SIERRA WIRELESS

HEART OF THE WIRELESS MACHINE®

# AC775 EGPRS Radio Calibration Procedures

| | |
|---|---|
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# 1 General

## *1.1 Purpose*

This document outlines and details the calibration and test methods used by the factory to calibrate the AC775 EGPRS wireless modems. The calibration procedures outlined in this document may change with time. These changes will come as the test system is constructed and more details become known about the wireless modem's software and hardware architectures.

## *1.2 Scope*

This document contains a list of calibrations. The purpose and method of the calibration are described in enough detail so that a calibration system, including hardware and software, may be developed from these descriptions. Where possible, references to test equipment are made. However, specifying calibration limits has been avoided, where possible, in this document. If limits have been given, they should only be taken as example.

## *1.1 Glossary of terms*

| | |
|---|---|
| ADC | - analog to digital converter |
| AFC | - automatic frequency control |
| AGC | - automatic gain control |
| BBC | - baseband codec (code/decoder) |
| CW | - continuous wave signal (unmodulated signal) |
| DAC | - digital to analog converter |
| DSP | - digital signal processor |
| MS | - mobile station (DUT) |
| NVRAM | - non volatile random access memory |
| PCL | - power control level |
| PLL | - phased locked loop |
| Rx | - receiver |
| RSSI | - received signal strength indicator |
| SWI | - Sierra Wireless Inc. |
| TCVCXO | - temperature compensated voltage control crystal oscillator or TCXO |
| Tx | - transmitter |
| DUT | Device under test – the AC775 |
| SWI | Sierra Wireless Inc |
| NV | Novram |
| BW | Band width |
| Tbd | To be determined |

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### *1.2 References*

| Ref. # | Doc. # | Document title |
|---|---|---|
| R-1 | 3GPP TS 05.05 V8.8.0 | Digital cellular telecommunications system (Phase 2+); Radio transmission and reception |
| R-2 | 3GPP TS 05.02 V8.8.0 | Digital cellular telecommunications system (Phase 2+); Multiplexing and multiple access on the radio path |
| R-3 | 3GPP TS 51.010-1 V4.5.0 | Digital cellular telecommunications system (Phase 2+); Mobile Station (MS) conformity specification |
| R-4 | Projmemoxxx | Layout of NV. |
| R-5 | Project Memo 006 | Radio Requirements Specification For AC775 Quad-Band EGPRS Terminal |
| R-6 | Projmemo025 | Custom AT Commands |
| R-7 | 2110198 | CONFIGURATON MANAGEMENT AND DOCUMENTATION |

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# 2 Calibration and System Station

There are two groups of tests done at this station. The first control the modem in diagnostic mode and determine tuning factors that are stored in the unit's NV. If a unit passes these tests, it will be reset to use these values and initiate a call in its normal mode of operation. Once a call is established between the test equipment and the DUT, the System group of tests will be done.

This station will accept a cased (with frame-kit) AC775. The unit will not have a FSN label but its NV will be initialized with one.

Testing will be done with 5V, a current limit of 2.0 amps and a voltage limit of 5.5V applied to the unit.

Test history bytes will be set in the DUT's NV that will indicate if the unit has passed the Calibration station's group of tests. There are separate bytes for the Baseband and RF tests completed on this station.

The calibration date and calibration count will be written into the DUT's NV.

Note that not all PCL/Γ TX levels are checked after calibration. Only the highest power levels are.

| |
|---|
| If the unit has been through the calibration station, reinitialize all calibration NV items that would affect RF performance. This information should be in the test history section of the NV. |

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### 2.1.1 Calibration

Values found during testing will be placed into the NV according to the layout of values given in R-4.

#### *2.1.1.1 Settings for All Tests*

Any undefined settings in the individual calibration test descriptions are specified in this section.

2.1.1.1.1 DUT

**Table 1: Calibration Channels**

| | |
|---|---|
| PCS | 661 |
| DCS | 698 |
| GSM850 | 190 |
| GSM900 | 37 |

Note: Normally a station dependent offset is added to each channel. Since there are defined boundaries imposed for the TX Frequency calibration, the channels are not offset to ensure that they do not cross the boundaries.

**Table 2: Standard DUT TX Signal.**

| | |
|---|---|
| Bit Modulation | Random data with TSC5 (AT!DNBDAT=3) |
| Training sequence | 5 |
| Burst per frame | 1 |
| Burst type | Continuous |

***TX Note:***

There are two ramp profiles used by the firmware. The correct one must be selected and in use during the power measurement. To select, send the AT command:

AT!TXPLE=1,x where x=PCL level being found.

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2.1.1.1.2 CMU

**Table 3: CMU RX Settings for TX Calibration Tests**

| Setting | Value |
|---|---|
| Training Sequence | Any |
| RF Mode (affects TX measurements, how it adjusts to varying power levels) | Auto |
| RF Attenuation | Normal |
| Trigger Source | IF Power |
| Trigger Level | -26 dBm |
| Trigger Slope | Rising Edge |
| Frequency Offset | 0 Hz |
| 8PSK Filter | *600 kHz* |
| Number of bursts/measurement – GMSK | 20 |
| Number of bursts/measurement – 8PSK | 50 |
| 8PSK Measurement mode | Data Compensation |

**Table 4: CMU TX Settings for RX Calibration Tests**

| Setting | Value |
|---|---|
| Bit Modulation | Off |
| Transmission | Continuous |
| Frequency Offset | 67.7 kHz |

### *2.1.1.2 AC775 Communications*

Power up the AC775 assembly, and check that it responds to an AT command by returning "OK". Fail the unit if it does not.

