Programmes After Market Services
NPM-5 Series Phones

Troubleshooting

Issue 1 11/01

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Abbreviations used

BB	Baseband
CMT	Cellular Mobile Telephone
DC	Direct Current
ESD	Electro Static Dicharge
f:	Frequency of signal (measured with Spectrum Analyzer)
LF:	Low frequency (measured with oscilloscope)
LO	Local Oscillator
P:	Power of signal in decibels (dB) (measured with Spectrum Analyzer)
PA	Power Amplifier
PCB	Printed Circuit Board
PLL	Phase Locked Loop
RF	Radio Frequency
RX	Receiver
T:	Time between pulses
TX	Transmitter
UHF	Ultra High Frequency
V:	Voltage of signal (measured with oscilloscope)
VCO	Voltage controlled oscillator
VHF	Very High Frequency

CMT Troubleshooting

Baseband Testpoints

Figure 1: Topside Components

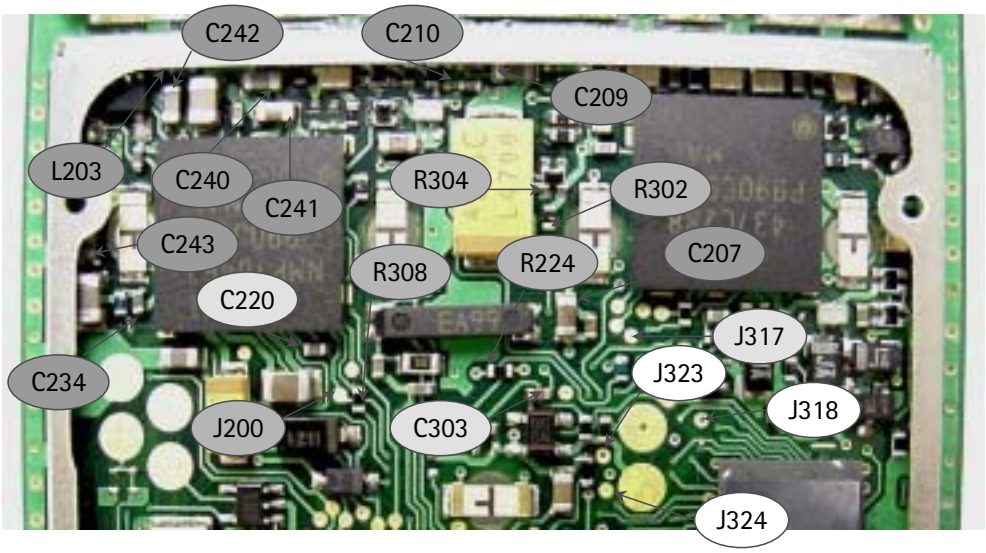


Figure 2: Bottom Side Components

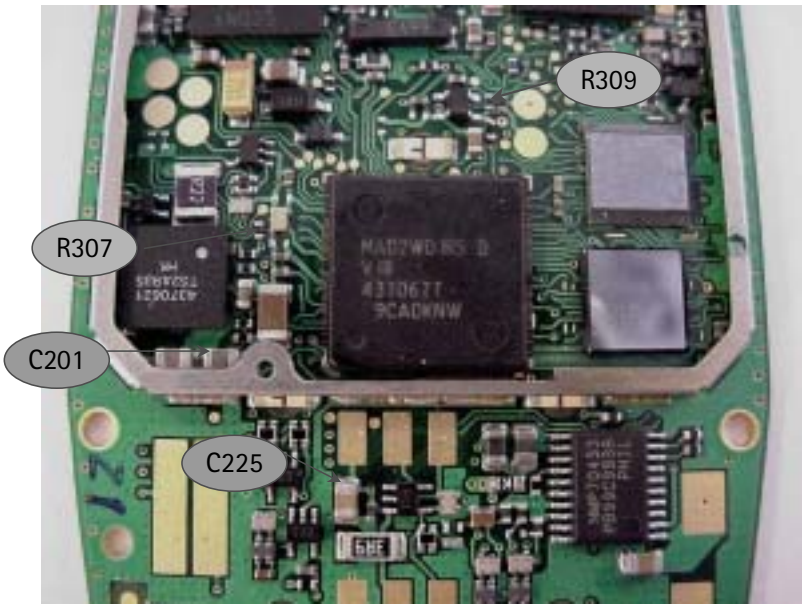


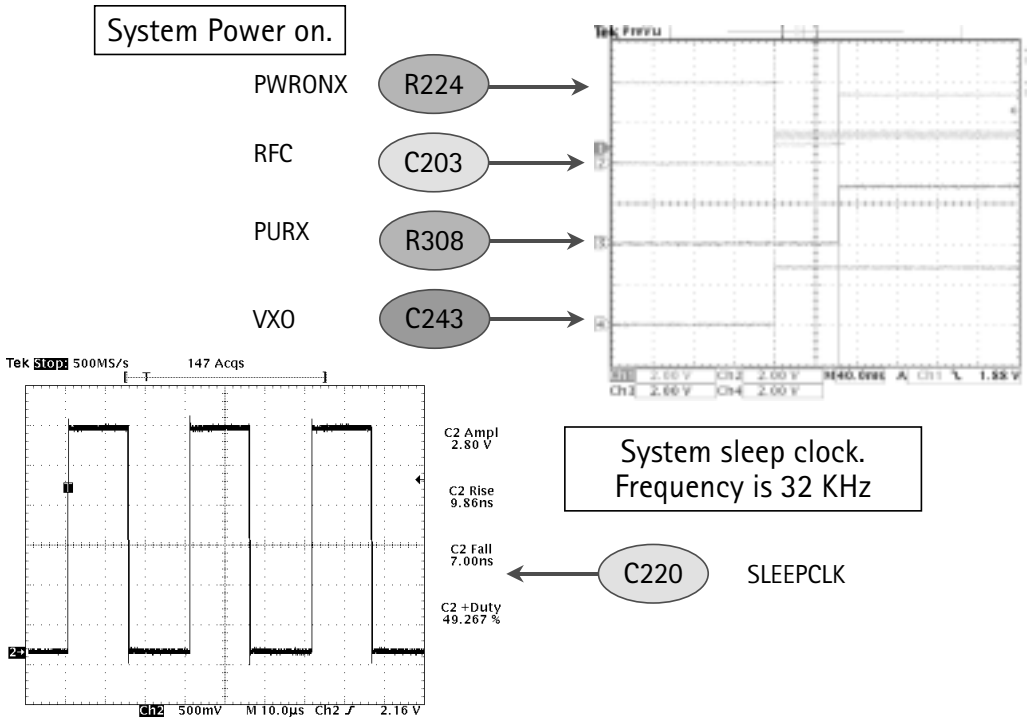
Table 1: CMT baseband test points

Test point	Net	Name	Condition	DC -level min	Nominal	Max.	
General							
R309	VPP		Flash or emulated EPROM write	1.7V	2.8V	2.85V	
J200	CCONTCSX		Active State	Pulsed active 0V Normal state 2.8V			
R308	PURX		Power up/down	Reset state 0V Normal state 2.8V			
R224	PWRON	PWRONX/ WDDISK	Power on	Reset state 0V Normal state 2.8V			
R304	FBUS_TX	FBUS(1)	Power on	Pulsed DC (0V to 2.8V)			
R302	FBUS_RX	FBUS(0)	Power on	Pulsed DC (0V to 2.8V)			
R307	MBUS		Power on	Pulsed DC (0V to 2.8V)			
Power supplies							
C201	VB(baseband)		Active state	3.0V	3.6V	4.2V	UI pwr supply
C240	VRX		Active state	2.7V	2.8V	2.85V	
R564	VXO		Active state	2.7V	2.8V	2.85V	
L203	VSYN_1	VCOS (RF)	Active state	2.7V	2.8V	2.85V	
C241	VSYN_1	Vsynte (RF)	Active state	2.7V	2.8V	2.85V	
C242	VTX	Vmod (RF)	Active state	2.7V	2.8V	2.85V	
C209	VBB		Active state	2.7V	2.8V	2.85V	
C207	VCOBBA		Active state	2.7V	2.8V	2.85V	
C234	VCP	VSV	Active state	4.8V	5.0V	5.0V	
C225	VSIM		Active state	2.8V (3V SIMcard) 5.0V (5V SIMcard)			
C210	VREF_2	VREF	Power on	1.5V +/- 1.5%			
Clock							
C220	SLEEPCLK	SCLK	Power on	Pulsed DC (0V to 2.8'v)			
C303	RFC	RFCLK	Active state				Typ. 0,8Vpp (Min 0.5Vpp, max. 2.0Vpp)
J317	COBBACLK	COBBAIF(2)	Active state	Pulsed DC (0V to 2.8'v)			
MCU							
J323	MEMC(7)	RAMSelX	Active state	Pulsed active 0V Non-actice 2.8V			

Test point	Net	Name	Condition	DC -level min Nominal Max.	
J324	MEMC(0)	ROM1SelX	Active state	Pulsed active 0V Non-actice 2.8V	
J318	MEMC(4)	EsysRessetX	Power on	Pulsed active 0V Non-actice 2.8V	

Power Schematic - Plots

Figure 3: Power test points



CPU Schematic - Plots

Figure 4: CPU test points

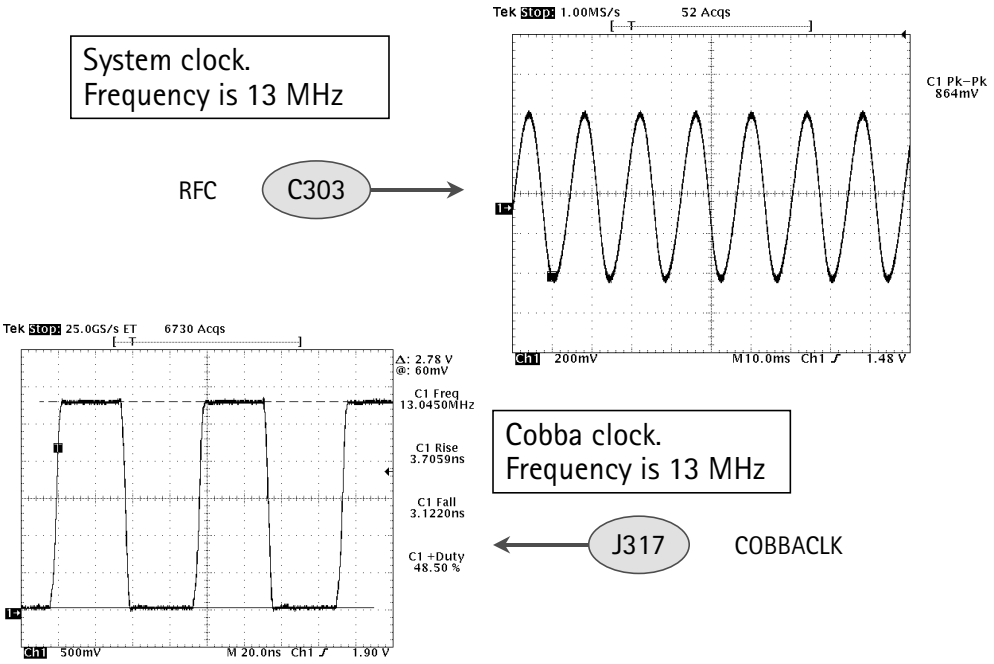
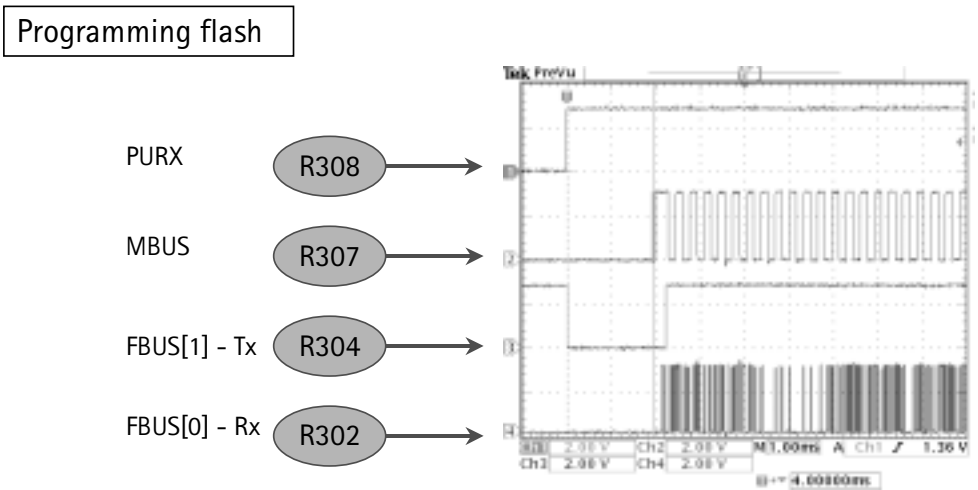


Figure 5: Flash programming

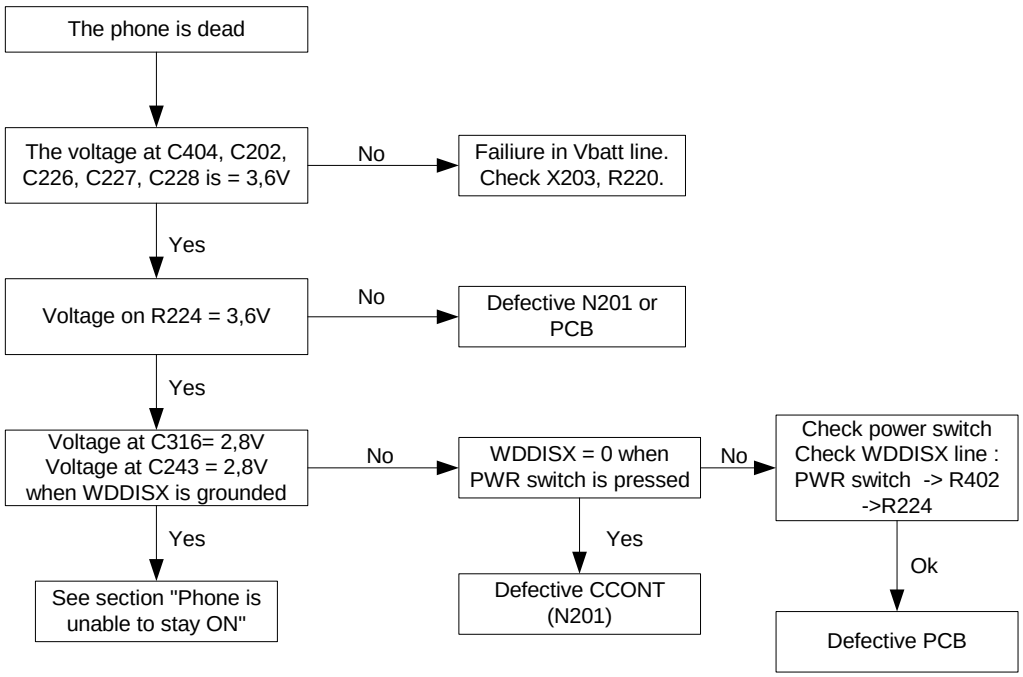


Troubleshooting Charts for CMT

1. Phone is Dead

"Phone is dead" means that the phone does not take current when the power switch is pressed or when the watchdog disable pin WDDISX is grounded. Nominal supply voltage to the phone is 3,6 V (Vbat voltage). If the battery voltage is below 3,1 V the CCONT prevents the phone from powering up

Figure 6: .Dead phone



2. Flash Programming Does Not Work

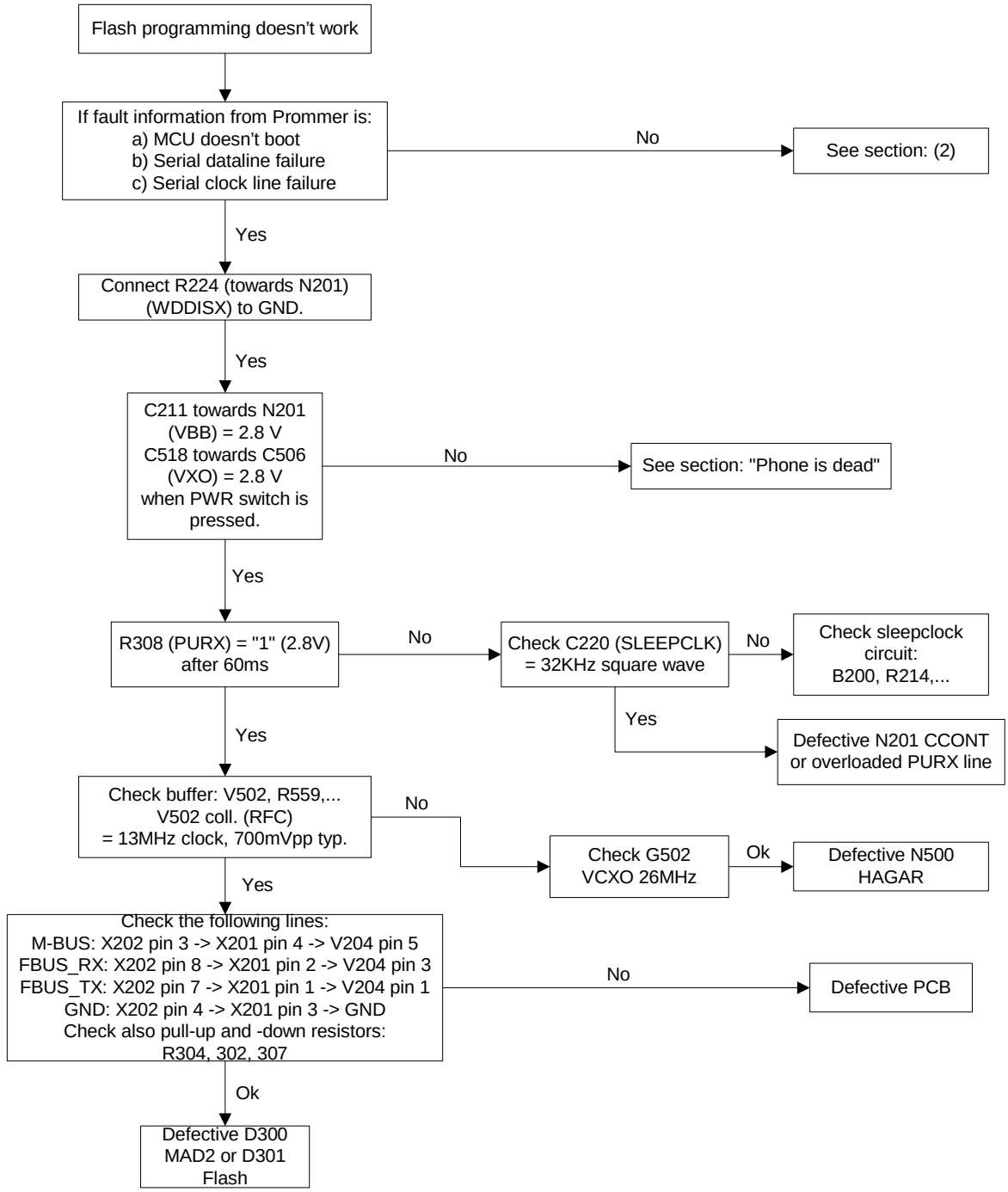
The flash programming is done in two steps and via two different connectors. FLALI (Flash align - **Production only !!!**) is the first programming step and it is done via the X202 connector. This connector, however is hidden when the PCB is placed in the D-cover and therefore the last programming step must be done via the FINUI (Final UI) connector X201. The two main differences between these two connectors are :

- Flash programming voltage is produced in a different way (external Vpp in FLALI).Signal routings are different.
- In case of a flash programming error the prommer box is able to give some information on the error that has occurred.
- The error information could be :
- MCU does not boot
- Serial clock line failure
- Serial data line failure
- External RAM failiure
- Algorithm file or alias ID not found
- MCU flash Vpp error

Because of the use of ìBGA components it is not possible to verify if there is a short-circuit in any of the lines to and from the MAD2WD1 and the SRAM/flash circuits.
The troubleshooting diagrams for flash programming are shown next page.

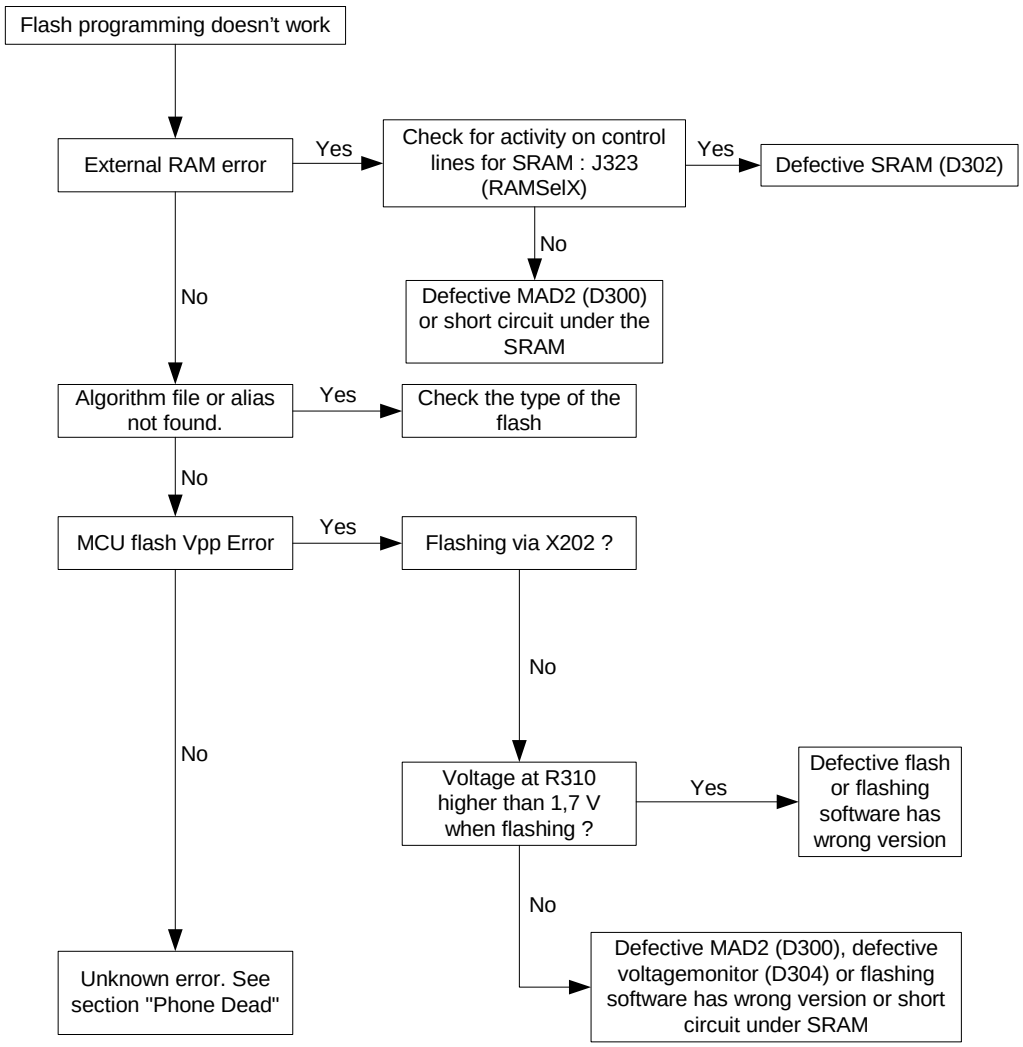
2.1 Flash programming diagram (1)

Figure 7: Flash programming troubleshooting



2.2 Flash programming diagram (2)

Figure 8: Flash programming troubleshooting 2



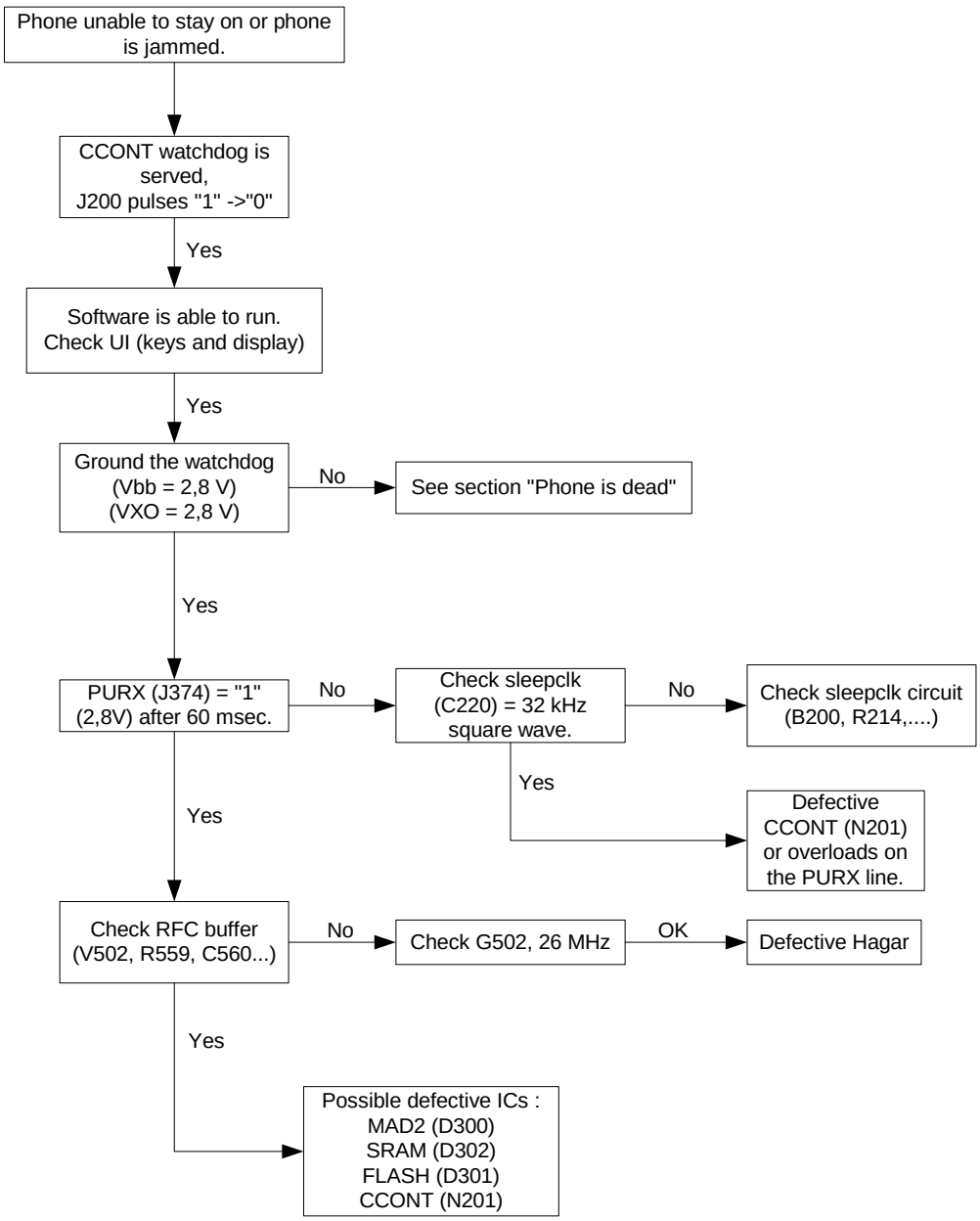
3. Phone Stays On or is Jammed

If this kind of error occurs after flashing the most plausible reason is open pins on an IC.

