

R&S[®]CMW-Z11 and R&S[®]CMW

Determining the Path Loss

Application Sheet

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Muehldorfstr. 15, 81671 Munich, Germany

Phone: +49 89 41 29 - 0

Fax: +49 89 41 29 12 164

E-mail: info@rohde-schwarz.com

Internet: <http://www.rohde-schwarz.com>

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The following abbreviations are used throughout this guide: R&S® CMW is abbreviated as R&S CMW. The Accessories R&S® CMW-Zxx are abbreviated as R&S CMW-Zxx. R&S® CMU200 is abbreviated as R&S CMU200.

1 Path Loss Measurement

This application sheet describes how to determine the path loss for devices (e.g. mobile phones) tested in a Universal RF Shielding Box CMW-Z10 using a Wideband Radio Communication Tester R&S CMW.

RF signals are attenuated on their way from the equipment under test (EUT) to the test instrument and back. The total path loss in either direction includes the contribution of the range path loss PL_r due to the distance r between the EUT and the test antenna of the Universal RF Shielding Box (including its connection to the RF ANT connector), the loss PL_A introduced by the antenna, and any loss PL_{ex} in the signal path between RF ANT and the input/output connector of the test instrument. All these contributions may depend on the signal direction.

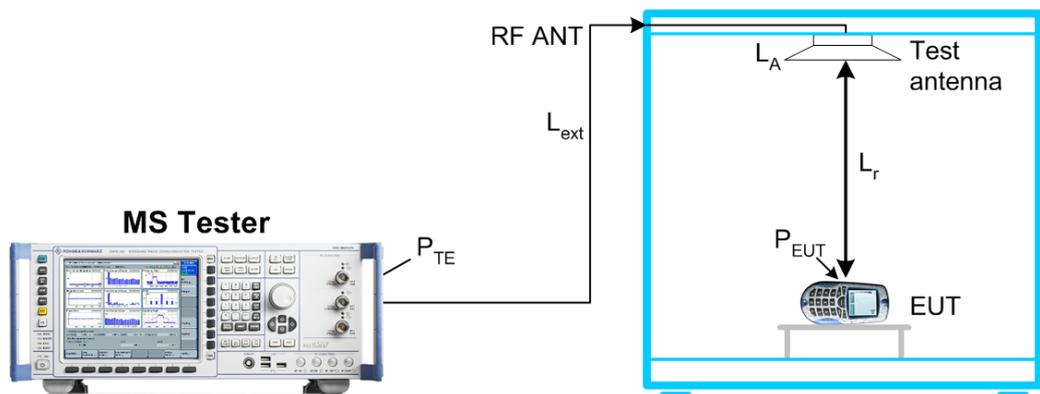


Fig. 1-1: Path loss

We define the total path loss for the two signal directions as the difference between transmitted and received powers:

- $Input\ path\ loss/dB = P_{EUT, out} - P_{TE, in}$
 $= \langle EUT\ output\ power \rangle / dBm - \langle RF\ input\ power\ at\ tester \rangle / dBm$
- $Output\ path\ loss/dB = P_{TE, out} - P_{EUT, in}$
 $= \langle Generator\ level\ of\ tester \rangle / dBm - \langle Received\ signal\ level\ at\ the\ EUT \rangle / dBm$

Once the path loss values are known for a given EUT type, position, and RF connection they can be reported to the test instrument as external attenuation factors ("External Attenuation (Input)", "External Attenuation (Output)"). The tester will then correct all power measurements by the reported input path loss and increase its RF generator level to compensate for the output path loss.

In the definitions above the sign of the input and output path loss is in accordance with the definition of external input and output attenuation factors ("Ext. Att. Input", "Ext. Att. Output") in the R&S CMW and R&S CMU200.



Path loss and EUT type, EUT position

The path loss values depend on the EUT type. Results for a particular EUT (e.g. a mobile phone) type should be determined using a fully functional and proven device ("golden" device); they may then be applied to all EUTs of the same type.

If the EUT is placed on the table inside the Universal RF Shielding Box, the RF field of the test antenna is circularly polarized and sufficiently homogenous so that measurement results do not much depend on the exact position and orientation of the EUT antenna. Consequently, the path loss measurement procedure described in this chapter is sufficient for basic receiver and transmitter tests.

