Product: Vector Network Analyzer R&S®ZVA

Measuring the S-Parameters of a 50 to 75 Ohm impedance matching device using the Vector Network Analyzer ZVA

Application Note

This document describes how the advanced calibration techniques of the ZVA Vector Network Analyzer can solve the challenges of measuring the S-Parameters on impedance matching devices. The document describes the concept and setup required to perform the calibration of the ZVA and making the measurement.

The procedure described in this application note applies to the ZVB and ZVT Vector Network Analyzers as well.

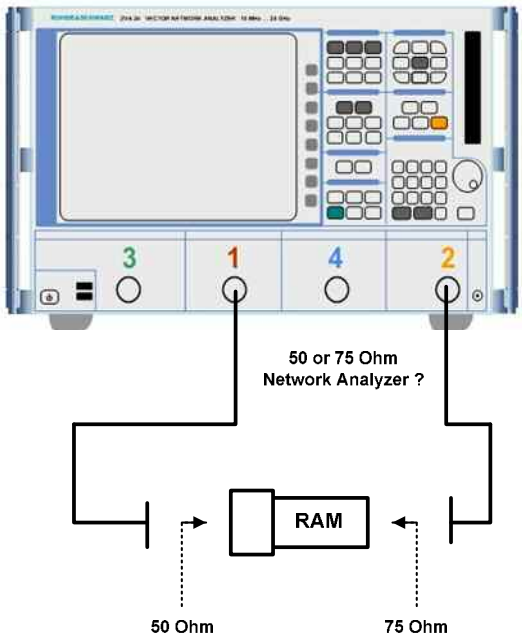
ROHDE&SCHWARZ

Subject to change – Kenneth Rasmussen, 03.2009

Contents

1. Introduction

This document is designed to be a guide to help point the user in the right direction for configuring the ZVA Vector Network Analyzer to make relevant measurements on impedance matching devices like Minimum Loss Pads.



With the previous generation of Vector Network Analyzers, measurement of the S-Parameters on impedance matching devices like Minimum Loss Pads (MLP) was impossible. This is due to the fact that MLP's have different impedances at the Input and Output ports. Traditionally, VNA's could not do a full 2-port calibration with different impedances on the test ports. But with the arrival of the ZVA generation of Vector Network Analyzers and the UOSM calibration method, this is now possible.

This application will use the R&S RAM, a DC - 2.7 GHz 50Ω/75Ω Matching Pad as the Device-Under-Test (DUT).

Due to limited or no availability of calibration kits in other than 50Ω and 75Ω impedances, it is not practical to convert to other impedances.

For further information please refer to the internal help of the ZVA [HELP] or alternatively you can access the help online at the Rohde & Schwarz website,

http://www.rohde-schwarz.com/webhelp/zva/start.htm

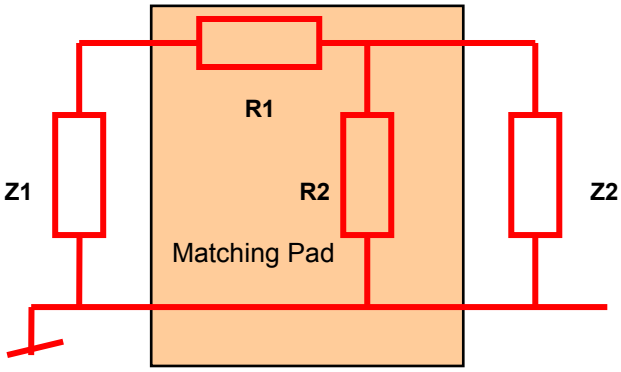
In this document:

- Hardkeys are shown as [MODE] [PRESET] [HELP]
  Softkeys are shown as [Start]
  Windows buttons and tabs are shown as *Set Power…*
  Windows dialog box names are shown as Set Powers

2. R&S RAM, Minimum Loss Pad

The Minimum Loss Pad (or L-pads) can be used to perfectly match one impedance to another, but the loss is high. In microwave engineering, this is usually not acceptable; we'd rather match two impedances with near-zero loss by using reactive components, which limits the bandwidth of the solution. In instrumentation systems however, we normally prefer a frequency-independent device like the MLP to do the impedance conversion. A typical application for the MLP is when we want to measure TV signals in a 75 Ohm system with a 50Ω Spectrum Analyzer. Here the MLP will provide the proper matching between the different impedances. However this comes at the expense of additional power loss.