Normally the CCONT will power the phone down after 30 seconds if the watchdog has not been served by SW. Connecting an oscilloscope to J200 (DataSelX on the CCONT) can monitor the watchdog updating. Normally there is a short pulse from 1 to 0 every 8 seconds. Grounding J200 can disable the power off function..

3.1 Troubleshooting diagram,ad.3

Figure 9: Jammed phone.

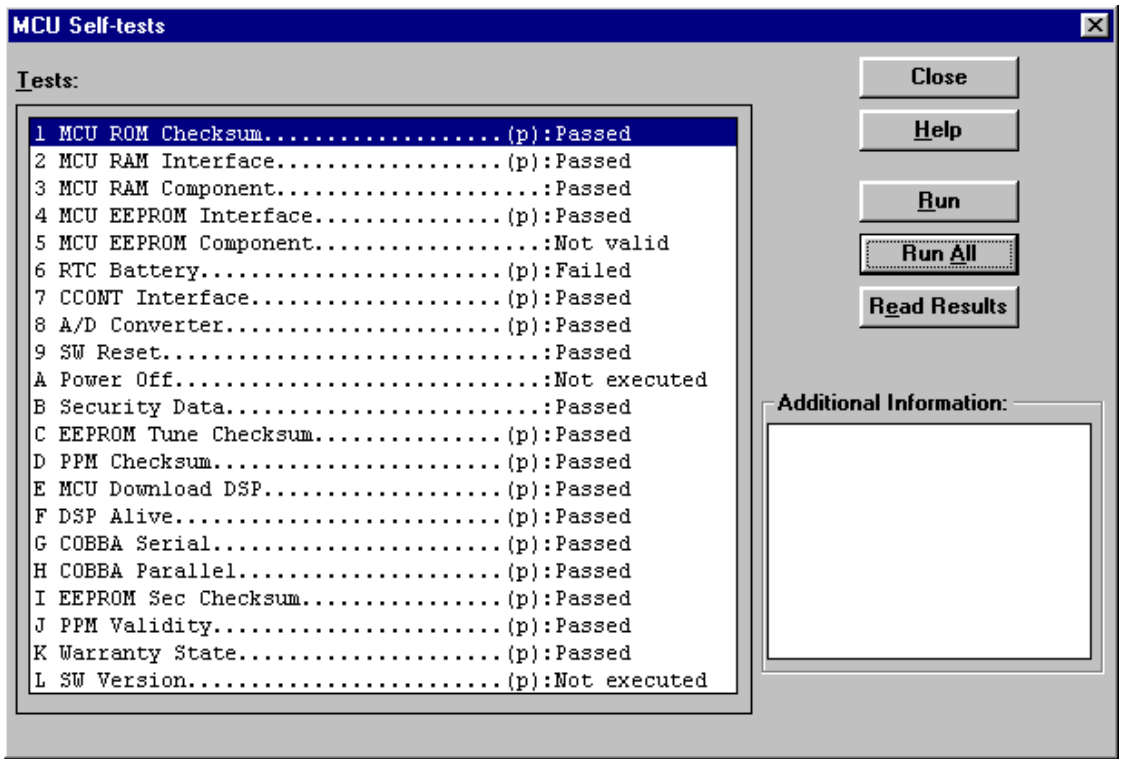


4. Display Information : "Contact Service"

If the message "Contact Service" is displayed one or more parts of the software is unable to execute properly. At the same time, the watchdog is triggered and is thereby able to tell if an error has occurred. Selftest functions are executed when the phone is powered on and if one or more selftest functions fails, the message "Contact Service" is shown in the display.

MCU selftest cases can be split into two categories : the ones that are executed during power up and the ones that are executed only with a PC connected. These test and the items included are as follows :

Figure 10: MCU Self Test window



The information shown above can be used to diagnose the phone.

Explanation of MCU ROM Checksum : A 16 bit checksum is calculated from the flash code and the result is then compared to the one found in the flash.

5. No network found, No Call established

When the phone is unable to either find a network or establish a call, both the RF part and the baseband part can cause it. The phone can be set to required mode (RF measurements) by the WinTesla service software in order to determine if the error is placed either in the RF part or the baseband part.

There are two circuits that supplies the RF part of the phone. These circuits are :

MAD2WD1 (D300)

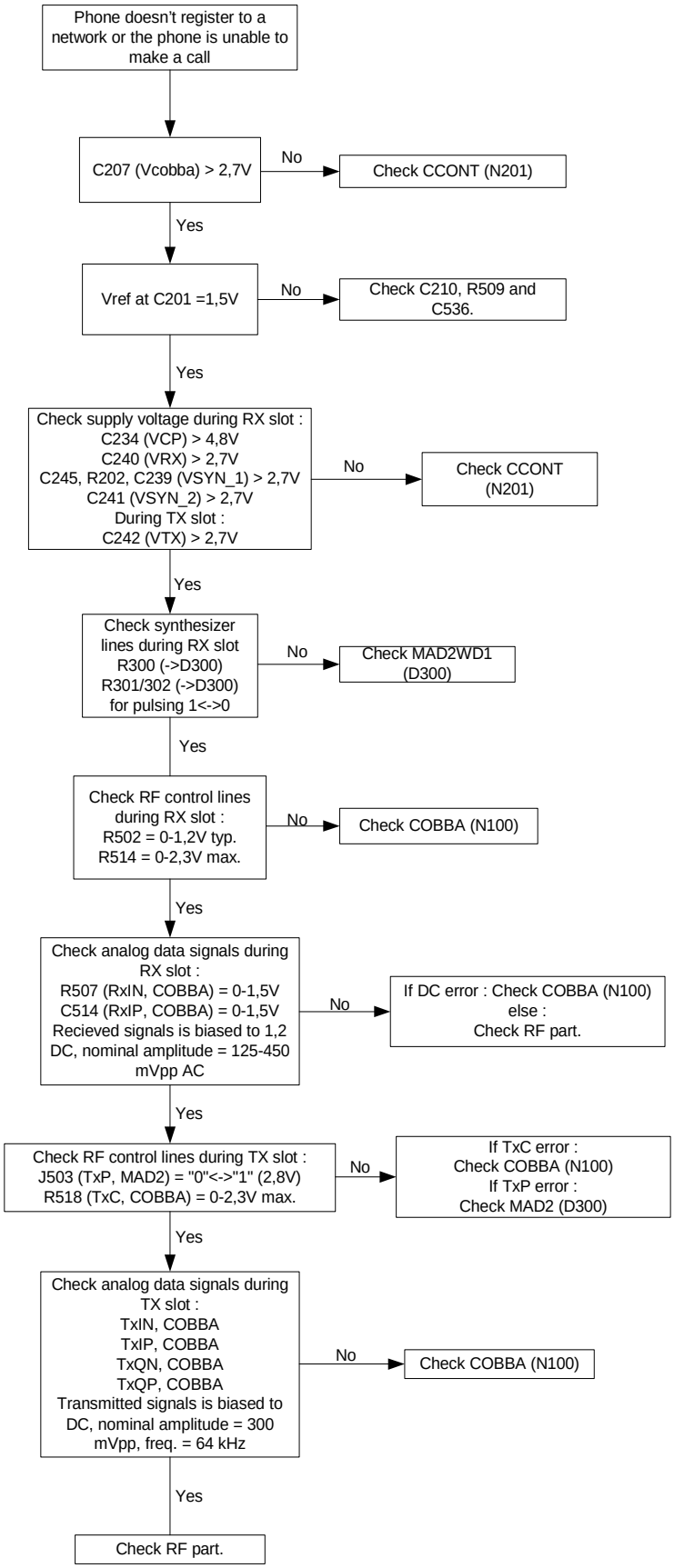
COBBA (N100)

The MAD2WD1 circuit supplies the RF part with the digital control signals : SynthEna, TxP, etc. and the COBBA supplies the RF part with the analog control signals : AFC, TxC etc

After power up, DSP indicates all the completed functions by changing the state of the XF pin as shown overleaf.

6. Phone does not register to network

Figure 11: Phone not registering to network



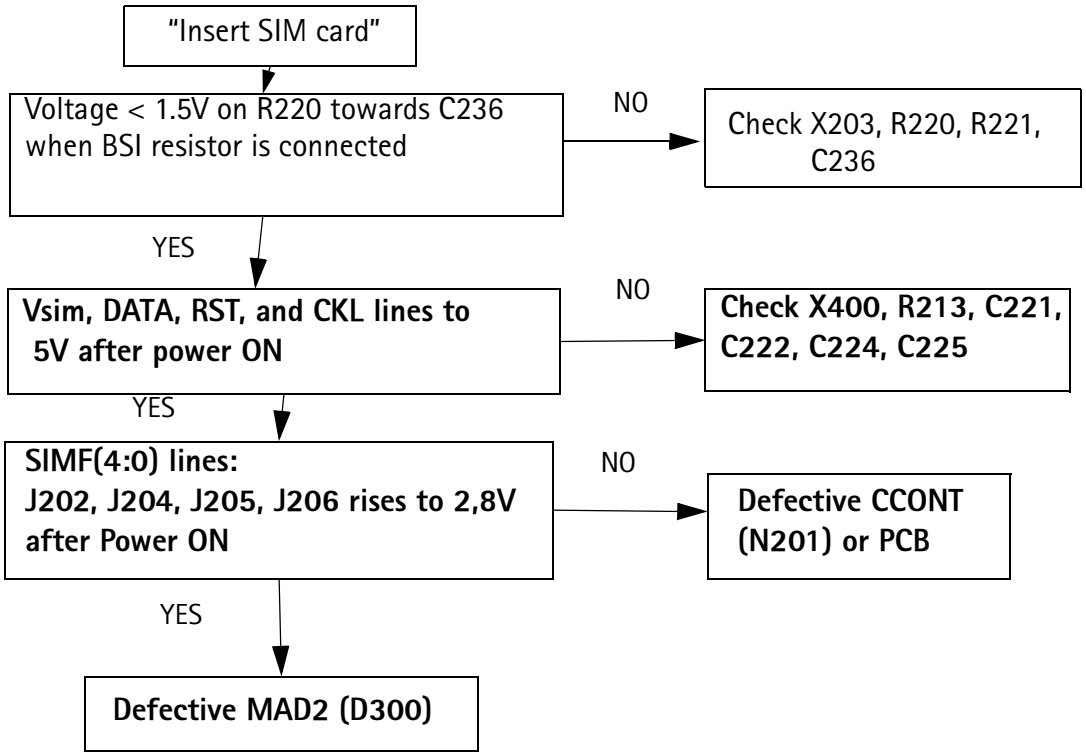
7. Sim Related Errors

The SIM interface from the MAD2WD1 (D300) to the SIM connector (X400) can be tested without a SIM card. When the power is switched on and the BSI terminal is grounded by a resistor, all interface lines (VSIM, DATA_A, SIMRST_A, SIMCLK) rises, first to 3V the to 5V. This is repeated four times. In this way it is possible to find errors in the SIM interface without a SIM card.

In case of a "SIM card rejected" error, the ATR message is actually sent from the SIM card but it is somehow corrupted, the data signal levels are out of spec. or the factory set values is incorrect (SIM locks etc.).

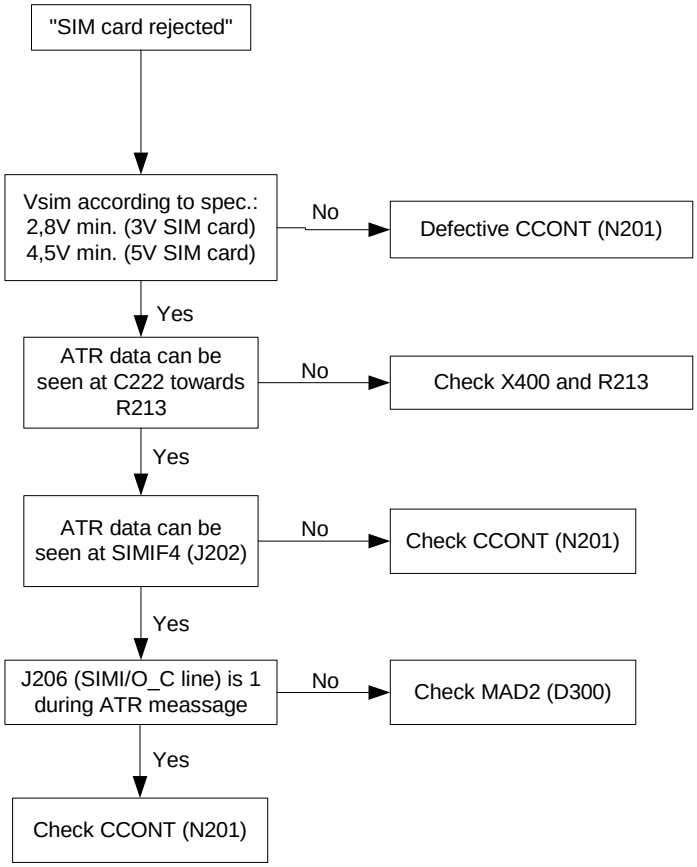
7.1 "Insert SIM card" error

Figure 12: SIM error 1



7.2 "SIM card rejected" error

Figure 13: SIM card error 2



8. Audio Faults

Note : All checking must be done with a fully functional UI module connected.

Figure 14: 8.1Internal earpiece

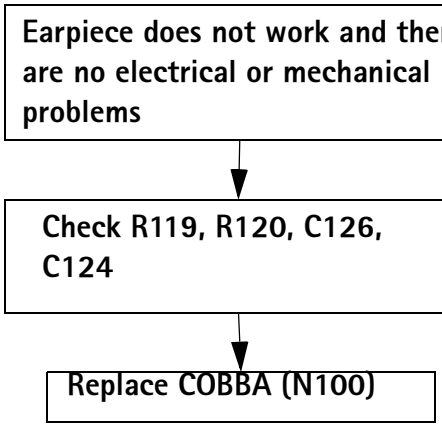


Figure 15: 8.2Internal microphone

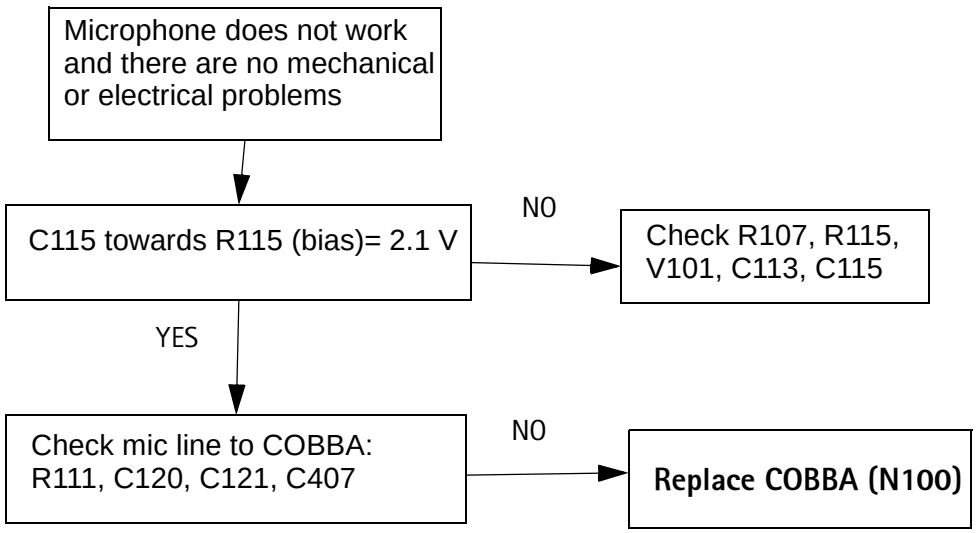


Figure 16: External earpiece

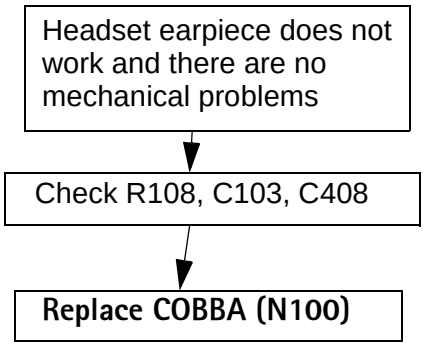
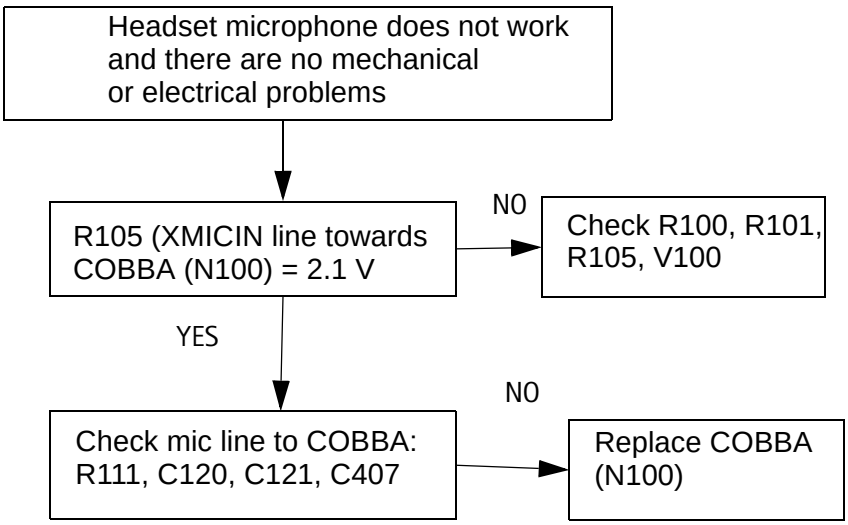


Figure 17: 8.4External microphone



9. Charging Error

Figure 18: No detection of charger

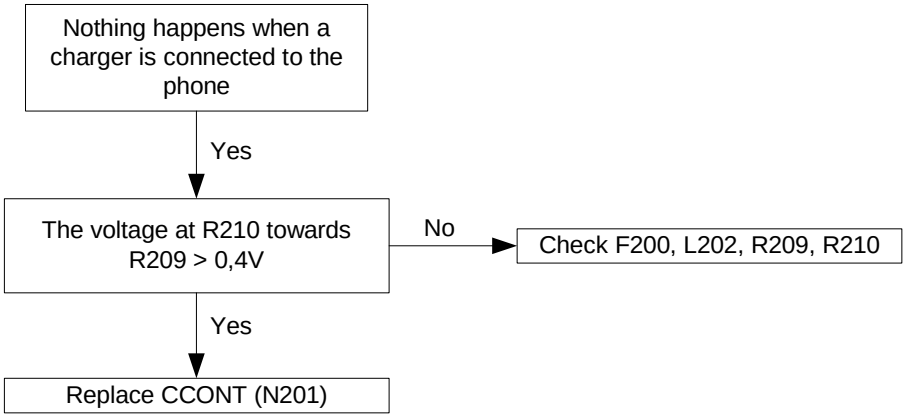
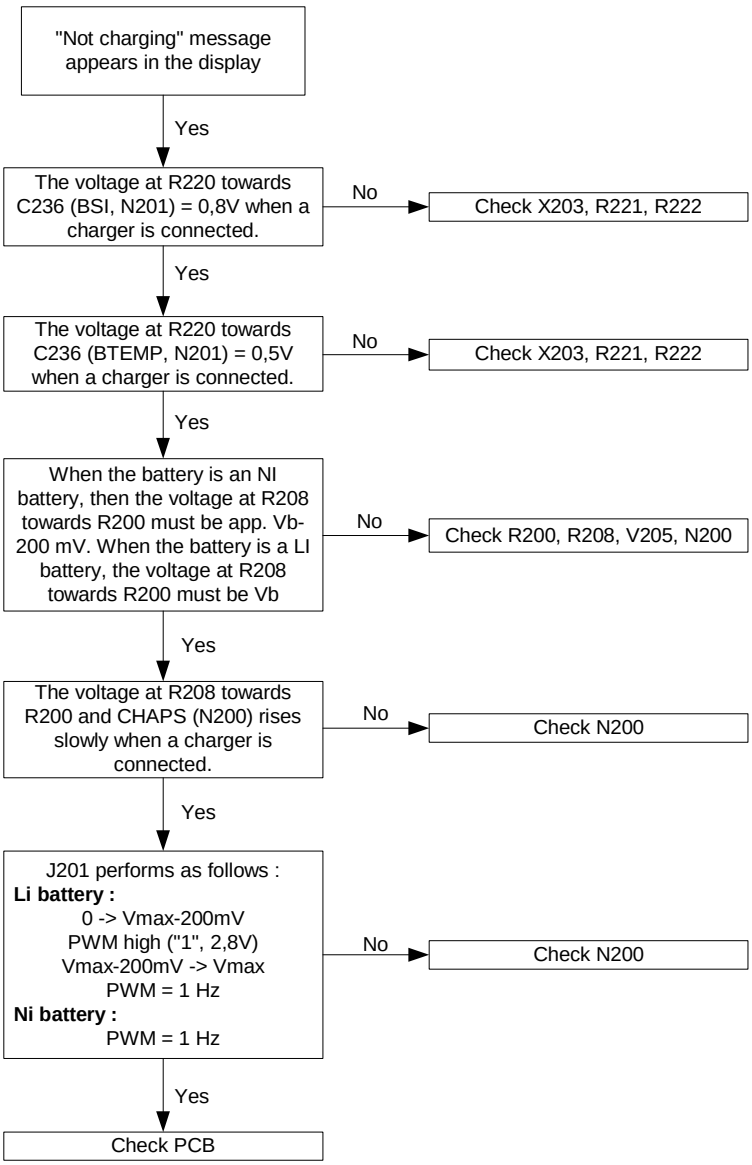


Figure 19: Not Charging" message



RF Troubleshooting

Two types of measurements are used in the following. It will be specified if the measurement type is "RF" or "LF".

- RF measurements should be done with a Spectrum Analyzer and a high-frequency 500 ohm passive probe, for example HP54006A. (Note that when measuring with the 500 ohm probe the signal will be around 20 dB attenuated. The values in the following will have these 20 dB subtracted and represent the real value seen on the spectrum analyzer).

- LF (Low frequency) and DC measurements should be done with a 10:1 probe and an oscilloscope. The probe used in the following is 10MΩ/8pF passive probe. If using another probe then bear in mind that the voltages displayed may be slightly different.

Always make sure the measurement set-up is calibrated when measuring RF parameters on the antenna pad. Remember to include the loss in the module repair jig when realigning the phone.

Most RF semiconductors are static discharge sensitive**.** So ESD protection must be taken during repair (ground straps and ESD soldering irons). Hagar is moisture sensitive so parts must be pre-baked prior to soldering.

Apart from key-components described in this document there are a lot of discrete components (resistors, inductors and capacitors) for which troubleshooting is done by checking if soldering of the component is done properly and checking if the component is missing from PCB. Capacitors can be checked for short-circuiting and resistors for value by means of an ohmmeter, but be aware in-circuit measurements should be evaluated carefully.

In the following both the name EGSM and GSM900 will be used for the lower band and both PCN and GSM1800 will be used for the upper band.

RF Key Component Placement

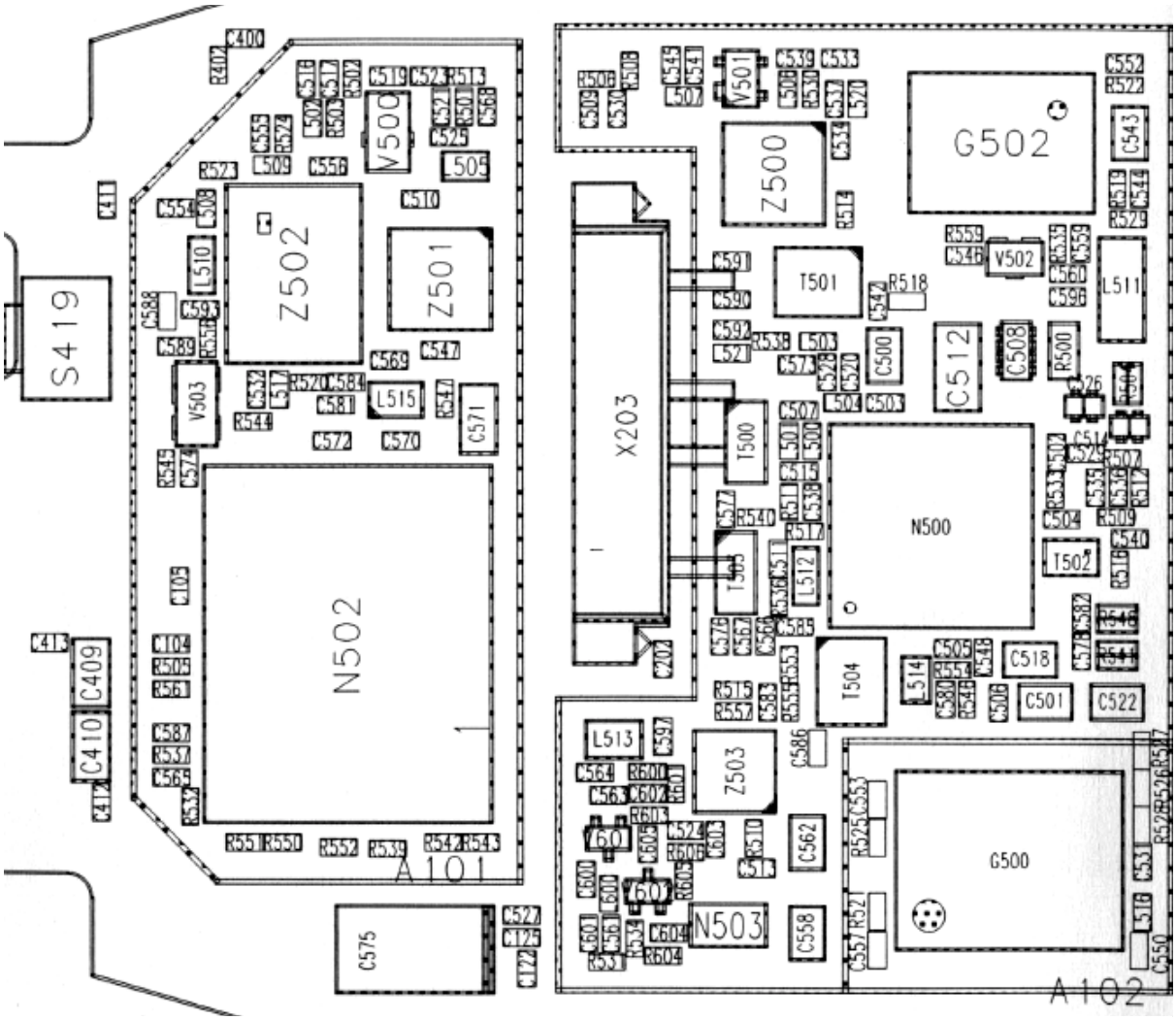


Table 2: RF Key Components

N502	**Power amplifier (PA)**
Z502	RXTX switch
Z501	1st Dual RX SAW filter (GSM900 & GSM1800)
Z500	2nd Dual RX SAW filter (GSM900 & GSM1800)
G502	VCTCXO (26 MHz Crystal oscillator)
N500	Hagar RF IC
G500	VCO (3.6 GHz UHF VCO)
Z503	TX SAW filter (GSM)

