1. INTRODUCTION

1.1 Testing phases

Production testing is divided to two phases, **module** and **product** testing.

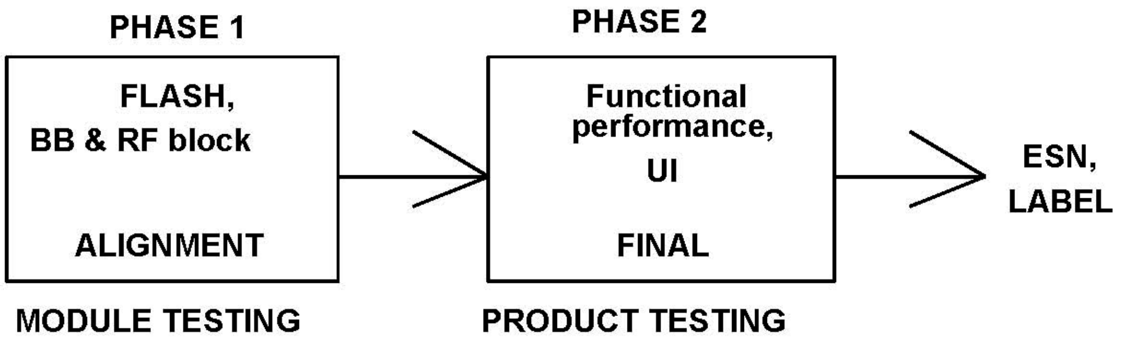


Figure 1. Testing Phase

1.2 Module Testing Phase 1

1.2.1 Tests and alignments for RF

During the design phase of the engine, all the tests and alignments will be optimized by analyzing previous build data and flashing new values into the phone.

1.2.2 Recommended Equipment

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

RF signal generator, frequency range up to 2.2 GHz frequency resolution 10 Hz frequency accuracy ±0.1 ppm amplitude resolution 0.1 dB

Spectrum analyzer frequency range up to 2 GHz dynamic range 70 dB sweep time min. 50 ms

PC and Phoenix / FastTrace SW.

1.3 Alignments

1.3.1 AFC

Automatic Frequency Control (AFC) is needed to align the frequency error caused by component differences around the crystal, the crystal itself and temperature drift.

There are two AFC tunings. The first one "AFC Coarse" is a rough tuning, where we are setting the window for the fine tuning (AFC Fine). The tunings are made in mid channel on the lowest band (850 band channel 190).

When tuning the coarse value, the easiest way is to monitor the frequency error on the signal analyzer when the phone is in burst mode. Then the value should be moved in either direction starting at middle value 31. When the frequency error is on its lowest, then the coarse value is found.

This procedure is to be used when tuning the coarse value in automatic mode.

1. Set AFC Fine value to 8192.

2. Set phone to burst on 850 band channel 190.

3. Set AFC Coarse (CDAC) value to 31 *(CDAC_X)*.

4. Measure the frequency error *(FreqErr_X*).

5. Increase coarse value with e.g. 5 = 36 *(CDAC_Y)*.

6. Measure frequency error again *(FreqErr_Y)*.

7. Now the next coarse value is calculated from the previous two. An interpolation calculation will show the next value.

$$New\_CDAC = CDAC\_X * (CDAC\_Y - CDAC\_X) * \frac{FreqErr\_X}{FreqErr\_Y - FreqErr\_X}$$

8. Loop 3 to 7 until minimum Frequency Error has been found.

9. Store CDAC in RF RAM.

1.3.2 AFC Fine

The fine tuning has the purpose of finding the Fine DAC (FDAC) that make the frequency error zero or very close to zero (±100Hz).

Also in tuning the Fine value, the easiest way is to monitor the frequency error on the signal analyzer when the phone is in burst mode. Then the value should be moved in either direction starting at middle value 4096. When the frequency error is on its lowest, then the fine value is found.

This procedure is to be used when tuning the fine value in automatic mode.

