Alignment Procedures and Tuning Parameters

PRODUCT: RM-917

1. INTRODUCTION

This document describes the alignment procedures and tuning parameters pertaining to RM-917 in the production environment

2. TESTING PHASES

Production testing is divided to two phases, module and product testing. All RF tunings are performed and verified on module testing phase. In the product testing phase the performance and the functionality of complete assembled phone is verified.

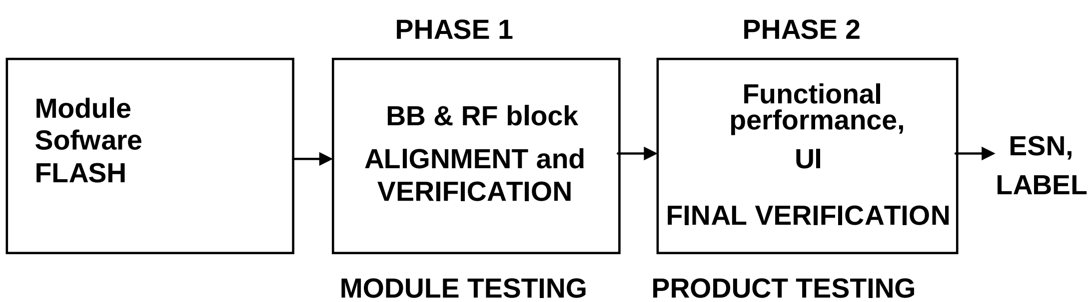

Figure 1. Testing Phase

3. MODULE TESTING: EQUIPMENT

3.1 Tests and alignments for RF

Purpose: RF alignments are used to tune the product performance to the level that is sufficient to fulfill the applicable mobile terminal system specification (3GPP TS 51.010 for GSM, 3GPP TS 34.121 for WCDMA and 3GPP TS 36.521 for LTE). Those parameters are tuned where physical or electrical parameters of individual components are not constant enough to fulfill the specification without tuning.

3.2 Test & Alignment Equipment

The following equipment is required for the RF tests and alignments:

- A Communication Test Box
- A computer with the production tuning software linked to the testbox via GPIB
- A DIAG USB/USB cable connecting the phone to the computer
- RF cable from the phone’s antenna connector to the test box

4. MODULE TESTING: ALIGNMENTS

4.1 Receiver Calibration

Purpose: To measure Digital Variable Gain Amplifier (DVGA) offsets and multiple Low Noise Amplifier (LNA) offsets at multiple chosen frequency indexes. The LNA offset adjusts and compensates for gain stages and is the different between a particular LNA gain stage and the LNA’s highest gain stage. The DVGA offset adjusts the overall DVGA Gain such that the output power at the DVGA output is always constant so that the RSSI value matches the actual RX Power at the antenna connector

Method: Signal with known level is fed to the receiver and its’ level is measured by the phone on multiple frequencies within all receiving bands.

4.1.1 WCDMA Receiver Calibration

A Factory Test Mode (FTM) command instructs the call box to output a forward link power level for each frequency index. The process is repeated for up to 16 frequency indexes. The measurements are then taken and the resulting values are stored in the Non-Volatile (NV) Memory in the form of:

NV_Cx_<band>_VGA_GAIN_OFFSET_I

NV_Cx_<band>_VGA_GAIN_OFFSET_VS_FREQ_I

NV_Cx_<band>_LNA_1_OFFSET_I

NV_Cx_<band>_LNA_1_OFFSET_VS_FREQ_I

NV_Cx_<band>_LNA_2_OFFSET_I

NV_Cx_<band>_LNA_2_OFFSET_VS_FREQ_I

NV_Cx_<band>_LNA_3_OFFSET_I

NV_Cx_<band>_LNA_3_OFFSET_VS_FREQ_I

The calibration is done on both: the Primary and the Diversity Receiver.

