated. If the applied calibration kit is different from the calibration kit specified for calibration, the calibration accuracy will be reduced. The degree of accuracy reduction depends on the difference between the specified calibration kit and actual calibration kit.

### 3) Accuracy of interpolation measurement

If the instrument settings are different from calibration settings, calibration data can be automatically interpolated into the analyzer. In this case, the measurement accuracy cannot be predicted and may drop greatly or not be affected. The measurement error must be determined depending on the actual situation. If the phase shift added by two measurement points exceeds 180 degrees, the measurement accuracy will drop greatly as the correct phase data cannot be interpolated. Generally, the probability of accuracy reduction may increase as a result of interpolation in the following cases:

- When the frequency span between measurement points is increased;
- When the frequency span between measurement points is too large;
- When the measurement frequency is high, especially above 10GHz.

### 4) Influence of power level

The power level must not be changed after calibration in order to realize the highest accuracy of error correction. However, if the power level is changed under the same conditions as the attenuator settings in calibration, the accuracy of S-parameter measurement only declines a little. If the attenuator settings are changed, the accuracy of error correction will decline further.

### 5) System impedance

The system impedance must be changed in measurement of the impedance device (not 50Ω) such as the waveguide device. The default system impedance is 50Ω.

#### a) Setting of system impedance

Menu path: [System] > [Configuration] > [System impedance...].

Enter the system impedance value in the [Impedance] box and click [OK] to close the dialog box.

### 6) Port extension

The measurement reference plane may be changed as a result of connection of the cable, adapter or fixture after calibration, which may lead to increase of the phase shift. In this case, the additional phase deviation can be compensated by means of port extension. Port extension is the simplest method to compensate the additional phase shift between the calibration plane and tested device plane, but cannot be used to compensate the loss and mismatch of the path between the calibration plane and tested device plane. Therefore, the loss and mismatch should be minimized to realize the highest measurement accuracy. For setting of port extension, refer to “[Setting of port extension](#)” in “[6.5 Improvement of Phase Measurement Accuracy](#)”.

### 7) Correct isolation calibration

Isolation calibration in full double-port calibration is applied to correct the crosstalk error between ports. It is required only in measurement of large insertion loss, such as the out-of-band suppression of the filter, isolation of the switch, etc. When the crosstalk signal is close to the base noise of the analyzer, additional noise will be produced in the error model as a result of isolation calibration. In order to improve the calibration accuracy, you should:

- Perform isolation calibration if necessary;
- Use the narrow intermediate frequency bandwidth;
- Reduce noise by scanning averaging.

The test port of the analyzer should be connected with a load in isolation calibration. In order to realize the highest calibration accuracy, it is preferred to connect the loads to two measurement ports at the same time for isolation calibration. If only one load is provided, connect a well-fitted device to the non-measurement port.

## 7.5 Measurement Errors

Understanding of the source of measurement error and the way of error correction can help to improve the measurement accuracy, as a certain degree of uncertainty still exists no matter how carefully the measurement is done. The following kinds of errors may be produced in measurement with the analyzer.

### 7.5.1 Drift Errors

- Drift errors are produced by performance changes of the instrument or test system after calibration.
- The thermal expansion of the interconnected cables in the instrument and the performance changes of microwave mixer are main causes of the drift error. The drift errors can be eliminated by recalibration.
- The duration of accurate calibration depends on the test environment. The stable environment can help to minimize the drift error.

### 7.5.2 Random Errors

The random error cannot be predicted or eliminated by means of calibration. The influence on measurement results can be reduced by some methods. Random errors are mainly divided into three types:

#### 1) Random error of instrument

a) Electrical disturbance of internal components of the analyzer may result in random noise, mainly including:

- Low-level noise arising from the base noise within the receiver broadband;
- High-level noise or data track jittering, which is mainly caused by the base noise inside the instrument and phase noise of the LO source.

b) The random noise error can be reduced in the following methods:

- Increase the source power input into the tested device;
- Reduce the intermediate frequency bandwidth;
- Apply the function of scanning averaging.

#### 2) Switch repeatability error

The switch is used to change attenuator settings of the source. If the switch acts, contact closing may be different from previous closing sometimes. In this case, the measurement accuracy will be affected seriously. Therefore, the attenuator settings should not be changed in high-accuracy measurement so as to reduce the switch repeatability error.

#### 3) Connector repeatability error

Connector wear may result in electrical performance changes. Proper connection maintenance can help to reduce the connector repeatability error.

### 7.5.3 System Errors

System errors are caused by non-ideal hardware properties and may be repeatable (therefore, it can be predicted). It is assumed that system errors do not change over time. System errors can be determined by calibration and eliminated by mathematical calculation in measurement.

System errors cannot be fully eliminated. Due to limitations of the calibration process, some residual errors may exist after calibration, mainly resulting from:

- Non-ideal calibration standard;
- Connector connection;
- Interconnected cable;
- Instrument.

All measurements are affected by the dynamic accuracy and frequency errors. For reflection measurement, relevant residual errors include:

- Effective direction;
- Effective source matching;

- Effective reflection tracking.

For transmission measurement, relevant residual errors include:

- Crosstalk
- Effective load matching;
- Effective transmission measurement.

### 1) Direction errors

The directional coupler or bridge is used for reflection measurement. The coupling end of the ideal coupler can only output the reflection signal to the receiver for measurement. Actually, a small number of incident signals will leak to the coupling port through the main channel of the coupler, which may result in directional errors in measurement. Directional errors can be determined and reduced in the following methods.

- Connect the load to the measurement port during calibration and regard the load port free from reflection.
- The output signal of the coupling port is the leakage error signal.
- Reduce the directional error signals in reflection measurement.

### 2) Crosstalk errors

Ideally, only the transmission signal through the tested device can reach the receiver. Actually, a small number of signals reach the receiver through other paths in the analyzer. Such signals are called crosstalk signals. Crosstalk errors can be determined and reduced in the following methods.

- Connect the loads to Port 1 and 2 at the same time during calibration.
- The signal measured by the measurement receiver is the leakage signal of the analyzer.
- Eliminate the crosstalk errors by means of error correction during transmission measurement.

### 3) Source matching errors

Ideally, the measurement receiver can receive all signals reflected from the tested device in reflection measurement. Actually, part of the signals reflected by the tested device are reflected by the measurement port back to the tested device. As such signals cannot be measured by the measurement receiver, source matching errors will be produced. They can be determined and reduced in the following methods.

- Connect the short-circuit device to the measurement port in calibration. The signals reflected by the short-circuit device will be measured by the receiver. Measurement results will be saved in the analyzer.
- Connect the open-circuit device to the port. The signals reflected by the open-circuit device will be measured by the receiver. Measurement results will be saved in the analyzer.
- The measurement results will be compared with the known values of the open-circuit device and short-circuit device to determine source matching errors.
- Eliminate source matching errors by means of error correction in reflection and transmission measurement.

### 4) Load matching errors

In the ideal transmission measurement, transmission signals through the tested device are received by the measurement receiver. Actually, part of the signals are reflected by the test port and cannot be measured, thus resulting in load matching errors. The load matching errors can be determined and reduced in the following methods.

- Directly connect Port 1 and 2, with zero length.
- If the source is located on Port 1, measurement signals of Receiver A includes the reflection signals of Port 2. If the source is located on Port 2, measurement signals of Receiver 2 include the reflection signals of Port 2. Thus, load matching errors can be determined.
- Eliminate source matching errors by means of error correction in reflection and transmission measurement.

### 5) Reflection tracking errors

The signals of Receiver A and R1 or B and R2 are compared in reflection measurement. This is called ratio

measurement. In the ideal reflection measurement, the frequency responses of Receiver A and R1 or B and R2 should be identical. Actually, this is impossible and reflection tracking errors may be produced, i.e. vector sum errors caused by test deviations. The error amplitude and phase change with the frequency. Deviations are mainly caused by the following factors:

- Signal separator;
- Test cable and adapter;
- Difference between the reference and test signal paths.

Reflection tracking errors can be determined and reduced in the following methods.

- Connect the short-circuit device to the measurement port in calibration. The signals reflected by the short-circuit device will be measured by the receiver. Measurement results will be saved in the analyzer.
- Connect the open-circuit device to the port. The signals reflected by the open-circuit device will be measured by the receiver. Measurement results will be saved in the analyzer.
- The measurement results will be compared with the known values of the open-circuit device and short-circuit device to determine source matching errors.
- Eliminate reflection tracking errors by means of error correction in reflection and transmission measurement.

### 6) Transmission tracking errors

The signals of Receiver A and R2 or B and R1 are compared in transmission measurement. This is called ratio measurement. In the ideal transmission measurement, the frequency responses of Receiver A and R2 or B and R1 should be identical. Actually, this is impossible and transmission tracking errors may be produced, i.e. vector sum errors caused by test deviations. The error amplitude and phase change with the frequency. Deviations are mainly caused by the following factors:

- Signal separator;
- Test cable and adapter;
- Difference between the reference and test signal paths.

Transmission tracking errors can be determined and reduced in the following methods.

- Directly connect Port 1 and 2, with zero length.
- Measure the signals of Receiver A and R2 or B and R1.
- Determine transmission tracking errors by comparing the signals of two receivers.
- Eliminate transmission tracking errors by means of error correction in transmission measurement.

## 7.6 Editing of Calibration Kit Definition

The [Edit calibration kit] dialog box is used to edit the definition of the calibration kit or create a user-defined calibration kit.

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### 7.6.1 Calibration Kit Definition

Each standard calibration kit (represented by the standard kit ID) is a specific and accurately defined physical device. For example, ID1 of 85056A calibration kit means a 2.4mm male open-circuit device. Standard kits are divided into four types: open-circuit device, short-circuit device, load and through type device/adaptor/air line. Each type of calibration kit has the specific model structure, including the number and physical characteristics of the standard kit. The majority of calibration kits are equipped with a group of adaptors subject to accurate phase matching. The other standard calibration kits must be defined before use.

### 7.6.2 Custom Calibration Kit

Sometimes you may need to edit the calibration kit definition file or create the user-defined calibration kit. In most of measurement applications, the default calibration kit model is suitable for accurate calibration. However, the user-defined calibration kit should be created in the following applications.

- The connector type is different from that defined in the calibration kit model.
- The standard calibration kit different from the defined is used. For example, use three short-circuit devices of different deviations instead of the open-circuit device, short-circuit device and load in one-port calibration.
- Improve the accuracy of the predefined calibration kit model. If the actual properties of the standard calibration kit can be described with the model, the calibration will be more accurate. For example, change the load impedance into 50.1Ω, instead of the defined 50Ω.

To create the user-defined calibration kit, first define the connector type, such as APC7, 3.5mm, APC2.4mm (50Ω), etc. Although more than one connector type can be defined, it is preferred to define one connector type for each kind of calibration kit. The female and male connectors must be defined separately.

### 7.6.3 Create Calibration Kit

- 1) Click [**Calibration**] > [**Edit calibration kit...**]. The [**Edit calibration kit**] dialog box will appear.
- 2) Click [**Insert new calibration kit**]. The [**Edit calibration kit**] dialog box will appear.
  - a) Input the name of the user-defined calibration kit in the [**Calibration kit name**] box.
  - b) Click [**Add**] in the **connector type** zone. The [**Add connector**] dialog box will appear.
- 3) In the [**Add connector**] dialog box:
  - a) Enter the connector name in the **name** box.
  - b) Select the connector type of the calibration kit in the **connector type** zone: [**Female**], [**Male**] or [**No Gender**].
  - c) Set the minimum and maximum working frequency range of the connector in the **frequency range** zone.
  - d) Enter the characteristic impedance (such as 50Ω) of the connector in the **impedance** zone [**Z0**].
  - e) Select the connector medium type in the [**Medium**] box: **coaxial** or **waveguide**.
  - f) Check the entered contents and click [**OK**] to close the dialog box. Then it is not allowed to edit connector information.
  - g) The connector of the other polarity can be added by click [**Add**] in the connector type zone of the [**Edit calibration kit**] dialog box and repeated the above steps.
- 4) Click [**Add**] under the [**Standard kit**] box of the [**Edit calibration kit**] dialog box. The [**Add standard kit**] dialog box will appear. Select the standard kit to be added: [**Open-circuit device**], [**Short-circuit device**], [**Load**], [**Through type**], [**Adapter**] and [**Transmission line**]. Click [**OK**] to close the [**Add standard kit**] dialog box. At the same time, the [Edit] dialog box corresponding to the selected standard kit will appear.
- 5) In the [**Standard**] (such as open-circuit device) dialog box, enter the definition data. For the limited standard kit, the frequency range may be different from that of the connector. Set the frequency range according to the actual minimum and maximum frequency of the standard kit, and click [**OK**] to close the dialog box.

6) Repeat Step 4) and 5) to define all standard calibration kits among custom calibration kits.

#### 7.6.4 Edit calibration kit

1) Click [**Calibration**] > [**Edit calibration kit...**]. The [**Edit calibration kit**] dialog box will appear.

2) Click the calibration kit to be modified in the dialog box.

3) Click [**Edit calibration kit**]. The [**Edit calibration kit**] dialog box will appear. Edit the calibration kit.



Fig. 7.9 [Edit calibration kit] Dialog Box

#### 4) [Open] button

Open the calibration kit list and calibration kit definition file.

#### 5) [Save as] button

Save the current calibration kit list and calibration kit definition as a file.

#### 6) [Restore all calibration kits] button

Reinstall all calibration kits supported by the network analyzer.

#### 7) Calibration kit installation zone

##### a) [Import calibration kit] button

Call the [**Open**] dialog box and import the calibration kit definition in the hard disc or other drives.

##### b) [Save as] button

Open the [**Save as**] dialog box to save the selected calibration kit definition.

##### c) [Insert new calibration kit] button

Open the [**Edit calibration kit**] dialog box to create a new calibration kit definition.

##### d) [Edit calibration kit] button

Open the [**Edit calibration kit**] dialog box and modify the selected calibration kit definition.

e) **[Delete calibration kit]** button

Delete the selected calibration kit definition.

f) **[Recover calibration kit]** button

Recover the modification of the selected calibration kit into the factor setting state.

g) **[^] and [v]** button

Click the [^] and [v] button to select the calibration kit.

**7.6.5 [Edit calibration kit] Dialog Box**



Fig. 7.10 [Edit calibration kit] Dialog Box

**1) Calibration kit identification zone**

a) **[Calibration kit ID]** box

Display or edit the ID number of the existing calibration kit (or the inserted new calibration kit).

b) **[Calibration kit name]** box

Display or edit the name of the calibration kit.

c) **[Calibration kit description]** box

Display or edit the characteristic description of the calibration kit.

**2) Connector type zone**

a) **[Connector]** box

Click the [**Connector**] box or **arrow** button to select the connector type.

**b) [Add] button**

Click the [**Add**] button. The [**Add connector**] dialog box will appear. Add the new connector type of the calibration kit.

**c) [Modify] button**

The [**Modify connector name**] dialog box will appear. Modify the connector name.



Fig. 7.11 [Change connector name] Dialog Box

**3) Type zone**

**a) [Calibration method] box**

Click it to select the calibration method corresponding to the type.

**b) [Edit type] button**

Click it and the [**Type information**] dialog box to set the type of the calibration kit.

**4) Standard zone**

**a) [Calibration kit] box**

Display the ID, name and description of the calibration kit supported by the analyzer at present.

**b) [Add] button**

The [**Add standard**] dialog box will appear. Add the new definition of calibration standard.

**c) [Edit] button**

Click it and the [**Standard calibration kit (such as the open-circuit device, short-circuit device, load, through type connector/air line/adapter)**] dialog box will appear. Modify the definition of the selected standard calibration kit.

**d) [Delete] button**

Delete the definition of the selected standard calibration kit.

**e) [Delete all] button**

Delete the definitions of all standard calibration kits.

**f) [^] and [v] button**

Select the standard calibration kit.

**7.6.6 [Add connector] Dialog Box**



Fig. 7.12 [Add connector] Dialog Box

### 1) Characteristic zone

#### a) [Name] box

Define the name of the calibration kit connector.

#### b) [Description] box

Define the characteristic description of the calibration kit connector.

### 2) Frequency range

#### a) [Minimum frequency] box

Define the allowable minimum frequency of the standard calibration kit in calibration.

#### b) [Maximum frequency] box

Define the allowable maximum frequency of the standard calibration kit in calibration.

### 3) Connector type zone

Select the connector polarity of the standard calibration kit: [Female], [Male] and [No Gender].

### 4) Impedance zone

Define the characteristic impedance of the standard calibration kit.

### 5) Medium zone

Define the medium of the standard calibration kit: [Coaxial] or [Waveguide].

## 7.6.7 [Type information] Dialog Box



Fig. 7.13 [Add connector] Dialog Box

### 1) Calibration kit type zone

Select the calibration type to be edited or observed.

### 2) [>>] and [<<] button

Click the [>>] and [<<] button to add or delete the standard calibration kit of the selected type or select the standard calibration kit in the [Non-selected standard calibration kits] box. Click the [>>] button to add the selected standard calibration kit into the [Selected standard calibration kits] box. Select the standard calibration kit in the [Selected standard calibration kits] box. Click the [<<] button to delete the standard calibration kit of the selected type.

### 3) [^] and [v] button

Adjust the sequence of the standard calibration kits in the [Selected standard calibration kits] box. All the standard calibration kits in the [Selected standard calibration kits] box will appear in the [Measurement of multiple standard kits] dialog box. Select the corresponding standard calibration kit according to the polarity (female or male) of the measurement port and the frequency range of the measurement.

Select the standard calibration kit in the [Selected standard calibration kits] box. Click [^] or [v] to change the sequence of standard calibration kits. This is usable in the following measurement applications. Multiple standard calibration kits are required for one calibration type to cover the whole frequency range. The sequence of the standard calibration kits in the [Selected standard calibration kits] box is the same as that in the [Measurement of multiple standard kits] dialog box.

## 7.6.8 [Add standard] Dialog Box



Fig. 7.14 [Add standard] Dialog Box

### 7.6.9 [Open-circuit device] Dialog Box



Fig. 7.15 [Open-circuit device] Dialog Box

#### 1) Characteristic zone

##### a) [Standard calibration kit ID] box

Display or edit the serial number of the standard calibration kit.

##### b) [Name] box

Display or edit the name of the standard calibration kit.

##### c) [Description] box

Display or edit the characteristic description of the standard calibration kit.

#### 2) Frequency range

##### a) [Minimum frequency] box

Define the minimum working frequency of the open-circuit device in calibration.

b) **[Maximum frequency]** box

Define the maximum working frequency of the open-circuit device in calibration.

### 3) Connector zone

Define the connector polarity of the open-circuit device: **male**, **female** or **no gender**.

### 4) Open-circuit characteristic zone

Define the fringe capacitance of the open-circuit device with **[C0]**, **[C1]**, **[C2]** or **[C3]**.

### 5) Delay characteristic zone

a) **[Delay]** box

Define the one-way transmission time from the calibration plane to standard calibration kit.

b) **[Loss]** box

Define the energy loss caused by the skin effect of the standard calibration kit, in ohms/S, corresponding to the frequency in 1GHz. Respectively measure the loss and delay time of the standard calibration kit at 1GHz and calculate the loss by the following formula:

$$\text{Loss}\left(\frac{\Omega}{\text{S}}\right) = \frac{\text{Loss}(\text{dB}) \times Z_0(\Omega)}{4.3429(\text{dB}) \times \text{Delay}(\text{S})}$$

c) **[Impedance]** box

Define the impedance of the standard calibration kit.

## 7.6.10 [Short-circuit device] Dialog Box



Fig. 7.16 [Short-circuit device] Dialog Box

### 1) Short circuit characteristic zone

Define the residual inductance of the short-circuit device with **[L0]**, **[L1]**, **[L2]** and **[L3]**.

### 7.6.11 [Load] Dialog Box



Fig. 7.17 [Load] Dialog Box

#### 1) Load type zone

##### a) [Fixed impedance] radio box

Select it to set the load type as the fixed load.

##### b) [Sliding resistance] radio box

Select it to set the load type as the sliding load.

##### c) [Specific impedance] radio box

Select it to set the load different from the system impedance  $Z_0$ . The settings of the **complex impedance** zone are not effective until the [Specific impedance] radio box is selected.

#### 2) Complex impedance zone

##### a) [Real part] box

Define the real part of the impedance.

##### b) [Imaginary part] box

Define the imaginary part of the impedance.

### 7.6.12 [Through type/transmission line/adaptor] Dialog Box



Fig. 7.18 [Through type/air line/adaptor] Dialog Box

### 1) Connector zone

Define the connector types of two ports of the standard calibration kit in the [Port 1] and [Port 2] box.

## 7.7 Standard Calibration Kit

This section mainly introduces the basic principle of the calibration kit and some terms in the calibration kit definition file.

### 1) Calibration kit

The calibration kit is a set of physical devices known as standard calibration kits. Each standard calibration kit is accurately known or predicted according to the frequency change amplitude and phase response. To use the definition of the standard calibration kit, the response value must be defined mathematically. Then the calibration type corresponding to the error correction model is formed.

### 2) Standard calibration kit

The standard calibration kit is the reference benchmark of error correction measurement. The electrical delay, impedance, loss and other characteristics of each standard calibration kit have been accurately defined. The definitions are saved in the analyzer and used to calculate various errors of the error model. The analyzer can measure the responses of standard calibration kits in calibration, and errors can be calculated by comparing the measurement results and the known values of the model. The influence of errors on measurement results is eliminated by mathematical operation which is also known as error correction.

### 3) Types of standard calibration kit

Four types of standard calibration kits are provided, corresponding to the structures or types of various definitions. The four types are as follows:

Standard calibration kit	Terminal impedance
Open-circuit device	$\infty\Omega$
Short-circuit device	$0\Omega$
Load	System impedance
Through type connector/air line/ adapter	No terminal impedance

### 4) Definition of standard calibration kit

The definition of the standard calibration kit describes the electrical characteristics and frequency range, including:

a) Minimum frequency

Specify the allowable minimum frequency of the standard calibration kit in calibration.

b) Maximum frequency

Specify the allowable maximum frequency of the standard calibration kit in calibration.

c) Z0

Specify the characteristic impedance of the standard calibration kit, instead of the characteristic impedance of the system or the terminal impedance of the standard calibration kit.

d) Delay

Specify the uniform length of the transmission line between the defined standard calibration kit and actual calibration plane.

e) Type

Specify the type of the standard calibration kit: open-circuit device, short-circuit device, load and through type connector/air line/adaptor.

f) Loss

Specify the energy loss caused by skin effects.

g) Definition of loss model

The loss unit is ohms/S, corresponding to the frequency unit 1GHz. Respectively measure the loss and delay time of the standard calibration kit at 1GHz and calculate the loss by the following formula:

$$\text{Loss}\left(\frac{\Omega}{S}\right) = \frac{\text{Loss(dB)} \times Z_0(\Omega)}{4.3429(\text{dB}) \times \text{Delay(S)}}$$

h) Fringe capacitance model of open-circuit device

The open-circuit device almost has no ideal reflection characteristics as a result of the effects of fringe capacitance at high frequency. The phase shift changes with the frequency. Such effects cannot be eliminated. The fringe capacitance is defined in the open-circuit device model. The capacitance model is a cubic polynomial function of the frequency. The polynomial coefficient is determined according to the actual characteristics of the open-circuit device. The equation of the fringe capacitance model is as follows:

$$C = (C_0) + (C_1 \times F) + (C_2 \times F^2) + (C_3 \times F^3) \quad (F \text{ refers to the measurement frequency}).$$

i) Residual inductance model of short-circuit device

The short-circuit device almost has no ideal reflection characteristics as a result of the effects of residual inductance at high frequency. The phase shift changes with the frequency. Such effects cannot be eliminated. The fringe inductance is defined in the short-circuit device model. The inductance model is a cubic polynomial function of the frequency. The polynomial coefficient is determined according to the actual characteristics of the open-circuit device. The equation of the residual inductance model is as follows:

$$L = (L_0) + (L_1 \times F) + (L_2 \times F^2) + (L_3 \times F^3) \quad (F \text{ refers to the measurement frequency}).$$

## 7.8 TRL Calibration

TRL (Thru-Reflect-Line) calibration includes a series of calibration technologies, such as TRM (Thru-Reflect-Match). In the TRL calibration, 12 error coefficients are determined with two standard calibration kits for transmission and one standard calibration kit for reflection. In the traditional SOLT calibration, however, 12 error coefficients are determined with one standard calibration kits for transmission (T) and three standard calibration kits for reflection (SOL).

### 1) Why to perform TRL calibration?

TRL calibration is accurate and even more accurate than SOLT calibration in some cases. However, only a few

calibration kits support TRL. TRL calibration is always done when high measurement accuracy is required but the calibration kit of the same connector type as the tested device is provided, such as use of the fixture in measurement or use of the probe in wafer measurement. In this case, the calibration kit with the same medium as the tested device must be created and defined. It is easier to make three TRL standard calibration kits than to make four SOLT standard calibration kits. One disadvantage of TRL calibration is that multiple standard calibration kits are required for the transmission line in broadband calibration. For example, two standard calibration kits are required for the transmission line at 2GHz to 26GHz. The standard calibration kits for the transmission line should be particularly long at low frequency.

## 2) TRL standard calibration kit

Three standard calibration kits should be defined for TRL calibration: through type, reflection type and transmission type.

### a) Through type standard calibration kit

The length of the through type can be zero or not zero. The zero-length through type is more accurate as a result of no loss or characteristic impedance. The electrical delay of the through type is different from that of the transmission type. The through type standard calibration kit with the amplitude and phase defined accurately can be used to establish the measurement reference plane.

### b) Reflection standard reflection kit

The reflection standard calibration kit is a physical device of large reflection coefficient. The reflection standard calibration kits connected to two measurement ports must have the same characteristics. If the reflection amplitude is not required but the phase is required in calibration, the electrical length of the standard calibration kit must be within  $1/4$  of the wavelength. The reflection standard calibration kit with the amplitude and phase defined accurately can be used to establish the measurement reference plane.

### c) Transmission line type standard calibration kit

The transmission line type standard calibration kit is used to measure the measurement reference impedance after calibration. TRL calibration has the following disadvantages as a result of limitations of the transmission line type standard calibration kit.

- The impedance of the transmission line type standard calibration kit must be the same as that of the through type standard calibration kit.
- The electrical length of the transmission line type standard calibration kit must be different from that of the through type standard calibration kit.
- The transmission line type standard calibration kit must have the appropriate electrical length within the whole frequency range. The phase difference of the transmission line type standard calibration kit and through type standard calibration kit must be between  $20^\circ$  and  $160^\circ$  at each frequency point. Therefore, the actual coverage range of a single transmission line is 8:1. In order to cover a wider frequency range, multiple transmission line type standard calibration kits are required.
- The transmission line type standard calibration kit should be particularly long at low frequency. The optimal length is  $1/4$  of the wavelength corresponding to the geometric average frequency (square root of the product of the starting frequency  $\times$  ending frequency) within the frequency span.

### d) Matching standard calibration kit

If the transmission line of specific length or loss cannot be made, use the matching standard calibration kit instead of the transmission line.

- The matching standard calibration kit is a low-reflection terminal to be connected to the port.
- Use the matching standard calibration kit as the transmission line of high loss and infinite length in calculation of the error coefficient of TRL calibration.
- Change the impedance of the matching standard calibration kit into the reference impedance of measurement.

## 7.9 Fixture Compensation Calibration

The fixture simulator function is used for network port impedance transformation, double-port fixture de-embedding, matching circuit embedding and four-port fixture embedding/de-embedding in the mathematical sense.

It can be used to simulate various measurements based on measurement results in applications, and also rapidly simulate the corresponding measurement results in a real-time manner. The measurement results of the port with the impedance of  $50\Omega$  can be transformed into measurement results of any impedance by means of port impedance transformation. The double-port fixture de-embedding function can be applied to remove any network characteristic between the measurement end face and DUT end face, which is defined in the Touchstone data file, so as to extend to the corresponding calibration surface. The matching circuit embedding function is used to transform the original measurement results into the specific simulation result determined by inserting the matching circuit between the DUT and test port (one-port). The four-port fixture embedding/de-embedding function is used to simulate embedding/de-embedding of the four-port fixture, so as to obtain the simulation results of the tested device after embedding/de-embedding of part of the network.

The handling process of the whole fixture simulator is shown in Fig. 7.19.

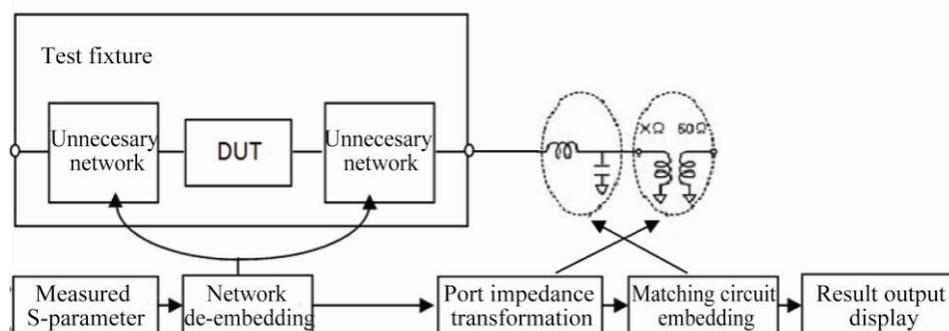


Fig. 7.19 Handling Process of Fixture Simulator

## Prompt

### S-parameter

The S-parameter of the fixture or matching circuit can be obtained at first to realize the above functions. It is represented by the circuit model or Touchstone data file. Fixture embedding/de-embedding is realized according to the known S-parameter of the fixture.

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- [Enabling of fixture function](#) .....252
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- [Four-port fixture embedding/de-embedding](#) .....259

### 7.9.1 Terms of Fixture Simulator

#### ➤ Fixture

The fixture refers to a device which is set between the tested device and cable and used to fix the tested device. The S-parameter is the key to fixture embedding and de-embedding. However, it is difficult to determine the S-parameter. One of the current feasible methods is to establish the fixture model by linear simulation or simulate the fixture with the three-dimensional electromagnetic structure, and the other method is used to determine the fixture loss and delay time by means of port extension.

#### ➤ Touchstone data file (SnP file)

It is a data format created by EEsoft before purchase by HP, or widely known as the S2P format. If multiple ports are extended, the file is generally known as the SnP file, where n represents the number of ports. The corresponding S-parameters of n ports are saved in this file.

#### ➤ Circuit parameter model

The impedance of the components and circuits should be matched in the microwave component and circuit design phase. Generally, the conjugate matching circuit is composed of the resistance (R), inductance (L), capacitance (C) and conductance (G) in the impedance matching design. The parameter form of the conjugate matching circuit is referred to as the circuit parameter model.

### 7.9.2 Enabling of Fixture Simulation Function

Menu path: [Calibration] > [Fixture simulator]. Click [Fixture enabling on/OFF] under [Fixture simulator]. Then this option will change into [Fixture enabling ON/off]. Thus the **fixture simulator** function is enabled (in this case, all the functions of the fixture simulator are effective). In the default mode, this option is [Fixture enabling on/OFF], indicating that the **fixture simulator** function is shut down.



Fig. 7.20 Enabling of Fixture Simulation Function

### 7.9.3 Matching Circuit Embedding

This function is used to transform the original measurement results into one characteristic determined by inserting the matching circuit between the DUT and test port (one-port). The inserted matching circuit is selected from the five preset circuit models or from the circuits defined in the double-port Touchstone file.

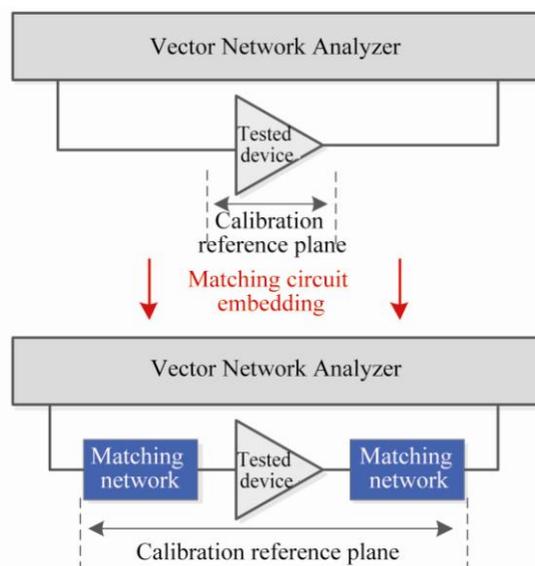


Fig. 7.21 Schematic Diagram of Matching Circuit Embedding (take the double-port tested device as an example)

#### 1) [Matching circuit embedding] dialog box

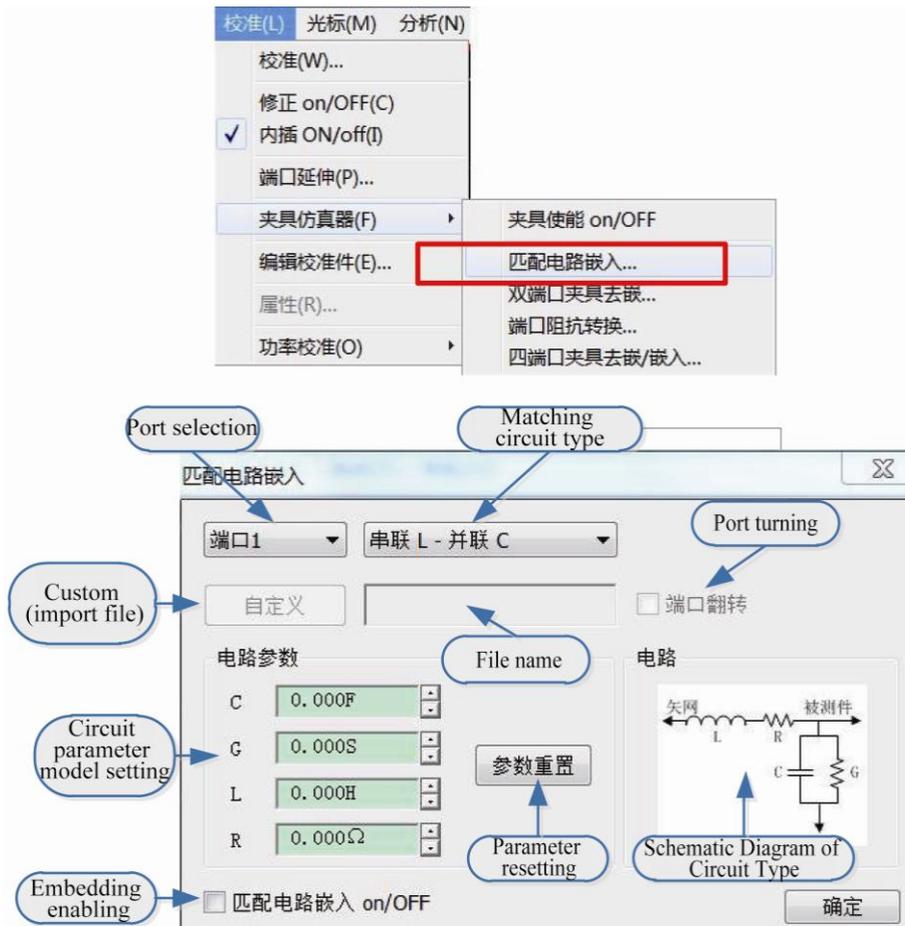


Fig. 7.22 [Matching circuit embedding] Interface

a) [Port selection] drop-down menu

Select the port number of the matching circuit embedded into the vector network.

b) [Matching circuit type] drop-down menu

Select the embedded matching circuit type. The network analyzer is provided with the following import formats: None (with no circuit embedded), **5 circuit parameter models** and **S2P** file. Different schematic diagrams will appear in the [Circuit] bar when different types are selected.



Fig. 7.23 [Matching circuit type] Drop-down Menu

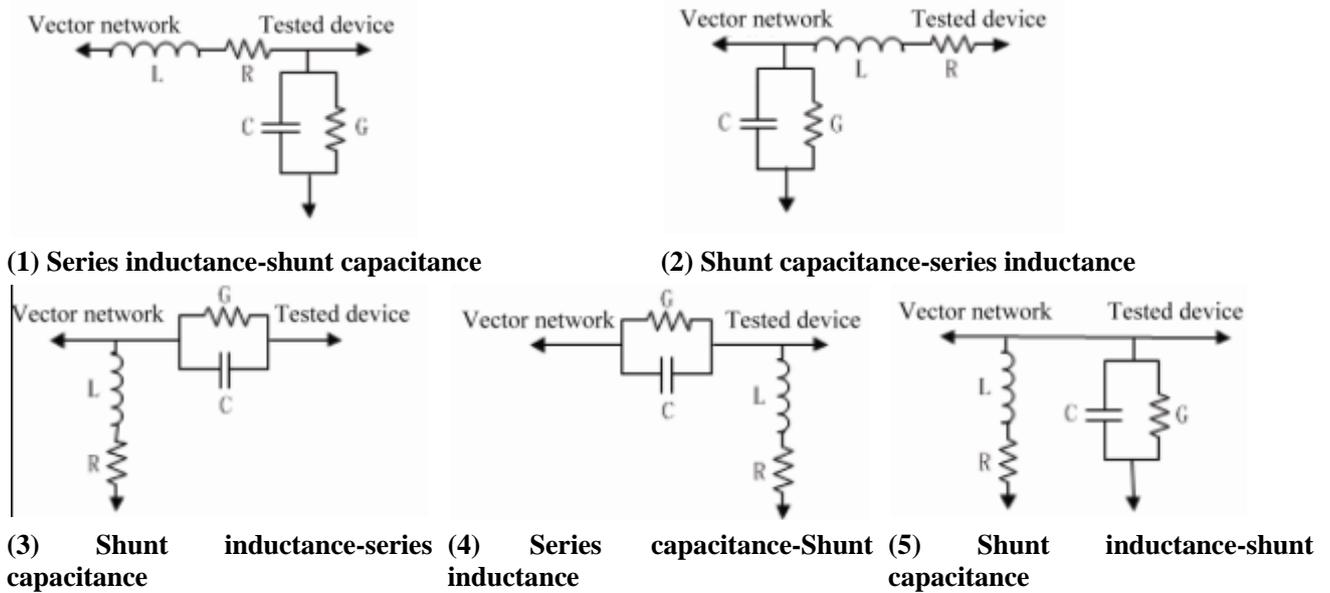


Fig. 7.24 Five Parameter Types of Embedded Matching Circuit

c) **[Custom]** button

This is not available in the default mode. If **[User]** is selected in the **[Matching circuit type]** drop-down menu is selected, this button will be available. Click this button and select the **S2P** file for import of fixture S-parameters in the pop-up dialog box. After the file is selected, the name of the imported file will be displayed in the box on the right side of the **[Custom]** button.

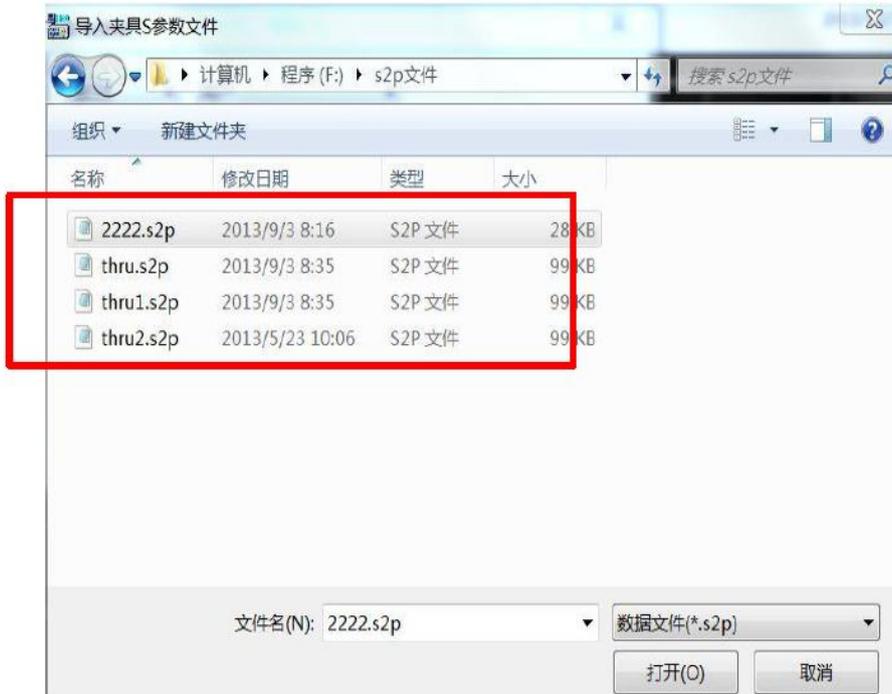


Fig. 7.25 Selection of S2P File to Be Imported

d) **[Port turning]** check box

This is not available in the default mode. If **[User]** is selected in the **[Matching circuit type]** drop-down menu is selected, this check box will be available. Click this check box to turn the port number of the imported **S2P** file.

e) **[Circuit parameter model setting]** edit box

This is not available in the default mode. If one of the **five circuit parameter models** is selected in the **[Matching circuit type]** drop-down menu, this edit box will be available. Modify the parameter in the edit box to change the relevant parameter of the corresponding **circuit parameter model**.

f) **[Parameter resetting]** button

This is not available in the default mode. If one of the **five circuit parameter models** is selected in the **[Matching circuit type]** drop-down menu, this button will be available. Click this button to reset all the contents in the **[Circuit parameter model setting]** edit box.

g) **[Matching circuit embedding on/OFF]** check box

Click it to enable the matching circuit embedding function.

h) **[OK]** button

Click it to make the settings in the dialog box effective for the current active channel.

## 2) Steps of matching circuit embedding

Menu path: **[Calibration]** > **[Fixture simulator]**. Click **[Matching circuit embedding...]** in the **[Fixture simulator]** sub-menu. The **[Matching circuit embedding]** dialog box will appear.

Tick **[Matching circuit embedding on/OFF]** in the dialog box to enable the matching circuit embedding function.

Click the **[Port selection]** drop-down menu and select the matching circuit embedding port.

Select the type of the embedded circuit in the drop-down menu on the right side of **[Port selection]**. The network analyzer is configured with **five circuit parameter models** and **custom** mode. The schematic diagram is shown in the **[Circuit]** box.

If the **circuit parameter model** is selected as the circuit type, edit the corresponding **capacitance**, **inductance**, **resistance** and **conductance** in the corresponding **circuit parameter** bar. Click **[Parameter resetting]** to recover the default parameter. If “User-defined” is selected as the circuit type, the **[Custom]** button will be available. Click the **[Custom]** button and select the S2P file to be used in the pop-up dialog box. The file name will be displayed in the lateral square box. Thus the **[Port turning]** check box will appear. Click this check box to customize port turning in the S2P file.

Click **[OK]** to complete the setting.

### 7.9.4 Double-port Fixture De-embedding

The network de-embedding function can be used to eliminate the characteristics of any network defined by the Touchstone data file between the measurement end face and DUT end face, so as to extend the corresponding calibration plane.

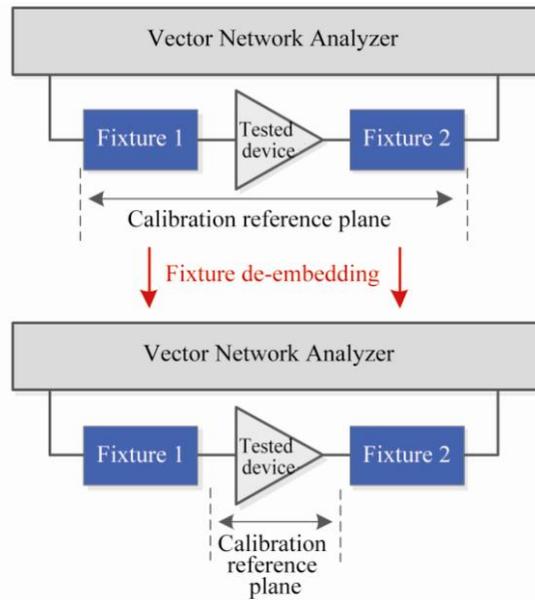


Fig. 7.26 Schematic Diagram of Fixture De-embedding (take the double-port tested device as an example)

**1) [Double-port fixture de-embedding] dialog box**

a) **[Port selection]** drop-down menu

Select the vector network port number of the fixture to be de-embedded.

b) **[De-embedding type]** drop-down menu

Select the de-embedding type in the drop-down menu on the right side of [Port selection]. The network analyzer is configured with the user-defined de-embedding type. The contents in the schematic diagram will change if different types are selected.

c) **[Import file]** button

This is not available in the default mode. If [User] is selected in the [De-embedding type] drop-down menu, this button will be available. Click this button and select the S2P file for import of the fixture S-parameter in the pop-up dialog box (as shown in Fig. 7.25). After the file is selected, the file name will be display in the box on the right side of the [Import file] button. At the same time, the relevant maximum/minimum frequency will be updated on the frequency range display bar of the vector network port and file.

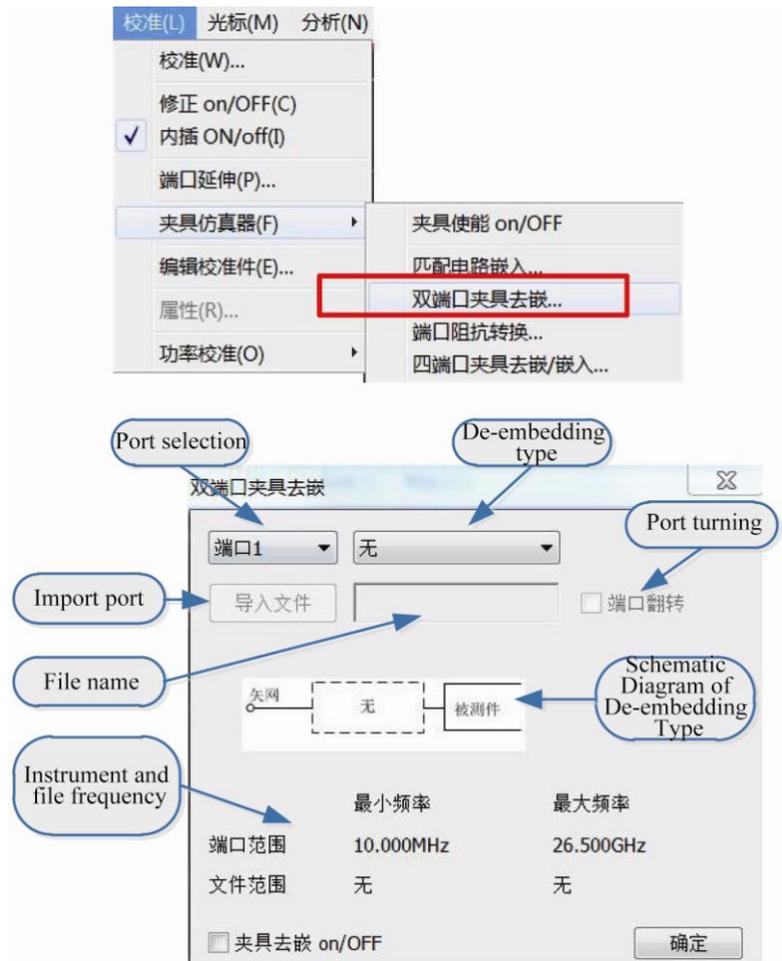


Fig. 7.27 [Double-port fixture de-embedding] Interface

d) [Port turning] check box

This is not available in the default mode. If [User] is selected in the [De-embedding type] drop-down menu, this check box will be available. Click this check box to turn the port number of the imported S2P file.

e) [Fixture de-embedding on/OFF] check box

Click it to enable the double-port fixture de-embedding function.

f) [OK] button

Click it to make the settings in the dialog box effective for the current active channel.

2) Steps of double-port fixture de-embedding

Menu path: [Calibration] > [Fixture simulator]. Click [Double-port fixture de-embedding...] in the [Fixture simulator] sub-menu. The [Double-port fixture de-embedding] dialog box will appear.

Click the [Fixture de-embedding on/OFF] button in the dialog box to enable the double-port fixture de-embedding function.

Click the [Port selection] drop-down menu and select the port for fixture de-embedding.

Select the de-embedding type in the drop-down menu on the right side of [Port] selection. The network analyzer is configured with the user-defined de-embedding type.

If [User] is selected in the [De-embedding type] drop-down menu, this button will be available. Click the [Import file] button and select the S2P file to be used in the pop-up dialog box. The file name will be displayed in the lateral square box. The vector network frequency information and file frequency information will be updated.

Click the [Port turning] check box to turn the power in the custom S2P file. The corresponding schematic diagram

will change accordingly.

Click [OK] to complete the setting.

### 7.9.5 Port Impedance Transformation

The measurement result with the port impedance as the system impedance can be transformed into the measurement result of any impedance.

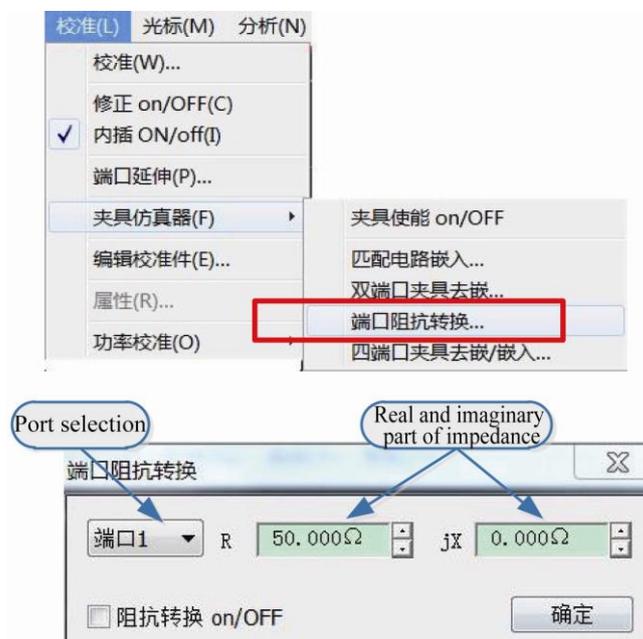


Fig. 7.28 [Port impedance transformation] Interface

#### 1) [Port impedance transformation] dialog box

##### a) [Port selection] drop-down menu

Select the number of the vector network port for impedance transformation.

##### b) [Real part of impedance] edit box

Modify the parameter in the edit box to set the impedance value to be obtained by transformation.

##### c) [Impedance transformation on/OFF] check box

Select it to enable the port impedance transformation function.

##### d) [OK] button

Click it to make the settings in the dialog box effective for the current active channel.

#### 2) Steps of port impedance transformation

Menu path: [Calibration ] > [Fixture simulator]. Click [Port impedance transformation...] in the [Fixture simulator] sub-menu. The [Port impedance transformation] dialog box will appear.

Tick the [Impedance transformation on/OFF] button in the dialog box to enable the port impedance transformation function.

Click the [Port selection] drop-down menu and select the port for impedance transformation.

Edit the real part and imaginary part of the impedance to be transformed in the [R (real part of impedance)] and [jX (imaginary part of impedance)] edit box.

Click [OK] to complete the setting.

### 7.9.6 Four-port Fixture Embedding/De-embedding

Simulate embedding/de-embedding of the four-port fixture to obtain the simulation results of the tested device after

embedding/de-embedding of part of the network.

1) [Four-port fixture embedding/de-embedding] dialog box

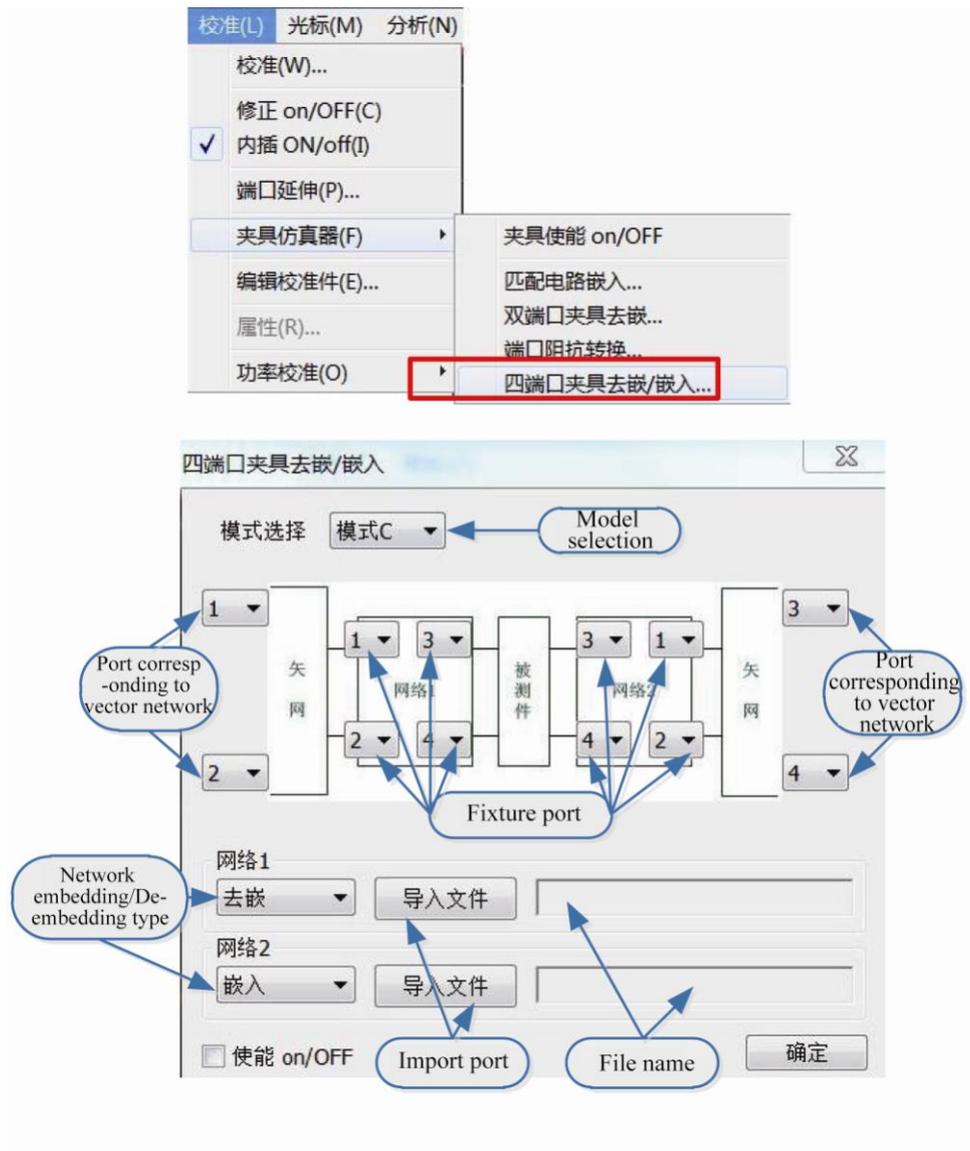


Fig. 7.29 [Four-port fixture embedding/de-embedding] Interface

a) [Mode selection] drop-down menu

Select the fixture embedding/de-embedding mode. The vector network analyzer is configured with three network models (**Mode A, B and C**).

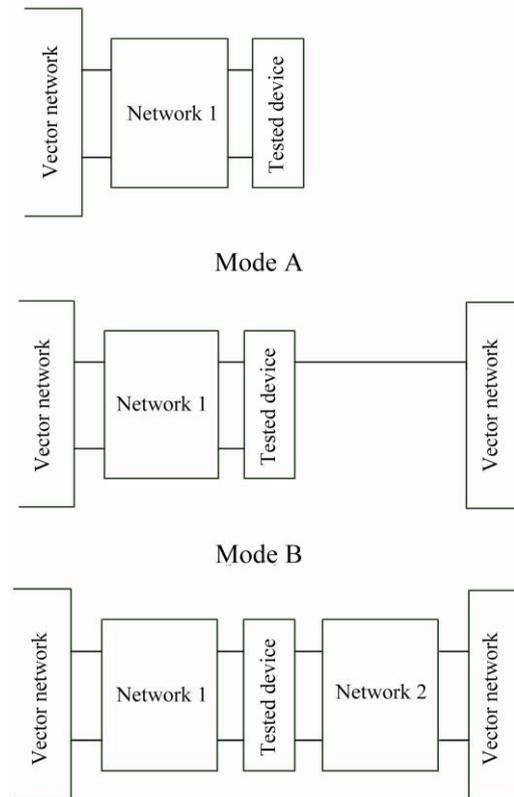


Fig. 7.30 Three Modes of Fixture Embedding/De-embedding

b) **[Network embedding/de-embedding type]** drop-down menu

The network embedding/de-embedding type is the first item of the drop-down menu of **Network 1** (**Network 2** is enabled in **Mode C**). The drop-down menu includes three options: **none**, **de-embedding** and **embedding**.

c) **[Import file]** button

Click this button and select the **S4P** file for import of the fixture S-parameter in the pop-up dialog box (as shown in Fig. 7.25). After the file is selected, the file name will be display in the box on the right side of the **[Import file]** button.

d) **[Port selection]** drop-down menu

The port selection part includes the vector network port and fixture port. The [Fixture port] drop-down menu is not displayed in the default mode. The selected mode and network embedding/de-embedding type will be displayed in the schematic diagram. Select the corresponding port relationship to determine the number of the embedding/de-embedding port and the corresponding relationship to the port for file import.

e) **[Enable on/OFF]** check box

Select this check box to enable the fixture embedding/de-embedding function.

f) **[OK]** button

Click it to make the settings in the dialog box effective for the current active channel.

**2) Steps of four-port fixture embedding/de-embedding**

Menu path: **[Calibration]** > **[Fixture simulator]**. Click **[Four-port fixture de-embedding/embedding...]** in the **[Fixture simulator]** sub-menu. The **[Four-port fixture de-embedding/ embedding]** dialog box will appear.

Tick the **[Enable on/OFF]** button in the dialog box to enable the four-port fixture embedding/de-embedding function.

Click the **[Mode selection]** drop-down menu and select the embedding/de-embedding network model. The vector network analyzer is configured with three network models (**Mode A, B and C**).

Select the embedding/de-embedding type of Network 1 in the drop-down menu of **Network 1** (**Network 2** is enabled in **Mode C**).

If **embedding** or **de-embedding** is selected, the **[Import file]** button will be available. Click the **[Import file]** button and select the **S4P** file to be used in the pop-up dialog box. The file name will be displayed in the lateral square box.

Click **[OK]** to complete the setting.

## 7.10 Electronic Calibration

Electronic calibration is a process to obtain system errors by means of standard measurements of the electronic calibration kit through the network analyzer and calculation according to the fixed value of the electronic calibration kit. The accuracy of electronic calibration is close to that of mechanical calibration. At the same time, artificial errors arising from connection of the standard calibration kit in calibration of the vector network analyzer can be reduced, thus improving the calibration accuracy, calibration speed and calibration result consistency and reducing the losses of the test port and expensive test cable.

Each electronic calibration kit is configured with a unique S-parameter saved in the internal memory. In the calibration process, the vector network analyzer can call the standard S-parameter of the electronic calibration kit to obtain the vector error coefficient by means of complex measurement and calculation.

Compared with mechanical calibration, electronic calibration has obvious advantages:

- 1) High speed and automatic operation. All the calibration can be completed by one connection, thus reducing the times of calibration kit connection, menu button selection operations, operation time, connector wear and costs for maintenance of the test port connector of the test instrument and the calibration kit connector.
- 2) Low risk and high measurement accuracy. The requirements for operators are low, and the possibility of errors caused by operators is reduced, which is conducive to the promotion of the network analyzer in the military, research and production applications.
- 3) New technology and high quality. New calibration and error correction technologies are applied to make the accuracy higher than that of mechanical calibration.



Fig. 7.31 Connection of Four-port Network Analyzer and Electronic Calibration Kit

### Prompt

#### **Electronic calibration kit and electronic calibration:**

For more details, refer to the *User Manual of AV2040X Electronic Calibration Kit*.

## Attention

### Precautions of electronic calibration:

1. Do not disconnect or insert or connect the USB interface equipment during communication with the USB interface. Do not pull down the USB cable immediately after calibration, as data communication may not be over.
2. Do not change the cable connection during calibration. Keep the ambient temperature stable in calibration; otherwise, calibration indicators will be affected.



Fig. 7.32 [Electronic calibration kit] Interface

### Process of electronic calibration:

A. Connect one end of the USB cable to the USB interface of the electronic calibration kit and the other end to the USB interface of the front panel or rear panel of the vector network analyzer. Run the vector network analyzer to preheat it for 30min at least. At the same time, the red WAITING indicator of the electronic calibration kit will be lit, indicating that preheating of the electronic calibration kit is started. Generally, the double-port electronic calibration kit should be preheated for 10min, and the four-port electronic calibration kit for 18min. When the internal temperature of the electronic calibration kit reaches the set temperature, the red READY indicator will be ON (the preheating time is related to the ambient temperature).

B. According to the characteristics of the tested device, set the frequency range, intermediate frequency bandwidth, power level and other excitation information of the vector network analyzer.

C. After preheating, connect the port of the electronic calibration kit to the test port of the vector analyzer through the test cable, and execute the required calibration according to the prompts of the vector network analyzer. Calibration steps are as follows:

Step 1: select [**Calibration (V)...**] in the menu.



Fig. 7.33 Calibration Menu

Step 2: Select [**Electronic calibration (ECal)**] and click [**Next**] to enter the electronic calibration function.



Fig. 7.34 Selection of Calibration Type

Step 3: Select the module and characteristic data of the electronic calibration kit with the [**Calibration kit selection...**] button, as shown in the following figure.

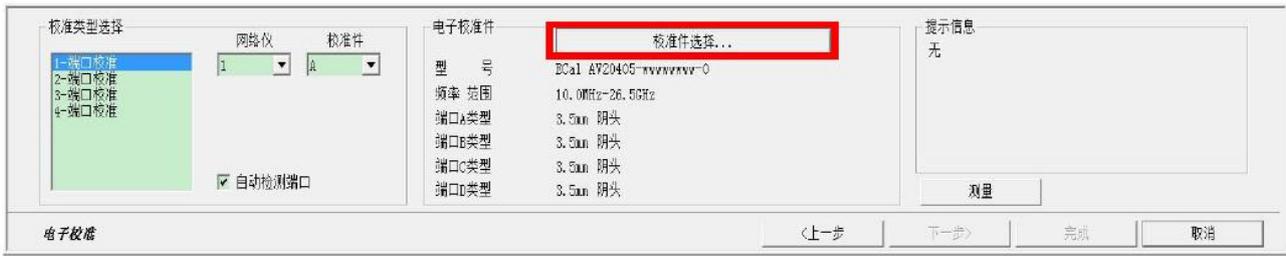


Fig. 7.35 Selection of Electronic Calibration Kit and Characteristic Data

## Attention

### Selection of electronic calibration kit and characteristic data:

If only one electronic calibration kit is connected to the vector network analyzer, the following calibration steps can be directly performed without calibration kit selection.

Step 4: Select the multi-port or one-port calibration in the [Selection of calibration type], as shown in the following figure.



Fig. 7.36 Calibration Port Setting

Step 5: Tick the [Automatically test port connection] function.

You can select whether to tick the [Automatically test port connection] function in the “calibration selection” combined box. If this option is ticked (default), the vector network analyzer can test the connection of the port of the electronic calibration kit and the measurement port of the vector network analyzer, as shown in the following figure. If this option is not ticked, calibration will be done directly according to the set connection mode. (If the frequency measurement range set in the vector network analyzer is beyond the frequency range of the electronic calibration kit, the information shown in the following figure will appear. Exit the window, reset the calibration frequency range and repeat the electronic calibration process).



Fig. 7.37 [Automatically test port connection] Option

Step 6: Click **[Measurement]** to start the measurement of electronic calibration. If necessary, click the **[Interrupt scanning]** to interrupt scanning.



Fig. 7.38 Start and Interruption of Scanning

Step 7: Click **[OK]** to save calibration results after measurement.