Note that for a given input and output impedance, only one solution exists for an L-pad where the input and output are to be perfectly matched; this is what we know as the Minimum Loss Pad.



L-Pad matching network (Z1 > Z2)

The equations for calculating the values of R1 and R2 are simple to derive using Ohm's Law. For Z1 > Z2 the following applies:

$$R1 = Z1\sqrt{1-\frac{Z2}{Z1}} \qquad R2 = \frac{Z2}{\sqrt{1-\frac{Z2}{Z1}}}$$

The attenuation (or insertion power loss) is defined as (Power Out)/(Power In):

$$Pout/Pin = \frac{1}{\left(\sqrt{\frac{Z1}{Z2}}+\sqrt{\frac{Z1}{Z2-1}}\right)\wedge 2}$$

Please note, this is the linear value, not dB! The attenuation can be expressed in dB as follows:

$$Attenuation(dB) = 10Log_{10}\left(\frac{Pout}{Pin}\right)$$

For the R&S RAM, which converts from 75Ω to 50Ω, the following values apply:

R1 = 43.3 Ω
R2 = 86.6 Ω
Attenuation (dB) = -5.7 dB

3. Measurement Setup for the Minimum Loss Pad

To measure the S-Parameters of a Minimum Loss Pad, the following equipment are required:

- R&S ZVA — Vector Network Analyzer
- R&S ZCAN 50Ω — Type-N 50Ω Calibration Kit, 3 GHz
- R&S ZCAN 75Ω — Type-N 75Ω Calibration Kit, 3 GHz
- R&S RAM — Matching Pad, 50Ω/75Ω
- AG 1250-0597* — Type-N(m) 50Ω to Type-N(f) 75Ω mech. Adapter
- PE 9350* — Type-N(f) 50Ω to Type-N(m) 75Ω mech. Adapter
- Test Port Cables — 2 required. Model depends on ZVA connectors

*) AG : Agilent Technologies PE : Pasternack Enterprices

WARNING!

At first glance, 50Ω and 75Ω Type-N connectors looks identical, but be careful. The center pin of the 75Ω connectors is thinner than the center pin of the 50Ω connectors.

Special care should be taken when mating 75Ω devices. Inserting a 50Ω male connector into a 75Ω female connector can result in damage of the 75Ω female connector.

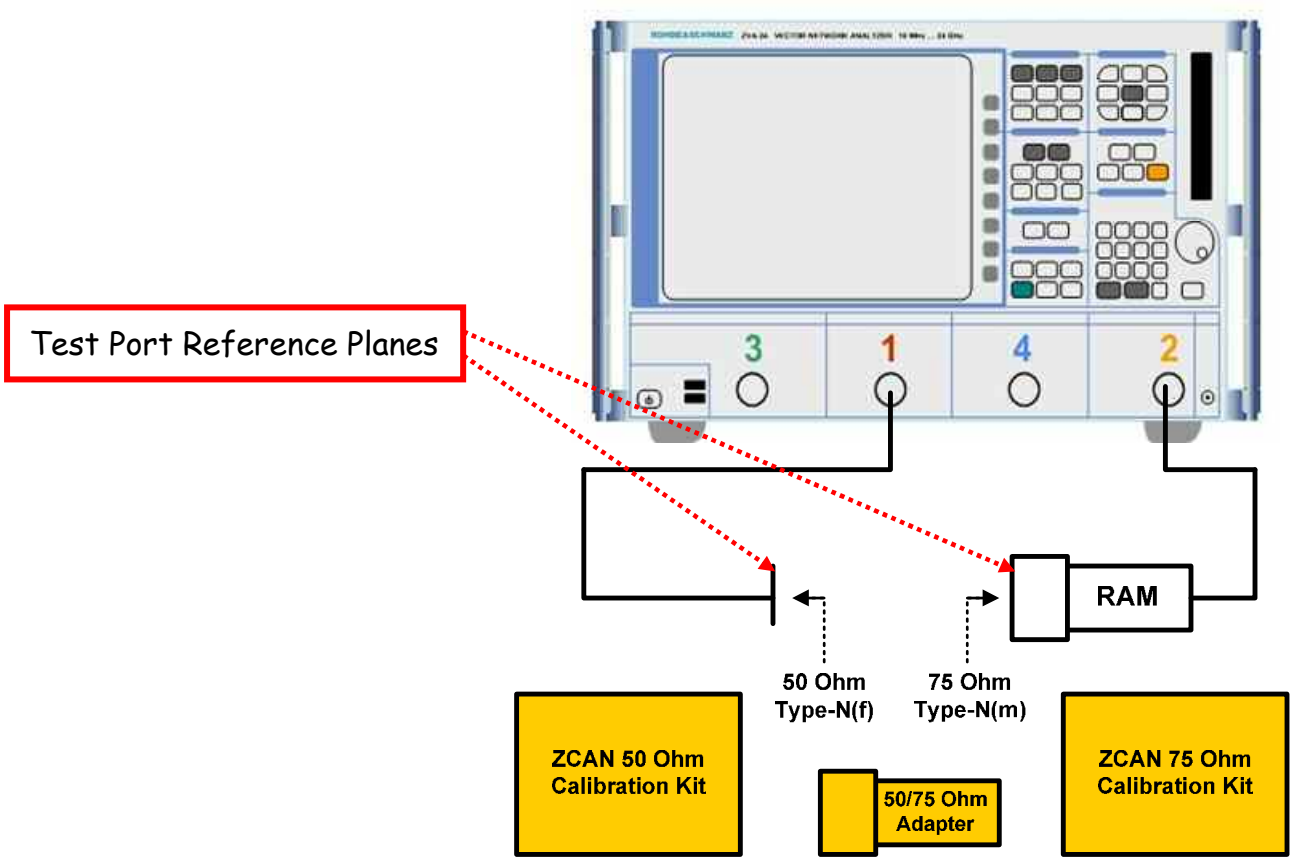
On the other hand, the 75Ω male connector cannot damage the 50Ω female connector due to the thinner center pin.