1. Set AFC Coarse to the value found in Coarse tuning e.g. 9.

2. Set phone to burst on 850 band channel 190.

3. Set AFC Fine (FDAC) value to 6000 *(FDAC_1)*.

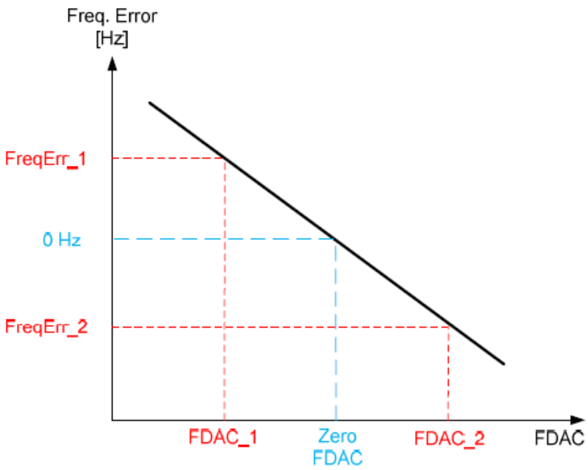
4. Measure the frequency error *(FreqErr_1*).

5. Set AFC Fine value to 10000 *(FDAC_2)*.

6. Measure frequency error again *(FreqErr_2)*.

7. The AFC Fine value is directly calculated from these two measurements, hence we know the offset and slope of the frequency error as a function of the Fine DAC, and we know the frequency offset must be zero.

8. Store FDAC in RF RAM.



1.3.3 RX Level

RX Level (RXLEV) is to be calibrated to make sure the phone is reporting right values back to the network provider. In this calibration we will align the receive path loss there might be, in each band, hence the power received at the antenna is the same power the engine “sees” after receiver path including filters etc.

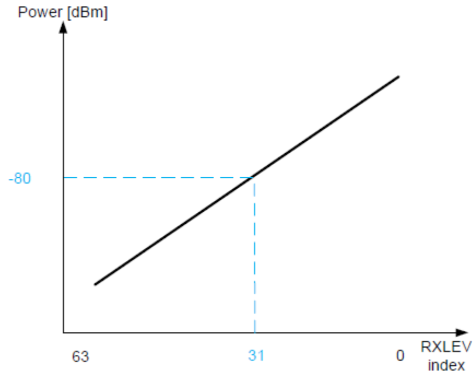
There are 64 gain levels. We need to align the one in the middle (31) because the slope is already known and thus we only need to align the offset at this index. The results [0:63] are all called SysGain values. This will be SysGain_31.

For each band we apply a -80dBm signal to the RF switch input, and ask the phone to do the calculations and store the offsets.

In RX the Band information is all that is needed. The channel numbers are already known to the phone.

Please notice that the RX frequencies used are all having an offset of +67.710 Hz (All 0 – zeros) which will be needed to set to the signal generator center frequency and hence get a more accurate reading from the phone.

As mentioned before the slope is already known (±40) in either direction from used RXLEV index 31, see figure.



Follow this description to calibrate RX.

1. Set the Signal generator to output -80 dBm + the cable loss for the measurement system at the used frequency.

2. Set the Frequency from Table 1 for the band used.

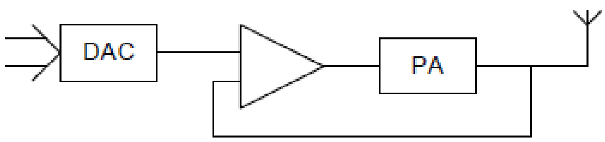
3. Command the phone to do the SysGain calculation and receive result. (see section 4.1.1)

4. Repeat for all bands.

1.3.4 TX power in GMSK Mode

This component is intended to perform the alignment of the TX power stage. Because of component variations all phones in production must be aligned to be within specifications.

The principles of the TX power PA stage is shown below. A D/A converter controls an amplifier within the power loop. By changing the D/A value the TX power will change accordingly.



