TUNE-UP / ALIGNMENT PROCEDURES

RFCAL
EM3420

REVISION: 1.1

DATE: SEPTEMBER 10, 2004

1. Purpose

The purpose of this document is to describe RF calibration for the EM3420 wireless modem module.

2. Overview

The complexity of the RF calibration process can be simplified by dividing it into basic groups.
For CDMA, there are three groups:

1. Receiver DVGA calibration.
2. Transmitter AGC calibration.
3. Power detector calibration.

The RF calibration process described in the following sections is performed for both PCS and Cell band transceivers. Unless noted, the same procedure is used for each band.

3. CMDA Receiver Calibration

3.1. Receiver DVGA Calibration

The goal of RX calibration is to calculate values for the non-volatile memory (NV) parameters that will be used by the phone software to accurately estimate the incoming RX signal strength. Maximum dynamic range is achieved by reducing the gain of the LNA in discrete steps based on received signal strength. In order for the software to do this, the absolute gain of the receiver in each state must be known.

We have separated the RX AGC calibration into two sections.

- "DVGA Offset". Calibration across frequency at a single input power. This information is the gain of the receiver in the highest gain state.
- "LNA Offset". Calibration to measure the gain change between the LNA gain states. With the LNA Offsets in combination with the DVGA Offset the absolute gain of the receiver is known in all the possible gain states.

Table 1 below lists the frequency compensation bins for PCS.

Bin	0	1	2	3	4	5	6	7
Channel	0-74	75-149	150-224	225-299	300-374	375-449	450-524	525-599
Comp Channel	37	112	187	262	337	412	487	562

Bin	8	9	10	11	12	13	14	15
Channel	600-674	675-749	750-824	825-899	900-974	975-1049	1050-1124	1125-1199
Comp Channel	637	712	787	862	937	1012	1087	1162

Table 4: Compensation Bin to Channel Mapping for the PCS Rx

3.1.1. DVGA Offset Calibration Process

The process of DVGA Calibration is described below.

MEASURE THE AGC RESPONSE

1. Pre-load the DVGA Offset to 0.
2. Set the received signal power to –82 (-81 for PCS) dBm.
3. Set the received frequency to the first calibration channel, typically PCS CH37, Cell CH 1013.
4. Record the RX AGC.
5. Calculate the DVGA Offset.
6. Repeat steps 3 thru 5 for all calibration frequencies
7. Set NV item VGA_GAIN_OFFSET to DVGA Offset of center channel.
8. Calculate DVGA Gain Offset vs. Freq for 16 bins

3.2. LNA Offset Compensation versus frequency

The LNA Gain difference between Gain States can vary across frequency. LNA Offset Calibration for each frequency bin can account for these changes. The calibration items are configured as an absolute offset at center channel and a delta to the center channel offset for each frequency.

3.2.1. LNA Offset vs. Freq Calibration Process

Measure the difference in LNA gain between Gain states for each frequency bin frequencies

1. Load the DVGA offset and DVGA Offset vs. Freq Values determined in the DVGA Offset Calibration process. Set LNA Offset (gain state 0 to gain state 1) to 0.
2. Set the receiver and signal generator to the center calibration channel.
3. Set the received signal power to a single, unchanging power level, based on LNA gain state and switch point.
4. Set the LNA gain state to 0.
5. Measure and record the RX_AGC_VALUE_0.
6. Set the LNA gain State to 1.
7. Measure and record the RX_AGC_VALUE_1.
8. Calculate LNA_Offset_0-1 = RX_AGC_VALUE_0 – RX_AGC_VALUE_1
9. Set the receiver and signal generator channel to each of the frequency compensation channels and repeat steps 4 thru 7.
10. Repeat steps 3 thru 7 for each frequency bin.

4. CDMA Transmitter Calibration

4.1. CDMA TX Phone Operation

The transmit power range as defined by the chipset is –52.3 dBm to +33 dBm. The EM3420 is not capable of producing the maximum power as defined by the chipset, which covers multiple classes of units. The calibration process sets the actual maximum power to ensure compliance.

4.2. PA Bias Switching

The Mobile Station Modem (MSM) supports up to 4 linearizaition tables and corresponding offsets. The EM3420 will utilize 2 tables. The PA Range State Machine controls when the PA bias is switched. It produces 2 control lines internal to the MSM that select between the 4 linearizer tables, offsets, and R1, R0 control lines. At low power, defined by the PA being in low bias mode, the first linearizer table will be valid. This table will be loaded with values determined by sweeping the TX over a partial range of output power. The bias switch point will be tentatively set at approximately 18 dBm so the appropriate sweep for the low bias condition will be –55 dBm to +20 dBm. Linear extrapolation is to be used to fill the remaining table entries. Linearizer Table 2 would be used for the high bias state. The power sweep is defined from 5 dBm to full power. Entries in the table below 5 dBm are filled by linear extrapolation. By design the extrapolated entries in the table should not be used during normal operation but the table should be completed with meaningful number as a safety precaution. The amount of overlap between the two tables is driven primarily by the need to ensure sufficient hysterisis in the PA rise and PA fall points to prevent ratcheting.

4.2.1. Calibration Process

The TX Calibration station uses a Power Meter to measure the output from the EM3420. Power Meters are inherently a broadband instrument so that the power reading is an addition of all power within the input bandwidth of the instrument. This causes an issue measuring low output powers from the phone. The phone is calibrated to nominally –54 dBm channel power. At this power level the integrated noise over the 60 MHz PCS TX frequency band is comparable with the channel power preventing the power meter from making an accurate measurement. The workaround for this issue is to make measurements at higher transmit powers only and extrapolate the results to lower power levels.

