# Ceyear

3656 Series
Vector Network Analyzer

User Manual

China Electronic Technology Instruments Co..Ltd(CETI)

August 2018

PREFACE

Thank you for using 3656 series vector network analyzer produced by China Electronics Technology Instruments Co., Ltd (CETI) adhering to the ISO9000 quality standards. Please carefully read this manual for your convenience. We are devoted to providing for you high-quality products and first-class after-sales service with your most concerns and demands in mind. Following the consistent tenet of "High Quality and Considerable Service", we are committed to provide for our customers satisfactory products and services, and sincerely hope that we will bring convenience to your work. For any questions, please contact us:

Tel	**+86-0532-86896691**
Website	**www.ceyear.com**
Email	**sales@ceyear.com**
Address	**No. 98 Xiangjiang Road, Qingdao City,China**
Zip	**266555**

This manual introduces the applications, performance & features, basic principle, operation method, and maintenance and precautions of the 3656 series vector network analyzer, which is intended to help you be familiar with and master the operation methods and key points of the controller as soon as possible. Please carefully read this manual to use this product in a better way and create higher economic benefits.

However, due to time constraints and limitations of the author, the manual may be subject to errors or deficiencies. We sincerely welcome your corrections! We apologize for any inconvenience caused by our mistake in our work.

NOTE：

This manual is the third version of the 3656 Series Vector Network Analyzer User Manual, with the version number of A.3.

This manual may be subject to change without notice. China Electronics Technology Instruments Co., Ltd reserves right of final interpretation of the content and the terms of this manual.

This manual is the property of CETI. Without our permission, any organizations or individuals shall neither alter/temper nor duplicate/transmit this manual for profits; otherwise, CETI reserves the right to pursue any liabilities therefrom.

Editor

August, 2018

CONTENTS

Chapter I   Overview

This chapter briefly introduces the characteristics and application notes of 3656 Series Vector Network Analyzer, including the following:

■   Product overview

■   Notes

Section 1   Product Overview

3656 Series Vector Network Analyzer is the new generation of economic products promoted upon the experience in research and manufacture of vector network Analyzer for years. In terms of hardware, it adopts new technologies, which has greatly improved the key performance indicators of complete machine; in terms of software, it adopts embedded computers with Pentium chips and Windows operating system, which has greatly improved the connectivity and usability of complete machine.

3656 Series Vector Network Analyzer has powerful functions such as time domain and frequency domain, and provide multiple display in formats such as logarithm magnitude, linear magnitude, standing-wave ratio (SWR), phase, group delay, Smith circle diagram Smith chart and polar coordinates as well as multiple calibrations including the calibration of response, single port, response isolation and enhanced response, the calibration of full double ports and the electric calibration. The color LCD display in multiple windows and channels and a number of interfaces such as USB interface, LAN network port, GP-IB interface and VGA interface are also provided.

The 3656 Series Vector Network Analyzer can measure quickly and accurately the characteristics of the tested part DUT in respect of magnitude, phase and group delay of S parameters. They have a high-efficiency and powerful error correction capability and are extensively applied in military industry and civil fields such as element, unit component, radar, aerospace, electronic interference & countermeasure, telecommunication, radio and TV.

1   Main features

- 64 independent Measure channels for quick execution of complicated test programs
- 32 display windows and 8 trajectory trace curves displayed simultaneously in each window
- Time domain analysis
- Interfaces such as LAN, USB, GP-IB and VGA display
- Multiple display formats such as magnitude, phase, group delay, Smith circle diagramchart, polar coordinates and standing-wave ratios
- Windows XP Operation System

●   10.4 true-color and high-resolution LCD providing simultaneous display in multiple windows and channels

1.1   Multi-window and multichannel Measure display

3656 Series Vector Network Analyzer provides up to 32 windows and 64 Measure channels, which can measure multiple parameters of DUT, without repeat calls of instrument state, so as to speed up the test process.

Fig. 1-1   Multi-window and Multichannel Measure Display

1.2   Wide dynamic range

The wide dynamic range of 3656 Series Vector Network Analyzer can measure strong suppression filter precisely.
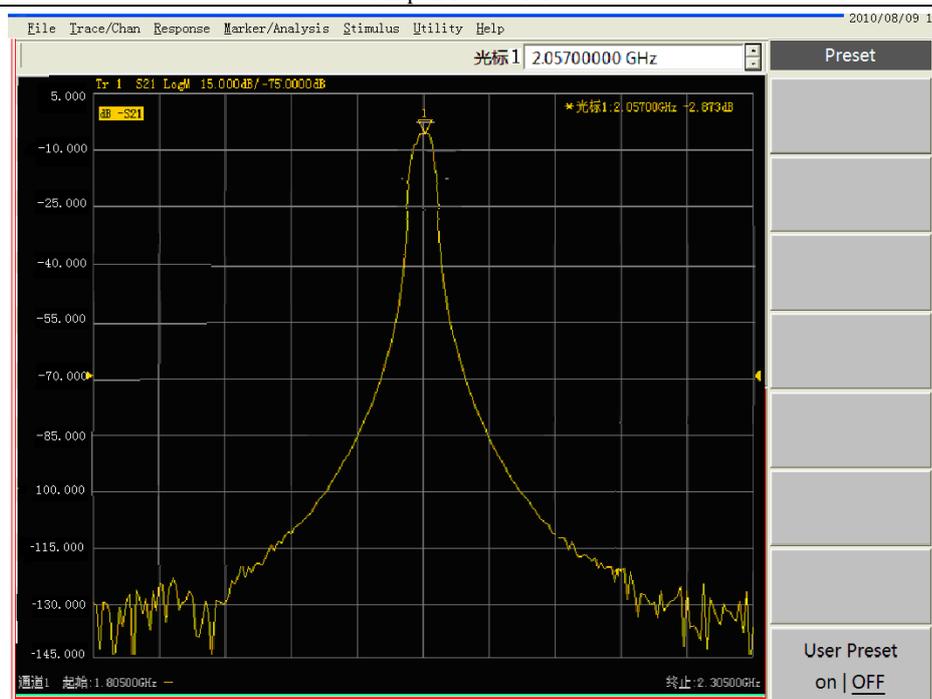
Fig. 1-2   Measure Result of Strong Suppression Filter

1.3   Automated test

A lot of time can be saved during automated test, and the cost of test can be reduced efficiently by using flexible automated environment:

● Control Vector Network Analyzer by SCPI command to complete automated test.

● Implement the code directly through LAN or GP-IB interface from Vector Network Analyzer or an external PC.

1.4   Data storage and communication

3656 Series integrated Vector Network Analyzer is built-in hard-disk with high capacity and has LAN, USB and other communication functions. Various test traces and results can be kept in many ways and transmitted mutually with a computer.

1.5   GP-IB interface

3656 Series Vector Network Analyzer provides a 24-pin D type female GP-IB connector, which meets IEEE-488 standard and is used for sending and receiving GP-IB/SCPI command.

1.6   USB interface

3656 Series Vector Network Analyzer provides 4 USB interfaces, which can be connected conveniently with keyboard, mouse, printer, electronic calibration kit and other peripherals with USB interfaces.

1.7   Print function

3656 Series Vector Network Analyzer provides powerful print functions, with which the measured and displayed contents can be output and printed through a printer to the specified file. The printer can be a local or network printer and the type can be LAN or USB interface; the Measure printing can be realized as long as the printer is added in Windows XP operating system.

2   Typical Application Examples

2.1   Application of filter Measure

Vector network analyzer is a main measuring instrument for filter, and the filter automatic statistical function unavailable in the previous vector networks has been added in this Series of vector network in particular for this Measure category, where loss, ripple wave, suppression and other main indexes of filter can be directly read from the screen; in addition, auto search function of bandpass filter is also availabe, which increases Measure speed greatly.
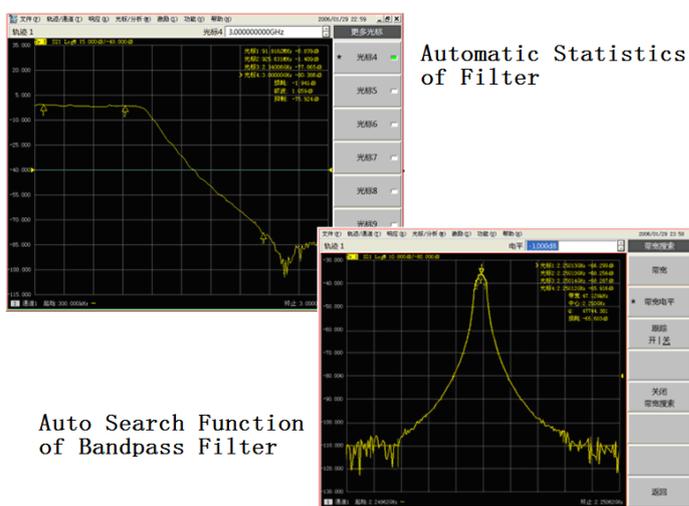
Fig. 1-3   Application of Filter Measure

2.2   Application of time domain Measure

Cable length and fault location can be tested by using the time domain function of vector network analyzer.
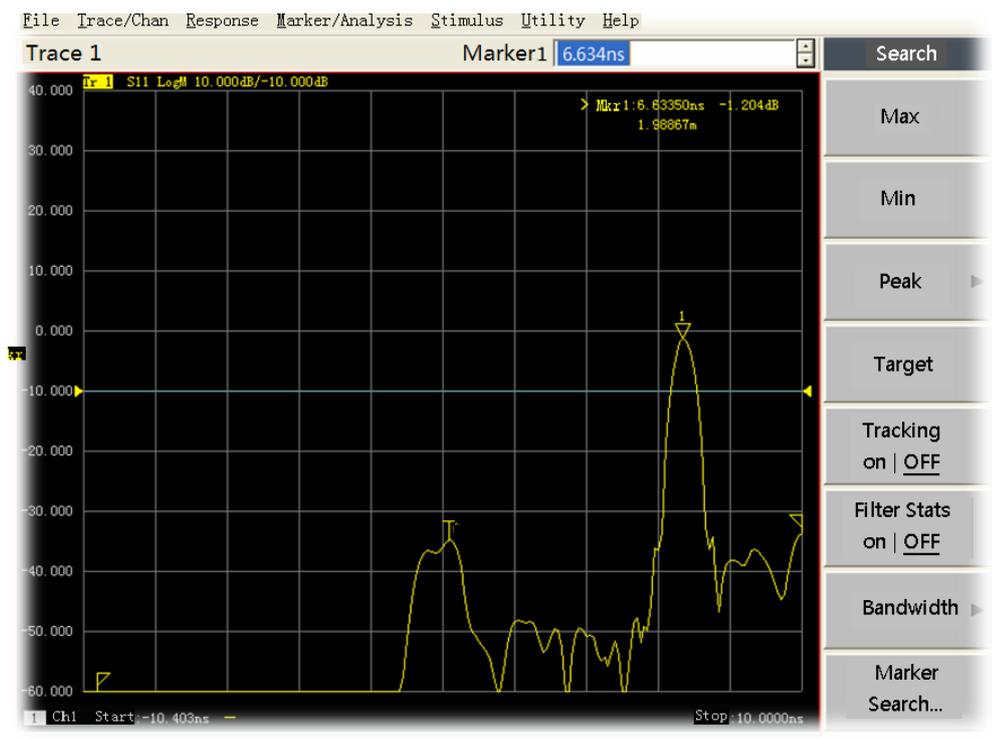
Fig. 1-4   Application of Time Domain Measure

Section 2   Notes

This section lists the notes during the use of 3656 Series Vector Network Analyzer. Users shall read this section carefully before operation to prevent damages to the Analyzer due to improper use.

1   Powering-on of Analyzer

a)   Before powering-on, please make sure that the external power supply of the Analyzer shall meet the following requirements: 220V(±10%), 50Hz(±5%); or 110V(±10%), 60Hz(±5%); Output power >150W.

b)   Power on the Analyzer by using a three-core power outlet with protective grounding wire, and confirm that the grounding wire has been grounded reliably.

c)   Power on the Analyzer by using power cord equipped with the instrument or that of the same type.

d)   Take strict cations against ESD during usage, ESD voltage over 500V at input port may damage the internal circuit of the Analyzer; to ensure the personal safety of users, anti-static accessories must include at least 1MΩ resistance isolated from the ground.

Refer to Section 2, Chapter II "Notes before Powering-on" for details about powering-on of the Analyzer.

2   Power the Analyzer ON and OFF

a)   Analyzer shall be operated at an ambient temperature range of 0℃~40℃, and the working environment shall be kept well ventilated; Forced air cooling measures shall be taken when total thermal power in cabinet is greater than 800W.

b)   Power cord of the Analyzer must be unplugged when the external power supply needs to be cut off completely from the Analyzer.

c)   Don't power the Analyzer off through the power switch on rear panel.

Refer to Section 3, Chapter II "Power the Analyzer ON and OFF" for details about the power on and power off of the Analyzer.

3   Operation of Analyzer

a)   Signal entered to Analyzer port shall not exceed its tolerance level, damage limit level of the Analyzer port: +26 dBm RF power; entry over the above range may burn down the Analyzer.

b)   Carry out inspection and maintenance for the connector and use the correct connection method for the connector.

c)   Deletion of ex-factory data files on the Analyzer, change of BIOS settings of the Analyzer and self-installation of any other third party software on the Analyzer are all prohibited, because these actions may lead to abnormal operation of the Analyzer, even may burn out hardware circuit.

d)   When files are transmitted through USB and network interface of the Analyzer, the safety of the

files and file storage medium shall be ensured to prevent the Analyzer from being infected with virus.

e) To ensure Measure accuracy, the Analyzer shall be warned up for more than 30 minutes before the Measure.

f)   It is prohibited to place heavy objects on the Analyzer, otherwise the instrument may be damaged due to extrusion.

Please refer to "Connector Maintenance and Measure Connection" in Chapter III for details about the maintenance and connection of the connector.

Section 3   Safety Protection

1   Instrument Safety

1.1   Notes for instrument safety

a)   Please use the designated packing box during instrument transportation to avoid falling off or fierce impact that causes damage to the instrument in handling;

b)   Check whether the power fuse on the instrument is normal, otherwise the instrument will be damaged after energizing!

c)   Please use the 220V AC three-core stabilized voltage supply as the power supply to the instrument. Avoid interference by the peak pulse of high-power that causes damage to the hardware inside the instrument;

d)   Make sure that the power supply is well grounded. Bad or mistaken grounding may result in damage to the instrument;

e)   During operation of the instrument and equipment, anti-static measures, such as, wearing an antistatic wrist strap shall be taken to prevent ESD damage to the instrument;

f)   Injection of DC signal at the output port of the instrument shall be prohibited and reverse power of the signal shall be not more than 0.5 W, otherwise, the instrument will be damaged;

g)   If the instrument is powered by batteries or has internal batteries, batteries of the same type or recommended equivalent type shall be used for replacement, otherwise, there is a risk of explosion.

h)   The instrument shall not be operated in humid, inflammable or explosive environment.

1.2   Safety tips for other devices

a)   When connecting the instrument, please first check the instrument working status and close the RF output to prevent large output power signal from damaging DUT;

b)   When the instrument is powered on or carrying out self-test, power output may be high and please disconnect all external devices! When self-test calibration is completed and if the instrument is in unknown state, reset or restart the instrument before connecting to DUT;

c)   When instrument like the signal generator is used and when the signal generator displays "instability amplitude" , the user is prompted that the signal generator output power is instable at this time; turn off the RF switch or power switch, disconnect all external devices to avoid possible impact on DUT.

2   Notes to Personnel Safety & Protection

a)   Please select suitable handling tools to handle the instrument and packing box, and they shall be moved by at least two people. Place them gently to avoid falling off of the instrument that causes personal injury.

b)   Make sure that the power supply is well grounded. Bad or mistaken grounding may cause personal injury.

c)   If the instrument needs to be wiped, please carry out the operation with power-off to prevent the risk of electric shock, the instrument appearance can be wiped with dry or slightly damp soft cloth, do not try to clean inside of the instrument.

d)   There is potential danger of microwave radiation when microwave instruments operate in high-power status, so appropriate radiation protection measures shall be taken.

e)   If damage to the product is suspected, please send qualified maintenance personnel to carry out inspection; do not arbitrarily open the cap to carry out operation.

3   Explanation of Terms in the Manual

⚠ !	**NOTE:**	"NOTE" prompts important operation tips or cautions, etc.
⚠	**WARNING:**	"WARNING" prompts such cases as dangerous voltage, personal injury or instrument damage and loss of important data, etc.
☞	**STATEMENT:**	"STATEMENT" gives instructions or prompts.

Section 4   Environmental Protection

1   Treatment of Packing Box

We promise that the product pacage is harmless waste, please keep the packing boxes and pads in good condition for future transportation; as an alternative, the generated package can also be treated according to local environmental regulations.

2   Scrap Treatment

a)   Parts replaced during maintenance and upgrade of the instrument shall be recovered and treated by China Electronic Technology Instruments Co..Ltd(CETI); arbitrary disposal of the scrapped instrument shall be prohibited; please transfer it to China Electronic Technology Instruments Co..Ltd(CETI) or to qualified professional recovery unit for recycling and treatment.

b)   If batteries are used inside the instrument, the batteries replaced down shall not be arbitrarily discarded and shall be recycled separately as chemical waste!

Unless otherwise specified, the above operations shall be carried out according to national "Regulations for the Administration of the Recovery and Disposal of Waste Electric and Electronic Products" and local environmental laws and regulations.

Part I   Operation Instruction

Chapter II　Must-read

Welcome to use 3656 Series Vector Network Analyzer produced by China Electronic Technology Instruments Co..Ltd(CETI). Before operation, please read this chapter carefully to prevent damages to the Analyzer or occurrence of unexpected accidents caused by improper operation; if there is any problem, please contact us promptly and we will solve them as soon as possible. This chapter includes the following content:

- Open-case inspection
- Notes before powering-on
- Power Analyzer on and off
- System recovery of Analyzer

Section 1　Open-case Inspection

Packing boxes shall be checked and objects in the boxes shall be inspected according to the following steps:

a)　Check whether the packing boxes are damaged.

b)　Take out instruments from the packing boxes to check whether they are damaged during transportation.

c)　Verify whether all accessories and documents has been assorted with the instruments against "Packing List".

If packing boxes or damping materials in the boxes are damaged, please first check whether instruments and accessories in the boxes are complete, and then carry out electric performance test for Analyzer.

The requisite accessories and documents in packing boxes include:

- A power cord
- A USB interface mouse
- One "3656 Series Vector Network Analyzer User Manual"
- A "Packing List".

If the instruments are damaged during transportation or the accessories are incomplete, please notify us. We will carry out maintenance or exchange as you required as soon as possible; please keep transport materials for future transport packing.

Section 2   Notes before Powering-on

1   Power Supply Requirements

3656 Series Vector Network Analyzer uses 220V or 110V AC, and the requirements of the Analyzer on external power supply during normal operation are listed in the following table:

Table 2-1   Power Supply Requirements

Power Supply Parameters	Applicable Range	
Output Voltage Output Power Working Frequency	AC220/240V >150W 50Hz	AC100/115V >150W 50/60Hz

To prevent or reduce the damage to Analyzer hardware due to mutual disturbance generated by different equipments through power supply, especially the peak pulse disturbance generated by high-power equipment, 220V or 110V AC stabilized voltage supply is preferred to supply power for the Analyzer.

2   Power Inspection

3656 Series Vector Network Analyzer adopts three-core power cord interface in compliance with international safety standards. Before powering-on of the Analyzer, make sure that protective grounding wire of the power socket has been grounded reliably, and then plug the power cord plug into a standard three-core socket. Ground-free or improper ground could damage the instrument, and even cause personal injury, so do not use the power cord without protective grounding.

3   Selection of Power Cord

The Analyzer uses three-core power cord in compliance with international safety standards. When power cord is plugged into suitable power socket with protective ground, the shell of the instrument will be grounded through the power cord. It's recommended to use power cord equipped with the instrument; when replacing the power cord, it's best to use the one of the same type as that equipped with the instrument.

⚠	**WARNING:**	**Before powering-on of the Analyzer, please confirm whether the power supply meets the requirements in Table 2-1.** **Improper or incorrect grounding could damage the instrument, and even cause personal injury. Before powering-on and starting-up of the Analyzer, make sure that it can be grounded reliably through power cord.** **The switch on front panel of the Analyzer is only a standby switch. The Analyzer can be ensured to be completely separated from the external power supply only when the power cord is removed.**

Before initial powering-on, please refer to Section 3 of this chapter "Power the Analyzer On and Off".

4 ESD Protection

ESD protection is often an overlooked issue. The discharge of static accumulated on human body could easily damage the Analyzer internal sensitive circuit elements and greatly reduce the reliability of the instrument; Even the discharge of undetected static may also cause permanent damage to the device. Therefore, the following ESD protection measures shall be taken as far as possible:

a) Test on worktable with a grounded and conductive table mat.

b) When accessing devices or accessories and carrying out test connection, please wear an anti-static wrist strap, which shall be connected with the table mat, and the resistance of the series connection between the table mat and the ground shall at least be 1MΩ.

c) When working in areas with conductive ground, please wear an anti-static wrist strap, even if the conductivity of the ground can not be determined.

d) Before cleaning and checking ESD sensitive devices and Analyzer Measure port or carrying out connections, please make yourself grounded, which can be realized by seizing the grounded instrument Measure port or the shell of the cable connector to be tested.

e) Before the cable is connected to the Analyzer Measure port or ESD sensitive devices, the center conductor of the cable must be grounded first, and the Measure connection can be carried out by the following steps:

1) Connect a short circuiter to one end of the cable to allow the center conductor and outer conductor of the cable for short-circuit.

2) When wearing an anti-static wrist strap, please grasp the shell of cable connector.

3) When the connection of the other end of the cable is completed, remove the short circuiter.

Section 3   Power the Analyzer On and Off

1   Power the Analyzer On

a)   Connect Analyzer and AC power by using a three-core power cord meeting the requirements, and turn on the power switch on rear panel of the Analyzer.

b)   Press 【On/Standby】 key in left bottom corner of the front panel, but don't press or hold it long.

c)   When the indicator light on front panel turns green, the Analyzer will need about 40 seconds to start up Windows XP system and implement a series of self-test and adjustment programs, then the main Measure procedure will run. In order to make the Analyzer achieve the required performance index, the instrument shall be warmed up for more than 30 minutes before conducting the Measure.

	WARNING:	**Before powering the analyzer on, please check whether the voltage of the power is normal in case of any damage to the instrument.** **When the instrument is placed in the cabinet, you have to ensure the air flowing inside and outside the cabinet. When there is a 100W heat power increase inside the cabinet, the environmental temperature (outside the box) is required 4℃ lower than the highest allowed temperature. If the total heat power inside the cabinet exceeds 800W, enforcement air cooling measures have to be taken.**

2   Running of the Analyzer Application Program

The analyzer will automatically run the vector network application program when starting up; if the application is exited, the following methods can be used to re-run the Measure program:

2.1   Mouse or touch screen procedure

Click **[Start]** on the taskbar on the left bottom corner of the screen, and point the mouse to **[Program]** in the Start menu and then **[3656A(B/D) Vector Network Analyzer]** in the Program sub-menu; in the pop-up sub-menu, click **[3656A(B/D) Vector Network Analyzer];** the analyzer starts running Measure application. Or double click the desktop shortcut to run vector network analyzer applications.

2.2   Front panel keys procedure

Click the 【**Preset**】 key in UTILITY area, the analyzer starts running vector network analyzer Measure application.

3   Power the Analyzer Off

3.1   Mouse or touch screen procedure

a)   Click **[File]** in the File menu, and click **[Exit]** to quit analyzer application.

b)   Click **[Start]**; in the Start menu, click **[Shutdown]**.

c)   In Shutdown dialog box, click **[Shutdown]**, the analyzer will shut down its power to enter Standby mode.

d)   Under the analyzer Standby mode, disconnect the rear panel power switch of the analyzer or unplug the power cord if necessary.

3.2   Front panel keys procedure

a)   Click 【**On/Standby**】 key on the left bottom corner of the front panel of the analyzer, but do not press or hold it too long.

b)   The analyzer will automatically quit Measure application program, turn off its power to enter the Standby mode.

c)   Under the analyzer Standby mode, disconnect the rear panel power switch of the analyzer or unplug the power cord if necessary.

	WARNING:	**The analyzer may not response to the mouse or keypad operation due to abnormality in operating system or applications, in such case, shut down the analyzer by pressing the [On/Standby] key for at least 4 seconds. Normally this should be avoided since the system may become unstable. Most of the time the Analyzer is able to recover. But that does not mean this is a safe operation.**

Section 4　Operating System Recovery

Due to abnormal shutdown of Analyzer by users, infection with virus or installation of other software on the Analyzer may cause abnormal operation of Analyzer operating system. At this time, the Analyzer needs to be recovered to factory default state according to the following steps:

a)　Shutdown Analyzer and connect a keyboard to Analyzer USB interface.

b)　Press down 【**On/Standby**】 key, and the System Recovery prompt as shown in the following Figure. appears on the screen.

To Start the Product Recovery program, press F11

Fig. 2-1　Operating System Recovery

c)　Press the【**F11**】key of the keyboard, and the System Recovery wizard menu as shown in the following Figure. appears on the screen.
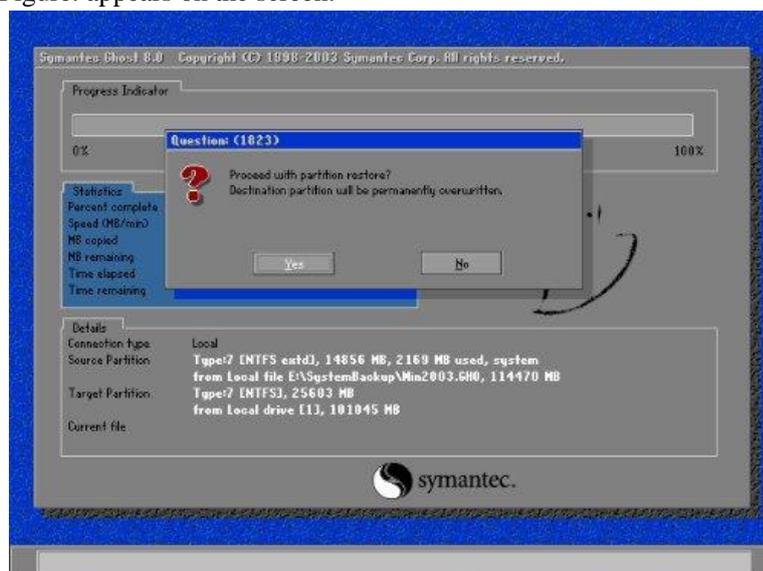
Fig. 2-2　System Recovery Wizard Menu

d)　Click **[Yes]** on the System Recovery Wizard Menu and the system recovery will begin.

	WARNING:	It's prohibited to install any third party's software on 3656 Series Vector Network Analyzer, which may lead to abnormal operation of Analyzer, even burn down hardware circuit.
	NOTE:	When system recovery is completed, all software installed on the Analyzer shall return to factory default status. If users have upgraded Analyzer Measure and control software after buying the Analyzer, they need to upgrade it again after system recovery is completed. Please backup useful data on disk C of Analyzer in advance to disk D or USB memory.

Chapter III   Routine Maintenance

1   Cleaning of Front Panel

After a period of use, the front panel of Analyzer shall be cleaned according to the following steps:

a)   Shut down the Analyzer and unplug power cord.

b)   Gently wipe the front panel with clean soft cotton cloth dipped in special detergent (alcohol prohibited).

c)   Then dry it with clean soft cotton cloth.

d)   The power cord can only be connected after special detergent is dry.

2   Connector Maintenance and Measure Connection

Although connectors of calibration kit, test cable and Analyzer Measure port are designed and manufactured according to the highest standards, all of them has limited service life. Since abrasion during normal operation is inevitable, the performance index of connectors will decrease and can not even meet the Measure requirements, therefore, correct connector maintenance and Measure connection not only can help get accurate and repeatable Measure results, but also extend the service life of connectors and reduce Measure cost. During actual use, the following aspects shall be paid attention.3

2.1   Connector inspection

When connectors are inspected, anti-static wrist strap shall be worn; the following items shall be checked by using magnifying glass:

a)   Whether there is abrasion or deep scratch on plate surface of connectors.

b)   Whether connector thread is out of shape.

c)   Whether there is metal particle on connector thread and bonding surface.

d)   Whether connector inner conductor is bent, ruptured or eccentric.

e)   Whether the threaded sleeve of connector is malrotation.

	WARNING:	Even in the first Measure connection, any damaged connector may cause damages to the good one connected to it; therefore, obviously defective connectors shall be marked for processing or repair.

2.2   Cleaning of connector

When connectors are cleaned, anti-static wrist strap shall be worn. Clean connectors according to the following steps:

a)   Remove loose particles on connector threads and bonding surface by using clean and low pressure air, and conduct thorough inspection of the connector.

If further cleaning is needed, the following steps shall be followed:

b) Wet (but not soak) a lint-free cotton swab with isopropyl alcohol.

c) Remove dirt and scrap on connector bonding surface and threads by using a cotton swab. When cleaning the inner surface, do not impose external force on center inner conductor or leave cotton swab fiber on center conductor of the connector.

d) Allow the alcohol evaporates, then blow the surface by using compressed air.

e) Check the connector and confirm there are no particles or residues.

f) If the defect is still visible after cleaning, the connector may be damaged, and shall not be used again; in addition, the reason for damage shall be confirmed before Measure connection.

2.3 Connection methods for connector

Before Measure connection, connectors shall be inspected and cleaned, make sure that the connector is clean and undamaged during connection, anti-static wrist strap shall be worn; the correct connection methods and steps are as follows:

a) Align the axis of two interconnected devices to ensure that the axis is in a straight line; slip the pin of male connector concentrically into the finger hole of female connector.

b) Move the two connectors straight together so that they can joint smoothly, rotate the threaded sleeve of the connector (Not rotating the connector) until it is tightened; during connection, there should not be relative rotation between the connectors.

c) Use a torque wrench to tighten and complete the final connection, note that the torque wrench shall not surpass the starting break point; the rotation of the connectors can be prevented by using an auxiliary wrench.

2.4 Disconnection method

a) Support the connector to prevent any distorting, shaking or bending force being imposed on the connector.

b) Use an open end wrench to prevent rotation of the main connector.

c) Use another wrench to loose the threaded sleeve of the connector.

d) Rotate the threaded sleeve of the connector by hand to complete the final disconnection.

e) Pull straight and separate the two connectors.

2.5 Using method of torque wrench

a) Confirm that the torque settings of torque wrench are correct before using.

b) Before imposing force, make sure that the angle between torque wrench and another wrench (used for support connectors or cables) is within 90°.

c) Hold the tail end of the torque wrench handle and impose force in the direction perpendicular to

the handle until it reaches the break point of the wrench.

2.6　Use and preservation of connector

a)　Connector shall be protected with a sheath when it is not used.

b)　Scattering various connectors, air lines and calibration standards in one box is not allowed, as it is the most common cause of connector damage.

c)　Keep the connector and the Analyzer in the same temperature, the temperature of the connector will be changed significantly by holding it by hand or cleaning it with compressed air; the connector shall be used for calibration when its temperature is stable.

d)　Don't touch the bonding surface of the connector, because it's difficult to remove grease and dust particles from the bonding surface.

e)　Don't put the connector on hard surface with the contact surface downward, and the contact with any hard surface may damage the galvanized coating and bonding surface of the connector.

f)　Wearing an anti-static wrist strap and working on grounded conductive table mat can protect the Analyzer and connector against the impact of ESD discharge.

2.7　Using of adapter

If the type of Analyzer Measure port is different from that of the used connector, an adapter must be used for Measure connection; in addition, even if the Analyzer Measure port is of the same type with the connector of the measured piece port, using the adapter is also a good idea. In both cases, the Measure port can be protected, its service life can be prolonged and maintenance cost can be reduced. The adaptor shall be inspected and cleaned carefully before being connected to the Measure port of the Analyzer and a high-quality adaptor shall be used, so as to reduce the impact of mismatch on Measure accuracy.

2.8　Mating plane surfaces of connector

Reference plane is an important concept in microwave Measure, for Network Analyzer, it is the reference plane of all Measure. During calibration, the reference plane is defined as a plane bonding the Measure port and calibration standards; good connection and calibration depends on whether the points on the bonding plane between connectors can be touched straight.

Chapter IV   Quick Start

This chapter details the front and rear panels, as well as the operation and interface of the Analyzer, including the following:

- Front Panel Tour
- Rear Panel Tour
- Interfaces
- Traces, Channels and Windows

☛	**STATEMENT:**	In this manual, the keys on the front panel are indicted as 【XXX】and XXX is the name of the keys. The menus and keys on the screen are displayed as [XXX] and XXX is the names of menus and keys.

Section 1   Front Panel Tour

The front panel of 3656 Series vector Network Analyzer is shown in the following Figure., including a number of key functional zones, display zones, USB interfaces and Measure ports. The section will describe the function and performance index of each part in details.
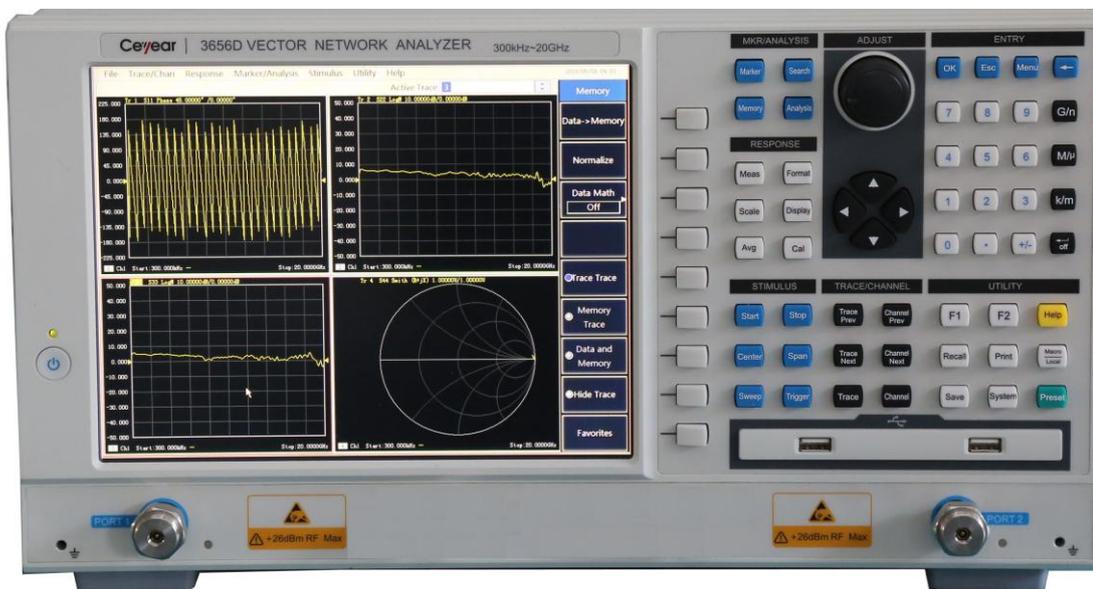
Fig.4-1   Front Panel of the 3656D Analyzer
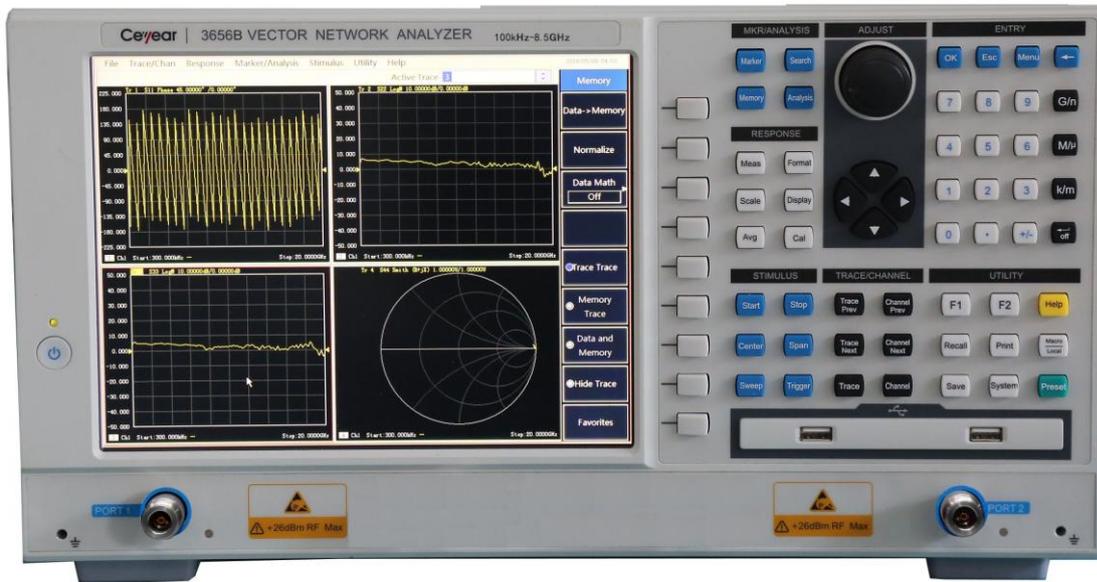
Fig.4-2   Front Panel of the 3656A/B Analyzer

1   ADJUST BLOCK

It covers the navigation keys and Adjust knobs.

Fig.4-3   ADJUST Keys

Adjust Knobs

Turn the knob to adjust the setting value in the currently Stimulus input box;

Pressing down the knob has the same function as mouse click.

【□】 and 【□】

● Move the option menu towards left or right in operation interface of vector network

procedure.

- Swith stimulated options dialog box of operation interface of vector network procedure.
- When operation interface of vector network procedure is not in action or shutdown, and any user operation interface other than vector network procedure or the user interface of Help in vector network is entered, it is operatable by moving mouse arrow towards both left and right. (Default position of mouse arrow is bottom right corner of the screen)

【△】 and 【▽】

- Move choice menu items in the menu upwards and downwards.
- It plays the following roles in dialog box:
  * Change numeral value.
  * Select items in dropdown list.
  * Select the desired option in a group of option buttons.
- When operation interface of vector network procedure is not in action or shutdown, and any user operation interface other than vector network procedure or the user interface of Help in vector network is entered, it is operatable by moving mouse arrow towards both left and right. (Default position of mouse arrow is bottom right corner of the screen)

2   UTILITY BLOCK

For operation of instrument system.

Fig.4-4   UTILITY Keys

【Save】

It's used for saving instrument status, calibration data or Measure data in specified files.

【**System**】

It's used for some system-related configuration and selection of software language, etc.

【**Preset**】

It's used to reset Analyzer to default (predefined) status.

【**Recall**】

It's used for invoking files containing Analyzer status, calibration data and Measure data.

【**Print**】

It's used to start printing function, select print settings and printer for printing.

【**Micro/Local**】

- When Analyzer is in external control state, press this key to make the Analyzer re-respond to the buttons on front panel.

- When Analyzer is in normal working state, press this key to access a set of user-defined macros associated with executable files.

Analyzer can name and store 10 macros at most.

⚠	**CAUTION:**	You must have the applications installed on the analyzer hard disk that are necessary to run the executable files in the set of macros.

【**F 1**】

It is used to record shortcut keys in operating a certain Measure (the record can be effective only by operating with front-panel keys).

【**F 2**】

It is used to record shortcut keys in operating a certain Measure (the record can be effective only by operating with front-panel keys).

【**Help**】

It is used to open the user manual of the analyzer (a built-in file).

3   RESPONSE BLOCK

It's used for various operation of Measure data Trace.
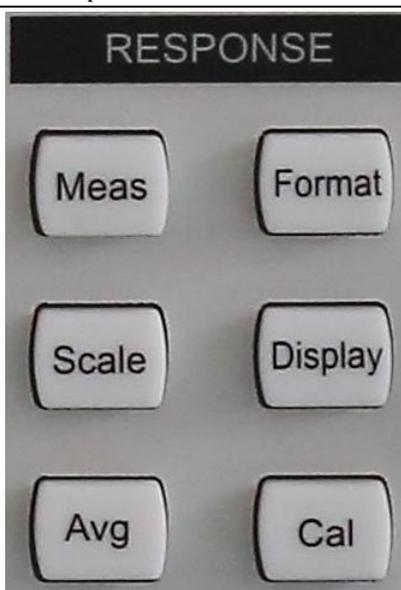
Fig.4-5   RESPONSE Keys

【**Meas**】

It is used to select the type of S parameter to be measured and the type of any specific-value or non-specific value power Measure.

【**Format**】

It is used to select the format in which the Measure data are displayed on the analyzer.

【**Scale**】

It is used to set the scale at which the Measure trace is displayed on the analyzer.

【**Display**】

It is used to create a new window, select or Stimulus the current window, or make display settings.

【**Avg**】

With the key 【**Avg**】 , the noise can be reduced by use of the Measure averaging function. The analyzer reduces the effect of random noise on the Measure result by executing complex exponential average of a number of sweeps for designated times when the average factor is designated.

【**Cal**】

The Measure calibration can be started to make operations such as power calibration.

4   TRACE/CHAN   BLOCK

Managing Trace and Channel on display of Analyzer.

Fig. 4-6   TRACE/CHANNEL Keys

【**Trace Prev**】

It is used to Stimulus previous trace curve.

【**Channel Prev**】

It is used to Stimulus previous channel curve.

【**Trace Next**】

It is used to Stimulus the next trace curve.

【**Channel Next**】

It is used to Stimulus the next channel curve.

【**Trace**】

The corresponding trace soft-key menu will be displayed. Press the corresponding soft-keys to make creation, deletion or selection of the Stimulus traces.

【**Channel**】

Display the corresponding channel soft-key menu and make channel management with corresponding soft-keys.

5   STIMULUS   BLOCK

Determining the range, sweep type or trigger mode of the measured data.
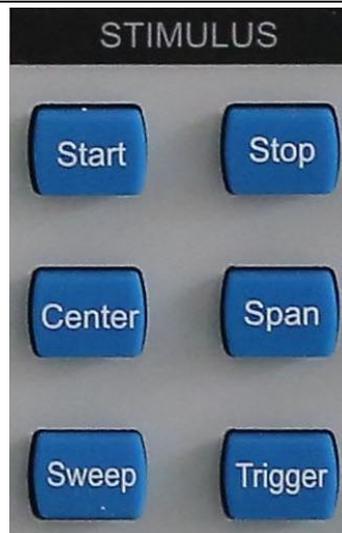
Fig. 4-7   STIMULUS Keys

【**Start**】

It is used to set the range of starting frequency value and the frequency offset.

【**Stop**】

It is used to set the stop frequency value.

【**Center**】

It is used to set the center frequency value.

【**Span**】

It is used to set the frequency range.

【**Sweep**】

It is used to select the manner of signal source sweep and relevant properties.

【**Trigger**】

It is used to set how to start an initialized sweep Measure.

6　MKR/ANALYSIS　BLOCK

Controlling all aspects of data analysis, including marker and mathematical calculation.
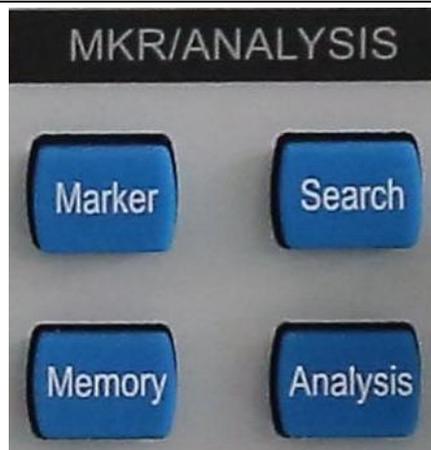
Fig. 4-8   MKR/ANALTSIS Keys

【**Marker**】

It is used to Stimulus the marker and set the stimulus value of the marker. The marker can provide digital reading of the Measure result. The analyzer can support at most 9 markers and the reference marker R.

【**Search**】

It provides the marker search function. Press this key to Stimulus a marker if there are no markers displayed.

【**Memory**】

It is used to set the mathematical operation and saving of Measure data by the analyzer.

【**Analysis**】

It includes the functions such as limit test, trace statistic, conversion of gates, windows and time domains.

7   ENTRY BLOCK

These keys are used to enter Measure settings.

Fig.. 4-9   ENTRY Keys

【**OK**】

It is used to confirm the setting and entry value in the dialog box and close the dialog box. It is equivalent to the "OK" button in the dialog box.

【**Esc**】

It is used to ignore the setting and entry in the dialog box and close the dialog box. It is equivalent to the "cancel" button in the dialog box.

【**Menu**】

Press the key 【**Menu**】 to browse the menu with the **navigation** key. Press this key and then press the utility key on the front panel to quickly open the dialog box for utility setting. For example, press the key 【**Menu**】 and then press the key 【**Search**】 to open the dialog box for search setting.

【←】

The marker will backspace to delete the previous entry by pressing this key, after the value is entered.

Numeric Key

The numbers 0 – 9 are included. It is used to enter the value in Measure setting and complete entry by pressing the corresponding unit key.

Unit Key

It is used to end the value entry and allocate a unit to the entry value. The corresponding units to keys are as below:

【**G/n**】   G/n ($10^9/10^{-9}$)

【**M/μ**】   M/μ ($10^6/10^{-6}$)

【**k/m**】   k/m ($10^3/10^{-3}$)

【**↵/off**】   Basic unit: dB, dBm, degree, second, Hz or dB/GHz. It can be also used to enter

the value without a unit. It has the function equivalent to Enter key.

⚠ !	**CAUTION:**	After entering the value, you need to press the unit key to finish the setting. When entering the value without units, press 【↵】 to finish the entry. When using the external connected keypad, press the character key correspondent to the unit to finish the setting.

【**·**】

It is used to enter the decimal point when entering a decimal value.

【**+/-**】

Before inputting a value, press this key to Stimulus entry of a positive or negative value.

8   Soft-keys

They work with the keys in other utility areas on the front panel and can easily carry out all instrument operations without a mouse.

- An additional key can be used as a user key.
- Soft key menu associated with a key can be called up by pressing this key on front panel.

Fig. 4-10   Soft-keys

9   USB Interface

USB interface can be used to connect keyboard, mouse or other USB devices, a total of 2 USB interfaces meeting USB2.0 specifications are provided on front panel, the interface jack is A-type configuration (embedded 4 contacts: contact 1 on the left); each interface has the following features:

- Contact 1: Vcc: 4.75V~5.25V, maximum output current: 500mA.

- Contact 2: data -.

- Contact 3: data +.

- Contact 4: ground.

Fig. 4-11   USB Interfaces

10   Display Screen

Screen display of Analyzer is shown in the following Figure..
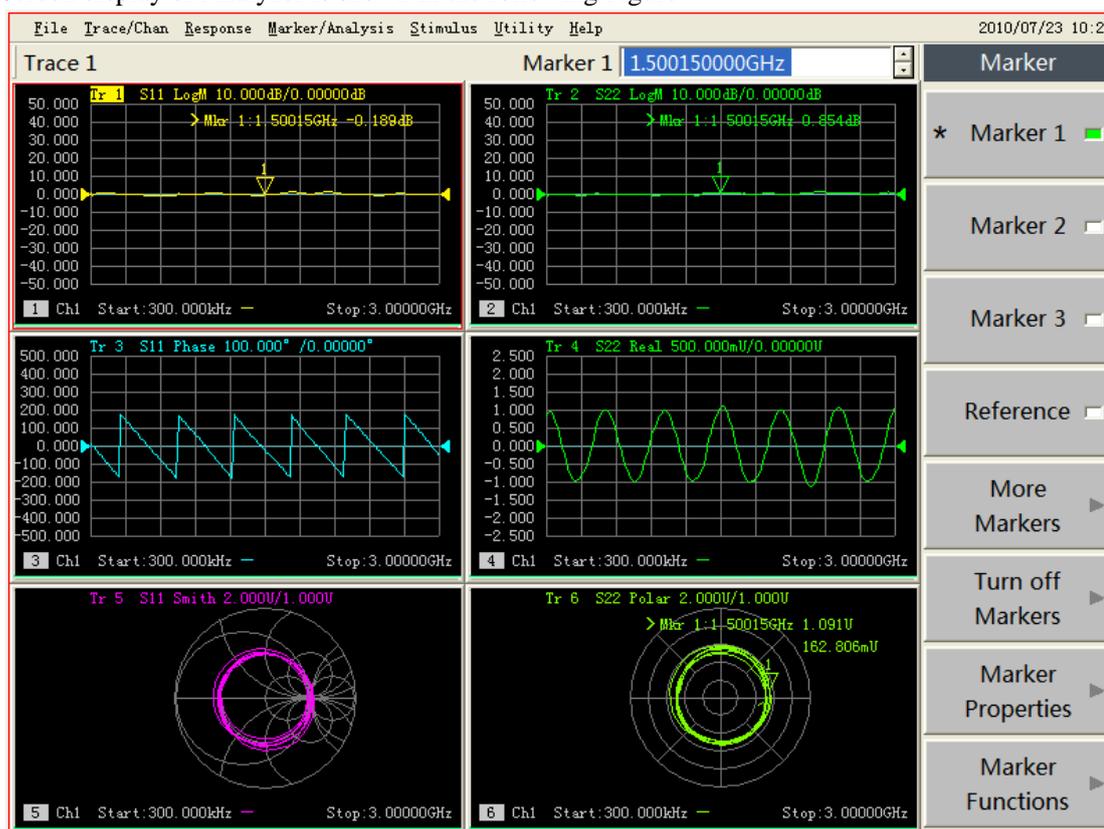

Fig. 4-12   Display Screen of the Analyzer

TFT LCD is adopted for the display screen of Analyzer, with technical specifications as follows:

- TFT, 10.4 inches, LCD

- Resolution: 1024×768.

● Brightness: >300NIT.

Please refer to Section 9, Chapter V "Setting Analyzer Display" for details about the functions and settings of each display element of screen.

11 【On/Standby】Key and Indicator Light

【**On/Standby**】toggles the analyzer between On and Standbys condition.

● For the On condition, the indicator light is green.

● For the Standbys condition, the indicator light is orange.

● When the analyzer is On, press 【**On/Standby**】, the analyzer will quit the application program, switch off the power and enter Standbys condition automatically.

● When the analyzer is Standby, press 【**On/Standby**】, the analyzer will automatically run Windows XP Operation System and load the Measure application program of the analyzer.

● The key 【**On/Standby**】 is only a standby switch that is not connected directly to the external power supply and can not cut off connection of the analyzer with the external power supply. The external power supply to the analyzer can be disconnected with the power switch on the rear panel. Removing the power cord can completely cut off connection of the analyzer with the external power supply.

Fig. 4-13   【On/Standby】Key and Indicator Light

12 Measure Ports

Fig. 4-14   Measure Ports of the 3656D Analyzer

Fig. 4-15   Measure Ports of the 3656A/B Analyzer

The 3656D analyzer includes two 3.5mm male interfaces, and the 3656A/B analyzer includes two type-N interfaces for measurement. The switching can be made between the RF source and receiver to

measure the DUT in two directions. The yellow lamp is used to indicate the current source output port.

The input damage level: RF power: +26dBm, DC voltage: ±30V.

 WARNING: The damage level limit of the analyzer is +26dBm RF power or ±30V DC voltage. The input exceeding the above range may burn the instrument.

Section 2   Rear Panel Tour

The rear panel of Analyzer is shown as the following Figure.:

Fig. 4-16   Analyzer Rear Panel

1   10MHz Reference Connector

Fig. 4-17   10MHz Reference Connector

1.1   10MHz reference input connector

10MHz reference input BNC female connector is used for input of external reference signals. If a 10 MHz external reference signal is detected at this port, it will be used as the instrument frequency references instead of the internal frequency reference. The requirements of the analyzer to the 10MHz input reference signals are as follows:

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

1.2   10MHz reference output connector

10 MHz reference output BNC female connector provides reference signals with the following

properties:

- Output frequency: 10MHz ±10ppm.

- Signal type: sine wave.

- Output level: 10dBm±4dB.

- Output impedance: 50Ω.

2   GP-IB Connector

GP-IB connector is a 24-pin D female connector for sending and receiving GP-IB/SCPI command, complying with IEEE-488 standard.
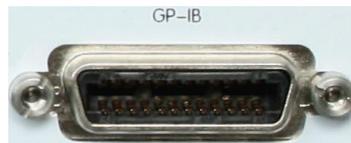
Fig. 4-18   GP-IB Connector

3   VGA Output Connector

This is a 15-pin D female connector connecting VGA display with the corresponding resolution externally, therefore, we can use internal and external displays to observe Measure in the averagetime, and wherein, the default resolution of external monitor is 800×600, which is the same as the resolution of internal liquid crystal display of Analyzer.

Fig. 4-19   VGA Output Connector

In the Windows table, click the right button of the mouse and with the right click menu, the multi-monitor mode can be conFig.d.
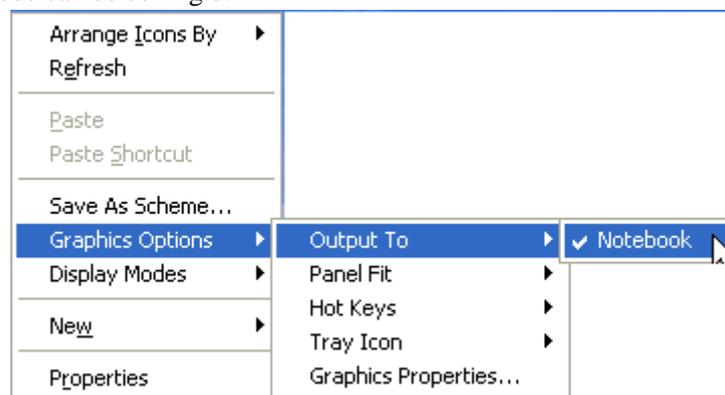
Fig. 4-20   Configuration of Multi-Display Mode

- When [**Monitor**] is checked, only the external VGA monitor can be used to observe the display and there is no display on the internal LCD.

- When [**Computer**] is checked, only the internal LCD can be used to observe the display and there is no display on the external VGA.

- When **[Monitor+Computer]** is checked, the external VGA monitor and the internal LCD can be used at the same time.

4 LAN Connector

This is a 10/100 BaseT Ethernet connector with standard 8-pin structure, which can automatically select one from the two data rates.

Fig. 4-21   LAN Connector

5 USB Connector

The plughole of the connector is Type A configuration (embedding 4 contacts: Contact 1 is on the left), providing two interfaces complying with USB 2.0 specification, and the property of every interface is as below:

- Contact 1: Vcc, 4.75V~5.25V, 500mA (maximum output current).
- Contact 2: Data-.
- Contact 3: Data+.
- Contact 4: Ground.

This connector can connect USB mouse, keyboard and other USB interface devices.

Fig. 4-22   USB Connector

6 External Trigger Input Connector

The vector network performs the trigger sweep via the input signal on the connector.

Fig. 4-23 External Trigger Input Connector

7 External Trigger Output Connector

After the system is all set, the vector network can output trigger signals.

Fig. 4-24   External Trigger Output Connector

8 Power Socket and Power Switch

Fig. 4-25   Power Socket and Power Switch

8.1   Power socket

The power socket is used to connect power cords and the three-core power cord with ground wire (along with instrument) is recommended, and it is better to use the power cord of the same type with that sent along with the instrument, if replaced. When the connection between Analyzer and external power supply must be cut off to avoid electric shock (e.g. when the Analyzer is maintained), the plug of power cord connected with Analyzer or external power supply shall be unplugged.

Refer to "Notes before Powering-on" in Section 2 of Chapter II for detailed power-on information.

8.2   Power switch

During the normal working process of Analyzer, the power switch shall be kept in "ON" position, and shutdown of Analyzer cannot be realized with the method of switching off power switch or unplugging power cord, which may cause faults on software or hardware of Analyzer. Refer to "Power the Analyzer On and Off" in Section 3 of Chapter II for detailed process of shutdown.

Section 3   Interface

The Analyzer interface refers to the method of setting and operating Analyzer by users, including front panel interface and mouse-driven user interface:

1   Front Panel Interface

Users can use front panel key to set and operate Analyzer by 2 ways.

1.1   Using soft-key toolbar

This method can finish the setting of Analyzer quickly via 4 steps, as follows:

a)   Press the corresponding utility keys of the front panel to Stimulus the soft-key toolbar of the item.

b)   Observe the function options of active project toolbar.

c)   Select required function based on the corresponding soft-key.

d)   Enter values (if necessary).

1.2   Use a Drop-down List

This method can use all functions of Analyzer, but the operation is relatively complicated and trivial, and the specific steps are as below:

a)   Press 【**Menu**】 key to switch to the Menu/Dialog mode.

b)   Press the 【□】、【□】 keys and【△】,【▽】 keys to browse the menu; press down the knob key to make a selection.

c)   Browse and set the dialog box through the 【□】、【□】 keys (if the dialog box is open).

d)   Entry values (if necessary).

e)   Press the 【**OK**】 in the **ENTRY** area to close the dialog box (if the dialog box is opened).

2   Mouse Interface

The following operations can be done by using mouse:

a)   Click on the menu bar to display the drop-down list.

b)   Click the existing item soft-key toolbar to select the function.

c)   Click the Measure toolbar to add Measure tracks.

d)   Click the Control toolbar to control the sweep.

e)   Click the Incentives toolbar to set the Sweep excitation.

f)   Click the Marker toolbar to set the marker.

g)   Right click on the screen to display the right click menu.

Sweep Control Toolbar

Frequency Items softkey Toolbar

Menu bar

Stimulus Toolbar

Measurement

Toolbar

Marker Toolbar

Right click menu
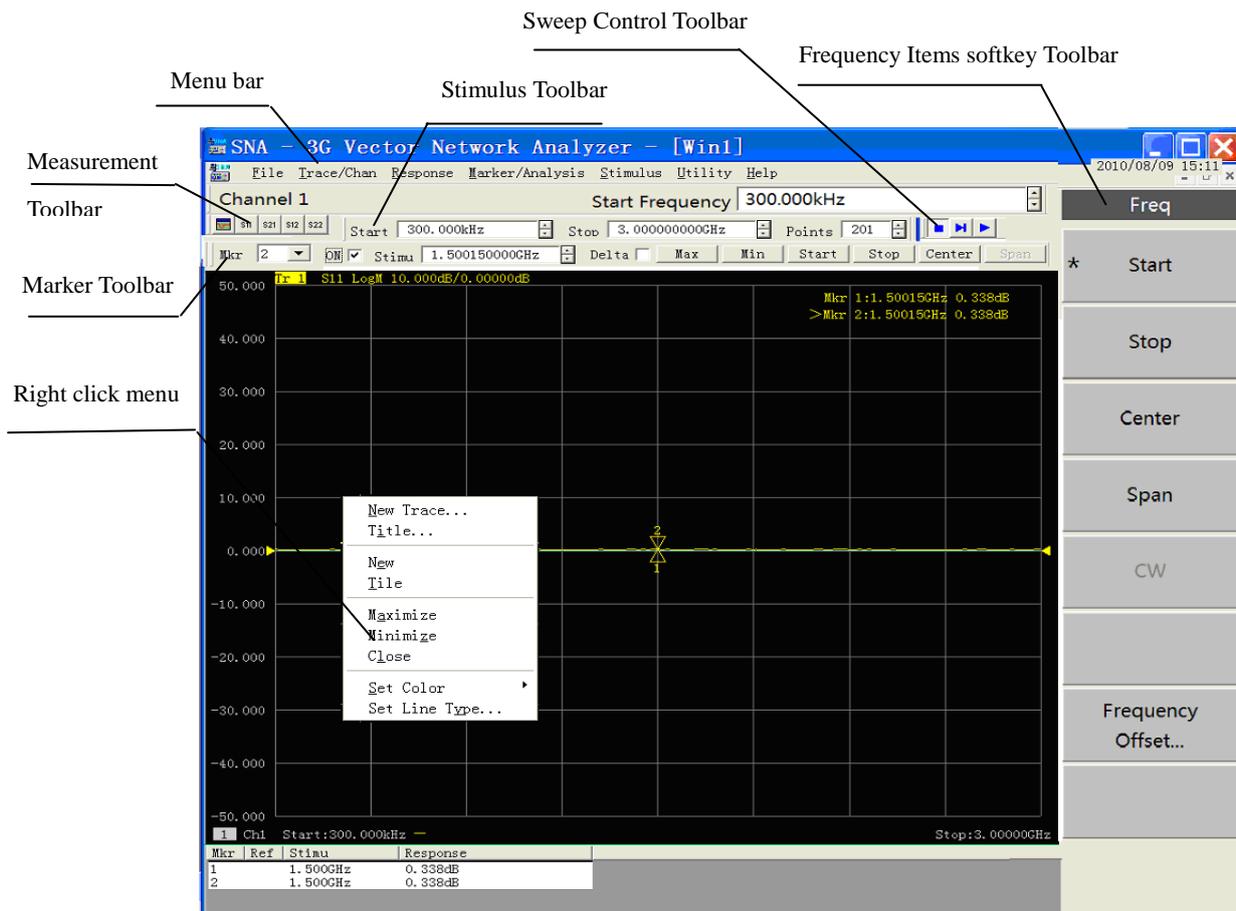
Fig. 4-26   Analyzer Mouse Interface

Section 4   Traces, Channels and Windows

1   Traces

Trace is a series of measured data points and its setting will influence arithmetical operation and display of measured data, and only when Trace is in the Stimulus state, it can change its setting. Single click the corresponding Trace state button to activate the Trace, and the detailed setting method is shown in "Changing Stimulus State of Trace" Part of "Selecting Measure Parameter" in Section 2 of Chapter V, and the setting for Trace includes:

- Pparameters
- Format
- Scale
- Calibration ON / OFF
- Trace Math
- Marker
- Electrical Delay
- Phase Bias
- Smoothing
- Time Domain Transformation

2   Channels

Channels contain traces. The analyzer supports up to 64 independent channels. Channel settings determine how the trace data is measured. All traces that are assigned to a channel share the same channel settings. A channel must be selected (active) to modify its settings. When the traces in a channel are active, the channel is also active. The following are channel settings:

- Frequency span
- Power
- Calibration data
- IF bandwidth
- Number of Points
- Sweep Setup
- Average
- Trigger (some settings)

3   Window

Window is used to observe Measure traces. The analyzer supports up to 32 windows, with each window displaying up to eight traces. Window and channel are completely independent. Through the

[Response] menu, window display can be set.

3.1 Creating a new window

3.1.1 By mouse or touch screen

Click the **[Response]** and in the drop-down list, click **[Display]**; select **[New Window]** in the **[Windows]**, and the analyzer will create a window, which is defaults for no traces.
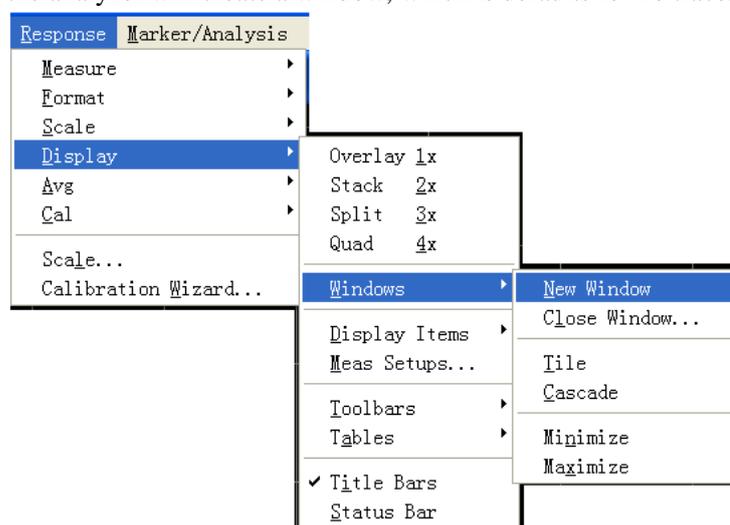
Fig. 4-27 Creating a New Window

3.1.2 By front panel keys

    a) Press 【**Display**】 key in the **RESPONSE** area.

    b) In the soft-key menu displayed on the right screen, press **[Windows]** corresponding soft-key to display the lower soft-key menu.

    c) Press **[New Window]** corresponding soft-key, and the analyzer will create a new window, which are defaults for no traces.

3.2 Viewing a Window with the Full Screen View

When there are too many windows on the screen, the windows will be too small and the traces will not be clear; then the full screen can be used to display a particular window for better viewing of the traces.

3.2.1 By mouse or touch screen

When you operate with the mouse, there are 3 following ways:

    ● When the title bar is open, click the **[Max]** button on the bar.

    ● When the title bar is closed, click the window you want to view with the full screen so that the corresponding window is set as the current active window, click **[Response]**, in the **Response** menu, click **[Display]**, and in the lower menu, select **[Max]** in the **[Windows]**.

    ● Point the mouse to the window you want to view with the full screen and press the right button of the mouse. Click **[Max]** in the right button menu.

3.2.2 By front panel keys

a)   Press the【**Display**】key in the **RESPONSE** area. Press **[Windows]** corresponding soft key on the right side of the screen to display the lower menu; press **[More]** corresponding soft-key.

b)   Press **[Select Window]** corresponding soft-key, select the window to be Stimulus in the dialog box of **Active Window** by【△】, 【▽】 keys and press **[Max]** corresponding soft-key.

Chapter V   Measure Setting

We can return the Analyzer back to a known measuring condition by resetting, and then select Measure setting and regulate display of Analyzer so as to make a better observation of Measure results, and this chapter describes the detailed methods for setting, including:

■   Resetting Analyzer

■   Selecting Measure parameter

■   Setting frequency range

■   Setting signal power level

■   Sweep Setup

■   Selecting triggering mode

■   Setting data format and scale

■   Observing multi-Trace and enabling multichannel

■   Setting Analyzer display

■   ConFig. 4-port Measure

Section 1   Resetting Analyzer

1   Reset state

When **[Preset]** key is pressed, the Analyzer will be returned to the known default state which is known as reset state, and the reset state for 3656 Series Vector Network Analyzer is set as follows:

a)   Measure parameter:

S_{11}

b)   Frequency setting:

Start frequency: 100kHz(3656A/B)

300kHz(3656D)

Stop frequency: 3GHz(3656A)

8.5GHz(3656B)

20GHz(3656D)

CW Time: 2GHz

c) Power setting:

Measuring port power: 0dBm

Coupled port power: on

Attenuation : automatic attenuation

Attenuation value : 0dB

d) Sweep Setup:

Sweep type: linear frequency

Sweep time: automatic

Sweep spot number: 201

e) Segment Sweep Setup:

Number of started segment: 1

Start frequency: 100kHz(3656A/B)

                300kHz(3656D)

Stop frequency: 3GHz(3656A)

                8.5GHz(3656B)

                20GHz(3656D)

Spots: 21

Power: 0dBm

Intermediate frequency bandwidth: 30kHz

f) Trigger setting:

Trigger source: internal

Trigger mode: continuous

g) Display format:

Format: log-magnitude

When different formats are chosen, the corresponding setting in detail is as follows:

Avg factor: 1

Smoothing: off

Smoothing factor: 2.49% of value range

Electrical delay: 0s

Velocity factor: 1

Phase offset: 0o

Display Trace: data Trace

i) Calibration setting

Correction: off

Interpolation: on

Calibration type: none

Calibration kit No.: current calibration kit No.

System impedance: 50Ω.

Port extension: off

Port extension value: 0s

j) Marker setting

Original frequency: 1.50005GHz(3656A)

4.25005GHz(3656B)

10.0001GHz(3656D)

Reference marker R: off

Discrete marker: off

Format: Trace format

Type: standard

Marker search type: minimum

Search domain: full bandwidth

Marker table: blank

Marker coupling: off

Displaying all Trace markers: on

k) Limit test setting:

Limit test: off

Limit line display: off

Failure sound warning: off

l) Limit table setting

Type: OFF

Start activation: 100kHz(3656A/B)

300kHz(3656D)

Stop activation: 3GHz(3656A)

8.5GHz(3656B)

20GHz(3656D)

Start response: -100dB

Stop response: 100dB

m) Time domain transformation setting

Time domain transformation: off

Transformation mode: band-pass

Transformation start: -10ns

Transformation stop: 10ns

Gaesarian window β factor: 6.0

Time domain gate: off

Gate start: -10ns

Gate stop: 10ns

Gate shape: standard

Gate type: band-pass

n) Global display setting

Status bar of Trace: on

Frequency/activation: on

Marker reading: on

Toolbar displayed: current input

Status bar: off

2   User reset state

The Analyzer can be reset to a known default state or a state defined by user. Under the default condition, the Analyzer is reset to the default state defined before leaving factory and it can be reset to the state specified by user via setting.