For over-the-air (OTA) performance tests, a more elaborate "reference path loss" measurement is required to remove the test system's influence from radiated power and sensitivity results; see application sheet 1ZKD-20.

1.1 Required Equipment

The coupling factors can be measured with the following equipment:

- Universal RF Shielding Box CMW-Z10 (with integrated test antenna and RF cable)
- Fully functional and proven EUT (mobile phone)
- Wideband Radio Communication Tester R&S CMW with network-specific software options. For an overview of necessary R&S CMW types and firmware versions refer to [table 1-1](#).

1.2 Input Path Loss

If an external input attenuation is reported to the test instrument, all EUT power readings are increased. The tester shows the actual EUT transmitter output power which is higher than the level at its input connectors.

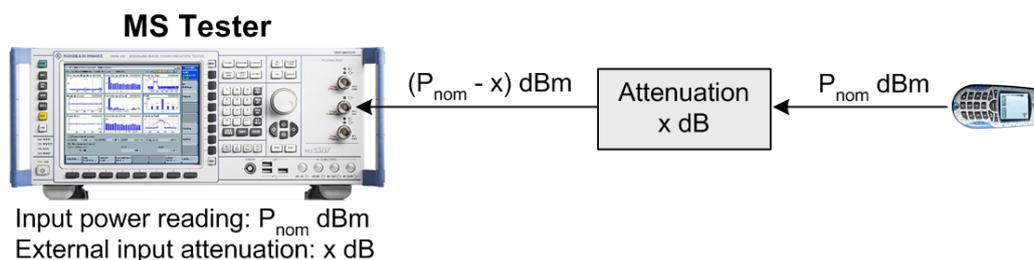


Fig. 1-2: Definition of input path loss

1.3 Output Path Loss

If an external output attenuation is reported to the test instrument, the generator power is increased relative to the nominal generator power setting. The actual signal power at the input of the EUT, after attenuation by the test setup, is equal to the nominal generator power.

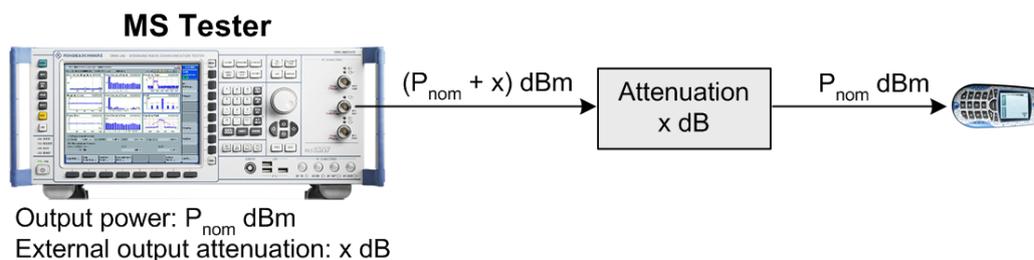


Fig. 1-3: Definition of output path loss

1.4 Determining Path Loss Values: R&S CMW

External input and output attenuation factors are reported in the configuration dialogs of the different measurement and generator/signaling firmware applications of the R&S CMW. The procedure for determining the path loss values is analogous for all networks; for an overview refer to [chapter 1.4.4, "Other Network Standards"](#), on page 8. The following example shows the necessary steps for a WiMAX mobile phone.



The following example requires an R&S CMW tester (model R&S CMW500 or R&S CMW270) equipped with the "WiMAX Measurements" and the "WiMAX Signaling" firmware applications. If no signaling application is available for a given network standard, you have to determine the received signal power and the transmitter output power of your EUT by external means.

1.4.1 Preparatives

In the following example, the EUT is a WiMAX MS supporting a 10 MHz bandwidth. The procedure for other bandwidths is similar, however, some more R&S CMW settings may have to be adjusted.

1. Connect the N connector of your Universal RF Shielding Box CMW-Z10 to the bidirectional RF connector RF 1 COM of the R&S CMW, preferably using the high-quality RF cable supplied with the Universal RF Shielding Box.
2. Place a fully functional and proven MS on the EUT table.
3. Switch on the R&S CMW and the MS.

1.4.2 Input Path Loss

Determining the input path loss requires the "WiMAX Measurements" and the "WiMAX Signaling" firmware applications.

1. Access the "WiMAX Signaling" firmware application and establish a connection between the R&S CMW and the MS, using default settings.