### *2.1.1.3 AC775 FSN*

Verify that the unit has a proper FSN. Check that the FSN begins with a character value, and that there are non-zero values for the day, month and year fields. Fail the unit if it any of these fields are not as described.

### *2.1.1.4 Smoke Station Test History*

Read the units test history bytes and fail the unit if they do not indicate that it has passed the Smoke station's Baseband and RF testing.

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### *2.1.1.5 AFC*

This test need only be done for the PCS band, and is done on the centre channel.

**Purpose**

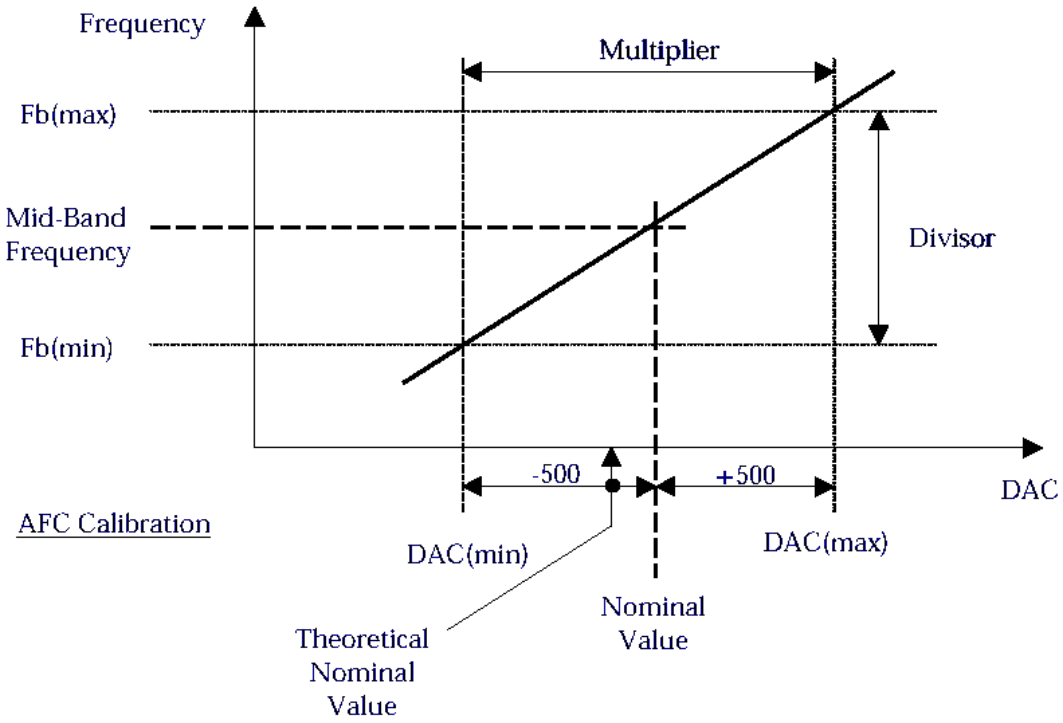
Calibration of the AFC is carried out to ensure that the clock frequency is correctly synchronized to that of the network.

**Method**

Because the relationship between the DAC and the clock frequency is a linear one, the AFC calibration of an individual DUT may be characterized by three parameters:

1. a nominal value
2. a multiplier
3. a divisor

The nominal value is the DAC value required to give the desired clock frequency of the mid-band channel. The multiplier and divisor give the slope and therefore allow for the calculation of the correct DAC value for all other frequencies.




**Procedures**

1. Get the DUT transmitting a standard TX GMSK signal on the calibration channel. Use a TX DAC that sets the power to about 23-27dBm for a normally functioning DUT.
2. Set the DUT's AFC DAC to its lowest value and measure the frequency error Fl.
3. Set the DUT's AFC DAC to its highest value and measure the frequency error Fh.

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4. Calculate the slope (NV_slope) and intercept DAC (NV_int) values and compare them to the limits specified for each. If they are outside the limits fail the unit and do not write the values into NV. Otherwise save them to NV.

$$NV_slope = \frac{(Fh - Fl)}{\text{(high AFC DAC value – low AFC DAC VAlue)}} * 200500$$

NV_int = (low AFC DAC value) – Fl / NV_slope;

***Notes:***

- CMU measurement Group: MOD

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### *2.1.1.6 DC Offset*

This test is to be done only for the PCS Band.

**Purpose**

Calibration of the TX DC offset is carried out to ensure that the origin offset is within specified limits. This offset is measured by the CMU's *origin offset suppression* parameter.

**Method**

1. Get the DUT transmitting a standard TX 8PSK signal on the calibration channel. Use the AFC intercept DAC found in the AFC test. Set the TX power scaling to a value that sets the TX output power to 24dBm for the average good unit.
2. Measure the TX signal's origin offset suppression value, and adjust the I and Q offset (BBC DC Offset value) until its below the maximum specified value.
3. Save the settings of I and Q found into NV.

***Notes:***

- CMU measurement Group: MOD:EVM:EPSK
- Adjust the I and Q in steps no larger than 1.

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### *2.1.1.7 TX Power Scaling – GMSK*

This test is to be repeated on the middle channel of each band.

**Purpose**

Scaling factors are calibrated to ensure that the transmitted output power of the DUT meets the levels specified in R-1 for each supported power level. These levels are band dependent and the test system will not necessarily aim for the standard target power level in order to conserve host resources. The power values for each level are specified in tables 1 and 2 below.

