R&S®ZCWM-570 Waveguide Calibration Kit WM-570

Technical Information

1322.3599.92 ─ 01

ROHDE&SCHWARZ

Test & Measurement

Technical Information

This document provides technical information on the following waveguide calibration kits:

- R&S®ZCWM-570, Waveguide Calibration Kit WM-570, 330 GHz to 500 GHz, Short, Shim, Match (1322.3099.10)
- R&S®ZCWM-570, Waveguide Calibration Kit WM-570, 330 GHz to 500 GHz, Short, Shim, Match, Sliding Match (1322.3099.11)

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1 Safety Instructions

The calibration kit has been designed and tested in accordance with the EC Certificate of Conformity and has left the manufacturer's plant in a condition fully complying with safety standards.

⚠ CAUTION

General safety instructions

To maintain this condition and to ensure safe operation, you must observe all instructions and warnings given in this section.

Mechanical protection

The calibration kit (especially the waveguide flanges) must be protected against mechanical damage. Furthermore the waveguides must be shielded from dust.

While not mounted, protect the waveguide flanges by putting on the included caps. Avoid scratching the contact surfaces of the waveguide flanges.

Mounting a standard

The waveguide flanges of the standards are high-precision mechanical components that can be damaged by improper handling, e.g. by canting the flanges. Use a flat, stable surface for your test setup and align the flanges accurately before mounting.

Opening the standards

Do not disassemble the standards. This applies especially to the Sliding Match standard. The standards can be repaired only at the manufacturer's service department.

Avoid heavy shocks

Heavy shocks can damage internal parts of the standards. Shock-proof packing shall therefore be used for storage and dispatch of the calibration kits. Use the wooden box for this purpose.

Damage caused by cleaning agents

Cleaning agents contain substances that may damage the standards, e.g. solvent-containing cleaning agents may damage the labeling. Never use cleaning agents such as solvents (thinners, acetone etc.), acids, bases or other substances. Protect the waveguides from any liquids.

The outer surfaces of the standards may only be cleaned using a soft, lint-free dust cloth.

Damage level

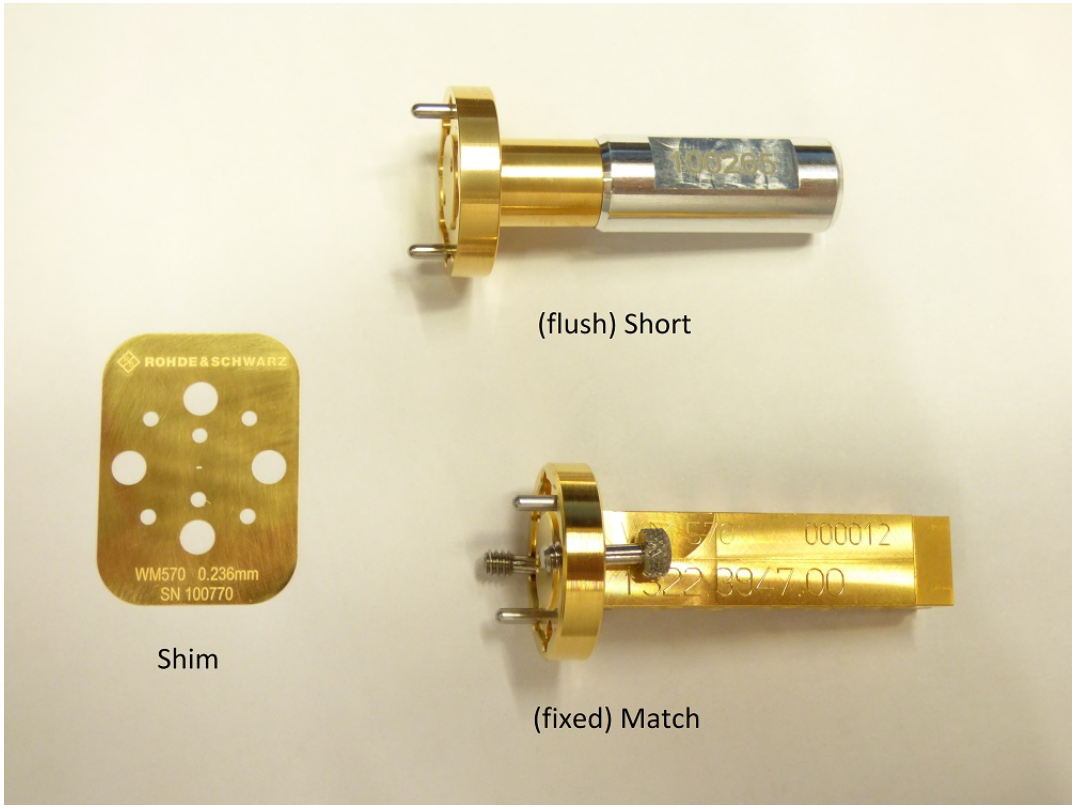
The damage power level of fixed and sliding match is indicated in the data sheet. Exceeding this level may damage the Match standards.