Please note the difference on the center pin thickness between 75Ω (Upper) and 50Ω (Lower) connectors.

Make the following setup with the ZVA as preparation for the calibration.

Please note that the Port 1 reference plane must be 50Ω Type-N(f) and that Port 2 reference plane must be 75Ω Type-N(m).

The 75Ω side of the RAM is a Type-N(f), so an additional 75Ω Type-N(m-m) adapter are required to realize the 75Ω Type-N(m) reference plane on Port 2.



Calibration Setup for the Minimum Loss Pad measurement

To configure the ZVA for the measurement, press the following keys:

[PRESET]

[START CENTER] [Start] 10 MHz

[STOP SPAN] [Stop] 2.7 GHz

[PWR BW AVG] [Power] 0 dBm

[PWR BW AVG] [Meas Bandwidth] [1 kHz]

[PWR BW AVG] [Average Factor] 10, [Average On]

4. UOSM Calibration

An adapter represents a through standard with unknown characteristics (in particular, with unknown delay time/transmission phase). The analyzer can perform a TOSM calibration with an unknown through, provided that it is reciprocal (S21 = S12). The modified TOSM calibration is referred to as UOSM (Unknown through – Open – Short – Match) calibration. It can be selected as follows:

1. If different connector types and/or impedances are assigned to the test ports, the analyzer automatically replaces TOSM –> UOSM.

2. If the same connector types are used but the appropriate through standard is not defined, the analyzer also replaces TOSM –> UOSM.

