R&S®DST200
Determining the Reference Path Loss
Application Sheet

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Test & Measurement

Application Sheet

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The following abbreviations are used throughout this guide: R&S® DST200 is abbreviated as R&S DST200. The Accessories R&S® DST-Bxx are abbreviated as R&S DST-Bxx. The network analyzers R&S® ZVx are abbreviated as R&S ZVx.

1 Reference Path Loss Measurement

This application sheet describes how to determine the reference path loss for a Universal RF Shielding Box CMW-Z10 using a vector network analyzer.

Over-the-air (OTA) measurements attempt to determine the performance of radio transmitters and receivers in a test environment which closely simulates the conditions in which the devices will be used. OTA tests for mobile phones have been promoted and specified by the Cellular Telecommunications & Internet Association (CTIA); refer to the "CTIA Certification, Test Plan for Mobile Station Over the Air Performance, Method of Measurement for Radiated RF Power and Receiver Performance, Rev. 3.0".

An important preparatory stage of any OTA measurement consists of removing the test system's influence from the radiated power and sensitivity results. To this end the equipment under test (EUT) is replaced by a reference antenna with known gain characteristics, and a reference path loss measurement is performed. The reference measurement is combined with the known gain of the reference antenna to determine an **isotropic** reference correction for the power and sensitivity results. The remainder of this section outlines how to perform the reference path loss measurement using the Universal RF Shielding Box in combination with a vector network analyzer. For a detailed description of the measurement method refer to section "Range Reference Requirements" in the CTIA certification document.

The reference path loss measurement is different from the path loss measurement described in Application Sheets 1ZKD-18 and 1ZKD-19 where the EUT (typically, a mobile phone) provides the information about the path loss values.

1.1 Required Equipment

The reference path loss can be measured with the following equipment:

- Universal RF Shielding Box CMW-Z10 (with integrated test antenna)
- Option R&S DST-B102, DST200 Interface Panel, RF
- Vector network analyzer, e.g. R&S ZVA, R&S ZVB, R&S ZVL
- Calibrated reference antenna with known gain

1.2 Background

The purpose of the reference path loss measurement is to relate the measured radiated power or sensitivity of the EUT to the same quantities from an ideal isotropic radiator. We define the total reference path loss PL of the Universal RF Shielding Box as the difference:

$$PL = P_{RA} - P_{TA,\,ISO}$$

where P_{RA} is the input power and $P_{TA,\,ISO}$ is the output power, assuming that the chamber is equipped with an isotopic radiator. As shown in figure 1-1, $P_{TA,\,ISO}$ depends on the propagation loss along the cable, the test antenna, and in free space.

Most conveniently, the RF input signal for the reference path loss measurement is fed to an additional RF feed through (the "Double N Connector" R&S DST-B102 mounted at one of the lower connector ports); the RF output signal is tapped at the standard upper "RF ANT" connector.

Disturbance due to cabling

Watch that the connecting cable does not disturb the radiation pattern of the isotropic radiator (or reference antenna, see below). The cable must be either outside the radiated field or perpendicular to the electric field **E**.

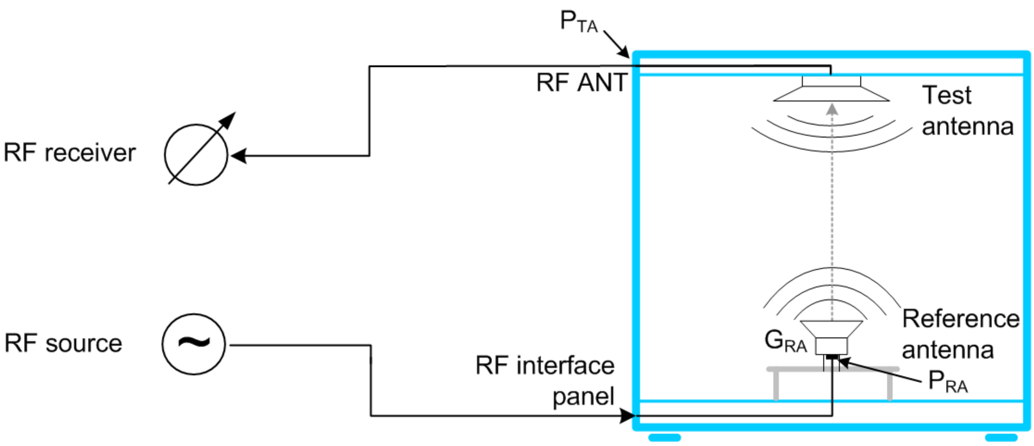

Fig. 1-1: Schematic test setup for reference path loss measurement

In practice, the ideal isotropic radiator is replaced by a calibrated reference antenna. The (known) gain of the reference antenna G_{RA} is defined as the difference between the antenna's actual radiated power and the ideal isotropic power, hence:

$PL = G_{RA} + P_{RA} - P_{TA}$

In the equation above, P_{TA} denotes the output power of the Universal RF Shielding Box in the presence of the reference antenna, including the effect of the antenna's radiation characteristics. The power difference $P_{RA} - P_{TA}$ can be measured as described below. Together with the known value of G_{RA} this determines the total reference path loss PL.