**Method**

1. Get the DUT transmitting a standard TX GMSK signal on the calibration channel. Use the AFC intercept DAC found in the AFC test.
2. Measure the power and adjust the TX scaling factor till the output power is within limits of the highest PCL for the current band. I.e. PCL 15 is 0.0dBm. Record the scaling factor used.
3. Repeat step 2 for the next highest PCL level until a scaling factor is found for each PCL. Fail the unit if the output power of the mobile could not be adjusted to within the specified limits of a target.
4. Save all the scaling factors found into the Novram.

***Notes:***

- CMU measurement: for all but the highest power level: WPOW
- CMU measurement: for the highest power level: POW

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The output power of GSM850/EGSM900 can be controlled based on the following table:

**Table 5: GMSK TX PCL levels for GSM 900 and GSM 850 Bands**

| GMSK | | |
|---|---|---|
| Γ | PCL | Nominal Output power (dBm) |
| 3 | 5 | *31.25 |
| 4 | 6 | *30 |
| 5 | 7 | 29 |
| 6 | 8 | 27 |
| 7 | 9 | 25 |
| 8 | 10 | 23 |
| 9 | 11 | 21 |
| 10 | 12 | 19 |
| 11 | 13 | 17 |
| 12 | 14 | 15 |
| 13 | 15 | 13 |
| 14 | 16 | 11 |
| 15 | 17 | 9 |
| 16 | 18 | 7 |
| 17-29 | 19-31 | 5 |

*Adjusted for power conservation.

**Table 6: GMSK TX PCL levels for PCS and DCS Bands**

| | GMSK | |
|---|---|---|
| Γ | PCL | Nominal Output power (dBm) |
| 3 | 0 | *28.25 |
| 4 | 1 | *27 |
| 5 | 2 | 26 |
| 6 | 3 | 24 |
| 7 | 4 | 22 |
| 8 | 5 | 20 |
| 9 | 6 | 18 |
| 10 | 7 | 16 |
| 11 | 8 | 14 |
| 12 | 9 | 12 |
| 13 | 10 | 10 |
| 14 | 11 | 8 |
| 15 | 12 | 6 |
| 16 | 13 | 4 |
| 17 | 14 | 2 |
| 18-31 | 15-28 | 0 |

*Adjusted for power conservation.

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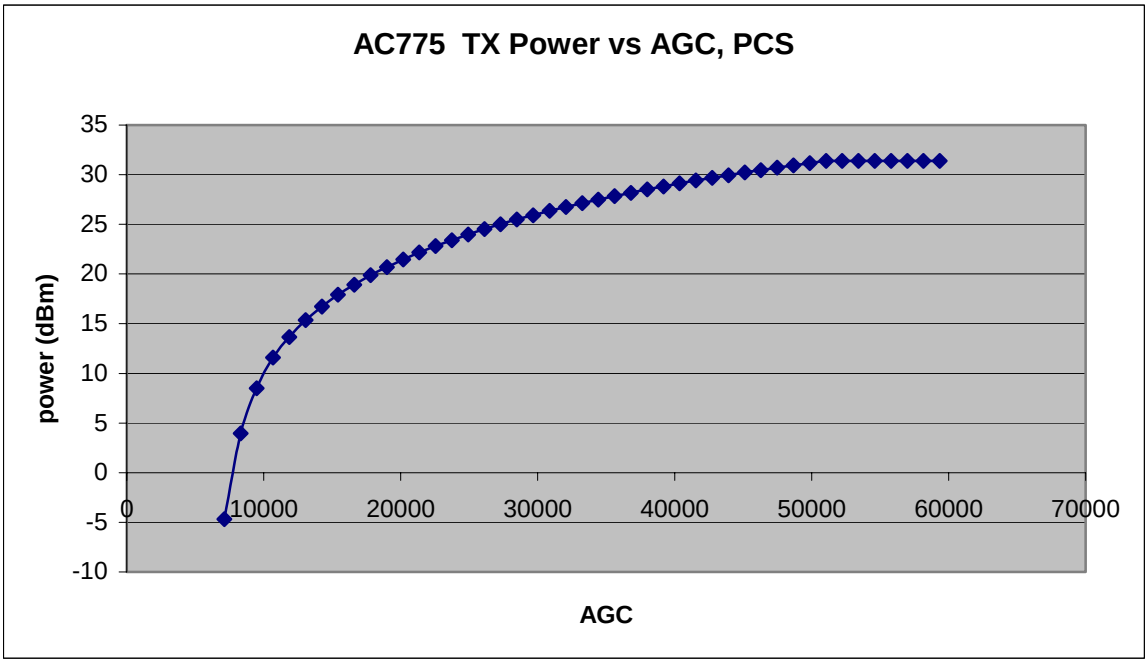


**Figure 1: AC775 TX Power versus AGC for GMSK Modes**

The AC775 has no power detection feedback circuitry for the GMSK transmission state. (Known as G0 mode).

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### *2.1.1.8 TX Frequency correction – GMSK*

This test is to be repeated each band.

**Purpose**

The TX power scaling calibration is done on a single channel across a range of powers. It is accurate only on the channel it was done, which is the centre channel in the band. To keep the TX power for a given PCL constant across the band, scaling factor adjustment values need to be determined for a given set of channels.

**Method**

**Table 7: TX Frequency Compensation channel boundaries.**

| | | | | |
|---|---|---|---|---|
| PCS | 512 | 650 | 651 | 810 |
| DCS | 512 | 700 | 701 | 885 |
| GSM850 | 128 | 200 | 201 | 251 |
| GSM900 | 975 | 1023 | 0 | 124 |

Note: These are the same channels as those used in the GMSK TX Frequency Compensation calibration.