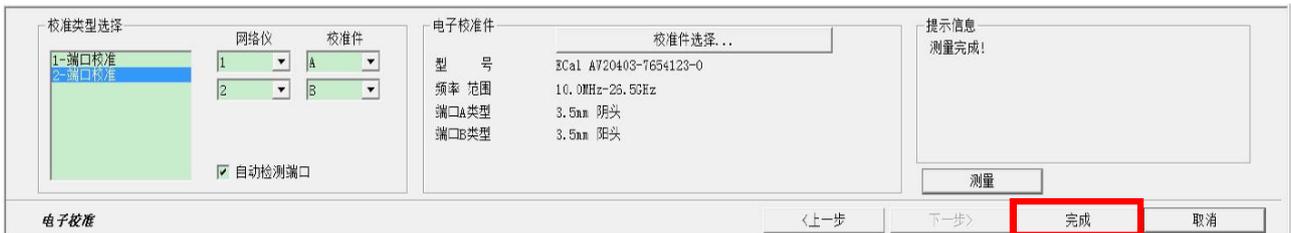


Fig. 7.39 Completion of Calibration

Step 8: Connect the test cable and check the through curve (S21) after calibration. You can roughly observe whether calibration is successful. If the vector network analyzer has good hardware performance, the amplitude of the through curve will be within plus or minus 0.2dB. Remove the test cable from the port of the electronic calibration kit and connect the tested device to start measurement.

## 8 Basis of Network Measurement

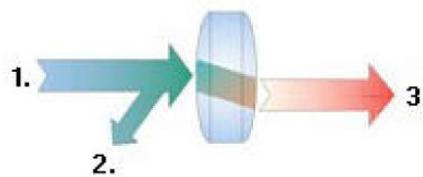
This chapter introduces the following contents:

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### 8.1 Reflection Measurement

Reflection measurement is an important part of network measurement. At first, the reflection measurement will be introduced. In order to better understand reflection measurement, the optical wave is applied to simulate the traveling wave transmission along the transmission line.

If any optical element such as the lens is set, part of light will be reflected by the lens, but the majority of light will be transmitted continuously through the lens. If the surface of the optical element is a mirror, the majority of light will be reflect, and only a little light will be transmitted or no light will be transmitted.



1. Incident light    2. Reflected light    3. Transmitted light

Fig. 8.1 Light Reflection and Transmission

The RF signal will be reflected if the impedance of two connectors is different from each other. Reflection measurement is a process to measure the ratio of the reflected signal and incident signal. The incident signal is measured by Receiver R, and the reflected signal is measured by Receiver A. Therefore, the result of reflection measurement is a ratio of A and R (i.e. A/R). The reflection characteristic of the tested device can be fully quantified with the signal amplitude and phase information of Receiver A and R. Among the S-parameter terms,  $S_{11}$  represents the reflection of Port 1 (input port) of the tested device and  $S_{22}$  represents the reflection of Port 2 (input port) of the tested device. Reflection measurement aims to ensure the efficient transmission of RF energy. If energy is reflected, only a little energy will be transmitted to the expected place. In addition, if too much energy is reflected, the device may be burnt, such as the output power amplifier.

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#### 8.1.1 Reflection Measurement Expression

The data of reflection measurement can be expressed in various methods according to the requirements. Various expressions are based on the same reflection measurement data and can be respectively displayed in one or more graphic format(s). See details in “4.7 Selection of Data Format and Scale”.

##### 8.1.1.1 Return Loss

A simple way to express reflection data is the return loss, which is a scalar in dB. The return loss refers to the dB

difference between the reflected signal and incident signal. If the impedance matches exactly, the return loss will be infinite. For the open, short or no-loss reactive circuit, the return loss is 0dB. For example, if the logarithmic format is applied in measurement, the reflection measurement data will be -18dB, indicating that the return loss is 18dB (ignoring the minus sign).

### 8.1.1.2 Standing Wave Ratio

The standing wave will be produced if two groups of waves are transmitted in the opposite directions along one transmission line. In this case, the voltage standing wave ratio (VSWR or SWR for short) can be applied. SWR is defined as the ratio of the maximum RF envelope voltage and minimum RF envelope voltage at the given frequency. It is a scalar. If the impedance matches exactly, SWR is 1. For the open, short or no-loss reactive circuit, SWR is infinite.

### 8.1.1.3 Reflection Coefficient

Another way to express reflection measurement is the reflection coefficient ( $\Gamma$ ), including the amplitude and phase information. The amplitude part of  $\Gamma$  is referred to as  $\rho$ . The reflection coefficient is a ratio of the reflection voltage and incident voltage. The  $\rho$  value range is 0-1. If the transmission line is connected with characteristic impedance, all the energy will be transmitted to the load, with no energy reflection.  $\rho=0$ . If the transmission line is connected through the open-circuit device or short-circuit device, all the energy will be reflected.  $\rho=1$ . There is no unit of measurement for  $\rho$ .

Below is the phase information of reflection. If the signal wavelength is larger than the conductor length at high frequency, the reflected wave can be regarded as the wave transmitted in the direction opposite to the incident wave. The standing wave will be produced in case of mixing of the incident and reflected wave. In this case, the voltage-enveloped amplitude will change along with the transmission line position.

If the transmission line is connected with characteristic impedance, with no reflection signal, the energy will be transmitted in one direction along the transmission line, and all the energy of the incident signal will be transmitted to the load, as shown in the following figure.

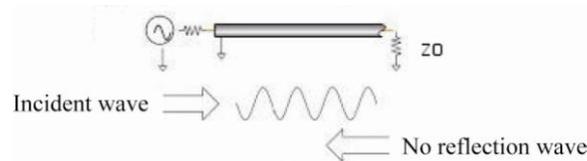


Fig. 8.2 Signal Transmission of Transmission Line Connected through Load

If the transmission line is connected through the short-circuit device, all the energy will be reflected to the signal source, and the amplitude of the reflected wave will be the same as that of the incident wave ( $\rho=1$ ), and the voltage of both ends of the short-circuit device is 0. The phase of the reflected voltage wave of the short-circuit point is the same as that of the incident voltage wave (180-degree difference), and the voltage will be counterbalanced.

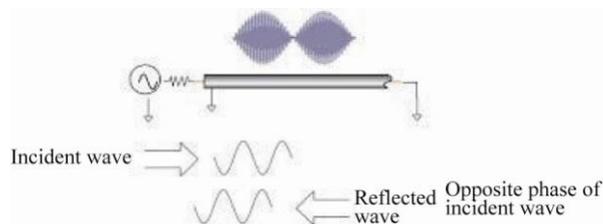


Fig. 8.3 Signal Transmission of Transmission Line Connected through Short-circuit Device

If the transmission line is connected through the open-circuit device, all the energy will be reflected to the signal source, the amplitude of the reflected wave is the same as that of the incident wave ( $\rho=1$ ), no current flows through the open-circuit device, and the reflected voltage wave is the same as the incident voltage wave.

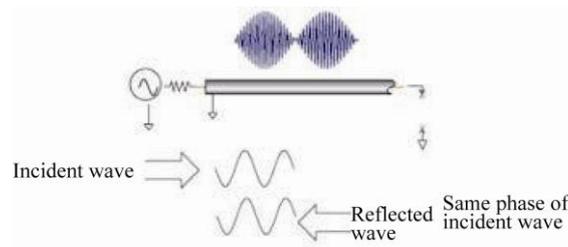


Fig. 8.4 Signal Transmission of Transmission Line Connected through Open-circuit Device

If the transmission line is connected through a  $25\Omega$  resistor, part of the energy will be absorbed, and part of the energy will be reflected to the signal source. The amplitude of the reflected wave is  $1/3$  of that of the incident wave. The voltage is subject to  $180$ -degree difference at the resistor. The phase relationship changes with the distance of the end resistor along the transmission line. The valley of the standing wave figure is not approaching zero, and the peak is smaller than that of the open-circuit device and short-circuit device.

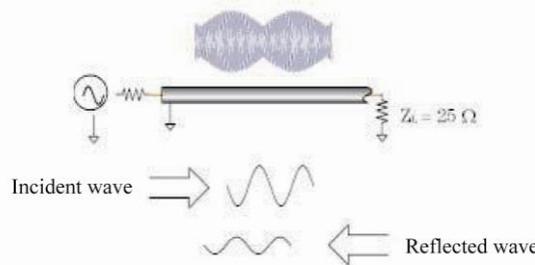


Fig. 8.5 Signal Transmission of Transmission Line Connected through  $25\Omega$  Resistor

### 8.1.1.4 Impedance

The impedance is another way to express the reflection data. For impedance details, refer to the “Smith Chart Format” section of “4.7 Selection of Data Format and Scale”.

### 8.1.2 Summary of Reflection Measurement Expression

Various kinds of reflection data are calculated based on the same measurement data. The data relationship is shown in Fig. 8.6.

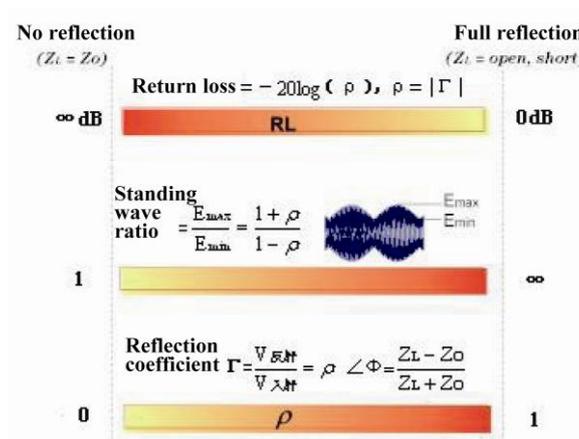


Fig. 8.6 Relationship of Reflection Expressions

## 8.2 Phase Measurement

### 8.2.1 What is phase measurement?

It is important to understand the amplitude and phase information of the tested device to integrate high-level devices. Similar to the amplitude measurement, the S-parameter is also applied in phase measurement. Phase

measurement is a kind of relative (ratio) measurement instead of absolute measurement. The phase of the signal into the device (incident signal) and the response signal are compared in phase measurement. The response signal may be reflected signal or transmitted signal. Given that the analyzer is accurately calibrated, the phase difference (i.e. phase shift) of two signals is the measurement result of phase characteristics of the tested device. The following figure shows the phase deviation between the incident signal and transmitted signal observed through the oscilloscope.

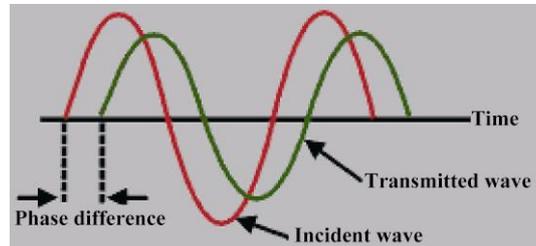


Fig. 8.7 Phase Shift between Signals

### 8.2.2 Why to perform phase measurement?

Phase measurement is an important function of the vector network analyzer. Fig. 8.8 shows the reasons for accurate measurement of the amplitude and phase.

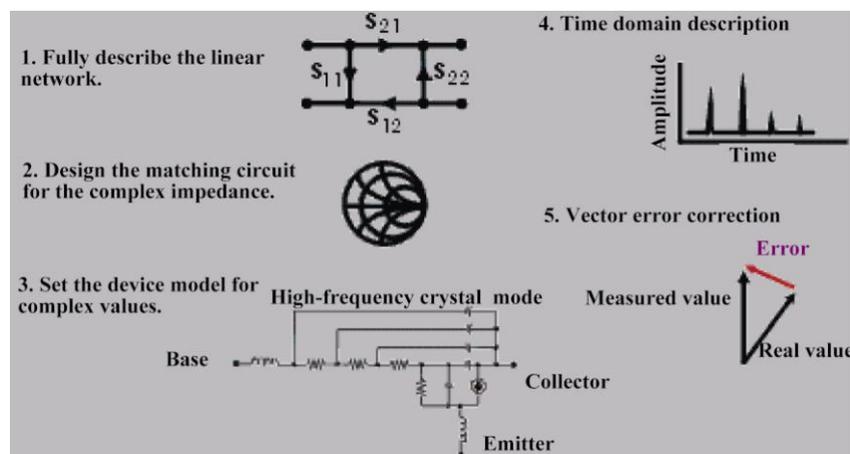


Fig. 8.8 Reasons for Accurate Amplitude and Phase Measurement

If the element and circuit are used to transmit signals in the communication system, signal distortion must be within the normal limits. The signal distortion can be divided into two types.

- 1) Linear distortion: refer to the failure to keep the flat amplitude and linear phase shift within the relevant frequency range as a result of frequency changes.
- 2) Nonlinear distortion: refer to the new spectrum component of the circuit, such as AM-PM transformation.

It is important to accurately measure the amplitude and phase characteristics of the element or circuit, so as to ensure the efficient transmission or adsorption of energy in the circuit and prevent the distortion in signal transmission. A good example to prevent distortion is to measure the complex impedance of the antenna.

### 8.2.3 Use of Phase Format of Analyzer

The phase format of the analyzer is used to display the phase changes over the frequency or power. The phase difference beyond  $\pm 180^\circ$  between the reference signal and response signal cannot be measured by the analyzer. If the phase value varies from  $+180^\circ$  to  $-180^\circ$ , the sawtooth type phase measurement track will be displayed on the analyzer. The sawtooth waveform may not reach  $+180^\circ$  or  $-180^\circ$  sometimes in measurement at the discrete frequency points. The data points of  $+180^\circ$  and  $-180^\circ$  may not be the points of scanning measurement.

#### Phase Format

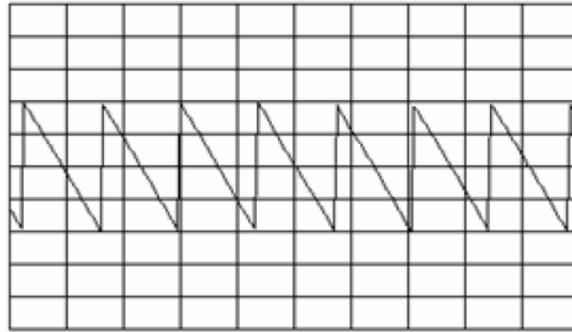


Fig. 8.9 Phase Format of Analyzer

### 8.2.4 Type of Phase Measurement

- 1) Complex impedance: the complex impedance data such as the resistance, reactance, amplitude and phase can be determined by  $S_{11}$  and  $S_{22}$  measurement and observed in the Smith chart and polar coordinate format. See details in “8.4 Complex Impedance”.
- 2) AM-PM transformation: the unexpected phase deviation may be caused by system amplitude changes in the AM-PM transformation measurement, defined as the output phase change of each 1dB increase of the power input into the amplifier, in degree/dB. Measurement is done at the 1dB gain compression point. See details in “8.7 AM-PM Transformation”.
- 3) Linear phase deviation: refer to the phase distortion produced in measurement of the tested device. Ideally, the phase shift of the tested device is linear to the frequency. The deviation produced relative to the theoretical phase deviation is referred to as the linear phase deviation (also known as the phase linearity). See details in “8.9 Linear Phase Deviation”.
- 4) Group delay: it is another way to measure the phase distortion of the device. The transition time of the signal of specific frequency through the device is measured, and the group delay is calculated according to the derivative of the measured phase response. See details in “8.5 Group Delay”.

### 8.2.5 Linear Phase Deviation and Group Delay

The linear phase deviation and group delay are phase information of the measurement device but for different purposes.

- 1) Advantages of linear phase deviation measurement:

- a) The noise is lower than that of group delay measurement.
- b) The characteristics of the device transmitting phase-modulated signals can be better represented. In this case, it is more appropriate to use the phase as the unit instead of the second.

- 2) Advantages of group delay measurement:

- a) Compared with the linear phase deviation measurement, phase distortion can be explained more easily.
- b) The characteristics of the tested device can be represented accurately. The phase ripple slope is calculated by the analyzer in group delay measurement and depends on the ripple quantity within the unit frequency. Phase responses with the same phase ripple peak-peak value are compared. Large phase slope response may result in large group delay changes and signal distortion.

## 8.3 Amplifier Parameter Specifications

This section introduces the measurement parameters of the amplifier.

### 8.3.1 Gain

The gain refers to the ratio between the output power (to the characteristic impedance load) and input power (from the characteristic impedance source) of the amplifier and can be calculated by the following formula.

$$\tau = \frac{V_{\text{trans}}}{V_{\text{inc}}}$$

$$\text{Gain (dB)} = -20\log_{10}|\tau|$$

$$\text{Gain (dB)} = P_{\text{out}} \text{ (dBm)} - P_{\text{in}} \text{ (dBm)}$$

The output power of the amplifier is proportional to the input power in the case of small signal. The small-signal gain is within the linear zone. With the power level of the input signal increasing, the amplifier will be saturated, and the output power will reach the limit, leading to gain decline. The large signal gain is within the nonlinear zone. See details in “[Appendix 5 Gain Compression Measurement of Amplifier](#)”.

### 8.3.2 Gain Flatness

The gain flatness refers to the gain change of the amplifier within the working frequency range. See details in “[8.10 Small Signal Gain and Flatness](#)”.

### 8.3.3 Reverse Isolation

Reverse isolation is applied to measure the transmission between the output end and input end. Similar to gain measurement, only the excitation signal is applied to the output end of the amplifier. See details in “[8.9 Reverse Isolation](#)”.

### 8.3.4 Gain Drift Changes over Time (temperature and bias)

The gain drift refers to the maximum gain change over time, with the other parameters unchanged. It is a function of the time. The gain drift related to other parameters can be measured, such as the gain deviation over the temperature, humidity and bias voltage.

### 8.3.5 Linear Phase Deviation

Refer to the deviation of linear shifts. Ideally, the phase shift of the amplifier is a linear function of the frequency. See details in “[8.8 Linear Phase Deviation](#)”.

### 8.3.6 Group Delay

The group delay refers to the transition time of the signal through the amplifier. It is a function of the frequency. The ideal linear phase shift has a constant change rate over the frequency. In this case, the group delay is a constant. In the actual measurement, the group delay is calculated by the following formula:

$$\tau_g \text{ (sec)} = - \frac{\Delta \theta}{\Delta \omega}$$

$$= - \frac{1}{360} * \frac{\Delta \theta}{\Delta f}$$

See details in “[8.5 Group Delay](#)”.

### 8.3.7 Return Loss (standing wave ratio, $\rho$ )

The return loss refers to the reflection matching of the amplifier relative to the system impedance  $Z_0$  in measurement of the input or output port. It can be calculated by the following formula:

$$\Gamma = \frac{V_{\text{refl}}}{V_{\text{inc}}} = \rho \angle \theta$$

$$\text{Reflection coefficient} = \rho$$

$$\text{Return loss (dB)} = -20\log_{10}\rho$$

$$\text{SWR} = \frac{1+\rho}{1-\rho}$$

### 8.3.8 Complex Impedance

The amount of energy reflected by the device is associated with the complex impedance of the device. The complex impedance is composed of the resistance component and reactance component and can be calculated with the system characteristic impedance and reflection coefficient by the following formula:

$$Z = \frac{1+\Gamma}{1-\Gamma} * Z_0$$

$$= -R + jX$$

See details in “8.4 Complex Impedance”.

### 8.3.9 Gain Compression

The amplifier is configured with one gain zone, in which is the gain is not associated with the input power level (i.e. small signal gain). When the power level increases to a certain value, the amplifier will be saturated, which may result in gain declining.

Gain compression is determined by measuring the 1dB gain compression point of the amplifier. The 1dB gain compression point refers to the output power at which the amplifier gain decreases by 1dB relative to the small signal gain. Generally, the measured value is used to describe the power output capacity of the amplifier. See details in “Appendix 5 Gain Compression Measurement of Amplifier”.

### 8.3.10 AM-PM Transformation Coefficient

The output signal phase change arising from the input signal amplitude change is measured in AM-PM transformation. The unit of AM-PM transformation is degree/dB. Measurement is done at the 1dB gain compression points. See details in “8.7 AM-PM Transformation”.

## 8.4 Complex Impedance

The complex impedance data can be observed in S11 or S22 measurement of the tested device, including the phase and amplitude information such as the series resistance, series reactance and impedance, in the Smith chart or polar coordinate format.

### 8.4.1 What is complex impedance?

The complex impedance data can be determined according to the S11 or S22 measurement results of the tested device. The reflection power of the tested device is associated with the impedance of the device and measurement system. For example, the complex reflection coefficient ( $\Gamma$ ) will not be 0 unless the impedance of the device and system is fully identical (that is, the efficiency of power transmission from the source to load is the highest). Each  $\Gamma$  value corresponds to the unique complex impedance of the device. The complex impedance is a function of the frequency.

$$Z_L = [(1 + \Gamma) / (1 - \Gamma)] * Z_0$$

Where,  $Z_L$  is the impedance of the tested device, and  $Z_0$  is the characteristic impedance of the measurement system. The Smith chart format and polar coordinate format are the most suitable for impedance measurement. See details in the “Smith chart format” and “Polar coordinate format” of “4.7 Selection of Data Format and Scale”.

### 8.4.2 Improvement of Impedance Measurement Accuracy

- 1) If the full scale value is 1, Smith chart is the easiest to understand.
- 2) If the cursor is used in the Smith chart or polar coordinate format, the discrete cursor mode can be applied to obtain higher measurement accuracy.
- 3) The uncertainty of reflection measurement is influenced by the following factors:
  - a) Direction
  - b) Reflection tracking
  - c) Source matching
  - d) Load matching

The influence of these factors can be reduced in the full double-port calibration. If the output end of the tested device is connected with a high-quality load, the same measurement accuracy can be achieved by means of one-

port calibration.

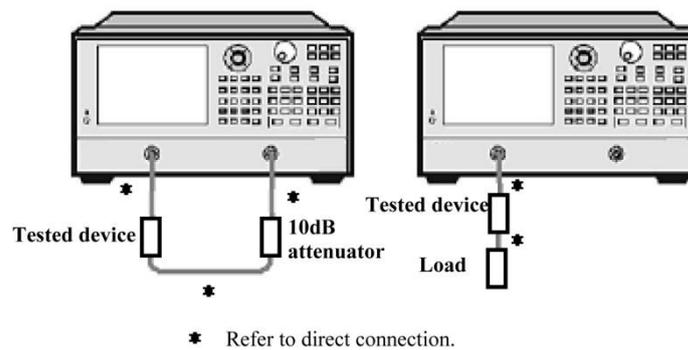


Fig. 8.10 Connection in Impedance Measurement

1) If the tested device is connected between two ports of the analyzer after one-port calibration, it is recommended to connect a 10dB attenuator to the output end of the tested device to improve the measurement accuracy. If the full double-port calibration has been done, the attenuator is not required as the load matching error is modified in the full-port calibration.

2) If the double-port device is connected to one port of the analyzer after one-port calibration, a high-quality load (such as the standard load of the calibration kit) must be connected to the output port of the device.

### 8.4.3 Steps of Complex Impedance Measurement

- 1) Reset the analyzer.
- 2) Set and calibrate the analyzer.
- 3) Connector shown in Fig. 8.10 for  $S_{11}$  or  $S_{22}$  measurement.
- 4) Observe the impedance data:
  - a) Select the Smith chart format.
  - b) Set the scale of the displayed measurement results to facilitate observation.
  - c) Open the cursor, and move the cursor along the track to read the resistance and reactance component of the complex impedance of the data point.
  - d) Print or save the data.
- 5) Observe the admittance data (if necessary):
  - a) Open the cursor and select the  $G+jB$  cursor format to read the admittance data.
  - b) Set the scale of the displayed measurement results to facilitate observation.
  - c) Move the cursor along the track to read the conductance and susceptance component of the complex admittance of the data point, in siemens (S).
  - d) Print or save the data.
- 6) Observe the amplitude and phase of the reflection coefficient:
  - a) Select the Smith chart or polar coordinate format.
  - b) Open the cursor and select the logarithmic/phase or linear/phase format.
  - c) Set the scale of the displayed measurement results to facilitate observation.
  - d) Move the cursor along the track to read the amplitude and phase information of the data point.
  - e) Print or save the data.

## 8.5 Group Delay

The phase distortion of the tested device is measured in group delay measurement. The group delay refers to the

actual transition time of the signal through the tested device and changes over the frequency. The aperture of group delay measurement must be specified to describe the group delay indicator.

### 8.5.1 What is group delay?

The group delay refers to:

- 1) Measure of phase distortion of the device.
- 2) Relationship between the signal transition time through the device and the frequency.
- 3) Derivative of the phase characteristic of the device relative to the frequency.

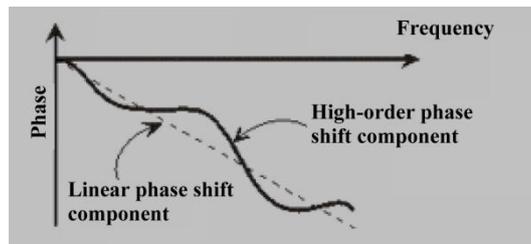


Fig. 8.11 Phase Shift and Group Delay

$$\text{Group delay} = \frac{-d\phi}{d\omega} = \frac{-1}{360^\circ} \cdot \frac{d\theta}{df}$$

$\Phi$  is in radian,  $\omega$  in radian/second,  $\theta$  in degree and  $f$  in Hz.

The phase characteristic of the device includes the linear phase shift component and high-order phase shift component.

- 1) Linear phase shift component: refer to the average transition time of the signal, indicating the electrical length of the device.
- 2) High-order phase shift component: refer to the transition time change over the frequency, a cause of signal distortion.

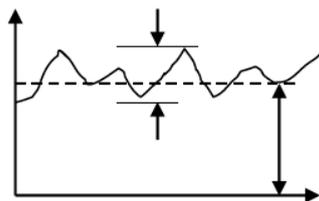


Fig. 8.12 Group Delay

In the group delay measurement:

- 1) The linear phase shift component represents the average group delay.
- 2) The high-order phase shift component represents the average group delay deviation (group delay ripple).
- 3) Similar to the linear phase deviation resulting in distortion, the group delay deviation will also result in signal distortion.
- 4) The track of group delay measurement indicates the passing time of each frequency signal through the tested device.

The group delay of the analyzer is calculated in the following methods:

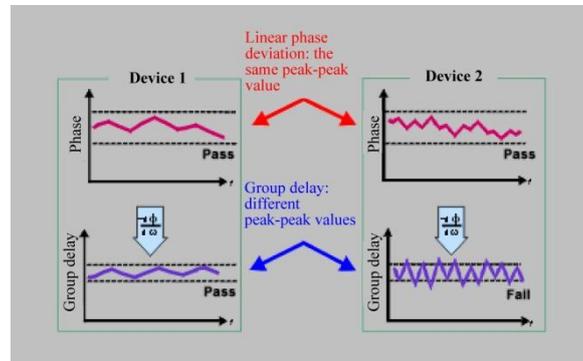
$$\text{Group delay} = \frac{-d\phi}{d\omega} = \frac{-1}{360^\circ} \cdot \frac{d\theta}{df}$$

$\Phi$  is in radian,  $\omega$  in radian/second,  $\theta$  in degree and  $f$  in Hz.

- 1) Calculate the phase change ( $-d\Phi$ ) according to the phase data.
- 2) Use the specified frequency aperture as the frequency change ( $d\omega$ ).

3) Using the above two values, calculate the approximate value of the phase change rate over the frequency. The approximate value is the group delay (assuming that the phase changes linearly within the specified frequency aperture).

### 8.5.2 Why to measure the group delay?



The group delay is more accurate than the linear phase deviation to represent the phase distortion, as shown in Fig. 8.13.

Fig. 8.13 Comparison of Group Delay and Linear Phase Deviation

- 1) The upper half part of the figure shows the measurement results of the linear phase deviation of Device 1 and 2. Although the track shape varies, the linear phase deviations of both devices are identical.
- 2) The lower half part of the figure shows the measurement results of the group delay of Device 1 and 2. The group delay of Device 1 is different from that of Device 2, as it is calculated by the analyzer according to the phase ripple slope. The phase ripple slope depends on the ripple quantity within the unit frequency.

### 8.5.3 What is the aperture of group delay?

The analyzer will measure the phase of two adjacent frequency points and calculate the phase slope in group delay measurement. The frequency interval (frequency interval) between two phase measurement points is referred to as the aperture. Different group delay values can be obtained by changing the aperture. This is why the aperture of measurement must be known before comparison of group delay data.

The default aperture of group delay of the analyzer is the frequency interval of two adjacent scanning points. Apply the following two methods to change the aperture:

- 1) Change the number of measurement points or the frequency span.
  - a) Increase the number of points or reduce the frequency span to narrow the aperture.
  - b) Decrease the number of points or increase the frequency span to widen the aperture.

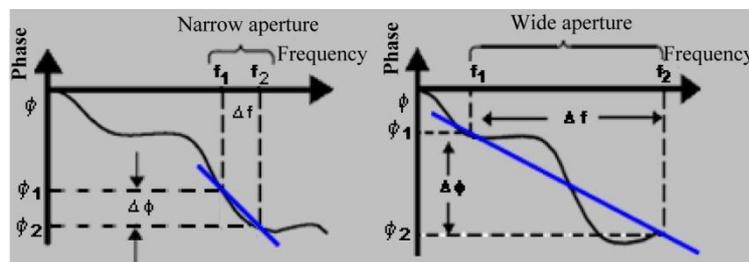


Fig. 8.14 Influence of Group Delay Aperture on Measurement Results

## Attention

### Relationship of the aperture and group delay:

If the aperture is too wide and the phase shift of adjacent frequency points is more than  $180^\circ$ , errors will occur in group delay calculation.

2) Apply the smoothing function of the analyzer.

Perform scanning once, enable the smoothing function and change the value percentage in smoothing settings. This is similar to change of the frequency interval between scanning points. This method allows a wider group delay aperture, and the phase shift is allowed to exceed  $180^\circ$  within the smoothing aperture.

Group delay measurement can be done in the following scanning types:

- a) Linear frequency;
- b) Logarithmic frequency;
- c) Segment scanning.

The group delay aperture depends on the frequency interval and the scanning point density, therefore, it changes in the logarithmic frequency and segment scanning mode.

### 8.5.4 Improvement of Measurement Accuracy of Group Delay

It is important to keep the phase difference of adjacent measurement points less than  $180^\circ$  during group delay measurement; otherwise, the phase and group delay information will be incorrect, as shown in Fig. 8.15. Insufficient sampling may occur in measurement of the device of long electrical delay. Adjust the following settings until the measurement track does not change so as to ensure that the phase difference of two adjacent points is less than  $180^\circ$ .

- 1) Increase the number of points.
- 2) Reduce the frequency span.

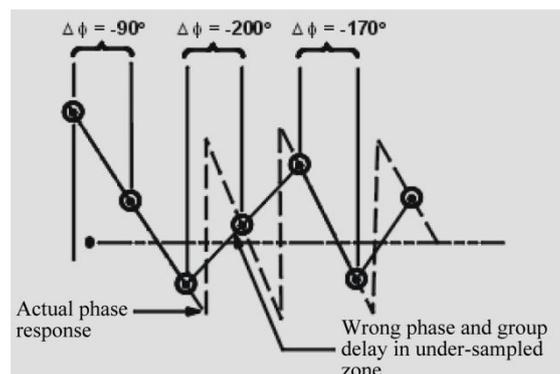


Fig. 8.15 Influence of Insufficient Sampling on Group Delay Measurement

The frequency response is a main error of group delay measurement. This error can be significantly reduced by means of through type response calibration. Perform the full double-port calibration to realize higher accuracy. For the amplifier, the response may vary with the temperature. Therefore, the test should be done at the working temperature of the amplifier.

### 8.5.5 Steps of Group Delay Measurement

- 1) Reset the analyzer. Adjust the source power of the analyzer to test the amplifier.
  - a) Set the source power of the analyzer within the linear zone of the analyzer response (generally at least 10dB less than the 1dB input compression point).
  - b) If required, connect one attenuator to the output port of the amplifier to fully attenuate the output power of the amplifier and prevent the receiver at the reception end of the analyzer from compression or burning.
- 2) Connect the tested device, as shown in Fig. 8.16.

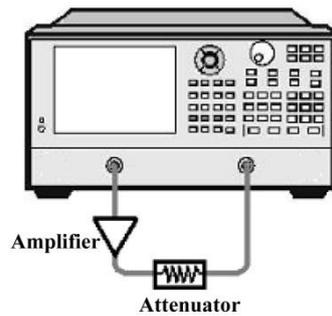


Fig. 8.16 Connection in Group Delay Measurement

- 3) Select the S21 measurement mode.
- 4) Select the settings corresponding to the tested device, including:
  - a) Format: phase.
  - b) Scale: automatic scale.
  - c) Number of measurement points: select the appropriate number to avoid insufficient sampling.
- 5) Remove and calibrate the tested device.
- 6) Reconnect the tested device.
- 7) Set the group delay display format and the scale of measurement display to realize the best observation effect.
- 8) Increase the aperture and reduce the noise on the track by the smoothing function of the analyzer. At the same time, keep meaningful details. Take the following steps to increase the aperture:
  - a) Enable the smoothing function of the analyzer.
  - b) Change the smoothing aperture (max. 25% of the frequency span).
- 9) Read the group delay of the relevant frequency through the cursor.
- 10) Print or save the data.

## 8.6 Absolute Output Power

The absolute output power is the relationship between the displayed absolute power (dBm or W) and frequency.

### 8.6.1 What is the absolute output power?

The absolute output power is the power of the reception port of the analyzer. This is the absolute power, not based on the incident power or source power (or the ratio). The value indicated on the longitudinal axis of the grid is in dBm in the logarithm amplitude format. It is the power tested based on 1mW.

0dBm=1mW

-10dBm=0.1mW

+10dBm=10mW

The value indicated on the vertical axis of the grid in the logarithm amplitude format is in W.

### 8.6.2 Why to measure the absolute output power?

If the absolute power instead of the relative power must be used as the amplifier output, the absolute output power must be measured. In gain compression measurement, the absolute output power of the amplifier should be measured based on 1dB compression. In order to improve the measurement accuracy, considerations must be given to the following factors:

- 1) If necessary, fully attenuate the output power of the amplifier. Too high power may lead to the following results:
  - a) The output power is higher than the input compression level of the receiver of the analyzer, which may lead to inaccurate measurement results.

- b) The receiver of the analyzer may be burnt.
- 2) Attenuate the output power of the amplifier with the attenuator or coupler.
- 3) The amplifier has different response values corresponding to temperature differences. The test must be done at the working temperature of the amplifier.

### 8.6.3 Steps of Measurement of Absolute Output Power

- 1) Reset the analyzer.
- 2) Select the non-ratio power measurement (the source is set on Port 1 and Receiver B is used for input).
- 3) Set the source power of the analyzer as 0dBm.
- 4) As shown in Fig. 8.17, connect the amplifier and provide the DC bias. If necessary, use an external attenuator to fully attenuate the output power of the amplifier so as to prevent the receiver on Port 2 of the analyzer from compression or burning.

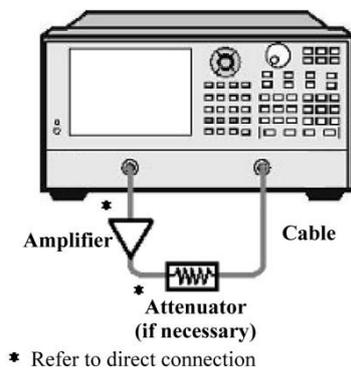


Fig. 8.17 Connection in Absolute Output Power Measurement

- 5) Select the analyzer settings corresponding to the amplifier to be tested.
- 6) Remove the amplifier, and connect the attenuator and cable between two ports. Apply the track operation function and save the data track into the memory. Apply the data/saving function for normalization. If the attenuator and cable are used in amplifier measurement, they must be included in normalization measurement.
- 7) Reconnect the amplifier.
- 8) Set the scale of measurement display to realize the best observation effect. Read the absolute output power corresponding to the frequency through the cursor.
- 9) Print or save the data.

## 8.7 AM-PM Transformation

AM-PM transformation of the amplifier represents the phase deviation caused by system amplitude changes.

### 8.7.1 What is AM-PM transformation?

AM-PM transformation represents the unexpected phase deviation (PM) caused by system amplitude changes (AM). The unexpected phase deviation (PM) in the communication system may be caused for the following reasons:

- 1) Accidental amplitude change (AM):
  - a) Power fluctuation;
  - b) Thermal drift;
  - c) Multipath attenuation.
- 2) Deliberate signal amplitude modulation:
  - a) QAM (quadrature amplitude modulation);
  - b) Sudden pulse modulation.

AM-PM transformation is generally defined as the output phase change in radian/dB, corresponding to 1dB increase of the scanning power applied on the input end of the amplifier (at the 1dB gain compression point). The phase response of the ideal amplifier is not associated with the power level of the input signal.

### 8.7.2 Why to measure AM-PM transformation?

AM-PM transformation is a key parameter in the following phase (angle) modulation system.

- 1) FM
- 2) QPSK
- 3) 16QAM

The unexpected phase deviation (PM) will result in deterioration of the analog signal performance or increase of the bit error rate (BER) of the digital communication system. It is easy to measure the bit error rate (BER) of the digital system, but this is not helpful to understand the root causes of bit errors. AM-PM transformation is one of the main factors resulting in bit errors. Therefore, it is critical to quantify this parameter in the communication system. The following I/O figure shows why bit errors are produced in AM-PM transformation.

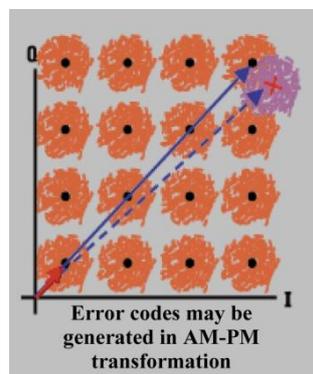


Fig. 8.18 Bit Errors in AM-PM Transformation

- 1) The expected state change is from the small solid-line vector into large solid-line vector.
- 2) As a result of AM-PM transformation, the large solid-line vector may end like that shown by the dotted line in the actual situation. This is caused by the phase shift arising from changes of the input power level.
- 3) For the 64QAM signal (only the quadrant is drawn) shown in Fig. 8.18, bit errors occur in the statistics if the noise circles of each state are overlapped.

### 8.7.3 Factors Related to Measurement Accuracy

When the network analyzer is used to measure AM-PM transformation, the frequency of the amplitude modulation signal is approximate to the reciprocal of the scanning time. Even if the highest scanning power is set, the modulation frequency is low (generally less than 10Hz). This may result in slight temperature changes of the tested device in the scanning process, especially the thermal mass of the amplifier is small (typically for the unsealed device). If the nonlinear characteristic of the amplifier is sensitive to thermal changes, the measurement result obtained in this method may have errors. In order to improve the measurement accuracy, considerations should be given to the following factors.

- 1) The amplifier response may be vary with the temperature. The test must be done at the working temperature of the amplifier.
- 2) If necessary, fully attenuate the output power of the amplifier. Too high power may lead to the following results:
  - a) The output power is higher than the input compression level of the receiver of the analyzer, which may lead to inaccurate measurement results.
  - b) The receiver of the analyzer may be burnt.
- 3) Attenuate the output power of the amplifier with the attenuator or coupler.
- 4) The influence of the frequency response of the attenuator or coupler must be taken into consideration during calibration. They are part of the test system and must be included in the calibration process. The influence of such

accessories can be reduced or eliminated by the perfect technology of error correction.

5) The frequency response is an error which plays a dominant role in AM-PM transformation measurement. The through type response calibration can be applied to significantly reduce the error.

### 8.7.4 Step of AM-PM Transformation Measurement

- 1) Reset the analyzer.
- 2) Select S21 measurement in the power scanning mode.
- 3) Set the starting and ending power level of power scanning of the analyzer. The starting power level should be within the linear zone (generally at least 10dB less than the 1dB compression point) of the amplifier response, and the ending power level should be within the compression zone of the amplifier response.
- 4) If necessary, use the external attenuator or coupler to fully attenuate the output power of the amplifier and prevent the receiver on Port 2 of the analyzer from compression or burning.
- 5) As shown in Fig. 8.19, connect the amplifier and provide the DC bias.

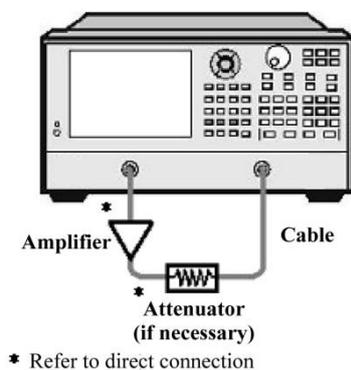


Fig. 8.19 Connection in AM-PM Transformation Measurement

- 6) Select the analyzer settings corresponding to the tested amplifier so as to perform gain compression measurement in the power scanning mode at the selected frequency. See details in “[Appendix 5 Gain Compression Measurement of Amplifier](#)”.
- 7) Remove and calibrate the amplifier. The attenuator, coupler and cable used in amplifier measurement must be included in calibration.
- 8) Reconnect the amplifier, open the cursor R and set the cursor at the 1dB gain compression point of the amplifier. Open the second cursor, activate the  $\Delta$ cursor mode, and set the excitation value of the second cursor as -1dBm.
- 9) Change S21 measurement from the logarithmic amplitude format into the phase format (requiring no re-calibration).
- 10) Read the phase difference between the cursor. This value is the AM-PM transformation coefficient at the 1dB gain compression point.
- 11) Print or save the data.

## 8.8 Linear Phase Deviation

The linear phase deviation refers to the phase distortion of the device. The electrical delay function of the analyzer is applied in measurement to eliminate the linear part of the phase shift and realize high-resolution nonlinear part, i.e. linear phase deviation.

### 8.8.1 What is linear phase shift?

The signal wavelength will decrease with the incident signal frequency increasing during signal transmission. In this case, the obvious phase shift will be produced. The phase shift is linear when the phase response of the device is proportional to the frequency. The track indicating the relationship between the phase and frequency on the analyzer is an oblique line. The slope is proportional to the electrical length of the device. The phase shift must be linear for signal transmission without distortion.

### 8.8.2 What is linear phase deviation?

In the actual cases, the delay time of many devices corresponding to some frequencies is longer than that corresponding to the other frequencies so as to form the nonlinear phase shift, including distortion of many frequency component signals. One method to determine the nonlinear phase shift is to measure the linear phase deviation.

As phase distortion is caused by linear phase deviation, the linear part of the phase response should be removed in measurement. This can be realized by the electrical delay function of the analyzer. If the electrical length of the tested device is removed mathematically, the linear phase deviation or phase distortion will be left.

### 8.8.3 Why to measure the linear phase deviation?

Linear phase deviation measurement has the following advantages:

- a) The measurement result is the phase data, instead of the group delay data in second. The phase data may be more usable for the device transmitting modulation signals.
- b) Provide a measurement method with noise lower than that of group delay measurement.

### 8.8.4 Use of Electrical Delay Function

The electrical delay characteristic of the analyzer has the following functions:

- 1) Simulate the transmission line of adjustable length and no loss to facilitate the installation in or removal from the signal path.
- 2) Compensate changes of the electrical length of the tested device.
- 3) Make the phase measurement track on the analyzer flat, to realize the high-resolution observation of the track and find nonlinear details of the phase.
- 4) Provide a method to easily observe the linear phase deviation of the tested device.

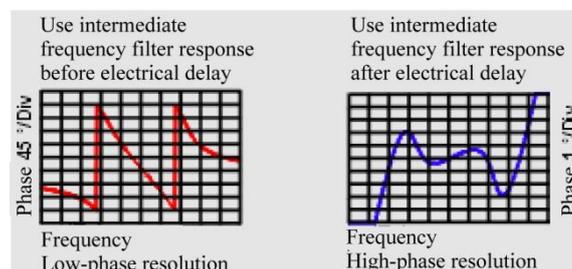


Fig. 8.20 Observation of Linear Phase Deviation by Electrical Delay Function

See electrical delay details in “6.5.1 Electrical Delay”.

### 8.8.5 Factors Related to Measurement Accuracy

The frequency response is an error which plays a dominant role in linear phase deviation measurement. The through type response calibration can be applied to significantly reduce the error. In order to achieve higher accuracy, the full double-port calibration should be done.

### 8.8.6 Steps of Linear Phase Deviation Measurement

- 1) Reset the analyzer. Adjust the source power of the analyzer to test the amplifier.
  - a) Set the source power of the analyzer to make the amplifier working within the linear zone (generally at least 10dB less than the 1dB compression point).
  - b) If necessary, use the external attenuator or coupler to fully attenuate the output power of the amplifier and prevent the receiver on Port 2 of the analyzer from compression or burning.
- 2) Select the S21 measurement mode.
- 3) Connect the tested device as shown in Fig. 8.21.

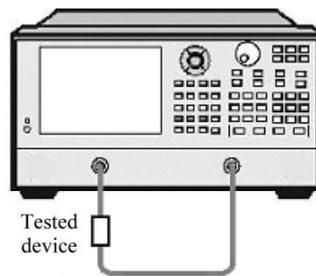


Fig. 8.21 Connection in Linear Phase Deviation Measurement

- 4) Select the analyzer settings corresponding to the tested device, including the phase format.
- 5) Remove and calibrate the tested device.
- 6) Reconnect the tested device and set the scale of measurement display to facilitate observation.
- 7) Change the electrical delay to make the phase track flat.
- 8) Read the linear phase deviation through the cursor.
- 9) Print or save the data.

## 8.9 Reverse Isolation

Reverse isolation aims to measure the reverse transmission response from the output to input of the amplifier.

### 8.9.1 What is reverse isolation?

The degree of isolation from the output end to input end of the device is measured in reverse isolation. Reverse isolation measurement is similar to positive gain measurement, but with the following differences.

- 1) The excitation signal is applied on the output port of the amplifier.
- 2) The response signal is measured at the input end of the amplifier.
- 3) The equivalent S-parameter is  $S_{12}$ .

### 8.9.2 Why to measure reverse isolation?

The ideal amplifier should have infinite reverse isolation, and no signal is transmitted from the output end back to the input end. Actually, the signal may be transmitted through the amplifier in the opposite direction. This kind of unexpected reverse transmission may result in the interference of the reflected signal of the output port to the signal transmitted forwards. Therefore, it is important to quantify reverse isolation.

### 8.9.3 Factors Related to Measurement Accuracy

As the amplifier generally has high loss in the reverse direction, the attenuator or coupler is not required to protect the receiver of Port 1 in reverse transmission measurement. In case of no attenuator, the dynamic range and measurement accuracy will be improved. The source power can be increased to improve the dynamic range and accuracy.



## Warning

**The power must not be overloaded forward scanning or full double-port calibration.**

With the attenuator eliminated and RF power increased, the receiver of Port 2 of the analyzer may be burnt in forward scanning. Thus, forward scanning or full double-port calibration must not be done until the forward power is low enough, which cannot result in burning of the receiver of Port 2 of the analyzer.

If the tested amplifier is highly isolated, the level of the reverse signal may be close to the base noise or crosstalk level of the receiver. In order to reduce the base noise, the averaging function can be applied. The dynamic range and accuracy of measurement can be improved by increasing the averaging times or reducing the intermediate frequency bandwidth, at the sacrifice of measurement speed.

- 1) If the measurement accuracy is affected by the crosstalk, the through type response and isolation calibration can

be implemented to reduce crosstalk errors. Use the same averaging factor and intermediate frequency bandwidth during calibration and measurement.

- 2) The frequency response of the test is a main error source in reverse isolation measurement. It can be eliminated by through type response or through type response/isolation calibration.
- 3) If the temperature varies, the amplifier response may be thoroughly difference. The test should be done at the working temperature of the amplifier.

#### 8.9.4 Steps of Reverse Isolation Measurement

- 1) Reset the analyzer.
- 2) Select the S12 measurement type.
- 3) Connect the amplifier as shown in Fig. 8.22 and provide the DC bias.

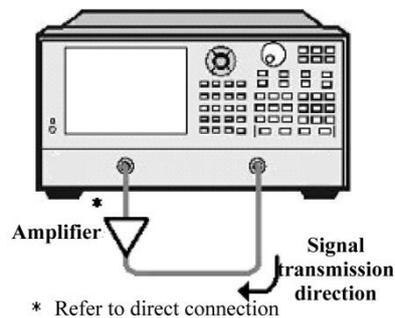


Fig. 8.22 Connection in Reverse Isolation Measurement

- 4) Set the analyzer corresponding to the tested amplifier.
- 5) Remove and calibrate the amplifier and perform through type response calibration or through type response/isolation calibration.
- 6) Reconnect the amplifier and set the scale of measurement display to facilitate observation.
- 7) Read the reverse isolation value at the corresponding frequency point through the cursor.
- 8) Print or save the data.

### 8.10 Small Signal Gain and Flatness

The small signal gain refers to the gain of the amplifier within the linear working zone. Generally, it is measured at the constant input power within the frequency scanning range. The gain flatness refers to the gain change within the specified frequency range.

#### 8.10.1 What is gain?

The amplifier gain is defined as the power difference between the output signal and input signal of the amplifier (power unit: dBm), given that the input impedance of the amplifier is the same as the output impedance. It is the characteristic impedance of the system.

- 1) The gain is referred to as S21 among the S-parameter terms.
- 2) The gain is expressed as the logarithmic ratio of the output power and input power (dB).
- 3) If the input level and output level are expressed in dBm (equivalent to the power 1mW), the gain can be calculated by subtracting the output level by the input level.
- 4) The amplifier gain generally refers to the minimum gain within the working frequency range. Some amplifiers are provided with the minimum and maximum gain at the same time to prevent under-excitation or over-excitation at subsequent levels of the system.

#### 8.10.2 What is flatness?

The flatness refers to the amplifier gain change within the specified frequency range. The amplifier gain change may result in distortion of the signal through the amplifier.

### 8.10.3 Why to measure the small signal gain and flatness?

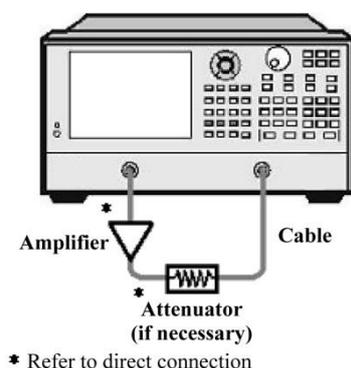
The gain deviation within the specified bandwidth may result in unequal amplification of frequency components of the signal and distortion of the transmitted signal. The small signal gain refers to the amplifier gain at the specific frequency of the  $50\Omega$  system and the flatness refers to the amplifier gain deviation within the specified frequency range of the  $50\Omega$  system.

### 8.10.4 Factors Related to Measurement Accuracy

- 1) If the temperature varies, the amplifier response may be thoroughly difference. The test should be done at the working temperature of the amplifier.
- 2) If necessary, fully attenuate the output power of the amplifier. Too high output power may lead to the following results:
  - a) The output power exceeds the input compression level of the receiver of the analyzer, resulting in inaccurate measurement results.
  - b) The receiver of the analyzer may be burnt.
- 3) The output power of the amplifier can be attenuated with the attenuator or coupler. As the attenuator or coupler is part of the test, the influence of mismatch and frequency response on the measurement accuracy must be taken into consideration in calibration. Proper error correction can be implemented to reduce the influence of such accessories.
- 4) The frequency response of the test is the most important error source of small signal gain and flatness measurement. This kind of error can be reduced significantly by through type response calibration. The measurement accuracy can be improved by full double-port calibration.
- 5) The dynamic range and accuracy can be improved by reducing the intermediate frequency bandwidth or using the measurement averaging function, but at the sacrifice of measurement speed.

### 8.10.5 Steps of Small Signal Gain and Flatness Measurement

- 1) Reset the analyzer.
- 2) Select the measurement parameter S21.
- 3) Set the source power of the analyzer to make the amplifier working within the linear zone (generally at least 10dB less than the 1dB compression point).
- 4) If necessary, use the external attenuator or coupler to fully attenuate the output power of the amplifier and prevent the receiver on Port 2 of the analyzer from compression or burning.



- 5) Connect the amplifier as shown in Fig. 8.23 and provide the DC bias.

Fig. 8.23 Connection in Small Signal Gain and Flatness Measurement

- 6) Set the analyzer corresponding to the tested amplifier.
- 7) Remove and calibrate the amplifier. The attenuator, coupler and cable used in measurement must be included in calibration.
- 8) Reconnect the amplifier.

- 9) Set the scale of measurement display to facilitate observation. Read the small signal gain at the corresponding frequency point through the cursor.
- 10) Observe the peak-peak ripple within the whole frequency range through the cursor to measure the gain flatness.
- 11) Print or save the data.

## 9 Remote control

This chapter mainly describes the program control basics, program-control interface and configuration method and basic VISA interface programming method of AV3672 series vector network analyzers, as well as the concept of I/O instrument driver library. to facilitate remote control of the user. Specific contents include:

- [Basis of remote control](#) .....291
- [Remote control port and configuration](#) .....306
- [Basic VISA interface programming method](#) .....311
- [I/O library](#) .....319

### 9.1 Basis of Remote Control

#### 9.1.1 Remote Control Interface

The instrument with the remote control function generally supports four kinds of remote control interface: LAN, GPIB, RS-232 and USB. Specific port models depend on the instrument functions.

The remote control interfaces and associated VISA addressing character strings are shown in the following table.

Table 9.1 Types and VISA Addressing Character Strings of Remote Control Interfaces

Program Control Interface	VISA Addressing Character String	Description
LAN (LocalAreaNetwork)	<b>VXI-11 protocol:</b> TCPIP::host_address[::LAN_device_name][::INSTR] <b>Original socket protocol:</b> TCPIP::host_address::port::SOCKET	Remote control can be realized by the connecting the instrument through the network port on the rear panel of the instrument. For details, refer to: 9.2.1 LAN Interface
GPIB (IEC/IEEEBusInterface)	GPIB::primaryaddress[::INSTR]	Remote control can be realized by the connecting the instrument through the port on the rear panel of the instrument. Comply with the IEC625.1/IEEE 418 bus interface standard. For details, refer to: 9.2.2 GPIB interface
USB (UniversalSerialBus)	USB::<vendorID>::<product_ID>::<serial_number>[::INST R]	Port of the rear panel of the instrument For details, refer to: 9.2.3 USB interface

##### 9.1.2.1 LAN Interface

The vector network analyzer can be controlled remotely by the 10Base-T and 100Base-T LAN computer. Various instruments in the LAN are combined into a system for unified control with the computer in the network. In order to realize the remote control within LAN, the vector network analyzer should be configured with the port connector, network card, relevant network protocol and network service in advance. At the same time, the controlling computer in the network should be configured with the instrument control software and VISA library in advance. Three working modes of the network card:

- 10Mbit/s Ethernet IEEE802.3;
- 100Mbit/s Ethernet IEEE802.3u;
- 1Gbit/s Ethernet IEEE802.3ab.

Connect the controlling computer and vector network analyzer to the common TCP/IP network through the network ports. Use the RJ45 cable (shielded or non-shielded Class 5 twisted pair) between the computer and vector network analyzer. Use the packet transmission mode in data transmission, as the speed of LAN transmission is high. Generally, the cable between the computer and vector network analyzer must be no more than 100m long (100Base-T and 10Base-T). For more details of LAN communication, visit <http://www.ieee.org>. LAN interfaces are introduced below.

### 1) IP address

Ensure that the physical connection is smooth for remote control of the vector network analyzer by LAN. Open “Local IP” in the menu of the vector network analyzer and set the address within the subnet. Example: if the IP address of the master control computer is 192.168.12.0, the IP address of the vector network analyzer should be 192.168.12.XXX, where XXX is 1 to 255.

Only the IP address is required to establish the network connector. The VISA addressing character string is as follows:

TCPIP::host address[::LANdevicename][::INSTR] or

TCPIP::host address::port::SOCKET

Where:

- TCPIP refers to the applied network protocol.
- host address refers to the IP address of the instrument or the host name, used to identify and control the controlled instrument.
- LANdevicename refers to the handle number of the protocol and device (optional).
  - Select the VXI-11 protocol for No. 0 device.
  - Select a new high-speed LAN instrument protocol for No. 0 high-speed LAN instrument.
- INSTR refers to the instrument source type (optional).
- “port” refers to the socket port number.
- SOCKET refers to the original network socket resource class.

Example:

- If the IP address of the instrument is 192.1.2.3, the effective resource string of VXI-11 protocol is:

TCPIP::192.1.2.3::INSTR

- Use the following string for original socket connection:

TCPIP::192.1.2.3::1024::SOCKET

---

## Prompt

### Identification of multiple instrument in remote control system

If multiple instruments are connected in the network, distinguish them with the separate IP address and associated resource string. The respective VISA resource string is used by the master control computer to identify the instrument.

---

### 2) VXI-11 protocol

XI-11 standard is based on the ONCRPC (Open Network Computing Remote Procedure Call) protocol and suitable for the network/transmission layer of the TCP/IP protocol. The TCP/IP network protocol and related network services are configured in advance. The connection-oriented communication complies with the sequential exchange

requirements, and connection interruptions can be identified to prevent the loss of information.

### 3) Socket communication

The TCP/IP protocol is connected to the network analyzer in the network through the LAN socket. Socket is a basic approach used in computer network programming, which enables network communication among applications employing different hardware and operating systems. In this method, the vector network analyzer is connected to the computer through the port for two-way communication.

Socket is a kind of software specially programmed and has defined the information necessary for network communication such as IP address and device port number and integrated some basic operations of network programming. Socket can be used as long as the packaged libraries are installed in the OS. Berkeley Socket Library applied in UNIX and Winsock Library applied in Windows constitutes the two common socket libraries.

The socket of the vector network analyzer is compatible with the Berkeley socket and Winsock through the application program interface (API). Besides, it is also compatible with other standard socket API. The command will be sent by the socket program to control the vector network analyzer through SCPI commands. The socket port number of the vector network analyzer must be set before the LAN socket is used. The socket port number of the vector network analyzer is 1024.

#### 9.1.2.2 GPIB Interface

The GPIB is a kind of remote control interface which is widely applied at present. Various kinds of instruments can be connected through GPIB cables to form a test system with the master control computer. In order to realize remote control, the master control computer should be configured with the GPIB bus card, drive program and VISA library in advance. In the communication process, the controlled instrument is addressed by the master control computer according to the GPIB bus address, and the user can set the GPIB address and ID query string. The default GPIB communication language is SCPI command.

Refer to ANSI/IEEE 488.1-1987 and ANSI/IEEE 488.2-1992 for detailed definitions and descriptions on GPIB and relevant interface operations. For details, visit the IEEE website <http://www.ieee.org>.

The byte is used in information processing of GPIB. The data transmission rate can reach 8MBps. Therefore, the speed of data transmission of GPIB is high. The data transmission speed is limited by the distance between the equipment/system and computer, pay attention to the following items in GPIB connection.

- At most 15 instruments can be connected through GPIB interfaces.
- The total length of the transmission cable must not exceed 15m or twice of the number of instruments in the system. Generally, the maximum length of the transmission cable between devices must not exceed 2m.
- For parallel connection of instruments, use “or” connecting lines.
- Connect the terminal of the IEC bus cable to the instrument or controlling computer.

#### 9.1.2.3 RS-232 Interface

The RS-232 interface is a traditional method of remote control, as only a digit is sent and received once. The transmission rate is less than that of GPIB or LAN transmission. At present, this method is not commonly used. Similar to GPIB and LAN connection, instrument parameters such as the baud rate should be set in communication to match with the parameters of the master control computer. The RS-232 interface is used for transmitting SCPI command characters in the ASCII code form.

#### 9.1.2.4 USB Interface

The vector network analyzer can be connected to the computer through the USB interface for USB type remote control. In this case, the computer should be configured with the VISA library in advance to automatically test and configure the instrument for USB connection, instead of entering the instrument address character string or installing the separate drive program.

#### USB address:

Address character string format: USB::::<productID>::>[:INSTR]

Where:

- <vendorID> refers to the vendor code.

- <productID> refers to the instrument code.
- <serialnumber> refers to the serial number of the instrument.

**Example:**

USB0::0x0525::0x1100::1404001::INSTR

0x0525: vendor code.

0x1100: instrument code.

1404001: serial number of the instrument.

### 9.1.2 Message

Messages transmitted through the data lines are divided into the following two types.

#### 1) Interface message

The low attention line should be installed for communication between the instrument and master control computer, and then interface messages can be transmitted to the instrument through the data line. Interface messages must be transmitted by the instrument with the GPIB bus function.

#### 2) Instrument message

For the structure and grammar of instrument messages, refer to “5.1.4 SCPI Commands”. According to the transmission direction, instrument messages can be divided into the command and instrument response. Unless otherwise specified, the same method should be applied for use of instrument messages with the remote control interface.

##### a) Command:

The command (programming message) is a kind of message transmitted by the master control computer to the instrument, used for remote control of the instrument function and query of the status information. Commands are divided into the following two types:

- According to the influence on the instrument:
  - Setting command: change the instrument setting status, such as resetting, frequency setting, etc.
  - Query command: inquire and return data, such as instrument identification or parameter query. The query command ends with a suffix question mark.
- According to the definition in the standard:
  - General command: the function and grammar are defined in the IEEE488.2 standard, and this kind of command is suitable for all kinds of instruments, and if possible, used for standard status register management, resetting, automatic testing, etc.
  - Instrument control command: a kind of instrument characteristic command, used to realize the instrument functions. Example: frequency setting.

The grammar should comply with the SCPI specifications.

##### b) Instrument response:

The instrument response (response message and service request) is a kind of query result message transmitted by the instrument to the computer. This kind of message includes the measurement result, instrument status, etc.

### 9.1.3 SCPI Command

#### 9.1.3.1 SCPI Command Introduction

SCPI (Standard Commands for Programmable Instruments) is a command set, which is established based on the IEEE488.2 Standard and suitable for all instruments. It mainly aims to apply the same programmed commands for the same functions to realize the universality of programmed commands.

The SCPI command is composed of the command head and one or more parameter(s), which are separated by spaces. The command head includes one or more key field(s). The command with the suffix question mark is the query command. The command can be divided into general command and special command of different

grammatical structures. The SCPI command has the following features:

- 1) Program control commands are applicable to the test function, but not for instrument description.
- 2) Program control commands can help to reduce the repetition of similar test functions and ensure the program compatibility.
- 3) Program control messages are defined in the layer which is not related to the hardware of the physical layer in communication.
- 4) Program control messages are not related to the programming method and language. The SCPI test program is easy to transplant.
- 5) Program control commands are scalable to adapt to measurement control of various scales.
- 6) The SCPI command is “live” due to the extensibility. For more SCPI details, refer to:

IEEE Standard 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation. New York, NY, 1998.

IEEE Standard 488.2-1987, IEEE Standard Codes, Formats, Protocols and Comment Commands for Use with ANSI/IEEE Std488.1-1987. New York, NY, 1998.

Standard Commands for Programmable Instruments (SCPI) VERSION 1999.0.

For details of the program control command set, classification and specifications of AV3672 series vector network analyzers, refer to:

- 1) “[3 Program Control Commands](#)” of the program control manual.
- 2) “[Appendix A Table of Subsystem-based SCPI Command Classification](#)” of the program control manual.

### **9.1.3.2 SCPI Command Specifications**

#### **1) General Terms**

The following terms are applicable to this section. In order to better understand the contents, you should know the exact definitions of such terms.

#### **Controller**

Any computer used to communicate with SCPI devices. The PC, minicomputer or card in a card cage can be used as the controller. Also, some intelligent devices can be used as controller.

#### **Equipment**

Any device supporting SCPI. The majority of devices are electrical measurement or excitation devices for communication through the GPIB interface.

#### **Program Message:**

A combination of one or more properly formatted SCPI commands. Programming messages instruct a device how to measure and output signals.

#### **Response Message**

A combination of data in specified SCPI formats. Response messages are always transmitted from a device to a controller or monitor. Response messages inform the controller of the internal status or measured values of a device.

#### **Command**

Any command compliant with SCPI standard. Messages control the combination of device commands. Generally, the commands consist of keyword, parameter and punctuation.