When performing the TX linearization the card is controlled in offline mode. R0, R1 and TX AGC lines are controlled directly by the software. The EM3420 will use 2 bias states for the PA.

1. Place phone is offline-d mode
2. Program the synthesizer for the reference channel, typically Ch 600 in PCS mode and Ch 384 in Cell mode.
3. Configure the PA for low bias mode.
4. As mentioned in section 4.2.1, if using the non frequency selective power meter, minimum valid measured power will be around –40 dBm. The first valid measured point shall be between –42 and –37 dBm.
5. Step the TX AGC voltage and measure the output power at each step. The AGC voltage shall be varied in such a manner that the output power covers the range from the minimum valid measurement to approximately +20 dBm. Specifically there shall be one real measurement between 16 and 20 dBm.
6. A typical step size found is to be 26 lsb's that correspond to about 5 dB per step. This will vary to some extent with each unit since this is direct control of the PDM voltage and the step size in dB will vary with AGC characteristics. The phone might also have some voltage scaling in the AGC circuitry. Use linear interpolation to calculate the values between measured points. The lowest 3 valid measurements shall be used to extrapolate below -40 dBm (best fit straight line). The highest 3 valid measurements will be used to extrapolate above +20 dBm.
7. Reconfigure the PA for high bias mode.
8. Step the TX AGC voltage and measure the output power at each step. The range of measured power levels shall nominally cover 5 dBm to full power. The first actual measured min power shall be between -10 and -5 dBm. Max power will depend on actual design but as a start at least 1 actual measurement shall be taken above +24 dBm.
9. Calculate values below -10 dBm.

10. Perform interpolation to calculate values for TX Linearizer table.

4.3. TX Gain Compensation versus frequency

Frequency compensation is performed for both linearizer tables. The power level for frequency compensation is derived from the TX linearizer tables.

4.3.1. TX Gain Comp vs. Frequency Process

The TX frequency compensation is performed at 0 and +18 dBm. The compensation is performed for each of 16 frequency bins. The NV parameter is an offset to the address of the RAS RAM table calculated as follows: NV = integer ((Power (Freq Bin) – Power (Cal Channel))/1/10.

1. Set Phone to Offline-d
2. Set phone to low PA bias mode
3. Program Synthesizer to Calibration Channel. Typically this is Ch 600 for PCS mode and Ch 384 for Cell mode.
4. Setup Power Meter: Auto averaging with 2% accuracy.
5. Set transmitter Power to 0 dBm within convergence limit of 2.0 dB. Record actual power.
6. Keep the TX AGC constant for the duration of test.
7. Reprogram the synthesizer to Frequency Compensation Channels and measure TX Power.
8. Calculate NV parameter TX Gain Comp vs. Frequency
9. Set phone to high PA bias mode
10. Repeat steps 3 through 8

4.4. Power detector/TX Limit calibration

Setting the maximum power limit in the EM3420 consists of calibrating the detector and then using this information to set the maximum power output.

4.4.1. Power Detector vs. TX gain control Calibration Process

The function of this calibration test is to generate the Detector vs. EXP_AGC table. This is done by sweeping the address of the TX RAS RAM table from 0x300 to 0x3ff. This corresponds to approximately 11.75 dBm to 33 dBm. The transmitter, of course will saturate long before +33 dBm. The sweep is accomplished by setting the transmitter to max power out, and stepping the TX_GAIN _Limit value while measuring the detector voltage at each step. The detector is only assumed to be accurate over a narrow dynamic range as defined by the detector offset and span. The detector offset is defined to be the detector value at an output power from the phone of 18 dBm. The span defines the valid detector range referenced to the offset of 18 dBm. Since the span defines the upper limit of the maximum valid detector range, for margin the valid range upper end is defined to be 10 LSBs below the saturated detector level. The span is then the maximum valid detector minus the offset.

1. Set unit to mode offline-d
2. Set unit to “CDMA ALL UPS”
3. Set frequency to reference channel, typically Ch 600 in PCS mo de and Ch 384 in Cell mode.
4. Set TX max limit to each of the values listed.

Limit value = 0x300
Limit value = 0x310
Limit value = 0x320
LIMIT value = 0x330
LIMIT value = 0x340
LIMIT value = 0x350
LIMIT value = 0x360
LIMIT value = 0x370
LIMIT value = 0x380
LIMIT value = 0x390
LIMIT value = 0x3A0

LIMIT value = 0x3B0
LIMIT value = 0x3C0
LIMIT value = 0x3DF
LIMIT value = 0x3EF
LIMIT value = 0x3FF

5. Read detector value at each limit value.

4.4.2. CDMA Limit vs. Frequency Process

The CDMA max limit algorithm allows limit adjustments versus frequency. Any transmitter gain variation after the detector, such as with the duplexer, can be accounted for with frequency compensation. To derive the offset, the transmitter is set to the desired frequency, and output power is adjust to the maximum power level. The detector value is read. The EXP_AGC for the new frequency is found using the DETECTOR vs. EXP_AGC table generated in section 4.4.1. The calibration value is the EXP_AGC at the new frequency minus the center channel EXP_AGC in a 2's complement format.

1. Set unit mode offline-d
2. Turn on the Transmitter
3. Set unit to channel 37 in PCS mode.
4. Adjust TX AGC Voltage until output power is at desired level.
5. Read the detector value.
6. Calculate EXP_AGC based on detector calibration table.
7. Perform steps 4 through 6 for each frequency calibration bin.
8. Calculate NV parameter CDMA_LIM_VS_FREQ [bin #] = EXP_AGC [bin #] – EXP_AGC [center channel].