By transmitting a series of samples DAC (coefficients) values and measuring the corresponding output powers, the power levels including base level can be aligned.

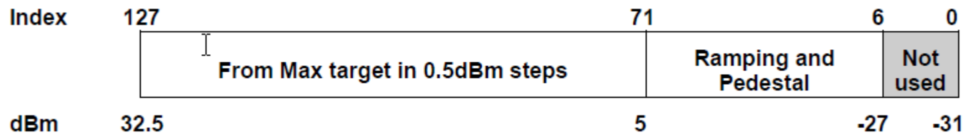
In RM-497 the individual power levels must be as stated in table below.

GSM850		GSM1900	
Power level	Target Power	Power Level	Target Power
5	32.5 dBm	0	30.5 dBm
6	31 dBm	1	28 dBm
7	29 dBm	2	26 dBm
8	27 dBm	3	24 dBm
9	25 dBm	4	22 dBm
10	23 dBm	5	20 dBm
11	21 dBm	6	18 dBm
12	19 dBm	7	16 dBm
13	17 dBm	8	14 dBm
14	15 dBm	9	12 dBm
15	13 dBm	10	10 dBm
16	11 dBm	11	8 dBm
17	9 dBm	12	6 dBm
18	7 dBm	13	4 dBm
19	5 dBm	14	2 dBm
		15	0 dBm

1.3.4.1 Tuning Procedure

We measure at 16 different DAC values on the PA curve. We only need to measure sample points on the useful part of the PA curve, i.e. from 33dBm to 5 dBm in low band. In this example for low band we measured just above the target 32.5 dBm for PVL 5 and just under lowest target for PVL 19 (5 dBm). Then we also did some test points in the area for the Ramping and Base-level (Pedestal) which are from -27 to 5 dBm. Here we did some more measurements due to the 2nd order curvature.

The TX_DB_CONVERT index table has 128 values, and it is set to determine the 128 values that produce TX output powers in 0.5 dB steps starting at maximum power (32.5 dBm) and decreasing.



We are using 32.5 dBm as the maximum power instead of 33 dBm. The DAC which are calculated to give the power of 32.5 dBm, (in this case) 0x340 are stored in the top most position of the TX_DB_CONVERT index table (127).

Index	127	126	125	124	123	...	11	10	9	...	3	2	1	0
Target	32.5	32.0	31.5	31.0	30.5	...	-25.5	-26.0	-26.5	...	-29.5	-30.0	-30.5	-31.0
DAC	0x340	0x337	0x32E	0x325	0x31B	...	0x047	0x035	0x035	...	0x035	0x035	0x035	0x035

When the tuning DAC table values are calculated, a target table has to be generated from those coherent data.

Each band has a target table in the phone memory, in consist of 19 entries. Maximum power level starts at index 3 (table index starts at 0). Entry 0 to 2 are reserved for different Power Class Engines.

For low band Power level 5 target value is needed to be stored from index 3. And for high band power level 2 starts at index 3.

In this example the Power level 5 is to be tuned to 32.5 dBm. Then the test algorithm will look for which “Target Index” to store in the “Lookup table index”. In this case 127 are stored in the lookup table entry 3. Next target value is 31.0 dBm. A quick look in the table tells the value 124 which are stored in lookup table index 4 and so forth until all target values are covered.

For good practice the leading places 0-2 and last index place 19 (for low bands only) are filled with the same values as the nearest Index number. Please see table below for better understanding.

