# Characterizing RF Losses between GSM Phones and Test Equipment

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Cell phone testing is designed to determine the performance of the phone before it is placed in use on a live network. In an effort to define a consistant way to do the testing, the standards dictate that testing be done at a point which is defined to be the phone's antenna. But the test equipment is generally connected to the phone either through an antenna coupler or a direct cable connection. In the case of a direct connection, losses will occur on the cable and there may be additional losses due to an impedance mismatch between the cable and test equipment. Of course, the losses will be even greater when an antenna or antenna coupler is used to provide the connection between the test equipment and phone. Test specifications require that a specific level of RF energy must be supplied to the phone's antenna during testing and that the phone's RF output be measured at the antenna. In order to accurately test the phone, the bidirectional losses between the RF port on the test equipment and the phone must be accurately measured.

**GSM phones can be easily characterized on one-box tester**

Several methods can be used to characterize RF methods. A complex approach which is sometimes recommended involves a sophisticated set up using several pieces of equipment such as signal generators, power meters, vector network analyzers, and spectrum analyzers. This type of setup can accurately measure RF losses but has the disadvantage that it requires expensive equipment that may not be available and would be expensive to purchase. Most RF go/no go testing is done with a one-box tester so the ideal approach would be to use the same instrument used to test the phones to characterize the RF losses. A one-box tester can be used to quickly and accurately characterize GSM phones because their transmitted power can be controlled and they are capable of reporting their received power. The rest of this application note will outline a method by which the Anritsu MT8815A one-box tester can be used to measure the RF losses between the tester and a GSM cell phone.

The method described here relies upon setting the transmission power of the phone to a known level and reading the received report on the tester. The difference between the power generated by the phone and the power received by the tester is the RF loss. It's important to measure losses in both directions because GSM phones transmit and receive on different frequencies so losses are often substantially different in uplink and downlink directions. This can be accomplished by setting the power on the tester to a known level and querying the phone to determine the received power. Because this method involves approximation, it is also necessary to take an average of measurements performed on multiple phones.

**Consistently setting up phone in tester**

Obviously, the phone should be characterized using the same method, direct cable or antenna coupler, that will be used for testing. It's also important to identify a consistent method of setting up the phone that will be used both for characterization and for testing. If the RF connector snaps onto the phone this is relatively easy.  If the connector will not snap into place, another way to ensure that the connection is consistent must be found.  In the case of using an antenna or an antenna coupler, the phone antenna needs to be consistently positioned relative to the test antenna or antenna coupler.  Many antenna couplers have a clamp or guide and strap method to assist in this placement. An RF shield box is recommended to avoid interference from local base stations.

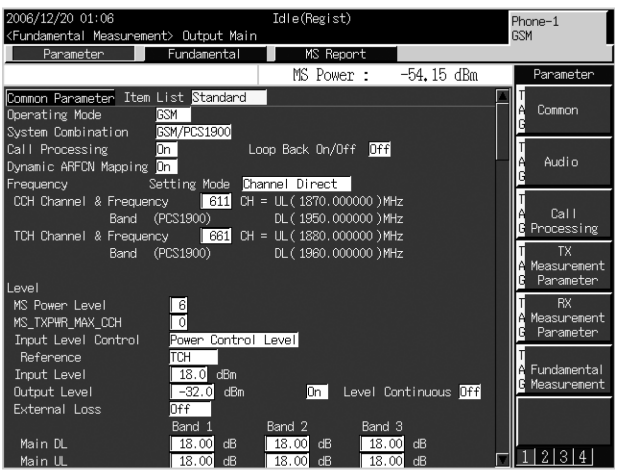



Figure 1:  Communications Setup for GSM

After a consistent phone connection is established, a call is placed from the tester to the phone. The tester's communications parameters must be set so that the phone will camp on the broadcast channel. Figure 1 shows the correct communications parameters on the MT8815A. Note that the External Loss value is set to off. This is necessary because if the External Loss value is set to on the tester will adjust the power level to compensate for various factors and this will reduce the accuracy with which the phone can be characterized. The MS Power Level is at 6 which sets the phone's output level high but below its maximum level. The output level is high because that makes it easier to obtain good measurements. However, if the maximum power level were used the phone might reduce the output level towards the lower end of the specification range in an effort to extend the battery life.

