DOLPH MICROWAVE

Waveguide Calibration Kit Instruction Manual

Summarize

This standard kit is mainly used for waveguide calibration of vector network analyzers. Operating procedure Reference Operating at 40 MHz to 40 GHz. The Anritsu 37369A vector network analyzer.

The waveguide calibration kit includes all the precision waveguide calibration elements needed to correct 12 errors when measuring waveguides in VNA, ensuring accurate and reliable measurement results.

Waveguide Calibration Kit Box

The precision components and corresponding tools required for calibration provided by the waveguide calibration kit are shown below.

Each precision waveguide calibration kit includes a list of components:

Precision WG Calibration Kit Includes List			
No.	**Descripption**	**Parameter**	**Qty**
1	WG to Coaxial Adapter	Each of Male and Female Connector, VSWR⩽1.25:1	2

2	WG Matched Termination	VSWR⩽1.03	1
3	WG Short Plate	VSWR⩾60	2
4	1/4 λ Precision WG Section	L=1/4 λ	1
5	1/8 λ Precision WG Section	L=1/8 λ	1
6	3/8 λ Precision WG Section	L=3/8 λ	1
7	Packing Case of Aluminum Alloy	/	1
8	Screws	/	1

● Calibration Principle

➢ Selection of calibration technology

Many of today's vector network analyzers (VNA) have strong processing power and flexibility and provide more calibration methods for users to choose from, mainly: SOLT (short-circuit-open-load-through-pass), TRL (straight-reflection-transmission line) methods.

SOLT calibration is easy to operate and provides excellent accuracy and repeatability. This calibration method requires the use of short circuit, open circuit and load standard calibration components, and the measurement accuracy is closely related to the accuracy of the standard components, and is generally only suitable for coaxial environment measurement.

TRL (Thru, Reflect, Line) calibration is generally used when high accuracy is required and the connection type between the standard calibration part and the tested part is different.

TRL calibration is a more accurate calibration method than SOLT calibration, especially suitable for measurement in non-coaxial environments.

Its standard parts do not need to be completely or precisely defined as SOLT standard parts, the accuracy of calibration is only partially related to the quality and repeatability of TRL standard parts, rather than completely determined by the standard parts, and it is easier to manufacture and characterize three TRL standard parts than to manufacture and characterize four SOLT standard parts.

Therefore, for non-coaxial waveguide calibration, TRL calibration technology can only be used more accurate than SOLT calibration.

- **Calibration of 12 error models by TRL method**

Generally, the measurement system can be simplified into three network phase cascades as shown in Figure 2.

The signal flow diagram corresponding to the 12-item system error model is shown in Figure 3, where there are 6 items in the forward direction and 6 items in the reverse direction of the tested component.

Figure 3 shows the forward error terms: E11 (direction), E22 (source matching), ER (load matching), E12 (reflection tracking), ET (transmission tracking), and EX (crosstalk). R, A, and B represent the signal of the network analyzer reference port, channel A, and channel B respectively, and RFin is the output of the signal source. Assuming that the calibration network A is reciprocal, we have E12= E21.

