

# Frequency synthesizer module based on MAX2871/ADF4350/ADF4351

## Frequency synthesizer SHF module based on MAX2871/XX1002

(HW version 4 / SynProg version 3.7)

### 1 Introduction

The frequency synthesizer module ("module" later in text module) and module version with frequency doubler ("SHF module" later in text) can be used in several operation modes:

1. Signal source controlled from the PC
2. Autonomous signal source which can generate four frequencies preprogrammed by the user
3. Beacon which can send CW text, the scan mode with up to four frequencies is also available. All beacon parameters are user programmable.

Module specifications depends of the installed synthesizer chip, see tables below for the details:

**Table 1 ADF4350/ADF4351/MAX2871 module specifications**

Parameter	Value		
	ADF4350	ADF4351	MAX2871
Frequency range, MHz	137,5..4400	35..4400	23.5..6000
Output level (no less then), dBm	+10	+10	+10*
Signal leakage in CW pause, dB	-70		
External reference level, Vp-p	0.8..3.3 (+1..+13dBm at 50Ohm)		
Power supply voltage, V	+5		
Supply current, mA	170		
Dimensions (LxWxH), mm	56x38,5x6		

\* Up to 4.5GHz output frequency, output level is not less then +5dBm at higher frequencies

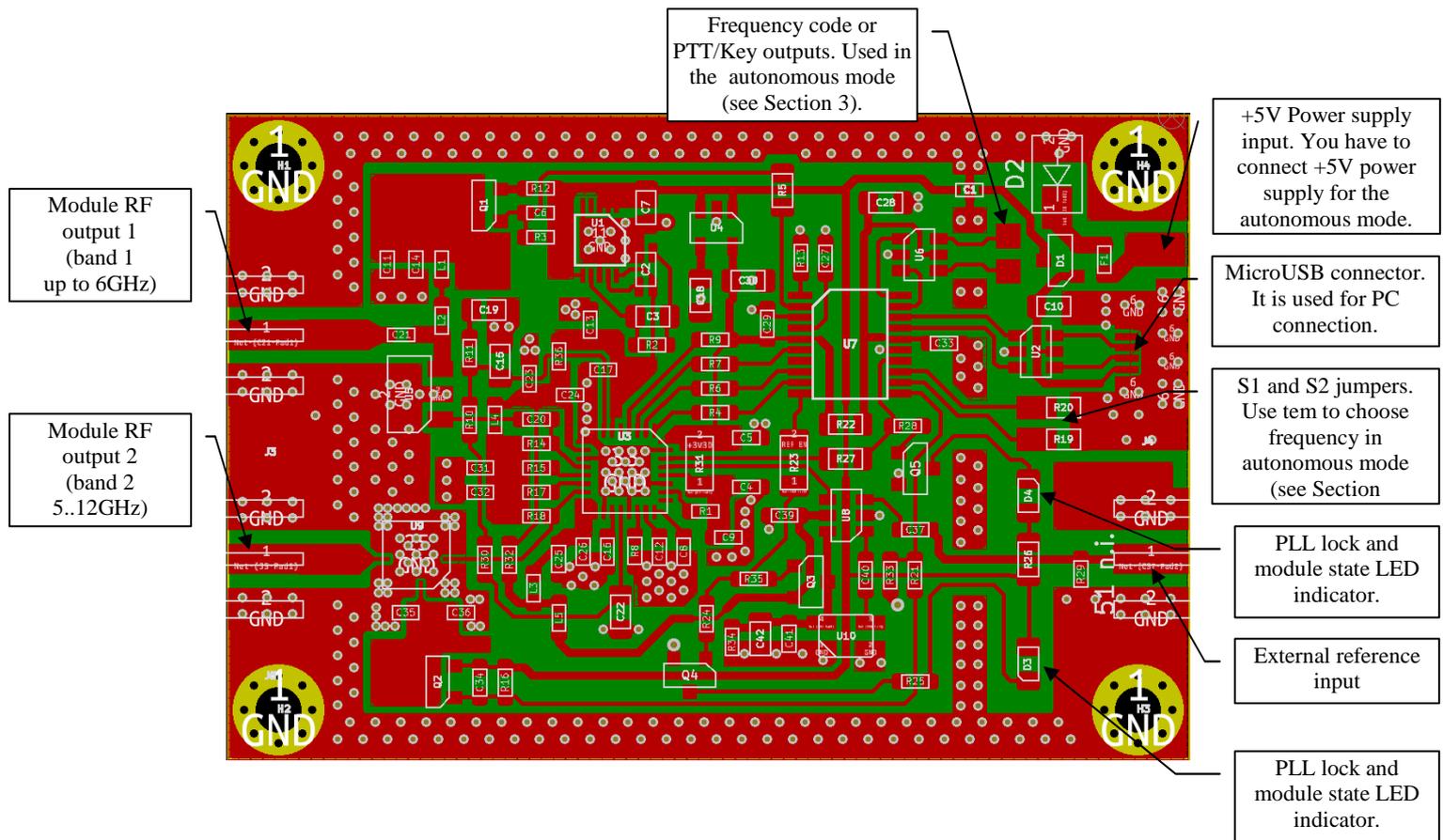
**Table 2 SHF module (MAX2871 and X1002-QH doubler) specifications**