2.1   Setting user reset state

2.1.1   By mouse or touch screen

a)   Single click **[Utility]** and then single click **[Define User State..]** in the system menu to display the dialog box of defining user reset state.

b)   Single click **[save current state as user state]** button, the Analyzer will save the current instrument setting as user reset state.

c)   If you want to use the existing state, single click **[load exist file as user reset state]** button, select state file from the opened dialog box to enalbe it, and the selected file is used as state file for user reset by Analyzer.

d)   Click **[Enable user reset state]** to mark check box.

e)   Single click **[OK]** button to close the dialog box.
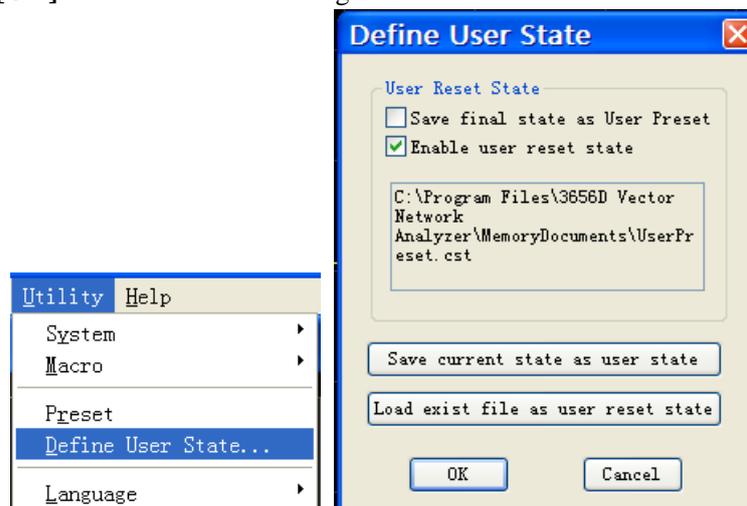
Fig.5-1   Define User Reset State

2.1.2   By front panel keys

      a)   Press 【**Menu**】 key in ENTRY area.

      b)   Press 【□】、【□】keys in ADJUST area to switch to the **[Define User State]** menu item under the system menu and press the knob   key in Adjust area to display the dialog box of Define User Reset State.

      c)   If you want to make the current setting of Analyzer be user reset state, press 【□】、【□】keys to switch to **[Save Current State as User Preset]** button and then press the knob key.

      d)   If you want to use the existing state, press 【□】、【□】key to switch to **[Load Existed File as User reset State]** button and then press the knob   key, and select state file from the opened dialog box to enable it and the selected file is used as state file for user reset by Analyzer.

      e)   Press 【□】、【□】keys in ADJUST area to switch to **[Enable User Reset State]** and press the knob key to mark check box.

      f)   Press 【**OK**】 key in ENTRY area to close dialog box.

3   Resetting Analyzer

3.1   By mouse or touch screen

Single click **[Utility]**, and then single click **[Preset]** in the **Utility** menu.

Utility	Help	
System		▶
Macro		▶
Preset		
Define User State...		
Language		▶
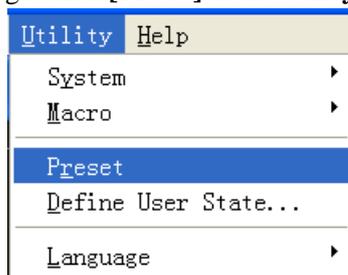
Fig. 5-2   Resetting Analyzer

3.2   By front panel keys

Press 【**Preset**】 key in UTILITY area.

Section 2   Selecting Measure Parameter

We can set the Analyzer to use the following parameters to measure electrical properties of a device:

- S parameter (fixed ratio)
- Arbitrary ratio (Measure of user-defined ratio)
- Measure of non-ratio power (absolute power Measure)

1   S Parameter

S parameter (scattering parameter) is used to describe how a device changes input signals, which can depict reflection and transmission properties of DUT. S parameter uses the numeric arrangement pattern specified to indicate the ratio relation of two complex vectors including amplitude and phase information.

$$S_{\text{output input}}$$

Output refers to the output port number of response signals of DUT and input averages the input port number of activation signals of DUT. The Analyzer includes two Measure ports, which can measure S parameter of a device with one or two ports. We can set the signal output port measured by S parameter, and when the activation signals are output from Port 1 of Analyzer, we call it that the Analyzer is under positive-going Measure, and when the activation signals are output from Port 2, it is believed that the Analyzer is experiencing reverse Measure, and the Analyzer can switch over direction of Measure automatically based on selected Measure parameters, therefore, all of 4 S parameters for a two-port device can be measured through one connection.

4 S parameters of a dual-port device are S_{11}, S_{12}, S_{21} and S_{22}, Fig. 5-3 will give further description for S parameters, wherein:

- a stands for the activation signal input to DUT.
- b stands for reflection and transmission signals of DUT (response signal).

S parameter is complex linear value, of which the Measure accuracy depends on index of calibration kit and adopted Measure and connection technology and is also related with the matching conditions of non-activation port, and its unfavorable load matching will make a_2 during positive-going Measure and a_1 during reversing Measure unequal to zero, which disobeys the definition of S parameter and introduces Measure errors. Full dual-port calibration can modify source and load matching errors to improve accuracy of Measure. The following parameters can be measured with S parameters:

a) **Reflection** Measure**: S11 and S22**

- Return loss
- Standing Wave Ratio (SWR)
- Reflection coefficient
- Impedance

- S_{11} and S_{22}

b) Transmission Measure: S_{21} and S_{12}

- Insertion loss

- Transmission coefficient

- Gain

- Group Delay

- linear phase offset

- Electrical delay

- S21 and S12
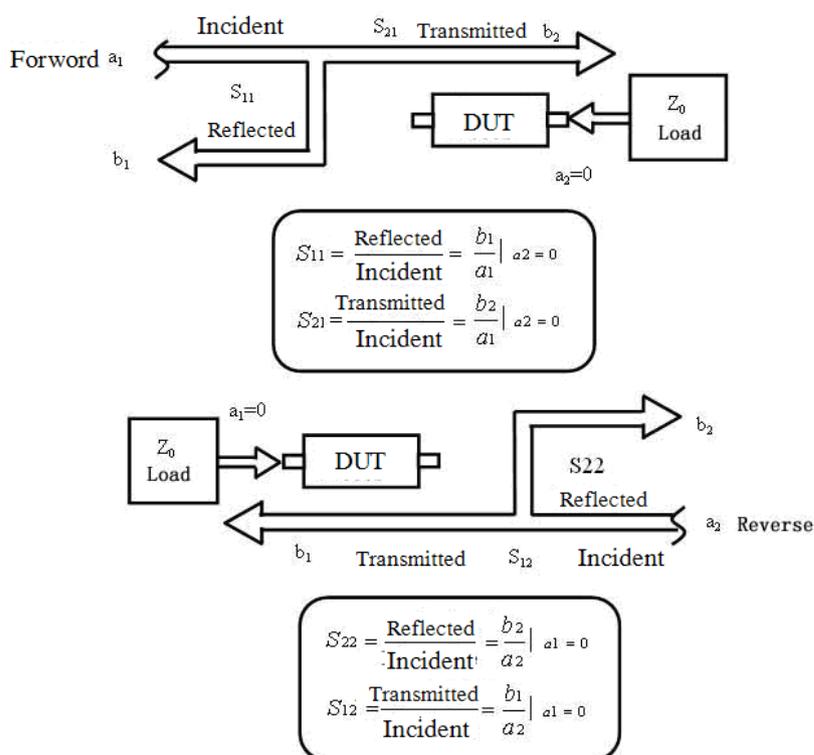
Fig. 5-3   Definition of S Parameter

1.1 Creating new S parameter Measure Trace

1.1.1 By mouse or touch screen

a) Single click **[Trace]**, single click **[New Trace...]** in **[New Trace]** menu, and display the dialog box of New Create Trace.

b) Select new S parameter Measure Trace to be created in the dialog box.

c) Single click **[OK]** button to close the dialog box after the setting is completed.
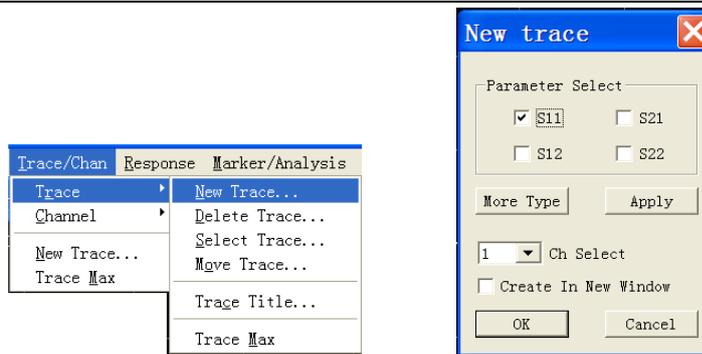
Fig. 5-4   Create New S Parameter Trace

1.1.2   By front panel keys

a)   Press 【**Trace**】 key in TRACE/CHAN area.

b)   Press the corresponding soft-key of **[New S-Param]** to create new Traces.

1.1.3   Creating new Trace dialog box

Parameter select zone

It is used to select new S parameter Measure Trace to be created.

[More Type]

Opening the dialog box to create new arbitrary ratio or non-ratio power Measure Traces.

[Ch Select]

It is used for selecting the channel for a new Trace.

[Create in New Window]

During marking, the Trace shall be created in a new window and the Trace created in current Stimulus window at eliminating.

2   Arbitrary ratio Measure

The arbitrary ratio Measure allows to select input signals and reference signals for ratio Measure from receivers (A, B, R1 and R2).

2.1   Creating new arbitrary ratio Measure Trace

2.1.1   By mouse or touch screen

a)   Single click **[Trace/Chan]**, single click **[New Trace...]** in **[Trace]** menu, and display the dialog box of Create New Trace.

b)   Single click **[More Type]** button in the dialog box to display the dialog box of New Trace.

c)   Select the output port of Analyzer source signals from **[Source]** box.

d)   Click **[Scale Type]** to mark check box.

e)   Select input receiver for ratio Measure from Input zone.

f)   Select reference receiver for ratio Measure from Reference zone.

g)   Single click **[OK]** button to close the dialog box.
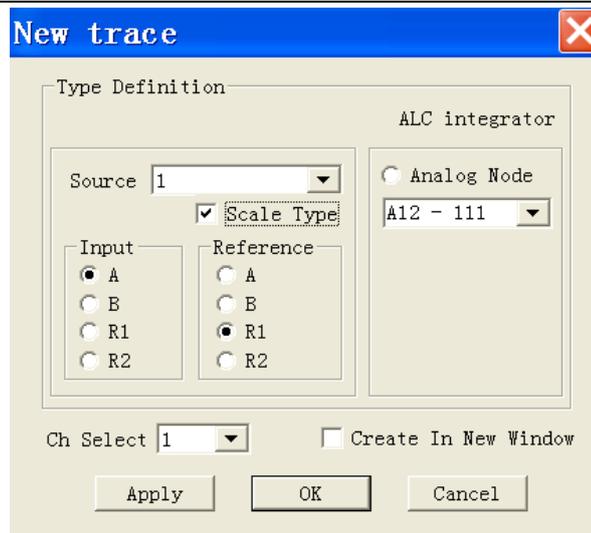
Fig. 5-5　Creating New Arbitrary Ratio Measure Trace

2.1.2　By front panel keys

a)　Press 【**Trace**】 key in TRACE/CHAN area and press the soft-key corresponding to **[New Trace…]** in soft-key menu displayed on the right of screen to show New Trace dialog box.

b)　Press 【□】、【□】 keys in ADJUST area to switch to **[More Type]** button and press the knob key to display New Trace dialog box.

c)　Press 【□】、【□】 keys in ADJUST area to switch to **[Source]** box and press 【△】 and 【▽】 keys or rotate knob to select source output port of Analyzer.

d)　Press 【□】 、【□】 keys in ADJUST area to switch to **[Scale Type]** and press the knob key to mark check box.

e)　Press 【□】 、【□】 keys in ADJUST area to switch to Input zone and press 【△】 and 【▽】 keys or rotate knob to select input receiver of ratio Measure.

f)　Press 【□】、【□】keys in ADJUST area to switch to Reference zone and press【△】 and 【▽】 keys or rotate knob to select reference receiver of ratio Measure.

g)　Press **[OK]** key in ENTRY area to close dialog box.

3　Non-ratio power Measure

The non-ratio power Measure parameter can measure the absolute power entering receivers (i.e. A, B, R1 and R2), but Measures of phase and group delay and any other Measures enabling average functions cannot be performed.

3.1　Creating new non-ratio power Measure Trace

3.1.1　By mouse or touch screen

a)　Single click **[Trace/Chan]**, single click **[New Trace...]** in **[Trace]** menu, and display the dialog box of Create New Trace.

b)　Single click **[More Type]** button to display the dialog box of New Trace.

    c)   Select the source output port of Analyzer from **[Source]** box.

    d)   Click **[Scale Type]** to eliminate check box (if marked).

    e)   Select Measure receiver of signals from Input zone.

    f)   Single click **[OK]** button to close the dialog box after the setting is completed.

3.1.2   By front panel keys

    a)   Press 【**Trace**】 key in TRACE/CHAN area and press the soft-key corresponding to **[New Trace…]** in the corresponding soft-key menu to show New Trace dialog box.

    b)   Press 【□】、【□】 keys in ADJUST area to switch to **[More Type]** button and press the knob key to display New Trace dialog box.

    c)   Press 【□】、【□】keys in ADJUST area to switch to **[Source]** box and press 【△】 and 【▽】 keys or rotate knob to select source output port of Analyzer.

    d)   Press 【□】、【□】 keys in ADJUST area to switch to **[Scale Type]** and press the knob key to eliminate check box (if marked).

    e)   Press 【□】、【□】 keys in ADJUST area to switch to Input zone and press 【△】 and 【▽】 keys or rotate knob to select Measure receiver of signals.

    f)   Press 【**OK**】 key in ENTRY area to close dialog box.

3.1.3   Creating new Trace dialog box (arbitrary ratio and non-ratio power Measure)

[Source]

Select output port of Analyzer source signals.

[Scale Type]

When marking, create new arbitrary ratio Measure Trace and create new non-ratio power Measure Trace during elimination.

[Input]

Select input receiver for Analyzer measuring response signals of DUT.

[Reference]

Select reference receiver for Analyzer performing ratio Measure.

[Ch Select]

It is used for selecting the channel for a new Trace.

[Create in New Window]

During marking, the Trace shall be created in a new window and the Trace created in current Stimulus window during elimination.

4   Changing Measure Type of Trace

For Analyzer, if some Trace needs to be set and modified, the Trace must be changed to be the current Stimulus Trace, and then can be modified.

4.1   Changing Stimulus state of Trace

4.1.1   By mouse or touch screen

Single click Trace Status Bar on the upper part of window and the corresponding Trace becomes the current Stimulus Trace.

Tr 1 A Log M 0.000dBm/10.000dBm   Tr 2 S11 Log M 0.000dB/10.000dB

Fig. 5-6   Changing Stimulus State of Trace

4.1.2   By front panel keys

Press **[Trace Prev]** key or **[Trace Next]** key in TRACE/CHAN area. Or, the following operation methods can be employed:

a)   Press 【**Trace**】 key in TRACE/CHAN area and press the soft-key corresponding to **[Select Trace]** in the corresponding soft-key menu to show Current Trace dialog box.

b)   Press 【△】 and 【▽】 keys in ADJUST area or rotate knob to select the Trace requiring to be Stimulus in Current Trace dialog box.

4.2   Setting S parameter Measure type of current Stimulus Trace

4.2.1   By mouse or touch screen

a)   Single click **[Response]** and point to **[Measure]** in Response menu to display submenu of Measure.

b)   Single click S parameter Measure type to be selected from the submenu.
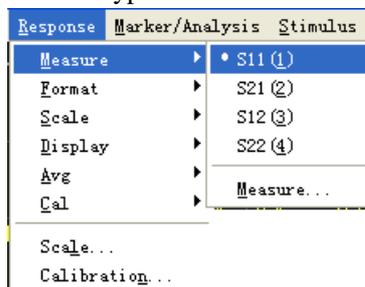
Fig. 5-7   Setting S Parameter Measure Type of Current Stimulus Trace

4.2.2   By front panel keys

a)   Press 【**Meas**】 key in RESPONSE area.

b)   Press the corresponding soft-key to select S-parameter Measure type on existing soft-key menu.

4.3   Changing current Stimulus Trace to be arbitrary ratio type

4.3.1   By mouse or touch screen

a)   Single click **[Response]** and point to **[Measure]** in Response menu to display submenu of Measure.

b)   Single click menu item of **[Measure…]** in submenu to display Measure dialog box.

c)   Single click **[More Type]** button to display Measure dialog box.

d)   Select the source output port of Analyzer from **[Source]** box.

e) Click **[Scale Type]** to mark check box.

f) Select input receiver for ratio Measure from Input zone.

g) Select reference receiver for ratio Measure from Reference zone.

h) Single click **[OK]** button to close the dialog box after the setting is completed.
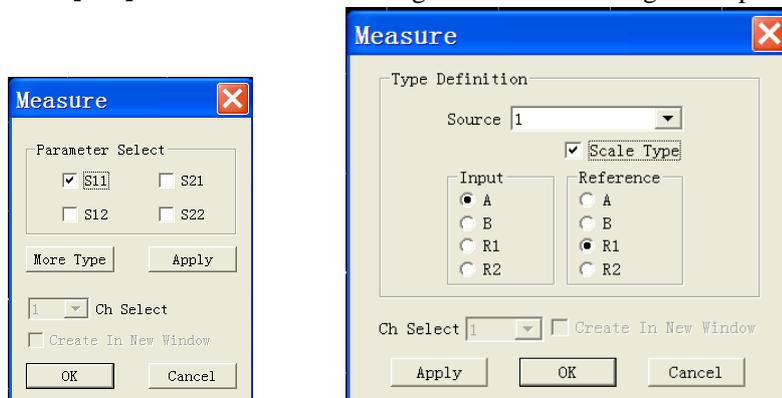
Fig. 5-8   Changing Current Stimulus Trace to be Arbitrary Ratio Type

4.3.2   By front panel keys

a) Press 【**Meas**】 key in RESPONSE area and single click the soft-key corresponding to **[Measure…]** to display Measure dialog box.

b) Press 【▢】、【▢】 keys in ADJUST area to switch to **[More Type]** button and press the knob key to display Next-level Measure dialog box.

c) Press 【▢】、【▢】keys in ADJUST area to switch to **[Source]** box and press 【△】 and 【▽】 keys or rotate knob to select source output port of Analyzer.

d) Press 【▢】、【▢】 keys in ADJUST area to switch to **[Scale Type]** and press the knob key to mark check box.

e) Press 【▢】、【▢】 keys in ADJUST area to switch to Input zone and press 【△】 and 【▽】 keys or rotate knob to select input receiver of ratio Measure.

f) Press 【▢】、【▢】keys in ADJUST area to switch to Reference zone and press 【△】 and 【▽】 keys or rotate knob to select reference receiver of ratio Measure.

g) Press 【**OK**】 key in ENTRY area to close dialog box.

4.4   Changing current Stimulus Trace to be non-ratio power Measure type

4.4.1   By mouse or touch screen

a) Single click **[Response]** and point to **[Measure]** in Response menu to display submenu of Measure.

b) Single click **[Measure…]** in submenu to display Measure dialog box.

c) Single click **[More Type]** button to display Measure dialog box.

d) Select the source output port of Analyzer from **[Source]** box.

e) Click **[Scale Type]** to eliminate check box (if marked).

    f)   Select Measure receiver from Input zone.

    g)   Single click **[OK]** button to close the dialog box after the setting is completed.

4.4.2   By front panel keys

    a)   Press 【**Meas**】 key in RESPONSE area and single click the soft-key corresponding to **[Measure…]** to display Measure dialog box.

    b)   Press 【▢】、【▢】 keys in ADJUST area to switch to **[More Type]** button and press the knob key to display Next-level Measure dialog box.

    c)   Press 【▢】、【▢】 keys in ADJUST area to switch to **[Source]** box and press 【△】 and 【▽】 keys or rotate knob to select source output port of Analyzer.

    d)   Press 【▢】、【▢】 keys in ADJUST area to switch to **[Scale Type]** and press the knob key to eliminate check box (if marked).

    e)   Press 【▢】、【▢】 keys in ADJUST area to switch to Input zone and press 【△】 and 【▽】 keys or rotate knob to select Measure receiver.

    f)   Press 【**OK**】 key in ENTRY area to close dialog box after the setting is completed.

Section 3   Setting Frequency Range

The frequency range refers to the frequency span of device Measure and the frequency resolution of 3656 Series vector Network Analyzer is 1Hz. The whole frequency range includes several wave bands, and when frequency Sweep passes through switching points of these wave bands or sweeps the highest frequency of setting for retracing Sweep, the power input to DUT will be adjusted to minimum to prevent oversized peak power from burning up DUT. If the frequency range of Sweep only consists of one wave band, the power will be kept unchanged at retracing Sweep. The frequency range of every wave band of Analyzer is shown as follows:

Table 5-2   Wave Band Division of 3656 Series

Wave Band	3656 A	3656 B	3656D
B0	100kHz~5MHz	100kHz~8MHz	300kHz~10MHz
B1	5MHz~10MHz	8MHz~8500MHz	10MHz～20000MHz
B2	10MHz~748MHz		
B3	748MHz~1500MHz		
B4	1500MHz~3000MHz		

1   Setting Frequency Range

There are two methods of setting frequency range:

- Designating start frequency and stop frequency
- Designating center frequency and frequency span

1.1   Setting start frequency and stop frequency

1.1.1   By mouse or touch screen

   a)   Single click **[Stimulus]**, point to **[Freq]** in Stimulus menu, and single click menu item of **[Start/Stop…]** to display Frequency Start/ Stop dialog box.

   b)   Single click **[Start]** box and input start frequency value.

   c)   Single click **[Stop]** box and input stop frequency value.

   d)   Single click **[OK]** button to close the dialog box after the setting is completed.
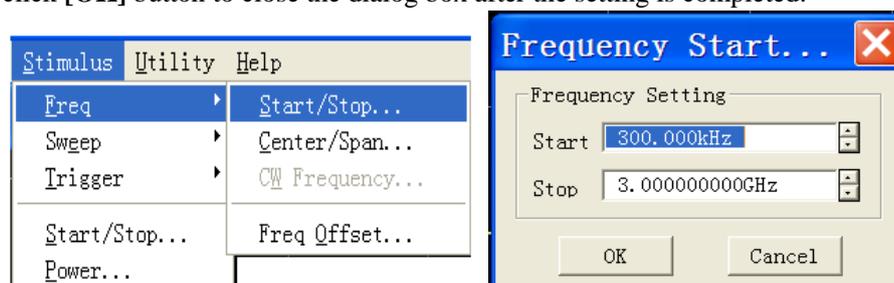
Fig. 5-9   Designating Start Frequency and Stop Frequency

1.1.2   By front panel keys

    a)   Press【Start】key in STIMULUS area to set start frequency value in existing input bar.

    b)   Press【Stop】key in STIMULUS area to set stop frequency value in existing input bar.

1.2   Setting the center frequency and frequency span

1.2.1   By mouse or touch screen

    a)   Single click **[Stimulus]**, point to **[Freq]** in Stimulus menu, and single click menu item of **[Center/Span…]** to display Frequency Center/Span dialog box.

    b)   Single click **[Center]** box and input center frequency value.

    c)   Single click **[Span]** box and input frequency span value.

    d)   Single click **[OK]** button to close the dialog box after the setting is completed.
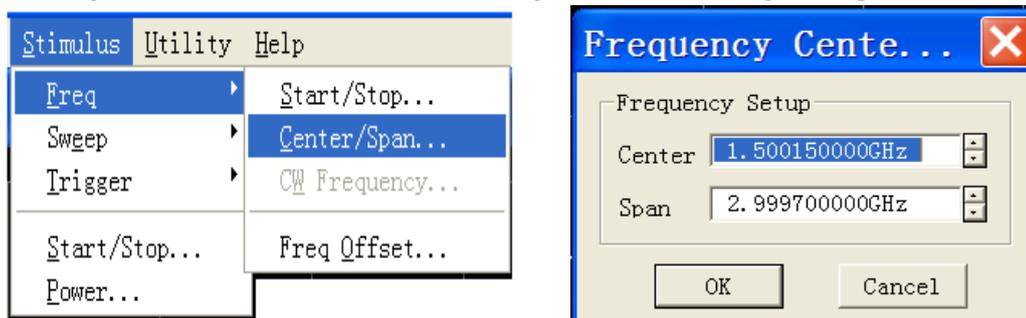
Fig. 5-10   Designating Center Frequency and Frequency Span

1.2.2   By front panel keys

    a)   Press【Center】key in STIMULUS area to set center frequency value in existing input bar.

    b)   Press【Span】key in STIMULUS area to set frequency span value in existing input bar.

Section 4   Setting Signal Power Level

Power level refers to the power level for Analyzer measuring port output source signals and the technical index for power level of output signals at port of 3656 Series Vector Network Analyzer is as below:

Table 5-3   Source Signal Power Level Index

Frequency	Source Power Range (dBm)	Setting Resolution (dB)
3656A (100kHz~3GHz)	-45~+10	0.01
3656B (100kHz~8.5GHz)	-55~+10	0.01
3656D（300kHz～20GHz）	-25～+10	0.01

1   Setting Power Level

1.1   By mouse or touch screen

   a)   Single click **[Stimulus]** and single click **[Power…]** in Stimulus menu to show Power dialog box.

   b)   Single click **[Port Power Level]** box and input power level from Port 1. The port power is coupled under default condition, so the power level of Port 2 is also set.

   c)   If the power level for every port shall be set independently, eliminate **[Port Power Coupled]** check box, select setting port in **[Port]** box, and set power level in **[Port Power Level]** box.

   d)   Single click **[OK]** button to close the dialog box.
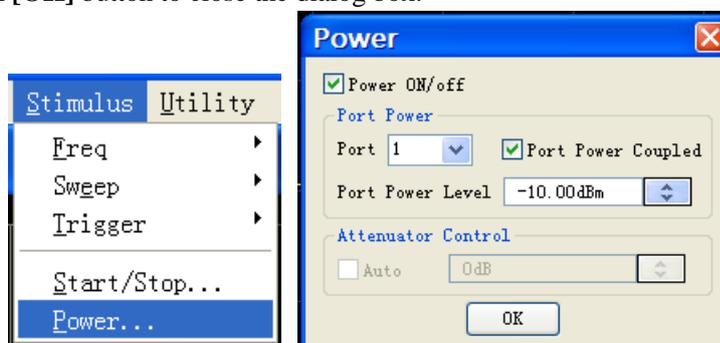
Fig. 5-11   Setting Power Level

1.2   By front panel keys

   a)   Press 【**Sweep**】 key in STIMULUS area and press the soft-key corresponding to **[Power]** on existing soft-key menu.

   b)   Input power level in Power Level dialog box.

1.3   Power dialog box

   [Power ON/off]

During marking, power can be output normally from port and the output power from port turned off

during elimination.

Selecting port zone

a) **[Port]**

Select the port for setting power level.

b) **[Port Power Coupled]**

By default, Mark **[Coupled Port Power]** check box and the power level settings for 2 ports of Analyzer are identical. However, some Measure applications requires different power levels for Port 1 and Port 2, e.g. gain and reverse isolation of high-gain amplifier shall be measured, because the power required by amplifier input port is much lower than that by output port, and power of every port of Analyzer must be set respectively. When **[Coupled Port Power]** check box is eliminated, the Analyzer allows to set power level for every port respectively.

	WARNING:	**If the input power at Measure port of Analyzer is too large, it may burn the receiver of Analyzer and the maximum input radio-frequency power level at Measure port of Analyzer is: +26dBm.**

---

c) **[Port Power Level]**

It is used to set power level of port.

Attenuator control zone

[Auto] and [Attenuation control]

When the **[Auto]** check box is not checked, the Analyzer can be set as any power level within the allowed power range. On the contrary, [Attenuation control] is disabled and the Analyzer can select automatically attenuator setting   to utilize   the   optimal power range.

2   Turning Port Power Off

2.1   By mouse or touch screen

a)   Single click **[Stimulus]** and single click **[Power…]** in Stimulus menu to show Power dialog box.

b)   Eliminate **[Power ON/off]** check box.

c)   Single click **[OK]** button to close the dialog box.

2.2   By front panel keys

a)   Press【Sweep】key in STIMULUS area and press the soft-key corresponding to **[Power]** on existing soft-key menu.

b)   Press the corresponding soft-key to **[Power ON | off]** menu on the corresponding soft-key menu.

Section 5   Sweep Setup

Sweep refers to the measuring process of continuous data points with activation values in specified sequence.

1   Sweep type

The Analyzer supports five types of sweep as follows:

a)   Linear frequency

This is the default sweep type for Analyzer. The frequency intervals between two neighboring measuring points are equal.

b)   Logarithmic frequency

Under the setting of logarithmic frequency, source frequency increases in logarithmic step size and frequency ratios between two neighboring measuring points are the same.

c)   Power sweep

Power sweep is adopted for power-sensitive parameters, such as gain compression or AGC (automatic gain control) slope. Power sweep is conducted in CW Time. The maximum settable sweep range is 25dB and the default power sweep range is -15dBm~+10dBm. During sweep, the power is sweepned with scattered step value from start value to end value and the step size is decided by Sweep spot number and power range.

d)   CW Time

For this sweep type, Analyzer is set to single sweep frequency. The measuring data is sampled continuously and precisely in time interval decided by Sweep time and measuring points, showing the change of measuring data over time.

e)   Segment sweep

This sweep type is made up with several segments, each of which can be defined with independent power level, IF bandwidth and Sweep time. When calibrations are completed for all segments, Measures can be conducted for one or more segments. The segments are defined in the sequence of frequency increase and the frequency range cannot overlap. The attenuator setting for power level of all segments must be the same so as to prevent the attenuator from being damaged by frequent switching of attenuator. When the attenuator setting for current defined segment is different from that for defined segment, Analyzer will automatically change the power level and attenuator setting for defined segment.

2   Setting of Sweep Type

2.1   Setting of sweep type - linear frequency

2.1.1   By mouse or touch screen

a)   Click **[Stimulus]**, then click **[Sweep Type...]** in menu **[Sweep]** to show Sweep Type dialog

box.

b) Click **[Linear Frequency]** option button in Sweep Type.

c) Set start frequency, stop frequency and Sweep spot number in Sweep Feature.

d) Click **[OK]** button to close the dialog box.
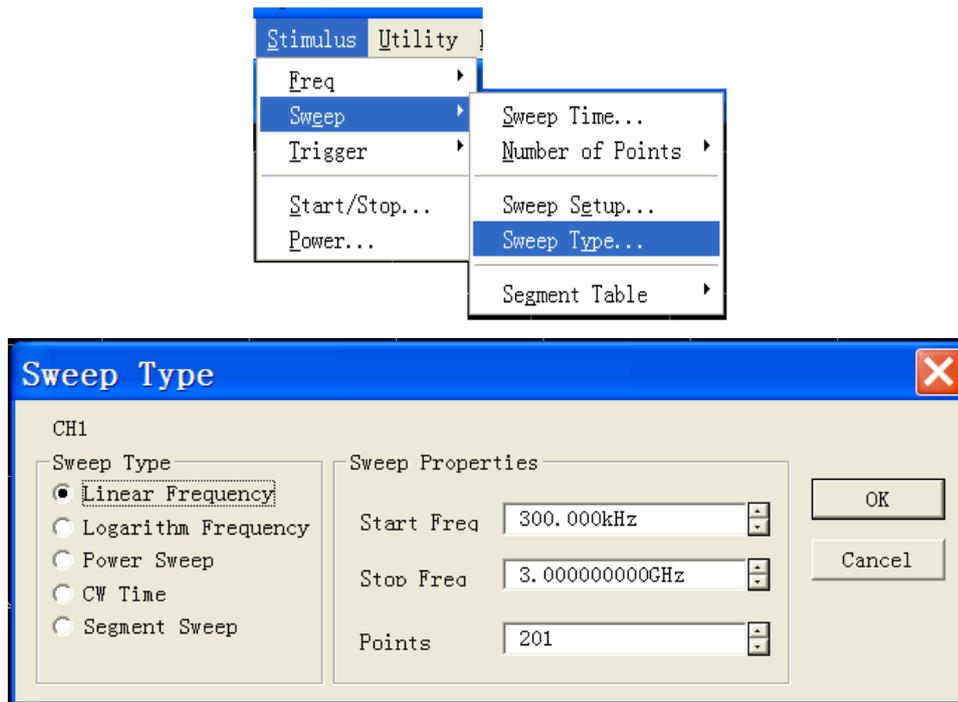
Fig. 5-12   Setting of Sweep Type - Linear Frequency

2.1.2   By front panel keys

a) Press 【**Sweep**】 key in STIMULUS area and press the soft-key in soft-key menu corresponding to **[Sweep Type]**.

b) Press the soft-key corresponding to **[Linear Frequency]** to select the sweep type.

c) Press 【**Start**】 key in STIMULUS area and enter start frequency in Start Frequency box; press 【**Stop**】 key in STIMULUS area and enter stop frequency in Stop Frequency box.

d) Press 【**Sweep Setup**】 key in STIMULUS area, press the soft-key corresponding to **[Number of   Points]** and enter Sweep spot number in Number of Points box.

2.2   Setting of sweep type - logarithm frequency

2.2.1   By mouse or touch screen

a) Click **[Stimulus]**, then click **[Sweep Type...]** from menu **[Sweep]** to show Sweep Type dialog box.

b) Click **[Logarithm Frequency]** option button from Sweep Type.

c) Set start frequency, stop frequency and Sweep spot number in Sweep Feature.

d) Click **[OK]** button to close the dialog box.
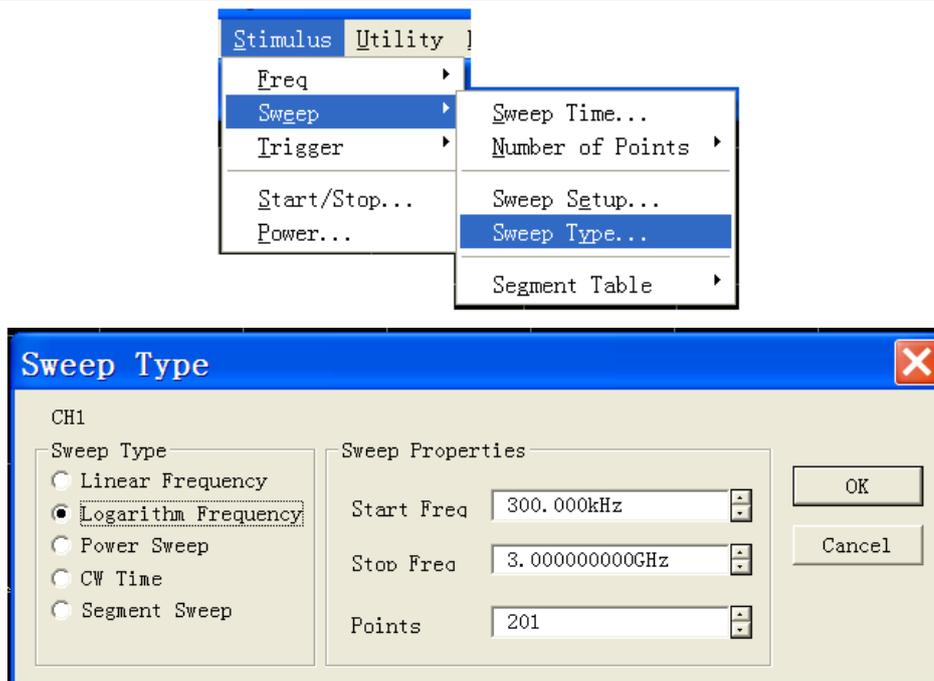
Fig. 5-13　Setting of Sweep Type - Logarithmic Frequency

2.2.2　By front panel keys

a)　Press 【**Sweep**】 key in STIMULUS area and press the soft-key in soft-key menu corresponding to **[Sweep Type]**.

b)　Press the soft-key corresponding to **[Logarithm Frequency]** to select the sweep type.

c)　Press 【**Start**】 key in STIMULUS area and enter start frequency in start frequency box; press 【**Stop**】 key in Stimulus area and enter stop frequency in stop frequency box.

d)　Press 【**Sweep**】 key in STIMULUS area, press the soft-key corresponding to **[Number of Points]** and enter Sweep spot number in **Number of Points** box.

2.3　Setting of power sweep type

2.3.1　By mouse or touch screen

a)　Click **[Stimulus]**, then click **[Sweep Type...]** from menu **[Sweep]** to show dialog box Sweep Type.

b)　Click **[Power Sweep]** option button from Sweep Type.

c)　Set start power, stop power and center frequency in Sweep Feature.

d)　Click **[OK]** button to close the dialog box.
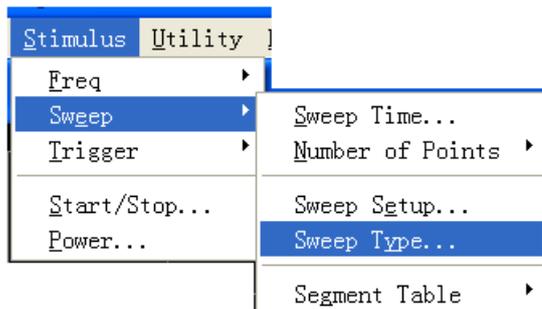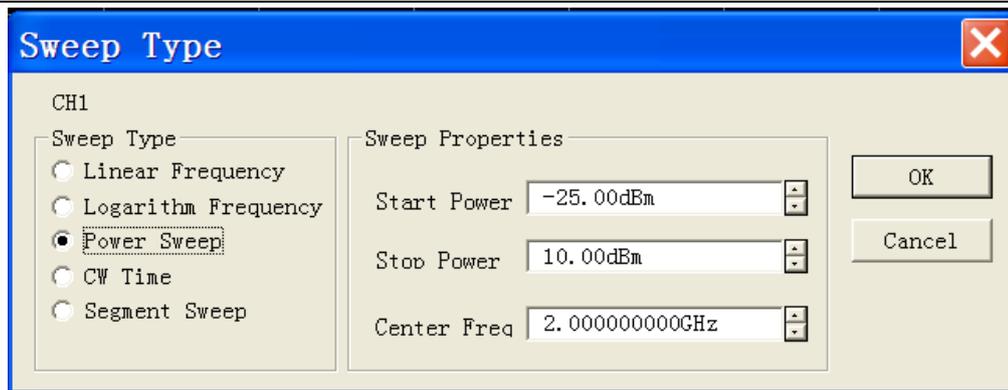
Fig. 5-14   Setting of Power Sweep Type

2.3.2 By front panel keys

    a)   Press 【**Sweep**】 key in STIMULUS area and press the soft-key on soft-key menu corresponding to **[Sweep Type]**.

    b)   Press the soft-key corresponding to **[Power Sweep]** to select the sweep type.

    c)   Press 【**Start**】 key in STIMULUS area to show corresponding soft-key menu. Press soft-key corresponding to **[CW Frequency]** and enter center frequency value in CW Frequency box.

    d)   Press 【**Sweep**】 key in STIMULUS area, press in soft-key menu the soft-key corresponding to **[Power]**; press in submenu the soft-key corresponding to **[Start Power]** and enter start power in Start Power box; press the soft-key corresponding to **[Stop Power]** and enter stop power in Stop Power box.

2.4   Setting of CW Time sweep type

2.4.1   By mouse or touch screen

    a)   Click **[Stimulus]**, then click **[Sweep Type...]** from menu **Sweep** to show Sweep Type dialog box.

    b)   Click **[CW Time]** option button from Sweep Type.

    c)   Set center frequency, Sweep time and Sweep spot number in Sweep Feature.

    d)   Click **[OK]** button to close the dialog box.
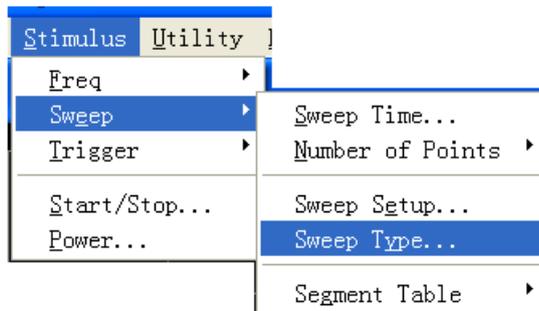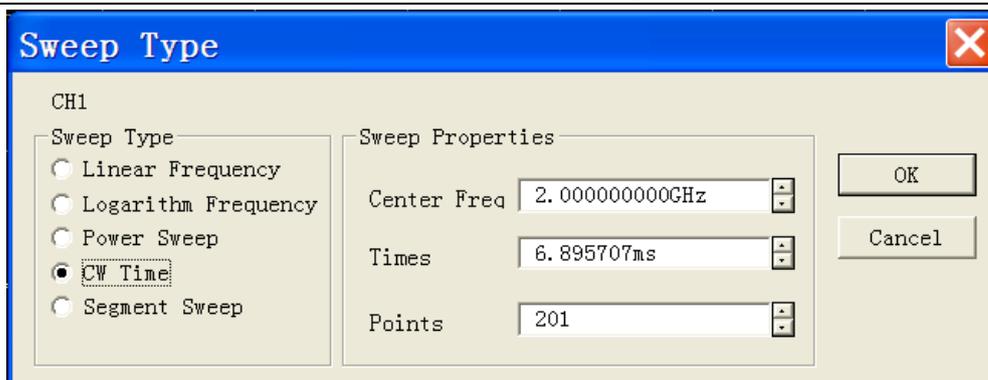
Fig.5-15   Setting of CW Time Sweep Type

2.4.2   By front panel keys

a)   Press 【**Sweep**】 key in STIMULUS area and press the soft-key in soft-key menu corresponding to **[Sweep Type]**.

b)   Press the soft-key corresponding to **[CW Time]** to select the sweep type.

c)   Press 【**Start**】 key in STIMULUS area to show corresponding soft-key menu. Press soft-key corresponding to **[CW Time]** and enter center frequency value in **CW Frequency** box.

d)   Press 【**Sweep Setup**】 key in STIMULUS area, press the soft-key corresponding to **[Sweep Time]** and enter Sweep time in Sweep Time box; press the soft-key corresponding to **[Number of   Points]** and enter Sweep spot number in **Number of Points** box.

2.5   Setup of segment sweep type

2.5.1   By mouse or touch screen

a)   Click **[Stimulus]**, then click **[Sweep Type...]** from menu **[Sweep]** to show the dialog box of **Sweep Type**.

b)   Click **[Segment Sweep]** option button from Sweep Type.

c)   Click **[OK]** button to close the dialog box.
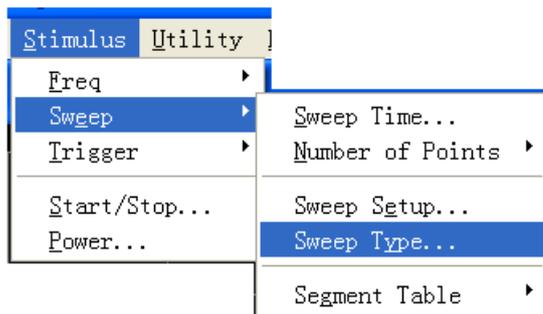
Fig.5-16　Setup of Segment Sweep Type

Options in Sweep Feature zone

- **[Independent Power Level]** check box: when selected, independent power level can be set for each segment which must be with the same attenuator setting.

- **[Independent IF Bandwidth]** check box: when selected, independent IF bandwidth can be set for each segment.

- **[Independent Sweep Time]** check box: when selected, independent Sweep time can be set for each segment.

- **[Show Table]** button: click the button to show segment table, then create and edit the segment table.

- **[Hide Table]** button**:** click to hide segment sweep list.

2.5.2　By front panel keys

    a)　Press　【**Sweep**】　key in STIMULUS area and press the soft-key in soft-key menu corresponding to **[Sweep Type]**.

    b)　Press the soft-key corresponding to **[Segment Sweep]** to select the sweep type.

    c)　Press the soft-key corresponding to **[Segment Table on |　OFF]** to show segment table for edit.

2.6　Insertion and deletion of segment

    The segment table can be edited only when it's in display status.

2.6.1　By mouse or touch screen

    a)　Click **[Stimulus]**, point to **[Segment Table]** in **Sweep** submenu to show the submenu of segment table.

    b)　Select **[Show Table]** in Segment Table submenu.

    c)　Click **[Insert Segment]** in Segment Table submenu to insert a new segment before the selected segment.

    d)　Click **[Delete Segment]** in Segment Table submenu to delete all selected segments. Click **[Delete All Segment]** to delete all segments.
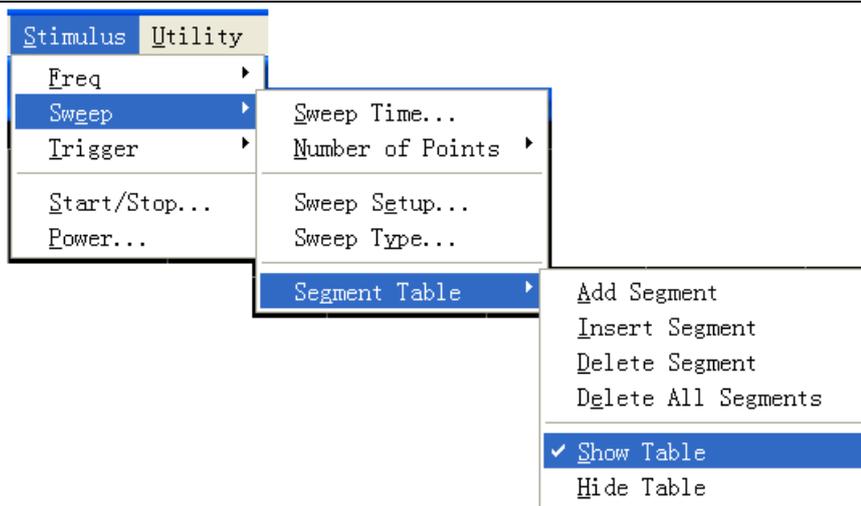
Fig. 5-17   Insertion and Deletion of Segment

2.6.2   By front panel keys

    a)   Press 【**Sweep**】   Key in STIMULUS area to show corresponding soft-key menu.

    b)   Press the soft-key corresponding to **[Segment Table]** menu and press the soft-key corresponding to **[Segment Table on | OFF]**   to show segment table.

    c)   Press the soft-key corresponding to **[Insert Segment]** menu to insert a new segment before the selected segment.

    d)   Press the soft-key corresponding to **[Delete Segment]** menu to delete all selected segments.

When the last segment of the segment table is in **ON** status, Analyzer will add automatically one segment in OFF status; when the last segment of the segment table is in Stimulus status, several segments can be added quickly by continuously pressing 【▽】   key in ADJUST area or turning the knob.

2.7   Edit segment table

2.7.1   By mouse or touch screen

    a)   Double click **[State]** box for segment, select ON or OFF to open or close segment.

    b)   Double click **[Start]** box for segment and enter start frequency of the segment.

    c)   Double click **[Stop]** box for segment and enter stop frequency of the segment.

    d)   Double click **[Points]** box for segment and enter Sweep spot number of the segment.

    e)   Double click **[PWR]** box for segment and enter power level of the segment (when Independent Power Level option is enabled).

    f)   Double click **[IFBW]** box for segment and enter IF bandwidth (when Independent IF Bandwidth option is enabled).

    g)   Double click **[Time]** box for segment and set Sweep time (when Independent Sweep Time option is enabled).

2.7.2   By front panel keys

a) Press 【△】,【▽】 key in ADJUST area or turn the knob to select the segment to be edited.

b) Press 【□】、【□】keys in ADJUST area to **[Status]** box, press 【↵/off】 key in ENTRY area to enable submenu, press 【△】,【▽】 or turn the knob to select ON and press【↵/off】key to select enabled segment. When OFF is selected, the segment will be closed.

c) Press 【□】、【□】keys to **[Start]** box, press 【↵/off】 key to Stimulus Input box, then enter start frequency.

d) Press 【□】、【□】keys to **[Stop]** box, press 【↵/off】 key to Stimulus Input box, then enter stop frequency.

e) Press 【□】、【□】keys to **[Points]** box, press 【↵/off】 key to Stimulus Input box, then enter Sweep spot number.

f) Press 【□】、【□】keys to **[PWR]** box, press 【↵/off】 key to Stimulus Input box, and then enter power level (when Independent Power Level option is enabled).

g) Press 【□】、【□】keys to **[IFBW]** box, press 【↵/off】 key to Stimulus Input box, then enter IF bandwidth (when Independent IF Bandwidth option is enabled).

h) Press 【□】、【□】keys to **[Time]** box, press 【↵/off】 key to Stimulus Input box, then enter Sweep time (when Independent Sweep Time option is enabled).

3 Sweep Time

When Measure settings are completed, Analyzer will adopt the fastest Sweep time as possible, but more Sweep time may be added to meet specific Measure needs. The maximum settable Sweep time is 86400 seconds. If Sweep time is set to be 0 second, Analyzer will select automatically the fastest Sweep time. When Sweep time is more than or equal to 300 milliseconds, Analyzer will display a Sweep indicator to indicate a point-to-point Measure Sweep. Sweep indicator is an upward small arrow, pointing to the point on the Trace which just finished Measure.

3.1 Setting of Sweep time

3.1.1 By mouse or touch screen

a) Click **[Stimulus]**, then click **[Sweep Time...]** in menu **Sweep** to show Sweep Time dialog box.

b) Enter Sweep time in **[Sweep Time]** box.

c) Click **[OK]** button to close the dialog box.
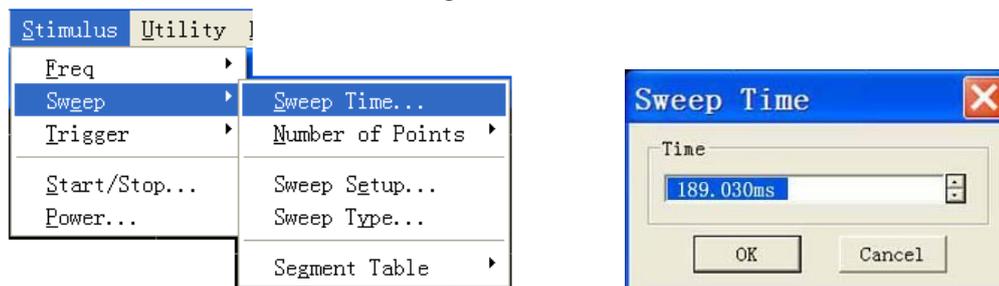
Fig. 5-18   Setting of Sweep Time

3.1.2 By front panel keys

    a)   Press 【Sweep】 key in STIMULUS area.

    b)   Press the soft-key corresponding to **[Sweep Time]** and enter Sweep time in **Sweep time** box.

4 Sweep Setup

4.1   By mouse or touch screen

    a)   Click **[Stimulus]**, then click **[Sweep Setup...]** in menu **Sweep** to show Sweep Setup dialog box.

    b)   Click **[Channel]** box to select setting channel.

    c)   If the default Step Sweep mode is adopted, click **[Dwell Time]** box and set the dwell time of each measuring point; if analog sweep mode takes priority, clear **[Step Sweep]** check box.

    d)   If Alternate Sweep mode is to be selected, select **[Alternate Sweep]** check box.

    e)   If external fixed amplitude is needed, select **[External ALC]** check box.

    d)   After setting, click **[OK]** button to close the dialog box.
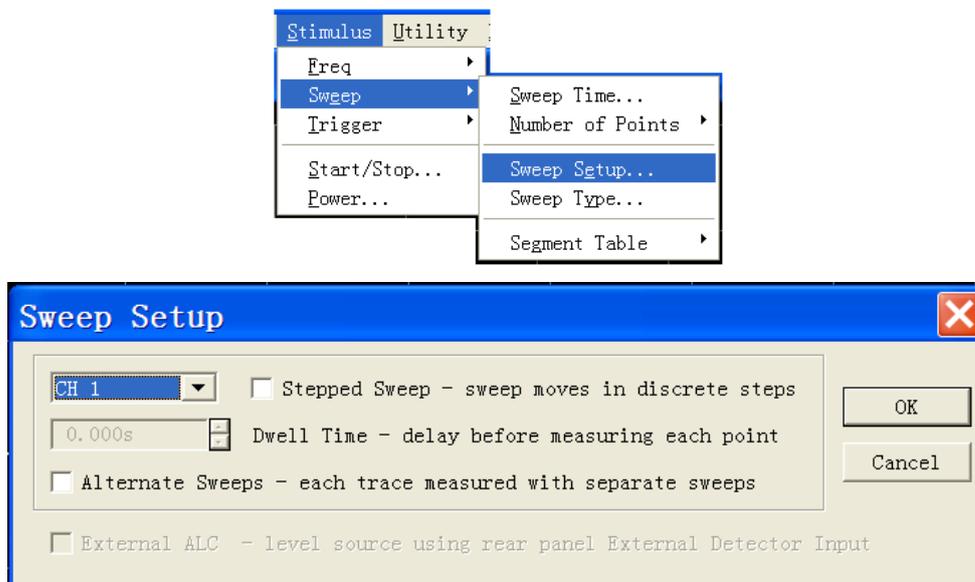
Fig. 5-19   Sweep Setup

4.2 By front panel keys

    a)   Press 【Sweep】 key in STIMULUS area to show corresponding soft-key menu. Press the soft-key corresponding to **[Sweep Setup…]** to show Sweep Setup dialog box.

    b)   Press 【□】、【□】 keys in ADJUST area to **[Channel]** box. Press 【△】,【▽】 key in ADJUST area or turn the knob to select channel setting.

    c)   If the default Step Sweep mode is adopted, press 【□】、【□】 keys to **[Dwell Time]** box to set dwell time of each measuring point.

    d)   If Alternate Sweep mode is to be selected, press 【□】、【□】keys to **[Alternate Sweep]** check box,

and press the knob　key to select the check box.

e)　If external fixed amplitude is needed, press【 □】、【 □】key to **[External ALC]** check box, and press

the knob　key to select the check box.

f)　After setting, press 　【**OK**】　key in ENTRY area to close the dialog box.

4.3　Sweep Setup dialog box

[Channel] box:

Select the channel adaptable to Sweep Setup.

[Step Sweep] check box

When Step Sweep mode is selected, the source will be tuned to a frequency measuring point, waiting for measuring of this frequency point after a specified dwell time, and then it will be tuned to the next frequency point. This working mode is slower than Analog Sweep mode, but can conduct precise Measure for devices with long electrical delay. When this check box is cleared, Analyzer may operate either in Analog Sweep mode or Step Sweep mode, which depends on the setting of Sweep time and IF bandwidth but preferentially selects Analog Sweep mode according to Measure settings.

[Dwell Time] input box

It will appoint the dwell time of Analyzer at each point before Measure data is obtained, which is suitable for Step Sweep working mode only.

Section 6   Selecting Triggering Mode

Trigger signal is the signal controlling the Analyzer for Sweep Measure. Trigger settings determines the Sweep mode of Analyzer and when the sweep stops and returns to hold mode. The Analyzer is quite flexible in trigger function settings.

1   Simple Trigger Settings

Simple trigger settings can set the trigger mode for the current Stimulus channel only.

1.1   By mouse or touch screen

    a)   Click **[Stimulus]** and point to **[Trigger]** in **Stimulus** menu to show the submenu of Trigger.

    b)   Select the trigger mode needed in the submenu.
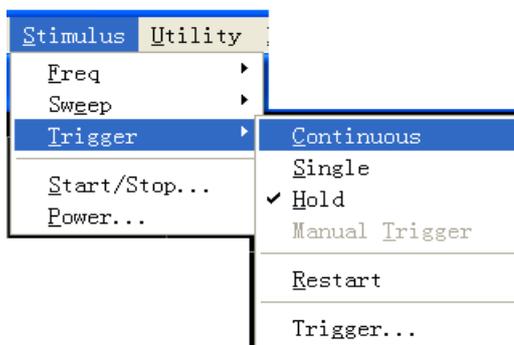
Fig. 5-20   Simple Trigger Mode

1.2   By front panel keys

    a)   Press 【**Trigger**】 Key in STIMULUS area to show corresponding soft-key menu.

    b)   Press the corresponding soft-key to select the trigger mode needed.

2   Detailed Trigger Settings

2.1   By mouse or touch screen

    a)   Click **[Stimulus]**, point to **Trigger** in Stimulus menu and click **[Trigger...]** in the submenu of Trigger to show Trigger dialog box.

    b)   Complete trigger settings in the dialog box.

   c)   After setting, click **[OK]** button to close the dialog box.
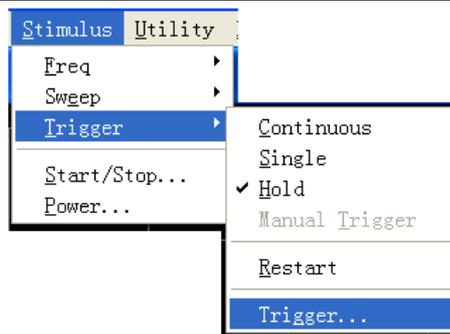
Fig. 5-21　Submenu of Trigger
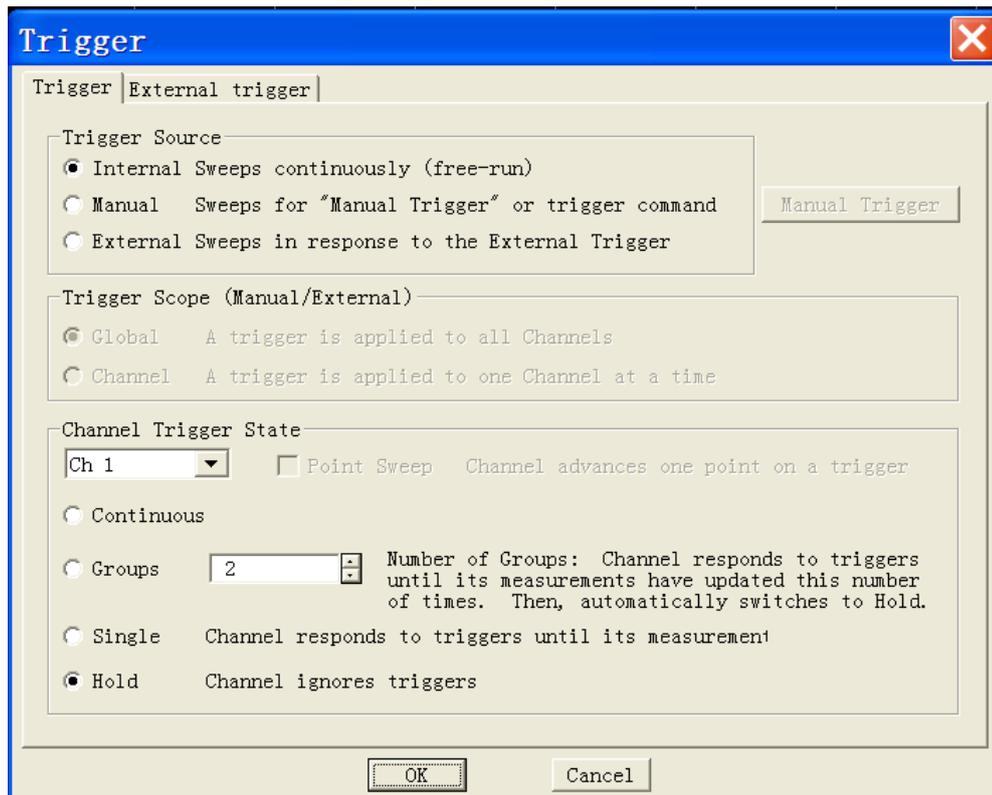
Fig. 5-22　Trigger Dialog Box

2.2　By front panel keys

a) Press 【**Trigger**】 Key in STIMULUS area to show corresponding soft-key menu.

b) Press the soft-key corresponding to **[Trigger…]** to show Trigger dialog box.

c) Complete trigger settings in the dialog box.

d) After setting, press 【OK】 key in ENTRY area to close the dialog box.

2.3　Trigger dialog box

Trigger source zone

Trigger source settings determine where the trigger signal is from. Effective trigger signal will generate only when the Analyzer is not Sweep. The Analyzer may select 3 types of trigger source:

internal, manual and external. Once the trigger source is set, the Analyzer will apply this trigger source to all channels.

a)   [Internal] (default)

The Analyzer will automatically control the generation of trigger signal.

The Analyzer will generate a trigger signal immediately after a Measure.

b)   [Manual]

Manual trigger signal may be generated by the following averages:

Click [Manual Trigger] button in Trigger dialog box.

Press the Trigger key in front panel and press the corresponding soft-key to [Manual Trigger] in soft-key toolbar.

Call program control command.

c)   [External]

Trigger signal is input from external trigger input connector on the rear panel.

The signal is TTL level.

Level trigger, active level (high active or low active) is set via External Trigger dialog box.

Pulse width shall be at least 1us but not longer than Sweep time (several triggers may be aroused when pulse width is longer than Sweep time).

Trigger Scope zone

Trigger range settings determine what Measure channels of Analyzer will receive trigger signal. There are two settings for trigger range: All and Channel:

a)   [All]

This is the default setting for Analyzer. All the other channels will receive trigger signal except for the channel in **Hold** mode.

b)   [Channel]

Only the next channel not in **Hold** mode will receive trigger signal. When Measure is completed for the current channel, Analyzer will select automatically the next channel to receive trigger signal. All the other channels will be selected in order except for the channel in **Hold** mode. This setting has no evident influence on Measure unless **Trigger Source** is set to be manual status. When **Channel** setting is selected, **spot sweep** function will be available.

Channel Trigger State zone

Trigger settings determine how many trigger signals will be received by one channel. There are four channel trigger status:

a)   [Continuous]

The channel will receive unlimited trigger signals and continue to sweep.

b)   [Group]

The channel will receive the trigger signal with the number specified in [Group] input box to

conduct Sweep for specified times and then enter into Hold mode.

c) [Single]

The channel will receive one trigger signal to conduct one Sweep, and then enter into Hold mode.

d) [Hold]

The channel will not receive trigger signal and stop Sweep.

e) [Channel Selection]

Select the channel adaptable to trigger settings.

f) [Spot Sweep]

This trigger mode can be selected only when trigger source is manual or external and trigger range is channel. Under spot sweep mode, when the channel receives trigger signal, the next data point in the Sweep will be measured. The channel will receive trigger signal until all Measures in the channel are complete, and then it will trigger the next channel not in Hold mode.

2.4 External trigger dialog box
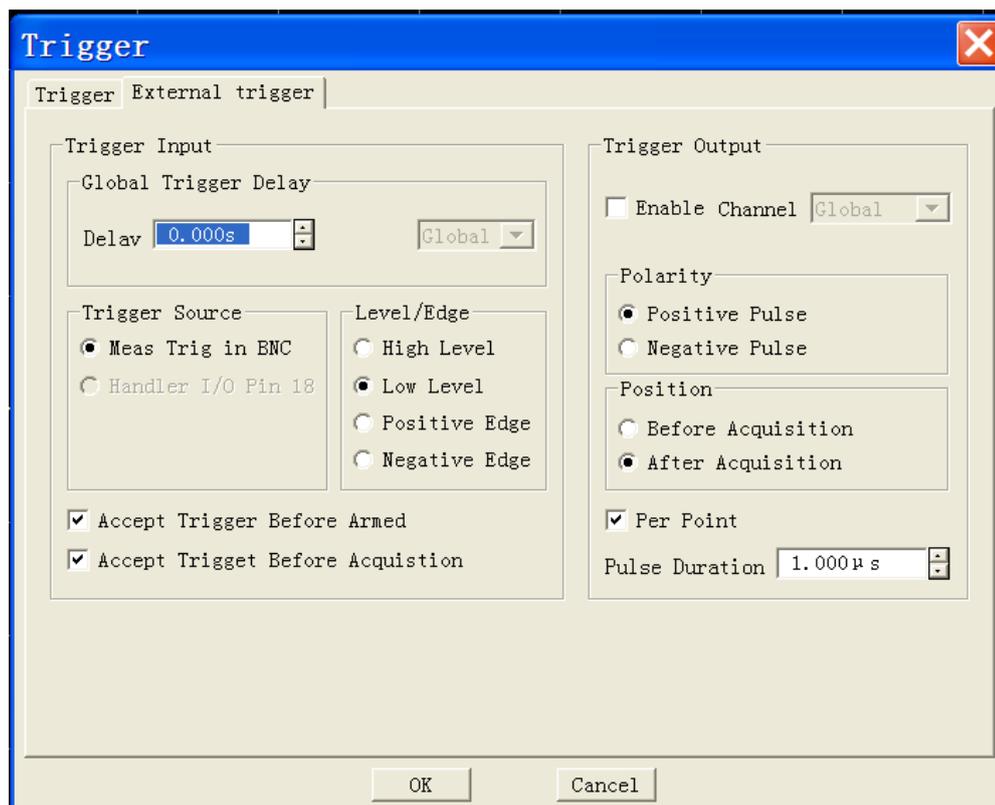
Fig. 5-23   External Trigger Dialog Box

Trigger input zone

Global trigger delay zone

When external trigger signals are received, the Analyzer will start Sweep after the delay time as set in Time Delay dialog box.

Trigger source zone

It can be set that through which rear panel connector the Analyzer will receive trigger signals.

Level/edge zone

    a) High level

    When the Analyzer is ready for triggering, it will trigger at the high level of the selected TTL

    input signal.

    b) Low level

    When the Analyzer is ready for triggering, it will trigger at the low level of the selected TTL

    input signal.

    c) Positive edge

    When the Analyzer is ready for triggering, it will trigger at the next rising edge of the received

    signal.

    d) Negative edge

    When the Analyzer is ready for triggering, it will trigger at the next falling edge of the received

    signal.

⚠	**NOTE:**	**When the channel receives trigger signal, it will start all sweep Measures in the channel: firstly all positive Measures (S_{11}, S_{21}) shall be conducted and then reverse Measures (S_{12}, S_{22}), except for the following situation:** ⑴ **Alternate Sweep is selected.** ⑵ **Spot Sweep is selected.**

Trigger output zone

  Enable channel

When selected, it may trigger output.

  Polarity zone

Set the polarity of trigger output.

  Position zone

Set where the trigger output may occur and the width of trigger pulse.

Section 7   Selecting Data Format and Scale

Data format refers to the way the Analyzer graphically displays Measure data. The data format most suitable for understanding the property of measured piece shall be selected during the Measure. This section introduces 9 data formats and how to set the scale so as to better display measuring information.

1   Data Format

1.1   Rectilinear coordinate format

7 among the 9 data formats display measuring data information in rectilinear coordinate, which is also called Descartes format, X/Y format or linear grid format. This is most suitable for displaying frequency response information of the measured piece. Rectilinear coordinate will display the following information:

- By default, X axis displays activation value in linear scale (frequency, power or time).
- Y axis displays the corresponding response value at different activation values.
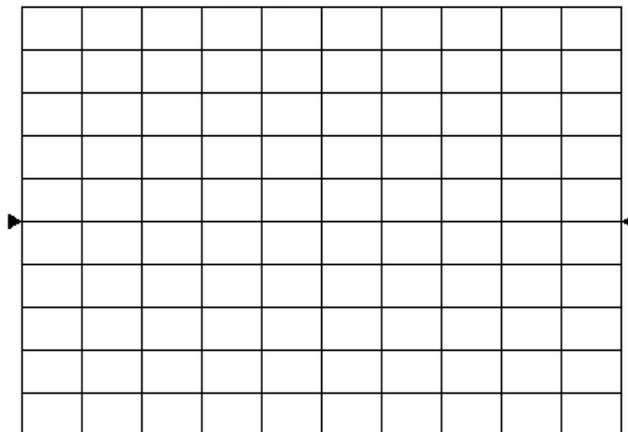
Fig. 5-24   Rectilinear Coordinate Format

The 7 data formats displayed in rectilinear coordinate are:

a)   Log-magnitude format
- Display magnitude information (without phase information).
- Y axis unit: the unit is dB when ratio is measured and it is dBm when non-ratio power is measured.
- Suitable typical Measure: return loss, insertion loss and gain.

b)   Phase format
- Display phase information (without magnitude information).
- Y axis unit: phase (degree).
- Suitable typical Measure: linear phase deviation.

c)   Group delay format

- Display the transfer time of signal passing through the measured piece.

- Y axis unit: time (second).

- Suitable typical Measure: group delay.

d) Linear magnitude format

- Only positive value will be displayed.

- Y axis: no unit (U) when ratio is measured and the unit is watt (W) when non-ratio power is measured.

- Suitable typical Measure: reflectance and transfer factor (magnitude value), time domain transformation.

e) SWR format

- It display reflection Measure data through the formula:$(1+\rho)/(1-\rho)$, in which ρ is the reflectance.

- It is effective only reflection Measure is conducted.

- Y axis: no unit.

- Suitable typical Measure: standing wave ratio format.

f) Real format

- Display the real part of measuring complex data.

- Similar with linear magnitude format, but may display positive and negative value.

- Y axis: no unit.

- Suitable typical Measure: time domain Measure, auxiliary input voltage signal Measure for maintenance purpose.

g) Imaginary format

- Display the imaginary part of measuring complex data only.

- Y axis: no unit.

- Suitable typical Measure: impedance Measure when matching network is designed.

1.2   Polar coordinate format

Polar coordinate format includes magnitude and phase information, and the vector value is read by the following averages:

The magnitude for any point is determined by the displacement from this point to the center point (or zero point). By default, the magnitude is in linear scale and the outer circle is set to be of the ratio 1.

The phase value of any point is determined by its included angle to X axis.