1.3 Measurement

A vector network analyzer (VNA) is ideally suited for the reference path loss measurement because the necessary steps are all part of its basic functionality. The VNA will perform most of the necessary calculations by itself. To measure the power difference $P_{RA} - P_{TA}$,

1. Calibrate the connecting cables between the VNA source port and the input connector of the reference antenna and between the output connector ("RF ANT") of the chamber and the VNA receiver port.

2. Measure the connected Universal RF Shielding Box in transmission.

Cable calibration

The suggested test setup uses port 1 of the VNA as a source port, port 2 as a receive port. Calibration is performed with all cables connected to both analyzer ports. For best accuracy, use high-quality RF cables and perform a full two-port calibration. Connect the required calibration standards successively to the cable ends as required by the selected calibration type.

The calibrated VNA results will relate to the cable ends. Calibration moves the "reference plane" from the VNA ports towards the input and output connectors of the chamber.

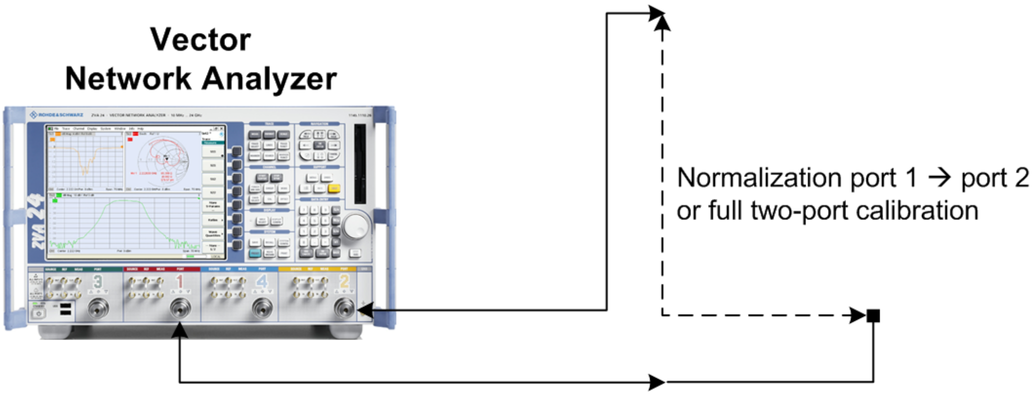

Fig. 1-2: VNA test setup for cable calibration

Transmission measurement

Apply the calibration and connect the cable ends to the input connector of the reference antenna and the RF ANT connector of the Universal RF Shielding Box. Measure the forward transmission coefficient S_{21}, converted to a dB-magnitude value (this is the preset measurement mode of many VNAs). The power difference $P_{RA} - P_{TA}$ is equal to the negative of the transmission coefficient:

$$P_{RA} - P_{TA} = -|S_{21}|$$

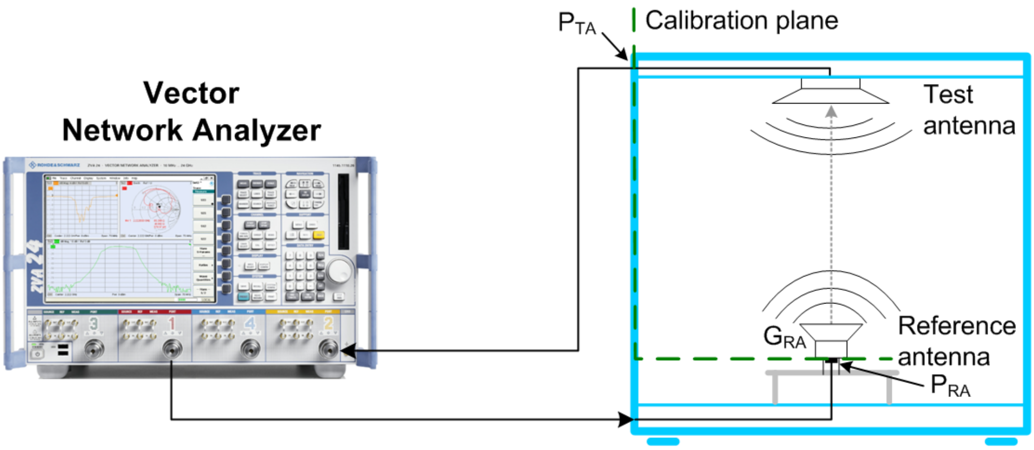

Fig. 1-3: VNA test setup for transmission measurement

Reference path loss calculation

To determine the reference path loss, add the antenna gain to the VNA results:

$PL = G_{RA} - |S_{21}|$

Reference path loss values must be acquired for all test frequencies, most easily by configuring an appropriate frequency sweep at the VNA. The path loss values must be stored and used to correct the OTA performance test results.

1.4 Additional Information

The Universal RF Shielding Box CMW-Z10 and its accessories are described in the operating manual, stock no. 1515.1421.02. The operating manual also provides a table of generic path loss values, obtained over a wide frequency range, which you may use for comparison with your measurement results.