6(b) - RF Troubleshooting and Manual Tuning Guide

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Introduction

This document describes the troubleshooting and RF tuning of Nokia 6600 (NHL-10). In general, two types of measurements have to be performed during the troubleshooting and repair of phones:

- RF measurements shall be done with a spectrum analyzer, either connected directly to the RF connector of the board (“antenna point”), or used together with a high-frequency probe to measure RF signals at points along the TX or RX chain.
- LF (Low-Frequency) and DC measurements shall be done either with a multimeter, or with an oscilloscope together with a 10:1 probe.

All tuning must be done with Phoenix Service Software, version A9 2003.15.2.25, or later.

Always make sure that the measurement set-up has been calibrated when measuring RF parameters at the RF connector. Remember to include the correct losses in the module repair jig and the connecting cable when realigning the phone.

Most RF semiconductors are static discharge sensitive. ESD protection must be taken into account during repair (ground straps and ESD soldering irons).

Mjølner RF ASIC is moisture sensitive. Therefore, Mjølner RF ASIC must be pre-baked prior to soldering.

RF calibration done via Phoenix software is temperature sensitive because of calibration of 26MHz reference oscillator (VCXO). According to the Mjølner specification, ambient temperature has to be in the range of 22 to 36^{o}C.

General troubleshooting

The first step of fault-finding should always be a visual inspection. Carefully inspect the RF area using a microscope and look for cracks, solder bridges, dry joints, missing components, components that have partially come off and other anomalies. Capacitors can be checked to see that they are not short-circuited, and inductors that they are not open circuits. Also check that power supply lines are not short-circuited, i.e. not 0Ω to ground.

Instruments needed for trouble-shooting (minimum requirement):

- Oscilloscope
- Multimeter
- Spectrum analyzer (SA)

Note:
Use an attenuator at the spectrum analyzer input to ensure that the SA will not become damaged by excessive input power from the phone. Check the spectrum analyzer for maximum allowable input power.

- Power supply that can deliver at least 2Adc
- Nokia 6600 module jig (also called test jig)
- PC with Phoenix installed

Note:
In this text the following terms are used interchangeably:
GSM900 = EGSM900 = EGSM
GSM1800 = DCS band
GSM1900 = PCS band

RF Key Component Placement

The following figure shows the key components of the RF section.

Figure 1: RF Key Components

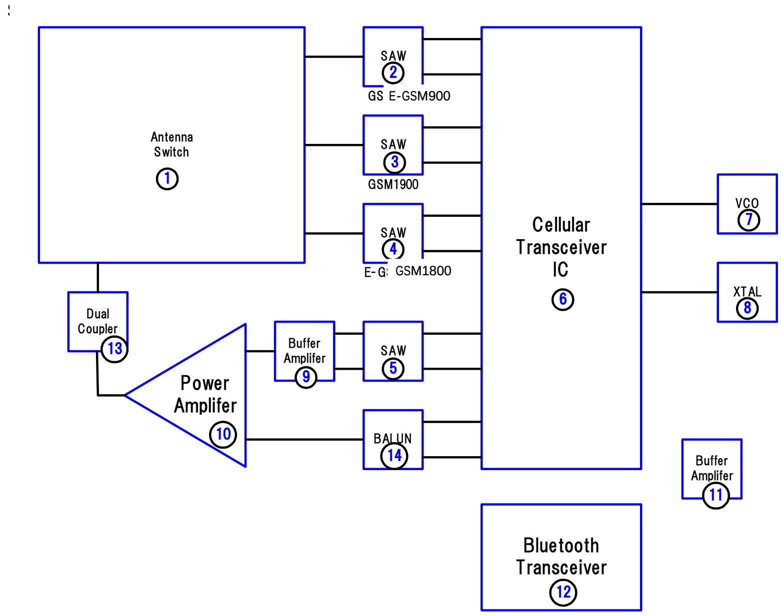


Figure 2: RF Key Components

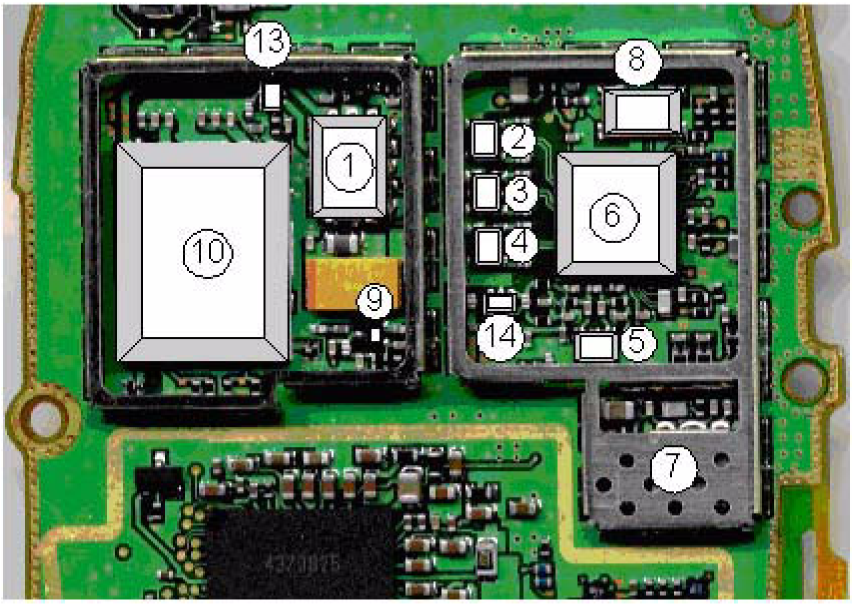
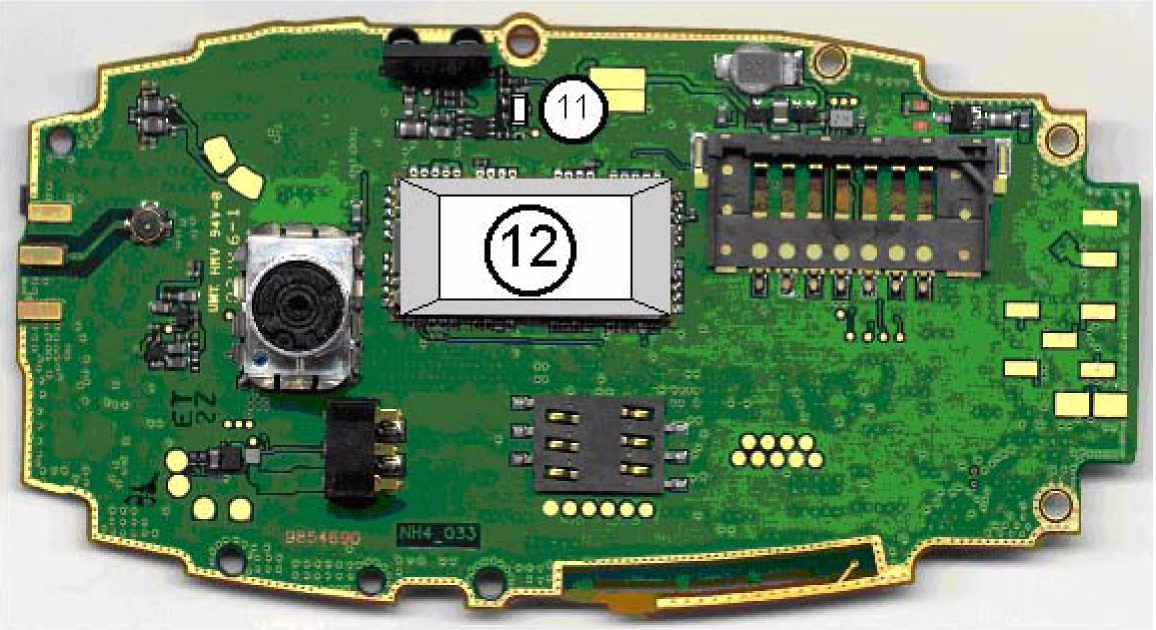


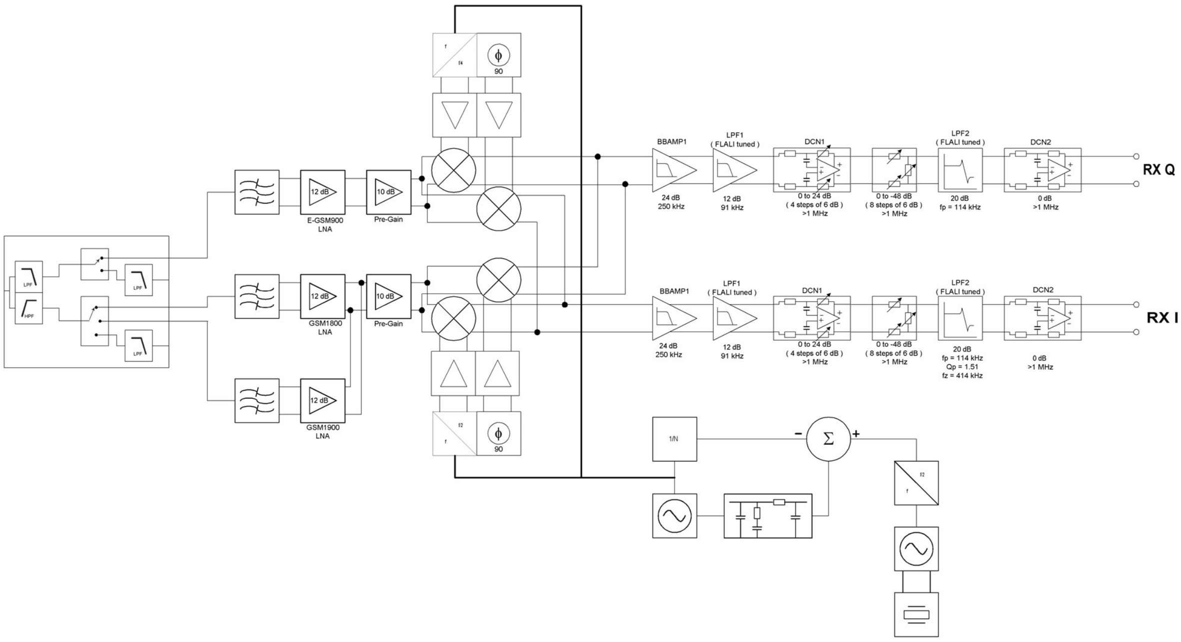
Figure 3: RF Key Components



Receiver Troubleshooting

General Description

Figure 4: Receiver Signal Path



The receiver is a direct conversion, triple-band linear receiver. NHL-10 uses Mjølner RFIC with external VCO.

The received RF signal from the antenna/RF connector goes into the RF antenna switch where the signal is fed to the E-GSM900, GSM1800 or GSM1900 path. For each band, a RX band-pass SAW filter with unbalanced input and balanced output follows. All blocks are specified as 50Ω single ended, only the SAW filter output to the Mjølner input is differentially matched to LNA G_{opt}. The LNAs are integrated in Mjølner and have two gain levels. The first one is max. gain nominally 12 dB, the second one is about 30 dB below max. gain. The gain selection control of the LNAs is done via the serial interface.

The differential RX signals are further amplified in the “pre-gain” stage and then mixed down to baseband inside Mjølner using two Mixers with a 90° phase shift in the LO signal resulting in an in- and quadrature phase paths. Local oscillator signal is generated with the external VCO. The VCO signal is buffered and divided by 2 (DCS/PCS) or by 4 (EGSM). Accurate phasing is generated in LO dividers.