As there is no frequency information, frequency information is read through marker. By default, the marker format is real/imaginary part. The other formats may be selected through the Marker dialog box in Marker menu.
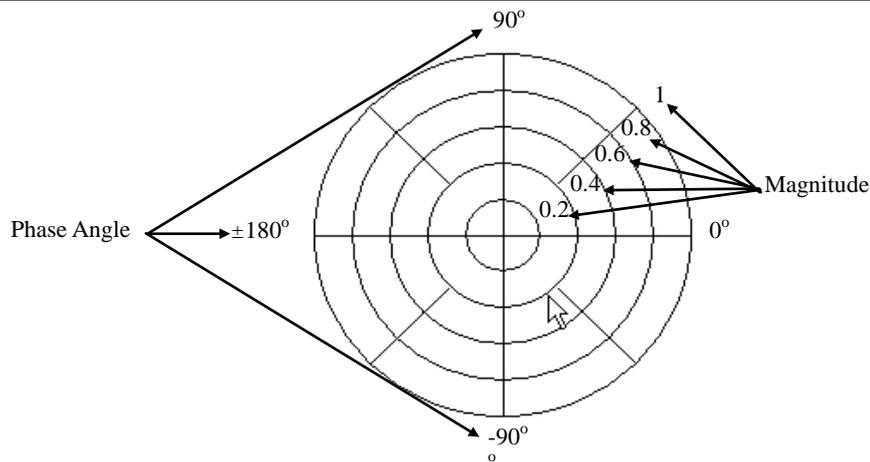
Fig. 5-25   Polar Coordinate Format

1.3   Smith Chart format

Smith Chart is a tool for mapping the reflection Measure data of the measured piece to impedance. Each point on the chart represents one complex impedance made up of real resistance (R) and virtual reactance (±jX). The resistance value, reactance value and reactance equivalent capacitance or inductance of the measured piece may be read through the marker.
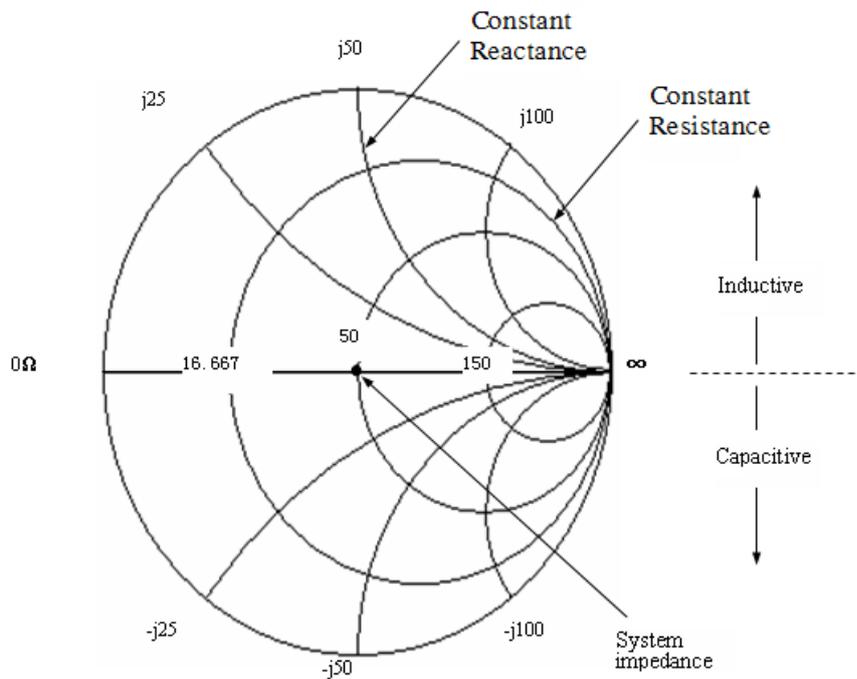
Fig. 5-26   Smith Chart Format

- The central horizontal axis of Smith Chart represents pure resistance, and the center point of horizontal axis represents system impedance; the far left resistance is zero which represents short circuit; the far right resistance of horizontal axis is infinite which represents enabled

circuit.

- On the chart, the points on the circle intersecting with horizontal axis have the same resistance value.

- On the chart, the points on the circle (or arc) tangent with horizontal axis have the same resistance value.

- On the chart, the reactance of the upper part is positive, therefore it's inductive zone; the reactance of the lower part is negative, therefore it's capacitive zone.

2   Setting of Data Format

2.1   By mouse or touch screen

   a)   Click **[Response]** and point to **[Format]** in Response menu to show the submenu of Format.

   b)   Select the format needed in the submenu.
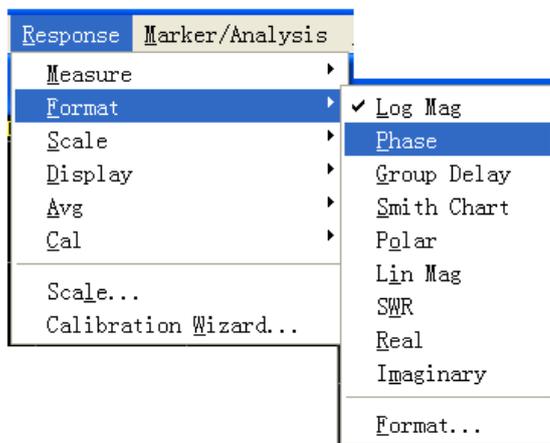
Fig. 5-27   Data Format Settings

2.2   By front panel keys

   a)   Press 【**Format**】 key in RESPONSE area to show corresponding soft-key toolbar.

   b)   Press the corresponding soft-key to select the format needed.

3   Scale

Scale is used to set the scale of the vertical part of grid shown. In Polar coordinate format or Smith Chart format, it is used to set the full scale of the outer circle. The scale and format settings determine the display mode of measuring data on the screen. In Logarithmic format, the scale setting range is: 0.001dB/grid~500dB/grid.

3.1   Setting of scale

3.1.1   By mouse or touch screen

   a)   Click **[Response]**, point to **[Scale]** in Response menu to show submenu. Click **[Scale...]** to show Scale dialog box.

   b)   Click the corresponding input zone or button to set suitable scale, reference position and reference

value.

c)　After setting, click **[OK]** button to close the dialog box.
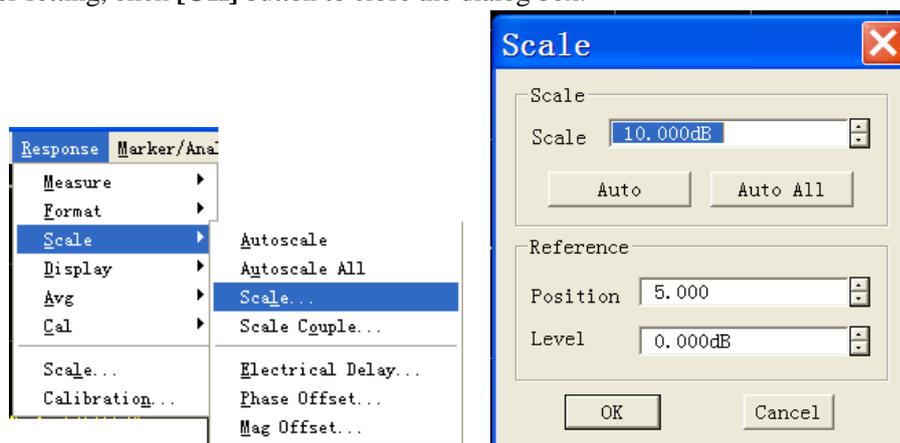
Fig. 5-28　Scale Settings

suitalble

3.1.2　By front panel keys

a)　Press【**Scale**】key in RESPONSE area to show corresponding soft-key toolbar.

b)　Press the soft-key corresponding to **[Autoscale]** and Analyzer will set automatically suitable scale and reference level.

c)　Press the soft-key corresponding to **[Scale]** and set suitable scale in **Scale Per division** box.

d)　Press the soft-key corresponding to **[Reference Level]** and set reference level in **Reference Level** box.

e)　Press the soft-key corresponding to **[Reference Position]** and set suitable reference position in **Reference Position** box.

3.1.3　Scale settings dialog box

Scale zone

a)　**[Scale]**

Set the scale.

b)　**[Auto Scale]**

Click **[Auto Scale]** button, the Analyzer will select automatically vertical scale to better show the Stimulus Trace in the vertical grid of the screen. The activation value is not influenced, but the scale and reference value will be changed.

● The Analyzer will select suitable scaleality factor to show the data in 80% zone of the screen.

● If the reference position is at the center of the screen, the reference value will select the center value of the Trace on the screen.

c)　**[Auto All]**

Click **[All Auto Scale]** button, the Analyzer will set suitable scale for all Traces in the window to better show them in the vertical grid of the window.

Reference setting zone

a)   **[Position]**

Reference position refers to the position of the reference line in rectangular chart. In the chart, the position of the line at the bottom is 0, the position of the line at the top is 10 and the default value at reference position is 5.

b)   **[Level]**

Reference value refers to the value of reference line in rectangular coordinates format and the value of outer circle in polar coordinate and Smith Chart format. Its setting range in log-magnitude format is -500dB~+500dB.

Section 8 Observing Multi-Trace and Enabling Multichannel

1 Measure Settings for Pre-Configuration

The pre-configuration of Analyzer provides a most convenient way to conduct Measure for multi-Trace, multichannel and multi-window. The Analyzer provides for four Measure settings for pre-configuration, each of which, when selected, shall close the current Trace and window and create new Trace and window. The arrangement for the window of the four pre-configurations is as follows:
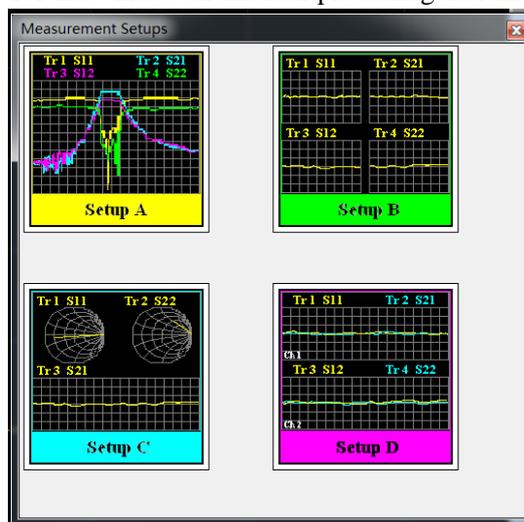
Fig. 5-29 Arrangement for Pre-Configuration Window

a) Setup A

Setting A will create four Traces in window 1: S11, S21, S12 and S22, log-magnitude format and channel 1 setting.

b) Setup B

Setting B will create four Traces in four windows, log-magnitude format, and channel 1 setting.S11 displays in window 1, S21 displays in window 2, S12 displays in window 3 and S2displays in window 4.

c) Setup C

Setting C will create three Traces in three windows and channel 1 setting. S11, Smith Chart format displays in window 1; S22, Smith Chart format displays in window 2; and S21, log-magnitude format displays in window 3.

d) Setup D

Setting D will create four Traces in two windows, two channel settings and log-magnitude format.S11 and S21 display in window 1, channel 1 setting; S12 and S22 display in window 2, channel 2 setting.

1.1 Pre-Configuration Measure Settings

1.1.1   By mouse or touch screen

    a)   Click **[Response]**, point to **[Display]** in Response menu and select **[Meas Setups]** in the submenu.

    b)   Select the pre-configuration Measure needed in the pop-up dialog box.
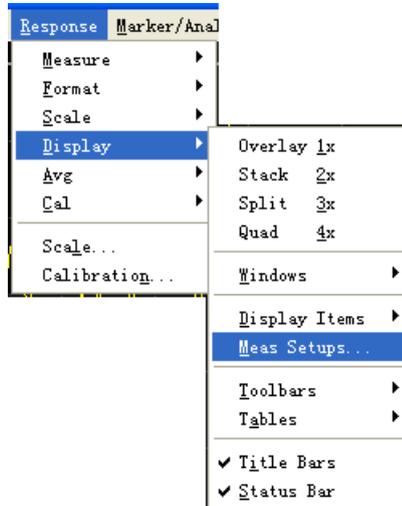


Fig. 5-30   Pre-Configuration Meas Setups

1.1.2   By front panel keys

    a)   Press 【**Display**】 key in RESPONSE area to show corresponding soft-key toolbar.

    b)   Press **[Meas Setups…]** and press the corresponding soft-key to select pre-configuration Measure.

2   Window Arrangement

The Analyzer provides several methods to adjust window display:

- Move the window and adjust the window of the Analyzer with mouse.

- Arrange the window of the Analyzer with **[Tile]**, **[Cascade]**, **[Minimize]** and **[Maximize]** menu item.

- Click **[Display]** in **Response** menu and select four window arrangements.

- Adjust or hide the display of Analyzer window by use of **[Minimize]**, **[Maximize/Restore Down]** and **[Close]** button.

- Press 【**Display**】 key on **Response** keypad on front panel to show corresponding soft-key toolbar. Press corresponding soft-key to **[Window]**, select the window to be Stimulus, and press the soft-key corresponding to **[More...]** to set window display.

The [**Display**] menu item in **Response** menu of Analyzer provides for four window arrangements, which can allocate the existing Traces to different windows according to certain arithmetic. The provided window arrangement modes include:

  a) Overlay $1_\times$

For this type of arrangement, all Traces overlaying by each other can be displayed in one window.

b)   Stack 2×

For this type of arrangement, all Traces can be displayed in two windows which are vertically stacked.

c)   Split 3×

For this type of arrangement, all Traces can be displayed in three windows, two of which are at the top and one at the bottom.

d)   Quad 4×

For this type of arrangement, all Traces can be displayed in four windows, each of which takes up 1/4 of the screen.

2.1   Window arrangement settings

2.1.1   By mouse or touch screen

a)   Click **[Response]** and point to **[Display]** in Response menu to show the submenu.

b)   Select the arrangement mode of window in the submenu shown.
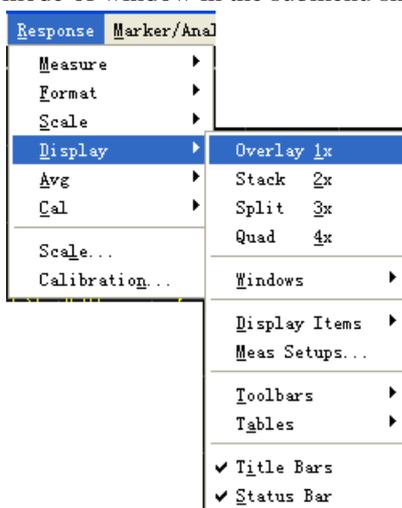
Fig. 5-31   Window Arrangement Settings

2.1.2   By front panel keys

a)   Press 【**Display**】 key in RESPONSE area to show soft-key toolbar.

b)   Press the corresponding soft-key to select the window arrangement mode needed.

3   Moving Traces

The Analyzer supports the dragging of mouse to move Traces in Measure window. If the Measure channel for moving Traces is not included in the purpose window, the purpose window will create corresponding channel after Trace movement. The setting method is as follows:

a)   If there are several Traces displaying in the window, click the up-down arrow button at the Trace status bar for roll display until the Trace status button required displays in the Trace status

bar.

b)   Point to the Trace status button corresponding to the moving Trace with mouse. Press the left key of mouse and hold on.

c)   Drag the mouse until the mouse pointer turns to motion indicator " ✛ ", drag the mouse pointer to Trace status bar of the purpose window, release the left key of mouse and the Trace moving finishes.

Section 9   Setting Analyzer Display

We can define OSD (on screen display) by means of Display menu in Response menu of the Analyzer. Optional screen display elements contain the status bar, tool bar, form, Measure setting, Trace status, title bar, etc., and they are quite useful for observation, setup and Measure modification.

1   Status Bar

Ready   CH1   S11   MATH: /   COR: OFF   AVER: 5 COUNT: 5   SMOOTH: 5   TRANSFORM: ON   GATE: ON   GPIB: LOCAL   REF: EXT

When the status bar is enabled, it is displayed at the bottom of screen, and displayed contents are as follows:

- ● Current Stimulus channel

- ● Measure parameters of current Stimulus Trace

- ● Display the arithmetical operation carried out by Stimulus Trace when the Trace computation function is enabled

- ● Error modification condition of Stimulus channel

- ● Average factors of current Stimulus channel and times of average operation carried out are displayed, when average function is enabled.

- ● Smoothing spots are displayed when smoothing function is enabled.

- ● TRANSFORM:ON is displayed when time domain transformation function is enabled.

- ● GATE:ON is displayed when gate function is enabled.

- ● GP-IB condition: LOCAL or REMOTE

- ● Clock reference signal condition: INT or EXT

1.1   Triggering of status bar display

1.1.1   By mouse or touch screen

Click **[Response]** once, point at **[Display]** on dropdown menu to get the submenu, click and tick **[Status bar]** to enable status bar display, and remove the tick to close status bar display.
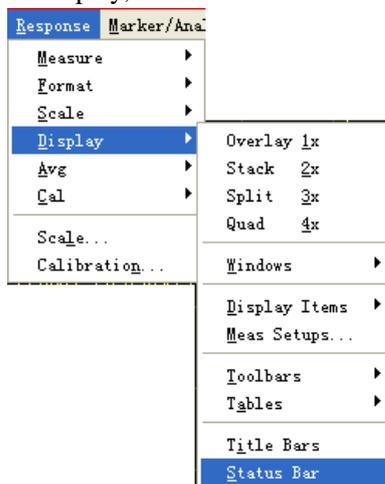
Fig. 5-32   Triggering of Status Bar Display

1.1.2   By front panel keys

a) Press【**Display**】in RESPONSE area, the corresponding soft-key tool bar turns up, and press soft-key corresponding to **[More]**.

b) Press soft-key corresponding to **[Status bar on/OFF]** in the displayed soft-key tool bar to enable the status bar display.

2   Tool Bar

The Analyzer can simultaneously display 6 different tool bars at most, and it is quite easy to set up Measure by the tool bar.

a)   Active input tool bar

The active input tool bar is displayed at the top of screen and under the menu bar; press different Utility keys on the front panel, different active input tool bars will be displayed, and it is feasible to input corresponding numerical value if names of tool bars correspond to names of keys.

b)   Marker tool bar

The marker tool bar is used to set up and modify marker, as well as change Analyzer setup. By the marker tool bar, it is feasible to set up:

●   Current Stimulus marker

●   Activation value of Stimulus marker

●   Δ marker, carry out maximum/minimum value search, and set up start/stop and center/span activation value of the Analyzer according to the marker position.

When the marker tool bar is enabled, if you want to change the position of Stimulus marker by the knob on the front panel, firstly click [Stimulus] frame in the marker tool bar, and then turn the knob to change the marker position, referring to Section 1 "Marker" in Chapter VIII for detailed information about marker.

c)   Measure tool bar
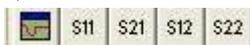
The Measure tool bar is used to create required S parameter Trace in the current Stimulus window or new window, create S parameter Trace in the current Stimulus window when the leftmost button in the Measure tool bar is uplifted ( ), and create S parameter Trace in the new window when the button is pressed down ( ).

d)   Sweep control tool bar

Buttons on the sweep control tool bar respectively set up the trigger way of the Stimulus channel to be:

●   **Hold** mode

● **Single Sweep**, and then enter into **Hold** mode

● **Continuous Sweep**

Refer to Section 6 "Selection of Trigger Mode" in Chapter V for detailed information about trigger.

e)   Stimulus toolbar
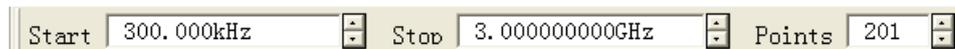
The Stimulus toolbar is used to observe and set up sweep activation, and it is able to set up:

● Start activation value

● Stop activation value

● Sweep spot number

f)   Time domain toolbar

The following settings can be carried out by using the time domain toolbar:

● Enable or stop the time domain transformation and the time gate functions.

● Change settings of start/stop or center/span of the time domain transformation and the time gate time.

● Click **[More…]** button to open the **Time Domain Transformation** dialog box.

● Click **[X]** button to close the time domain toolbar.

g)   Close all menus

Click **[All OFF]** menu, and all toolbars can be closed once.

2.1   Triggering of toolbars display

2.1.1   By mouse or touch screen

a)   Click **[Response]**, point at **[Display]** on the Response menu, and point at **[Toolbars]** on the display submenu.

b)   Click the tool bar to be set up in Toolbars submenu, enable toolbar display when checking, and close toolbar display when removing the tick.
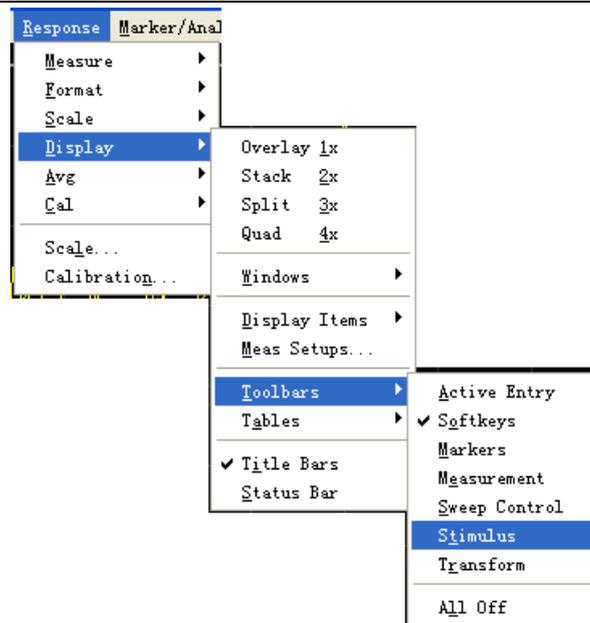
Fig. 5-33   Triggering of Toolbars Display

2.1.2   By front panel keys

  a) Press **[Display]** in RESPONSE area to display the corresponding soft-key tool bar, and press soft-key corresponding to **[More]**.

  b) Press the soft-key corresponding to **[Toolbars]** to display the **Toolbars** submenu.

  c) Press the wanted toolbar soft-key, enable the toolbar display when it is "**On**", and close toolbar display when it is "**Off**".

3   Tables

The Analyzer can display the marker table, limit table and segment table, and it can observe and modify their settings (can not edit the marker table).

  ● The table is displayed under the corresponding window.

  ● Every window can display only one table every time.

a) Marker table

Fig. 5-34   Marker Table

The marker table is used to display settings of marker, and these settings contain:

  ● Marker number

  ● Reference marker (used for the relative Measure)

  ● Activation value of marker

  ● Response valve at the place of marker

Refer to Section 1 "Marker" in Chapter VIII for detailed information about marker.

b)   Limit table

	Type	Begin Stimulus	End Stimulus	Begin Response	End 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. 5-35   Limit Table

The limit table is used to display and modify the limit test settings, and these settings contain:

● Type of limit test (MAX, MIN or OFF)

● Start and stop activation values of the limit line segment

● Start and stop response values of the limit line segment

● Display type of the limit line segment (SLOT, FLAT or POINT)

Refer to Section 3 "Limit Test" in Chapter VIII for detailed information about limit test.

c)   Segment table

	State	Start	Stop	Points
1	ON	300.000kHz	3.000GHz	21
2	ON	3.000GHz	3.000GHz	21
3	OFF	3.000GHz	3.000GHz	21

Fig. 5-36   Segment Table

The segment table is used to set up and modify the segment Sweep, and these settings contain:

● Segment condition (ON/OFF)

● Start and stop activation values of the segment

● Sweep spot number of the segment

● Power level (each segment can be set up individually)

● Intermediate-frequency bandwidth (each segment can be set up individually)

● Sweep time (each segment can be set up individually)

Refer to the part of "Segment sweep" in Section 5 "Sweep Setup" of Chapter V.

3.1   Triggering of table display

3.1.1   By mouse or touch screen

a)   Click **[Response]**, point at **[Display]** on the **Response** menu, and point at **[Tables]** on the display submenu.

b)   Click the table to be set up in the **Tables** submenu, enable the table display when checking, and close table display when removing the tick.
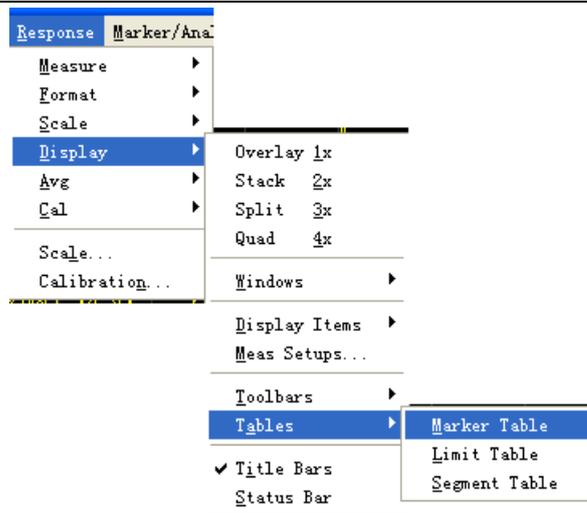
Fig. 5-37   Triggering of Tables Display

3.1.2   By front panel keys

    a)   Press 【**Display**】 in RESPONSE area to display the corresponding soft-key tool bar, and press soft-key corresponding to **[More]**.

    b)   Press the soft-key corresponding to **[Tables]** to display **Table**s submenu.

    c)   Press the corresponding soft-key to select the table to be enabled.

4   Measure Display

We can display and hide 6 kinds of Measure information to set up and observe Measure, and the information contains:

- Trace status bar
- Frequency/Activation
- Marker reading
- One marker for each Trace
- Big marker
- Limit test result
- Limit line
- Title

a)   Trace status bar

    The Trace status bar is displayed above each window on the screen, and displayed contents are as follows:

- Measure parameter and format
- Scale

● Reference value

Clicking the Trace status bar can make the corresponding Trace change to the current Stimulus Trace so as to set up the Trace. Click the right mouse button when the marker is on the Trace status button, use right key menu to delete the Trace or set up the scale, color and line type of the Trace.

b) Frequency/activation value

The frequency/activation information is displayed under each window on the screen, this display can be hidden for the purpose of keeping secret. For detailed setting methods, pls refer to the part of "Triggering Measure display" below this section. The information it displays is as follows:

- Channel No.
- Start activation value
- Stop activation value

c) Marker reading

The marker reading information is displayed at the top right corner of each window on the screen, and it displays information as follows:

● Marker No.

● Activation value of marker

● Response value of marker selection format

Refer to Section 1 "Marker" in Chapter VIII for detailed information about marker.

d) One marker for each Trace

When checking this item, only 1 marker can be enabled on each Trace.

e) Big marker

When checking this item, the typeface of marker reading becomes bigger.

f) Limit test result

The limit test result (PASS or FAIL) is displayed at the lower right corner of each window.

g) Limit line

The limit line targets at Stimulus Trace display in the designated window, and its position depends on following settings;

● Limit table

● Format

● Scale

● Reference level

Refer to Section 3 "Limit Test" in Chapter VIII for detailed information about limit test.

Please refer to the part of "Triggering Measure display" in this section for the method of displaying the limit line and limit test result.

h)   Title

Each window can have a title, the title can be created by the **Title Input** dialog box below, and it is displayed at the upper right corner of the window. If you want to remove the title, delete it in **[Input]** box of the dialog box and click **[OK]** button to close the dialog box.
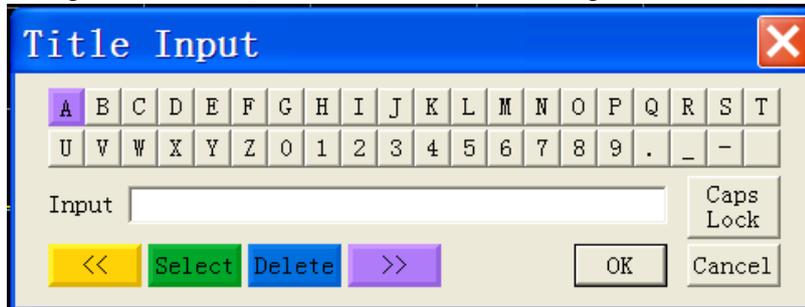
Fig. 5-38   Title Input Dialog Box

Refer to the part of "Triggering Measure display" in the section for the method of displaying the **Title Input** dialog box.

4.1   Triggering of Measure display

4.1.1   By mouse or touch screen

a)   Click **[Response]**, point at **[Display]** on the dropdown menu, and point at **[Display Items]** on the display submenu.

b)   Click the Measure display item to be displayed or hidden on the **Display Items** submenu, Display the Measure display item when checking, and hide the Measure display item when removing the tick.
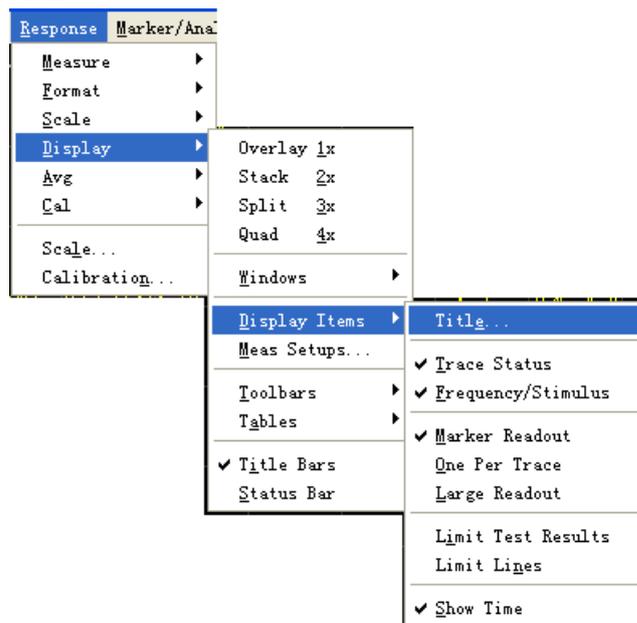

Fig. 5-39   Triggering of Measure Display

4.1.2   By front panel keys

    a)   Press 【**Display**】key in RESPONSE area, and press the soft-key corresponding to **[Display Items]** on the soft-key menu.

    b)   Press the soft-key corresponding to **[Marker Display]** on the soft-key menu. The three items of **[Mkr Readout <u>ON</u> |off], [One per Trace on|<u>OFF</u>]** and **[Larde Readout on|<u>OFF</u>]** will turn up, press the corresponding soft-key to select the desired Measure display.

    c)   Press 【**Analysis**】 in the MKR/ANALYSIS area, the soft-key menu turns up, press the soft-key corresponding to **[Limits]**, the **[Limit Test on|<u>OFF</u>]** and **[Limit Line on|<u>OFF</u>]** turn up, and press the corresponding soft-key to select the desired Measure display.

5   Triggering of Data Trace and Memory Trace Display

5.1   By mouse or touch screen

Click **[Marker/Analysis]**, point at **[Memory]** on the submenu, and click **[Data Trace]** or **[Memory Trace]** on the **Save** menu.

Display the corresponding Trace when checking, and hide the corresponding Trace when removing the tick.
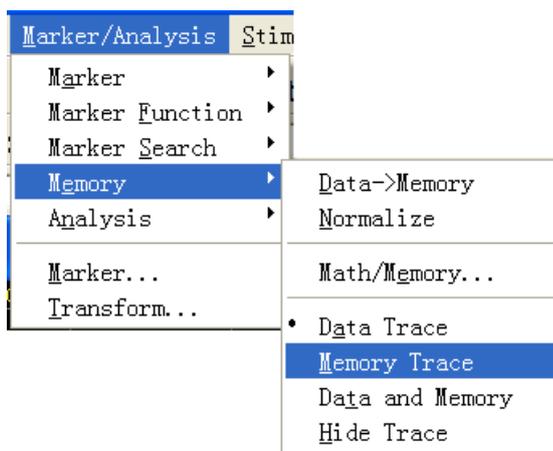
Fig. 5-40   Triggering of Data Trace and Memory Trace Display

If you want to observe the saved Trace, you must save the Trace into memory firstly, and then you can carry out arithmetical operation, including plus, minus, multiply and divide on the data Trace and saved Trace. Pls refer to the part of "Trace Computation and Statistics" in Section 2 of Chapter VIII for detailed information.

5.2   By front panel keys

Press 【**Memory**】 in the MKR/ANALYSIS area to display the corresponding soft-key menu, it is feasible to display corresponding Trace when pressing and checking the soft-key corresponding to **[Data Trace]** or **[Memory Trace]**, hide the corresponding Trace when removing the tick.

6　Title Bar

The title bar contains the main Measure applications title bar and window title bar, and it displays window titles and window control buttons. Hiding the title bar is able to hide all title bars on the screen, so that there is a bigger screen area to display the Measure result.

6.1　Triggering of title bar display

6.1.1　By mouse or touch screen

Click **[Response]**, and click **[Display]** on the submenu, then click **[Title Bars]** on the Display submenu. Display the title bar when checking, and hide the title bar when removing the tick.
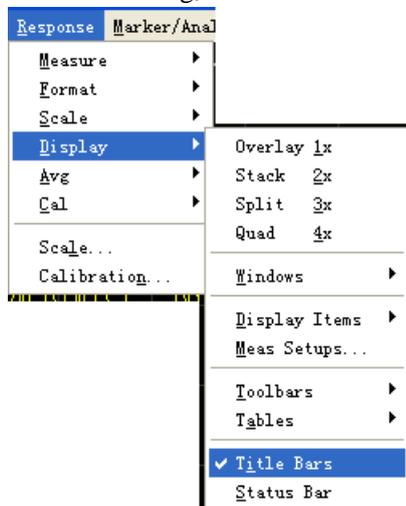
Fig. 5-41　Ttriggering of Title Bars Display

6.1.2　By front panel keys

a) Press【**Display**】in RESPONSE area, the corresponding soft-key tool bar turns up; Press **soft-key** corresponding to **[More]**, and the submenu turns up.

b)　Press the soft-key corresponding to **[Title Bar on|OFF]**, display the title bar when it is "**ON**", and hide the title bar when it is "**OFF**".

7. User Configuration Display

7.1 By mouse or touch screen

a) Single click [**UTILITY**], single click [**ConFig.**] on the [**System**] menu, and single click [**User Config…**] on the appearing submenus to display the User ConFig. dialog box.
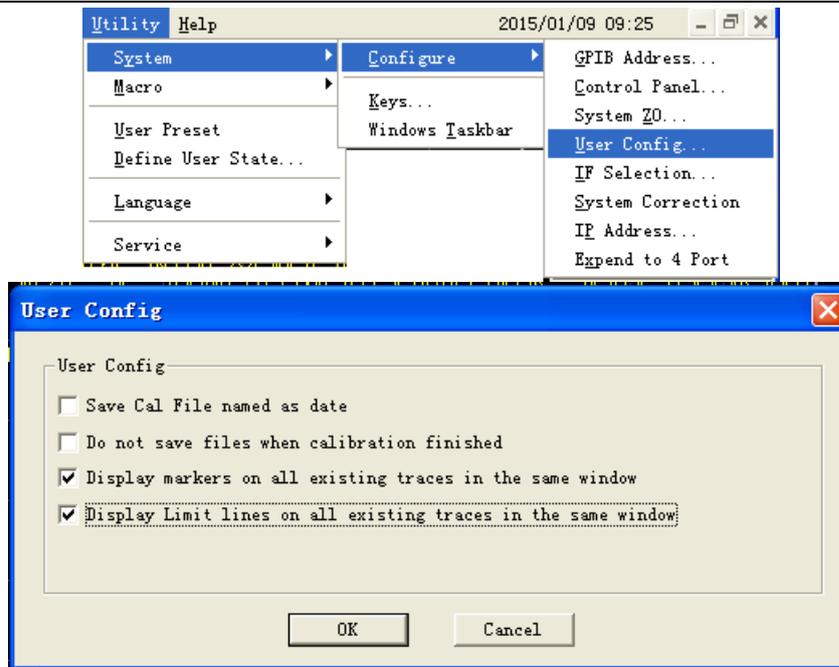
Fig. 5-42 User ConFig.ation Dialog Box

b) Tick the option "**Display markers on all exiting trace in the same window**" and the option "**Display Limit lines on all existing traces in the same window**".

Section 10　ConFig. 4-port Measure(3656A/B Option)

The default measurement mode of 3656 Series Vector Network Analyzer is 2-port mode, but which can be conFig.d to 4-port mode through software, and the 4-port measurement can be implemented by means of external extension device.

1. Turning 4-port Mode On

1.1　By mouse or touch screen

　　a)　Click **[UTILITY]** menu, single click **[ConFig.]** on the **[System]** menu, and single click **[Extend to 4-port]** on the submenu appeared.

　　b)　Click **[OK]** button in the pop-up dialog box to confirm the changing settings and close the dialog box.
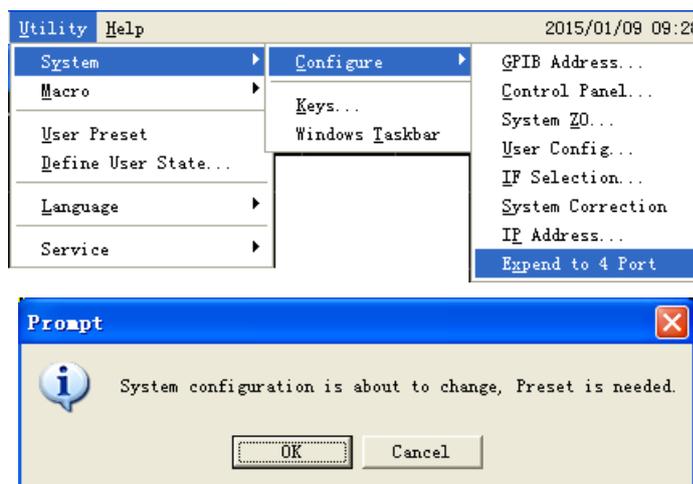
Fig. 5-43　Turning 4-port Mode On

2. Turning 4-port Mode Off

2.1　By mouse or touch screen

　　a)　Click **[UTILITY]** menu, single click **[ConFig.]** on the **[System]** menu, and single click **[Extendto 4-port]** on the submenu appeared.

　　b)　Click **[OK]** button in the pop-up dialog box to confirm the changing settings and close the dialog box.
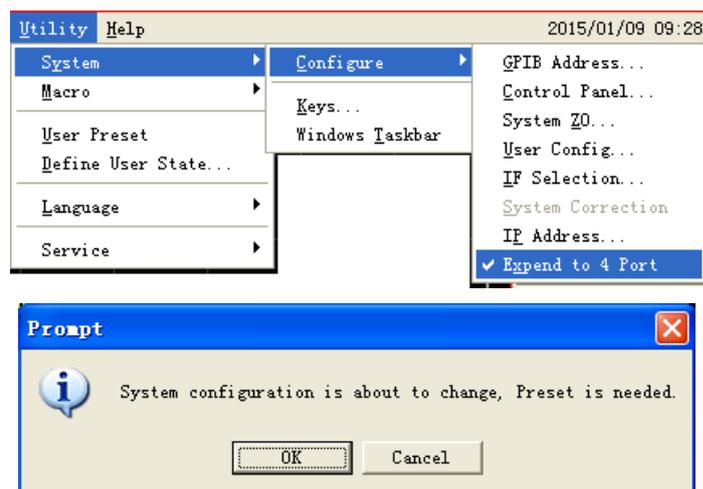
Fig. 5-44 Turning 4-port Mode Off

Chapter VI   Optimal Measure

This chapter discusses how to increase the Measure precision, and its contents are as follows:

■   Reducing accessory influence

■   Increasing reflection Measure precision of the low loss two-port device.

■   Increasing dynamic range

■   Increasing Measure precision of the long Electrical delay devices

■   Increasing phase Measure precision

■   Reducing trace noise

■   Reducing receiver crosstalk

■   Increasing Sweep points

■   Increasing Measure stability

■   Increasing Sweep speed

■   Increasing multistate Measure efficiency

■   Transmitting data quickly

■   Using macro

Section 1   Reducing Accessory Influence

The accessories used during the test sucha as cables may affect the Measure precision of the tested device. Proper methods can be selected according to actual situation during the test.

1   Removal of Unnecessary Response by Time Domain Gate

The time domain gate is an important function of time domain transformation, which makes the Analyzer be able to remove some responses through mathematical operation. The time domain gate function can be used to remove unnecessary responses in both reflection and transmission Measures.

a)   Time domain gate function in reflection Measure

Utilization of time domain gate function in reflection Measure can be used to separate required response (like return loss of filter) and useless response (like adaptor reflection or connector mismatch).

b)   Time domain gate function in transmission Measure

Utilization of time domain gate function in transmission Measure can separate the responses of designated route in the multiple-pass unit. If the gate function is used in the time domain transformation, the time domain gate can be closed and the gate function can be kept effective to research the frequency response of measured piece. The time domain gate filter has the following two types:

- **Band-pass**: to filter the response outside the pass band

- **Band-stop**: to filter the response inside the stop band

Please refer to Section 4 "Time Domain Gate Filtering" in Chapter Ⅹ for detailed information about time domain gate filtering.

Please refer to Section 7 "Setting Time Domain Transformation Measure" in Chapter Ⅹ for detailed information about the time domain transformation Measure.

Section 2   Increasing Reflection Measure Precision of Low Loss Two-port Device

The tow-port calibration modifies all system errors of the Analyzer, while the one-port calibration only modifies the direction, source match and response error but not the positive load match error. Therefore, under the condition of one-port calibration, in order to increase the reflection Measure precision of the two-port device, the non-Measure port of the measured piece shall be connected with high quality load to reduce the load match error, and this method is particularly applicable to reflection Measure of the low loss two-way device, such as the filter pass band and cable. When Measure is carried out on the device with high reverse isolation, it is unnecessary to consider the problem of load match, and the following method can be taken to terminate the non-Measure port of the two-port device during the one-port calibration.

- Connect a match load (like load in calibration parts) with high performance to the non-Measure port of the measured piece, and the Measure precision of this method is close to that of the absolute two-port calibration.

- Connect a precision attenuator of 10dB to the non-Measure port of the measured piece and connect the attenuator output to the non-activation port of the Analyzer, this can nearly double the attenuation value of the attenuator by matching with effective loads of the Analyzer, namely 20dB.

When the return loss of the low loss two-port device such as filter is measured, the direction and load match of the Analyzer will greatly affect Measure precision, and the following calculation indicates that: during the one-port calibration, for example, adding a high quality attenuator between the non-Measure port of the measured piece and the non-activation port of the Analyzer can improve the load match of the Analyzer, so that the Measure precision of one-port calibration is increased. Set the Analyzer, filter and attenuator's Specifications as follows (corresponding linear values given in the bracket);

Analyzer: Original load match (NALM)=18dB(0.126)

Direction (NAD)=40dB(0.01)

Filter: Insertion loss (FIL)=1dB(0.891)

Return loss (FRL)=16dB(0.158)

Attenuator: Insertion loss(FIL)=1dB(0.316)

Return loss (ARL)=32.26dB(0.024)

a) Measure result without attenuator:

At this moment, the output port of the filter is directly connected with the non-activation port of the Analyzer, and the Measure error caused by load match is:

$$LME1=FIL×NALM×FIL=0.891×0.126×0.891=0.1$$

The directional error is:

$$NAD=0.01$$

If the error signal and return signal of the filter are absolutely in the same direction, the Measure result of return loss is:$FIL_+=-20\log(｜FRL+LME1+NAD｜)=11.4dB$

If the error signal and return signal of the filter are absolutely in opposite directions, the Measure result of return loss is:

$$FIL_-=-20\log(｜FRL-LME1-NAD｜)=26.4dB$$

Namely, if the actual return loss of the filter is 16dB, the Measure result may be any value from 11.4dB to 26.4dB.

b)   Measure result with attenuator:

After the attenuator is added, the direction of the Analyzer, load match and reflection of the attenuator may cause the Measure error, and the Measure error caused by the load is:

$$LME2=FIL×AIL×NALM×AIL×FIL=0.01$$

The Measure error caused by the attenuator reflection is:

$$RLE=FIL×ARL×FIL=0.019$$

The directional error is:

$$NAD=0.01$$

If the error signal and return signal of the filter are absolutely in the same direction, the Measure result of return loss is:

$$FIL_+=-20\lg(｜FRL+LME2+RLE+NAD｜)=14.1dB$$

If the error signal and return signal of the filter are absolutely in opposite directions, the Measure result of return loss is:

$$FIL-=-20\lg(｜FRL-LME2-RLE-NAD｜)=18.5dB$$

Namely, if the return loss of the filter is 16dB, the Measure result may be any value from 14.1dB to 18.5dB. Thus, adding the attenuator can reduce uncertainty of Measure and increase Measure precision.

When the reflection Measure is carried out on the low loss two-port device, taking any one of the following measures can get the precise Measure result:

- Carry out the one-port calibration, and connect a high quality load to the output port of the measured piece during the Measure.

- Carry out the one-port calibration, and insert a 10dB attenuator with high quality between the output port of the measured piece and the non-activation port of the Analyzer during the Measure.

- Carry out the complete two-port calibration, and directly connect the output port of the

measured piece to the receiving port of the Analyzer.
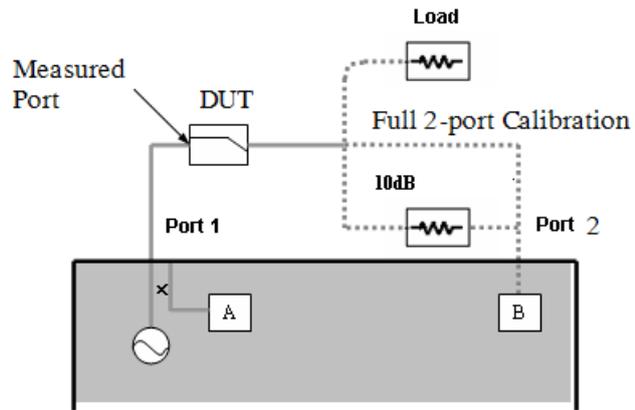
Fig. 6-1   Precise Reflection Measure of Two-port Device

Section 3   Increasing Dynamic Range

The dynamic range refers to the difference between the maximum power that Analyzer allows to input and the minimum measurable power (noise background). In order to make the Measure correct and effective, the input signal must in this range. If the amplitude of the measured signal varies greatly, for example, the Measure of out-of-band suppression of the filter, it is quite necessary to increase the dynamic range of Measure. The following Figure. is a typical dynamic range during the Measure.
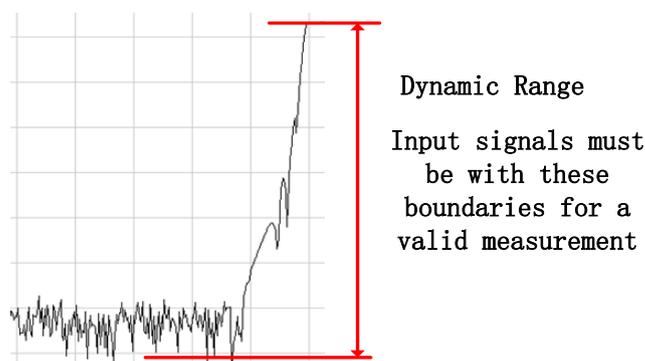
Fig. 6-2   Dynamic Range

In order to reduce the uncertainty of Measure, the dynamic range of the Analyzer shall be larger than the response range of the measured piece. When the tested signal is at least 10dB higher than the noise background, the precision can be increased effectively. The following methods are helpful for increasing the dynamic range:

1   Increasing Input Power of The Measured Piece

Increasing input power of the measured piece can make the Analyzer much more precisely measure the input power of the measured piece, however, attention shall be paid to that it may cause compression distortion if the input of Analyzer's receiver is too high and the receiver may break down if the input is high to a certain extent. Please refer to Section 4 "Setting Signal Power Level" in Chapter Ⅴ for the method of setting Analyzer power.

	WARNING:	**If the gain of the measured piece is very high, it is not feasible to use the maximum source output power, because that may burn down the receiver of the Analyzer.**

2   Reducing Noise Background of the Receiver

The following methods can be used to reduce the noise background and to increase the dynamic range

of the Analyzer:

- Reduce the crosstalk of Analyzer's receiver, and please refer to Section "Reducing Receiver Crosstalk" in this Chapter for detailed information.

- Reduce the intermediate-frequency bandwidth, and please refer to the part of "Reducing intermediate-frequency bandwidth" in Section 6 "Reducing Trace Noise" of Chapter Ⅵ for the setting method.

- Set the Sweep average, and please refer to the part of "Sweep average" in Section 6 "Reducing Trace Noise" of this Chapter for the setting method.

　NOTE:　　**Due to the influences of some settings of the Analyzer, increasing the dynamic range may cause the rise of Measure time.**

Section 4   Increasing Measure Precision of Long Electrical Delay Device

In the given instant, the frequency of signal output by the measured piece may strictly equal to the frequency of the signal entering into the measured piece. For instance, when the Analyzer measures a long cable by swift Sweep, frequency of the cable terminal signal will fall behind the source frequency of the Analyzer. If the frequency deviation is quite obviously when compared with the intermediate-frequency detector bandwidth, the Measure result will have errors due to filtering of the intermediate-frequency filter. During the Measure, it is feasible to remove this kind of Measure error by reducing the sweep frequency speed, and there are three methods to reduce the sweep frequency speed of the Analyzer.

1   Increasing Sweep Time

Increasing Sweep time reduces the speed of frequency change and increases dwell time at every spot of data Measure, it can effectively reduce the frequency difference input and output by the measured piece, and please refer to the part of "Setting of Sweep time" in Section 5 "Sweep Setup" of Chapter Ⅴ for the detailed setting method.

2   Increasing Sweep Points

Increasing Sweep spot number can reduce the speed of frequency changes, and please refer to Section 8 "Increasing Number of Points" in this Chapter for the setting method.

3   Setting Dwell Time by Averages of Step-Sweep

In the way of step-Sweep (default mode of the Analyzer), do not take samples of Measure until the phase lock of a frequency spot is finished. Measure sampling time can be controlled by setting dwell time. Make sure that the input and output frequencies of the measured piece are the same during the Measure. Please refers to the part of "Sweep Setup" in Section 5 "Sweep Setup" of Chapter Ⅴ for the setting methods.

Section 5   Increasing Phase Measure Precision

The following functions of the Analyzer can be used to increase the phase Measure precision.

1   Electric Time Delay

Electrical delay simulates the length change of the nondestructive transmission line by averages of mathematical operation, it can remove linear phase shift component of the measured piece so as to measure the linear phase offset of the measured piece better, and the Analyzer supports setting Electrical delays respectively for each Measure Trace.

1.1   Setting of Electrical delay

1.1.1   By mouse or touch screen

a)   Click **[Response]** to display the sub-menu, and click **[Electrical delay…]** on **[Scale]** submenu to display **Electrical delay** dialog box.

b)   Set the delay value in the **[Electrical delay]** box.

c)   Set the speed factor in the **[Velocity Factor]** box.

d)   In the **Medium** area, click the option button to select the medium type of **[Coaxial]** or **[Waveguide]**.

e)   If **Waveguide** medium type is selected, input low-frequency cut-off frequency in **[Cutoff Freq]**.

f)   After the setting is finished, click **[OK]** button to close the dialog box.
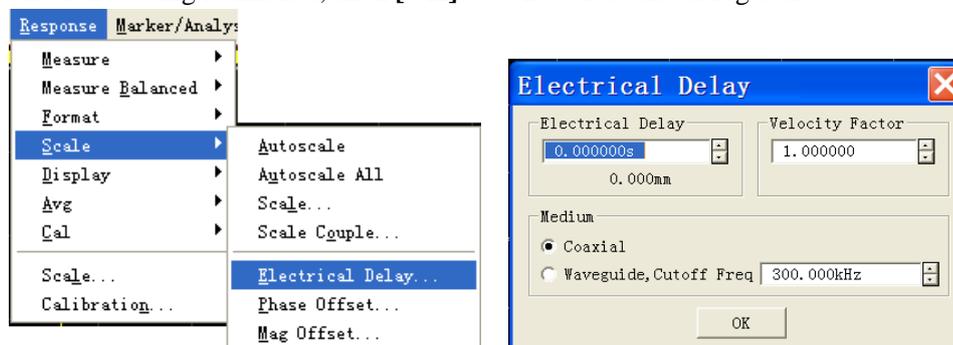
Fig. 6-3   Setting of Electrical delay

1.1.2   By front panel keys

a)   Press 【**Scale**】 key in RESPONSE area, and press the soft-key corresponding to **[Electrical delay]** on the emergent soft-key menu.

b)   Set the value of Electrical delay in the displayed **Electrical delay** dialog box.

c)   Press the soft-key corresponding to **[More]** to display the subordinate soft-key menu, and press the soft-key corresponding to **[Velocity Factor]** to set the speed factor.

d)   Press the soft-key corresponding to **[Media <u>COAX</u> |Wave]** to select the medium type.

e)   If **Waveguide** medium type is selected, press the soft-key corresponding to **[Waveguide**

Cutoff Freq] to set up the low frequency cut-off   frequency of   waveguide.

1.1.3   Electrical delay dialog box

[Electrical delay]

Set the delay value of increase or removal, the delay unit is time, and it is used to compensate for the linear phase shift of the measured piece.

[Velocity Factor]

Set the relative speed of the measured piece medium, the vacuum speed factor is 1, the speed factor of PVC cable medium is 0.66, and the speed factor of PTEF medium is 0.7.

Medium area

a)   **[Coaxial]**

During the selection, the remission line which incidates increase is a coaxial line, and the speed factor must be set up at the same time.

b)   **[Waveguide]**

During the selection, the transmission line which indicates increase is the waveguide, and the low frequency cut-off frequency of waveguide must be set up.

c)   **[Cutoff Freq]**

Set the low frequency cut-off frequency of waveguide.

2   Port Extensions and Loss

After the calibration, it is feasible to move Measure reference plane by port extension, and that can avoid carrying out calibration once more. For example, the following two conditions need to use port extension function.

- After the calibration, it is found that a piece of cable needs to be added into the Measure configuration, and the port extension function is used to define the cable length added to the specific port of the Analyzer.

- The DUT need to be tested on the clamp, so calibration can not be carried out directly. Utilizing port extension can compensate for the delay (phase shift) caused by the clamp, and the port extension can automatically apply the Electrical delay to all Measures relevant to a specific port.

In addition to port extension, you can also set the loss value, and you can get more accurate results by correcting the loss caused by port extension. Loss value can be set in two ways: directly set a DC loss value, or specify the loss value at two frequency points. It can be set for each port at the same time.

2.1   Setting of port extensions and loss

The Analyzer is set with two ways to set up port extension and loss values:

• When the extended electrical length and phase length of cable or clamp are already known, delay

parameter and loss parameters such as time and distance, etc. can be manually set.

  • Measure through the Short or Open standards connected to the port by automatic port extension function, and automatically calculate the port extension and loss value for each port.

Note: You can set the port extension and loss of port-specific channel, the set value of the channel will not affect other channels!

2.1.1   Setting manually

2.1.1.1 By mouse touch screen

    a)   Click **[Response]**, and point at **[Cal]** in the **Response** menu to display **Calibration** submenu.

    b)   Click **[Port Extensions…]** to display **Port Extensions** dialog box, select **Port 1** or **Port 2** from the drop-down box of port selection; and click **[Port Extension ON]** to tick the check box.

    c)   Set the value of [**Dist.**] and [**Time**] in the **Delay** zone, select the distance unit from the drop-down box of [**Meters**]; set the speed factor in the **[Velocity Factor]** box

    d)   Tick [**Loss 1**] and [**Loss 2**] in the **Loss** zone, input the loss value in the loss input box; set the frequency value in [**@Freq 1**] and [**@Freq 2**].
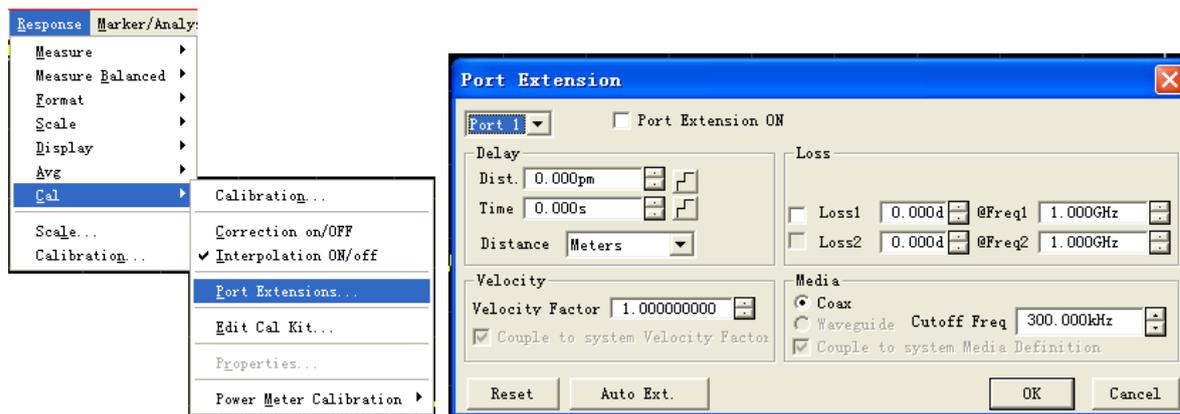
Fig. 6-4   Setting of Port Extensions

2.1.2   By front panel keys

    a)   Press 【**Cal**】 key in RESPONSE zone, and press the soft-key corresponding to **[More]** in the emergent soft-key menu.

    b)   Press the soft-key corresponding to **[Velocity Factor]** to set the speed factor.

    c)   Press the soft-key corresponding to **[Port Extensions]** to display the submenu, and press the soft-key corresponding to **[Extensions on|OFF]** to enable the port extension function.

    d)   Press the soft-key corresponding to **[Manual Extensions Port1]** to display the submenu, and press the soft-key corresponding to **[Port1 Loss]** to enable the loss setting function of port 1.

    e)   Press the soft-key corresponding to **[Loss1 Swich on｜OFF]** to enable the function of loss 1, and press the soft-key o **[Loss1]** to input the loss value in the input box, then press the soft-key of **[Freq1]** to input the frequency value in theinput box; press the soft-key corresponding to **[Loss2   Swich on｜OFF]** to enable the function of loss 2, and press the soft-key o **[Loss2]** to

input the loss value in the input box, then press the soft-key of **[Freq2]** to input the frequency

value in theinput box.

f) Press the soft-key corresponding to **[Manual Extentsions Port2]** to display the submenu, and

press the soft-key corresponding to **[Port2 Loss]** to enable the loss setting function of port 2.

g) Press the soft-key corresponding to **[Loss1 Swich on｜OFF]** to enable the function of loss1,

and press the soft-key o **[Loss1]** to input the loss value in the input box, then press the soft-key

of **[Freq1]** to input the frequency value in theinput box; press the soft-key corresponding to

[Loss2 Swich on｜OFF] to enable the function of loss 2, and press the soft-key o **[Loss2]** to

input the loss value in the input box, then press the soft-key of **[Freq2]** to input the frequency

value in theinput box.

2.1.2   Setting automatically

2.1.2.1 By mouse or touch screen

a) Single click **[Response]** and point to**[Cal]** to display the calibration submenu.

b) Click **[Port Extensions...]** to display the **Port Extensions** dialog box, and select the operating

port from the drop-down box of port selection; click **[Port Extensions]** and tick the check box.

c) Click the **[Auto Ext.]** button to display the **Automatic PortExtension** dialog box.
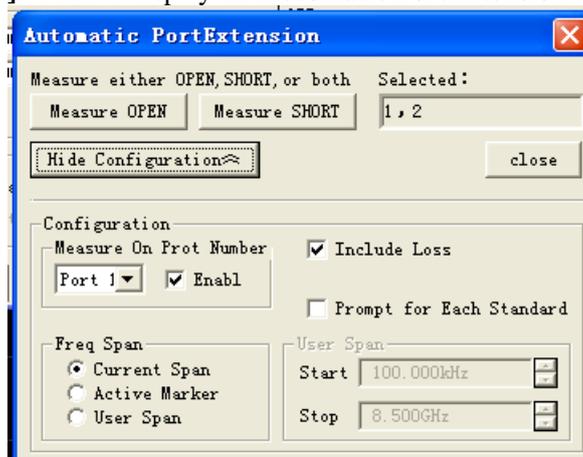
Fig. 6-5 Automatic Port Extentsions & Losses

d) Tick **[Include Loss]** in the **Configuration** area, select the port to be operated from the drop-down

box and tick **[Enable]**.

e) If prompts are needed in connecting calibration criterion, it may tick **[Prompt for Each**

Standard].

f) It may select the [**Current Span**], [**Active Marker**] or [**User Span**] in the **Preq Span** area as

required.

g) Click **[close]** to complete the automatic port extension function, and the analyzer will

automatically calculate the port extension and loss values and update data.

2.1.2.2   By front panel keys

a) Press the key【**CAL**】in RESPONSE zone, and press the soft-key corresponding to [**More**] on the

soft-key menu appeared.

b) Press the soft-key corresponding to **[Port Extensions]** to display the submenu, press the soft-key corresponding to **[Extensions on│OFF]** to enable port extension function.

c) Press the **[Auto Port Extension]** to display the submenu, and press the soft-key corresponding to **[Select Port Port 1, 2]** to select a port.

d) Press the soft-key corresponding to **[Select Port Measure Open]** to display the submenu, and it may select **[ALL]** ports or a specific port for measurement as required.

e) Press the soft-key corresponding to **[Select Port Measure Short]** to display the submenu, and it may select **[ALL]** ports or a specific port for measurement as required.

f) Press the soft-key corresponding to **[Method]** to display the submenu, and it may select the **[Current Span]**, **[Active marker]** or **[User Span]** as required.

g) Press the soft-key corresponding to **[Include Loss on│OFF]** to enable the function of automatic calculation of losses.

2.1.2.3 Auto Port Extensions dialog box

Configuration zone

a) **Drop-down box of measurement port**

Select port 1 or port 2.

b) **[Enable] check box**

Display the Enable state of currently selected port, and both ports of the analyzer are ON by default.

c) **[Include Loss]check box**

Automatically calculate losses if it is ticked.

d) **[Prompt for each Standard] check box**

Prompt is available when connecting calibration kit.

Freq Span zone

e) **[Current Span] radio**

Set the frequency range to full band.

f) **[Active marker] radio**

Set the frequency range to that between start frequency and stimulus marker frequency.

g) **[User Span] radio**

It is possible to set the start and stop frequency in the **User Define** zone if this box is checked.

[Open]

Port is connected with Open for Open measure.

[Short]

Port is connected with Short for Short measure.

[Hide Configuration]

    Hide the dialog box display of the whole **ConFig. Zone**.

[close]

    Turn off the automatic port extension dialog box.

3   Phase offset

The phase offset adjusts the phase Measure result by averages of mathematical operation, and the modification range is 0°~360°. For example, there are two conditions as follows where phase offset function is used:

- Improve the display of the phase Measure result to locate the display value in the screen center or the designated position. It is similar with changing reference electrical level in the amplitude Measure.

- Simulate the preconceived phase shift in the Measure. For example, a piece of cable need to be added in the Measure, and the phase shift due to it is known. At this moment, the phase offset function can be used to add that phase shift value and to simulate the whole Measure composition.

3.1   Setting of phase offset

3.1.1   By mouse or touch screen

    a)   Click **[Response]**, click **[Scale]** on the submenu, and Click **[Phase offset …]** on the **Scale** menu to display **Phase offset** dialog box.

    b)   Set the corresponding phase offset value in the **[Phase offset]** box.

    c)   Click **[OK]** button to close the dialog box.
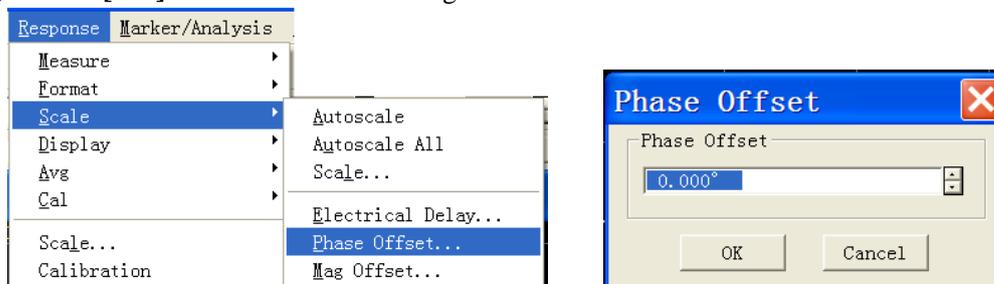
Fig. 6-6   Setting of Phase offset

3.1.2   By front panel keys

    a)   Press 【**Scale**】 key in RESPONSE area, and corresponding soft-key menu turns up.

    b)   Press the soft-key corresponding to **[Phase Offset]**, and set the phase offset value in the emergent **Phase Offset** box.

4   Interval between Frequency Spots

When the Analyzer Measures, it takes sample data on discrete frequency spots, and then it links all Measure spots and forms a Trace on the screen. If the phase shift of the two contiguous frequency spots

of the measured piece is more than 180°, the lack of data sampling will result in aliasing so that the phase gradient displayed at this moment is wrong. If such a condition takes place during the group delay Measure, the Measure result of group delay may be a negative value which is apparently wrong, as the Measure result of the surface acoustic wave filter shown below:

- The 1st Fig. shows the Measure results of 51 spots and the group delay is a negative value. Actually, it is impossible that the group delay of the measured piece is a negative value, which means that the Measure values of group delay cannot be below the 0 second reference line.

- The 2nd Fig. shows the Measure results of 201 spots, and the group delay is a positive value, namely the Measure values are above the 0 second reference line.
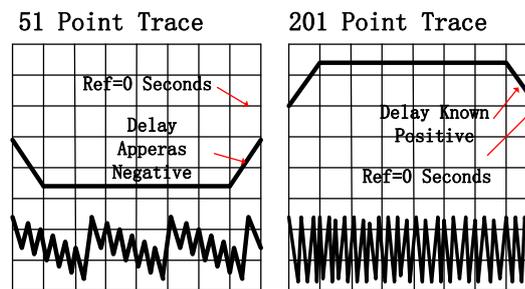
Fig. 6-7   Influence of Frequency Interval on Phase Measure

The following two methods can be taken to set the change of the front and rear phase Traces and to check whether there is aliasing during the Measure.

- Add Measure spots. Please refer to Section 8 "Increasing Number of Points " in this Chapter for the setting methods.

- Reduce the frequency span. Please refer to Section 3 "Setting Frequency Range" in Chapter V for the setting methods.

Section 6   Noise Reduction Techniques

The Analyzer receives the random noise from the channel, which would reduce the Measure precision. Several functions of the Analyzer introduced below can be used to reduce trace noise, decrease noise background, and get more precise Measure result and larger dynamic range.

1   Sweep Average

The Sweep average can reduce the influence on Measure from random noise, and the Analyzer takes average at a point via constant Sweep to calculate each Measure value. Setting of the average factor determines times of constant Sweep. The bigger the speed factor is, the more possible it is to reduce the influence on Measure from noise.

- The Trace average is applied to all Measure Traces in the channel, and all channels whose average functions are enabled will display an average counter.

- When the Sweep average is enabled, the average counter displays times of Sweep average carried out, and observing Trace changes and times of average carried out is good for selecting the best average factor.

- Although Sweep average can be carried out during non-ratio Measure, the desired result can not be got.

  * When the phase Measure for non-ratio Measure is averaged, the Measure result is still random, because the phase Measure is realized by averages of relative Measure and result of absolute phase Measure for a single receiver is random. Therefore, the certain result can not be got by averaging.

  * When the amplitude Measure for non-ratio Measure is averaged, the noise background would not fall down.

- Both the Sweep average and reduction of intermediate-frequency bandwidth can be carried out to reduce noise. If the quite low noise is required, it will be better to take Sweep average. Usually, the Sweep average takes longer time to reduce noise than reduction of intermediate-frequency bandwidth, because the required averaging times are much more.

The influence on noise of Sweep average is shown in the following Figure.:
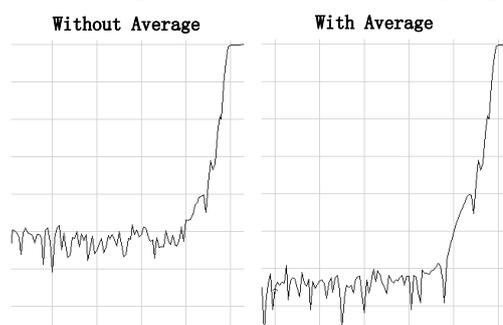

Fig. 6-8   Influence on Measure Result from Sweep Average

1.1   Setting of Sweep Average

1.1.1   By mouse or touch screen

    a)   Click **[Response]**, point at **[Avg]** on the submenu, and click **[Average…]** on **Avg** submenu to display **[Average]** dialog box.

    b)   Click **[Average <u>on</u>/OFF]** to tick the check box.

    c)   Click **[Average Factor]** box to set the average factor.

    d)   If the Sweep average needs to start again, click **[Restart]** button.

    e)   Click **[OK]** button to close the dialog box.
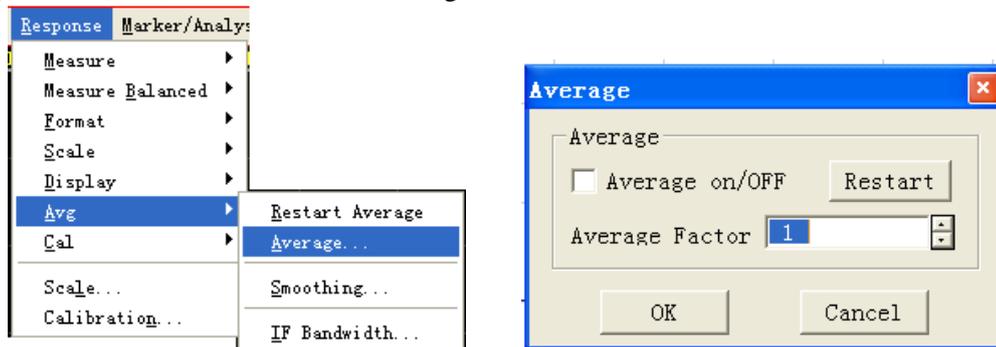
Fig. 6-9   Setting of Sweep Average

1.1.2   By front panel keys

    a)   Press   【**Avg**】   key in RESPONSE area.

    b)   Press the soft-key corresponding to **[Averaging Factor]**, and input the average factor in **Average Factor** box.

    c)   Press the soft-key corresponding to **[Averaging on|OFF]** to enable average function.

    d)   If the Sweep average needs to start again, press the soft-key corresponding to **[Averaging Restart]**.