2 Waveguide Calibration Kits

The waveguide calibration kit R&S®ZCWM-570 allows to calibrate network analyzers furnished with waveguide test ports of type WM-570. Dimensions and frequency range of this waveguide type are defined in IEEE standard 1785.1. The R&S®ZCWM-570 is particularly suited to calibrate a R&S®ZVA (or R&S®ZVT) with R&S®ZC500 converters.

The calibration kit contains the following standards:

- A Short standard that also serves as Reflect standard
- A (fixed) Match standard
- A Shim that contains a short transmission line.
  The length of this line corresponds to a quarter wavelength (λ/4) at the center of the frequency range of a converter R&S®ZC500. When combined with a Flush Short, the reflection coefficient has 180° phase at midband.
- A Sliding Match standard (kit 1322.3099.11 only) that provides more accurate results than the fixed Match standard – at higher test effort.



The following table provides an overview of the available standards for rectangular waveguide calibration and their technical implementation using the calibration kits.

Standard Type	Technical Implementation
Open	Not available in waveguides, replaced by Offset Short
(Flush) Short	Contained in calibration kit
Offset Short	Short + Shim, both contained in calibration kit
(Fixed) Match	Contained in calibration kit
Sliding Match	Contained in calibration kit 1322.3099.11
Reflect	= Short, contained in the calibration kit
Through	Direct through connection between the two test ports
Line 1	Through connection of the two test ports with Shim in between. Due to the limited bandwidth of the frequency converters (less than one octave), a second line is not needed.
Attenuation	Not contained in the calibration kit
Symmetrical Network	Not contained in the calibration kit

The standards in the calibration kit allow to perform all one-port and two-port calibration types supported by the R&S®ZVA, except for TNA.

At high mm-wave frequencies, a slight variation of Shim thickness has a significant influence on the phase shift of both Offset Short and Line standards. This mainly affects the accuracy of OSM and TOSM calibrations where the Offset Short is needed. In contrast, TRL accuracy is not compromised by a slightly inaccurate Line length, since this value only needs to be known approximately. Thus Shim thickness – and attenuation – are determined individually for each kit and recorded in a `.calkit` file. This file is stored on the USB memory stick contained in the kit. If the Shim gets damaged or lost, the complete kit needs to be sent to R&S service.

Prior to the first calibration, the characteristic data of the kit needs to be imported into the R&S®ZVA via "Channel > Calibration > Cal Kits > Import Kit...". Alternatively, press the "Import Kit..." button in the first dialog of the cal wizard invoked via "Channel > Calibration > Start Cal > {Cal Procedure}".

3 Sliding Match Standard

The Sliding Match standard is part of the calibration kit 1322.3099.11. It is a one-port standard consisting of a precision waveguide section with a movable, low-reflection load element. This standard is used when very small reflection coefficients must be measured that are below the specification of the fixed match.

During a Sliding Match calibration, a series of measurements is performed at constant frequency, but with varying position of the movable load element. On the whole, the positions have to extend over at least half of a wavelength (λ/2). The measured reflection coefficients are located on a circle. Knowing center and radius of this circle allows one to determine the reflection coefficient that would be measured for an ideal Match standard with zero reflection. This measured reflection coefficient is equal to the directivity error term. So a sliding match calibration allows the VNA software to determine directivity with higher accuracy than it would be possible with a fixed match.

