Panasonic

Matsushita Mobile Communications Development of Europe Ltd.

X70 Global RF Calibration Specification

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Summary of changes

Change Note Number	Date	Change Note Number	Date	Change Note Number	Date

CHANGE HISTORY

Revision	Modifications made	By	Date
0.1	Updated RSSI calibration banding	Martin Greaves	18/6/03
0.2	Updated Tx cal levels and gradient. Added dac offsets across band	P Quarmby	24/6/03
0.3	Cancelled		
0.4	Update VCXO cal description	P Quarmby	4/7/03
0.5	Further VCXO comments and DCS power window tightened	P Quarmby	10/7/03
0.6	Update cal windows to factory request	P Quarmby	14/7/03
0.7	Remove requirement to cal RX COMP values	M Greaves	15/7/03
0.8	Correct Rxlev window (was –89.5 to –91.5)	M Ireland	25/7/03

CONTENTS

1) Introduction

1.1 Calibration Sequence

The Calibration sequence should occur in the following order:

1. Carrier Power Calibration
2. VCXO frequency calibration
3. TX IQ Calibration
4. Receive Signal Strength Indication (RSSI) Calibration

Since power cycling of the board may occur between these various stages, the trimming data must be stored, using "Save Trimming Data".

1.2 General Conditions for Calibration

Vbat =3.7V.
RF load = 50ohms, return loss at phone end of RF connection better than 20dB.
Shield frames and lids must be fitted before any RF calibration/recalibration.
All keypad/backlight LED's must be turned off during calibration.
Factory temperature in the vicinity of the calibration stations must be **25C+5 -6C**.
RSSI calibration channels must be confirmed to be free from any local network interference.
All power measurements must be taken on a power meter with an accuracy of better than 0.3 dB. This not only applies to calibration but also to verification and QC checks.

1.3 Abbreviations

ADC	Analogue to Digital Converter
AFC	Automatic Frequency Control
AGC	Automatic Gain Control
APC	Automatic Power Control
ARFCN	Absolute Radio Frequency Channel Number
DAC	Digital to Analogue Converter
dB	decibels
dBc	decibels relative to a carrier signal
dBm	decibels relative to 1 milliwatt
GSM	Global System for Mobile Communications
HH	Handheld
LNA	Low-Noise Amplifier
MS	Mobile Station
PL	Power Level
RBW	Resolution Bandwidth
RSSI	Received Signal Strength Indication
RXLEV	RSSI level reported by SS
SS	System Simulator
Tx	Transmitter
VBW	Video Bandwidth
VCXO	Voltage Controlled Crystal Oscillator

2) VCXO Frequency Calibration

2.1 Purpose

Tolerance in the manufacture of the 26MHz crystal blank and in the value of vital components in the VCXO circuit mean that the nominal AFC control voltage must be adjusted to give a calibrated setting for the circuit to operate at 26MHz exactly at nominal room temperature.

The implication of this is that the calibration temperature must be **25C+5 -6C** for frequency calibration and that the PCBs must have stabilised to this temperature in the factory.

Since the VCXO frequency is slightly influenced by the RF shield can, calibration of frequency must be performed with the shield can wall sections and lids fitted.

Note: Calibration of the 1.95V reference voltage output to the thermistor, thermistor ADC input and AFCDAC output voltage should all have been done as part of the baseband calibration.

2.3) Frequency Calibration

This requires the AFCDAC to be varied and the FSYS frequency to be measured, but at final frequency. AFCDAC should be varied until TX freq error at final frequency is within 0.5ppm. For this to be valid the measurement equipment should be frequency locked to an external source that is absolutely accurate (eg Rubidium oscillator or GPS system).

Note: Details of all the listed test commands may be found in the X70 Test Command Interface Specification.

1. Connect the phone's RF output to a test set (HP8922 or HP8960).
2. Set the phone into TestSet Test mode.
3. Note: ensure that all keypad LED's and LCD backlight are switched off.
4. Switch on AUXDAC (see note below)
5. Send command to read phone temperature `"GET CRYSTAL TEMPERATURE IN DEGREES C"`
6. If data returned from (4) is outside the range 19.4°C to 30.3°C then reject the phone.
7. Set the phone to transmit on PL15 on channel **810 PCS**, with random data, normal bursts.
8. Adjust AFCDAC, using the command "Set Aux AFC Data" until TX frequency error is less than 0.5ppm (corresponds to <955Hz on ch 810).
9. Store Aux AFC Data value to "AFC_RAW_CAL_ADC".
10. Send command `to` read voltage representing phone temperature, ie ADC voltage from thermistor `DAC,"GET ADC DATA" from ADC "ADIN3"`
11. Send command "CALCULATE REFERENCE AFC" with value returned from step 9. This calculates and stores the reference AFC value

A check should then be carried out on the VCXO frequency accuracy by the following method:

1. Reset the phone.
2. Set the phone into TestSet Test mode.
3. Switch on AUXDAC (see note below)
4. Set the phone to transmit on PL15 on channel 810 PCS, with random data, normal bursts.
5. Send command "Apply AFC Setting"
6. Measure TX frequency error.
7. If TX frequency error is still within 0.5ppm then the phone is passed, otherwise reject the phone.