#### **Event Command**

Some commands are events and cannot be queried. Generally, there is no front panel key corresponding to the event command. The event command is used to trigger an event at the specific time.

#### **Query**

A special type of command. For query of control equipment, return to the response message conforming to the

controller grammar requirements. Query string always end with a question mark.

## 2) Command type

The SCPI command is divided into two types: general command and special instrument command. Figure 5.2 shows the differences of two types of commands. The general command is defined according to the IEEE488.2 standard, used for macro and status register management, synchronization and data storage. It can be easily identified with the star mark in front of the command. For example, \*IDN? , \*OPC and \*RST are common commands. The general command is not the special instrument command and can be explained in the same method, regardless of the current path setting.

The special instrument command is easy to identify with the colon (:). The colon is used at the beginning and between key words of the command expression, such as:SENS<num>:FREQUency[:CW? ]. Based on the internal functional modules of the instrument, special instrument commands are divided into corresponding subsystem command subsets. For example, the power subsystem (:POWER) includes relevant power commands, and the status subsystem (:STATus) includes the status control register commands.

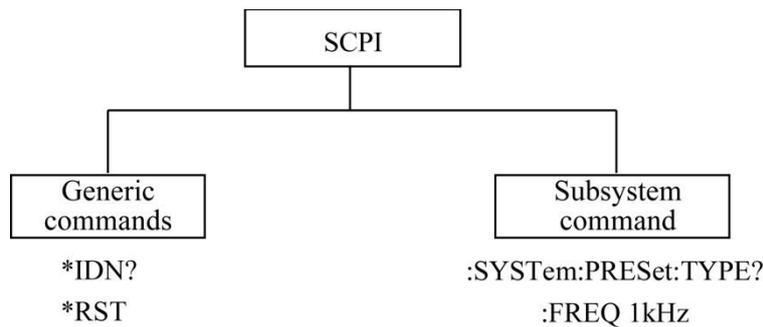


Fig. 9.1 Types of SCPI Commands

## 3) Grammar of special instrument command

A typical command is made up of keywords prefixed with colons (:). The keywords are followed by parameters. The following is an example syntax statement:

[ :SOURce ] :POWER [ :LEVEl ] MAXimum|MINimum

In the above example, “:POWER” is followed by [:LEVEl], with no space. “MINimum|MAXimum” behind [:LEVEl] is the parameter part. A space is used between the command and parameter. For the other parts of the grammar expression, see Table 9.2 and 9.3.

Table 9.2 Special Characters of Command Grammar

Symbol	Meaning	Examples
	The vertical line between the keyword and parameter means a variety of options.	TRIGger[:SEQUence]:SCOPE ALL CURRENT “ALL” and “CURRENT” are optional.
[]	The square brackets means that the included keywords or parameters are optional in the command. Even if the included keywords or parameters are ignored, the command will be executed.	TRIGger[:SEQUence]:SCOPE ALL CURRENT Where, SEQUence is optional.
<>	The part in the angle brackets must not be used according to the literal meaning in the command. The angle brackets mean the necessary part.	TRIGger[:SEQUence]:SCOPE <char> In this command, <char> must be replaced with the actual trigger range string. Example: “:TRIG:SCOPALL”.
{}	The braces mean that the parameter is optional.	[ :SOURce ] :LIST:POWER <val>{ ,<val> } Example: LIST:POWER5

Table 9.3 Command Grammar

Character, Keyword and Grammar	Examples
Upper-case lettering indicates the minimum set of characters required to execute the command.	[:SOURce]:FREQUency[:CW]?, FREQ is the short part of the command.
The lowercase character part of the command is optional. This flexible format is known as “flexible listening”. For more information, refer to the “Command Parameter and Response” section.	:FREQUency :FREQ, :FREQUency or FREQUENCY, both of which are correct.
If a colon is applied between two command mnemonics, the current path in the command tree will be moved to next layer. Refer to “Command Tree” for more information on command paths.	:TRIGger:OUTPut:POLarity? TRIGger is the keyword of the top layer of the command.
Adjacent parameters in the command should be separated with commas. The parameters have no influence on the path layer and do not belong to the command path part.	[:SOURce]:LIST:DWELl <val>{,<val>}
The semicolon is used to separate two adjacent commands, with no influence on the current command path.	:FREQ2.5GHZ;:POW10DBM
The blank character, such as <space> or <tab>, is generally ignored when not used between or in keywords. However, you must use the blank character to separate the command and parameter, with no influence on the current path.	“:FREQUency” or “:POWer:LEVel6.2” is not allowed. “:LEVel” and “6.2” must be separated with the space. i.e. :POWer:LEVel6.2

#### 4) Command tree

Special instrument commands are used in most of remote control programs. To analyze this kind of command, the SCPI structure should be similar to the file system, known as the command tree, as shown in Fig. 9.2.

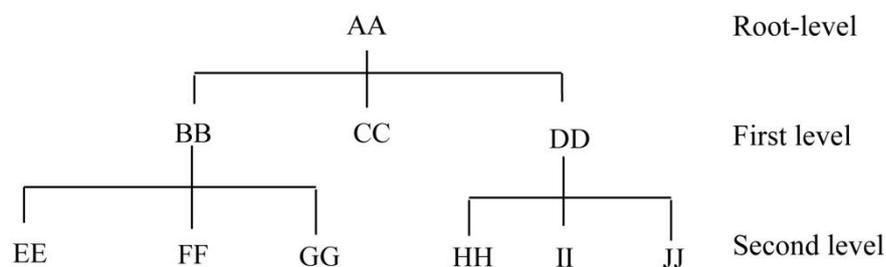


Fig. 9.2 Schematic Diagram of Simplified Command Tree

The top command is the root command, referred to as the “root”. Follow the specific path of the tree structure to next layer in command analysis. Example: :POWer:ALC:SOURce? Where, “:POWer” refers to AA, “:ALC” refers to BB, and “:SOURce” refers to GG. The whole command path is (:AA:BB:GG).

The **command interpreter**, a module of the instrument software, is dedicated to analysis of each received SCPI command. It is used to divide the command into separate command elements according to a series of rules to distinguish command tree paths. The current command should be kept unchanged after analysis, so as to analyze the subsequent command more rapidly and efficiently as the same command keyword may be used in various paths. The current command path should be set as the root after the instrument is started or reset (\*RST).

#### 5) Command parameter and response

SCPI defines different data formats for use in program and response messages. It does this to accommodate the principle of **forgiving listening** and **precise talking**. Refer to IEEE488.2 for more information. **Forgiving listening** means the command and parameter formats are flexible.

Example: power level command of the vector network analyzer:

SOURce<cnm>:POWer<port>[:LEVel][:IMMediate][:AMPLitude]<num>,[src]

The following commands are used to set the power level:

:SOURce:POWer:LEVel:IMMediate:AMPLitude-5, :SOURce:POWer-5,

:SOUR:POW:LEV:IMM:AMP-5, :SOUR:POW-5.

Various parameter types correspond to one or more response data type(s). The numeric type of the parameter will change into the data type in query. Response data are accurate, strictly referred to as “**precise talking**”.

For example, if the setting is -5dBm in the power level (:SOURce:POWer?) query, the returned response data will be -5.0000000000e+000 no matter the setting command is “:SOUR:POW:LEV:IMM:AMP-5” or “:SOUR:POW-5”.

Table 9.4 SCPI Command Parameters and Response Types

Parameter type	Response Data Types
Numeric	Real or integer
Extended Numeric	Integer
Discrete	Discrete
Boolean	Numeric Boolean
String	String
Piece	Block with Definite Length
	Block of uncertain length
Non-decimal Numeric	Hexadecimal system
	Octal
	Binary system

### Numerical parameter

Special instrument commands and general commands can be expressed as numeric parameters. All kinds of common decimal counting can be applied for reception of numeric parameters, including the plus or minus, decimal and scientific counting methods. If one device can only receive the specific numeric type, such as the integer, the received numeric parameter will be automatically rounded.

The following are examples of numeric parameters:

0	no decimal point required
100	fractional digits optional
1.23	leading signs allowed
4.56e<space>3	space allowed after the E in exponential
-7.89E-01	use either E or e in exponential
+256	leading + allowed
5	digits left of decimal point optional

### Extended Numeric Parameters

The numeric parameter is extended to specify the physical quantity in the majority of measurements related to special instrument commands. Extended numeric parameters accept all numeric parameter values and other special values as well. The extended numeric parameters include the MAXimum and MINimum. Other special values, such as UP and DOWN, are received depending on the analysis capability of the instrument. All effective parameters are listed in the SCPI command table.

Note: The extended numeric parameters are not applicable to general commands or STATus subsystem commands. The following are examples of extended numeric parameters:

101	Numerical parameter
1.2GHzGHz	can be used as the index (E009).

200MHzMHz	can be used as the index (E006).
-100mV	negative 100 millivolts
10 degrees	10 degree
MAXimum	sets parameter to largest possible value
MINimum	sets parameter to smallest possible value
UP	a stepper up
DOWN	a stepper down

### Discrete Parameters

Discrete parameters are used to identify a limited number of parameters to be set. Discrete parameters use mnemonics to represent each valid setting. Similar to the programmed command mnemonics, discrete parameter mnemonics are divided into long type, short type and uppercase/lowercase mixed type.

Discrete parameters and commands are used together in the following examples.

:TRIGger[:SEQuence]:SOURceBUS|IMMediate|EXTernal

BUS	GPIB,LAN,RS-232 triggering
IMMediate	immediate trigger
EXTernal	external triggering

### Boolean Parameters

The Boolean parameter represents one true or false binary condition, and only four possible values can be applied.

The following are examples of Boolean parameters:

ON	boolean true
OFF	boolean false
1	boolean true
0	boolean false

### String Parameters

For the character string type, the ASCII character string is allowed to be transmitted as the parameter. Single and double quotes are used as delimiters. The following are examples of string parameters:

“This is Valid” “This is also Valid” “SO IS THIS”

### Real Response Data

Most of test data are of real type, in the basic decimal or scientific counting format. Both formats are supported by most of advanced program languages.

The following are examples of real response data:

1.23E+0  
-1.0E+2  
+1.0E+2  
0.5E+0  
0.23  
-100.0  
+100.0  
0.5

### Integer Response Data

Integer response data are decimal representations of integer values including signs. For status register query, integer

response data will be returned in most cases.

Examples of integer response data:

0	Signs are optional
+100	leading + allowed
-100	leading + allowed
256	not any decimal point

### Discrete Response Data

Discrete response data are essentially similar to discrete parameters. The major difference is that only the discrete response data in the short uppercase format are returned.

Example of discrete response data:

INTernal	power leveled internally
EXTernal	power leveled externally
MMHead	power leveled by millimeter wave source module

### Numeric Boolean Response Data

Boolean response data returns a binary numeric value of 1 or 0.

### String Response Data

String response data are similar to string parameters. The main difference is that the double quotation marks instead of single quotation marks must be used as the separator of the string response data. Double quotation marks are allowed to be embedded in the string response data, with no character. Some examples of string response data are shown below.

“This is a string”

“one double quote inside brackets: (“”)”

### 6) System of numeric value of command

The command value can be entered in the binary, decimal, hexadecimal or octal format. An appropriate identifier should be applied in front of the value in the binary, hexadecimal or octal format. The identifier is not required in the decimal format (default). The entered value with no identifier will be saved in the decimal format. The following list shows the identifiers for the formats that require them:

- #B means that the figure is a binary value.
- #H means that the figure is a hexadecimal value.
- #Q means that the figure is an octal value.

The following are examples of SCPI command values and identifiers for the decimal value 45:

#B101101

#H2D

#Q55

In the following example, the hexadecimal value 000A is used to set the RF output power as 10dBm (or equivalent to the value in the selected unit, such as DBUV or DBUVEMF).

:POW#H000A

In the non-decimal format, the measurement unit such as DBM or mV is not used together with the value.

### 7) Command line structure

One command line may include multiple SCPI commands. The following methods can be applied to end the current command line:

- Enter;

- Enter key and EOI;
- EOI and the last byte.

Commands in the command line are separated by semicolons. Commands of different subsystems begin with the colon. For example:

```
MMEM:COPY"Test1","MeasurementXY";:HCOP:ITEM ALL
```

This command line includes two commands, the first of which is the MMEM subsystem command and the second of which is the HCOP subsystem command. If adjacent commands belong to the same subsystem and the command paths are subject to partial overlapping, the commands can be abbreviated. For example:

```
HCOP:ITEM ALL;:HCOP:IMM
```

This command line includes two commands which belong to the same level of the HCOP subsystem. The second command is started at the level lower than the HCOP command, and the colon at the beginning of the command can be omitted. The command line can be abbreviated as follows:

```
HCOP:ITEM ALL; IMM
```

### 9.1.4 Command Sequence and Synchronization

IEEE488.2 defines the difference of the overlapping command and continuous command.

- The continuous command refers to the command sequence to be executed continuously. Generally, the speed of command execution is high.
- The overlapping command refers to the command which is not executed automatically before execution of next command. The processing time of the overlapping command is generally long. The program is allowed to process other events synchronously.

Even if one command line includes multiple setting commands, commands may not be executed according to the reception sequence. In order to execute each command according to a certain sequence, all the commands must be transmitted as a separate command line.

#### **Example: command line including setting and query commands.**

If one command line includes query commands, query results are unpredictable. The returned value will be fixed if the following command is entered:

```
:FREQ:STAR 1 GHZ; SPAN 100;:FREQ:STAR?
```

Returned value: 1000000000(1GHz)

The returned value will not be fixed if the following command is entered:

```
:FREQ:STAR1GHz;STAR?;SPAN1000000
```

The returned result may be the current starting frequency of the instrument before command sending, as the commands will be executed one by one by the host program after command messages are received. The returned result may be 1GHz in the case of execution after the commands are received by the host program.

## Prompt

#### **Setting commands and query commands are sent separately.**

General rules: setting commands and query commands should be sent in different program messages in order to ensure that the returned results of query commands are correct.

#### **9.1.4.1 Prevention of Overlapping Execution of Commands**

In order to prevent overlapping execution of commands, multiple threads or commands can be applied, including \*OPC, \*OPC? or \*WAI. The three commands cannot be executed until the hardware is set. The computer may be forced to wait for a certain period to synchronize certain events in the programming process. The above methods are described below.

- **Use multiple threads in the control program.**

Multiple threads are used to complete waiting commands and synchronize the user interface and program, that is, the command “\*OPC?” is executed in each single thread, with no blockage of GUI or program threads.

➤ **The use of three commands in synchronous execution is shown in the following table.**

Table 9.5 Command Grammar

Method	Execution Action	Programming Method
*OPC	After command execution, set the operation completion bit in the ESR register.	Set ESEBIT0; Set SREBIT5; Send the overlapping command and *OPC; Wait for the service request signal (SRQ). The service request signal means that the overlapping command has been executed.
*OPC?	Stop executing the current command and return to 1. Only when the operation completion bit in the ESR register is set, the command will be returned, indicating that the previous command has been processed.	End the current command processing before executing other commands. Directly send the command after processing of the current command.
*WAI	Before executing *WAI, wait for sending of all commands. Then process the uncompleted commands.	End the current command processing before executing other commands. Directly send the command after processing of the current command.

### 9.1.5 Status Report System

The status report system is used to save all operation status information and error information of the current instrument. The operation status information and error information are respectively saved in the status register and error queue and can be inquired through the programmed interface.

- [Structure of status register organization](#) .....304
- [Application of status report system](#) .....305

#### 9.1.5.1 Structure of Status Register Organization

Register categories are as follows:

##### 1) STB and SRE

The top register of the status report system is composed of the status byte (STB) and associated shielding register, i.e. service request enabling register (SRE). STB is used to collect the information of registers of the lower layers and save the general working conditions of the instrument.

##### 2) ESR and SCPI status register

STB is used to receive the following register information:

- a) Relevant values of event status registers and event status enabling (ESE) shielding registers.
- b) SCPI status registers, such as STATus:OPERation and STATus:QUEStionable registers (defined by the SCPI standard), including specific operations of the instrument. All the SCPI status registers have the same internal structure (refer to “2.1.5.2 Structure of SCPI Status Register” of the program control manual).

##### 3) IST and PPE

The separate bit of SRQ and IST sign (“IndividualSTatus”) is composed of the combination of all statuses of the instrument. The STB data bit for the IST sign depends on the associated Parallel Poll Enable (PPE) Register.

##### 4) Output buffer zone

The output buffer zone is used to save messages returned by the instrument to the controller. It does not belong to the status report system, but is decisive to the MAV bit of STB. For details of the above registers, refer to “2.1.5 Status Report System” of the program control manual. Refer to Fig. 9.3 for the hierarchical structure of the status register.

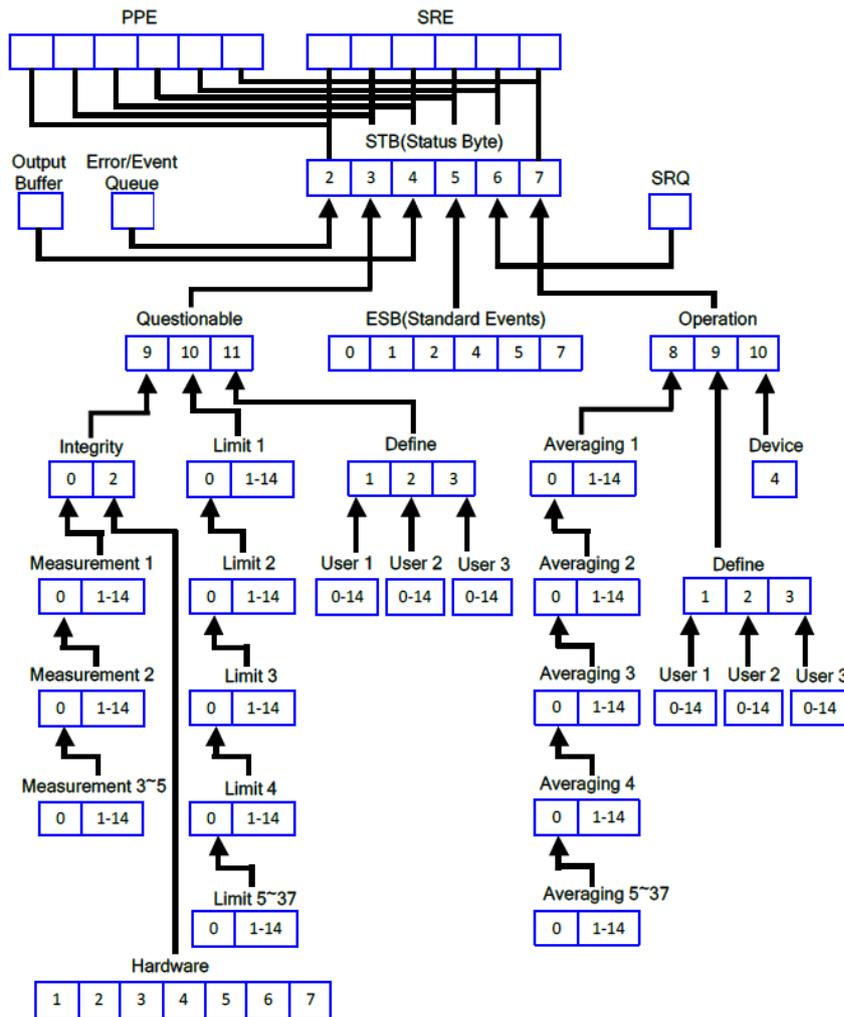


Fig. 9.3 Hierarchical Structure of Status Register

## Prompt

### SRE and ESE

The Service Request Enable (SRE) register is used as the enabling part of STB. Similarly, ESE can be used as the enabling part of ESR.

### 9.1.5.2 Application of Status Report System

The status report system is used to monitor the status of one or more instrument(s) in the test system. In order to properly realize the functions of the status report system, the controller in the test system must receive and evaluate the information of all instruments. Standard methods to be applied include:

- 1) Service request (SRQ) sent by the instrument.
- 2) Series query sent by the controlled to all instruments in the bus system, aiming to find the sender and causes of service request.
- 3) Parallel query of all instruments.
- 4) Query of specific instrument statuses with programmed commands.

For specific operations, refer to “2.1.5.4 Application Status Report System” of the program control manual.

### 9.1.6 Programming Precautions

- 1) Initialize the instrument status before changing the setting.

For instrument setting of remote control, initialize the instrument status (sending “\*RST”, etc.) and then set the required status.

**2) Command sequence**

Generally, the setting command and query command should be transmitted separately. Otherwise, the returned value of the query command will change according to the current instrument operation sequence.

**3) Fault response**

The service request must be sent by the instrument. The controller of the test system should be programmed to guide the instrument to actively send the service request if required, so as to enable the corresponding service interruption program.

**4) Error queue**

The error queue instead of the status register should be inquired once the service request is processed by the controller program, so as to find more accurate causes. The queue should be always inquired in the controller program test phase to obtain the commands sent by the controller to the instrument.

**9.2 Programmed Port and Configuration of Instrument**

- LAN .....306
- GPIB .....308
- USB .....309

**9.2.1 LAN**

The programmed LAN (Local Area Network) system is configured with SICL-LAN to control AV1443 series vector network analyzer.

**Attention**

**Use of USB master control port connector of the front panel:**

The Type-A connector of the front panel is a USB master control port connector. In the AV1443 series vector network analyzer, this port is connected to the flash disc with USB1.1 interface to upgrade the software in the instrument. It can also be connected to the USB keyboard and mouse to control the vector network analyzer. It must not be used for program control of the instrument.

**9.2.1.1 Establish Connection**

Connect the AV3672 series vector network analyzer and external controller (computer) to LAN through network cables, as shown in Fig. 9.4.

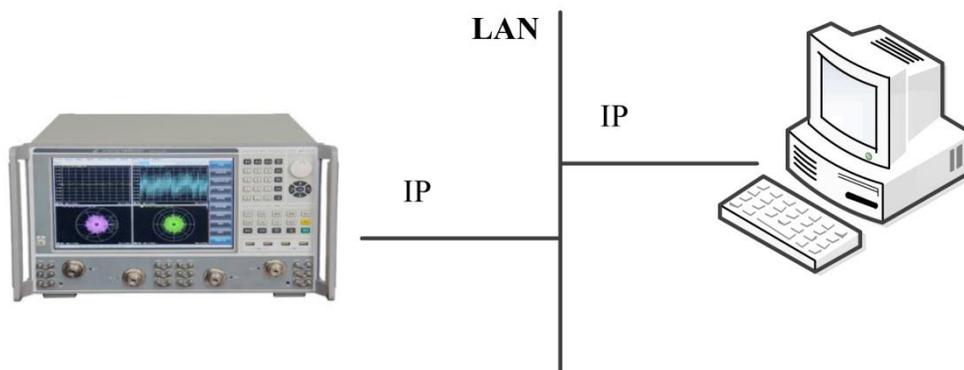


Fig. 9.4 Connection Diagram of LAN Interface



Fig. 9.5 LAN Interface of Rear Panel of Instrument

### 9.2.1.2 Interface Configuration

Ensure that the physical connection is smooth for remote control of the vector network analyzer by LAN. As the DHCP, domain name access and WAN are not supported, the network programming of the vector network analyzer is relatively simple. In the menu shown in Fig. 9.6, set the “IP address”, “Subnet mask” and “Default gateway” to be within the subnet with the master controller.

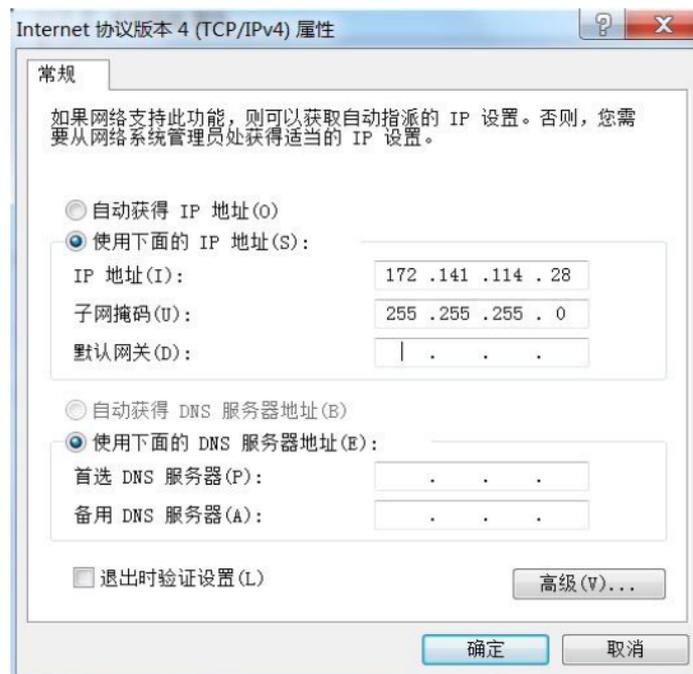


Fig. 9.6 LAN Interface Setting

## Attention

**Ensure normal physical connection of the vector network analyzer through the 10Base-TLAN or 100Base-TLAN cable.**

The vector network analyzer only supports the establishment of one LAN control system and static IP address setting, and does not support DHCP or access to the host through the DNS and domain name server. Therefore, it is not required to modify the subnet mask. The subnet mask of the instrument should be set as the fixed value 255.255.255.0.

## 9.2.2 GPIB

### 9.2.2.1 Establish Connection

Connect the AV3672 series vector network analyzer to the external controller (computer) through the GPIB cable, as shown in Fig. 9.7.

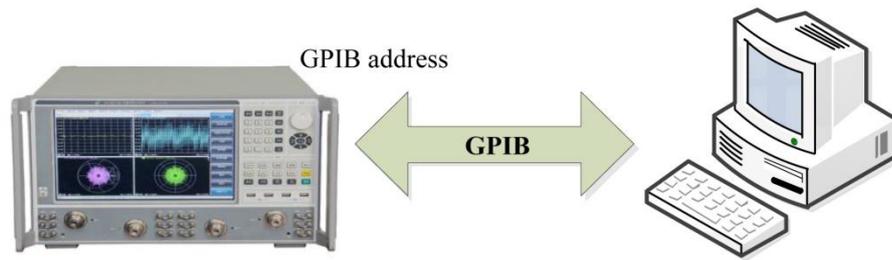


Fig. 9.7 Connection Diagram of GPIB Interface



Fig. 9.8 GPIB Interface of Rear Panel of Instrument

**9.2.2.2 Interface Configuration**

When the system is built with the vector network analyzer, the user may need to modify the GPIB address. The default local GPIB address is 16. Change the GPIB address as follows:

Press [System] > [Configuration] > [GPIB address (G)...] to enter the interface shown in Fig. 9.9. Modify the GPIB address in the [Local GPIB address] input box through the keyboard and mouse or number keys of the front panel.



Fig. 9.9 GPIB Interface Setting

### 9.2.3 USB

#### 9.2.3.1 Establish Connection

Connect the AV3672 series vector network analyzer to the external controller (computer) through the USB cable, as shown in Fig. 9.10.



Fig. 9.10 USB Connection Diagram



Fig. 9.11 USB Interface for Programming on Rear Panel of Instrument

#### 9.2.3.2 Interface Configuration

To build a system with the vector network analyzer, the user should obtain the VID, PID and serial number of the USB address. In the default mode, VID is 0525, PID is 1100, and the serial number is the same as that of factory settings of the instrument. The user can also view USB interface information by clicking [USB Test and Measurement Device (IVI) attribute] > [Details] > [Device example path] under the computer device manager of the master control computer, as shown in Fig. 9.12. Generally, the VID, PID and serial number information should not be changed under the programmed USB conditions.

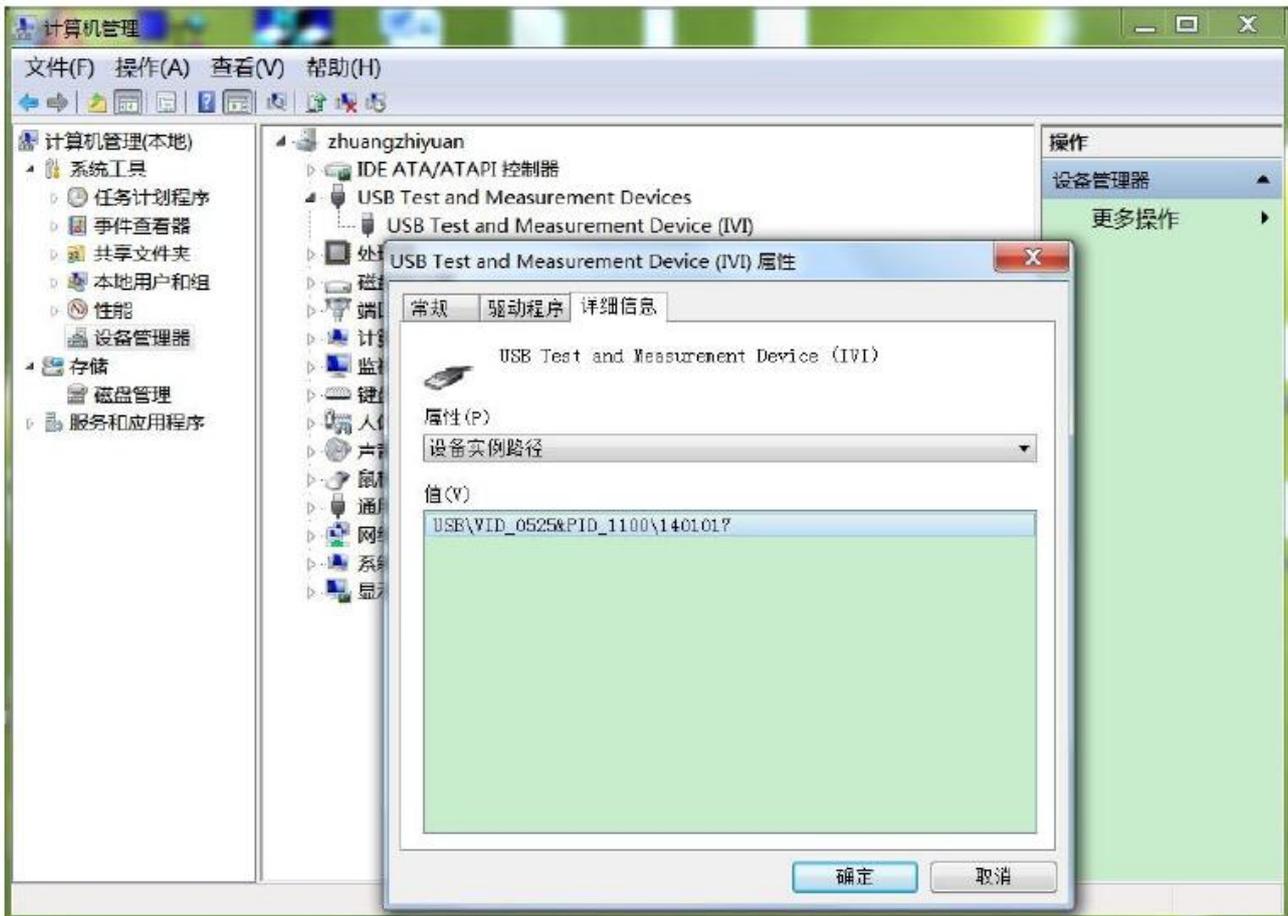


Fig. 9.12 USB Interface Information

## 9.3 Basic Programming Method of VISA Interface

The following example shows the basic method of instrument programming with the VISA library. Take the C++ language as the example.

- VISA library .....311
- Initialization and default state setting .....312
- Sending of setting command .....314
- Reading of measurement instrument state .....316
- Reading of frequency marker .....317
- Reading of track data .....317
- Command synchronization .....318

### 9.3.1 VISA Library

VISA is a general term of the standard I/O function library and related standards. The VISA library is a set of functions which can be called easily called. The core function can be used to control various kinds of devices, regardless of the interface type and I/O interface software operations. The function library is used to write the instrument drive program and complete command and data transmission between the computer and instrument to realize the programmed control of the instrument. The instrument connection with the program-controlled port (LAN, USB, GPIB, RS-232, etc.) can be established by initializing the address character string ("VISA resource string").

The VISA library must be installed at first for remote control. The VISA library includes the transmission functions of the bottom VXI, GPIB, LAN and USB interface to facilitate direct calling. The vector network analyzer supports

the following programmed interfaces: GPIB, LAN and RS-232. Such interfaces are used with the VISA library and programming languages to remotely control the vector network analyzer. At present, Agilent/OLibrary provided by Agilent is commonly used as the bottom I/O library.

Fig. 9.13 shows the relationship between the programmed interface, VISA library, programming language and vector network analyzer, with GPIB interface as an example.

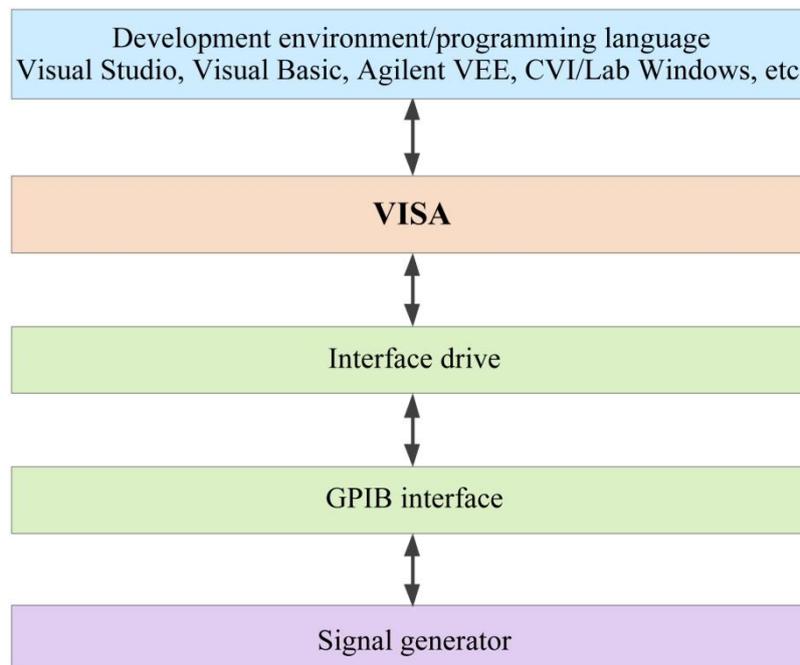


Fig. 9.13 Programming Software and Hardware Layer

### 9.3.2 Initialization and Default State Setting

Initialize the VISA resource manager at the beginning of programming. Open the VISA library and establish the communication connection between the VISA library and instrument. Specific steps are as follows.

#### 9.3.2.1 Generation of Global Variables

At first, generate global variables to be called by other program modules, such as instrument handle variables. The following global variables are included in the program example.

```
ViSession analyzer;
```

```
ViSession defaultRM;
```

```
Const char analyzerString [VI_FIND_BUFLLEN] = "GPIB0::16::INSTR";
```

```
Const analyzerTimeout = 10000;
```

The constant analyzerString refers to the instrument descriptor, “GPIB0” refers to the controller, and “16” refers to the instrument connected to the controller. Assuming that the instrument is connected LAN, the IP address is “192.168.1.1” and the port number is “1024”, the variable is:

```
Const char analyzerString [VI_FIND_BUFLLEN] = "TCPIPO::192.168.1.1::1024::SOCKET";
```

#### 9.3.2.2 Controller Initialization

The following example shows how to establish the communication connection between the VISA library and instrument (with the specified descriptor).

```
//Controller initialization: open the default resource manager and return the instrument handle to the analyzer.
```

```
void InitController()
```

```
{
ViStatus status;
```

```
status = viOpenDefaultRM(&defaultRM);
status = viOpen(defaultRM, analyzerString, VI_NULL, VI_NULL, &analyzer);
}
```

### 9.3.2.3 Instrument Initialization

/\*\*\*\*\*\*  
/

The following example shows the initialization of the default instrument state and clearing of the status register. “\n” refers to the terminator. The character string of each command should be ended with ‘\n’. This will not be described later.

/\*\*\*\*\*\*  
/

```
void InitDevice()
{
ViStatus status;
long retCnt;
status = viWrite(analyzer, "*CLS\n", 5, &retCnt); //reset status register
status = viWrite(analyzer, "*RST\n", 5, &retCnt); //reset instrument
}
```

### 9.3.2.4 Query of Instrument Measurement Information

/\*\*\*\*\*\*  
/

The following example shows all measurements, windows and tracks defined at present.

/\*\*\*\*\*\*  
/

```
void QueryMesaurement()
{
ViStatus status;
long retCnt;
char rd_Buf_CW[VI_READ_BUFLEN]; // #define VI_READ_BUFLEN 20
char rd_Buf_LVL[VI_READ_BUFLEN];
// query all measurements of Channel 1
status = viWrite(analyzer, ": CALC:PAR:CAT?\n", 15, &retCnt);
Sleep(10);
status = viRead(analyzer, rd_Buf_CW, 50, &retCnt);
// query all windows
status = viWrite(analyzer, ": DISP:CAT?\n", 11, &retCnt);
Sleep(10);
status = viRead(analyzer, rd_Buf_CW, 20, &retCnt);
// query all tracks of Window 1
status = viWrite(analyzer, ": DISP:WIND1:CAT?\n", 18, &retCnt);
Sleep(10);
status = viRead(analyzer, rd_Buf_CW, 20, &retCnt);
}
```

### 9.3.3 Sending of Setting Command

#### 9.3.3.1 Setting of Scanning Parameters

/\*  
\*\*\*\*\*  
\*/

The following example shows how to set the scanning parameters of AV3672 series vector network analyzers.

/\*  
\*\*\*\*\*  
\*/

**void SweepSettings()**

{

ViStatus status;

long retCnt;

// selection of measurement

status = viWrite(analyzer, ":CALC:PAR:SEL „CH1\_WIN1\_LINE1“ \n", 50,&retCnt);

// set the scanning type as linear scanning

status = viWrite(analyzer, ":SENSe1:SWEep:TYPE LIN\n", 30, &retCnt);

// set the intermediate frequency bandwidth as 3KHz

status = viWrite(analyzer, ":SENSe1:BANDwidth 3000\n", 30, &retCnt);

// set the starting frequency as 1GHz and ending frequency as 10GHz

status = viWrite(analyzer, ":SENS:FREQ:STAR 1e9\n", 30, &retCnt);

status = viWrite(analyzer, ":SENS:FREQ:STOP 1e10\n", 30, &retCnt);

// set the number of scanning points as 401

status = viWrite(analyzer, ":SENSe1:SWEep:POINts 401\n", 30, &retCnt);

// automatic setting of scanning time

status = viWrite(analyzer, ":SENSe1:SWEep:TIME:AUTO ON\n", 40, &retCnt);

// set the output power as -10dBm

status = viWrite(analyzer, ":SOUR:POW -10dBm\n", 22, &retCnt);

}

#### 9.3.3.2 Setting of Display Parameters

/\*  
\*\*\*\*\*  
\*/

The following example mainly includes:

Setting of data format;

Display of track, title and frequency notes;

Automatic scaling of track;

Query of scale, reference level and reference position;

Opening and setting of averaging;

Opening and setting of smoothing.

```

/*****/
void DisplaySettings()
{
ViStatus status;
long retCnt;
char rd_Buf_Data[VI_READ_BUFLEN]; // #define VI_READ_BUFLEN 20

// selection of measurement
status = viWrite(analyzer, ":CALC:PAR:SEL „CH1_WIN1_LINE1“ \n", 50,&retCnt);

// set the data format as logarithmic amplitude format
status = viWrite(analyzer, ":CALCulate1:FORMat MLOG\n", 30, &retCnt);

// display the track, title and frequency notes
status = viWrite(analyzer, ":Display:WINDow1:TRACe1:STATe ON\n", 40, &retCnt);
status = viWrite(analyzer, ":DISPlay:WINDow1:TITLe:STATe ON\n", 40, &retCnt);
status = viWrite(analyzer, ":DISPlay:ANNotation:FREQuency ON\n", 40, &retCnt);

// automatic scaling of track
status = viWrite(analyzer, ":Display:WINDow1:TRACe1:Y:Scale:AUTO\n", 50, &retCnt);

// query the scale, reference level and reference position
status = viWrite(analyzer, ": DISPlay:WINDow1:TRACe1:Y:SCALE:PDIVision?"\n", 60, &retCnt);
Sleep(10);
status = viRead(analyzer, rd_Buf_Data L, 20, &retCnt);
status = viWrite(analyzer, ":DISPlay:WINDow1:TRACe1:Y:SCALE:RLEVel?\n", 60, &retCnt);
Sleep(10);
status = viRead(analyzer, rd_Buf_Data, 20, &retCnt);
status = viWrite(analyzer, ": DISPlay:WINDow1:TRACe1:Y:SCALE:RPOSition?\n", 60, &retCnt);
Sleep(10);
status = viRead(analyzer, rd_Buf_Data, 20, &retCnt);

// open the averaging function and set the averaging factor as 5
status = viWrite(analyzer, ": SENSE1:AVERAge:STATe ON\n", 30, &retCnt);
status = viWrite(analyzer, ": SENSE1:AVERAge:Count 5\n", 30, &retCnt);

// open the smoothing function and set the smoothing aperture as 20%

```

```
status = viWrite(analyzer, ": CALCulate1:SMOothing:STATe ON\n", 40, &retCnt);
```

```
status = viWrite(analyzer, " CALCulate1:SMOothing:APERture 20\n", 40, &retCnt);
```

```
}
```

### 9.3.4 Reading of Measurement Instrument Status

The following example shows how to read the setting status of the instrument.

```
void ReadSettings()
```

```
{
```

```
ViStatus status;
```

```
long retCnt;
```

```
char rd_Buf_CW[VI_READ_BUFLEN]; // #define VI_READ_BUFLEN 20
```

```
char rd_Buf_LVL[VI_READ_BUFLEN];
```

```
// Querys the CW frequency
```

```
status = viWrite(analyzer, "FREQ:CENT?", 10, &retCnt);
```

```
Sleep(10);
```

```
status = viRead(analyzer, rd_Buf_CW, 20, &retCnt);
```

```
// query the amplitude
```

```
status = viWrite(analyzer, "POW:ALC:LEV?", 12, &retCnt);
```

```
Sleep(10);
```

```
status = viRead(analyzer, rd_Buf_LVL, 20, &retCnt);
```

```
// print the commissioning information
```

```
sprintf("Cw is %s", rd_Buf_CW);
```

```
sprintf("LEVel is %s", rd_Buf_LVL);
```

```
}
```

### 9.3.5 Reading of Frequency Marker

```
/******
```

The following example shows how to read the frequency scale information.

```
/******
```

```
void ReadMarker ()
```

```
{
```

```
ViStatus status;
```

```
long retCnt;
```

```
char rd_Buf_Marker[VI_READ_BUFLEN]; // #define VI_READ_BUFLEN 20
```

```
// open the frequency marker 1 and query the frequency marker peak (frequency and amplitude)
```

```
status = viWrite(analyzer, ":CALC:MARKER ON;MARKER: FUNCTION:EXECute MAXimum\n", 25, &retCnt);
```

```
// read the X-axis information
```

```

status = viWrite(analyzer, ":CALC:MARK:X?;", 15, &retCnt);
status = viRead(analyzer, rd_Buf_Marker, 30, &retCnt);
// read the Y-axis coordinate information
status = viWrite(analyzer, ":CALC:MARK:Y?;", 15, &retCnt);
status = viRead(analyzer, rd_Buf_Marker, 30, &retCnt);
}

```

### 9.3.6 Reading of Track Data

/\*  
\*/

The following example shows how to read the track data of the vector network analyzer.

/\*  
\*/

```

void QueryData ()

```

```

{

```

```

ViStatus status;

```

```

long retCnt = 0;

```

```

int points= 0

```

```

// #define VI_READ_BUFLEN 1000000

```

```

char rd_Buf_BigData[VI_READ_DATABUFLEN];

```

```

char rd_Buf_Data[VI_READ_BUFLEN]; // #define VI_READ_BUFLEN 20

```

```

// selection of measurement

```

```

status = viWrite(analyzer, ":CALCulate:PARameter:SElect 'CH1_WIN1_LINE1'\n", 25, &retCnt);

```

```

// obtain the number of scanning point

```

```

status = viWrite(analyzer, ":SENSe1:SWEep:POIN?\n", 15, &retCnt);

```

```

status = viRead(analyzer, rd_Buf_Data, 30, &retCnt);

```

```

points = atoi(rd_Buf_Data);

```

```

// scan once

```

```

status = viWrite(analyzer, ":SENSe1:SWEep:GROUps:COUNT 1\n",30, &retCnt);

```

```

status = viWrite(analyzer, ":SENS:SWE:MODE GROUps\n",30, &retCnt);

```

// sending and reading of data command. Here the data format is original data, divided into the real part and imaginary part. The returned character//string format is: "real part of the first point, imaginary part of the first point, real part of the second point, imaginary part of the second point..."

```

status = viWrite(analyzer, ": CALCulate:DATA? SDATA\n",30, &retCnt);

```

```

status = viRead(analyzer, rd_Buf_BigData, VI_READ_BUFLEN, &retCnt);

```

```

}

```

### 9.3.7 Command Synchronization

The method of command synchronization is introduced below, taking the scanning process as an example.

```

void SweepSync()

```

```

{
ViStatus status;
long retCnt;
ViEventType etype;
ViEvent eevent;
int stat;
char OpcOk [2];
/*****
/* Command INITiate[:IMMEDIATE] start single scanning ( closed in continuous scanningINIT:CONT OFF)*/
/* Execute next command of command buffer zone after single scanning */
/*****
status = viWrite(analyzer, "INIT:CONT OFF", 13, &retCnt);
// Method 1 of waiting for ending of scanning: use *WAI
status = viWrite(analyzer, "ABOR;INIT:IMM;*WAI", 18, &retCnt);

// Method 2 of waiting for ending of scanning: use *OPC?
status = viWrite(analyzer, "ABOR;INIT:IMM; *OPC?", 20, &retCnt);
status = viRead(analyzer, OpcOk, 2, &retCnt); //Wait for*OPC and return to "1"

// Method 3 of waiting for ending of scanning: use *OPC
// To enable GPIB service request, set "Disable Auto Serial Poll" as "yes"
status = viWrite(analyzer, "*SRE 32", 7, &retCnt);
status = viWrite(analyzer, "*ESE 1", 6, &retCnt); // enable service request ESR
// set event enabling bit to complete operation
status = viEnableEvent(analyzer, VI_EVENT_SERVICE_REQ, VI_QUEUE, VI_NULL);
// enable SRQ event
status = viWrite(analyzer, "ABOR;INIT:IMM;*OPC", 18, &retCnt);
// start scanning synchronously with OPC
status = viWaitOnEvent(analyzer, VI_EVENT_SERVICE_REQ, 10000, &etype, &eevent)
// wait for service request
status = viReadSTB(analyzer, &stat);
status = viClose(eevent); // close event handle
// prohibit SRQ event
status = viDisableEvent(analyzer, VI_EVENT_SERVICE_REQ, VI_QUEUE);
// main program continues.....
}

```

## 9.4 I/O Library

### 9.4.1 Overview of I/O Library

The I/O library is a library of pre-written software programs for the instrument, known as the instrument drive program, i.e. instrument driver. It is an intermediate software layer between the computer and instrument hardware equipment. It is composed of the function library, utility program, tool kit, etc., and is a set of software code modules. This set corresponds to a series of planned operations, such as instrument configuration, reading, writing, triggering, etc. It is installed the computer and used as a connecting bridge and link between the computer and instrument. With the easy-to-program high-level modular library, the user does not need to the complex special low-level programming protocol for the specific instrument. It is key to use the instrument driver to rapidly develop the test measurement application.

From the functional perspective, one general instrument driver is composed of five parts: functional body, interactive developer interface, program developer interface, subprogram interface and I/O interface, as shown in Fig. 9.14.

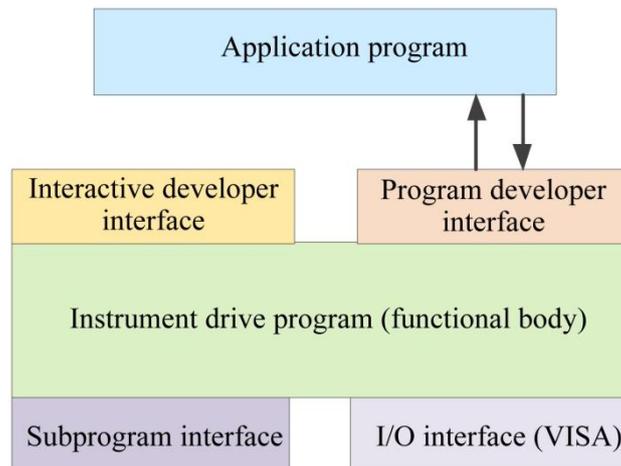


Fig. 9.14 Instrument Driver Structure Model

Details are as follows:

- 1) Functional body. This is the main functional part of the instrument driver and can be understood as the framework program of the instrument driver.
- 2) Interactive developer interface. To facilitate use, the graphical interactive developer interface is generally set in the application environment supporting instrument driver development. For example, the function panel of Labwindows/CVI is a kind of interactive development interface. Each parameter of the instrument driver function in the function panel is expressed in the graphical control form.
- 3) Programming developer interface. This is a software interface for the application program to call the instrument driver function, such as the dynamic link library file of instrument driver.dll in the Windows system.
- 4) I/O interface. It is used for actual communication between the instrument driver and instrument. It is allowed to use the special bus I/O software, such as GPIB and RS-232, or the general standard I/O software (VISA/I/O) to be used over multiple buses.
- 5) Subprogram interface. It is a software interface for the instrument driver to visit other supporting libraries, such as the data library, FFT function, etc. It will be used when other software modules, operating systems, program code libraries and analysis function libraries are called by the instrument driver after completion of tasks.

### 9.4.2 I/O Library Installation and Configuration

With applications in the test field, the I/O library has experienced various development phases from the traditional instrument to virtual instrument. In order ensure the instrument interchangeability in the automatic test system and the reusability of the test program, the instrument drive program has also experienced various development phases. At present, the popular universal driver is an IVI (Interchangeable Virtual Instruments) instrument driver. Based on the IVI specification, the new instrument programming interface, inserted drive program and VPP architecture on VISA are defined, so that the test application program is fully independent of the instrument hardware. In addition, the unique functions of instrument simulation, range detection and status caching are added to improve the system operating efficiency and truly realize the instrument interchangeability.

The IVI driver is divided into two types: IVI-C and IVI-COM. IVI-COM is based on the Microsoft component

object model (COM) technology, in the COMAPI form, and IVI-C is based on ANSIC, in the CAPI form. The two types of drivers are designed in accordance with the instrument categories defined in the IVI specifications. The application development environments are the same, including Visual Studio, Visual Basic, Agilent VEE, LabVIEW, CVI/LabWindows, etc.

In order to meet user requirements in different development environments, two types of drivers are needed at present. The IVI driver of the vector network analyzer is developed with the Nimbus Driver Studio technology. The IVI-COM and IVI-C driver and program installation packages are generated directly. For specific installation and configuration, refer to the accompany files of the selected control card and I/O library.

The installed IVI driver is divided into the IVI inherent function group and instrument function group (basic function group and extended function group). For specific functional classification, functions and attribute details, refer to the help file of the driver.

---

### Prompt

#### **Port configuration and I/O library installation:**

Before controlling the vector network analyzer with a computer, check whether the necessary port and I/O library are properly installed and configured.

---

---

### Prompt

#### **Use of I/O library:**

If the accompanying IVI-COM/C drive program installation package is installed, the function panel, help file and drive function example programs will be installed automatically to facilitate development and integration of the programmed functions.

---

## 10 Fault Diagnoses and Repair

This chapter will introduce how to find out problems and receive the after-sale service. Error information of the network analyzer is also introduced.

In case of any fault in operation of the purchased AV3672 series vector network analyzer or when you need to purchase relevant component or accessory, please contact us as we provide complete after-sales services.

In general, the trouble is caused by failure of hardware/software or users' misuse. Please contact us immediately in case of any trouble. For the vector network analyzer within the warranty period, we will implement free repair according to the commitments in the warranty; otherwise, we will charge the costs.

- [Operating principle](#) .....:323
- [Fault diagnosis and troubleshooting](#) .....:323
- [Error information](#) .....:325
- [Repair](#) .....:341

### 10.1 Operating principle

#### 10.1.1 Response of Tested Device to RF Signal

The test signals generated by the signal source of the vector network analyzer are input into the tested device. Part of the test signals are reflected by the tested device and other signals are transmitted. Fig. 10.1 shows the response of the tested device to the test signals.

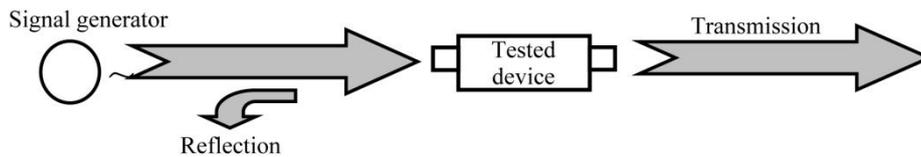


Fig. 10.1 Response of Tested Device to Signals

#### 10.1.2 Overall Principle

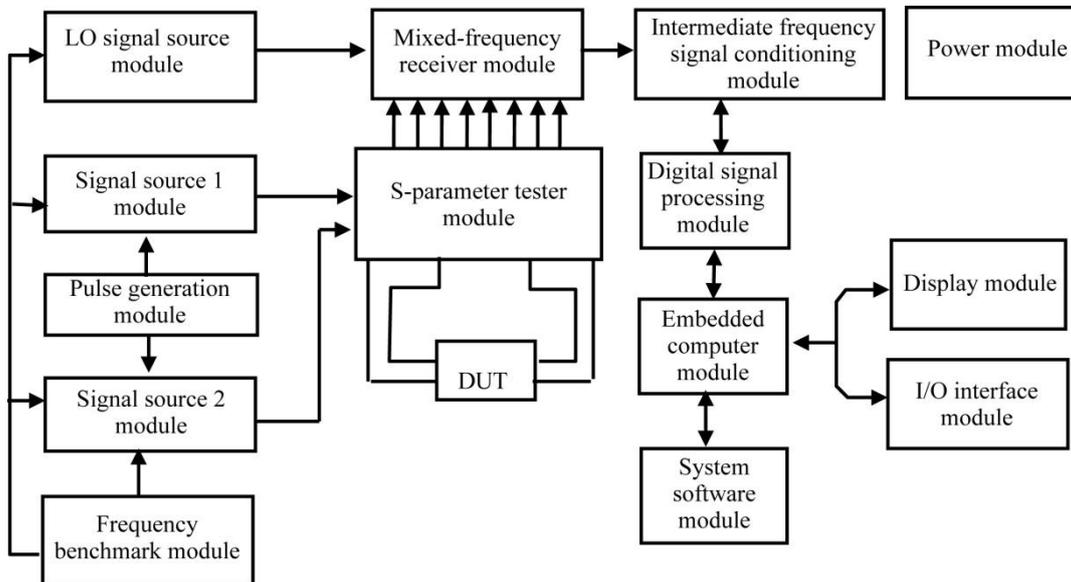


Fig. 10.2 Block Diagram of Overall Principle

AV3672 series vector network analyzers are intelligent test instrument designed based on the modular concept, with the embedded industrial computer module as the control center. The design concept includes the “embedded computer hardware platform based on the multi-processor + test module”, realizing the perfect combination of the test instrument and industrial computer. The test control software with the Windows operating system can make the human-machine interface of the instrument more friendly and the operation more convenient. The block diagram of

modular design of the instrument is shown in Fig. 10.2. The system mainly includes the LO signal source module, signal source module 1, signal source module 2, frequency benchmark module, S-parameter tester module, mixed-frequency receiver module, intermediate frequency signal processing module, digital signal processing module, embedded computer module, power supply module, display module, I/O interface module, software module, etc.

The frequency benchmark module is locked to the internal or external 10MHz reference signal to produce the locking reference signal for the LO source and signal source and the synchronization signal for the whole instrument.

The LO signal source module and excitation signal source module are locked to the reference signal output by the frequency benchmark module, to produce the required LO signal and RF signal through the switching frequency doubling device, subband bandpass filter and automatic level control circuit (ALC).

The S-parameter tester module is a signal separator to separate the incident signal, reflected signal and transmitted signal of the tested device.

In the mixed-frequency receiver module, the incident, reflected and transmitted signals including the amplitude and phase information of the tested device are mixed with LO signals, and the generated intermediate frequency signals are transmitted to the intermediate frequency signal conditioning module for further processing.

The intermediate frequency signals are conditioned by the intermediate frequency signal conditioning module to meet the requirements of the digital signal processing module for intermediate frequency signals.

In the digital signal processing module, the analog intermediate frequency signals are transformed into digital signals, and then the digital signals are processed to obtain the amplitude and phase information of the tested device. Measurement results are transmitted to the main CPU through the high-speed PCI bus.

The system test control module run on the embedded PC platform is used to transform the amplitude and phase information of the tested device into various formats, and the results are transmitted to the display module. In addition, the system software is also used for management of various interfaces and scheduling of various processes of the instrument.

## 10.2 Fault Diagnosis and Troubleshooting

### Prompt

#### Fault diagnosis and guidance

This section aims to guide simple judgment and disposal of faults of AV3672 series vector network analyzers. If necessary, provide accurate feedback to the manufacturer to solve problems as soon as possible.

If any information appears in the status indication zone of the user interface, view [Help] > [Error information] > [View error log] to know specific information.

- [System problems](#) .....323
- [Curve display anomaly](#) .....324
- [Scanning problems](#) .....324
- [Display problems](#) .....324
- [Response failure of front panel keys](#) .....324
- [Menu failure](#) .....324

### 10.2.1 System Problems

#### 10.2.1.1 The standby light is not ON.

Check whether the 220V AC power input of the network analyzer is normal. The allowable maximum deviation is 220V±10%. If the deviation is too large or small, the instrument may not work normally. In case of abnormality, check external wires for any failure; power on the instrument again and restart it after trouble-shooting. If the 220V AC power input is normal, check whether the power switch on the rear panel of the instrument is turned on. Under normal conditions, the power switch should be in the “ | ” state. If the fault is caused by the power supply of the instrument, send the instrument to the manufacturer for repair.

### 10.2.1.2 The system cannot be enabled after start-up.

If the system cannot be enabled after start-up, first check whether the hard disc on the rear panel is loose. If the hard disc is loose, tighten the fixing screw or pull out and reinsert the hard disc. If the hard disc is not loose, recover the system. For specific steps, refer to “[3.1.2.1 System Recovery of Network Analyzer](#)”.

### 10.2.1.3 The network analyzer software cannot be used after start-up.

If the network analyzer software cannot be used after start-up and system enabling, double-click the desktop icon  of the vector network analyzer or press the [Reset] key on the front panel or click [Start] > [Programs] > [Vector network analyzer] to start the program. If the software can be started smoothly, install the antivirus software to kill viruses and restart the instrument. If the software cannot be started automatically, download the vector network analyzer program and double-click the vector network analyzer installation program in the root directory of Disc D or E. Reinstall the vector network analyzer program with reference to “[3.1.2.2 Updating of Network Analyzer](#)”.

## 10.2.2 Curve Display Anomaly

The curve display anomaly is caused for various reasons. At first, check whether the user reset state is saved. Click [System] > [Custom user reset state] in the menu bar to open the [Custom user state] window. Remove the tick in the check box in front of “Save final state as user reset state” and “Enable user reset state”. Click OK to close the [Custom user state] window. Press [Reset] on the front panel. The S11 curve should be near 0 if the port is not connected with any load.

If the curve is still abnormal after the above methods are applied, contact our technical support personnel for solutions.

## 10.2.3 Scanning Problems

### 10.2.3.1 Scanning seems stopped.

The open-circuit curve of the port seems no scanning in the reset state. This is caused by high stability and scanning speed of the vector network analyzer. Click [Excitation] > [Scanning] > [Scanning time], enter 20 and press ENTER. Then you can see the scanning cursor.

### 10.2.3.2 Scanning is stopped.

Check whether the instrument is in the HOLD state. If the instrument is in the HOLD state, modify the trigger mode and press [Excitation] > [Trigger] > [Continuous scanning] or open the [Trigger] dialog box and set the automatic trigger mode.

### 10.2.3.3 The white scanning cursor is in the lower part of the screen.

Both ports should be scanned for correction after full double-port calibration. If only the track with the excitation source on Port 1 is displayed, the white cursor will appear in the lower part of the screen to scan Port 2. This is a normal scanning state and no change is required.

## 10.2.4 Display Problems

If the display window is blocked by the task bar, right-click the task bar, click [Attribute], tick “Automatic hide task bar” and click OK to close the dialog box. In this case, the task bar will be automatically hidden and the test window will not be blocked.

## 10.2.5 No Response of Front Panel Keys

In case of no response of front panel keys, which is caused by damage of the instrument drive program, download the vector network analyzer and reinstall it. For specific steps, refer to “[3.1.2.2 Updating of Network Analyzer Program](#)”. Select the “Complete” installation type and reinstall the drive program. If the problem still exists, recover the system. For specific steps, refer to “[3.1.2.1 System Recovery of Network Analyzer](#)”.

## 10.2.6 Menu Failure

In case of menu failure, at first check whether the GPIB status at the bottom of the window is LOCAL. If the program-controlled state is enabled, press the [Macro/Local] key on the front panel or connect the keyboard and press [Esc] to recover the local state.

## 10.3 Error Information

Any error will be reported in the error queue of SCPI (remote control interface) and the error queue displayed on the front panel. Two queues are displayed and processed independently. For details of the error queue of the front panel, refer to the User Manual.

If the SCPI (remote interface) error queue is used for access to messages, the error number and <Description> in the error queue will be displayed on the host terminal.

The error information of the vector network analyzer can be displayed and recorded in the error file. The user can select to select or not to select the error information.

### 10.3.1 Local Error Information

#### 10.3.1.1 Viewing of Error Information

**By interface operation:**

The error or warning prompt information in the test interface of the vector network analyzer in operation indicates operation or hardware problems. All prompt, warning and error events in operation are recorded in the error log of the vector network analyzer. Using the error log, the user can view the date, time, etc. of the concerned prompt, warning and error details, and click “Help” for further information. Only one piece of error information can be displayed at the specific time. As the problems may occur at the same time, the following operations can help to view all the error prompt information:

**Step 1:** press [Help] > [Error information] > [View error log]. The [Error log] window will pop up.

**Step 2:** prompt information will be displayed in the window.

**Step 3:** browse the error information with the mouse and close the dialog window.

**Step 4:** click [Clear error list] to clear historical error information.

#### 10.3.1.2 Description of Error Information

If any error is detected in measurement with the vector network analyzer, the warning or error information will be displayed in the test interface. In the default mode, error information will be displayed for a certain period of time. The user can keep error information displayed on the screen until “OK” is pressed, or select not to display the error information. When the error information is displayed on the screen, you can click [Help] for further help information, as shown in Fig. 10.3.



Fig. 10.3 [Information display mode] Dialog Box

Table 10.1 Level Distinguishing with Fonts and Colors

Color	Error Level	Error illustration
Red	Error	Error in measurement, such as failure caused by data loss or improper setting.
Blue	Warning	Irregular operation in measurement, such as failure of measurement as a result of mismatch of the instrument setting and displayed result or temporary disconnection with the external device.
Black	Prompt	Step setting or measurement information.

### 10.3.2 Program Error Information

### Error information formats

In the remote control mode, error information is recorded in the error log. Query the error information with the command "SYSTem:ERRor?". Error information formats are as follows:

"Time:"

"Error No.:"

"Error level:"

"Error type:"

#### Example:

Time: 20:40:21, 2014/11/16

Error No.: 1400

Error level: wrong

Error type: grammar error

Program error information is divided into two types:

- Negative error codes defined in the SCPI standard, not detailed here.
- Positive error codes of instrument characteristics, with details shown in the following table.