3. UOSM can be selected explicitly using [CAL] [Start Cal] [Other]....

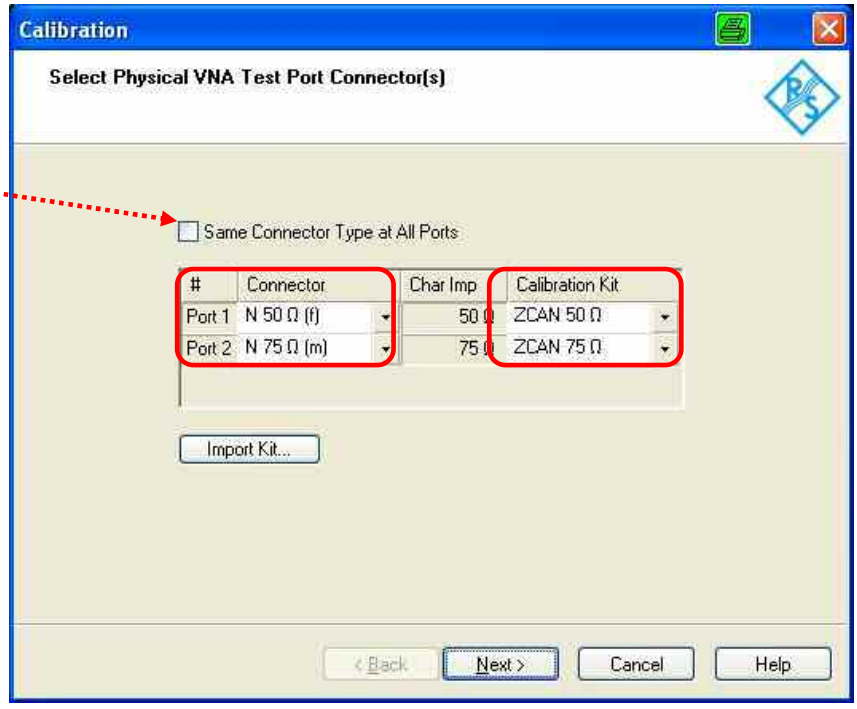
After acquiring the calibration sweep data for the unknown through, the analyzer automatically determines its delay time/transmission phase.

To start the ZVA calibration using UOSM, we just select a standard two port TOSM calibration. Since the setup applies to condition 1) above, UOSM will automatically be selected. Press the following keys:

[CAL] [Start Cal] [Two-Port P1 P2] [TOSM]

Configure Connector type and Calibration Kits as shown below:

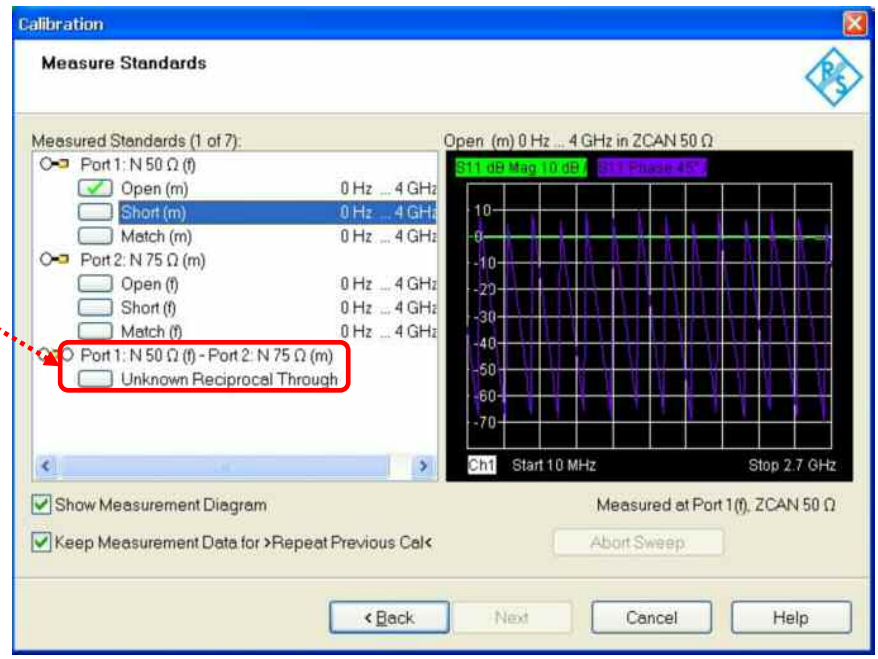
Uncheck this



Press *Next >* to proceed with the calibration.

Please connect calibration standards as shown below, one by one, and click the box to measure the standard.