The Rx BB chain incorporates AGC, channel select filter and DC compensation. The AGC is adjusted in 6 dB steps in Mjølner. The DCN1 gain can be adjusted to +24/+18/+12/+6/0 dB. The attenuator gain can step from 0/-6/-12/-18/-24/-30/-36/-42/-48dB. Other BB amplifiers have a nominal summed gain of 58dB. The total dynamic range of AGC alone is 72dB. The 3rd order active channel filters in Mjølner defines the channel selectivity (flat response up to +/-90kHz typical). Integrated base band filters are based on active RC filters with on-chip capacitors. The baseband filters are distributed to following stages: BBAMP1, LPF1, LPF2. DC compensation is split to DCN1 and DCN2. DCN1 is used to compensate DC offset from RF front-end imperfections. DCN2 centres the differential signal with respect to the common mode reference voltage of 1.35V. Differential, filtered I/Q-signals are finally fed to the sigma-delta ADC's in the UEM. Further filtering in the digital domain occurs in the sinc decimation filter and DSP based FIR filters

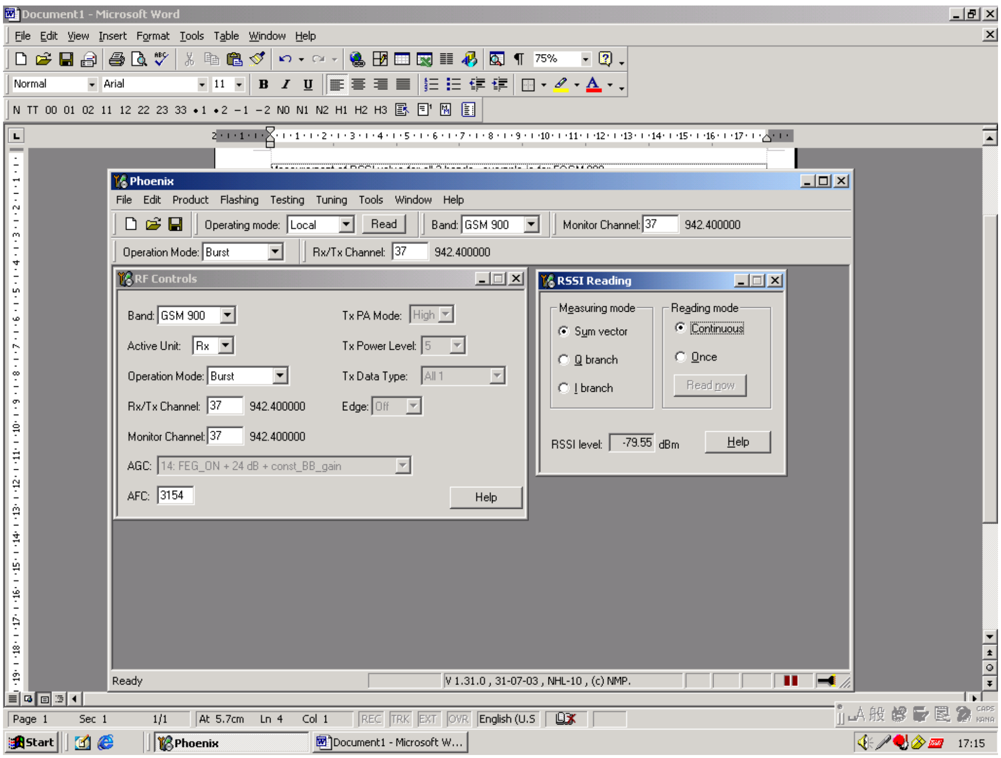
General Instructions for RX Troubleshooting

Connect the phone to a PC with DAU-9S cable and dongle and follow the following instructions.

Measuring RX I/Q signals using RSSI

- Start Phoenix Service Software and establish a connection to the phone.
- Select File -> Scan Product Ctrl R.
- Wait until the phone software version is shown in the lower part of the screen.
- Select Testing -> RF controls.
- Select Band -> GSM900/GSM1800/GSM1900.
- Active unit -> RX.
- Operation mode -> Burst.
- RX/TX channel -> 37/700/661.
- Select RF Alt-M
  Testing -> T
  RSSI -> R

The set-up now looks like this:



- Apply a signal with frequency of:
  EGSM: 942.467MHz (channel 37 + 67.710KHz offset),
  GSM1800: 1842.867MHz (channel 700 + 67.710KHz offset),
  GSM1900: 1960.067MHz (channel 661 + 67.710KHz offset),
  and a power level of –80dBm to the RF connector (remember to compensate for the cable loss).
- In RSSI reading click Read now.

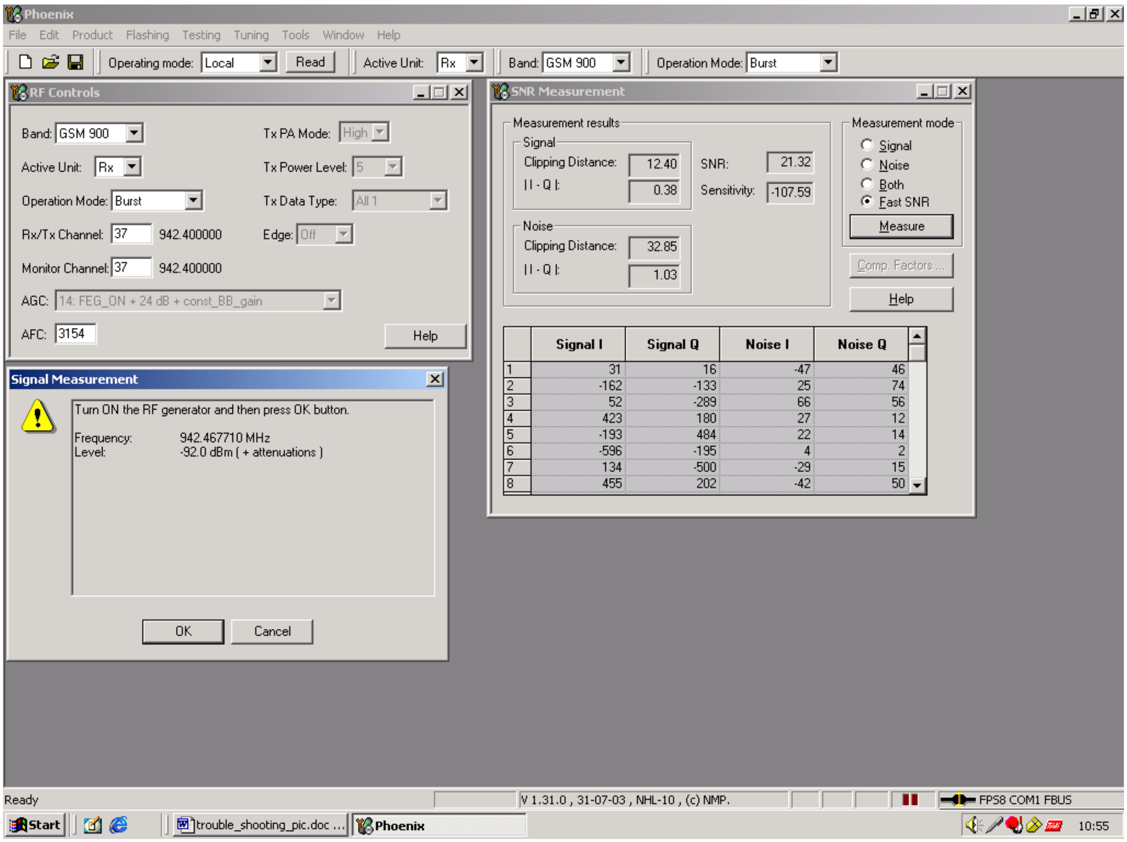
The resulting RSSI level should be –80dBm in each band.

Measuring RX performance using SNR measurement

Note: This measurement also provides an indication of the conducted sensitivity.

- Start Phoenix Service Software and establish a connection to the phone.
- Select File -> Scan Product Ctrl R.
- Wait until the phone software version is shown in the lower part of the screen.
- Select Testing -> RF controls.
- Select Band -> GSM900/GSM1800/GSM1900.
- Active unit -> RX.
- Operation mode -> Burst.
- RX/TX channel -> 37/700/661.
- Select Maintenance Alt-M
  Testing -> T
  SNR Measurement -> M
- Select Fast SNR.
- Choose the respective band (EGSM900, GSM1800, GSM1900).
- Press Measure.
- Follow the instructions for Signal generator set–up in the pop–up window.
- Press OK.
- Read the SNR result. The SNR should be: EGSM900: > 20dB
  GSM1800: > 18dB
  GSM1900: > 18dB
- Check the sensitivity value.

The set-up should now look as shown in the following figure. The icon also includes a pop-up window for reference.



Measuring the RX module manually using Oscilloscope and Spectrum Analyzer

Spectrum Analyzer level values depend on the probe type and should be validated using a known good NHL-10 sample. The levels that are given here are measured using a high frequency probe.

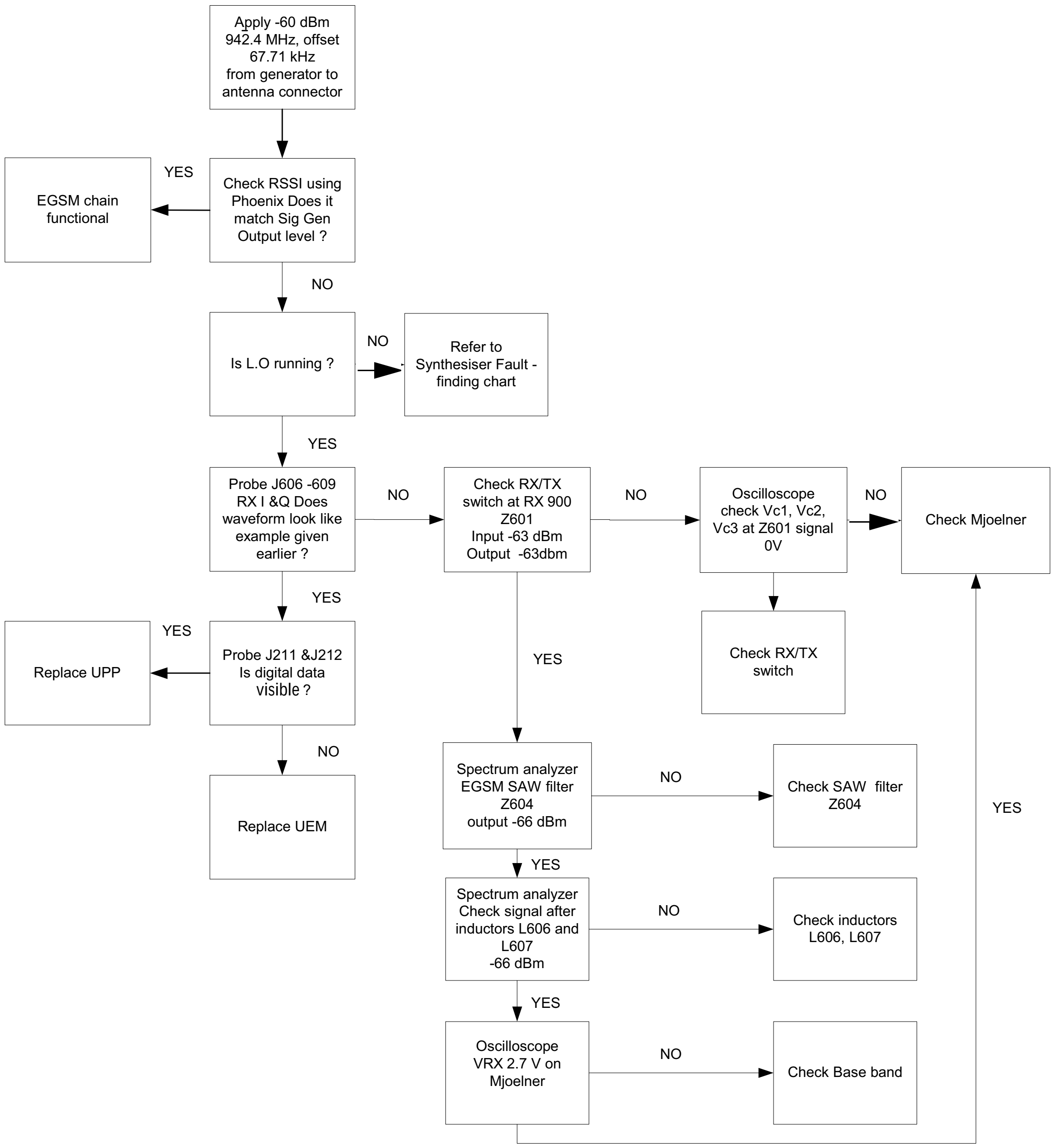
Measuring with Oscilloscope on RXINN or RXQINN (J606 –608) and RXID or RXQD (J211 – J212) is recommended only if RSSI reading does not provide enough information. No dedicated test points exist for RX I/Q signals, however, they can be accessed by probing on a via hole plating.

GSM900

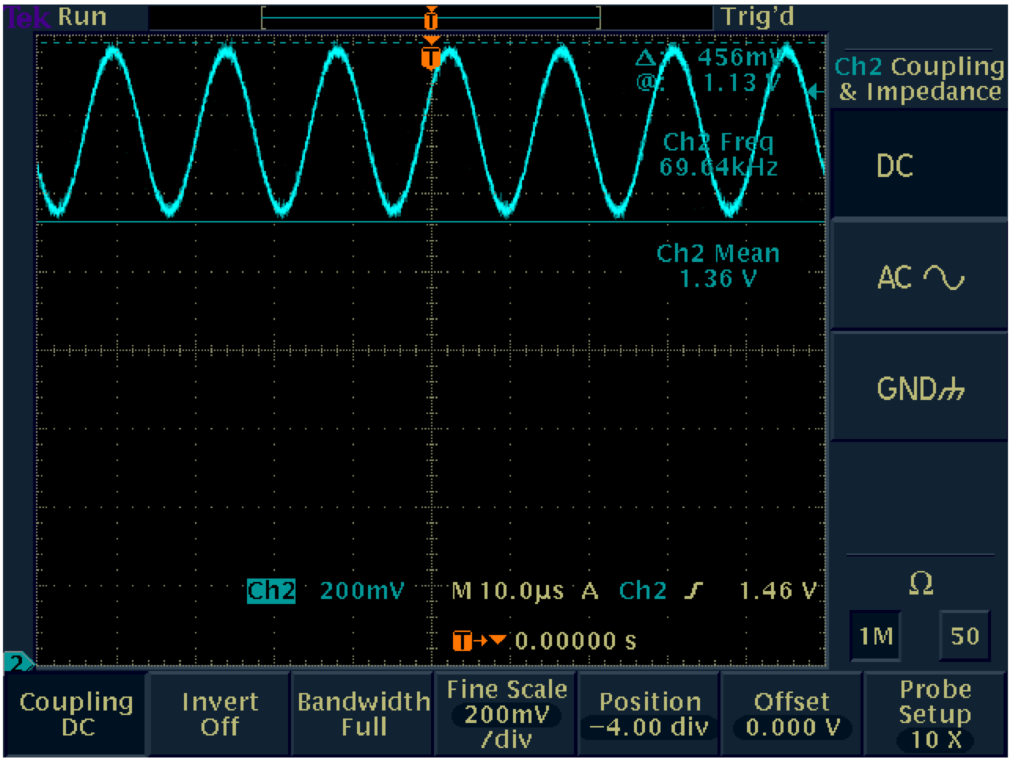
- Start Phoenix Service Software and establish a connection to the phone.
- Select **File -> Scan Product Ctrl** R.
- Wait until the phone software version is shown in the lower part of the screen.
- Select **Testing -> RF controls**.
- Select **Band -> GSM900**.
- **Active unit -> RX.**
- **Operation mode -> Continuous.**
- **RX/TX channel -> 7.**
- **AGC -> 9.**

The input freq/level of the signal generator is 942.467710MHz, -60dBm.