RF Component Locations

Figure 20: RF Component Locations 1

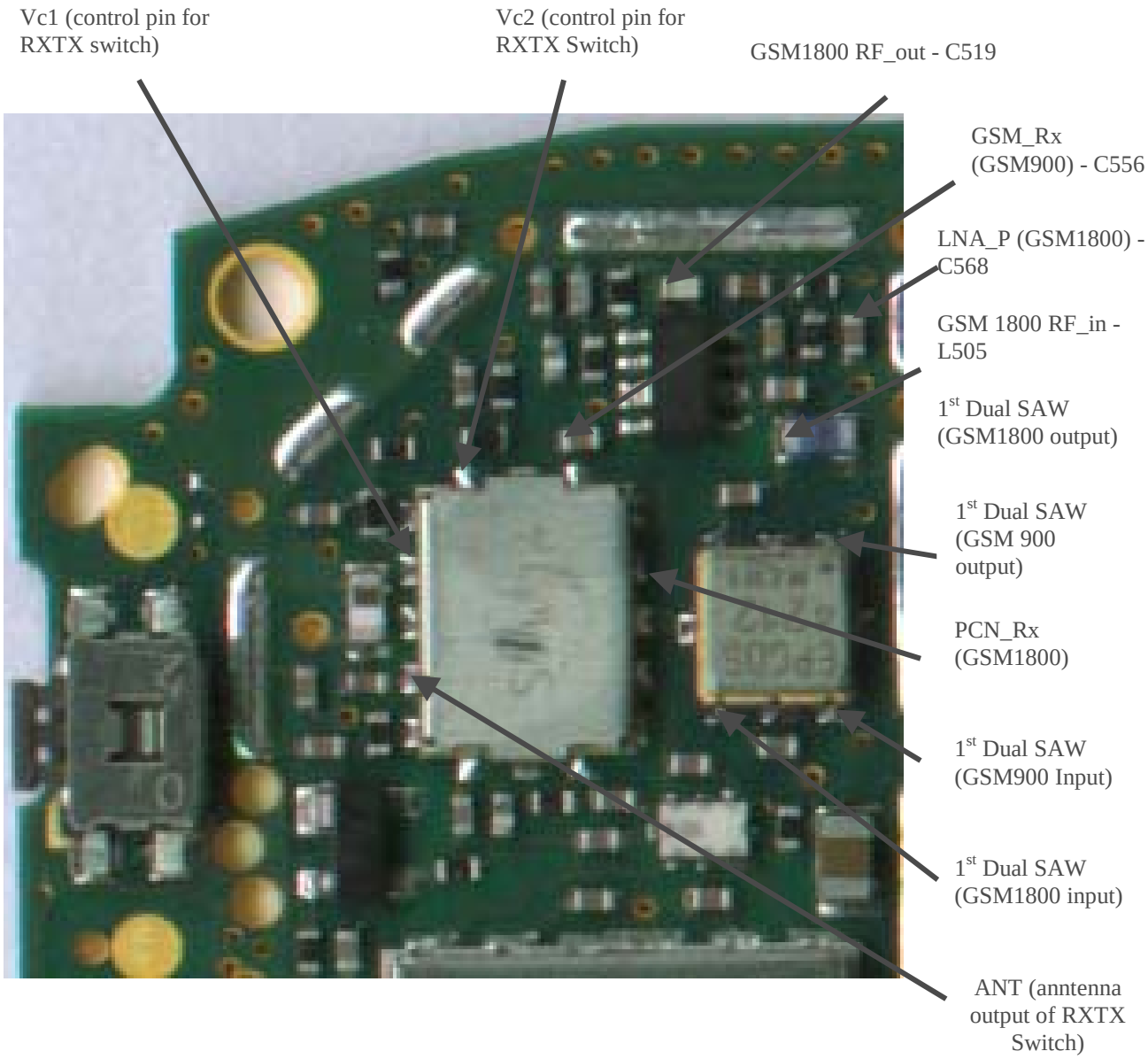
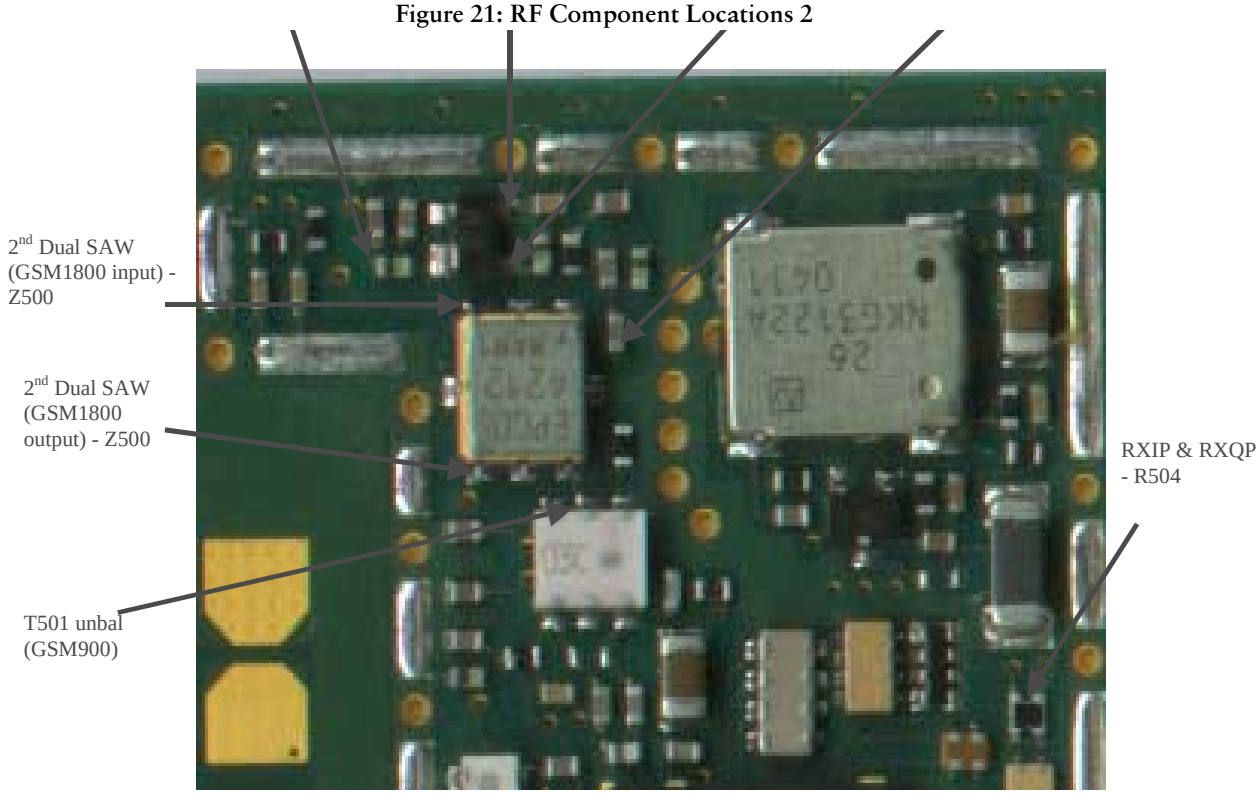


Figure 21: RF Component Locations 2



GSM900 Receiver Troubleshooting

General instructions for GSM900 RX troubleshooting

Connect the phone to a PC with the module repair jig.

Start Wintesla-Service-Software and

Select Product Alt+p

Open...

NPM-5

Select: Product Alt+p

Band b

EGSM e

Select: Testing Alt+e

RF Controls r

RX ContinuousAlt+r

Cont. Mode Ch: 60Alt+o, 60

AGC Absolute: 5

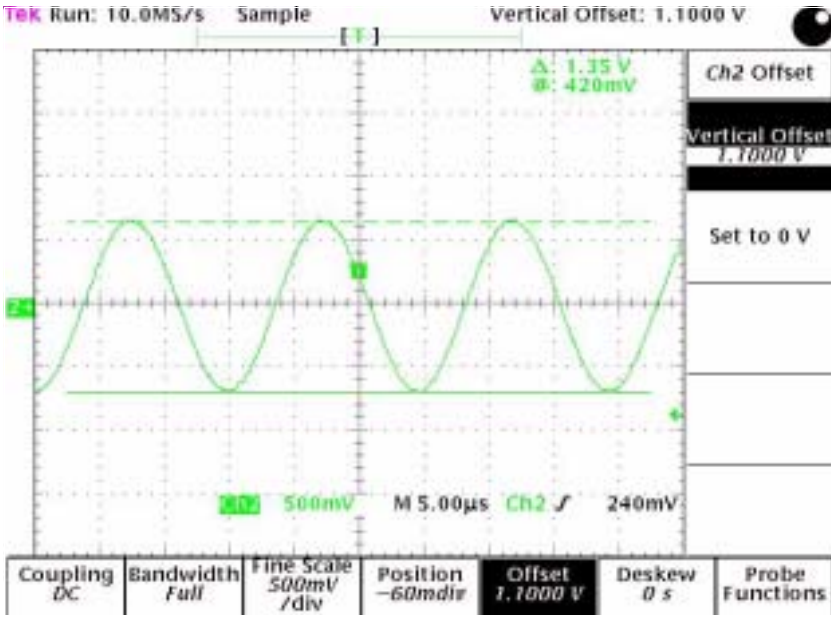
Apply

The set-up should now look like this:

Figure 22: RF Controls window

Apply a 947.0667 MHz (channel 60 + 67.710kHz offset) -55 dBm signal to the RF-connector.

Measuring with an oscilloscope on "RXIP" or "RXQP" this picture should be seen on a working GSM900 receiver:

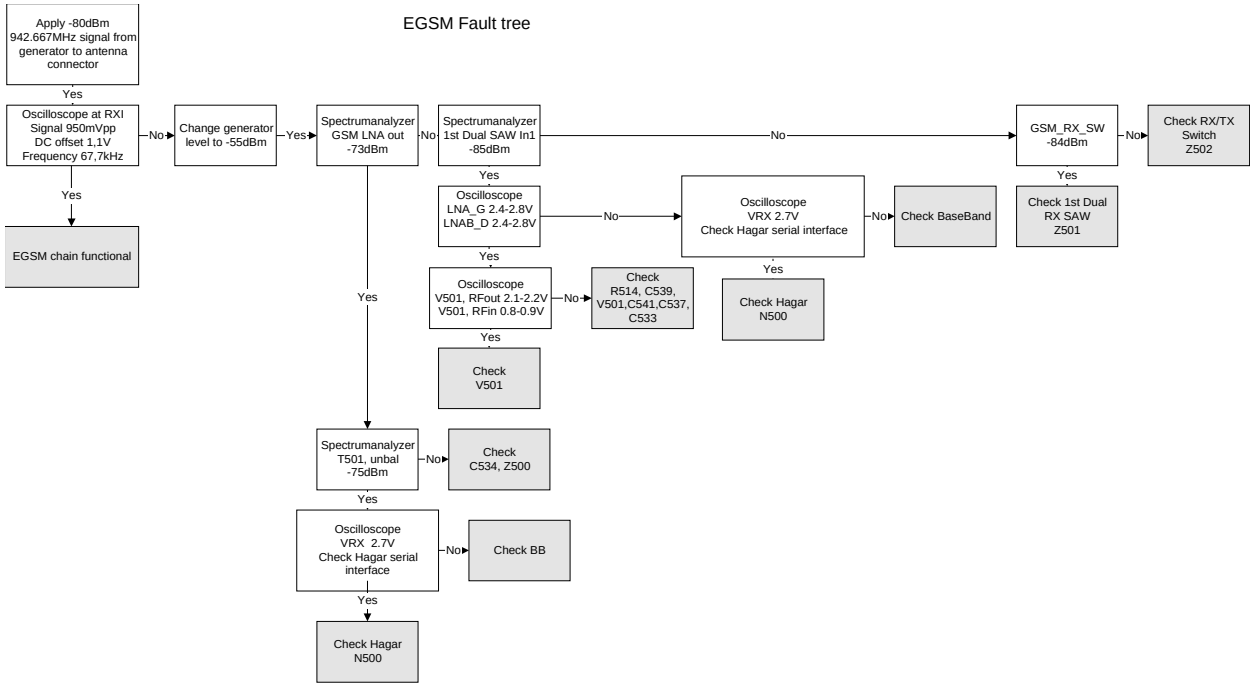


Signal amplitude	~1.35V
DC offset	1,1V
Frequency	67kHz

If this screen is not seen go to section troubleshooting chart for GSM of this document.

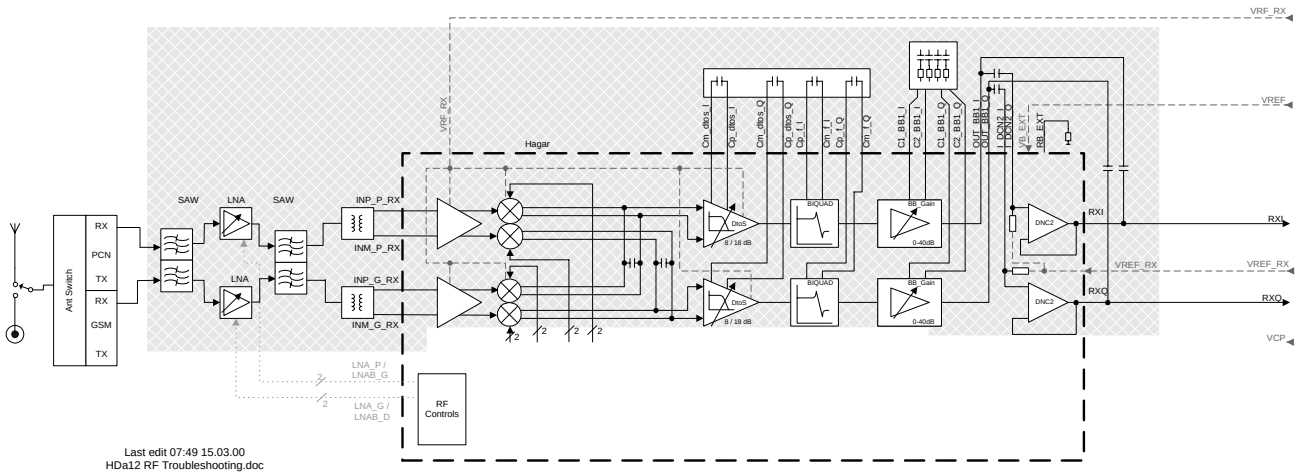
10. Troubleshooting chart for GSM900 receiver

Figure 23: EGSM Faut tree



GSM900 Signal path

For easy error tracing it is important to know the signal path of the GSM900 receiver. The components can be grouped into blocks and drawn as shown below.



RX/TX Switch

From the antenna-pad the RF signal is lead to the RX/TX switch (Z502).

The RX/TX switch is normally open to the two RX outlets GSM_Rx and DCS_Rx. If no control voltage is present at VC1 or VC2 the RX/TX switch will work as a diplexer and the GSM900 signal is pass to GSM_Rx and the GSM1800 signal to DCS_Rx.

From GSM_Rx the GSM900 signal is feed to the 1st Dual RX SAW filter via C556.

Front-end

The GSM900 front-end consists mainly of two SAW filters (Z501 and Z500) and one LNA (V501) in-between and finally one balun (T501). The SAW filters provides out-of-band blocking immunity, the LNA provides front-end gain and the balun provides a balanced signal for Hagar (N500)

The signal-path is through Z501 (In-band insertion-loss 3,5dB), through the matching circuit (C545, L507 and C541) and to the GSM900 LNA (V501, RFin).

The LNA has about 18dB gain when it is "on" (LNA_G = 2.8V and LNAB_D = 2.8V). If the signal applied to the antenna-connector is more than –45dBm the AGC will gain-step the LNA (LNA_G = 2.8V and LNAB_D = 0V) which means the LNA Gain will now have negative gain (loss) of –12 dB.

From the LNA (V501 RF out) the signal is lead through the LNA-output-matching-circuit (C537, L520 and C534), through the 2nd Dual RX SAW Z500 (In-band insertion-loss 3,5dB) to the GSM900 balun T501. From the balun the signal is balanced and is lead to Hagar (N500 IMP_G_RX and INM_G_RX).

Hagar

The balanced RX signal is mixed with a signal from the local oscillator at the same frequency as the wanted RX signal. After mixing the signal is converted to a single-ended signal in the DtoS (Differential to Single-ended) amplifier. The signal is now filtered in a BIQUAD filter to provide channel separation, amplified in the BB_Gain amplifier and DC compensated in DCN2.

GSM1800 Receiver Troubleshooting

General instructions for GSM1800 RX troubleshooting

Connect the phone to a PC with the module repair jig.

Start Wintesla-Service-Software and

Select Product Alt+p

Open...

NPM-5

Select: Product Alt+p

Band b

PCN p

Select: Testing Alt+e

RF Controls r

RX ContinuousAlt+r

Cont. Mode Ch: 700Alt+o, 700

AGC Absolute: 5

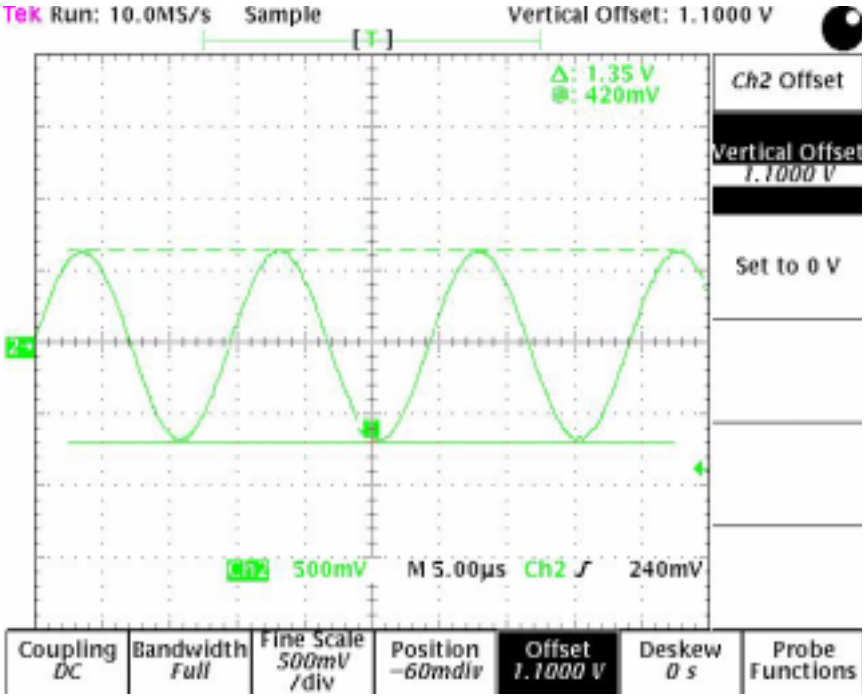
Apply

Figure 24: RF Controls PCN

Apply an 1842.867 MHz (channel 700 + 67.710kHz offset) -55 dBm signal to the RF connection (remember to compensate for cable and adapter attenuation).

Measuring with an oscilloscope on "Hagar RXI" or "Hagar RXQ" this picture should be seen on a working GSM1800 receiver:

Figure 25: PCN oscilloscope screen shot



Signal amplitude	~1.35V
DC offset	1,1V
Frequency	67kHz

If this screen is not seen not go to section troubleshooting chart of this document

11. Troubleshooting chart for GSM1800 receiver

Figure 26: PCN fault tree

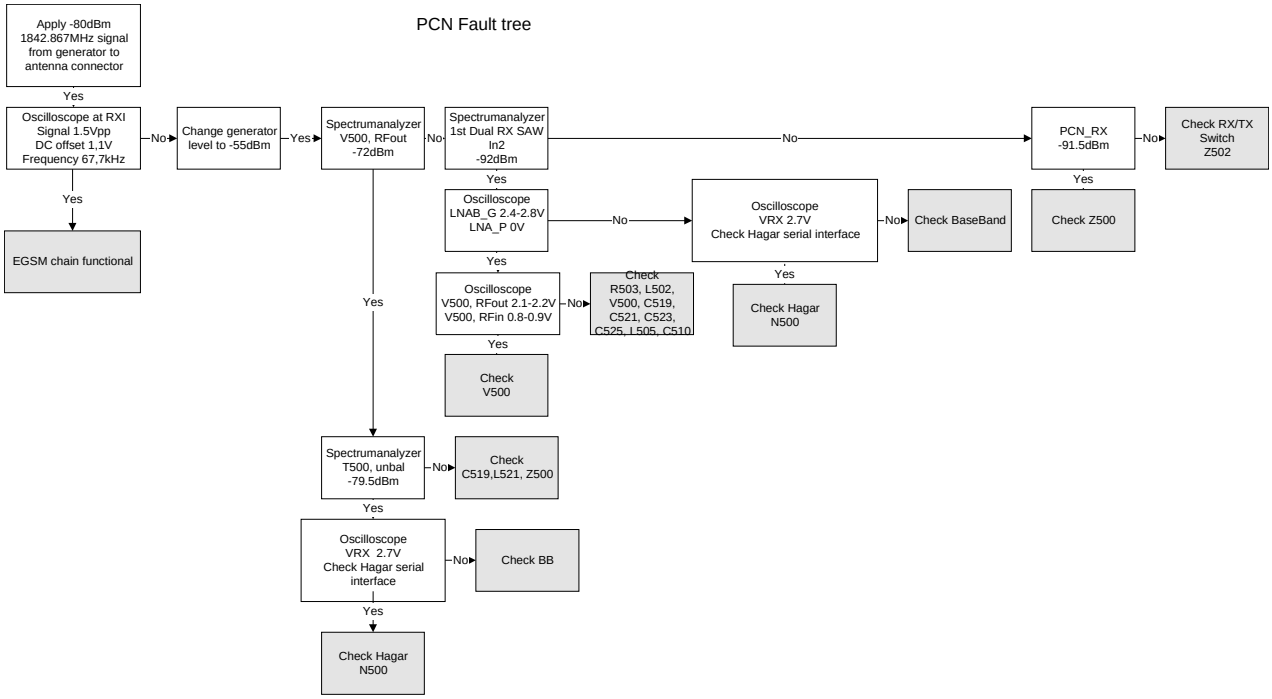
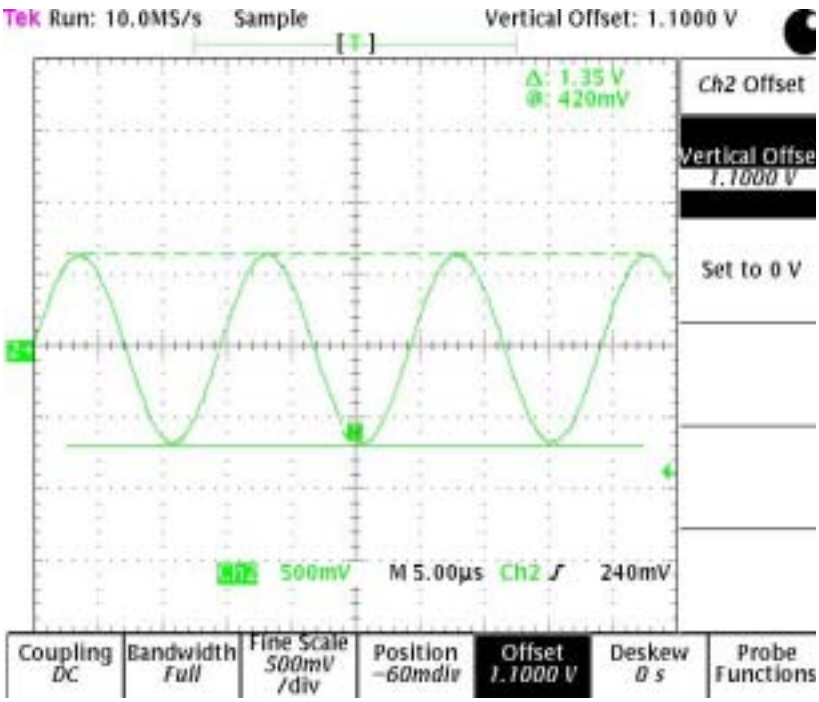


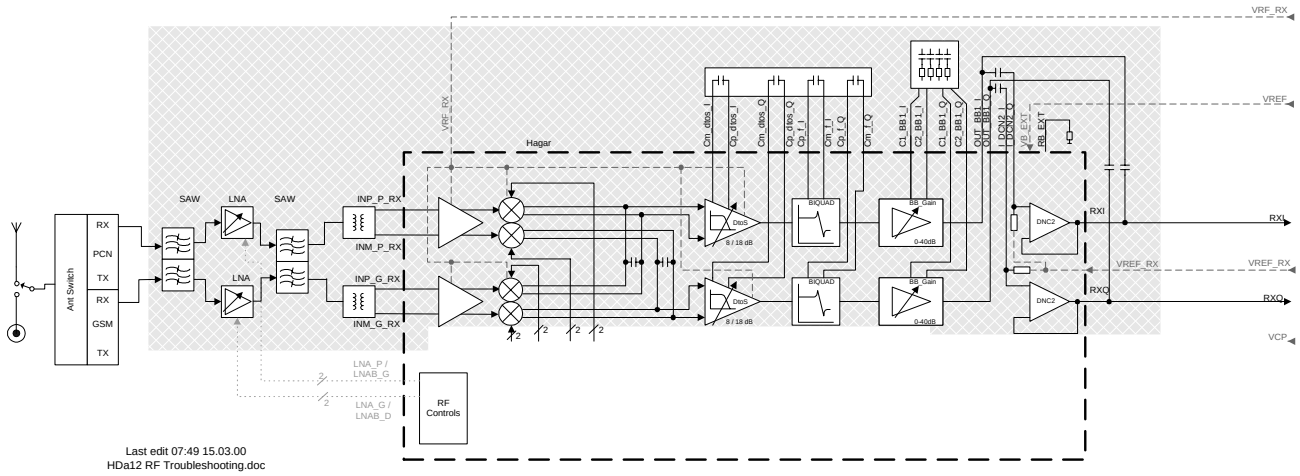
Figure 27: PCN oscilloscope screen shot



PCN Signal path

For easy error tracing it is important to know the signal path of the PCN receiver. The components can be grouped into blocks and drawn as shown below.

Figure 28: PCN Signal path



RX/TX Switch

From the antenna-pad the RF signal is lead to the RX/TX switch (Z502).

The RX/TX switch is normally open to the two RX outlets GSM_Rx and DCS_Rx. If no control voltage is present at VC1 or VC2 the RX/TX switch will work as a diplexer and the GSM900 signal is pass to GSM_Rx and the GSM1800 signal to DCS_Rx.

From GSM_Rx the GSM1800 signal is feed to the 1st Dual RX SAW filter via C547.

Front-end

The GSM1800 front-end consists mainly of two SAW filters (Z501 and Z500) and one LNA (V500) in-between and finally one balun (T500). The SAW filters provides out-of-band blocking immunity, the LNA provides front-end gain and the balun provides a balanced signal for Hagar (N500)

The signal-path is through Z501 (In-band insertion-loss 3,5dB), through the matching circuit (C510, L505 and C525) and to the GSM1800 LNA (V500, RFin).

The LNA has about 17dB gain when it is "on" (LNAB_G = 2.8V and LNA_P = 0V). If the signal applied to the antenna-connector is more than –45dBm the AGC will gain-step the LNA (LNAB_G = 2.8V and LNA_P = 0V) which means the LNA Gain will now have negative gain (loss) of –8 dB.

From the LNA (V500 RF out) the signal is lead through the LNA-output-matching-circuit (C519), through the 2nd Dual RX SAW Z500 (In-band insertion-loss 3,5dB) to the GSM1800 balun T500. From the balun the signal is balanced and is lead to Hagar (N500 IMP_P_RX and INM_P_RX).

Hagar

The balanced RX signal is mixed with a signal from the local oscillator at the same frequency as the wanted RX signal. After mixing the signal is converted to a single-ended signal in the DtoS (Differential to Single-ended) amplifier. The signal is now filtered in a BIQUAD filter to provide channel separation, amplified in the BB_Gain amplifier and DC compensated in DCN2.