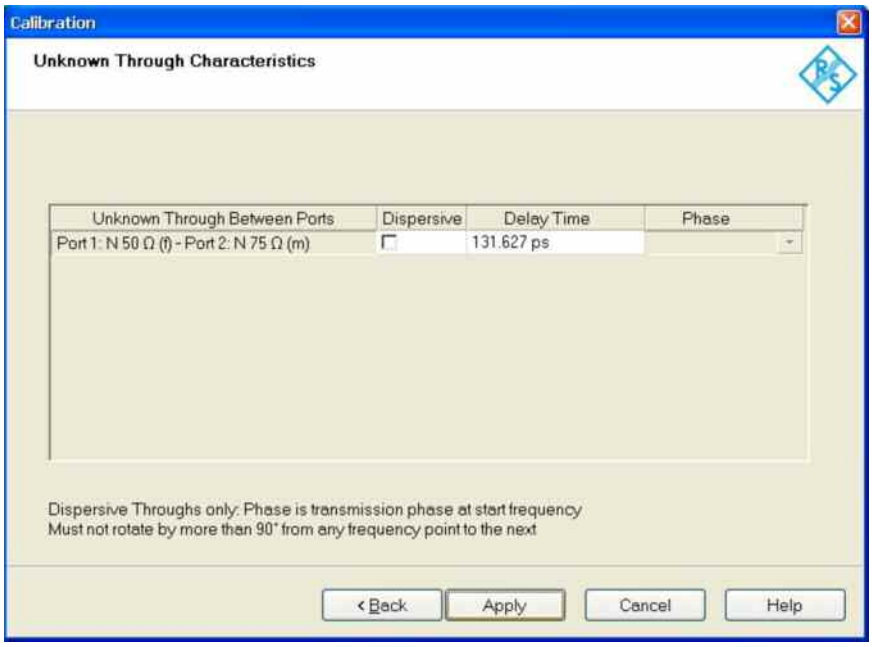
Unknown Reciprocal Through indicates that UOSM is being used for the calibration.



Press *Next >* to proceed when all standards are measured.

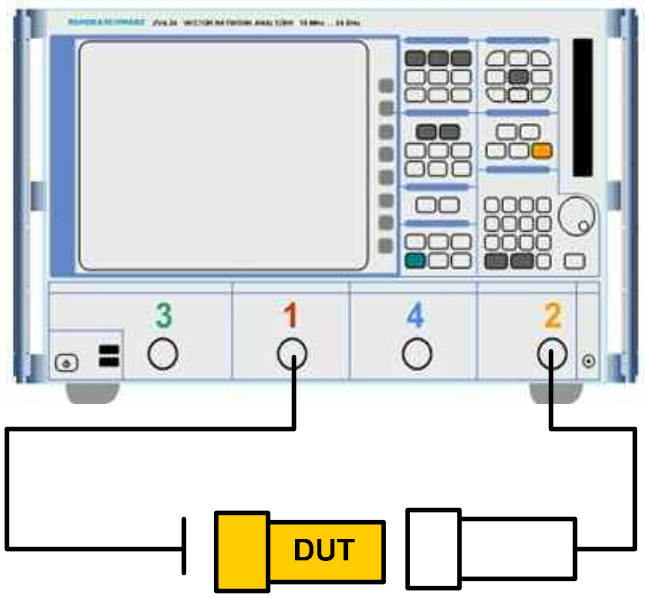
No action is required in the following window. Just press *Apply* to complete the calibration.

For a non-dispersive standard (Dispersive check box cleared), the Delay Time can be determined unambiguously, provided that the transmission phase difference between two consecutive sweep points is below 90 deg. In this case it is sufficient to press Apply in order to calculate the system error correction data and close the calibration wizard.



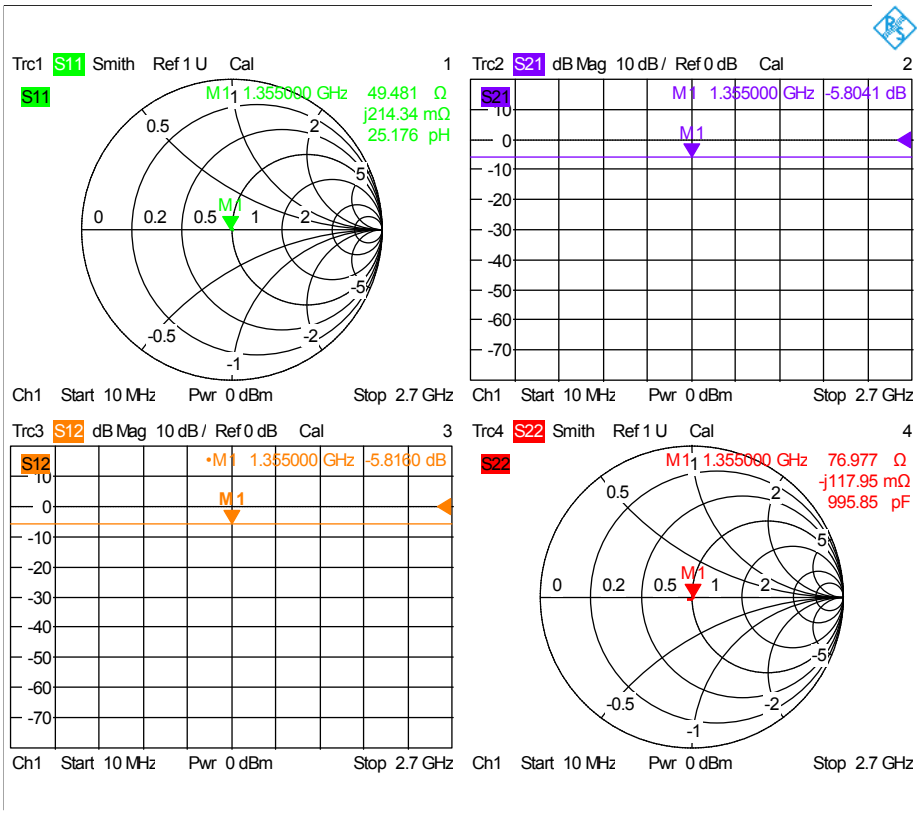
5. Measurement of R&S RAM, Minimum Loss Pad