Note for reading temperature via ADC/DAC: The AUXDAC has to be set to the calibrated value to achieve 1.95V. To do this, read the dac_offset calibration value from RDS (8 bit signed value), then set AUXDAC to (931 + dac_offset). This improves the accuracy of the temperature measurement.

2) Carrier Power Calibration

3.1 Purpose

Tolerancing in the Power Amplifier control circuit requires that the gain be adjusted, so that the GSM requirements of Tx output power versus power level are met. The output power of the HH is controlled by an 8-bit DAC; a DAC value of 255 corresponds to maximum power and a DAC value of 0 produces minimum power.

The nominal step between successive power levels for both bands is 2dB with limits of ±1.5dB (GSM 05.05 part 4.1.1). At maximum powers it may be necessary to avoid degradation of the switching transients experienced at high power.

To minimise the variation of Tx power with frequency due to component tolerance, each GSM band is split into sub-bands which are calibrated separately. The calibration bands and channels used are as follows:

Band Start	Band Stop	Calibration Channel	Sub-band
975	1009	992	PL_GSM_Bch
1010	20	3	PL_GSM_Lch
21	55	38	PL_GSM_Mch
56	90	73	PL_GSM_Hch
91	124	108	PL_GSM_Tch
512	586	544	PL_DCS_Bch
587	661	624	PL_DCS_Lch
662	736	698	PL_DCS_Mch
737	811	774	PL_DCS_Hch
812	885	885	PL_DCS_Tch
512	571	542	PL_PCS_Bch
572	631	602	PL_PCS_Lch
632	691	662	PL_PCS_Mch
692	751	722	PL_PCS_Hch
752	810	781	PL_PCS_Tch

3.2 Calibration Limits

3.2.1 GSM900

The following table shows the measurement limits according to power level.
There are two target specifications. If spec 1 is used this guarantees that linearity is also met. However if specification 2 is used then it is essential that in addition to absolute power that a check on the linearity from step to step is also used. The minimum separation between adjacent steps is 0.5 dB, and the maximum is 3.5 dB.

Power Level (PL)	Output Power (dBm)				
	Nominal	Specification 1		Specification 2	
		Minimum	Maximum	Minimum	Maximum
5	31.75	31.5	32.0	31.5	32.0
6	30.5	30.0	30.8	30	31.5
7	28.9	28.4	29.4	27.5	30.5
8	27	26.5	27.5	25.5	28.5
9	25	24.5	25.5	23.5	26.5
10	23	22.5	23.5	21.5	24.5
11	21	20.5	21.5	19.5	22.5
12	19	18.5	19.5	17.5	20.5
13	17	16.5	17.5	15.5	18.5
14	15	14.5	15.5	13.5	16.5
15	13	12.5	13.5	11.5	14.5

16	11	10.5	11.5	9	13
17	9	8.5	9.5	7	11
18	7	6.5	7.5	5	9
19	5	4.5	5.5	3	7

3.2.2 GSM1800

The following table shows the measurement limits according to power level.
There are two target specifications. If spec 1 is used this guarantees that linearity is also met. However if specification 2 is used then it is essential that in addition to absolute power that a check on the linearity from step to step is also used. The minimum separation between adjacent steps is 0.5 dB, and the maximum is 3.5 dB.

Power Level (PL)	Output Power (dBm)				
	Nominal	Specification 1		Specification 2	
		Minimum	Maximum	Minimum	Maximum
0	29.2	29.0	29.4	29.0	29.4
1	27.6	27.1	28.1	27.1	29.0
2	25.9	25.4	26.4	24.5	27.4
3	24	23.5	24.5	22.5	25.5
4	22	21.5	22.5	20.5	23.5
5	20	19.5	20.5	18.5	21.5
6	18	17.5	18.5	16.5	19.5
7	16	15.5	16.5	14.5	17.5
8	14	13.5	14.5	12.5	15.5
9	12	11.5	12.5	10.5	13.5
10	10	9.5	10.5	8.5	11.5
11	8	7.5	8.5	6.5	9.5
12	6	5.5	6.5	4.5	7.5
13	4.0	3.5	4.5	2.5	5.5
14	2	1.5	2.5	0	4
15	0	-0.5	0.5	-2	2

3.2.3 GSM1900

The following table shows the measurement limits according to power level.
There are two target specifications. If spec 1 is used this guarantees that linearity is also met. However if specification 2 is used then it is essential that in addition to absolute power that a check on the linearity from step to step is also used. The minimum separation between adjacent steps is 0.5 dB, and the maximum is 3.5 dB.