4.1.2 GSM Receiver Calibration

At each LNA Gain stage at up to 8 different frequency indexes, an FTM command is called that returns the RSSI for a given LNA gain range and receive signal level and the resulting values are stored in the NV memory as:

NV_GSM_RX_GAIN_RANGE_1_FREQ_COMP[i] = 16 x (10 x Log(RSSI[i]) - (RX lev at RF connector in dBm))
NV_GSM_RX_GAIN_RANGE_2_FREQ_COMP[i] = 16 x (10 x Log(RSSI[i]) - (RX lev at RF connector in dBm))
NV_GSM_RX_GAIN_RANGE_3_FREQ_COMP[i] = 16 x (10 x Log(RSSI[i]) - (RX lev at RF connector in dBm))
NV_GSM_RX_GAIN_RANGE_4_FREQ_COMP[i] = 16 x (10 x Log(RSSI[i]) - (RX levl at RF connector in dBm))

where i = 0,1,…7 are the 8 frequency indexes

4.2 Transmitter calibration

Purpose:

- To calibrate the power control circuitry so that output power is kept within the system specification.
- To avoid the use of high power level that could ruin the transmission spectrum, modulation quality
- To reduce current consumption.

4.2.1 GSM Transmitter Calibration Method:

In GSM TX calibration, TX AGC calibration is performed for the linear region of the PA, and the second step is the AMAM/AMPM predistortion calibration in the nonlinear region of the PA which is primarily used in high power EDGE/EGPRS mode.

In the linear region, the transmitter is turned on in continuous wave mode while sweeping through the (RF Amplifier Gain Index) RGI and the corresponding output power is measured and recorded. This is done in 3 frequency points per band for each of the PA gain range and the results are interpolated for other transmit channels.

For AMAM/AMPM predistortion calibration, the smallest RGI index that will allow the maximum 8PSK TX power is recorded for each of the 3 calibration frequency channels. The highest of these three RGI indexes is then selected and recorded in the NV memory as the basis for the AMAM/AMPM calibration. A known EDGE waveform is used, followed by phase drift correction between transmitter and the measurement equipment. Then, the waveform is aligned to determine the gain and phase distortion. Finally the AMAM gain and the AMPM phase data is smoothed and the values stored in NV memory. This calibration is done only in the top three Power Control Level (PCL) used for EDGE for each frequency band.

GSM Transmitter tuning targets:

GSM850, GMSK @ single slot transmission

Power level	Target power		Power level	Target power
5	32.5 dBm		14	14 dBm
6	31 dBm		15	12 dBm
7	28 dBm		16	10 dBm
8	26 dBm		17	8 dBm
9	24 dBm		18	6 dBm
10	22 dBm		19	4 dBm
11	20 dBm			
12	18 dBm			
13	16 dBm			

GSM850, GMSK @ dual slot transmission

Power level	Target power		Power level	Target power
5	30 dBm		14	14 dBm
6	30 dBm		15	12 dBm
7	28 dBm		16	10 dBm
8	26 dBm		17	8 dBm
9	24 dBm		18	6 dBm
10	22 dBm		19	4 dBm
11	20 dBm			
12	18 dBm			
13	16 dBm			

GSM850, GMSK @ triple slot transmission

Power level	Target power		Power level	Target power
5	28.2 dBm		14	14 dBm
6	28.2 dBm		15	12 dBm
7	28 dBm		16	10 dBm
8	26 dBm		17	8 dBm
9	24 dBm		18	6 dBm
10	22 dBm		19	4 dBm
11	20 dBm			
12	18 dBm			
13	16 dBm			

GSM850, GMSK @ four slot transmission

Power level	Target power		Power level	Target power

5	27 dBm		14	14 dBm
6	27 dBm		15	12 dBm
7	27 dBm		16	10 dBm
8	26 dBm		17	8 dBm
9	24 dBm		18	6 dBm
10	22 dBm		19	4 dBm
11	20 dBm			
12	18 dBm			
13	16 dBm			

EGPRS850, 8PSK @ single slot transmission

Power level	Target power		Power level	Target power
8	27 dBm		16	10 dBm
9	25 dBm		17	8.5 dBm
10	23 dBm		18	6.5 dBm
11	21 dBm		19	4.5 dBm
12	18.5 dBm			
13	16.5 dBm			
14	14.5 dBm			
15	12.5 dBm			

EGPRS850, 8PSK @ dual slot transmission

Power level	Target power		Power level	Target power
8	25.5 dBm		16	10 dBm
9	24.5 dBm		17	8.5 dBm
10	23.5 dBm		18	6.5 dBm
11	20.5 dBm		19	4.5 dBm
12	18.5 dBm			
13	16.5 dBm			
14	14.5 dBm			
15	12.5 dBm			