Tuning Target		Target Index	Lookup table index	PVL		DAC
32.5	=>	127	0			
32.5	=>	127	1			
32.5	=>	127	2			
32.5	=>	**127**	3	5	=>	**0x340**
31.0	=>	124	4	6	=>	0x325
29.0	=>	120	5	7	=>	0x302
27.0	=>	116	6	8	=>	0x2DF
25.0	=>	112	7	9	=>	0x2BD
23.0	=>	108	8	10	=>	0x29B
21.0	=>	104	9	11	=>	0x27A
19.0	=>	100	10	12	=>	0x258
17.0	=>	96	11	13	=>	0x235
15.0	=>	92	12	14	=>	0x212
13.0	=>	88	13	15	=>	0x1EF
11.0	=>	84	14	16	=>	0x1CF
9.0	=>	80	15	17	=>	0x1AE
7.0	=>	76	16	18	=>	0x18C
5.0	=>	72	17	19	=>	0x16B
5.0	=>	72	18			

This lookup table is to be stored together with real DAC table hence the phone can look up power level 5, which points to Target Index 127, which again points to DAC value 0x340 which will make the phone produce a TX-burst with an output power of 32.5 dBm.

The table is to be stored as Q-format 4, that is all Target indexes are to be multiplied by 16 before uploading, e.g. 127 * 16 = 2032.

1.3.5 TX power in EDGE Mode (EGPRS MCS5-9)

In 8PSK the TX target table is much easier to create and store than GMSK. We do not have an index pointing to an index, but only the target values multiplied by 32 (*Q-format* = *8*). But there still is an offset to the highest power level, and that is not the same for low and high bands.

Each band has a target table in the phone memory, it consists of 19 entries. Maximum power level starts at index 3, and when we here describe maximum power, we mean power level 5 for low bands and 0 for high bands (table index starts at 0). Entries 0 to 2 are reserved for different Power Class Engines. But in EDGE we only use from power level 8 in low band and 2 in high band.

For low band Power level 8 target value is needed to be stored from index 6. And for high band power level 2 starts at index 5.

In this example the Power level 8 is to be tuned to 26.5 dBm. In this case 26.5 * 32 = 848 is stored in the lookup table entry 6. Next target value is 25.0 dBm. This gives 800 and so forth until all target values are covered. For good practice the leading places 0-5/6 and last index place 19 (for low bands only) are filled with the same values as the nearest number. Please see table below for better understanding.

EDGE 850/900					EDGE 1800/1900			
PVL	Tuning Target		Target in Q-format 8	PMM Table index	Target in Q-format 8		Tuning Target	PVL
	26.5	=>	848	0	816		25.5	
	26.5	=>	848	1	816		25.5	
	26.5	=>	848	2	816		25.5	
5	26.5	=>	848	3	816	<=	25.5	0
6	26.5	=>	848	4	816	<=	25.5	1
7	26.5	=>	848	5	816	<=	25.5	2
8	26.5	=>	848	6	768	<=	24	3
9	25.0	=>	800	7	704	<=	22	4
10	23.0	=>	736	8	640	<=	20	5
11	21.0	=>	672	9	576	<=	18	6
12	19.0	=>	608	10	512	<=	16	7
13	17.0	=>	544	11	448	<=	14	8
14	15.0	=>	480	12	384	<=	12	9
15	13.0	=>	416	13	320	<=	10	10
16	11.0	=>	352	14	256	<=	8	11
17	9.0	=>	288	15	192	<=	6	12
18	7.0	=>	224	16	128	<=	4	13
19	5.0	=>	160	17	64	<=	2	14
				18	0	<=	0	15

TXC power control words are calculated to correspond to following target powers:

GSM850 8-PSK		GSM1900 8-PSK	
Power Level	Target Power	Power Level	Target Power
8	26.5 dBm	2	25.5 dBm
9	25 dBm	3	24 dBm
10	23 dBm	4	22 dBm
11	21 dBm	5	20 dBm
12	19 dBm	6	18 dBm
13	17 dBm	7	16 dBm
14	15 dBm	8	14 dBm
15	13 dBm	9	12 dBm
16	11 dBm	10	10 dBm
17	9 dBm	11	8 dBm
18	7 dBm	12	6 dBm
19	5 dBm	13	4 dBm
		14	2 dBm
		15	0 dBm