GSM900 Transmitter

General instructions for GSM900 TX troubleshooting

Start WinTesla-Service-Software and

Select: Product Alt+p

Band b

GSM g

Select: Testing Alt+e

RF Controls r

TX Burst Alt+b

TX Data Type: Random Alt+d, r

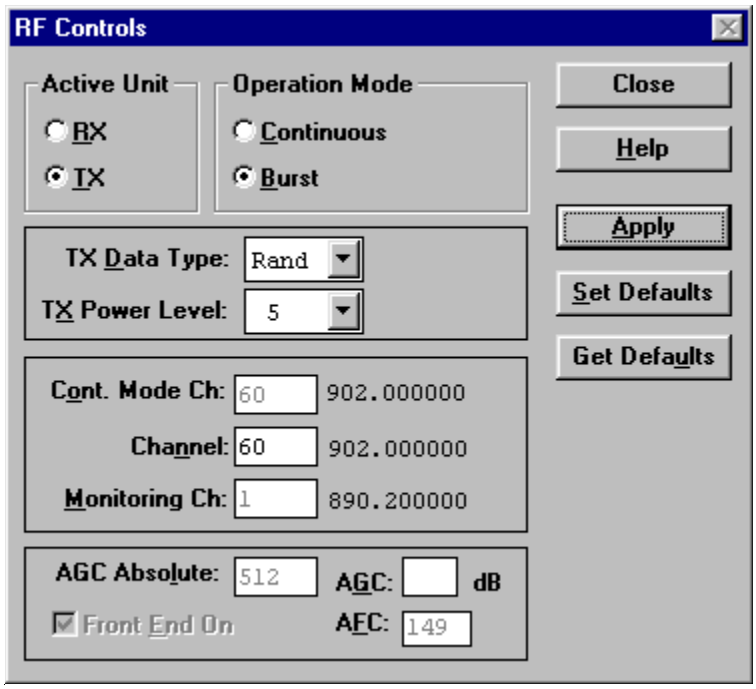
TX Power Level : 5 Alt+x, 5

Channel: 60 Alt+n, 60

Apply Alt+a

Your screen should look like this:

Figure 29: RF controls window



Measure the output power of the phone; it should be around 32 dBm.

Troubleshooting for GSM900 transmitter

Troubleshooting in output power

Figure 30: Measurement points

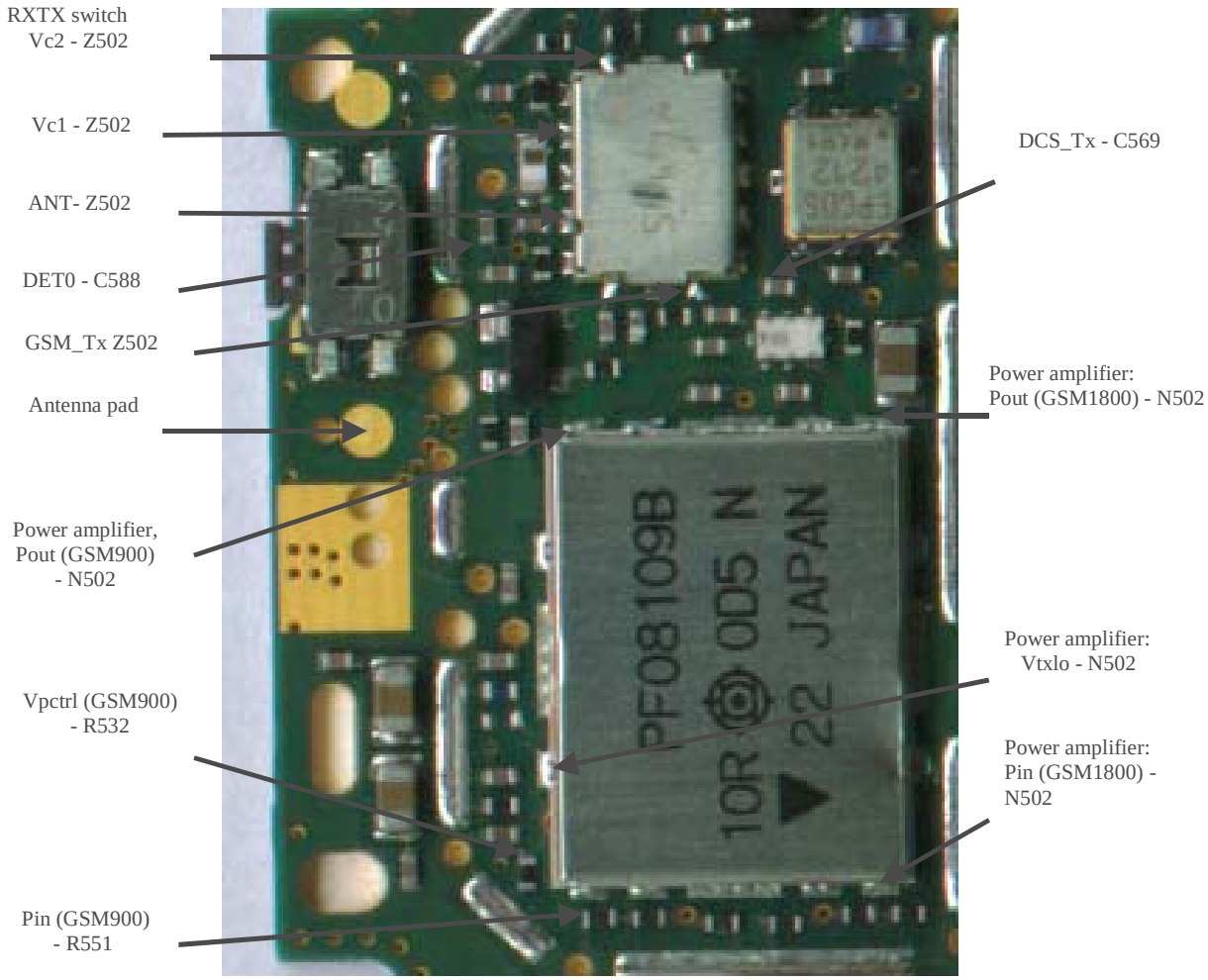
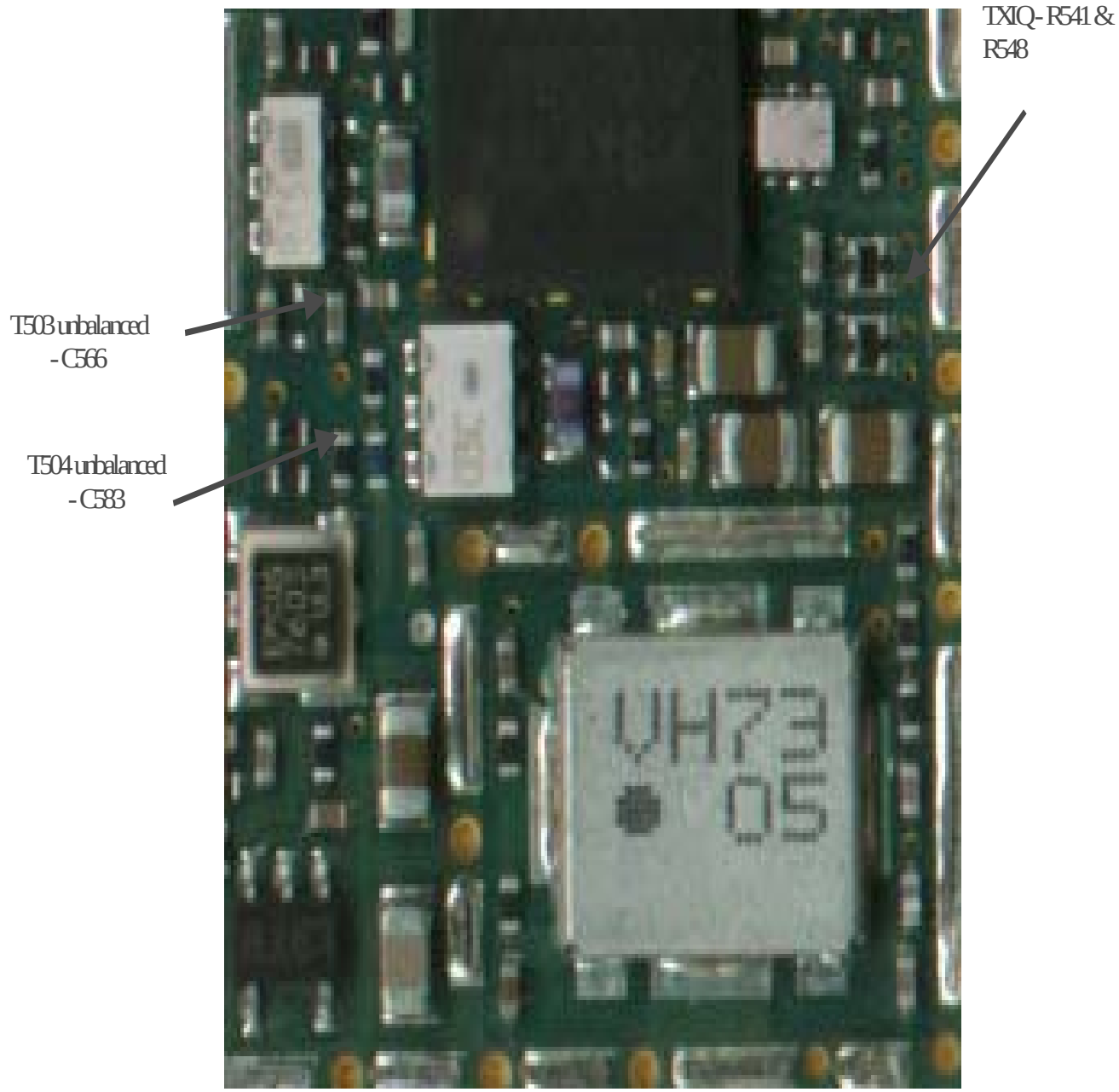
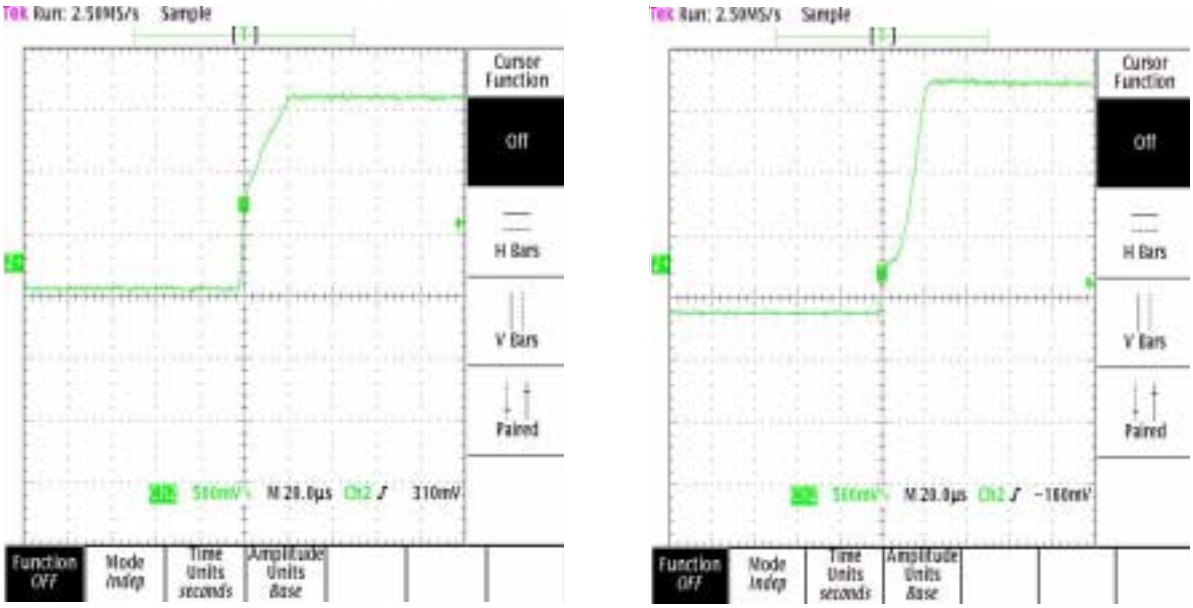


Figure 31: Measuremet points 2



For spectrum analyzer measurements in the following chart use the 500 ohm passive probe. Since the signal measured is bursted it is advised to set the analyzer to maxhold.

Figure 32: Oscilloscope screen shots



Troubleshooting modulation

The following plots show different situations of TX IQ measurements. Depending on the time the modulation may cause the signal to look differently.

Figure 33: Oscilloscope screen shots, TX IQ

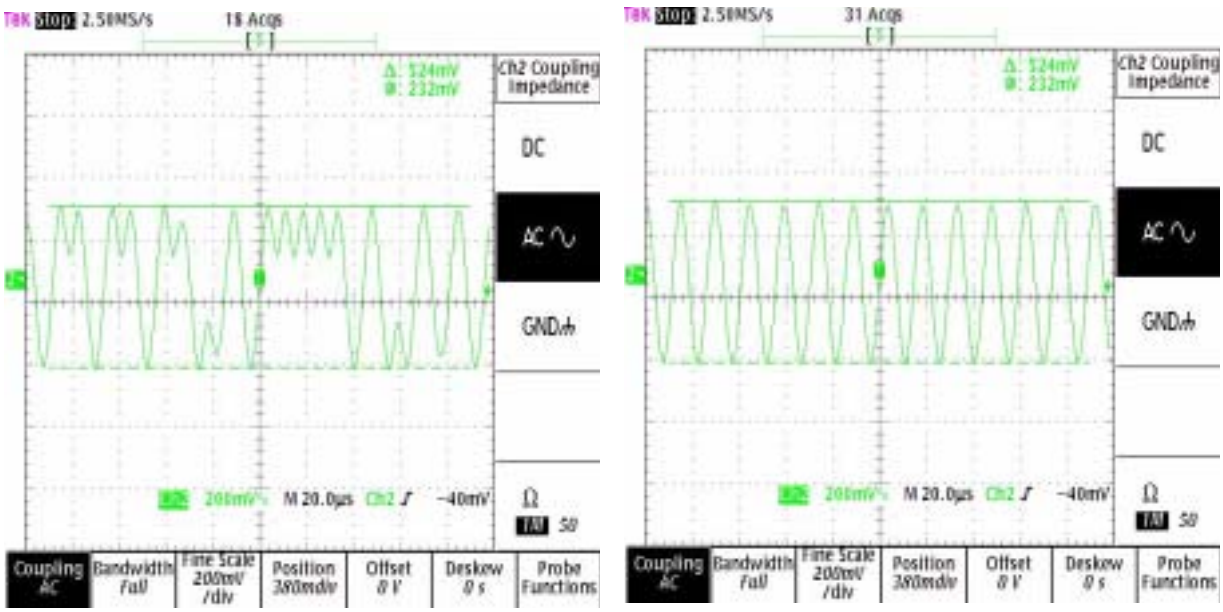
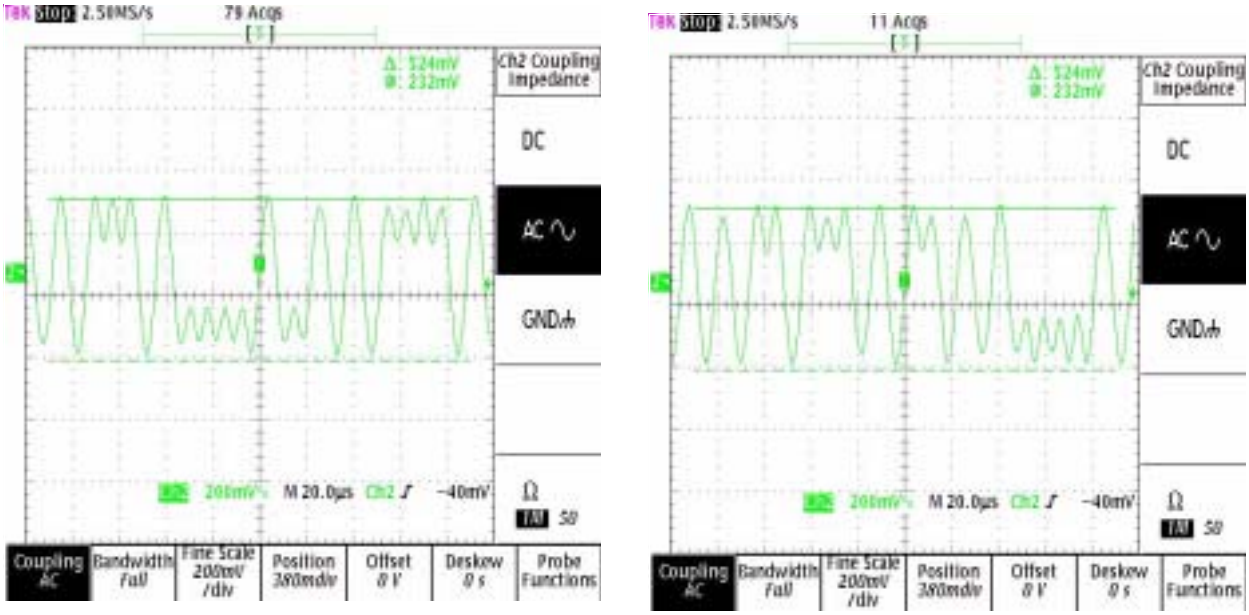


Figure 34: Oscilloscope screen shots



For instructions how to check Hagar and serial bus, refer to section Hagar and serial interface.

PCN Transmitter

12. General instructions for PCN TX troubleshooting

Apply a RF-cable to the RF-connector to allow the transmitted signal act as normal. RF-cable should be connected to measurement equipment or to at least a 10-dB attenuator, otherwise the PA may be damaged.

Figure 35: PCN TX troubleshooting

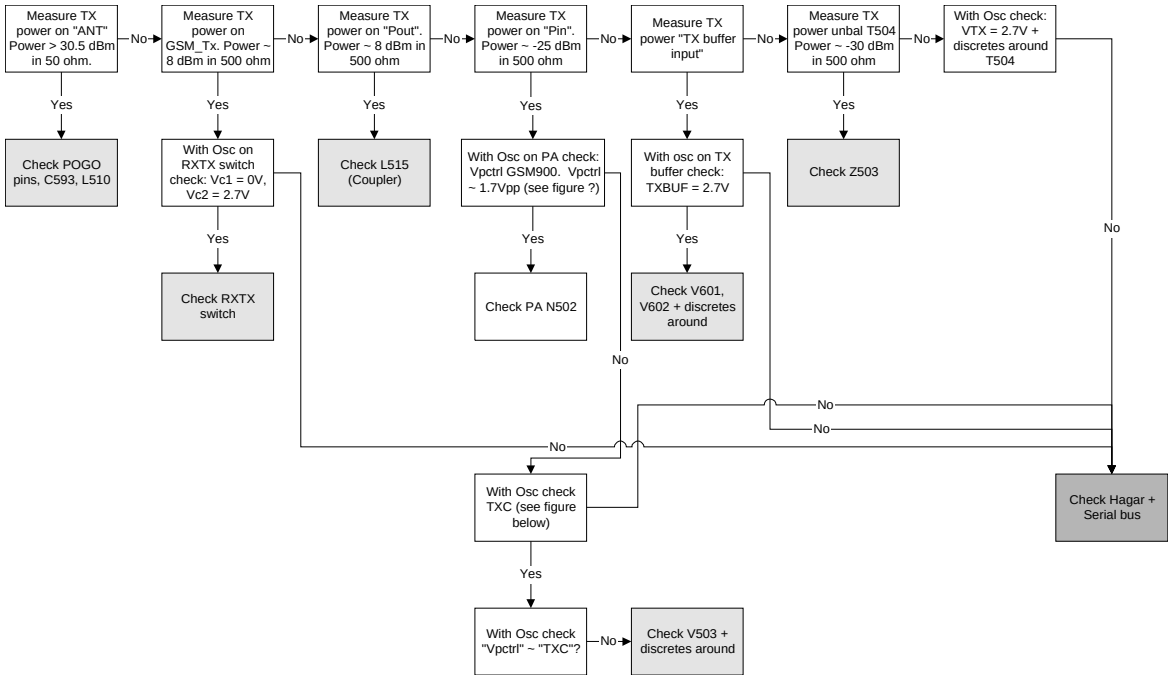
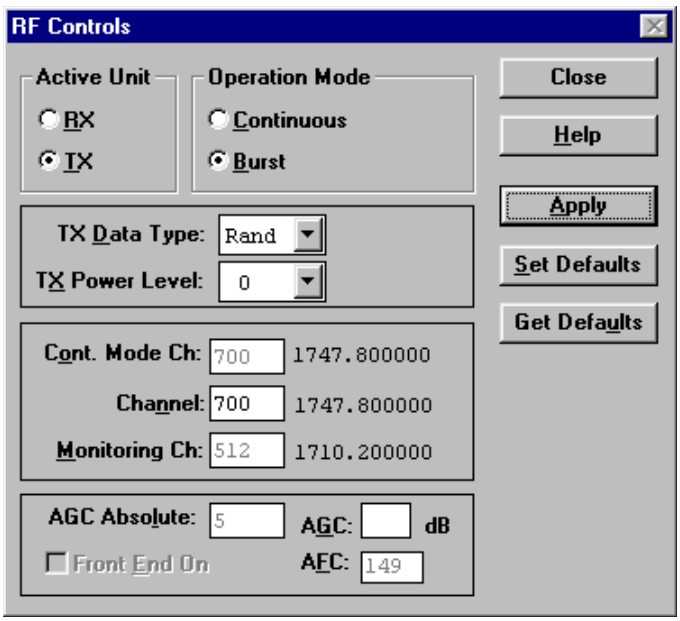
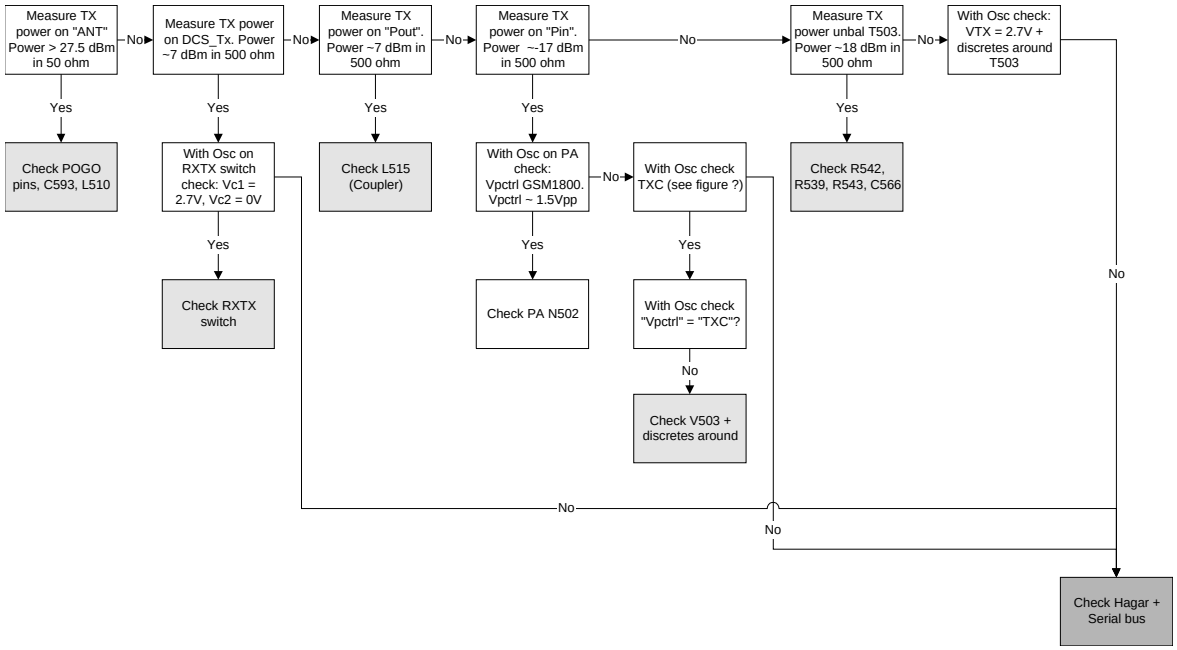


Figure 36: PCN TX RF control window



13. Troubleshooting chart for PCN transmitter

Figure 37: PCN TX troubleshooting

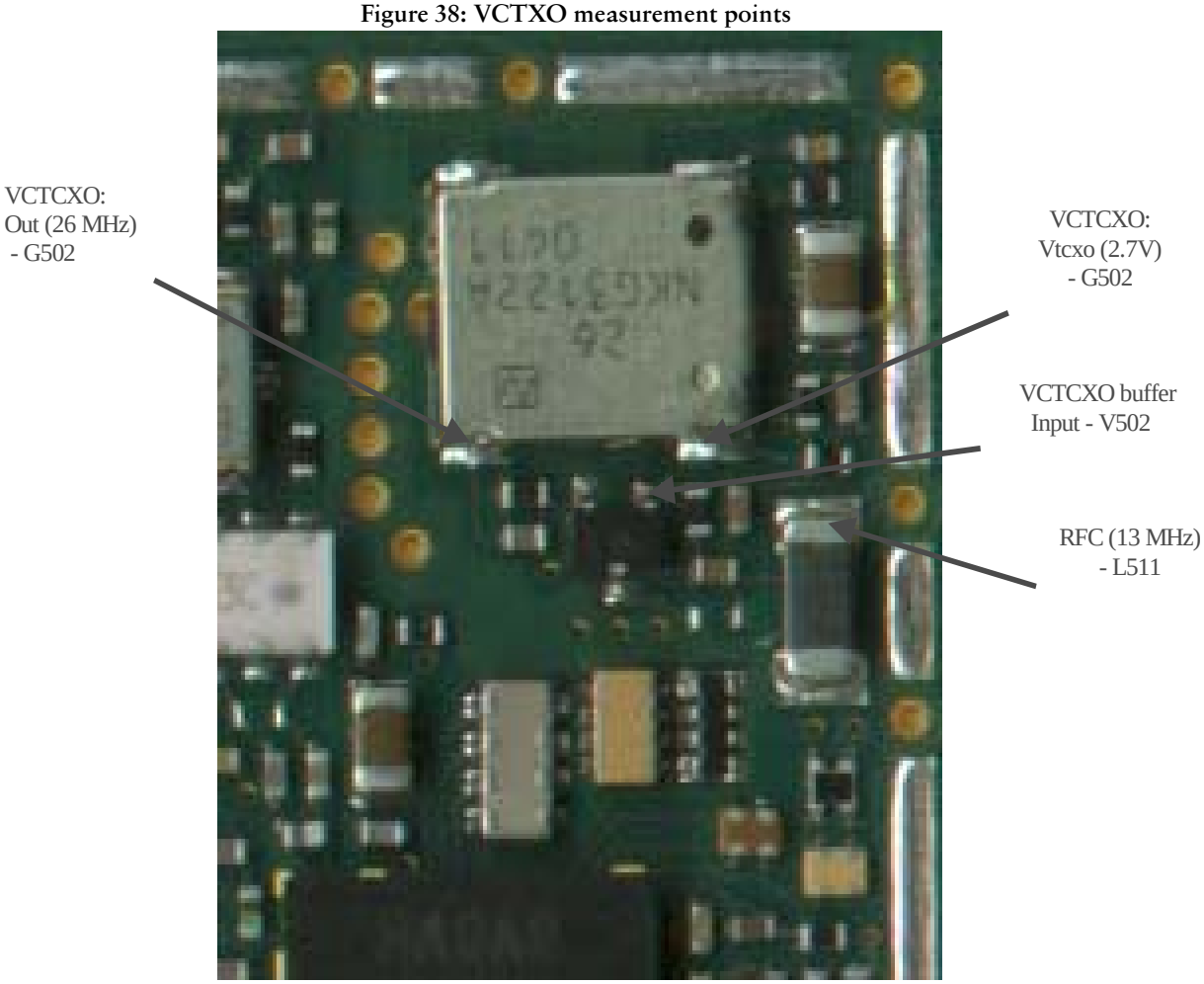


TXIQ signals look the same in PCN and GSM.