Figure 5: Fault finding chart for GSM900



Probed RX I/Q signals J606 - 609 with signal setting to 942.467710MHz, -60dBm. Note that the display is the same for both GSM1800/1900 bands as well.



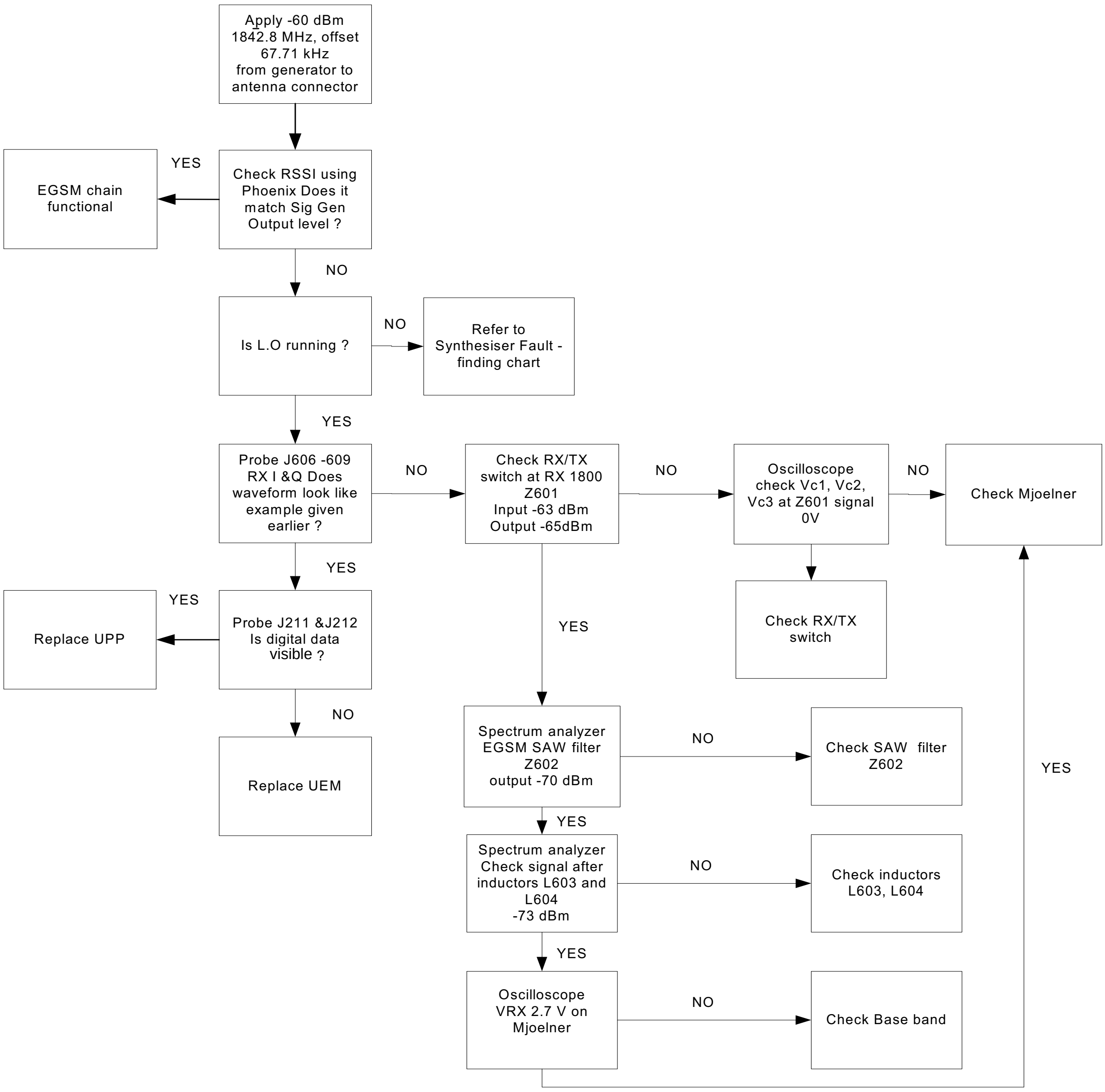
- Signal amplitude: 456mV
- DC offset: 1.36V
- Frequency: approx 67KHz

GSM1800

- Start Phoenix Service Software and establish a connection to the phone.
- Select File -> Scan Product Ctrl R.
- Wait until the phone software version is shown in the lower part of the screen.
- Select Testing -> RF controls.
- Select Band -> GSM1800.
- Active unit -> RX.
- Operation mode -> Continuous.
- RX/TX channel -> 700.
- AGC -> 9.

The input freq/level of the signal generator is 1842.867710MHz, -60dBm.

Figure 6: Fault finding chart for GSM1800

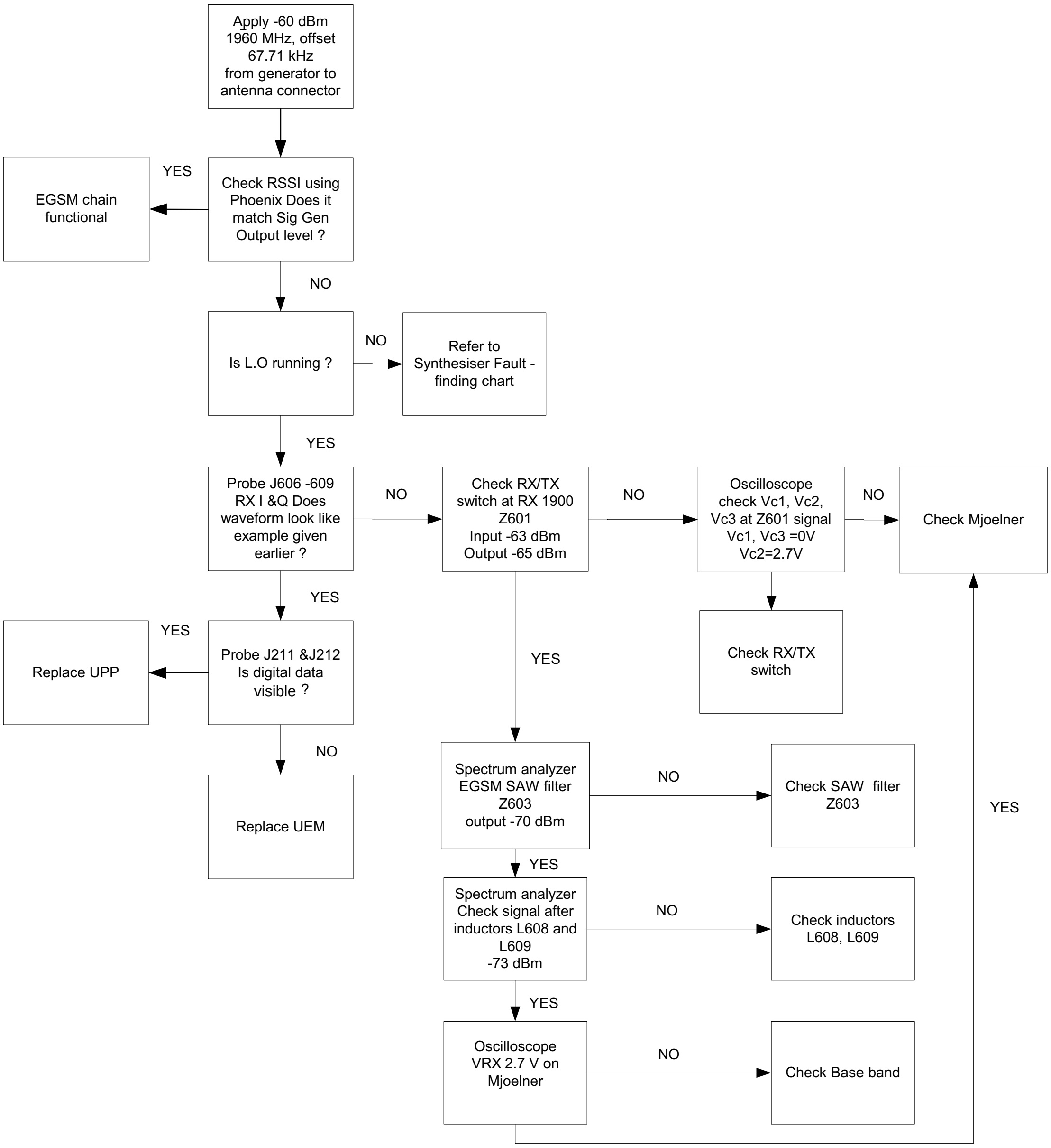


GSM1900

- Start Phoenix Service Software and establish a connection to the phone.
- Select File -> Scan Product Ctrl R.
- Wait until the phone software version is shown in the lower part of the screen.
- Select Testing -> RF controls.
- Select Band -> GSM1900.
- Active unit -> RX.
- Operation mode -> Continuous.
- RX/TX channel -> 661.
- AGC -> 9.