Table 10.2 List of Instrument Characteristic Error Information

Error code	Error Level	Error illustration
512	Prompt	<b>The secondary parameter (such as the power, intermediate frequency bandwidth, scanning time and step mode) of the calibration state has been changed.</b> <b>Type:</b> Changes of such parameters after calibration may result in inaccurate measurement.
513	Prompt	<b>Calibration cannot be done as a result of failure to complete all standard measurements.</b> This may be caused by enabling of the error correction function before all standard measurements for calibration.
515	Prompt	<b>The correction function cannot be enabled (no error correction data corresponding to Channel &lt;x&gt; or Measurement &lt;x&gt;). Perform calibration.</b> No error correction data corresponding to the specified channel and measurement.
516	Prompt	<b>The key parameters of the current instrument state do not match with the calibration set, and the correction function is shut down.</b> Key parameters include the scanning type, starting frequency, frequency span and point number.
517	Prompt	<b>The correction function is shut down as the interpolation function is shut down and excitation settings are changed.</b> The original excitation settings should be applied for the most accurate calibration.
518	Prompt	<b>Shut down the interpolation function, enable the correction function and recover the previous excitation settings.</b>
519	Prompt	<b>The excitation range is beyond the original calibration settings, resulting in shutdown of the correction function.</b> Correction data beyond the excitation settings will not be generated.
520	Prompt	<b>The calibration type of Channel &lt;x&gt; and Measurement &lt;x&gt; is "None". Select the calibration type by the [Calibration] menu or with the keys.</b> Calibration will not be done if the calibration type is not selected or the invalid calibration type is set. This error is caused by no calibration or calibration without calibration type selection.
521	Prompt	<b>The calibration type does not match the selected measurement type. The</b>

		<b>correction function is shut down or correction is not allowed.</b> Some kinds of calibration are only applicable to some S-parameters. For example, the Port 1 calibration for S11 is not applicable to Port 1 calibration of S22.
522	Prompt	<b>More standard kits should be measured.</b>
524	Prompt	<b>Not full double-port calibration.</b>
525	Prompt	<b>Two calibration kits are used.</b>
526	Prompt	<b>No user calibration data suitable for the channel are found.</b> Correction cannot be done as a result of no calibration.
527	Prompt	<b>The standard calibration kit is not required for the calibration type.</b> This error is caused if one undesired standard calibration kit is measured during calibration.
528	Prompt	<b>The electrical calibration system cannot be configured. Check whether the module is connected properly..</b> Before electrical calibration, normal communication between the network analyzer and electrical calibration module should be established at first, and the module should be confirmed; otherwise, electrical calibration cannot be done.
529	Prompt	<b>Out-of-limit data: beyond the design range.</b> Key parameters include the scanning type, starting frequency, frequency span and point number.
530	Prompt	<b>Execution error: the data dimensions do not match.</b>
531	Prompt	<b>Execution error: the array cleared.</b>
532	Prompt	<b>Execution error: the array function is invalid.</b>
533	Prompt	<b>Execution error: the array subscript is wrong.</b>
534	Prompt	<b>Execution error: the array subscript is out of limit.</b>
535	Prompt	<b>Execution error: the matrix rank is wrong.</b>
536	Prompt	<b>Execution error: CPU.</b>
537	Prompt	<b>Execution error: the module cannot be deleted.</b>
538	Prompt	<b>Execution error: the module cannot be written.</b>
539	Prompt	<b>Execution error: no input.</b>
540	Prompt	<b>Execution error: the system is busy and the command is invalid.</b>
541	Prompt	<b>Electrical calibration: the module is not on the RF channel. Connect the module to the specified port.</b> The RF channel is not connected to the electrical calibration module, and no signal is found in the corresponding calibration measurement.
542	Prompt	<b>Execution error: no space for new calibration kit. Delete one calibration kit.</b> Key parameters include the scanning type, starting frequency, frequency span and point number.
543	Prompt	<b>Execution error: the space is not enough.</b>
544	Prompt	<b>Execution error: other matrix errors.</b>
545	Prompt	<b>Execution error: unequal rank.</b>
546	Prompt	<b>Execution error: few constant ranks.</b>
547	Prompt	<b>Execution error: few variable ranks.</b>
548	Prompt	<b>Perform pre-calibration.</b>
549	Prompt	<b>Execution error: bug in the dynamic library of electrical calibration drivers or invalid module number.</b>
550	Prompt	<b>Execution error: accidental error from the electrical calibration driver.</b>
551	Prompt	<b>Execution error: error of the built-in driver.</b>
552	Prompt	<b>Hardware error: failure of access to the electrical calibration module.</b>
553	Prompt	<b>Hardware error: failure to release the LPT port. Restart the instrument.</b>

554	Prompt	<b>Hardware error: error of the vector network analyzer.</b>
555	Prompt	<b>Hardware error: failure to read enough data from the electrical calibration module.</b>
556	Prompt	<b>Suspension of the master control computer.</b>
557	Prompt	<b>Suspension of user operation.</b>
558	Prompt	<b>Out-of-limit memory.</b>
559	Prompt	<b>Ended query: the message is abandoned.</b>
560	Prompt	<b>Unfinished query: incomplete application message.</b>
561	Prompt	<b>Unfinished query: no content.</b>
562	Prompt	<b>Queue overflow.</b>
563	Prompt	<b>Setting conflict: requiring the additional standard calibration kit.</b>
564	Prompt	<b>Setting conflict: the adapter cannot be calibrated.</b>
565	Prompt	<b>Setting conflict: the command queue is subject to overflow.</b>
566	Prompt	<b>Setting conflict: calibration is stopped, as a result of changes of analyzer settings.</b>
567	Prompt	<b>Setting conflict: calibration is not done.</b>
568	Prompt	<b>Setting conflict: the specified GPIB board cannot be found.</b>
569	Prompt	<b>Setting conflict: gpib32.dll cannot be found/installed.</b>
570	Prompt	<b>Setting conflict: siel32.dll cannot be found/installed.</b>
571	Prompt	<b>Setting conflict: the network analyzer cannot be initialized (wrong address?).</b>
572	Prompt	<b>Setting conflict: the print port drive program or USB-driven dynamic library cannot be loaded.</b>
573	Prompt	<b>Setting conflict: the calibration canning mode is invalid.</b>
574	Prompt	<b>Setting conflict: the calibration type is invalid.</b>
575	Prompt	<b>Setting conflict: calibration is invalid.</b>
576	Prompt	<b>Setting conflict: the specified GPIB board number is invalid.</b>
577	Prompt	<b>Setting conflict: the specified GPIB board type is invalid.</b>
578	Prompt	<b>Setting conflict: the module state is invalid.</b>
579	Prompt	<b>Setting conflict: the state is invalid.</b>
580	Prompt	<b>Setting conflict: the LPT port must be 1-4.</b>
581	Prompt	<b>The electrical calibration system cannot be configured. Check whether the module is connected properly.</b>
582	Prompt	<b>Setting conflict: the specified LPT port does not exist.</b>
583	Prompt	<b>Setting conflict: use the frequency domain in calibration.</b>
584	Prompt	<b>Setting conflict: use the step scanning type in calibration.</b>
585	Prompt	<b>Setting conflict: the analyzer address must be 0-30.</b>
586	Prompt	<b>Setting conflict: wrong print port driver or USB-driven dynamic library.</b>
587	Prompt	<b>Grammar error: the ECAL: DELAY must include two digits.</b>
588	Prompt	<b>Grammar error: incorrect grammar.</b>
589	Prompt	<b>Grammar error: unknown command.</b>
590	Prompt	<b>The module port on the RF channel is wrong.</b>
591	Prompt	<b>The module does not conform to the requirements described by the user.</b>
592	Prompt	<b>The source power calibration data corresponding to the current measurement channel and source port are not found.</b> Try to enable the source power calibration function, but no calibration data are found.
593	Prompt	<b>Failure of source power calibration scanning or correction of the channel and source port corresponding to the current measurement.</b>

		Try to enable the source power calibration function, but calibration data are not complete.
594	Prompt	<b>Reserved.</b>
595	Prompt	<b>Reserved.</b>
596	Prompt	<b>The calibration function is enabled, but the calibration power is changed in source power calibration of Port 1 and Channel 2. The calibration function is not shut down, but the power value cannot be used to represent the calibration.</b> The source power calibration may be inaccurate.
597	Prompt	<b>The software version does not support the electrical calibration function.</b>
598	Prompt	<b>A circle cannot be properly fitted as a result of inappropriate sliding in measurement of the standard calibration kit for the sliding load. The original impedance of the standard calibration kit is used to determine the direction of one or more point(s).</b> To accurately describe the standard calibration kit, the sliding load must be moved properly to ensure sufficient sampling along the plural circle or Smith chart. Insufficient sampling may result in inaccurate results.
599	Prompt	<b>One unused channel is required but cannot be found. Release one channel and test it.</b>
600	Prompt	<b>Interpolation cannot be done to the original standard calibration kit in the segment scanning mode. Shut down the calibration function.</b>
601	Error	<b>Calibration is not complete (the standard calibration kit measurement is not completed).</b>
602	Error	<b>The correction function is not enabled.</b>
603	Error	<b>The power correction function cannot be enabled. Calibrate the power meter at first.</b>
604	Error	<b>The scanning state is changed, the power correction data are invalid, and the power correction function is shut down.</b>
605	Error	<b>The power correction function is shut down, and the original scanning state is recovered.</b> Key parameters include the scanning type, starting frequency, frequency span and point number.
608	Error	<b>The calibration type is not set.</b> Calibration can be done only when the calibration type is valid and the appropriate calibration type is selected.
609	Error	<b>Fail to achieve the calibration characteristics.</b> The specified calibration kit may be one of the optional calibration kits. For example, one standard calibration is required in response calibration, three in one-port calibration and 12 in full double-port calibration.
610	Error	<b>The calibration class is invalid for the current calibration type. Select a different calibration class or type.</b>
611	Error	<b>The standard calibration data corresponding to the selected calibration type are not found.</b> The original measurement data of the specified standard calibration kit is not found in the current measurement cache zone.
612	Error	<b>Error item data corresponding to the selected calibration type are not found.</b> No specified error item in the error correction cache zone (including all error coefficients of the current calibration).
613	Error	<b>Reserved.</b> The access to the calibration set is not successful. The calibration set may be deleted or destroyed.
614	Error	<b>The specified measurement is not compatible with the current calibration. Select a different measurement type or load a different calibration type or reinstall the</b>

		<p><b>calibration kit.</b> Prevent measurement selection so as not to shut down the measurement calibration function. Some calibration types do not support all measurements. For example, S111-PORT calibration cannot be used in S12 calibration measurement. If the measurement which is not supported by the current calibration is selected, prompt information will be given, and the calibration function will be shut down.</p>
615	Error	<p><b>A new calibration set has been created.</b> The newly created calibration set will be automatically named and sealed with the timestamp. Only the calibration set subject to calibration can be saved. In case of suspension or failure in completion of calibration, the calibration set will be deleted.</p>
617	Error	<p><b>The pre-calibration fails.</b></p>
620	Error	<p><b>The measurement state is changed, and the antenna and RCS calibration function is shut down.</b></p>
621	Error	<p><b>The measurement state is changed, and the antenna and RCS calibration function cannot be enabled.</b></p>
622	Error	<p><b>The calibration data are invalid, and the antenna and RCS calibration function cannot be enabled.</b></p>
634	Error	<p><b>Calibration set file: &lt;x&gt; loading failure.</b> The calibration set file is a collection of calibration sets and saved in the hard disc.</p>
635	Error	<p><b>Calibration set file: &lt;x&gt; saving failure.</b> File operation error and saving suspension.</p>
636	Prompt	<p><b>One calibration set is deleted.</b> One calibration set is successfully deleted. This may be caused as a result of application or deliberate operation of the user.</p>
637	Error	<p><b>Calibration set file version: &lt;x&gt; is not compatible with the current measurement.</b> The calibration set is not available as a result of version nonconformity. This may be caused by software upgrading.</p>
638	Error	<p><b>Incompatible calibration set: &lt;x&gt;of&lt;y&gt;, the saved calibration set is loaded.</b> Some calibration sets in the calibration set file are wrong.</p>
639	Prompt	<p><b>Calibration set file: &lt;x&gt; is not found. A new file will be created.</b> The calibration set file is saved in the hard disc. After start-up of the network analyzer, the file will be searched. If the file is found, it indicates that the file has been loaded; otherwise, a new file will be created, and the prompt will be provided.</p>
640	Error	<p><b>The specified calibration set is used at present.</b> It indicates that several calibration set users are performing calibration tasks, resulting in conflicts.</p>
641	Error	<p><b>The specified calibration set cannot be opened.</b> Many users are trying to visit the calibration set.</p>
642	Error	<p><b>Reach the maximum register number of the calibration set. Delete the old or useless calibration set before creating a new calibration set.</b> The network analyzer can be configured with 100 calibration sets.</p>
644	Error	<p><b>Calibration must be effectively done once before enabling the error correction function.</b> This generally indicates that the calibration is not completed or there is no calibration kit matching with the selected measurement type in the current calibration set.</p>
646	Error	<p><b>The calibration set is not loaded and the version is too new.</b> The new calibration file is used in the old software. The version is not compatible.</p>
772	Error	<p><b>The DSP board drive program does not work. Check the hardware. Use simulation data in the software.</b> Communication between the network analyzer and DSP board fails. The hardware or drive program may be faulty.</p>

773	Error	The serial bus of the instrument does not work properly. The serial EEPROM of the instrument may be all "1" or "0". This may be caused by hardware problems.
774	Error	<b>Intermediate frequency overload.</b>
848	Error	<b>Locking failure &lt;x&gt;.</b> The source phase can't be locked properly. This may be caused by hardware failure, poor calibration or data damage in serial EEPROM.
849	Error	<b>Phase locking failure &lt;x&gt;.</b>
850	Error	<b>Unknown hardware error.</b> The communication with DSP fails as a result of hardware problems.
855	Error	<b>The source amplitude is not stabilized.</b> The source amplitude cannot be properly stabilized at the required power. The indicated power is not accurate.
856	Error	<b>The LO amplitude is not stabilized.</b>
859	Error	<b>YIG calibration fails.</b> The internal auto-calibration tuning of the YIG oscillator fails.
861	Error	<b>The simulation slope calibration fails.</b> The internal simulation slope calibration fails.
865	Error	EEPROM writing fails. The storage of calibration data in EEPROM fails. This may be caused by hardware failure.
867	Error	<b>Try to write the input or read-only I/O port.</b> Try to write one input or read-only I/O port.
868	Error	<b>Try to read the input or write-only I/O port.</b> Try to read the input or write-only I/O port
1025	Error	<b>The instrument cannot be shut down normally. The program is not stable. Restart the instrument.</b> This is displayed when the vector network program crashes. If this message continues to appear, please consult the service center.
1026	Error	<b>The limit segment type is wrong.</b> Three limit segment types are provided: OFF. MAX and MIN.
1027	Warning	<b>The group delay format must not be used in the CW or power scanning mode.</b> The group delay format must not be used in the single-frequency scanning mode; otherwise, invalid data will be generated.
1028	Warning	<b>The limit line test fails.</b> The limit line test fails.
1029	Prompt	<b>The limit line test is successful.</b> The limit line test is successful.
1030	Warning	<b>Exceed the maximum number of tests.</b> At most 512 measurements can be created.
1031	Error	<b>An error occurs inside the analyzer. An error occurs when new measurement is added.</b> If this message continues to appear, please consult the service center.
1032	Warning	<b>The selected measurement is not found. Operation cannot be performed.</b> Conflict.
1033	Warning	<b>Measurement of the same name cannot be created.</b>
1034	Warning	<b>The selected track is not saved. Save the track before track operation.</b> The track must be saved before track operation.
1035	Prompt	<b>The averaging operation is completed.</b> COM programming information. The scanning averaging is completed, and the value reaches the set averaging factor.
1036	Error	<b>The scanning averaging of resetting is completed.</b>

		COM programming information. The scanning averaging is not completed, and the value does not reach the set averaging factor.
1037	Prompt	<b>At least three points are required for time domain transformation and gate operation. If less than three points are provided, cancel the time domain transformation and gate operation.</b>
1038	Prompt	<b>The stepping type must be used in the low-pass time domain measurement mode. The band-pass must be used in the pulse excitation type.</b>
1039	Warning	<b>Smoothing cannot be done as a result of insufficient points.</b>
1040	Warning	<b>If too may low-pass points in the time domain are beyond the frequency range, the system will automatically change into the band-pass mode.</b>
1041	Warning	<b>The low-pass frequency cannot be set in the current configuration.</b>
1103	Prompt	<b>The measurement name is repeated.</b>
1104	Error	<b>The number of measurements is out of limit.</b> At most 512 measurements can be created.
1105	Error	<b>The parameter is invalid.</b> The measurement parameter entered in programming is invalid.
1106	Error	<b>No measurement is found.</b> Conflict.
1107	Error	<b>The saved track is invalid and cannot be operated.</b> Save the track before track operation.
1108	Error	<b>No reference cursor.</b> Try to create the $\Delta$ cursor (only for COM) before creating the reference cursor.
1109	Error	<b>The data and saved track do not match with each other. The track operation is shut down.</b> Warning: channel settings are changed in track operation.
1110	Error	<b>The data and saved track do not match with each other. Measurement conditions of the memory and data tracks should be similar in track operation.</b> Try to perform track operation on the mismatching data and memory track.
1111	Error	<b>The cursor bandwidth is not found.</b> The track conforming to the specified bandwidth standard cannot be found.
1112	Error	<b>The peak value is not found.</b> The track conforming to the specified peak standard cannot be found.
1113	Error	<b>The target search value is not found.</b> The interpolation data point conforming to the search value requirements is not found.
1114	Error	<b>One auxiliary port must be provided for reflection measurement (such as S11) to clearly identify the Port 2 measurement of the multi-port device.</b>
1115	Warning	<b>As a result of measurement type or source port changes, the receiver power calibration is invalid and shut down.</b>
1116	Warning	<b>The non-ratio power measurement is required for receiver power calibration.</b>
1117	Warning	<b>The source power calibration mode matching the channel and source port is not found in the current active measurement. Before receiver power calibration, calibrate the source power or call one source power calibration type.</b>
1118	Error	<b>The operation is only applicable to standard measurement.</b>
1119	Error	<b>The custom measurement cannot be loaded as a result of mismatch with the hardware of the network analyzer.</b>
1120	Error	<b>The custom measurement cannot be loaded as a result of mismatch with the software of the network analyzer.</b>
1121	Error	<b>The custom measurement cannot be loaded for unknown reasons.</b>
1122	Error	<b>Custom measurement data processing is abnormal and will be terminated. The</b>

		software of the network analyzer may be not steady. It is recommended to shut down the program and run it again.
1123	Error	The operation is only applicable to custom measurement.
1124	Error	The proposed custom measurements are unavailable.
1125	Error	The proposed custom algorithm does not exist.
1126	Error	Normalization fails, as the divisor storage zone is invalid in measurement.
1127	Warning	The original data for measurement cannot be provided.
1128	Prompt	Time domain transformation or “Add” gate operation are not allowed in the selected scanning type or prohibited.
1284	Prompt	The instrument status word is changed.
1285	Prompt	<x> error caused by the received SCPI command: “<x>”.
1400	Warning	<x> command error.
1401	Warning	The command parameter must be entered in <x>.
1402	Warning	The command parameter entered in <x> is not correct.
1403	Error	The command in <x> cannot be queried.
1405	Error	Too few parameters for the <x> command root.
1406	Error	Too many parameters for the <x> command root.
1407	Error	The type of the parameter entered in <x> is wrong.
1408	Error	The unit of the parameter entered in <x> is wrong.
1409	Error	The unit of the parameter entered in <x> does not match.
1411	Error	The parameter of the character string in <x> is wrong.
1412	Error	The integer parameter in <x> is wrong.
1413	Error	The floating parameter in <x> is wrong.
1414	Error	The char parameter in <x> is wrong.
1415	Error	No unit can be set behind the parameter in <x>.
1416	Error	The number of characters of the character string in <x> exceeds 50.
1419	Error	The command in <x> must be queried.
1420	Error	The actual character number entered in <x> does not conform to the requirements.
1421	Error	The entered ASCII code is wrong.
1422	Error	The scientific input in <x> is wrong.
1425	Error	The memory allocation fails.
1427	Error	The entered MIN or MAX parameter is wrong.
1535	Prompt	Command obtained by grammar analysis: <x>.
1536	Warning	Each window supports 8 paths at most. The track <x> cannot be established in the window <x>.
1537	Warning	The number of data windows exceeds the limit (32), and the new window cannot be created.
1538	Warning	The data window does not exist, and measurement cannot be done. Try to create new measurement with no window displayed, by means of programmed SCPI operation.
1539	Warning	No data track appears in the selected window, and operation cannot be done.
1540	Warning	The track number exceeds the limit (<x> at most) for each window. The existing measurements cannot be arranged in the <x> windows. The track number exceeds the upper limit (8 at most) for each window. The existing measurement cannot be arranged in the specified window. Refer to the help information for arrangement of the existing measurements.

1541	Warning	<b>Failure to establish the connection to the specified printer.</b>
1542	Prompt	<b>Cancel the printing output.</b>
1616	Error	<b>No window is found.</b> The window specified in the program does not exist.
1617	Error	<b>Copy the ID of the specified window.</b>
1618	Error	<b>The number of windows exceeds the limit (32 at most), and new window cannot be created.</b> At most 32 windows can be set for each screen.
1619	Error	<b>The track number exceeds the limit (8 at most) for each window. The track &lt;x&gt; cannot be created.</b> At most 8 tracks can be set for each window. Refer to the relevant help information of track, channel and window setting.
1620	Error	<b>No track is found.</b>
1621	Error	<b>The printer cannot be identified by the operating system.</b>
1622	Error	<b>No active track.</b>
1623	Error	<b>The track exists.</b>
1624	Error	<b>The starting value or ending value cannot be set in the “full bandwidth” state.</b>
1625	Error	<b>The specified cursor does not exist.</b>
1626	Prompt	<b>The specified window exists.</b>
1792	Prompt	<b>Scanning is completed.</b>
1793	Prompt	<b>All trigger requests are completed.</b>
1794	Prompt	<b>The cursor bandwidth is not found.</b> The track conforming to the specified bandwidth standard cannot be found.
1795	Prompt	<b>At least one active segment with the scanning point number more than 0 should be included in the segment table so as to enable the segment scanning mode.</b> Try to set the segment scanning mode with no segment defined or no scanning point in the defined segment.
1796	Prompt	<b>Channel spam setting message.</b> This message appears as channel settings are changed but the original settings are still used to obtain data. The message to clear channel waste will be generated if data are obtained according to new channel settings.
1797	Prompt	<b>Channel spam clearing message.</b> The previous setting message appears when channel settings are changed but the original settings are still used to obtain data. This clearing message will appear when new channel data are obtained.
1798	Prompt	<b>The segment is not deleted properly.</b>
1870	Error	<b>Measurement is not selected.</b> Measurement is not selected.
1871	Error	<b>The channel number is beyond the range.</b> The specified channel number is beyond the allowed range.
1872	Error	<b>The channel is not found.</b> An unknown channel is specified under the program control.
1873	Error	<b>The proposed scanning segment is not found.</b> An unknown scanning segment is specified under the program control.
1874	Error	<b>The scanning segment table is empty.</b> At least one segment should be defined in the segment table scanning mode. This error only occurs in remote control.
1875	Error	<b>The number of scanning points of the active scanning segment table is 0.</b> At least one scanning point with segment should be set in the segment table scanning mode. This error only occurs in remote control.

1876	Error	<b>The specified source attenuation is invalid.</b> Try to set channel attenuation properties to the vector network analyzer with no source attenuator.
1877	Error	<b>There are too many scanning points and the logarithmic scanning mode fails. Reduce the number of scanning points.</b> The maximum number of scanning points should be 401 in the logarithmic scanning mode.
1878	Error	<b>The set point number is larger than the allowable number in the logarithmic scanning mode.</b> The maximum number of scanning points should be 401 in the logarithmic scanning mode.
2048	Error	<b>Options should be added based on the standard analyzer so as to enable this function.</b>
2049	Error	<b>The current measurement instrument does not have the function you need.</b>
2050	Error	<b>A conflict occurs between the required function and current instrument state.</b>
2051	Prompt	<b>The file &lt;x&gt; has been saved.</b>
2052	Error	<b>File &lt;x&gt; saving fails.</b>
2053	Error	<b>File opening fails or the file &lt;x&gt; is not found.</b>
2054	Error	<b>The &lt;x&gt; head is wrong.</b>
2055	Error	<b>The state file is invalid and cannot loaded!</b>
2056	Error	<b>Put forward the request to enter the sleep mode.</b>
2057	Error	<b>Wake up from the sleep mode. The PBT_APMRESUMEAUTOMATIC message is received.</b>
2058	Error	<b>Wake up from the standby state. The PBT_APMRESUMESUSPEND message is received.</b>
2059	Warning	<b>Wake up from the standby state. The PBT_APMRESUMECRITICAL message is received.</b>
2060	Warning	<b>Wake up from the unknown sleep mode. The NOPBT_Message message is received in allocation and trial recovery.</b>
2061	Error	<b>The file &lt;x&gt; already exists. The file is overridden.</b> Only in remote application.
2063	Error	<b>The file &lt;x&gt; has been restored.</b> Only in remote application.
2064	Error	<b>The &lt;x&gt; version is older than the current version.</b> Try to restore an invalid file.
2065	Error	<b>The &lt;x&gt; version is newer than the current version.</b> Try to restore the latest file of the network analyzer.
2066	Error	<b>The error occurs in reading of the file &lt;x&gt;.</b> The file may have been damaged.
2067	Error	<b>Window kernel error: &lt;x&gt;.</b>
2068	Error	<b>&lt;x&gt;GPIB: failure in REN setting and clearing.</b>
2069	Prompt	<b>Change the GPIB mode into the system controller mode.</b>
2070	Prompt	<b>Change the GPIB mode into the listening mode.</b>
2071	Prompt	<b>The GPIB system controller mode must be set in the local GPIB state of the network analyzer. Stop any remote control program and press [Macro/Local] to retest the network analyzer.</b> Refer to the LCL and RMT operation.
2072	Error	<b>The range setting is wrong.</b>
2073	Error	<b>The configuration has been changed. Perform scanning again.</b> The track conforming to the specified bandwidth standard cannot be found.

2074	Error	<b>The system controller mode of GPIB cannot be enabled.</b>
2075	Error	<b>IFC cannot be cleared by GPIB.</b>
2076	Error	<b>GPIB writing fails.</b>
2077	Error	<b>GPIB calling fails.</b>
2078	Error	<b>EDVR: system error.</b>
2079	Error	<b>ECIC: the GPIB interface should be in the CIC mode according to the function requirements.</b>
2080	Error	<b>ENOL: no listener for GPIB.</b>
2081	Error	<b>EADR: GPIB interface address is not correct.</b>
2082	Error	<b>EARG: the parameter is invalid for this function.</b>
2083	Error	<b>ESAC: the GPIB interface is not in the required system controller mode.</b>
2084	Error	<b>EABO: I/O operation is canceled (timeout).</b>
2085	Error	<b>ENEB: GPIB interface does not exist.</b> The track conforming to the specified bandwidth standard cannot be found.
2086	Error	<b>EDMA: DMA error.</b>
2087	Error	<b>EOIP: asynchronous I/O operations are performed.</b>
2088	Error	<b>ECAP: the operation fails.</b>
2089	Error	<b>EFSO: file system error.</b>
2090	Error	<b>EBUS: GPIB bus error.</b>
2091	Error	<b>ESTB: overflow of serial polling status byte queue.</b>
2092	Error	<b>ESRQ: query request signal blockage.</b>
2093	Error	<b>ETAB: table problems.</b>
2094	Error	<b>GPIB reading error.</b>
2095	Error	<b>The query is interrupted.</b>
2120	Error	<b>This method cannot be called by the late bound COM.</b>
2123	Error	<b>The weight is beyond the range.</b>
2124	Error	<b>File extension names are not consistent.</b>
2126	Error	<b>No file extension name.</b>
2127	Error	<b>The holder or file does not exist.</b>
2128	Error	<b>The specified file is not found.</b>
2129	Error	<b>WINNT anomalies occur in the automatic control layer.</b>
2130	Error	<b>Invalid port.</b>
2131	Error	<b>No printer is found.</b>
2132	Error	<b>Manual trigger is ignored.</b>
2133	Error	<b>Trigger setting fails.</b>
2134	Error	<b>Macro execution fails.</b>
2135	Error	<b>The macro definition is not complete.</b>
2136	Error	<b>Trigger is too quick, and redundant trigger is ignored.</b>
2137	Error	<b>The data block length is wrong.</b> Refer to the relevant section on how to obtain data from the network analyzer.
2139	Error	<b>The requested data are not found.</b>
2142	Error	<b>The provided parameter is beyond the range. Limit it within the range before application.</b>
2144	Error	<b>The request fails. No permit is found.</b>
2145	Error	<b>Return hresult&lt;x&gt; afer remote calling of the front panel function.</b> This indicates that the front panel may be faulty.

2146	Error	<b>The data is beyond the range.</b>
2147	Error	<b>Reserved.</b>
2148	Error	<b>Reserved.</b>
2149	Error	<b>Reserved.</b>
2150	Error	<b>&lt;x&gt; is beyond the range.</b>
2152	Error	<b>Front panel &lt;x&gt;.</b>
2153	Error	<b>Front panel information.</b>
2154	Error	<b>Power supply service &lt;x&gt;.</b> Many power supply service programs are running. Only one program can be applied. This is generally caused by operation of the installed program, especially CPU board upgrading.
2155	Error	<b>Power supply service &lt;x&gt;.</b>
2156	Error	<b>GPIB drive cannot be loaded or unloaded.</b>
2157	Error	<b>GPIB drive cannot be loaded or unloaded.</b>
2158	Error	<b>GPIB drive is loaded but does not work properly.</b>
2163	Error	<b>The resetting function is executed by the network analyzer.</b>
2164	Error	<b>The access to the file is rejected.</b> This means that the output file cannot be opened, like writing protection.
2165	Prompt	<b>The file type is subject to structural storage.</b>
2166	Error	<b>Triggering fails.</b>
2167	Error	<b>The parameter is beyond the range.</b>
2168	Prompt	<b>The &lt;x&gt; file already exists.</b>

## 10.4 Repair

### 10.4.1 Contact us

In case of failure of AV3672 series vector network analyzers, first check and save error information, analysis possible causes and perform early screening and troubleshooting with reference to “10.2 Fault Diagnosis and Troubleshooting”. If the problems are not solved, contact our service consultation center according to the following contact information, and provide the collected error information. We will assist you to solve the problems as soon as possible.

#### Contact information:

Free customer service telephone: **800-868-7041**.

Technical support: **0532-86889847 86897262**

Fax: **0532-86889056 86897258**

Website: [www.ei41.com](http://www.ei41.com)

Email: [eiqd@ei41.com](mailto:eiqd@ei41.com)

Postcode: 266555

Address: **98 Xiangjiang Road, Economic and Technological Development Zone, Qingdao, Shandong, China**

### 10.4.2 Packaging and Mailing

If you cannot solve the problem of the network analyzer, contact us by phone or fax. If it is confirmed that the network analyzer needs to be returned for repair, pack the network analyzer with the original packing material and box according to the following steps:

- 1) Write fault details of the network analyzer and place it with the network analyzer into the packing box.
- 2) Pack the network analyzer with the original packing material to reduce possible damage.
- 3) Set pads in the four corners of the outer packing box, and place the instrument into the outer packing box.

- 4) Seal the opening of the packing box with a tape and strengthen the packing box with nylon straps.
- 4) Mark “Fragile!” on the box. No touch! Handle with care! on the box body.
- 6) Transport the network analyzer as a precision instrument.
- 7) Keep the copies of all transport documents.

---

### Attention

#### **Pay attention to the packing of the network analyzer.**

The instrument may be damaged if packed with other materials. Do not pack the instrument with the polystyrene sphere; otherwise, the instrument cannot be fully protected, and the generated static electricity may be sucked into the fan to cause damage to the instrument.

The network analyzer is heavy. In order to prevent damage in transportation, please give priority to the original packaging material and double-layer package. If you must package the instrument by yourself, please ensure that the instrument will not be damaged in transportation.

---

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### Prompt

#### **Instrument packing and transportation**

Strictly observe the precautions in “[3.1.1.1 Unpacking](#)” during transportation or handling of the instrument.

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## 11 Technical Indicators and Measurement Methods

This chapter describes the technical indicators and measurement methods of AV3672 series vector network analyzers.

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### 11.1 Technical Indicators

This section lists the details of performance indicators and technical parameters of AV3672 series vector network analyzers. By reading this section, the user will have an accurate understanding on main performance indicators of the product. Normal working conditions of the instrument include the ambient temperature of 0°C to +40°C and 1 standard atmospheric pressure.

Main technical parameters of AV3672 series vector network analyzers are given below. The temperature of test environment should be  $23\pm 3^{\circ}\text{C}$ , and the ambient temperature change must not exceed  $\pm 1^{\circ}\text{C}$  after calibration. The pressure should be the atmospheric pressure.

#### Attention

#### Different models and options:

AV3672A/B/C/D are respectively used to test the frequency of 13.5GHz/26.5GHz/43.5GHz/50GHz.

AV3672A/B/C/D of standard configuration can be used to test the indicators of Port 1 and 2. The four-port type AV3672A/B/C/D can be used to test the indicators of Port 1, 2, 3 and 4.

#### 11.1.1 Frequency Range

Frequency range: AV3672A: 10MHz to 13.5GHz

AV3672B: 10MHz to 26.5GHz

AV3672C: 10MHz to 43.5GHz

AV3672D: 10MHz to 50GHz

#### 11.1.2 Frequency Accuracy

Frequency accuracy:  $\pm 1 \times 10^{-7}$  ( $23^{\circ}\text{C} \pm 3^{\circ}\text{C}$ )

#### 11.1.3 Frequency Resolution

Frequency resolution: 1Hz

#### 11.1.4 Port Output Harmonic Suppression

Table 11.1 Indicators of AV3672A/B Port Output Harmonic Suppression

(Power setting: -5dBm, 2/3 harmonics)

Frequency range	$10\text{MHz} \leq f \leq 4\text{GHz}$	$4\text{GHz} < f \leq 13.5\text{GHz}$	$13.5\text{GHz} < f \leq 26.5\text{GHz}$
Output harmonic suppression of Port 1 and 3	-51dBc	-60dBc	-60dBc
Output harmonic suppression of Port 2 and 4	-13dBc	-21dBc	-21dBc

Table 11.1 Indicators of AV3672C/D Port Output Harmonic Suppression (continued)

(Power setting: -5dBm, 2/3 harmonics)

Frequency range	$10\text{MHz} \leq f \leq 4\text{GHz}$	$4\text{GHz} < f \leq 13.5\text{GHz}$	$13.5\text{GHz} < f \leq 50\text{GHz}$
Output harmonic suppression of Port 1 and 3	-51dBc	-60dBc	-60dBc

Output harmonic suppression of Port 2 and 4	-13dBc	-21dBc	-60dBc
---	--------	--------	--------

### 11.1.5 Non-harmonic Suppression of Port Output

Table 11.2 Indicators of Non-harmonic Suppression of AV3672A/B Port Output

(Power setting: -5dBm; deviation frequency: 30kHz to 5MHz)

Frequency range	$10\text{MHz} \leq f \leq 13.5\text{GHz}$	$13.5\text{GHz} < f \leq 16\text{GHz}$	$16\text{GHz} < f \leq 26.5\text{GHz}$
Non-harmonic Suppression of Port Output	-40dBc	-40dBc	-30dBc

Table 11.2 Indicators of Non-harmonic Suppression of AV3672C/D Port Output (continued)

(Power setting: -5dBm; deviation frequency: 30kHz to 5MHz)

Frequency range	$10\text{MHz} \leq f \leq 13.5\text{GHz}$	$13.5\text{GHz} < f \leq 26.5\text{GHz}$	$26.5\text{GHz} < f \leq 50\text{GHz}$
Non-harmonic Suppression of Port Output	-40dBc	-35dBc	-30dBc

### 11.1.6 Maximum Output Power of Port

Table 11.3 Maximum Output Power Indicator of AV3672A/B Test Port

Frequency range	Maximum output power of Port 1 and 3		Maximum output power of Port 2 and 4
	Filtering mode	High power mode	
$10\text{MHz} \leq f \leq 50\text{MHz}$	+1 dBm	+9 dBm	+13 dBm
$50\text{MHz} < f \leq 4\text{GHz}$	0 dBm	+6 dBm	+13 dBm
$4\text{GHz} < f \leq 10\text{GHz}$	+13 dBm		+10 dBm
$10\text{GHz} < f \leq 13.5\text{GHz}$	+8 dBm		+8 dBm
$13.5\text{GHz} < f \leq 20\text{GHz}$	+6 dBm		+5 dBm
$20\text{GHz} < f \leq 26.5\text{GHz}$	+2 dBm		0 dBm

Table 11.3 Maximum Output Power Indicator of AV3672C/D Test Port (continued)

Frequency range	Maximum output power of Port 1 and 3		Maximum output power of Port 2 and 4
	Filtering mode	High power mode	
$10\text{MHz} \leq f \leq 50\text{MHz}$	+1 dBm	+9 dBm	+11 dBm
$50\text{MHz} < f \leq 4\text{GHz}$	0 dBm	+5 dBm	+10 dBm
$4\text{GHz} < f \leq 13.5\text{GHz}$	+6 dBm		+6 dBm
$13.5\text{GHz} < f \leq 40\text{GHz}$	+7 dBm		+7 dBm
$40\text{GHz} < f \leq 47\text{GHz}$	+2 dBm		+2 dBm
$47\text{GHz} < f \leq 50\text{GHz}$	-8 dBm		-8 dBm

### 11.1.7 Accuracy of Port Output Power

Accuracy of port output power (power setting: -5dBm):  $\pm 2\text{dB}$   $10\text{MHz} \leq f \leq 13.5\text{GHz}$  $\pm 3\text{dB}$   $13.5\text{GHz} < f \leq 26.5\text{GHz}$  $\pm 3\text{dB}$   $26.5\text{GHz} < f \leq 40\text{GHz}$  $\pm 4\text{dB}$   $40\text{GHz} < f \leq 43.5\text{GHz}$  $\pm 4\text{dB}$   $43.5\text{GHz} < f \leq 50\text{GHz}$ 

### 11.1.8 Scanning Range of Port Output Power

Table 11.4 Indicators of AV3672A/B Power Scanning Range

Frequency range	Power Scanning Range	
	AV3672A/B	AV3672C/D
$10\text{MHz} \leq f \leq 50\text{MHz}$	30dB	26dB
$50\text{MHz} < f \leq 4\text{GHz}$	32dB	
$4\text{GHz} < f \leq 13.5\text{GHz}$	37dB	32dB
$13.5\text{GHz} < f \leq 20\text{GHz}$	35dB	33dB
$20\text{GHz} < f \leq 26.5\text{GHz}$	23dB	
$26.5\text{GHz} \leq f \leq 40\text{GHz}$		33dB
$40\text{GHz} < f \leq 47\text{GHz}$		28dB
$47\text{GHz} < f \leq 50\text{GHz}$		18dB

### 11.1.9 Linearity of Port Output Power

Linearity of port output power ( $23^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ):  $\pm 2.0\text{dB}$

### 11.1.10 1dB Compression Level of Port

1dB compression level of AV3672A/B port:  $+10\text{dBm}$   $10\text{MHz} \leq f \leq 13.5\text{GHz}$

$+10\text{dBm}$   $13.5\text{GHz} < f \leq 16\text{GHz}$

$+2\text{dBm}$   $16\text{GHz} < f \leq 26.5\text{GHz}$

1dB compression level of AV3672C/D port:  $+8\text{dBm}$   $10\text{MHz} \leq f \leq 40\text{GHz}$

$+5\text{dBm}$   $40\text{GHz} < f \leq 43.5\text{GHz}$

$+5\text{dBm}$   $43.5\text{GHz} < f \leq 50\text{GHz}$

### 11.1.11 System Track Noise

Table 11.5 Indicators of AV3672A/B System Track Noise

(Power setting:  $-5\text{dBm}$ ; intermediate frequency bandwidth:  $1\text{kHz}$ )

Frequency range	Amplitude Track Noise	Phase Track Noise
$10\text{MHz} \leq f \leq 100\text{MHz}$	$\leq 0.007\text{ dB}$	$\leq 0.051^{\circ}$
$100\text{MHz} < f \leq 13.5\text{GHz}$	$\leq 0.002\text{ dB}$	$\leq 0.015^{\circ}$
$13.5\text{GHz} < f \leq 22.5\text{GHz}$	$\leq 0.002\text{ dB}$	$\leq 0.042^{\circ}$
$22.5\text{GHz} < f \leq 24\text{GHz}$	$\leq 0.003\text{ dB}$	$\leq 0.054^{\circ}$
$24\text{GHz} < f \leq 26.5\text{GHz}$	$\leq 0.005\text{ dB}$	$\leq 0.054^{\circ}$

Table 11.5 Indicators of AV3672C/D System Track Noise (continued)

(Power setting:  $-5\text{dBm}$ ; intermediate frequency bandwidth:  $1\text{kHz}$ )

Frequency range	Amplitude Track Noise	Phase Track Noise
$10\text{MHz} \leq f \leq 50\text{MHz}$	$\leq 0.200\text{ dB}$	$\leq 1.00^{\circ}$
$50\text{MHz} < f \leq 500\text{MHz}$	$\leq 0.020\text{ dB}$	$\leq 0.70^{\circ}$
$500\text{MHz} < f \leq 1\text{GHz}$	$\leq 0.005\text{ dB}$	$\leq 0.04^{\circ}$
$1\text{GHz} < f \leq 26.5\text{GHz}$	$\leq 0.004\text{ dB}$	$\leq 0.05^{\circ}$
$26.5\text{GHz} < f \leq 50\text{GHz}$	$\leq 0.008\text{ dB}$	$\leq 0.06^{\circ}$

### 11.1.12 Dynamic Range of System

Table 11.6 Dynamic Range Indicators of System

(Power setting: maximum port output power; intermediate frequency bandwidth: 1Hz; 23°C±3°C)

Frequency range	Dynamic Range of System	
	AV3672A/B	AV3672C/D
10MHz≤f≤500MHz	90dB	74dB
500MHz<f≤4GHz	120dB	118dB
4GHz<f≤10GHz	127dB	119dB
10GHz<f≤13.5GHz	120dB	118dB
13.5GHz<f≤20GHz	120dB	115dB
20GHz<f≤24GHz	115dB	
24GHz<f≤26.5GHz	110dB	
26.5GHz≤f≤35GHz		110dB
35GHz<f≤47GHz		105dB
47GHz<f≤50GHz		92dB

### 11.1.13 Indicators of Transmission Tracking, Reflection Tracking, Effective Source Matching and Effective Direction

Table 11.7 Indicators of Transmission Tracking, Reflection Tracking, Effective Source Matching, Effective Direction and Effective Load Matching of AV3672A/B

(Power setting: -5dBm; intermediate frequency bandwidth: 10Hz, 23°C±3°C)

Frequency range	10MHz≤f≤2GHz	2GHz<f≤13.5GHz	13.5GHz<f≤26.5GHz
Transmission tracking	±0.10dB	±0.11dB	±0.12dB
Reflection tracking	±0.04dB	±0.04dB	±0.05dB
Effective direction;	≥48dB	≥44dB	≥44dB
Effective source matching;	≥40dB	≥30dB	≥30dB
Effective load matching;	≥48dB	≥44dB	≥44dB

Table 11.7 Indicators of Transmission Tracking, Reflection Tracking, Effective Source Matching, Effective Direction and Effective Load Matching of AV3672C/D (continued)

(Power setting: -5dBm; intermediate frequency bandwidth: 10Hz, 23°C±3°C)

Frequency range	10MHz≤f≤2GHz	2GHz<f≤13.5GHz	13.5GHz<f≤40GHz	40GHz<f≤50GHz
Transmission tracking	±0.10dB	±0.11dB	±0.16dB	±0.20dB
Reflection tracking	±0.04dB	±0.04dB	±0.03dB	±0.04dB
Effective direction;	≥42dB	≥42dB	≥38dB	≥36dB
Effective source matching;	≥36dB	≥31dB	≥28dB	≥27dB
Effective load matching;	≥42dB	≥42dB	≥37dB	≥35dB

### 11.1.14 Indicators of Pulse Measurement Function Option (008)

#### 11.1.14.1 Rising Time of Pulse Modulation

Rising time of pulse modulation: ≤30ns 500MHz≤f≤50GHz

### 11.1.14.2 Falling Time of Pulse Modulation

Falling time of pulse modulation:  $\leq 30\text{ns}$   $500\text{MHz} \leq f \leq 50\text{GHz}$

### 11.1.14.3 Pulse Modulation Switching Ratio

Table 11.8 Indicators of Pulse Modulation Switching Ratio

Frequency range	$10\text{MHz} \leq f \leq 4\text{GHz}$	$4 < f \leq 50\text{GHz}$
Switch ratio of pulse modulation	$\geq 64\text{dB}$	$\geq 80\text{dB}$

### 11.1.15 Port Damage Level

Port damage level: 26dBm or 30VDC.



**Limit level of port damage: +26dBm or 30VDC. If the input is beyond the above range, the instrument may be burnt.**

### 11.1.16 Range of Working Temperature and Storage Temperature

Table 11.9 Range of Working Temperature and Storage Temperature

Operating temperature range	$0^{\circ}\text{C} \sim 40^{\circ}\text{C}$
Storage temperature range	$-30^{\circ}\text{C} \sim 70^{\circ}\text{C}$

### 11.1.17 Number of Measurement Points

The number of measurement points in each frequency scanning of AV3672 series vector network analyzers can be set between 1 and 32001.

### 11.1.18 Measurement Display Format

AV3672 series vector network analyzers have the following measurement display options: logarithmic amplitude, linear amplitude, standing wave ratio, phase, group delay, real part, imaginary part, Smith chart, and polar coordinates.

### 11.1.19 Display Window and Channel

AV3672 series vector network analyzers are equipped with a 12.1-inch color LCD display, with the resolution of 1280×800. At most 16 windows and 64 channels can be set. Each window supports 8 optional channels at most. All channels can be used for display at the same time. Each channel can be used to separately display basic S-parameters such as S11 and S21.

### 11.1.20 Averaging Factor

Averaging factor range of AV3672 series vector network analyzers: 1-1024.

### 11.1.21 Cursor Function

AV3672 series vector network analyzers are configured with 9 independent cursors to read and display the value of the measurement curve. Specific functions are as follows.

- a) Cursor search function: used for automatic search on the measurement curve, such as the maximum value, minimum value, right peak value, left peak value, etc.
- b)  $\Delta$  function: used to read the difference between the current cursor and reference cursor.
- c) Cursor function: used to set the current starting value, ending value, center value, span, reference value and delay time as the active cursor value.
- d) Bandwidth search function: used for automatic search to set the bandwidth (it can be set by the user, and the default value is 3dB) and calculate the Q value.

### 11.1.22 Scanning Type

AV3672 series vector network analyzers are configured with 5 scanning types:

- a) Linear frequency: default scanning type of the instrument. The frequency linearity continuously covers the whole frequency range.
- b) Logarithmic frequency: the source frequency increases in the logarithmic step manner, and the frequency ratio of two adjacent frequency points is identical.
- c) Power scanning: used in the CW mode.
- d) CW: set the single scanning frequency of the analyzer, continuously and accurately sample measurement data according to the interval determined with the scanning time and measurement point number, and display measurement data changes over time.
- e) Segment scanning: set the enabling of scanning involving multiple segments. The power level, intermediate frequency bandwidth and scanning time of each segment can be defined separately.

### 11.1.23 Intermediate Frequency Bandwidth

Intermediate frequency bandwidth: min. 1Hz and max. 5MHz; stepping modes: 40 in total.

### 11.1.24 Setting of Reference Level Amplitude

Setting range:  $\pm 500\text{dB}$

Setting resolution: 0.001dB

### 11.1.25 Setting of Reference Phase

Setting range:  $\pm 500^\circ$

Setting resolution: 0.01°

### 11.1.26 Storage Function

The following files can be saved: state calibration files (\*.cst), state files (\*.sta), calibration files (\*.cal), data files (\*.dat, \*.cti, \*.s1p, \*.s2p, \*.s3p and \*.s4p), table files (\*.prn) and graphical files (\*.bmp and \*.jpg).

### 11.1.27 Port Type

3.5mm standard connector (male)

### 11.1.28 Interface Types

Peripheral interfaces include: GPIB interface, USB interface, monitor interface and LAN interface.

## 11.2 Measurement Methods

Detailed operation procedures for each index test are prepared according to test instrument in the diagram. If other equivalent test instrument is adopted, refer to the instructions of the test instrument for operation procedures.

Reset instrument in test procedures refers to manufacturer's reset mode. If the instrument is under reset state defined by user, change it into manufacturer's reset state and then reset, ensuring original state of the instrument is known.

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## 11.2.1 Test of Frequency Accuracy

### 11.2.1.1 Items of Frequency Accuracy Test

Test the frequency accuracy indicators of frequency scanning signals output by AV3672 series vector network analyzers.

### 11.2.1.2 Instrument and Accessories for Test of Frequency Range and Accuracy

- 1) Frequency meter HP5361B
- 2) RF cable 1.

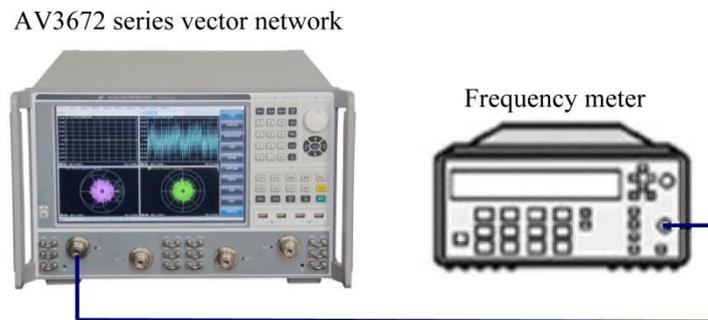


Fig.11.1 Block Diagram of Frequency Accuracy Test

### 11.2.1.3 Steps of Frequency Accuracy Test

- 1) As shown in Fig. 11.1, connect the system and preheat is for 60min at least.
- 2) Press [Reset] to set the initial state of AV3672 series vector network analyzers.
- 3) Press [Excitation] > [Scanning] > [CW] > [Frequency], and enter 10GHz. Press [Excitation] > [Trigger] > [Hold]. The reading of the frequency meter will be the frequency of the excitation signal of the analyzer.

## 11.2.2 Test of Frequency Resolution

### 11.2.2.1 Items of Frequency Resolution Test

Test the frequency resolution indicators of frequency scanning signals output by AV3672 series vector network analyzers.

### 11.2.2.2 Instrument and Accessories for Test of Frequency Resolution

- 1) spectrum analyzer AV4038
- 2) BNC cable 1.
- 3) RF cable 1.

### 11.2.2.3 Steps of Frequency Resolution Test

- 1) As shown in Fig. 11.2, connect the system and preheat is for 60min at least.
- 2) Press [Reset] to set the initial state of AV3672 series vector network analyzers.
- 3) Press [Scanning] > [Scanning type] > [CW] > [Frequency], and enter 10GHz. Press [Excitation] > [Trigger] > [Hold]. Record the measurement result of the spectrum analyzer.
- 4) Change the center frequency by 1Hz. If the reading of the spectrum analyzer also changes by 1Hz, the frequency resolution conforms to the technical indicator requirements.

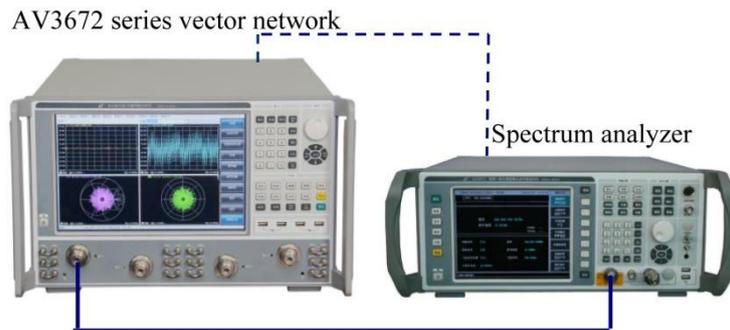


Fig. 11.2 Block Diagram of Frequency Resolution Test

### 11.2.3 Test of Port Output Harmonic Suppression

#### 11.2.3.1 Items of Test of Port Output Harmonic Suppression

Test the harmonic suppression indicators of frequency scanning signals output by the port of AV3672 series vector network analyzers.

#### 11.2.3.2 Instrument and Accessories for Test of Port Output Harmonic Suppression

- 1) spectrum analyzer AV4038 or R&SFSUP50
- 2) RF cable 1.

#### 11.2.3.3 Steps of Test of Port Output Harmonic Suppression

- 1) As shown in Fig. 11.3, connect the system and preheat is for 60min at least.
- 2) Press [Reset] to set the initial state of AV3672 series vector network analyzers. Click [Channel] > [Hardware configuration] > [Path configuration]. Select the filtering mode for the low-frequency segment of Port 1 and 3. Press [Power] > [-5] and the ENTER key.
- 3) Press [Scanning] > [Scanning time] > [10] and the ENTER key.
- 4) Press [Scanning] > [Scanning type] > [CW] > [Frequency], and enter 10MHz. Set the corresponding test frequency of the spectrum analyzer and record the reading of the spectrum analyzer. Set the second harmonic frequency of the spectrum analyzer as 20MHz and record the reading of the spectrum analyzer. The difference of two readings is the port harmonic suppression indicator.

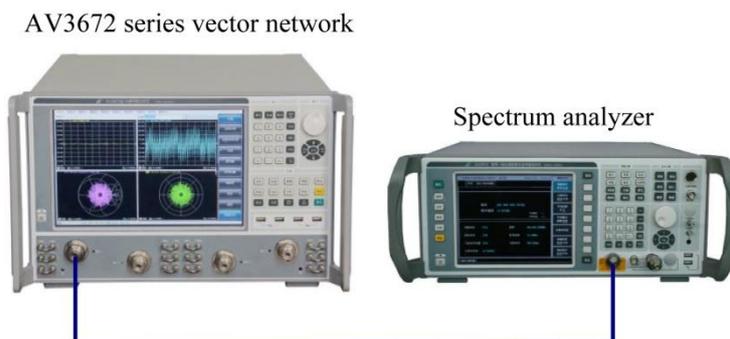


Fig. 11.3 Block Diagram of Test of Harmonic/Non-harmonic Suppression Test

### 11.2.4 Test of Non-harmonic Suppression of Port Output

#### 11.2.4.1 Items of Test of Non-harmonic Suppression of Port Output

Test the non-harmonic suppression indicators of frequency scanning signals output by the port of AV3672 series vector network analyzers.

#### 11.2.4.2 Instrument and Accessories for Test of Non-harmonic Suppression of Port Output

- 1) spectrum analyzer AV4038 or R&SFSUP50
- 2) RF cable 1.

### 11.2.4.3 Steps of Test of Non-harmonic Suppression of Port Output

- 1) As shown in Fig. 11.3, connect the system and preheat is for 60min at least.
- 2) Press [Reset] to set the initial state of the AV3672 series vector network analyzer. Click [Channel] > [Hardware configuration] > [Path configuration]. Select the filtering mode for the low-frequency segment of Port 1 and 3. Press [Power] > [-5] and the ENTER key.
- 3) Press [Scanning] > [Scanning time] > [10] and the ENTER key.
- 4) Press [Scanning] > [Scanning type] > [CW] > [Frequency], and enter 10MHz. Set the corresponding test frequency of the spectrum analyzer and record the reading of the spectrum analyzer. Search the maximum power of the non-harmonic signal with the frequency deviation of 30kHz to 5MHz. The difference of two values is the non-harmonic suppression indicator.
- 5) Respectively change the test frequency of the vector network analyzer and spectrum analyzer. Repeat Step (4) and measure the non-harmonic suppression indicators of other frequency points.

### 11.2.5 Test of Maximum Output Power of Port

#### 11.2.5.1 Items of Test of Maximum Output Power of Port

Test the maximum output power indicators of the port of AV3672 series vector network analyzers.

#### 11.2.5.2 Required Instrument and Accessories

- 1) Power meter AV2434 or ML2437A
- 2) Power probe AV71711 or MA2475A

#### 11.2.5.3 Steps of Test of Maximum Output Power of Port

- 1) As shown in Fig. 11.4, connect the system and preheat is for 60min at least.
- 2) Press [Reset] > [Power] > [+20] and the ENTER key.
- 3) Press [Scanning] > [Scanning time] > [20] and the ENTER key.
- 4) Press [Frequency] > [Starting frequency] and enter the starting frequency 10MHz. Press [Ending frequency] and enter the ending frequency 50MHz.
- 5) As shown in Fig. 11.4, calibrate/clear the power meter, connect the power probe to Port 1 and record the minimum reading.
- 6) Successively change the scanning frequency of the AV3672 series vector network analyzer. In the high power mode or filter mode required in the test, click [Channel] > [Hardware configuration] > [Path configuration]. Select the high power mode or filtering mode for the low-frequency segment of Source 1. The test result is the maximum output power of Port 1.
- 7) Connect the power probe to Port 2/3/4. Click [Measurement] > [S22]/[S33]/[S44]. Repeat Step (4) to (6) and measure the maximum output power of Port 2/3/4.



Fig. 11.4 Block Diagram of Port Output Power Test

### 11.2.6 Test of Port Output Power Accuracy

#### 11.2.6.1 Items of Test of Port Output Power Accuracy

Test the port output power accuracy indicators of V3672 series vector network analyzers.

### 11.2.6.2 Instrument and Accessories for Test of Port Output Power Accuracy

- |    |             |                    |
|----|-------------|--------------------|
| 1) | Power meter | AV2434 or ML2437A  |
| 2) | Power probe | AV71711 or MA2475A |

### 11.2.6.3 Steps of Test of Port Output Power Accuracy

- 1) As shown in Fig. 11.4, connect the system and preheat is for 60min at least. Press [Reset] > [Scanning] > [Scanning time] > [10] and the ENTER key. Press [Power] > [-5] and the ENTER key.
- 2) Press [Scanning] > [Scanning type] > [CW] > [Frequency] and enter 10MHz.
- 3) As shown in Fig. 11.4, connect the power probe, and record the reading.
- 4) Change the frequency point successively, and record the measurement result of the output power accuracy of Port 1.
- 5) Connect the power probe to Port 2/3/4. Click [Measurement] > [S22]/[S33]/[S44]. Measure the output power accuracy of Port 2/3/4.

## 11.2.7 Test of Scanning Range of Port Output Power

### 11.2.7.1 Items of Test of Scanning Range of Port Output Power

Test the scanning range indicators of the port output power of AV3672 series vector network analyzers.

### 11.2.7.2 Instrument and Accessories for Test of Scanning Range of Port Output Power

- |    |             |                    |
|----|-------------|--------------------|
| 1) | Power meter | AV2434 or ML2437A  |
| 2) | Power probe | AV71711 or MA2475A |
| 3) | RF cable    | 1.                 |

### 11.2.7.3 Steps of Test of Scanning Range of Port Output Power

- 1) As shown in Fig. 11.4, connect the system and preheat is for 60min at least. Press [Reset] > [Scanning] > [Scanning time] > [20] and the ENTER key. Click [Channel] > [Hardware configuration] > [Path configuration]. Select the high power mode for the low-frequency segment of Source 1 and 3.
- 2) Press [Scanning] > [Scanning type] > [Frequency scanning]. Set the starting frequency as -30dBm and ending frequency as +20dBm.
- 3) Press [Frequency] and enter 10MHz.
- 4) As shown in Fig. 11.4, connect the power probe. Observe the reading of the power meter. The difference between the maximum and minimum value is the power scanning range. Change frequency points and measure the corresponding power scanning ranges.
- 5) Connect the power probe to Port 2/3/4. Click [Measurement] > [S22]/[S33]/[S44]. Measure the output power scanning ranges of other ports.

## 11.2.8 Linearity of Port Output Power

### 11.2.8.1 Items of Test of Port Output Power Linearity

Test the port output power linearity indicators of AV3672 series vector network analyzers.

### 11.2.8.2 Instrument and Accessories for Test of Port Output Power Linearity

- |    |                 |   |
|----|-----------------|---|
| 1) | Soft test cable | Agilent 85131F (AV3672A/B) or FE0BN0BM025.0 (AV3672C/D) |
|----|-----------------|---|

### 11.2.8.3 Steps of Test of Port Output Power Linearity

- 1) As shown in Fig. 11.5, connect the system and preheat is for 60min at least.
- 2) Click [Reset] > [Response] > [Measurement] > [Measurement...] and [Receiver]. Select [B] and [Port 1] under [Source] port and click [OK].

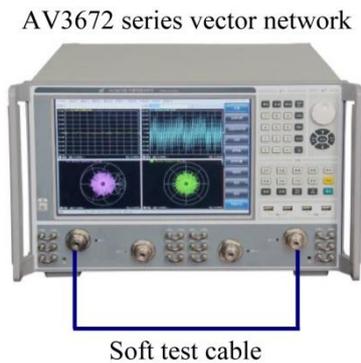


Fig. 11.5 Output Power Linearity of Test Port

- 3) Press [Channel] > [More] > [Hardware setting] > [Graphical configuration]. Select [Low-band high-power mode] and click [OK].
- 4) Press [Power] > [-10] > [OK].
- 5) Press [Analysis] > [Save] > [Normalization].
- 6) Press [Power] > [-25] and the ENTER key to change the power into -25dBm. After scanning once, press [Analysis] > [Track statistics] > [Track statistics ON/OFF]. Read the maximum and minimum value. Calculate the differences of the (absolute maximum and minimum value+10) minus the set power. The larger absolute value of two results is the power linearity.
- 7) Successively change the power and record the linearity value corresponding to each power value within 10MHz-50GHz.

### 11.2.9 dB Compression Level Test of Port

#### 11.2.9.1 Items of 1dB Compression Level Test of Port

Test the power indicators of 1dB compression level power of the port of AV3672 series vector network analyzers.

#### 11.2.9.2 Instrument and Accessories for 1dB Compression Level Test of Port

- 1) Ultra-broadband synthetic frequency scanning signal E8257D generator
- 2) RF cable 1.
- 3) BNC cable 1.

#### 11.2.9.3 Steps of 1dB Compression Level Test of Port

- 1) As shown in Fig. 11.6, connect the system and preheat it for more than 60min. Press [Reset] > [Response] > [Average] > [Intermediate frequency bandwidth]. Enter 100Hz.
- 2) Press [Scanning] > [Number of scanning points]. Enter 101.
- 3) Click [Power] > [Power state ON/OFF]. Shut down the power output.
- 4) Click [Response] > [Measurement] > [Measurement...] > [Receiver]. Activate [A] and click [OK].
- 5) Press [Scanning] > [Scanning type] > [CW] > [Frequency] and enter 10MHz.
- 6) Set the signal source output power as -15dBm and CW as 10MHz.
- 7) Click [Cursor] and record the cursor value. Increase the source output power by 1dB step by step, and observe the cursor value, until the 1dB compression point appears.
- 8) Change the frequency value and repeat Step (5) to (7) to measure the 1dB compression level of other frequency points.
- 9) Connect the signal source output cable in Fig. 11.6 to Port 2/3/4. Click [Response] > [Measurement] > [Measurement...] > [Receiver]. Activate [B]/[C]/[D] to measure the 1dB compression level of each frequency point of the other three ports.