**Table 8: PCL levels for TX Frequency Compensation.**

| | PCL |
|---|---|
| PCS, DCS | 0 |
| GSM850, GSM900 | 5 |

Do not do this test without conducting the AFC and GMSK TX Scaling Calibration first.

1. Get the DUT transmitting a standard TX GMSK signal. Use the AFC intercept DAC found in the AFC test.
2. Set the channel of the DUT to the first listed in Table 7.
3. Measure the power and adjust the TX scaling factor till the output power is within limits of the highest power PCL for the current band. I.e. PCS is PCL 0.
4. Calculate a scaling factory adjustment value for NV using the following formula:

$$\text{NV(channel \#1)} = \frac{\text{(power scale factor on channel \#1)} * 0X8000}{\text{(power scale factor on centre channel)}}$$

5. Repeat for the other 3 channels.

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6. Write all 4 NV scaling factor corrections into their proper location in NV.

***Notes:***

- The power scale factor from the center channel is that found in the GMSK TX Power Scaling calibration test.
- One of the 4 channels will be very close to the centre channel of the band on which the TX output power may not need adjusting. If any of the above channels is within 40 channels of the centre channel, skip it and write a value of 0x8000 in the NV. Do not skip more than one channel, and always skip the closest channel.
- CMU measurement Group: POW

### *2.1.1.9 TX Power Scaling – 8PSK*

This test is to be repeated on the middle channel of each band.

**Purpose**

Scaling factors are calibrated to ensure that the transmitted output power of the DUT meets the levels specified in R-1 for each supported power level. These levels are band dependent and the test system will not necessarily aim for the standard target power level in order to conserve host resources. The power values for each level are specified in tables 10 and 11 below.

**Method**

1. Get the DUT transmitting a standard TX 8PSK signal on the calibration channel. Use the AFC intercept DAC found in the AFC test.
2. Set the TX power scaling factor to a value that generates 10dBm of power for the average unit. Measure the power and require that it be within some dB to 10 dBm so that you can recognize a bad unit.
3. Set the TX power scaling factor to a value that generates 24dBm of power for the average unit. Measure the power and require that it be within some dB to 24 dBm so that you can recognize a bad unit.
4. Assume a linear relationship between the scaling factor and the TX power and calculate scaling factors for all output powers of Table 9 and Table 10.
5. Set the scaling factor to the calculated value for the highest output power and adjust and insure that its with limits to this power. If not, adjust the scaling factor until it is and record the new scaling factor. Fail the unit if the target TX power could not be reached.
6. Save all the scaling factors found into the Novram.

***Notes:***

- CMU measurement: POW EPSK
- Use Data compensation.

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The output power of GSM850/EGSM900 can be controlled based on the following table:

**Table 9: 8PSK TX PCL levels for GSM 900 and GSM 850 Bands**

| 8PSK | | |
|---|---|---|
| Γ | PCL | Nominal Output power (dBm) |
| - | - | - |
| - | - | - |
| - | - | - |
| 6 | 8 | 27 |
| 7 | 9 | 25 |
| 8 | 10 | 23 |
| 9 | 11 | 21 |
| 10 | 12 | 19 |
| 11 | 13 | 17 |
| 12 | 14 | 15 |
| 13 | 15 | 13 |
| 14 | 16 | 11 |
| 15 | 17 | 9 |
| 16 | 18 | 7 |
| 17-29 | 19-31 | 5 |

*Adjusted for power conservation.

**Table 10: 8PSK TX PCL levels for PCS and DCS Bands**

| 8PSK | | |
|---|---|---|
| Γ | PCL | Nominal Output power (dBm) |
| - | - | - |
| - | - | - |
| 5 | 2 | 26 |
| 6 | 3 | 24 |
| 7 | 4 | 22 |
| 8 | 5 | 20 |
| 9 | 6 | 18 |
| 10 | 7 | 16 |
| 11 | 8 | 14 |
| 12 | 9 | 12 |
| 13 | 10 | 10 |
| 14 | 11 | 8 |
| 15 | 12 | 6 |
| 16 | 13 | 4 |
| 17 | 14 | 2 |
| 18-31 | 15-28 | 0 |