Synthesizer

There is only one PLL synthesizer generating frequencies for both Rx and Tx in both bands (PCN and GSM). VCO frequency is divided by 2 or by 4 in HAGAR depending on which band is active.

Figure 38: VCTXO measurement points



General instructions for Synthesizer troubleshooting

Start WinTesla-Service-Software and

Select: Product Alt+p

Band b

EGSM e

Select: Testing Alt+e

RF Controls r

RX ContinuousAlt+r

Cont. Mode Ch: 60Alt+o, 60

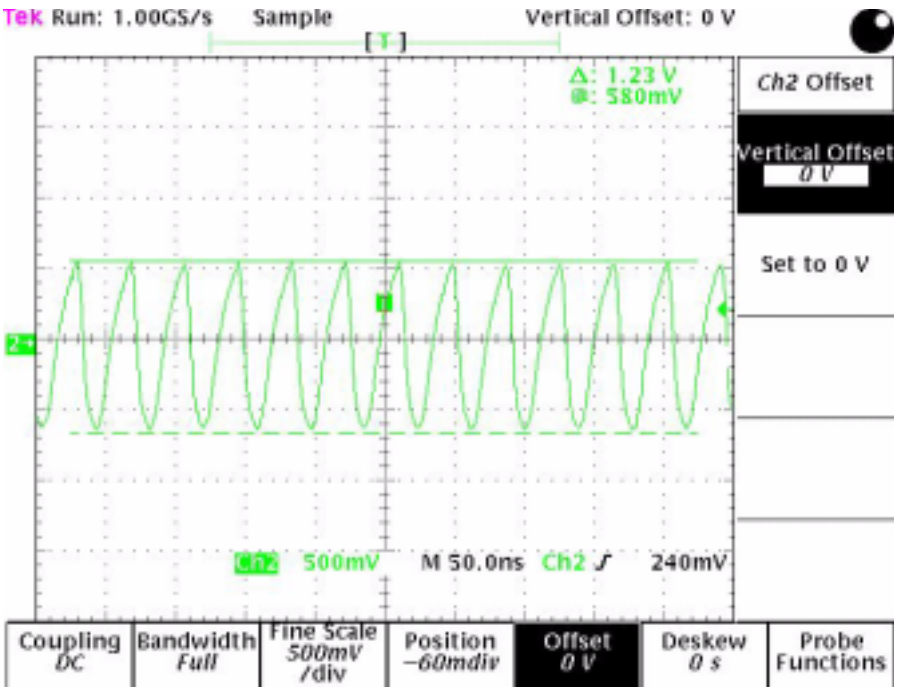
Measure the output of the VCO (G500) with spectrum analyzer and 500 ohm passive probe; the power should be around –20 dBm.

26 MHz reference oscillator (VCTCXO)

The 26 MHz oscillator (G502) is used as a reference frequency for the PLL synthesizer and as the system clock for BB (13 MHz) after it is divided by 2 in HAGAR. 26 MHz signal from the VCTCXO is approx. 0,8 Vpp. Frequency of this oscillator is adjusted by dc voltage (Vcon) coming from the DAC in COBBA. Range of Vcon is 0.3 – 2.3 V.

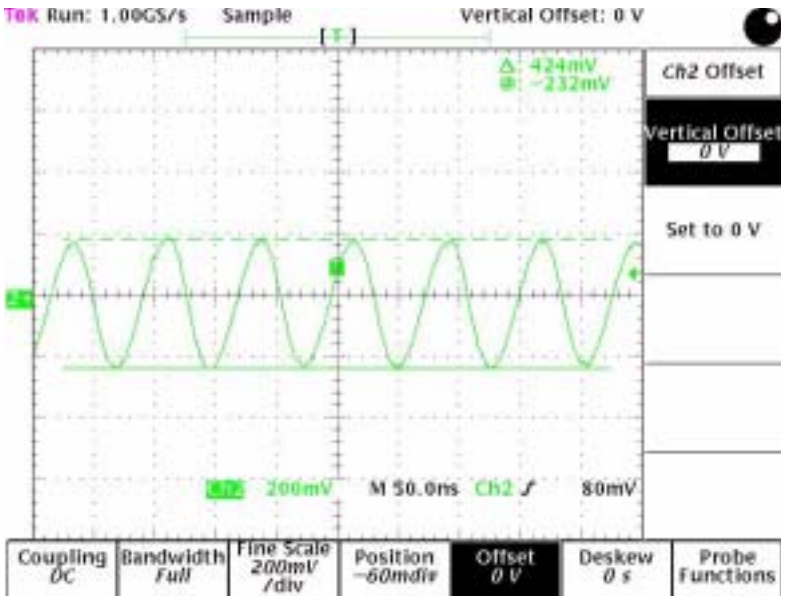
Measuring on the VCTCXO component

Figure 39: VCTCXO signal



Measuring on the VCTCXO buffer

Figure 40: VCTCXO buffer signal

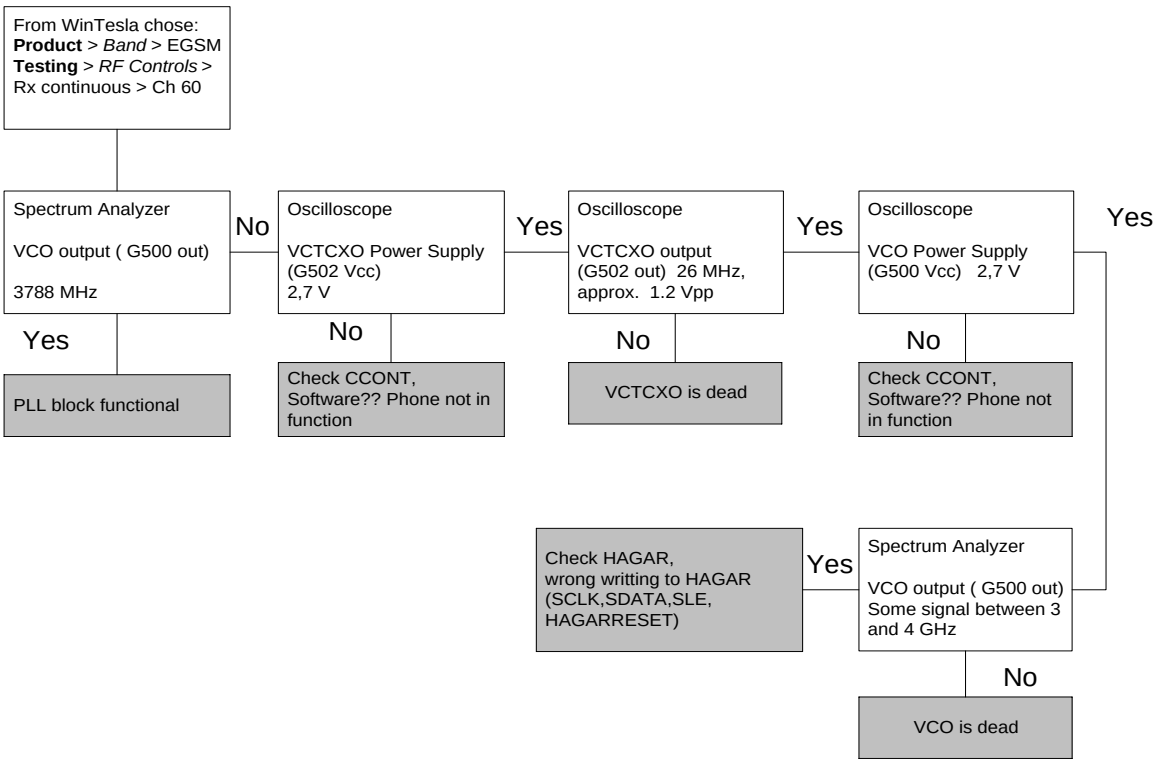


VCO

The VCO is generating frequencies in the range of 3420 – 3840 MHz when PLL is in function. These are divided by 2 or by 4 in HAGAR so that they can generate all channels in GSM and PCN. Frequency of the VCO is controlled by dc voltage (Vc) coming from the loop filter. Range of the Vc when PLL is in function is 0.7 – 3.8 V. Even if PLL is not in lock state (Vc out of range) there is some frequency at the output of the VCO (G500) which is between 3 and 4 GHz. This is of course true only if VCO is working and if VCO power supply is present (2.7V).

14. Troubleshooting chart for PLL Synthesizer

Figure 41: PLL synthesizer troubleshooting1

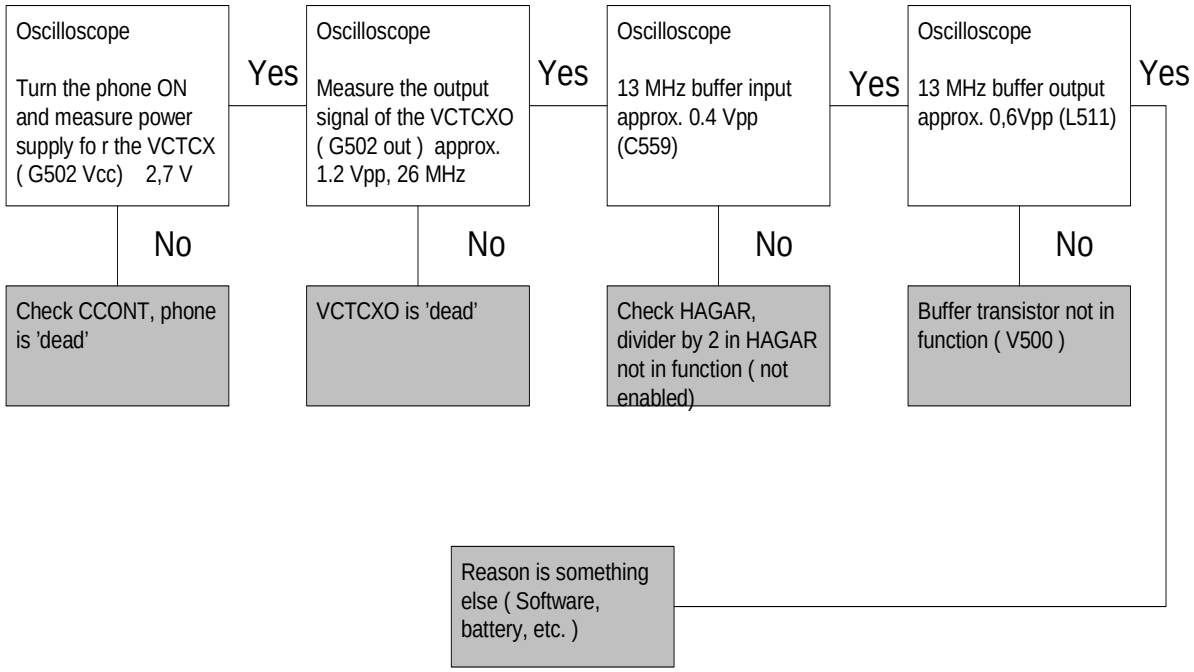


It is important to say that power supply for VCTCXO (VXO) is OFF only in 'Deep Sleep Mode' and power supply for VCO (G500 Vcc) is OFF in 'Sleep Mode'.

14.1 Dead phone troubleshooting

If the phone goes 'dead' very short time after the power is turned ON, possible reason for this might be that 13 MHz system clock signal is not coming to the BB. Use the following chart (Figure 42, "PLL synthesizer troubleshooting 2," on page 49) to locate the problem.

Figure 42: PLL synthesizer troubleshooting 2



Frequency lists

Table 3: PCN frequencies and corresponding VCO frequencies

CH	TX	vco	RX (TX+95)	VCO
512	1710.2	3420.4	1805.2	3610.4
513	1710.4	3420.8	1805.4	3610.8
514	1710.6	3421.2	1805.6	3611.2
515	1710.8	3421.6	1805.8	3611.6
516	1711.0	3422.0	1806.0	3612.0
517	1711.2	3422.4	1806.2	3612.4
518	1711.4	3422.8	1806.4	3612.8
519	1711.6	3423.2	1806.6	3613.2
520	1711.8	3423.6	1806.8	3613.6
521	1712.0	3424.0	1807.0	3614.0
522	1712.2	3424.4	1807.2	3614.4
523	1712.4	3424.8	1807.4	3614.8
524	1712.6	3425.2	1807.6	3615.2
525	1712.8	3425.6	1807.8	3615.6
526	1713.0	3426.0	1808.0	3616.0
527	1713.2	3426.4	1808.2	3616.4
528	1713.4	3426.8	1808.4	3616.8
529	1713.6	3427.2	1808.6	3617.2
530	1713.8	3427.6	1808.8	3617.6
531	1714.0	3428.0	1809.0	3618.0
532	1714.2	3428.4	1809.2	3618.4
533	1714.4	3428.8	1809.4	3618.8
534	1714.6	3429.2	1809.6	3619.2
535	1714.8	3429.6	1809.8	3619.6
536	1715.0	3430.0	1810.0	3620.0
537	1715.2	3430.4	1810.2	3620.4
538	1715.4	3430.8	1810.4	3620.8
539	1715.6	3431.2	1810.6	3621.2
540	1715.8	3431.6	1810.8	3621.6
541	1716.0	3432.0	1811.0	3622.0
542	1716.2	3432.4	1811.2	3622.4
543	1716.4	3432.8	1811.4	3622.8
544	1716.6	3433.2	1811.6	3623.2
545	1716.8	3433.6	1811.8	3623.6
546	1717.0	3434.0	1812.0	3624.0
547	1717.2	3434.4	1812.2	3624.4
548	1717.4	3434.8	1812.4	3624.8
549	1717.6	3435.2	1812.6	3625.2
550	1717.8	3435.6	1812.8	3625.6
551	1718.0	3436.0	1813.0	3626.0
552	1718.2	3436.4	1813.2	3626.4

553	1718.4	3436.8	1813.4	3626.8
554	1718.6	3437.2	1813.6	3627.2
555	1718.8	3437.6	1813.8	3627.6
556	1719.0	3438.0	1814.0	3628.0
557	1719.2	3438.4	1814.2	3628.4
558	1719.4	3438.8	1814.4	3628.8
559	1719.6	3439.2	1814.6	3629.2
560	1719.8	3439.6	1814.8	3629.6
561	1720.0	3440.0	1815.0	3630.0
562	1720.2	3440.4	1815.2	3630.4
563	1720.4	3440.8	1815.4	3630.8
564	1720.6	3441.2	1815.6	3631.2
565	1720.8	3441.6	1815.8	3631.6
566	1721.0	3442.0	1816.0	3632.0
567	1721.2	3442.4	1816.2	3632.4
568	1721.4	3442.8	1816.4	3632.8
569	1721.6	3443.2	1816.6	3633.2
570	1721.8	3443.6	1816.8	3633.6
571	1722.0	3444.0	1817.0	3634.0
572	1722.2	3444.4	1817.2	3634.4
573	1722.4	3444.8	1817.4	3634.8
574	1722.6	3445.2	1817.6	3635.2
575	1722.8	3445.6	1817.8	3635.6
576	1723.0	3446.0	1818.0	3636.0
577	1723.2	3446.4	1818.2	3636.4
578	1723.4	3446.8	1818.4	3636.8
579	1723.6	3447.2	1818.6	3637.2
580	1723.8	3447.6	1818.8	3637.6
581	1724.0	3448.0	1819.0	3638.0
582	1724.2	3448.4	1819.2	3638.4
583	1724.4	3448.8	1819.4	3638.8
584	1724.6	3449.2	1819.6	3639.2
585	1724.8	3449.6	1819.8	3639.6
586	1725.0	3450.0	1820.0	3640.0
587	1725.2	3450.4	1820.2	3640.4
588	1725.4	3450.8	1820.4	3640.8
589	1725.6	3451.2	1820.6	3641.2
590	1725.8	3451.6	1820.8	3641.6
591	1726.0	3452.0	1821.0	3642.0
592	1726.2	3452.4	1821.2	3642.4
593	1726.4	3452.8	1821.4	3642.8
594	1726.6	3453.2	1821.6	3643.2
595	1726.8	3453.6	1821.8	3643.6
596	1727.0	3454.0	1822.0	3644.0
597	1727.2	3454.4	1822.2	3644.4

598	1727.4	3454.8	1822.4	3644.8
599	1727.6	3455.2	1822.6	3645.2
600	1727.8	3455.6	1822.8	3645.6
601	1728.0	3456.0	1823.0	3646.0
602	1728.2	3456.4	1823.2	3646.4
603	1728.4	3456.8	1823.4	3646.8
604	1728.6	3457.2	1823.6	3647.2
605	1728.8	3457.6	1823.8	3647.6
606	1729.0	3458.0	1824.0	3648.0
607	1729.2	3458.4	1824.2	3648.4
608	1729.4	3458.8	1824.4	3648.8
609	1729.6	3459.2	1824.6	3649.2
610	1729.8	3459.6	1824.8	3649.6
611	1730.0	3460.0	1825.0	3650.0
612	1730.2	3460.4	1825.2	3650.4
613	1730.4	3460.8	1825.4	3650.8
614	1730.6	3461.2	1825.6	3651.2
615	1730.8	3461.6	1825.8	3651.6
616	1731.0	3462.0	1826.0	3652.0
617	1731.2	3462.4	1826.2	3652.4
618	1731.4	3462.8	1826.4	3652.8
619	1731.6	3463.2	1826.6	3653.2
620	1731.8	3463.6	1826.8	3653.6
621	1732.0	3464.0	1827.0	3654.0
622	1732.2	3464.4	1827.2	3654.4
623	1732.4	3464.8	1827.4	3654.8
624	1732.6	3465.2	1827.6	3655.2
625	1732.8	3465.6	1827.8	3655.6
626	1733.0	3466.0	1828.0	3656.0
627	1733.2	3466.4	1828.2	3656.4
628	1733.4	3466.8	1828.4	3656.8
629	1733.6	3467.2	1828.6	3657.2
630	1733.8	3467.6	1828.8	3657.6
631	1734.0	3468.0	1829.0	3658.0
632	1734.2	3468.4	1829.2	3658.4
633	1734.4	3468.8	1829.4	3658.8
634	1734.6	3469.2	1829.6	3659.2
635	1734.8	3469.6	1829.8	3659.6
636	1735.0	3470.0	1830.0	3660.0
637	1735.2	3470.4	1830.2	3660.4
638	1735.4	3470.8	1830.4	3660.8
639	1735.6	3471.2	1830.6	3661.2
640	1735.8	3471.6	1830.8	3661.6
641	1736.0	3472.0	1831.0	3662.0
642	1736.2	3472.4	1831.2	3662.4

643	1736.4	3472.8	1831.4	3662.8
644	1736.6	3473.2	1831.6	3663.2
645	1736.8	3473.6	1831.8	3663.6
646	1737.0	3474.0	1832.0	3664.0
647	1737.2	3474.4	1832.2	3664.4
648	1737.4	3474.8	1832.4	3664.8
649	1737.6	3475.2	1832.6	3665.2
650	1737.8	3475.6	1832.8	3665.6
651	1738.0	3476.0	1833.0	3666.0
652	1738.2	3476.4	1833.2	3666.4
653	1738.4	3476.8	1833.4	3666.8
654	1738.6	3477.2	1833.6	3667.2
655	1738.8	3477.6	1833.8	3667.6
656	1739.0	3478.0	1834.0	3668.0
657	1739.2	3478.4	1834.2	3668.4
658	1739.4	3478.8	1834.4	3668.8
659	1739.6	3479.2	1834.6	3669.2
660	1739.8	3479.6	1834.8	3669.6
661	1740.0	3480.0	1835.0	3670.0
662	1740.2	3480.4	1835.2	3670.4
663	1740.4	3480.8	1835.4	3670.8
664	1740.6	3481.2	1835.6	3671.2
665	1740.8	3481.6	1835.8	3671.6
666	1741.0	3482.0	1836.0	3672.0
667	1741.2	3482.4	1836.2	3672.4
668	1741.4	3482.8	1836.4	3672.8
669	1741.6	3483.2	1836.6	3673.2
670	1741.8	3483.6	1836.8	3673.6
671	1742.0	3484.0	1837.0	3674.0
672	1742.2	3484.4	1837.2	3674.4
673	1742.4	3484.8	1837.4	3674.8
674	1742.6	3485.2	1837.6	3675.2
675	1742.8	3485.6	1837.8	3675.6
676	1743.0	3486.0	1838.0	3676.0
677	1743.2	3486.4	1838.2	3676.4
678	1743.4	3486.8	1838.4	3676.8
679	1743.6	3487.2	1838.6	3677.2
680	1743.8	3487.6	1838.8	3677.6
681	1744.0	3488.0	1839.0	3678.0
682	1744.2	3488.4	1839.2	3678.4
683	1744.4	3488.8	1839.4	3678.8
684	1744.6	3489.2	1839.6	3679.2
685	1744.8	3489.6	1839.8	3679.6
686	1745.0	3490.0	1840.0	3680.0
687	1745.2	3490.4	1840.2	3680.4

688	1745.4	3490.8	1840.4	3680.8
689	1745.6	3491.2	1840.6	3681.2
690	1745.8	3491.6	1840.8	3681.6
691	1746.0	3492.0	1841.0	3682.0
692	1746.2	3492.4	1841.2	3682.4
693	1746.4	3492.8	1841.4	3682.8
694	1746.6	3493.2	1841.6	3683.2
695	1746.8	3493.6	1841.8	3683.6
696	1747.0	3494.0	1842.0	3684.0
697	1747.2	3494.4	1842.2	3684.4
698	1747.4	3494.8	1842.4	3684.8
699	1747.6	3495.2	1842.6	3685.2
700	1747.8	3495.6	1842.8	3685.6
701	1748.0	3496.0	1843.0	3686.0
702	1748.2	3496.4	1843.2	3686.4
703	1748.4	3496.8	1843.4	3686.8
704	1748.6	3497.2	1843.6	3687.2
705	1748.8	3497.6	1843.8	3687.6
706	1749.0	3498.0	1844.0	3688.0
707	1749.2	3498.4	1844.2	3688.4
708	1749.4	3498.8	1844.4	3688.8
709	1749.6	3499.2	1844.6	3689.2
710	1749.8	3499.6	1844.8	3689.6
711	1750.0	3500.0	1845.0	3690.0
712	1750.2	3500.4	1845.2	3690.4
713	1750.4	3500.8	1845.4	3690.8
714	1750.6	3501.2	1845.6	3691.2
715	1750.8	3501.6	1845.8	3691.6
716	1751.0	3502.0	1846.0	3692.0
717	1751.2	3502.4	1846.2	3692.4
718	1751.4	3502.8	1846.4	3692.8
719	1751.6	3503.2	1846.6	3693.2
720	1751.8	3503.6	1846.8	3693.6
721	1752.0	3504.0	1847.0	3694.0
722	1752.2	3504.4	1847.2	3694.4
723	1752.4	3504.8	1847.4	3694.8
724	1752.6	3505.2	1847.6	3695.2
725	1752.8	3505.6	1847.8	3695.6
726	1753.0	3506.0	1848.0	3696.0
727	1753.2	3506.4	1848.2	3696.4
728	1753.4	3506.8	1848.4	3696.8
729	1753.6	3507.2	1848.6	3697.2
730	1753.8	3507.6	1848.8	3697.6
731	1754.0	3508.0	1849.0	3698.0
732	1754.2	3508.4	1849.2	3698.4

733	1754.4	3508.8	1849.4	3698.8
734	1754.6	3509.2	1849.6	3699.2
735	1754.8	3509.6	1849.8	3699.6
736	1755.0	3510.0	1850.0	3700.0
737	1755.2	3510.4	1850.2	3700.4
738	1755.4	3510.8	1850.4	3700.8
739	1755.6	3511.2	1850.6	3701.2
740	1755.8	3511.6	1850.8	3701.6
741	1756.0	3512.0	1851.0	3702.0
742	1756.2	3512.4	1851.2	3702.4
743	1756.4	3512.8	1851.4	3702.8
744	1756.6	3513.2	1851.6	3703.2
745	1756.8	3513.6	1851.8	3703.6
746	1757.0	3514.0	1852.0	3704.0
747	1757.2	3514.4	1852.2	3704.4
748	1757.4	3514.8	1852.4	3704.8
749	1757.6	3515.2	1852.6	3705.2
750	1757.8	3515.6	1852.8	3705.6
751	1758.0	3516.0	1853.0	3706.0
752	1758.2	3516.4	1853.2	3706.4
753	1758.4	3516.8	1853.4	3706.8
754	1758.6	3517.2	1853.6	3707.2
755	1758.8	3517.6	1853.8	3707.6
756	1759.0	3518.0	1854.0	3708.0
757	1759.2	3518.4	1854.2	3708.4
758	1759.4	3518.8	1854.4	3708.8
759	1759.6	3519.2	1854.6	3709.2
760	1759.8	3519.6	1854.8	3709.6
761	1760.0	3520.0	1855.0	3710.0
762	1760.2	3520.4	1855.2	3710.4
763	1760.4	3520.8	1855.4	3710.8
764	1760.6	3521.2	1855.6	3711.2
765	1760.8	3521.6	1855.8	3711.6
766	1761.0	3522.0	1856.0	3712.0
767	1761.2	3522.4	1856.2	3712.4
768	1761.4	3522.8	1856.4	3712.8
769	1761.6	3523.2	1856.6	3713.2
770	1761.8	3523.6	1856.8	3713.6
771	1762.0	3524.0	1857.0	3714.0
772	1762.2	3524.4	1857.2	3714.4
773	1762.4	3524.8	1857.4	3714.8
774	1762.6	3525.2	1857.6	3715.2
775	1762.8	3525.6	1857.8	3715.6
776	1763.0	3526.0	1858.0	3716.0
777	1763.2	3526.4	1858.2	3716.4

778	1763.4	3526.8	1858.4	3716.8
779	1763.6	3527.2	1858.6	3717.2
780	1763.8	3527.6	1858.8	3717.6
781	1764.0	3528.0	1859.0	3718.0
782	1764.2	3528.4	1859.2	3718.4
783	1764.4	3528.8	1859.4	3718.8
784	1764.6	3529.2	1859.6	3719.2
785	1764.8	3529.6	1859.8	3719.6
786	1765.0	3530.0	1860.0	3720.0
787	1765.2	3530.4	1860.2	3720.4
788	1765.4	3530.8	1860.4	3720.8
789	1765.6	3531.2	1860.6	3721.2
790	1765.8	3531.6	1860.8	3721.6
791	1766.0	3532.0	1861.0	3722.0
792	1766.2	3532.4	1861.2	3722.4
793	1766.4	3532.8	1861.4	3722.8
794	1766.6	3533.2	1861.6	3723.2
795	1766.8	3533.6	1861.8	3723.6
796	1767.0	3534.0	1862.0	3724.0
797	1767.2	3534.4	1862.2	3724.4
798	1767.4	3534.8	1862.4	3724.8
799	1767.6	3535.2	1862.6	3725.2
800	1767.8	3535.6	1862.8	3725.6
801	1768.0	3536.0	1863.0	3726.0
802	1768.2	3536.4	1863.2	3726.4
803	1768.4	3536.8	1863.4	3726.8
804	1768.6	3537.2	1863.6	3727.2
805	1768.8	3537.6	1863.8	3727.6
806	1769.0	3538.0	1864.0	3728.0
807	1769.2	3538.4	1864.2	3728.4
808	1769.4	3538.8	1864.4	3728.8
809	1769.6	3539.2	1864.6	3729.2
810	1769.8	3539.6	1864.8	3729.6
811	1770.0	3540.0	1865.0	3730.0
812	1770.2	3540.4	1865.2	3730.4
813	1770.4	3540.8	1865.4	3730.8
814	1770.6	3541.2	1865.6	3731.2
815	1770.8	3541.6	1865.8	3731.6
816	1771.0	3542.0	1866.0	3732.0
817	1771.2	3542.4	1866.2	3732.4
818	1771.4	3542.8	1866.4	3732.8
819	1771.6	3543.2	1866.6	3733.2
820	1771.8	3543.6	1866.8	3733.6
821	1772.0	3544.0	1867.0	3734.0
822	1772.2	3544.4	1867.2	3734.4