Connect the device RAM to the calibrated reference planes of the ZVA as shown below;



With the UOSM calibration performed in the previous section, we now have the ZVA calibrated with Z_0 = 50Ω on Port 1 and Z_0 = 75Ω on Port 2. Note the marker readings in the S11 and S22 Smith Chart plots below.

The marker readings for S21 and S12 also show expected measurement results close to -5.7 dB power insertion loss in both directions.



6. Additional Information

This Application Note is updated from time to time. Please visit the website **www.rohde-schwarz.com** to download the latest versions
Please send any comments or suggestions about this application note to **info.rsdk@rohde-schwarz.com**.

7. Ordering Information

Listed are all R&S ZVA, R&S ZVB and R&S ZVT network analyzers. Of course, accessories like test cables, or manual and automatic calibration kits are available in addition. For details, please contact your local R&S sales office, or the R&S web site.

Order No.	Type	Designation
1145.1110.08	R&S ZVA8	Vector Network Analyzer, 2 Ports, 8 GHz
1145.1110.10	R&S ZVA8	Vector Network Analyzer, 4 Ports, 8 GHz
1145.1110.24	R&S ZVA24	Vector Network Analyzer, 2 Ports, 24 GHz
1145.1110.26	R&S ZVA24	Vector Network Analyzer, 4 Ports, 24 GHz
1145.1110.40	R&S ZVA40	Vector Network Analyzer, 2 Ports, 40 GHz
1145.1110.42	R&S ZVA40	Vector Network Analyzer, 4 Ports, 40 GHz
1145.1110.50	R&S ZVA50	Vector Network Analyzer, 2 Ports, 50 GHz
1145.1110.52	R&S ZVA50	Vector Network Analyzer, 4 Ports, 50 GHz
1300.0000.08	R&S ZVT8	Vector Network Analyzer, 2 - 8 Ports, 8 GHz
1300.0000.20	R&S ZVT20	Vector Network Analyzer, 2 - 6 Ports, 20 GHz
1145.1010.04	R&S ZVB4	Vector Network Analyzer, 2 Ports, 4 GHz
1145.1010.06	R&S ZVB4	Vector Network Analyzer, 4 Ports, 4 GHz
1145.1010.08	R&S ZVB8	Vector Network Analyzer, 2 Ports, 8 GHz
1145.1010.10	R&S ZVB8	Vector Network Analyzer, 4 Ports, 8 GHz
1145.1010.14	R&S ZVB14	Vector Network Analyzer, 2 Ports, 14 GHz
1145.1010.19	R&S ZVB14	Vector Network Analyzer, 4 Ports, 14 GHz
1145.1010.20	R&S ZVB20	Vector Network Analyzer, 2 Ports, 20 GHz
1145.1010.25	R&S ZVB20	Vector Network Analyzer, 4 Ports, 20 GHz
0800.8515.52	R&S ZCAN	0 Hz to 3 GHz, 50Ω Calibration Kit
0800.8515.72	R&S ZCAN	0 Hz to 3 GHz, 75Ω Calibration Kit

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