Power Level (PL)	Output Power (dBm)				
	Nominal	Specification 1		Specification 2	
		Minimum	Maximum	Minimum	Maximum
0	28.75	28.5	29.0	28.5	29.0
1	27.4	26.9	27.9	26.9	28.5
2	25.8	25.3	26.3	24.5	27.4
3	24	23.5	24.5	22.5	25.5
4	22	21.5	22.5	20.5	23.5
5	20	19.5	20.5	18.5	21.5
6	18	17.5	18.5	16.5	19.5
7	16	15.5	16.5	14.5	17.5
8	14	13.5	14.5	12.5	15.5
9	12	11.5	12.5	10.5	13.5
10	10	9.5	10.5	8.5	11.5
11	8	7.5	8.5	6.5	9.5
12	6	5.5	6.5	4.5	7.5
13	4.0	3.5	4.5	2.5	5.5
14	2	1.5	2.5	0	4
15	0	-0.5	0.5	-2	2

3.3 Calibration Procedure

The actual calibration algorithm is not discussed here. Any method is acceptable providing that EVERY power level on EVERY channel within each Tx band falls within the calibration windows set above. As a guide, approximate power vs. DAC setting gradients for each band are shown below. These will help any attempt to write an interpolation algorithm.

3.3.1 Equipment

HP8990 Peak Power Meter or equivalent.

Since the output power is slightly influenced by the RF shield can, calibration of power must be performed with the shield can wall sections and lids in place.

3.3.2 Initialisation

The initial DAC values and gradients for the HH are shown in the table below. Note that for GSM900 power levels PL0 to PL4 are not used.

Power Level (PL)	GSM900		GSM1800		GSM1900	
	Initial DAC	Initial Gradient (DACsteps/ dB)	Initial DAC	Initial Gradient (DACsteps/ dB)	Initial DAC	Initial Gradient (DACsteps/ dB)
0	203		202	4.6	205	4.7
1	203		195	4.7	198	4.8
2	203		187	4.7	189	4.7
3	203		179	4.5	181	4.6
4	203		170	4.3	172	4.4
5	203	4.6	162	4.2	164	4.2
6	197	4.5	154	4	156	4.1
7	189	4.4	146	3.9	148	3.9
8	181	4.4	138	3.9	140	3.9
9	173	4.3	130	4	132	4
10	164	4.2	123	4	124	4
11	156	4.1	115	4	116	4
12	148	4.1	107	3.9	108	4
13	140	4.1	99	3.9	100	3.9
14	132	4.1	91	3.9	92	4
15	123	4.1	84	4	84	4.1
16	114	4.1	N/A	N/A	N/A	N/A
17	106	4.1	N/A	N/A	N/A	N/A
18	98	4.2	N/A	N/A	N/A	N/A
19	90	4.2	N/A	N/A	N/A	N/A

The table below shows the estimates of the difference in DAC setting for the calibration channels against the middle channel calibration for all 3 bands. This applies to all power levels.

Band	BCh	LCh	MCh	HCh	TCh
GSM	-1 step	0 steps	Reference	0 steps	+ 1step
DCS	-1 step	-1 step	Reference	0 steps	0 steps
PCS	-1 step	0 steps	Reference	0 steps	+ 1step

4) I/Q Calibration

I/Q calibration should not be necessary for this product, however it may be advisable to write appropriate test commands in case this becomes necessary as a result of experience in the factory trial.

5) Receive Signal Strength Indication (RSSI) Calibration

Purpose

Component tolerances will affect the Receiver overall gain & frequency response and hence will degrade the accuracy of RXLEV reporting to the network. To prevent this it is necessary to calibrate out any variation. This is achieved using the RSSI calibration data, which consists of one reference compensation for the gain across the entire band (EGSM, DCS, PCS), and calibration values for further sub-bands to compensate out any ripple. Calibration offsets are performed in 1/2dB steps, with a positive calibration value increasing the reported RXLev value and a negative value reducing the reported RXLev value.