823	1772.4	3544.8	1867.4	3734.8
824	1772.6	3545.2	1867.6	3735.2
825	1772.8	3545.6	1867.8	3735.6
826	1773.0	3546.0	1868.0	3736.0
827	1773.2	3546.4	1868.2	3736.4
828	1773.4	3546.8	1868.4	3736.8
829	1773.6	3547.2	1868.6	3737.2
830	1773.8	3547.6	1868.8	3737.6
831	1774.0	3548.0	1869.0	3738.0
832	1774.2	3548.4	1869.2	3738.4
833	1774.4	3548.8	1869.4	3738.8
834	1774.6	3549.2	1869.6	3739.2
835	1774.8	3549.6	1869.8	3739.6
836	1775.0	3550.0	1870.0	3740.0
837	1775.2	3550.4	1870.2	3740.4
838	1775.4	3550.8	1870.4	3740.8
839	1775.6	3551.2	1870.6	3741.2
840	1775.8	3551.6	1870.8	3741.6
841	1776.0	3552.0	1871.0	3742.0
842	1776.2	3552.4	1871.2	3742.4
843	1776.4	3552.8	1871.4	3742.8
844	1776.6	3553.2	1871.6	3743.2
845	1776.8	3553.6	1871.8	3743.6
846	1777.0	3554.0	1872.0	3744.0
847	1777.2	3554.4	1872.2	3744.4
848	1777.4	3554.8	1872.4	3744.8
849	1777.6	3555.2	1872.6	3745.2
850	1777.8	3555.6	1872.8	3745.6
851	1778.0	3556.0	1873.0	3746.0
852	1778.2	3556.4	1873.2	3746.4
853	1778.4	3556.8	1873.4	3746.8
854	1778.6	3557.2	1873.6	3747.2
855	1778.8	3557.6	1873.8	3747.6
856	1779.0	3558.0	1874.0	3748.0
857	1779.2	3558.4	1874.2	3748.4
858	1779.4	3558.8	1874.4	3748.8
859	1779.6	3559.2	1874.6	3749.2
860	1779.8	3559.6	1874.8	3749.6
861	1780.0	3560.0	1875.0	3750.0
862	1780.2	3560.4	1875.2	3750.4
863	1780.4	3560.8	1875.4	3750.8
864	1780.6	3561.2	1875.6	3751.2
865	1780.8	3561.6	1875.8	3751.6
866	1781.0	3562.0	1876.0	3752.0
867	1781.2	3562.4	1876.2	3752.4

868	1781.4	3562.8	1876.4	3752.8
869	1781.6	3563.2	1876.6	3753.2
870	1781.8	3563.6	1876.8	3753.6
871	1782.0	3564.0	1877.0	3754.0
872	1782.2	3564.4	1877.2	3754.4
873	1782.4	3564.8	1877.4	3754.8
874	1782.6	3565.2	1877.6	3755.2
875	1782.8	3565.6	1877.8	3755.6
876	1783.0	3566.0	1878.0	3756.0
877	1783.2	3566.4	1878.2	3756.4
878	1783.4	3566.8	1878.4	3756.8
879	1783.6	3567.2	1878.6	3757.2
880	1783.8	3567.6	1878.8	3757.6
881	1784.0	3568.0	1879.0	3758.0
882	1784.2	3568.4	1879.2	3758.4
883	1784.4	3568.8	1879.4	3758.8
884	1784.6	3569.2	1879.6	3759.2
885	1784.8	3569.6	1879.8	3759.6

Table 4: GSM frequencies and corresponding VCO frequencies

CH	TX	vco	RX (TX+95)	VCO
975	880.2	3520.8	925.2	3700.8
976	880.4	3521.6	925.4	3701.6
977	880.6	3522.4	925.6	3702.4
978	880.8	3523.2	925.8	3703.2
979	881.0	3524.0	926.0	3704.0
980	881.2	3524.8	926.2	3704.8
981	881.4	3525.6	926.4	3705.6
982	881.6	3526.4	926.6	3706.4
983	881.8	3527.2	926.8	3707.2
984	882.0	3528.0	927.0	3708.0
985	882.2	3528.8	927.2	3708.8
986	882.4	3529.6	927.4	3709.6
987	882.6	3530.4	927.6	3710.4
988	882.8	3531.2	927.8	3711.2
989	883.0	3532.0	928.0	3712.0
990	883.2	3532.8	928.2	3712.8
991	883.4	3533.6	928.4	3713.6
992	883.6	3534.4	928.6	3714.4
993	883.8	3535.2	928.8	3715.2
994	884.0	3536.0	929.0	3716.0
995	884.2	3536.8	929.2	3716.8
996	884.4	3537.6	929.4	3717.6

997	884.6	3538.4	929.6	3718.4
998	884.8	3539.2	929.8	3719.2
999	885.0	3540.0	930.0	3720.0
1000	885.2	3540.8	930.2	3720.8
1001	885.4	3541.6	930.4	3721.6
1002	885.6	3542.4	930.6	3722.4
1003	885.8	3543.2	930.8	3723.2
1004	886.0	3544.0	931.0	3724.0
1005	886.2	3544.8	931.2	3724.8
1006	886.4	3545.6	931.4	3725.6
1007	886.6	3546.4	931.6	3726.4
1008	886.8	3547.2	931.8	3727.2
1009	887.0	3548.0	932.0	3728.0
1010	887.2	3548.8	932.2	3728.8
1011	887.4	3549.6	932.4	3729.6
1012	887.6	3550.4	932.6	3730.4
1013	887.8	3551.2	932.8	3731.2
1014	888.0	3552.0	933.0	3732.0
1015	888.2	3552.8	933.2	3732.8
1016	888.4	3553.6	933.4	3733.6
1017	888.6	3554.4	933.6	3734.4
1018	888.8	3555.2	933.8	3735.2
1019	889.0	3556.0	934.0	3736.0
1020	889.2	3556.8	934.2	3736.8
1021	889.4	3557.6	934.4	3737.6
1022	889.6	3558.4	934.6	3738.4
1023	889.8	3559.2	934.8	3739.2
0	890.0	3560.0	935.0	3740.0
1	890.2	3560.8	935.2	3740.8
2	890.4	3561.6	935.4	3741.6
3	890.6	3562.4	935.6	3742.4
4	890.8	3563.2	935.8	3743.2
5	891.0	3564.0	936.0	3744.0
6	891.2	3564.8	936.2	3744.8
7	891.4	3565.6	936.4	3745.6
8	891.6	3566.4	936.6	3746.4
9	891.8	3567.2	936.8	3747.2
10	892.0	3568.0	937.0	3748.0
11	892.2	3568.8	937.2	3748.8
12	892.4	3569.6	937.4	3749.6
13	892.6	3570.4	937.6	3750.4
14	892.8	3571.2	937.8	3751.2
15	893.0	3572.0	938.0	3752.0
16	893.2	3572.8	938.2	3752.8
17	893.4	3573.6	938.4	3753.6

18	893.6	3574.4	938.6	3754.4
19	893.8	3575.2	938.8	3755.2
20	894.0	3576.0	939.0	3756.0
21	894.2	3576.8	939.2	3756.8
22	894.4	3577.6	939.4	3757.6
23	894.6	3578.4	939.6	3758.4
24	894.8	3579.2	939.8	3759.2
25	895.0	3580.0	940.0	3760.0
26	895.2	3580.8	940.2	3760.8
27	895.4	3581.6	940.4	3761.6
28	895.6	3582.4	940.6	3762.4
29	895.8	3583.2	940.8	3763.2
30	896.0	3584.0	941.0	3764.0
31	896.2	3584.8	941.2	3764.8
32	896.4	3585.6	941.4	3765.6
33	896.6	3586.4	941.6	3766.4
34	896.8	3587.2	941.8	3767.2
35	897.0	3588.0	942.0	3768.0
36	897.2	3588.8	942.2	3768.8
37	897.4	3589.6	942.4	3769.6
38	897.6	3590.4	942.6	3770.4
39	897.8	3591.2	942.8	3771.2
40	898.0	3592.0	943.0	3772.0
41	898.2	3592.8	943.2	3772.8
42	898.4	3593.6	943.4	3773.6
43	898.6	3594.4	943.6	3774.4
44	898.8	3595.2	943.8	3775.2
45	899.0	3596.0	944.0	3776.0
46	899.2	3596.8	944.2	3776.8
47	899.4	3597.6	944.4	3777.6
48	899.6	3598.4	944.6	3778.4
49	899.8	3599.2	944.8	3779.2
50	900.0	3600.0	945.0	3780.0
51	900.2	3600.8	945.2	3780.8
52	900.4	3601.6	945.4	3781.6
53	900.6	3602.4	945.6	3782.4
54	900.8	3603.2	945.8	3783.2
55	901.0	3604.0	946.0	3784.0
56	901.2	3604.8	946.2	3784.8
57	901.4	3605.6	946.4	3785.6
58	901.6	3606.4	946.6	3786.4
59	901.8	3607.2	946.8	3787.2
60	902.0	3608.0	947.0	3788.0
61	902.2	3608.8	947.2	3788.8
62	902.4	3609.6	947.4	3789.6

63	902.6	3610.4	947.6	3790.4
64	902.8	3611.2	947.8	3791.2
65	903.0	3612.0	948.0	3792.0
66	903.2	3612.8	948.2	3792.8
67	903.4	3613.6	948.4	3793.6
68	903.6	3614.4	948.6	3794.4
69	903.8	3615.2	948.8	3795.2
70	904.0	3616.0	949.0	3796.0
71	904.2	3616.8	949.2	3796.8
72	904.4	3617.6	949.4	3797.6
73	904.6	3618.4	949.6	3798.4
74	904.8	3619.2	949.8	3799.2
75	905.0	3620.0	950.0	3800.0
76	905.2	3620.8	950.2	3800.8
77	905.4	3621.6	950.4	3801.6
78	905.6	3622.4	950.6	3802.4
79	905.8	3623.2	950.8	3803.2
80	906.0	3624.0	951.0	3804.0
81	906.2	3624.8	951.2	3804.8
82	906.4	3625.6	951.4	3805.6
83	906.6	3626.4	951.6	3806.4
84	906.8	3627.2	951.8	3807.2
85	907.0	3628.0	952.0	3808.0
86	907.2	3628.8	952.2	3808.8
87	907.4	3629.6	952.4	3809.6
88	907.6	3630.4	952.6	3810.4
89	907.8	3631.2	952.8	3811.2
90	908.0	3632.0	953.0	3812.0
91	908.2	3632.8	953.2	3812.8
92	908.4	3633.6	953.4	3813.6
93	908.6	3634.4	953.6	3814.4
94	908.8	3635.2	953.8	3815.2
95	909.0	3636.0	954.0	3816.0
96	909.2	3636.8	954.2	3816.8
97	909.4	3637.6	954.4	3817.6
98	909.6	3638.4	954.6	3818.4
99	909.8	3639.2	954.8	3819.2
100	910.0	3640.0	955.0	3820.0
101	910.2	3640.8	955.2	3820.8
102	910.4	3641.6	955.4	3821.6
103	910.6	3642.4	955.6	3822.4
104	910.8	3643.2	955.8	3823.2
105	911.0	3644.0	956.0	3824.0
106	911.2	3644.8	956.2	3824.8
107	911.4	3645.6	956.4	3825.6

108	911.6	3646.4	956.6	3826.4
109	911.8	3647.2	956.8	3827.2
110	912.0	3648.0	957.0	3828.0
111	912.2	3648.8	957.2	3828.8
112	912.4	3649.6	957.4	3829.6
113	912.6	3650.4	957.6	3830.4
114	912.8	3651.2	957.8	3831.2
115	913.0	3652.0	958.0	3832.0
116	913.2	3652.8	958.2	3832.8
117	913.4	3653.6	958.4	3833.6
118	913.6	3654.4	958.6	3834.4
119	913.8	3655.2	958.8	3835.2
120	914.0	3656.0	959.0	3836.0
121	914.2	3656.8	959.2	3836.8
122	914.4	3657.6	959.4	3837.6
123	914.6	3658.4	959.6	3838.4
124	914.8	3659.2	959.8	3839.2

Hagar and serial interface

In general, if a phone is not in a sleep mode, Hagar IC is always active.

This means that as long as we have set the phone in Normal mode or in Local mode (either RX or TX band) there is going to be some Hagar activities, which is controled through serial interface (SDATA,SCLK,SENA and HAGAR_RESET_X).

Pictures below show these four signals, measured on R301 (both SCLK and SENA) , on R300 (SDATA) and C540 (HAGAR_RESET_X). R301 and R300 are placed in BB part.

Figure 43: SCLK clock signal

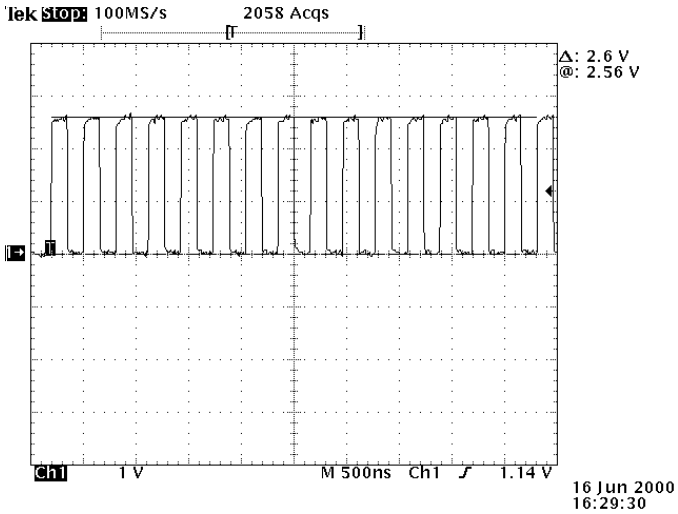


Figure 44: SENA enable signal

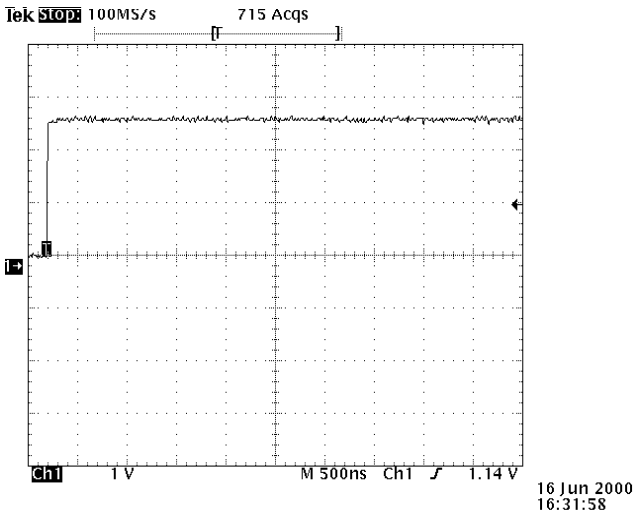


Figure 45: SDATA data signal

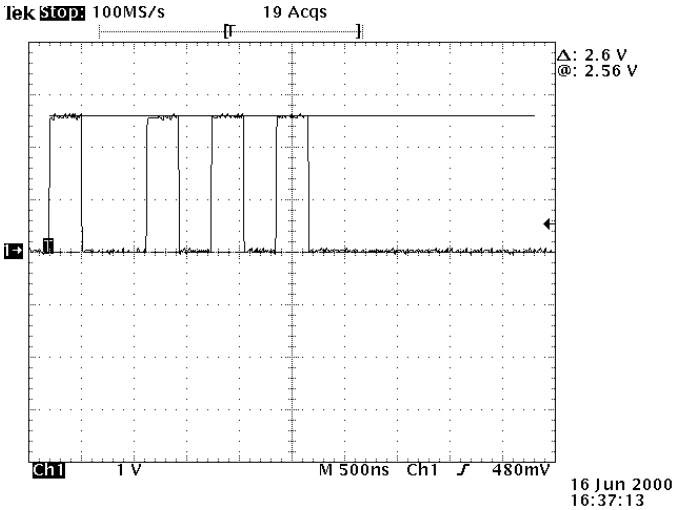
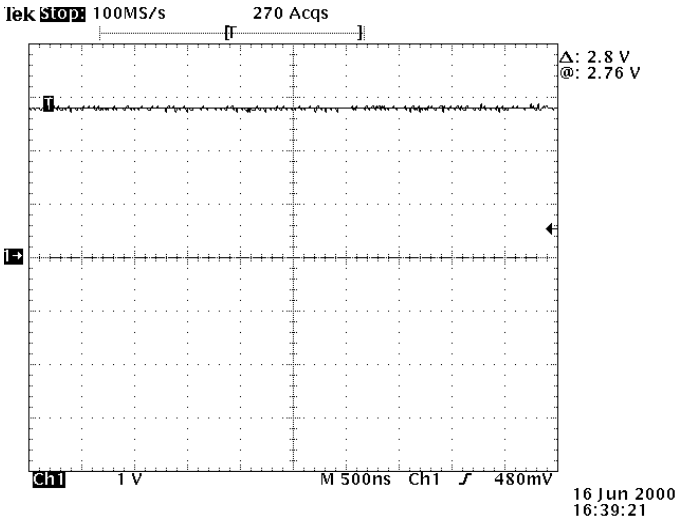


Figure 46: HAGAR _RESET_X hagar reset “on”



First precondition for Hagar to be in active (ON) mode is that HAGAR_RESET_X should be high (2.8V) and VREF, which is Hagar reference voltage, at 1.35V.

Easiest way to check these two voltages is by using oscilloscope with an standard passive probe (10kΩ/8pF). HAGAR_RESET_X is measured on C540 and VREF on C536.

Another " good spot" to check if Hagar's internal supplies are active, is to measure either on capacitor C538 or resistor R511. R511 is Hagar connection for a external resistor in order to create inernal bias currents. This volage should be excactly the same value as VREF on C536.

Next step towards examination of the the Hagar functionality can be based on verification of some important bias voltages and bias controls. Those signal coming from Hagar and they are used for controling the LNA's biasing(both 900/1800MHz), LNA power supply and TX power detector .

As a reference, here is a list of some typical test points for both Rx and Tx mode:

Table 5: List of test points

Frequency Band	RX	TX
EGSM	900 LNA bias control - L506 (pulses with ≈2.34V) 900 LNA power supply control – R514(pulses with ≈2.75V)	supply for the 900 PA buffer – R606 (pulses with ≈2.34V) bias voltage for power detector – C573 ("high" 2.8V)
PCN	1800 LNA bias control – R502 (pulses with ≈2.34V) 1800 LNA power supply control – R513(pulses with ≈2.75V)	bias voltage for power detector – C573 ("high" 2.8V)

UI Module Troubleshooting

This section is a guide to troubleshooting defective UI boards, using the Repair Jig available from AMS and various equipment suggested in Table 6, "List of equipment," on page 66.

Table 6: List of equipment

S/N	Hardware	Model	Description
1	Repair Jig	AMS	0770382
2	DC Power Supply	GPC-3030DQ	GW INSTEK Dual Tracking with 5V Fixed
3	Digital Oscilloscope	TDS3052	Tektronix
4	Digital Multimeter	Fluke 45 Dual Display Multimeter	Fluke (With Frequency Counter)

Tests and advice proposed in this document addresses to the probable failures in the MU4 UI module only. It is assumed that a good functional CMT module MA4 is available. Further it is assumed that the display module is mounted on the UI module and control is done through keypress on the UI module.

Troubleshooting method

Before dismantling the phone, perform quick functional and display check. These simple checks will help to identify the following fault area:

- Display Module
- LCD/Keyboard Backlight
- Keyboard/Hotkeys function
- Music Player
- FMR Player
- Line-In Recording
- FMR Recording
- Phone Audio Routing
- USB Connectivity for Upload/Download

Note: It is assumed that the signals from CMT are valid and good. This means that the

service center will have to ensure a good CMT to counter check against the UI module.

Display Module

The LCD display is controlled by the CMT via the 36-pin B2B connector.

Diagnostic Tests:

- Replace a good display module and verify.
- Visual inspection of the 36-pin B2B connector.

LCD/Keyboard Backlight

LCD and keyboard backlight is available whenever a key is pressed. Both signals are control by the CMT directly.

LCD Backlight

LCD backlight consists of D301, D302, D303, and D304.

Diagnostic Tests:

- Check VBAT with DVM
- Replace failed LED
- Visual inspection of the 36-pin B2B connector.

Keyboard Backlight

Keyboard backlight consists of D305, D306, D307, and D308.

Diagnostic Tests:

- Check VBAT with DVM
- Replace failed LED
- Visual inspection of the 36-pin B2B connector.

Keyboard/Hotkeys Functions

All the keys including the four hot keys are controlled by the MCU. The following failures may disable fully or partially keyboard functions.

Diagnostic Tests:

- Check that the dome sheet is properly aligned with the keypads.
- Ensure that there are no foreign particles on the keypads
- Check side keys SW753, SW754, SW755, and SW756. Ensure they are intact.
- Check presence of VBAT, VBB and UC_VCC @ U501 (Table 7, “UI module

voltages," on page 73)

- Check pull-down resistors R701, R703, R704, R705, and network resistor R702.
- Check presence of clock frequency 32.768kHz @ U301-Pin9 using oscilloscope (Figure 47, "MCU Clock Waveform – 32.768kHz," on page 74).
- Check PURX @U301-Pin58 = 2.8V

Music Player Function

These main devices are to be in good condition for the music player to function properly:

- U301 MCU
- U101 DSP
- U201 NAND Memory
- U601 Audio Codec

It is assume the user has a valid music file in the NAND memory.

Diagnostic Tests:

- Check the stereo headset has proper contact with the UI module.
- Check present of VBAT, VBB and UC_VCC, DVCC, AVCC, CVCC (Appendix A Table 2)
- Check operating current during play mode (Table 8, "UI current consumption in normal conditons," on page 73).
- Check present of clock frequency 32.768kHz @ U301-Pin9 using oscilloscope (Figure 47, "MCU Clock Waveform – 32.768kHz," on page 74).
- Check present of clock frequency 11.9952MHz @ U101-Pin97 and U601-Pin25 (Figure 48, "DSP Clock Waveform – 11.9952MHz," on page 75).
- Connect Stereo headset and check signal line ST_DET @ U301-Pin20 (Figure 9, "Accessories connection indication," on page 73)
- Check for digital activities @ U601-Pin4 using oscilloscope. This check will verify that the DSP are sending music information to the Codec.
- Check for analog activities @ U601-Pin9 and U601-Pin10 using oscilloscope. This check will verify that the Codec decode the digital music information correctly.

Line-In Recording Function

Line-In recording allows the user to record external music. These main devices are to be

in good condition for the music player to function properly:

- U301 MCU
- U101 DSP
- U201 NAND Memory
- U601 Audio Codec
- U602 Audio Routing Select

Diagnostic Tests:

- Check the Line-In jack has proper contact with the UI module.
- Check presence of VBAT, VBB and UC_VCC, DVCC, AVCC, CVCC (Table 7, “UI module voltages,” on page 73)
- Check operating current during recording mode (Table 8, “UI current consumption in normal conditons,” on page 73).
- Check presence of clock frequency 32.768kHz @ U301-Pin9 using oscilloscope (Figure 47, “MCU Clock Waveform – 32.768kHz,” on page 74).
- Check presence of clock frequency 11.9952MHz @ U101-Pin97 and U601-Pin25 (Figure 48, “DSP Clock Waveform – 11.9952MHz,” on page 75).
- Connect Line-In jack and check signal line LIN_DET @ U301-Pin21 (Table 9, “Accessories connection indication,” on page 73)
- Check the Audio Routing Select, U602-Pin10 and U602-Pin9 are routed corrected (Table 10, “Audio routing select,” on page 73).
- Check for analog activities @ U601-Pin19 and U601-Pin20 using oscilloscope. This check will verify that the music is successfully routed to the Codec.
- Check for digital activities @ U601-Pin6 using oscilloscope. This check will verify that the Codec are sending digitized music information to the DSP.
- Verify recorded music file in the NAND using NAM.

FMR Function

These main devices are to be in good condition for the music player to function properly:

- U301 MCU
- U101 DSP
- U201 NAND Memory
- U601 Audio Codec

- U801 FMR

It is important that a service personnel has a list of valid "live" FM channel for listening verification. These diagnostic steps do not require any signal generator.

Diagnostic Tests:

- Check the stereo headset has proper contact with the UI module since the stereo headset is used as antenna to FM signal
- Check Music Player function. This will ensure the MCU, DSP, NAND, and Audio Codec are functioning.
- Check presence of VBAT, and FM_VCC (Figure 47, "MCU Clock Waveform – 32.768kHz," on page 74).
- Check operating current during recording mode (Table 7, "UI module voltages," on page 73).
- Connect Stereo headset and check signal line ST_DET @ U301-Pin20 (Table 8, "UI current consumption in normal conditons," on page 73)
- Check the presence of 75kHz @ U801-Pin27 (Figure 49, "FMR Clock Waveform – 75kHz," on page 76).
- Tune the FM to 87.5MHz and 108MHz using the Manual Tuning Menu. Check the voltage at C815 and the reading should be 0.9V and 2V respectively.
- Check the 3-wire bus FM_WREN (U801-Pin31), FMR_DATA (U801-Pin30) and FMR_CLK (U801-Pin29) lines using oscilloscope. Check for activities when tuning is in progress.
- Check for analog audio activities @ C808 and C809 using oscilloscope. This check will verify that the modulated "live" FM signal is successfully demodulated by U801.
- Check the Audio Routing Select, U602-Pin10 and U602-Pin9 are routed corrected (Table 10, "Audio routing select," on page 73).
- Check for analog activities @ U601-Pin19 and U601-Pin20 using oscilloscope. This check will verify that the FM music is successfully routed to the Codec.
- Check for analog activities @ U601-Pin9 and U601-Pin10 using oscilloscope. This check will verify that the FM music has successfully by-pass the Codec.

FMR Recording Function

NPM-5 is capable of recording from "live" FM station. These main devices are to be in good condition for the music player to function properly:

- U301 MCU
- U101 DSP

- U201 NAND Memory
- U601 Audio Codec
- U602 Audio Routing Select
- U801 FMR

It is important that a service personnel has a list of valid "live" FM channel for listening verification. These diagnostic steps do not require any signal generator.