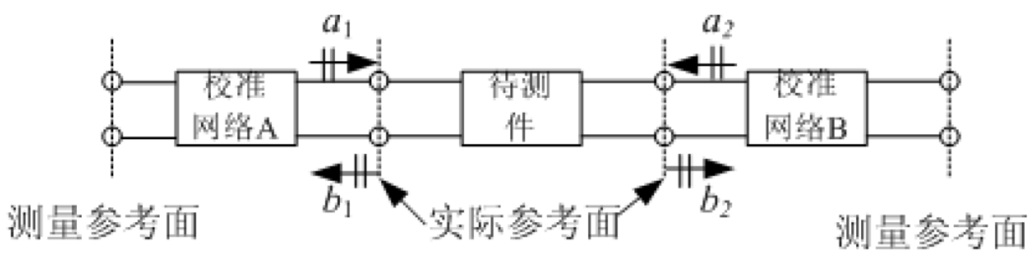

FIG. 2 Block diagram of S-parameter test system for two-port network

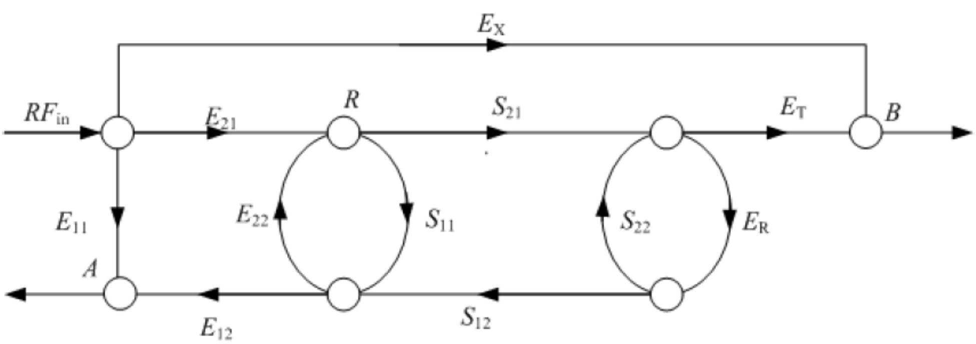

FIG. 3 describes the systematic error of the S-parameter test system using a 12-item error model. (Here is the forward error, the reverse error model is similar)

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When the straight-through-reflection-transmission line calibration method is used, the signal flow diagrams corresponding to the three connection methods are shown in Figure 4 (a), (b), (c) respectively. The straight-through state means that the two test ports are directly connected. Pass, so S11=S22=0, S21=S12=1,

then

$$R_T = \frac{E_{12}}{1-E_{22}E_R} \qquad (1)$$

$$A_T = E_{11} + \frac{E_{12}^2}{1-E_{22}E_R}E_R \qquad (2)$$

$$B_T = E_X + E_T\frac{E_{12}^2}{1-E_{22}E_R} \qquad (3)$$

For the reflection state, it means to connect both ports to the same large reflection load (such as short circuit), assuming that the reflection coefficient of both is Γ, and

There is no direct signal transmission between the two ports, so S11=S22=Γ, S21=S12=0,

then

$$R_R = \frac{E_{12}}{1-E_{22}\Gamma} \qquad (4)$$

$$A_R = E_{11} + \frac{E_{12}^2\Gamma}{1-E_{22}\Gamma} \qquad (5)$$

$$B_R = E_X \qquad (6)$$

For the transmission line state, that is, a standard air line segment of electrical length l with the same characteristic impedance as the calibration network is connected between the two ports,

Therefore, $S_{11}=S_{22}=0$, $S_{21}=S_{12}=e^{-i\beta l}$

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$$R_L = \frac{E_{12}}{1 - E_{22} E_R e^{-j2\beta l}} \qquad (7)$$

$$A_L = E_{11} + \frac{E_{12}^2 E_R e^{-i\beta l}}{1 - E_{22} E_R e^{-i\beta l}} \qquad (8)$$

$$B_L = E_X + E_T e^{-j2\beta l} \frac{E_{12}^2}{1 - E_{22} E_R e^{-j2\beta l}} \qquad (9)$$

According to the 9 equations obtained in the above calibration process, we can solve E11 (direction), E22 (source matching), ER (load matching),

E12 (reflection tracking), ET (emission tracking) and EX (crosstalk) as well as the reflection coefficient Γ and the transmission line parameter $e^{-i\beta l}$

Similarly, the corresponding error parameters of the inverse error model can also be determined by the same method.

The frequency sweep measurement system of modern automatic network analyzers will sample error models corresponding to different frequency points within the set measurement frequency band.

The parameters are stored and the accurate S parameters of the component under test are automatically calculated through the corresponding program.