The input freq/level of signal generator is 1960.067710MHz, -60dBm

Figure 7: Fault finding chart for GSM1900



Measurement points in the Receiver

Figure 8: Measurement points at the RX SAW filters –Z602, Z603, Z604

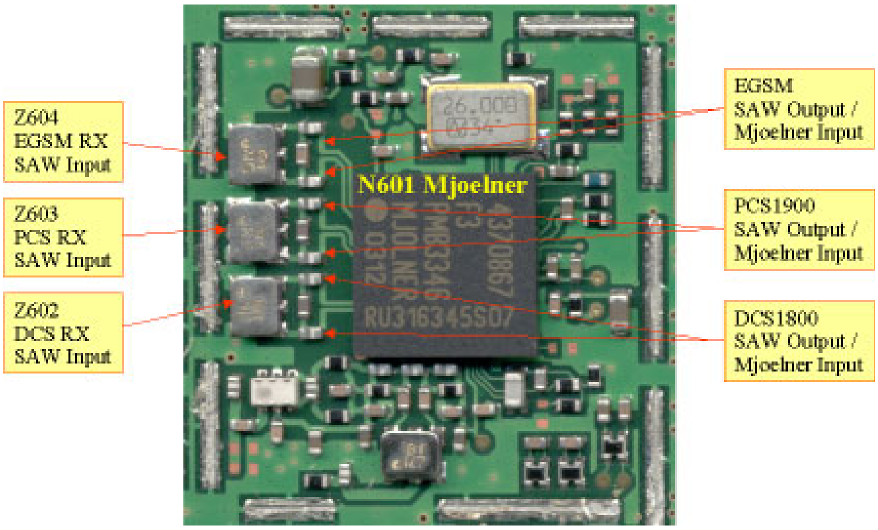


Figure 9: Measurement points for I/Q baseband signals

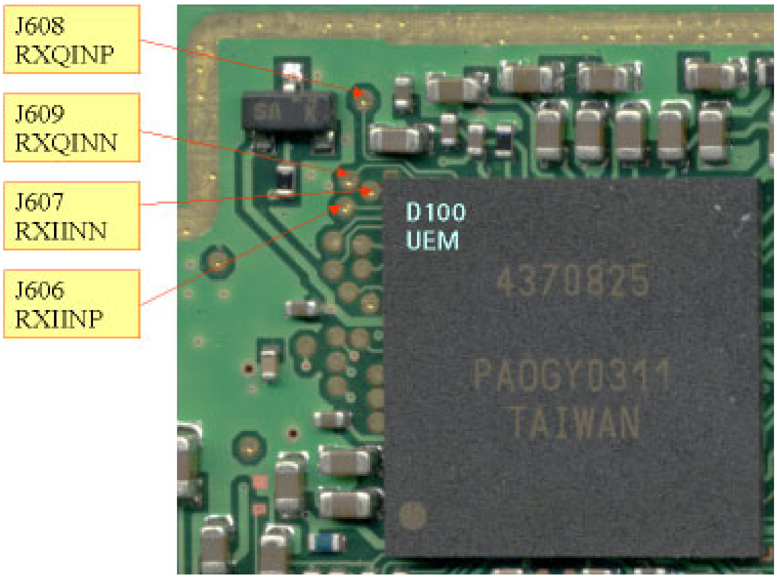


Figure 10: Measurement points for RX I/Q digital signals

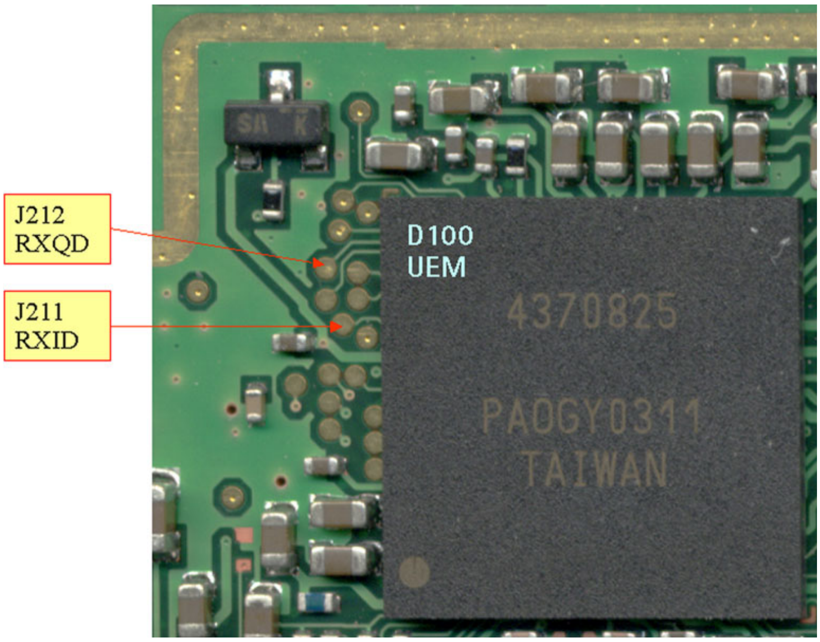
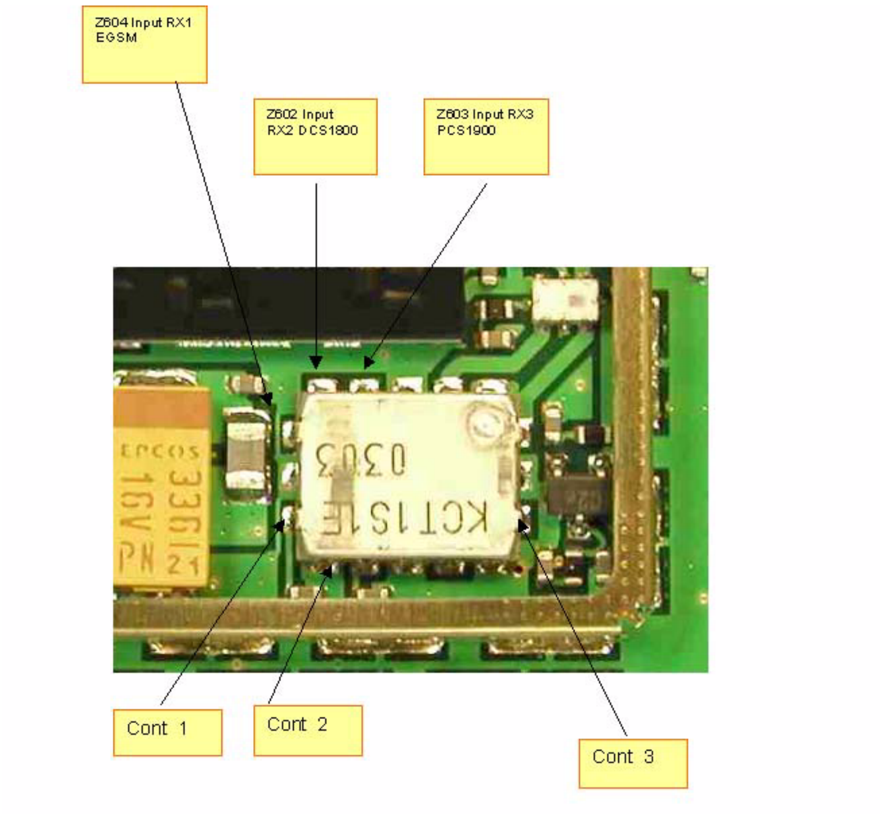


Figure 11: Measurement points at the Antenna switch

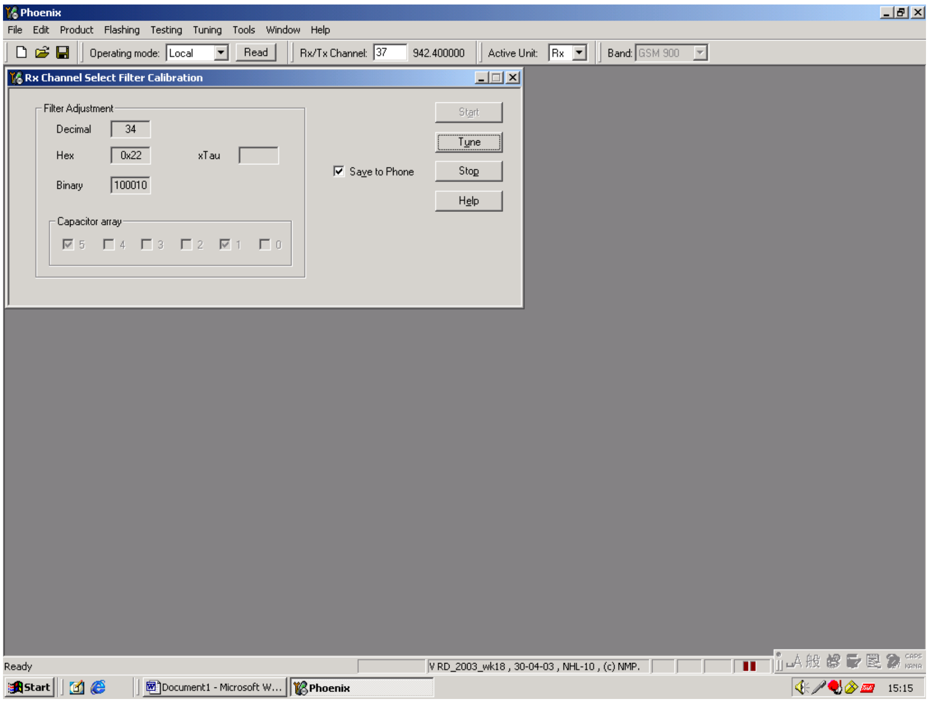


Tuning of the RX Using Phoenix

RX Channel Select Filter Calibration

This calibration is calibrating the Baseband filter inside Mjølner ASIC. It is done by internally measuring a prototype filter, for this reason the calibration is done once, not separately for all three bands.

- Select **Tuning -> RX Channel Select Filter Calibration**.



- Press **Tune**.

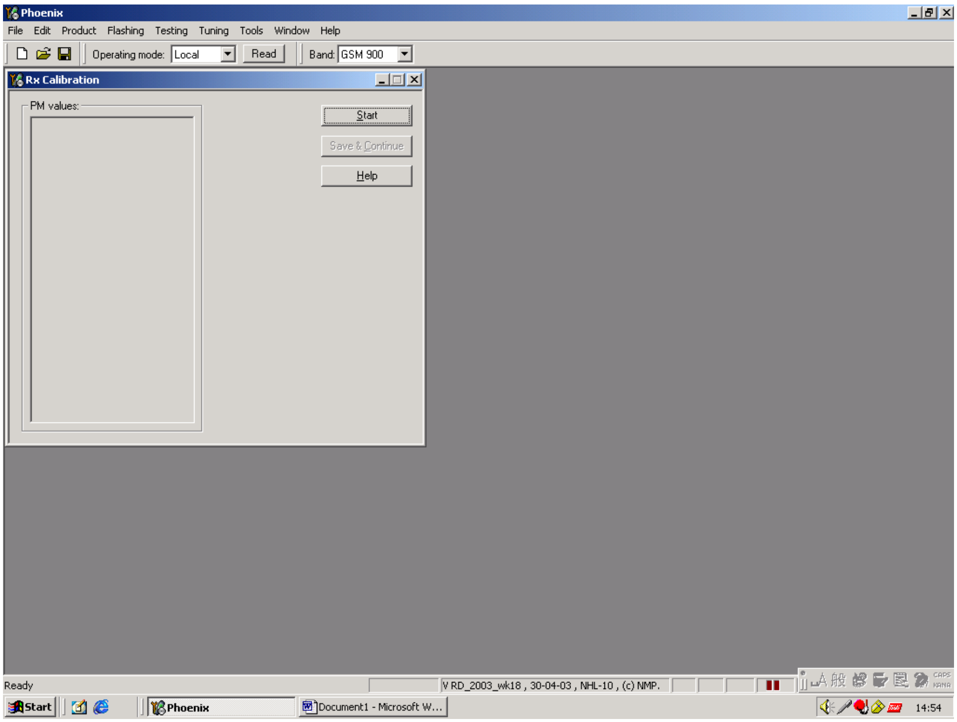
RX channel select filter calibration is finished.

RX Calibration

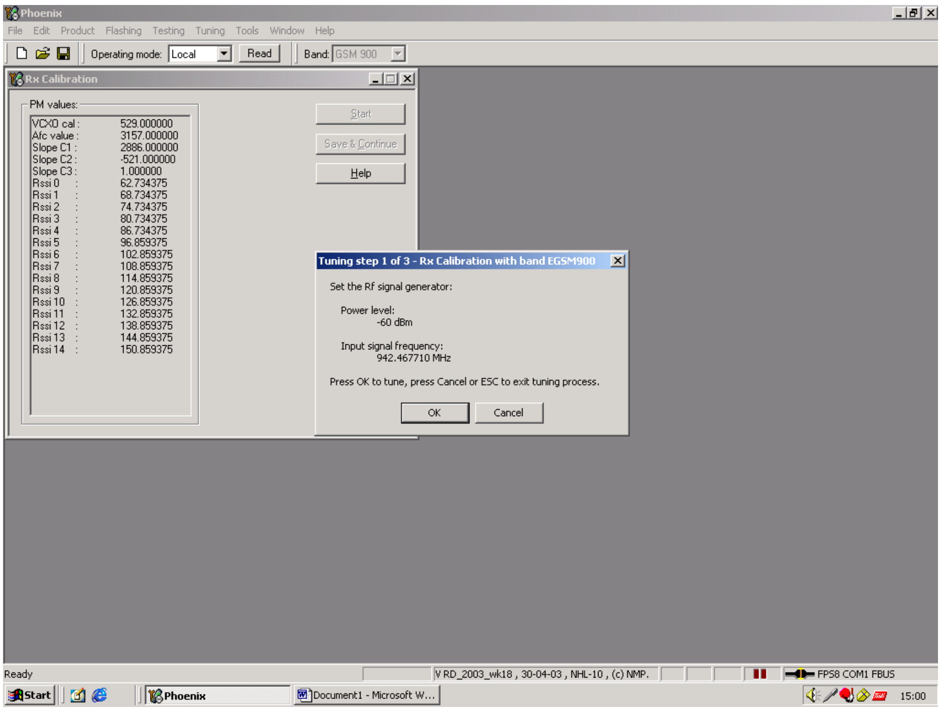
The RX Calibration is used to determine the gain at different gain settings for the front-end and the Mjølner ASIC and needs to be done in all three bands.

RX-calibration requires an external signal generator.

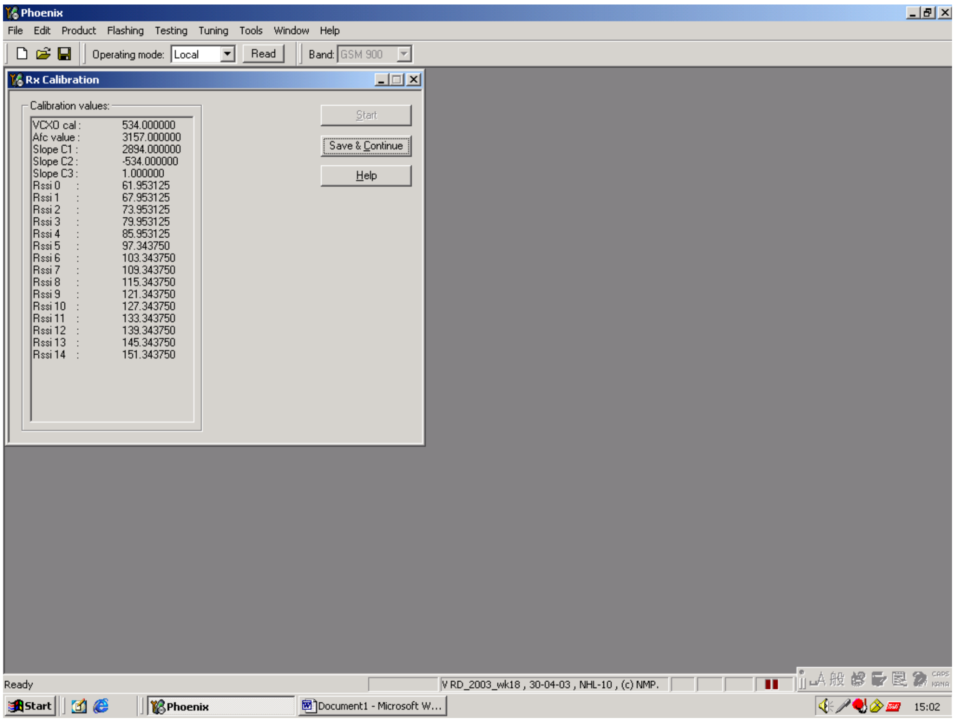
- Select **Tuning -> RX calibration**.
- Select band: **GSM900**.