2   Trace Smoothing

The Trace smoothing smoothes the Trace display by taking the average of contiguous data spots. Contiguous data spots averaged are called the smoothing aperture, and the Analyzer defines the aperture size by two methods: designating the spots to take the average and designating the percentage of value range. The smoothing function may reduce the peak value of noise on the Measure data Trace, but it would not increase the Sweep time.

	NOTE:	● **Do not use smoothing function when measuring the high resonance device or the device whose Trace change is comparatively fierce, because it would cause the Measure error.** ● **The Analyzer supports to set the smoothing for each Trace independently.**

The influence of the Trace smoothing is shown in the following Figure.:
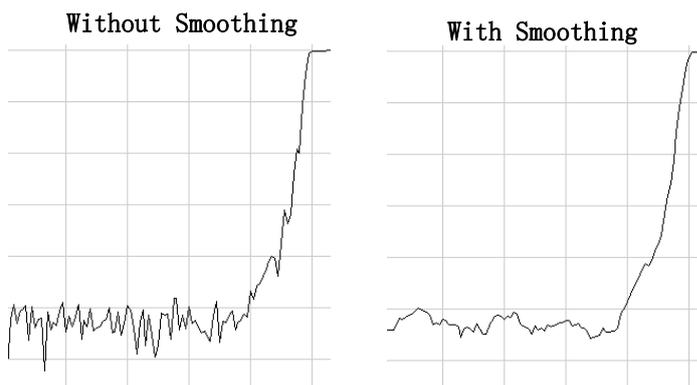
Fig. 6-10   Influence on Measure Result of Smoothing

2.1   Setting Smoothing

2.1.1   By mouse or touch screen

a)   Click **[Response]**, point at **[Avg]** on the submenu, and click **[Smoothing…]** on **Average** submenu to display **Smoothing** dialog box

b)   Click **[Smoothing on/OFF]** to tick the check box and Stimulus the smoothing function.

c)   Take one of the following methods to set smoothing aperture.

   ● Set smoothing percent (the maximum value is 25%) in **[Percent]** box

   ● Input the Points of smoothing aperture (the maximum value is 25% of total Sweep spot number) in the **[Points]** box.

d)   Click **[OK]** button to close the dialog box.
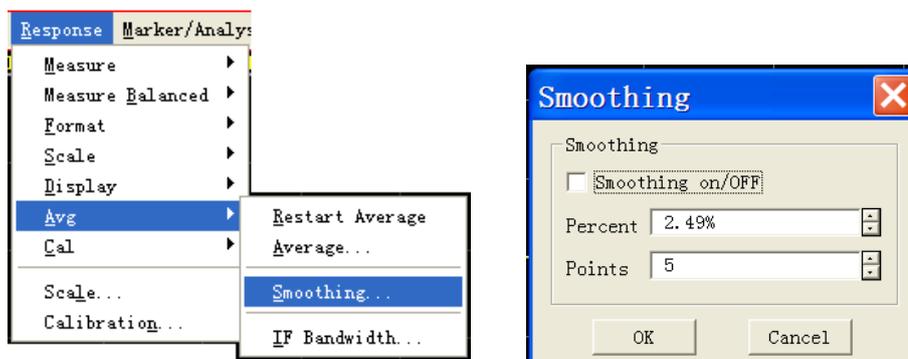
Fig. 6-11   Setting Smoothing

2.1.2   By front panel keys

    a)   Press 【**Avg**】 key in **Response** keys area.

    b)   Press the soft-key corresponding to **[Smoothing]** to display the corresponding soft-key menu.

    c)   Press the soft-key corresponding to **[Smoothing on|OFF]** to enable smoothing function.

    d)   Take one of the following methods to set smoothing aperture.

- Press the soft-key corresponding to **[Smoothing Percent]** to set smoothing percentage (maximum value is 25%).

- Press the soft-key corresponding to **[Smoothing Points],** and input the spots of smoothing (the maximum spot number is 25% of Sweep spot number).

3   Reducing IF Bandwidth

3656 Series Vector Network Analyzer converse the frequency of the received response signal to intermediate-frequency signal whose frequency is relatively lower. Bandwidth of the intermediate-frequency filter (IF bandwidth) can set downwards from 30kHz to the minimum 1Hz. Reducing the IF bandwidth can decrease the influence on the Measure result of random noise. Every 10 times the IF bandwidth is reduced, the noise background decreases 10dB, however, setting the intermediate-frequency bandwidth would make the Sweep time longer. The Analyzer supports setting the intermediate-frequency bandwidth for each channel and segment Sweep, and the influence on Measure from the intermediate-frequency bandwidth is as shown in the following Figure.:

Fig. 6-12   Influence on Measure Result from Intermediate-frequency Bandwidth

3.1   Setting of the intermediate-frequency bandwidth

3.1.1   By mouse or touch screen

- Click **[Response]**, point at **[Avg]** on the submenu, and click **[IF Bandwidth…]** on **Average** submenu to display **IF Bandwidth** dialog box

- Click **IF Bandwidth** box, and set the intermediate-frequency bandwidth.

- Click **[OK]** button to close the dialog box.
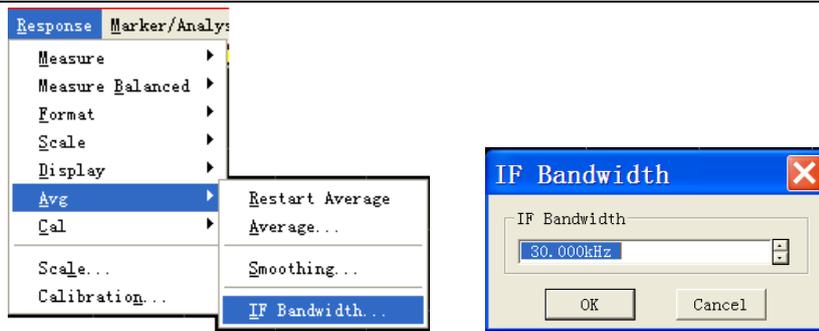
Fig. 6-13   Setting of Intermediate-frequency Bandwidth

3.1.2   By front panel keys

a)   Press 【**Avg**】 key in **Response** keys area.

b)   Press the soft-key corresponding to **[IF Bandwidth]**, and set the intermediate-frequency bandwidth value in **IF Bandwidth** dialog box.

Section 7   Reducing Receiver Crosstalk

Crosstalk refers to the energy leakage between Analyzer signal paths, which is a difficult problem high-loss transmission Measure is facing. Effects of crosstalk can be reduced through selecting alternate Sweep and carrying out isolation calibration.

- Energy leakage between signal paths leads to errors in transmission Measure.
- Crosstalk affects the precision of the following Measures:
  * Measures of high-loss devices, such as isolation Measure of the switch in cut-off status.
  * Measures of devices with wide dynamic ranges, such as Measure of filter.

1   Using Alternate Sweep Mode

Alternate Sweep only measures one receiver in A and B at a time, with the other one turned off, which helps to reduce crosstalk.

Note:

- **The Analyzer conducts reflection and transmission Measures respectively in the alternate sweep mode; therefore, when the Analyzer conducts reflection and transmission Measures at the same time, use of alternate sweep mode will double the Measure time.**
- **When only the reflection or transmission Measure is conducted, the alternate sweep function can be used to reduce the effects of crosstalk, without affecting the Measure time.**
- **Crosstalk will affect the Measure results only when the average function is used or intermediate-frequency bandwidth is reduced to make noise background low enough, where it is necessary to use the alternate sweep mode.**

1.1   Setting alternate sweep

1.1.1   By mouse or touch screen

    a)   Click **[Stimulus]**, and click **[Sweep Setup…]** on the **Sweep** submenu, to display the dialog box of **Sweep Setup**.

    b)   If multiple channels have been enabled, click the **[Channel]** box to select the channel for which the alternate Sweep Setup is required.

    c)   Click **[Alternate Sweeps]** and tick the check box.

    d)   Click **[OK]** button to close the dialog box.
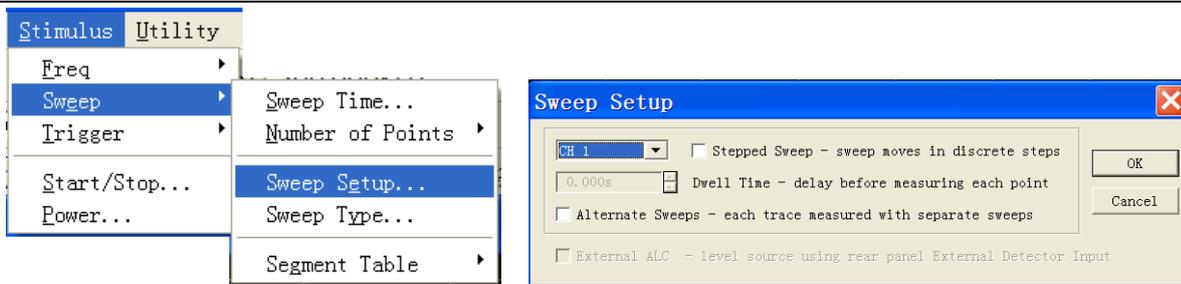
Fig. 6-14   Setting Alternate Sweep

1.1.2   By front panel keys

a)   Press 【Sweep】 key in the STIMULUS area to display the corresponding software menu.

b)   Press the soft-key corresponding to [Sweep Setup…], to display the dialog box of **Sweep Setup**.

c)   If multiple Measure channels are enabled, press 【□】、【□】 keys in the ADJUST area to switch to the [Channel] box, and press 【△】，【▽】keys or rotate the knob in the ADJUST area to select the channel for which the alternate Sweep Setup is required.

d)   Press 【□】、【□】 keys to switch to the check box of [Alternate Sweeps], and press **the knob key** in the ADJUST area to tick the check box.

e)   Press 【OK】 key in the **Entry** keys to close the dialog box.

2   Perform an Isolation Calibration

For transmission Measure, a response and isolation calibration helps to reduce crosstalk. This is because the Analyzer measures and subtracts the leakage signals during the measurement calibration. The calibration improves isolation so that it is limited only by the noise floor. If a higher Measure precision is wanted, full dual-port calibration without ignoring isolation shall be conducted. Crosstalk signal is generally below the noise background, so isolation calibration is necessary only when crosstalk signal is visible after the noise background is lowered.

Refer to "Crosstalk Error" in Section 5 "Measure Error" in Chapter VII for the detailed information on crosstalk error.

Refer to Section 3 "Calibration Guide" in Chapter VII for the detailed information on calibration process.

Section 8　Increasing Sweep Points

1　Sweep Points

One data point represents the Measure result under one activation. Sweep points number of the Anylyzer's single sweep can be defined, and the sweep time varies with sweep points number. Sweep points number in default settings is 201, and the maximum configurable points is 16001.
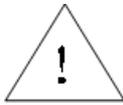
⚠ **NOTE:**	● **The optimum Trace resolution can be obtained by using the maximum sweep point number, so as to have a better observation of response of the measured piece.**
	● **If a higher Measure speed needs to be realized, the minimum sweep point number that can provide acceptable precision shall be taken.**
	● **The optimum sweep point number is the corresponding point number when the Measure Trace has no significant change with point number increasing.**
	● **In order to ensure the Measure precision, sweep point number in calibration and Measure shall be the same.**

1.1　Setting sweep points

1.1.1　By mouse or touch screen

 a)　Click **[Stimulus]**, and click **[Number of Points]** in the **[Sweep]** menu, to display the dialog box of Number of Points.

 b)　Click to select sweep point number on submenu.

 c)　If custom point number is required, click **[Custom…]** on submenu to display the dialog box of **Sweep Points**, and set sweep point number in Number of Points box.

 d)　Click **[OK]** button to close the dialog box after setting is completed.
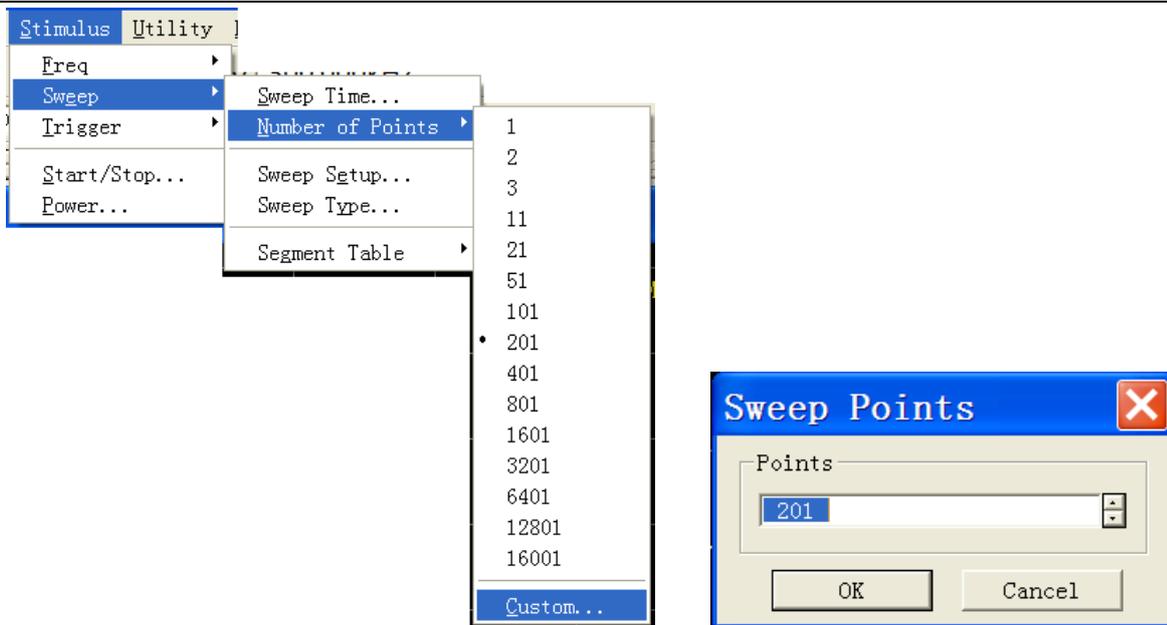
Fig. 6-15　Setting Sweep Points

1.1.2　By front panel keys

    a)　Press 【**Sweep**】key in STIMULUS area.

    b)　Press the soft-key corresponding to **[Number of Points]**, and set the Sweep point in Number of Points box.

Section 9   Measurement Stability

Unstable Measure result can be caused by several situations. In order to carry out repeatable Measures, a stable Measure environment is required. Factors affecting Measure stability mainly include:

1   Frequency Drift

Frequency precision of the Analyzer depends on its internal constant-temperature crystal oscillator of 10MHz. If the Measure application requires higher frequency precision and stability, we can drop the internal frequency standard, but provide a high-stable external frequency standard instead through a connector of **10MHz reference input** on the rear panel.

2   Temperature Drift

Temperature change and its consequent expansion or contraction can change properties of the following elements:

- Internal devices of Analyzer
- Calibration standards in calibration kit
- Measured piece
- Test cable
- Adapter

In order to reduce the effects of temperature drift in Measure, the following measures can be taken:

- Warming up the Analyzer for 30min before calibration and measurement.
- Open the calibration kit box 1 hour before calibration, and take calibration kit out of the protection foam.
- Measure in an environment with controllable temperature. In the temperature environment of 23℃±3℃, it can be ensured that all the technical Specifications of the Analyzer meet the requirements.
- Ensure the temperature stability of calibration kit, and avoid unnecessary touch of calibration kit during calibration process.
- Ensure that the difference between ambient temperature and temperature during calibration is within ±1℃.

3 Imprecise Calibration

If calibration is imprecise and correct response of the measured piece can not be obtained during Measure, in order to guarantee calibration precision, the following shall be taken into consideration:

- Calibration shall be conducted at the point connecting the measured piece, namely on the Measure plane, to ensure that Measure plane is the same as calibration plane.
- After calibration, in case that any additional accessory (such as cable, adapter or attenuator) is

inserted into the Measure assembly, port extension function is used to compensate additional electrical length and delay, and if a higher precision is wanted, calibration shall be conducted again.

● Use calibration kit in accordance with the definition in calibration process for calibration.

Pls refer to Section 4 "High-precision Measure Calibration" in Chapter VII for the detailed information on accurate calibration.

4   Measure Connection

Correct connection is essential for obtaining repeatable Measure results. The following measures shall be taken during Measure connection:

● Regularly check and clean connectors for all components in Measure assembly.

● Use correct connecting method.

● Avoid moving cable during Measure.

Refer to the "Connector Maintenance and Measure Connection" part in Chapter III "Routine Maintenance" for the detailed information on connector maintenance and Measure connection.

Section 10   Increasing Sweep Speed

Adopting maximum Sweep speed can improve Measure efficiency. The following settings shall be optimized during Measure to achieve the maximum Sweep speed:

1   Sweep Setup

The maximum Sweep speed is obtained by making the following settings carefully:

- **Frequency span:** only the frequency range concerning the measured piece shall be measured. Pls refer to Section 3 "Setting Frequency Range" in Chapter V for the setting method.

- **Segment sweep:** use segment sweep to measure the most concerned frequency band. Pls refer to the "Setting Segment Sweep Type" part in Section 5 "Sweep Setup" in Chapter V for the setting method.

- **Turnoff step sweep**: if Measure allows, do not use the step sweep mode, so as to achieve the minimum Sweep time. Refer to the "Sweep Setup" part in Section 5 "Sweep Setup" in Chapter V for the setting method.

- **Automatic** Sweep **time:** the fastest sweep can be obtained by using the default Sweep time for the current settings. Refer to the "Sweep Time" part in Section 5 "Sweep Setup" in Chapter V for the setting method.

- Sweep **point number:** the minimum Sweep points required for Measure shall be used. Refer to Section 8 "Increasing Sweep Points" in this chapter for the method of setting Sweep point number.

2   Reducing Noise Settings

Reasonable conduction of the following two settings can reduce Sweep time while acceptable Measure results can still be obtained:

- **Intermediate-frequency bandwidth:** use the widest intermediate-frequency bandwidth that can give acceptable tack noise and dynamic range. Refer to the "Reducing Intermediate-frequency Bandwidth" part in Section 6 "Reducing Trace Noise" in this chapter for the method of setting intermediate-frequency bandwidth.

- **Average:** Reduce average factors as much as possible or turn off average function. Refer to the "Sweep Average" part in Section 6 "Reducing Trace Noise" in this chapter for the setting method.

3   Selecting Calibration Type

Select the fastest calibration Measure meeting the Measure precision requirement. The time required for Sweep Measure without error correction is approximately the same as that for response of calibration correction, while forward and reverse Sweep Measures are required for error correction of

full dual-port calibration Measure to update Measure parameters, even if only one S parameter is displayed, so the required Measure time is the longest.

Refer to Section 2 "Selecting Calibration Type" in Chapter VII for the detailed information on calibration type.

4   Closing Unnecessary Functions

Analyzer must update information on all Stimulus functions. In order to accelerate Sweep, turn off all the following Analyzer functions not necessary for Measure application:

- Undesired Trace
- Unused marker
- Smoothing
- Limit test
- Trace computation
- Display

The Sweep speed of Analyzer depends on various Measure settings. Try more settings to achieve the maximum Sweep speed and to meet the required Measure result.

4.1   Deleting undesired Trace

4.1.1   By mouse or touch screen

    a)   Click the right mouse button on Status Bar key of the Trace to be deleted, to display the context menu.

    b)   Click **[Delete Trace]** in the context menu.


Fig. 6-16   Delete Undesired Trace

4.1.2   By front panel keys

    a)   Press 【**Trace**】 key in TRACE/CHAN area, and press the soft-key corresponding to **[Delete Traces]** on the corresponding soft-key menu.

    b)   Press the soft-key corresponding to the Trace to be deleted, then such Trace can be deleted.

4.2   Closing unused markers

4.2.1   By mouse or touch screen

    a)   Click **[Marker/Analysis]**, and click **[Marker…]** on **[Marker]** menu, to display **Marker** dialog box.

    b)   Select the markers to be closed in **Marker** Box.

    c)   Click **[On]** to clear the check box. If all markers are to be closed, click **[Close All]**.

    d)   Click **[OK]** button to close the dialog box.
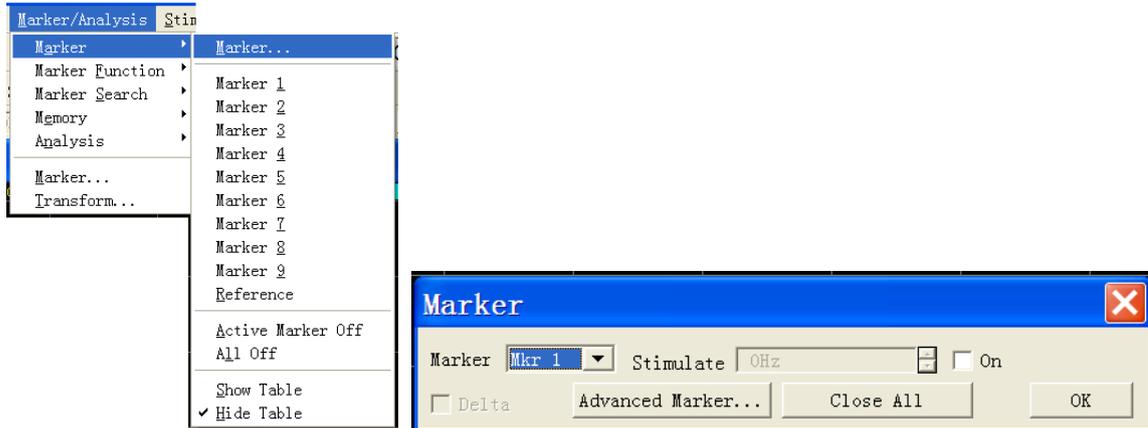
Fig. 6-17   Close of the Unused Marker

4.2.2   By front panel keys

    a)   Click   【**Marker**】   in MKR/ANALYSIS area to display the corresponding soft-key menu.

    b)   Click the soft-key corresponding to **[Turn Off Markers]** to display the submenu, and click the soft-keys corresponding to the markers to be closed.

    c)   If all markers are to be closed, click the soft-key corresponding to **[All Off]**.

4.3   Closing smoothing function

4.3.1   By mouse or touch screen

    a)   Click **[Response]**, and click **[Smoothing…]** on **[Avg]** menu, to display the **Smoothing** dialog box.

    b)   Click **[Smoothing on/OFF]** to clear the check box and turn off smoothing function.

    c)   Click **[OK]** button to close the dialog box.
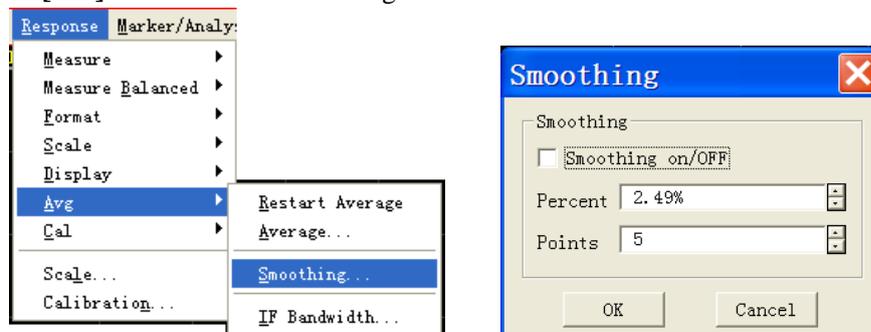
Fig. 6-18   Closing Smoothing Function

4.3.2   By front panel keys

    a)   Press 【**Avg**】 key in RESPONSE area to display the corresponding soft-key menu.

    b)   Press the soft-key corresponding to **[Smoothing]** menu item.

    c)   Click the soft-key corresponding to **[Smoothing on/OFF]** menu item to turn off smoothing function.

4.4   Closing limit test

4.4.1   By mouse or touch screen

    a)   Click **[Marker/Analysis]**, and click **[Limit Test…]** on **[Analysis]** menu, to display **Limit Test** dialog box.

    b)   Click **[Limit Test on/OFF]** to clear the check box and turn off limit test function.

    c)   Click **[OK]** button to close the dialog box.
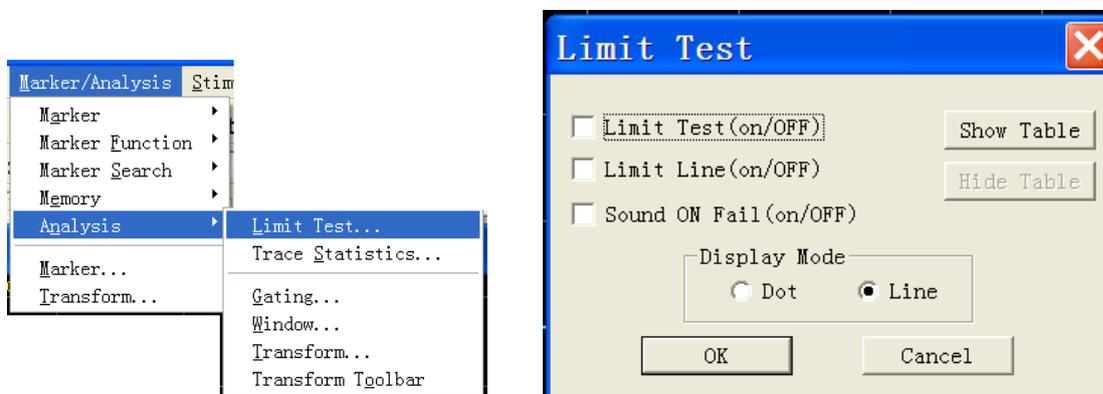
Fig. 6-19   Closing Limit Test

4.4.2   By front panel keys

    a)   Press 【**Analysis**】 key in MKR/ANALYSIS area to display the corresponding soft-key menu, and press the soft-key corresponding to **[Limits]** to display the submenu.

    b)   Press the soft-key corresponding to **[Limit Test on/OFF]** menu to turn off limit test function.

4.5   Turning off Trace computation function

4.5.1   By mouse or touch screen

    a)   Click **[Marker/Analysis]**, and click **[Math/Memory…]** on **[Memory]** menu, to display **Math/Memory** dialog box.

    b)   Select Data in **[Data Math]** box.

   c)   Click **[OK]** button to close the dialog box.
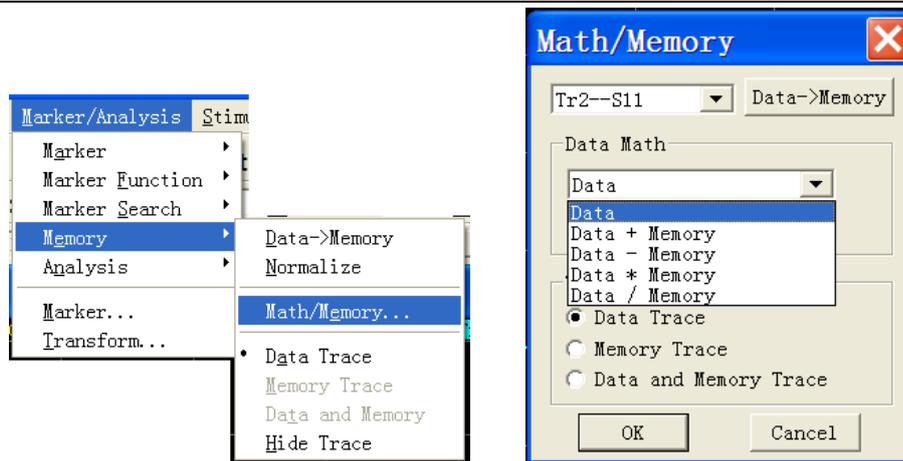
Fig. 6-20   Turning off Trace Computation Function

4.5.2   By front panel keys

a)   Click【**Memory**】in MKR/ANALYSIS area to display the corresponding soft-key menu.

b)   Press the soft-key corresponding to **[Data Math]**.

c)   Press the soft-key corresponding to **[Data Math Off]** to turn off Trace computation function.

Section 11   Increasing Multistate Measure Efficiency

If multi-parameter Measure is required to characterize the property of a device, various methods can be used to improve the Measure efficiency. Try the following methods to find the most suitable Measure application scheme for you.

1   Increasing Measure Efficiency through Measure Settings

In order to improve the Measure efficiency of the measured piece for which multiple parameters must be measured, it is very helpful to be familiar with Analyzer operation, which helps to establish the optimum Measure application scheme. Refer to Section 4 "Trace. Channel and Window of Analyzer" in Chapter IV for the detailed information on Trace, channel and window related to multi-parameters Measure.

1.1   Arranging a set of Measures reasonably

Arrange a set of Measures of the measured piece under one instrument status, and conduct such Measure via call-back function when the status of storage instrument is convenient. The pre-conFig.d Measure setting function can also be used to conduct a set of Measures. Refer to the "Pre-conFig.d Measure Settings" part in Section 8 "Observing Multi-Trace and Enabling Multi-Channel" in Chapter V for the detailed information.

1.2   Using segment sweep

Segment sweep is very convenient when the following settings need to be changed while characterizing the multi-parameters Measure of a device.

● Frequency range

● Power level

● Intermediate-frequency bandwidth

● Sweep spot number

Segment sweep allows defining a set of frequency ranges with respective attributes, so that Measures of the measured piece requiring various Measure settings can be completed through a single sweep. Refer to the "Setting Segment Sweep Type" part in Section 5 "Sweep Setup" in Chapter V for the detailed information on segment sweep.

1.3   Selective triggerMeasure

Measures shall be set as follows by using trigger function:

● Continuously updating those Measures with data of quick changes

● Occasionally updating those Measures with data of few changes

For example, tuning Measure of a filter can be set as:

● Passband response of a channel Measure filter is used for tuning.

● A channel is used for out-of-band response of the Measure filter.

Then tuning Measure of the filter can be observed consecutively. Continuously updating all channels will lead to reduction of response speed of the Analyzer, causing that the filter can not be tuned quickly. How to establish the following Measure settings is discussed below:

● Measure data in Channel 1 will be updated continuously.

● Measure data in Channel 2 will be updated as needed.

1.3.1   By mouse or touch screen

a)   Establish a two-channel Measure.

Click **[Response]**, click **[Meas Setups]** on **[Display]** submenu, and click **[Set D]** in the pop-up dialog box.

b)   Set trigger of Channel 1: update Measure data continuously.

1)   Click **[Stimulus]**, point to **[Trigger]** on **Stimulus** menu, and click **[Trigger…]** on **Trigger** submenu, to display the **Trigger** dialog box.

2)   Select **[Internal]** option button in **Trigger Source** zone.

3)   Click **[Channel]** box in **Trigger Settings** zone and select **Channel 1**.

4)   Click to select **[Continuous]** option button in **Trigger Settings** zone.

c)   Set trigger of Channel 2: update Measure data as needed.

1)   Click **[Channel]** box in **Trigger Settings** zone and select **Channel 2**.

2)   Click to select **[Single]** or **[Group]** option button in **Trigger Settings** zone. If **group** trigger mode is selected, enter the number of groups in **[Group]** input box.

3)   Click **[OK]** button to close the dialog box.

d)   Click **[Utility]**, and click **[KEYs]** on **[System]** menu, to display **Soft Keyboard** dialog box. Click **[Trigger]**, to display the soft-key toolbar corresponding to **Trigger**.

e)   Click the window below to make Channel 2 the current Stimulus channel.

f)   Update the Measure data in Channel 2.

Click **[Single]**, **[Group]** or **[Restart]** button on the soft-key toolbar corresponding to **Trigger**, to update the Measure data in Channel 2.

1.3.2   By front panel keys

a)   Establish a two-channel Measure.

Press 【**Display**】 key in RESPONSE area, press the soft-key corresponding to **[Meas Setups]** on the displayed soft-key menu, and press the soft-key corresponding to **[Setup D]** on the submenu.

b)   Set trigger of Channel 1: update Measure data continuously.

1)   Press 【**Display**】 key in RESPONSE area, press the soft-key corresponding to **[Windows]**,

and press **[Window 1]** on the displayed submenu to make Window 1 the current Stimulus window, and Channel 1 the current Stimulus channel.

2) Press 【**Trigger**】key in STIMULUSE area, and press the soft-key corresponding to **[Continuous]** on the displayed soft-key menu.

c) Set trigger of Channel 2: update Measure data as needed.

1) Press 【**Display**】key in RESPONSE area, press the soft-key corresponding to **[Windows]**, and **press [Window 2]** on the displayed submenu to make Window 2 the current Stimulus window, and Channel 2 the current Stimulus channel.

2) Press 【**Trigger**】 key in STIMULUSE area, and press the soft-key corresponding to **[Single]** or **[Group]** on the displayed soft-key menu.

d) Update the Measure data in Channel 2.

Press 【**Trigger**】key in STIMULUSE area, and press the soft-key corresponding to **[Single]**, **[Group]** or **[Restart]** on the displayed soft-key menu.

2 Automatically Changing Measure Settings

Automatically changing Measure settings through programming can improve the efficiency of multistate multi-parameters Measure effectively.

3 Quick Call Measure

The most effective method of call Measure is to save a set of Measures as an instrument status.

- The time difference between calling an instrument status including multiple Measures and calling an instrument status with only one Measure is very small.

- Each call requires corresponding time, and the calling time can be saved by calling in groups through establishing a set of Measures.

Section 12   Transmitting Data Quickly

Use of the fastest data transmission helps to improve Measure efficiency, and the following methods can be used to improve data transmission speed:

1   Using Single Trigger Mode

Using single trigger mode guarantees that Measure has been completed before data transmission.

1.1   Setting single trigger

1.1.1   By mouse or touch screen

    a)   Click **[Stimulus]**, point to **[Trigger]** on **Stimulus** menu, and click **[Trigger…]** on **Trigger** submenu, to display the **Trigger** dialog box.

    b)   Select **[Internal]** option button in **Trigger Source** zone.

    c)   Click **[Channel]** in **Trigger Settings** zone to select the Measure channel for data transmission.

    d)   Click to select **[Continuous]** option button in **Trigger Settings** zone, and click **[OK]** button to close the dialog box.

    e)   Update Measure results:

        1)   Click the corresponding Trace status button so that the Trace and Channel to be updated will become Stimulus Trace and Channel.

        2)   Click **[Utility]**, click **[keys]** on **[System]** submenu, and click **[Trigger]** in **Soft Keys** dialog box.

        3)   Click **[Single]** in **Trigger** soft-key toolbar.

1.1.2   By front panel keys

    a)   Press 【**Trigger**】 key in STIMULUSE area, and press the soft-key corresponding to **[Trigger…]** on soft-key menu, to display the **Trigger** dialog box.

    b)   Press 【□】、【□】 keys in ADJUST area to enter **Trigger Source** zone, and press 【△】, 【▽】 **keys** or rotate the knob to select **[Internal]** option button.

    c)   Press 【□】、【□】 **keys** in ADJUST area to enter **[Channel]** box in **Trigger Settings** zone, and press 【△】, 【▽】**keys** or rotate the knob to select the Measure channel for data transmission.

    d)   Press 【□】、【□】 **keys** in ADJUST area to select **[Continuous]** option button, and press 【**OK**】 key in **Enter** keys to close the dialog box.

    e)   Update Measure results:

        1)   Press 【**Channel**】 key in TRACE/CHAN area, and press the soft-key corresponding to the channel to be updated, to make it the channel to be Stimulus.

        2)   Press 【**Trigger**】 key in STIMULUSE area, and press the soft-key corresponding to **[Single]** on the soft-key menu.

2   Transmitting as Little Data as Possible

For instance, use segment sweep to reduce Trace spot, rather than transmitting the whole Trace with many linear points.

3   Using Real Number Format

The highest transmission speed can be obtained by selecting real number format in automatic Measure using SCPI.

4   Using LAN

The speed of data transmission by SCPI automatic Measure applications can be increased via LAN.

5   Using COM Program

The fastest data transmission speed can be realized by using COM in automatic Measure applications.

Section 13   Using Macro

Macro is an executable file loaded into and operated on the Analyzer. 3656 Series Vector Network Analyzer supports maximum 10 macros.

1   New Macro

a)   Click **[Utility]**, point to **[Macro]** on Utility menu, and click **[Macro Setup…]** on the submenu, to display the Macro Setup dialog box.

Fig. 6-21 Macro Setup

b)   Click to Stimulus the blank line below the existing macro settings in the Macro Settings dialog box, and click **[Edit]** button, to display the Macro Edit Window dialog box.
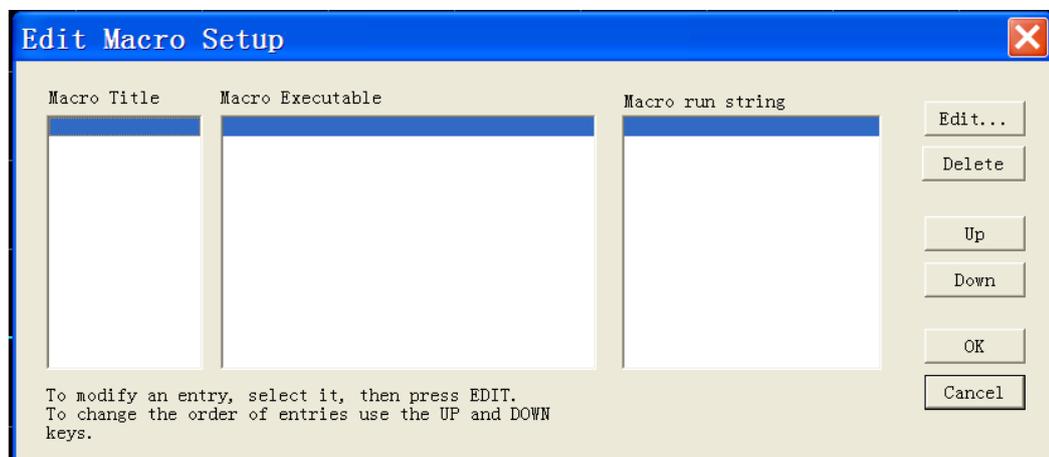
Fig. 6-22 Macro Settup Dialog Box

c)   Enter the caption text describing macro in **[Macro Name]** box.

d)   Enter the detailed path of executable file in **[Executable File]** box, or click **[…]** button to find the executable file.

e)   Enter the string parameters transmitted to the executable file in **[Parameter]** box.

f)   Click **[OK]** button to close the Macro Edit Window dialog box.

g)   Click **[OK]** button to close the Macro Setup dialog box.
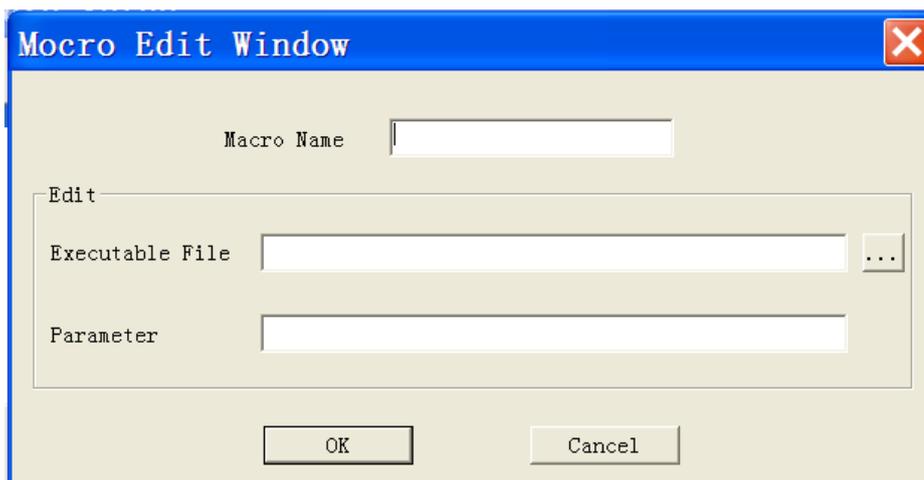
Fig. 6-23 Macro Edit Window Dialog Box

2   Macro Settings Dialog Box

[Macro Title]

To display the macro title, when [Macro/Local] key is pressed, the name of macro title is displayed in the active item toolbar button of Macro. When [Macro] is clicked in System menu, the name of macro title is displayed in the submenu item of Macro. In order to display the complete macro title in the active item toolbar button, the title should not exceed 14 characters. Macro title is associated with the executable file, so macro functions should be described so as to distinguish different macros. For instance, for a macro having access to 41st institute homepages, its title can be named "41st Institute Homepages".

[Macro Executable]

To display the full path of the executable file, e.g. macro with access to 41st institute homepages, path of the executable file is: C:\Program Files\Internet Explorer\IEXPLORE.EXE.

[Macro Run String]

To display the parameters transmitted to the executable file and quoted by the executable file. For instance, for macro with access to the homepages, parameters required for macro run are: http://www.ceyear.com.

[Edit]

Macro Edit Window dialog box is displayed when it is clicked, to set and modify the selected macro.

[Delete]

The selected macro is deleted when it is clicked.

[Up]

Click [Up] button to move the selected macro one line up, which is used to rearrange macro sequence.

Macro sequence in dialog box is consistent with the sequence appearing in the active item toolbar of Macro. Four macros are displayed in toolbar at a time, and the next four macros are displayed when press [Macro/Local] key again.

[Down]

Click [Down] button to move the selected macro one line down.

3   Macro Edit Window Dialog Box

[Macro Name]

It is used to set the name of macro title.

Edit Zone

a)   **[Executable File]**

It is used to set the full path of the executable file.

b)   **[…]**

It is used to browse drive and directory, locate the executable file, and create the full path of the executable file.

c)   **[Parameter]**

It is used to set the string parameter transmitted to the executable file for quotation.

Chapter VII   Calibration

This chapter introduces the basic calibration principle, the supported calibration types and the method to improve calibration precision for Analyzer calibration, including:

■　　Calibration overview

■　　Selecting calibration type

■　　Calibration setup

■　　High-precision Measure calibration

■　　Measure error

■　　Modifying the definition of calibration kit

■　　Calibration standard

■　　TRL calibration

Section 1   Calibration Overview

Measure calibration is a process determining system errors through measuring the standard with known properties and then removing the effects of those system errors while measuring the measured piece. Through calibration, Measure error can be reduced, and the Measure precision of Analyzer can be improved.

1   What is calibration

Calibration uses error model to eliminate one or more system errors, and Analyzer solves error item in error model through measuring high-quality calibration standard (such as open-circuit device, short-circuit device, load and through piece). Refer to the "System Error" part in Section 5 "Measure Error" in this chapter for the detailed information on system error.

When measuring, appropriate calibration method should be selected according to the requirements for Measure parameters and Measure precision. Refer to Section 2 "Selecting Calibration Type" in this chapter for the detailed information.

Various types of calibration can be completed by using calibration guide of Analyzer. Refer to Section 3 "Calibration Guide" in this chapter for the detailed information.

Measure precision after calibration depends on the quality of calibration standard and the model definition precision of calibration standard in the definition file of calibration kit. The definition file of calibration kit is saved in the Analyzer. In order to ensure Measure precision, the actually used calibration kit must conform to the definition in the definition file of calibration kit. Refer to Section 4 "High-precision Measure Calibration" in this chapter for the detailed information on accurate

calibration.

If user uses its own customized calibration kit (e.g. for fixture Measure calibration), the correct definition of calibration standard must be made, and definition of calibration standard must be made in the definition file of the user's calibration kit. Refer to Section 6 "Modifying Definition of Calibration Kit" in this chapter for the detailed information.

2   Why should calibration be conducted

It is impossible to manufacture ideal Analyzer hardware circuit without needing any error correction. Even though hardware circuits can work well and the need for error correction is negligible, the expense will be extremely high. Moreover, Measure precision of Analyzer is greatly affected by external accessories of the Analyzer, and changes amplitude and phase of test components such as connecting cable and adapter will shield the actual responses of the measured piece, so the effects of these accessories must be removed through calibration. Therefore, the best method is to make hardware as good as possible by weighing the performance and cost of hardware, and improve Measure precision through calibration. The brief process of calibration is as follows:

a)   Connect the Analyzer and the measured piece in accordance with Measure requirements, and select suitable Analyzer to set optimal Measure.

b)   Remove the measured piece, and selecte calibration type and calibration kit on Calibration menu.

c)   According to the prompts on the Calibration menu, connect the calibration standard required by the selected calibration type. The Analyzer works out error items through measuring the calibration standard, and saves them in Analyzer memory.

d)   Connect the measured piece for Measure. When error correction is enabled during device Measure, the effects of error items will be removed from Measure.

Section 2　Selecting Calibration Type

3656 Series Vector Network Analyzer supports 7 calibration types. The detailed information on each calibration type is as follows:

1　Open Response

a)　Calibration precision: low to medium.

b)　Measure parameters: S11 and S22.

c)　The required calibration standard: open-circuit device.

d)　The corrected system errors:

- Reflection Tracing

e)　Measure application:

- Reflection Measure on any port.

2　Short Response

a)　Calibration precision: low to medium.

b)　Measure parameters: S11 and S22.

c)　The required calibration standard: short-circuit device.

d)　The corrected system errors:

- Reflection Tracing

e)　Measure application:

- Reflection Measure on any port.

3　Through Response

a)　Calibration precision: medium.

b)　Measure parameters: S12 and S21.

c)　The required calibration standard: through standard.

d)　The corrected system errors:

- Transmission Tracing

e)　Measure application:

- Transmission Measure in any direction.
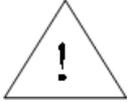
<table>
<tr><td>⚠
!</td><td>**Note:**</td><td>**The through standard is defined as zero length and zero loss in the definition file of calibration kit. If the adapter is used as through piece during calibration, in order to carry out accurate calibration, adapter properties must be characterized in the definition file of calibration kit. Refer to Section 4 "High-precision Measure Calibration" in this chapter for detailed information.**</td></tr>
</table>

4   Through Response and Isolation

a)   Calibration precision: medium.

b)   Measure parameters: S12 and S21.

c)   The required calibration standards: through standard, two loads (each port needs one load).

d)   The corrected system errors:

   ● Transmission Tracing

   ● Crosstalk

 e)   Measure application:

   ● Transmission Measure in any direction.

   ● Measure requiring isolation calibration to improve system dynamic range.

<table>
<tr><td>⚠
!</td><td>**Note:**</td><td>**If each port can not connect one load at the same time, isolation calibration can not be conducted.**</td></tr>
</table>

5   Enhanced Response Calibration

a)   Calibration precision: medium to high.

b)   Measure parameters: S12 and S21 or S22 and S12.

c)   The required calibration standards: through standard, open-circuit device, short-circuit device and load.

d)   The corrected system errors:

   ● Directivity

   ● Source matching

   ● Reflection Tracing

   ● Transmission Tracing

e) Measure application:

- Transmission Measure in any direction.

- Reflection Measure on any port.

6 1- Port (Reflection)

a) Calibration precision: high.

b) Measure parameters: S11 and S22.

c) The required calibration standards: open-circuit device, short-circuit device and load.

d) The corrected system errors:

- Directivity

- Source matching

- Reflection Tracing

e) Measure application:

- Reflection Measure on any port.

7 Quick SOLT

a) Calibration precision: medium.

b) Measure parameters: all.

c) The required calibration standards: open-circuit device, short-circuit device, load and through standard.

d) The corrected system errors:

- Directivity

- Source matching

- Reflection Tracing

- Crosstalk

- Transmission Tracing

- Load matching

e) Measure application:

- Measure of all S parameters.

8 Full Dual-port SOLT

a) Calibration precision: high.

b) Measure parameters: all.

c) The required calibration standards: open-circuit device, short-circuit device, load and through standard.

d)   The corrected system errors:

- Directivity

- Source matching

- Reflection Tracing

- Crosstalk

- Transmission Tracing

- Load matching

e)   Measure application:

- Measure of all S parameters.

- Measure requiring 12 errors correction to improve the Measure precision.

9   Full Dual-port TRL

a)   Calibration precision: very high.

b)   Measure parameters: all.

c)   The required calibration standards: through standard, reflection standard, and transmission standard.

d)   The corrected system errors:

- Directivity

- Source matching

- Reflection Tracing

- Crosstalk

- Transmission Tracing

- Load matching

e)   Measure application:

- Measure of all S parameters.

- Measure requiring 12 errors correction to improve the Measure precision.

- Measure requiring the maximum calibration precision.

Section 3   Calibration Setup

Calibration can be set up and conducted by using the **Calibration** menu of th Analyzer.

1   Starting Calibration

1.1   By mouse or touch screen

a) Click **[Response]**, and click **[Calibration Wizard…]** on the **[Cal]** submenu, to display the Calibration Wizard dialog box.
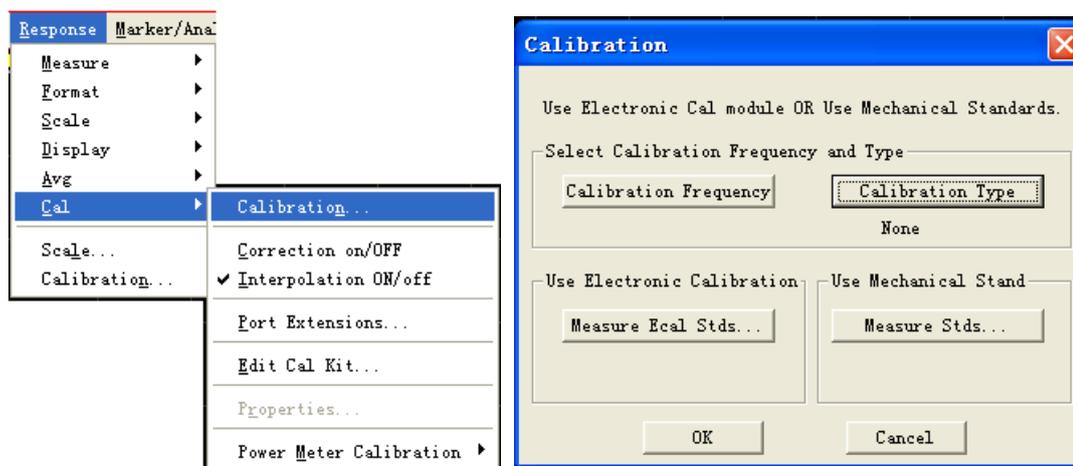
Fig. 7-1   Starting Calibration Wizard

b)   If it is required to set the frequency range of calibration, click **[Calibration Frequency]** button in Calibration dialog box, to display the **Frequency Start/Stop** dialog box. Click **[OK]** button to close **Frequency Start/Stop** dialog box after completing frequency setting.
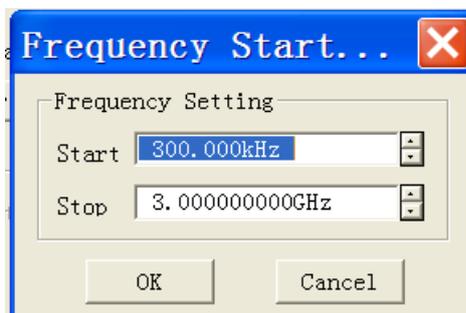
Fig. 7-2   Setting Calibration Frequency

c)   Click **[Calibration Type]** button in Calibration dialog box, to display the **Calibration Type** dialog box, and Click **[OK]** button to close **Calibration Type** dialog box after completing calibration type selection.

147

- The selectable calibration type is relevant to the Measure parameters of the current Stimulus channel. For instance, when Measure parameter is S_{11}, **Through Response** as well as **Through Response and Isolation Calibration** can not be selected.

- When conducting full dual-port calibration, if isolation calibration is not required, tick the **[Omit Isolation (2-Port Types)]** check box.
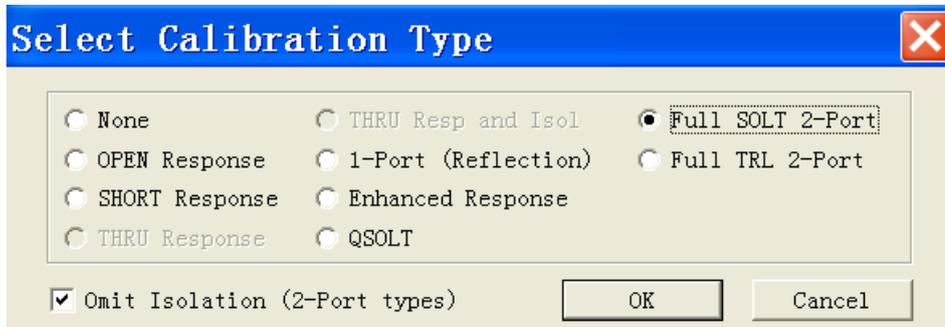
Fig. 7-3   Selecting Calibration Type

d)   Click **[Measure Stds]** button in the **Calibration** dialog box, to display the **Measure Mechanical Standard** dialog box.
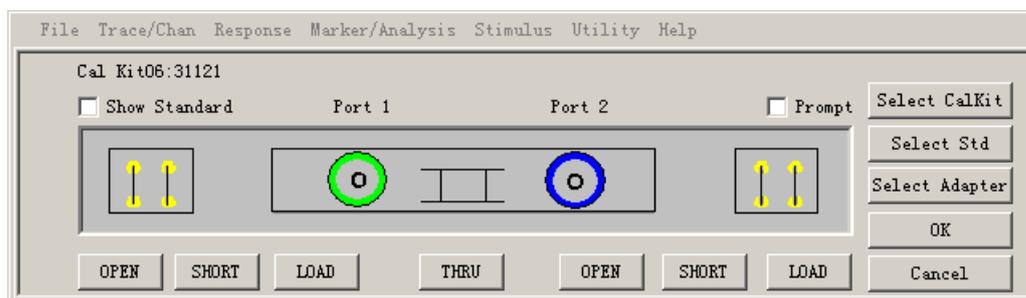
Fig. 7-4   Measure of Mechanical Standard Dialog Box

e)   If the used calibration kit is different from the default calibration kit of Analyzer, click **[Select CalKit]** button in the **Measure Mechanical Standard** dialog box, to display the **Select Calibration Kit** dialog box and select the used calibration kit in the box. Click **[OK]** button to close the **Select Calibration Kit** dialog box.
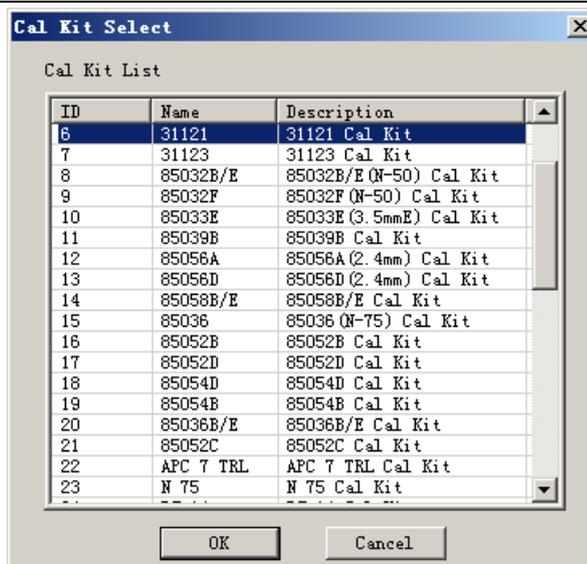
Fig. 7-5　Selecting Calibration Kit

f) If it is required to set calibration standard, click **[Select Std]** button in the **Measure Mechanical Standard** dialog box, to display the **Type Information** dialog box, and click **[OK]** button to close the **Type Information** dialog box after completing setting.
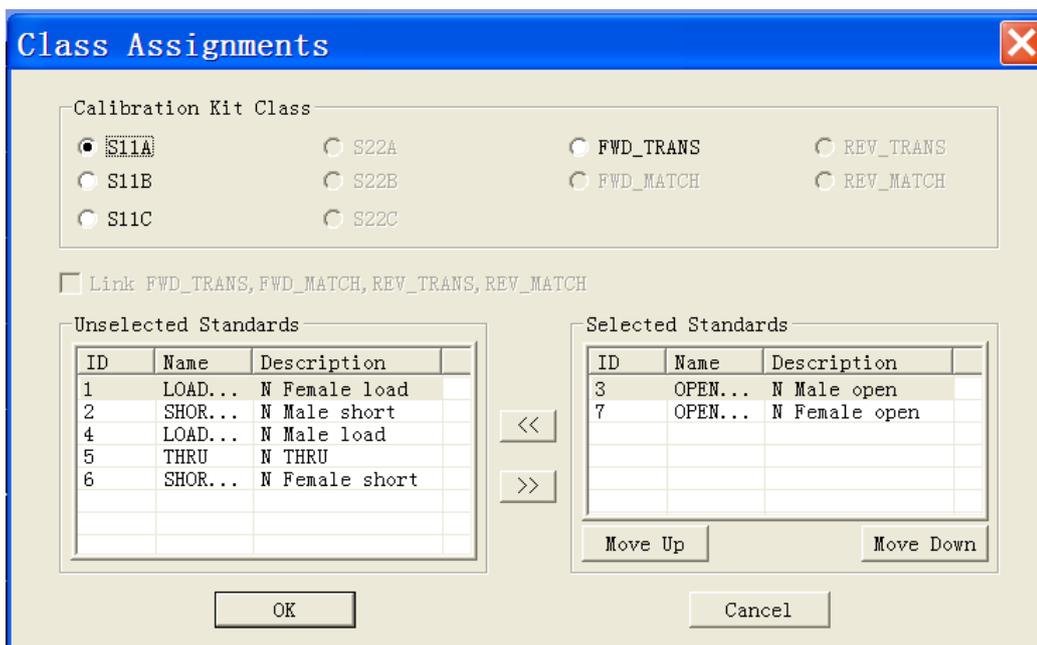
Fig. 7-6　Type Information Dialog Box

g) Connect calibration standard on the port, and tick the **[Show Standard]** dialog box in the top left corner of **Measure Mechanical Standard** dialog box. When the button corresponding to the calibration standard to be measured (such as **[OPEN**]) is clicked, the **Multiple Standards** dialog box will be displayed. If the average function should be used to reduce noise effects during

Measure of calibration standard, click to tick the **[Average]** check box, and set suitable average factors.
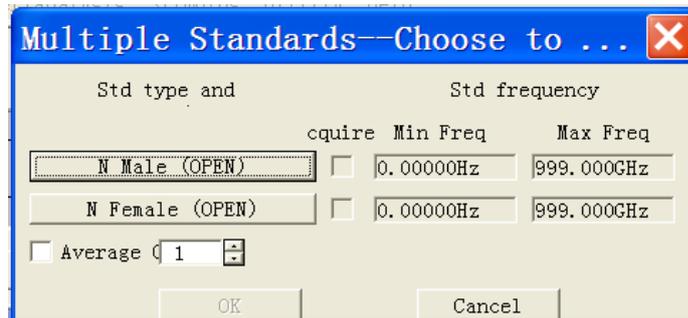
Fig. 7-7   Multiple Standards Dialog Box

⚠ !	**Note:**	**The connector type displayed in the Multi-calibration Kit Measure dialog box is the connector type for calibration standard, rather than the connector type for non-Measure port. In order to carry out accurate calibration, it must be guaranteed that the calibration standard selected in the dialog box conforms to the calibration standard actually measured during calibration process.**

h) If the **[Prompt]** dialog box in the top right corner of **Measure Mechanical Standard** dialog box is ticked, when the button corresponding to the calibration standard, e.g. **[N Male (OPEN)]**, is clicked in the **Multiple Standards** dialog box, the Prompt for **Connect Cal standard** dialog box will be displayed. Click **[OK]** button to start Measure after confirming the connected calibration standard is correct, and the Analyzer automatically ticks the corresponding **[Acquire]** check box in the **Multiple Standards** dialog box after Measure is completed. Click **[OK]** button to close the **Multi-calibration Kit Measure** dialog box after completing all the required calibration standard Measures. Button of the calibration standard whose Measure is completed in the **Measure Mechanical Standard** dialog box turns into green.
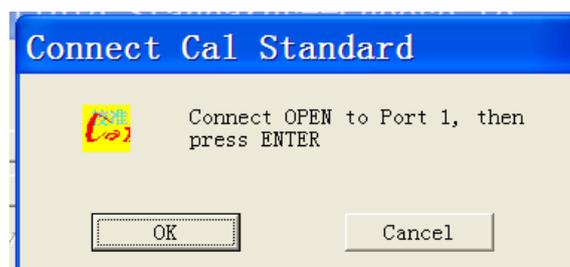
Fig. 7-8   Connect Calibration Standard Dialog Box

i) Repeat steps g) through h), to complete all the calibration standard Measures. Click **[OK]** button to close the **Measure Mechanical Standard** dialog box, to complete calibration.

1.2 By front panel keys

a) Press 【**Cal**】key in RESPONSE area, press the soft-key corresponding to **[Cal Kit]** to display the sub soft-key menu, and press the soft-key corresponding to the required calibration kit model to select calibration kit.

b) Press the soft-key corresponding to **[Mechanical Calibration]**, and select calibration type in the displayed sub soft-key menu.

c) Conduct a calibration Measure by taking **Thru Response** calibration Measure for example. Press the soft-key corresponding to **[Response],** and press the soft-key corresponding to **[Thru Response]** in the sub soft-key menu. Press the soft-key corresponding to **[FWD THRU]**. After this menu item turns into **[FWD <u>THRU</u>]**, a calibration Measure is completed by pressing **[DONE Response]**.

d) Repeat steps b) through c), to complete the required calibration standard Measures.

2. Calibration User Configuration

Calibration User Configuration includes two settings, **Save Cal File named as date** and **Do not save files when calibration finished**.

2.1 Mouse or touch screen procedure

a) Single click **[UTILITY]**, click [**ConFig.**] on the **[System]** menu, and click [**User Config**] on the submenu to display the **User Config** dialog box.
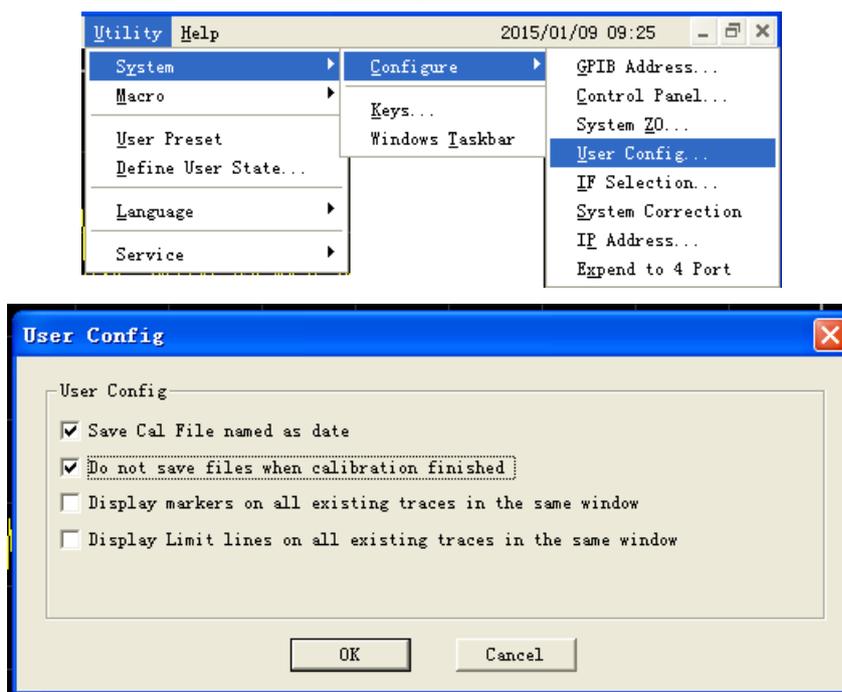
Fig. 7-9 User Config dialog box

b)   Tick **Save Cal File named as date** in the dialog box.

c)   Tick **Do not save files when calibration finished** in the dialog box.

Section 4   High-precision Measure Calibration

Calibration precision depends on the selected calibration type, calibration kit quality and calibration process. This section mainly discusses how to conduct high-precision calibration.

1   Measure Reference Plane

In most Measures, the measured piece is not directly connected to the port of Analyzer, but it is more likely to be connected by a test fixture or cable. If the maximum Measure precision is needed, calibration must be conducted on the connection surface of the measured piece, which is called Measure reference plane. If calibration is conducted on the Measure reference plane, errors related to Measure assembly (such as cable, test fixture, adapter between Analyzer port and reference plane) are removed through calibrating the measured piece.

2   Effects of Using Incorrect Calibration Kit

In normal conditions, calibration standard in calibration kit and the connector of the measured piece are of the same type. But in some cases, there may not be calibration kit of the same type as the connector of the measured piece. If the port of the measured piece is 3.5mm, connector type for Analyzer and calibration kit is N type. If N type calibration kit is used for calibration and adapter of N/3.5mm is connected for Measure, because the adapter is not included in calibration process, significant Measure error will be caused. If the used calibration kit is different from the calibration kit specified in calibration process, calibration precision will also be reduced, the extent of which depends on the difference between the specified calibration kit and the calibration kit actually used.

3   Precision of Interpolation Measure

When the status settings of Analyzer in Measure is different from the calibration status, Analyzer can automatically interpolate calibration data, then unpredictable Measure precision will be caused, which may reduce significantly, or may be not affected. Measure error must be determined according to the actual situation. When the increased phase shift of two measuring points exceeds 180°, because Analyzer can not interpolate the correct phase data, Measure precision will reduce significantly.

4   Effects of Power Level

In order to obtain a higher error correction precision, do not modify power level after calibration. However, when modifying power level under the same attenuator settings as in calibration, Measure precision of S parameters reduces a little. If attenuator settings are modified, error correction precision will reduce further.

5   System Impedance

To test the waveguide devices whose impedance is not 50Ω , you must change the system impedance. The default system impedance of 3656 Series is 50Ω , with 75Ω impedance system as option. If the customers need 75Ω impedance system, we can change the configuration before devlivery.

5.1   Setting system impedance

5.1.1   By mouse or touch screen

a)   Click **[Utility]**, point to **[ConFig.]** on **System** menu, and click **[System Z0…]** on ConFig. submenu, to display the System Zo dialog box.

b)   Set system Z0 value in **[Z0]**.

c)   Click **[OK]** button to close the dialog box.
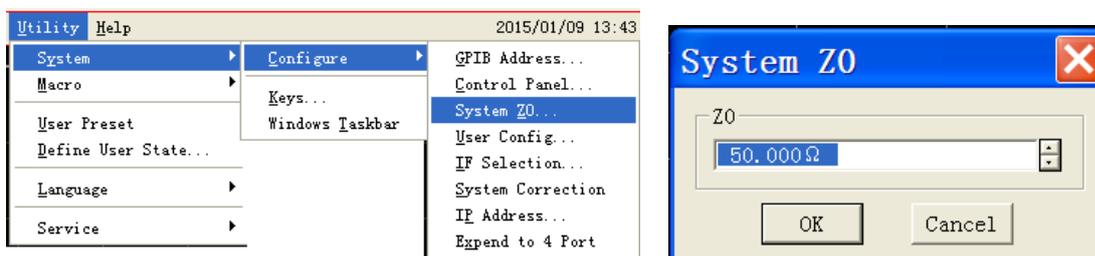
Fig. 7-10   Setting System Impedance

5.1.2   By front panel keys

a)   Press 【**System**】 key in UTILITY area, press the soft-key corresponding to **[ConFig.]** menu, and press the soft-key corresponding to **[System Z0]** on the displayed submenu, to display the System Z0 dialog box.

b)   Set system Z0 in the input box of **[System Z0]**.

6   Port Extension

Additional phase shift will be introduced by connecting additional cable, adapter or fixture after calibration, leading to change of Measure reference plane, and then the port extension function can be used to compensate additional phase shift. Port extension is the simplest way to compensate the additional phase shift between calibration plane and Measure plane, but it does not compensate loss and mismatching of the path between calibration plane and Measure plane, therefore, loss and mismatching shall be reduced as much as possible, to obtain the maximum Measure precision. Refer to the "Setting Port Extension" part of Section 5 "Increasing Phase Measure Precision' in Chapter VI for the method of setting port extension.

7   Conducting Isolation Calibration Correctly

Crosstalk error between ports is corrected in the calibration process of full dual-port calibration.

Isolation calibration is required only when high-insertion loss Measure, e.g. isolation Measure of filter with external inhibition and switch, is required. When crosstalk signal is very close to the noise background of Analyzer, isolation calibration will introduce noise in error model, so in order to improve calibration precision:

- Conduct isolation calibration only when necessary.

- Use narrow intermediate-frequency bandwidth.

- Use Sweep Average to reduce noise.

During isolation calibration Measure, load is required to be connected to the Measure port of Analyzer. In order to obtain the maximum calibration precision, it is better to connect loads to both Measure ports for isolation calibration Measure. In case of only one load, a well-matching device can be connected to the non-Measure port.