The corresponding error parameters of the reverse error model can also be determined by the same method.

The sweep frequency measurement system of modern automatic network analyzer will sample the error model parameters corresponding to different frequency points in the set measurement frequency band and store them, and calculate the accurate S-parameter of the component to be measured automatically through the corresponding program.

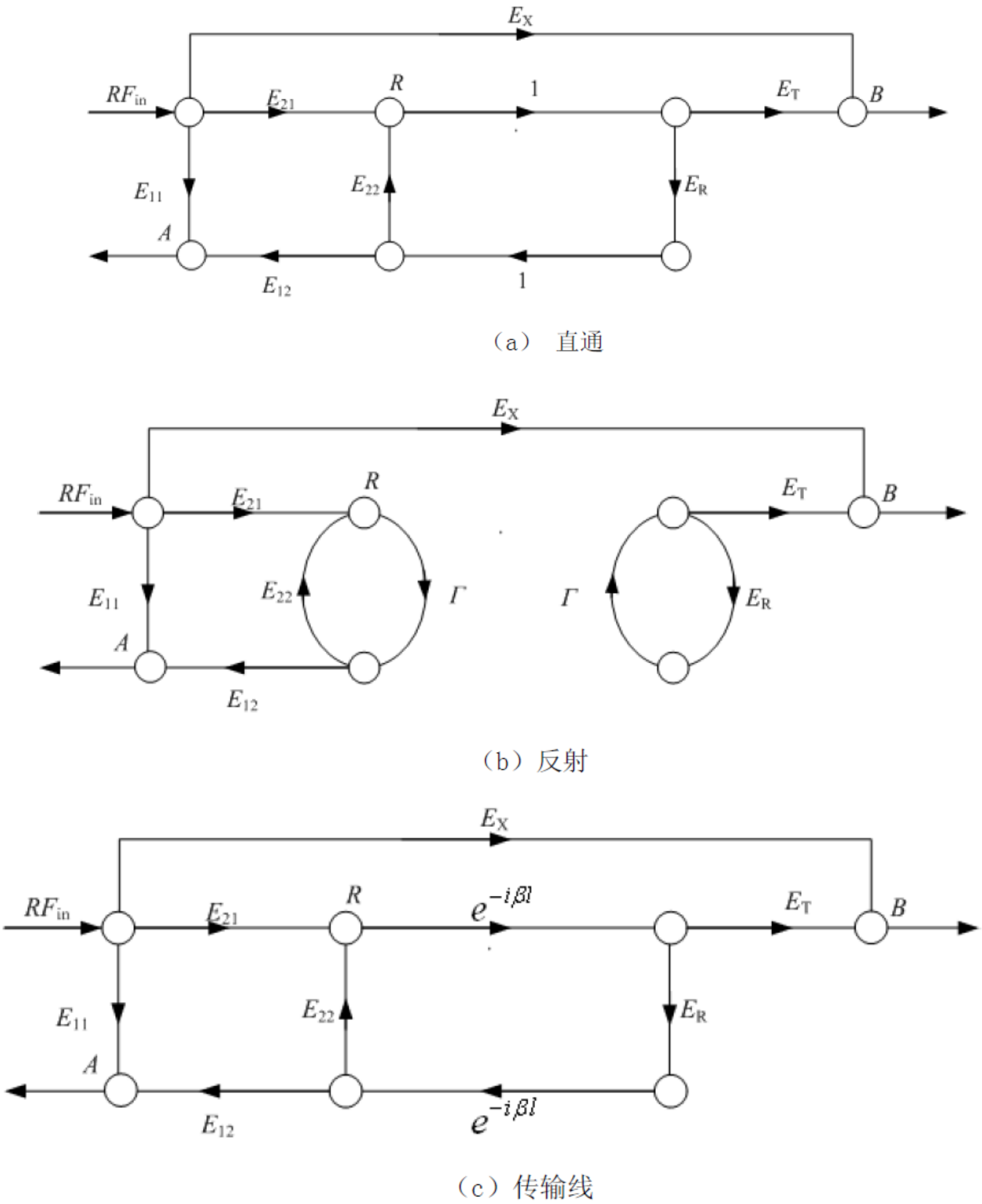

Figure 4 Signal flow diagram of straight-reflection-transmission line calibration method