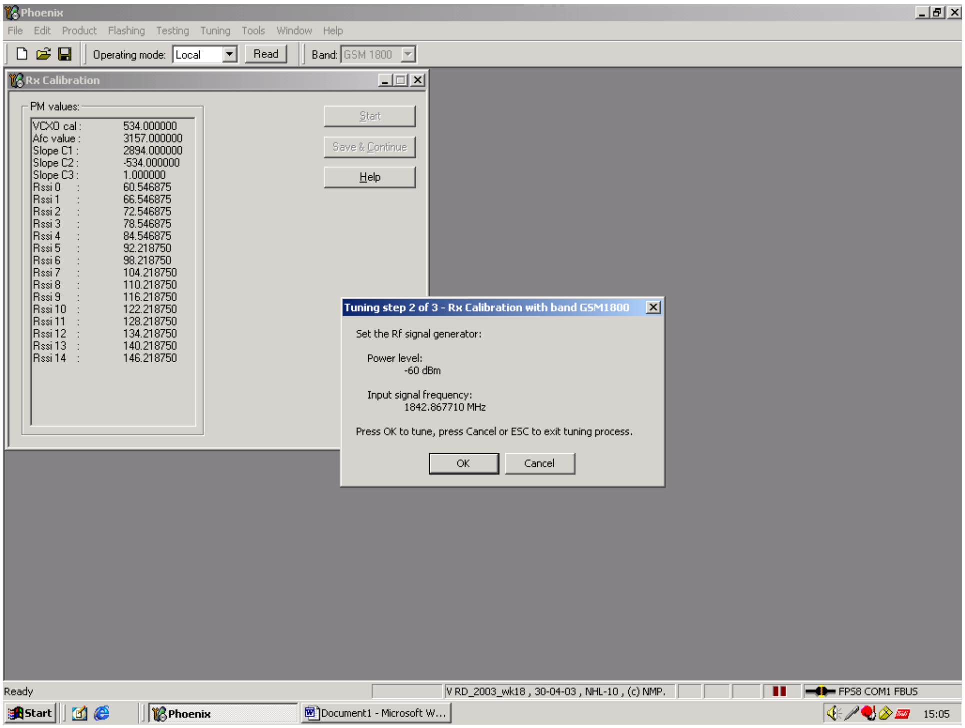
- Press **Start**.



- Follow the instructions in the pop–up window.
- Press OK.



- Press **Save & Continue**.



- Press **OK** and continue.

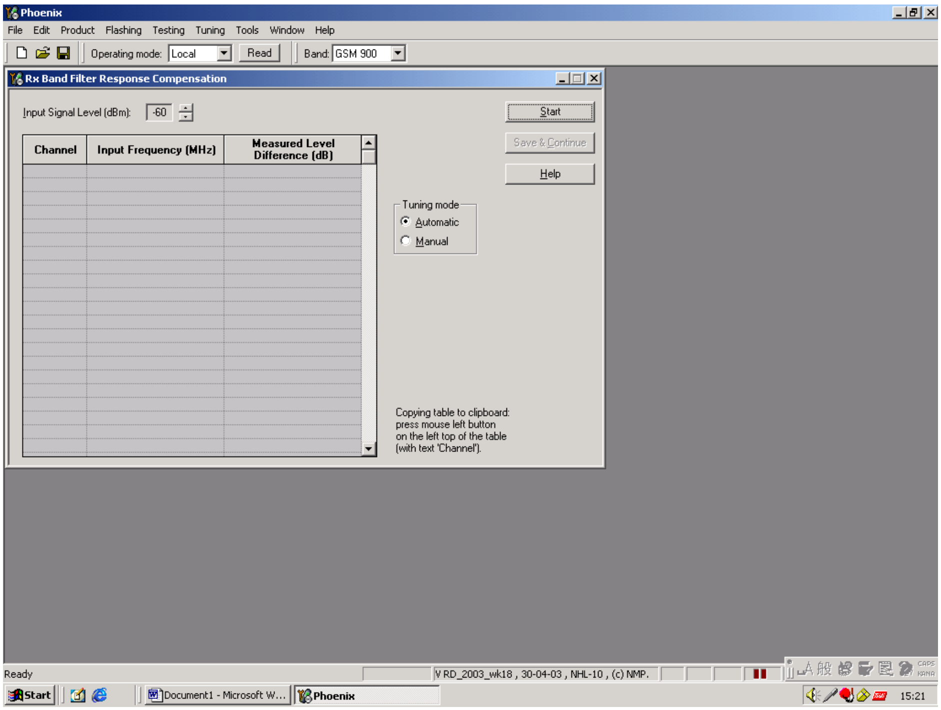
For GSM1900 just repeat the same procedure as for GSM900/GSM1800. If the calibration is OK, you should see “RX calibration was completed successfully” on the display.

RX Band Filter Response Compensation

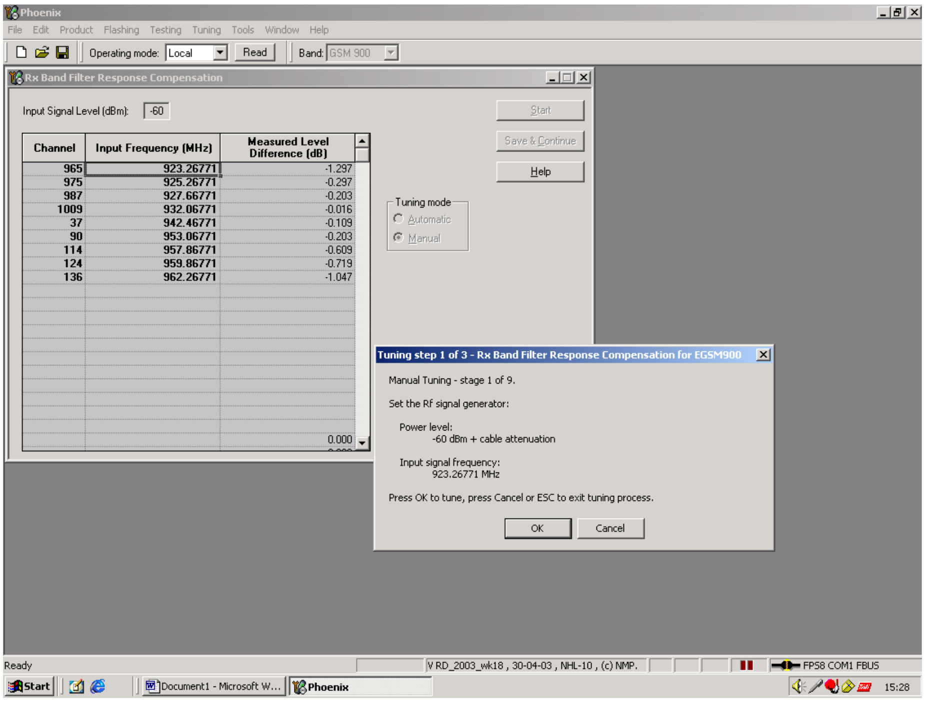
The Rx Band Filter Response Compensation has nine steps for each band.

The RF Band Filter Response Compensation requires an external signal generator.

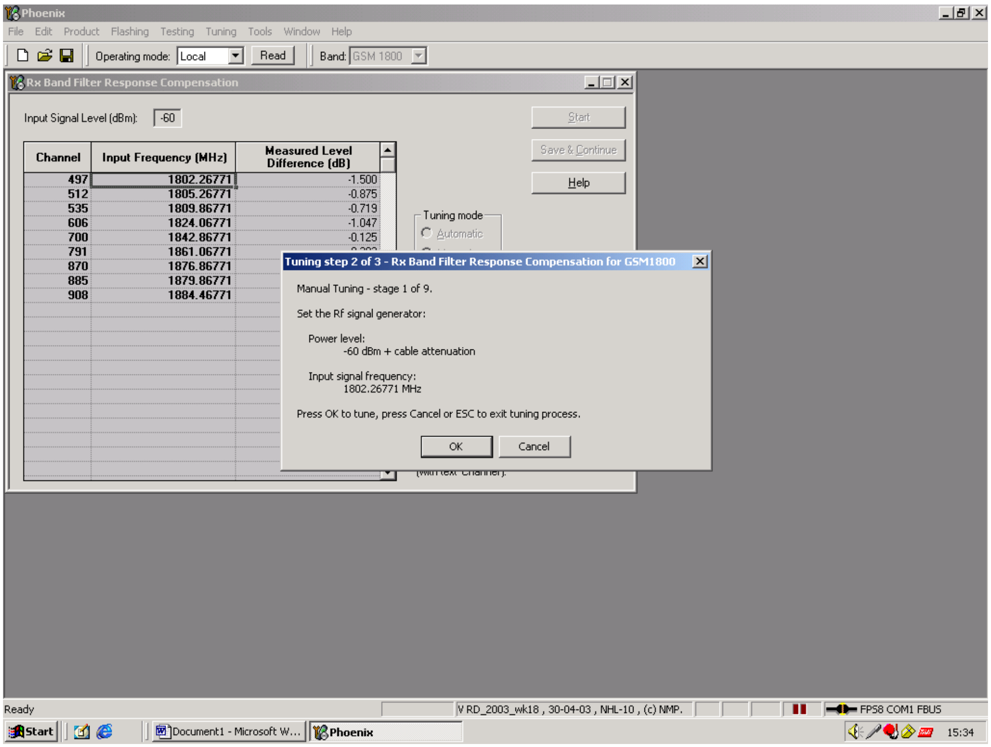
- Select **Tuning -> RX Band Filter Response Compensation**.



- Select **Manual**.



- Follow the instructions given in the following pop-up window. There are nine steps in all.
- After completing the nine steps of calibration at nine frequencies, press **Save & Continue**.



Repeat all steps as for GSM900 for the GSM1800 band. Follow all the instructions in the pop-up window. Repeat the procedure for GSM1900.

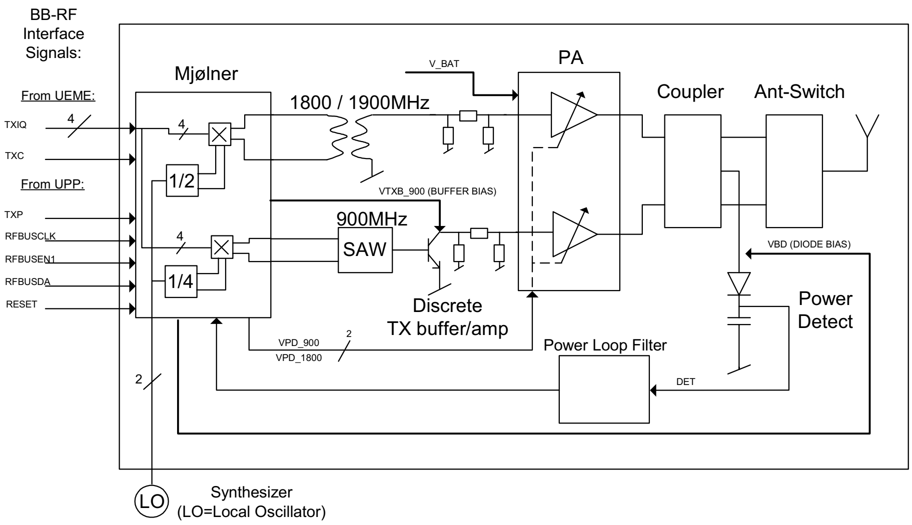
The tuning is completed.

Transmitter Troubleshooting

General Description

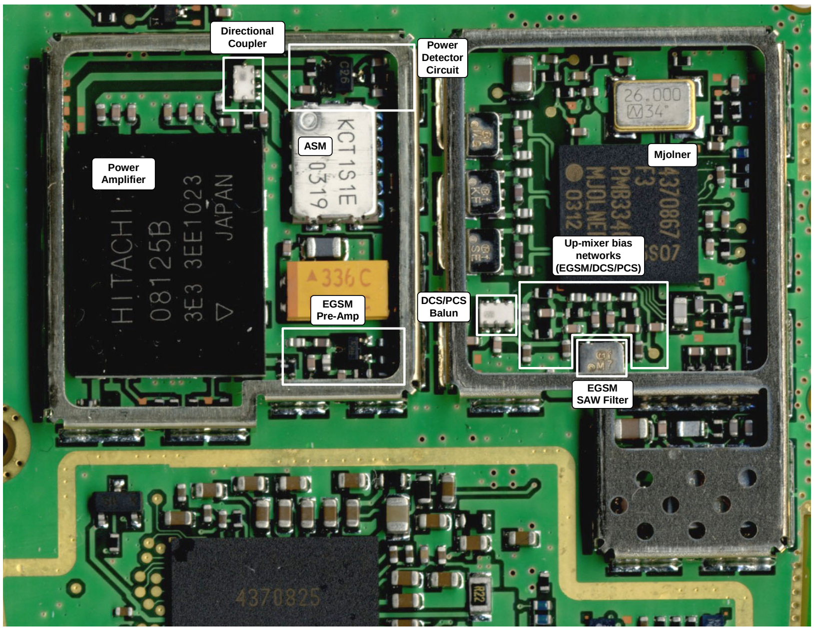
A simple block diagram of the TX part of the phone is shown in the following figure. The voice or data signals to be transmitted come from the UEME IC in the BB (Base Band) area, and go to the Mjølner IC, where they are up-converted to RF. The TX signals going from UEME to Mjølner are called the IQ signals, and consist of two balanced signals { TXIN, TXIP } and { TXQN, TXQP }, i.e. a total of four signal lines. In addition to the IQ-signals, there are also control signals going between BB and RF.