The sliding match algorithm requires at least three positions of the load element to be measured. The positions need not be equally spaced – quite the contrary: unequal spacing reduces the danger of reflection coefficients clustering only on a part of the circle circumference and thus lowering the accuracy of the algorithm.

Increasing the number of positions to 4 – 6 further reduces the uncertainty of the directivity term.

If the complete waveguide band is to be calibrated, use the following sliding match positions:

- 0 µm, 100 µm, 200 µm, 300 µm, 400 µm, 500 µm

If the adjusting knob is accidentally unscrewed completely, simply screw it on again.

4 Performing a System Error Calibration

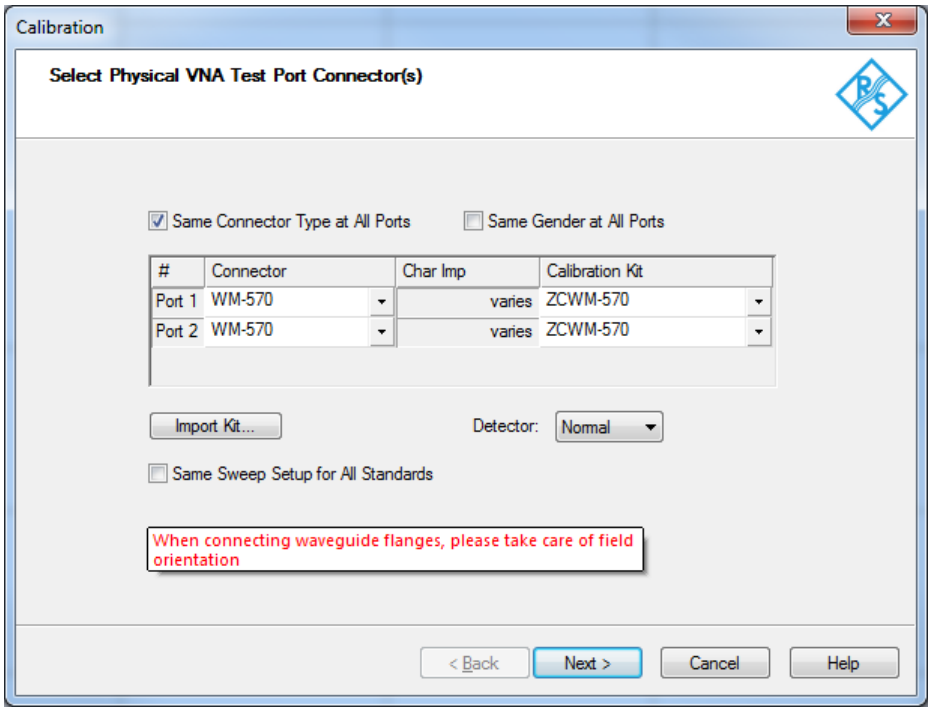
- Take care that the flange screws are tightened evenly to avoid an air gap between the flange faces.
- Thermal fluctuation causes length variation of the waveguide components and result in phase drift. An environment where temperature is stabilized to the range defined in the data sheet is a prerequisite for accurate measurements.
- Perform a power calibration before the system error calibration. For instructions, refer to the documentation of your frequency converter.
- If the output power of the frequency converter is changed after the system error calibration (e.g. by turning the knurled knob on the upper side of the converter), the correction terms become invalid. Thus adjust the output power of the frequency converter before starting calibration.