Calibration Steps

TRL calibration is performed using the short circuit bias calibration procedure provided in the Anritsu Usage Guide, a standard technique for wave calibration that uses a short circuit bias and a direct short circuit to distinguish the inherent errors of a waveguide measurement system. These errors include errors caused by connectors as well as inherent system errors such as radio frequency (RF) leakage, intermediate frequency (IF) leakage, and component coupling.

Specific calibration steps:

- **Step 1:**

Press "Begin Cal" on the panel.

- **Step 2:**

Select "CHANGE CAL METHOD AND LINE TYPE" from menu C11.

MENU C11
BEGIN CALIBRATION
KEEP EXISTING CAL DATA
REPEAT PREVIOUS CAL
AUTOCAL
CAL METHOD Xxxxxxx
TRANSMISSION LINE TYPE: Xxxxxxxx
CHANGE CAL METHOD AND LINE TYPE NEXT CAL STEP
PRESS <ENTER> TO SELECT

- **Step 3:**

When menu C11A appears, follow these instructions to move the cursor:

A. OFFSET SHORT, then press "Enter" and select short-circuit bias as the calibration method.

B. Waveguide, then press "Enter", the menu C5 will appear on the screen.

C. EXT CAL STEP, then press "Enter", the screen display will return to menu C11.

MENU C11A
CHANGE CAL METHOD AND
LINE TYPE
NEXT CAL STEP
CAL METHOD
STANDARD(NOT USED FOR WAVEGUID)

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OFFSET SHORT
LRL/LRM
TRANSMISSION LINE TYPE
COAXIAL
WAVE GUIDE
MICROSTRIP
PRESS <ENTER> TO SELECT

MENU C5
SELCT CALIBRATION TYPE
FULL 12-TERM
1 PATH
2 PORT
TRANSMISSION FREQUENCY RESPONSE
REFLECTION ONLY
PRESS <ENTER> TO SELECT

- **Step 4:**

When menu C11 reappears, verify that the OFFSET SHORT calibration method and WAVEGUIDE transmission line type have been correctly selected. Select NEXT CAL STEP and press "Enter" to continue.

- **Step 5:**

When menu C5 appears, you can select the calibration type, such as pointing the cursor to FULL 12-TERM and pressing the "Enter" key to confirm.

- **Step 6:**

The menu C5D appears to enable you to choose whether the calibration includes the leakage error term between the measurement channels. For a regular one to calibrate, you need to select these error terms. Therefore, move the cursor to INCLUDE ISOLATION (STANDARD) and press the "Enter" key to confirm.

MENU C5D
SELCT USE OF ISOLATION IN CALIBRATION

INCLUDE ISOLATION (STANDARD)
EXCLUDE ISOLATION
PRESS <ENTER> TO SELECT

- **Step 7:**

Menu C1 will enable you to select the frequency count to be tested during the calibration process. For example, you can select NORMAL(1601 POINTS MAXIMUM).

MENU C1
SELCT CALIBRATION DATA POINTS
NORMAL (1601 POINTS MAXIMUM)
C.W.(POINT)
N-DISCRETE FREQUENCIES(2 TO 1601 POINTS)
TIME DOMAIN (HARMONIC)
PRESS <ENTER> TO SELECT

- **Step 8:**

The next menu, C2, enables you to select the start and stop frequency of the calibration. For example, you can point the cursor to START, press 40 on the keyboard, and press the MHz key, and you can point the cursor to STOP and select the termination frequency of 20 GHz. After setting the measurement frequency band, select NEXT CAL STEP and press "Enter" to confirm.