When the R&S CMW shows the connection status "Network Entry Completed", press the "MS Channel Report" softkey.

2. Open the "Results > MS Channel Report" section in the measurement dialog and read the "UL TX Power (Data Carrier Power)" result.

MS Channel Report	
CINR Mean	28.000 dB
CINR Deviation	12.000 dB
UL TX Power (Data Carrier Power)	-37.000 dBm
RSSI Mean	-50.00 dBm
RSSI Deviation	-3.50 dB

Fig. 1-4: WiMAX Signaling: UL TX Power

3. Open the "WiMAX Measurements" application and press ON | OFF to start the measurement.
4. Open the "Multi Evaluation Configuration" dialog and enable an "Combined Signal Path" measurement scenario.

Scenario	Combined Signal Path
RF Routing	RF-Rx 1 Connector: RF1 COM
External Attenuation (Input)	0.00 dB
Frequency	3500.000000 MHz
Expected Nominal Power	0.00 dBm Ref.Level: 0.00 dBm
User Margin	0.00 dB

Fig. 1-5: WiMAX Measurement: RF Settings

5. Close the configuration dialog and read the average "Subcarrier Power > Data" result from the "Measurement Overview" tables.

Subcarrier Power				
Data [dBm]	-69.65	-69.55	-69.76	-69.43
Pilots [dBm]	-69.55	-69.46	-69.56	-69.37

Fig. 1-6: WiMAX Measurements: Subcarrier Power

6. To determine the input path loss of your mobile phone, subtract the measured "Subcarrier Power > Data" from the reported "UL TX Power (Data Carrier Power)" of the MS. In the example above, the input path loss equals to approx. $(-37.00 - (-69.65))$ dB = 32.65 dB.
7. Re-open the "Multi Evaluation Configuration" dialog and enter the input path loss as an "External Attenuation (Input)"; see figure 1-5.



For the example above we assume that the "UL TX Power" reported by the MS corresponds to the power of one subcarrier. Adjust the calculation if your MS uses a different definition of the "UL TX Power".

1.4.3 Output Path Loss

Determining the output path loss requires the "WiMAX Signaling" firmware application only.

1. Access the "WiMAX Signaling" firmware application and establish a connection between the R&S CMW and the MS, using default settings.

When the R&S CMW shows the connection status "Network Entry Completed", press the "MS Channel Report" softkey.

2. Open the "Results > MS Channel Report" section in the measurement dialog and read the "RSSI Mean" result.

MS Channel Report	
CINR Mean	20.000 dB
CINR Deviation	40.000 dB
UL TX Power (Data Carrier Pow...)	-19.500 dBm
RSSI Mean	-80.000 dBm
RSSI Deviation	-101.000 dB

Fig. 1-7: WiMAX Signaling: RSSI Mean

3. Expand the "General Settings > RF Output (Tx)" section and read the "Preamble Power".

RF Output (Tx)		FrontEnd 1
RF Routing		RF1 COM
External Attenuation		0.00 dB
Tx Power Data Carrier		-80.00 dBm
Preamble Power		-46.50 dBm

Fig. 1-8: WiMAX Signaling: Preamble Power

4. To determine the output path loss of your mobile phone, subtract the reported "RSSI Mean" from the "Preamble Power" of the downlink signal. In the example above, the output path loss equals to $(-46.5 - (-80.0)) \text{ dB} = 33.5 \text{ dB}$.
5. Enter the path loss as an "External Attenuation". The R&S CMW will increase its "TX Power Data Carrier" to ensure a correct input power at the MS receiver.



The RSSI scale covers DL powers between -123 dBm and -40 dBm . The 1-dB step width of the RSSI scale and the accuracy of the RSSI measurement at the MS limits the accuracy of the measured output path loss values. Ensure that the "Preamble Power" of your DL signal is within the RSSI range.

1.4.4 Other Network Standards

The measurement method outlined above is also suitable for determining path loss values for other network standards; [table 1-1](#) gives an overview of the necessary R&S CMW configuration and the essential settings.