EGPRS850, 8PSK @ triple slot transmission

Power level	Target power		Power level	Target power
8	23.5 dBm		16	10 dBm
9	23.5 dBm		17	8.5 dBm
10	22.5 dBm		18	6.5 dBm
11	20.5 dBm		19	4.5 dBm
12	18.5 dBm			

13	16.5 dBm			
14	14.5 dBm			
15	12.5 dBm			

EGPRS850, 8PSK @ four slot transmission

Power level	**Target power**		**Power level**	**Target power**
8	21.5 dBm		16	10 dBm
9	21.5 dBm		17	8.5 dBm
10	21.5 dBm		18	6.5 dBm
11	20.5 dBm		19	4.5 dBm
12	18.5 dBm			
13	16.5 dBm			
14	14.5 dBm			
15	12.5 dBm			

GSM1900, GMSK @ single slot transmission

Power level	**Target power**		**Power level**	**Target power**
0	28.5 dBm		9	11 dBm
1	27.5 dBm		10	9 dBm
2	25.5 dBm		11	7 dBm
3	23.5 dBm		12	5 dBm
4	21.5 dBm		13	3 dBm
5	19.5 dBm		14	1 dBm
6	17.5 dBm		15	-0.5 dBm
7	15.5 dBm			
8	13.5 dBm			

GSM1900, GMSK @ dual slot transmission

Power level	**Target power**		**Power level**	**Target power**
0	27.5 dBm		9	11 dBm
1	27.5 dBm		10	9 dBm
2	25.5 dBm		11	7 dBm
3	23.5 dBm		12	5 dBm
4	21.5 dBm		13	3 dBm
5	19.5 dBm		14	1 dBm
6	17.5 dBm		15	-0.5 dBm
7	15.5 dBm			
8	13.5 dBm			

GSM1900, GMSK @ triple slot transmission

Power level	Target power		Power level	Target power
0	25.7 dBm		9	11 dBm
1	25.7 dBm		10	9 dBm
2	25.5 dBm		11	7 dBm
3	23.5 dBm		12	5 dBm
4	21.5 dBm		13	3 dBm
5	19.5 dBm		14	1 dBm
6	17.5 dBm		15	-0.5 dBm
7	15.5 dBm			
8	13.5 dBm			

GSM1900, GMSK @ four slot transmission

Power level	Target power		Power level	Target power
0	24.5 dBm		9	11 dBm
1	24.5 dBm		10	9 dBm
2	24.5 dBm		11	7 dBm
3	23.5 dBm		12	5 dBm
4	21.5 dBm		13	3 dBm
5	19.5 dBm		14	1 dBm
6	17.5 dBm		15	-0.5 dBm
7	15.5 dBm			
8	13.5 dBm			

EGPRS1900, 8PSK @ single slot transmission

Power level	Target power		Power level	Target power
2	26 dBm		10	9.5 dBm
3	24 dBm		11	7.5 dBm
4	22 dBm		12	5.5 dBm
5	20 dBm		13	3.5 dBm
6	18 dBm		14	2 dBm
7	16 dBm		15	0 dBm
8	14 dBm			
9	12 dBm			

EGPRS1900, 8PSK @ dual slot transmission

Power level	Target power		Power level	Target power
2	24.5 dBm		10	9.5 dBm
3	24 dBm		11	7.5 dBm
4	22 dBm		12	5.5 dBm
5	20 dBm		13	3.5 dBm

6	18 dBm		14	2 dBm
7	16 dBm		15	0 dBm
8	14 dBm			
9	12 dBm			

EGPRS1900, 8PSK @ triple slot transmission

Power level	Target power		Power level	Target power
2	22.5 dBm		10	9.5 dBm
3	22.5 dBm		11	7.5 dBm
4	22 dBm		12	5.5 dBm
5	20 dBm		13	3.5 dBm
6	18 dBm		14	2 dBm
7	16 dBm		15	0 dBm
8	14 dBm			
9	12 dBm			

EGPRS1900, 8PSK @ four slot transmission

Power level	Target power		Power level	Target power
2	20.5 dBm		10	9.5 dBm
3	20.5 dBm		11	7.5 dBm
4	20.5 dBm		12	5.5 dBm
5	20 dBm		13	3.5 dBm
6	18 dBm		14	2 dBm
7	16 dBm		15	0 dBm
8	14 dBm			
9	12 dBm			

4.2.2 WCDMA Tx Limiting Power

Purpose: To calibrate the power control circuitry so that output power is kept within the system specification and power class for the device.