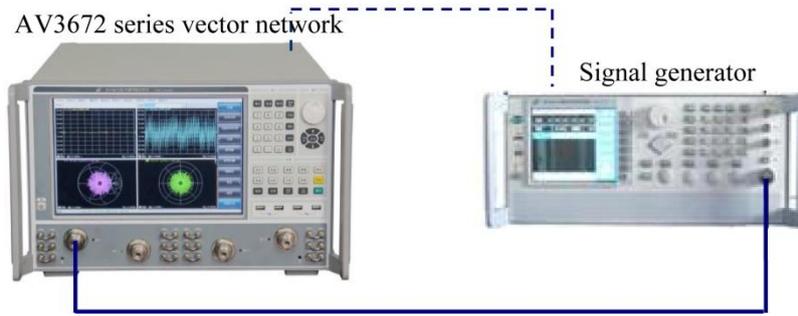


Fig. 11.6 Block Diagram of 1dB Compression Level Test of Port

### 11.2.10 System Track Noise Test

#### 11.2.10.1 Items of System Track Noise Test

Test track noise indicators of the output frequency scanning signal of AV3672 series vector network analyzers.

#### 11.2.10.2 Instrument and Accessories for System Track Noise Test

1) Soft test cable Agilent 85131F (AV3672A/B) or FE0BN0BM025.0 (AV3672C/D)

#### 11.2.10.3 Steps of System Track Noise Test

- 1) As shown in Fig. 11.7, connect the system and preheat is for 60min at least.
- 2) Click [Reset] to set the AV3672 series vector network analyzer into the initial state. Click [Power] > [-5] and the ENTER key.
- 3) Press [Scanning] > [Scanning time] > [10] and the ENTER key.
- 4) Click [Scanning] > [Scanning type] > [CW], and enter the center frequency 10MHz.
- 5) Click [Analysis] > [Track statistics] > [Track statistics ON/OFF].

AV3672 series vector network

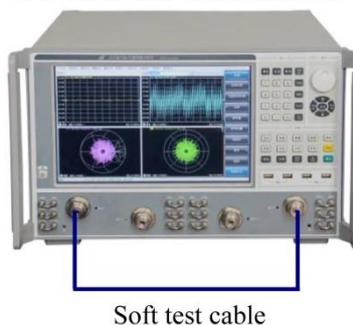


Fig. 11.7 Block Diagram of System Track Noise Test

#### Measurement of S12 amplitude track noise

- 6) Click [Measurement] > [S12].
- 7) Record the deviation displayed on the screen after scanning of the vector network analyzer.

#### Measurement of S12 phase track noise

- 8) Click [Response] > [Format] > [Phase].
- 9) Record the deviation displayed on the screen.

#### Measurement of S21 phase track noise

- 10) Click [Measurement] > [S21].
- 11) Record the deviation displayed on the screen after scanning of the vector network analyzer.

#### Measurement of S21 amplitude track noise

- 12) Click [Response] > [Format] > [Logarithmic amplitude].
- 13) Record the deviation displayed on the screen.
- 14) Change the frequency value and repeat Step (4) to (13). Measure the track noise value of other frequency points.

## 11.2.11 Dynamic Range Test of System

### 11.2.11.1 Items of Dynamic Range Test of System

Test the indicators of the dynamic range of the system after response isolation calibration with AV3672 series vector network analyzers.

### 11.2.11.2 Instrument and Accessories for Dynamic Range Test of System

- 1) 3.5mm coaxial calibration kit AV31121 (AV3672A/B) or AV31123 (AV3672C/D)
- 2) Soft test cable Agilent 85131F (AV3672A/B) or FE0BN0BM025.0 (AV3672C/D)

### 11.2.11.3 Steps of Dynamic Range Test of System

#### Test of dynamic range of Port 1:

- 1) As shown in Fig. 11.8, connect the system and preheat is for 60min at least.
- 2) Click [Reset] and set the AV3672 series vector network analyzer into the initial state. Click [Power] > [+20] and press the ENTER key. Click [Channel] > [Hardware configuration] > [Path configuration]. Select the high power mode for the low-band segment of Source 1 and 3.
- 3) Click [Measurement] > [S12].
- 4) Click [Scale] > [Reference value] and enter -100.
- 5) Click [Scanning] > [Number of scanning points], and enter 101.
- 6) Click [Response] > [Average] > [Intermediate frequency bandwidth], and enter 1Hz.
- 7) Click [Calibration] > [Non-guided calibration] and [Through type response and isolation].
- 8) Click [Selection of calibration kit] > [AV31121] > [Through type] to start through type calibration.
- 9) After through type calibration, as shown in Fig. 11.9, disconnect the tow cables and connect loads to two calibration cable ports.
- 10) Select [Load]. Select [Enable averaging] in the pop-up dialog box. Set the averaging factor as 8, and continue calibration.
- 11) After all calibrations, click [OK]. Then click [Response] > [Average] > [Averaging factor] and enter 8 to enable the averaging function.
- 12) After averaging, the maximum value of the displayed curve within each frequency range is the dynamic range of Port 1.

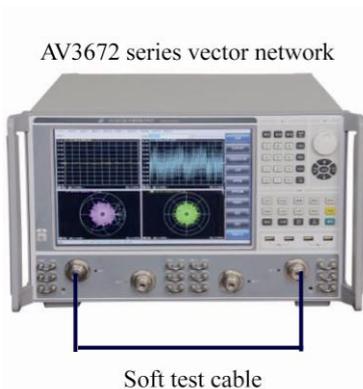


Fig. 11.8 Block Diagram I of Dynamic Range Calibration Test of System

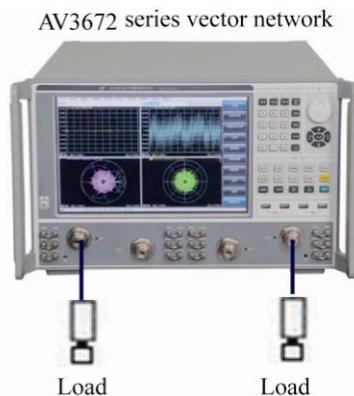


Fig. 11.9 Block Diagram II of Dynamic Range Calibration Test of System

#### Test of dynamic range of Port 2:

13) Click [Measurement] > [S21].

14) Repeat Step (7) to (12) to test the dynamic range of Port 2.

**Test of dynamic range of Port 3:**

15) As shown in Fig. 11.10, connect the system.

16) Click [Measurement] > [S34].

17) Click [Calibration] > [Non-guided calibration] and [Through type response and isolation].

18) Click [Selection of calibration kit] > [AV31121] > [Through type] to start through type calibration.

19) After through type calibration, as shown in Fig. 11, disconnect the tow cables and connect loads to two calibration cable ports.

20) Select [Load]. Select [Enable averaging] in the pop-up dialog box. Set the averaging factor as 8, and continue calibration.

21) After all calibrations, click [OK]. Then click [Response] > [Average] > [Averaging factor] and enter 8 to enable the averaging function.

22) The maximum value of the displayed curve within each frequency range is the dynamic range of Port 3.

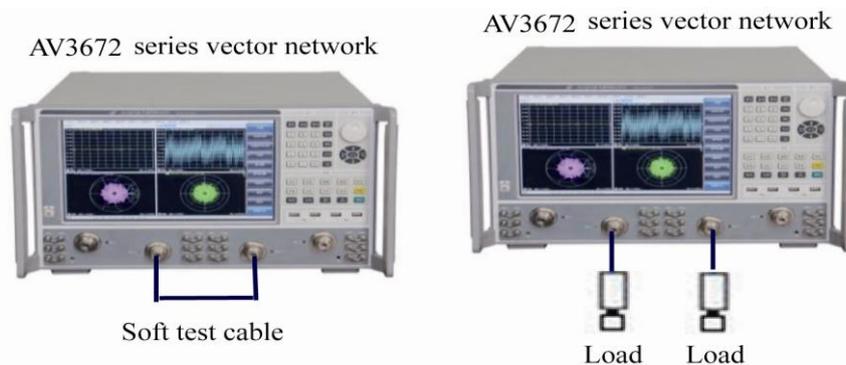


Fig. 11.10 Block Diagram I of Dynamic Range Calibration Test of System

Fig. 11.11 Block Diagram II of Dynamic Range Calibration Test of System

**Test of dynamic range of Port 4:**

23) Click [Measurement] > [S43].

24) Repeat Step (18) to (22) to test the dynamic range of Port 4.

**11.2.12 Test of Transmission Tracking, Reflection Tracking, Effective Source Matching, Effective Direction, etc.**

**11.2.12.1 Items of Test of Transmission Tracking, Reflection Tracking, Effective Source Matching, Effective Direction and Effective Load Matching**

Test the indicators of transmission tracking, reflection tracking, effective source matching, effective direction and effective load matching after the full double-port calibration with AV3672 series vector network analyzers.

**11.2.12.2 Instrument and Accessories for Test of Transmission Tracking, Reflection Tracking, Effective Source Matching, Effective Direction and Effective Load Matching**

- 1) 3.5mm coaxial AV31121 (AV3672A/B) or AV31123 (AV3672C/D) calibration kit
- 2) Soft test cable Agilent85131F (AV3672A/B) or FE0BN0BM025.0 (AV3672C/D)

**11.2.12.3 Steps of Test of Transmission Tracking, Reflection Tracking, Effective Source Matching, Effective Direction and Effective Load Matching**

1) As shown in Fig. 11.12, connect the system and preheat is for 60min at least.

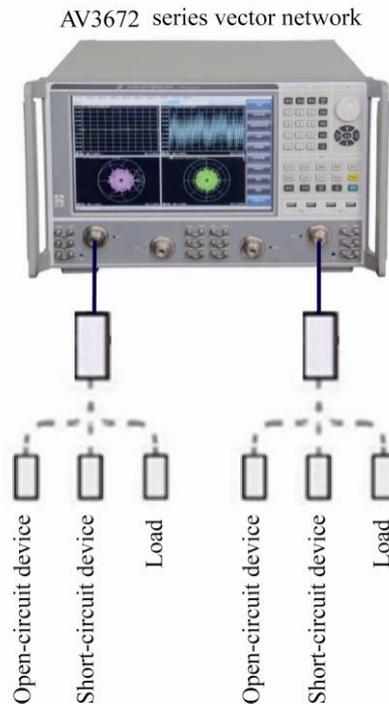


Fig. 11.12 Block Diagram I of Connection of Full Double-port Calibration

- 1) Click [Reset] to set the AV3672 series vector network analyzer into the initial state. Click [Power] > [-5] and the ENTER key.
- 2) Click [Scanning] > [Number of scanning points], and enter 51.
- 3) Click [Response] > [Average] > [Intermediate frequency bandwidth], and enter 10Hz.
- 4) Click [Calibration]. Select [Non-guided calibration] > [Full double-port SOLT].
- 5) Click [Selection of calibration kit] > [AV31121].
- 6) Respectively connect the open-circuit device, short-circuit device and load to two ports. Select [Open-circuit device], [Short-circuit device] and [Load] and start calibration.
- 7) After calibration, connect the system as shown in Fig. 11.13. Select [Through type] to start through type calibration.
- 8) After the full double-port calibration, click [OK] and disconnect the test cable calibration plane.
- 9) Click [Cursor] > [Cursor search...]. In the pop-up [Cursor search] dialog box, select “User setting 1” in [Search domain], and set the starting and ending value of [User domain]. Click [Execute] and respectively select “Maximum” and “Minimum” in [Search type].

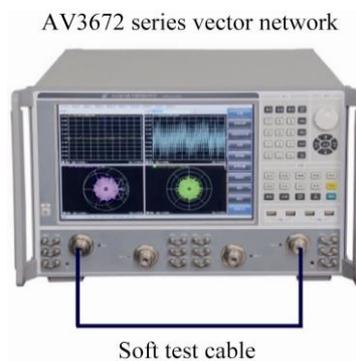


Fig. 11.13 Block Diagram II of Connection of Full Double-port Calibration

**Test of transmission tracking of Port 1**

1) Click [Measurement] > [S12]. As shown in Fig. 11.13, reconnect the test cable.

11) Change the starting and ending value of [User domain]. Search “Maximum” and “Minimum” in the set range. The larger absolute value is the transmission tracking value of Port 1.

#### **Test of transmission tracking of Port 2**

12) Click [Measurement] > [S21].

13) Change the starting and ending value of [User domain]. Search “Maximum” and “Minimum” in the set range. The larger absolute value is the transmission tracking value of Port 2.

#### **Test of effective load matching of Port 1**

14) Click [Measurement] > [S11].

15) Change the starting and ending value of [User domain]. Search the maximum value within the range. The maximum value is the effective load matching value of Port 1.

#### **Test of effective load matching of Port 2**

16) Click [Measurement] > [S22].

17) Change the starting and ending value of [User domain]. Search the maximum value within the range. The maximum value is the effective load matching value of Port 2.

#### **Test of reflection tracking of Port 1**

18) Connect the short-circuit device to the test cable end face of the test port 1. Click [Measurement] > [S11]. Then click [Analysis] > [Save] > [Normalization].

19) Change the range setting of [User domain]. Search the “Maximum” and “Minimum” within 10MHz-2GHz, 2-13.5GHz and 13.5-26.5GHz. The larger absolute value is the reflection tracking value of the test port 1.

#### **Test of effective source matching of Port 1**

20) Click [Analysis] > [Save] > [Track operation] > [Data + memory].

21) Connect the open-circuit device to the test cable end face of the test port 1. Click [Scale] > [Reference value], and enter -50.

22) Change the starting and ending value of [User domain]. Search the maximum value within the set range. The effective source matching value of the test port 1 is the difference of the obtained cursor value minus 6.

#### **Test of effective direction of Port 1**

23) Connect the load to the test port 1. Click [Analysis] > [Save] > [Track operation] > [Close].

24) Change the starting and ending value of [User domain], and search the maximum value within the set range. The maximum value is the effective direction value of the test port 1.

#### **Test of reflection tracking of Port 2**

25) Connect the short-circuit device to the test cable end face of the test port 2. Click [Measurement] > [S22]. Then click [Analysis] > [Save] > [Normalization].

26) Change the starting and ending value of [User domain]. Search the “Maximum” and “Minimum” within the set range. The larger absolute value is the reflection tracking value of the test port 2.

#### **Test of effective source matching of Port 2**

27) Click [Analysis] > [Save] > [Track operation] > [Data + memory].

28) Connect the open-circuit device to the test cable end face of the test port 2. Click [Scale] > [Reference value], and enter -50.

29) Change the starting and ending value of [User domain]. Search the maximum value within the set range. The effective source matching value of the test port 2 is the difference of the obtained cursor value minus 6.

#### **Test of effective direction of Port 2**

30) Connect the load to the test port 2. Click [Analysis] > [Save] > [Track operation] > [Close].

31) Change the starting and ending value of [User domain], and search the maximum value within the set range. The maximum value is the effective direction value of the test port 2.

32) Refer to the full double-port calibration steps of the test port 1 and 2, i.e. Step (5) to (9), and calibrate Port 3 and 4.

#### **Test of transmission tracking of Port 3**

33) Click [Measurement] > [S34]. As shown in Fig. 13, reconnect the test cable to Port 3 and 4.

34) Change the starting and ending value of [User domain]. Search the “Maximum” and “Minimum” within the set range. The larger absolute value is the transmission tracking value of the test port 3.

#### **Test of transmission tracking of Port 4**

35) Click [Measurement] > [S43].

36) Change the starting and ending value of [User domain]. Search the “Maximum” and “Minimum” within the set range. The larger absolute value is the transmission tracking value of the test port 4.

#### **Effective load matching of test port 3**

37) Click [Measurement] > [S33].

38) Change the starting and ending value of [User domain]. Search the maximum value within the range. The maximum value is the effective load matching value of Port 3.

#### **Test of effective load matching of Port 4**

39) Click [Measurement] > [S44].

40) Change the starting and ending value of [User domain]. Search the maximum value within the range. The maximum value is the effective load matching value of Port 4.

#### **Test of reflection tracking of Port 3**

41) Connect the short-circuit device to the test cable end face of the test port 1. Click [Measurement] > [S33]. Then click [Analysis] > [Save] > [Normalization].

42) Change the starting and ending value of [User domain]. Search the “Maximum” and “Minimum” within the set range. The larger absolute value is the reflection tracking value of the test port 3.

#### **Test of effective source matching of Port 3**

43) Click [Analysis] > [Save] > [Track operation] > [Data + memory].

44) Connect the open-circuit device to the test cable end face of the test port 3. Click [Scale] > [Reference value], and enter -50.

45) Change the starting and ending value of [User domain]. Search the maximum value within the set range. The effective source matching value of the test port 3 is the difference of the obtained cursor value minus 6.

#### **Test of effective direction of Port 3**

46) Connect the load to the test port 3. Click [Analysis] > [Save] > [Track operation] > [Close].

47) Change the starting and ending value of [User domain], and search the maximum value within the set range. The maximum value is the effective direction value of the test port 3.

#### **Test of reflection tracking of Port 4**

48) Connect the short-circuit device to the test cable end face of the test port 4. Click [Measurement] > [S44]. Then click [Analysis] > [Save] > [Normalization].

49) Change the starting and ending value of [User domain]. Search the “Maximum” and “Minimum” within the set range. The larger absolute value is the reflection tracking value of the test port 4.

#### **Test of effective source matching of Port 4**

50) Click [Analysis] > [Save] > [Track operation] > [Data + memory].

51) Connect the open-circuit device to the test cable end face of the test port 4. Click [Scale] > [Reference value],

and enter -50.

52) Change the starting and ending value of [User domain]. Search the maximum value within the set range. The effective source matching value of the test port 4 is the difference of the obtained cursor value minus 6.

#### Test of effective direction of Port 4

53) Connect the load to the test port 4. Click [Analysis] > [Save] > [Track operation] > [Close].

54) Change the starting and ending value of [User domain]. Search the maximum value within the set range. The maximum value is the effective direction value of the test port 4.

### 11.2.13 Test of Pulse Modulation Rising/Falling Time

#### 11.2.13.1 Items of Test of Pulse Modulation Rising/Falling Time

Test the pulse modulation rising/falling time indicators of AV3672 series vector network analyzers

#### 11.2.13.2 Instrument and Accessories for Test of Pulse Modulation Rising/Falling Time

- |    |                  |        |
|----|------------------|--------|
| 1) | Power meter      | N1913A |
| 2) | Peak power probe | N1924A |

#### 11.2.13.3 Step of Test of Pulse Modulation Rising/Falling Time

1) As shown in Fig. 11.14, connect the system. Click [Reset] to set the AV3672 vector network analyzer into the initial state. Preheat the instrument for more than 60min.

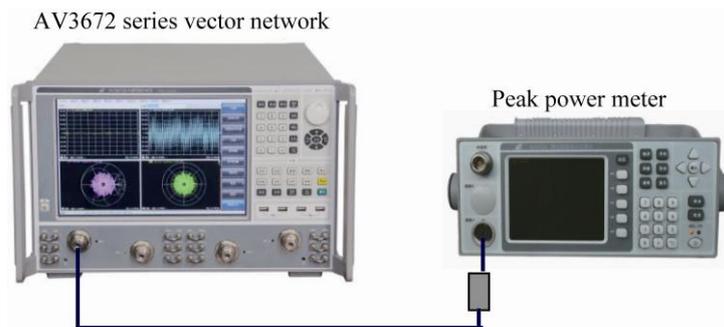


Fig. 11.14 Block Diagram of Test of Pulse Modulation Rising/Falling Time Indicators

2) Connect the peak power probe to the calibration port and calibrate the RF power analyzer.

3) Click [Power] > [-10] and the ENTER key.

4) Click [Scanning] > [Scanning type] > [Macro], and enter the center frequency 500MHz. Click [Macro] > [Pulse] > [Narrow band pulse] > [Source modulation] (interval: 150ns; pulse width: 60ns; intermediate frequency gate: 60ns) > [Pulse mode on/off] > [Calculate] > [Apply] to enable the pulse mode.

5) Change the frequency of the AV3672 series vector network analyzer and the peak power meter. Repeat Step (4) to (5).

6) Read the measurement result of the peak power meter.

### 11.2.14 Pulse Modulation Switching Ratio Test

#### 11.2.14.1 Items of Pulse Modulation Switching Ratio Test

Test the switching ratio indicators of the output modulation pulse of AV3672 series vector network analyzers.

#### 11.2.14.2 Instrument and Accessories for Pulse Modulation Switching Ratio Test

- |    |                   |                      |
|----|-------------------|----------------------|
| 1) | spectrum analyzer | AV4038 or R&S FSUP50 |
| 2) | BNC cable         | 1.                   |
| 3) | RF cable          | 1.                   |

#### 11.2.14.3 Steps of Pulse Modulation Switching Ratio Test

1) As shown in Fig. 11.15, connect the system and preheat is for 60min at least.

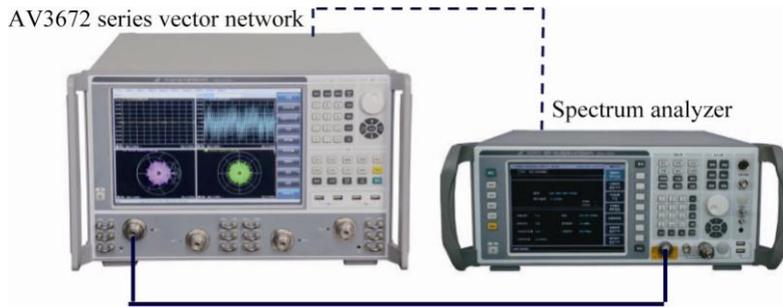


Fig. 11.5 Block Diagram of Pulse Modulation Switching Ratio Test

- 2) Press [Reset] to set the initial state of AV3672 series vector network analyzers.
- 3) Press [Scanning] > [Scanning type] > [CW] > [Frequency] and enter 10MHz.
- 4) Set the center frequency of the spectrum analyzer as 10MHz. Adjust the spectrum analyzer and record the signal power P(ON). This power value is equal to the power value corresponding to high pulse modulation input, i.e. “Pulse ON”.
- 5) Click [Macro] > [Pulse] > [Configuration] > [Pulse generator/modulator]. Select not to use the internal modulator. Click [Pulse mode] > [Calculate] > [Apply] to enable the pulse mode of the analyzer. As no external pulse signal is connected, the equivalent input signal is low, and the instrument works in the “Pulse OFF” mode. Measure the signal power P(OFF) with the spectrum analyzer and record it.
- 6) Calculate the difference of the power values measured in the “Pulse ON” and “Pulse OFF” mode. The difference is the actual pulse modulation switching ratio of the tested frequency point.
- 7) Click [Macro] > [Pulse] > [Pulse mode on/off] > [Apply] to cancel the pulse mode. Modify the frequency point and repeat Step (3) to (6) to obtain the pulse modulation switching ratio of the other frequency points.

## Appendix

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## Appendix 1 Typical Measurement Example

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AV3672 series vector network analyzers are provided with various options and measurement settings are complex. Technological knowledge and practical experience are required to be skillful in operation of the instrument. In order to help you rapidly get familiar with the measurement process, the measurement attenuator is taken as an example below to introduce the process and relevant settings for measurement of ordinary double-port devices. Refer to Appendix 5 “Measurement of Amplifier Gain Compression” for the measurement of amplifier gain compression and Appendix 6 “Mixer Measurement” for the measurement of the mixer.

Preparation before measurement: one AV3672 series vector network analyzer, two 3.5mm test cable, one calibration kit (AV31121), tested device (attenuator) and adapter (if necessary).

### 1.1 Startup, Preheating for 30min and Resetting of Analyzer



Reset into the system reset state to ensure all settings are known.

### 1.2 Frequency and Power Setting

For more details, refer to “4.3 Setting of Frequency Range” and “4.4 Setting of Signal Power Level”.

Click [Frequency] and [Power] on the front panel and [Modify] in the auxiliary menu bar. Enter the value through the input keys on the front panel. Click ENTER. Thus setting is completed. See the following figure:



**Prompt**

**Frequency and power setting**

- 1) Default frequency range of the system: 10MHz-13.5GHz/26.5GHz/43.5GHz/50GHz/67GHz; power level: -5dBm.
- 2) The frequency range is set according to measurement needs. The power level is the power of the output port of the excitation source. In principle, if the power of the output port of the tested device does not exceed +10dBm, measurement will not be affected by power level changes.

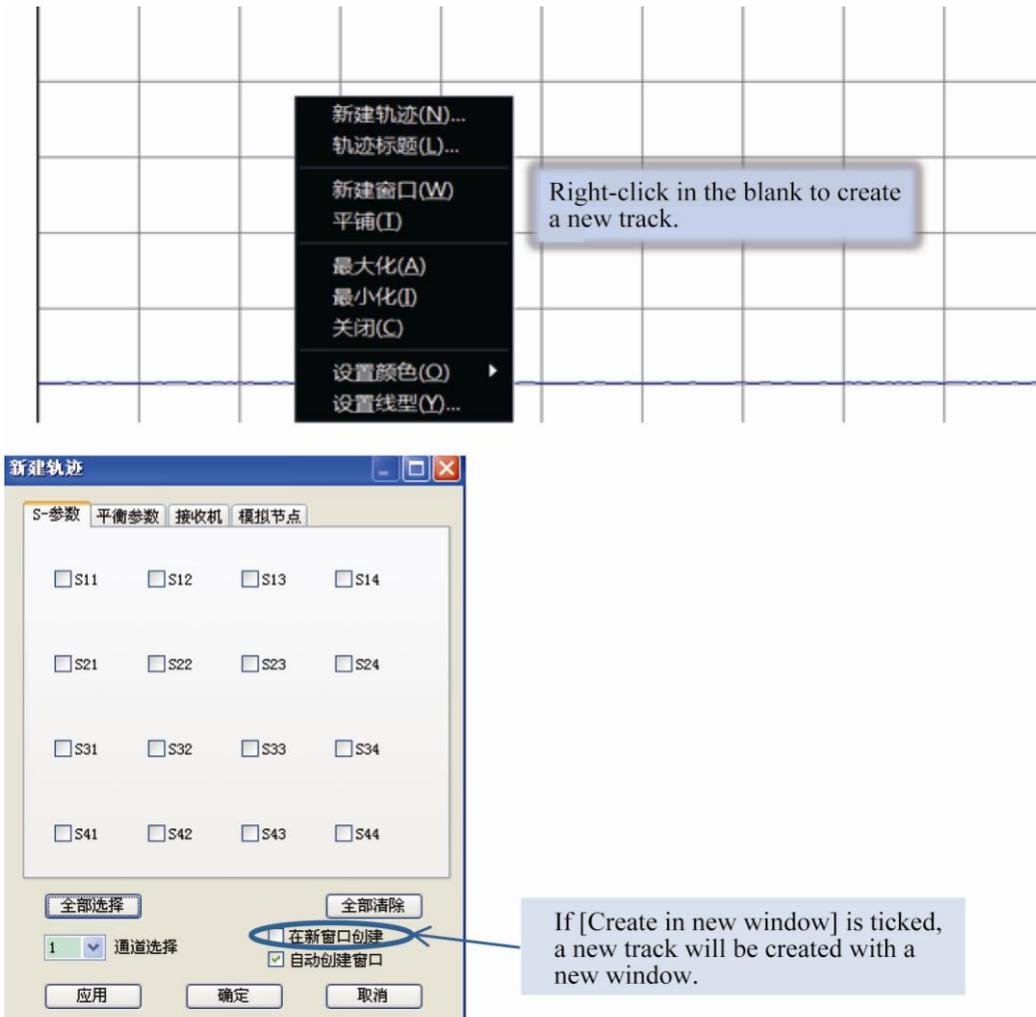
**1.3 Selection of Measurement Parameter and Creating of New Track.**

For more details, refer to “4.2 Selection of Measurement Parameter”.

Right-click the title bar and select [Measurement] to change the S-parameter of the current track. Tick the S-parameter to be measured in the dialog box and click OK.



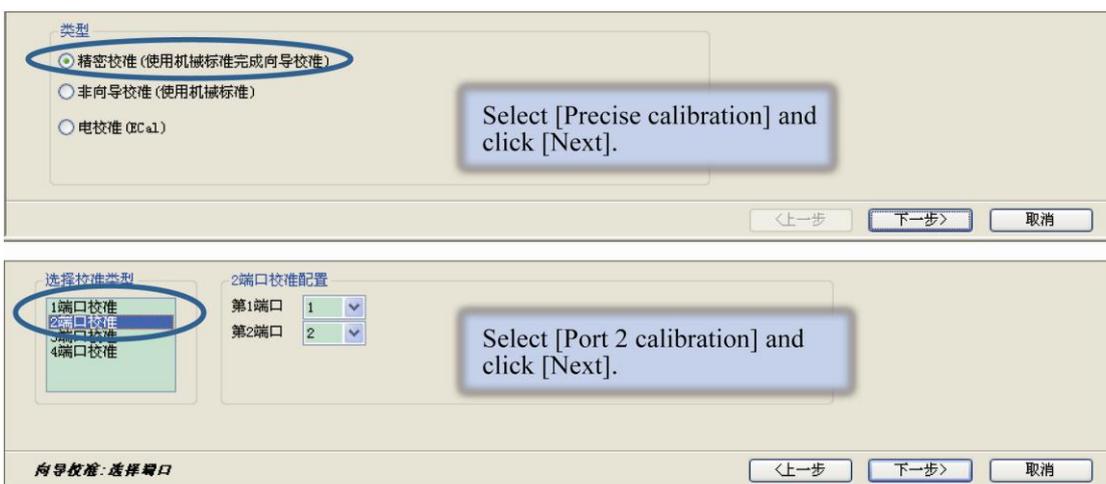
Right-click the blank and select [New track] to add one measurement track. Select the S-parameter to be added and click OK.

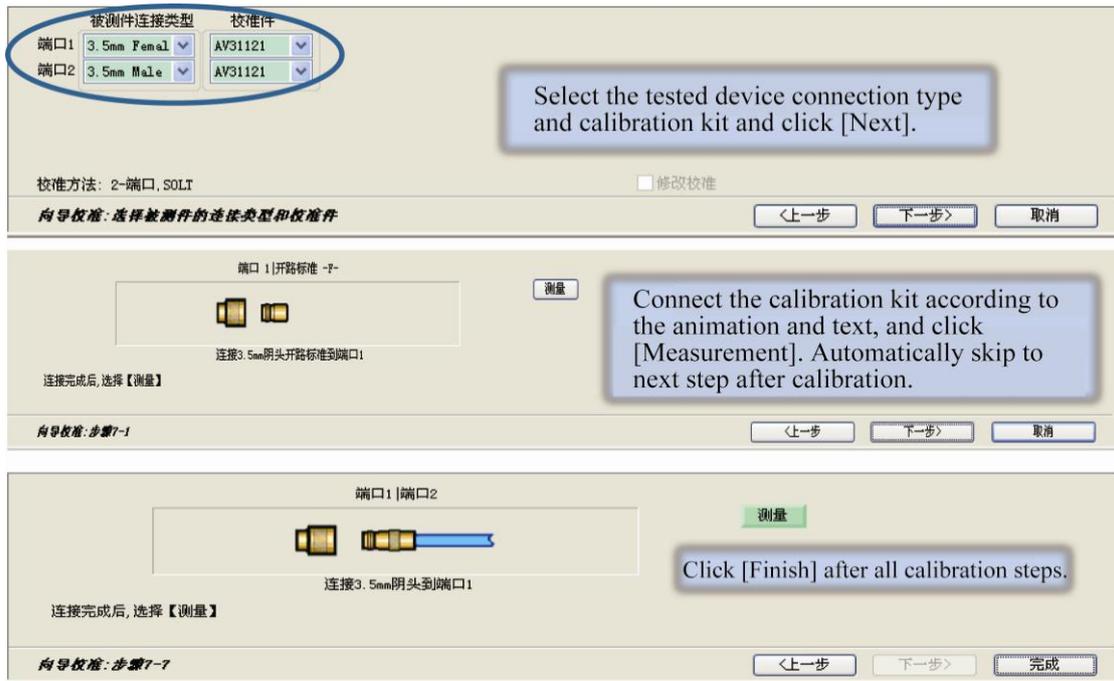


### 1.4 Calibration.

For more details, refer to “7 Calibration”.

Press [Calibration] on the front panel and click [Calibration] in the auxiliary menu bar.





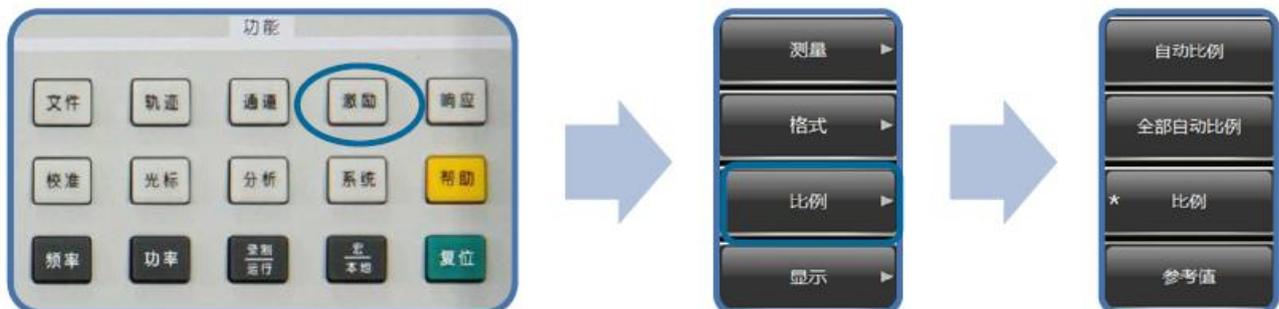
### 1.5 Connection of Tested Device

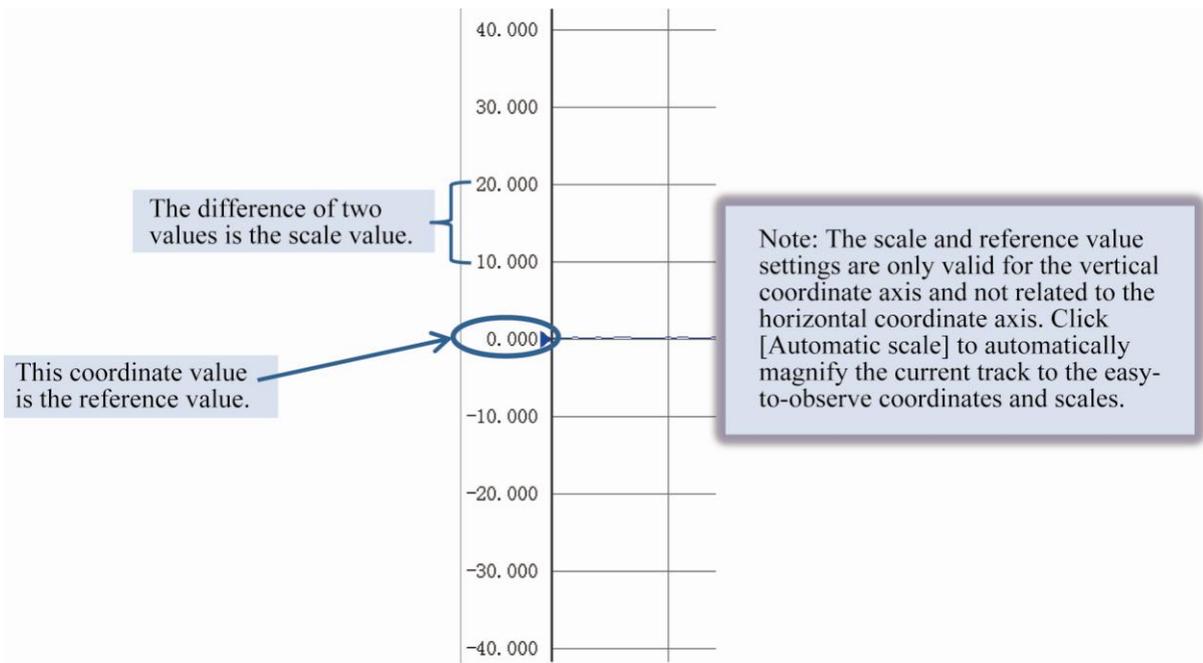


### 1.6 Scale Adjustment and Data and Analysis

For more details, refer to “4.7 Setting of Data Format and Scale”.

If necessary, press [Response] on the front panel, click [Scale] in the auxiliary menu bar, and perform corresponding setting.





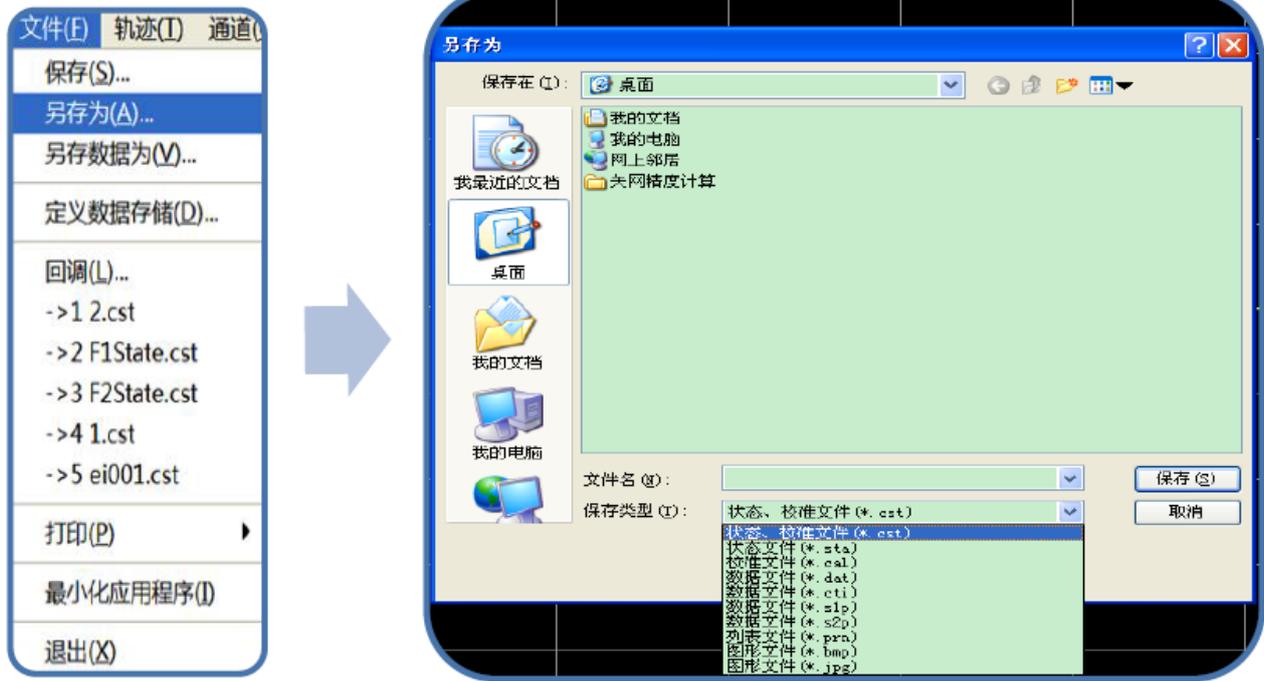
Press [Cursor] on the front panel to open the cursor. Rotate the knob and adjust the frequency corresponding to the cursor. The cursor reading is displayed in the upper right corner of the screen.



### 1.7 Recording or Saving of Data

For more details, refer to “3.6 Data Output”.

Menu path: [File] > [Save as]. Select the saving path and type and click [Save].



Statement:

- 1) The state file and calibration file can be called by the main program, but cannot be edited and processed with other programs.
- 2) The data file can be exported and printed or edited and processed with other kinds of software, but cannot be called.
- 3) The graphical file can be exported and printed, but cannot be called. The default file saving path is C:\ProgramFiles\EI41\Network Analyzer\MemoryDocuments. The user can set the saving path according to the needs.

## Appendix 2 Time Domain Measurement

- Recording or Saving of Data .....371
- Resolution and range of time domain measurement .....373
- Window filtering .....378
- Time gate filtering .....380
- Time domain measurement data .....384
- Time domain measurement data .....389
- Setting of time domain transformation measurement .....392

### 2.1 Principle of Time Domain Measurement

If the analyzer is configured with the time domain option, you can observe the device response in the time domain.

The analyzer displays the response of the tested device with frequency changes in general measurement. This is referred to as the frequency domain measurement. However, in the time domain measurement, the frequency domain data are subject to inverse Fourier transformation into the time domain data, the measurement results are displayed with the time as the X-axis, the response values appear at the discrete time points, and the characteristics and limitations of the tested device can be analyzed. The following figure shows the frequency domain and time domain reflection measurement results of the same cable with two bends. Each bend may result in transmission line mismatching or impedance change.

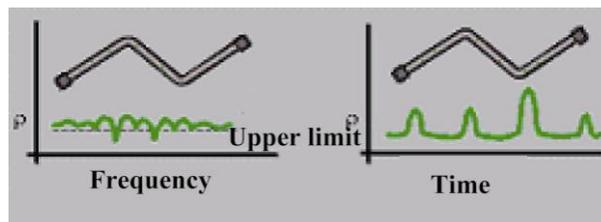


Fig. 2.1 Frequency Domain and Time Domain Measurement

1) The  $S_{11}$  frequency domain response measured at the input port shows the combined reflection response arising from mismatching of the cable with wave interactions. The exact physical location of cable mismatching cannot be determined easily.

2) The time domain response shows the location and degree of each mismatch. It can be seen that the second bend of the cable mismatches obviously.

In the time domain, the gate function can be used to filter undesired response, followed by transformation of time domain data into frequency domain data. This function can be used to measure the response of specific signals in the measurement network and remove the influence of external devices such as the connector or adapter.

The traditional time domain reflectometer (TDR) can be simulated by the time domain measurement function. Use TDR to send an impact or step signal to the tested device. Observe the reflected signal energy. The impedance change of the tested device can be determined by analyzing the amplitude, duration and waveform of the reflected signal. Actually, the incident impact or step signal is not produced by the network analyzer. Instead, frequency scanning measurement is done, and the time domain information is calculated by the Fourier algorithm based on the frequency domain measurement results. So far, the time domain transformation is measured with the  $S_{11}$  ratio for the majority of universal network analyzers.  $S_{11}$  reflection measurement is not simply to display the reflected signal measured by Receiver A or B. Instead, the measurement result of the ratio between the measurement receiver and reference receiver is displayed. In addition, system errors can be eliminated by calibration in the  $S_{11}$  ratio measurement. This is particularly important to time domain measurement. The measurement reference plane is established by calibration, and the calibration point is the zero point of the X-axis (time) and used as the reference point for all the time and distance data. Due to calibration, the time and amplitude data are accurate. The steps of time domain measurement of the analyzer are as follows:

- 1) Collect the data of the original receiver (A and R).
- 2) Perform ratio operation.

- 3) Perform calibration error correction.
- 4) Transform the frequency domain data into the time domain data.
- 5) Display the measurement result.

## 2.2 Resolution and Range of Time Domain Measurement

This section discusses how to observe all effective time domain data of the tested device and how to perform setting to obtain the highest resolution and maximum measurement range.

- [Response resolution](#) .....373
- [Display resolution](#) .....375
- [Measurement range](#) .....376

### 2.2.1 Response Resolution

- [Concept of response resolution](#) .....373
- [Factors affecting time domain response resolution](#) .....373
- [Ways of optimization of response resolution](#) .....375

#### 2.2.1.1 Concept of Response Resolution

The time domain response resolution of the analyzer refers to the capability to distinguish two adjacent responses. For the responses of the same amplitude, it is equal to the pulse width of the impact response defined at the 50% (6dB) amplitude point, or the rising time of the step response defined at 10% to 90% of the amplitude, as shown in Fig. 2.2.

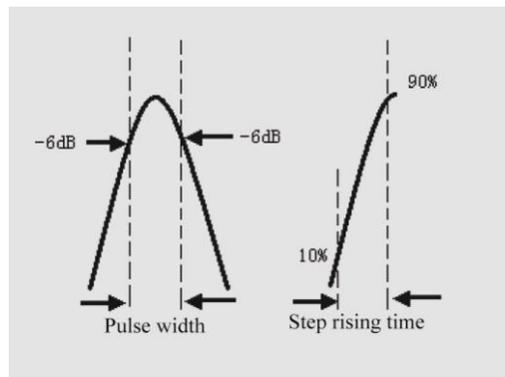


Fig. 2.2 Time Domain Response Resolution

#### 2.2.1.2 Factors Affecting Time Domain Response Resolution

##### 1) Frequency span

Fig. 2.3 shows the influence of the frequency span on the response resolution.

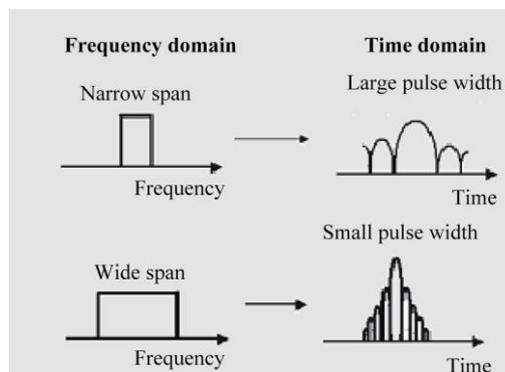


Fig. 2.3 Influence of Frequency Span on Response Resolution

- a) The response measured within the narrow frequency span is the pulse overlapping effect of separate impact responses.
- b) The analyzer can distinguish different responses during measurement within the wide frequency span.
- c) The frequency span is inversely proportional to the pulse width, that is, the wider the frequency span is, the

narrows the impact response pulse is, and the shorter the rising time of step responses is.

## 2) Window width ( $\beta$ parameter)

a) The response resolution is a function of the window width of time domain transformation.

b) The approximate resolution can be calculated by the following formulas. The formulas are only applicable to responses of the same amplitude and are used to calculate the pulse width of 50% and the rising time of steps of 10% to 90%.

$$\begin{aligned}
 &\text{Low-pass step} \\
 \text{Response Resolution} &= \frac{0.45}{\text{Frequency span}} \times \begin{cases} 1.0 \text{ Minimum window} \\ 2.2 \text{ Standard window} \\ 3.3 \text{ Maximum window} \end{cases} \\
 &\text{Low-pass impact} \\
 \text{Response Resolution} &= \frac{0.6}{\text{Frequency span}} \times \begin{cases} 1.0 \text{ Minimum window} \\ 1.6 \text{ Standard window} \\ 2.3 \text{ Maximum window} \end{cases} \\
 &\text{Band-pass impact} \\
 \text{Response Resolution} &= \frac{1.2}{\text{Frequency span}} \times \begin{cases} 1.0 \text{ Minimum window} \\ 1.6 \text{ Standard window} \\ 2.3 \text{ Maximum window} \end{cases}
 \end{aligned}$$

The window width selection depends on the responses of the tested device. If the response is signals of the same level, the minimum window will be used to improve the resolution of measurement; otherwise, the maximum window will be used to improve the dynamic range of measurement.

### Prompt

#### Calculate the pulse width in time domain transformation measurement.

It is not required to manually calculate the pulse width in actual time domain transformation measurement. In the [Time domain transformation] dialog box, the analyzer will automatically calculate the pulse width according to the current settings.

## 3) Time domain transformation mode

The response resolutions measured in the low-pass and band-pass transformation mode are different. For the same frequency span and scanning point number, the resolution in the low-pass mode is higher. Compared with the band-pass mode, the pulse width can be reduced by half. The following figure shows the resolution comparison of the two modes.

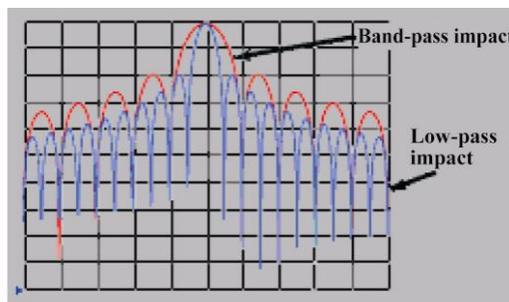


Fig. 2.4 Influence of Transformation Mode on Resolution

### 2.2.1.3 Ways of Optimization of Response Resolution

1) In most cases, large frequency span is selected to obtain high time resolution. However, the frequency setting must conform to the working frequency requirements of the tested device.

2) The resolution is affected by the frequency span, window width and time domain mode.

### 2.2.2 Display Resolution

The time domain display resolution refers to the capability to accurately position one signal response over time. High display resolution can help to improve the positioning accuracy of the peak point and zero point of the response. The display resolution is affected by the time span and scanning point number.

$$\text{Display resolution} = \text{time span}/(\text{scanning point number}-1)$$

The display resolution can be adjusted in the following two methods:

- 1) Reduce the time span.
- 2) Increase the number of scanning points.

## Prompt

**Change of the number of measurement points may reduce the calibration accuracy.**

Fig. 2.5 shows the measurement results of the same tested device within different time spans.

- 1) The resolution of 50ps can be obtained within the time span of 10ns.
- 2) The resolution of 12.5ps can be obtained within the time span of 2.5ns.

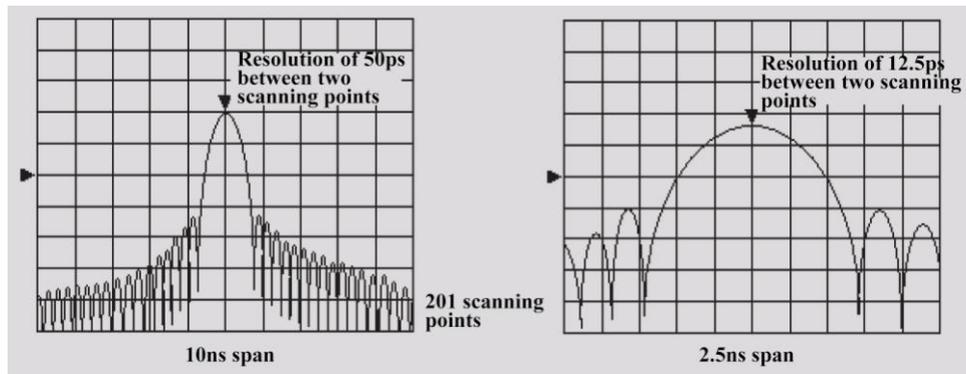


Fig. 2.5 Display Resolution

## Prompt

- 1) Change of the time span has no influence on the capability of the analyzer to distinguish two close signals.
- 2) Change of the scanning point number may result in change of the frequency span in the low-pass mode and also has certain influence on the response resolution.

### 2.2.3 Measuring range

In the time domain measurement, the measurement range is defined as the maximum time span which can be set. The response will not be repeated in measurement within the time span. The measurement range is inversely proportional to the response resolution. If one of them is increased, the other will decrease.

As shown in Fig. 2.6, the time domain waveform is a periodic signal repeated over time. Therefore, the response will be repeated. The repeated response (false response) is not real response of the tested device, and only appears within the specific time interval (1/scanning point frequency interval). Therefore, the measurement range is determined by the frequency range  $\Delta F$  of scanning points.

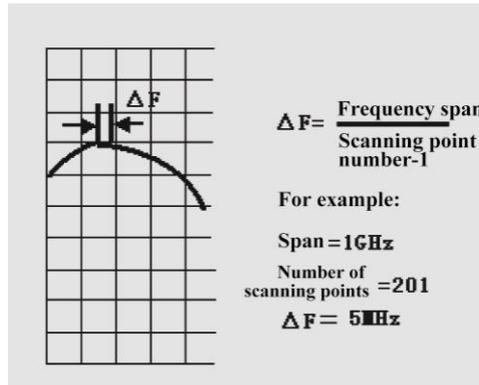


Fig. 2.6 Definition of Frequency Interval of Scanning Points

In the time domain measurement, the maximum ending time can be set as  $1/\Delta F$ . The measurement range is proportional to (scanning point number-1) and inversely proportional to the frequency span. In order to improve the measurement range, the following two settings can be modified:

- 1) Increase the number of scanning points.
- 2) Reduce the frequency span.

### Attention

**All the above modifications must be done before calibration.**

The measurement range in m can be calculated by dividing the vacuum light speed by the frequency interval  $\Delta F$ . The physical length of the actual measurement range can be calculated by further multiplying the relative range of the transmitted medium. The relative rates of some transmission mediums are as follows:

- 1)  $V(\text{polyethylene})=0.66$
- 2)  $V(\text{PTFC})=0.70$

Physical length of actual measurement range =  $V/\Delta F \times 3 \times 10^8 \text{m/s}$

## 2.3 Window Filtering

Affected by the side lobe and pulse width, the time resolution of time domain transformation is limited to a certain degree. The window filtering function can be applied to reduce the influence of such factor. The analyzer has the window function for time domain transformation to distinguish various responses more effectively. This function can be used to change the response pulse width, side lobe level and step response rising time.

- [Window filtering](#) .....378
- [Correct setting of window value](#) .....379
- [Window characteristics](#) .....379

### 2.3.1 Window Filtering

#### 2.3.1.1 Concept of Window Filtering

Sudden changes may occur to the starting and ending frequency in the time domain measurement. This may cause over-travel and ringing in the time domain step response. The window filtering function can be applied to reduce the influence of sudden changes of the frequency domain. The network analyzer also has the following disadvantages:

- 1) **Pulse width of impact response or rising time of step response:** caused by the band limits of the system, limiting the capability of the analyzer to distinguish two adjacent response signals. The pulse width is inversely proportional to the frequency span of measurement. The frequency span should be increased to reduce the pulse width.
- 2) **Side lobe of impact response:** caused by sudden changes of the ending frequency. The adjacent high-level response side lobe may result in hiding of low-level response signal, limiting the dynamic range of time domain measurement. The window filtering function can be used to inhibit the side lobe, as shown in Fig. 2.7.

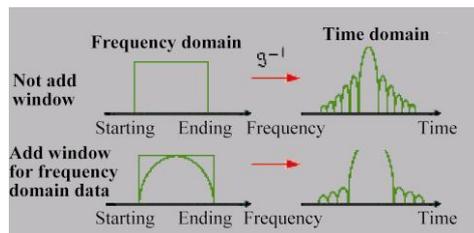


Fig. 2.7 Side Lobe Suppression by Window Filtering

#### 2.3.1.2 Advantages of Window Filtering

- 1) The narrow window can be applied to reduce the pulse width of impact response, improve the response resolution and better distinguish two adjacent responses.
- 2) The wide window can be applied to reduce the side lobe level of the impact response, improve the dynamic range and better measure the low-level response.

#### 2.3.1.3 Influence of Window Filtering

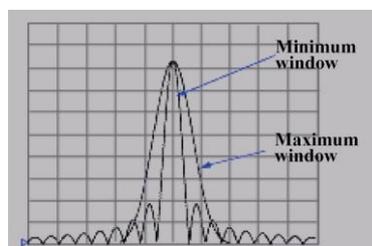


Fig. 2.8 Influence of Window on Response Signal

As shown in Fig. 2.8, the window filtering function of the analyzer for frequency domain measurement data has the following influence on the time domain measurement response of the tested device:

- 1) It can influence the side lobe level and pulse width and improve the measurement resolution in the impact transformation mode.

2) It can reduce over-travel and ringing in the low-pass step transformation mode.

### 2.3.2 Correct Setting of Window Value

As shown in Fig. 2.9, the appropriate window value must be selected according to the response of the tested device.

- 1) **If the tested device has the response of the same amplitude:** select the small window to obtain the small pulse width and improve the resolution of time domain measurement.
- 2) **If the tested device has the response of different amplitude:** select the large window to obtain the low side lobe level and improve the dynamic range of time domain measurement.

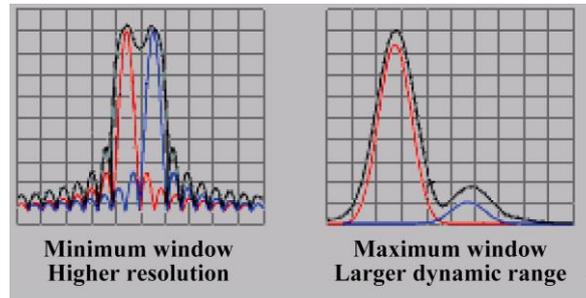


Fig. 2.9 Correct Setting of Window

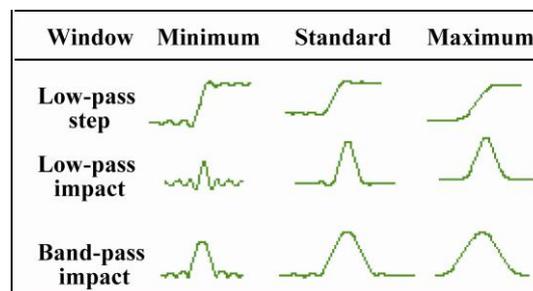
### 2.3.3 Window Characteristics

The side lobe level is associated with the selected window in the time domain measurement, and the response resolution is associated with the frequency span and the selected window. Schedule 2.1 shows the window characteristic indicators within the frequency span of 2.997GHz.

Schedule 2.1 Window Characteristic Indicators within Frequency Span of 2.997GHz

Transformation Mode	Window	Response Resolution		Side Lobe Level
		Step rising time	Pulse width	
Low-pass step	Minimum	150ps		-21dBc
	Standard	330ps		-60dBc
	Maximum	494ps		<-70dBc
Low-pass impact	Minimum		200ps	-13dBc
	Standard		320ps	-44dBc
	Maximum		481ps	<-75dBc
Band-pass impact	Minimum		400ps	-13dBc
	Standard		641ps	-44dBc
	Maximum		941ps	<-75dBc

Schedule 2.2 Time Domain Waveform of Reflection Measurement of Short-circuit Device with Window



## 2.4 Time Gate Filtering

The time gate function can be used to select or remove one response in the time domain. Then the processed time domain data can be transformed by the analyzer into the frequency domain data for observation. In other words, the time domain transformation function can be shut down after time gate filtering of the time domain data. Observe

the frequency domain response of the tested device in the effective mode of the time gate function. For example, the time gate can be used to eliminate the influence of multi-path transportation in the transmission measurement. You can only observe one separate time domain response signal each time and analyze the influence of each separate response on measurement results in the frequency domain.

- [How to use gate function](#) .....380
- [Gate setting](#) .....381
- [Gate shape](#) .....381

### 2.4.1 How to Use Gate Function

The time gate function can be used in actual measurement according to the following steps.

- 1) Measure the tested device in the frequency domain.
- 2) Open the time domain transformation function. The time domain response of the tested device will be calculated by the analyzer.
- 3) Select the gate shape.
  - a) **Band-pass**: set the gate at the center of the response to be reserved, and open the gate function. The response beyond the gate will be removed from the displayed measurement by means of mathematical operation.
  - b) **Band resistance**: set the gate at the center of the response to be removed, and open the gate function. The response within the gate will be removed from the displayed measurement by means of mathematical operation.
- 4) Close the time domain transformation function. Observe the frequency domain response of the tested device to understand the influence of the removed response on the measurement result. Fig. 2.10 shows the measurement application of the band-pass time gate.

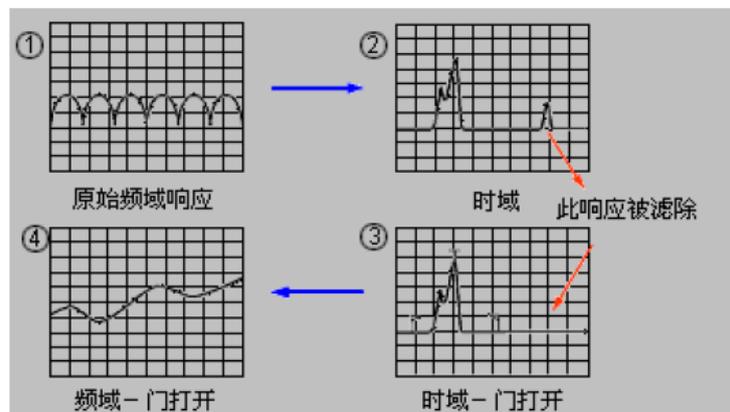


Fig. 2.10 Measurement Application of Band-pass Time Gate

### 2.4.2 Gate Setting

Define the gate boundary and function by the following settings:

- 1) **Starting and ending**: define the gate cutoff time (-6dB).
- 2) **Center**: define the center time of the gate.
- 3) **Span**: equal to the difference of the ending time minus starting time.
- 4) **Gate type**:
  - a) **Band-pass**: filter the response beyond the gate.
  - b) **Band resistance**: filter the response within the gate.

### 2.4.3 Gate Shape

#### 2.4.3.1 Gate Shape

The gate, similar to the window filter, is shaped like a filter. You can select the reasonable filter shape (smallest,

standard, wide and largest) to optimize measurement.

- 1) **Smallest gate:** the side lobe level of the filter is the highest, the edge drop is the steepest, and the passband ripple is the largest.
- 2) **Largest gate:** the side lobe level of the filter is the lowest, the edge drop is the most gentle, and the passband ripple is the smallest.

### 2.4.3.2 Passband Ripple

The gate is a band-pass (band-resistance) filter. Filters of various shapes have different characteristics. The following figure shows passband ripples of four kinds of filters, in which the scale is 0.5dB/grid. It can be seen in Fig. 2.11 that the smallest gate has the largest ripple.

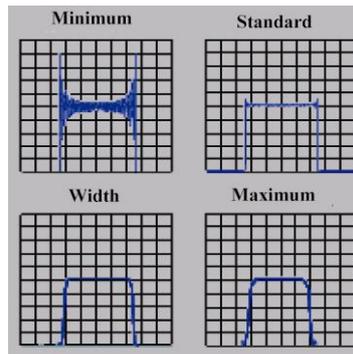


Fig. 2.11 Passband Ripple of Various Gate Filters

### 2.4.3.3 Side Lobe Level

As shown in Fig. 2.12, four kinds of filters have different side lobe levels. The side lobe level and cutoff rate must be balanced in actual measurement.

- 1) The smallest gate has the highest side lobe level and cutoff rate. It is applicable for removal of the unexpected response near the measured response.
- 2) The largest gate has the lowest side lobe level and cutoff rate, the widest passband and the largest attenuation outside the gate band.

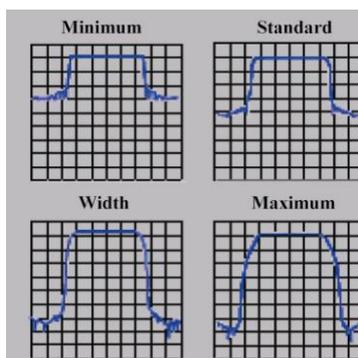


Fig. 2.12 Side Lobe Levels of Various Gates

### 2.4.3.5 Gate Characteristics

Various gates have different characteristics. Schedule 2.3 lists the characteristic indicators of various gates. The gate characteristics are defined with the following indicators:

- 1) **Passband ripple and side lobe level:** describe the gate shape.
- 2) **Cutoff time:** the interval between the gate ending time (filter edge-6dB) and the first side lobe peak point.
- 3) **Minimum gate span:** twice of the cutoff time.

Schedule 2.3 Characteristic Indicators of Various Gates

Gate Shape	Passband Ripple	Side Lobe Level	Cutoff Time	Minimum Gate Span
Minimum	±0.10dB	-48dB	1.4/frequency span	2.8/frequency span
Standard	±0.01dB	-68dB	2.8/frequency span	5.6/frequency span
Width	±0.01dB	-57dB	4.4/frequency span	8.8/frequency span
Maximum	±0.01dB	-70dB	12.7/frequency span	25.4/frequency span

Fig. 2.13 shows the complete gate shape and the meanings of characteristic indicators.

- 1)  $T_1$  is the gate span, equal to the difference of the ending time minus starting time.
- 2)  $T_2$  is the time between the passband edge and the point of -6dB, indicating the filter cutoff rate.
- 3)  $T_3$  is the time between the point of -6dB and gate resistance band edge.

For all kinds of gates,  $T_2$  is equal to  $T_3$ . Both sides of the filter center are completely symmetrical.