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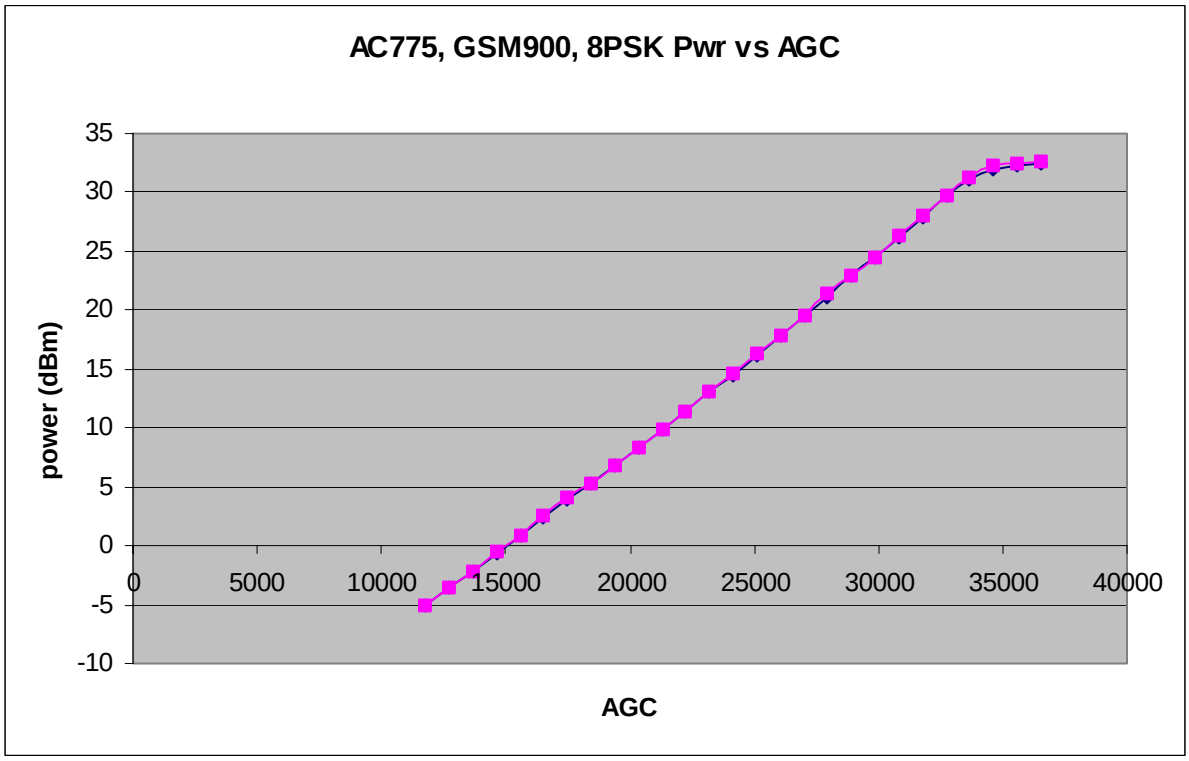


**Figure 2: AC775 TX Power vs AGC in Edge Mode**

The AC775 has feedback circuitry for the EDGE transmission state. (Known as E0 mode). This creates a linear relationship between the AGC and output power. This allows for a quick calibration because a sampling of two carefully selected points (AGC,power), can provide enough information to determine the AGC settings for all TX PCL's.

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### *2.1.1.10 TX Frequency Compensation –8PSK*

This test is to be repeated each band.

**Purpose**

The TX power scaling calibration is done on a single channel across a range of powers. It is accurate only on the channel it was done, which is the centre channel in the band. To keep the TX power for a given PCL constant across the band, scaling factor adjustment values need to be determined for a given set of channels.

**Method**

**Table 11: TX Frequency Compensation channel boundaries.**

| | | | | |
|---|---|---|---|---|
| PCS | 512 | 650 | 651 | 810 |
| DCS | 512 | 700 | 701 | 885 |
| GSM850 | 128 | 200 | 201 | 251 |
| GSM900 | 975 | 1023 | 0 | 124 |

Note: These are the same channels as those used in the GMSK TX Frequency Compensation calibration.

**Table 12: Γ levels for 8PSK TX Frequency Compensation.**

| | Γ |
|---|---|
| PCS, DCS | 5 |
| GSM850, GSM900 | 6 |

Do not do this test without conducting the AFC and 8PSK TX Scaling Calibration first.

1. Get the DUT transmitting a standard TX 8PSK signal. Use the AFC intercept DAC found in the AFC test.
2. Set the channel of the DUT to the first listed in Table 11.
3. Measure the power and adjust the TX scaling factor till the output power is within limits of the highest power PCL for the current band. I.e. PCS is PCL 0.
4. Calculate a scaling factory adjustment value for NV using the following formula:

$$NV(\text{channel \#1}) = \frac{(\text{power scale factor on channel \#1}) * 0X8000}{(\text{power scale factor on centre channel})}$$

5. Repeat for the other 3 channels.

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6. Write all 4 NV scaling factor corrections into their proper location in NV.

Notes:

1. The power scale factor from the center channel is that found in the GMSK TX Power Scaling calibration test.
2. One of the 4 channels will be very close to the centre channel of the band on which the TX output power may not need adjusting. If any of the above channels is within 40 channels of the centre channel, skip it and write a value of 0x8000 in the NV. Do not skip more than one channel, and always skip the closest channel.

***Notes:***

- The power scale factor from the center channel is that found in the 8PSK TX Power Scaling calibration test.
- One of the 4 channels will be very close to the centre channel of the band on which the TX output power may not need adjusting. If any of the above channels is within 40 channels of the centre channel, skip it and write a value of 0x8000 in the NV. Do not skip more than one channel, and always skip the closest channel.
- CMU measurement Group: POW:EPSK

### *2.1.1.11 AM Loop*

This test is to be repeated on the middle channel of each band.

The AFC test must be successfully completed first, and the DAC value found from must be used during the test.

**Purpose**

8PSK is produced by the radio's PA, which modulates the amplitude of the phase-modulated carrier (GMSK). The PA thus has two inputs: the phase modulated carrier and the amplitude modulation. Each of these inputs is complex in the fact that they have different gains for different carrier frequencies – aka they have different bandwidths.

To maximize the performance of the radio, the bandwidth of the amplitude modulation input to the PA is adjusted to fit that of the phase modulation input. Changing the gain on the feedback from the PA, which is combined with the amplitude modulation input, does this. This feedback loop is the AM loop, and the gain is known as the A0 gain.

When the bandwidth is too narrow, the EVM and Spectrum due to modulation gets bad. When it's too wide, the TX signal spills over to the RX band, and the RX noise increases.