N.B. All calibration must be performed with shield can wall sections and lids fitted.

Equipment (for both bands)

Signal Generator:

Modulation: C.W. (At Calibration Frequency + 67.7kHz)
R.F. Input Level: -90dBm

EGSM

Within the EGSM band five calibration sub-bands are defined. Calibration needs to only be performed in the RSSI_GSM_Lch sub-band – the data from this should be copied to all other bands. The RSSI_GSM_Comp value does not need calibrating.

Band Start	Band Stop	Calibration Channel	Calibration Frequency (MHz)	Calibration Limits (Absolute level)	Sub-band
975	999	Copy calibration value from RSSI_GSM_Lch			RSSI_GSM_Bch
1000	16	0	935.0	-89.5dBm to –90.5dBm	RSSI_GSM_Lch
17	58	Copy calibration value from RSSI_GSM_Lch			RSSI_GSM_Mch
59	100	Copy calibration value from RSSI_GSM_Lch			RSSI_GSM_Hch
101	124	Copy calibration value from RSSI_GSM_Lch			RSSI_GSM_Tch
-	-	No calibration required			RSSI_GSM_Comp

Initialisation

MS Test Mode:

AGC Setting: 73
RSSI_GSM_Bch : 0x00
RSSI_GSM_Lch : 0x00
RSSI_GSM_Mch: 0x00
RSSI_GSM_Hch : 0x00
RSSI_GSM_Tch : 0x00
RSSI_GSM_Comp: 0x00

GSM1800

Within the GSM1800 band five calibration sub-bands are defined. However, since the response is relatively flat only two calibration points are required. RSSI_DCS_Hch should be calibrated, and the value obtained should be copied to RSSI_DCS_Mch and RSSI_DCS_Tch. The RSSI_DCS_Comp value does not need calibrating.

Band Start	Band Stop	Calibration Channel	Calibration Frequency (MHz)	Calibration Limits (Absolute level)	Sub-band
512	536	Copy calibration value from RSSI_DCS_Lch			RSSI_DCS_Bch
537	676	661	1835.0	-89.5dBm to –90.5dBm	RSSI_DCS_Lch
677	766	Copy calibration value from RSSI_DCS_Hch			RSSI_DCS_Mch
767	861	786	1860.0	-89.5dBm to –90.5dBm	RSSI_DCS_Hch
861	885	Copy calibration value from RSSI_DCS_Hch			RSSI_DCS_Tch
-	-	No calibration required			RSSI_DCS_Comp

Initialisation

MS Test Mode:

AGC Setting:	73
RSSI_DCS_Bch :	0x00
RSSI_DCS_Lch :	0x00
RSSI_DCS_Mch :	0x00
RSSI_DCS_Hch :	0x00
RSSI_DCS_Tch :	0x00
RSSI_DCS_Comp:	0x00

GSM1900

Within the GSM1900 band five calibration sub-bands are defined. All sub-bands points must be calibrated to minimise ripple. The overall gain compensation must be performed to within ±0.5dB at all points. The RSSI_PCS_Comp value does not need calibrating.

Band Start	Band Stop	Calibration Channel	Calibration Frequency (MHz)	Calibration Limits (Absolute level)	Sub-band
512	546	521	1932.0	-89.5dBm to –90.5dBm	RSSI_PCS_Bch
547	611	556	1939.0	-89.5dBm to –90.5dBm	RSSI_PCS_Lch
612	661	621	1952.0	-89.5dBm to –90.5dBm	RSSI_PCS_Mch
662	761	716	1971.0	-89.5dBm to –90.5dBm	RSSI_PCS_Hch
762	810	786	1985.0	-89.5dBm to –90.5dBm	RSSI_PCS_Tch
-	-	No calibration required			RSSI_PCS_Comp

Initialisation

MS Test Mode:

AGC Setting:	73
RSSI_DCS_Bch :	0x00
RSSI_DCS_Lch :	0x00
RSSI_DCS_Mch :	0x00
RSSI_DCS_Hch :	0x00
RSSI_DCS_Tch :	0x00
RSSI_DCS_Comp:	0x00

6) Related documents

GD67 Baseband Calibration MMCDE_GD67_HW003
GD67 Test Command Interface Specification MMCDE-SW-C-P0500-03
GD67 AFC System: Crystal behaviour compensation in software MCUK-SW-GD67-319
GD67 AFC Calculation Algorithm – not officially documented yet.
"How to use "F" format numbers" – not officially documented yet.
GD67 AFC software compensation system "**Overview of 26MHz calibration".**