8　Calibration of Non-insertable Device

Measure ports can be connected together directly after insertable DUT are removed from Measure ports, as shown in the following Figure.:
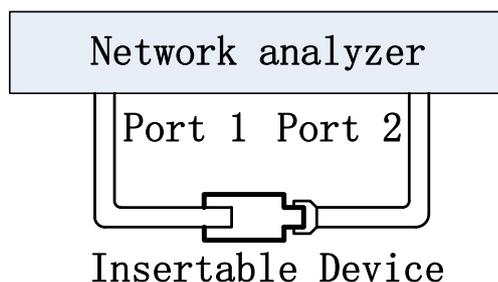
Fig. 7-11　Measure Connection of Insertable Device

When calibrating the insertable device, Measure ports are directly connected together on Measure reference plane, which is called zero-length through, namely, the through piece is with zero length, no delay and loss. Calibration kit is not provided with through standard piece, and Measure ports can not be directly connected together on Measure reference plane when calibrating non-insertable device, as shown in the following Figure., so calibration of non-insertable device can not be conducted directly.
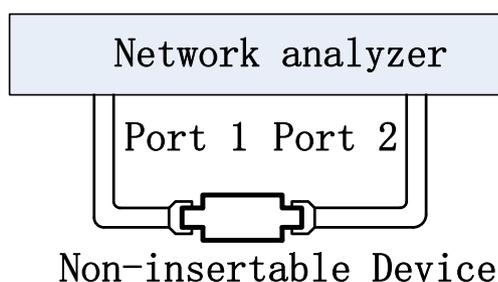

Fig. 7-12　Measure Connection of Non-insertable Device

When calibrating non-insertable device, if an adapter is used during calibration process for through connection and such adapter is not included in subsequent Measure, Measure precision will be reduced. Calibration methods of non-insertable device include:

8.1   Calibration method of through adapter with unknown properties

It is the simplest calibration method with the poorest precision. Adapter is directly used for through calibration Measure during calibration process. Due to unknown loss and delay properties of the adapter, its effects can not be removed in Measure. This method will deteriorate transmission Tracing error, and can not correct load matching error effectively.

8.2   Method of defining through adapter

Method of defining through adapter is to specify the loss and delay of through standard piece in the definition file of calibration kit for Analyzer, to remove effects of through adapter during calibration process, and to correct transmission Tracing error of Analyzer. But because the effects of reflection of adapter itself are not considered, load matching error can not be completely corrected.

Adapter manufacturer generally provides loss and delay data of the adapter, if not, it can be measured directly. Because the through adapter used is also a non-insertable device itself, correct calibration method must be adopted. Equivalent adapters exchanging method and adapter removing method to be discussed below can be used for calibration. Calibration process for method of defining through adapter is as follows:

a)   Use equivalent adapters exchanging method or adapter removing method for calibration.

b)   Measure loss and delay of through adapter.

c)   Modify the definition of through standard in the definition file of calibration kit. Refer to Section 6   "Modifying Definition of Calibration Kit" in this chapter for the detailed process.

d)   Use the through adapter for full dual-port calibration.

8.3   Equivalent adapters exchanging method

This calibration method works very well for Measures of non-insertable devices with identical connector type (e.g. the DUT with ports of SMA and female). Use two adapters with precise matching of impedances, insertion loss and electrical delay in calibration, one for through calibration during full dual-port calibration process, the other for reflection calibration and Measure of the measured piece. Calibration kit manufacturers provide such adapters. Type of the adapter used in calibration is related to the specific connector type for Measure port and the measured piece. Calibration process of an equivalent adapters exchanging method is as follows:

a)   Select Full Dual-port SOLT calibration in Calibration Guide.

b)   Connect Adapter A between Port 1 and Port 2, for through calibration Measure.
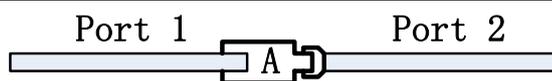
Fig. 7-13   Calibration Connection 1 for Equivalent Adapters Exchanging Method

c)   Remove Adapter A, and connect Adapter B to the correct port (Port 1 in this example). Connect open-circuit device, short-circuit device and load to Adapter B and Port 2 respectively for reflection calibration of full dual-port SOLT calibration.

Fig. 7-14   Calibration Connection 2 for Equivalent Adapters Exchanging Method

d)   Keep Adapter B connected to Port 1, for Measure of the measured piece.

Fig. 7-15   Measure Connection for Equivalent Adapters Exchanging Method

Calibration error of equivalent adapters exchanging method results from property matching error and connection error between adapters.

| ⚠ | **NOTE:** | **Adapter B is a part of the whole Measure assembly. The measured piece is directly connected to the adapter, and precise matching adapter may be worn due to multiple Measure connections. As an alternative, equivalent adapters exchanging method is used to measure properties of the through adapter, and method of defining through adapter is adopted for calibration of non-insertable devices.** |

8.4   Adapter removing calibration

Adapter removing calibration offers the most precise calibration method for Measure of non-insertable devices, which requires connecting the adapter to Port 1 and Port 2 of Analyzer respectively for two full dual-port calibrations. Then adapter properties can be determined, thus removing effects of adapter completely.

Conducting adapter removing calibration requires a through adapter with the same connector type as the measured piece as well as calibration kit corresponding to the connector type of the measured

piece.

Section 5   Measure Error

Learning the Measure errors sources and error correction methods is helpful for improving the precision of Measure, because there is still uncertainty however carefully the Measure is done. Three kinds of errors may occur when the Network Analyzer is used to carry out Measure:

1   Drift Error

- Drift error occurs due to the performance alteration of the Analyzer or test system after the calibration.

- Major reasons of drift error are the expansion and contraction of cable interconnected inside the Analyzer and the property alteration of the receiver. Drift error can be eliminated by re-calibration.

- Measure environment determines how long the accurate calibration will be kept; stable environmental temperature can minimize the drift error.

For detailed information about the method of obtaining stable Measure results, refer to Section 9 "Measure Stability" of Chapter VI.

2   Random Error

Though random errors are unpredictable and can not be eliminated by calibration, their impact on the Measure results can be decreased by some methods. Random errors can be divided into three types:

2.1   Random noise error of Analyzer

Electric disturbances of internal components of Analyzer may contribute to random noise, mainly including:

- Low level noise caused by broadband background noise.

- High level noise or data Trace vibration, mainly caused by the background noise inside the Analyzer and LO source phase noise.

Random noise error can be decreased by following methods:

- Increase source power input to the measured piece.

- Decrease intermediate-frequency bandwidth.

- Use Sweep average.

2.2   Repeatability error of switch

For the Analyzer, RF mechanical switch is adopted to change over the settings of the source attenuator. When the switch is actuated, some times, the closing of contact differs from the closing state last time, and that will affect the Measure accuracy terribly if it happens. Thus during the high-precision Measure, changing the settings of attenuator should be avoided so as to decrease the repeatability error of switch.

2.3   Repeatability error of connector

Every time the connector is connected, its status is different, which leads to repeatability error. Abrasion of connector will change its electrical performance. Correct connection and maintenance method of the connector can be used to decrease the repeatability error.

For details of maintenance and connection of connector, see contents of " Routine Maintenance" in Chapter III.

3   System Error

System error is caused by undesirable properties of Analyzer hardware, which is repeatable (thus it is predictable), assuming it does not change with time. System errors can be eliminated by calibration and eliminated during the Measure through mathematical calculation.

However, they can not be eliminated thoroughly and some residual errors are always left due to the limitation of calibration. Residual system errors after the calibration are mainly from:

- Undesirable calibration standards.
- Measure connection.
- Interconnection cable.
- Instrument itself.

For reflection Measure, related residual errors are:

- Effective directivity.
- Valid source matching.
- Valid reflection tracing.

Additionally, for transmission Measure, following residual errors will be added as:

- Crosstalk.
- Valid load matching.
- Valid transmission tracing.

3.1   Directivity errors

Analyzer makes reflection Measure through directional coupler or bridge. At the coupling end of ideal coupler, only reflection signals are output to the receiver for Measure, and actually, a few of incident signals will leak to the coupling port via the primary route of coupler and directional errors may occur in the Measure. Analyzer determines and decreases directional errors through following methods:

a)   In calibration, connect the load to the metering port and believe that the load port will not reflect back.

b)   Output signals of coupling port are rightly the directional error signals leaked out.

c)   Subtract directional error signals during the Measure.

3.2   Crosstalk error

Ideally, only transmission signals passing through the measured piece get to the receiver, and actually, a few signals will get to the receiver via other routes of the Analyzer which are called crosstalk signals. The Analyzer determines and decreases crosstalk errors by following methods:

a) Connect load at port 1 and port 2 in calibration.

b) Signals received in Measure receiver are the crosstalk signals leaking out of the Analyzer.

c) Eliminate the crosstalk errors through error correction during the Measure.

3.3   Source matching error

In reflection Measure, on the ideal conditions, the Measure receiver receives all signals reflected from the DUT, but actually, a part of signals reflected back from the DUT are reflected back to the DUT by the measuring port. Receiver can not measure said signals so that source matching errors will occur. The Analyzer determines and decreases source matching errors by following methods:

a) In calibration, connect the short-circuit device to the measuring port, use the Analyzer to measure reflected signals coming from the short-circuit device and store the measured values in the Analyzer.

b) Connect the open-circuit device to the port, use the Analyzer to measure the reflected signals coming from the open-circuit device and store the measured values in the Analyzer.

c) Use the Analyzer to compare the measured values with the given values of open-circuit device and short-circuit device so as to determine the source matching errors.

d) Eliminate the source matching errors through error correction during the Measure.

3.4   Load matching error

In ideal transmission Measure, measure the transmission signals via the DUT that the receiver receives, and actually, partial signals are reflected by the measuring port and can not be measured, thus load matching errors may occur. The Analyzer determines and decreases load matching errors by following methods:

a) Connect port 1 with port 2 together to carry out zero-length through.

b) When the source is at port 1, Measure signals of receiver A include reflected signals of port 2, and when the source is at port 2, Measure signals of receiver B include reflected signals of port 1, thus load matching errors can be determined.

c) Eliminate the load matching errors through error correction during the Measure.

3.5   Reflection Tracing error

Reflection Measure is done by comparing signals of receivers A and R1 or signals of receivers B and R2, which is also called ratio Measure. For ideal reflection Measure, frequency responses of receivers A and R1 or receivers B and R2 are identical, but actually, that is impossible, thus reflection Tracing errors may occur. Reflection Tracing errors are vectors and errors resulting from various test

deviations, and their magnitudes and phases will vary with the frequency. Sources of those deviations include:

- Signal separation devices.
- Test cable and adapter.
- Difference between reference and Measure signal routes.

The Analyzer determines and decreases reflection Tracing errors by following methods:

a) In calibration, connect the short-circuit device to the measuring port, use the Analyzer to measure reflection signals coming from the short-circuit device and store the measured values in the Analyzer.

b) Connect the open-circuit device to the port, use the Analyzer to measure the reflected signals coming from the open-circuit device and store the measured values in the Analyzer.

c) Use the Analyzer to compare the measured values with the given values of open-circuit device and short-circuit device so as to determine the reflection matching errors.

d) Eliminate the reflection matching errors through error correction during the Measure.

3.6   Transmission Tracing error

Transmission Measure is done by comparing signals of receivers A and R2 or signals of receivers B and R1, which is also called ratio Measure. For ideal transmission Measure, frequency responses of receivers A and R2 or receiver B and R1 are identical absolutely. But actually, that is impossible, and then transmission Tracing errors may occur. Transmission Tracing errors are vectors and errors resulting from various test deviations, and their magnitudes and phases will vary along with the frequency. Sources of those deviations include:

- Signal separation devices.
- Test cable and adapter.
- Difference between reference and Measure signal routes.

The Analyzer determines and decreases transmission Tracing errors by following methods:

a) Connect port 1 with port 2 together to carry out zero-length through.

b) Measure signals of receivers A and R2 or signals of receivers B and R1.

c) Determine the transmission Tracing errors by comparing the signals in both receivers.

d) Eliminate the transmission Tracing errors through error correction during the Measure.

Section 6   Modifying the Definition of Calibration Kit

The Analyzer can be used to change the definition of calibration kit or create calibration kit defined by customers themselves.

1   Definition of calibration kit

Each calibration standard (represented by standard ID) in calibration kit are specified physical device with accurate definition. There are 4 basic types of calibration standards totally: open-circuit device, short-circuit device, load and through piece/adapter/transmission line. Each standard has their own special model structure in which numerical and physical characteristics of the standards are described. It is permitted to use other calibration standards besides calibration kit only if the properties of standards are defined in advance.

2   Changing and creating calibration kit

For most Measure applications, default calibration kit model is enough to carry out accurate calibration, but sometimes, it may be required to modify calibration kit definition document or create user-defined calibration kit, for example, in several Measure applications below, it is required to create user-defined calibration kit or modify the definition of calibration kit:

- Connector type is not in conformity to the definition of calibration kit model.
- Use standards different from the calibration kit definition, e.g., use three different offset short-circuit devices to replace open-circuit device, short-circuit device and load to implement single-port (reflection) calibration.
- Improve the precision of predefined calibration kit model. The calibration will be more accurate when the model can describe the actual properties of standards better, e.g., Change the impedance value of the load into actual value 50.1Ω instead of 50Ω in the definition.
- Modify the definition of through piece to implement non-insertable device calibration.
- Implement TRL calibration.

When the user-defined calibration kit is created by an user, the connector type must be defined first, such as APC7、3.5mm、Type-N(50Ω), in addition, it is best that each calibration kit is limited with only one connector type though each calibration kit is permitted to be defined with more than one connector type. It is required to make definitions respectively if connectors are divided into female connector and male connector.

2.1   Modification of calibration kit definition

a)   Click **[Response]**, click **[Edit Cal Kit…]** on the **[Cal]** menu, display **Edit Cal Kit** dialog box.

b)   Click the calibration to be modified in the dialog box, click **[Edit Kit]** button, display **Edit Kit** dialog box.

c) Select the calibration standard to be modified in Standard box in Edit Calibration Kit dialog box, click **[Edit…]**, display related dialog box and modify the calibration standards.

d) After the completion of modification, respectively click **[OK]** button to close all dialog boxes.
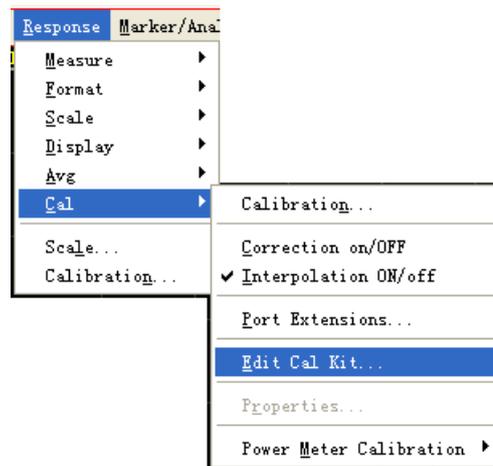
Fig. 7-16   Modification of Calibration Kit Definition

2.2   Creation of user-defined calibration kit

a) Click **[Response]**, click **[Edit Cal Kit…]** on **[Cal]** menu, display Edit Calibration Kit dialog box.

b) Click **[Insert New …]** button, then Edit Calibration Kit dialog box displays, make following settings in Calibration Kit Identification zone of the dialog box:

● Input user-defined ID No. of calibration box in **[Kit Number]**.

● Input user-defined name of calibration kit in **[Kit Name]**.

● Input characteristic description of calibration kit in **[Kit Description]**.

c) Click **[Add]** button at Connector zone, then Add Connector dialog box displays, make following settings:

● Select connector type at **Gende**r zone: **[Male], [Female]** or **[No Gender].**

● Input connector name in **[Connector Family]** box at **Identification** zone.

● Input property description of connector in **[Description]** box at **Identification** zone.

● Set minimum and maximum working frequencies of the connector at **Frequency Range** zone.

● Input characteristic impedance value in **[Z0]** at Impedance zone, e.g., 50Ω.

● Select medium type of the connector in **Media**: **COAX** or **WAVE**.

● Click **[OK]** button to close the dialog box after correct check and input, and it is forbidden to edit the connector property any more.

d) Repeat step c) to complete the addition of all connectors.

e) Click **[Add…]** button at **Standard** zone in **Edit Kit** dialog box, display **Add Standard** dialog

box displays, select the standard to be added from **[OPEN], [SHORT], [LOAD], [THRU],**
[ADAPTER] or **[LINE]**, click **[OK]** button to close Add Standards dialog box, at the same time
display the edition dialog box of the selected standard(s).

f) Complete defining the standards in the edition dialog box of Standard (Such As Open); for
    band-pass calibration standards, their frequency scope may be different from the working
    frequency scope of the connector. Set minimum and maximum frequencies based on the actual
    properties of calibration standards, then click **[OK]** button to close the dialog box after the
    completion of setting.

g) Repeat step e)~f) to complete defining all standards of user-defined calibration kits.

h) Click **[Class Assignments]** and select standard type in **Edit Kit** dialog box, then click **[Edit]**
    button, display **Class Assignments** dialog box, and click **[OK]** button to close **Class Assignments**
    dialog box after completing classifying calibration standards.

i) Click **[OK]** button to close **Edit Kit** dialog box.

2.3 Modification of calibration kit dialog box
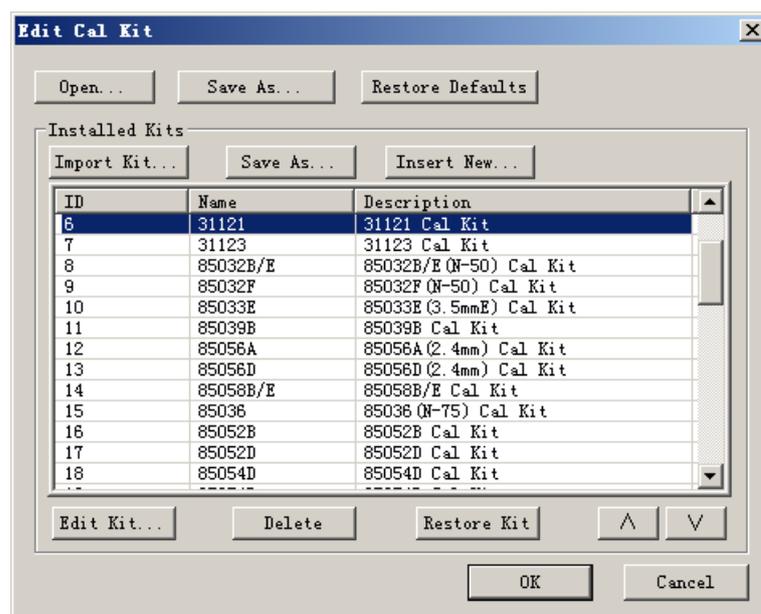
Fig. 7-17   Modification of Calibration Kit Dialog Box

[Open]

Open calibration kit listfile and pack definitions of all calibration kits listed in the file into the
Analyzer.

[Save As]

Save definitions of all calibration kits which are in current Analyzer into calibration kit listfile.

[Restore Defaults]

Re-install all calibration kits that the Analyzer supports.

Installed Kits zone

a) **[Import Kit…]**

Call Open dialog box and import calibration kit definition files saved on the hardware or other drivers.

b) **[Save As]**

Open Save As dialog box and save the definition of selecting calibration kits.

c) **[Insert New…]**

Open Edit Calibration Kit dialog box and create a new calibration kit definition.

d) **[Edit Kit…]**

Display Edit Calibration Kit dialog box and modify the selected calibration kit definitions.

e) **[Delete]**

Delete the selected calibration kit definitions.

f) **[Restore Kit]**

Recover the modification of selected calibration kits and return to default state.

g) **[∧], [∨]**

Click **[∧], [∨]** buttons to select calibration kits.

2.4   Edit Kit dialog box
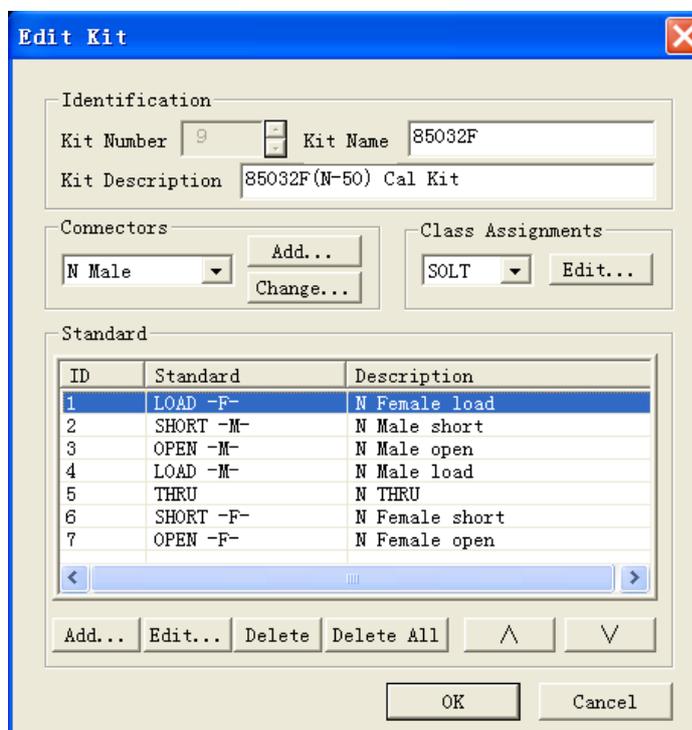
Fig. 7-18   Edit Kit Dialog Box

Identification zone

a) **[Kit Number]**

Display ID No. of calibration kits.

b) **[Kit Name]**

Display or edit names of calibration kits.

c) **[Kit Description]**

Display or edit property description of calibration kits.

Connectors zone

a) **[Connector]**

Click to select connector type.

b) **[Add]**

Click **[Add]** button to display Add Connectors dialog box and add new connector types of calibration kits.

c) **[Change]**

Click and display Modify Connector Name dialog box as below and modify names of connectors.
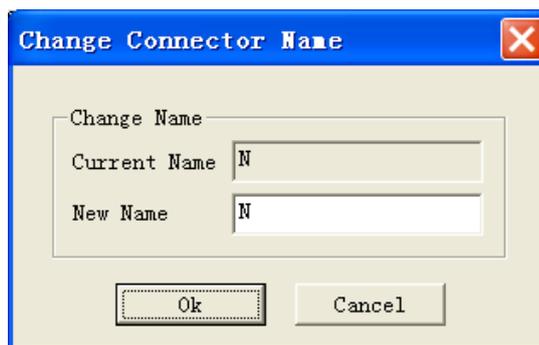
Fig. 7-19   Change Connector Name Dialog Box

Class Assignments zone

a) **[Class]**

Select calibration methods and classify the calibration standards. Selectable calibration methods include: SOLT and TRL.

b) **[Edit]**

Click Edit Type button to display Type Information dialog box and classify calibration standards.

Standards zone

a) **[Calibration Standard]**

Display ID, names and descriptions of all calibration standards in edited calibration kits, to select calibration standards.

b) **[Add]**

Click and display Add Standards dialog box and select new calibration standards to be added.

c)   **[Edit]**

Click **[Edit]** button to display edit dialog box of selected calibration standards, and modify the definitions of calibration standards.

d)   **[Delete]**

Click and delete definitions of selected calibration standards.

e)   **[Delete All]**

Click to delete definitions of all calibration standards in calibration kits.

f)   **[∧], [∨]**

Aim to select calibration standards.

2.5   Add Connector dialog box

Fig. 7-20   Add Connector Dialog Box

Identification zone

a)   **[Connector Family]**

Define names of calibration kits connectors.

b)   **[Description]**

Define property description of calibration kits connectors.

Frequency Range zone

a)   **[Min Freq]**

Defines minimum frequency at which the connector of calibration standard is allowed to be used.

b)   **[Max Freq]**

Defines maximum frequency at which the connector of calibration standard is allowed to be used.

Gender zone

Select the polarities of connecters from **[Male], [Female]** or **[No Gender].**

Impedance zone

[Z0]

Define the characteristic impedance of the connector.

Media zone

[Media]

Select the medium defining calibration standards: coaxial or waveguide.

2.6   Dialog box of Class Assignments
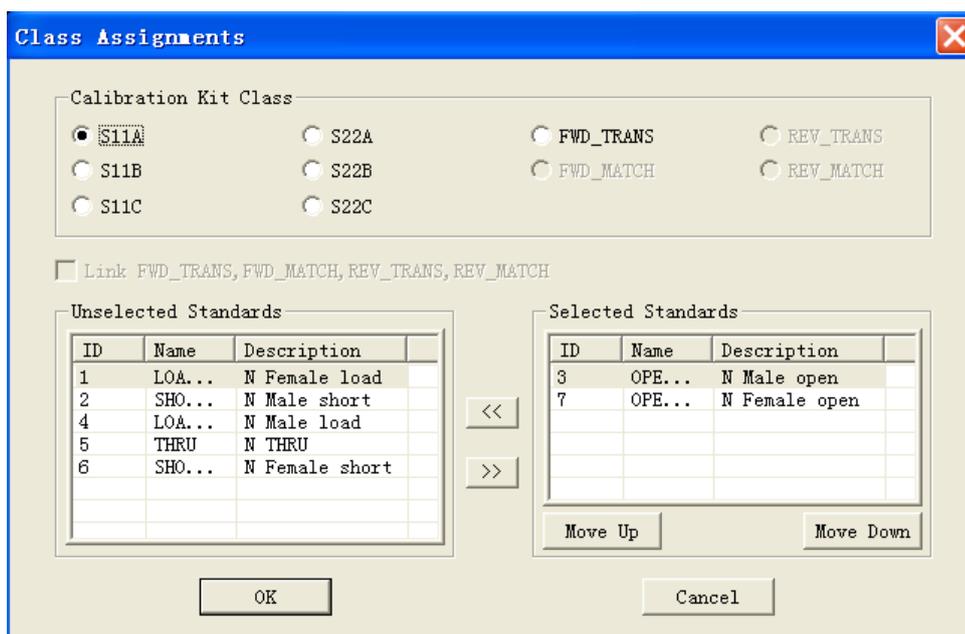
Fig. 7-21   Dialog box of Class Assignments

Calibration Kit Class Area

Select the type of calibration kit to be edited or observed.

[>>], [<<]

Use **[>>]** and **[<<]** buttons to add or delete calibration standards included in the selected calibration kit type, select calibration standards in Unselected Standards box, click **[>>]** button to add the selected standards into Selected Standards box; select calibration standards in Selected Standards box, click **[<<]** button to delete calibration standards in calibration kit type.

[Selected Standards]

Display the calibration standards included in current calibration kit type.

[Move Up] and **[Move Down]**

Use **[Move Up]** and **[Move Down]** buttons to adjust the display order of calibration standards in Selected Standards box; in the course of calibration, all calibration standards in Selected Standards

169

box will appear in Multiple Calibration Kits Measure box, and it is required to selecte related calibration standards based on the positive and negative polarities of measuring ports and the frequency scope of the Measure.

Select calibration standards in Selected Standards box, click **[Move Up]** or **[Move Down]** button to change the display order of calibration standards, which is quite helpful in following two Measure applications:

● It is required for one calibration kit type to use several calibration standards to cover the whole frequency scope, and the display order of standards in Selected Standards box is consistent with that of calibration standards in Multiple Calibration Kits Measure dialog box, thus it is best to arrange calibration standards based on the working frequency scope.

● While using male and female calibration kits to make calibration, it is possible to determine the display order of calibration standards as per the port configuration of DUT, e.g., port 1 of measured piece is male, port 2 is female, arrange the male standard pieces at row 1 while distributing standards of type S11, and arrange the female standard pieces at row 1 while distributing standards of type S22, for making selection in calibration.

[Unselected Standards]

Display the standards not included in current calibration kit type.

2.7   Dialog box of Modify TRL Calibration Class Assignments
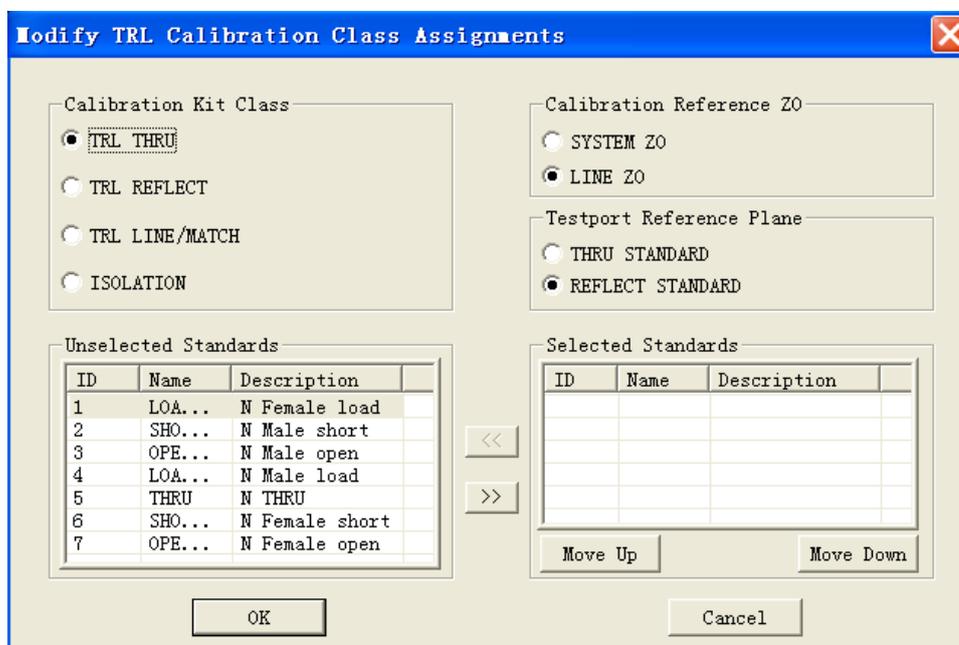
Fig. 7-22   Dialog box of Modify TRL Calibration Class Assignments

Calibration Reference Z0 zone

a) **[System Z0]**

Regard the system impedance as reference impedance, and select this option button when the impedance of measuring port differs from that of transmission line.

b) **[Line Z0]**

Regard the impedance of transmission line as reference impedance or the center of Smith Chart, and summarize all reflections from the transmission line as directional errors.

Test Port Reference Plane zone

a) **[THRU STANDARD]**

Use the definition of through standard to built Measure reference plane, and select this option button when the length of through standard is 0.

b) **[REFLECT STANDARD]**

Use the definition of reflection standard to build Measure reference plane, and select this option button when the through standard is not very proper and the delay of reflection standard is defined accurately.

2.8　Opens dialog box

Fig. 7-23　Opens Box

Identification zone

a) **[Standard ID]**

Used to display and edit ID No. of calibration standards.

b) **[Label]**

Used to display or edit names of standards.

c) **[Open Description]**

Used to display or edit characteristic description of standards.

Frequency Range zone

a) **[Min Freq]**

Define the minimum frequency at which the open-circuit device can operate in calibration.

b) **[Max Freq]**

Define the maximum frequency at which the open-circuit device can operate in calibration.

Connector zone

[Connector]

Select the type of open-circuit device connector.

Open Characteristics zone

Define the magnitude of open-circuit device fringe capacitance through **[C0], [C1], [C2]** or **[C3]** box.

Delay Characteristics zone

a) **[Delay]**

Define one-way transmission time from calibration plane to calibration standard.

b) **[Loss]**

Define the energy loss of calibration standard due to skin effect. The unit is Gohm/S and the frequency is 1GHz. In loss calculation, respectively measure the insertion loss and delay of calibration standards at 1GHz, and use following formula to calculate:

$$\text{Loss } (\frac{\Omega}{\text{S}}) = \frac{\text{Insertion loss (dB)} \times \text{IMPEDANCE}(\Omega)}{4.3429(\text{dB}) \times \text{DELAY (S)}}$$

b) **[Z0]**

Define the impedance of standard.

2.9   Shorts dialog box
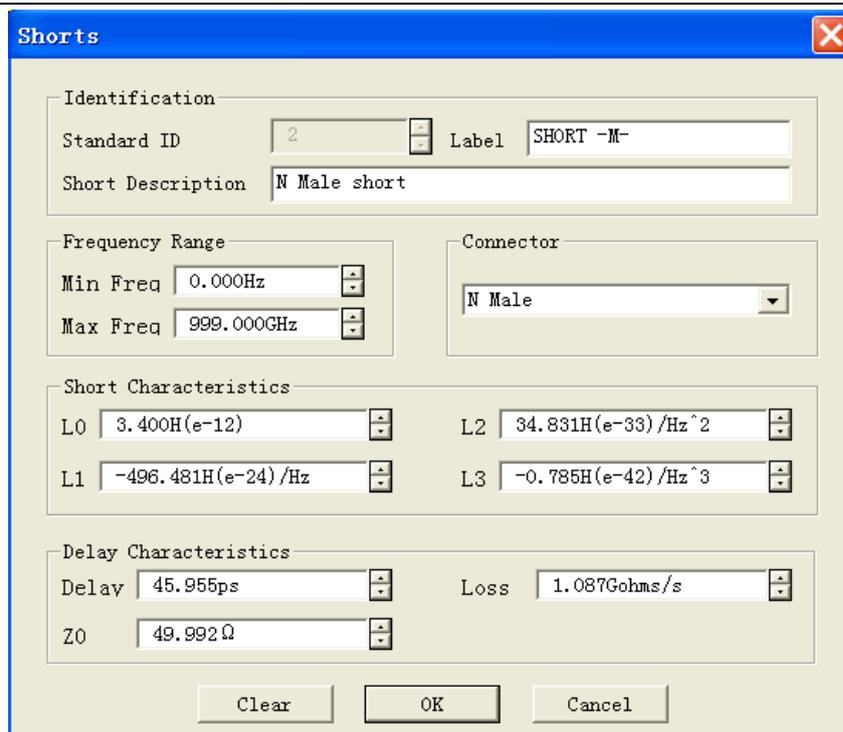
Fig. 7-24   Shorts Dialog Box

Short Characteristics zone

Define the magnitude of short-circuit device residual inductance through [L0], [L1], [L2] and [L3]
box.

2.10   Loads dialog box
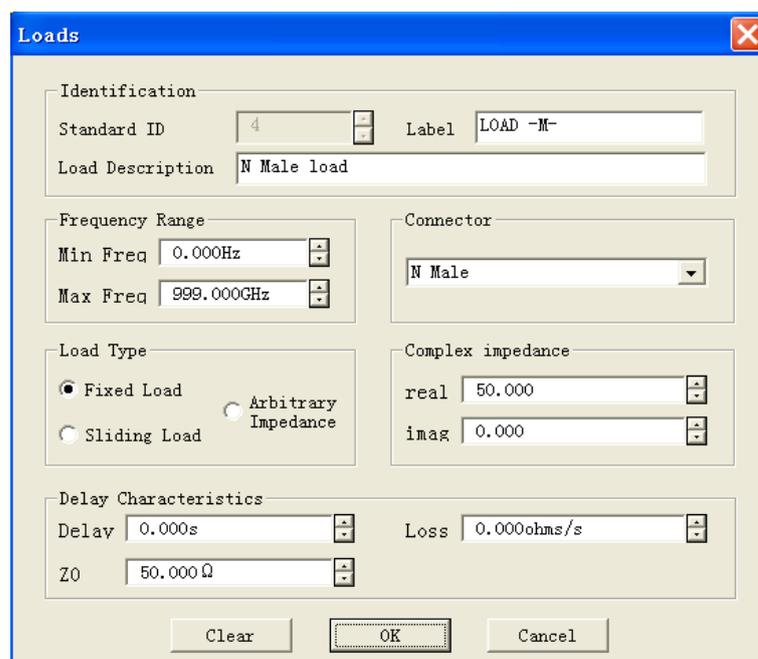
Fig. 7-25   Loads Dialog Box

Load Type zone

a) **[Fixed Load]**

Designate the load type as blocked load by selecting it.

b) **[Sliding Load]**

Designate the load type as slip load by selecting it.

c) **[Arbitrary Impedance]**

Designate the load with impedance value different system impedance Z0 by selecting it. And the setting of Complex Impedance zone is valid only when the [Special Impedance] is selected.

Complex Impedance zone

a) **[Real]**

Define the resistance of complex impedance.

b) **[Imag]**

Define the reactance of complex impedance.

Section 7   Calibration Standards

This section mainly describes basic principles of calibration kits and some terms in calibration kit definition files.

1   Calibration Kit

Calibration kit is composed of a set of physical devices named calibration standards. The response information of each standard magnitude and phase changing along with the frequency is accurately known or predictable. To enable the Analyzer to use the definitions of these calibration standards, the response value of each standard must be defined by mathematical methods, and all standards must be organized into calibration types which correspond with the error modification models used by the Analyzer.

2   Calibration Standards

Calibration standards provide the basic reference when the Analyzer carrying out error modification Measure. The Electrical delay, impedance and loss of each standard has been accurately defined, and the Analyzer saves these definitions and calculates all error items in the error models through those definitions. The Analyzer in calibration measures the responses of these calibration standards and calculate them to obtain error items by comparing the measured values with the given values of standards. While measuring the DUT, get rid of the impact of those error items on the Measure results through the mathematics theory named as error modification.

3   Types of Calibration Standards

Calibration standards are divided into 4 types which correspond with different standard definition structures or forms. These 4 calibration standard types are shown as follows:

Calibration standards	Terminal impedance
Open-circuit device	$\infty\Omega$
Short-circuit device	0Ω
Load	System impedance
Through/air line/adapter	No terminal impedance

4   Definitions of Calibration Standards

Definitions of calibration standards describe electrical properties of standards and frequency scopes in which they can be used, including:

a)   Minimum Frequency

Designate minimum frequency that standards can be used in calibration.

b)   Maximum Frequency

Designate maximum frequency that standards can be used in calibration.

c)　Impedance

Designate the characteristic impedance of standards, neither characteristic impedance of system nor terminal impedance of standards.

d)　Delay

Define the transmission delay of the transmission line between calibration standards and actual calibration plane.

e)　Type

Designate types of calibration standards: open-circuit device, short-circuit device, load or through/transmission line/adapter.

f)　Loss

Designate the energy loss due to skin effect. The loss unit is Gohm/S, and the related frequency is 1GHz. In loss calculation, respectively measure the loss and delay of calibration standards at 1GHz, and use following formula to calculate:

$$LOSS\left(\frac{\Omega}{S}\right)=\frac{\text{INSERTION LOSS (dB)}\times\text{IMPEDANCE}(\Omega)}{4.3429(\text{dB})\times\text{DELAY(S)}}$$

g)　Open-circuit device fringe capacitance model

At high-frequency segment, due to the impact of fringe capacitance, the open-circuit device has few ideal reflection properties and its phase shift will change along with frequencies. Those impacts can not be eliminated. But the model of open-circuit device defines fringe capacitance, and said capacitance model is a cubic polynomial with the frequency as the function; coefficients of polynomial are determined by actual properties of open-circuit device. The equation of fringe capacitance model is:

C=(C0)+(C1×F)+(C2×F2)+(C3×F3) (F represents measuring frequency)

h)　Short-circuit device residual inductance model

At high-frequency segment, due to the impact of fringe capacitance, the short-circuit device has few ideal reflection properties and its phase shift will change along with frequencies. Those impacts can not be eliminated. But short-circuit device model defines residual inductance, and said inductance model is a cubic polynomial with the frequency as the function; coefficients of polynomial is determined by actual properties of short-circuit device. The equation of residual inductance model is:

$$C=(L0)+(C1\times F)+(C2\times F^2)+(C3\times F^3) \text{ (F represents measuring frequency)}$$

5   Classification of Calibration Standards

When the definition of calibration standards is completed, it must be distributed to a calibration type. One calibration type is composed of one group of standards which is organized on the basis of the error modification model of the Analyzer. The number of calibration types is equivalent to the number of error items to be modified in error model, e.g., response calibration requires one calibration type only; each port calibration requires three calibration types; one full dual-port SOLT standard in neglection of isolation requires ten calibration types. Each calibration type may include one calibration only or several standards.

5.1   S11A, S11B, S11C (S22A, S22B, S22C)

S11A, S11B and S11C standard types are used for reflection calibration of port 1, while S22A, S22B and S22C are used for the reflection calibration of port 2. Besides, they are used for full dual-port calibration and used to determine directional, source matching and reflection Tracing errors. Standards distributed in S11A, S22A are open-circuit devices, standards distributed in S11B, S22B are short-circuit devices, standards distributed in S11C, S22C are load.

5.2   TRANS and MATCH (FWD and REV)

The four types are applicable for implementing full dual-port SOLT standards: standards of TRANS type are used to determine transmission Tracing errors and standards of MATCH type are used to determine the load matching errors. Typical standards included in the four types are through pieces or delay lines.

5.3   ISOLATION

Standards of ISOLATION type are adapted for implementing SOLT calibration and TRL calibration, to determine the forward and backward crosstalk error in error modification model. The distributed calibration standards are loads.

5.4   TRL through

Standards of TRL through type are applicable for implementing full dual-port TRL calibration. This type includes a through standard or a short transmission line. If through piece of non-zero length is included, corresponding calibrations are called LRL calibration and LRM calibration.

5.5   TRL reflection

Standards of TRL reflection type are applicable for implementing full dual-port TRL calibration. This type is supposed to include a high-reflection coefficient standard, and is open-circuit device or short-circuit device usually. In calibration, it is not required to know the given actual magnitude value

of standard reflection coefficient, but the phase angle must be determined. In the process of TRL calibration, both ports should use identical reflection standards.

5.6   TRL transmission line/matching

Standards of TRL transmission line/matching type are used to implement full-dual port TRL standards, and it is supposed to include a transmission line standard or a load standard or both. If transmission line standard is used, it must have its phase shift different from through standard by $20^{o}\sim160^{o}$, thus available frequency scope can be limited as 8:1, e.g., 2~18GHz. A wider frequency scope can be covered with several transmission lines of different lengths and usually a load is used to cover the lower end of the frequency, because the transmission line is too long to be used in this frequency scope. When using a load, the corresponding calibration types are TRM or LRM.

Section 8   TRL Calibration

TRL (Thru-Reflect-Line) calibration includes a series of calibration technologies, such as TRM(Thru-Reflect-Match). TRL calibration determines 12 error coefficients by measuring two transmission standards and a reflection standard, while conventional SOLT calibration determines the 12 error coefficients by measuring a transmission standard (T) and three reflection standards (SOL).

1   Why making TRL calibration?

TRL calibration is quite accurate and is more accurate than SOLT calibration in some situations, but calibration kits available for TRL are few. If high Measure precision is demanded and there is no calibration kit of the same type with measured piece connector, e.g., use fixture to make Measure or use probes to measure on the wafter, it is often required to make TRL calibration. Then it is necessary to build and define calibration kits which are the same with the measured piece medium, and it is easier to develop 3 TRL standards than develop 4 SOLT standards. TRL standard has an disadvantage that it is required to use several transmission line standards while make wideband calibration, e.g., the frequency range of 2GHz~26GHz requires two transmission line standards, and the transmission line standard is quite long in low frequency range.

2   TRL calibration standard

Three standards are required in TRL calibration kit: through standard, reflection standard and transmission line standard.

2.1   Through standard

Through standard can be zero length or non-zero length. The standard of zero length is more accurate because of no loss and characteristic impedance. Electrical delay of through standard must differ from the transmission line standard. It can be used to build the Measure reference plane in calibration if its phase and electrical length are defined accurately.

2.2   Reflection standard

Reflection standard can be any physical device with high reflection coefficient. Properties connected to the reflection standards of two measuring ports must be identical absolutely. In calibration, regardless of the magnitude reflected by standard piece, the phase must be given and the electrical length must be within 1/4 wavelength. It can be used to build Measure reference plane if the magnitude and phase of reflection standard is defined accurately.

2.3   Transmission line standard

Transmission line standard is used to develop Measure reference impedance after the calibration. TRL standard is inadequate in following aspects due to the limitations of transmission line standard:

- Transmission line standard must have the same impedance with through standard.

- Electrical length of transmission line standard can not be identical with that of through standard.

- Transmission line standard must have appropriate electrical length in the whole frequency scope. At each frequency point, the phase difference between transmission line standard and through standard must be more than 20° and less than 160°, thus the frequency scope that actual single transmission line can cover is 8:1. To cover wider frequency range, several transmission line standards are required.

- Transmission line standard is quite long at low frequency range. The optimized length of transmission line standard is 1/4 wavelength of frequency-span geometric average frequency (square root of start frequency $\times$ stop frequency).

2.4   Matching standard

Matching standard can be used to replace the transmission line when the required length or lost transmission line can not be produced.

- Matching standard is low reflection terminal connected to the port.

- While calculating the error coefficients of TRL calibration, take the matching standard as high-loss transmission line of indefinite length.

- Impedance of matching standard becomes reference impedance for measurement.

Chapter VIII   Data Analysis

This chapter intends to describe how to read Measure result and calculate and Analysis the result, including following contents:

- Marker
- Trace computation and statistics
- Limit test
- Bandwidth test
- Bandwidth searching
- Ripple test
- Fixture Simulator
- Parameter Transformation

Section 1   Marker

Marker can be used to read measured data, search measured values of specified types and change the settings of Analyzer. Each Trace can use 9 normal markers and 1 reference marker.

1   Create a marker

1.1   By mouse or touch screen -marker toolbar

   a)   Click **[Response]**, point to **[Toolbars]** on **[Display]** menu, click and check **[Markers]** on Toolbar submenu, then the Analyzer displays Marker toolbar.

   b)   Select the marker to be enabled in **[Mkr]** box of the toolbar.

   c)   Click and check **[ON]** check box.

   d)   Set activation values of the marker in **[Stimu]** box.
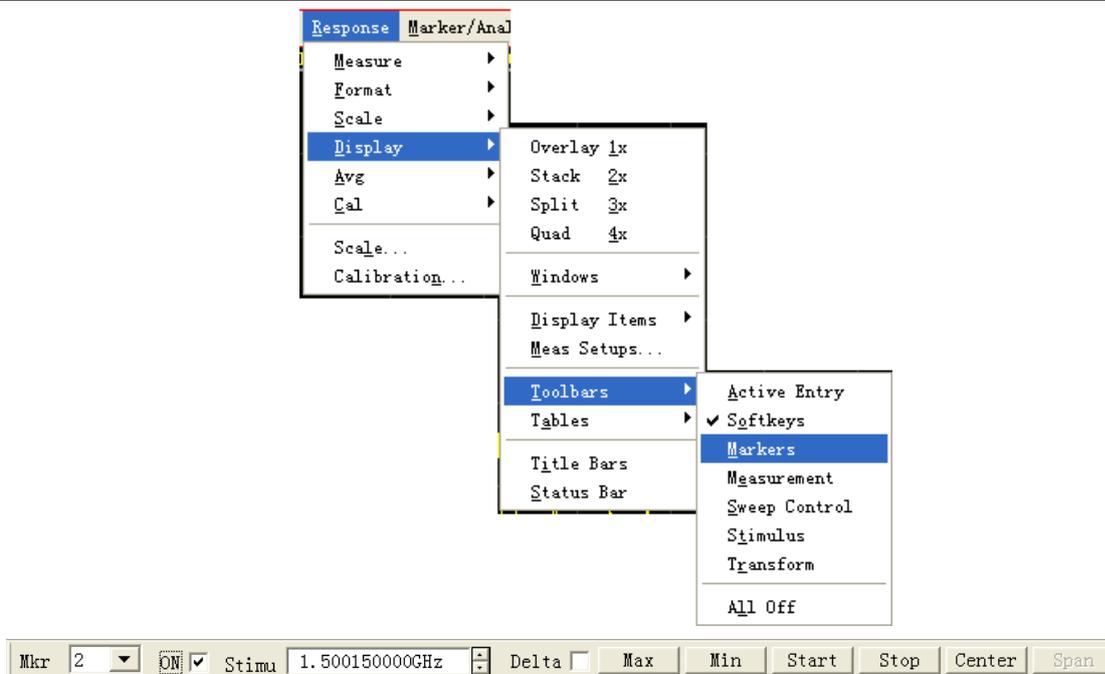
Fig. 8.1   Using Marker Toolbar to Create the Marker

1.2   By mouse or touch screen - marker dialog box

   a)   Click **[Marker/Analysis]**, click **[Marker…]** on **[Marker]** menu, display Marker dialog box.

   b)   Select the marker to be enabled in **[Marker]** box.

   c)   Click and check **[on]** check box.

   d)   Set activation values of the marker in **[Stimulate]** box.

   e)   Click **[OK]** button to close the dialog box.
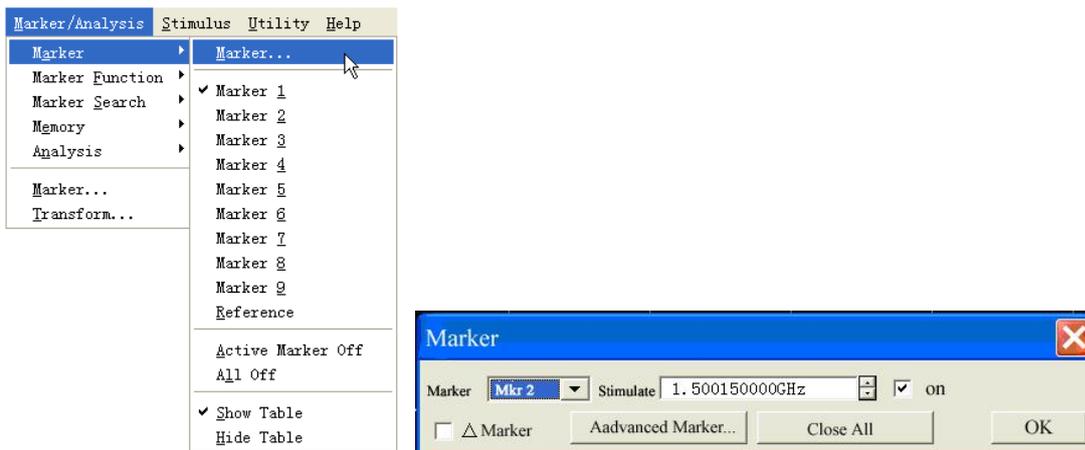
Fig. 8.2   Using Marker Dialog Box to Create the Marker

1.3   By mouse or touch screen -marker menu

   a)   Click **[Marker/Analysis]**, point to **[Marker]** on Marker/Analysis menu, display Marker

submenu.

b)   Click and select the marker to be enabled on submenu.
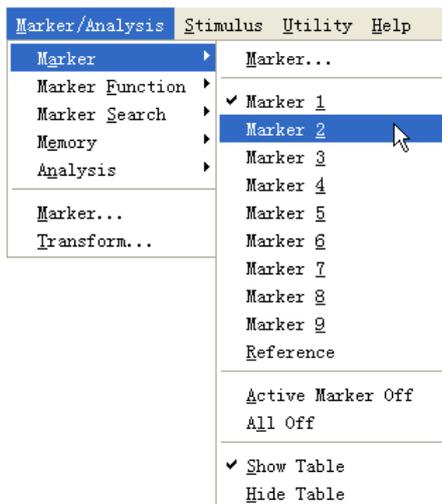
Fig. 8.3   Using Marker Menu to Create Marker

1.4   By front panel keys

a)   Press 【**Marker**】 key at MKR/ANALYSIS area, display the marker to be enabled in appropriate soft-key menu toolbar.

b)   Press the soft-key corresponding to the marker to be enabled to enable the marker.

c)   Set marker activation values in **Marker** box of the toolbar.

1.5   Marker dialog box

[Marker]

Used to select the marker to be defined.

[Stimulate]

Set and select the activation values of marker axle X.

[on]

Check it to enable the marker in [Marker] box, clear and close the marker in [Marker] box.

[∆ Marker]

When checking it, the Analyzer displays the relative values between selected marker and marker R.

If marker R is not enabled, it will be enabled automatically.

[Advanced Marker]

Click it and display [Marker Advanced Options] dialog box.

[Close All]

Click it and close all enabled marker.

2   Moving the marker

a)   Select the marker to be moved by one of the methods mentioned above to make it be the current Stimulus marker.

b)   Use appropriate methods to move the marker

    1)   Click **[Stimu]** box in Marker toolbar, and move the marker by following methods:

- Directly input marker activation values.

- Revolve the knob to move the marker.

- Click UpDown on **[Stimu]** box to move the marker.

- Press 【△】 or 【▽】 in ADJUST area to move the marker.

    2)   Click **[Stimulate]** box in Marker dialog box, and move the marker by following methods:

- Directly input marker activation values.

- Revolve the knob to move the marker.

- Click UpDown on **[Stimulate]** box to move the marker.

- Press 【△】 or 【▽】 in ADJUST area to move the marker.

    3)   Move the marker by following methods in the **Marker** box of Marker corresponding to the soft-key toolbar.

- Directly input activation values.

- Revolve the knob to move the marker.

- Click UpDown on **Marker** box to move the marker.

- Press 【△】 or 【▽】 in ADJUST area to move the marker.

For above described methods of moving the marker, the marker can only be moved after it is activated. Besides, 3656 Series Vector Network Analyzer supports moving the marker by dragging the mouse directly, and the method is:

Point the mouse to indicator "∇" (activated marker) or "Δ" (unactivated marker) of the marker to be moved, press left mouse button, then after the mouse pointer becomes horizontal Adjust indicator "↔", drag the mouse to the position where the marker is required to be moved, release the left mouse button and complete moving the marker.

3   Marker Search

Marker search function can be used to search special measured value. Without matching measured data, marker will retain unchanged in the current position.

3.1   By mouse or touch screen

a)   Click **[Marker/Analysis]**, click **[Marker Search…]** on **[Marker Search]** menu, and then Marker Search dialog box will be displayed.

b)   Select the marker used for searching measured value in the **[Marker]** box.

c)   Set up search type and search domain in the dialog box, and click **[Execute]** button to search measured value.

d)   Click **[OK]** button to close the dialog box.
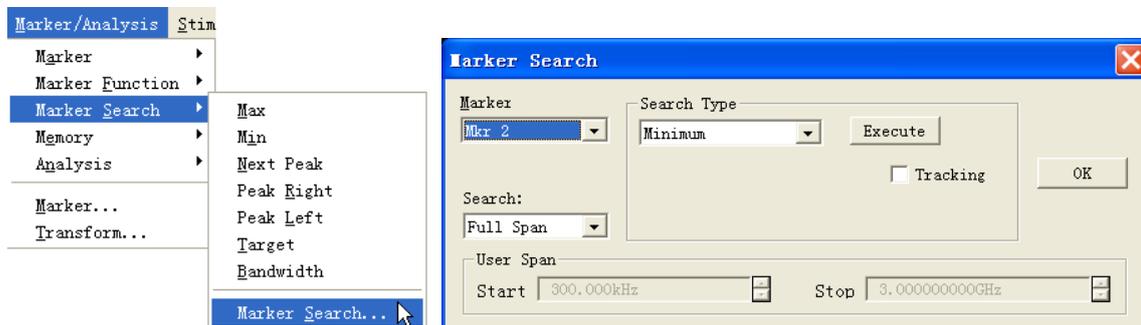
Fig. 8-4   Marker Search

3.2   By front panel keys

a)   Press **【Search】** key in MKR/ANALYSIS area.

b)   Press corresponding soft-key to select search function in soft-key search toolbar.

3.3   Marker Search dialog box

[Marker]

Select the marker which makes search definition and implements search function.

[Search]

It is used to define the search scope of marker; the default search scope is full bandwidth, and in addition, it supports 9 users' settings. When selecting the search scope of user settings, definition must be made for user settings in the scope of user domain. The search scopes of user settings can be mutually overlapped, and different markers can use the same search domain; the following Figure. shows a set of search scopes of user settings.
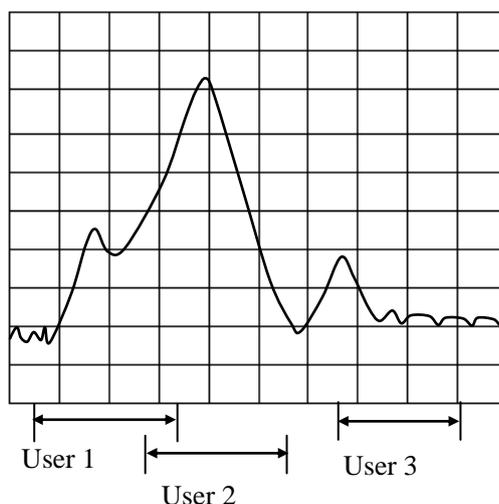

Fig. 8-5   Search Scope of User Settings

User Span

Define search scope of user settings through **[Start]** box and **[Stop]** box.

Search Type Zone

a)   [Type]

It is used to select search type of marker; the Analyzer supports the following 7 search types.

- **Minimum value:** to search the minimum measured data point.

- **Maximum value:** to search the maximum measured data point.

- **Right peak value:** to search the next effective peak value at the right side of marker.

- **Left peak value:** to search the next effective peak value at the left side of marker.

- **Next peak value:** to search the next peak value lower than current marker amplitude value.

When searching peak value, definition of peak must be made at first. Definition of peak is made through **[threshold]** and **[shift]** boxes. **[Threshold]** box defines the minimum peak point. The peak point of effective peak must be above threshold, and valleys at both sides can be lower than threshold. **[Bias]** box defines the minimum vertical distance between peak point and valley point, the vertical distance between the peak value of effective peak and valleys at both sides must be larger than offset value. The default threshold value is -100dB, and offset value is 3dB. Definition and settings of peak value for Analyzer are as below:

Threshold: -50dB

Bias: 10dB

Scale: 10dB/grid

In the following Figure., A is an effective peak, threshold and offset of which satisfy requirements; B is not an effective peak, without satisfactory offset; C is also not an effective peak, without satisfactory threshold.
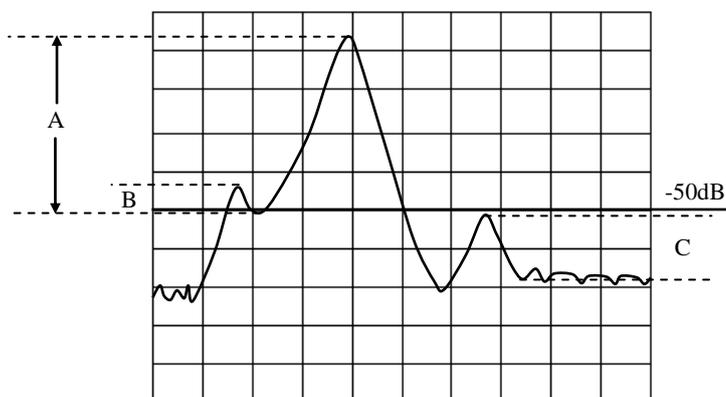

Fig. 8-6   Definition of Peak

- **Target**: input the target value to be searched in the **[Logarithm Value]** box, and click **[Execute]** value. When marker moves to the first target value at the right side of current marker position, continuously click **[Execute]** button to make marker move to the next target value at the right side until to the highest end of activation value, and then return to the lowest end of activation value to search target value.

    * When selecting **[Discrete Marker]** check box in the **[Marker Advanced Options]** dialog box, if a data point is respectively at both sides of interpolative target value, marker will move to the discrete data point mostly close to the target value.

    * When clearing **[Discrete Marker]** check box in the **[Marker Advanced Options]** dialog box, marker will move to the interpolative data point equal to target value.

- **Left target**: only searching the target value at the left side of current marker.

- **Right target**: only searching the target value at the right side of current marker.

- **Bandwidth**: when selecting bandwidth search function, set up level which **drops** from peak value at both sides in **[level]** box (defaulted as -3dB), click **[Execute]** button to make bandwidth Measure at this level. Use marker 1~4 during Measure, marker 1 searches the maximum peak value, marker 2 searches the point at the left side of peak value dropping to the specified level, marker 3 searches the point at the right side of peak value dropping to the specified level, and marker 4 searches the center point of bandwidth, and the following data will be shown after the completion of Measure:

Marker1:　　　　X-axis value and Y-axis values of peak point.

Bandwidth:　　　X-axis D-value of marker 2 and 3.

Center:　　　　X-axis center value between marker 2 and 3.

Q-value:　　　　Ratio of center frequency to bandwidth.

Loss: Y-axis value of marker 4, this is the loss value of filter center.

b) **[Execute]**

Click [Execute] button to carry out marker search with specified type once.

c) **[Tracking]**

When selecting **[Tracing]** check box, Analyzer shall implement search function after the completion of Sweep each time according to the current search type and settings of search domain, thus it can be ensured that marker is at the expected position after Sweep every time. If marker Tracing function is on, the activation value of search marker can be manually set up.

4　Marker Function

Status settings of Analyzer can be changed by Stimulus marker position, such as initial frequency and stop frequency.

4.1   Set up Measure by marker function

4.1.1   By mouse or touch screen -marker function dialog box

    a)   Click **[Marker/Analysis]**, and click **[Marker Function…]** on the **[Marker Function]** menu to display Marker Function dialog box.

    b)   Select the required Analyzer function settings in the dialog box.

    d)   Click **[OK]** button to close the dialog box after setting is complete.
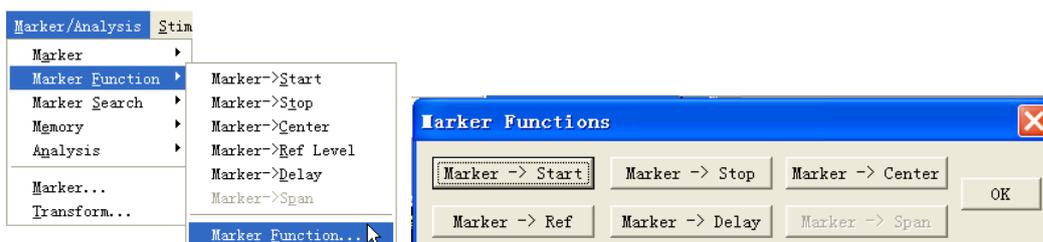
Fig. 8-7   Measure by Use of Marker Function Dialog box Settings

4.1.2   By mouse or touch screen -marker toolbar

    a)   Click **[Response]**, point to **[Toolbar]** of the **[Display]** submenu, click and select **[Marker]** on the Toolbar submenu to display Marker toolbar.

    b)   Select the required Analyzer function settings in the Marker toolbar.

4.1.3   By front panel keys

    a)   Press 【**Marker**】 key in MKR/ANALYSIS area.

    b)   Press corresponding soft-key of **[Marker Functions]**, and press corresponding soft-key to select Analyzer setting functions in the arisen marker function soft-key toolbar.

 NOTE: **Marker function soft-key toolbar provides 5 types of Analyzer setting functions: start, stop, center, reference and delay.**

4.1.4   Marker function dialog box

[Marker->Start]

    When clicking, start value of Sweep Setup is equal to the value for Stimulus marker.

[Marker->Stop]

    When clicking, stop value of Sweep Setup is equal to the value for Stimulus marker.

[Marker->Center]

    When clicking, center value of Sweep Setup is equal to the value for Stimulus marker.

[Marker->Ref Level]

When clicking, reference value settings are equal to response values for Stimulus marker.

[Marker->Delay]

When clicking **[Marker->Delay]** button, Analyzer will use phase slope to adjust Electrical delay of receiving path, thus the phase locus near the Stimulus marker can be flatten. This function can be used to make electrical length and phase offset Measure, and it is only applicable for ratio Measure.

[Marker->Span]

When clicking it, span value of Sweep Setup is equal to activation D-value between Stimulus marker and marker R (△ marker value), and this button is only valid when marker is Stimulus and △ marker function is on.

5   Advanced Marker Option Setting

5.1   By mouse or touch screen

a)   Click **[Marker/Analysis]**, and click **[Marker …]** on the **[Marker]** menu to display Marker dialog box.

b)   Click **[Advanced Marker…]** button to display Advanced Marker dialog box.

c)   Set up marker in the dialog box.

d)   Click **[OK]** button to close the dialog box.
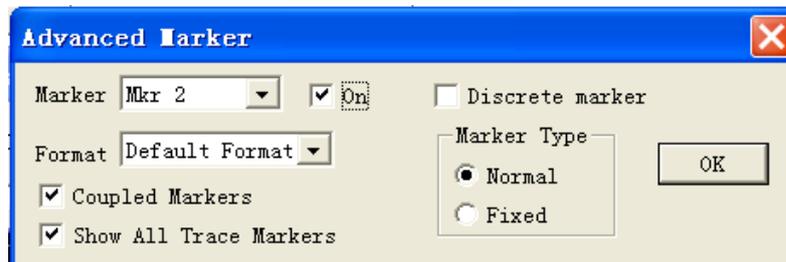
Fig. 8-8   Marker Advanced Options Dialog box

5.2   By front panel keys

a)   Press 【**Marker**】 key in MKR/ANALYSIS area, and press corresponding soft-key of **[Marker Properties]** on the arisen soft-key menu.

b)   Press corresponding soft-key of **[Advanced Marker]** to display Advanced Marker dialog box.

c)   Set up marker in the dialog box.

d)   Press 【**OK**】 button in the input keypad to close the dialog box after settings are completed.

5.3   Advanced Marker dialog box

[Marker]

Select the marker to be set up.

[On]

When it is selected, marker in [Marker] box will be displayed on screen, and corresponding marker display will be close if it is cleared.

[Discrete Marker]

When it is selected, marker only displays data at actual measuring point, and it also displays interpolative data point between measuring points when it is cleared.

[Format]

Select the format of marker to display measured data, the format of marker data can be different from that of screen Trace data, but they are same under the default condition.

[Coupled Marker]

When selecting and enabling marker coupling function, markers with the same number on different Traces and corresponding markers on Stimulus Traces have the same activation value settings. Change of Stimulus settings of Stimulus marker can also change Stimulus settings of markers with the same number on other Traces at the same time. If domains of X-axis are identical (for instance, the same as frequency domain or time domain), all markers of channels, Traces and windows are coupled, and the markers on Traces different from Stimulus Traces X-axis will not be coupled. When clearing the check box, only settings for Stimulus marker can be changed.

[Show All Trace Markers]

When selecting it, markers of all Traces will be displayed, and when clearing it, only markers of Stimulus Traces will be displayed.

Marker type zone

a) **[Normal]**

Standard marker has fixed X-axis position, Y-axis position will change with amplitude of Trace data, and marker can be shifted left and right on X-axis by changing activation value of marker.

b) **[Fixed]**

According to the position on Traces when it is set up as Fixed type marker, the marker will constantly keep fixed X-axis and Y-axis coordinates unchanged; it will not fluctuate with change of Trace data amplitude. Its position on X-axis can be shifted by changing its activation value, but coordinate on Y-axis can remain unchanged. This type of marker is mainly used to observe change of Trace marker, for example, the fixed type marker can be used to compare variance of insertion loss before and after tuning wave-filter.

6 Marker Table

Marker Table can be enabled to display all marker data of Stimulus Traces, and marker data will be displayed in specified format of each marker.

6.1 Settings of show table

6.1.1   By mouse or touch screen -marker menu

    a)   Click **[Marker/Analysis]**, point to **[Marker]** on Marker/Analysis menu.

    b)   Select **[Show Table]** on submenu to enable Show table.

    b)   Select **[Hide Table]** on submenu to close Show table.
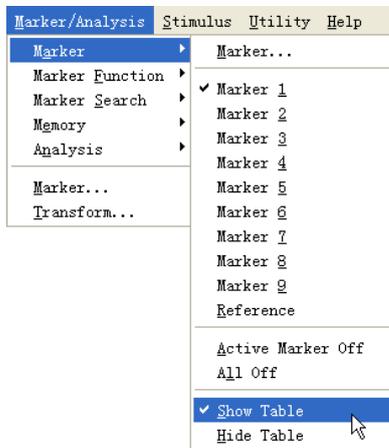
Fig. 8-9   Settings of Show table via Marker Menu

6.1.2   By mouse or touch screen -view menu

    a)   Click **[Response]**, point to **[Table]** on **[Display]** menu.

    b)   Select **[Marker Table]** on submenu of Table to enable Marker Table display.

    c)   Click clear and select **[Marker Table]** on submenu of Table to close Marker Table display.
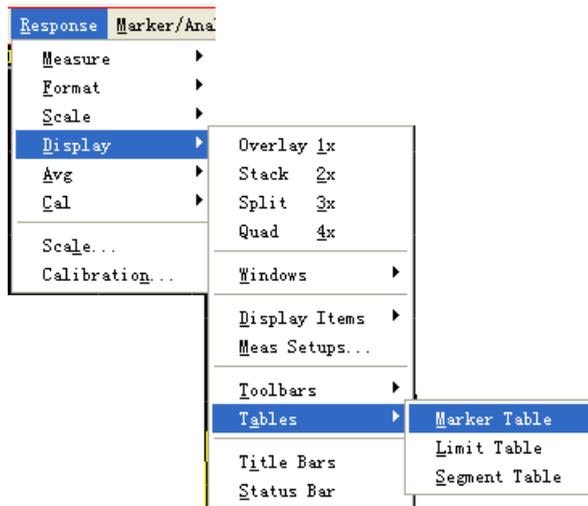
Fig. 8-10   Settings of Marker Table Display by View Menu

6.1.3   By front panel keys

    a)   Press 【**Display**】 key in RESPONSE area, and press **[More]** corresponding soft-key on arisen

soft-key menu.

b) Press corresponding soft-key of **[Tables]**, press corresponding soft-key of **[Marker Table]** on arisen soft-key menu to select and enable Marker Table display.

c) Press corresponding soft-key of **[Hide Table]** to select and close Marker Table display.

Section 2　Trace Computation and Statistics

Analyzer can carry out 4 types of mathematical operation to current Stimulus Trace and storage Trace; in addition, it also provides 3 kinds of Trace statistical functions.

1　Trace Computation

Before Execution of any type of Trace computation, a Trace must be saved in memory, and Trace computation is vector operation made on complex data before formatted display.