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**Method**

To determining the correct setting of the AM Loop gain, we set the radio to generate two pure carrier signals: one "in band" at an offset of 216kHz, and the other "out of band" at and offset 6.5MHz. It's been calculated that the AM loop gain sets the desired bandwidth when the difference in signal strength of the two signals is 13dB. Because each offset has + and – counterparts about the carrier, there are two sets of differences (one above the carrier, and one below). The average of the two sets is then desired to be about 13dB.

Do not do this test without conducting the AFC and 8PSK TX Scaling Calibration first.

1. Get the DUT transmitting a standard TX 8PSK signal on the calibration channel. Use the AFC intercept DAC found in the AFC test. Set Γ to 5 for PCS and DCS bands, 6 for GSM bands.
2. Send the string "at!dsynth=15,2147571899" to set the radio into MODE????.
3. Measure the average difference in 216kHz and 6.5MHz signal strengths and adjust the A0 Gain ("at!dsynth=15,…") until it is with specified limits of 13dB.
4. Reinitialize the radio, returning it to its normal mode.

***Firmware Notes:***

Setting the AT!dsynth=15,0xXXXXXXXX is band dependent. For a setting of VAL:

PCS1900: XXXXXXXX= 0x8048063E + val*2&11
PCS1900: XXXXXXXX= 0x80480636 + val*2&11
PCS1900: XXXXXXXX= 0x8048062E + val*2&11
PCS1900: XXXXXXXX= 0x80480626 + val*2&11

To reinitialize the radio:

AT!DBURST= ???
at!dsynth=15,2147571867

***Measurement Notes:***

- Uses CMU's NPOW measurement group.
- Resolution BW:30kHz
- Set the CMU's trigger source to "IMMediate".

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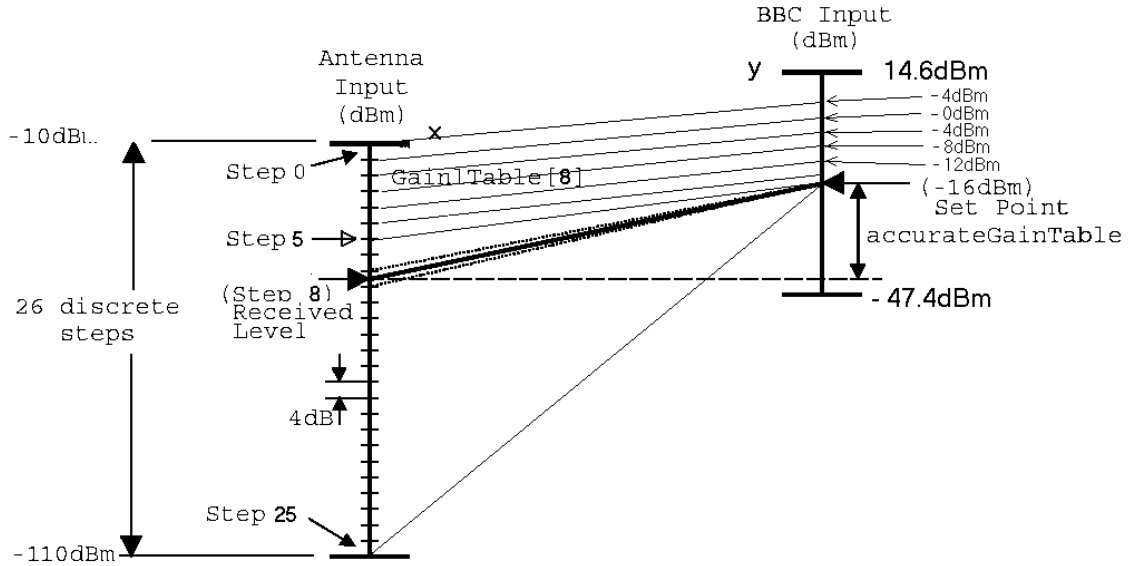
*2.1.1.12 RX AGC Power Gain*

This test is to be repeated on the middle channel of each band.

**Purpose**
Calibration of the AGC is required to ensure that received signals remain within the useable range of the BBC.

**Method**




The output dynamic range (-10dBm to -110dBm in 26 discrete gain steps and in 4dB increments) of the Radio is mapped onto the input range BBC with nominal Set Point at –16dBm.

The **gainCode** is a number from 0-25 that is used to look up AGC gain values in the **accurateRadioGainTable** table in the NV. **Gaincodes** are uniquely assigned to a given input power range with a width of 4dB.

The **accurateRadioGainTable** is a table of 26 values per band that is used to calculate the actual received level based upon the level seen at the input to the BBC.

**Procedures**

1. Load the current set of **accurateRadioGainTable** values. These values will be corrected an amount based on the RSSI error measured.
2. Set the DUT to the desired band and middle channel.

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3. Transmit a CW signal to the DUT at a power level of –10dBm, with a frequency offset of 67.7kHz. Using the gaincode of 0, read the RSSI, averaging the values to suit time and accuracy requirements.
4. Calculate the adjusted **accurateRadioGainTable** value for this gaincode and input power using the following formula:

New value = old value – 16/(dBm) * (DUT RSSI (dBm) – power of signal generator(dBm))

5. Decrease the power to the unit by 4dB and use a gaincode of 1 to measure the RSSI and repeat the calculation in the previous step to determine the new value. Continue to decrease the power and increment the gaincode until new **accurateRadioGainTable** values have been found for all 26 gaincodes.
6. As it is calculated, demand that the new gaincode values are within specified limits (one set for each gaincode), and fail the unit as soon as one is found outside these limits.
7. If all new **accurateRadioGainTable** values are found within limits, save the results to NV.