As a general rule the R&S CMW must be equipped with a signaling application (option R&S CMW-KSxxx) plus a measurement application (option R&S CMW-KMxxx) for every measured network standard. After the R&S CMW has established a connection with the EUT, the reported EUT output power is displayed in the measurement dialog of the signaling application. The R&S CMW input power must be determined using the measurement application. The input path loss is the difference between the two values:

Input path loss = EUT output power – R&S CMW input power

The R&S CMW generator power corresponds to the downlink/forward signal power that the R&S CMW uses for the connection; it is generally defined at the beginning of the configuration dialog of the signaling application, among other RF settings. The received signal level is reported by the EUT and appears in the measurement dialog of the signaling application. The output path loss is the difference between the two values:

Output path loss = R&S CMW generator power – Received signal level of EUT



Accuracy considerations

The EUT reports its output power and the received signal power as digital values (power steps). Each value denotes a power range, which necessarily limits the accuracy of the measurement method. The accuracies quoted below correspond to the distance between the reported power steps.

Differences for CDMA2000 and 1xEV-DO networks

In general CDMA2000 mobile stations (MS) and 1xEV-DO access terminals (AT) do not report their input and output power. The input path loss is most conveniently obtained in a measurement scenario where the MS/AT transmits at its known maximum power. The output path loss can be determined in an access probe measurement; see remarks 1 to 4 after the following table.

Table 1-1: Path loss measurements for different network standards using the R&S CMW

Standard	Required R&S CMW models	Required software options	Firmware version	EUT output power (UL)	R&S CMW input power (UL)	Resolution of input path loss / dB	R&S CMW generator power (DL)	Received signal level of EUT (DL)	Resolution of output path loss / dB
WIMAX	R&S CMW270 R&S CMW500	R&S CMW-KS700 R&S CMW-KM700	≥V1.0.10.1	UL TX Power (Data Carrier Power)	Subcarrier Power > Data Power	0.5	TX Power Data Carrier	RSSI Mean (– 40 dBm at max.)	1
GSM	R&S CMW280 R&S CMW500	R&S CMW-KS200 R&S CMW-KM200	≥V1.0.15.0	RF Settings > TCH/PDCH > Circuit Switched > PCL	Burst Power	1	RF Settings > TCH/PDCH > Reference Level	RX Level (– 48 dBm at max.)	1
WCDMA	R&S CMW280 R&S CMW500	R&S CMW-KS400 R&S CMW-KM400	≥V1.0.15.20	Transmitted UE Power	UE Power (RMS)	1	RF Settings > RF Power Downlink > Output Channel Power (for) / dBm + Physical Downlink Settings > P-CPICH Level / dB	CPICH RSPC (– 25 dBm at max.)	1
CDMA2000	R&S CMW500	R&S CMW-KS800 R&S CMW-KM800	≥V1.0.15.0	Max. Power (acc. to power class) ¹⁾	MS Power (1.23 MHz BW) ²⁾	–	CDMA power ³⁾	<Power offset> – (MS Power (1.23 MHz BW) – <Input path loss>) ⁴⁾	–
1xEV-DO	R&S CMW500	R&S CMW-KS880 R&S CMW-KM880	≥V1.0.15.0	Max. Power (acc. to power class) ¹⁾	AT Power (1.23 MHz BW) ²⁾	–	CDMA power ³⁾	<Power offset> – (AT Power (1.23 MHz BW) – <Input path loss>) ⁴⁾	–

- 1) See standard 3GPP2 C.S0011-A, "Maximum RF Output Power". Establish a connection and send TPC bits to command the MS/AT to transmit at maximum power. The maximum power depends on the power class of the MS.
- 2) The input power loss is the known maximum output power of the MS, depending on its power class, minus the measured MS power while the MS transmits at maximum power.
- 3) See standard 3GPP2 C.S0011-A, "Range of Open Loop Output Power". To obtain access probes with constant power, configure the signaling application as follows: "Network > Access Probes > Access Probes: Ignore, Probe Increment 0 dB".
- 4) When transmitting access probes, the MS/AT applies the open loop condition: the sum of the mean input power plus the mean output power is equal to a constant "Open Loop Power Offset". The mean output power of the MS/AT is the access probe power measured by the R&S CMW plus the input path loss determined previously. Open loop power offset values are specified in standard TIA-1030-C, depending on the band class and the spreading rate. Consequently the path loss measurement must be repeated for different band classes.

1.5 Additional Information

A separate application sheet describes how to determine input and output path loss values using a Universal Radio Communication Tester R&S CMU200.

The Universal RF Shielding Box CMW-Z10 and its accessories are described in the operating manual, stock no. 1204.7095.12.