1.1　Settings of Trace computation

1.1.1　By mouse or touch screen

    a) Click **[Marker/Analysis]**, and click **[Math/Memory]** on **[Memory]** menu to display Math/Memory dialog box.

    b) Set up math and display of Trace in the dialog box.

    c) Click **[OK]** button to close the dialog box.
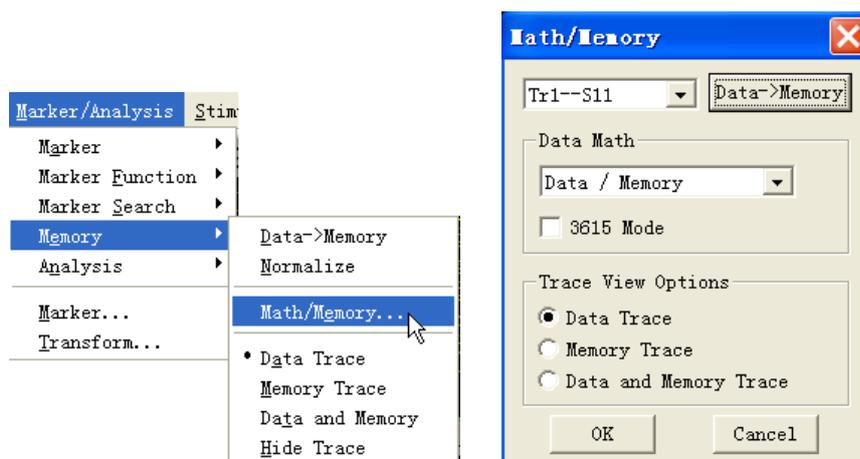
Fig. 8-11　Settings of Trace Computation

1.1.2　By front panel keys

    a) Press 【**Memory**】 key in MKR/ANALYSIS area.

    b) Press corresponding soft-key of **[Data->Memory]** to save current measured Trace data in memory.

    c) Press corresponding soft-key of **[Date Math Off]** to display various mathematical operation and set up computation of Trace according to corresponding soft-key.

    d) Press corresponding soft-key of **[Data Trace]** to display measured data.

    e) Press corresponding soft-key of **[Memory Trace]** to only display measured data.

    f) Press corresponding soft-key of **[Data and Memory]** to display measured data and stored data

at the same time.

1.1.3   Computation/ Storage dialog box

[Data->Memory]

When clicking it, current measured data will be saved in memory.

[Data Math]

It is used to select Trace computation type, and the Analyzer supports the following Trace computation:

- Data: it will not make any type of mathematical operation.

- Data + Memory: it will implement addition computation for measured data and stored data.

- Data – Memory: it implements subtraction operation for measured data and stored data, and this function can be used for simple error correction; firstly save vector error data in memory, and then subtract error data from measured data of the part.

- Data * Memory: it will implement multiplication operation for measured data and stored data.

- Data / Memory: it implements division operation for measured data and stored data, and this function is mainly used to make ratio Measure, such as gain and attenuation Measure.

Trace View Option Zone

a)   [Data Trace]

When it is selected, data after Trace computation will be only displayed.

b)   [Memory Trace]

When it is selected, stored Trace data will be only displayed.

c)   [Data and Memory Trace]

When selecting it, data Trace and storage Trace after Trace computation will be displayed at the same time.

2   Trace Statistics

The Analyzer provides statistics functions for average, standard deviation and peak-to-peak value Traces, which can be used to calculate full Stimulus bandwidth or statistical value within user definition scope. Each channel supports full bandwidth and statistical ranges of 9 user settings, these ranges are identical to search domain of user settings in marker search, they use the same memory address, therefore, they share the same Stimulus settings. If search domain of channel user settings is defined through marker search function, the same range settings can be called by selecting corresponding user settings in Trace statistics.

Trace statistical function can easily measure peak-peak value of pass-band ripple wave without searching maximum value and minimum value. Statistic of Trace is calculated according to data

display format:

- Rectangular Coordinates Format: statistic is calculated according to displayed scalar data.

- Polar Coordinates and Smith Chart Format: statistic is calculated according to display value of data in log-magnitude format.

2.1 Settings of Trace statistics

2.1.1 By mouse or touch screen

a) Click **[Marker/Analysis]**, and click **[Trace Statistics…]** on the **[Analysis]** menu to display Trace Statistics dialog box.

b) Click **[Statistics]** and select check box to enable Trace statistical function.

c) Click **[User Range]** box to select setting of Trace statistical range.

d) If select user settings range, click **[Start]** and **[Stop]** boxes in definition zone of user domain, and input definition of user settings range.

e) Click **[OK]** button to close the dialog box after settings are completed.
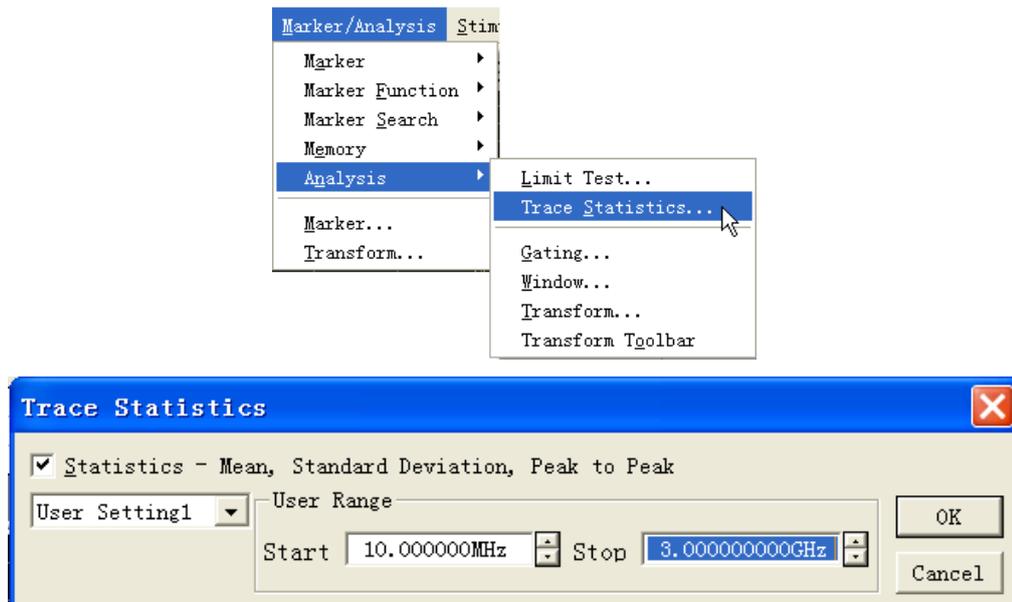
Fig. 8-12 Settings of Trace Statistics

2.1.2 By front panel keys

a) Press 【**Analysis**】 key in MKR/ANALYSIS area, and press corresponding soft-key of **[Statistics]** on arisen soft-key menu.

b) Press corresponding soft-key of **[Trace Statistics…]** to display Trace Statistics dialog box.

c) Press 【□】、【□】 keys in ADJUST area to shift to **[Statistics-Mean，Standard Deviation,Peak to Peak]** check box, press the knob key and select check box to enable Trace statistical function.

d)   Press 【□】、【□】 keys to shift to **[User Setting]** box, press 【△】 and 【▽】 keys in ADJUST area or rotate knob to select settings of Trace statistical range. If select user settings range, click 【□】、【□】 keys to shift to **[Start]** and **[Stop]** boxes in definition scope of **user Range** so as to input definition of user settings range.

e)   Press 【**OK**】 button in the input keypad to close the dialog box after settings are completed.

2.1.3   Trace statistical dialog box

[Statistics-Mean, Standard Deviation, Peak to Peak]

When it is selected, Trace statistical function will be on, and when it is cleared, Trace statistical function will be off.

[User Setting]

It is used to select range settings of Trace statistics, and full bandwidth or 9 user-defined settings can be selected.

Definition Zone of User Range

a)   **[Start]**

It is used to define starting value of user settings range.

b)   **[Stop]**

It is used to define ending value of user settings range.

Section 3   Limit Test

Limit test function can compare measured data with defined constraint (limit), and the user-defined limit will be displayed on screen in the form of limit line. There are the following advantages for using limit line.

- It provides the debugging personnel with an intuitive indication.
- It provides index properties of a device meeting required standard.
- It provides intuitive comparison between measured data of device and index requirements.

Limit test function can compare measured data with defined limits, and provide PASS and FAIL information; each Trace can support more than 100 separate limit line sections to make precise definition for limit.

1   Creating and Editing Limit Line

Analyzer can create limit lines for all measured Traces; a limit line is composed of multiple separate limit line sections, each line section is determined by 4 coordinates: start and stop activation values of X-axis and starting and ending response values of Y-axis, and limit line is created and edited by using limit table.

1.1   By mouse or touch screen

a) Click **[Marker/Analysis]**, and click **[Limit Test …]** on the **[Analysis]** menu to display Limit Test dialog box.

b) Click **[Show Table]** button in the dialog box to turn on limit table display.

c) Click **[OK]** button to close the dialog box.

d) Click **[Type]** box of limit table, and select limit test type in drop-down box.

e) Double-click **[Begin Stimulus]** box to set up start activation value.

f) Double-click **[End Stimulus]** box to set up stop activation value.

g) Double-click **[Begin Response]** box to set up initial response value.

h) Double-click **[End Response]** box to set up stop response value.

i) Click **[Limit Type]** box of limit table, and select limit line display type in drop-down box.

j) After opening limit line section of last row, Analyzer will automatically add a row under limit table, repeat steps d)~h) to complete edition and addition of all limit sections.
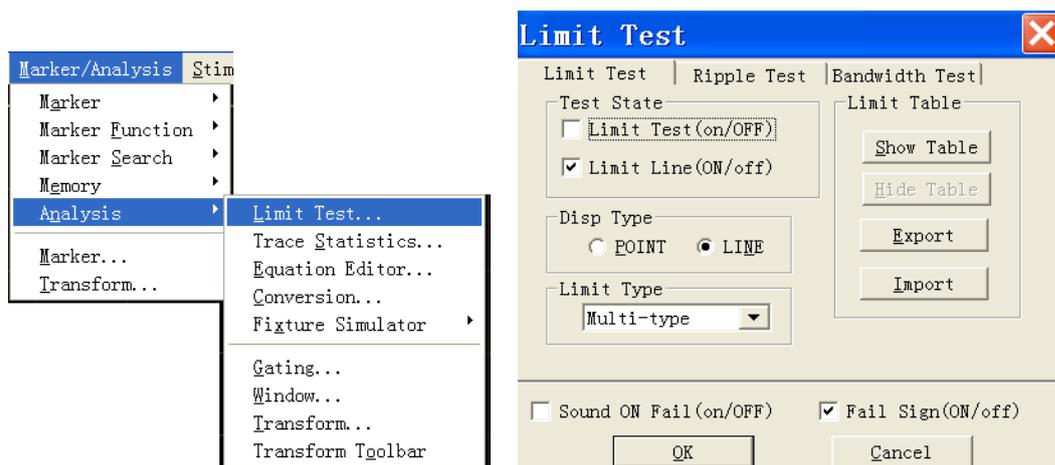
Fig. 8-13   Display Limit Table

1.2   By front panel keys

a)   Press 【**Analysis**】 key in MKR/ANALYSIS area, press corresponding soft-key of **[Limits]** on arisen soft-key menu, press corresponding soft-key of **[Edit Limit Table]**，and press corresponding soft-key of **[Limit Table on/Off]** to turn on Limit Table Display.

b)   Press 【□】、【□】keys in ADJUST area to shift to **[Type]** box of limit table, press the knob button in ADJUST area to open Type drop-down box, rotate knob or press 【△】 and 【▽】 keys in ADJUST area to select limit test type and pressthe knob key for confirmation of choice.

c)   Press 【□】、【□】keys to shift to **[Begin Stimulus]** box, and press the knob key to Stimulus start activation input box, and set up start activation value.

d)   Press【□】、【□】 keys to shift to **[End Stimulus]** box, and press the knob key to Stimulus stop activation input box, and set up start activation value.

e)   Press 【□】、【□】keys to shift to **[Begin Response]** box, and press the knob key to Stimulus start response input box, and set up start response value.

f)   Press 【□】、【□】keys to shift to **[End Response]** box, and press the knob key to Stimulus stop response input box, and set up stop response value.

g)   Press 【□】、【□】keys to shift to **[Limit Type]** box of limit table, and press the knob key to open the drop-down box of limit type, rotate the knob or press the【△】, 【▽】 keys in ADJUST area to select the limit line display type, and press **the knob** key to confirm the selection.

h)   After opening limit line sections of last row, Analyzer will automatically add a row under limit table, different row can be selected to edit by pressing【△】 and 【▽】keys. When active region is at the last row, a row will automatically add under limit table when pressing 【▽】.

i)   Repeat Steps b)~h) to complete addition and edition of all limit line sections.

1.3   Limit Table

	Type	Begin Stimulus	End Stimulus	Begin Response	End 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. 8-14   Limit Table

Type

Setting limit test types in type box:

MAX: When Trace is above limit line section, limit test fails.

MIN: When Trace is below limit line section, limit test fails.

OFF: Stop the limit section test

Begin Stimulus and End Stimulus

They are used to set up begin and end stimulus values of limit line section (X-axis start and stop coordinates of limit line section).

Begin Response and End Response

They are used to set up begin and end response values of limit line section (Y-axis start and stop coordinates of limit line section).

Limit Type

Setting the limit line display types:

・SLOP:display declined limit line

・FLAT:display horizontal limit line

・POINT:display punctual limit line

2   Setting Limit Test

After limit line is created, the limit line of some Trace can be chosen to display or hide. When the limit line is hidden, corresponding limit test is still effective. For limit test which can not be made for stored Traces, it can be chosen to send out alarming and display FAIL information to instruct limit test. When enabling limit test function, failed part of traces for limit test will be displayed as red, and passed parts of traces will remain unchanged. You can change the color of FAIL information through the color setup item in the right key menu of the mouse.

2.1   By mouse or touch screen

a)   Click **[Marker/Analysis]**, and click **[Limit Test …]** on [**Analysis**] menu to display Limit Test dialog box.

b)   Set up limit test in the dialog box.

c)   Click **[OK]** button to close the dialog box.

2.2   By front panel keys

a) Press 【**Analysis**】 key in MKR/ANALYSIS area, and press corresponding soft-key of [**Limit**] on arisen soft-key menu.

b) Press corresponding soft-key of [**Limit Test on/OFF**] to trigger enable and close of limit test function.

c) Press corresponding soft-key of [**Limit Line on/OFF**] to trigger display of limit line.

d) Press corresponding soft-key of [**Sound on Fail on/OFF**] to enable failure sound prompt.

e) Press corresponding soft-key of [**Fail Sign on/OFF**] to trigger display of FAIL Mark of limit test.

f) Press corresponding soft-key of [**Edit Limit Table**] , and press corresponding soft-key of [**Limit Table on/OFF**] on the sub-menu to trigger display of limit table.

Limit test is only made at actual Sweep measured point, when Sweep points are less, performance index of measured piece may not meet requirements, but it still can pass limit test, therefore during actual Measure, adequate canning points must be used to make limit test.

2.3   Limit Test dialog box

[**Limit Test(ON/off)**]

When it is selected, limit test function of Stimulus Trace will be enabled, when it is cleared, limit test function of Stimulus Trace will be closed.

[**Limit Line(ON/off)**]

When it is selected, limit line of Stimulus Trace will be displayed on screen, when it is cleared, display of limit line of Stimulus Trace will be closed, but it will not affect limit test function.

[**Sound on Fail**]

When it is selected, if Trace data point test is failed, buzzer will send out warning tone.

[**FAIL Mark(ON/off)**]

When it is selected, if Trace data point test is failed, the mark of fail will be displayed on the screen.

[**Dot**]

Use symbol "v" (Measure type as MAX) and "^"(Measure type as MIN)to indicate corresponding discrete limit value of measured data point during selecting.

[**Line**]

Use line to connect all discrete limit set point during selecting.

[**Show Table**]

When it is clicked, limit table will be showed for edition, and when the limit table is enabled, the button will change into forbidden status.

[**Hide Table**]

When it is clicked, limit table display will be closed, and if it is closed, the button will change into forbidden status.

[Export Table]

When it is clicked, storage dialog box will turn up, you can select storage route and store the file with *.csv format.

[Import Table]

When it is clicked, storage dialog box will turn up, select the storage route of the file to be opened and you can open file with *.csv format.

[Limit Test Type]

Single-click the drop-down box, you can select limit test type. There are totally four types: Multi-type limit line、Declined limit line、Punctual limit line and Horizontal limit line.

Section 4   Bandwidth Test

Bandwidth test function is mainly applied to test the bandwidth of band-pass filter.

Bandwidth test can find out signal peak value in the pass band and locate two points on specified amplitude on the two sides of the pass band. The amplitude is lower than the signal peak value and can be adjusted through setting N dB point (default value is 3 dB). The frequency range between the two points is the bandwidth of the filter under test.

Bandwidth test can set the minimum bandwidth and maximum bandwidth that the users allow before testing and the tested bandwidth will compare automatically with the two values. If the result is not satisfactory, the users will see the fail information on the screen or hear the sound hint, which are convenient for the the users to see if the characteristics of the device under test can meet the requirement.

1   Open and set bandwidth test

The bandwidth threshold(N dB point)、maximum bandwidth and minimum bandwidth must be set before making bandwidth test and multiple traces can be set.

1.1 By mouse or touch screen

a)   Click **[Marker/Analysis]**，and click **[Limit Test...] o**n **[Analysis]** menu to display Limit Test dialog box.。

b)   Click **[Bandwidth Test]** button in the dialog box to display bandwidth test dialog box.
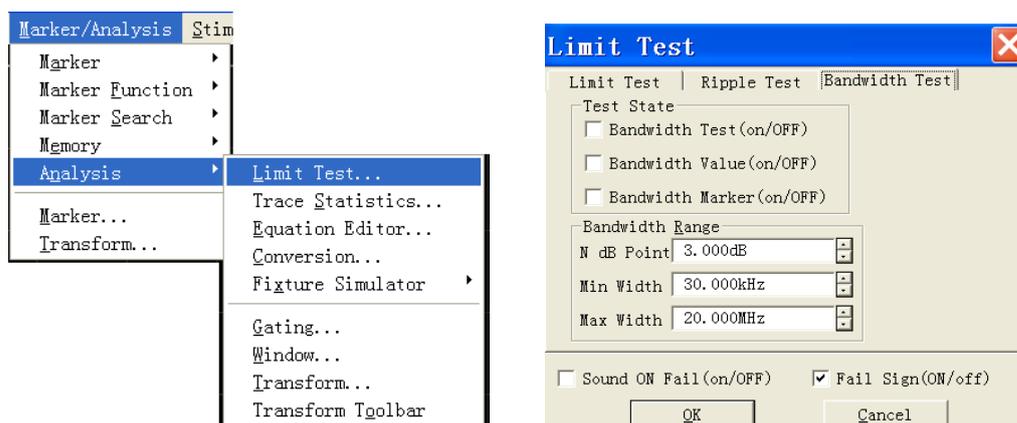
Fig. 8-15   Bandwidth Test Dialog Box

c)   Click **[Bandwidth Test(on/OFF)]** in the check box to enable the bandwidth test.

b)   Click **[Bandwidth Value(on/OFF)]** check box to display the tested bandwidth on the screen.

c)   Click **[Bandwidth Marker (on/OFF)]** check box to display the bandwidth locating mark on the screen.

d)   Click **[N dB Point]** box to set the threshold of bandwidth.

e) Click **[MIN width]** box to set Minimum bandwidth.

f) Click **[MAX width]** box to set Maximum bandwidth.

g) Click **[Sound On Fail(on/OFF)]** check box to make sound alarm when the bandwidth test fails.

h) Click **[Fail Sign(on/OFF)]** check box to display FAIL when bandwidth test fails.

i) Click **[OK]** to finish the setup of bandwidth test.

1.2 By front panel keys

a) Press 【**Analysis**】 key in MKR/ANALYSIS area，and press corresponding soft-key of **[Bandwidth Test]** on the soft-key menu that turns up.

b) Press corresponding soft-key of **[BW Test on|OFF]** to enable bandwidth test.

c) Press corresponding soft-key of **[BW Display on| OFF]** to enable bandwidth display function.

d) Press corresponding soft-key of **[BW Marker on|OFF]** to enable bandwidth locating marker.

e) Press corresponding soft-key of **[Fail Sign on|OFF]** to enable the display of fail mark of bandwidth test.

f) Press corresponding soft-key of **[N dB Points]**, and set bandwidth threshold in the input box.

g) Press corresponding soft-key of **[Min BW]** and set minimum bandwidth in the input box.

h) Press corresponding soft-key of **[Max BW]** and set maximum bandwidth in the input box.

2   Display bandwidth test result

The result of bandwidth test is displayed on the upper left side of the trace, if the test is passed, the word " PASS"will turn up on the screen. The red T shaped bandwidth mark distribute on the two sides of bandwidth.
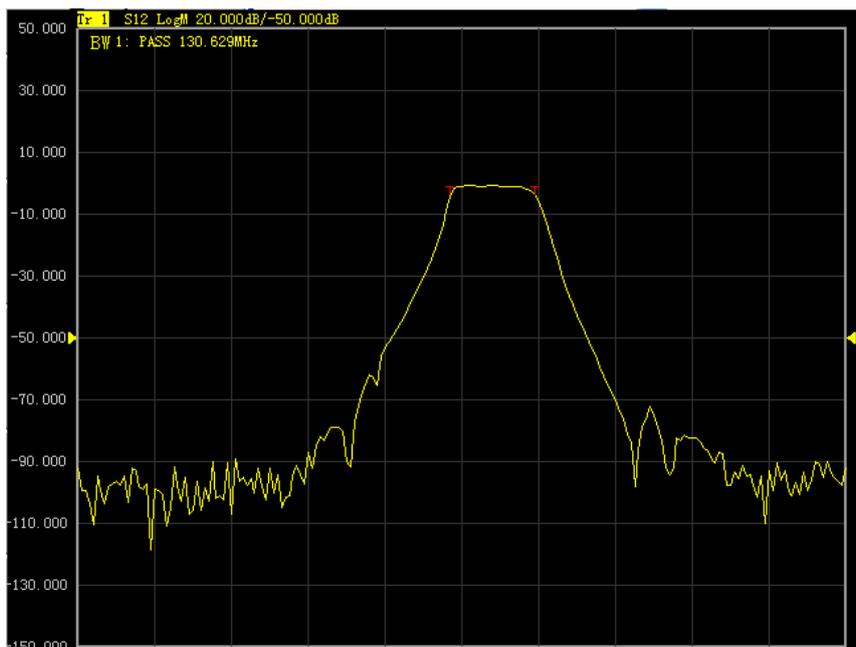

Fig.8-16 Bandwidth Test Result Display

3   Close bandwidth test

3.1 By mouse or touch screen

a)   Click **[Marker/Analysis]** and click **[Limit Test...]** on the menu of **[Analysis]** to display limit test
dialog box.

b)   Click **[Bandwidth Test]** button in the dialog box to display the bandwidth test dialog box.

c)   Click **[Bandwidth Test(on/OFF)]** check box to close bandwidth test.

d)   Click **[Bandwidth Value(on/OFF)]** check box to close the display of bandwidth test.

e)   Click **[Bandwidth Marker (on/OFF)]** check box to close the display of bandwidth locating
marker.

f)   Click **[OK]** to close bandwidth test.

3.2 By front panel keys

a)   Press【**Analysis**】key in MKR/ANALYSIS area and press corresponding soft-key of **[Bandwidth
Test]**on the soft-key menu that turns up.

b)   Press corresponding soft-key of **[BW Test ON|off]** to close bandwidth test function.

c)   Press corresponding soft-key of **[BW Display ON|off]** to close the display of bandwidth .

d)   Press corresponding soft-key of **[BW Marker ON|of]** to close the locating marker of bandwidth.

e)   Press corresponding soft-key of **[Fail Sign ON|off]** to close the display of fail mark of bandwidth
test.

Section 5   Bandwidth Searching

Bandwidth searching is a function to confirm trace bandwidth、center frequency、cut-off point、Q value and insertion loss through searching signal peak value in the band.

Bandwidth searching function menu has newly increased the filter test function, which is used for the automatic test of filter. The tested parameters of filter is automatically displayed on the screen, this function simplifies the setup of filter test process and improves the test speed of filter.

1   Open and close bandwidth searching

Bandwidth searching can only be set through soft-key menu.

a)   Press【Search】key in MKR/ANALYSIS area, press corresponding soft-key of **[Bandwidth]** on the soft-key menu that turns up.

b)   Press corresponding soft-key of **[Bandwidth]** to enable bandwidth searching function.

c)   Press corresponding soft-key of **[Bandwidth Level]** and set bandwidth level in the input box which can change the bandwidth cut-off   frequency.

d)   Press corresponding soft-key of **[Tracking on|OFF]** to enable search and track function.

e)   Press corresponding soft-key of **[Bandwidth Off]** to close bandwidth searching function.

2   Display bandwidth searching result

The six parameters of bandwidth will be displayed on the upper right of the trace.
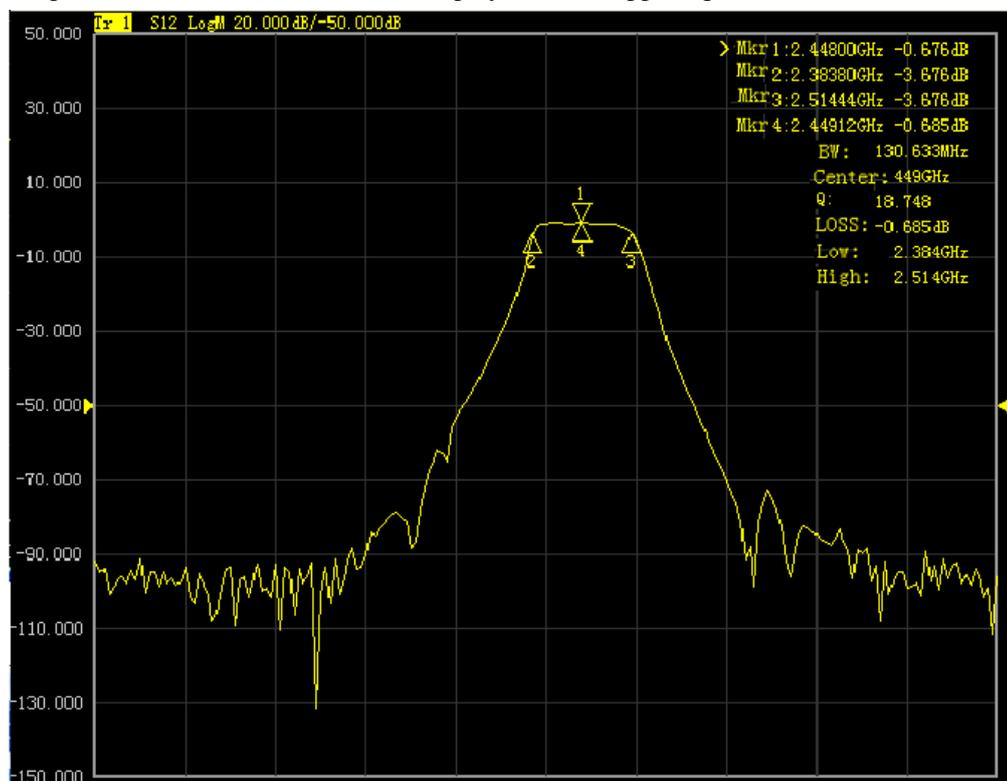

Fig. 8-17 Bandwidth Searching

2.1   Parameter definition

BW

Frequency difference between right and left cut-off frequency point.

Center

The middle frequency between right and left cut-off frequency point.

Q

The value of dividing bandwidth with central frequency.

LOSS

The tested value of bandwidth central frequency point.

Low

The lower frequency of the two points which are lower than the signal peak value on specific bandwidth level.

High

The higher frequency of the two points which are lower than the signal peak value on specific bandwidth level .

3   Filter test

The analyzer is installed with a shortcut function for the test of filter. All the tested parameters will be displayed on the screen and it is very convenient for users to see the test results. The filter test function decreases the manual setup during the test process and improves the test speed greatly.

3.1 Open and close filter test

The filter test function can only be set through soft-key menu.

a)   Press【**Search**】key in MKR/ANALYSIS area, and press corresponding soft-key of **[Bandwidth]** on the soft-key menu that turns up.

b)   Press corresponding soft-key of **[Tracking on|OFF]** to enable track function.

c)   Press corresponding soft-key of **[Filter Test]** and press corresponding soft-key of **[Filter Test on|OFF]** to enable filter test function.

d)   Press corresponding soft-key of **[BW1 Level]** and set the level value of bandwidth1 in the input box.

e)   Press corresponding soft-key of **[BW2 on|OFF]** to enable bandwidth2 function.

f)   Press corresponding soft-key of **[BW2 Level]** and set the level value of bandwidth2 in the input box.

g)   Press corresponding soft-key of **[Freq Offset]** and set the value of frequeny difference percentage in the input box.

h)　Press corresponding soft-key of **[Filter Test <u>ON</u>|off]** to close filter test function.

3.2 Display bandwidth searching result

The eight parameters of filter test will be displayed on the upper left side of the trace. Enabling the **filter test** , the bandwith searching function will be activated automatically and the six parameters of bandwidth test will be displayed on the upper right side of the trace.
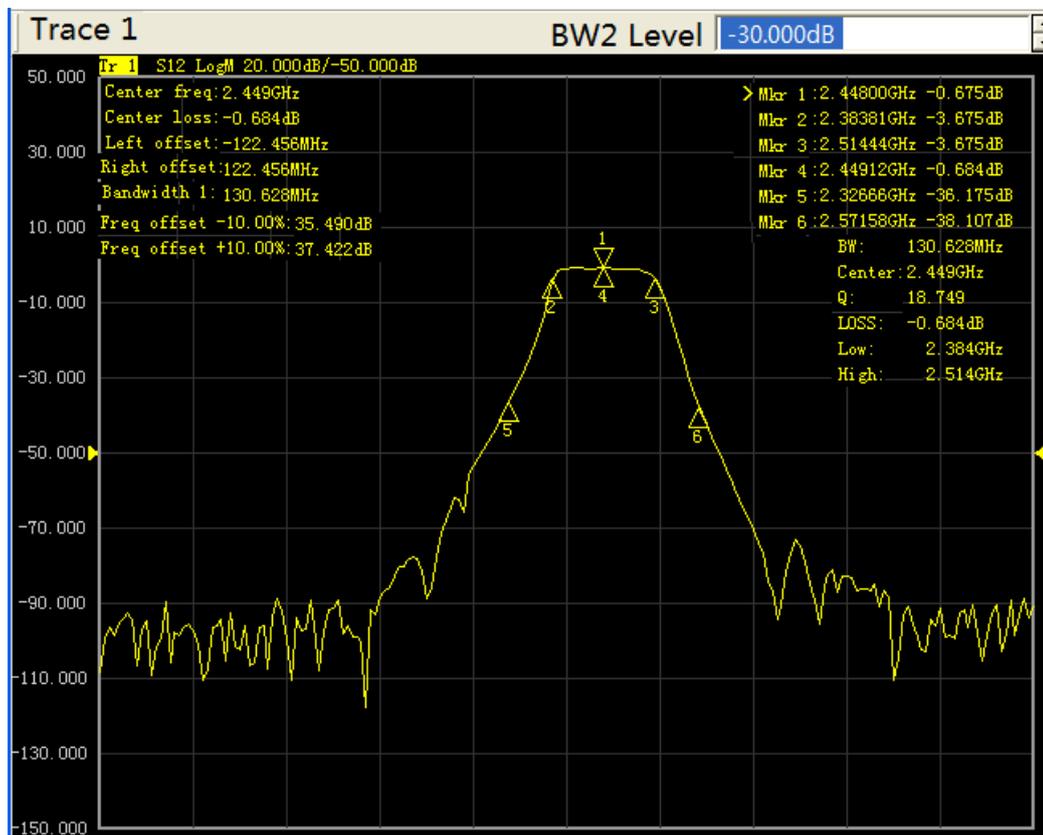

Fig. 8-18　Filter Test

Section 6　Ripple Test

Ripple test can assess the test results through setting up fluctuation limit. It compares the test data with the defined fluctuation limit, provides PASS and FAIL information and the test result will be displayed directly on the screen. Each trace supports 12 separated limit segments at best. Each limit segment can be set with start stimulus, stop stimulus and maximum fluctuation value. The stimulus setup of different segments can overlap.

1　Create and edit ripple limit line

It can make multiple ripple limit test at one time and you only need to set the ripple limit after activating the trace.

1.1　By mouse or touch screen

a) Click **[Marker/Analysis]** and click **[Limit Test...]** of the **[Analysis]**to display limit test dialog box.

b) Click **[Ripple Test]** button in the dialog box to display the ripple test box.
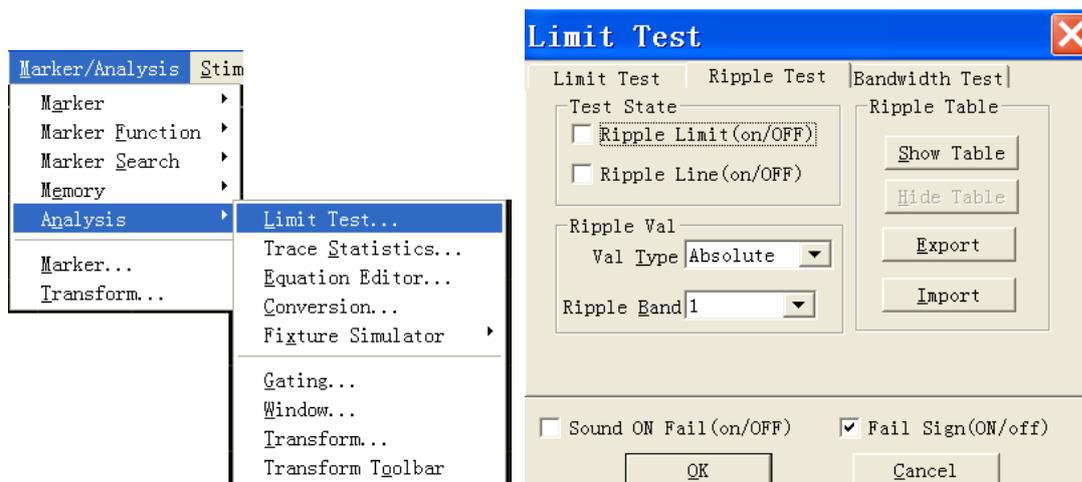
Fig. 8-19 Display Ripple Test Box

c)　Click **[Show Table]** button in the dialog box to enable ripple limit table.

d)　Click **[Type]** box in the ripple limit table, and select "**ON"** to activate the table.

e)　Double click **[Begin Stimulus]** box to set the initial stimulus value.

f)　Double click **[End Stimulus]** box to set the stop stimulus value.

g)　Double click **[MAX Ripple]** box to set maximum fluctuation value.

h)　The analyzer will add a new row to the limit table after opening the last row.

Repeat step d)~g)to completer the editing and adding of all limit segments.

1.2　By front panel keys

a) Press 【**Analysis**】key in MKR/ANALYSIS area，press corresponding soft-key of **[Ripple Test]** on the soft-key menu that turns up, press **[Edit Ripple Limit]** and press **[Ripple Table on|OFF]** on the sub-menu to open the ripple limit table.

b) Press 【□﹚、【□ **keys** in ADJUST area to **[Type]** box of ripple limit table，press **the knob** key in ADJUST area to open type drop-down box, rotate the knob or 【△】、【▽】 keys in ADJUST area to select, and press**the knob** key to confirm the selection.

c) Press 【□﹚、【□ **keys** to **[Begin Stimulus]** box，press **the knob** key to enable the start stimulus input box to set the initial stimulus value.

d) Press 【□﹚、【□**keys** to **[End Stimulus]** box，press **the knob** key to enable the stop stimulus input box to set the stop stimulus value.

e) Press 【□﹚、【□ **keys** to **[MAX Ripple]** box，press **the knob** key to enable maximum fluctuation input box to set maximum fluctuation value.

f) The analyzer will add a new row to the limit table after opening the last row. Press 【△】,【▽】 keys to select different rows of the limit table to edit, when the active area is in the last row, press 【▽】 key to add a new row to the limit table.

g) Repeat step b)~f)to complete the adding and editing of all the limit segments.

1.3   Ripple limit table

	Type	Begin Stimulus	End Stimulus	Max Ripple
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. 8-20   Ripple Limit Tabble

Type

The type box is used to set the type of limit test:

·ON:to activate the limit segment test.

·OFF:to close the limit segment test.

Begin stimulus and End stimulus

To set the start stimulus value and stop stimulus value of ripple limit line segment.

Max Ripple

To set the maximum fluctuation value the limit line can display in the ripple segment test.

2   Set ripple test

After the creation of ripple limit line, you can choose to display or hide the ripple limit line of any trace. When the limit line is hidden, the corresponding ripple test is still effective. You can choose to send out

alarm sound and display FAIL mark to indicate the test. When the ripple test function is enabled, the default color of the failed trace is set to red and you can change the color through the color setup of the right key menu of the mouse and the color of the passed part of the limit test remains unchanged.

2.1   By mouse or touch screen

a)Click **[Marker/Analysis]**,click **[Limit Test...]** in the **[Analysis]** menu to display the limit test box.

b)Set the limit test in the dialog box.

c) Click **[OK]** button to close the box.

2.2   By front panel keys

a) Press 【**Analysis**】 key in MKR/ANALYSIS area and press corresponding soft-key of **[Ripple Test]** on the soft-key menu that turns up.

b) Press corresponding soft-key of **[Ripple Test on|OFF]** to trigger the opening and closing of limit test function.

c) Press corresponding soft-key of **[Ripple Show on|OFF]** to display the ripple limit line.

d) Press corresponding soft-key of **[Fail Sign on|OFF]** to enable the FAIL mark display of the limit test.

e) Press corresponding soft-key of **[Edit Ripple Limit]** and press corresponding soft-key of **[Ripple Table on|OFF]** in the sub-menu that turns up to enable the display of limit table.

The ripple test is only made at actual sweeping test points. When there is a few sweeping points, the performance of the device under test may not meet the requirement but it can also pass the ripple test. So, in the actual test, you must use enough sweeping points.

2.3   Ripple test dialog box

Ripple Limit (on/OFF)

To enable the ripple test function if checked, to disable the ripple test function if unchecked.

Ripple Line (on/OFF)

To display the fluctuation line of the activated trace if checked, to close the display if unchecked,but it does not influence the ripple test function.

Sound ON Fail (on/OFF)

If checked, the buzzer will send out alarm sound when the data point test on the trace fails.

Fail Sign (on/OFF)

If checked, the FAIL mark will be displayed on the screen when the data point test on the trace fails.

Show Table

Click it to display and edit the ripple limit table. It will be shifted to disabled state after the table is opened.

Hide Table

Click it to close the display of ripple limit table.It will be shifted to disabled state after the table is closed.

Export

Click it, storage dialog box will appear. Users could select storage route and save the file with *.csv format.

Import

Click it, storage dialog box will appear. Select the storage route of the file to be opened. It can open the file of *.csv format.

Val Type

Click the drop-down box to select the ripple value type: none、absolute、margin.The default setup of the analyzer is absolute value.

Ripple Band

Click the drop-down box to select the number of fluctuation limit segments to be opened and it can open 12 segments at best.

3   Display ripple test result

If the result of ripple test passes, the word "PASS" will appear on the upper left side of the screen, otherwise, the word " FAIL" will appear on the screen. If multiple trace tests are made at the same time, the word " PASS" or " FAIL" for each trace will appear respectively at the same time. The stimulus ranges of different ripple limit segments can overlap with different fluctuation limits.
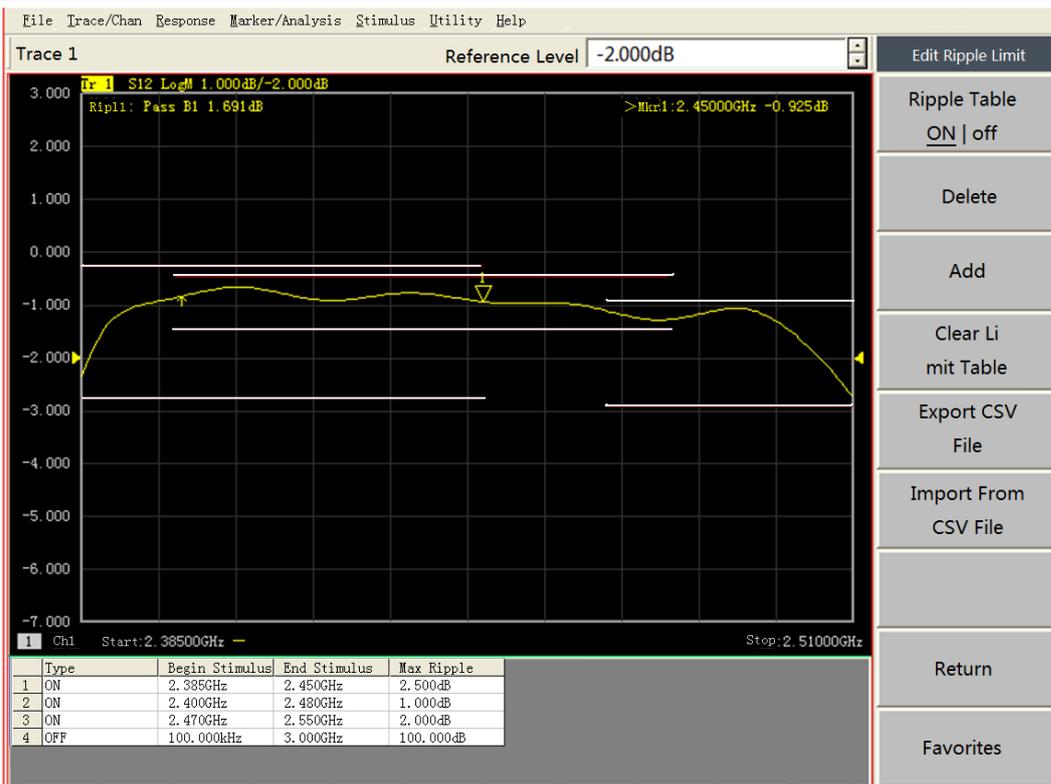
Fig. 8-21　　Ripple Test Result

Section 7   Fixture Simulator

Fixture simulator could simulate various test conditions which are based on the test results during the manufacturing. It will make quick and real-time simulation on the corresponding test result.

1   Reference impedance conversion of port

To converse the test result under 50Ω port impedance to the test results under any port reference impedance.

1.1   By mouse or touch screen

a)   Click **[Marker/Analysis]** menu,click **[Fixture Simulator]** on the menu of **[Analysis]** and click **[Fixture Simulator on/OFF]** on the sub-menu to open fixture simulator function.

b)   Click **[Marker/Analysis]** menu, click **[Fixture Simulator]** on the menu of   **[Analysis]** and click **[Z Conversion]** on the sub-menu to open impedance conversion dialog box.

c)   Click **[On/Off (Z)]** button to enable impedance conversion function.

d)   Enter corresponding values in the editing box of the real part and imaginary part of the port1 and port2.

e)   Click **[OK]** button to open the dialog box and save the input;click **[Cancel]** button to close the dialog box and cancel the saving of the input.
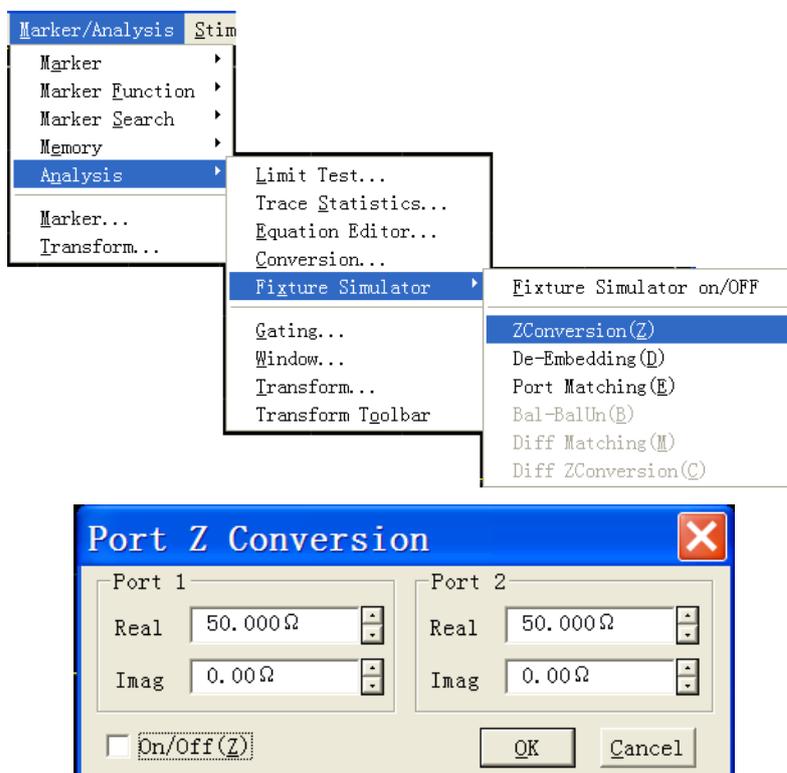

Fig. 8-22 Impedance Conversion Dialog Box

1.2   By front panel keys

a)   Press【**Analysis**】key in MKR/ANALYSIS area, and press corresponding soft-key of **[Fixuture Simu…]** on the soft-key menu that turns up.

b)   Press corresponding soft-key of **[Fixture Simu… on|OFF]** to trigger the opening and closing of fixture simulator function.

c)   Press corresponding soft-key of **[Port ZConver…]** and press corresponding soft-key of **[Z Conversion on|OFF]** on the sub-menu to enable the impedance conversion function.

d)   Press corresponding soft-key of **[Port1 Z0 Real], [Port1 Z0 Imag], [Port2 Z0 Real], [Port2 Z0 Imag]** , and enter corresponding value in the input box that turns up.

2   Network De-embedding

Network De-embedding function can eliminate any network characteristics defined by Touchstone data file(.snp) between test plane and DUT plane to extend corresponding calibration plane.

2.1 By mouse or touch screen

a)   Click **[Marker/Analysis]** menu, click **[Fixture Simulator]** on the menu of **[Analysis],** and click **[Fixture Simulator on/OFF]** on the sub-menu to enable the fixture simulator function.

b)   Click **[Marker/Analysis]** menu, click **[Fixture Simulator]** on the menu of **[Analysis],** and click **[De-embedding]** on the sub-menu that turns up to open the fixture de-embedding dialog box.

c)   Click **[ON/OFF]** button in the dialog box to enable the fixture de-embedding function.

d)   Click corresponding soft-key of **[Enable1], [Enable2]** button of port1 and port2 to activate the de-embedding function of corresponding port.
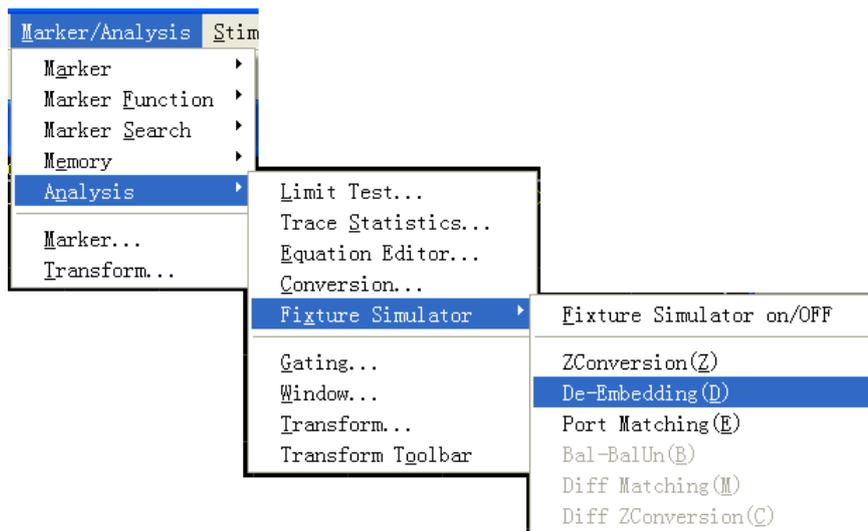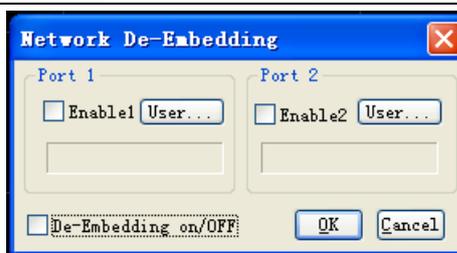
Fig. 8-23 Display Fixture De-embedding Dialog Box

e)   Click **[Import File]** button of corresponding port, select the S2P file to be used in the dialog box

that turns up and the file name will be displayed in the box at the lower part.

f)   Click **[OK]** button to close the dialog box, and save the input;click **[Cancel]** button to close the

dialog box,and cancel the saving of the input.

2.2   By front panel keys

a)   Press 【**Analysis**】 key in MKR/ANALYSIS area, and press corresponding soft-key of **[Fixture**

Simu…] on the soft-key menu that turns up.

b)   Press corresponding soft-key of **[Fixture Simu… on|OFF]** to open and close the fixture

simulator function.

c)   Press corresponding soft-key of **[De-Embedding]** and press corresponding soft-key of

[De-Embedding on|OFF] on the sub-menu of soft-key that turns up to enable the network

de-embedding function.

d)   Press the soft-key of **[Select   Port 1|2]**, to shift to corresponding port.

e)   Press the soft-key of **[Select Type User|None]**, to shift to corresponding type;User corresponds to

the enabling of corresponding port; None corresponds to the disabling of the corresponding port.

f)   Press the soft-key of **[User File…]** select the S2P file to be used in the dialog box that turns up

and the file name will be displayed under the soft-key.

	NOTE:	**If the imported port impedance from the S2P file is not identical to the system value, the system will automaticall converse the value to the S parameter under the system impedance; if the imported frequency range and frequency point number from the S2P file are not identical to the setup of system, the system will automatically make interpolating method to calculate according to the system setup of frequency range and frequency point number. The de-embedding will not be done on the part of frequency range which exceeds the range S2P file sets.**

---

3   Matching circuit embedding

It can add virtual matching circuit for every test port to simulate the whole test characteristics.

3.1   By mouse or touch screen

a)   Click**[Marker/Analysis]** menu, click **[Fixture Simulator]** on the menu of **[Analysis]** and click **[Fixture Simulator on/OFF]** on the sub-menu to enable the fixture simulator function.

b)   Click **[Marker/Analysis]** menu, click **[Fixture Simulator]** in the menu of **[Analysis]**, and click **[Port Matching]** on the sub-menu that turns up to open the matching circuit embedding dialog box.

c)   Click **[On/Off]** button in the dialog box to enable the matching circuit embedding function.
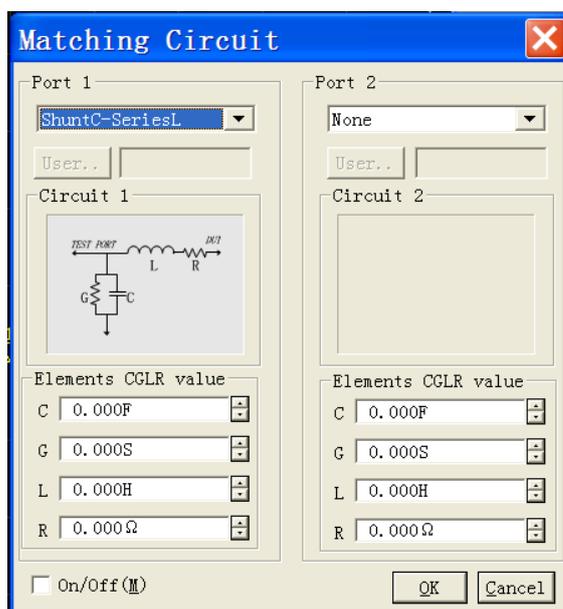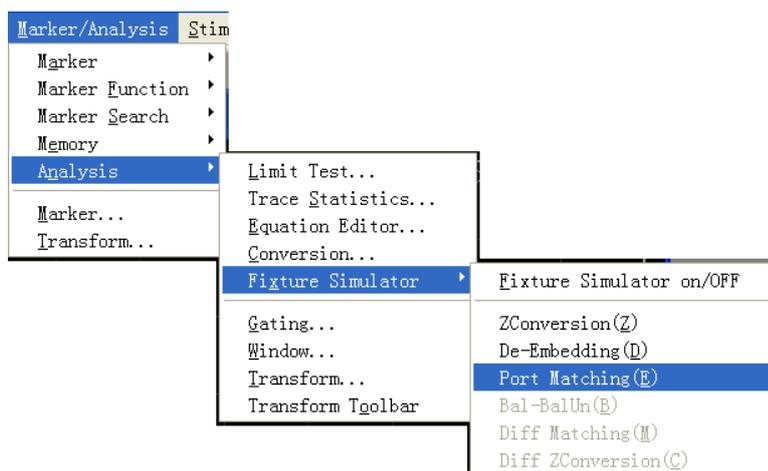
Fig. 8-24 Display Matching Circuit Embedding Dialog Box

d)   Choose proper circuit type in the drop-down box corresponding to port1 and port2, the circuit type will be displayed at the lower part. Enter the value of capacitance, conductance, inductance and resistance in corresponding editing box; when the circuit type is USER, the **[Self Define]** button will be in enabled state, click **[Self Define]** button, select the S2P file to be used in the dialog box that turns up and the file name will be displayed in the box aside.
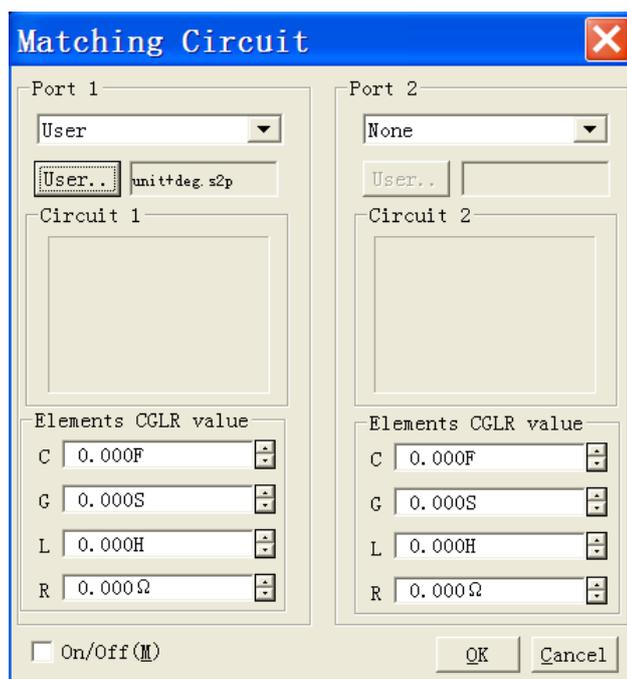
Fig. 8-25 Self Define Matching Circuit Embedding Dialog Box

3.2   By front panel keys

a)   Press【**Analysis**】key in MKR/ANALYSIS area, and press corresponding soft-key of **[Fixture Simu…]** on the soft-key menu that turns up.

b)   Press corresponding soft-key of **[Fixture Simu… on|OFF]** to trigger the opening and closing of fixture simulator function.

c)   Press corresponding soft-key of **[Port Matching]** and press corresponding soft-key of **[Port Matching on|OFF]** on the sub-menu that turns up to enable the matching circuit embedding function.

d)   Press corresponding soft-key of **[Select Port 1|2]** to shift to corresponding port.

e)   Press corresponding soft-key of **[Select Circuit]**, choose proper circuit type on the sub-menu that turns up. When the circuit type is "User", you can choose the S2P file to be used in the dialog box that turns up and press corresponding soft-key of **[Back].**

f)   Press corresponding soft-key of **[C(F)], [G(S)], [L(H)], [R(Ω)]**, and enter the value in corresponding editing box.

NOTE:	**If the imported port impedance from the S2P file is not identical to the system value, the system will automaticall converse the value to the S parameter under the system impedance; if the imported frequency range and frequency point number from the S2P file are not identical to the setup of system, the system will automatically make interpolating method to calculate according to the system setup of frequency range and frequency point number. The de-embedding will not be done on the part of frequency range**

which exceeds the range S2P file sets.

Section 8   Parameter Transformation

Parameter transformation function can transform the test result of S parameter into other parameters in real time.

1   Parameter transformation

1.1   By mouse or touch screen

a)   Click **[Marker/Analysis]** menu，and click **[Conversion]** on the menu of **[Analysis]** to open the dialog box of parameter transformation.

b)   Click the **[Enable]** check box in the dialog box to enable the parameter transform function.

c)   Click the parameter transformation type box in the dialog box and select the parameter type to be transformed on the drop-down menu.
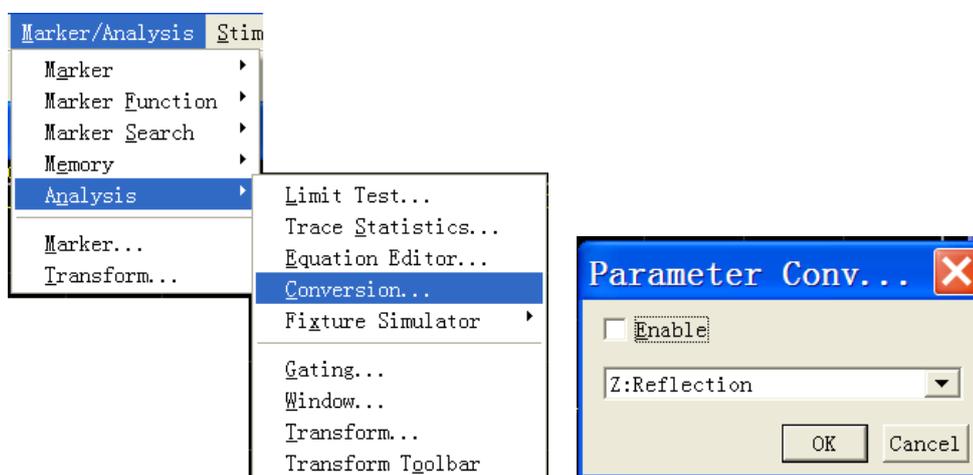

Fig. 8-26   Parameter Transformation Dialog Box

1.2   By front panel keys

a)   Press 【**Analysis**】 key in MKR/ANALYSIS area and press **[Conversion]** on the soft-key menu that turns up.

b)   Press **[Conversion on|OFF]** to trigger the opening and closing of parameter transformation function.

c)   Press **[Function]**, and select corresponding transformation type on the sub-menu of soft-key that turns up.

2   Function type of parameter transformation

Parameter transformation function is used to transform the test result of S parameter $（S_{xy}）$into the following parameters:

Impedance $（Z_r）$ and admittance $（Y_r）$ in reflection test

$$Z_r = Z_{0X} \times \frac{1 + S_{xy}}{1 - S_{xy}} , \quad Y_r = \frac{1}{Z_r}$$

Impedance(Z_t)and admittance(Y_t) in transmission test

$$Z_t = \frac{2 \times \sqrt{Z_{0X} \times Z_{0Y}}}{S_{xy}} - \left(Z_{0X} + Z_{0Y}\right), \quad Y_t = \frac{1}{Z_t}$$

Impedance(Z_{ts})and admittance (Y_{ts}) in the parallel transmission

$$Z_{ts} = \frac{S_{xy}}{2 \times \sqrt{\dfrac{1}{Z_{0X}} \times \dfrac{1}{Z_{0Y}}} - \left(\dfrac{1}{Z_{0X}} + \dfrac{1}{Z_{0Y}}\right) \times S_{xy}} , \quad Y_{ts} = \frac{1}{Z_{ts}}$$

Inverse: $1/S_{xy}$

Adjoint:It means to conjugate on complex S_{xy} ,in which, Z_{0X} and Z_{0Y} represent the characteristic

Impedance of port X and port Y respectively.

When the impedance conversion function in the fixture simulator is enabled, the characteristic impedance of corresponding port is the set value in the impedance conversion. Otherwise, use the system impedance Z_0 (default value is 50Ω).

Chapter IX   Data Output

The chapter introduces how to save and call back status settings and Measure results of the Analyzer, and it also introduces methods for printing out Measure results with a printer, including:

■   Saving and calling back files

■   Printing Measure display

Section 1   Saving and Calling back Files

Analyzer supports saving and call-back of files in multiple formats.

1   Saving File

1.1   By mouse or touch screen

Click **[File]**, click **[Save]** or **[Save As…]** on file menu.
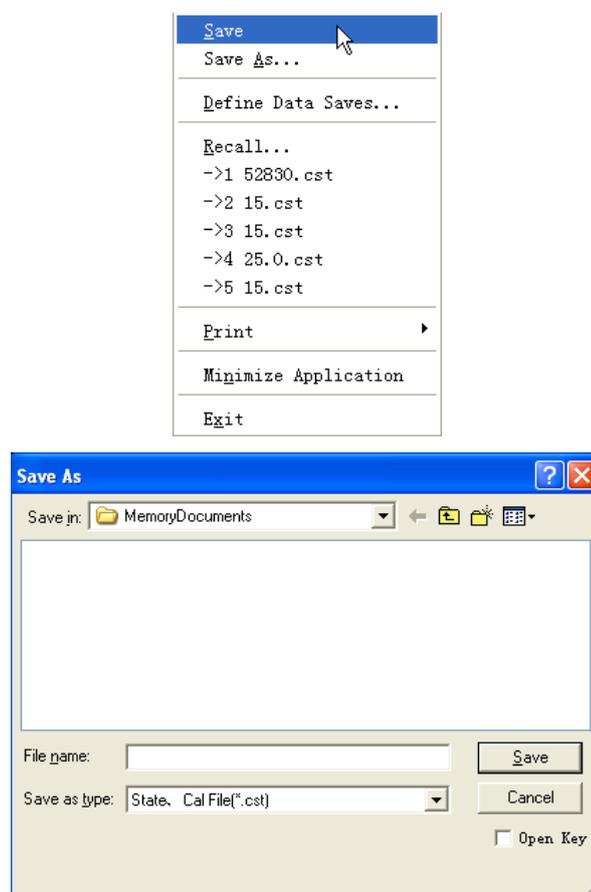
Fig. 9-1   Saving File

● When clicking **[Save]**, Analyzer will save instrument status and calibration data in default file of a specified directory, and if default file already exists, Analyzer will display a dialog box

for confirming whether it is covered.

- When click **[Save As…]**, Analyzer will open **[Save As]** dialog box for file save settings.

1.2 By front panel keys

a) Press 【**Save**】 key in UTILITYT area.

b) Press corresponding soft-key of **[Save default.cst]** to save instrument status and calibration data in default file (default.cst) of Analyzer, if default file already exists, a dialog box is displayed to ask if user would cover it.

c) Press corresponding soft-key of **[Save As]** to display Save As dialog box, and save file according to user setup.

1.3 Save As dialog box

[Save In:]

It is used to display and set up file storage path.

[File List]

It is used to display folder under current path and save all type matching files; if click a file among them, file name of save data can be setup, and if double-click folder, the current path can be modified.

[File Name]

It is used to set up saved file name, display input file name or clicked file name in [Listed File] box.

[Save as Type]

It is used to select file save type, and the Analyzer supports the following file types:

- cst file: to save Analyzer status and calibration data.
- sta file: only to save Analyzer status data.
- cal file: only to save calibration data of Analyzer.
- dat file: If user selects to save dat type file, when clicking [Save] button, Analyzer will open Data Save Setting dialog box, it will save Trace data as per user requirements.
- s1p and s2p files: If user selects to save s1p or s2p type files, when clicking [Save] button, Analyzer will open Designated Data Storage Format dialog box, and it will save Trace data as per user requirements.
- prn file: only to save current Stimulus Trace data.
- bmp file: to save screen display information of Analyzer in BMP format.
- jpg file: to save screen display information of Analyzer in jpeg format.

2 Calling back file

It can save Analyzer status and calibration data, if necessary it will be called-back in the future. Analyzer supports the following 3 types of files for call-back.

- sta file:status data of Analyzer is saved in sta files, including settings, Trace data, limit line and marker of Analyzer.

- cal file: calibration data is only saved in cal file, excluding status data of Analyzer. Correction precision of calibration data is relevant to status setting of Analyzer; therefore, in order to obtain the highest Measure precision, it shall be ensured that status settings of Analyzer during cal file call-back consistent with that during calibration, otherwise calibration precision can not be guaranteed.

- cst file: cst file saves all Measure status and calibration data of Analyzer, therefore calling cst file can save test time and improve Measure accuracy.

2.1 By mouse or touch screen

a) Click **[File]**, and click **[Recall]** on file menu to display Open dialog box.

b) Select call-back file type in **[Files of Type]** box.

c) Set up directory of call-back file through **[Look in:]** box and the following **[File name]** box.

d) Use the following methods to load call-back file.

- Double-click call-back file in **[File name]**.

- Click call-back file in **[File name]**, and click **[Open]** button.

- Input called-back file name in **[File name]** box, and click **[Open]** button.
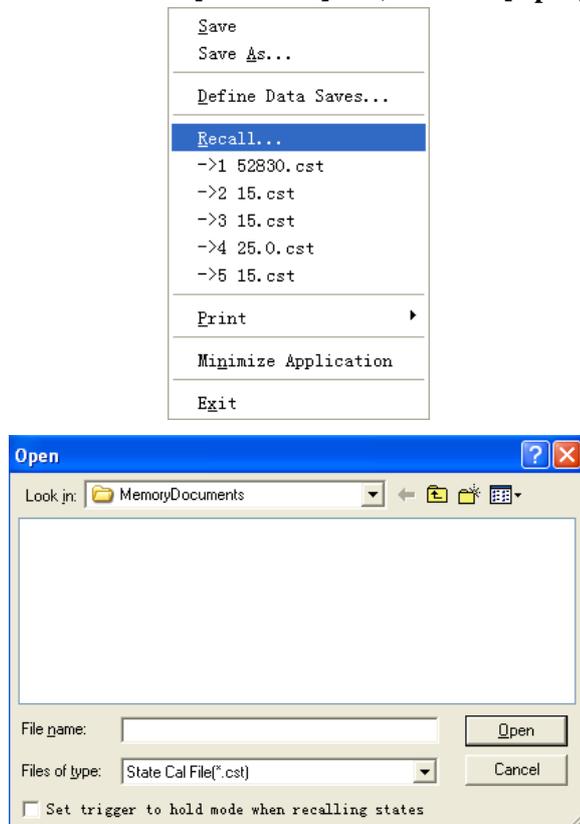
Fig. 9-2　Call-Back File

2.2   By front panel keys

    a)   Press 【**Recall**】 key in function keypad.

    b)   Press corresponding soft-key to load corresponding call-back file in a default directory.

    c)   If there is no required call-back file in call-back soft-key toolbar, press corresponding soft-key of 【**Recall…**】 to open dialog box, and select call-back file or change path and call files in other directories.

3   Data File

Data files save Measure results in ASCII format, these files can be edited by using test editing software and spreadsheet software, but can not be called back by Analyzer itself. Analyzer can save three types data files.

3.1   dat file

    Dat file is used to save Measure data of the Stimulus Trace or all Traces, data is saved in formatting or unformatted form, and data save mode is defined by Data Save Setting dialog box.

3.1.1   Saving dat file

3.1.1.1   By mouse or touch screen

    a)   Click **[File]**, and click **[Save As…]** on File menu to display Save As dialog box.

    b)   Set up the saved file type as Data File (*.dat) in **[Save as Type]** box.

    c)   Set up file save directory via **[Save In:]** box and **[File List]** box.

    d)   Set up the saved file name in **[File Name]**.

    e)   Click **[Save]** button to display Data Save Setting dialog box

    f)   Set up content and format of saved file in the dialog box, click **[Formatted]** or **[Unformatted]** button to save data file, and then close the dialog box.

3.1.1.2   By front panel keys

    a)   Press 【**Save**】 key in function keypad.

    b)   Press corresponding soft-key of **[Save As]** to display **[Save As]** dialog box.

    c)   Press 【□】、【□】keys in regulating keypad to shift to **[Save as Type]** box, press 【△】 and 【▽】 keys in regulating keypad or rotate knob to select save file type as data file (*.dat), and press 【↵/off】 key of Enter keypad to complete selection.

    d)   Set up file save directory via **[Save In:]** box and **[File List]** box.

    e)   Press 【□】、【□】 keys to shift to **[File Name]** box, and set up the saved file name.

    f)   Press 【**OK**】 key in Enter keypad to display Data Save Setting dialogue.

    g)   Set up content and format of saved file in the dialog box, click 【□】、【□】 keys to shift to **[Formatted]** or **[Unformatted]** button, press 【**OK**】 key to save data and close dialog box.

3.1.1.3   Data Save Setting dialog box
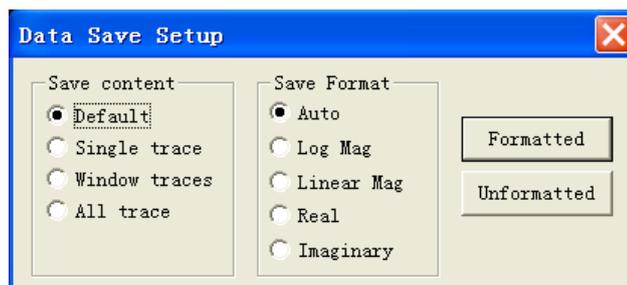
Fig. 9-3   Data Save Setting Dialog box

Save content zone

Save content zone will define which Trace data is saved in file.

a) **[Default]**

To save Stimulus Trace data of all windows.

b) **[Single Trace]**

To save current Stimulus Trace data.

c) **[Window Traces]**

To save all Trace data in current Stimulus window.

d) **[All Trace]**

To save all Trace data

Save format zone

a) **[Auto]**

Save data according to actual display format of Trace

b) **[Log Mag]**

Save Trace data according to logarithm amplitude format.

c) **[Linear Mag]**

Save Trace data according to linear amplitude format.

d) **[Real]**

Save Trace data according to real part format.

e) **[Imaginary]**

Save Trace data according to imaginary part format.