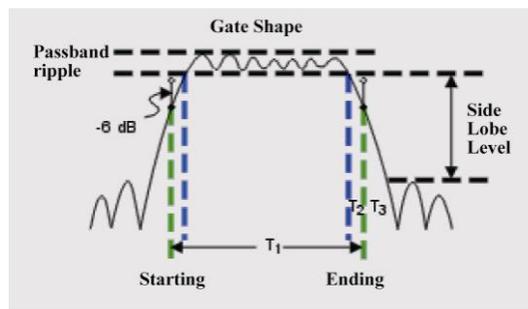


Fig. 2.13 Schematic Diagram of Gate Shape

#### 2.4.3.6 Minimum Gate Span

Each kind of gate is configured with a recommended minimum gate span for proper use. The minimum gate span is determined by the limited cutoff rate and provided by the following formula. In this case, the filter passband is equal to 0.

$$T_{1MIN} = 2 \times T_2$$

If the set gate span is smaller than the minimum value, the analyzer will have the following effects:

- 1) The gate shape is distorted, with no passband.
- 2) The gate is distorted.
- 3) The starting time and ending time are not indicated correctly.
- 4) The side lobe level may increase.

## 2.5 Time Domain Measurement Data

In order to help the user understand device response within the time domain, this section shows the examples of various measurements.

- [Masking](#) .....384
- [Reflection measurement in band-pass mode](#) .....385
- [Transmission measurement in band-pass mode](#) .....386
- [Error positioning of low-pass mode](#) .....387
- [Reflection measurement in low-pass mode](#) .....387
- [Transmission measurement in low-pass mode](#) .....388

### 2.5.1 Masking

#### 2.5.1.1 Masking Effect

Masking can help the user to understand time domain measurement data, due to the influence on the response observed by the user in time domain measurement.

- 1) Masking will occur in case of one interruption or one loss closest to the reference channel. Each concurrent interruption response will be affected by masking.
- 2) The energy reflected or absorbed by the first interruption cannot reach the second or subsequent breaking point.
- 3) The effect is that each interruption response is smaller than the first response which will occur but cannot be predicted.

#### 2.5.1.2 Masking arising from Energy Reflection

Masking arising from reflection will occur in case of any major error configuration. As shown in Fig. 2.14, masking is displayed in the following example of linear impedance.

- 1) Connect one 50Ω line to one 25Ω air line and then connect one 50Ω transmission line.
- 2) The first breaking point is subject to reflection with the coefficient of 0.333 (equivalent to a 25Ω resistor).
- 3) The response reflection coefficient is not 0.333 after the 25Ω terminal (equivalent to a 50Ω resistor). For the two Δ markers, the difference of the orders of magnitude is 35.355mU. This is because the energy reflected by the second pulse generation point is subject one-unit attenuation based on the reflection of the first out-of-tune point.

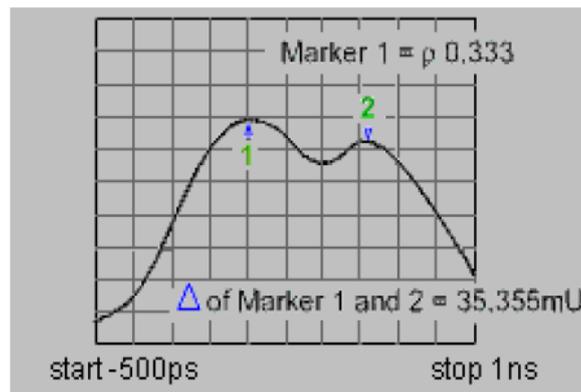


Fig. 2.14 Influence arising from Energy Reflection on Measurement

#### 2.5.1.3 Masking arising from Energy Adsorption

Masking arising from energy adsorption refers to the masking occurring in measurement of the circuit with loss. Fig. 2.15 shows an example of masking of next cable in the open loop.

- 1) The return loss of the open-loop response on MARKER1 is -2.445dB (in the LOGMAG mode).
- 2) The expected response is a typical value in the open loop.

3) The marker is a sum of forward and reverse path losses.

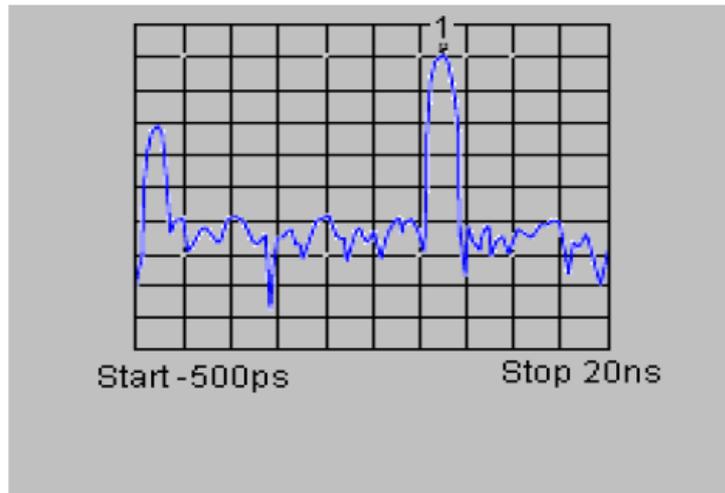


Fig. 2.15 Influence of Influence arising from Energy Adsorption on Measurement

## 2.5.2 Reflection Measurement in Band-pass Mode

### 2.5.2.1 Data on Horizontal Axis

The time for one pulse refers to the time from the test port to breaking point and then back to the test port.

### 2.5.2.2 Data on Vertical Axis

- 1) Refer to the return loss (dB) in the LOGMAG mode.
- 2) Refer to the reflection coefficient in the LINMAG mode.

Fig. 2.16 shows an example of reflection measurement in the band-pass mode.

- 3) A pulse is at the zero point on the time axis, and refers to the time from the test port to the first breaking point.
- 4) The concurrent pulse refers to next breaking point of the pulse.

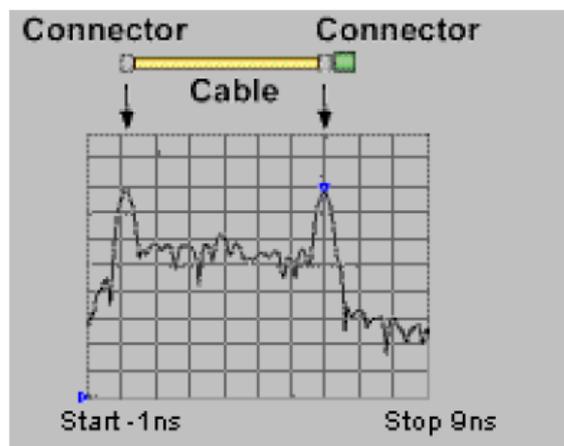


Fig. 2.16 Reflection Measurement in Band-pass Mode

## 2.5.3 Transmission Measurement in Band-pass Mode

### 2.5.3.1 Data on Horizontal Axis

Refer to the transmission delay of the tested device.

### 2.5.3.2 Data on Vertical Axis

- 1) Refer to the transmission loss or gain in the LOGMAG mode.
- 2) Refer to the transmission coefficient in the LINMAG mode.

Fig. 2.17 shows an example of transmission measurement in the band-pass mode.

- 3) This example shows the information of multiple paths transmitted in the SAW (surface acoustic wave) filter in the selected mode.
- 4) The pulse which is the closest to the time point 0 refers to the transmission time of on the shortest path from the output to input of the network analyzer. It may be or not be the largest pulse or best transmission path.
- 5) Each concurrent pulse may be transmitted in other paths from the input to output. However, such paths are all longer than the shortest path.

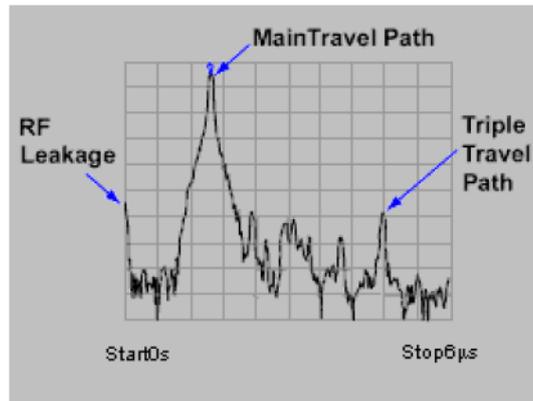


Fig. 2.17 Transmission Measurement in Band-pass Mode

## Prompt

### Observation of the main path of SAW filter response:

In order to see the main channel of SAW filter response, you can set the gate to block all pulses except main pulses. Only the frequency response of the main path can be displayed in the frequency domain.

### 2.5.4 Error Positioning of Low-Pass Mode

The response of the time domain reflectometer (TDR) can be simulated in the low-pass test mode. It includes all useful and decisive information of the breaking point. The following figure shows the low-pass response of the known breaking point. The waveform of each circuit element is simulated corresponding to the  $S_{11}$  response of the low-pass time domain mode. You are allowed to observe the step response or pulse excitation pulse in the low-pass mode.

IMPEDANCE	STEP RESPONSE	IMPULSE RESPONSE
OPEN	 Unity Reflection	 Unity Reflection
SHORT	 Unity Reflection = 180	 Unity Reflection = 180
RESISTOR $R > Z_0$	 Unity Reflection	 Unity Reflection
RESISTOR $R < Z_0$	 Unity Reflection	 Unity Reflection
INDUCTOR	 Unity Reflection	 Unity Reflection
CAPACITOR	 Unity Reflection	 Unity Reflection

Fig. 2.18 Waveform of Low-pass Time Domain Response of Discontinuous Circuit

## Prompt

The step response can help you to easily understand the characteristics of the breaking point. This mode is closer to the traditional TDR measurement.

### 2.5.5 Reflection Measurement of Low-Pass Mode

#### 2.5.5.1 Data on Horizontal Axis

The data on the horizontal axis refers to the time from the test port to breaking point and then back to the test port. Note: Enter the appropriate speed factor to confirm the actual physical length.

#### 2.5.5.2 Data on Vertical Axis

Refer to the reflection coefficient ( $\rho$ ) in the REAL mode. The following example shows reflection measurement of the pulse response and step response in the low-pass LOGMAG mode.

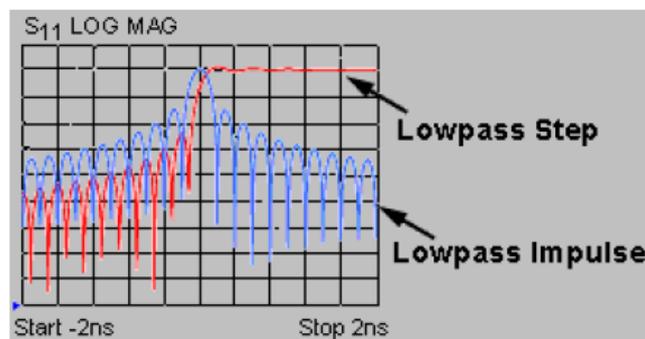


Fig. 2.19 Reflection Measurement of Low-pass Mode

The following example shows reflection measurement of two different cables in the low-pass REAL mode.

1) The low-pass response includes the method of calibration of the impedance located at the breaking point, etc.

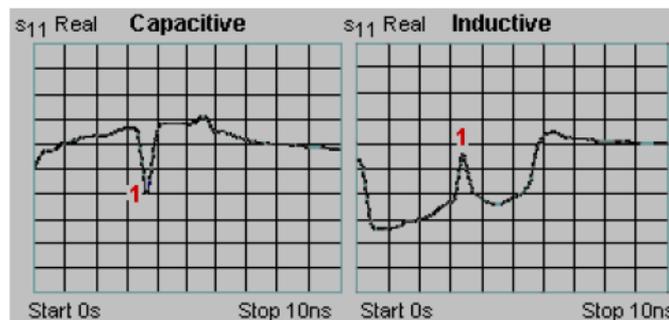


Fig. 2.20 Low-pass Step Measurement Results of Different Cables

2) Left measurement: refer to the capacitive breaking point of the response of the coiled cable.

3) Right measurement: refer to the inductive breaking point of the response of the worn cable.

### 2.5.6 Transmission Measurement of Low-pass Mode

#### 2.5.6.1 Data on Horizontal Axis

1) Average time through the device within one frequency range.

2) Electrical delay of one device over time.

#### 2.5.6.2 Data on Vertical Axis

1) Refer to the real unit (such as the voltage) in the REAL mode.

2) Refer to the transmission loss or gain (dB) in the LOGMAG mode (only for the pulse).

The following figure shows the low-pass step response of the amplifier.

- 1) The average group delay within the whole measurement frequency range varies with the time for the step response and amplifier response.
- 2) The stepping time of frequency domain scanning refers to the balanced time to reach to the highest frequency point. The higher the frequency is, the shortest the rising time is.
- 3) One suppression signal appears in the rise of the amplifier response.

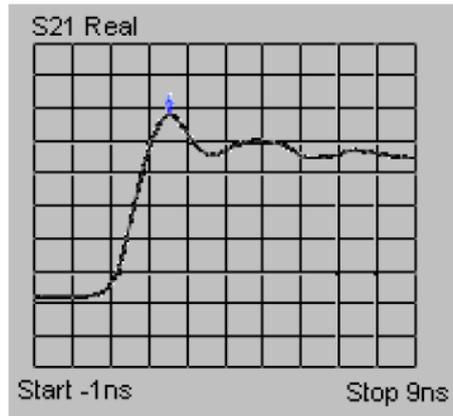


Fig. 2.21 Low-pass Step Measurement Result of Amplifier

## Prompt

### Application scope of vertical axis format:

The REAL (radiation coefficient) mode is the most usable for the low-pass step response. It can be applied for the pulse response. In order to obtain the best dynamic range of the large or small breaking point which can be observed, it is recommended to the LOGMAG mode.

## 2.6 Band-pass and Low-pass Time Domain Mode

Select the time domain mode before setting the measurement value.

- [Mode comparison](#) .....389
- [Mode selection according to tested device](#) .....390
- [Frequency range and data point number](#) .....390
- [Pulse and step response](#) .....391
- [Use of data format](#) .....391

### 2.6.1 Mode Comparison

#### 2.6.1.1 Band-pass Mode

- 1) It is a kind of simple application.
- 2) It is only applicable to the band-pass device which cannot be operated down to 0Hz.
- 3) The frequency with the set starting and ending value can be measured.
- 4) It is only applicable to the cases in which the pulse response excludes 0Hz as a result of data transformation in measurement.
- 5) It can be used in reflection and transmission measurement.
- 6) Errors are allowed.

#### 2.6.1.2 Low-pass Mode

- 1) It can be used for the low-pass device which can be operated down to 0Hz.
- 2) The traditional time domain reflectometer (TDR) can be simulated.
- 3) The frequency with a relationship to the case of 0Hz should be measured. The first new data point should be calculated in the frequency domain.
- 4) It can be applied in the cases including 0Hz due to data transformation in measurement.
- 5) It is allowed to locate errors and verify the type of impedance (capacitive or inductive) at the breaking point.
- 6) It can be used in reflection and transmission measurement.
- 7) The response resolution of the low-pass mode is higher than (twice) the band-pass mode within the same frequency span.

### 2.6.2 Mode Selection according to Tested Device

- 1) Select the band-pass mode if the tested device is operated with the band-pass, band-resistance or high-pass filter.
- 2) Select the low-pass mode if the tested device includes all frequencies, including 0Hz. Even if the device response is repeated at the lower limit of the frequency span, the low-pass mode is also applicable.

### 2.6.3 Frequency Range and Data Point Number

#### 2.6.3.1 Band-pass Mode

- 1) The user can select the starting and ending frequency within some measurement ranges.
- 2) The analyzer will obtain data from the starting frequency and ending frequency.
- 3) Only the pulse response is provided.

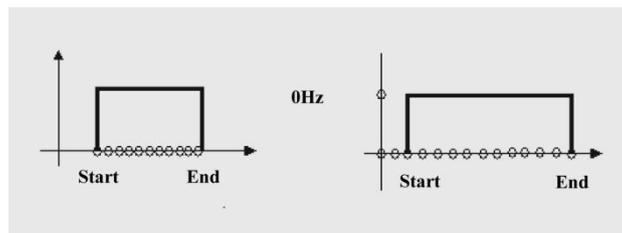


Fig. 2.22 Band-pass Mode

#### 2.6.3.2 Low-pass Mode

- 1) DC conditions which can be inferred from a few points at the beginning are required in the frequency domain.
- 2) The data point number should be equal to that of the space.
- 3) The analyzer is configured with the harmonics of the starting frequency for measurement.
- 4)  $F_{ending} = N \times F_{starting}$  ( $N$ =scanning point number). Each value of  $N$  is limited at the ending frequency.

### Attention

#### F(starting) and F(ending) parameter

The minimum value of  $F(\text{starting})$  is 300kHz,  $F(\text{ending})$  must be  $N \times 300\text{kHz}$  at least.

### 2.6.4 Pulse and Step Response

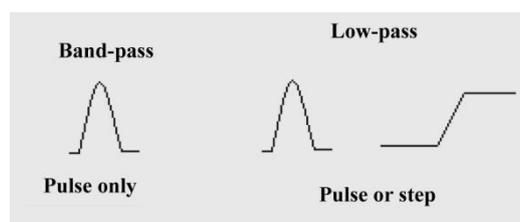


Fig. 2.23 Low-pass Mode

The network analyzer will have this kind of time domain response in case of pulse or step excitation of the tested device.

- 1) **Low-pass excitation:** voltage waveform from 0 to maximum and then back to 0. The pulse width is determined according to the frequency span in the frequency domain measurement.
- 2) **Low-pass step:** voltage waveform from 0 to maximum. The step rising time is determined according to the maximum frequency in the time domain frequency.

## Attention

### **Application scopes of two low-pass time domain transformation modes:**

The low-pass step mode is the most easiest to explain time domain transformation of the breaking point. The TDR data of the general inductive and capacitive breaking point can be provided in the two modes.

- 3) For the frequency response data, the analyzer depends on the selected transformation mode to calculate the step, pulse or band-pass response setting.
- 4) The analyzer will display such data in the time domain response. For more information of the influence of the frequency span on the pulse width and rising time, refer to “Response and Range”.

## **2.6.5 Use of Data Format**

### **2.6.5.1 Linear Magnitude**

- 1) For the reflection measurement mode, the average linear magnitude of the reflection coefficient within the measurement range will be displayed.
- 2) For the transmission measurement mode, the average transmission coefficient of the transmission path within the measurement frequency range will be displayed.
- 3) This format is applicable to observation of the responses close to the magnitude.

### **2.6.5.2 Log Format**

- 1) For the reflection measurement mode, the uni response of the return loss (dB) will be displayed. The displayed value is the average value of return losses of the breaking point within the measurement frequency range.
- 2) For the transmission measurement mode, the unit response of the transmission loss or gain (dB) will be displayed. The displayed value is the average loss of the transmission path within the measurement frequency range.
- 3) This format is applicable to observation of the wide dynamic range of the transmission response.

### **2.6.5.3 Standing Wave Ratio**

For the reflection measurement mode, the average standing wave ratio (SWR) of the breaking point within the measurement frequency range will be displayed.

### **2.6.5.4 Format for the low-pass mode: REAL.**

- 1) The real unit response will be displayed in this format.
- 2) The low-pass mode should be applied if the tested device has the response down to the DC value.
- 3) The band-pass mode should be applied if the tested device has no measurement response to the DC value.

## **2.7 Setting of Time Domain Transformation Measurement**

Menu path: [Analysis] > [Time domain] > [Time domain transformation...]. The [Time domain transformation] dialog box will appear.

Tick the [Time domain transformation] check box to enable the time domain transformation function.

Click [Starting], [Ending] or [Center], and [Span] box to set the range of time domain transformation.

Select the transformation mode in the [Transformation mode] zone: [Low-pass excitation], [Low-pass step] or [Band-pass].



Fig. 2.24 Setting of Time Domain Transformation Measurement

Setting of the **window** function: click [**Time domain transformation**] dialog box > [**Window**], and set the window filter in the following three methods.

- Drag the slider with the mouse until the pulse width or side lobe level conforms to the requirements.
- Click the [**Kaiser window  $\beta$  parameter**] box, and set the  $\beta$  value, until the pulse width or side lobe level conforms to the requirements.
- Click the [**Pulse width**] box and directly set the response pulse width.



Fig. 2.25 Time Domain Transformation Measurement--Window Setting

Setting of the time domain gate filtering function: click [**Time domain transformation**] dialog box > [**Gate**], and tick the [Gate] check box to enable the time domain gate filtering function.

- Click [**Starting**], [**Ending**] or [**Center**] and [**Span**] box to set the gate boundary.
- Select the gate type in the [**Gate type**] box: **band-pass** and **band-resistance**.
- Select the gate shape in the [**Gate shape**] box: **smallest**, **standard**, **wide** and **largest**.

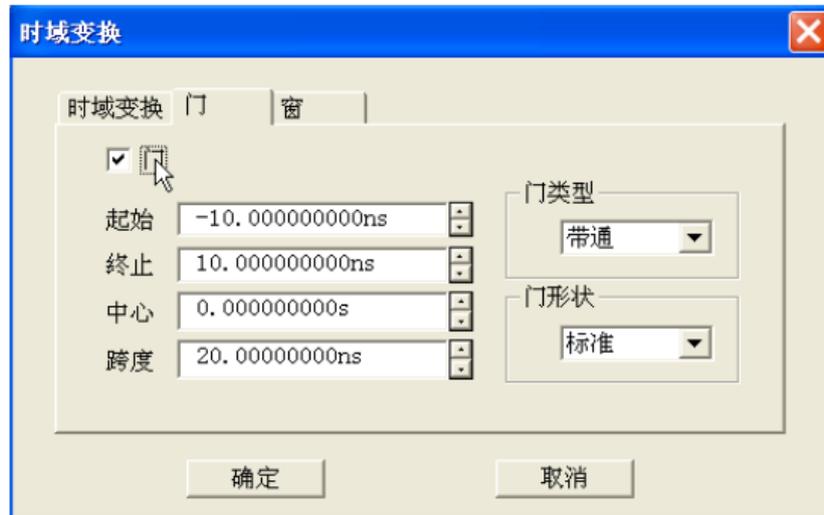


Fig. 2.26 Time Domain Transformation Measurement--Gate Setting

To observe the frequency domain response of the tested device with the effective gate function, click the **[Time domain transformation]** button in the **[Time domain transformation]** dialog box and then clear the **[Time domain transformation]** check box.

**Ways of time domain transformation setting:**

- Enable the time domain transformation and gate functions, and close the **[Time domain transformation]** dialog box. Change the boundary settings of the time domain gate by dragging the mouse. The starting and ending value of the gate are respectively represented by “↖” and “↗”. Point the gate starting and ending symbol with the mouse, left-click the mouse until the mouse pointer changes into the horizontal adjustment indicator “↔”. Drag the mouse and move the gate boundary indicator to the desired position. Release the left-click of the mouse. Thus gate starting or ending settings are completed.
- After setting the time domain measurement in the **[Time domain transformation]** dialog box, close the **[Time domain transformation]** dialog box. Open the **time domain** toolbar and adjust the settings of time domain measurement. Thus you can observe the influence of setting changes on measurement more clearly. For the setting of the **time domain** toolbar, refer to “Trigger Toolbar Display” of “4.9 Setting of Analyzer Display”.

**Attention**

**Calibration of time domain measurement:**

If calibration is required before measurement in the low-pass time domain mode, you must select the low-pass measurement mode in the **[Time domain transformation]** dialog box or set the starting frequency of measurement by clicking the **[Set frequency--low-pass]**. It is recommended to perform calibration after all time domain measurement settings.

## Appendix 3 Frequency Deviation Measurement

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- Coupling and non-coupling mode setting .....396
- Calibration of frequency deviation measurement .....398
- Typical application of frequency deviation measurement .....399

### 3.1 Setting of Frequency Deviation Measurement

In the frequency deviation measurement mode, the source output power of the vector network analyzer is adjusted to different receiving frequencies. AV3672 series vector network analyzers have the function of frequency deviation measurement based on the hardware and software. Appendix 3 mainly introduces the basic settings of frequency deviation measurement.

1) Open the setting dialog box.

- By the front panel: press **[Excitation]** and click **[Frequency] > [Frequency deviation]** on the right side of the screen.
- By the menu: click **[Excitation] > [Frequency] > [Frequency deviation]** on the screen.

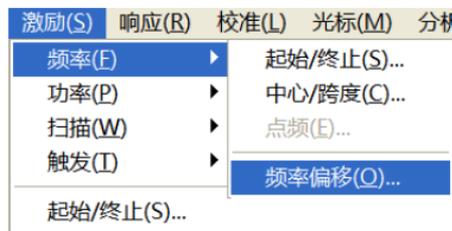


Fig. 3.1 Opening of Measurement Setting Dialog Box

2) After the above operations, the following setting dialog box will pop up. The excitation and response in frequency deviation measurement respectively correspond to the source and receiver. The source and receiver settings are divided into the following two types. Source 2 is used to provide the signal power for Port 3 and 4. Set the source frequency in the **[Power and attenuation]** dialog box. For specific operations, refer to Section 4.4 in the text. Such operations are not repeated here.

- Main coupling setting;
- The separate source and receiver values can be set for non-coupling.



Fig. 3.2 [Frequency deviation measurement] dialog box

**Frequency deviation (on/OFF):** enable the frequency deviation measurement mode for all the current measurement channels. If the frequency deviation mode is not enabled, all the measurement channels have the same signal frequency.

**Main setting:** set the current test channel. The source or receiver has the same scanning type as the main setting in the coupling mode. The coupling frequency setting range can be calibrated with the main setting value by the specified mathematical formula according to the multiplier and divisor settings (detailed in next section). In this method, the source and receiver parameters can be changed by changing the main setting. The main setting parameter can be changed only in the frequency deviation ON mode.

The main setting cannot be used until the source and receiver are set in the coupling mode. The non-coupling mode is used more commonly. In this case, the source and receiver parameters can be set separately. Click **[Excitation] > [Power] > [Power and attenuation]** to set Source 2.

**Receiver:** all the receivers in the channel, including the reference receiver, can be adjusted by the “Setting” item to the specific frequency.

**Scanning type:** set for each item. Pay attention to the following items:

- Power scanning and segment scanning cannot be applied at the same time;
- Invalid data will be produced in case of source and receiver deviations in the non-coupling logarithmic frequency scanning mode;
- The coupling logarithmic frequency scanning mode can be applied in the following two cases:
  - 1) Frequency deviation=0, multiplier=1 and divisor=1.
  - 2) Multiplier=0.

**X-axis display:** select the X-axis display mode in the window.

**Y-axis uniform interval display:** for segment scanning.

### Attention

**Frequency deviation function:**

If the frequency deviation function is enabled, all receivers of channels, including the reference receiver, will be adjusted to the set value. In this case, the source frequency is different from the receiver frequency, resulting in inaccurate S-parameter measurement data of all receivers, including the reference receiver. Double-channel measurement must be applied to measure and display accurate results in the source and receiver frequency measurement. The frequency deviation and loss can be calibrated by the formula editor. The calibration method is introduced in the following section.

## 3.2 Setting of Coupling and Non-coupling Mode

### 3.2.1 Setting of Coupling Mode

Click **[Excitation] > [Power] > [Power and attenuation]** in the menu bar and open the [Frequency deviation] dialog box. Right-click the setting bar and click the pop-up **[Edit]** menu. The [Source coupling setting] dialog box will pop up, as shown in the following figure.

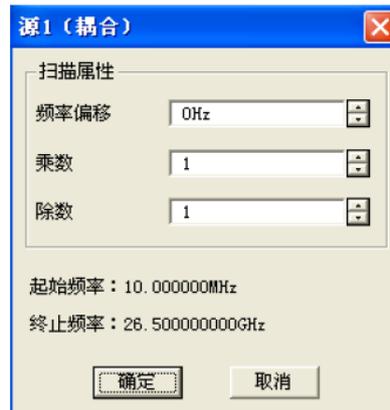


Fig. 3.3 [Source 1 coupling setting] Dialog Box

➤ **Coupling formula:**

Starting frequency = [main setting starting frequency\*(multiplier/divisor)]+frequency deviation

Ending frequency = [main setting ending frequency\*(multiplier/divisor)]+frequency deviation

➤ **Frequency deviation:** set the frequency deviation value in Hz. The deviation of mixer measurement is LO frequency. The frequency deviation range is ±1000GHz.

➤ **Multiplier:** set the multiplier, ±1000.

a) If the multiplier is negative, the source scanning frequency is from high frequency to low frequency. For the lower variable-frequency mixer, the set value of input power should be lower than the LO frequency.

b) If the set multiplier is 0, the starting frequency is equal to the frequency deviation.

➤ **Divisor:** set the divisor value between 1 and 1,000.

**3.2.2 Setting of Non-coupling Mode**



Fig. 3.4 [Non-coupling setting] Dialog Box

Various setting windows are set for different scanning types. The setting items of each kind of scanning frequency are respectively introduced below.

➤ **Linear and logarithmic scanning:** select the starting frequency or center frequency and set the number of scanning points.

➤ **Power scanning:** set the center frequency and the number of scanning points.

➤ **CW:** set the CW frequency and scanning time.

➤ **Segment scanning:** the flexible measurement configuration function is set for segment scanning in the

non-coupling mode. Pay attention to the following items in the segment scanning setting.



Fig. 3.5 [Segment scanning setting] Dialog Box

- 1) Click OK when the total number of scanning points of the effective segment is equal to the total number of channel scanning points.
- 2) The independent intermediate frequency bandwidth and independent scanning time are valid for the main setting and non-coupling receiver and invalid for the source.
- 3) The independent power is valid for the main setting and non-coupling source mode and invalid for the receiver.

### 3.3 Calibration of Frequency Deviation Measurement

In the traditional calibration process, errors are corrected through the measurement reference channel. The excitation frequency is different from the response frequency in frequency deviation measurement. Therefore, the traditional standard calibration mode cannot be used for error correction, such as the full double-port SOLT mode. The source and receiver power calibration mode should be applied for error correction in the frequency deviation measurement.

Click [**Calibration**] > [**Calibration...**] > [**Power calibration**] on the front panel and open the [Power calibration] option. For details, refer to “7 Calibration”.

- 1) Source power calibration
  - On the premise of no consideration to the receiver accuracy, set the accurate power corresponding to the excitation frequency.
  - No channel copying function.
- 2) Receiver calibration
  - Set a calibrated source.
  - No channel copying function.
- 3) Mismatch error

If the connector of different impedance is connected between measurement points, mismatch error will occur. The mismatch error can be eliminated by means of full double-port calibration in S-parameter measurement. This problem cannot be solved easily in frequency deviation measurement. The simplest way is to connect a high-quality attenuator between the input end and the mixer output port. The ports can be matched effectively by adding one attenuator between ports, so as to increase the attenuation value to be more than twice. The larger the attenuation value is, the better the improvement effect is good, but the smaller the dynamic range of measurement is.

#### 4) LO accuracy and stability

If the LO signal is not accurate or stable in the frequency deviation measurement mode, the output signal will be

beyond the edge or band-pass of the intermediate frequency filter. At the same time, the LO power also plays an important role in mixer measurement. Therefore, the LO power accuracy and stability must be ensured.

### 3.4 Typical Application of Frequency Deviation Measurement

- Frequency transformation loss (gain) measurement .....399
- Frequency transformation compression measurement .....400
- Isolation measurement .....400
- Harmonic distortion measurement .....402
- Return loss and standing wave ratio measurement .....402

#### 3.4.1 Frequency Transformation Loss (Gain) Measurement

The frequency transformation loss is defined as the power ratio of the output frequency and input frequency at the given LO power. The LO power has the influence on the frequency transformation loss. The frequency transformation loss reflects the energy conversation efficiency of the input signal of the mixer from the current frequency into the output frequency. If the frequency transformation loss is not flat within the measurement frequency range, part of valuable information of the output signal will be lost.

Transmission measurement should be applied to measure the frequency transformation loss. The input signal power will be measured by entering the specific excitation and LO signal power. If the output frequency is different from the input frequency, the frequency deviation measurement must be applied.

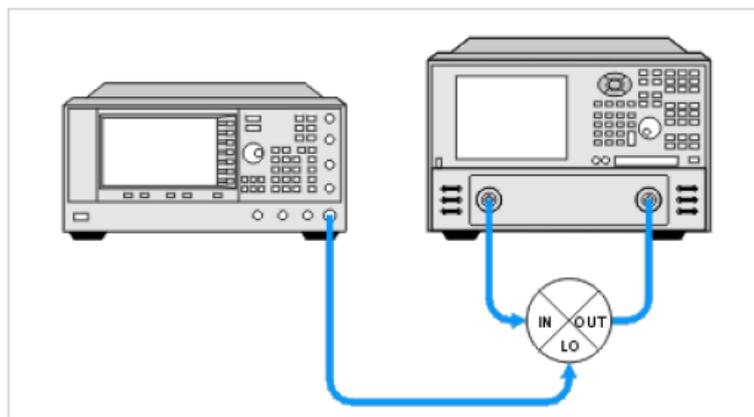


Fig. 3.6 Schematic Diagram of Device Connection in Frequency Transformation Loss Measurement

The following example briefly shows the measurement setting process. Assume that the RF signal frequency range is 1-2GHz, the fixed LO frequency is 500MHz, and the output frequency is 1.5GHz to 2.5GHz. At first, set the scanning frequency range as 1GHz to 2.5GHz and calibrate the source and receiver power. Open the frequency deviation measurement mode. Set the source and receiver scanning frequency range according to the measurement requirements. Open the [Frequency deviation] mode and click OK. Click [Measurement] > [Measurement...] > [Receiver]. Set the numerator of the measurement item as B and denominator as R1 to obtain the measurement curve. This curve represents the frequency transformation loss of the mixer.

#### 3.4.2 Frequency Transformation Compression Measurement

The frequency transformation compression value refers to the maximum input signal power of the linear working zone of the mixer, and is similar to the gain compression value of the amplifier. In order to better understand the frequency transformation compression, first understand the physical meaning of frequency transformation loss, i.e. the ratio of the output signal power and input signal power. This ratio remains constant within a certain input power range. When the input signal power increases to the threshold, the constant will change. The input signal power value with the change ratio less than the constant ratio 1dB is referred to as the 1dB compression power value.

The frequency transformation compression ratio represents the dynamic working range of the device. Therefore, the frequency transformation compression measurement is indispensable for the mixer. The measurement and connection are the same as those in the frequency transformation loss measurement. However, the power scanning mode should be set. The compression point of 1dB or 3dB can be found in the measurement curve through the

cursor.

### 3.4.3 Isolation Measurement

Isolation measurement is used to measure leakage signals between channels. If the degree of isolation of the mixer increases, the number of signals leaking into other parts will decrease. The signal frequency of isolation measurement is the same as the excitation frequency, instead of the frequency after transformation. Therefore, the frequency deviation measurement mode is not necessary in isolation measurement. Main measurement items include: LO/IF isolation, IF/RF isolation and RF/IF isolation.

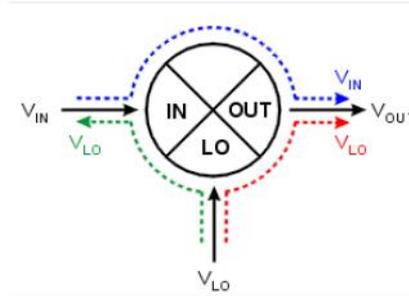


Fig. 3.7 Diagram of Signal Leakage of Mixer

New signals will be generated by the signals leaking into the tested device and the expected signals, which will result in crosstalk. The unexpected signals cannot be easily filtered by the filter. The measurement connection is shown in the following figure. Pay attention to the following two items in measurement.

- 1) The isolation between the input port (IN) and output port (OUT) is closely related to the LO power. Therefore, the normal LO power should be provided in measurement.
- 2) Except two test ports, the other should be connected to a terminal. The terminal may not be the load of specific impedance ( $50/75\Omega$ ). For example, if the output power of the mixer is connected to the filter, the filter can be used as the terminal in isolation measurement.

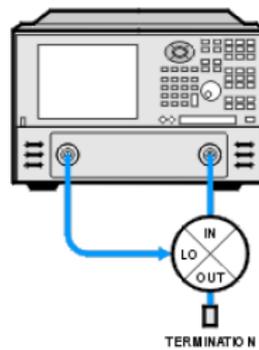


Fig. 3.8 LO/RF Isolation Test

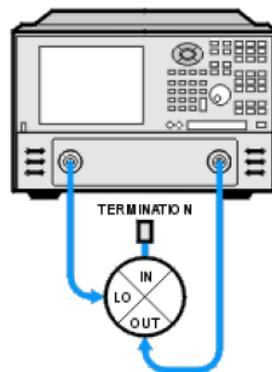


Fig. 3.9 LO/IF Isolation Test

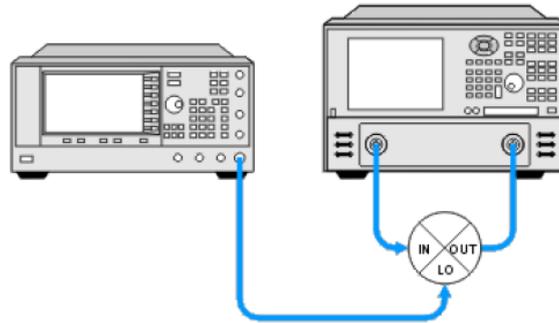


Fig. 3.10 RF/IF Isolation Test

3) The RF/IF leakage of the frequency converter is tested in the same method as that of the mixer test. However, the filter is always set on the output port of the frequency converter. Therefore, the vector network analyzer should have a large dynamic range. Some frequency converters are equipped with the built-in local oscillator. The LO/RF or LO/IN leakage can be measured in various methods.

- Adjust the frequency of the vector network analyzer to be the same as the local oscillator. Connect the RF or IN port of the frequency converter to the receiver end of the vector network analyzer. Do not connect the source to any port.
- The LO leakage can be measured with the frequency meter. The frequency of the spectrometer should be adjusted to the LO frequency.

#### 3.4.4 Harmonic Distortion Measurement

The harmonic signal is a multiple of the mixer RF input signal or LO signal. Harmonic distortion will occur to the mixer output port. It is may caused by nonlinear characteristics of the device. Harmonic distortion is different from intermodulation distortion arising from different signals. The intermodulation distortion is mainly caused by intermodulation signals produced with two or more signals in the mixer.

Harmonics can be measured with the frequency deviation measurement option of the vector network analyzer. Set the LO frequency of the mixer as 0, and then set the multiplier of the RF input to obtain the harmonic output. As the harmonic unit is dBc, the difference between RF signals and harmonics should be calculated. Calibrate the source and receiver within the whole frequency range before measurement. Open the frequency deviation mode, and set the multiplier as 2 for second harmonics and 3 for third harmonics.

#### 3.4.5 Return Loss and Standing Wave Ratio Measurement

The return loss and standing wave ratio are measured in the linear reflection measurement. As the reflection frequency of the frequency converter does not change, the frequency transformation measurement is a kind of reflection measurement. If the return loss is large, the energy of the transmitted signal will be reduced, and the capability to carry information will be weakened. Therefore, the return loss should be strictly measured in actual operation.

Set the measurement mode in the return loss or standing wave ratio mode. The connection is shown in the following figures.

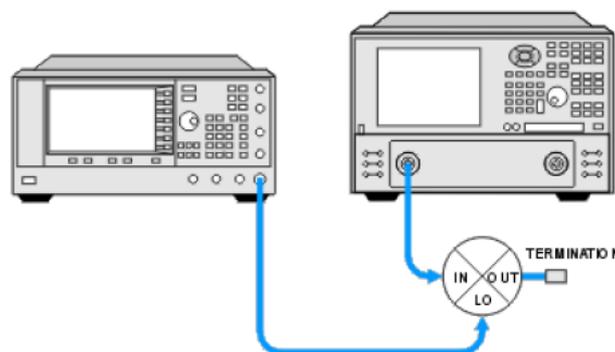


Fig. 3.11 Test of Return Loss of Mixer Input Port

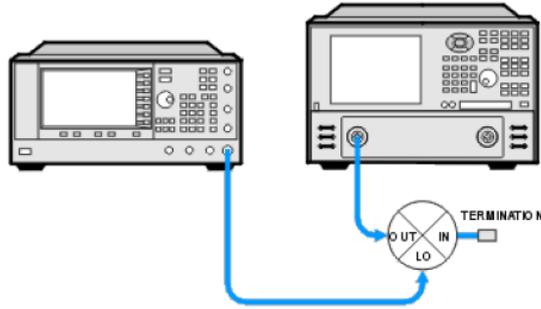


Fig. 3.12 Test of Return Loss of Mixer Output Port

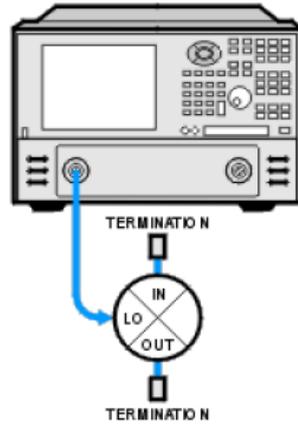


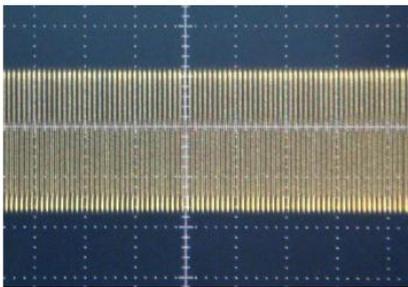
Fig. 3.13 Test of Return Loss of Mixer LO Port

## Appendix 4 Pulse Measurement

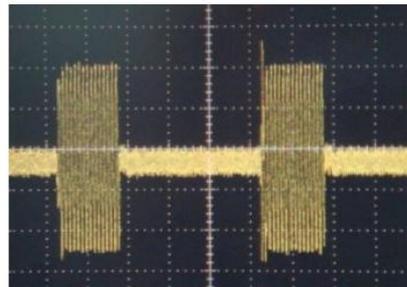
- Time domain waveform .....405
- [Pulse Measurement] dialog box .....405
- Pulse envelope .....407
- Broadband pulse measurement .....408
- Pulse generator/modulation configuration .....409

### 4.1 Time Domain Waveform

If required, the AV3672 series vector network analyzer can be set into the pulse mode. In the pulse mode, the continuous wave is output after pulse modulation. The time domain waveform is shown in Fig. 4.1.



a. Time Domain Waveform of Continuous Wave



b. Time Domain Waveform of Pulse

Fig. 4.1 Time Domain Waveform

### 4.2 [Pulse measurement] Dialog Box

Menu path: [System] > [Macro] > [Pulse].

The [Pulse measurement] dialog box is shown in Fig. 4.2.



Fig. 4.2 [Pulse measurement] Dialog Box

- 1) **PRF/IFBW configuration:** if one parameter is changed, the associated parameters will change accordingly.
  - a) **Pulse repetition frequency (PRF):** set the frequency of the pulse generated by the pulse generator.
  - b) **Pulse repetition interval (PRI):** set the pulse generation interval of the pulse generator.
  - c) **Intermediate frequency bandwidth of receiver:** set the intermediate frequency bandwidth of the analyzer, 1Hz to 10Hz.
  - d) **Fixed PRF:** if this item is selected, PRF will not change with the receiver bandwidth.
- 2) **Modulation/gate**
  - a) **Width:** pulse width.
  - b) **Delay:** delay before pulse generation.
- 3) **Duty ratio:** if [Calculate] is pressed, the duty ratio of the source and each reception channel will be automatically calculated and displayed.
  - a) **Pulse mode ON/OFF:** if this option is selected, the pulse function will be enabled.
  - b) **Apply:** if this button is pressed, all the configurations will take effect.

## Attention

### Setting of pulse duty ratio:

The prerequisite of narrow-band pulse calculation is to set the pulse duty ratio no more than 90%. But the calculated pulse duty ratio may exceed 90%. In this case, the calculation result will prevail.

### 4.3 Pulse Envelope

Click the **[Pulse envelope]** button in the [Pulse measurement] dialog box or click **[View] > [Pulse envelope]** in the menu to call the [Pulse envelope] dialog box. If this dialog box is gray and unavailable, select **[Pulse Mode ON/OFF]** and click **[Calculate]** and **[Apply]**. The [Pulse envelope] dialog box is shown in Fig. 4.3.

#### 1) Time parameter

a) **Starting and ending time:** determine the size of the pulse envelope display window. In order to display the complete pulse, the width between the starting value and ending value must be no less than the sum of the source modulation width plus delay.

b) **Step:** determine the interval of two adjacent track points of the pulse envelope curve, i.e. track point number = (ending value-starting value)/step. If the track point number increases, the calculation time will increase accordingly.

#### 2) Measurement parameters

a) **CW frequency:** set the CW frequency.

b) **Source port:** select the output source. For the double-port analyzer, Port 1 is used to output the pulse modulation signal. For the four-port analyzer, Port 1 and 3 are used to output the pulse modulation signal.

c) **Parameters:** select S-parameters to be measured in the drop-down list, including A, B, C, D, R, S<sub>11</sub>, S<sub>21</sub>, S<sub>31</sub> and S<sub>41</sub>.

d) **Data format:** logarithmic amplitude, linear amplitude and phase.

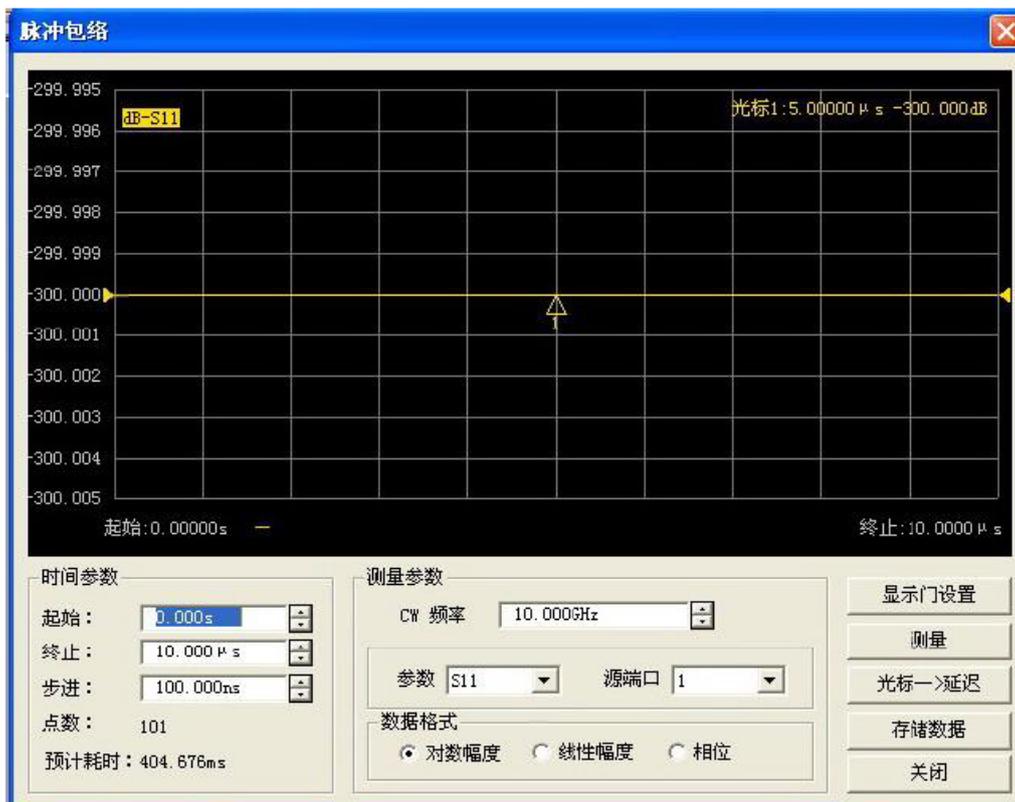


Fig. 4.3 [Pulse envelope] Dialog Box

e) **Display gate setting:** if this button is clicked, the dialog box shown in Fig. 5.4 will appear. You can set the source modulation and gate. After setting, click **[Apply gate]** and **[Hide gate]**. Then the dialog box shown in Fig. 4.4 will appear again.



Fig. 4.4 Display Gate Setting

f) **Measurement**: click this button to start calculation according to the parameter settings and display the pulse envelope waveform. **[Pulse envelope measurement]** will appear in the calculation process.

#### 4.4 Broadband Pulse Measurement

Click the [Broadband pulse] option. The [Broadband pulse measurement] dialog box shown in Fig. 4.5 will appear.



Fig. 4.5 [Broadband pulse measurement] Dialog Box

### 1) Type

a) **Scanning frequency (frequency domain)**: set the [Scanning frequency measurement] as the broadband pulse measurement mode. In this case, the amplitude frequency response of each frequency point under pulse excitation will be measured. Set the scanning frequency range with the **starting** value and **ending** value.

b) **Envelope (time domain)**: set [Envelope measurement] as the broadband pulse measurement mode. In this case, the pulse envelope characteristics under the specified CW frequency excitation will be measured.

c) **Pulse point (time domain)**: set [Pulse point measurement] as the current pulse measurement mode. In this case, the frequency response characteristics of the specified pulse delay point at the specified CW frequency will be measured.

2) **Starting, ending and CW value**: set the frequency according to the current measurement type, the same as system settings.

3) **Point number and time**: set the scanning point number and scanning time of the current measurement, the same as system settings.

4) **Intermediate frequency bandwidth-automatic**: set the intermediate frequency bandwidth of current digital processing. If "Automatic" is selected, the system will automatically select the maximum intermediate frequency bandwidth of broadband pulse measurement.

5) **Modulation source**: select the modulation signal source. If "External" is selected, the source modulation signal is sent by Pin 8 of the pulse input port of the rear panel. If "Pulse 1", "Pulse 2", "Pulse 3" and "Pulse 4" are selected, the source modulation signal is sent by the internal 4-way pulse generator of the system. If "OFF" is selected, the source modulation signal is OFF, and no signal is output by the source. If "CW" is selected, the signal modulation is normally OFF, and the source outputs continuous waves.

6) **Pulse repetition interval, width and delay**: set the width, delay and interval of the pulse generator. The sum of the delay and width of the pulse signal must be less than the pulse interval; otherwise, the system will be in a state of uncertainty.

7) **Enable 0-4**: enable or disable the output of the internal 5-way pulse generator of the analyzer. Pulse 1-4 are used

as the modulation source, and Pulse 0 is used to produce the pulse synchronization signal, the same as the synchronization function of the **receiver and pulse generator** in the **[Pulse trigger]** dialog box, to synchronize the data processing of the analyzer and the signal generation of the pulse generator. The default mode of broadband pulse measurement is to enable the pulse generator 0. Disabling of the pulse generator 0 will result in distortion of processing data of the analyzer.

8) **Apply**: apply the current setting to the current active channel.

9) **Minimize**: minimize the [Pulse measurement] dialog box window.

10) **Close**: close the [Pulse measurement] dialog box and exit the pulse measurement mode. To keep the current channel in the pulse measurement mode, you must not exit the [Pulse measurement] dialog box and select **[Minimize]** to hide the [Pulse measurement] dialog box.

#### 4.5 Pulse Generator/Modulator Configuration

Click **[Configuration]** > **[Pulse generator/modulator configuration]** in the menu (Fig. 4.6). The dialog box shown in Fig. 4.7 will appear.

1) **Source modulation**: select the internal pulse generator or the external pulse input of the rear panel as the modulation source.

2) **External pulse setting**: this option is available if the [Internal pulse generator] option is not selected.

a) **GPIB address**: set the GPIB address of the external pulse generator.

b) **Output**: select the pulse output module.

c) **Common time base**: the frequency (10MHz) of the network analyzer is used as the reference frequency of the external pulse generator.

d) **Pulse output**: enable the [Pulse output] function.

#### 3) External gate/modulator setting

a) **High**: set the high-level voltage of TTL.

b) **Low**: set the low-level voltage of TTL.

c) **External impedance**: set the impedance of the tested device (DUT).

d) **Effective low level**: select it to make the low level of TTL effective; otherwise, the high level of TTL will be effective.

4) **Use of internal modulator**: select it to set the instrument in the internal modulator protection state.

5) **Use of internal pulse generator**: properly set the available items in this dialog box.

6) **Use of internal gate**: select it to set the instrument in the internal gate protection state.



Fig. 4.6 Configuration Menu



Fig. 4.7 Pulse Generator/Modulator Configuration

7) **Receiver gain control:** click [Configuration] > [Receiver gain control] (Fig. 4.8). The dialog box shown in Fig. 4.9 will appear.



Fig. 4.8 Receiver Gain Control Menu

- a) **Automatic:** the analyzer will automatically select the appropriate receiver gain.
- b) **Low:** about 30dB attenuation.
- c) **Medium:** about 15dB attenuation.
- d) **High:** about 0dB attenuation.



Fig. 4.9 [Receiver gain configuration] Dialog Box

## Appendix 5 Amplifier Gain Compression Measurement

This chapter introduces the basic principle and measurement method of the two-dimensional scanning option of amplifier gain compression measurement.

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- [Overview of gain compression measurement](#) .....412
- [Steps of gain compression measurement](#) .....418

### 5.1 Principle of Amplifier Gain Compression

The amplifier has a linear gain zone, in which the input power level of the amplifier is linear to the output power level. The gain of this zone is referred to as the small signal gain (also known as the linear gain). While the input power increases to a certain level, the gain will decrease, making the amplifier in the approximately saturated state. The input power level at which the amplifier gain is 1dB less than the linear gain is defined as the input power of 1dB gain compression.

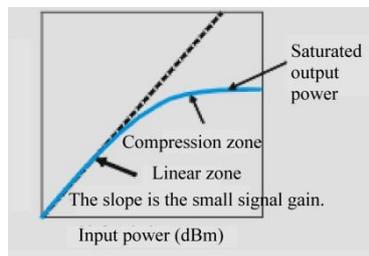


Fig. 5.1 Input and Output Characteristics of Amplifier

- 1) The amplifier gain at any power level is the slope of the corresponding curve.
- 2) When the amplifier works in the linear zone, the gain is constant and not related to the input power level. The gain in this zone is often referred to as the small signal gain.
- 3) If the input power increases, the amplifier gain will decrease and the amplifier will work in the compression zone.
- 4) The 1dB compression point is commonly used in the amplifier compression measurement. It is defined as the input power (sometimes output power) corresponding to the 1dB decrease of the amplifier gain (equivalent to the small signal gain of the amplifier).

If the amplifier is driven by the sine signal, the amplifier output will not be the sine signal in compression. The output contains the harmonic component, in addition to the fundamental component of the input signal. If the input power increases, the amplifier will be saturated, but the output power remains unchanged. In this case, the output power does not change if the input power of the amplifier further increases. In some cases, such as the traveling wave tube (TWT) amplifier, the actual output power will decrease if the input power continues to increase in the saturated state. This means that the amplifier has negative gain. As the amplifier is expected to work in the linear zone, it is important to know the input signal of gain compression.

### 5.2 Overview of Gain Compression Measurement

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#### 5.2.1 Terms of Amplifier Gain Compression

➤ **Linear power level**

Refer to the input power of the amplifier in the linear gain (also known as the small signal gain) zone.

➤ **Reference gain**

Refer to the gain for reference in calculation of the compression level. The specific meaning varies from the selected compression method.

➤ **Compression level**

Refer to the specific compression amount reduced relative to the reference gain. The value is generally 1dB.

➤ **Target gain**

Refer to the gain at the specific compression level (such as the 1dB compression). This item is not included in the parameters of amplifier gain compression measurement, however, it is important to understand various compression factors.

For example, perform the following settings of linear gain compression:

Linear gain (amplifier gain in the linear zone) = 10.2dB

Compression level (fixed value) = 1dB

Target gain=9.2dB

The target gain refers to the gain close to 9.2dB, which is searched in amplifier gain compression. The value may not be exactly 9.2dB.

➤ **Compression point**

The gain measured at this point is the closest to the target gain. All compression parameter data are measured at this point, including the input power, output power and gain of the compression point.

### 5.2.2 Parameter Curve of Gain Compression

In the amplifier gain compression curve:

- 1) The frequency value is displayed on the horizontal axis. The specified compression point is found by measurement and calculation of the power scanning curve at each frequency point.
- 2) The specific parameters of the compression point are shown in the vertical axis. The linear S-parameters displayed by the amplifier gain compression channel are used for measure the transmission and reflection parameters of the amplifier in the linear zone.

### 5.2.3 Gain Compression Parameters

The parameters are determined based on the assumption that Port 1 is used for DUT input and Port 2 for DUT output.

Schedule 5.1 Compression Parameters

	Parameter	Description
Linear S-parameter	S11	Matching input
	S21	Gain
	S12	Reverse isolation
	S22	Matching output
Compression parameter	CompIn21	Input power of compression point
	CompOut21	Output power of compression point
	CompGain21	Gain of compression point
	CompS11	Matching input of compression point
	RefS21	Linear gain used to calculate the level. The specific meaning is associated with the selected compression method.
	DeltaGain21	Compression point gain--linear gain (logarithmic format)

### 5.2.4 Compression Method

#### ➤ Compression from linear gain

The reference gain is the gain of the linear zone. The target gain is calculated by subtracting the specific compression level (1dB) from the linear gain. Example:  $8.3\text{dB} - 1\text{dB} = 7.3\text{dB}$ .

#### ➤ Compression from maximum gain

The linear zone of amplifier gain may not be fully linear. The maximum gain measured at various frequency points is used as the reference gain (S21). The target gain is calculated by subtracting the specific compression level (1dB) from the maximum gain.

#### ➤ Compression in the saturated state

If the amplifier is measured in the nonlinear zone, this method can be used to better display the compression point, as shown in the following figure.

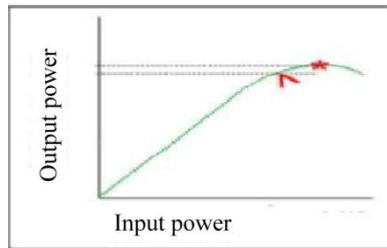


Fig. 5.2 Schematic Diagram of Calculation of Compression in Saturated State

The maximum output power can be found at each frequency\*. Then the input power is decreased until the output power decreases by the specific value (1dB). This point is called compression point^.

#### ➤ Compression from return point and X/Y compression

The two compression methods are similar to each other.

The difference of the linear zone and compression point of the input power (X-axis) are utilized in the two methods.

For the Y axis:

The gain is displayed on the Y axis in the compression from the return point.

The output power is displayed on the Y axis in the X/Y compression.

The methods to search the compression point are different in two-dimensional scanning and intelligent scanning.

The following figure shows the calculation at the same frequency in the method of compression from the return point and X/Y compression.

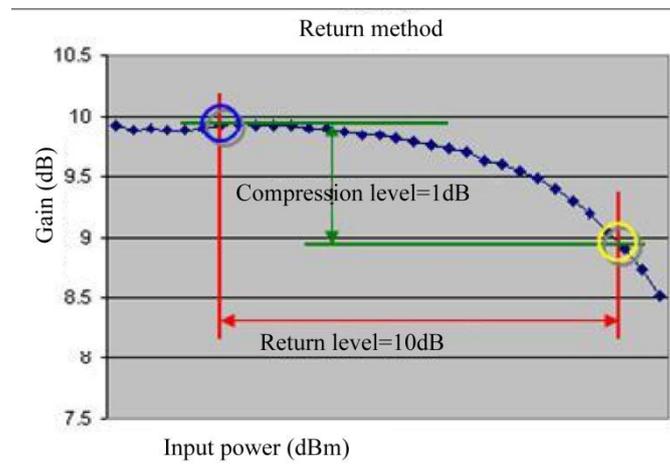


Fig. 5.3 Schematic Diagram of Calculation of Compression from Return Point

Note: The compression point (in the yellow circle) is the point at which the input power is 10dB higher than that of

the reference point (in the blue circle) and the gain is 1dB lower than that of the reference point.

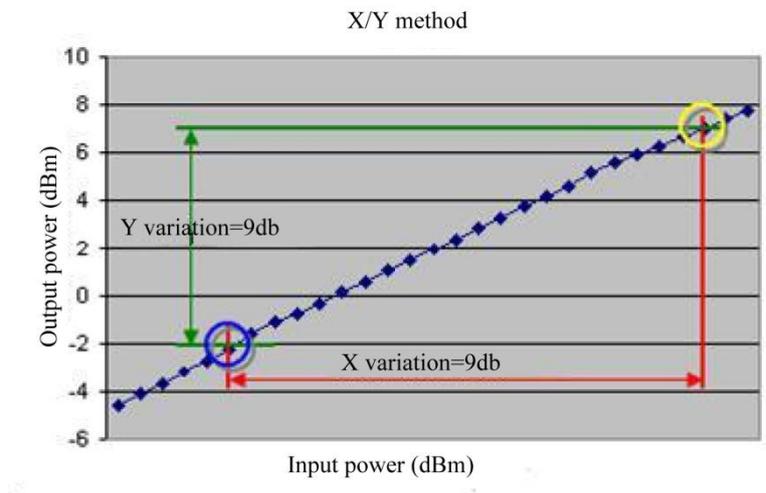


Fig. 5.4 Schematic Diagram of Calculation of X/Y Compression

Note: The compression point (in the yellow circle) is the point at which the input power is 10dB higher than that of the reference point (in the blue circle) and the output power is 9dB higher than that of the reference point.

### 5.2.5 Data Acquisition Mode

Three data acquisition modes are provided for amplifier gain compression: two two-dimensional scanning modes and one intelligent scanning mode.

In order to observe the general power scanning at the signal frequency, compression analysis characteristics should be applied.

In the two kinds of scanning modes:

- 1) The S-parameter at the linear power level should be measured first in all amplifier gain compression measurements. Reflection parameters are measured after the full port calibration.
- 2) The gain is calculated according to the measured frequency and power.
- 3) The compression is found by searching after data measurement. Generally, the compression point is a point between two measurement points which are the closest to the target gain.
- 4) The point will be marked in the corner at the left bottom of the current scanning program display and beside the channel indicator after each scanning process.

## Prompt

### Compression point of return compression and X/Y compression

In the return compression and X/Y compression, the specified starting-ending power range of amplifier gain compression is not regarded as the minimum return or X-axis value. The closest compression point will always be displayed.

#### ➤ Two-dimensional scanning mode

- 1) The power is scanned at each frequency point, that is, each frequency point is scanned from the starting power to ending power. It can be seen in the following example that the device reaches the highest power level ( $p_3 = \text{power}_3$ ) at the first frequency ( $f_1 = \text{frequency}_1$ ). In this case, the device will be heated early in measurement, which will affect compression results.

The following example shows the values of three frequency points and three power points, and nine results are obtained.

Schedule 5.2 Power Scanning Data of Various Frequency Points

1	2	3	4	5	6	7	8	9
f1,p1	f1,p2	f1, p3	f2,p1	f2,p2	f2,p3	f3,p1	f3,p2	f3,p3

2) The frequency is scanned at each frequency point, that is, the frequency is scanned from the starting frequency to ending frequency at each power level.

Schedule 5.3 Frequency Scanning Data of Various Power Points

1	2	3	4	5	6	7	8	9
f1,p1	f2,p1	f3, p1	f1,p2	f2,p2	f3,p2	f1,p3	f2,p3	f3,p3

Observe and save the two-dimensional data.

It is impossible to display all two-dimensional measurement data on the vector network analyzer. However, data can be saved in the “.csv” and read through the Excel.

In addition, the compression analysis function can be used for observe all power scanning information at the selected frequency.

➤ **Intelligent scanning mode**

Intelligent scanning is generally the fastest and most accurate method of gain compression measurement. Different from the two-dimensional scanning mode, the specific frequency/power points are not measured in intelligent scanning. Instead, a series of fixed power values are searched. The “intelligent assumption” of the input power of each frequency is made to find the compression level within the upper limit range. This assumption is more accurate than continuous power scanning.

Intelligent scanning is repeated until one of the following cases occur:

- 1) All the data points are within the limit range. When the compression level of the data point reaches the specific limit, measurement is continued and the input power changes to improve the measured value within the limit range.
- 2) The specific compression level of the residual frequency beyond the limit range cannot be obtained. This is because the starting power is too high or the ending power is too low.

The repeated maximum value can be obtained. If the measured gain is beyond the limit range before reaching the specified maximum limit, the final power scanning point will be used as the compression point.