**Setting the Input Level Control**

Note that the Input Level Control is set to Power Control Level. This will set the MT8815A electronics in a manner that will optimally measure power if the power transmitted by the phone is near the level that is expected. Setting the Input Level Control to Power Control Level also causes the Input level to show the expected output power of the phone, in this case 18 dBm. This means the measured power is outside the optimal measurement range for the MS Power Level. Before this screen shot was taken, the Input Level of the MT8815A was set to -5 dBm which is very close to the loss-adjusted expected output level of the phone, resulting in an optimal measurement.

In Figure 1, the status shown at the top of the picture is "Idle(Regist)". This indicates that the phone has also registered on the system by performing the location update procedure. At this point the call can be established either by dialing a number on the phone and pressing send or by pressing the start key on the MT8815A and then pressing the answer key on the phone to accept the call.

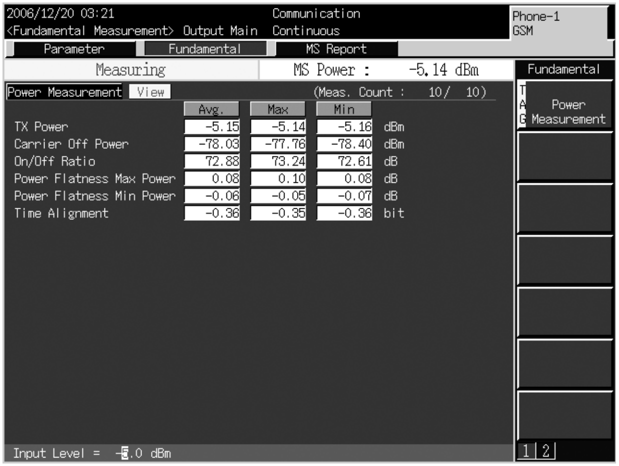
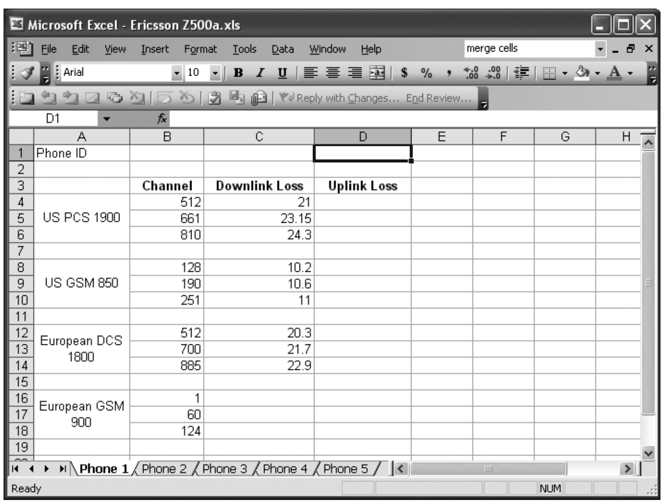



Figure 2: Measuring Power

The measured power as received at the tester is shown to be -5.15 dBm in Figure 2 while Figure 1 shows that the output power of the phone is set to 18 dBm. The difference between the phone's output and the signal received at the tester is the downlink loss of the system.

18.0 - (-5.15) = 23.15 dB loss.



| | A | B | C | D |
|---|---|---|---|---|
| 1 | Phone ID | | | |
| 2 | | | | |
| 3 | | **Channel** | **Downlink Loss** | **Uplink Loss** |
| 4 | US PCS 1900 | 512 | 21 | |
| 5 | | 661 | 23.15 | |
| 6 | | 810 | 24.3 | |
| 7 | | | | |
| 8 | US GSM 850 | 128 | 10.2 | |
| 9 | | 190 | 10.6 | |
| 10 | | 251 | 11 | |
| 11 | | | | |
| 12 | European DCS 1800 | 512 | 20.3 | |
| 13 | | 700 | 21.7 | |
| 14 | | 885 | 22.9 | |
| 15 | | | | |
| 16 | European GSM 900 | 1 | | |
| 17 | | 60 | | |
| 18 | | 124 | | |
| 19 | | | | |