Diagnostic Tests:

- Perform test on page 68 – Line-In Recording Function to verify the recording path is good.
- Perform test on Chapter on "FMR Function" – FMR Function to verify the FMR path is good.
- Check operating current during recording mode (Table 8, "UI current consumption in normal conditons," on page 73).
- Check the Audio Routing Select, U602-Pin10 and U602-Pin9 are routed corrected (Table 10, "Audio routing select," on page 73).
- Verify recorded music file in the NAND using NAM.

Phone Audio Routing Function

Phone audio is available in UI either as on-board (earpiece) or as external (via stereo headset).

For on-board phone audio, ensure the earpiece on the display module has proper contact to the UI pads.

For external phone audio,

Diagnostic Tests:

- Check the stereo headset has proper contact with the UI module.
- Connect Stereo headset and check signal line ST_DET @ U301-Pin20 (Table 9, "Accessories connection indication," on page 73)
- Connect HDC-5 and check signal line HDC5_INT @ U301-Pin23 (Table 9, "Accessories connection indication," on page 73)
- Check the Audio Routing Select, U602-Pin10 and U602-Pin9 are routed corrected (Table 9, "Accessories connection indication," on page 73).
- Check for analog signal activities at both sides of C641 and C642.

USB Connectivity Function

For this section, it is assumed the service center has a PC and special version of NAM suitable for multiple NPM-5 connection.

These main devices are to be in good condition for the music player to function properly:

- U301 MCU
- U101 DSP
- U201 NAND Memory
- U401 USB

Diagnostic Tests:

- Check presence of VBAT, VBB and UC_VCC, DVCC, AVCC, CVCC, USB_VCC (Table 7, “UI module voltages,” on page 73)
- Check operating current during USB mode (Table 8, “UI current consumption in normal conditons,” on page 73).
- Check presence of clock frequency 32.768kHz @ U301-Pin9 using oscilloscope (Table 47, “MCU Clock Waveform – 32.768kHz,” on page 74).
- Check presence of clock frequency 11.9952MHz @ U101-Pin97 and U601-Pin25 (Table 48, “DSP Clock Waveform – 11.9952MHz,” on page 75).
- Check presence of clock frequency 6MHz @ U403-Pin4 (Table 50, “USB Clock Waveform – 6MHz,” on page 77).
- Connect USB cable to UI USB socket and check signal line USB_DET_INT @ U301-Pin24 (Table 9, “Accessories connection indication,” on page 73)
- Observe on the PC Windows’s Explore that “Removable Disk” appear.

Appendix A: UI Module Voltages And Current Consumption

Table 7: UI module voltages

LDO Voltages	Lower Limit	Nom.	Upper Limit	Input Voltage	Enable Signal Voltage
U501 UC_VCC	2.66V / 2.744V	2.8V	2.856V / 2.94V	VBAT	VBB = 2.8V
U502 DVCC	2.66V / 2.744V	2.8V	2.856V / 2.94V	VBAT	DVCC_ON = 2.7V
U503 AVCC	2.66V / 2.744V	2.8V	2.856V / 2.94V	VBAT	AVCC_ON = 2.7V
U504 FMR_VCC	2.66V / 2.744V	2.8V	2.856V / 2.94V	VBAT	FM_ON = 2.7V
U505 CVCC	1.580V / 1.520V	1.6V	1.620V / 1.680V	VBAT	CVCC_ON = 2.7V
U506 USB_VCC	2.945V / 3.038V	3.1V	3.162V / 3.255V	VBAT	USB_ON = 2.7V

Table 8: UI current consumption in normal conditons

Operation Modes	Typical Current Consumption (mA)	MaximumCurrent Consumption (mA)
MP3/AAC Playback	84	86
AAC Recording	110	125
FM Radio Playback	56	58
FM Radio Recording	115	125
USB Uploading/Downloading	82	84
Standby Mode	0.17	0.18

Table 9: Accessories connection indication

Line Symbol	Accessories Connected (V)	Accessories Disconnected (V)
ST_DET (Stereo Headset Detect)	2.77	0.26
LIN_DET (Stereo Line-In Detect)	2.77	0.26
HDC5_INT (HDC5 Mono Headset Detect)	1.8	0.26
USB_DET_INT (USB Detect)	2.7	0.0009

Table 10: Audio routing select

Line-In Source	ADC_SEL1 = 0V	ADC_SEL2 = 0V
FMR Source	ADC_SEL1 = 2.7V	ADC_SEL2 = 0V
Phone Source	ADC_SEL1 = 0V	ADC_SEL2 = 2.7V
Invalid	ADC_SEL1 = 2.7V	ADC_SEL2 = 2.7V

Appendix B: Signals on oscilloscope screen

Figure 47: MCU Clock Waveform – 32.768kHz

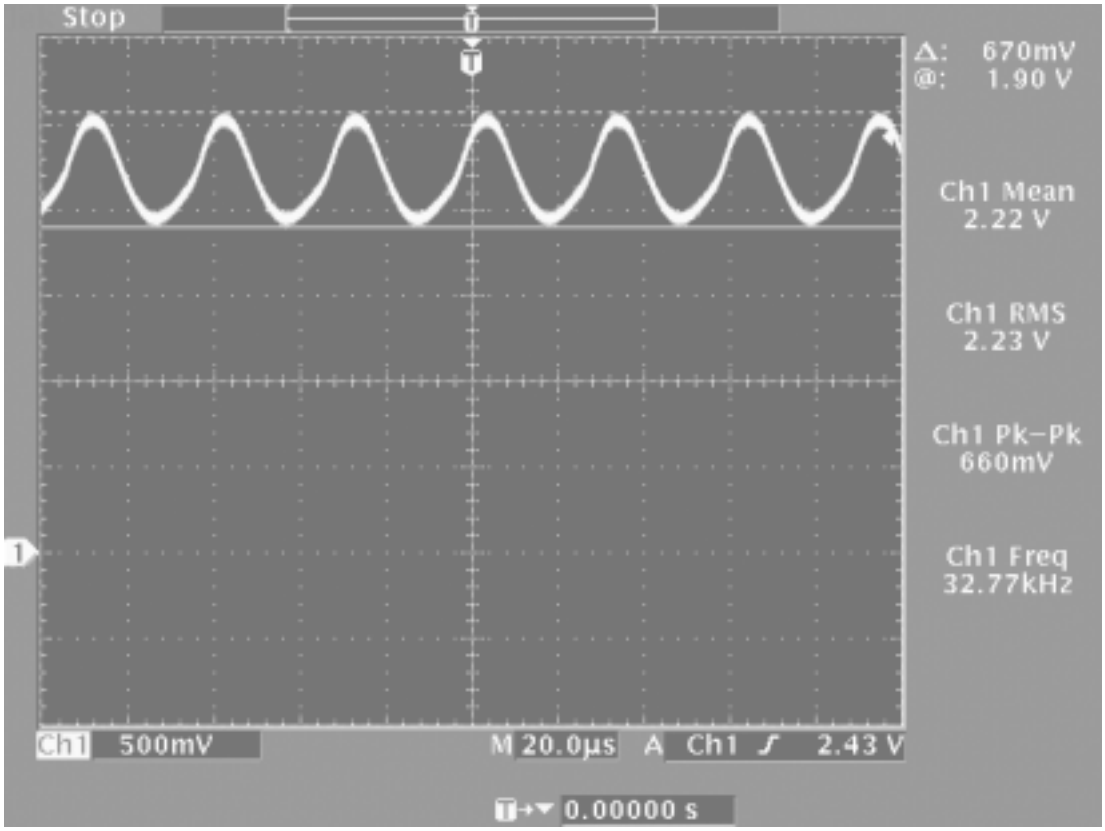


Figure 48: DSP Clock Waveform – 11.9952MHz

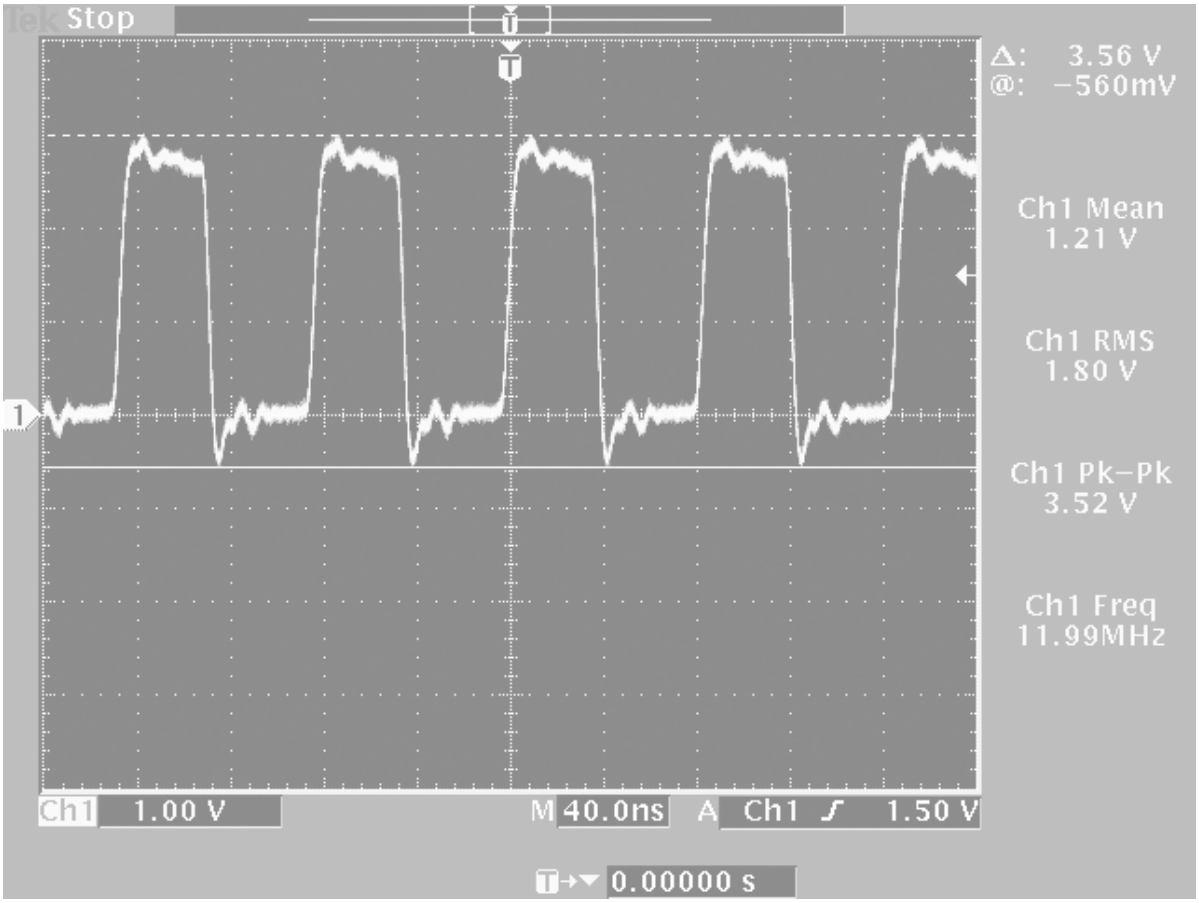


Figure 49: FMR Clock Waveform – 75kHz

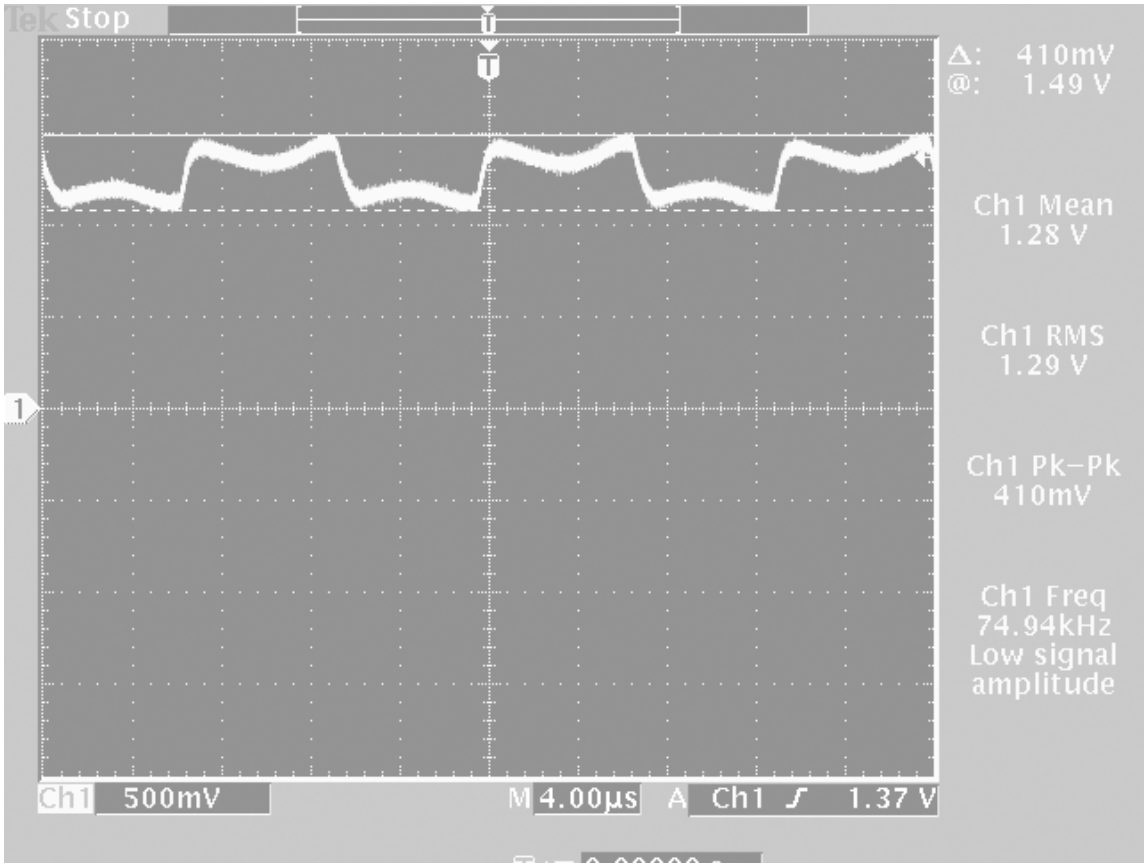
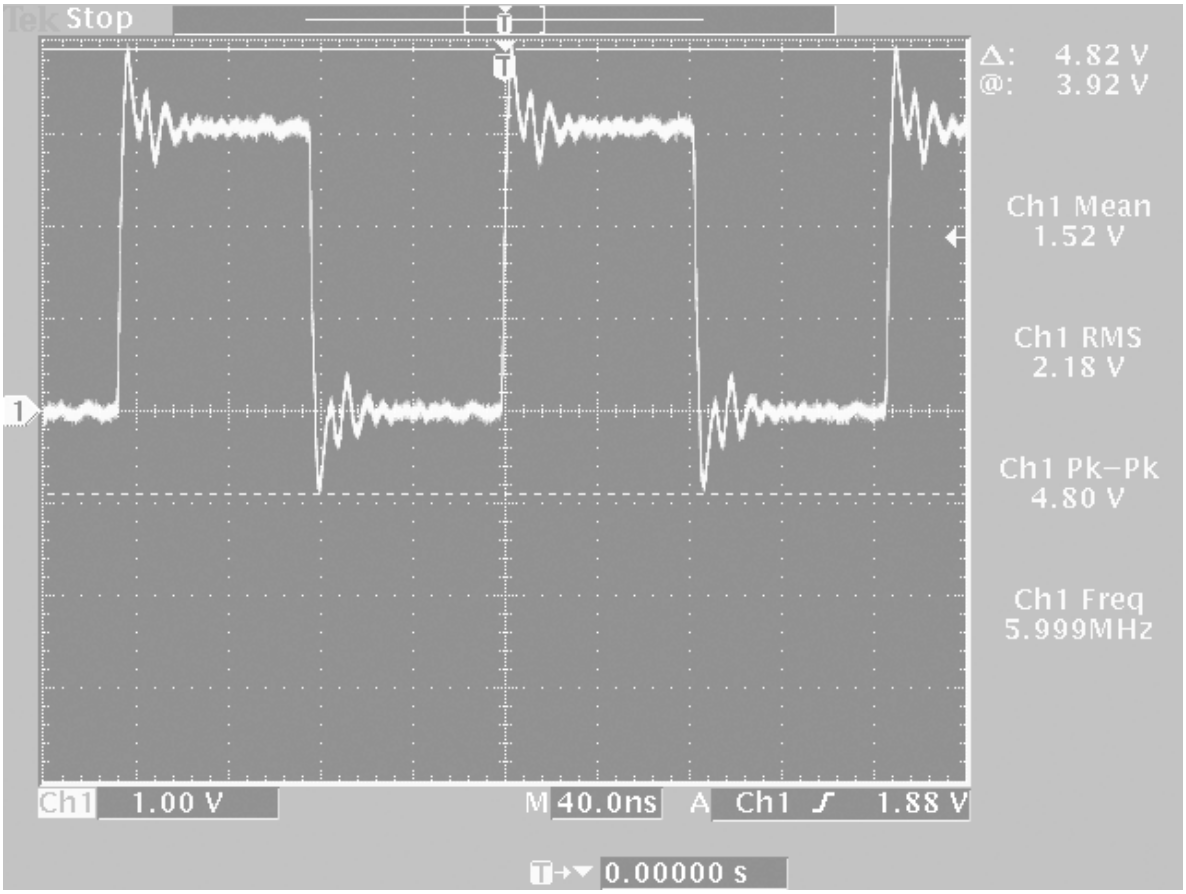