**5.2.6 Compression Method of Intelligent Scanning**

The working mode varies according to the compression method in the intelligent assumption program. In the return and X/Y compression, the input power of DUT changes greatly in the repeated scanning. This will affect the DUT and measurement results.

All the amplifier gain compression measurements are started from the S-parameter of the linear power level. The reflection coefficient cannot be measured until the double-port calibration function is available or the reflection parameter is displayed.

**1) Return and X/Y compression**

The linear zone and compression zone are separated in the two scanning methods. The signals within the same frequency range should be scanned at different power levels in the repeated scanning. The first half of scanning aims to measure the DUT return of X-axis power level. The second half of scanning aims to measure the corresponding starting-ending power range of the DUT at the compression power level. At the beginning of the second half, the power level will increase if the return or X-axis value increases. The specific time is set as the DUT response to power level changes. The input power must not be reduced to the minimum value in safety scanning. Instead, safety scanning aims to prevent DUT from being greatly influenced by power changes.

## 2) Linear gain compression

After the reference gain is measured in the linear input power zone, DUT can be pushed to the high-power compression level for repeated measurement. The power is increased or decreased according to the DUT power level in subsequent measurements to reach the expected compression level. Generally, the appropriate algorithm can be obtained after the third repeated scanning, so as to draw the curve and accurately find the compression point.

### Attention

#### **Influence of power scanning on measurement results**

DUI may change greatly in different scanning processes. The influence can be reduced by enabling safety scanning or carefully selecting the appropriate settings.

#### **1) Maximum gain compression**

The maximum gain of each frequency point will be saved to calculate the compression point. In the intelligent scanning mode, additional repeated scanning of each frequency point will not be done to search the possible maximum gain of the amplifier.

#### **2) Compression in saturated state**

The external maximum gain of each frequency point will be saved to calculate the compression point. In the intelligent scanning mode, additional repeated scanning of each frequency point will not be done to search the possible maximum gain of the amplifier.

#### **5.2.7 Factors Related to Measurement Accuracy**

The analyzer must have high power to drive the amplifier into the saturated zone. If the power level of the signal source of the analyzer does not conform to the requirements, a preamplifier should be set in front of the tested amplifier to improve the power level. The applied preamplifier must be included in calibration. If necessary, the output of the amplifier should be fully attenuated. Too high output power may cause the following results.

- a) The output power is higher than the input compression level of the receiver of the analyzer, which may lead to inaccurate measurement results.
- b) The analyzer receiver may be damaged.

The output power of the amplifier can be attenuated by the attenuator or coupler. As part of the test, the influence of the attenuator or coupler must be taken into consideration. Proper error correction can help to reduce the influence of such accessories.

- a) The frequency response is a main error source of gain compression measurement. The error can be reduced significantly by means of through type response calibration.
- b) The amplifier has different response values corresponding to temperature differences. The test must be done at the working temperature of the amplifier.
- c) The dynamic range and accuracy can be improved by reducing the intermediate frequency bandwidth or using the measurement averaging function, but at the sacrifice of measurement speed.

### **5.3 Steps of Gain Compression Measurement**

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#### **5.3.1 Analyzer Resetting**

### 5.3.2 Enabling of Gain Compression Measurement

Menu path: **[Response]** > **[Measurement]** > **[Measurement type]**. Select **[Gain compression]** and click **[OK]**. The default setting is Channel 1. To enable the gain compression measurement in a new channel, click **[New channel]**.



Fig. 5.5 Opening of Measurement Dialog Box

### 5.3.3 Gain Compression Setting

#### 5.3.3.1 Frequency Setting

Menu path: **[Response]** > **[Measurement]** > **[Gain compression setting]**. Click **[Frequency]** to set the frequency. After setting, click **[OK]** to close the dialog box.



Fig. 5.6 [Frequency setting] Dialog Box

Notes of scanning setting:

- **Point number:** the number of measured frequency points. The number of frequency point may be restricted by the number of power points.
- **Intermediate frequency bandwidth:** set the intermediate frequency bandwidth to obtain the acceptable track noise in measurement at the linear power level. The track noise is directly related to the measurement accuracy of the compression point. The small value (narrow intermediate frequency bandwidth) can help to improve the accuracy, but the measurement speed will be reduced.
- **Starting/ending, center and span:** set the frequency range to measure the gain compression.

The data point number is limited. The maximum number of data points depends on the data acquisition method and compression method, shown as follows.

Schedule 5.3 Limitations of Data Point Number of Two Scanning Modes

<b>Compression Method</b>	<b>Intelligent scanning</b> (reduce the number of frequency points to ensure that the total number of data points is within the limited range)	<b>Two-dimensional scanning</b> (reduce the number of power points to ensure that the total number of data points is within the limited range)
Linear gain compression	Data point number=frequency point number Maximum=20,001	Data point number=frequency point number*power point number Maximum power=2,001 Maximum data point number=20,000
Maximum gain compression	Data point number=frequency point number Maximum=20,001	
X/Y or return compression	Data point number=2*frequency point number Maximum 20,001	

## Attention

### Setting of frequency and power point number:

Although you are allowed to enter any number in the dialog box, the entered value will be checked after the ENTER or OK key is pressed. The entered value beyond the limits will be reduced to the maximum allowable range to prevent error prompts.

### 5.3.3.2 Power Setting

Menu path: **[Response]** > **[Measurement]** > **[Gain compression setting]**. Click **[Power]** to set the power. After setting, click **[OK]** to close the dialog box.

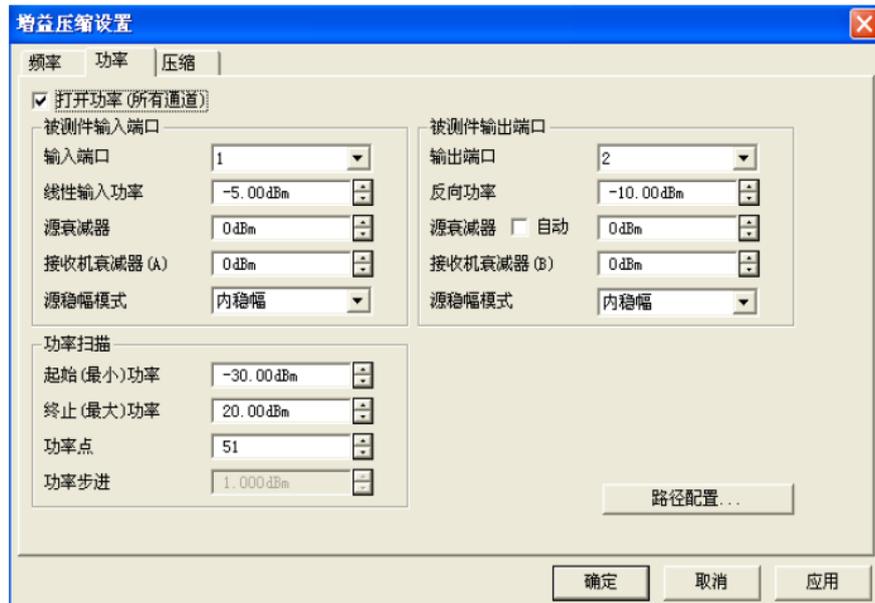


Fig. 5.7 [Power Setting] Dialog Box

**Input port of the tested device:**

Refer to the analyzer port connected to the DUT input end.

- **Linear power level:** refer to the input power to keep DUT in the linear zone. The linear gain is the reference value to calculate the linear compression gain. The matching input is also calculated at the power level.
- **Source attenuator:** refer to the attenuator which is closely related to the connected DUT input port. It is used to adjust the input power range of DUT. The attenuation values of continuous scanning of all vector network analyzer channels are the same.
- **Receiver attenuator:** refer to the attenuator which is closely related to the connected DUT output port. If the power of about +10dBm is input into the receiver test port, compression may be done by the receiver of the vector network analyzer. However, with the receiver attenuation, low input power may affect the accuracy of power measurement and result in high noise. Therefore, the intermediate frequency bandwidth should be decreased to reduce noise.
- **Source amplitude stabilization mode:** refer to the specific amplitude stabilization mode. The internal stabilized amplitude or open loop can be selected. The open loop must be used in broadband pulse measurement.

**Output port of the tested device:**

Refer to the analyzer port connected to the DUT output end.

- **Reverse power:** refer to the power level of reverse scanning of the analyzer port connected to the DUT output end. The port power will not be coupled automatically. This power value is valid only in the following cases. Otherwise, the setting is invalid. The output matching and reverse isolation are measured.

The full double-port correction is done. The application of reverse power to DUT can be prevented by full double-port calibration or enhanced response calibration.

- **Source attenuator:** refer to the attenuator specified as the port to be connected to the DUT output end. This device affects the power output range of DUT.
- **Receiver attenuator:** refer to the attenuator specified as the receiver to be connected to the DUT output port.
- **Source amplitude stabilization mode:** select the specified internal amplitude stabilization mode.

**Power scanning:**

- **Power point number:** refer to the number of power points required for two-dimensional scanning measurement. The power point number may be limited by the frequency point number. This item is not included in intelligent scanning, as the compression level is found based on sufficient power points in the intelligent scanning mode.
- **Starting and ending power**

**Two-dimensional scanning:** for the return, X/Y and maximum gain compression, the reference gain and compression point are measured within the power range. Therefore, the range should be wide enough to include the reference gain and compression point. For example, if the return level is 10dB, the power range must be more than 10dB. Otherwise, the closest reference gain and compression point will be used to determine the compression value in amplifier gain compression, which will lead to inaccurate results. In the linear gain compression, the reference gain is measured at the linear power level, and the starting and ending power levels are used to find the compression point.

**Intelligent scanning:** the power range is set to be larger than the compression point searched in amplifier gain compression. The reference gain found in compression is applied to the linear power level. The return and X-axis value are determined according to the compression method. The repeated scanning to find the compression point should be reduced.

## Prompt

### Low-band high-power mode

If DUT needs higher input power to realize compression below 3.2GHz, the high power mode should be used. Click [Path configuration] > [Low-band high-power mode].

- **Power step:** calculated according to the current starting, ending and point number settings. It cannot be changed directly.

### Path configuration:

Open the [Path configuration] dialog box.

#### 5.3.3.3 Compression Setting

Menu path: [Response] > [Measurement] > [Gain compression setting]. Click [Compression] to set compression. After setting, click [OK] to close the dialog box.



Fig. 5.8 [Compression setting] Dialog Box

### Compression Method

- **Linear gain compression:** the compression level is measured according to the linear compression level. The linear power level is used in linear compression measurement.
- **Maximum gain compression:** the compression level is measured according to the maximum compression level. In intelligent compression, the maximum compression value is updated after each repetition.
- **Return point compression:** this method is used to find the compression point according to the compression level and return point.
- **X/Y compression:** this method is used to find the compression point with specific parameters (X and Y) as standards.
- **Saturated compression:** similar to maximum gain compression. The specific compression level is measured according to the maximum power beyond the level. This method can be used to better find the compression point in measurement of the nonlinear gain amplifier. In intelligent scanning, the maximum power is updated in each repetition. In order to increase the possibility to measure the actual maximum value of the amplifier, low increments of accurate roughness should be applied in safety scanning.

### 5.3.4 Calibration

After setting, perform amplifier gain compression calibration. Click [**Calibration**] > [**Calibration...**]. Complete all calibrations according to the guide.

1) Select the connection type and calibration kit of the tested device. The selection must be based on the actual connector type of the tested device; otherwise, subsequent calibration will be affected.

#### Description of setting:

**Port 1:** refer to the type of the port of the tested device connected to Port 1.

**Port 2:** refer to the type of the port of the tested device connected to Port 2.

**Power meter:** the same type as that of connection to Port 1.

**Calibration kit:** model of the selected calibration kit. The inserted electronic calibration kit will be automatically detected by the analyzer and displayed.

**Power calibration port:** set the amplifier input port as the power calibration port.

**Frequency deviation:** refer to the difference between the amplifier input power and calibrated power. It is generally caused by the adapter or attenuator between the calibration plane and power meter. In case of no frequency deviation, ignore this option.

**Tolerance:** refer to the error tolerance of power calibration.

**Maximum reading times:** scanning will be repeated automatically if the power calibration fails. The maximum reading times are the times of repeated scanning. If power calibration still fails after exceeding maximum reading times, scanning will not be repeated and next step will be started directly.

**Power meter configuration:** select the power meter model/ if the USB power probe developed by the 41st Institute is inserted, the probe will be detected automatically and the options will be provided.

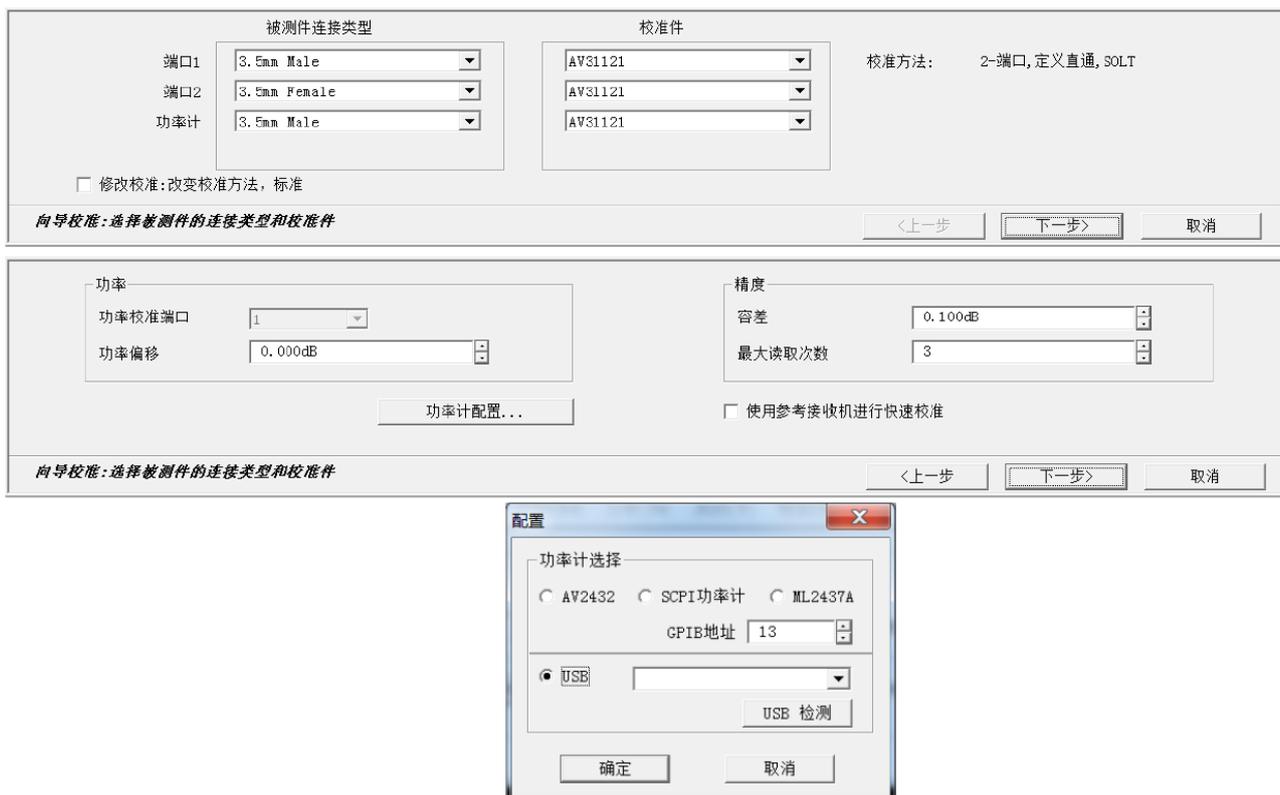


Fig. 5.9 Selection of Connection Type of Tested Device and Calibration Kit

2) Perform connection as shown in the figure. After connection, click [Measurement]. The analyzer will automatically skip to next step after measurement. After all measurements, click [Finish]. Thus all the calibrations are completed.



Fig. 5.10 Illustration of Calibration Steps

### 5.3.5 Connection of Tested Device and Provision of Deviation

As shown in Fig. 5.11, connect the amplifier and provide the DC deviation.

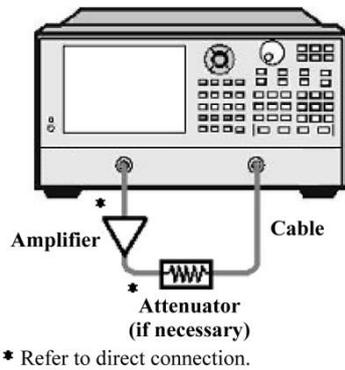


Fig. 5.11 Connection of Gain Compression Measurement

### 5.3.6 Adding of Track

To obtain more measurement parameters, new tracks should be added. Click [**T**rack] > [**N**ew track]. Tick the track to be created, and click [**O**K] to close the dialog box.



Fig. 5.12 [New track] Dialog Box

### 5.3.7 Printing or Saving of Data

Click [**F**ile] > [**S**ave as]/[**S**ave data as]. Select the saving format and path.

## Appendix 6 Mixer Measurement

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### 6.1 Overview of Mixer Measurement

Mixer measurement mainly includes scalar and vector measurement.

#### 6.1.1 Comparison of Scalar/Vector Mixer Measurement

Schedule 6.1 Comparison of Scalar/Vector Mixer Measurement

	Scalar Measurement	Vector Measurement
<b>Overall comparison</b>	<ul style="list-style-type: none"> <li>➤ High accuracy of frequency transformation gain and loss measurement</li> <li>➤ Optional for phase measurement.</li> <li>➤ SOLT and power calibration</li> <li>➤ Simpler than vector measurement</li> </ul>	<ul style="list-style-type: none"> <li>➤ High accuracy of phase and group delay measurement</li> <li>➤ Require the combination of SOLT calibration and interchangeable mixer/filter in calibration</li> <li>➤ Complete setting and calibration procedures</li> <li>➤ Easy converter measurement after calibration</li> </ul>
<b>Measurement</b>	<ul style="list-style-type: none"> <li>➤ Support forward and backward measurement.</li> <li>➤ The tested device can be connected to any port of the vector network analyzer.</li> </ul>	<ul style="list-style-type: none"> <li>➤ Amplitude response VC21</li> <li>➤ Phase response</li> <li>➤ Group delay</li> <li>➤ The input end of the tested device must be connected to Port 1 of the analyzer.</li> <li>➤ The output end of the tested device can be connected to any port of the analyzer.</li> </ul>
<b>Equipment requirements</b>	<ul style="list-style-type: none"> <li>➤ Power meter and probe</li> </ul>	<ul style="list-style-type: none"> <li>➤ Reference mixer</li> <li>➤ Calibration mixer/filter pair (S21=S12)</li> </ul>
	Mechanical or electronic calibration kit	

#### 6.1.2 Measurement Limitations

### Prompt

Mixer measurement is not applicable in the following cases.

- Analog frequency canning
- Logarithmic frequency scanning
- Non-ratio reception measurement
- Electronic calibration described by the user.
- Time domain
- Balance measurement
- Port extension
- Some fixture features
- External test setting

### 6.2 Scalar Mixer Measurement

#### 6.2.1 Hardware Configuration

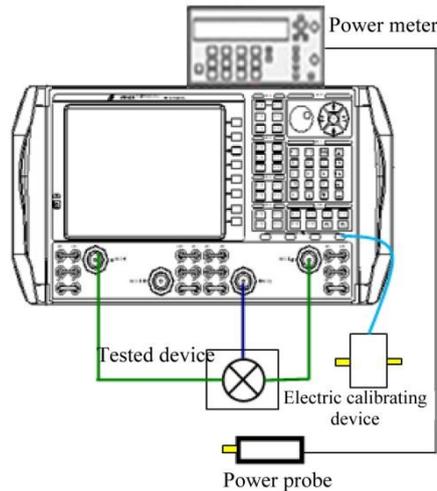


Fig. 6.1 Hardware Setting

One power meter, two signal sources and one calibration kit are required in the scalar mixer measurement calibration. The calibration kit is divided into the mechanical calibration kit and electronic calibration kit. The electronic calibration kit inserted into the USB interface (as shown in the above figure) can be automatically identified by the analyzer. The tested device can be connected to any port of the instrument. For the four-port vector network analyzer, the internal source 2 can be used as the LO input end, so no external source is required.

### 6.2.2 Setting of Measurement Type

Menu path: **[Response]** > **[Measurement]** > **[Measurement type]**. Select **[Scalar mixer measurement + phase]** and click **[OK]**. The default setting is Channel 1. For mixer measurement in a new channel, click the **[New channel]** button.

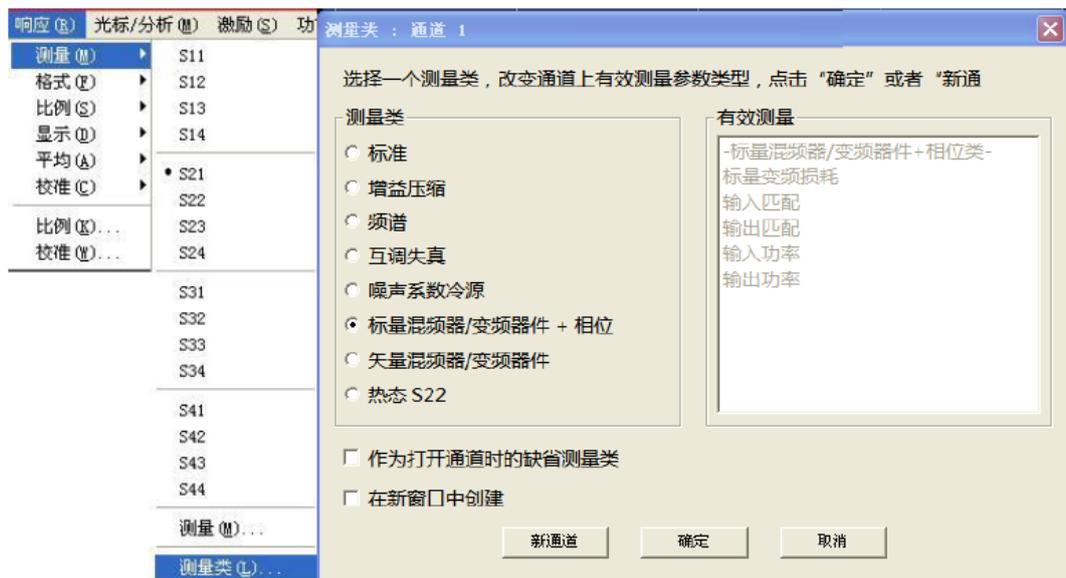


Fig. 6.2 Setting of Mixer Measurement

### 6.2.3 Setting of Mixer Measurement

Menu path: **[Response]** > **[Measurement]** > **[Mixer setting]**. Set the **[Scanning setting]**, **[Power setting]**, **[Mixer frequency setting]**, **[Mixer power setting]** and **[Mixer setting]** in the pop-up dialog box.

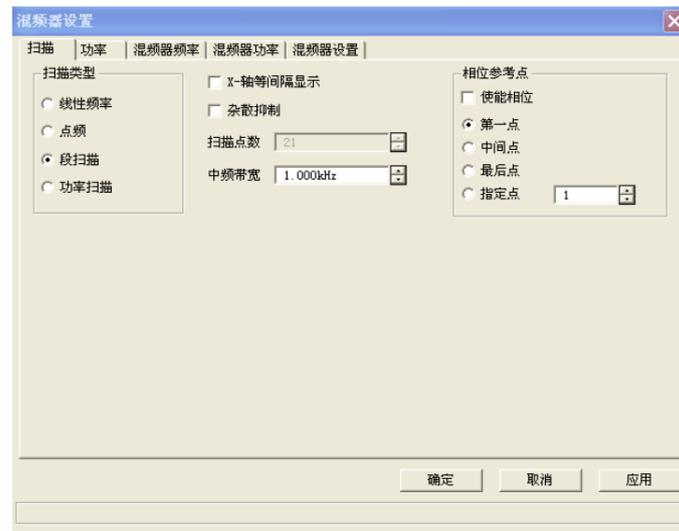


Fig. 6.3 [Mixer setting] Dialog Box

### 1) [Scanning setting] dialog box

a) **Scanning type**: see the detail in “4.5.1 Scanning Type” in the manual. The default setting is **[Linear frequency]**. Select **[CW]**, **[Segment scanning]** and **[Power scanning]** in the dialog box.

b) **[X-axis uniform interval display]** check box: the default setting is gray and unavailable. This option cannot be ticked until segment scanning is selected.

c) **[Stray suppression]**: tick it to enable the stray signal suppression function of the host.

d) **[Number of scanning points]** check box: set the frequency points to be measured.

e) **[Intermediate frequency bandwidth]** check box

Set the intermediate frequency bandwidth at the linear power level to obtain the acceptable track noise. The track noise is directly related to the measurement accuracy of the compression point. The small value (narrow intermediate frequency bandwidth) can help to improve the accuracy, but the measurement speed will be reduced.

### f) Phase reference point

A phase coupling relationship is provided by the phase measurement technology of scalar mixer measurement in each scanning from one frequency point to next frequency point. The phase measurement of the first point is random in each scanning. However, the initial phase deviation has no influence on measurement of the group delay, linear phase differential, etc. In order to keep the phase track of the random phase, all phases should be normalized in scanning to obtain a stable and normalized phase curve. Generally, a measurement point of good signal-to-noise ratio is selected as the reference point of normalization. The phase of the selected point is generally 0. The setting will be applied in measurement and reference scanning. In the segment scanning mode, the reference point is the middle fixed point.

- **[Enable phase]**: tick it to enable the phase coupling relationship.
- **[First point]**: tick it to set the first frequency point of scanning as the phase reference point.
- **[Middle point]**: tick it to set the middle frequency point of scanning as the phase reference point.
- **[Last point]**: tick it to set the last frequency point of scanning as the phase reference point.
- **[Specify point]**: specify one point within the scanning frequency range as the phase reference point through the drop-down box.

### 2) [Power setting] dialog box

Power setting: click **[Power]** in the dialog box, and the following dialog box will appear.

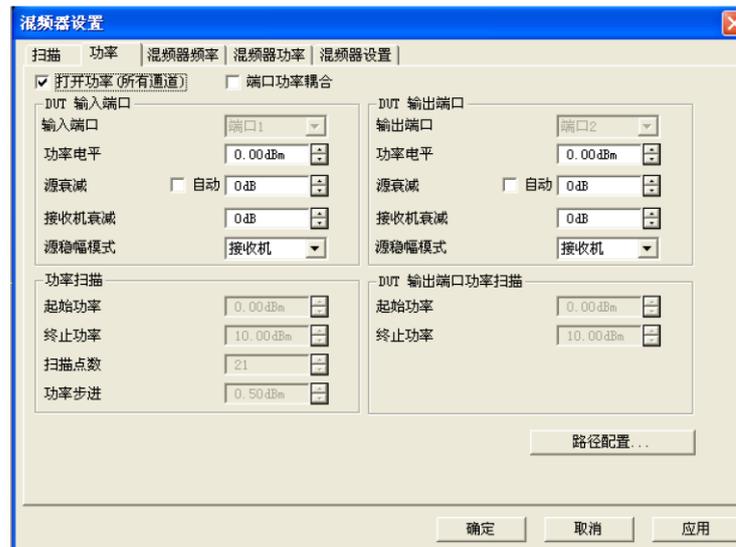


Fig. 6.4 [Power Setting] Dialog Box

**a) [Enable power (all channels)]**

It is used to control the enabling and disabling of RF power of all channels. Tick it to enable the power; otherwise, the power will be OFF.

**b) [Port power coupling]**

It is used to correlate the power levels of the DUT input and output port. If this option is not ticked, the power settings of two ports are relatively independent.

**c) DUT input/output port**

➤ **[Input/output port]**

It is used to configure the measurement port for the DUT input and output end. In the vector mixer measurement mode, the reference mixer should be connected to Port 1. Therefore, the input end of DUT must be connected to Port 1 of the test instrument.

➤ **[Power Level]**

Set the level of the input and output port of DUT.

➤ **[Source attenuation]**

If “Automatic” is selected, the test instrument can select the attenuation value according to the actual measurement to meet test requirements. The attenuation value can be customized to meet the required input power. All ports must have the same attenuation value in the continuous scanning mode.

➤ **[Receiver attenuation]**

Set the receiver attenuation of DUT port.

➤ **[Source amplitude stabilization mode]**

Options: internal amplitude stabilization, open loop (only for the broad pulse measurement mode) and receiver.

**d) Power scanning of DUT input and output port** (only when the power scanning mode is selected in the scanning bar)

➤ **[Starting power and ending power]**

Set the starting and ending power of the input/output port.

➤ **[Number of scanning points]**

Set the number of scanning power points.

➤ [Power step]

The step value is calculated according to the current starting frequency, ending frequency and scanning point number.

e) [Path configuration]

If this option is ticked, the following [Path configuration] dialog box will pop up. Set the configuration of the signal path to each port in the channel.

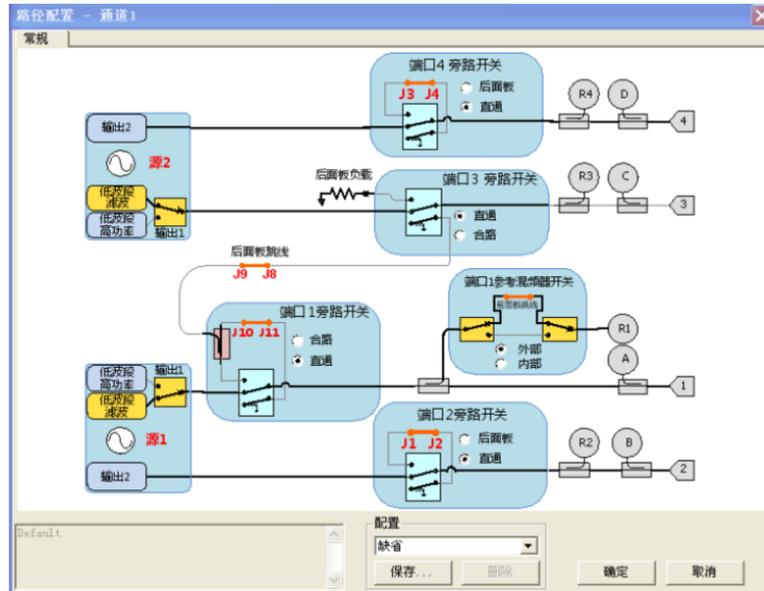


Fig. 6.5 [Path configuration] Dialog Box

3) [Mixer frequency setting] dialog box

Click [Mixer frequency], and the following dialog box will pop up.

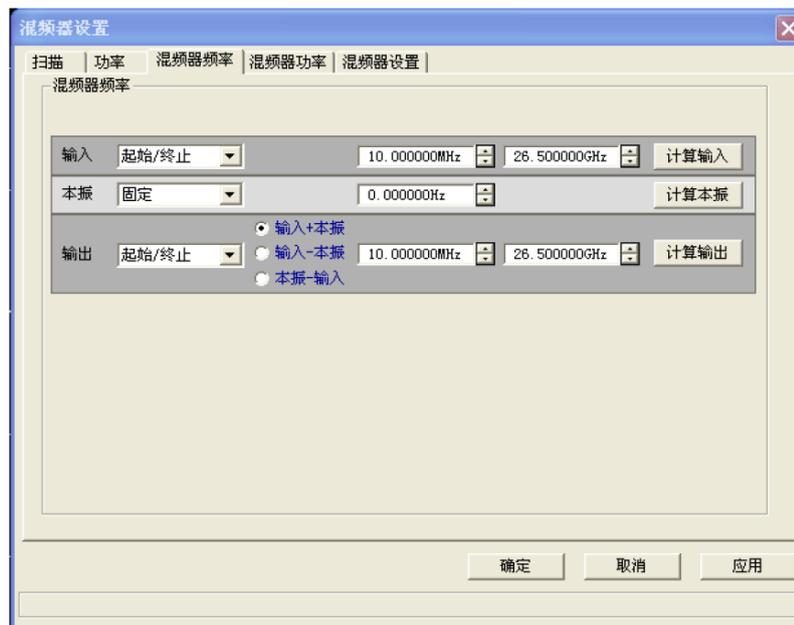


Fig. 6.6 [Mixer frequency setting] Dialog Box

a) Frequency setting mode

➤ [Starting/ending]

Select it in the drop-down box and respectively enter the starting frequency and ending frequency in the frequency range.

➤ **[Fixed]**

Select it in the drop-down box and entered the fixed frequency in the frequency range.

➤ **[Center/span]**

Select it in the drop-down box and respectively enter the center frequency and ending frequency in the frequency range.

b) Frequency calculation mode

➤ **[LO + input]**

If this option is selected, the output frequency will be the sum of the LO and input frequency.

➤ **[Input-LO]**

If this option is selected, the output frequency will be the difference of the input frequency minus LO frequency.

➤ **[LO-input]**

If this option is selected, the output frequency will be the difference of the LO frequency minus input frequency.

➤ **[Input calculation]**

When the LO and output frequency are set, click **[Input calculation]** to automatically calculate the input frequency.

➤ **[Output calculation]**

When the LO and input frequency are set, click **[Output calculation]** to automatically calculate the output frequency.

➤ **[LO calculation]**

When the input and output frequency are set, click **[LO calculation]** to automatically calculate the LO frequency.

---

## Prompt

### Frequency setting

- Select **[Starting/ending]**, **[Fixed]** and **[Center/span]** in the drop-down box. **[Fixed]** must be selected. If the scanning mode in the **[Scanning]** dialog box is **[CW]** or **[Power scanning]**, the mixer frequency is **[Fixed]**.
- It is not required to input all frequencies. Set two frequencies at first, and then click **[Calculate]** to obtain the third frequency. To set the input and output frequency range, click **[LO calculation]** to automatically calculate the LO frequency range.

---

### 4) **[Mixer power setting]** dialog box

Click **[Mixer power]**, and the following dialog box will pop up.

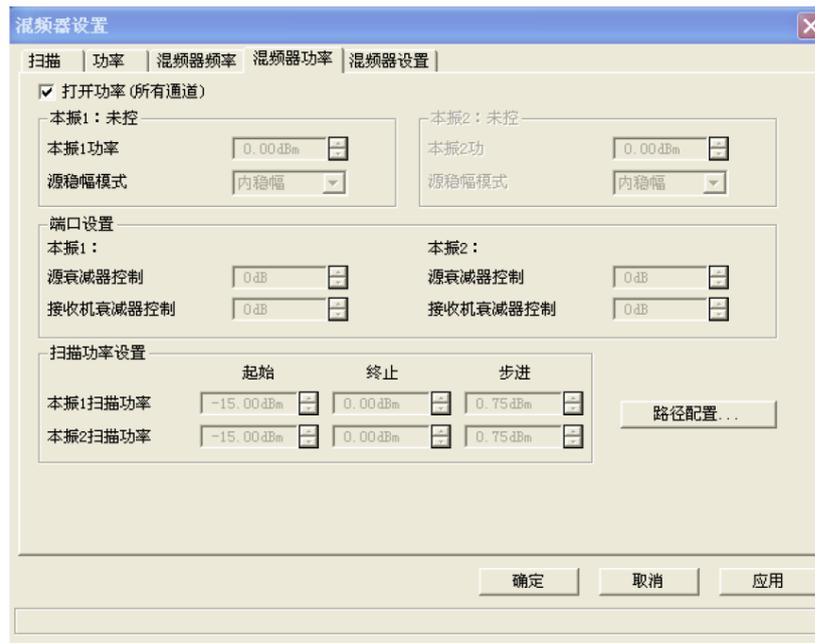


Fig. 6.7 [Mixer power setting] Dialog Box

#### a) Enable power (all channels)

Tick it to open the internal sources of all channels of the vector network analyzer and clear it to remove the internal sources of all channels.

#### b) LO 1

The default setting is “uncontrolled”. Set the LO 1 port in the [Mixer setting] dialog box. The corresponding port will be displayed.

##### ➤ [LO 1 power]

Set the power of LO 1.

##### ➤ [Source amplitude stabilization mode]

Select [**Internal amplitude stabilization**], [**Open loop**] (only for the broad pulse measurement mode) and [**Receiver**] according to the actual measurement requirements. The default mode is [**Internal amplitude stabilization**].

#### c) LO 2

The default setting is “uncontrolled”. Set the LO 2 port in the [Mixer setting] dialog box. The corresponding port will be displayed.

##### ➤ [LO 1 power]

Set the power of LO 2.

##### ➤ [Source amplitude stabilization mode]

Select [**Internal amplitude stabilization**], [**Open loop**] (only for the broad pulse measurement mode) and [**Receiver**] according to the actual measurement requirements. The default mode is [**Internal amplitude stabilization**].

#### d) Port setting

##### ➤ [Source attenuator setting]

Set the attenuation value of LO.

##### ➤ [Receiver attenuation control]

Set the attenuation value of the receiver.

**d) Scanning power setting**

The default mode is gray. If the [Power scanning] mode is selected, the scanning power can be set.

**f) Path configuration**

If this option is clicked, the [Path configuration] will pop up. Configure the path.

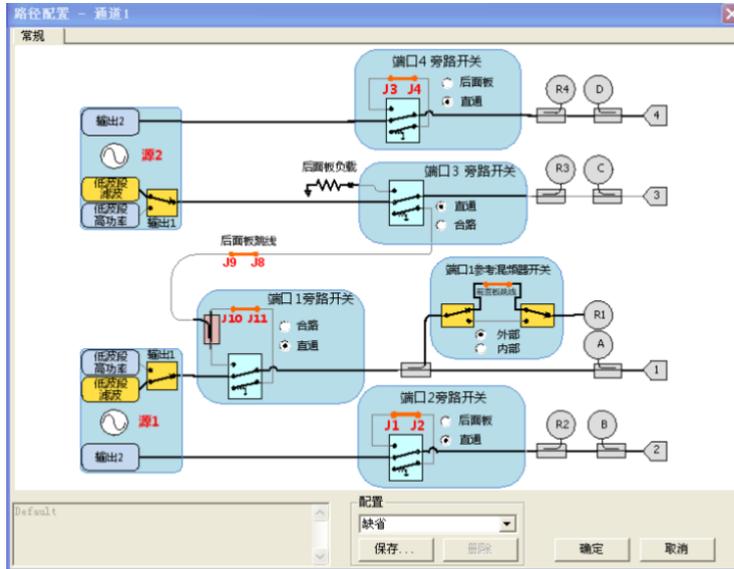


Fig. 6.8 [LO path configuration] Dialog Box

**5) [Mixer setting] dialog box**

Click [Mixer setting], and the following dialog box will appear.

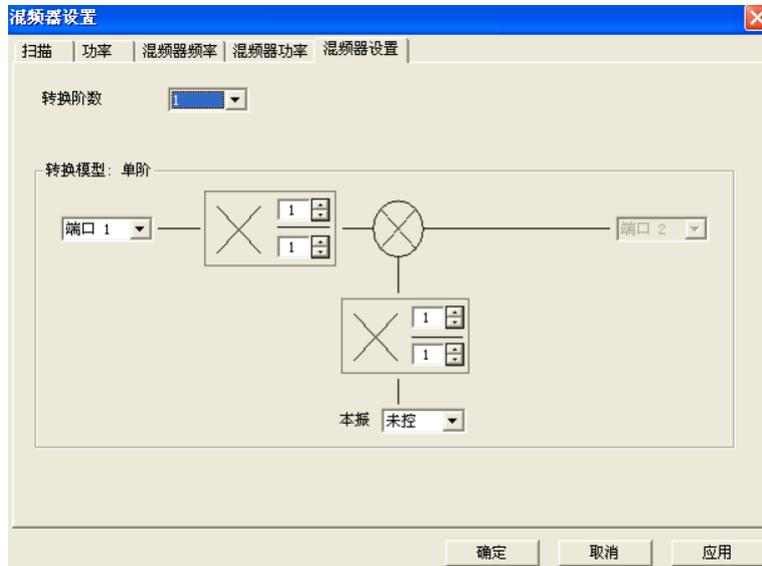


Fig. 6.9 [Mixer setting] Dialog Box

**Transformation orders:** click the drop-down box, and select the orders of transformation. The default mode is 1-order. If the 2-order mode is selected, mixer transformation will be done twice, and the corresponding transformation model is a 2-order model.

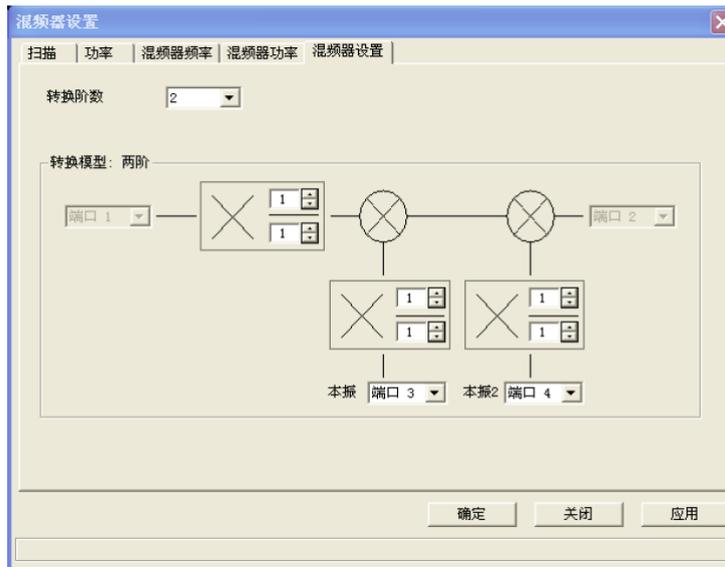


Fig. 6.10 Mixer Mode Setting Dialog Box

**Transformation model:** set [Input port], [LO port] and [Output port] of the mixer in the model dialog box. If the LO and LO2 are not set, one external source can be used to provide the fixed LO; otherwise, the port must be configured.

**Fraction multiplier:**



The (numerator/denominator) combination is a decimal and multiplied by the input and output frequency. The default coefficient of the numerator/denominator of the multiplication base is 1, and the adjustable range is 1 to 10. The negative is not allowed. If the multiplication coefficient changes, the [Output frequency range] in the [Frequency setting] box will change accordingly. With the fraction multiplier, the receiver frequency can be tuned to the harmonics of the mixer.

### 6.3 Calibration of Scalar Mixer Measurement

Perform calibration after mixer measurement setting. Menu path: [Calibration] > [Calibration...]. Complete all calibrations according to the guide.

#### 1) Calibration setting



Fig. 6.11 Calibration Setting

a) **Edit mixer:** click it to modify the mixer settings.

b) **Calibrate the input and output end with the power meter (do not use the through type calibration mode).**

If the through type calibration mode is unavailable, tick this option. In this case, the input and output end can be calibrated with the power meter in the subsequent calibration.

c) **Waveguide/fixture/carrier setting:** the default mode is gray and unavailable.

## 2) Phase correction

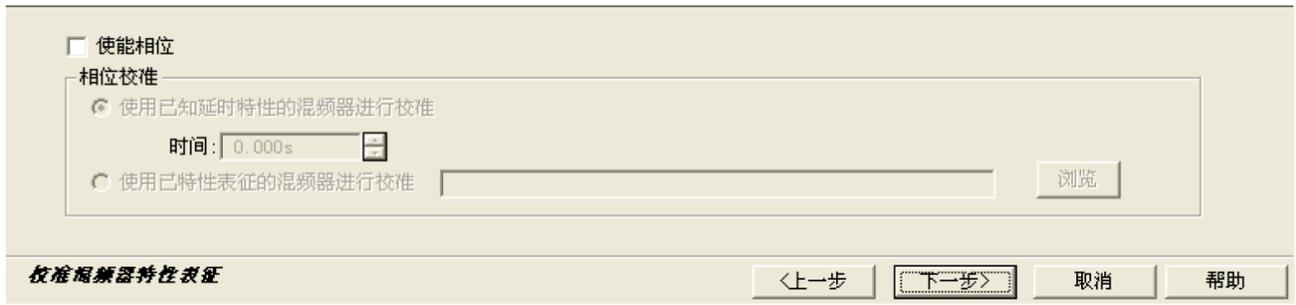


Fig. 6.12 Characteristic Description of Calibration Mixer

a) [Enable phase]: tick it to enable the phase measurement mode.

### b) Phase calibration

In the scalar mixer measurement calibration, the phase delay of the calibrated mixer can be measured and compared with the known delay. The difference is used to correct the phase measurement of the scalar mixer. One of the following phase calibrations can be selected.

#### ➤ [Calibrate with mixer of known delay characteristics]

Input the delay of the mixer with the known fixed characteristics.

#### ➤ [Calibrate with mixer of known characteristics]

Select [Browse] and open the \*.S2P of the calibration mixer with the known characteristics.

It is more accurate to use the \*.S2P file (describe the delay within the measurement frequency range) than to use the known delay. The “.S2PX” file is used for segment scanning of the scalar mixer measurement and phase measurement. The following two methods are used to describe the calibration mixer. In the whole frequency range of the scalar mixer:

- 1) Use the mixer characteristic guide. The calibration mixer has the same requirements as the vector mixer.
- 2) Measure the group delay of the calibration mixer in the calibrated vector mixer measurement channel, and save the group delay in the \*.S2P or \*.S2PX file.

### 3) Select the DUT connection type and calibration kit.



Fig. 6.13 Connector and Calibration Kit

Select the specific connection type and calibration kit type of the tested device for various ports. If the connector of the tested device is of waveguide type, modify the system impedance into 10Ω before calibration. For setting steps, refer to the system impedance settings.

### a) Connection type of tested device

- [Port 1]: the interface type of the tested device connected to Port 1.
- [Port 2]: the interface type of the tested device connected to Port 2.
- [Input power sensor]: the same type as that of connection to Port 1.

b) **Calibration kit:** model of the selected calibration kit. The inserted electronic calibration kit will be automatically detected by the analyzer and displayed.

c) **[De-embedding of adapter of power sensor input end]**

If the connector type of the power sensor is different from that of the tested device, the adapter connected to the power sensor on the reference plane should be measured and modified to ensure accurate measurement. If this option is ticked, the adapter will be measured and corrected in the following calibration steps.

d) **Modification calibration:** tick it and click [Next]. Then the [Modify through type calibration] dialog box shown in the following figure will appear.

4) **Modification of through type calibration**



Fig. 6.14 Modification of Through Type Connection

a) **Through type calibration:** including [Zero-length through type calibration], [Custom through type calibration] and [Unknown through type calibration]. Select one in the drop-down box.

b) **[Calibration type/calibration standard]:** click it and the [Calibration type] dialog box in 6.6.5 will pop up.

c) **[Add through type calibration or remove through type calibration]:** click [Add through type calibration] to add the through type calibration; and click [Remove through type calibration] to remove the unnecessary through type calibration.

5) **Port power calibration setting dialog box**

a) **Power**

- **Power calibration port:** set the amplifier input port as the power calibration port.
- **Power deviation:** refer to the difference between the amplifier input power and calibrated power. It is generally caused by the adapter or attenuator between the calibration plane and power meter. In case of no frequency deviation, ignore this option.

b) **Accuracy**

- **Tolerance:** refer to the error tolerance of power calibration.
- **Maximum reading times:** scanning will be repeated automatically if the power calibration fails. The maximum reading times are the times of repeated scanning. If power calibration still fails after exceeding maximum reading times, scanning will not be repeated and next step will be started directly.

c) **Power meter configuration:** select the power meter model/ if the USB power probe developed by the 41st Institute is inserted, the probe will be detected automatically and the options will be provided.

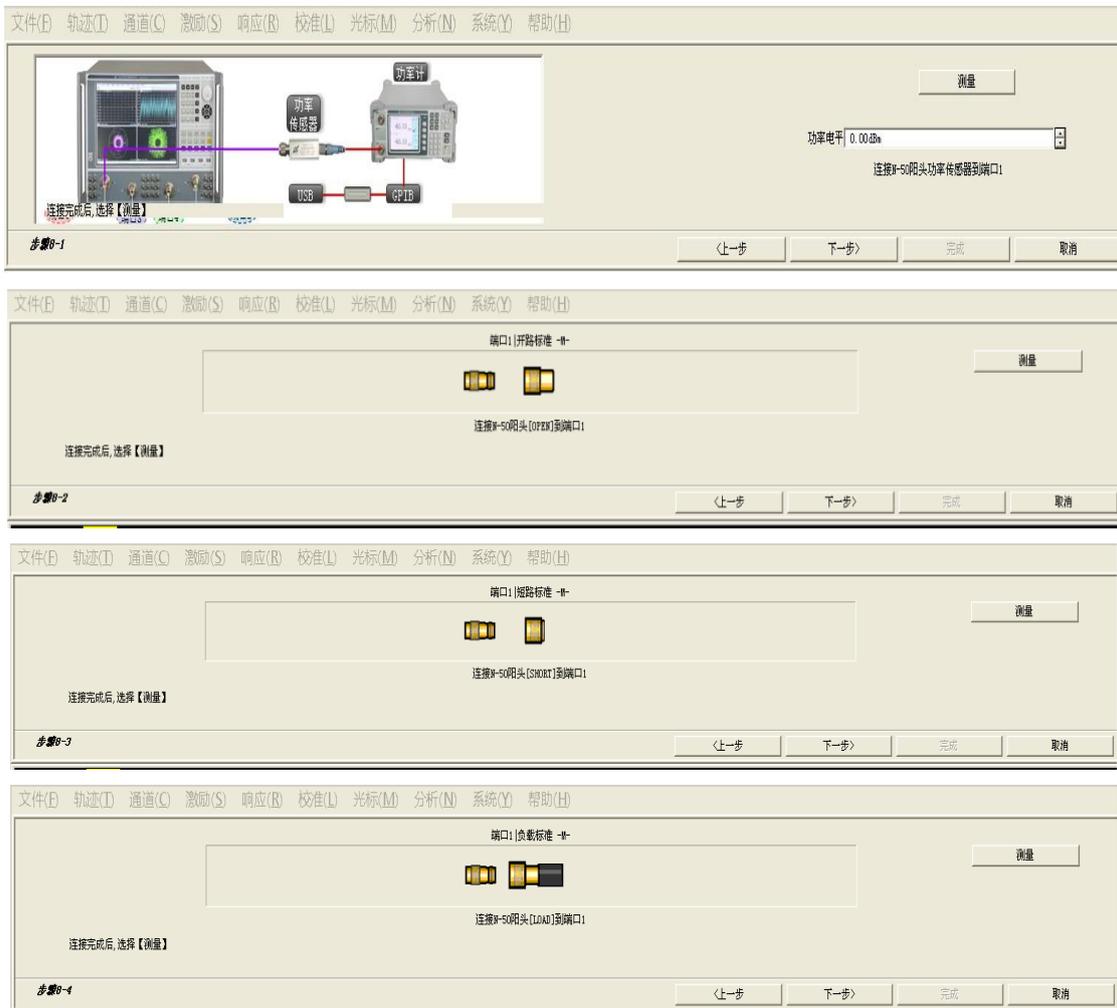


Fig. 6.15 Port Power Calibration Setting Dialog Box

The power calibration level is generally 0dBm. The low power level may result in low-level calibration with noise. If additional elements are added between the test port and calibration reference plane, the power level of the power sensor can be adjusted properly to be slightly higher than 0dBm.

### 6) Calibration steps

Perform connection as shown in the figure. After connection, click [Measurement]. The analyzer will automatically skip to next step after measurement. After all measurements, click [Finish]. Thus all the calibrations are completed.



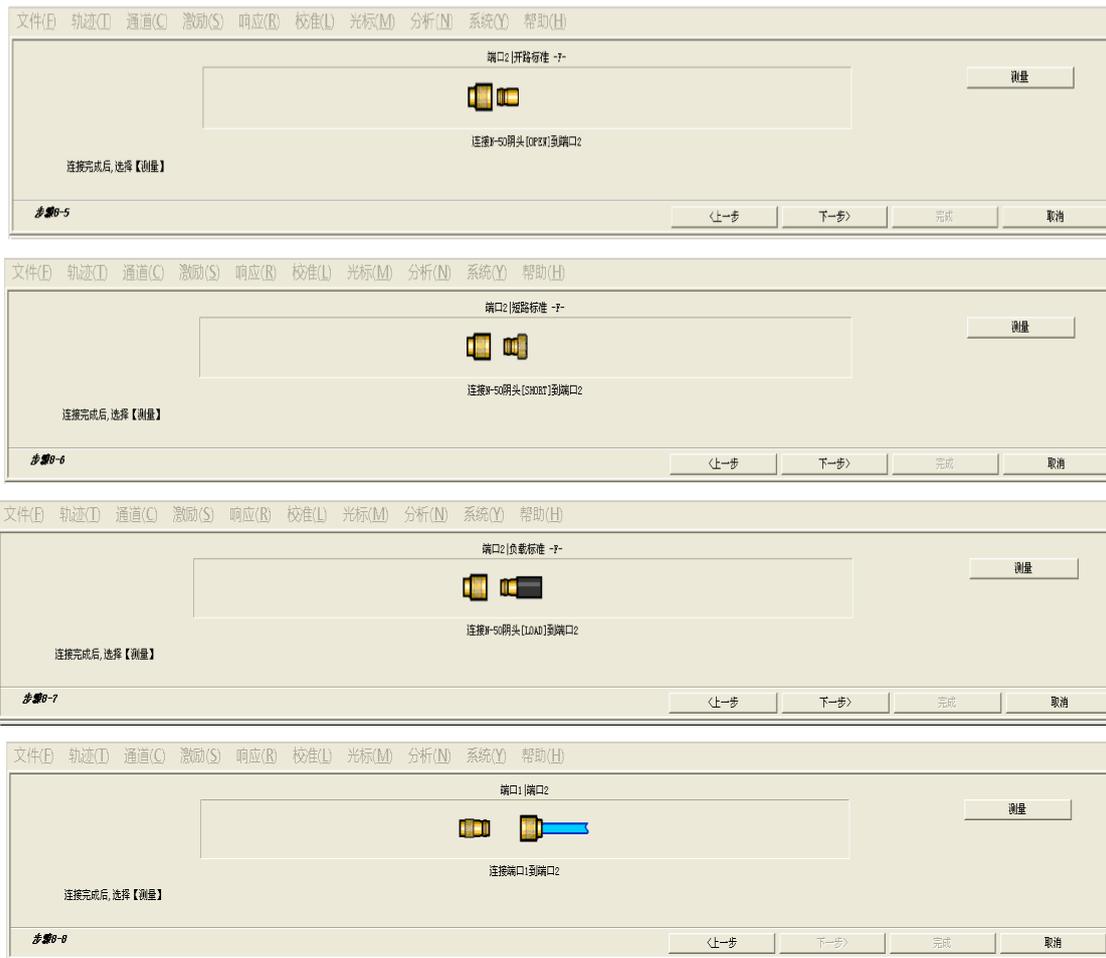


Fig. 6.16 Dialog Box of Calibration Steps

### 7) Track adjustment

Measure the tested device after calibration. To display more measurement parameters, Click [Track] > [New track]. Select one parameter in the list.



Fig. 6.17 [New track] Dialog Box

The input port is for the frequency signal before frequency transformation, and the output port for the frequency signal after frequency transformation. The DUT input and output port can be connected to any port of the vector network analyzer.

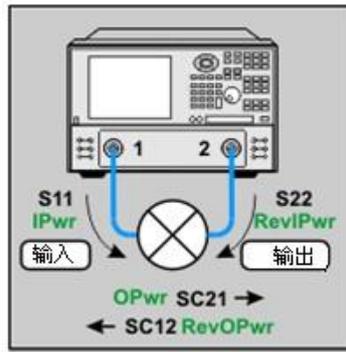


Fig. 6.18 Schematic Diagram of Measurement Parameters

Mixer parameters are defined as follows.

Schedule 6.2 Measurement Parameters of Scalar Mixer

	Parameter	Description
Scale parameter	S11	Matching input, indicating the input port excitation and response (A/R1)
	S22	Matching output, indicating the output port excitation and response (B/R2)
	SC21	Frequency transformation loss, indicating the input port excitation and output port response (B/R1)
	SC12	Reverse isolation, indicating the output port excitation and input port response (A/R2)
Non-scalar parameter	IPwr	Input power, indicating the input port excitation and response.
	RevIPwr	Reverse input power, indicating the output port excitation and response.
	OPwr	Output power, indicating the input port excitation and output port response.
	RevOPwr	Reverse output power, indicating the output port excitation and input port response.

## 6.4 Vector Mixer Measurement

### 1) Hardware setting of vector mixer measurement

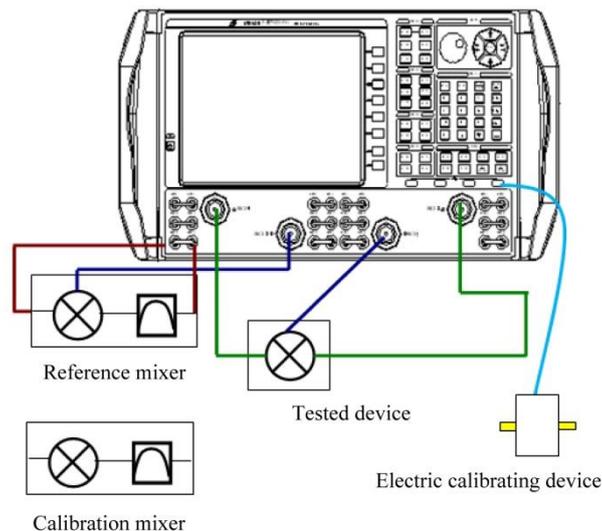


Fig. 6.19 Measurement Hardware Equipment

#### a) Reference mixer

The reference mixer is used to provide phase reference for measurement and connected between the input end and output end of the reference channel R1 of the vector network analyzer.

As part of the test system, the reference mixer should be kept unchanged in the whole calibration and measurement process. The mixer is controlled by the switch. You can select whether to set the mixer in the measurement path of the instrument. For details, refer to the manual switching control of the mixer.

The performance of the reference mixer is allowed to be different from that of the calibration mixer or test mixer, but the frequency range of the reference mixer must be the same as that of the test mixer. In short, it is necessary to select the reference mixer which can be used in various settings. For example, the broad-band mixer should be used instead of the narrow-band mixer.

One low-pass filter is connected to the output end of the reference mixer, to eliminate LO signals leaking out of the mixer and prevent losses and errors caused by LO leakage. In a strict sense, it is necessary to set a filter.

Connection of the reference mixer to the instrument:

- i. Connect the input end of the reference mixer to the output end of the reference source R1
- ii. Connect the output end of the reference mixer to the input end of the reference source R1 of the instrument.

### b) Calibration mixer/filter

The calibration mixer/filter is a standard through type device in the vector mixer measurement calibration and must conform to the following requirements:

- i. The mixer should bidirectionally cover the whole range of the test mixer. This means that the amplitude and phase response are the same in the upper and lower transformation direction, as shown in the following figure.

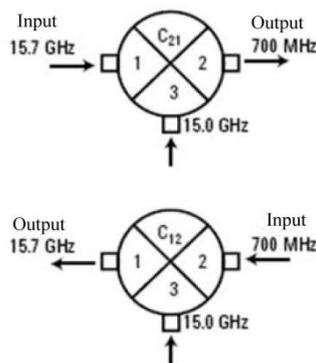


Fig. 6.20 Two-way Amplitude and Phase Response

- ii. If the input frequency range and output frequency range are overlapped, the input/output isolation of the mixer should be at least 1dB higher than the frequency transformation loss of the frequency overlapping part.
- iii. The filter at the output end of the calibration mixer must be able to filter unnecessary mixing products and ensure the passing of required mixing products.

### c) Direction of calibration mixer/filter and reference mixer

The direction of the reference mixer is always the same as that of the tested mixer to ensure that the output frequency is the same as that of DUT. The calibration mixer/filter can be used as the LO source at the upper and lower transformation frequency. The internal source 2 can be used as the LO signal.

## 2) Establishment of vector mixer measurement

- a) By the front panel: press [Measurement] > [Measurement type].
- b) Select [Vector mixer measurement] and click [Delete current measurement]. Then click [New channel] to establish the measurement in a new channel.
- c) Set one VC21 measurement. The completion prompt will be displayed.
- d) To add other parameters, click [Track] > [New track]. Select one parameter from the list.

## 3) Parameters of vector mixer measurement

The DUT input end is generally connected to Port 1, and the DUT output end can be connected to any port.

- a) VC21 VC31 and VC41: transformation loss or gain in the default mode, indicating the input end excitation and output end response.
- b) S11: input end excitation and response.
- c) S22, S33 and S44: output end excitation and response.
- d) R1 or R: input end excitation, and absolute power (not corrected) measured at the receiver end R1.
- e) B, C and D: input end excitation, and absolute power (not corrected) measured at the output end.

#### 4) Setting of vector mixer calibration measurement

##### Menu path:

By the front panel: click **[Frequency]** > **[Mixer setting]**.

By the mouse: click **[Excitation]** > **[Frequency]** > **[Mixer setting]**.

The following dialog box will appear on the screen. The mixer settings are the same as the scalar mixer settings.

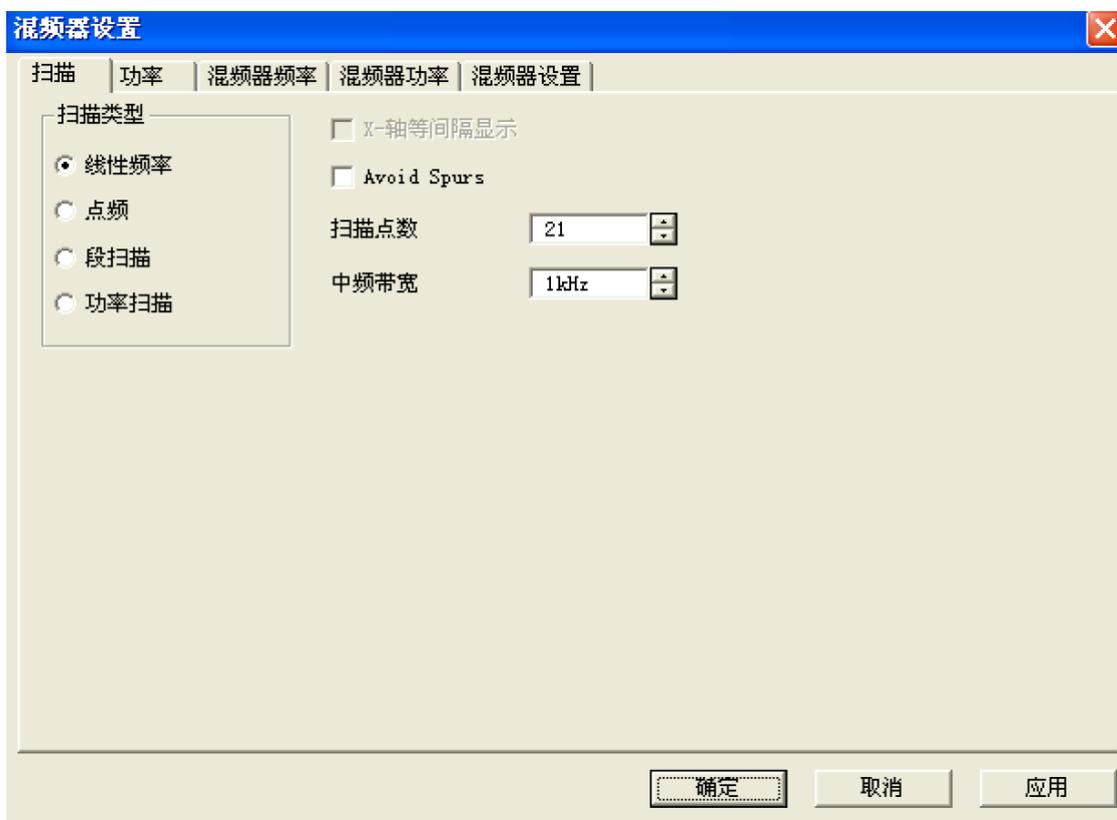


Fig. 6.21 [Vector mixer measurement calibration] Dialog Box

### 6.5 Vector Mixer Measurement Calibration

The user can complete the calibration according to the guide. The first three steps describe the calibration mixer used for through type calibration.