Figure 1: TX RF Block Diagram



The picture below shows the two shielding cans where the TX circuitry is located (the lid has been removed). The shielding can on the right side contains BB-RF interface circuitry, the Mjølner RF system IC, a SAW filter for the EGSM band, and a balun for the DCS/PCS band. The shielding can on the left side contains the power amplifier (PA), the EGSM pre-amplifier, the directional coupler, the power detector, and the Antenna Switch Module (ASM).

Figure 2: GSM RF area



Preparation for Fault Finding

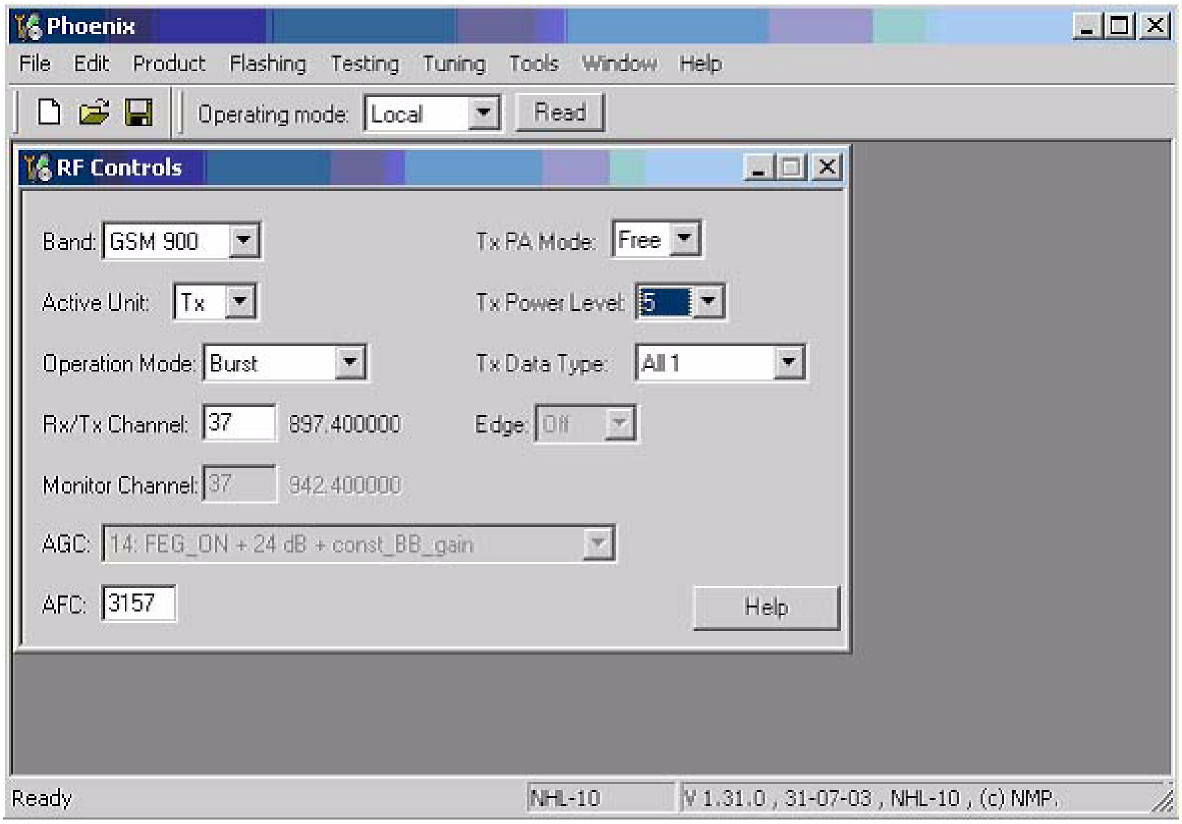
1. Place phone (mechanics removed) on module jig.
2. Connect the module jig to the PC via a DAU-9S cable.
3. Connect the module jig to the power supply (4.2V).
4. Connect the RF output to a spectrum analyzer or another measurement instrument.
   Use a 10dB attenuator at the input to spectrum analyzer to avoid damaging it.
5. Make sure the dongle is connected and start Phoenix.
6. In Phoenix, select **File -> Open Product -> NHL-10 6600 Product Menu**.
7. Select **Testing -> RF Controls**.
8. From the toolbar, set **Operating Mode** to **Local**.
9. Select band: **GSM900**, **GSM1800** or **GSM1900**.
10. Set **Operation Mode** to **Burst**.
11. Set **Active Unit** to **TX**.
12. Set **TX Data Type** to **All1**.

13 Set **RX/TX Channel** to 37 for GSM900, 700 for GSM1800 or 661 for GSM1900.

14 Set TX PA **Mode** to **Free**.

15 Set TX **Power Level** to 5 in GSM900, otherwise to 0.

Phoenix should now look as shown in the following figure.



Fault-finding chart: TX-BB interface and control signals

Figure 3: Fault finding chart of BB-TX interface & some control signals

Start

Using a multimeter, check power supply lines to Mjolner:

Line	Voltage	Test Points
VR1a	4.75V	J612
VR2	2.78V	J613
VR3	2.78V	J614 (J601)
VR5	2.78V	J616
VR6	2.78V	J617
VR7	2.78V	J618

Not OK → Check UEME (D190) in BB area

OK ↓

Using the oscilloscope, check TXC and TX IQ lines from UEME to Mjolner:

Line	Testpoint	DC Voltage	AC Voltage	Frequency
TXIOUTP	R715	1.1Vdc	0.4Vp-p	67kHz
TXIOUTN	R715	1.1Vdc	0.4Vp-p	67kHz
TXQOUTP	R716	1.1Vdc	0.4Vp-p	67kHz
TXQOUTN	R716	1.1Vdc	0.4Vp-p	67kHz
TXC	J611	Depends on the power level		217Hz

Not OK → Check UEME (D190) in BB area

OK ↓

Using the oscilloscope, check TXP from UPP:

Line	Testpoint	Vpp	Frequency
TXP	J610	1.8V	217Hz

Not OK → Check UPP (D100) in BB area

OK ↓

Using the oscilloscope, check control signals from Mjolner to ASM[1]:

Line	Testpoint	GSM900	GSM1800	GSM1900	Period
Cont1	R702	0V	2.7V	2.7V	4.615ms
Cont2	R703	0V	2.7V	2.7V	4.615ms
Cont3	R701	2.7V	0V	0V	4.615ms

[1]ASM = Antenna Switch Module

Not OK → Check serial interface between Mjolner & UPP

OK ↓

Use Phoenix to set TX_Data_Type to 'Random' and to set TX Power Level to '5'

↓

Use the oscilloscope to check the voltage supply line to the transistorized pre-amplifier: VTXB_900

Not OK → Check serial interface between Mjolner & UPP

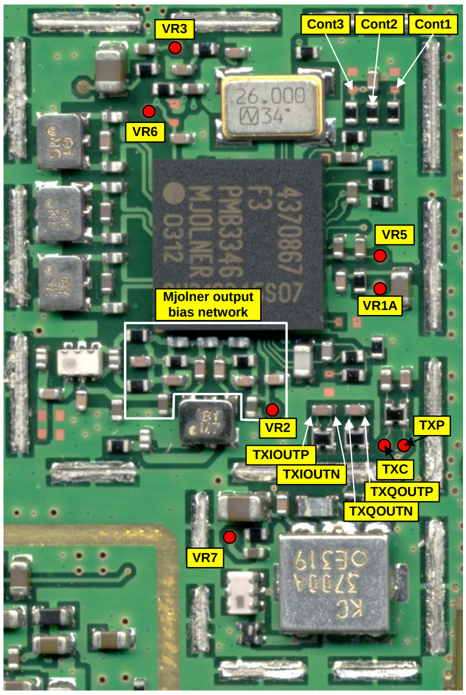
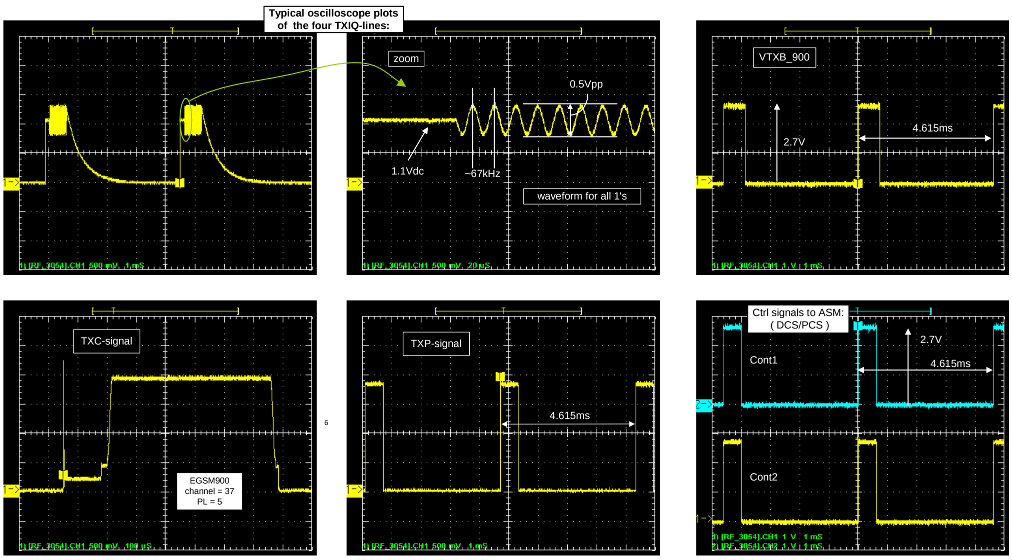
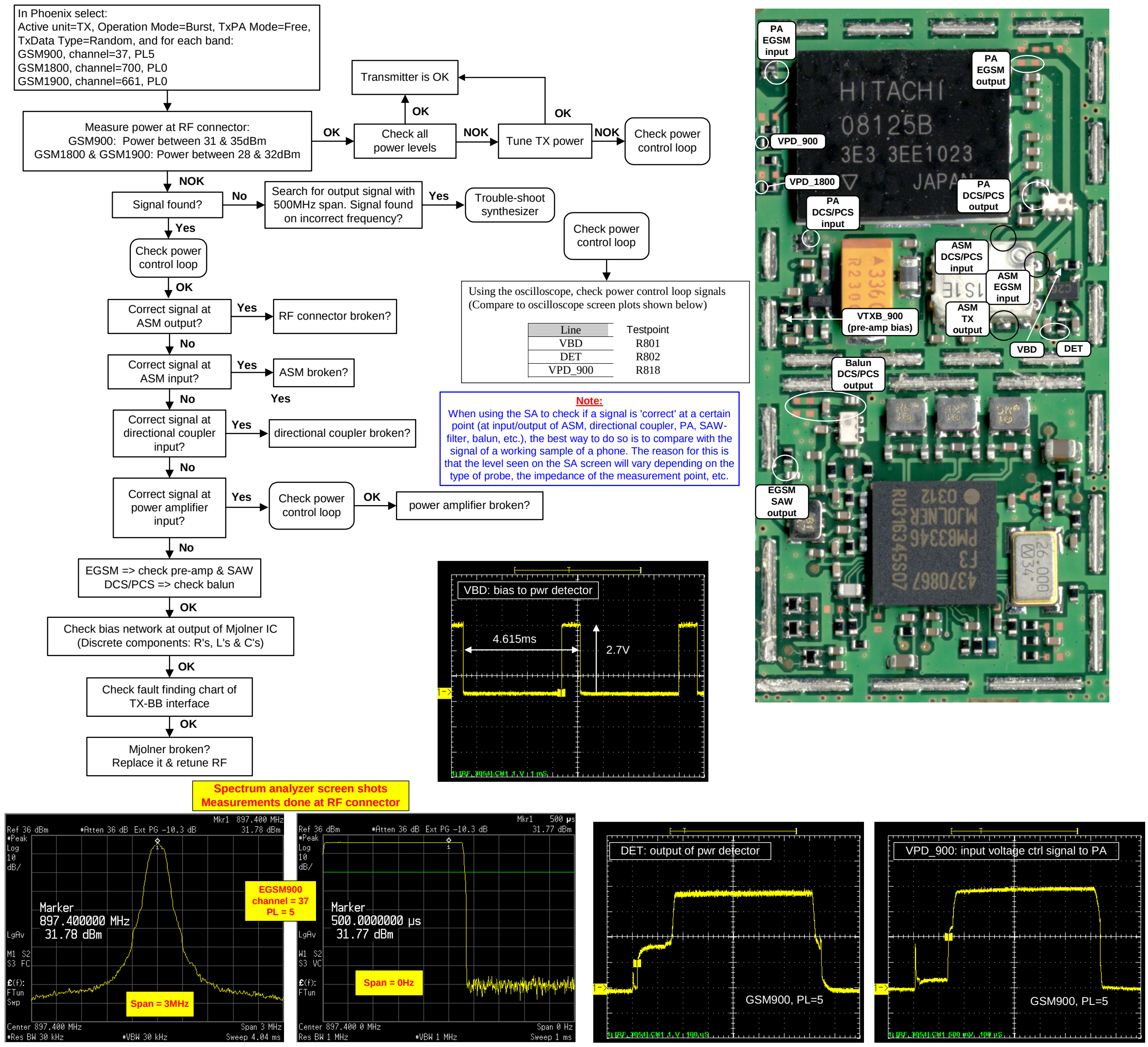


Figure 4: Oscilloscope screen shots



Fault-finding chart: RF side of transmitter



Transmitter Tuning

Introduction

In the transmitter, there are two kinds of tunings that can be performed. These are IQ-tuning and power level tuning. In general, different repairs require different tunings. In order to decide which tuning is necessary after a repair, it is important to understand well the functionality of the repaired circuit. In general, it is recommended that if any TX component is changed, both these tunings are done.