***Notes:***

- Average over at least 4 RSSI readings from DUT.

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### 2.1.2 System

At the time of the writing of this document, it was known that the Rhode & Schwarz CMU 200 would be used. Only where it cannot be avoided, or where it is very important, test descriptions will refer to the functionality of this test set.

#### *2.1.2.1 Test Channels*

All system tests are done on a low and high channel in the band.

**Table 13: System Test channels.**

| Band | BCCH | TCH for Call | Low Chan | High Chan |
|---|---|---|---|---|
| GSM850 | 162 + offset | 192 | 140 + offset | 239 + offset |
| GSM900 | 32 + offset | 62 | 987 + offset | 112 + offset |
| DCS | 735 + offset | 740 | 524 + offset | 873 + offset |
| PCS | 600 + offset | 610 | 524 + offset | 798 + offset |

Offset – a low value around 0 that's used to assign the test station a unique set of channels to use. Valid range is from –12 to 12 in increments of 3.

#### *2.1.2.2 Test Parameters Used*

The session parameter settings for each test will be the following unless otherwise noted. These values should be set during test set initialization before any testing is done.

**Table 14: Common System Test Settings**

| Parameter | Value |
|---|---|
| Timeslots | Single Slot, slot #3 |
| Frequency hopping | Disabled |
| Timing advance | 0 sym |
| Statistic Count (# bursts averaged over) | GMSK: 50<br>8PSK: 100 |
| Max Level | Automatic |
| Attenuation | Low Noise or Low Distortion or Normal ??? (SEE EVM test) |

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**Table 15: System Tests – Parameter Summary.**

| Test | Parameters Measured | RSSI (BCCH signal strength) | Modulation | Connection Type | Coding Scheme | Test Mode | Main Slot Γ or PCL |
|---|---|---|---|---|---|---|---|
| Call | | -80 dBm | 8PSK | Data Packet | MSC5 | A | PCS&DCS : Γ=5<br>GSM 850 & 900 Γ=5 |
| 8PSK Combo | EVM RMS<br>EVM Peak<br>EVM 95%<br>Origin Offset<br>TX Power<br>Power Ramp Mask | | | | | | |
| Spectrum | Due to Modulation<br>Due to Switching | | | | | | |
| GMSK Combo (TX) | Freq. Error<br>Peak Phase Error<br>RMS Phase Error<br>Power<br>Power Ramp Mask | -80 dBm | GMSK | CSC | Full Rate | N.A. | PCS&DCS : PCL=0<br>GSM 850 & 900: PCL=5 |
| GMSK Combo (RX) | RSSI | -55,<br>-90 dBm* | | | | | |
| Spectrum | Due to Modulation<br>Due to Switching | -80 dBm | | | | | |
| BER | BER | -104 dBm* | | | | | |

* Exact values are specified in the test limit and configuration file.

The DUT is the MS (Mobile Station) and the test set is the base station and network. All control of the DUT is done through the test set. Do not directly tell the DUT to transmit at power level X, but instead tell the test set to set the MS gamma to X.

All system tests for a band begin with either a call or handover. If the connection is lost at any time during testing, fail the unit.

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*2.1.2.3 Call or Handover*

Ensure that the DUT was reset after having its calibration NV values written. Also ensure that the DUT is in the proper band for the call. This should be done before resetting the unit to activate the NV values found in the calibration tests.

This test requires that a call or handover be successful to pass. A call will be completed for the PCS and DCS bands, and a handover for the GSM850 (from PCS) and GSM900 (from DCS) bands.

**Calls for PCS and DCS:**

Turn the BCCH on, and then power up the DUT. Allow 20 seconds for the test set to synchronize (Circuit switched) and attach (Data Packet) with/to the DUT. Fail the unit if it does not do so. Initiate a connection between the CMU and DUT. Allow 5 seconds for this to be established, failing the unit if not done so.

Note: For Circuit Switched calls, the DUT should be configured to automatically answer an incoming call from the test set. (ATS0=1)

**Handover for GSM850 and GSM900:**

Allow 5 seconds for a successful handover to be completed failing the unit if not so.

*2.1.2.4 TX – 8PSK*

Tell the test set to initiate a set of EVM measurements. Gather values from the measurement for the following and compare against limits. Fail the unit if any value is outside limits.

- (%) RMS EVM
- (%) Peak EVM
- (%) max EVM 95th-percentile
- (dB) min Origin Offset suppression (caused by DC offset in the Baseband signal)
- TX power Mask
- TX Power (according to Γ setting)

CMU Measurement: The CMU measures these values over time for a burst. They are then averaged. The measurement is repeated for the number of statistic cycles the test is set up to do. (See Table 14: Common System Test Settings)

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Demand that each measured power value be within some limit to the targets specified in Table 9and Table 10. Also demand that the PCL levels are separated by some specified amount. Fail the unit if any of these conditions are not met.

### *2.1.2.5 Spectrum Due to Modulation – 8PSK*

Although the GSM limit specifications are equal for GMSK and 8PSK, the test set carries a separate set of limits for each, ensure at the beginning of the test that the test set's configured to use the correct power limit mask – GMSK.

The test set measures the power at 9 equally spaced points on each side of the channel of interest separated by 0.2MHz, plus two additional points at 0.1MHz and 0.25 MHz offsets. It then compares these vales to the pre-programmed limit mask which contains limits for the entire set of values collected.

Let the test set complete this test, returning only a pass or fail. During test system initialization, ensure that the test set's pre-coded Spectrum due to Modulation test parameters match those specified in R-5. Retrieve the results, and pass or fail the unit.