MENU C2
FREQ RANGE OF CALIBRATION
START 0.0400000000GHz
START 20.000000000GHz
201 DATA PTS

0.99800000 GHz STEPSIZE
MAXIMUM NUMBER OF DATA POINTS 1601 MAX PTS 801 MAX PTS 401 MAX PTS 201 MAX PTS 101 MAX PTS 51 MAX PTS
NEXT CAL STEP
PRESS <ENTER> TO SELECT

➢ **Step 9:**

When menu C3B appears, you can move the cursor to the parameter if you want to modify any of the parameters displayed in blue letters

If you want to change WAVEGUIDE PARAMETERS, move the cursor to Waveguide parameters and press Enter to confirm.

MENU C3B
CONFIRM CALIBRATION PARAMETERS
LOAD TYPE BRAODBAND
THROUGH LINE PARAMETERS
WAVEGUIDE PARAMETERS: XXXXXXXX
TEST SIGNALS
START CAL
PRESS <ENTER> TO SELECT

➢ **Step 10:**

When menu C15 appears, move the cursor to the two pending options and press "Enter" to confirm the two pending options as follows:

A. se INSTALLAEDWAVEGUIDE KIT: Selecting this item will enable the Waveguide to be displayed in blue IDENTIFER, CUTOFF FREQ, SHORT1, SHOTR2.

MENU C15
SELECT WAVEGUIDE KIT TO USE
-INSTALLED KIT-
IDENTIFIER XXXX
CUTOFF FREQ XX.XXXXXXXXX GHz
SHORT 1 XX.XXXX mm
SHORT 2 USE INSTALLAEDWAVEGUIDE KIT
MENU C15A
ENTER WAVEGUIDE PARAMETERS
WAVEGUID CUTOFF FREQ XX.XXXXXXXXX GHz
OFFSET LENGTH SHORT 1 XX.XXXX mm
OFFSET LENGTH SHORT 2 XX.XXXX mm
PRESS <ENTER> WHEN COMPLETE
USE DEFINED
XX.XXXX mm

B.se DEFINED: Selecting this will bring up the menu C15A, which will enable you to customize the waveguide parameters. After you have defined the waveguide parameters, you will return to menu C3B.

Step 11:
Continue the calibration process by connecting the appropriate isolators, wideband loads, short-circuiters, and straight-through wires as instructed by the instrument..

Test The Toolbox

The calibrator is used to calibrate the VNA. What is the performance after calibration? The measurement accuracy reached the required calibration target?

The best way to confirm that the calibration is effective is to measure an accurate and well known device and confirm its performance parameters.

The inspection box is the inspection tool to check the calibration effect. The test box consists of reflection and transmission test parts. The test parts have performance parameters that have been accurately measured. After the VNA system is calibrated, the VNA system's calibrated effect can be judged by comparing the data of the measured inspection parts with the original data of the inspection parts.

Although VNA provides fairly accurate complex data, it can only be accurate to a certain extent. So it needs to be done regularly calibration data and VNA system performance are checked.

Inspection of calibration data can reveal problems such as improper connection of calibration elements, improper rotation, or test ports out of range.

Dolph-Microwave has developed a number of accurate waveguide inspection toolkits for waveguide systems of various specifications (BJ-3 to BJ-900). Calibration and inspection boxes are also available for non-standard waveguides.

Each kit includes 20 dB and 50 dB attenuators, straight waveguides, and a standard reflective load. The characteristic parameters of all components in each inspection toolbox have been calibrated at specific frequencies, and these data are stored in the inspection toolbox on floppy disks or in random paper reports.

The test element is measured with calibrated VNA, and then the measurement data is compared with the data stored on the floppy disk. If the agreement is quite good, it indicates that the system is working properly and the measured data is accurate and reliable.

For the test device, because its characteristic parameters have been calibrated, it is not necessary to use it often, otherwise its characteristics will not be consistent with the nominal value.