[Formatted]

Save Trace data as per the format setting in Save Format Zone.

[Unformatted]

Save Trace data according to real or imaginary part format.

3.2   snp (s1p and s2p) files

Files in snp format can be called by computer assistance engineering (CAE) software (such as ADS of Agilent company), it is a data output file, but can not be called by Analyzer itself. s1p file saves property of single port device, only including one S parameter (S11/S22), and s2p file saves properties of f double port device, including four S parameters. If full double-port correction is enabled, Analyzer will save all four S parameters in s2p file. If full double-port correction is closed, Analyzer will save as much as possible Measure data in s2p file. For instance, if full double-port correction is closed, current Stimulus Trace is S11，and S21Measure still exists in channel, Measure results of S11 and S21 will be saved in s2p file, because there is no effective Measure data of S11 and S21 , corresponding data in s2p file is 0.

3.2.1   Saving snp file

3.2.1.1   By mouse or touch screen

    a)   Click **[File],** and click **[Save As…]** on File menu to display Save As dialog box.

    b)   Set up the saved file type as Data File (*.dat)in **[Save as Type]** box.

    c)   Set up file save directory via **[Save In:]** box and **[File Name]** box.

    d)   Set up file name in **[File Name]** box.

    e)   Click **[Save]** button to complete data storage.

3.2.1.2   By front panel keys

    a)   Press 【**Save**】 key in UTILITY area.

    b)   Press corresponding soft-key of **[Save As]** to display **[Save As]** dialog box.

    c)   Press 【□】、【□】 keys in ADJUST area to shift to **[Save as Type]** box, press 【△】 and 【▽】 keys in ADJUST area or rotate knob to select save file type as data file (*.s1p) or (*.s2p), and press **[↵/off]** key in ENTRY area to complete selection.

    d)   Set up file save directory via **[Save In:]** box and **[File List]** box.

    e)   Press 【□】、【□】 keys to shift to **[File Name]** box, and set up file name.

    f)   Press 【↵/off】 key in ENTRY area to display Data Save Setting dialog box.

    g)   Press 【□】、【□】 keys to shift to format selection zone, press 【△】、【▽】 keys or rotate knob to select data save format.

    h)   Press 【**OK**】 key to close dialog box, and complete data save at the same time.

3.3   prn file

prn file save measured data of Stimulus Trace in the form of row and column, and each row corresponds to a measuring point: the first column corresponds to measured activation value, the second column corresponds to measured response value. Columns are separated by comma (,), and format is as following:

S11	Log Mag
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

3.3.1   Saving prn file

3.3.1.1   By mouse or touch screen

a)   Click **[File]**, and click **[Save As…]** on File menu to display Save As dialog box.

b)   Set up file storage type as List File (*.prn) in **[Save as Type]** box.

c)   Set up file save directory via **[Save In:]** box and **[File List]** box.

d)   Set up file name in **[File Name]** box.

e)   Click **[Save]** button to save file and close the dialog box.

3.3.1.2   By front panel keys

a)   Press 【Save】 key in UTILITY area.

b)   Press corresponding soft-key of **[Save As]** to display **[Save As]** dialog box.

c)   Press【□】、【□】keys in ADJUST area to shift to **[Save as Type]** box, press 【△】 and 【▽】 keys in ADJUST area or rotate knob to select save file type as list file (*.prn).

d)   Set up file save directory via **[Save In:]** box and **[File List]** box.

e)   Press 【□】 、 【□】 keys to shift to **[File Name]** box, and set up file name.

f)   Press 【OK】 key in ENTRY area to save file and close the dialog box.

Section 2   Printing Measure Display

Analyzer can output or print Measure display content to a specified file via printer. Printer can be local or network printer, types including parallel port, serial port or USB interface printers. Measure print can be realized once addition of printer to Windows XP operation system is completed.

1   Setting Print Content

Analyzer supports settinging print content and printout mode, and methods are as following:

1.1   By mouse or touch screen

a)   Click **[File]**, and click **[Page Setup…]** on **[Print]** menu to display Page Settings dialog box.

b)   Set up printed content in the dialog box.

c)   Click **[Ok]** button to close the dialog box.
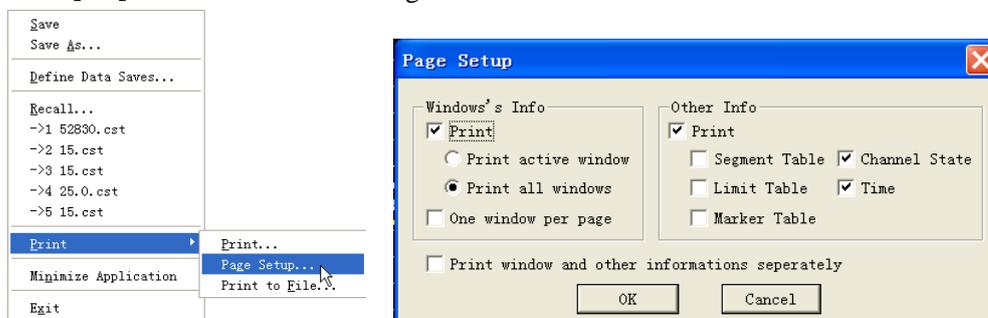
Fig. 9-4   Print Content Setting

1.2   Dialog box of print Page Setup

Window's Info zone

a)   [Print]

If it is selected, window Trace information will be printed, and if not, window Trace information will not be printed. The following options can be effective only when the check box is selected.

b)   [Print Active Window]

If selecting it, only the content of current Stimulus window is printed.

c)   [Print All Windows]

If selecting it, content information of all windows will be printed.

d)   [One Window per Page]

If it is selected, one window is only printed per page; if it is cleared, all windows content will be continuously printed without forced page break.

Other Info zone

a)   [Print]

When it is selected, other settings and status information will be printed, and the following options are effective; when it is cleared, and the information will not be printed.

b)   [Segment Table]

When it is selected, segment table will be printed.

c)   [Limit Table]

When it is selected, limit table will be printed.

d)   [Marker Table]

When it is selected, marker table will be printed.

e)   [Channel State]

When it is selected, channel settings status information will be printed.

f)   [Time]

When it is selected, current time information will be printed.

[Print Window and Other Information Separately]

When it is selected, window information and other setup information will be printed on separate pages, and when it is cleared, and the information will be printed on the same page.

2   Printing Measure Display

After addition of printer to Windows XP operation system of Analyzer is completed and print content is set up in Measure application program, the required Measure information can be output via the printer.

2.1   By mouse or touch screen

a)   Click **[File]**, and click **[Print…]** on **[Print]** menu to display Print Setup dialog box.

b)   Click **[OK]** button to begin print after print setup is completed in dialog box.
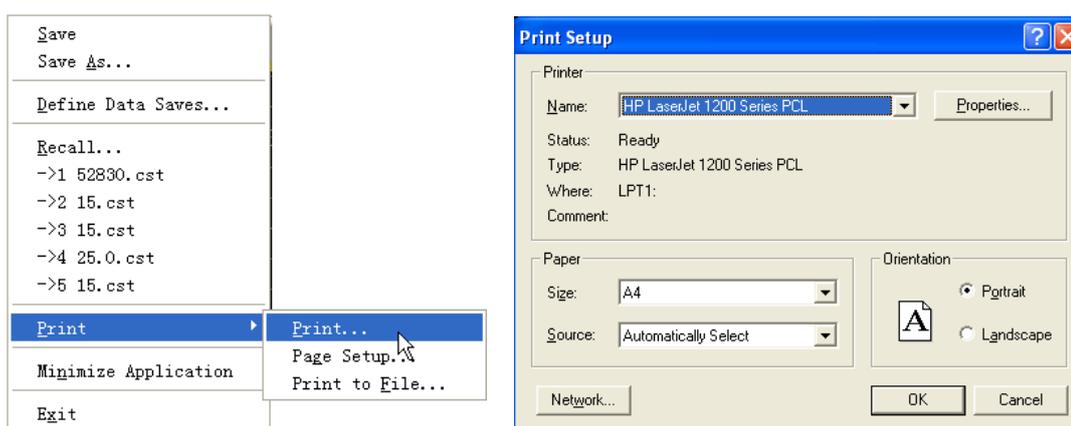
Fig. 9-5   Print Measure Information

2.2   By front panel keys

a)   Press 【**Print**】 key in UTILITY area, and press corresponding soft-key of **[Print…]** to display

Print Setup dialog box.

b) Press **[↵]** key in ENTRY area to begin print after settings are completed.

3 Printing to File

Analyzer supports outputting the printed content to bmp file. If multi-page print is required, multiple bmp files will be automatically established. Each file corresponds to one page, and other files are indentified in the form of "file name (number).bmp", such as amp.bmp, amp(1).bmp and amp(2).bmp.

3.1 By mouse or touch screen

a) Click **[File]**, and click **[Print to File…]** on **[Print]** menu to display Save As dialog box.

b) Set up file storage directory and file name in the dialog box.

c) Click **[Save]** button to save file.

3.2 By front panel keys

a) Press 【**Print**】 key in UTILITY area, and press corresponding soft-key of **[Print to File…]** to display Save As dialog box.

b) Set up file save directory and file name in the dialog box.

c) Press 【**OK**】 key in ENTRY area to save file.

Chapter X   Time Domain Measure

This chapter describes the basic principle for time domain Measure performed by Analyzer, how to set up the instrument to improve accuracy of time domain Measure and how to Analysis result of time domain Measure, including contents below:

■ Principle for time domain Measure

■ Resolution and range of time domain Measure

■ Window filtering

■ Time domain gate filtering

■ Time domain Measure data

■ Band pass and low pass time domain modes

■ Setting time domain transformation Measure

Section 1   Principle for Time Domain Measure

In general Measures, the Analyzer displays the response of measured piece which varies with frequency, and this is called frequency domain Measure. When performing time domain Measure, the Analyzer obtains time domain data through inverse Fourier Transform of frequency domain, the Measure results are indicated by taking time as X axis, the response values appear at the time of separation and characteristics or fault points of the measured piece can be Analysisd. Fig. below is the reflection Measure result of frequency domain and time domain of the same cable which has two bends, both bending points resulting in transmission line mismatch or impedance change.
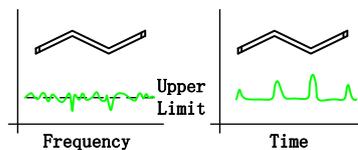

Fig. 10-1   Frequency Domain and Time Domain Measures

● Frequency domain response of S11 measured at input port indicates the combined reflection response caused by interaction of mismatched cable waves; however, definite physical location of the cable mismatch is hard to be determined.

● Time domain response indicates location and size of each mismatch and we can see from the response that apparent mismatch occurs at the second bend of the cable.

● In time domain, the Analyzer can filter undesired responses by using gate function and then

231

converts time domain data back to frequency domain data. This function can be used to measure response of specific signal in network and filter effects of external instruments such as connector or adapter.

Time domain Measure function of the Analyzer simulates conventional time domain reflectometer (TDR). An impulse or step-function signal is transmitted to the measured piece from time domain reflectometer, then observe energy of the reflected signal and impedance change of the measured piece can be determined by analyzing amplitude, duration and waveform of the reflected signal. When performing time domain Measure, Network Analyzer doesn't generate incident impulse or step-function signal actually, but performs Sweep Measure and then calculates time domain information from frequency domain Measure result through Fourier Algorithm.

Generally, Vector Network Analyzer performs time domain transformation Measure through ration Measure. S_{11} reflection Measure does not only indicate size of the reflected signal received by receiver A or B simply, but also indicates the Measure result of the ratio between Measure receiver and reference receiver. In addition, S_{11} ratio Measure can eliminate system errors by calibration, which is very important to time domain Measure, since Measure reference plane is set through calibration and the calibrating point becomes zero point of time axis X, all time and distance data take this point as a reference point, and both time and amplitude data are very accurate through calibration.

Section 2 Resolution and Range of Time Domain Measure

This section discusses how to observe all effective time domain data of the measured piece and how to set up the instrument to obtain highest resolution and maximum Measure range.

1 Response Resolution

Time domain response resolution of the Analyzer refre to the capability of Analyzer to distinguish two adjacent responses. For response of identical amplitudes, it equals to the pulse width of impulse response defined by 50% (6dB) amplitude point, or the rise time of step response defined by 10%~90% amplitude point, shown as Fig. below:
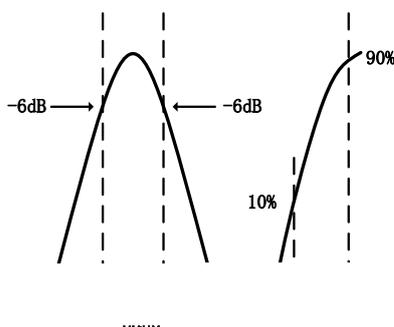

Fig. 10-2   Time Domain Response Resolution

Time domain response resolution is affected by factors below:

   a)   **Frequency span**

   Fig. below indicates the effect of frequency span toward response resolution:
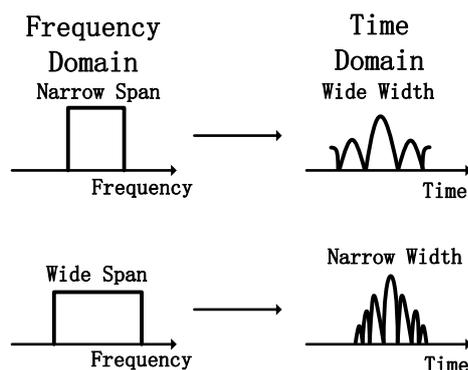

Fig. 10-3   Effect of Frequency Span toward Response Resolution

   ●   Time domain Measure response under narrow frequency span is indicated as that impulse response pulses which shall be independent from each other are overlapped.

   ●   When performing time domain Measure under broad frequency span, the Analyzer can

distinguish different response pulses well.

- Frequency span and pulse width are in inverse ratio. The broader the frequency span is, the narrower the impulse response pulse is; The shorter the step response rise time is, the higher the response Measure resolution is.

b) Window width (parameter β)

Response resolution is also the function of time domain transformation window width. The smaller the β is, the narrower the impulse response pulse is, and the shorter the step response rise time is , the higher the response Measure resolution is.

Selection of window width depends on response of the measured piece. If the response is signal with equal electrical level, minimum window shall be applied to improve Measure resolution, and if not, maximum window shall be applied to improve dynamic range of Measure; see Section 3 "Window Filtering" in this chapter for detailed information about window setting.

⚠	**NOTE:**	**When setting time domain Measure, in Time Domain Transform dialog box, the Analyzer will calculate width of response pulse automatically according to current setting.**

c) Time domain transformation mode

In low-pass and band-pass transformation modes, resolutions of Measure responses are different. For the same frequency span and Sweep spot number, low-pass mode has higher resolution and pulse width can reduce by half compared with band-pass mode; Fig. below provides the resolution comparison in two modes.
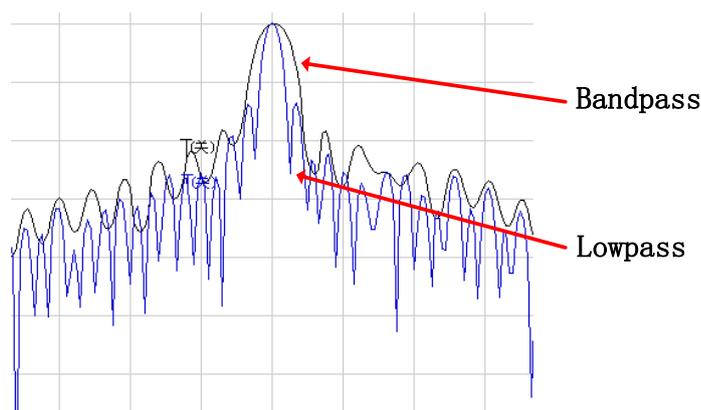

Fig. 10-4   Effect of Transformation Modes on Resolution

See Section 6 "Band Pass and Low Pass Time Domain Modes" in this chapter for detailed information about time domain transformation mode.

Techniques to optimize response resolution

- In most conditions, the highest time resolution is obtained by selecting maximum frequency span; however, frequency setting must meet operating frequency requirements of the DUT.

- Resolution is affected by frequency span, window width and time domain mode, so optimal setting must be performed according to response of the DUT.

2　Display Resolution

Display resolution of time domain refers to the capability to locate a signal response accurately in term of time. Good display resolution can improve peak point of response and location accuracy of zero point and display resolution is affected by time span and Sweep spot number:

$$Display\,resolution = \frac{time\,span}{scanning\,spot\,number - 1}$$

Display resolution can be improved with two methods below:

- Reduce time span.
- Increase Sweep spot number.

Fig. below provides the Measure result of the same measured piece in different time spans with 201 Sweep spot number.

- Resolution of 50 psec can be obtained within time span of 10nsec.
- Resolution of 12.5 psec can be obtained within time span of 2.5nsec.

Span 10nsec　　201 Points　Span　2.5nsec
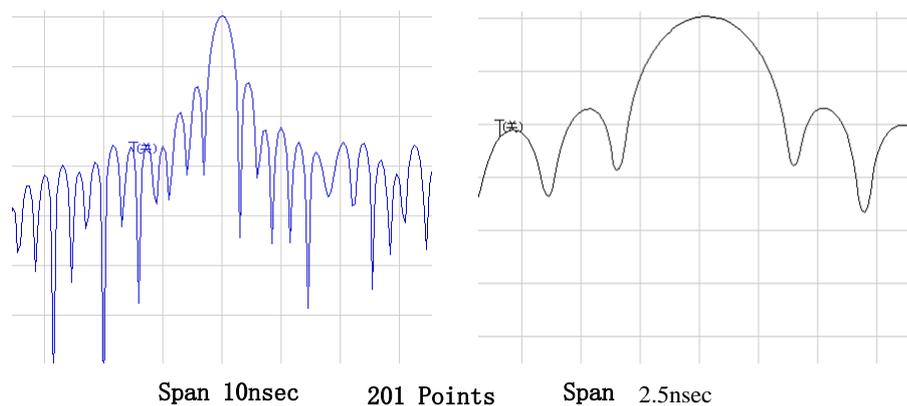
Fig.10-5　Display Resolution

⚠	**NOTE:**	● **Change of time span won't affect the Analyzer's capability to distinguish two signals adjacent to each other.**
		● **Changing Sweep spot number in low-pass mode will change**

frequency span, which affects response resolution to some extent.

3   Measure Range

In time domain Measure, Measure range can be defined as the maximum time span set and no repeated response will occur within this time span when performing Measure.

Measure range has an inverse relationship with response resolution; one increase, the other will be reduced.

Time domain waveform is the periodic signal repeating with time, thus repeated response will occur. Repeated response (false response) is not true response of the measured piece and it only appears at specific time interval (1/frequency interval of Sweep spots), hence Measure range is determined by frequency interval ∆F of Sweep spots:
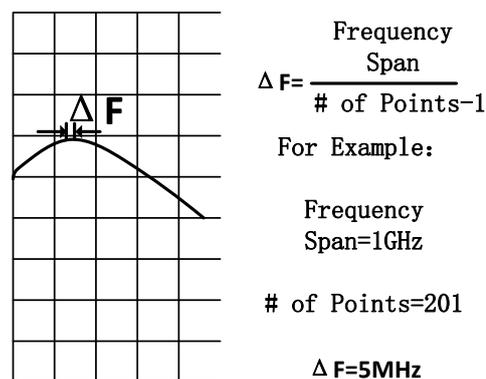

Fig.10-6   Frequency Interval Definition of Sweep Spots

When performing time domain Measure, maximum terminal time that can be set is: $1/\Delta F$, Measure range is in direct scale to Sweep spot number - 1 and in inverse scale to frequency span, to increase Measure range, setting of two items below can be modified:

- Increase Sweep spot number.
- Reduce frequency span.

 NOTE: **In order to ensure Measure accuracy, modification mentioned above must be performed prior to calibration.**

Measure range in meter can be obtained by multiplying vacuum light velocity with Measure, in order to calculate physical length of actual Measure range, relative speed rate of transmission medium shall be

multiplied also and relative speed rate of some medium are below:

- Vpolythene = 0.66

- Vpolytef = 0.70

Physical length of actual Measure range $= \dfrac{V_{medium}}{\triangle F} \times 3 \times 10^8 \, \text{m/s}$

Section 3   Window Filtering

Due to effect of sidelobe and pulse width, time domain transformation is limited in term of resolution. Window filtering function can be used to mitigate the effect when performing Measure. Window function provided by the Analyzer in time domain can distinguish various responses effectively and it can change width of response pulse, rise time of step response and sidelobe level.

1   Advantages of Window Filtering

In frequency domain Measure, sudden change exists at initial and terminal frequencies, which will result in overshoot and ringing in step response of time domain. Using window filtering function can reduce effect caused by sudden change in frequency domain; besides, Analyzer also has following deficiencies when performing time domain Measure:

- Pulse width of impulse response or rise time of step response: this is caused by limitation property of the system itself, limiting the capability of Analyzer to distinguish two adjacent response signals. Pulse width is in inverse scale to frequency span measured, and to reduce pulse width, frequency span shall be increased.

- Impulse response sidelobe: this is caused by sudden change at terminal frequency. Sidelobe of adjacent high electrical level response will cover low level response signal, which limits dynamic range of time domain Measure, however, using window filtering can inhibit sidelobe, shown as Fig. below:
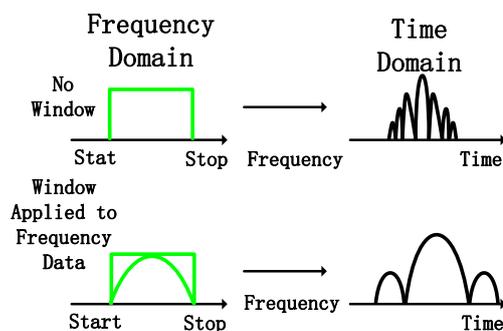

Fig.10-7   Inhibiting Sidelobe by Use of Window Wave Filter

- Using narrow window can reduce width of impulse response pulse and improve response resolution to distinguish two adjacent responses in a better way.

- Using broad window can reduce sidelobe level of impulse response and improve dynamic range to measure low level response in a better way.

Effects when using window wave filter is shown below:
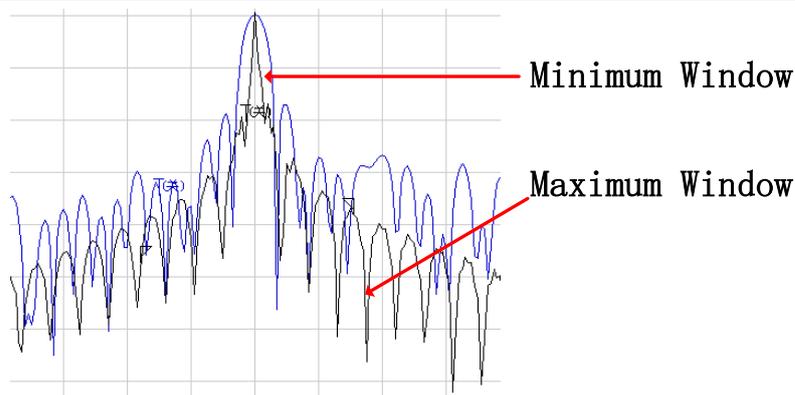
Fig.10-8   Effect of Window toward Response Signal

The Analyzer performs window filtering to frequency domain Measure data and has following effects on time domain Measure of the measured piece:

- In impulse transformation mode, it affects pulse width and sidelobe level, changing resolution and dynamic range of Measure.

- In low-pass step transformation mode, it can mitigate overshoot and ringing.

2   Setting Window Value Correctly

When performing time domain Measure, proper window value must be selected according to response type of the measured piece:

- Response of the measured piece with identical amplitude: small window is selected to obtain narrow pulse width to improve resolution of time domain Measure.

- Response of the measured piece with different amplitudes: large window is selected to obtain low sidelobe level to improve dynamic range of time domain Measure.
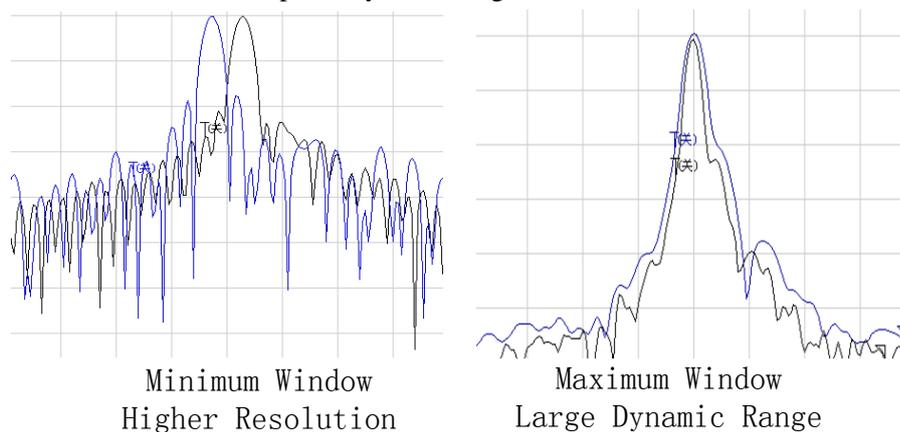

Fig.10-9   Correct Window Setting

Section 4   Time Domain Gate Filtering

Use of time domain gate function can select or filter a specific response in time domain, while the Analyzer can transform the processed time domain data to frequency domain again for observation. That is to say, after time domain filtering is performed to time domain data, function of time domain transformation can be turned off, and then frequency domain response of the measured piece can be observed in the condition that function of time domain is effective. For example, during transmission Measure, eliminate effect of multi-pass transmission by use of time domain gate, or observe a single time domain response signal at a time and then Analysis the effect of each single response toward Measure result in frequency domain.

1   How to Use Gate Function

In actual Measure, Measure steps with time domain gate function are as follows:

a)   Measure the measured piece in frequency domain.

b)   Switch on time domain transformation function and the Analyzer will calculate time domain response of the measured piece.

c)   Select gate type:

● Band-pass: set the gate at the center requiring response reservation, switch on gate function and response outside the gate is removed from the displayed Measure through mathematical manipulation.

● Band-stop: set the gate at the center from which the response is to be eliminated, switch on gate function and response inside the gate is removed from the displayed Measure through mathematical manipulation.

d) Turn off time domain transformation function, observe frequency domain response of the measured piece and see the effect of specific response toward Measure result.

Fig. below illustrates the Measure application of a band-pass time domain gate:

1

Original Frequency
Response

2

Time Domain

Filter Out
This Response

4

Frequency Response W/Gate

3
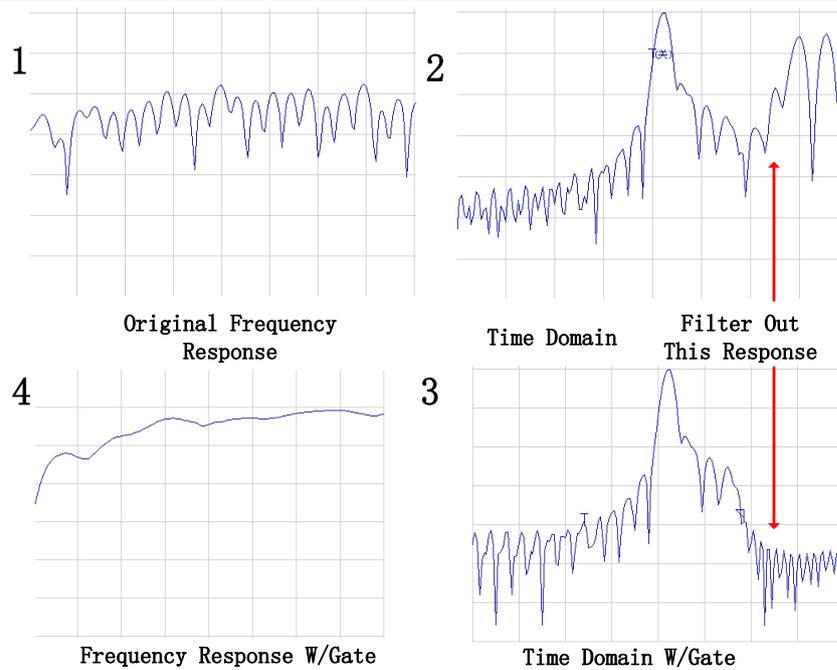
Time Domain W/Gate

Fig.10-10   Observing Effect of Single Response toward Measure Result by Use of Time Domain Gate

2   Gate Settings

Border and function of the gate can be set and defined as below:

- Start and stop: to define -6dB cut-off time of the gate.

- Center: to define center time of the gate.

- Span: it equals to terminal time minus start time.

- Gate Type:

  * **Band-pass:** to filter response outside the gate.

  * **Band-stop:** to filter response inside the gate.

3   Gate Form

Similar to window wave filter, the gate also has corresponding wave filter form and Measure can be optimized by selecting reasonable wave filter form:

- **Minimum gate:** the wave filter has highest sidelobe level, with sharpest edge falling and maximum band-pass ripples.

- **Maximum gate:** the wave filter has lowest sidelobe level, with slowest edge falling and minimum pass band ripples.

3.1   Passband ripples of the gate

The gate is a pass band (or band-stop) wave filter on time domain and each form of wave filter has different filter property. Fig. below indicates band-pass ripples of four filters in different forms and the

scale in the Fig. is 0.5dB/grid. It can be seen from the Fig. that the minimum gate has the largest band-pass ripples.
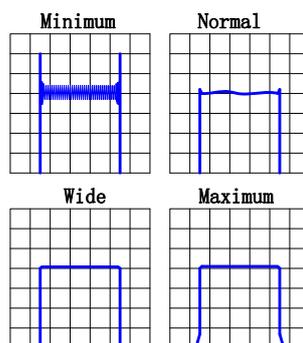

Fig.10-11   Band-Pass Ripples of Different Gate Wave Filters

3.2   Sidelobe level of the gate

Four wave filters of different forms have different sidelobe levels, in actual Measure, there must be a balance between lower sidelobe level and faster cut-off ratio.

- The minimum gate is with highest sidelobe level and fasted cut-off speed, which is very applicable to filtering undesired interference near the response.
- The maximum gate is with lowest sidelobe level, slowest cut-off speed, widest gate band-pass and maximum attenuation outside the gate band.
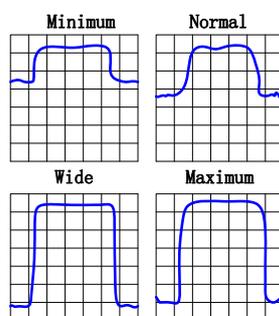

Fig.10-12   Sidelobe Level of Different Gates

3.3   Property index of the gate

Different forms of gate have different properties and the properties are defined by index below:

- **Pass band ripples and sidelobe level:** to descript the gate form.
- **Cut-off time:** it is the time between end time of the gate (at -6dB of the filter edge) and the first sidelobe peak point.
- **Minimum gate span:** it equals to end time minus start time and it is twice of the cut-off time.

Table 10-1   Property Index of Different Gates

Gate Form	Pass Band Ripple	Sidelobe Level	Cut-off Time	Min. Gate Span
Min.	±0.10dB	-48dB	1.4/frequency span	2.8/frequency span
Standard	±0.01dB	-68 dB	2.8/frequency span	5.6/frequency span
Width	±0.01dB	-57 dB	4.4/frequency span	8.8/frequency span
Max.	±0.01dB	-70 dB	12.7/frequency span	25.4/frequency span

Each form of gate has a recommended minimum gate span to operate correctly, which is determined by limited cut-off ratio of the gate. If the gate span set is smaller than this minimum value, the Analyzer will produce effects below:

- The gate form is distorted, without pass band.

- Indication of start and end time is incorrect.

- Sidelobe level would be increased.

Section 5　Time Domain Measure Data

This section will provide examples of various Measure types to facilitate understanding of time domain response of the measured piece.

1　Screening

Screening will affect the response observed during time domain Measure; therefore, when explaining time domain Measure data, what is screening and its effect toward Measure result must be known clearly.

- Screening occurs when discontinuous points or loss nearest to reference plane affects response of each discontinuous point.

- Energy reflected or absorbed by the first discontinuous point won't approach the subsequent discontinuous points.

- Response of each subsequent discontinuous point is smaller than that without screening.

1.1　Screening caused by energy reflection

With serious mismatch, screening by energy reflection happens, examples below illustrate such phenomenon:

- When a section of 50Ω transmission line is connected with a section of 25Ω air line and connected with another 50Ω transmission line, reflection coefficient of both discontinuous points is 0.333.

- During time domain Measure, if reflection coefficient of the first discontinuous point is about 0.333, this is the right case.

- Response value of the second discontinuous point is not 0.333 and it can be found from Δmarker that there is an amplitude of 35mU between two responses, this is because that energy reflection caused by the first mismatch makes the incident pulse amplitude of the second response smaller than unit value 1U.
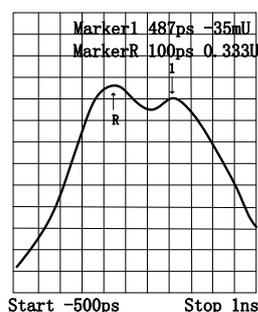

Fig.10-13　Effect of Screening Caused by Energy Reflection toward Measure

1.2   Screening caused by energy absorption

Screening caused by energy absorption happens when measuring loss circuit. In Measure below, an open-circuit device is terminated to a cable and the Measure result displays the screening caused by energy absorption.


Start −500ps   Stop 20ns
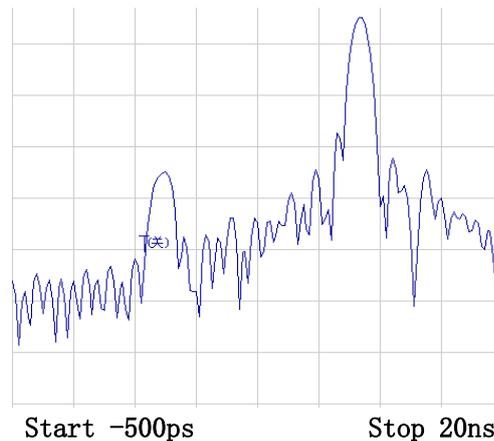
Fig.10-14   Effect of Screening Caused by Energy Absorption toward Measure Result

- Marker 1 displays that return loss of open-circuit device is -2.5dB (observed in the format of logarithm amplitude).
- Actual return loss of open-circuit device shall be 0dB.
- Value of Marker 1 represents the sum of forward and backward pass losses.

2   Reflection Measure in Band Pass Mode

Horizontal axis data:
- It represents the time used when pulse is transmitted from measuring port and transferred to discontinuous point and then gets back to measuring port.

Vertical axis data:
- With format of logarithm amplitude, it represents return loss (dB).
- With format of linear amplitude, it represents reflection coefficient.

An example of reflection Measure in band pass mode is provided below:
- There is a pulse at 0 point on time axis, which represents the first discontinuous point (connector) met from the measuring port output.
- The subsequent pulse represents the second discontinuous point (connector) met by impulse signal.
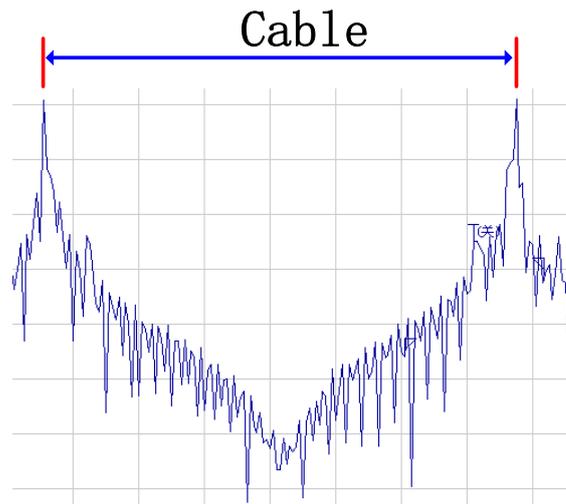
Fig.10-15   Reflection Measure in Band Pass Mode

3   Transmission Measure in Band Pass Mode

Horizontal axis data:

- It represents transmission delay when passing the measured piece.

Vertical axis data:

- In the format of logarithm amplitude, it represents transmission loss or transmission gain.

- In the format of linear amplitude, it represents transmission coefficient.

An example of surface filter (SAW) transmission Measure in band pass mode is provided below:
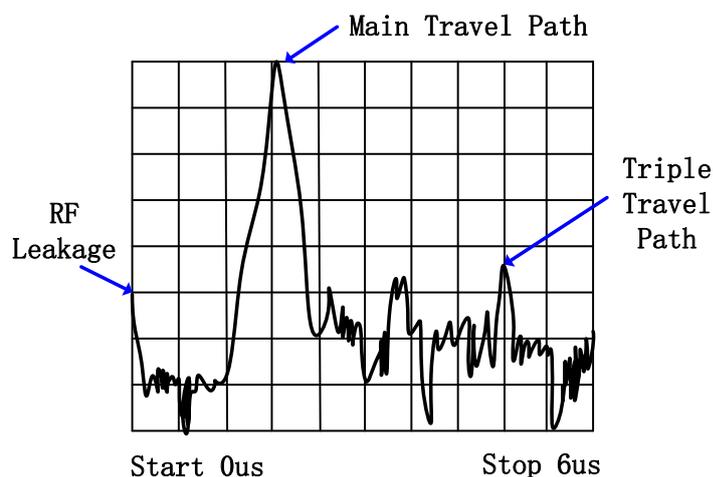

Fig.10-16   Transmission Measure in Band Pass Mode

- Three transmissions in surface acoustic wave (SAW) filter can be found from Measure results: the signal is reflected back to input port by output port and then reflected back to output port again.

- Pulse closest to 0 time point represents transmission time of the shortest path between input and output of the measured piece; however, it is neither the maximum pulse definitely nor representing the expected transferring path.

- Each subsequent pulse represents other potential paths which are longer than the shortest path.

In order to observe main path response of surface filter (SAW), other responses can be filtered by gate function to observe frequency response of the main path only.

4   Fault Location by the Use of Low Pass Mode

The measured piece response of time domain reflectometer (TDR) can be simulated by the use of real part format and such response includes definite discontinuous type of information which is very useful. Fig. below provides the low pass response in the format of known discontinuous real part, and each discontinuous circuit has corresponding time domain S_{11} response waveform. Measure can be performed by the use of low pass step or low pass impulse mode; however, it is easier to distinguish discontinuous types by the use of low pass step mode, which is similar to Measure with conventional time domain reflectometer (TDR).

IMPEDANCE	STEP RESPONCE	IMPULSE RESPONCE
OPEN	Unity Reflection	Unity Reflection
SHORT	Unity Reflection=180	Unity Reflection=180
RESISTOR R>Z0		
RESISTOR R<Z0		
INDUCTOR		
CAPACITOR		
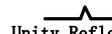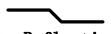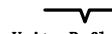
Fig.10-17   Low Pass Time Domain Response Waveform of Discontinuous Circuit

5   Reflection Measure in Low Pass Mode

Horizontal axis data:

- It represents the time used when pulse is transmitted from measuring port and transferred to discontinuous point and then gets back to measuring port.

Vertical axis data:

- In real part format, it represents reflection coefficient (ρ).

Example below is the Measure result of the same reflection by the use of both low pass impulse and low pass step modes:

S11 LOG MAG

Lowpass
  Step

Lowpass
Impulse

Start -2ns   Stop 2ns
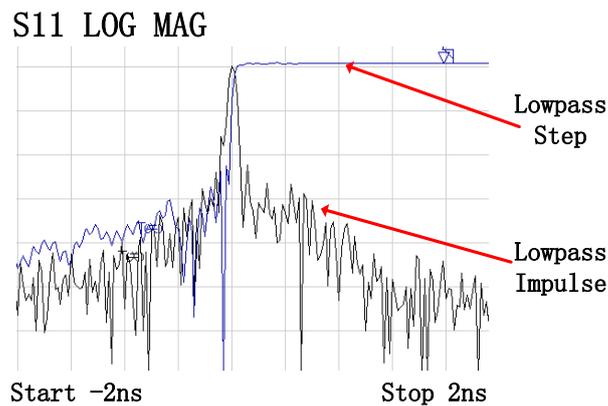
Fi.10-18   Reflection Measure in Low Pass Mode

Example below provides Measure results of two different cables in real part format and low pass response includes physical location and impedance type information of the discontinuous points.


S11 Real Capacitive   S11 Real Inductive

Start 0ns   Stop 10ns   Start 0ns   Stop 10ns
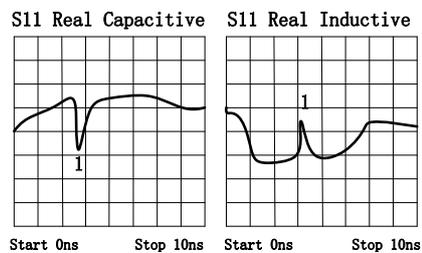
Fig.10-19   Low Pass Step Measure Results of Different Cables

- **The left Measure:** response of the bending cable with capacitive discontinuous points.
- **The right Measure:** response of the wearing cable with inductive discontinuous points.

6   Transmission Measure in Low Pass Mode

Horizontal axis data:

- Average transmission time during which the signal passes the measured piece in a frequency range.
- Average Electrical delay of the measured piece.

Vertical axis data:

- In logarithm amplitude format, it represents transmission loss and gain   (limited to impulse mode only).

An example of low pass step response of amplifier is provided below:
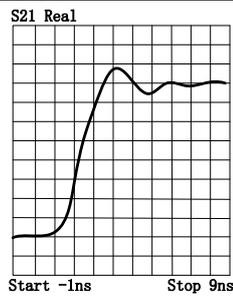
Fig.10-20   Low Pass Step Measure Results of Amplifier

- Average group delay within Measure frequency range is the differential value between step and amplifier response.

- Step rise time is directly related to highest frequency of frequency domain sweep, the higher the frequency, the shorter the rise time is.

- Ringing of amplifier response indicates that it is underdamped design.

	NOTE:	For low pass step response, the most useful format is real part format; for low pass impulse response, real part format can be used also; however, in order to obtain better dynamic range to measure discontinuous points of different sizes, it is better to use log-magnitude format.

Section 6   Band Pass and Low Pass Time Domain Modes

When setting time domain Measure, transformation mode must be selected first and this section will make comparison between band pass and low pass Measure modes.

1   Modes Comparison

1.1   Band pass mode

- Easiest use.

- Very applicable to Measure of band pass instruments not working to direct current.

- It is allowable to set start and stop frequency randomly.

- It measures impulse response only since there is no DC item in transformation data.

- It can perform reflection and transmission Measure.

- It can be used for fault location.

1.2   Low pass mode

- Very useful to measure low pass instruments that can work to direct current.

- It simulates conventional time domain reflectometer (TDR).

- Measure frequency points are related to DC item harmonic wave and DC item is obtained through point extrapolation at frequency domain start.

- Since transformation data includes DC item, it can be used for impulse and step response Measure.

- It can locate fault and distinguish impedance types (capacity, induction) indicated by discontinuous points.

- It can perform reflection and transmission Measure.

- For the same frequency span, it has higher response resolution compared with band pass mode.

2   Mode Selection

- If the measured piece operates at band pass, band stop or high pass state, select band pass mode.

- If low end operating frequency of the measured piece can be up to direct current, i.e. frequency response falls rapidly at low end, select low pass mode also.

3   Frequency Span and Number of Points

3.1   Band pass mode

- Any start and stop frequency can be selected within operating frequency range of the Analyzer.

- The Analyzer utilizes all Measure data within start and stop frequency range.

- It provides impulse response only.

3.2   Low pass mode

- It is required to obtain direct current item through several measuring point extrapolation starting from a frequency domain.

- Data points with equifrequent interval are required.

- All Measure frequency points of the Analyzer are related to start frequency harmonic wave.

- Stop frequency=start frequency x Sweep spot number, it has certain limitation for each Sweep spot number N and selection of start and stop frequency.

⚠	NOTE:	**Lowest start frequency that can be set for Analyzer is 100kHz; therefore, the lowest stop frequency value is N×100kHz, of which N is Sweep spot number.**

4   Impulse Response and Step Response

The Analyzer can display impulse response and step response of the measured piece, just like using impulse or step signal to stimulate measured piece.

- **Impulse activation:** it is a voltage waveform, of which the amplitude value changes to 1 from 0 and then changes back to 0 again, and pulse width depends on frequency span for frequency domain Measure.

- **Step activation:** it is a voltage waveform, of which the amplitude value changes to 1 from 0 and step rise time depends on the highest frequency for frequency domain Measure.

- According to transformation mode selected, the Analyzer calculates low pass impulse, low pass step or band pass impulse response by the use of frequency domain data.

5   Useful Data Format

5.1   Useful data format in band pass mode

- Linear amplitude format
    * For reflection Measure, this format represents the average amplitude of reflection coefficient (ρ) within the whole Measure frequency range.
    * For transmission Measure, this format represents the average transmission coefficient (τ) of the transmission path within the whole Measure frequency range.
    * This format is very useful to observe the response with similar amplitudes.

- Log-magnitude format
    * For reflection Measure, this format represents return loss (dB) and the display value represents average return loss of discontinuous points within the whole Measure

251

frequency range.

* For transmission Measure, this format represents transmission loss or gain (dB) and the display value represents average loss or gain of the transmission path within the whole Measure frequency range.

* This format is very useful to observe the response of dynamic range.

● Standing wave ratio

* For reflection Measure, this format represents the average value of standing wave ratio of the discontinuous points within the whole Measure frequency range.

5.2   Useful data format in band pass mode

● Real part

* This format utilizes real part unit to represent response of the measured piece.

Section 7   Setting Time Domain Transformation Measure (Optional)

1   By mouse or touch screen

a)   Click **[Marker/Analysis]**, click **[Transform...]** on submenu to display Time Domain Transform dialog box.

b)   Click to select **[Transform]** check box and Stimulus time domain transformation function.

c)   Click **[Start], [Stop]** or **[Center], [Span]** box to set time domain Measure range.

d)   Select transformation mode in Transformation Mode zone: **[Low Pass Impulse], [Low Pass Step]** or **[Band Pass]**.
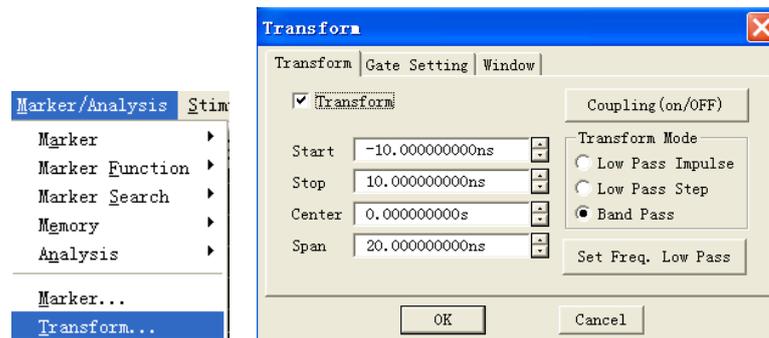
Fig.10-21   Setting Time Domain Transformation Measure

e)   Set Window function: click **[Window]** Selection Button in Time Domain Transform dialog box and set window filter with three methods below:

- Drag sliding box with mouse till pulse width or sidelobe level meets the requirement.
- Click **[Gaesarian Window β Para]** box to adjust setting of value β, till pulse width or sidelobe level meets the requirement.
- Click **[Pulse Span]** box to set response pulse width directly.
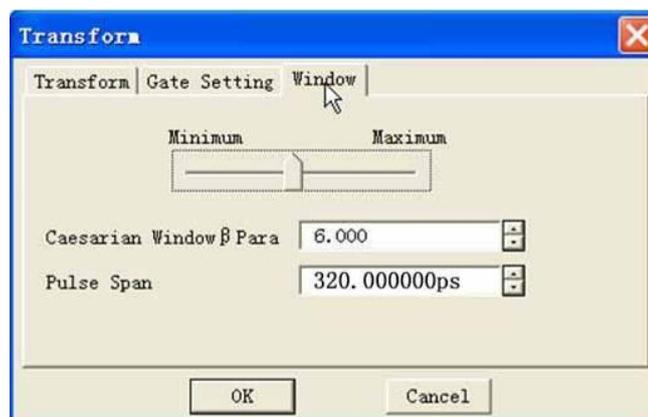
Fig.10-22   Time Domain Transformation Measure—Setting Window

f)   Set filtering function of time domain gate: click **[Gate Setting]** option button in Time Domain Transform dialog box and click to select **[Gating]** check box to enable filtering function of time domain gate.

- Click **[Start], [Stop]** or **[Center], [Span]** box to set gate border.
- Select gate type in **[Gate Type]** box: band pass, band stop.
- Select gate form in **[Gate Shape]**: minimum, normal, wide, maximum.
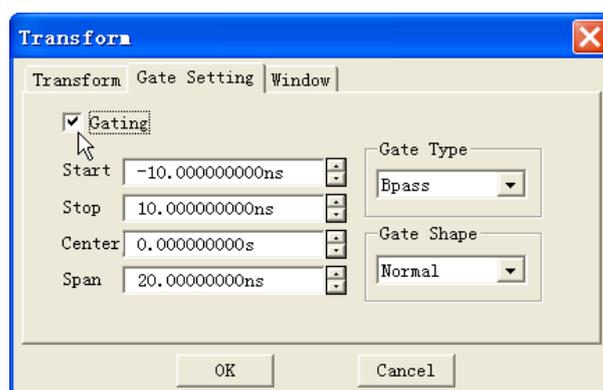
Fig.10-23   Time Domain Transformation Measure—Gate Setting

g)   If it is necessary to observe frequency domain response of the measured piece when the gate function is still effective, click **[Transform]** option button in Time Domain Transform dialog box and click to clear **[Transform]** check box.

h)   Click **[OK]** button to close Time Domain Transform dialog box after setting.

Techniques for time domain transformation setting

- When closing Time Domain Transform dialog box while starting time domain transformation and time domain gate, drag the mouse to change border settings of time domain gate: indicate start and stop of the gate with symbol "▽" and "▽", point start or stop symbol of the gate with the mouse, press left key of the mouse, when mouse pointer become horizontal indication "↔", drag mouse to move border indicating symbol of the gate to location required and release left key to finish the setting of gate start or stop.

- After setting of time domain Measure are finished through Time Domain Transform dialog box, close Time Domain Transform dialog box, enable Time Domain toolbar to adjust settings for time domain Measure, and in this way, effect of setting change toward Measure can be observed clearly. See "Trigger Toolbar Display" in Section 9 "Setting Analyzer Display" in Chapter V for setting method of Time Domain toolbar.

⚠ **NOTE:** **If calibration is required prior to Measure of time domain in low pass mode, low pass Measure mode must be selected in time domain Measure dialog box or start frequency for Measure must be set by clicking [Set Frequency. Low Pass] button firstly. It is recommended to carry out calibration after all settings for time domain Measure are finished.**

2   By front panel keys—Time Domain Transform Dialog Box

a)   Press 【**Analysis**】 button in MKR/ANALYSIS area, press soft-key corresponding to **[Transform]**, corresponding soft-key menu appears, press corresponding soft-key of **[Transform …]** to display Time Domain Transform dialog box.

b)   Press 【□】、【□】 keys in ADJUST area to switch to **[Transform]** check box, press the knob button to select check box to Stimulus time domain transformation function.

c)   Press 【□】、【□】 keys to switch to Transformation Mode zone, Press 【△】, 【▽】 keys in ADJUST area or rotate knob to select **[Low Pass Impulse]**, **[Low Pass Step]** or **[Band Pass]** mode.

d)   Press 【□】、【□】 keys to switch to **[Start], [Stop]** or **[Center], [Span]** box to set time domain Measure range.

e)   Set window function: press 【□】、【□】 keys to switch to **[Transform]** option button, press 【△】, 【▽】 keys or rotate knob to switch to **[Window]** option button and then set window filter in   three methods below:

   ●   Press 【□】、【□】 keys to switch to sliding block box, press【△】, 【▽】keys or rotate knob till pulse width or sidelobe level meets the requirement.

   ●   Press 【□】、【□】keys to switch to **[Gaesarian Window β Para]** box to adjust setting of value β, till pulse width or sidelobe level meets the requirement.

   ●   Press 【□】、【□】keys to switch to **[Pulse Span]** box to set response pulse width directly.

f)   Set filtering function of time domain gate: press 【□】、【□】 keys to switch to **[Window]** option button, press 【△】, 【▽】 keys or rotate knob to switch to **[Gate Setting]** option button, press 【□】、【□】 keys to switch to **[Gating]** check to, pressthe knob key to select the check box and Stimulus filtering function of time domain gate, then set the function of time domain gate.

   ●   Press the 【□】、【□】 keys to switch to **[Start], [Stop]** or **[Center], [Span]** box to set gate border.

   ●   Press 【□】、【□】 keys to switch to **[Gate Type]** box, press 【△】, 【▽】 keys or rotate knob to select gate type: band pass, band stop.

   ●   Press 【□】、【□】 keys to switch to **[Gate Shape]** box, press 【△】, 【▽】 keys or rotate knob to select gate form: minimum, standard, wide, maximum.

255

g) If it is necessary to observe frequency domain response of the measured piece when the gate function is still effective, press 【□】、【□】keys to switch to **[Gate Setting]** option button, press 【△】, 【▽】 keys or rotate knob to switch to **[Transform]** option button, press 【□】、【□】 keys to switch to **[Transform]** check box, press the knob　key to clear the check box and close time domain transformation function.

h) Press 【OK】 key in Input keypad to close Time Domain Transform dialog box after setting.

Chapter XI   Guidance on Network Measure

This chapter introduces the definitions and measuring methods of various network Measure parameters, including:

- Reflection Measure
- Phase Measure
- Instruction of Amplifier Parameters
- Complex Impedance
- Group Delay
- Absolute Output Power
- AM-PM Conversion
- Gain Compression
- Linear Phase offset
- Reverse Isolation
- Small-Signal Gain and flatness

Section 1   Reflection Measure

Reflection Measure is an important part in network Measure, now we discuss what reflection Measure is first, and to better understand reflection Measure, we use light wave to simulate the transmission of travelling wave along transmission line:

When incident light meets certain optical element such as optical lens, part of the light is reflected and leaves the lens while most light is transferred continuously through the lens; if surface of the optical element is mirror surface, most light will be reflected, and only minor part or no light transmission is continued.
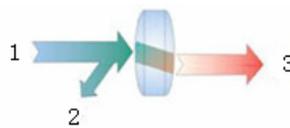
1. Incident 2. Reflected 3. Transmitted

Fig.11-1   Reflection and Transmission of Light

For radio frequency signal, reflection happens when impedances of two connectors are different. Reflection Measure is to measure the ratio relationship between reflected signal and incident signal. The Analyzer measures incident signal with receiver R and measures reflected signal with receiver A,

hence reflection Measure is often represented as the ratio of A to R (A/R). We can use signal amplitude and total phase information quantification of receivers A and B to indicate reflection property of the measured piece. In the terms of S parameters, S_{11} represents reflection at port 1 (input port) of the measured piece and S_{22} represents reflection at port 2 (output port) of the measured piece. The purpose of reflection Measure is to ensure effective transmission of radio frequency energy, if the energy is reflected, it averages that only little energy is transferred to expected place, and if too strong energy is reflected, components such as output power amplifier will be burnt.

1   Representation of Reflection Measure

When performing reflection Measure, reflection data can be represented in various methods according to information needed. Different representing methods are calculated according to the same reflection Measure data and each method can be displayed by one or more graph formats; see Section 7 "Selecting Data Format and Scale" in Chapter V for detailed information.

1.1   Return loss

Return loss, which is a scalar quantity in dB, is the easiest way to represent reflection data. Return loss is dB value of difference between the reflected signal and the incident signal; when impedance is matched completely, return loss is infinite, and for open-circuit, short-circuit or non-loss reactive circuit, return loss is 0dB. For instance, when Measure is performed on Analyzer in log-amplitude format, reflection Measure data displayed is -18dB, when representing return loss, the minus is neglected, say that return loss of the component is 18dB.

1.2   Standing wave ratio

Standing wave generates when two groups of wave transfer in opposite directions on the same transmission line and such case can be represented with voltage standing wave ration (VSWR or shorted as SWR). SWR is defined as the ratio of the maximum radio frequency envelope voltage to minimum radio frequency envelope voltage at given frequency, it is a scalar quantity, when impedance is matched completely, SWR equals to 1, for open-circuit, short-circuit or non-loss reactive circuit, SWR is infinite.

1.3   Reflection coefficient

Reflection coefficient (Γ), which is the ratio of reflected voltage to incident voltage, is another way to represent reflection Measure, and Γ includes amplitude and phase information; amplitude of Γ is called ρ which has no unit, and its value selection range is 0~1. When transmission line is terminated with characteristic impedance, all energy is transferred to load other than reflected, and ρ=0. When transmission line is terminated with open-circuit device or short-circuit device, all energy is reflected, and ρ=1.

Now, we discuss phase information of reflection. When signal frequency is very high and the signal wavelength is shorter than conductor length, the reflected wave can be understood as the wave transferred in opposite direction of incident wave; hence standing wave happens when incident wave combines with reflected wave, resulting in change in amplitude of voltage envelope with change of transmission line location.

When transmission line is terminated with characteristic impedance, there is no reflected signal, and energy transfers in one direction along the transmission line and energy of all incident signals is transferred to load, shown as Fig. below:
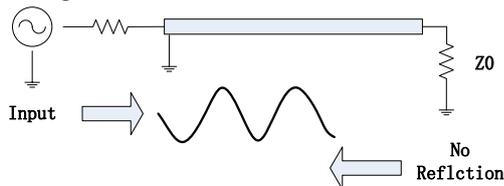
Fig.11-2   Signal Transmission of Transmission Line Terminated with Load

When transmission line is terminated with short-circuit device, all energy is reflected back to signal source, amplitude of reflected wave equals to that of incident wave ($\rho=1$) and voltages at two ends of short-circuit device is 0, hence voltage wave reflected at short-circuit point is 180° opposite to incident voltage wave and the voltages are mutual offset.
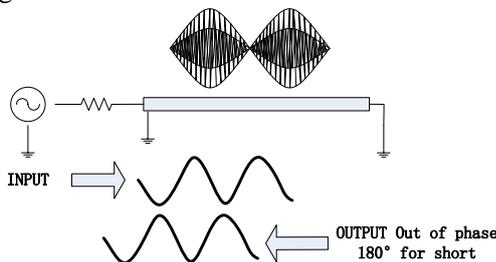
Fig.11-3   Signal Transmission of Transmission Line Terminated with Short-Circuit Device

When transmission line is terminated with open-circuit device, all energy is reflected back to signal source, amplitude of the reflected wave equals to that of incident wave ($\rho=1$), no current flows through the open-circuit device and reflected voltage wave is identical to incident voltage wave.
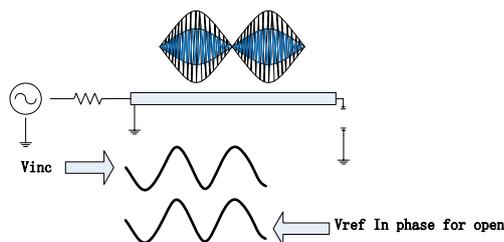
Fig.11-4   Signal Transmission of Transmission Line Terminated with Open-Circuit Device

When transmission line is terminated with 25Ω resistance, part of energy is absorbed while other part is reflected back to signal source. Amplitude of reflected wave is 1/3 of that of incident wave and the voltage is 180° opposite at the resistance, phase relationship between the two changes as the change in distance from the terminated resistance along the transmission line. Wave trough in standing wave graph doesn't tend to 0 any more and wave crest is small than that appears when terminated with open-circuit device and short-circuit device.
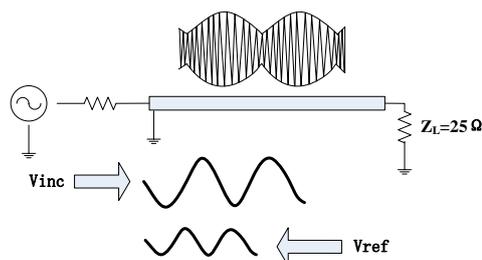
Fig.11-5   Signal Transmission of Transmission Line Terminated with 25Ω Resistance

1.4   Impedance

Impedance is another way to represent reflection data, see "Smith Chart Format" in Section 7 "Selecting Data Format and Scale" in Chapter V.

2   Overview of Reflection Measure Representation

Various data representing reflection are calculated according to the same Measure data and the relationship among is shown in Fig. below:

No Reflection   Full Reflection

$Z_L = Z_0$ $Z_L = \text{Open, Short}$

Return Loss $= -20\log(\rho)$ $\rho = |\Gamma|$

∞ dB   RL   0dB

$$VSWR = \frac{E_{MAX}}{E_{MIN}} = \frac{1+\rho}{1-\rho}$$

E_{MAX}
E_{MIN}

1   ∞

Reflection Coefficient $\Gamma = \dfrac{Vref}{Vinc} = \rho \angle \Phi = \dfrac{Z_L - Z_0}{Z_L + Z_0}$

0   ρ 1
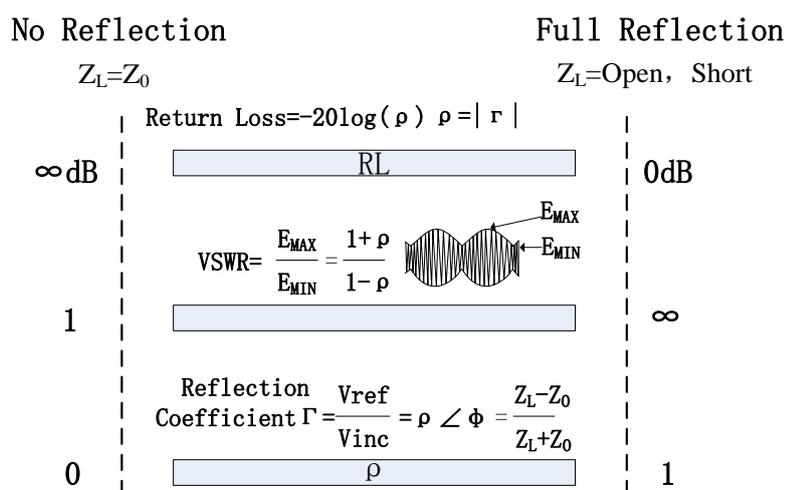
Fig.11-6   Relationships among Various Reflection Representations

Section 2   Phase Measure

1   What is Phase Measure

Understanding of both amplitude and phase information of the measured piece is very important for high level of component integration. Like amplitude Measure, phase Measure is also performed with parameter S. Phase Measure is relative (ratio) Measure other than absolute Measure, and when measuring, compare the phase entering device signal (incident signal) with phase of device response signal which can be incident signal or transmission signal. Assuming the Analyzer has been calibrated accurately, the phase difference (i.e. phase shift) between two signals is the Measure result of phase property of the measured piece. Fig. below displays the phase shift that can be observed through oscillograph between incident signal and transmission signal.
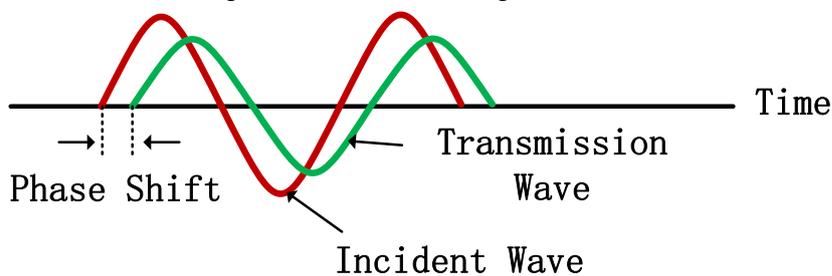
Fig.11-7   Phase Shift between Signals

2   Why Phase Measure is Performed

Phase Measure is an important measuring function of vector Network Analyzer. Fig. below lists the reasons to measure amplitude and phase accurately.
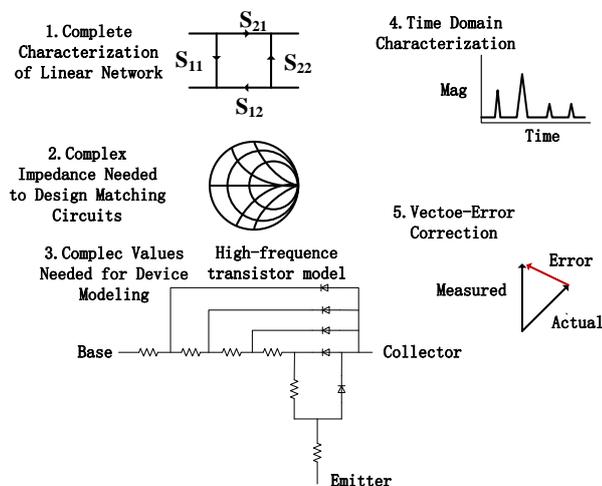
Fig.11-8   Reasons for Accurate Measure of Amplitude and Phase

When elements and circuits are used to transfer signals in communication system, signal distortion exceeding normal limit is not allowed. Signal distortion includes two types below:

- **Linear distortion:** it indicates the amplitude that cannot maintain flatness and linear phase shift within the concerned frequency band as the change in frequency.

- **Non-linear distortion:** it indicates new spectrum components in circuit.

Measuring amplitude and phase properties of the element and circuit is very important, since it can ensure that such circuits transfer or absorb energy effectively, preventing transmission signal distortion.

3　Phase Format for the Use of Analyzer

Phase format of the Analyzer displays phase change of the DUT with the change of frequency or power. Since the Analyzer cannot measure difference larger than ±180° between reference signal and response signal, phase value measured varies between +180° and -180° and the Analyzer displays hackle phase Measure Trace. Saw-tooth waveform cannot reach +180° and -180° all the time, this is because that Measure is performed on discrete frequency points, while data points at +180° and -180° may be beyond Sweep measuring points.
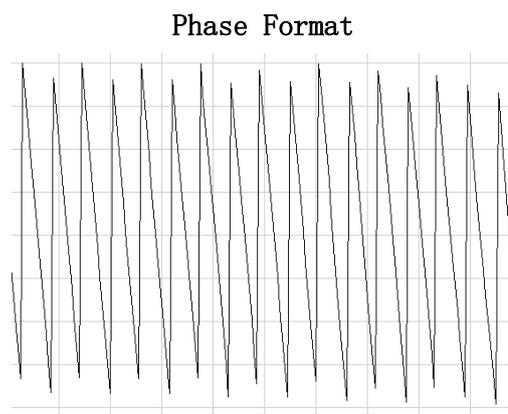
Phase Format

Fig.11-9　Phase Format for the Analyzer

4　Types of Phase Measure

- **Complex impedance:** complex impedance such as resistance and reactance can be determined by measuring S11 and S22, complex impedance of the measured piece can be observed by the use of smith chart and polar coordinate, refer to Section 4 "Complex Impedance" in this chapter for detailed information.

- **AM-PM conversion:** undesired phase offset occurs in AM-PM conversion Measure due to system amplitude change and it is defined as the change in output phase from input to power increase of amplifier 1dB, the unit is "degree/dB", measure at the gain compression

point of 1db, refer to Section 7 "AM-PM Conversion" in this chapter.

● **Linear phase offset:** linear phase offset is to measure phase distortion of the measured piece. In ideal condition, phase offset and frequency of the measured piece are in linear relationship, amount of deviation occurs relative to theoretical phase offset is called linear phase offset (also called phase linearity), see Section 9 "Linear Phase offset" in this chapter for detailed information.

● **Group delay**: group delay is another way to represent phase distortion of measuring piece, and it measures transition time within which the signal of the specific frequency for group delay passes the device. The Analyzer calculates group delay according to derivative of the measured phase; see Section 5 "Group Delay" in this chapter for detailed information.

5   Linear Phase offset and Group Delay

Both linear phase offset and group delay are phase information of measuring device, while they are used for Measures of different purposes.

Advantages of linear phase offset Measure:

● Lower noise level than group delay.

● It can better indicate the properties of the device transmitting phase modulation signals, and at this moment, phase as the unit is more proper than second.

Advantages of group delay Measure:

● It is easier to explain phase distortion than phase offset.

● Properties of the measured piece can be indicated in the most accurate way. Since the Analyzer calculates slope coefficient of phase ripples when measuring group delay and slope coefficient of phase ripple depends on ripple number in frequency unit, compare phase responses with the same phase ripple peak value and the larger phase slope coefficient response will result in:

* Larger change in group delay.

* Larger signal distortion.

Section 3   Instruction of Amplifier Parameters

1   Gain

Gain is the ratio of output power (output to load of characteristic impedance) of amplifier to its input power (input from source of characteristic impedance), which can be calculated by the following formula:

$$\tau = \frac{Vtrans}{Vinc}$$

$$Gain(dB) = 20\log_{10}(|\tau|) = Pout\ (dBm) - Pin\ (dBm)$$

In the case of small-signal, output power of amplifier is scaleal to its input power and small-signal gain is the gain within linear region.