Note: All tunings are done in local mode using Phoenix to control the phone.

TX IQ Tuning

The tuning must be carried out in all three bands. In addition to Phoenix, a spectrum analyzer (SA) is needed. Connect the SA to the RF connector of the module jig. The settings of the spectrum analyzer will depend on the band to be tuned. The following table summarizes the settings for each of the three bands.

Table 1: Spectrum Analyzer Settings

	EGSM900	GSM1800	GSM1900
Center frequency	897.4MHz	1747.8MHz	1880MHz
Frequency span	300kHz	300kHz	300kHz
Resolution Bandwidth	3kHz	3kHz	3kHz
Video Bandwidth	3kHz	3kHz	3kHz
Sweep Time	3 sec	3 sec	3 sec
Trace Type	Clear/Write	Clear/Write	Clear/Write
Detector Type	Max Peak	Max Peak	Max Peak
Reference Level	35dBm	35dBm	35dBm
Marker 1	897.33229 MHz	1747.73229 MHz	1879.93229 MHz
Marker 2	897.4MHz	1747.8MHz	1880MHz
Marker 3	897.46771MHz	1747.86771MHz	1880.06771MHz

For this tuning, two windows of Phoenix must be open: (1) **Testing** -> **RF Controls**, and (2) **Tuning** -> **TX IQ Tuning**, as seen in figures below.

Figure 1: Phoenix set-up

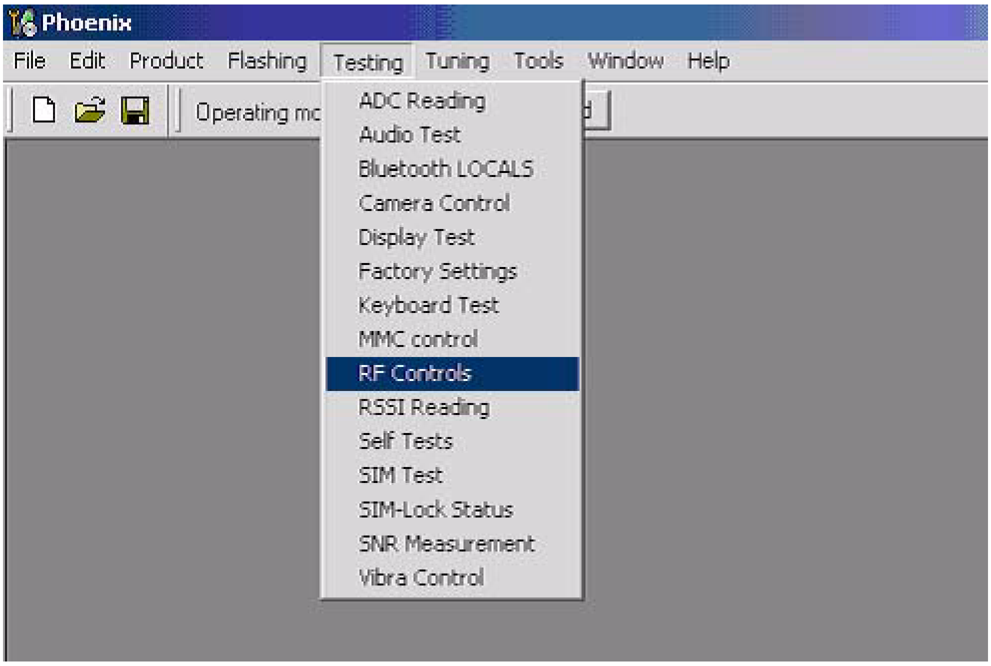
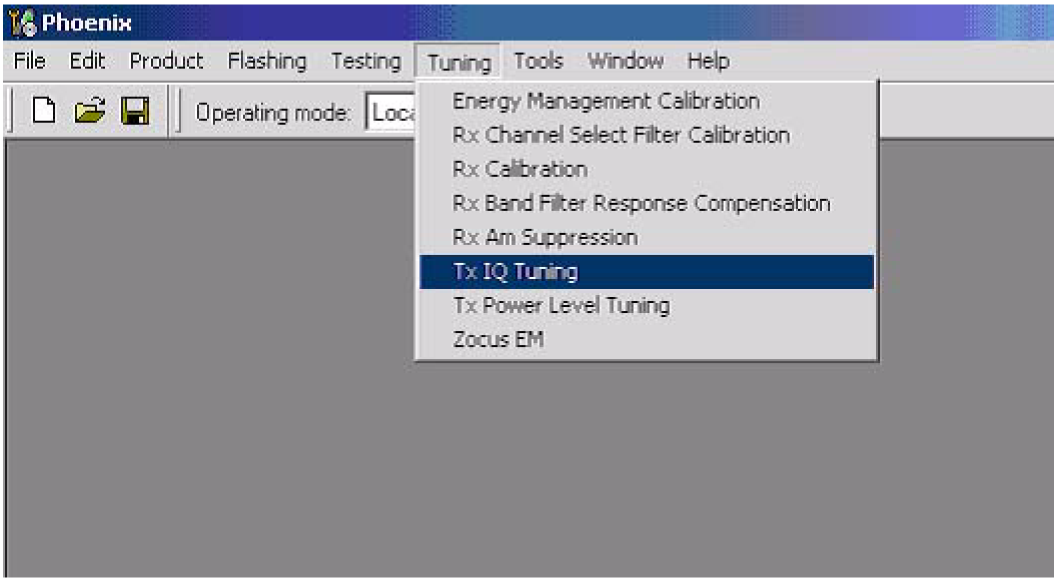
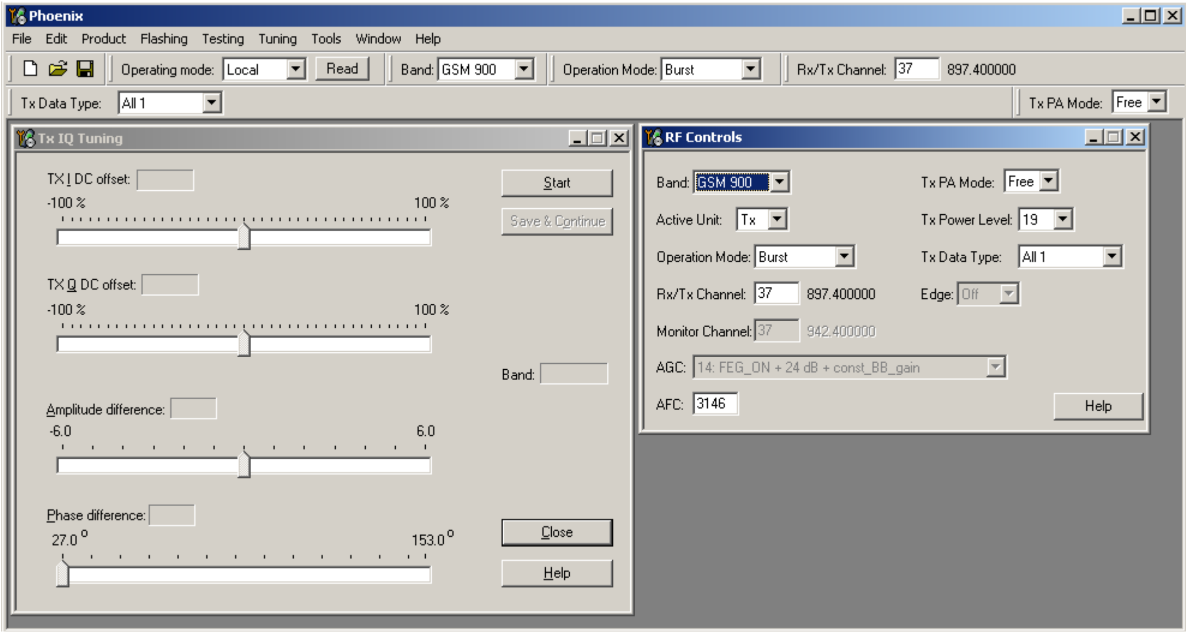


Figure 2: Phoenix set-up



After opening the two before-mentioned windows, Phoenix should look as shown in the following figure.

Figure 3: Phoenix set-up



The following table summarises the settings of the RF control window for the IQ tuning of the three bands.

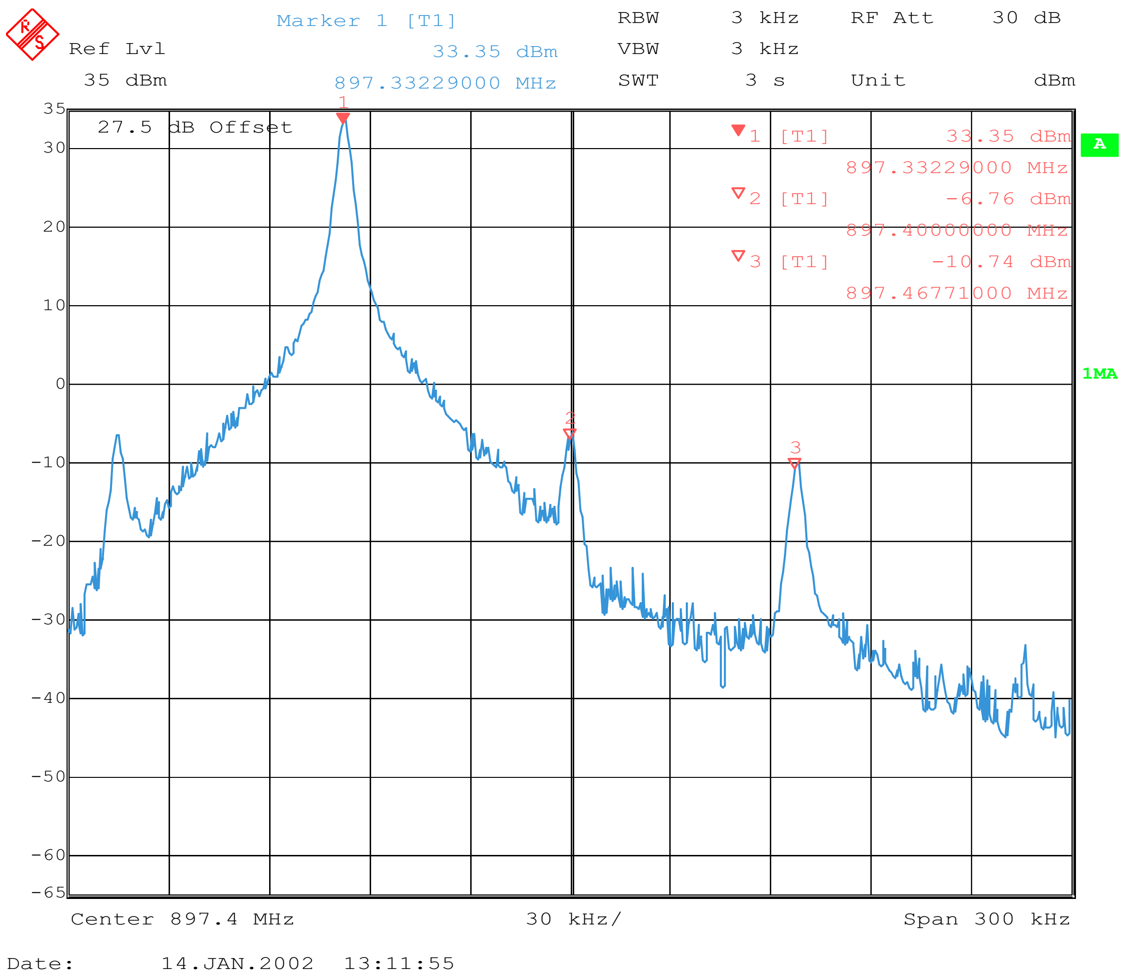
Table 2: RF Control Window Settings

Band	TX Data Type	TX Power Level	RX/TX Channel
GSM900	All 1	5	37
GSM1800	All 1	0	700
GSM1900	All 1	0	661

To start the IQ tuning, press **Start** in the **IQ Tuning** window.

The spectrum analyzer screen should now look similar to that of the figure below (GSM900 case).