Figure 3: Downlink data stored

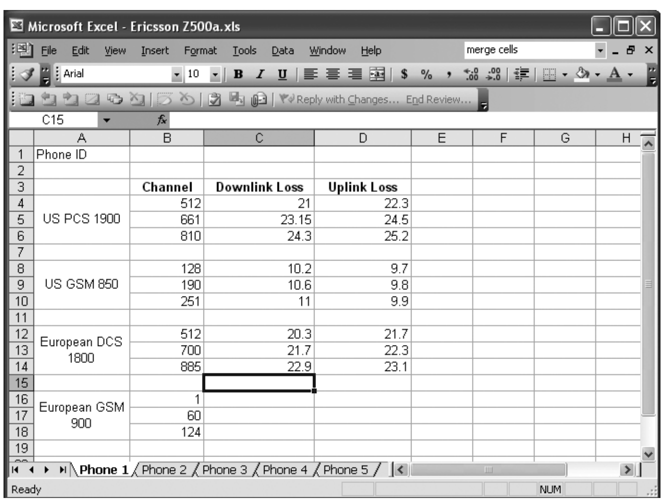
The measurements should be repeated for a representative assortment of channels within each band. The band, channel, losses and whether the measurement is uplink or downlink should be recorded as shown in Figure 3.


Figure 4: Mobile reported information

**Determining the uplink losses**

The next step is to calculate the uplink losses. This step takes advantage of the fact that GSM phones can be asked to report the power level they are receiving from the base station. Access this value on the MT8815A by pressing the Focus key on the front panel to highlight the MS Report tab as shown in Figure 4. This figure shows that this particular phone was reporting an RXLEVEL of 54, which translates to value between -57 and -56 dBm. Let's assume that the phone is actually receiving -56.5 dBm. Figure 1 shows that the MT8815A was actually transmitting at -32 dBm. Then the uplink loss is …

-32 - (-56.5) = 24.5 dB



| | A | B | C | D |
|---|---|---|---|---|
| 1 | Phone ID | | | |
| 2 | | | | |
| 3 | | **Channel** | **Downlink Loss** | **Uplink Loss** |
| 4 | US PCS 1900 | 512 | 21 | 22.3 |
| 5 | | 661 | 23.15 | 24.5 |
| 6 | | 810 | 24.3 | 25.2 |
| 7 | | | | |
| 8 | US GSM 850 | 128 | 10.2 | 9.7 |
| 9 | | 190 | 10.6 | 9.8 |
| 10 | | 251 | 11 | 9.9 |
| 11 | | | | |
| 12 | European DCS 1800 | 512 | 20.3 | 21.7 |
| 13 | | 700 | 21.7 | 22.3 |
| 14 | | 885 | 22.9 | 23.1 |
| 15 | | | | |
| 16 | European GSM 900 | 1 | | |
| 17 | | 60 | | |
| 18 | | 124 | | |
| 19 | | | | |



Figure 5: Fully filled loss table

Because of the indirect nature of these measurements, five different phones should be tested and the band, channel, losses and whether the uplink or downlink is measured is should be recorded as shown in Figure 5. After testing is completed, check the test results for each phone to look for unrepresentative results. For instance, assume that the downlink losses found for five phones at channel 661 in the US PCS 1900 MHz band are 23.15, 23.6, 22.7, 23.0, and 30.0. The value 30 is an outlier that is not representative of the rest of the data. Therefore the data for that phone should be considered suspect, and only the data from the other 4 phones should be used. In this case, the average loss is 23.22 dB. The average should be calculated for the uplink and the downlink for each channel that the phone will be tested on.