Method: During calibration, at each predefined frequency index and at a predefined PA gain range, two sets of tables created that represent the TX power level and its corresponding PDM values. From these two tables, a relationship is established between the TX AGC control values and their corresponding output powers for each of the PA gain stage.

The WCDMA Tx calibration includes:

- Tx AGC calibration
- Tx compensation vs Frequency
- HDET calibration

WCDMA1900 (band II)

Max power	**22.5 dBm**
Min power	< -50 dBm
Min step size	1 ± 0.5 dB

WCDMA1700/2100 (band IV)

Max power	**24 dBm**
Min power	< -50 dBm
Min step size	1 ± 0.5 dB

WCDMA850 (band V)

Max power	**23.5 dBm**
Min power	< -50 dBm
Min step size	1 ± 0.5 dB

HSDPA

In HSDPA operation the output power is reduced relative to the tuning target power for WCDMA and dependant of sub test configuration.The output power values listed below for HSDPA are for RMS detector. The output power measurement is dependent on the detector type used in the measuring equipment. If average detector is used the result will be lower than values measured with RMS detector.

Maximum output power (RMS)

HSDPA Band2 (1900)	**subtest 1**	**subtest 2**	**subtest 3**	**subtest 4**
WCDMA Max Power	22.5 dBm	22.5 dBm	22.5 dBm	22.5 dBm
MPR (Maximum power reduction)	0 dB	0 dB	0.5 dB	0.5 dB
Additional power reduction	0 dB	0 dB	0 dB	0 dB
HSDPA maximum output power	22.5 **dBm**	22.5 **dBm**	**22 dBm**	**22 dBm**

HSDPA Band4 (850)	**subtest 1**	**subtest 2**	**subtest 3**	**subtest 4**
WCDMA Max Power	24 dBm	24 dBm	24 dBm	24 dBm
MPR (Maximum power reduction)	0 dB	0 dB	0.5 dB	0.5 dB
Additional power reduction	0 dB	0 dB	0 dB	0 dB
HSDPA maximum output power	**24 dBm**	**24 dBm**	**23.5 dBm**	**23.5 dBm**

HSDPA Band5 (850)	**subtest 1**	**subtest 2**	**subtest 3**	**subtest 4**
WCDMA Max Power	23.5 dBm	23.5 dBm	23.5 dBm	23.5 dBm
MPR (Maximum power reduction)	0 dB	0 dB	0.5 dB	0.5 dB
HSDPA maximum output power	23.5 dBm	23.5 dBm	23 dBm	23 dBm

HSUPA

In HSUPA operation the output power is reduced relative to the tuning target power for WCDMA and dependant of sub test configuration. The output power is reduced by an additional power reduction to increase PA linearity.

MPR and E-TFC MPR are two separate power control routines, where higher one will be dominant. Therefore for subtest 1 it is E-TFC MPR, which affects to maximum output power while for subtests 2 to 4 are affected by MPR.

Due to how HSUPA power output testing is implemented in 3GPP TS, actual measured power output can be between 0 to 1.5 dB lower than specified in tuning targets depending of the point, where maximum output power was achieved. This is because transmit power control (TPC) step size can vary between 0.5-1.5dB and after DUT has reported maximum output power and changed E-TFCI, DUT is asked to return one power step back

Maximum output power (RMS)

HSUPA 1900 (Band II)	**subtest 1**	**subtest 2**	**subtest 3**	**subtest 4**	**Subtest 5**
MPR (Maximum power reduction)	1 dB	2 dB	3 dB	2 dB	1 dB
Additional power reduction	0 dB	0 dB	0dB	0 dB	0 dB
HSUPA output power	**21.5dBm**	**20.5 dBm**	**19.5 dBm**	**20.5dBm**	**21.5**