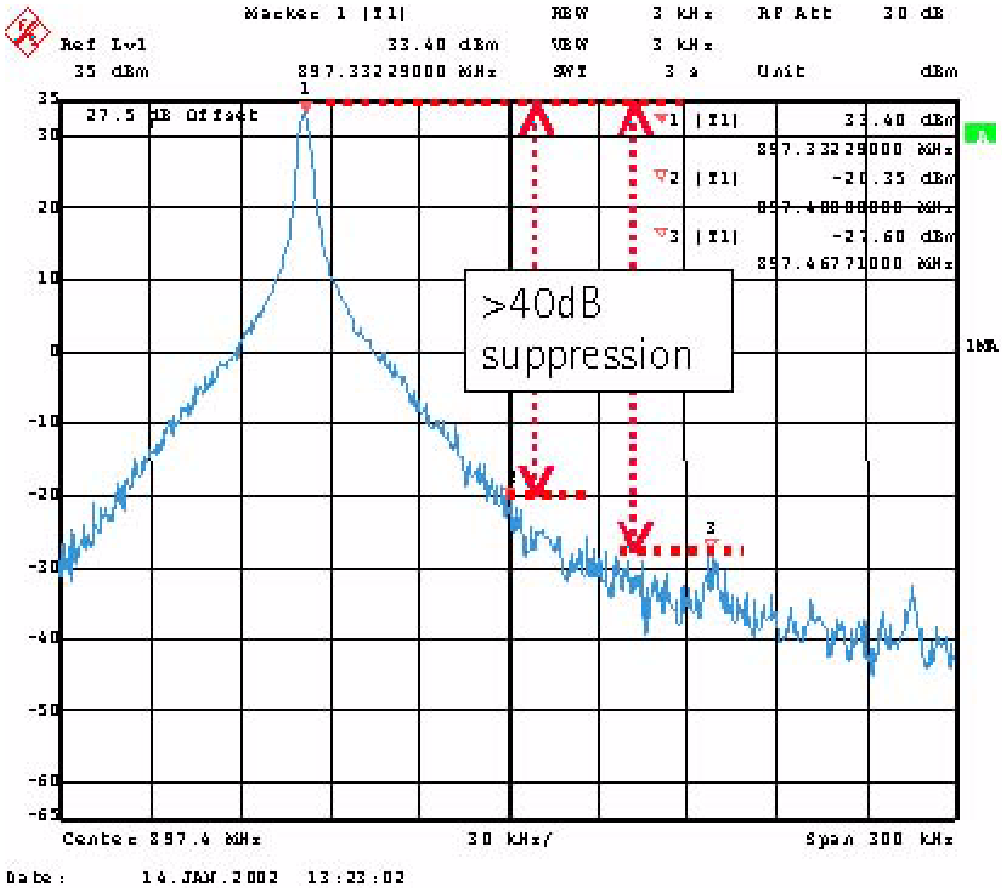
Figure 4: Spectrum analyzer screen shot when performing IQ tuning



The purpose of this tuning is to reduce the frequency components at marker 2 (carrier leakage) and marker 3 (+67kHz / upper sideband) as much as possible. Adjust the **TXI DC Offset** and the **TXQ DC Offset** buttons in the TX IQ Tuning window so that the carrier level (marker 2) reaches a minimum. After this adjustment, the carrier (marker 2) should be at least 40dB below the lower side band (marker 1).

Next, use the **Amplitude difference** and the **Phase difference** buttons in the **TX IQ Tuning** window to adjust the upper side band (marker 3) to a minimum. Now, marker 3 should also be at least 40dB below marker 1.

At this point, the spectrum analyzer screen should look similar to that of the figure below.



After reducing the amplitude of the frequency components at marker 2 and 3 to a minimum, press **Save & Continue**. The EGSM tuning has now been completed.

Now, using the spectrum analyzer settings of Table 1, and the RF control settings of Table 2, follow exactly the same procedure to perform IQ tuning in the GSM1800 and GSM1900 bands.

TX Power Level Tuning

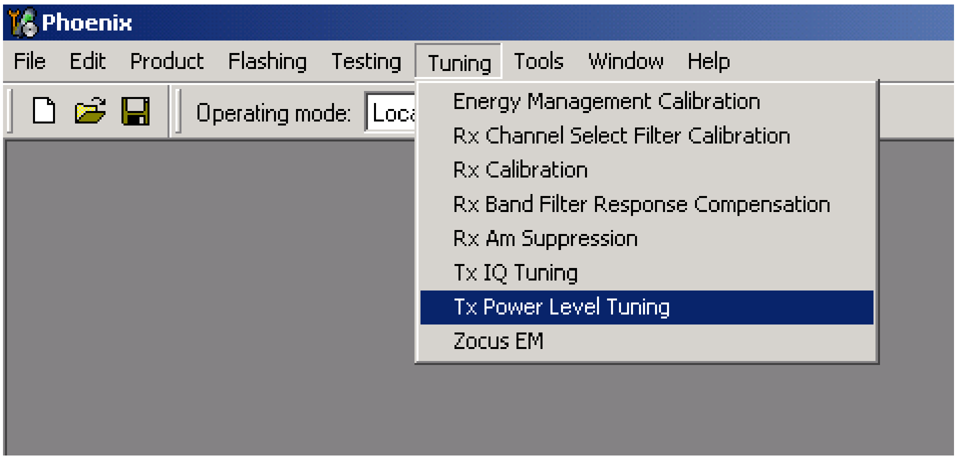
This tuning is done separately in all three bands, and requires a spectrum analyzer to measure the burst power of the GSM RF signal. When measuring the RF output (burst) power on a spectrum analyzer, use the settings found in the following table:

Table 3: Spectrum Analyzer Settings

	EGSM900	GSM1800	GSM1900
Center frequency	897.4MHz	1747.8MHz	1880MHz
Frequency span	Zero-span	Zero-span	Zero-span
Resolution Bandwidth	1MHz	1MHz	1MHz
Video Bandwidth	1MHz	1MHz	1MHz
Sweep Time	1ms	1ms	1ms
Trigger Type	Video	Video	Video
Trace Type	Clear/Write	Clear/Write	Clear/Write
Detector Type	Max Peak	Max Peak	Max Peak

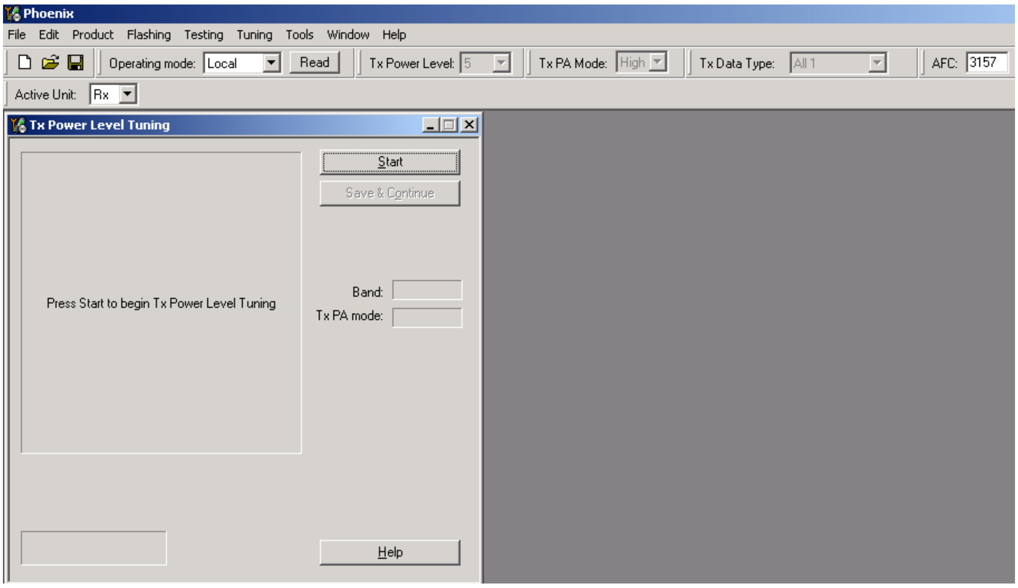
In Phoenix, select **Tuning** -> **TX Power Level Tuning**.

Figure 5: Phoenix menu select



Phoenix should now as shown in the figure below.

Figure 6: Phoenix power level tuning menu



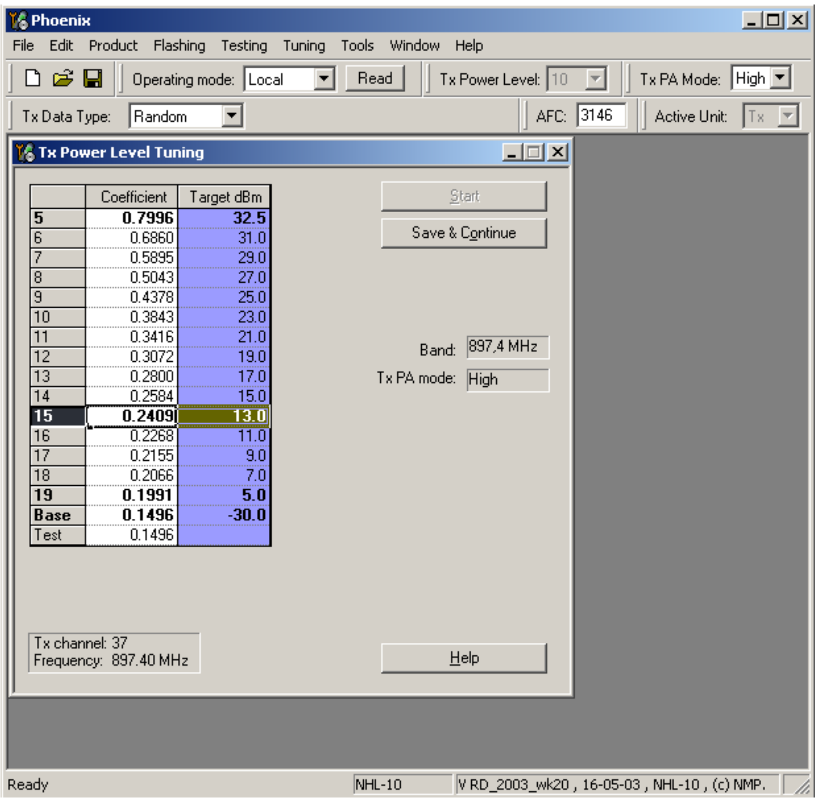
Connect the module jig RF output to the measurement instrument. In the EGSM band the power must be tuned in both high and low TX PA mode. In the two upper bands (GSM1800 and GSM1900) there is only one mode.

For each band, tune the power by adjusting the coefficient in the **Tx Power Level Tuning** window in Phoenix until the target level is reached (measured on the spectrum analyzer). Remember to take into account the external power loss, i.e. the loss of the cable and the external attenuator at the spectrum analyzer input. The coefficient must be tuned for the base level and other levels, marked with bold letters in Phoenix (GSM900: PL19/15/7/5, GSM1800/1900: PL15, 11, 0).

When the tuning has been completed, press **Save & Continue** to save the new tuning values into the phone memory.

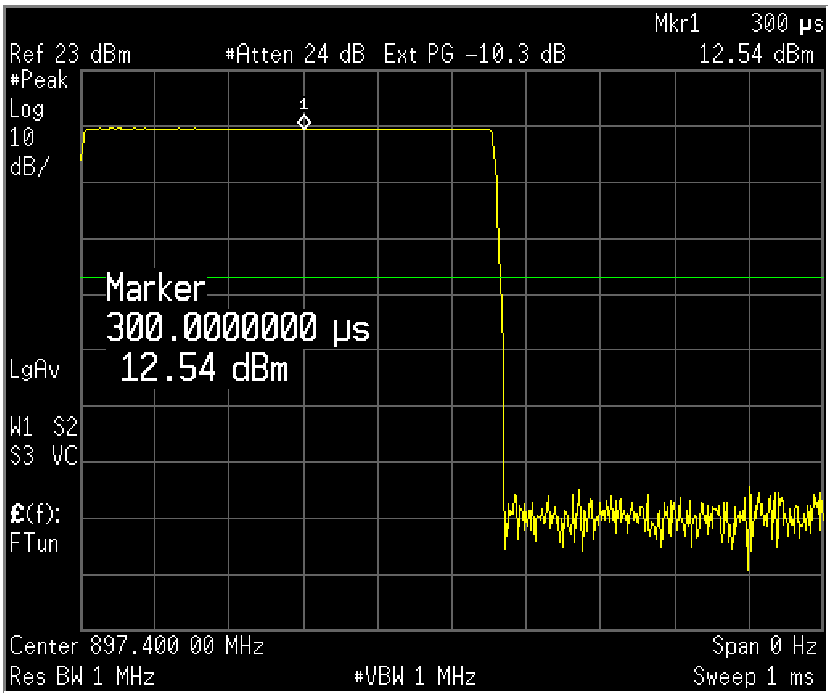
The following figure shows the power level tuning at the GSM900 band.

Figure 7: Phoenix screen shot



The next figure shows the spectrum analyzer screen shot associated with the above Phoenix screen shot.

Figure 8: Spectrum analyzer screen short during power level tuning



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