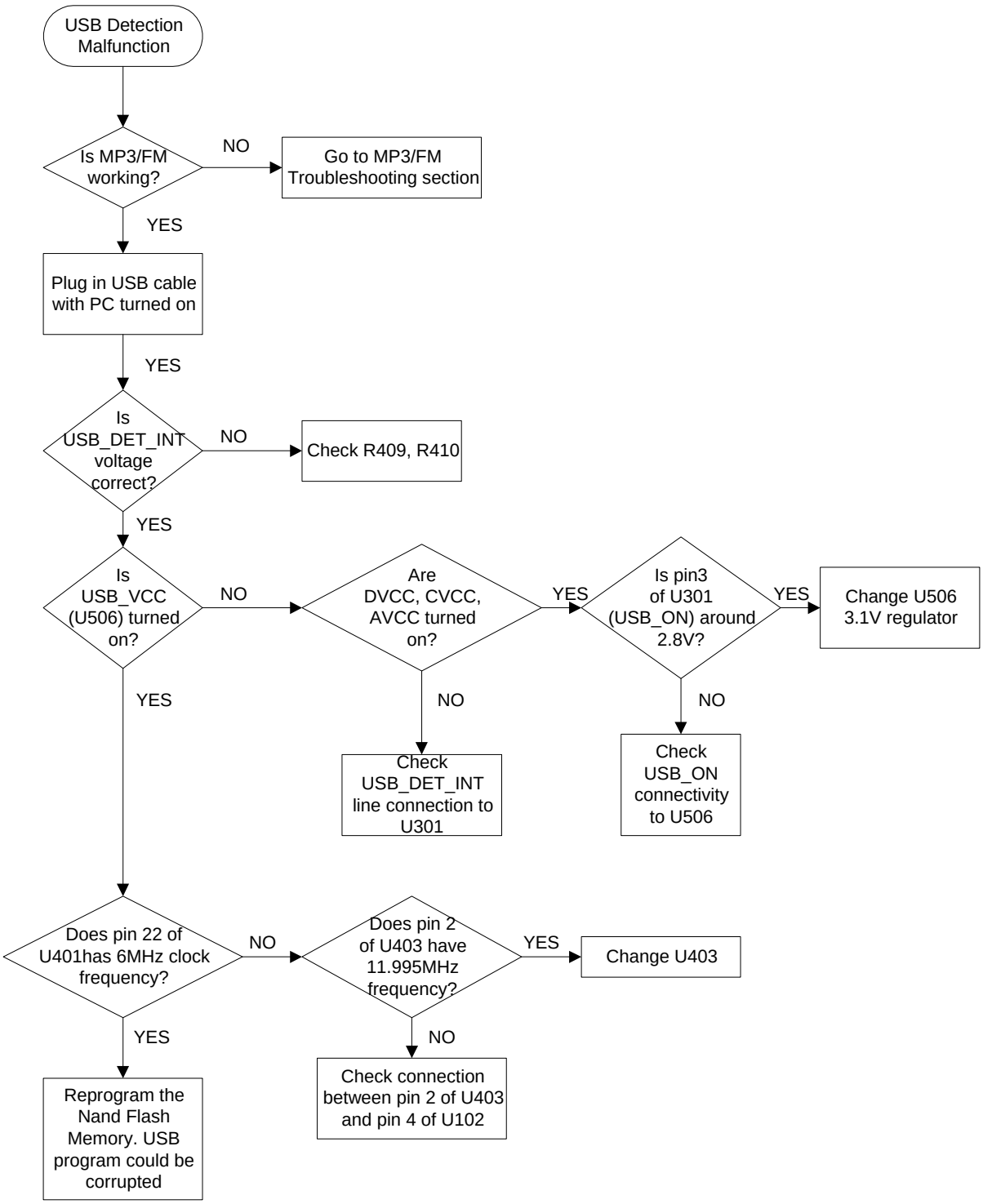
Figure 50: USB Clock Waveform – 6MHz



Appendix C: Troubleshooting flow charts

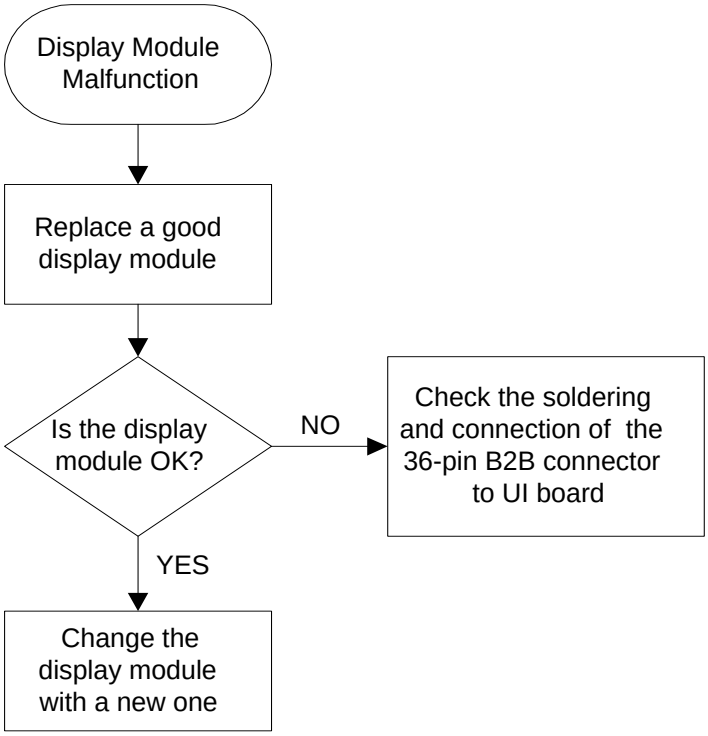
15. General UI troubleshooting

Figure 51: General UI troubleshooting



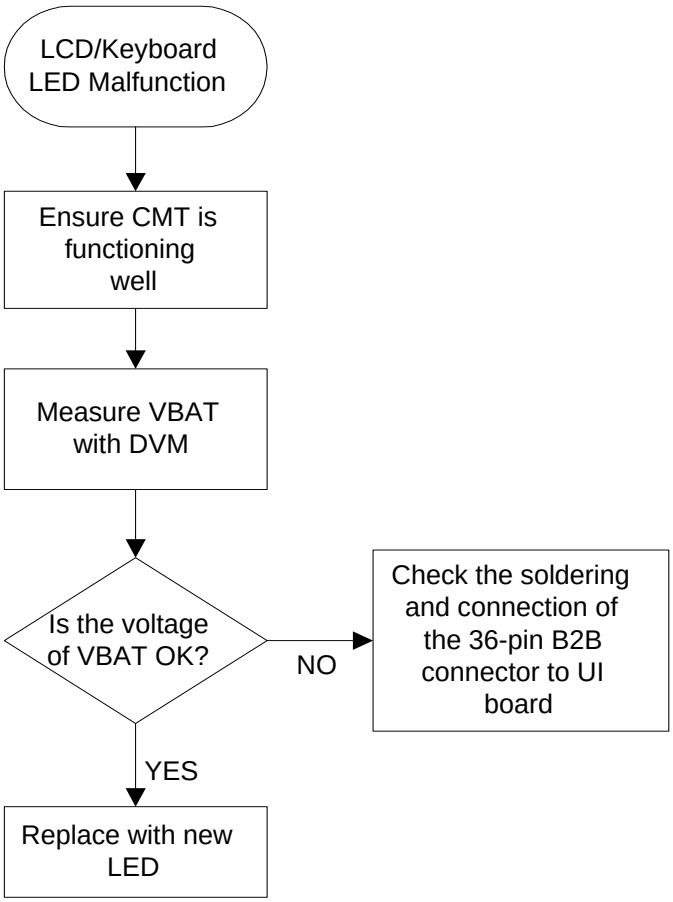
16. Display module malfunction

Figure 52: Display Module - No Display,



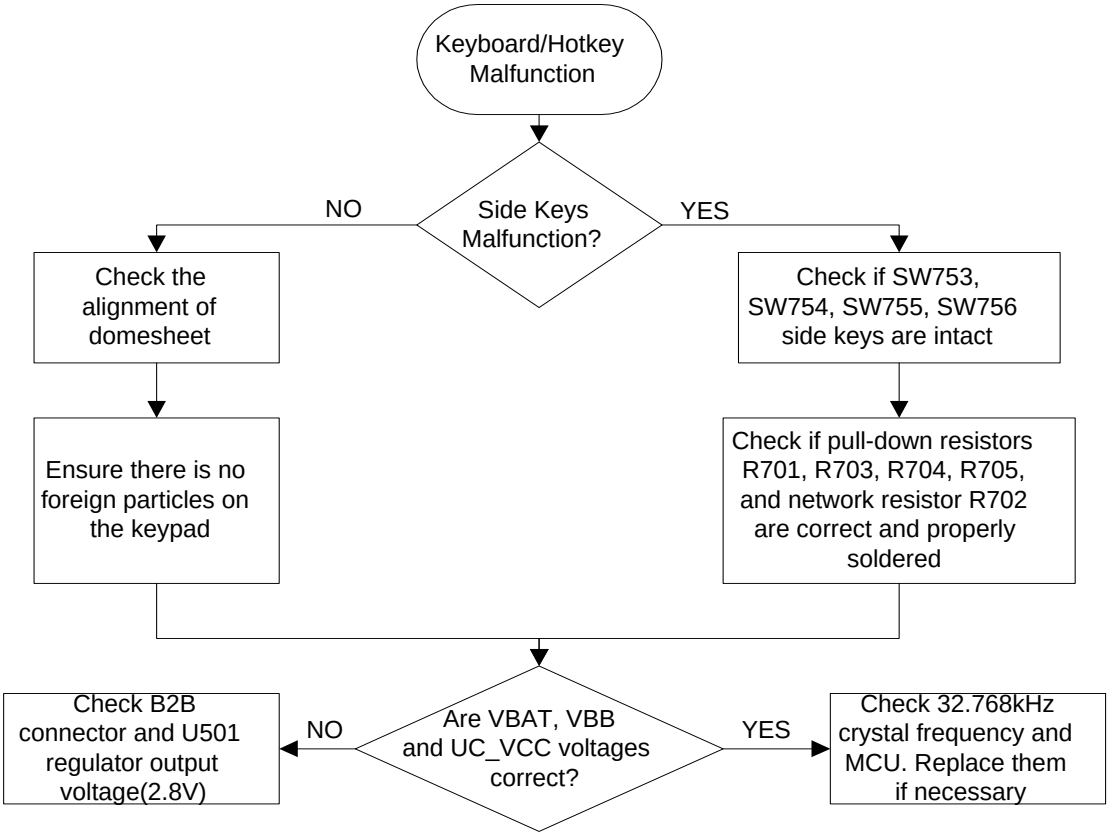
17. No backlight in LCD or keyboard

Figure 53: LCD/Keyboard LED - No Light



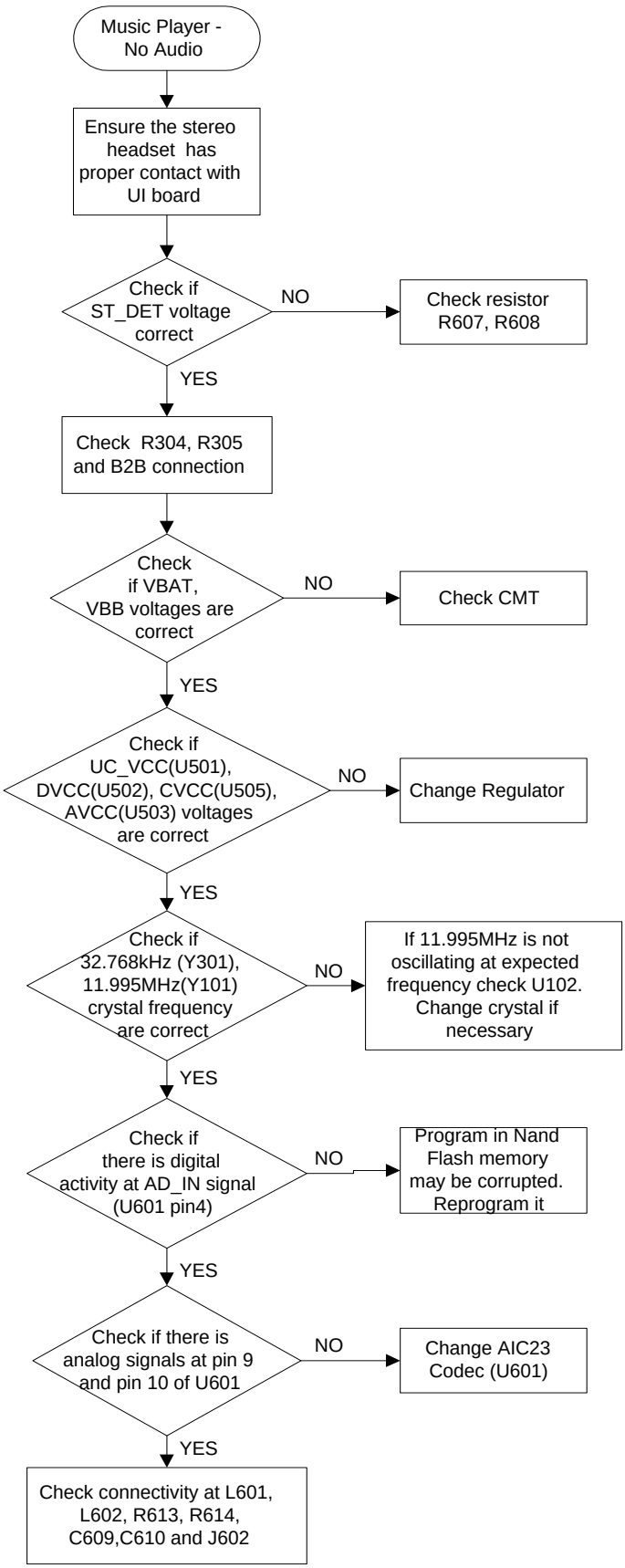
18. Keyboard or hot keys do not respond

Figure 54: Keyboard/Hotkey do not respond



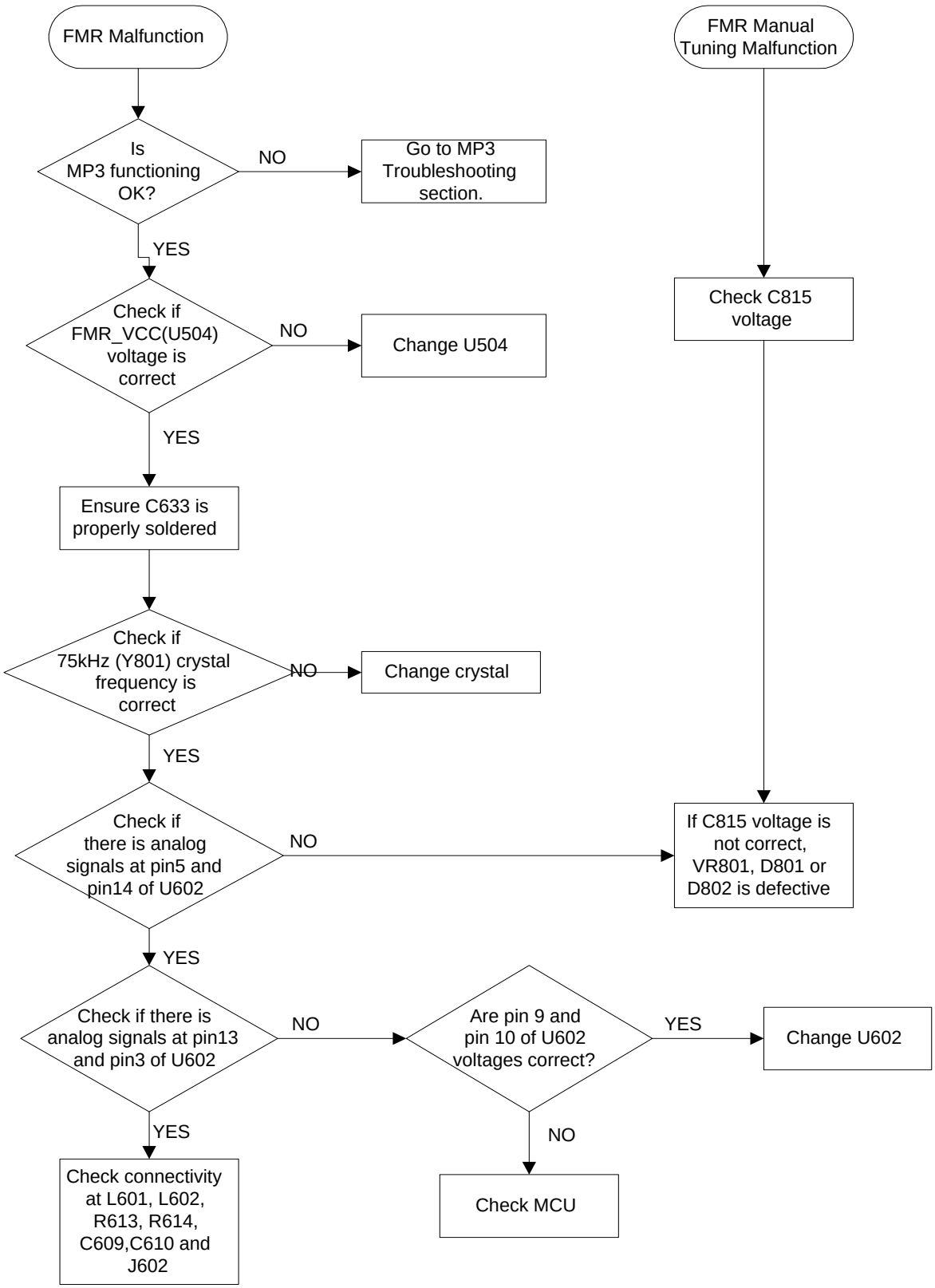
19. No audio in Music Player

Figure 55: Music player - no audio



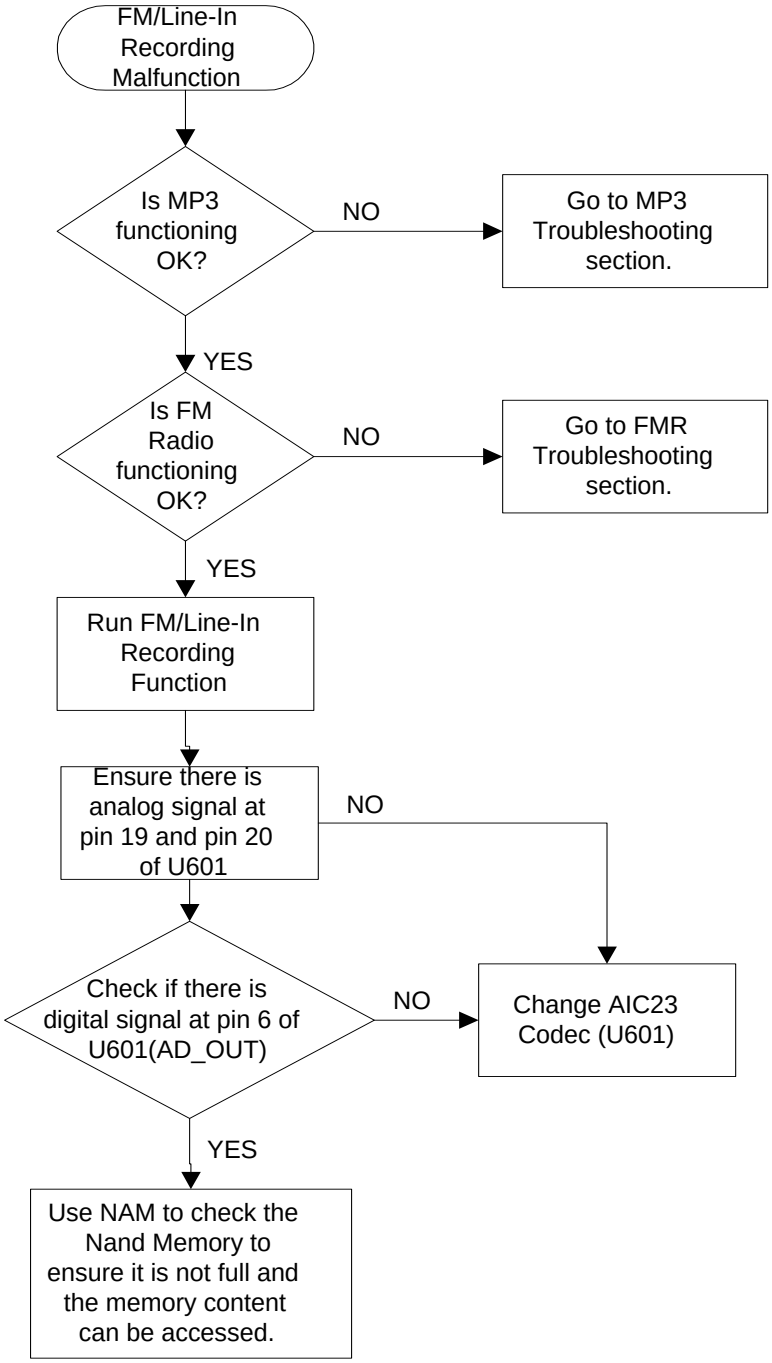
20. No FM audio or manual FM tuning malfunction

Figure 56: No FM audio or manual FM tuning malfunction



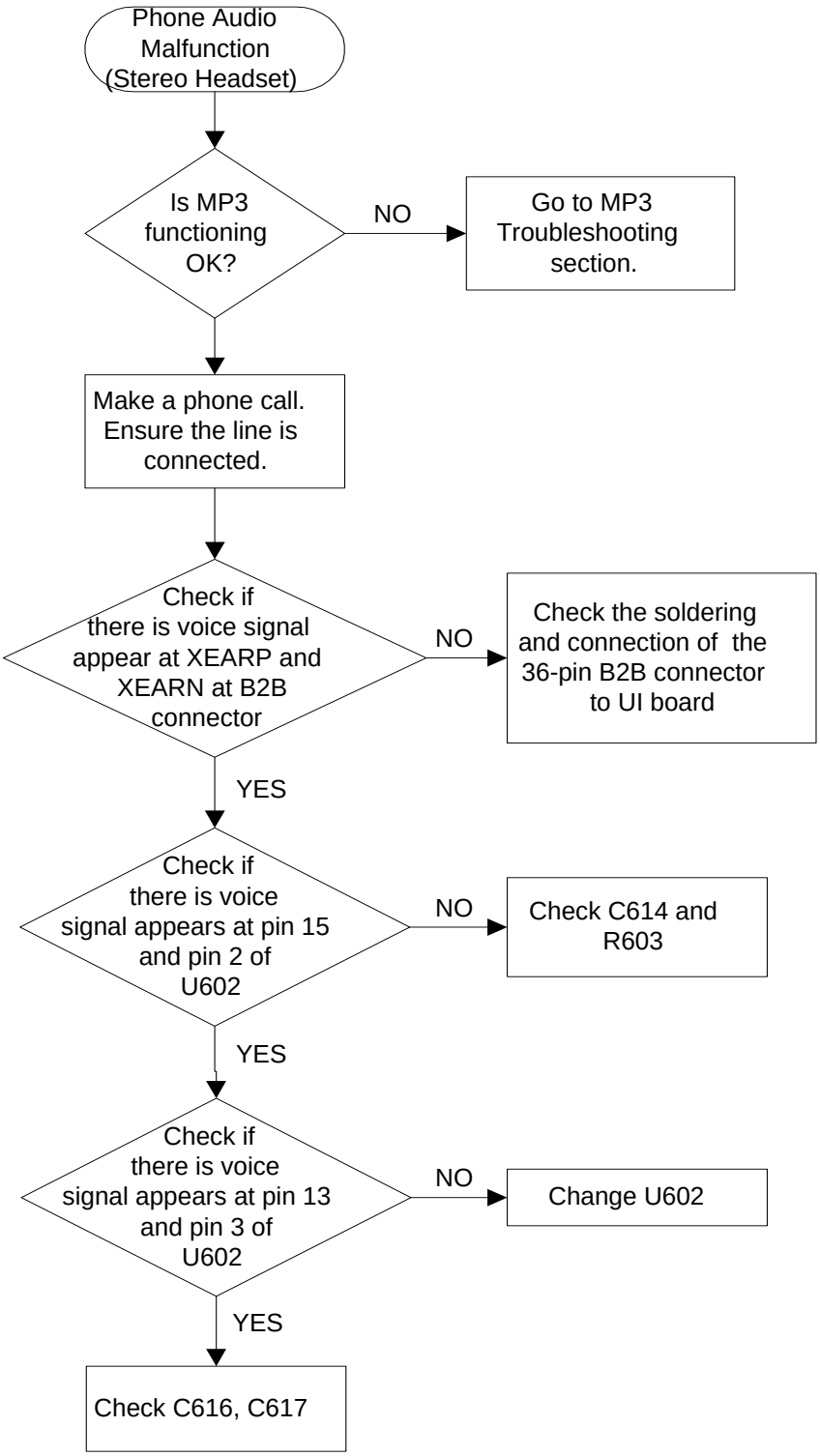
21. FM recording not possible

Figure 57: FM recording not possible



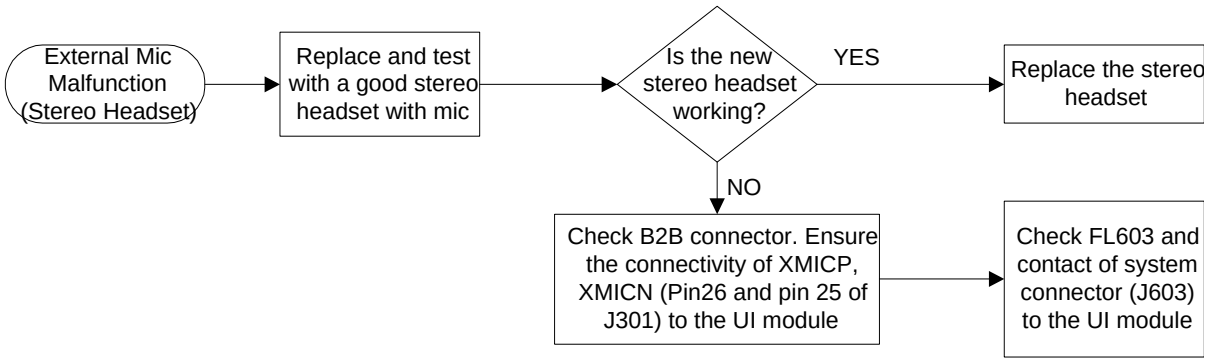
22. Stereo audio malfunction

Figure 58: Stereo audio malfunction



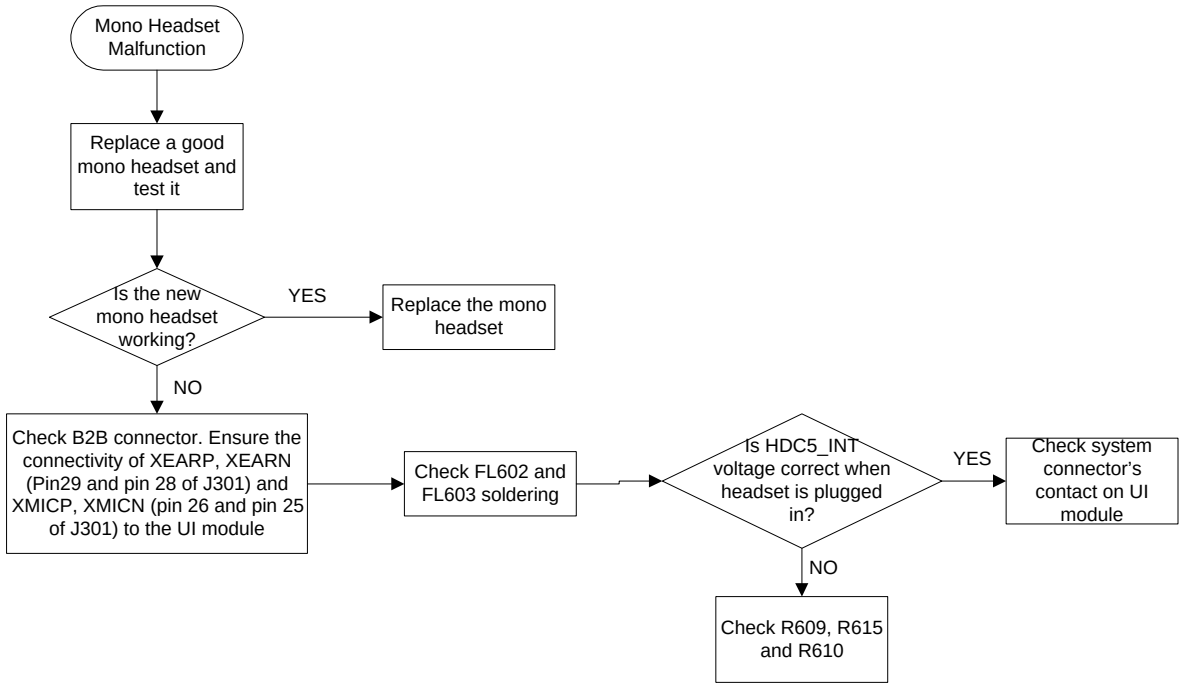
23. Stereo headset microphone malfunction

Figure 59: Stereo headset microphone malfunction



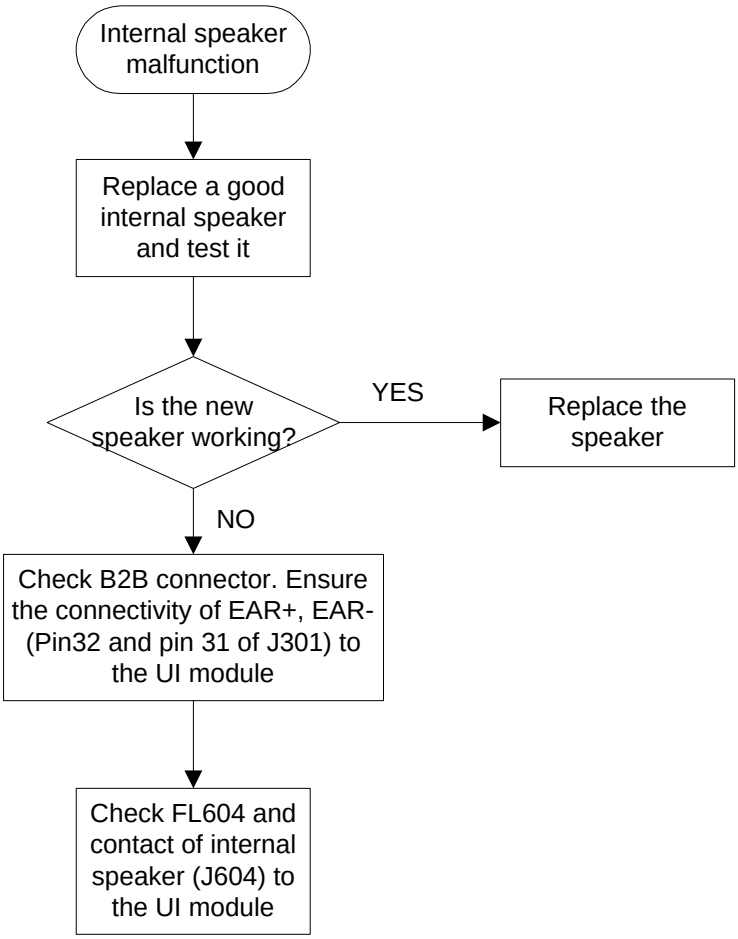
24. Mono headset malfunction

Figure 60: Mono headset malfunction



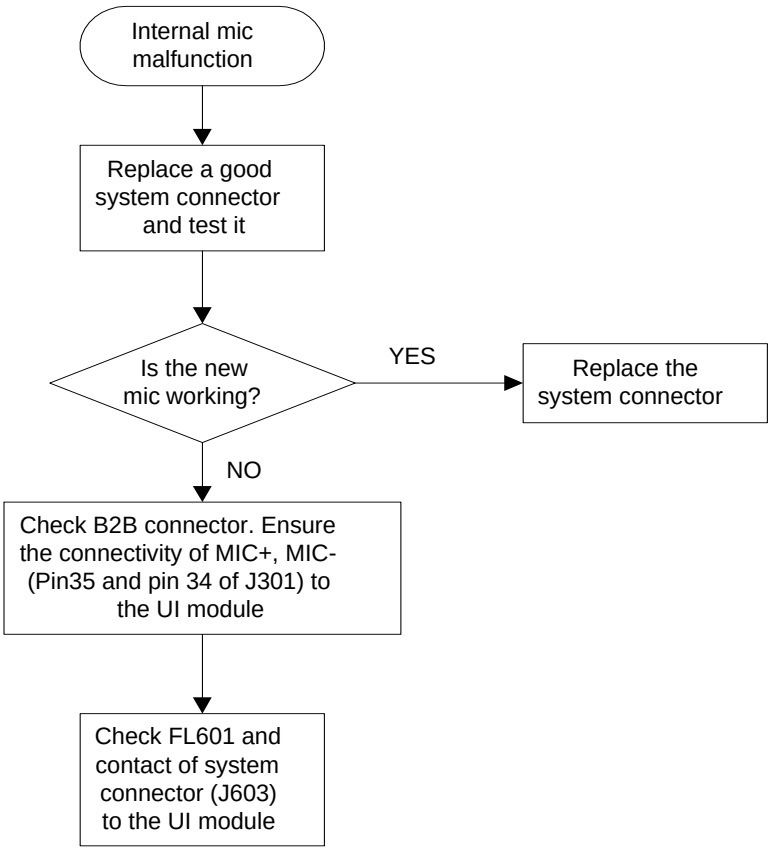
25. Phone speaker malfunction

Figure 61: Phone speaker malfunction



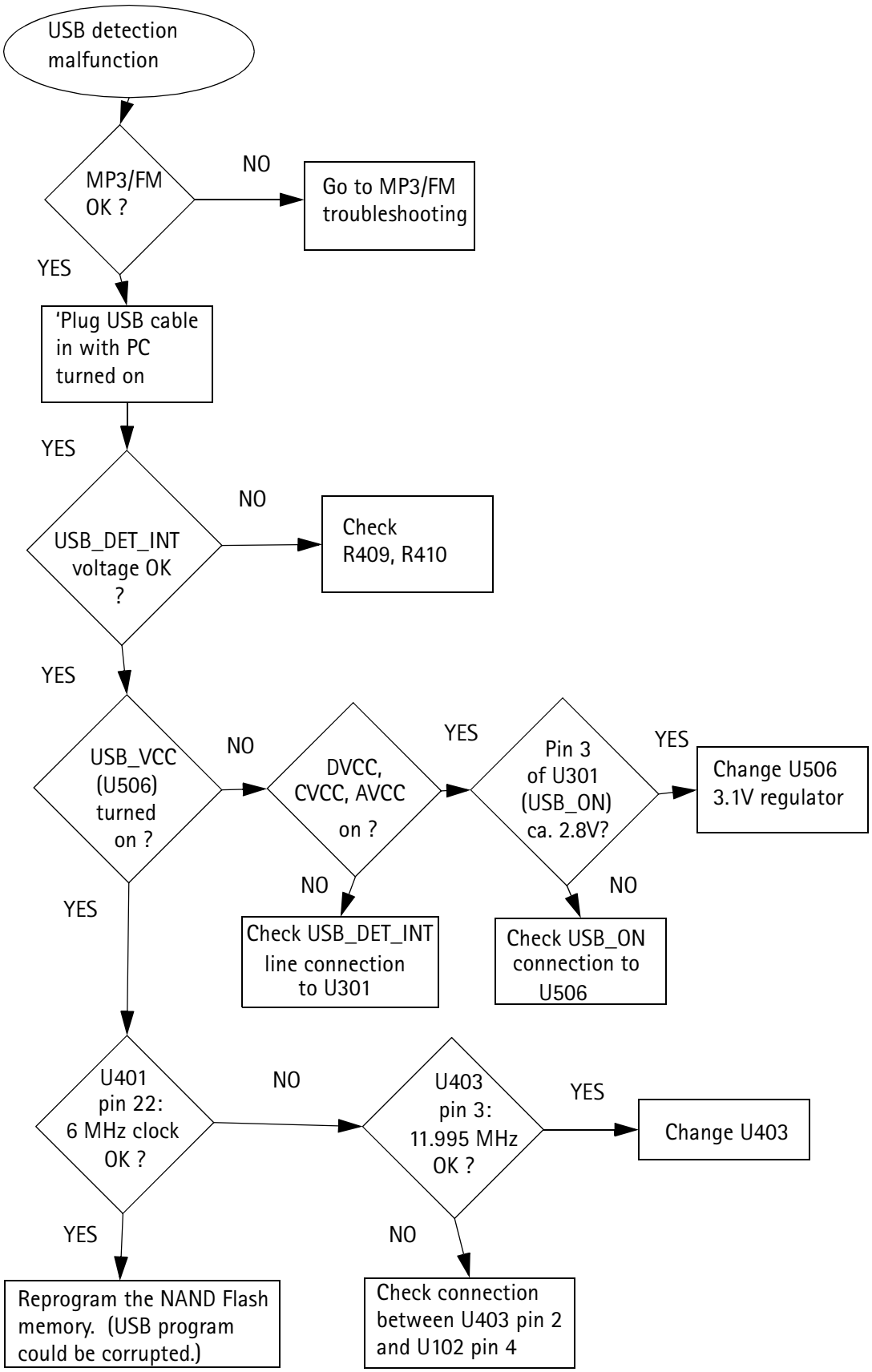
26. Phone microphone malfunction

Figure 62: Phone microphone malfunction



27. USB detection malfunction

Figure 63: USB detection malfunction



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