With the increase of power level of input signal, the amplifier becomes saturation. Drop of gain is caused by output power reaching its limit. Gain of large-signal is within non-linear region. Refer to Section 8 "Gain Compression" of this chapter for more information.

2   Gain Flatness

Gain flatness averages gain variation within operating frequency range of amplifier. Refer to Section 11 "Small-signal Gain and Flatness" of this chapter for more information.

3   Reverse Isolation

Reverse isolation measures transmission between output port and input port and is similar to gain Measure. Reverse isolation, however, adds activation signal to output port of amplifier, which is different from gain Measure. Refer to Section 10 "Reverse Isolation" of this chapter for more information.

4   Drift of Gain with Time (Temperature, Bias)

It averages when all other parameters remain unchanged, max variation value of gain with time, and it is a function of time. Gain drift related to other parameters can also be calculated, such as drift of gain with temperature, moister and offset voltage.

5   Linear Phase offset

It averages modification value between linear phase shifts. Ideally, phase shift of amplifier is a linear function of frequency. Refer to Section 9 "Linear Phase offset" of this chapter for more information.

6   Group Delay

Group delay measures transit time of signal passing through amplifier, which is a function related to frequency. With the change of frequency, ideal linear phase-shift phase has constant rate of change, and

at this time, group delay is a constant. Group delay can be calculated by the following formula at actual Measure case:

$$t_G \ (\text{sec}) = \ -\frac{\Delta\varphi}{\Delta\omega} = -\frac{1}{360}*\frac{\Delta\theta}{\Delta f}$$

Refer to Section 5 "Group Delay" of this chapter for more information.

7   Return Loss (Standing Wave Ratio, ρ)

Return loss measures reflective match of amplifier relative to system impedance at input or output port, and return loss can be calculated by the following formula when it is measured:

$$\Gamma \ = \frac{\text{Vref}}{\text{Vinc}} = \rho \ \angle\theta \ (\text{Reflection coefficient}=\rho)$$

$$\text{Return loss(dB)} = -20\log_{10} \ (\rho)$$

$$\text{SWR} = \ \frac{1+\rho}{1-\rho}$$

8   Complex Impedance

Energy reflected by device relates to its complex impedance. Complex impedance consists of resistive component and reactive component, which can be calculated from system characteristic impedance and reflectance coefficient, as follows:

$$Z_L = \frac{1+\Gamma}{1-\Gamma} \times Z_0$$

Refer to Section 4 "Complex Impedance" of this chapter for more information.

9   Gain Compression

Amplifier has a linear gain region, in which gain is independent to level of input power (gain of small-signal). When power level increases to a certain value, amplifier becomes saturation to reduce the gain.

Gain compression is determined by measuring 1dB gain compression point of amplifier (P1dB). 1dB gain compression point averages output power of amplifier gain when gain of small-signal reduces 1dB, which is usually used to describe power output capacity of amplifier. Refer to Section 8 "Gain Compression" of this chapter for more information.

10   AM-PM Conversion

AM-PM conversion measures phase variation of output signal caused by amplitude modification of input signal of amplitude, and its unit is "degree/dB". AM-PM conversion is usually measured at 1dB gain compression point. Refer to Section 7 "AM-PM Conversion" of this chapter for more information.

Section 4   Complex Impedance

When conducting S_{11} or S_{22} Measure to DUT, complex impedance data of DUT, such as Series resistance and series reactance, can be observed in the same way of observing amplitude and phase information. Complex impedance data can be observed by using Smith Chart format.

1   What is Complex Impedance

Complex impedance data can be determined by S_{11} or S_{22} Measures of DUT, and reflected power of measured elements are related to impedance values of devices and measuring system. For example, only if impedance value of device and system is totally the same, complex reflection coefficient (Γ) is 0 (i.e. transmission efficiency of power from source to load is the max).Every Γ value has a unique complex impedance value, and complex impedance is a function of frequency.

$$Z_L = \frac{1 + \Gamma}{1 - \Gamma} \times Z_0$$

Where Z_L is impedance of measured device, and Z_0 is characteristic impedance of measuring system. Smith Chart format is suitable for measuring impedance. Refer to "Smith Chart Format" of Section 7 "Selecting Data Format and Scale" of Chapter V for more information.

2   Improvement of Measure Accuracy of Impedance

- When scale value is set to 1, Measure result of impedance can be understood easily by using Smith Chart format.

- When marker is used in Smith Chart format, higher Measure accuracy can be obtained by using discrete marker mode.

- Uncertainty of reflection Measure is influenced by following factors:
  * Directivity
  * Reflection Tracing
  * Source matching
  * Load matching

When calibrated with full dual-port, effects of these factors can be reduced. If output of measured piece connects to high quality load, single-port calibration can provide the same Measure accuracy, too. Measure connection of complex impedance is as follows:


Device Under Test   10dB Attenuator

Device
Under Test
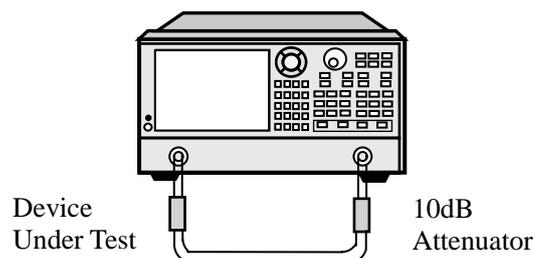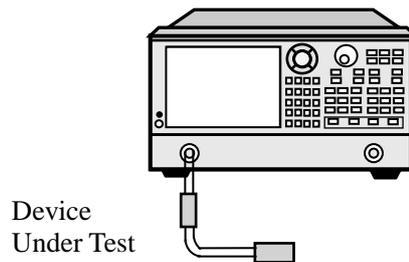
Fig. 11-10   Measure Connection of Impedance

●   After single-port calibration, if measured piece is connected between two ports of Analyzer, it is recommended to connect 10dB precision attenuator at output port of measured piece to improve Measure accuracy; but if full dual-port calibration has been conducted, since full dual-port has calibrated and modified load matching error, such attenuator is unnecessary to be connected.

●   After single-port calibration, if dual-port device is connected to one port of Analyzer, high quality load (e.g. load standard in calibration kit) must be connected at output port of device.

3   Measure Steps of Complex Impedance

a)   Reset Analyzer.

b)   Set and calibrate Analyzer.

c)   Connect devices as illustrated above to conduct S_{11} or S_{22} Measure.

d)   Observe impedance data:

    1)   Select Smith Chart format.

    2)   Set the scale of shown Measure results to conduct best observation.

    3)   Enable the marker, and move the marker along the Trace to read resistive and reactive component which require complex impedance of data point.

    4)   Print or store the data.

e)   Observe admittance data (if required):

    1)   Enable the marker, and select marker format of "G+jB" to read admittance data.

    2)   Set the scale of shown Measure results to conduct best observation.

    3)   Move the marker along the Trace to read conductance and susceptance component which require complex admittance of data point. Unit of conductance and susceptance is Siemens (s).

    4)   Print or store the data.

f)   Observe amplitude and phase of reflection coefficient:

    1)   Select Smith Chart or polar coordinate format.

    2)   Enable the marker and select marker format of logarithmic/phase or linear/phase.

3) Set the scale of shown Measure results to conduct best observation.

4) Move the marker along the Trace to read amplitude and phase information of required data point.

5) Print or store the data.

Section 5   Group Delay

Phase distortion of measured piece can be known by group delay Measure. Group delay is the actual transit time of signal passing through measured piece, which changes with frequency. When group delay index is indicated, it must be specified to be used to aperture of group delay Measure.

1   What is Group Delay

Group delay is:

- A method to measure phase distortion of device.

- Transit time of signal passing through device, which changes with frequency.

- Derivative for phase/frequency property of device.
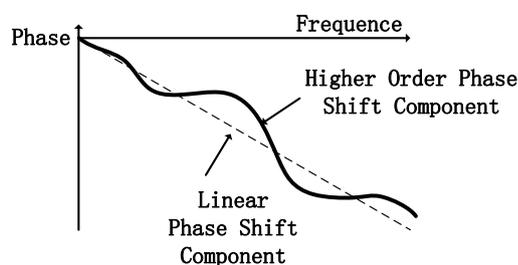
Fig. 11-11   Phase Properties of Device

Phase properties of device consist of linear phase-shift component and high phase-shift component:

- **Linear phase-shift component:** represents average transit time of signal, which indicates electrical length of device.

- **High phase-shift component:** represents transit time changing with frequency, which is the reason of signal distortion.

In group delay Measure:

- Linear phase-shift component represents average group delay.

- High phase-shift component represents modification to average group delay (ripple of group delay).

- As linear phase offset will cause distortion, group delay modification will cause signal distortion, too.

- Measure Trace for group delay of Analyzer indicates time of each frequency signal passing trough measured piece.
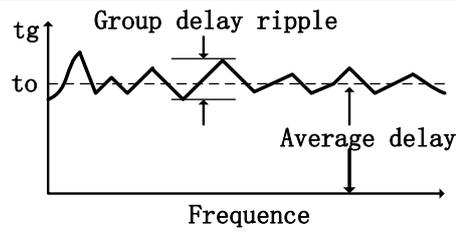
Fig. 11-12   Group Delay Properties of Device

Group delay is calculated by Analyzer with following methods:

- Phase change (-dφ) is obtained from phase data.

- Take the specified frequency aperture as frequency variation (dω).

- Calculate approximation of phase changing with frequency by using the above two values, and this approximation is group delay (provided phase linear change is within specified frequency aperture).

$$\text{Group Delay} = \frac{-d\varphi}{d\omega} \qquad \begin{array}{l} \varphi \text{ in radians} \\ \omega \text{ in radians/sec} \end{array}$$

$$= \frac{-1}{360} \bullet \frac{d\theta}{df} \qquad \begin{array}{l} \theta \text{ in Degrees} \\ f \text{ in Hz} \end{array}$$

2   Why should Group Delay be Measured

Usually, group delay can indicate phase distortion more accurate than linear phase offset, as illustrated below:
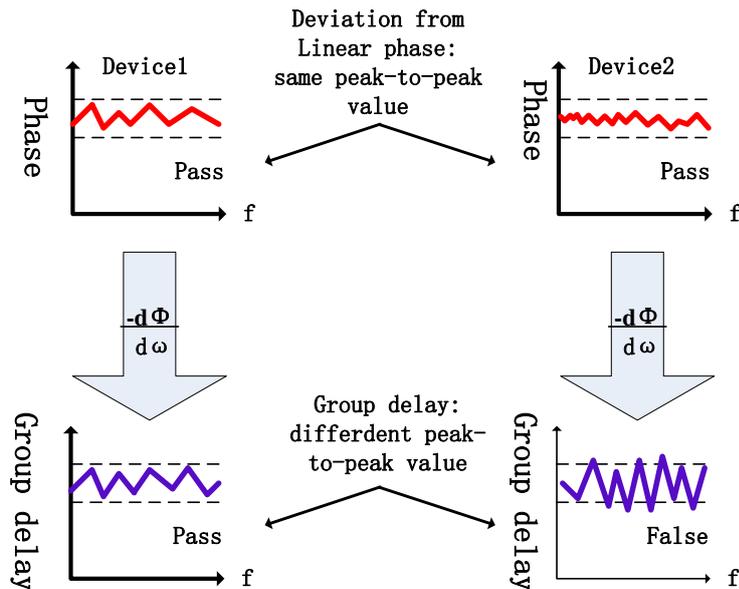
Fig. 11-13   Comparison of Group Delay and Linear Phase offset

- Upper portion of the Fig. indicates Measure results for linear phase offset of Devices 1 and 2. Although shape of Traces are different, Measure result for linear phase offset of two devices is identical.

- Lower portion of Fig. indicates Measure results for group delay of Devices 1 and 2. Since group delay is calculated by Analyzer by using slope of phase ripple, group delays of two devices are different. Phase ripple slope depends on the number of ripple in frequency.

3   What is Group Delay Aperture

When group delay is measured, phase on two adjacent frequency points shall be measured by Analyzer and then phase slope shall be calculated. Frequency interval (frequency difference) between two phase measuring points is known as aperture. Change of aperture can obtain different group delay values, and this is why apertures used in Measure must be known when group delay data are compared.
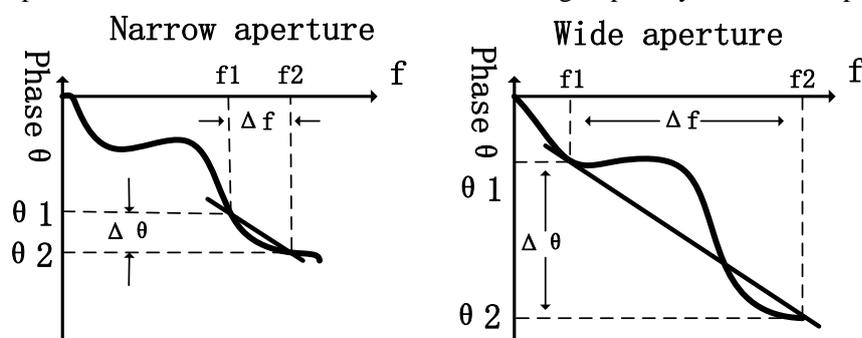
Fig. 11-14   Effects of Group Delay Aperture on Measure Results

Group delay aperture used in Measure of Analyzer is frequency interval of two adjacent sweep spots. The size of aperture can be changed by the following two methods:

a)   Change Measure spot or frequency span

- Increase spot or reduce frequency span to narrow aperture.
- Reduce spot or increase frequency span to widen aperture.

NOTE: **If aperture is too wide and when phase-shift between adjacent frequency points is more than 180°, error in group delay calculation may occur.**

b)   Utilize smoothing function of Analyzer

Conduct single sweep and enable smoothing function to change percentage of span in smooth set, which has the same effects as changing frequency interval between Sweep spots. This method allows wider group delay aperture to cause phase-shift of more than 180o within smooth

aperture.

Group delay can be measured under the following sweep types:

- Linear frequency

- Logarithmic frequency

- Segment sweep

Group delay aperture depends on frequency interval between measuring points, so that group delay aperture changes under sweep types of logarithmic frequency and segment sweep.

4   Improving Measure accuracy of group delay

When conducting group delay Measure, phase difference between adjacent measuring points shall be guaranteed to be less than 180°, or else phase and group delay information errors may occur, as follows:
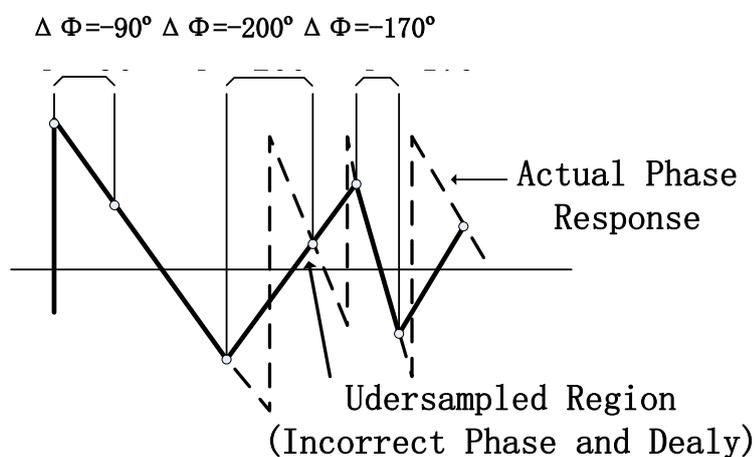
Fig. 11-15   Effects of Under-sampling on Group Delay Measure

When measuring long Electrical delay device, occur under-sampling may occur. Phase difference between two adjacent points can be ensued to be less than 180°by Adjust following settings until phase Measure Trace doesn't change.

- Increase spot number

- Reduce frequency span

Frequency response is the main error in group delay Measure. Through response calibration can significantly reduce such error. To obtain higher accuracy, full dual-port calibration shall be conducted. For amplifier, response may change with temperature, so that amplifier test shall be conducted under working temperature required.

5   Measure steps of group delay

a)   Reset Analyzer, if the measured piece is amplifier, source power of Analyzer must be adjusted:

● Source power of Analyzer shall be set to linear region of amplifier response (Usually, it shall at least be 10dB lower than the compression point of 1dB input).

● Connect attenuator at output port of amplifier to completely attenuate output power of amplifier, so as not to cause compression or burn-down of receiver at receiving port of Analyzer, if required.

b)   Connect measured piece as illustrated below.
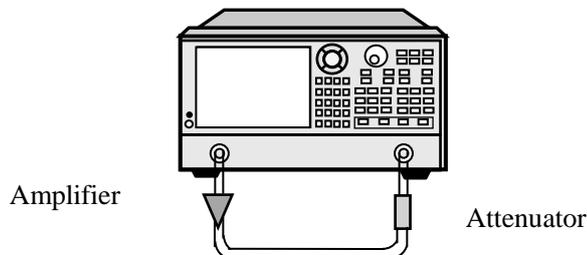
Fig. 11-16   Measure Connection of Group Delay

c)   Select S21 Measure.

d)   Select settings for measured piece, including:

● Format: phase.

● Scale: automatic.

● Measure spot number: select appropriate spot number to avoid under-sampling.

e)   Remove measured piece to conduct calibration.

f)   Reconnect measured piece.

g)   Display format is set as group delay. Set scale for Measure to conduct best observation.

h)   Increase the aperture, reduce noise on Trace by using smoothing function of Analyzer, and simultaneously, keep averageingful details. Following steps shall be taken to increase the aperture:

1)   Enable smooth function of Analyzer.

2)   Change smoothing aperture (the max is 25% of frequency span).

i)   Read group delay at concerned frequency by using marker.

j)   Print or store the data.

Section 6　Absolute Output Power

1　What is Absolute Output Power

Absolute output power measures power at receiving port of Analyzer, and such power is an absolute one without referring to (or scale to) incident power or source power. At this time, in log-magnitude format, unit of values related to ordinate axis of grid shall be dBm. dBm is the power measured by reference of 1mW:

- 0dBm=1mW
- -10dBm=100μW
- +10dBm=10mW

In linear magnitude format, unit of values related to ordinate axis of grid shall be W.

2　Why should Absolute Output Power be Measured

When amplifier output must be expressed by absolute power other than relative power Measure, absolute output power shall be measured. For example, when conducting gain compression Measure, absolute output power of amplifier at 1dB compression is usually measured. To improve Measure accuracy, following factors must be considered:

- Since too-large output power may cause the following results, output power of amplifier shall be completely attenuated, if necessary:
  - * Exceeding input compression level for receiver of Analyzer and resulting in inaccuracy of Measure results.
  - * Burning down receiver of Analyzer.
- Output power of amplifier can be attenuated by attenuator or coupler.
- Under different temperature conditions, amplifier has different response values. Amplifier can be measured only when it is under working temperature required.

3　Measure Steps of Absolute Output Power

a) Reset Analyzer.

b) Select non-ratio power to measure (source is input at Port 1 and B of receiver).

c) Source power of Analyzer is set to 0dBm.

d) Connect amplifier and provide DC offset as illustrated below. If necessary, use external attenuator to completely attenuate output power of amplifier and avoid compressing or burning down of receiver at Port 2 of Analyzer.
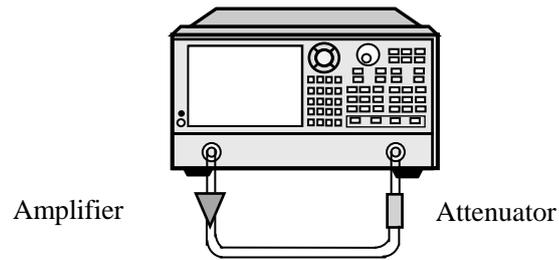
Fig. 11-17   Measure Connection of Absolute Output Power

e)   Select settings of Analyzer according to measured amplifier.

f)   Remove amplifier, connect the remaining attenuators and cables between two ports, use trajectory calculation function to store data Trace into memory and use data/storage function to conduct normalized calibration. If attenuator and cables are required when conducting amplifier Measure, normalized calibration must be conducted to them.

g)   Reconnect amplifier.

h)   Set scale for Measure to conduct best observation. Read absolute output power at required frequency by using marker.

i)   Print or store the data.

Section 7   AM-PM Conversion

AM-PM conversion of amplifier measures phase offset caused by change of system amplitude.

1   What is AM-PM Conversion

AM-PM conversion measures phase offset (PM) caused by amplitude modification (AM) of system. In communication system, phase offset (PM) may be caused by following reasons:

a)   Undesigned amplitude modification

- Mains fluctuation

- Thermal drift

- Multipath fading

b)   Intentional signal amplitude modulation

- QAM (quadrature amplitude modulation).

- Burst pulse modulation.

AM-PM conversion is usually defined as modification of output phase when Sweep power added to input port of amplifier increases 1dB (at 1dB gain compression point). Unit of AM-PM conversion is "degree/dB". If phase response of an amplifier is unrelated to power level of input signal, such amplifier is an ideal one.

$$\text{AM/PM Conversion} = \frac{\text{Mag(PM out)}}{\text{Mag(AM in)}} \text{(deg/dB)}$$
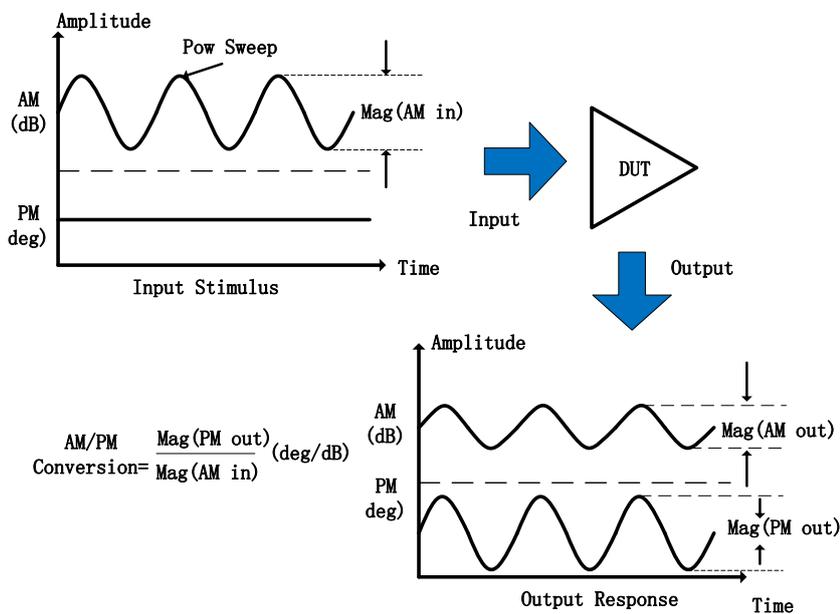
Fig. 11-18   Definition of AM-PM Conversion

2   Why should AM-PM Conversion be Measured

In the following phase (angle) modulation system, AM-PM conversion is a very important parameter:

- FM

- QPSK

- 16QAM

Undesirable phase offset (PM) may cause performance deterioration of analog signal or increase bit error (BER) in digital communication system. Although it is very easy to measure bit error rate (BER) in digital system, such Measure cannot facilitate to understand root cause of error code. AM-PM conversion is the main factor to cause bit error, therefore, it is essential to quantitatively measure this parameter in communication system.

- Desirable state change is from small solid line vector to large solid line vector.

- Because of AM-PM conversion, large solid line vector may finish like dotted line indicated, which is resulted from phase-shift caused by change of input power level.

- For 64QAM signal (only one quadrant) indicated above, overlapping of phase noise circle around each state averages that bit error will occur statistically.

3　Factors Related to Measure Accuracy

AM-PM conversion is measured by using Network Analyzer, and frequency of amplitude-modulated signal is approximate to reciprocal of sweep time. Modulation frequency is very low (usually lower than 10Hz), even if the fastest power Sweep is set. This may cause slight temperature change of measured piece in Sweep process, especially when thermal mass of amplification equipment is very small (unpackaged device is typical). If non-linear property of amplifier is very sensitive to thermal changes, errors may exist in Measure results obtained from such method. Therefore, in order to improve Measure accuracy, following factors shall be considered in Measure:

- Under different temperature conditions, amplifier response may be entirely different; therefore, test shall be conducted under working temperature required.

- Output power of amplifier shall be completely attenuated, if necessary. Too-large output power may cause following consequences:
  * Exceeding input compression level of receiver of Analyzer and resulting in inaccuracy of Measure results.
  * Burning down receiver of Analyzer.

- Output power of amplifier can be attenuated by using attenuator or coupler.

- During calibration, frequency response effects of attenuator and coupler must be considered. Since both of them are portions of test system, they must be calibrated. Perfect error modification technology can reduce or eliminate effects of these accessories on Measure accuracy.

- Frequency response is the error which plays a dominant role in AM-PM conversion Measure

component. Such error can be significantly reduced by using through response calibration.

4   Measure Steps of AM-PM Conversion

a)   Reset Analyzer.

b)   Select S21 Measure under power sweep mode.

c)   Set start and stop power levels for power sweep of Analyzer. Start power level shall be within linear region of amplifier response (usually at least 10dB lower than the compression point of 1dB input), and stop power level shall be within compression zone of amplifier response.

d)   If required, output power of amplifier shall be completely attenuated by using external attenuator or coupler to avoid compressing or burning down of receiver at Port 2 of Analyzer.

e)   Connect amplifier and provide DC offset as shown below.
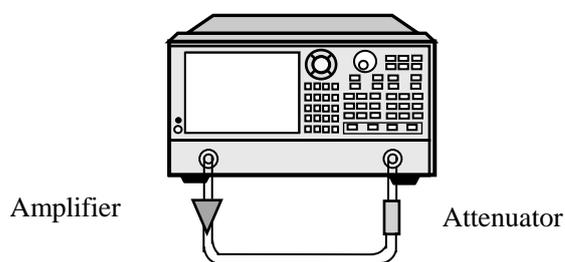
Fig. 11-19   Measure Connection of AM-PM Conversion

f)   Select Analyzer settings according to measured amplifier to conduct gain compression Measure of power sweep at selected frequency. For details, please refer to Section 8 "Gain Compression" of this chapter.

g)   Remove the amplifier to conduct calibration. If attenuator, coupler and cables are required when calibrating amplifier, such devices must be calibrated, too.

h)   Reconnect amplifier, enable Marker R and place it at 1dB gain compression point of amplifier; enable the second marker and Stimulus marker mode Δ. Incentive value of the second marker is set to -1dBm.

i)   Change format of S21 Measure from log-magnitude to phase (no need to recalibration).

j)   Read phase difference between markers, and such value is the AM-PM conversion coefficient at 1dB gain compression point.

k)   Print or store the data.

Section 8   Gain Compression

Gain compression measures power level that causes amplifier compression. In actual Measure, gain compression of amplifier is determined by the following three steps:

a) Measure gain compression of frequency Sweep and find out frequency point that 1dB gain compression first occurs.

b) Measure gain compression of power sweep. Conduct power sweep at certain frequency (frequency is determined from above Measure) to determine input power of gain reducing 1dB.

c) Measure absolute output power to determine absolute output power at compression service (unit: dBm).

1   What is Gain Compression

When input power of amplifier is increased to a certain level and results in gain declining of amplifier, which causes output power to increase with non-linear trend, gain compression occurs. Analyzer has the capability of power Sweep and frequency Sweep. Non-linear compression properties of amplifier can be determined by power sweep. Input and output properties of amplifier are shown below.
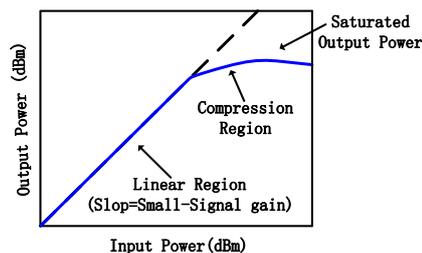
Fig. 11-20   Input and Output Properties of Amplifier

● Gain of amplifier at certain power level is the slope of such curve.

● When amplifier is working in linear region, gain is constant and unrelated to power level. Gain within this region is usually defined as small-signal gain.

● With the increase of input power, gain of amplifier begins to reduce and the amplifier enters into compression zone.

● The most common method used to measure amplifier compression is 1dB compression point Measure, which is defined as input power (sometimes, output power) of amplifier gain reducing 1dB (relative to small-signal gain of the amplifier).

2   Why should Gain Compression be Measured

When amplifier is driven by sinusoidal signal, output of amplifier is no longer sinusoidal signal at the time of compressing. Harmonic component, not only fundamental component of input signal occurs in

output signal. With the further increase of input power, amplifier becomes saturate and output power remains unchanged, and at this time, further increase of input power of amplifier will not change output power. In some cases, such as traveling wave tube (TWT) amplifier, actually, output power after saturation will reduce with the continuous increase of input power, which averages that the amplifier has negative gain. Since amplifier working in linear region is wished, it is very important to understand the size of input signal that causes gain compression.

3   Factors Related to Measure Accuracy

Analyzer must provide saturation area with a large enough power-driven amplifier. If power level for signal source of Analyzer cannot meet the requirement, preamplifier is required to improve power level in front of measured amplifier. If preamplifier is used, it must be calibrated. Since too-large output power may cause the following results, amplifier output shall be completely attenuated, if necessary:

- Exceeding input compression level of receiver of Analyzer and resulting in inaccuracy of Measure results.

- Damaging receiver of Analyzer.

- Output power of amplifier shall be attenuated by attenuator or coupler. As attenuator and coupler are components of Measure, their effects must be considered when conducting calibration. Correct error modification method can reduce effects brought by these accessories.

- Frequency response is the main error source in gain compression Measure, which can be significantly reduced by conducting through response calibration.

- Under different temperature conditions, amplifier response may be entirely different; therefore, test shall be conducted under working temperature required.

- Accuracy can be improved by reducing intermediate frequency bandwidth or utilizing Measure average, but Measure speed will be omitted.

4   Measure Steps of Gain Compression

4.1   Gain compression Measure of frequency Sweep

Gain compression Measure of frequency Sweep finds out frequency point that 1dB gain compression first occurs.

a)   Reset Analyzer.

b)   Select S21 Measure parameter and set source power of Analyzer to make amplifier work in linear region (power is usually 10dB lower than input 1dB compression point).

c)   If required, output power of amplifier shall be completely attenuated by using external attenuator or coupler to avoid compressing or burning down of receiver at Port 2 of Analyzer.

d)   Connect amplifier and provide DC offset as shown below.
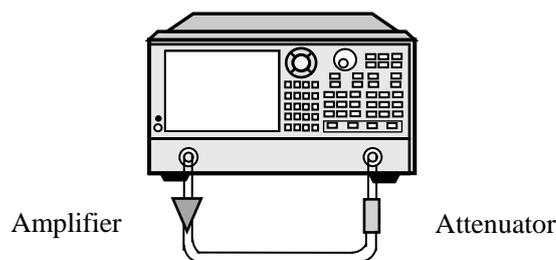
Fig. 11-21   Measure Connection of Gain Compression of Frequency Sweep

e) Set Analyzer according to measured amplifier. Narrower intermediate frequency bandwidth may be used to decrease effects of noise.

f) Remove amplifier to conduct through response calibration. If attenuator, coupler and cables are required when measuring amplifier, such devices must be calibrated, too.

g) Reconnect amplifier, enable marker and roughly place it at the center of frequency span.

h) Scale of Analyzer is set to 1dB/grid.

i) Increase source power progressively, until 1dB gain compression is observed at the first frequency of certain portion of the Trace.

j) Find out frequency that 1dB gain compression first occurs by using marker, and write down such frequency for subsequent Measure.

k) Print or store the data.

4.2 Gain compression Measure of power sweep

Gain compression Measure of power sweep determines input power which causes 1dB gain compression when power sweep is conducted at certain frequency (frequency determined in Measure step j) above).

a) If frequency of power sweep has not been determined, conduct gain compression Measure of frequency Sweep above.

b) Set S21 Measure under power sweep mode, following settings are included:

● CW Time is set to frequency determined in step j) of gain compression Measure of frequency Sweep.

● Set start and stop power level of sweep. Start power level shall make the amplifier be within linear region (usually, power shall be at least 10dB lower than input 1dB compression point), and stop power level shall make the amplifier be within compression zone.

c) The scale is set to 1dB/grid.

d) If required, output power of amplifier shall be completely attenuated by using external attenuator or coupler to avoid compressing or burning down of receiver at Port 2 of Analyzer.

e) Connect amplifier and provide DC offset as shown below.
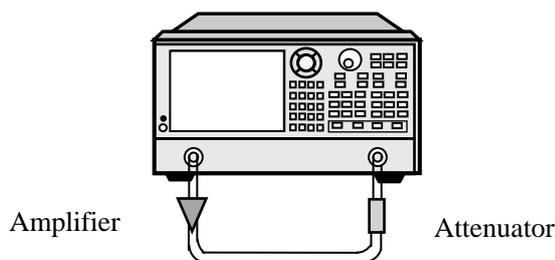
Fig. 11-22   Measure Connection of Gain compression of Power sweep

f)   Set Analyzer according to measured amplifier.

g)   Remove amplifier to conduct through response calibration. If attenuator, coupler and cables are required when measuring amplifier, such devices must be calibrated, too.

h)   Reconnect the amplifier, enable marker and determine input power of place where 1dB gain compression occurs.

i)   Print or store the data.

4.3   Absolute output power Measure

Absolute output power Measure determines absolute output power of amplifier at compressing (dBm).

a)   Select non-ratio power Measure method by using test components indicated in the previous Fig.. Source is set to input at Port 1 and B.

b)   Remain CW Time settings of gain compression Measure of power sweep previously.

c)   Marker is set to input power level (determined by Measure step h) previously) that 1dB gain compression occurs.

d)   Read response value of marker and determine absolute output power of amplifier at 1dB gain compression (dBm).

e)   Print or store the data.

| ⚠ | **NOTE:** | **Calibration cannot be conducted when measuring absolute power. Since loss caused by attenuator and cables cannot be compensated, modification must be manually conducted.** |

Section 9   Linear Phase Offset

Linear phase offset measures phase distortion of device. In Measure, linear part of phase-shift is removed by using Electrical delay function of Analyzer, so as to display non-linear part of phase-shift with high resolution: linear phase offset.

1   What is Linear Phase Shift

When transmitting signal, significant phase shift will occur with shorter and shorter signal wavelength, which is caused by increase of incident signal frequency. When phase response of device is scaleal to frequency, linear phase-shift occurs. Relationship Trace of phase and frequency displayed on Analyzer is an oblique line, whose slope is scaleal to electrical length of device. Undistorted signal transmission must have linear phase-shift.

2   What is Linear Phase offset

Actually, delays of some devices to some frequencies are larger than that to other frequencies, which form non-linear phase-shift and cause frequency spectrum (including several frequency component signals) distortion. Linear phase offset Measure is one way to determine size of such non-linear phase-shift.

Since phase distortion is only caused by linear phase offset, it is wished to remove relevant linear portion of phase response from Measure, which can be realized by using Electrical delay function of Analyzer. Electrical length of measured piece can be removed by mathematization, and the remaining is linear phase offset or phase distortion.

3   Why should Linear Phase off set be Measured

Linear phase offset Measure has following merits:

- Measure result is phase data, not group delay data with the unit of second. For devices that transmit modulation signal, phase data may be more practical.
- Provide a Measure method which has lower noise than group delay.

4   Utilization of Electrical delay Function

Electrical delay property of Analyzer has following functions:

- By simulating lossless transmission line with changeable length, transmission line can be conveniently added to signal path or removed from it.
- Compensate change for electrical length of measured piece.
- Make phase Measure Trace of Analyzer be straight, observation Trace with high resolution to find out non-linear details of phase.
- Provide a method of conveniently observing linear phase offset of measured piece.
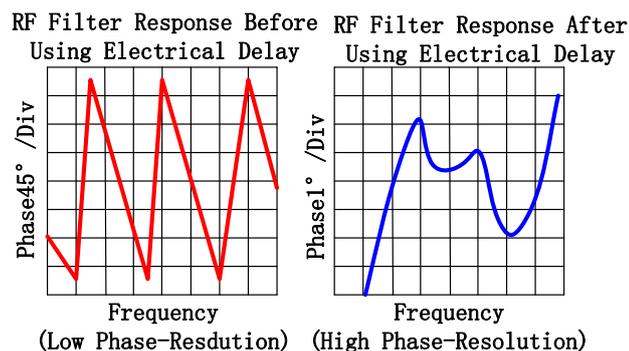
Fig. 11-23   Observing Linear Phase offset by Using Electrical delay Function

For details of Electrical delay, please refer to "Electrical delay" in Section 5 "Increasing Measure Accuracy of Phase" of Chapter VI.

5   Factors Related to Measure Accuracy

Frequency response of test component is an error which plays a major role in linear phase offset Measure and which can be significantly reduced by conducting through response calibration. In order to obtain higher accuracy, full dual-port calibration shall be conducted.

6   Measure Steps of Linear Phase offset

a)   Reset Analyzer, if the measured piece is an amplifier, source power of Analyzer may be adjusted:

- Set source power of Analyzer to make amplifier work in linear region (power is usually 10dB lower than input 1dB compression point).

- If required, output power of amplifier shall be completely attenuated by using external attenuator or coupler to avoid compressing or burning down of receiver at Port 2 of Analyzer.

b)   Select S21 Measure.

c)   Connect measured piece as shown below.

Amplifier
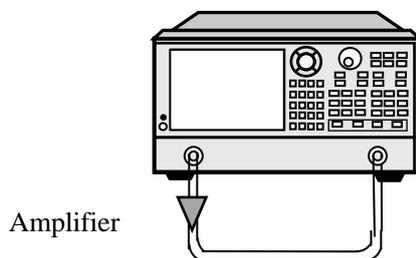
Fig. 11-24   Measure Connection of Linear Phase offset

d)   Set Analyzer according to measured piece, including setting format as phase.

e)   Remove measured piece to conduct calibration.

285

f)   Reconnect measured piece; set scale of Measure display to conduct best observation.

g)   Change Electrical delay to straighten phase Trace.

h)   Read linear phase offset by using marker.

i)   Print or store the data.

Section 10　Reverse Isolation

Reverse isolation measures reverse transmission response of amplifier from output to input.

1　What is Reverse Isolation

Reverse isolation measures isolation degree of device from output port to input port. Measure of reverse isolation is similar to that of forward gain, but has following differences:

- Activation signal is added to output port of amplifier.

- Response signal is measured at input port of amplifier.

- Its equivalent S parameter is S12.

2　Why should Reverse Isolation be Measured

Ideal amplifier shall have infinite reverse isolation, with no signal transmitting back to input port from output port. However, actually, signal may pass through the amplifier on the reverse direction. Such undesirable reverse transmission may cause reflected signal at output port to disturb signal required by forward transmission; therefore, it is very important to quantify reverse isolation.

3　Factors Related to Measure Accuracy

Since high loss of amplifier is usually represented at reverse direction, when measuring reverse transmission, external attenuator or coupler are not needed to protect receiver at Port 1. Removing attenuator and coupler will increase dynamic range, so as to improve Measure accuracy. Larger dynamic range and higher accuracy can be provided by increasing source power.

WARNING: **With removing of attenuator and increasing of radio-frequency power, receiver at Port 2 of Analyzer may be burnt down in forward sweep. Therefore, forward sweep or full dual-port calibration shall not be conducted, unless settings of forward power are low enough not to burn down receiver at Port 2 of Analyzer.**

If isolation of measured amplifier is very large, level of reverse transmission signal may be close to noise floor or Crosstalk level of receiver. In order to reduce noise floor, averages can be used, average number can be increased or dynamic range and accuracy of Measure can be improved by reducing intermediate frequency bandwidth, but Measure speed will be omitted.

- When Measure accuracy is affected by crosstalk level, crosstalk error can be reduced by conducting through response and isolation calibration. During calibration and Measure, identical average factor and intermediate frequency bandwidth must be adopted.

● In reverse isolation Measure, frequency response of test component is the main error source, which can be eliminated by conducting through response or through response and isolation calibration.

● Under different temperature conditions, amplifier response may be entirely differentl therefore, test shall be conducted under working temperature required.

4   Measure Steps of Reverse Isolation

a)   Reset Analyzer.

b)   Select S12 Measure.

c)   Connect amplifier and provide DC offset as shown below.
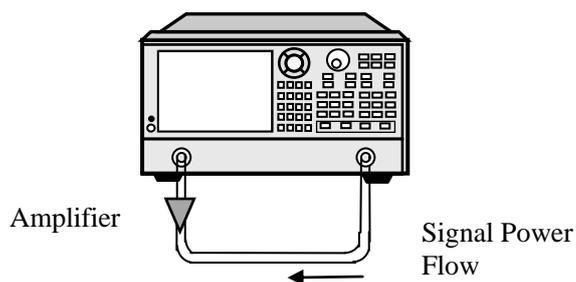
Fig. 11-25   Measure Connection of Reverse Isolation

d)   Set Analyzer according to measured amplifier.

e)   Remove the amplifier and conduct through response calibration or through response and isolation calibration.

f)   Reconnect the amplifier; set scale of Measure display to conduct best observation.

g)   Read reverse isolation at concerned frequency by using marker.

h)   Print or store the data.

Section 11   Small-signal Gain and Flatness

Small-signal gain is the gain of amplifier in linear working zone, which is usually measured under constant input power of sweep range. Gain flatness measures changes of gain in the specified frequency range.

1   What is Gain

Gain of amplifier is defined as power difference between output signal and input signal of amplifier (power unit is dBm). Besides, input and output impedance of amplifier is assumed to be identical and be characteristic impedance of the system.

- S parameter term used by gain is called as S21.
- dB used by gain represents log-ratiomethod of output power and input power.
- When input and output level are represented by dBm (i.e. 1mW power), gain can be calculated from output level minus input level.
- Gain of amplifier usually refers to the minimum gain in working frequency range. Minimum and maximum gains are given by some amplifiers simultaneously to ensure that subsequent levels of system will not be under-excitation or over-excitation.

2   What is Flatness

Flatness averages gain change of amplifier within the specified frequency range. Gain change of amplifier may cause distortion of signal which passes through the amplifier.

3   Why should Small-signal Gain and Flatness be Measured

Owing to gain offset in concerned bandwidth, frequency components of signals have not been enlarged on a par, which will cause transmission signal distortion. Small-signal gain represents gain of amplifier at specific frequency of 50Ω system, and flatness represents gain offset of amplifier in specified frequency range of 50Ω system.

4   Factors Related to Measure Accuracy

- Under different temperature conditions, amplifier response may be entirely different; therefore, test shall be conducted under working temperature required.
- Since too-large output power may cause the following results, output power of amplifier shall be completely attenuated, if necessary:
  * Exceeding input compression level of receiver of Analyzer and resulting in inaccuracy of Measure results.
  * Burning down receiver of Analyzer.

- Output power of amplifier can be attenuated by using attenuator or coupler. As attenuator and coupler are components of Measure, their effects of mismatch and frequency response on Measure accuracy must be considered when calibrating. Correct error modification method can reduce effects brought by these accessories.

- Frequency response of Measure component is the main error in Measure of small-signal gain and flatness, which can be significantly reduced by conducting through response calibration. Besides, full dual-port calibration can obtain higher Measure accuracy.

- Dynamic range and accuracy can be improved by reducing intermediate frequency bandwidth or utilizing Measure average, but Measure speed will be omitted.

5   Measure Steps of Small-signal Gain and Flatness

a)   Reset Analyzer.

b)   Select S21 Measure parameter.

c)   Set source power of Analyzer to make amplifier work in linear region. Usually, power is 10dB lower than input 1dB compression point.

d)   If required, output power of amplifier shall be completely attenuated by using external attenuator or coupler to avoid compressing or burning down of receiver at Port 2 of Analyzer.

e)   Connect amplifier and provide DC offset as shown below.
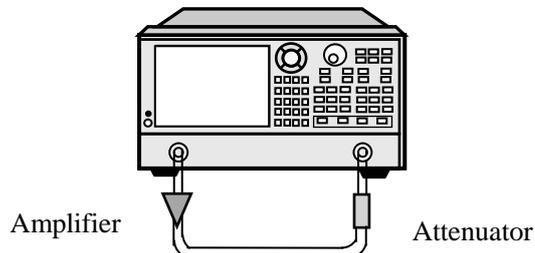
Fig. 11-26   Measure Connections of Small-signal Gain and Flatness

f)   Set Analyzer according to measured amplifier.

g)   Remove the amplifier and conduct calibration. Attenuators, couplers and cables used in Measure must be calibrated.

h)   Reconnect amplifier.

i)   Set scale of Measure display to conduct best observation. Read small-signal gain at concerned frequency point by using marker.

j)   By using marker, observe peak-to-peak ripple within the entire frequency range to measure gain flatness.

k)   Print or store the data.

Chapter XII   Four-port Calibration and Measurement

The 3656D analyzer provides the function of four-port measurement. This chapter will introduce the detailed four-port calibration and measurement methods.

■   Four-Port Calibration

■   Selection of Four-port Measurement Parameters

Section 1   Four-port Calibration

In order to ensure the accuracy of the measurement results, the instrument shall be calibrated before the test. So as to reduce the system error. The full four-port calibration will be taken as an example to introduce the calibration process.

1   Start Calibration

1.1   By mouse or touch screen

Click〔Response〕 and click 〔Calibration...〕in **[Cal]** submenu，and the Calibration dialog will be displayed.
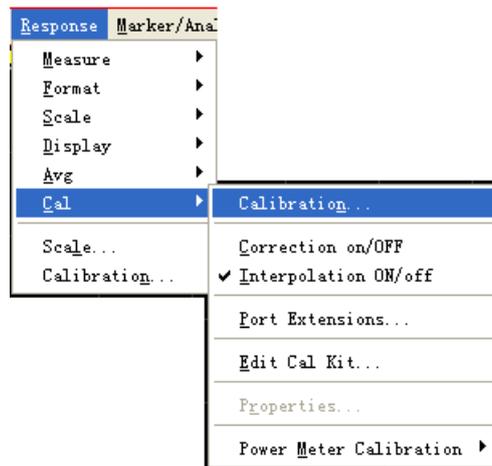
图 12-1   start calibration

1.2   By front panel keys

a) Press down 【**Cal**】 key in the RESPONSE key area，and press down the corresponding soft key of **[Cal wizard...]** in the displayed soft key menu, and the calibration dialog will pop up.

b) Set the calibration type：the **[Calibration Type]** dialog will pop up as shown in the following picture.Select **[SmartCal]**, click **[Next]** to pop up the **[Select Cal Type]** dialog.,Select 〔4 Port Cal〕. click **[Next]**, and select the connectors type and the calibration kits of the corresponding DUT according to the port type of the DUT.
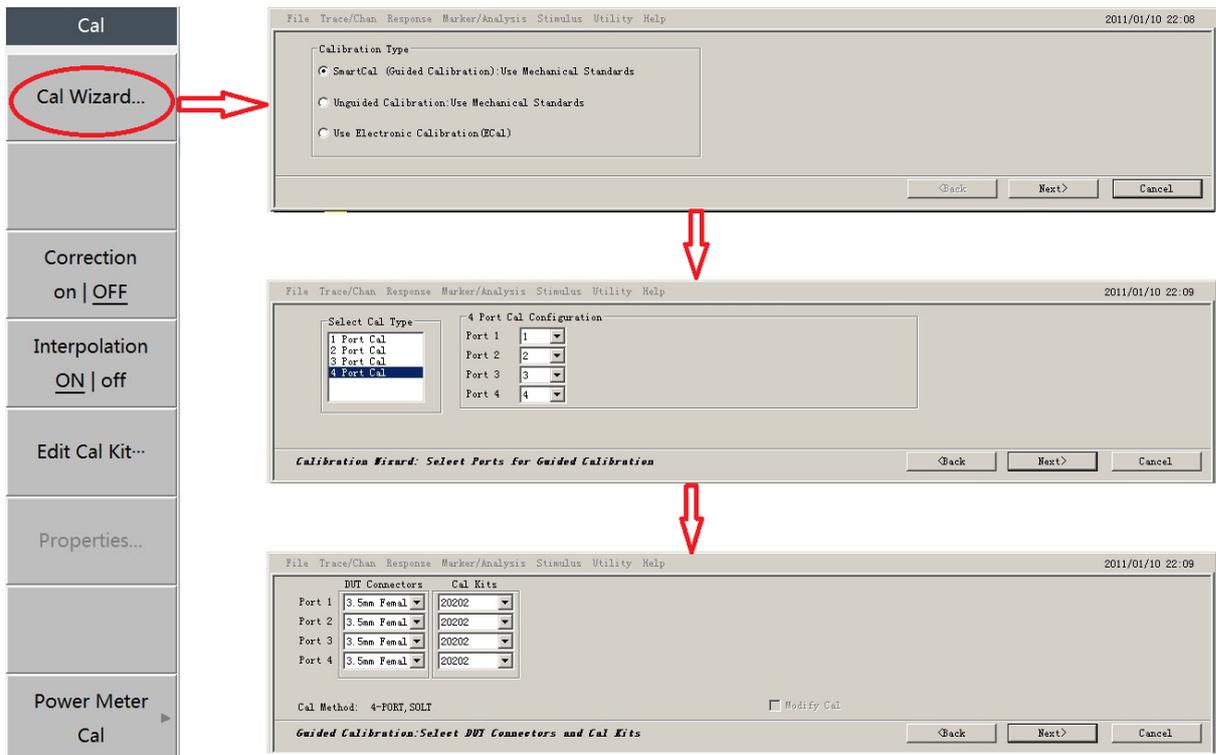
Fig. 12-2   Calibration Setting Process

c) Click **[Next]** in the above picture to enter the calibration interface as shown in Fig. 12-3. Connect the OPEN sandard to the the other end of the cable connected to the port 1. Press **[Measure]**, after PORT1 OPEN calibration is completed, and the dialog will automatically skip to the PORT1 SHORT calibration interface as shown in Fig. 12-4. Complete 18-step calibration of the full four-port in turn according to the prompts as shown in Fig. 12-5, and click **[Finish]**. 6 **[Delay]** dialogs of specifying the delay for the adapter as shown in Fig. 12-6 will pop up in turn, and then click **[OK]** to complete full four-port calibration.

Fig.12-3 Interface of PORT1 OPEN Calibration
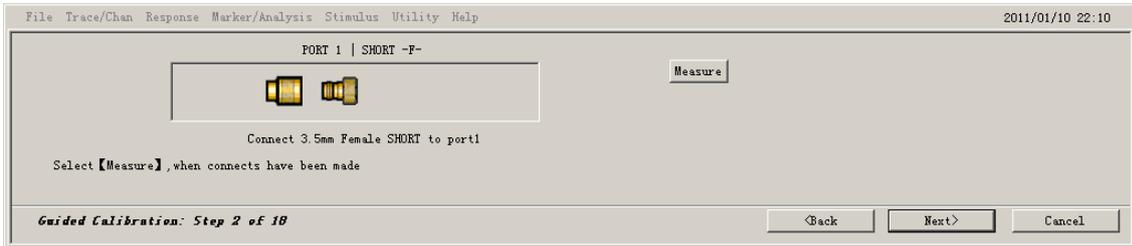
Fig.12-4 Interface of PORT1 SHORT Calibration
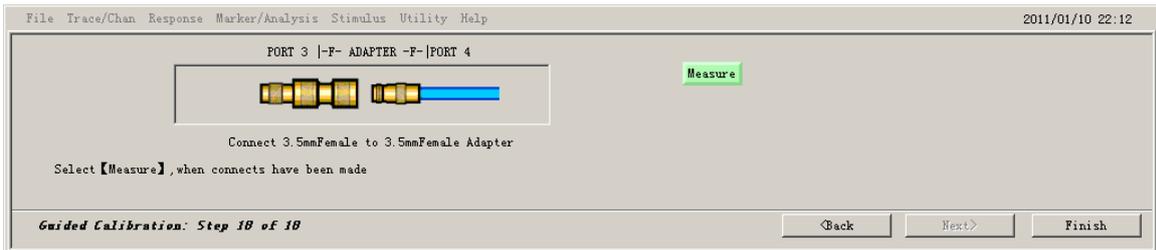
Fig. 12-5 Interface of the Full-port Calibration Completion

Fig. 12-6 Delay Dialog Box

Section 2   Selection of Four-port Measrement Parameters

1   Selection of S-parameter

1.1   By mouse or touch screen

As shown in Fig. 12-8, click **[Response]**, and click **[Measure]** submenu to select the required S-parameter. Or click **[Response]**, and click **[Measure...]** in the [**Measure**] submenu. After the Measure dialog pops up as shown in Fig. 12-9, click the required S-parameter, and click [**OK**].
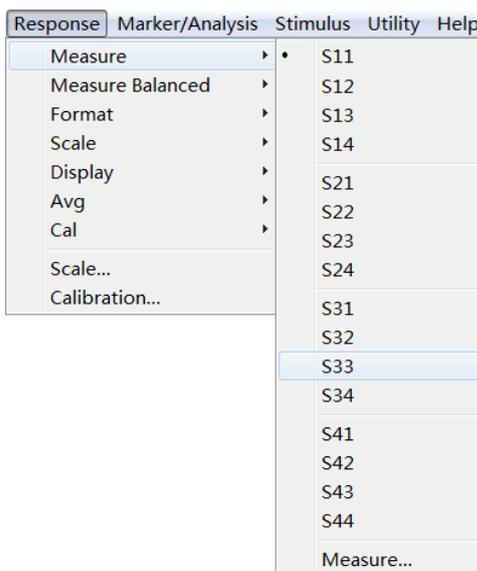
Fig 12-7   Selection of S-parameter
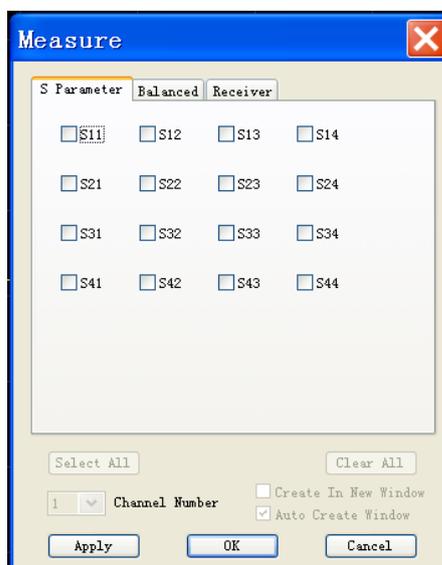
Fig 12-8   Measure Parameter Dialog Box

1.2   By front panel keys

Press **[Meas]** key in the **Response** key area, and press down **[Measure...]** menu item in the displayed soft

key menu. After the Measure dialog pops up as shown in Fig. 12-9, click the required S-parameter, and click [**OK**].

2   Selection of balanced parameter

Select the **Balanced** tab in the Measure dialog as shown in Fig. 12-9, and click [**Change**] button. According to the type of the actual measured differential device, select the corresponding topology in the [**Balanced DUT Topology/Logical Port Mapping**] dialog, click [**OK**], and select the required balanced parameters.
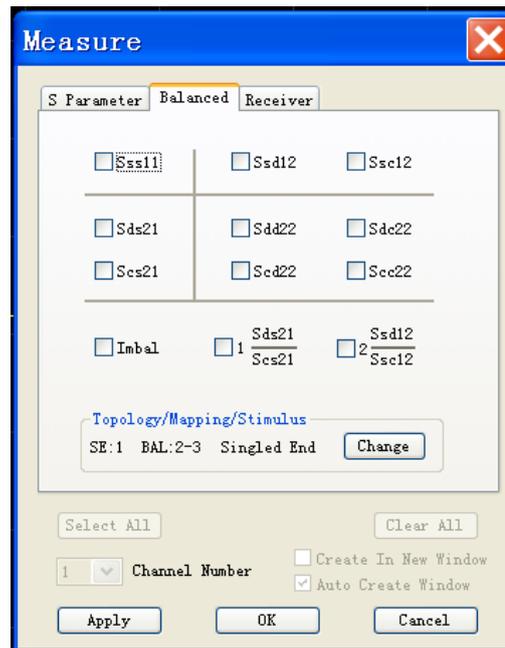
Fig 12-9 Balanced Parameter Setting Ⅰ
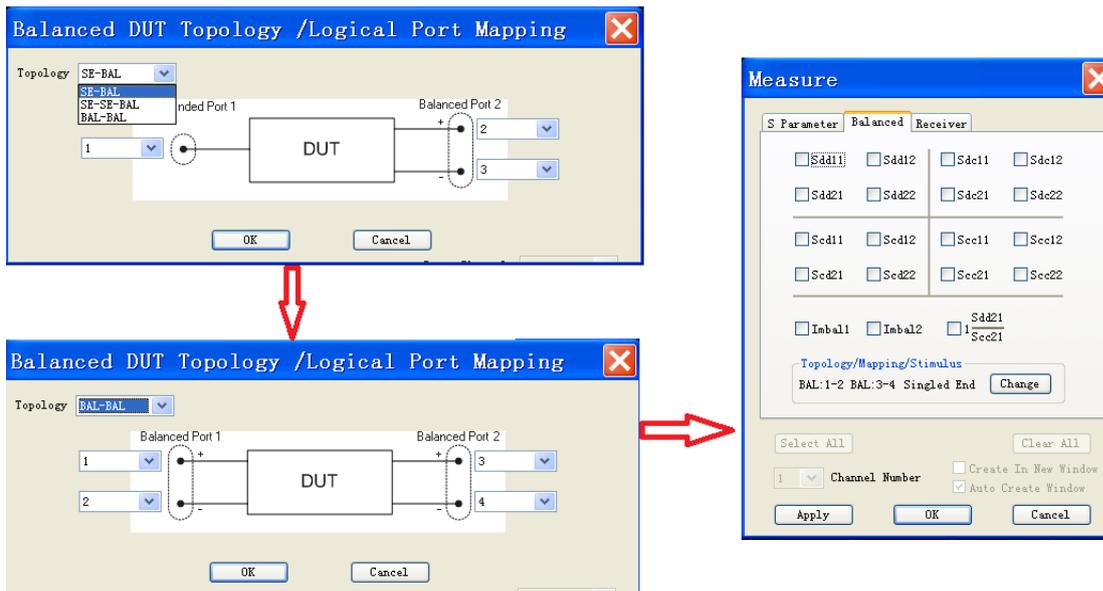
Fig 12-10 Balanced Parameter Setting Ⅱ

3   Selection of Reciever

Select the **Receiver** tab in the Measure dialog as shown in Fig. 12-9, and activate the corresponding receiver required as shown in Fig. 12-12.
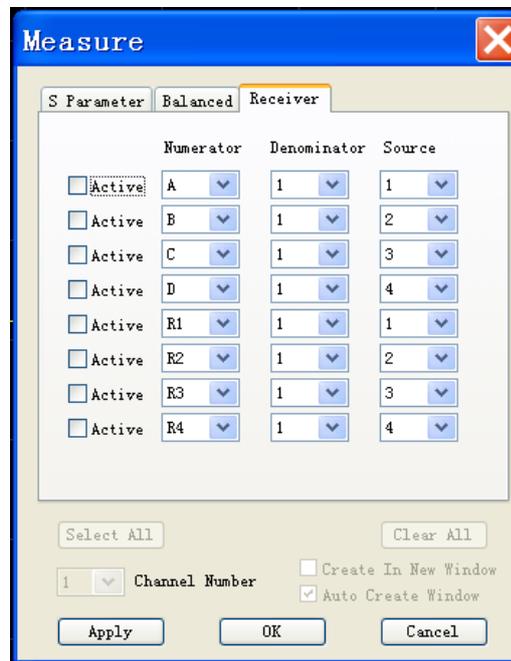
Fig 12-11 Selection of Receiver

Part II   Technical Instruction

Chapter XIII   Operating Principle

This chapter summarizes basic operating principles of 3656 Series Vector Network Analyzer (VNA).

1   Response of DUT to Radio-frequency Signal

Activation signals of test are generated from signal source of Analyzer. When test signals are input into DUT, some are reflected and others are transmitted. Fig. 12-1 indicates response to test signals passing through measured device.
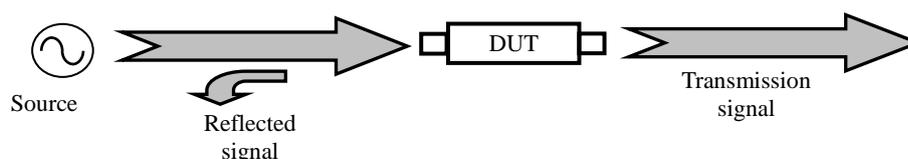

Fig. 13-1   Response of DUT to Signal

2   Principle of Complete Machine

3656 Series Vector Network Analyzer is used to measure reflection and transmission property of device and network. The complete machine mainly consists of signal source, local oscillator, S parameter test module, LO power divider mixer module, digital signal processing and embedded computer module and liquid crystal display (LCD) module. S parameter test equipment module is used to generate reference signal and separate reflected signal and transmission signal of measured piece: when source is output at Port 1, reference signal R1, reflected signal A and transmission signal B are generated; when source is output at Port 2, reference signal R2, reflected signal B and transmission signal A are generated. RF signal is converted into IF signal with fixed frequency by LO power divider mixer module. Local oscillator and signal source phase lock are on the same reference base to guarantee that phase data of measured piece cannot be lost during frequency transformation. In digital signal processing and embedded computer module, analog IF is converted into digital signal, and amplitude and phase information of measured piece is obtained from calculation. Such information sends the results to display module after various transformation processing, and liquid crystal display module displays amplitude and phase information of measured piece in the format required by user. Principle block diagram of complete machine is as follows:
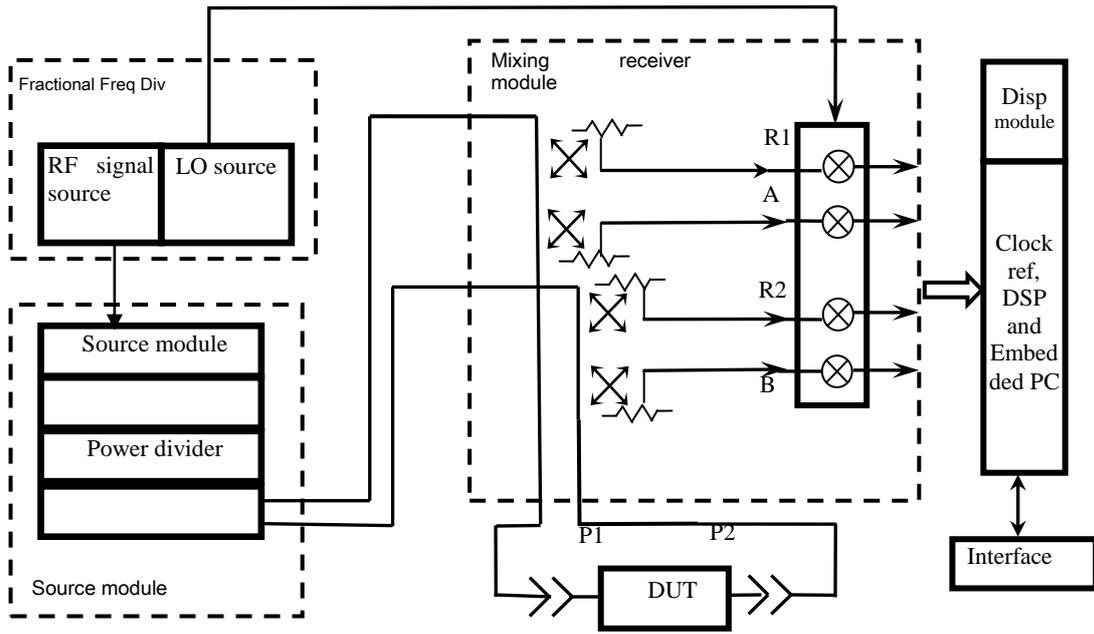
Fig. 13-2   Overall Block Diagram

Chapter XIV   Technical Parameter

This chapter lists performance indexes and technical parameters of 3656 Series Vector Network Analyzer in detail. By reading this chapter, user may have a more precise understanding to main performance indexes of this product. Normal working condition of Analyzer: ambient temperature of 0℃~+40℃, 1 normal atmosphere pressure, and ambient temperature of test data of 23℃±3℃.

3656A/B Technical Parameter

Test Item	3656A		3656B	
Frequency Range	100kHz ～ 3GHz		100kHz ～ 8.5GHz	
Frequency Resolution	1Hz		1Hz	
Frequency Accuracy	$\pm5\times10^{-6}$(23℃±3℃)		$\pm5\times10^{-6}$(23℃±3℃)	
Power Range	-45dBm～+10dBm		-55dBm～+10dBm	
Dynamic Range	（10Hz）（3kHz） 100kHz～1MHz　90dB　60dB 1MHz～10MHz　110 dB　80 dB 10MHz～3GHz　125dB　95dB		（10Hz）（3kHz） 100kHz～20MHz　110dB　80dB 20MHz～3GHz　125 dB　95 dB 3GHz～6GHz　123dB　93dB 6GHz～8.5GHz　118dB　88dB	
Reflection Track	100kHz～10MHz　±0.030dB 10MHz～3GHz　±0.020dB		100kHz～3GHz　±0.030dB 3GHz～6GHz　±0.040dB 6GHz～8.5GHz　±0.050dB	
Transmission Track	100kHz～10MHz　±0.030dB 10MHz～3GHz　±0.020dB		100kHz～3GHz　±0.030dB 3GHz～6GHz　±0.040dB 6GHz～8.5GHz　±0.050dB	
Effective Directivity	100kHz～10MHz　49 dB 10MHz～3GHz　46 dB 100kHz～10MHz　49dB（OptionH01） 10MHz～3GHz　46dB（OptionH01）		100kHz～3GHz　46dB 3GHz～6GHz　40dB 6GHz～8.5GHz　38dB	
Effective Source Match	100kHz～10MHz　44dB 10MHz～3GHz　40dB 100kHz～10MHz　43dB（OptionH01） 10MHz～3GHz　21dB（OptionH01）		100kHz～3GHz　36dB 3GHz～6GHz　35dB 6GHz～8.5GHz　33dB	
Effective Load Match	100kHz～10MHz　49 dB 10MHz～3GHz　46 dB 100kHz～10MHz　48dB（OptionH01） 10MHz～3GHz　41dB（OptionH01）		100kHz～3GHz　44dB 3GHz～6GHz　40dB 6GHz～8.5GHz　36dB	
Test Points	1 to 16001			
IF Bandwidth	Min.1Hz；Max.5MHz，in 1，2，3，5，7step			
Port connector type	N type（female）　50ohm system impedance N type（female）　75ohm system impedance　（3656-H01）			
Number of test ports	2			
Number of test receivers	4			
Reference level amplitude setting	Setting range：±500dB			

	Setting resolution：0.001dB
Reference phase setting	Setting range：±500°
	Setting resolution：0.01°
Time-base reference output	Output frequency：10MHz
	Output level：+10dBm±4dB
Digital interface	GP-IB、USB、Ethemet interface and VGA
Operation system	Windows XP
Display	10.4-inch high brightness LCD
Test domain	Frequency domain, Time domain
Dimensions	435×233×348 (W×H×D)（including foot pad, foot, lateral stripping, input and output port）
Power consumption	150W
Power supply	50Hz single phase 220V or 50Hz/60Hz single phase 110V AC
Weight	16kg

3656D Technical Parameter

Test Item	3656D		
Frequency range	300kHz ～ 20GHz		
Frequency resolution	1Hz		
Frequency accuracy	$\pm 1\times 10^{-6}$(23℃±3℃)		
System dynamic range IF Bandwidth：10Hz	Frequency range	2-port	4-port
	300kHz～100MHz	95dB	90 dB
	100MHz～1GHz	110dB	100 dB
	1GHz～6GHz	120dB	115 dB
	6GHz～8GHz	117dB	110 dB
	8GHz～10GHz	115dB	105 dB
	10GHz～15GHz	110dB	100 dB
	15GHz～20GHz	100dB	90 dB
Reflection track	300kHz～10MHz ±0.030dB 10MHz～3GHz ±0.040dB 3GHz～20GHz ±0.050dB		
Transimission track	300kHz～10MHz ±0.030dB 10MHz～3GHz ±0.040dB 3GHz～6GHz ±0.100dB 6GHz～20GHz ±0.150dB		
Effective directivity	300kHz～10MHz 46dB 10MHz～3GHz 42dB 3GHz～6GHz 38dB 6GHz～20GHz 36dB		
Effective source match	300kHz～10MHz 37dB 10MHz～3GHz 37dB 3GHz～6GHz 31dB 6GHz～20GHz 28dB		
Effective load match	300kHz～10MHz 44dB		

	10MHz～3GHz 42dB
	3GHz～6GHz 38dB
	6GHz～20GHz 36dB
Test points	1 to 16001
IF Bandwidth	Min.1Hz；Max.5MHz，in 1，2，3，5，7 step
Port connector type	3.5mm(Male)， 50ohm system impedance
Number of test ports	2/4
Number of test receivers	2/4
Reference level amplitude setting	Setting range：±500dB Setting resolution：0.001dB
Reference phase setting	Setting range：±500° Setting resolution：0.01°
Time-base reference output	Output frequency：10MHz Output level：+10dBm±4dB
Digital interface	GP-IB,USB,Ethernet interface and VGA
Operation system	Windows XP
Display	10.4-inch high brightness LCD
Test domain	Frequency domain, Time domain
Dimensions	436×236.5×410 (W×H×D) (including foot pad, foot, lateral stripping, input and output port)
Power consumption	150W
Power supply	50Hz single phase 220V or 50Hz/60Hz single phase 110V AC
Weight	18kg