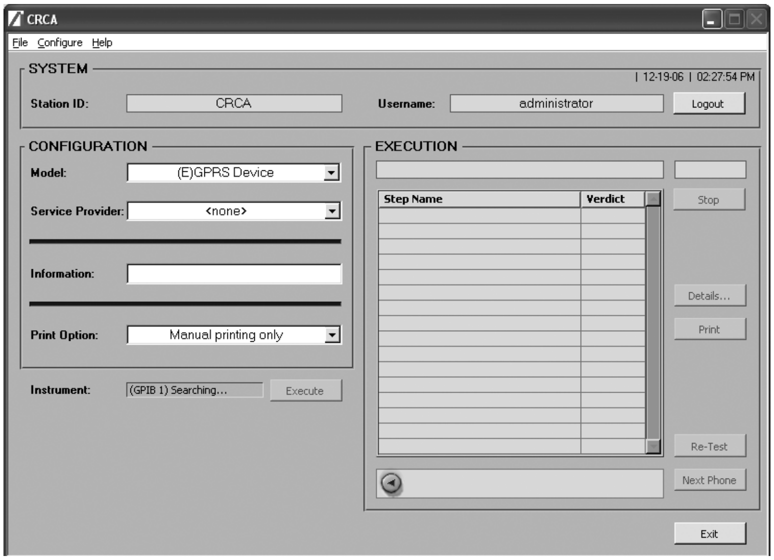



Figure 6: CRCA

The data should then verified by testing each phone at -104.5 dBm less the average RF losses on the receive path. All phones should pass and if they do not it may be necessary to tweak the loss data to ensure each of the phones passes. The easiest way to set up the loss table and test phones for go/no go status is to use the CRCA program shown in Figure 6. Using the CRCA program is outside the scope of this document.

When testing mobile phones, many of the measurements depend on knowing the power received and transmitted at the phone's antenna. However test equipment can only be manufactured and calibrated to the RF port of the device. Therefore the differences in the power levels between the RF port and the mobile phone antenna must be determined and compensated. This document discussed how to a the one-box tester to determine and compensate for those loses.

**About Related Anritsu Company Offerings**

Anritsu offers a line of equipment designed for cellular phone testing.

**RF Shielding Encloser with Antenna Coupler**

Anritsu offers the MA8120E Shield Box for Mobile Phone Testing. This RF enclosure has a built in antenna coupler as well the capability to connect a coax cable to the phone. Some of the features of the MA8120E include:

- Frequency: 800 to 2500 MHz
- Shield characteristics: More than 60 dB
- Dimensions: 330(W) x 181(H) x 393(D) mm
- Operating Temperature: +10° to +50 °C

**Cellular Phone Testers**

Anritsu offers three different cellular phone testers – the MT8510B, the MT8815A, and the MT8820A.

MT8510B

The MT8510B is a low cost Go/No Go tester for testing WCDMA and GSM phones. It can use a separate control PC to update the test software, control the tester, or install test parameters. Otherwise, the MT8510B runs

standalone with no external PC needed.  Some of the features of the MT8510B include:
- Supports W-CDMA/UMTS and GSM
- Voice codec for W-CDMA
- Multi-band support
- 10-line color TFT LCD
- Front panel USB connector for simple software upgrade using USB memories
- Remote software upgrade via Ethernet 10/100 Mbps link

MT8815A

The MT8815A is a full featured tester.  It runs faster than the MT8510A, and includes a more complete test suite. It also supports more protocols than the MT8510B does.  It supports WCDMA, GSM/GPRS/EGPRS, cdma2000 1xRTT, cdma2000 1xEV-DO, AMPS voice channel, and PHS.  Some of the features of the MT8815A include:
- W-CDMA Measurement Function including transmitter, receiver, and performance tests
- GSM/GPRS/EGPRS Measurement Function with GSM and EGPRS Measurement Software and TDMA Measurement Hardware
- cdma2000 1X Measurement Function with cdma2000 Measurement Software and Hardware
- cdma2000 1xEV-DO Measurement Function  with 1xEV-DO Measurement Software and Hardware
- AMPS Audio Board with cdma2000 Measurement Software
- PDC Measurement Function with PDC Measurement Software and TDMA Measurement Hardware
- PHS Measurement Function with PHS Measurement Software and TDMA Measurement Hardware
- Real-Time Voice Encoding and Decoding
- Test Function for Packet Communication Data Transfer
- cdma2000 1X/1xEV-DO Synchronous Function
- Call Processing Function
- High-speed, Easy-to-Use GPIB Control

MT8820A

The MT8820A is identical to the MT8815A with one major exception – the MT8820A has an option for a second RF unit, and when used in combination with the Parallel Phone measurement option, allows the testing of two phones at the same time.  This gives the customer the testing power of two testers while only taking the space of a single tester.  The protocols supported and the features are the same as the MT8815A.

CRCA

Then MX880150B - Computer-Aided Radio Communication Analysis (CRCA) Software option provides external control of the MT8801C, MT8815A and MT8820A Radio Communication Analyzers. Together, an analyzer and this software form a single, effective, and easy-to-use test solution for fast, automated testing of most of the world's wireless phones. This test system supports IS-136, GSM, GPRS/EDGE, IS-95, cdma2000 1x, 1xEV-DO, and W-CDMA.

Specifications are subject to change without notice.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