Parameter	Value	
	Output 1	Output 2
Frequency range, MHz	23,5..6000	5000..12000
Output level (no less then), dBm	+10*	+10
Signal leakage in CW pause, dB	-60	TBD
External reference level, Vp-p	0.8..3.3 (+1..+13dBm at 50Ohm)	
Power supply voltage, V	+5	
Supply current, mA	170	220
Dimensions (LxWxH), mm	56x38,5x6	

\* Up to 4.5GHz output frequency, output level is not less then +5dBm at higher frequencies

The RF part of the module is basically the same as in the synthesizer module described in this article <https://vhfdesign.com/ru/pll-lo/lo-pll-adf4350.html> . The new module differs by the controller and the firmware, so much more features were realized. There is also SHF module variant with the additional frequency double on the second output. It provides the same functionality and parameters (as usual module) on the first output, but has second output for the 5..12GHz band.

## 2 Module connections and jumpers



## 3 Autonomous mode

*Note: you have to use external power supply (or USB charger) to run module in autonomous mode. You will be unable to run module in autonomous mode if module is connected to the USB port of computer.*

The module use in autonomous mode is straightforward and simple. When the power is applied to the module (the USB interface should not be connected in this mode) it should blink five times with the LOCK led (blinking indicated that MCU and connection between the MCU and synthesizer chip is OK). The module then will start to operate according to the programmed mode of operation and S1/S2 jumpers state (see Section 2 and Table 3). The LOCK led should lit if programmed frequencies are correct and module operates correctly.

In signal source mode the module will generate one of the user preprogrammed frequencies according to the S1/S2 jumpers state (see Table 3).

In beacon mode (with scanning disabled) module will send the programmed text in the endless loop on the frequency selected by the S1/S2 jumpers.

In beacon mode with scanning enabled the module will send the preprogrammed text on the frequency selected by the S1/S2 jumpers, then it will switch on the next frequency and will send the text again, and so on in the endless loop. So it will send the text sequentially on the active frequencies. The current frequency can be determined by using 1 and 2 contacts on the board

(see Section 2 and Table 4), you have to switch those outputs to *Frequency code* mode (see Section 4.5). Also the PTT and CW keying signals can be obtained at the 1 and 2 contacts if the corresponding output mode was selected (see Section 4.5).

**Table 3 Frequency selection by the jumpers**

<b>Jumpers state</b>	<b>Frequency</b>
S1, S2	F1
S2	F2
S1	F3
Not installed	F4

**Table 4 Frequency code on 1 and 2 contacts**

<b>Current frequency</b>	<b>Contact</b>	
	<b>1</b>	<b>2</b>
F1	3.3V	3.3V
F2	0V	3.3V
F3	3.3V	0V
F4	0V	0V