### *2.1.2.6 Spectrum Due to Switching – 8PSK*

Although the GSM limit specifications are equal for GMSK and 8PSK, the test set carries a separate set of limits for each, ensure at the beginning of the test that the test set's configured to use the correct power limit mask – GMSK.

The test set measures the power at 4 points on each side of the channel of interest at offsets of 0.2, 0.6, 1.2 and 1.8 MHz. It then compares these vales to the pre-programmed limit mask.

Let the test set complete this test, returning only a pass or fail. During test system initialization, ensure that the test set's pre-coded Spectrum due to Modulation test parameters match those specified in R-5. Retrieve the results, and pass or fail the unit.

### *2.1.2.7 Spectrum Due to Modulation – GMSK*

This is done the same was as described in section 2.1.2.5 Spectrum Due to Modulation – 8PSK, but done with the DUT in a circuit switched call.

### *2.1.2.8 Spectrum Due to Switching - GMSK*

This is done the same was as described in section 2.1.2.6 Spectrum Due to Switching – 8PSK, but done with the DUT in a circuit switched call.

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*2.1.2.9 RSSI – GMSK*

The RSSI signal strength measured by the DUT is transferred to the CMU during a call in the receiver report of the mobile. The value has the corresponding signal strength:

**Table 16: BS reported Signal Strength from MS**

| Value | Corresponding signal strength |
|---|---|
| 63 | > -48 dBm |
| 62 | -49 to –48 dBm |
| 61 | -50 to –49 dBm |
| … | |
| 1 | -110 dBm to –109 dBm |
| 0 | <-110 dBm |

Select two power input power levels for the DUT to measure, say –55 and –90 dBm. One at a time, input this power on a selected channel in the band, and query the CMU for the RSSI value of the receiver report of the DUT. Repeat for the second value.

Note: Convert the RX report values to the average of their possible values. I.e.

**Table 17: MS RX Report Value to dBm**

| Value | Test System Corresponding signal strength |
|---|---|
| 63 | -48 dBm |
| 62 | -48.5 dBm |
| 61 | –49.5 dBm |
| … | |
| 1 | –109.5 dBm |
| 0 | <-110 dBm |

*2.1.2.10 RX Sensitivity or BLER – 8PSK*

The Bit Error Rate *(BER)* is the ratio of erroneous bits to the total number of transferred bits in percent (also referred to as samples in the operating mode *BER*).
The CMU outputs the bit error rate according to bit classes:

- BER = Erroneous bits / total number of bits * 100%
- BER II = Erroneous class II bits / total number of class II bits * 100%
- BER Ib = Erroneous class Ib bits / total number of class Ib bits * 100%

The 78 *class II bits* have no error protection, which is why they quickly produce transmission errors.

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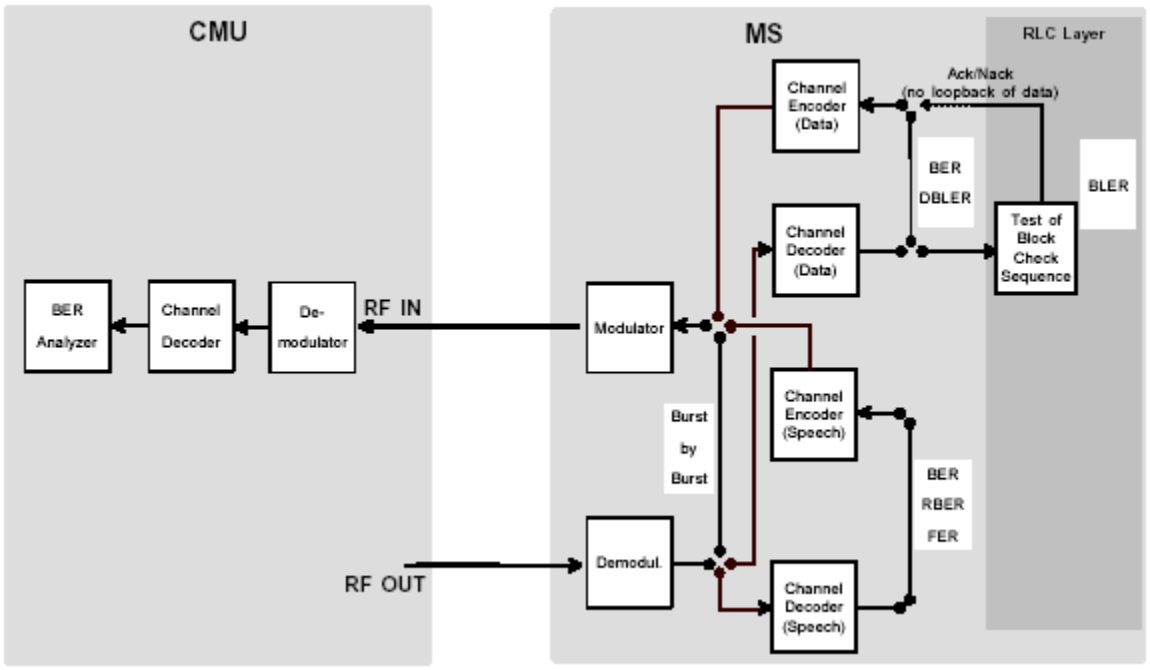
MS = Mobile station or DUT

**Table 18: Data Loop-back for BER Testing.**




Configure the CMU to measure BER (class II bits), for a very low BCCH level (i.e. –104dBm). Require that the BER is not above some maximum limit, and fail the unit if it is not.

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