4.1 TRL Calibration

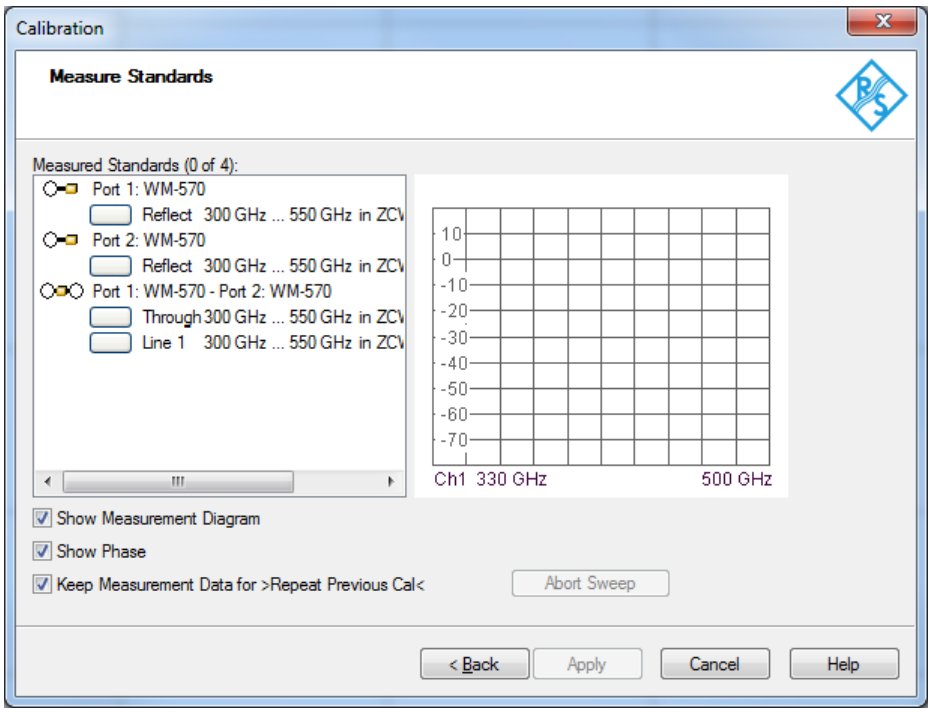
The following example refers to a TRL calibration of two frequency converters R&S®ZC500, connected to a four port network analyzer R&S®ZVA. The test setup is described in the Getting Started guide of the R&S®ZCxxx converter family. It is suitable for transmission and reflection measurements on two-port waveguide DUTs in the frequency range of the converters.

The calibration procedure using the analyzer's "Calibration Wizard" is straightforward (for details refer to the help system of the R&S®ZVA, section "Guided Calibration"):

1. Activate the frequency converter mode by connecting the USB port of at least one converter to the VNA and answering the questions in the dialogs that are displayed at the analyzer GUI.
2. Initiate a TRL calibration by selecting "Channel > Calibration > Start Cal > Two Port P1 P2 > TRL" from the main menu.
   If the cal kit has not been imported before, import it from the USB memory stick via button "Import Kit..."



3. Click "Next" to proceed to the "Measure Standards" step.



4. Connect the Short standard to waveguide test port 1 (on the converter that has RF IN connected to VNA port 1) and select "Port 1: WM-570 > Reflect" to start the calibration sweep.
5. Repeat step 4 in an analogous manner for test port 2.
6. Establish a through connection between the test ports and select "Port 1: WM-570 - Port 2: WM-570 > Through" to start the calibration sweep.
7. Establish a line connection by placing the Shim between the test ports and select "Port 1: WM-570 - Port 2: WM-570 > Line 1" to start the calibration sweep.
8. Click "Apply" to finish the calibration wizard.

   The VNA calculates the system error correction data and applies them to the current channel.

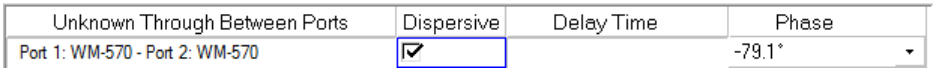
- Whenever the fixed Match standard is used in a calibration technique, it can be replaced by the sliding Match to improve directivity; see chapter Chapter 3, "Sliding Match Standard", on page 6.
- It is possible to check the calibration by measuring a standard that was not required by the current calibration method. Use e.g. the fixed Match to check a TRL calibration.
  Note however that this check is incomplete. For example, transmission uncertainty cannot be verified with a one-port standard.

4.2 UOSM Calibration

UOSM calibration uses an unknown through connection and yields two solutions related to different transmission phase values.

Any reciprocal two-port network ($S_{21} = S_{12}$) can be used as unknown through. A piece of waveguide, whether straight of bent, fulfills the reciprocity condition.

The two solutions differ by 180 deg and only one of them is valid. In a coaxial system the analyzer selects the correct solution automatically. In waveguide, however, automatic selection only succeeds if the start frequency is pretty far above cutoff. Otherwise, the correct solution has to be selected manually. At the GUI of the R&S®ZVA, the following dialog opens during calculation of the system error correction data (see step 8 above):



Check "Dispersive" and select the correct solution in the "Phase" drop-down list.