## 4 Module use with PC

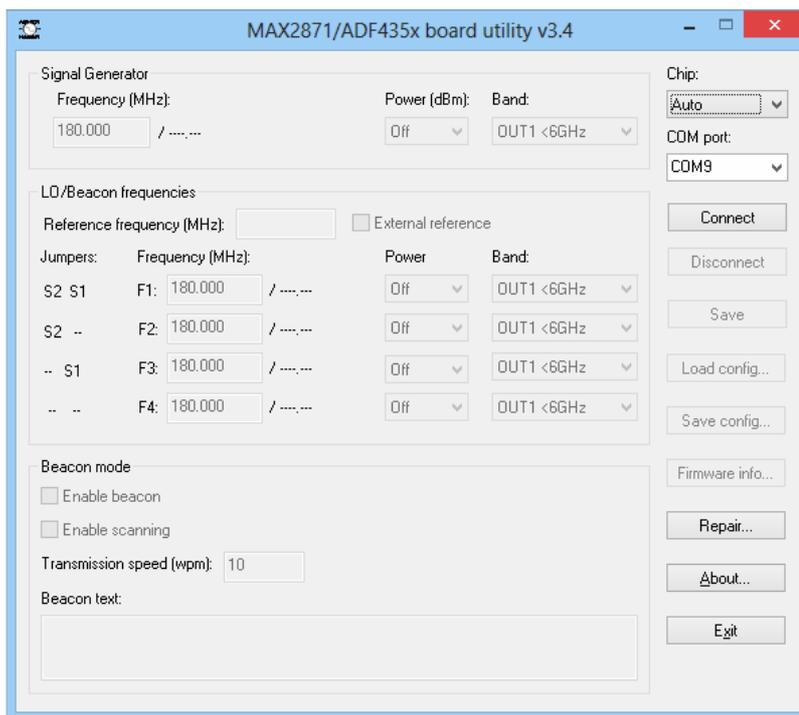
### 4.1 Connecting module to PC

You have to connect module to PC to program it, use in the signal source controlled from the PC mode or updating module firmware.

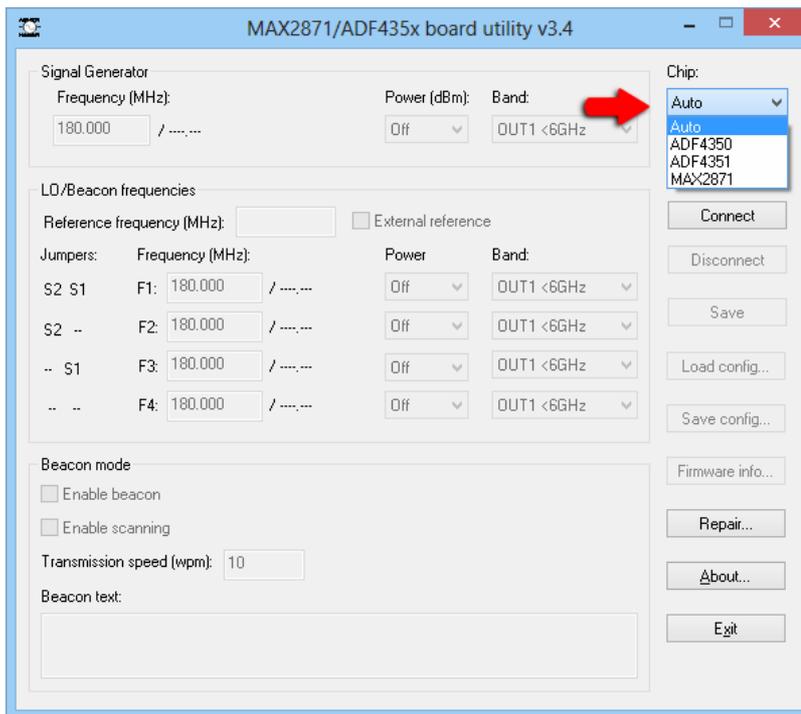
Connect standard microUSB cable to the module and then connect it to the PC's USB port (you **should not** supply external power to the module). The PC should find the STMicroelectronics Virtual COM Port and install drivers for it automatically. You can download and install driver manually from here <https://vhfdesign.com/data/zip/en.stsw-stm32102.zip> or here <http://www.st.com/en/development-tools/stsw-stm32102.html> in case of any difficulties.

When the drivers are installed and the module is connected to the PC's USB port run **SynProg** (the program can be downloaded from this page <https://vhfdesign.com/ru/pll-lo/lo-pll-usb.html>). You should see the following main program dialog on start up (see below). The synthesizer chip type can be determined automatically for the module firmware version 3.01.0373 or higher. If your module has older firmware you can select chip type manually or upgrade module firmware to use automatic chip selection feature.