- 1) Use the mechanical or electronic calibration kit. Perform the full double-port SOLT calibration in the whole input and output frequency range of DUT.
- 2) Add the LO calibration kit. Connect the open-circuit device, short-circuit device and load to the output terminal to describe the input and output matching of the calibration mixer/filter. Save the S2P file after calibration. If the same excitation settings are applied, data can be called for vector mixer measurement calibration.
- 3) Connect the reference mixer to Port 1 and between the input and output of the reference channel R of the front panel. Connect the output port of the calibration mixer/filter to Port 2.

- 4) Use the calibration mixer/filter in the through type calibration.
- 5) Calculate the errors and correct the phase measurement of the test mixer/converter.

**1) Use the mouse or front panel.**

- a) By the front panel: click **[Calibration] > [Calibration guide]**.
- b) By the mouse: click **[Response] > [Calibration guide]**.



Fig. 6.22 Setting of Vector Mixer Calibration

**2) [Help] dialog box for mixer characteristic calibration**

Click [Next], and the following dialog box will appear.

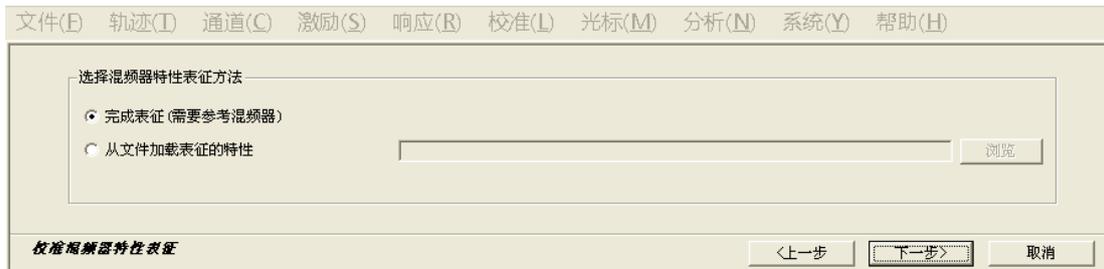


Fig. 6.23 Calibration Mixer Characteristics

- **Characterization (using the reference mixer):** one mixer is used for characterization, in addition to vector mixer measurement calibration. The mixer characterization file will be saved after calibration. Select this option if no characterization file needs to be loaded.
- **Characteristic loading from file:** load one S2P calibration mixer characterization file by clicking [Browse].

**Prompt**

**Mixer characterization**

- One \*.S2PX file should be loaded in segmented vector mixer measurement.
- The frequency ranges of S2P files must be identical or wider than the frequency range of frequency transformation measurement. If the frequency range of the S2P file is larger, the interpolation method should be applied to match measurement.
- The connection direction of the calibration mixer must be the same as that in the characterization file. As the direction is not specified in the file, connection should be done carefully.
- The mixer characterization can be calibrated separately.

**3) Connection type of tested device**



Fig. 6.24 Connection Type and Calibration of Tested Device

Select the specific connection type and calibration kit type of the tested device for each port.

**[Mixer output]:** connected to the filter output end of the calibration mixer. Specify the calibration kit/standard to measure the calibration mixer/filter.

**[Modify calibration]:** select it and click [Next] to modify the calibration dialog box.



Fig. 6.25 Modification of Through Type Connection

**Through type calibration:** including [Zero-length through type calibration], [Custom through type calibration] and [Unknown through type calibration]. Select one in the drop-down box.

**[Add through type calibration or remove through type calibration]:** click [Add through type calibration] to add the through type calibration; and click [Remove through type calibration] to remove the unnecessary through type calibration.

#### 4) Dialog box of vector mixer calibration steps

Respectively connect the open-circuit device, short-circuit device and load to Port 1 and 2 according to the prompts. Add the appropriate adapter between Port 1 and 2 for through type measurement. Connect the open-circuit device, short-circuit device and load to the output end of the image filter for respectively measurements.







Fig. 6.26 [Vector mixer calibration] Dialog Box

### 5) [Help] dialog box for saving of mixer characteristics

The vector network analyzer has the function to save characteristic data of the calibration mixer. After calibration, the mixer characteristic calibration file will be saved to the specified path. If the same calibration mixer is used in vector mixer measurement calibration, the saved S2P file can be called directly.



Fig. 6.27 [Save characteristics] Dialog Box

**Browse:** find the path to save the characteristic data of the calibration mixer. Use the default or custom name.

**Next:** click [Next] to complete system calibration after saving the characteristics of the calibration mixer.

## 6.6 Embedded LO Mixer Measurement

A fixed LO is embedded in the tested mixer. The characteristics of the embedded LO can be applied in vector mixer, scalar mixer measurement, IMDX, IMXSpectrum, GCX and NFX measurement.

It is challenging to measure such devices for the following two reasons.

- 1) The reference mixer with the same LO frequency is required in vector mixer measurement. The independent internal source or external source must be used as LO of the reference mixer. At the same time, LO is controlled by the instrument. The measurement speed is higher if the internal source 2 is used.
- 2) All the embedded LO measurement must be adjusted with the analyzer receiver to the exact frequency to measure the mixer output. Thus the LO frequency must be accurate.

### 1) How to measure the embedded LO?

Enter the nominal frequency of the embedded LO in the [Mixer setting] dialog box, as the starting point of measurement.

Before measurement scanning of the tested device, start background scanning to determine the frequency of the embedded LO obtain the configurable accuracy. Background scanning:

- 1) Broadband scanning: initially measure the embedded LO frequency, and add one frequency range near the selected data point. The input signal of the tested device must be selectively adjusted to CW. Receiver B is used to scan the selected frequency range near the preset output frequency. Obtain the desired difference between the output signal and the found frequency, and apply the obtained result in adjustment.

2) Accurate scanning: Receive B is used to measure the selected data point. Measure the ratio of the phase and time, and calculate the exact frequency deviation, until reaching the allowable residual value or maximum degree of repetition.

3) The reference mixer will be upgraded automatically if the LO frequency is determined in vector mixer measurement.

**2) How to use the embedded LO to measure the tested device?**

1) Establish the vector mixer measurement, scalar mixer measurement, IMDx, IMx Spectrum, GCX or NFX measurement.

2) Enter the nominal frequency of the embedded LO as the LO frequency in the [Mixer setting] dialog box.

3) Perform calibration.

4) Open and complete the [Embedded LO model] dialog box.

5) Measure the vector mixer (frequency transformation amplifier).

**a) LO source of the reference mixer:**

1) Internal source

2) One external source: controlled by the instrument. Use the 10MHz reference frequency to lock the instrument.

**b) Calibration precautions**

The LO source is commonly used by the reference mixer and calibration mixer in the calibration process. One power distributor should be added when the external source is used, as shown in the following figure.

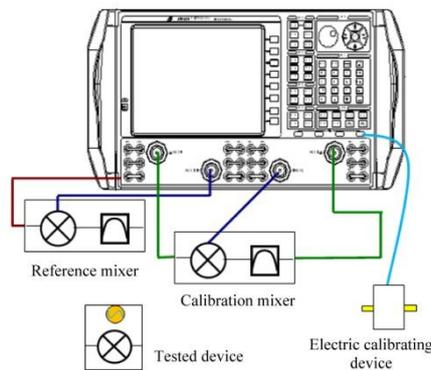


Fig. 6.28 Embedded LO Calibration

The LO source is only used by the reference mixer in the measurement process. The LO port of the calibration mixer should be well matched, so that the LO port of the reference mixer remains unchanged after calibration. See the following figure. The above considerations are not necessary if the internal source 2 is used.

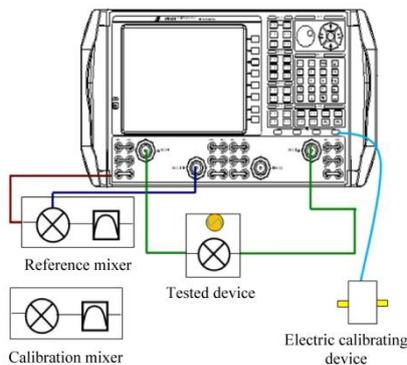


Fig. 6.29 Embedded LO Measurement

The embedded LO measurement needs no specific settings in the scalar mixer measurement, IMDX, IMxSpectrum

and NFX measurement.

**c) How to open [Embedded LO mode] dialog box**

With the mouse

Click [**R**esponse].

Then click [**M**easurement].

Click [**S**earch LO]. The [Embedded LO mode] dialog box will appear.

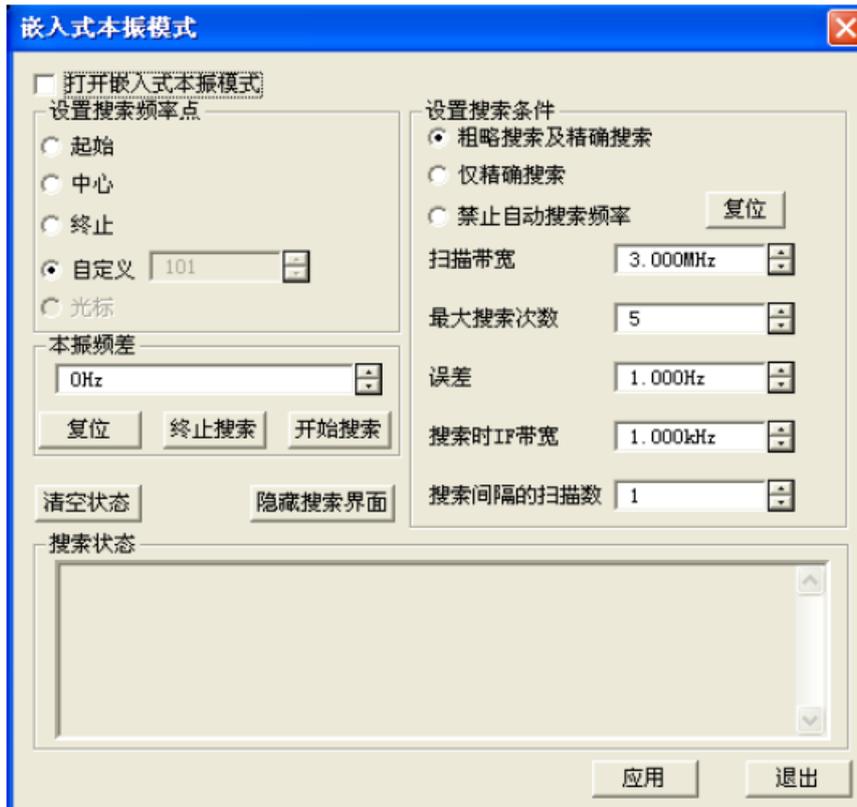


Fig. 6.30 [Embedded LO mode] Dialog Box

**d) [Help] dialog box for embedded LO**

“**Adjust setting**”: to balance the LO measurement speed and frequency. You can see that the accuracy will be reduced if noise appears on the measurement track.

“**Enable embedded LO mode**”: click it to enable the embedded LO measurement.

“**Set search frequency point**”: select or specify the scanning data point of the mixer to find the embedded LO frequency. If one marker is activated, the data point can be used. For broadband and accurate scanning, select the point of the lowest noise in mixer scanning. Generally, the scanning center is selected. If the filter is used, select the filter center.

“**LO frequency difference**”: measure the absolute difference between the embedded LO frequency and the LO setting in the [Mixer setting] dialog box. This value changes in each measurement of the LO frequency. This is a method to change the set frequency of the mixer and ensure that calibration is effective.

“**Reset**”: set the LO frequency as 0Hz.

“**Start search**”: set in the current dialog box and search and measure the actual LO frequency. Data will be displayed in the [Search status] box.

“**Set search conditions**”: the ratio of the scanning time to the LO frequency measurement accuracy depends on the set conditions. You can see that the accuracy will be reduced if noise appears on the measurement track.

“**Reset**”: reset all settings into default settings.

“**Rough search and accurate search**”: the whole tuning process is executed in background scanning each time.

“**Only accurate search**”: broadband tuning is not executed in each scanning. This setting is used when the embedded LO is stable.

“**Disable automatic frequency search**”: only the LO frequency difference measured previously is applied to the reference mixer LO and receiver.

“**Search bandwidth**”: reduce the scanning span to limit the data point number of broadband scanning measurement and accelerate measurement.

“**Maximum search times**”: maximum scanning point number for accurate scanning. If the search times reach the maximum times, use the final measurement result.

“**Error**”: if two consecutive accurate measurements are within the error range, use the last measurement result. If the accurate measurement result is beyond the error range, use the last measurement result.

“**IF bandwidth of search**”: refer to the IF bandwidth in the broadband and accurate tuning scanning. If the IF bandwidth increases, the scanning speed will increase accordingly and the signal may not be found.

“**Scanning times within search interval**”: set the interval and execute tuning within the interval. “Scanning times within search interval: 3” means that tuning scanning is added once every three times of measurement scanning. If the embedded LO has drift or the tested device is changed frequently, set “Scanning times within search interval: 1”.

“**State search**”: it is allowed to execute LO measurement scanning in the text or icon form.

“**Clear state**”: remove the text information displayed currently.

“**Display search interface**”: enable the nearest graphical display scanning of embedded LO measurement.

### e) Connection of preamplifier

The source power should be higher than the input power in mixer measurement. One high-frequency preamplifier can be used as an additional source. The following part describes how to establish and calibrate the scalar mixer measurement with the high-frequency preamplifier.

Connect one high-frequency preamplifier between the source output of the front panel and the connection port of the coupler, as shown in the following figure. The specific diagram of the instrument may be different.

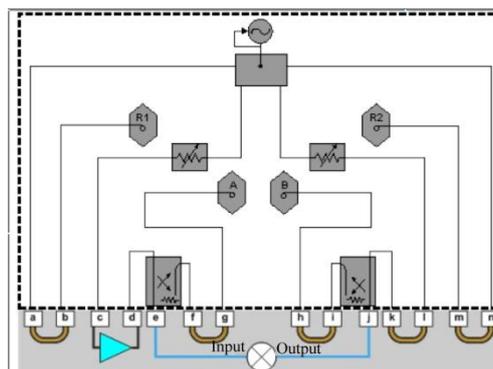


Fig. 6.31 Schematic Diagram of Preamplifier Connection

### 3) Measurement and calibration steps

In the following steps:

Test port power: refer to the power level of the source output end.

Correction power: enter the required power level of the mixer input and output port.

It is assumed in the following procedures that the excitation source is applied to the mixer input port for SC11 and sc21 measurement and mixer output port for SC22 and SC12 measurement.

- 1) Determine the gain of the high-frequency preamplifier. If the mixer frequency crosses the input and output range, the gain has the obvious slope. Check the high-frequency preamplifier with the gain slope.
- 2) Determine the correction power of the mixer input and output port.
- 3) Calculate the power of the two test ports. Reduce the input and output correction power level by the amplifier gain.
- 4) Clear the port power coupling bar in the [Power] dialog box of the instrument. Various ports may have different power levels.
- 5) Enter the calibration test power of each port.
- 6) Select the connection type of the tested device and calibration kit according to the guide of scalar mixer measurement calibration. Click [View/Change source calibration setting] to open the [Source calibration setting] dialog box.
- 7) Enter the preamplifier gain in the [Power deviation] box.

High-frequency preamplifier with gain slope:

The scalar mixer measurement calibration is executed within the whole mixer input and output range. Therefore, the high-frequency preamplifier is limited by the deviation within the whole input and output power range of the mixer. In order to compensate the gain slope, one source attenuator should be added and the frequency deviation and initial power should be set to prevent uneven distribution of the source power in the calibration process.

Assuming that the low gain of the preamplifier is 30dB, and the high gain is 20dB. If the entered frequency deviation is 30dB and the actual gain decreases to 20dB, PNA may be beyond the ALC range. The source power of PNA will be increased corresponding to the 10dB gain decrease. Therefore, one deviation power value is added in the middle of the amplifier gain bandwidth.

If possible, set one attenuator to keep ALC probably in the middle of the frequency range to obtain the desired IF gain correction power. This means that the ALC power can be increased or decreased according to the gain slope. If the gain is too large and the source instability cannot be prevented by setting, one flatter high-frequency preamplifier must be used.

## Appendix 7 Intermodulation Distortion Measurement

This chapter includes the following contents:

- [Concept of intermodulation distortion](#) .....452
- [Parameters of Intermodulation distortion](#) .....453
- [Intermodulation distortion measurement of amplifier frequency scanning](#) .....457
- [Intermodulation spectrum measurement of amplifier frequency scanning](#) .....463

### 7.1 Concept of Intermodulation Distortion

If various frequency signals are input into one device or system at the same time, the output port will generate the signals of different frequency due to nonlinear characteristics of the tested device. The typical measurement method is to input two kinds of single-tone signals of different frequencies and the same power to test the spectrum of output signals. Several measurement methods can be used to determine the intermodulation distortion parameters of the tested device.

Intermodulation distortion may result in signals of predictable frequency. The intermodulation frequency of one dual-frequency system is as follows:

$$f_{IM} = mf_1 \pm nf_2$$

Where, m and n are natural numbers, and m+n is the orders of intermodulation distortion. The odd-order products (such as 3-order, 5-order, etc.) are close to the frequency of double-tone input signals and have potential effect on the nearby communication channel. Except 2-order products, the products of higher even orders are generally far away from the frequency of double-tone input signals and not taken into account.

Fig. 7.1 shows the two double-tone input signals of the same power and approximate distortion products of intermodulation. It can be seen in Schedule 7.1 that the frequency of odd-order products is close to that of main signals. For most devices, the intermodulation distortion products are more obvious in the case of system compression distortion.

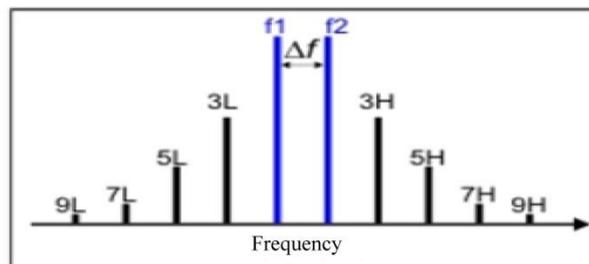


Fig. 7.1 Intermodulation Product of Double-tone Signals ( $f_1$  and  $f_2$ ) and Odd Orders

Schedule 7.1 Intermodulation Distortion Products Close to Main Signal Frequency

Intermodulation Product	Low Frequency	High Frequency
Main tone signal	<b>f1</b>	<b>f2</b>
	100MHz	120MHz
3-order intermodulation	<b>2f1-f2</b>	<b>2f2-f1</b>
	80MHz	140MHz
5-order intermodulation	<b>3f1-2f2</b>	<b>3f2-2f1</b>
	60MHz	160MHz
7-order intermodulation	<b>4f1-3f2</b>	<b>4f2-3f1</b>
	40MHz	180MHz
9-order intermodulation	<b>5f1-4f2</b>	<b>5f2-4f1</b>
	20MHz	200MHz
2-order intermodulation	<b>f2-f1</b>	<b>f1+f2</b>

	20MHz	220MHz
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## 7.2 Intermodulation Distortion Parameters

This section mainly introduces the basic parameters of amplifier and mixer measurement. Such parameters can be extended to more than 150 intermodulation parameters by changing the intermodulation order, intermodulation sound position (high order, low order and average) and intermodulation sound measurement port.

- [Basic parameters](#) .....453
- [Intermodulation distortion application](#) .....456

### 7.2.1 Basic parameters

#### 7.2.1.1 Sound Power Parameter

The sound power parameter is the absolute power of the main sound signals, odd-order products (up to 9 orders) and 2-order products. The sound power of the input end and output end of the tested device can be measured. As intermodulation sound signals appear in pairs, the high order, low order or average of sound signals can be measured.

The average sound power is calculated by the following formula:

$$Avg = \frac{Hightone(dBm) + Lowtone(dBm)}{2}$$

If the frequency difference of double-tone signals is less than 10MHz in measurement of 2-order products, the low order (f2-f1) will be below the lower frequency limit of the analyzer. Therefore, the low order of 2-order products cannot be measured in this case.

#### 7.2.1.2 Sound Gain Parameter

The sound gain (in dB) refers to the sound power ratio of the output end and input end. As sound signals appear in pairs, the low order, high order or average value can be applied to calculate the sound gain.

The sound frequency of the input end is different from that of the output end in intermodulation distortion measurement of the frequency converter.

#### 7.2.1.3 Intermodulation Distortion Parameters

The intermodulation distortion parameters are used to describe the power difference between the distortion product and main sound signal and calculated according to the sound power. They can also be used to measure 2-order, 3-order and 5-order intermodulation products. The input end and output end can be set as the measurement port. You can also select to measure the high order, low order or average value. The calculation formulas of intermodulation distortion parameters are as follows:

$$IMxLo = PwrxLo - PwrMainLo$$

$$IMxHi = PwrxHi - PwrMainHi$$

$$IMx = Pwrx - PwrMain$$

$$IMxLoIn = PwrxLoIn - PwrMainLoIn$$

$$IMxHiIn = PwrxHiIn - PwrMainHiIn$$

$$IMxIn = PwrxIn - PwrMainIn$$

Where:

- x is the intermodulation distortion order (2, 3, 5, 7, and 9).
- The suffix “Hi” indicates high order, “Lo” indicates low order and “none” indicates the average value.
- The suffix “In” indicates the input end of measurement and “none” indicates the output end.

#### 7.2.1.4 Intersection Point Parameters

As shown in Fig. 7.2, the black curve and green curve respectively shows the main sound signal power and intermodulation sound output power. It can be seen that if the output power of the main sound signal increases, the

intermodulation sound output power will increase at the predictable and steeper slope. The main sound output power is equal to the intermodulation sound output power at a certain point. This point is generally defined as the intersection point. The intersection point cannot be directly measured with the test instrument. Instead, it is calculated by measuring the main sound power and intermodulation sound output power.

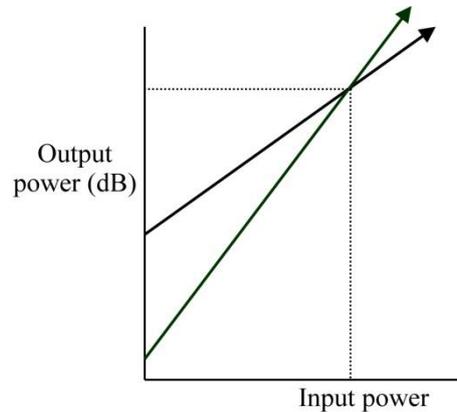


Fig. 7.2 Schematic Diagram of Intersection Point Parameters

The function of intermodulation distortion measurement can be used to calculate and display the theoretical intersection point power of the input end and output end of the tested device, i.e. input intersection point (IIP) and output intersection point (OIP).

Measurement orders can be set in intersection point measurement: 2, 3, 5, 7, and 9. The sound positions include high order, low order and average. The measurement ports include the input end and output end. For the 2-order intersection point, only the low order and high order can be measured, and the average value is not supported.

The calculation formulas of intermodulation distortion intersection points are as follows:

$$OIP_{xHi} = PwrMain - IM_{xHi}/(x-1)$$

$$OIP_{xHiIn} = PwrMain - IM_{xHiIn}/(x-1)$$

$$OIP_{xLo} = PwrMain - IM_{xLo}/(x-1)$$

$$OIP_{xLoIn} = PwrMain - IM_{xLoIn}/(x-1)$$

$$OIP_x = PwrMain - IM_x/(x-1)$$

$$OIP_{xIn} = PwrMain - IM_{xIn}/(x-1)$$

$$IIP_{xHi} = PwrMainIn - IM_{xHi}/(x-1)$$

$$IIP_{xHiIn} = PwrMainIn - IM_{xHiIn}/(x-1)$$

$$IIP_{xLo} = PwrMainIn - IM_{xLo}/(x-1)$$

$$IIP_{xLoIn} = PwrMainIn - IM_{xLoIn}/(x-1)$$

$$IIP_x = PwrMainIn - IM_x/(x-1)$$

$$IIP_{xIn} = PwrMainIn - IM_{xIn}/(x-1)$$

Where:

- OIP refers to the output intersection point.
- IIP refers to the input intersection point.
- $x$ =order (2, 3, 5, 7 and 9)
- PwrMain=main sound signal of the input end or output end of the tested device.
- $IM_x$ =main sound signal power-intermodulation sound power (from the intermodulation distortion parameter)

### 7.2.1.5 Composite Triple Beat (CTB)

According to the NCTA standard, CTB is defined as the modulation beat of target channel signal arising from the

triple beat produced by nonlinear characteristics of the tested device. CTB is the ratio of the signal level of the target channel to the maximum average level of beat components. Here beat components are distributed around the carrier frequency of the target channel. Intermodulation distortion supports the following two types of CTB:

- CTB: approximate value based on the beat of the middle part of the band.
- CTBE: approximate value based on the beat of the edge part of the band.

The calculation formula is as follows:

$$CTB(dB) = -2(P_i - P_s) + 6 + 10 \log(3N^2/8) + CTB \text{ Offset}$$

$$CTBE(dB) = -2(P_i - P_s) + 6 + 10 \log(N^2/4) + CTB \text{ Offset}$$

Where:

- $P_i$  = power of 3-order intersection point of output end (dBm): OIP3 (Lo|Hi)
- $P_s$ : select according to the composite normalization mode:
- PDBM or PDBMV mode:  $P_s = \text{CompositeNormalizedCTBPower}$
- NumberofCarriers mode:  $P_s = P_{wrMain} (AVG) - 10 \log(N/2)$
- None mode:  $P_s = P_{wrMain} (AVG)$
- CTBOFFset = calculated value of CTB
- $N$  = carrier number.

Note: The CTB deviation and  $N$  value can only be set with the SCPI or COM command.

#### 7.2.1.6 Composite Second Order (CSO) Beat

According to the NCTA standard, the CSO beat is defined as the modulation beat of the target channel signal arising from the second order beat of the tested device (as a result of nonlinear characteristics). It refers to the ratio of the signal level of the target channel and the maximum average level of beat components. Here beat components are distributed around the carrier frequency 0.75MHz and 1.25MHz of the target channel. The CSO beat refers to the ratio of the carrier level of the target channel to the peak level of the second order beat near 0.75MHz and 1.25MHz of the carrier frequency. Intermodulation distortion supports the CSO parameter test. The calculation formula is as follows:

$$CSO(dB) = (P_i - P_s) + 10 \log(N) + CSO \text{ Offset}$$

Where

- $P_i$  = 2-order intermodulation power of output end: OIP (Lo | Hi)
- $P_s$ : one of the following composite normalization modes:
- PDBM or PDBMV mode:  $P_s = \text{CompositeNormalizedCSOPower}$
- NumberofCarriers mode:  $P_s = P_{wrMain} (AVG) - 10 \log(N/2)$
- None mode:  $P_s = P_{wrMain} (AVG)$
- CSOOFFSET = calculated deviation of CSO
- $N$  = number of distortion products

Note: The CSOOFFSET and  $N$  value can only be set with the SCPI or COM command.

#### 7.2.1.7 Intermodulation Distortion

According to the NCTA standard, the signal of the stray channel is modulated to the target channel. Due to nonlinear characteristics of the tested device, intermodulation distortion will be caused. Intermodulation distortion refers to the power ratio of the modulation signal of the target channel to the stray interference modulation signal.

Intermodulation distortion supports the XMOD parameter measurement by the following formula:

$$XMOD = -2(P_i - P_s) + 6dB + 20 \log(N)$$

Where

- $P_i$ =three-order intersection point power of output end: OIP3 (Lo|Hi)
- $P_s$ =carrier power: PwrMain (AVG)
- $N$ =carrier number.

### 7.2.2 Intermodulation Distortion Application

The intermodulation distortion function requires two main sound signals produced in the analyzer. Fig. 7.3 shows the schematic diagram of the four-port vector network analyzer with double sources and internal combiner.

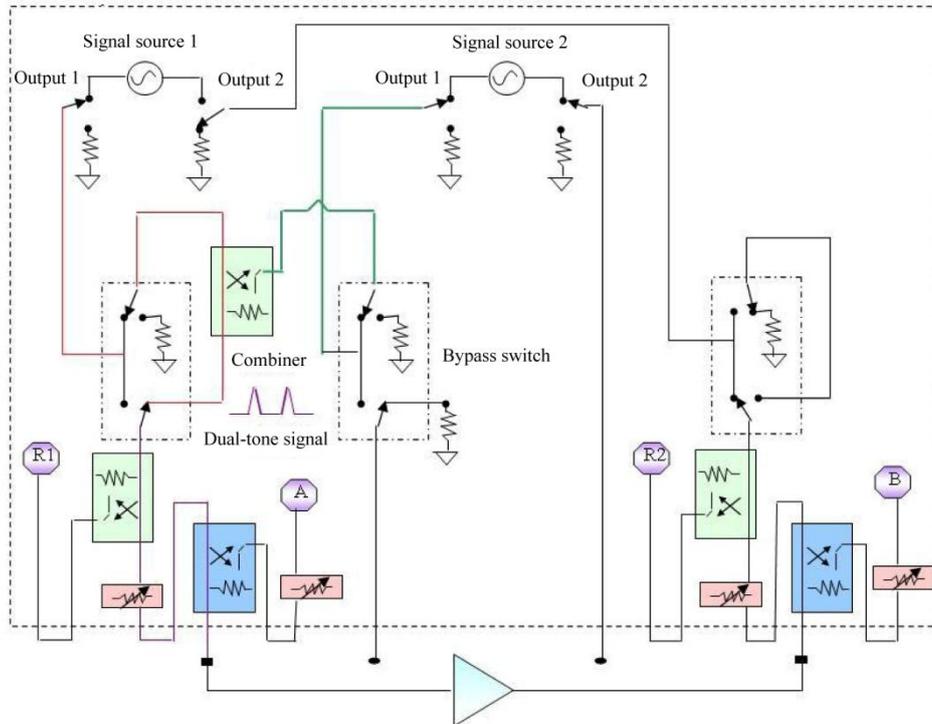


Fig. 7.3 Internal Configuration of Intermodulation Distortion

According to the parameters to be tested and the scanning type, the source and receiver frequency of the analyzer are adjusted automatically through the intermodulation distortion program, to cover the power of all main sound signals and intermodulation sound signals required for measurement. For example, the power of the double-tone signal and the high order and low order of the three-order intermodulation sound should be measured in the three-order intermodulation parameter measurement.

#### 7.2.2.1 Excitation Setting Limitation and Out-of-range Intermodulation Sound

Two double-tone signals produced by the internal source of the network analyzer are required for the intermodulation distortion function. Therefore, the frequency of the double-tone signal should be within the frequency range of the analyzer. In order to prevent the double-tone signal frequency  $f_1$  and  $f_2$  from being out of the upper and lower limit of the analyzer frequency, the parameter settings will be adjusted if necessary.

However, the frequency of the intermodulation products may be lower than that of the network analyzer. For example, if the double-tone signal frequency is 10MHz and 15MHz, only the minimum frequency (10MHz) can be measured, although the measurement parameter IM3Lo (3-order (low) product) can be measurement.

#### 7.2.2.2 Limitations of Measurement Point Number

At most 32,001 points can be measured in one scanning. However, according to the measurement parameters, background measurement may be executed several times by the analyzer. Therefore, the analyzer may require a long time of background measurement before data refreshing if the point number is large.

### 7.3 Intermodulation Distortion Measurement of Amplifier Frequency Scanning

This section includes the following contents:

- Characteristics and limitations .....457

- [Calling of intermodulation distortion measurement interface](#) .....457
- [Setting of intermodulation distortion measurement parameters](#) .....460
- [Simple intermodulation distortion calibration](#) .....462

### 7.3.1 Characteristics and Limitations

#### 7.3.1.1 Characteristics

- The distortion parameter measurement can be set rapidly and easily, and at most 9-order products can be measured.
- The input and output of the tested device can be measured.
- Support various double-tone scanning modes: linear and list frequency scanning (double-tone center frequency) mode, voice span scanning mode, power scanning mode and CW (fixed double-tone frequency) mode.
- The network analyzer is configured with the high-power, high-linearity and low-harmonic signal source for rapid and accurate measurement.
- Support calibration and correction.
- The IF bandwidth for measurement of the main sound signal and intermodulation sound signal can be set separately.

#### 7.3.1.2 Limitations

- The two ports do not support the transformation test. The measurement of the frequency converter will be introduced later.
- The connection between the tested device and the port of the vector network analyzer is limited. Set [Power] to change the port connection.

### 7.3.2 Calling of Intermodulation Distortion Measurement Interface

Menu path: [Response] > [Measurement] > [IMD measurement setting].



Fig. 7.4 Intermodulation Distortion Setting with Mouse

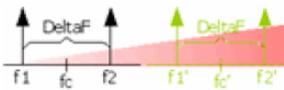
#### 7.3.2.1 Intermodulation Setting of Frequency Scanning

##### 1) Frequency sheet



Fig. 7.5 [Intermodulation distortion frequency setting] Dialog Box

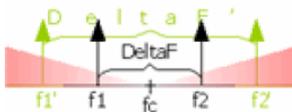
- **Linear scanning  $f_c$  (center frequency)**



The sound span and power of the double-tone signal are fixed. Scan the center frequency ( $f_c$ ) of the double-tone signal. Set the starting and ending value of the center frequency of the signal, or specify the center frequency point and scanning width corresponding to  $f_c$ .

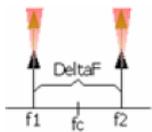
For the center frequency ( $f_c$ ), the receiver can be adjusted to measure all the sound power values.

- **Linear scanning  $\Delta F$  (sound span)**



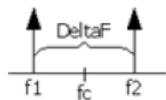
The center frequency and power of the double-tone signal are fixed. The frequency difference (sound span) of the double-tone signal is the starting difference to ending difference.

- **Power sweep**



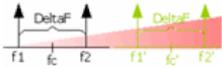
The frequency of the main sound signal is fixed (set through  $f$  and  $f_2$  or  $f_c$  and  $\Delta F$ ). The main sound signal power is scanned from the starting frequency to ending frequency. The power  $f_1$  and  $f_2$  can be set separately (in [Power]) or in a coupled manner.

- **CW**



The frequency and power of the main sound signal are fixed. The analyzer will measure the data of specified points, and X axis shows the number of points.

- **Segment scanning  $f_c$**



The segment table is edited in the same manner as the standard segment, like the center frequency of scanning.

- **intermediate-frequency bandwidth**

The intermediate frequency bandwidth can be set separately in the main sound signal and intermodulation sound measurement. The power of the main sound signal is generally high, so the large intermediate frequency bandwidth can be applied for rapid measurement. The power of the intermodulation sound signal is generally low, so the small IF bandwidth can be applied for accurate measurement. [Reduce intermediate frequency bandwidth at low frequency]: if the frequency is lower than 748MHz, the noise will become poor, especially when the frequency is 10MHz to 45MHz. If this option is selected, the intermediate frequency bandwidth smaller than the set value in the interface will be applied in measurement of the frequency below 748MHz.

## 2) Power sheet



Fig. 7.6 [Intermodulation distortion power setting] Dialog Box

Set the RF power of the intermodulation distortion measurement and the main sound power of frequency scanning.

- **Power ON/off (all channels):** enable or disable the function to measure the RF source power of all channels.
- **DUT input end**
- **Input port:** select Port 1 or 3. The external combiner is required for Port 3.
- **Source attenuation:** set the power attenuation value of Port 1. Otherwise, the input signal power range of the tested device will be affected.
- **Receiver attenuation:** protect Receiver A from burning.
- **DUT output end**
- **Output port:** select Port 2 or 4.
- **Source attenuation:** improve the load matching of the output end of the tested device. If the output signal power is up to 10dBm, the attenuator power may be 0dB. If the output signal power increases by 10dBm, the attenuation value will increase by 10dB accordingly.

- **Receiver attenuation:** set the receiver attenuation value for Port 2. If the input power of the test port of the receiver is about 10dBm, receiver compression may occur. However, if the receiver attenuation value increases, the power will decrease in measurement, and high noise will be produced. In this case, the intermediate frequency bandwidth of intermodulation sound can be decreased to reduce the influence of noise of intermodulation signal.
- **Sound power setting**
- **Coupled double-tone power:** set the f1 power of the double-tone signal, that is, f2 is equal to f1.
- **f1 power:** set the f1 power of the input or output signal of the tested device, within the range from -30dBm to 30dBm. If the coupling power is selected, f1 and f2 can be set at the same time.
- **f2 power:** if the coupling power is not selected, the f2 power of the input or output signal of the tested device can be set, within the range from -30dBm to 30dBm.
- **Starting power, ending power, f1 step power and f2 step power:** after the scanning type is selected, set the starting and ending power of f1 and f2 or set the two signals at the same time in the coupled form manner.

### 7.3.3 Parameter Setting of Intermodulation Distortion Measurement

#### 7.3.3.1 Adding of Intermodulation Distortion Parameters

Menu path: [Track] > [New track].

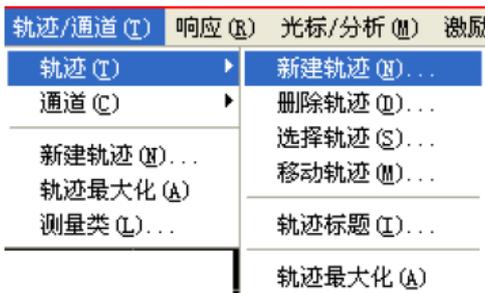


Fig. 7.7 Parameter Setting of Intermodulation Distortion

#### Setting of new track for intermodulation



Fig. 7.8 Parameter Setting of Intermodulation Distortion Measurement

Set intermodulation distortion parameters in the dialog box shown in Fig. 7.8. At most 5 parameters can be set at a time, click [Apply] to create a new track. If the dialog box is not applied, more tracks can be selected. The added tracks and windows should conform to the analyzer limitation requirements.

### 7.3.3.2 Parameter Setting of Intermodulation Distortion

#### 1) Type

- **Sound power:** measure the absolute power of the specified sound signal.
- **IMD relative power:** measure the ratio of the f1 to f2 power of the intermodulation sound and main sound.
- **IIP power:** calculate the theoretical intersection point power of the input end of the tested device, i.e. theoretical power corresponding to the same intermodulation sound and main sound power of the orders to be calculated.
- **OIP power:** calculate the theoretical intersection point power of the output end of the tested device, i.e. theoretical power corresponding to the same intermodulation sound and main sound power of the orders to be calculated.
- **CTBE:** composite triple beat distortion based on edge band, for three orders and output end.
- **CTB:** composite triple beat distortion based on middle band, for three orders and output end.
- **CSO:** composite second order beat distortion, for two orders and output end.
- **XMOD:** three-order intermodulation distortion of output end.
- **Sound gain:** measure the sound signal power and calculate the ratio of the signal power of the output end to input end. The frequency of the input signal is different from that of the output signal.

#### 2) Sound signal selection

Select the sound signal to be measured and displayed.

- **High order:** measure and display intermodulation signal with the frequency higher than the main sound frequency;
- **Low order:** measure and display intermodulation signal with the frequency lower than the main sound frequency;
- **Average:** measure and display average value of the intermodulation signal of main sound signals from the high-order and low-order end.
- **Maximum:** measure and display the maximum value of the intermodulation signal of main sound signals from the high-order and low-order end.
- **Minimum:** measure and display the minimum value of the intermodulation signal of main sound signals from the high-order and low-order end.

### Attention

#### Precautions of two-order intermodulation

- The two-order intermodulation sound may be beyond the frequency range of the network analyzer. In this case, the upper limit and lower limit of the frequency of the analyzer will be measured.
- If the high-frequency signal or lower-frequency signal is beyond the frequency range of the network analyzer, the average value will not be measured.
- The average value will not be measured in the two-order intermodulation sound, as the frequency difference of the high-order and low-order intermodulation sound is large.
- Select [Include two-order intermodulation] in the [Calibration] dialog box to calibrate 2-order sound.

### 3) Order and measurement port selection

- Select the orders of intermodulation products in the dialog box, including 1, 2, 3, 5, 7 and 9. If “1” is selected, the main sound signal will be measured, and the parameter name is ended with the “Main” marker; otherwise, the order number should be added behind the parameter name.
- Measurement can be done at the input end or output end. If the input end is selected, add “In” behind the parameter name, such as PwrMainIn. If the output end is measured, there is no additional marker behind the parameter name, such as PwrMain. The input end is tested with the reference receiver, and the output end is tested with the measurement receiver.

#### 7.3.4 Simple Intermodulation Distortion Calibration

##### 7.3.4.1 Overview

1. The source power calibration and receiver calibration interface is used in simple intermodulation distortion calibration.

2. The intermodulation sound order can be selected in calibration.

3. Port 1 is connected to the power meter to calibrate the reference receiver and measurement receiver.

- The source and receiver frequency can be calculated with the vector network analyzer, including main signals and all intermodulation signals.
- Port 1 is connected to the power meter. The reference receiver R1 can be calibrated in source and receiver calibration.
- The reference receiver R1 is used to calibrate the main signal source. At first, calibrate the low-frequency power of Source 1 and then calibrate the high-frequency power of Source 2. Source 1 and 2 should be disconnected to ensure impedance matching.
- Directly connect Port 1 and 2 and correct Receiver B by means of calibration.

### Attention

If the main sound signals frequency changes, calibration may fail.

Changes of the main sound signal frequency may result in failure of calibration. The state change may occur to the starting/ending/center frequency, frequency span, scanning point number, scanning type, etc.

##### 7.3.4.2 Selection of Product Signal

- **Maximum calibration order:** select the intermodulation product which can be measured (5 orders at most). Low-frequency and high-frequency signal and intermodulation products of smaller odd orders can be calibrated. For example, the main signals and high-order and low-order products (such as 3-order and 5-order products) can be calibrated in 5-order intermodulation measurement.
- **Include 2-order calibration:** calibrate 2-order products, the frequency of which is always subject to large deviation from the main signal frequency.

Fig. 7.9 Intermodulation Distortion Calibration Process

- **Power Level:** execute the power calibration value of Port 1. As the standard calibration power of the power meter is 0dBm, 0dBm is generally selected as the power of source power calibration. If one component is added between the source and calibration reference plane, the calibration power should be adjusted to keep the power of the calibration port of the power meter at 0dBm.

The pages of other calibration steps are the same as those of source calibration and receiver calibration, so they are

not detailed here.

### 7.3.4.3 Saving of Intermodulation Distortion Power Data of Frequency Scanning

Only the logarithmic power amplitude in intermodulation distortion measurement data of frequency scanning can be saved in the “\*.csv” file. The file can be read with the Microsoft Excel program, and the data of last scanning will be saved in the “\*.csv” file.

**Menu path:** [Save] > [Save data as]. Click “File type=IMD scanning data (\*.csv)”.

## Attention

### Precautions for data saving

- Save the power values of current parameters, including the power of the input end and output end. For the average, maximum and minimum type, all high-order and low-order data will be saved: UTAvg|OUTLo|OUTHi|INAv|INLo|INHi.
- All the displayed intermodulation products will be saved.
- Only the power values of intermodulation products are saved, and the calculated values will not be saved.
- If the calibration function is enabled before saving, all the data will be calibrated. At the same time, original data will be saved.

## 7.4 Intermodulation Spectrum Measurement of Amplifier Frequency Scanning

This section mainly introduces the intermodulation spectrum measurement, which can be done with frequency scanning intermodulation spectrum measurement at the same time. As the two measurements are greatly different from each other, intermodulation spectrum measurement is usually done separately. This section introduces the intermodulation spectrum measurement in the following parts.

- [Concept of intermodulation spectrum](#) .....463
- [Creating of intermodulation spectrum channel](#) .....464
- [Parameters of intermodulation spectrum track](#) .....464
- [\[Intermodulation spectrum setting\] dialog box](#) .....465

### 7.4.1 Concept of Intermodulation Spectrum

The intermodulation spectrum channel of the vector network analyzer is configured with one traditional spectrum analyzer interface to measure the intermodulation distortion of the tested device. The intermodulation spectrum channel interface is different from the frequency scanning intermodulation distortion channel. As f1 and f2 of the main signal are fixed in intermodulation spectrum measurement, the receiver can receive the output signal of the tested device in the frequency scanning mode, and the display interface is shown in Fig. 7.10.

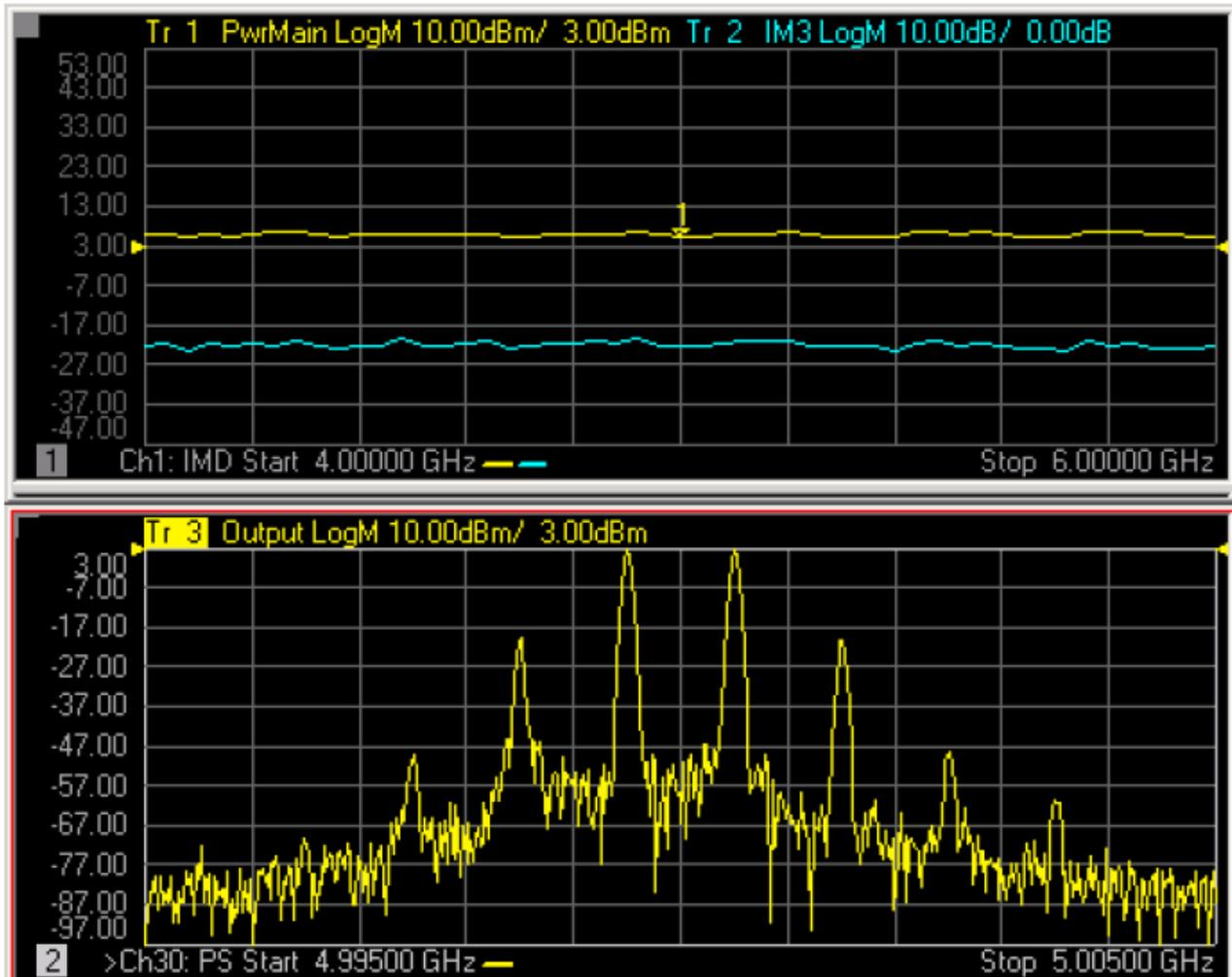


Fig. 7.10 Frequency Scanning Intermodulation Distortion Measurement Interface (upper figure) Intermodulation Spectrum Measurement Interface (lower figure)

The vector network analyzer is different from the typical spectrum analyzer in that one signal source is set in the analyzer and no signal source is set in the spectrum analyzer. Therefore, the vector network analyzer can work in the intermodulation spectrum channel or frequency scanning intermodulation distortion channel. Main signals of different frequencies ( $f_1$  and  $f_2$ ) can be generated by setting the signal source. Setting items mainly include the frequency and power of main signals.

### Receiver setting

The intermodulation spectrum receiver can be set to work only in the intermodulation spectrum channel. Setting items includes the intermodulation products of different orders (depending on the frequency range and center frequency) and bandwidth.

The number of measurement channel points can be changed by selecting different bandwidths. The point number decreases with the bandwidth increasing. The corresponding relationship is as follows:

$$N = (\text{Span}/\text{ResBW}) * 3$$

Each data point can be measured several times in the intermodulation spectrum channel to filter unnecessary image interference (produced inside the vector network analyzer). Therefore, the high-purity signal capture path will be provided, and no false response will be generated in measurement.

### 7.4.2 Creating of Intermodulation Spectrum Channel

The intermodulation spectrum channel can be created independently or together with the existing frequency scanning intermodulation distortion measurement channel which has been set.

### Creating of Independent Spectrum Measurement Channel

1. Front panel of the network analyzer: click [Measurement] > [Measurement type].
2. Select the **spectrum measurement** type and click **OK** (delete the existing measurement channel), or [New channel] (create a new measurement channel).

#### 7.4.3 Intermodulation Spectrum Track Parameters

##### Add intermodulation spectrum track

Menu path: [Track] > [New track].

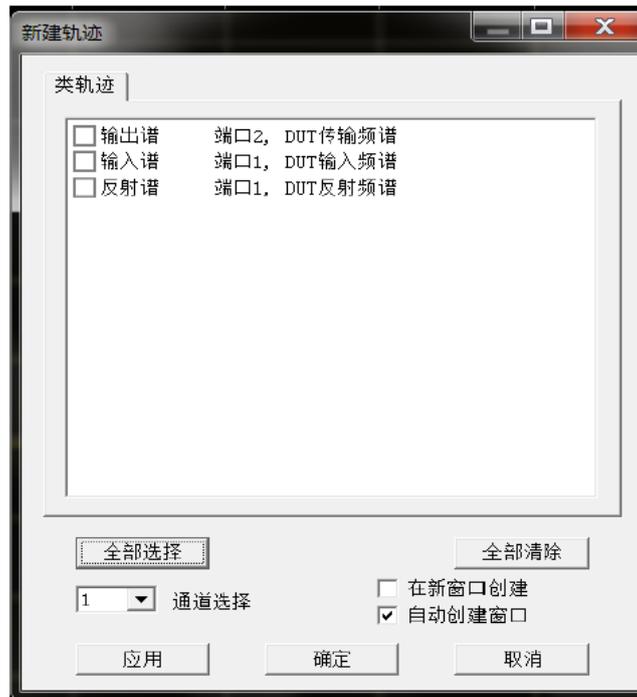


Fig. 7.11 [Intermodulation spectrum track parameter selection] Dialog Box

**Output spectrum:** observe the output signal of the tested device and the input signal of Port 2 (Receiver B) of the network analyzer.

**Input spectrum:** observe the input signal (Receiver R1) of the tested device. This function is used to measure the frequency of intermodulation products so as to determine the power of the false signal of the tested device.

**Reflection spectrum:** observe the reflection signal of the input end of the tested device, measured by Port 1 (Receiver A) of the network analyzer.

#### 7.4.4 [Intermodulation spectrum setting] Dialog Box

This section introduces **how to open the [Intermodulation spectrum setting] dialog box**. The vector network analyzer is configured with the method of quick access.

##### 7.4.4.1 Use of Hard/Soft Buttons of Front Panel

1. Click [Scanning].
2. Then click [Spectrum setting].

##### 7.4.4.2 Mouse Operation Menu

1. Click [Excitation].
2. Then click [Frequency].
3. Select [Spectrum setting].

- **Frequency bar**

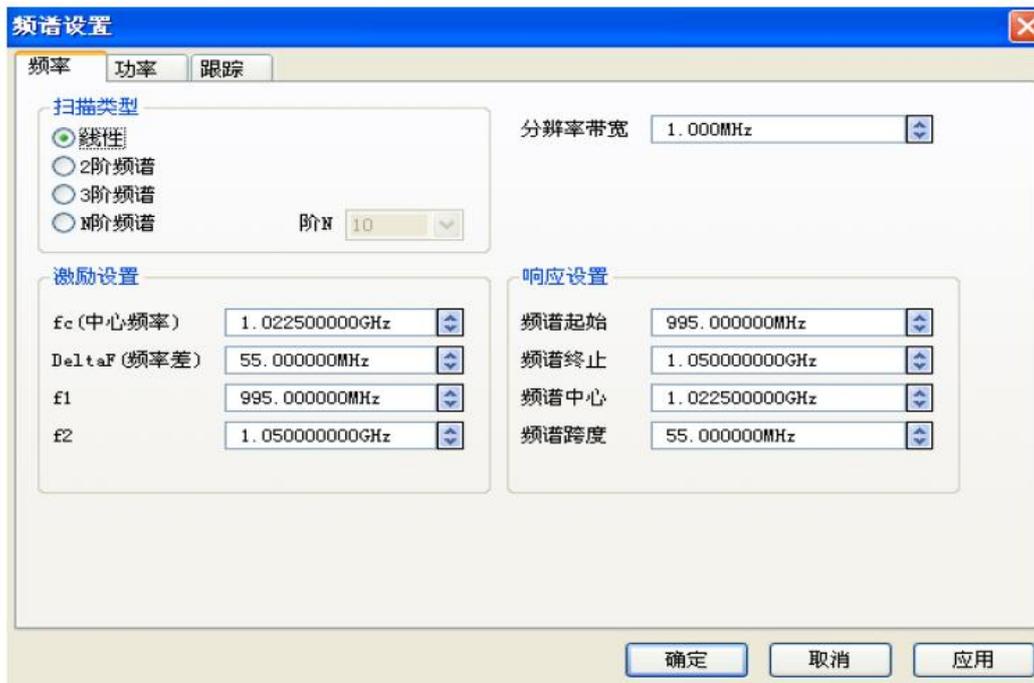


Fig. 7.12 Frequency Bar Menu for Spectrum Setting

## Attention

**Number of intermodulation spectrum channel points=3\*spectrum span/resolution bandwidth.  
Transformation cannot be done directly.**

1. **Scanning type:** the intermodulation spectrum receiver is configured with various modes to display any frequency range and distortion products of different orders.

- **Linearity:** the starting/ending frequency, center frequency and span of the receiver can be freely set at the given value of f1 and f2.
- **2-order spectrum:** in order to facilitation the observation of the high-frequency 2-order harmonics and surrounding spectrum, the settings coupled with the excitation f1 and f2 are set within the frequency range of the receiver. Center frequency= $f_1+f_2$ , and span= $3*(f_2-f_1)$ .
- **3-order spectrum:** in order to facilitation the observation of the 3-order harmonics and surrounding spectrum, the settings coupled with the excitation f1 and f2 are set within the frequency range of the receiver. Center frequency= $(f_1-f_2)/2$ , and span= $4*(f_2-f_1)$ .
- **N-order spectrum:** in order to facilitation the observation of the N-order main products, the settings coupled with the excitation f1 and f2 are set within the frequency range of the receiver. Center frequency= $(f_1-f_2)/2$ , and span= $N*(f_2-f_1)$ .

2. **Resolution bandwidth:** the Gaussian filter instead of the standard intermediate frequency filter is used in the intermodulation spectrum channel to improve the functions similar to those of the traditional spectrum analyzer. Bandwidth options: 3MHz, 1MHz, 600kHz, 300kHz, 150kHz, 100kHz and 60kHz.

3. **Excitation setting:** this option can be used to set the frequency of the main sound signal when the tracking function is shut down.

- **fc (center frequency)**  $= (f_1+f_2)/2$ ;
- **DeltaF (frequency difference)**  $= (f_2-f_1)$ ;
- **f1**=low frequency of main sound signal;
- **f2**=high frequency of main sound signal.

4. **Response setting:** the frequency scanning range of the receiver can be set by setting the starting/ending frequency and center frequency/span in the linear frequency scanning mode.

- **Starting spectrum**=the first frequency point of power spectrum scanning;
- **Ending spectrum**=the last frequency point of power spectrum scanning;
- **Center spectrum**=(starting frequency+ending frequency)/2;
- **Spectrum span**=(ending spectrum-starting spectrum).
- **Power bar**



Fig. 7.13 Power Bar of Spectrum Setting

- **Track bar**

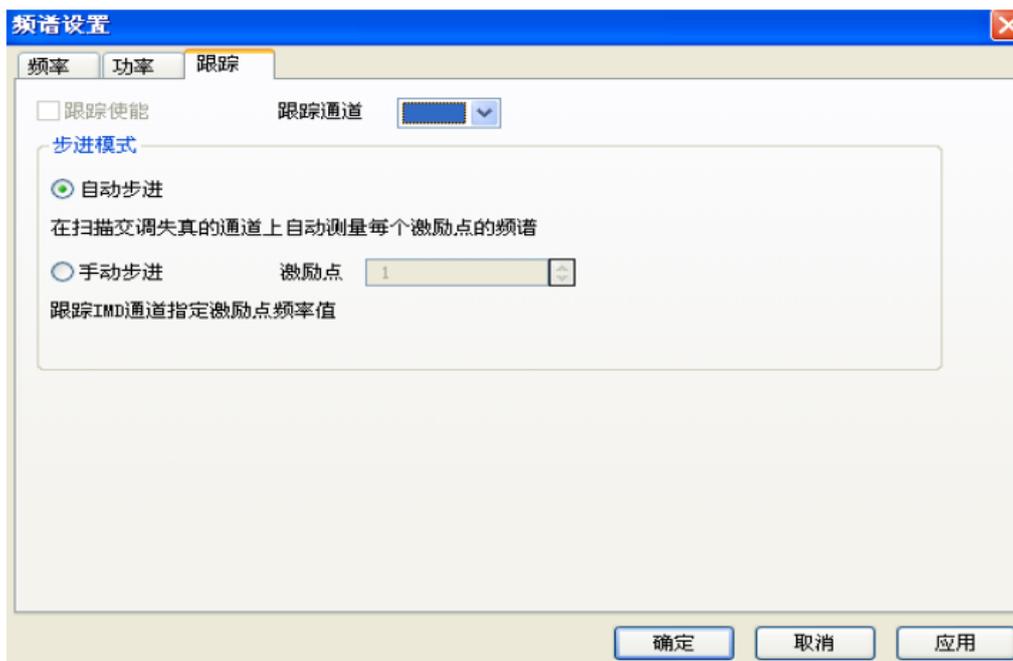


Fig. 7.14 Track Bar of Spectrum Setting

This dialog box is applied to the cases with the intermodulation distortion measurement channel, i.e. coexistence of two channels.

1. **Enable tracking:** if this option is selected, the excitation frequency setting is invalid, and all the settings of the frequency scanning intermodulation distortion channel will be copied into the intermodulation spectrum channel, such as the frequency, power, attenuator setting and calibration settings.

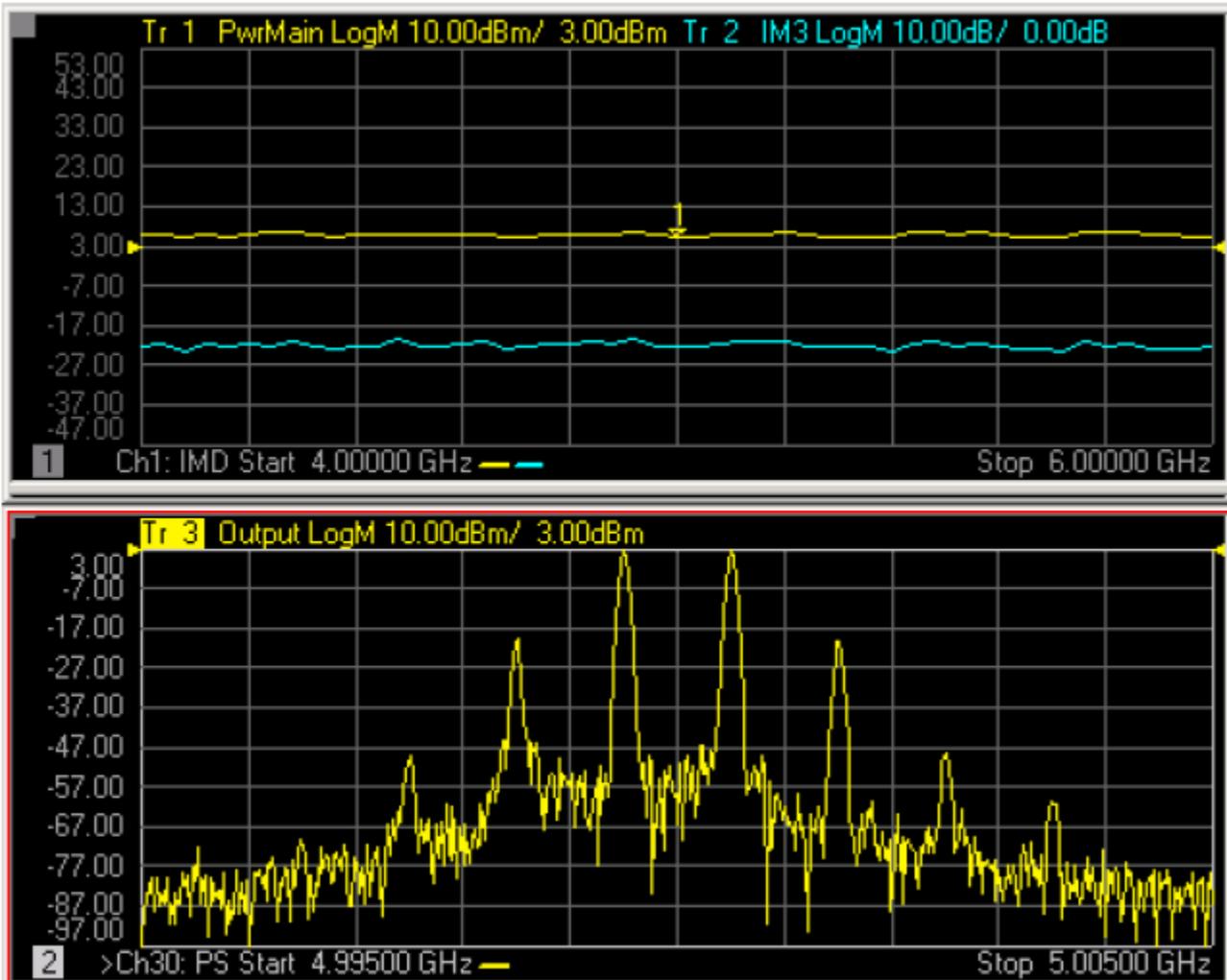


Fig. 7.15 Intermodulation Spectrum Track (lower figure) Frequency Scanning Intermodulation Distortion Track (upper figure)

- The upper figure of Fig. 7.15 shows the intermodulation distortion measurement window, in which the scanning range is 4GHz-6GHz, the sound span is fixed, and the center frequency of the double-tone sound is 5GHz.
  - The lower figure of Fig. 7.15 shows the intermodulation measurement window, in which the center frequency is the same as that in the upper figure, i.e. 5GHz. But the frequency span is smaller ( $\pm 500$ KHz). The receiver settings of the intermodulation spectrum channel are mainly used to measure the main sound signals and three-order, five-order and seven-order intermodulation products.
2. **Step mode:** refer to the mode for intermodulation distortion channel tracking of the digital intermodulation spectrum measurement, when the tracking function is enabled.
- **Automatic step:** automatically track the frequency of the current data point of the IMD channel at the double-tone signal frequency of intermodulation spectrum measurement. After each spectrum measurement, the frequency of the double-tone signal will be automatically set as the frequency of next data point of the IMD channel.

- **Manual step:** if this option is selected, the double-tone frequency of intermodulation spectrum measurement will be the same as the frequency of the specified data point of the IMD channel (the number of points is specified by the user).