HSUPA 1700/2100 (Band IV)	**subtest 1**	**subtest 2**	**subtest 3**	**subtest 4**	**Subtest 5**
MPR (Maximum power reduction)	1 dB	2 dB	3 dB	2 dB	1 dB
Additional power reduction	0 dB	0 dB	0dB	0 dB	0 dB
HSUPA output power	**23 dBm**	**22 dBm**	**21 dBm**	**22 dBm**	**23 dBm**

HSUPA 850 (Band V)	**subtest 1**	**subtest 2**	**subtest 3**	**subtest 4**	**Subtest 5**
MPR (Maximum power reduction)	1 dB	2 dB	3 dB	2 dB	1 dB
Additional power reduction	0 dB	0 dB	0dB	0 dB	0 dB
HSUPA output power	**22.5**	**21.5 dBm**	**20.5 dBm**	**21.5dBm**	**22.5**

β values for transmitter characteristics tests with HS-DPCCH and E-DCH (from 3GPP TS 34.121-1 v8.10.0 table C.11.1.3)

Sub-test	β_c	β_d	β_d **(SF)**	β_c/β_d	β_{HS} *(Note1)*	β_{ec}	β_{ed} *(Note 4) (Note 5)*	β_{ed} **(SF)**	β_{ed} **(Codes)**	**CM (dB)** *(Note 2)*	**MPR (dB)** *(Note 2)*	***AG Index*** *(Note 5)*	***E-TFCI***
1	11/15 *(Note 3)*	15/15 *(Note 3)*	64	11/15 *(Note 3)*	22/15	209/225	1309/225	4	1	1.0	0.0	20	75
2	6/15	15/15	64	6/15	12/15	12/15	94/75	4	1	3.0	2.0	12	67
3	15/15	9/15	64	15/9	30/15	30/15	β_{ed}1: 47/15 β_{ed}2: 47/15	4 4	2	2.0	1.0	15	92
4	2/15	15/15	64	2/15	4/15	2/15	56/75	4	1	3.0	2.0	17	71
5	15/15	0	-	-	5/15	5/15	47/15	4	1	1.0	0.0	12	67

Note 1: For sub-test 1 to 4, Δ_{ACK}, Δ_{NACK} and Δ_{CQI} = 30/15 with β_{hs} = 30/15 * β_c. For sub-test 5, Δ_{ACK}, Δ_{NACK} and Δ_{CQI} = 5/15 with β_{hs} = 5/15 * β_c.
Note 2: CM = 1 for β_c/β_d =12/15, β_{hs}/β_c=24/15. For all other combinations of DPDCH, DPCCH, HS- DPCCH, E-DPDCH and E-DPCCH the MPR is based on the relative CM difference.
Note 3: For subtest 1 the β_c/β_d ratio of 11/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to β_c = 10/15 and β_d = 15/15.
Note 4: In case of testing by UE using E-DPDCH Physical Layer category 1, Sub-test 3 is omitted according to TS25.306 Table 5.1g.
Note 5: β_{ed} can not be set directly, it is set by Absolute Grant Value.
Note 6: For subtests 2, 3 and 5, UE may perform E-DPDCH power scaling at max power which could results in slightly smaller MPR values.

4.3 Kv calibration

Purpose: To minimize the Kv gain mismatch in GSM TX Phase-Lock Loop (PLL) to improve RMS phase error.

Method: An FTM calibration command is called and the PLL is locked. At this point the Kv code is read 10 times to produce an average value. The procedure is then repeated 40 additional times and the average of the averages is stored in the NV memory.

4.4 Thermistor calibration

The device has an internal thermistor that must be characterized for every device.

- The thermistor ADC is read at room temperature (20 °C to 26 °C), and then the thermistor ADC readings are extrapolated for the maximum and minimum temperature values and stored in NV_ENH_THERM.min and NV_ENH_THERM.max.

  Note: NV_ENH_THERM.min corresponds to min ADC, which corresponds to max temperature.

- Two predetermined slopes are used for the extrapolation process (one for values below room temp, and one for values above room temp).

5. MODULE TESTING: VERIFICATION

Purpose of verification phase in module testing is to ensure that tuned powers are tuned within reasonable accuracy at select power levels. Maximum values are also measured at this time.

6. PRODUCT TESTING: VERIFICATION

No engine steps included in this process.

7. LABEL

Assigns an IMEI and loads customer SW as well as prints the end product's label.