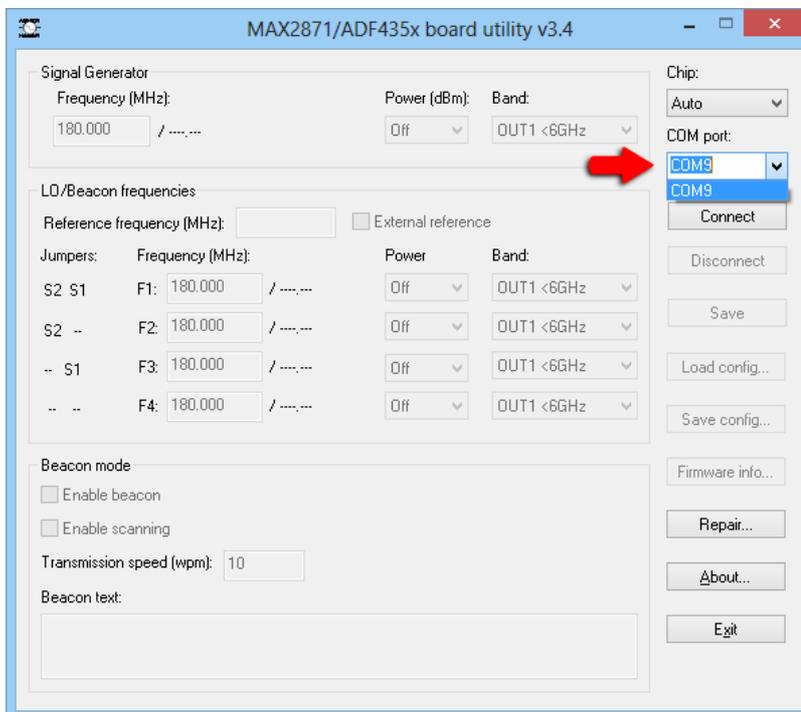
When you run **SynProg** program it sets automatic chip selection mode and selects first available COM port:



Select the correct chip in the *Chip* dropdown list for the manual chip type selection, for the automatic chip type selection leave *Auto* value:



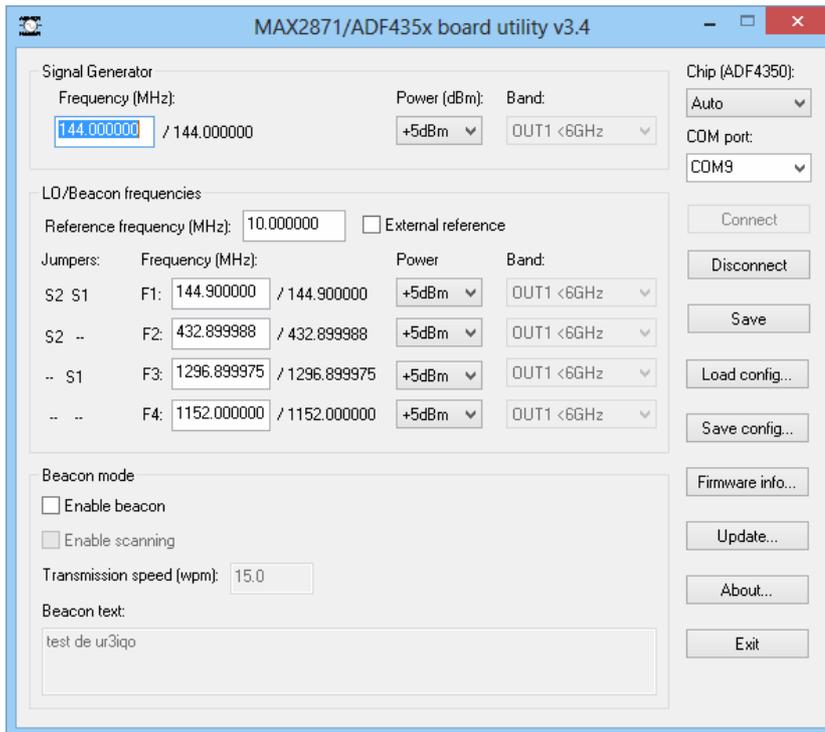
Select the correct virtual COM port (one assigned to the module during drivers installation, see above) in the *COM Port* combobox:



Press the *Connect* button.

The synthesizer control controls should become active as well as *Disconnect*, *Save*, *Load config*, *Save config* buttons (the band selection dropdown lists *Band* will become active for the SHF module). The parameters displayed in the program will correspond to the currently

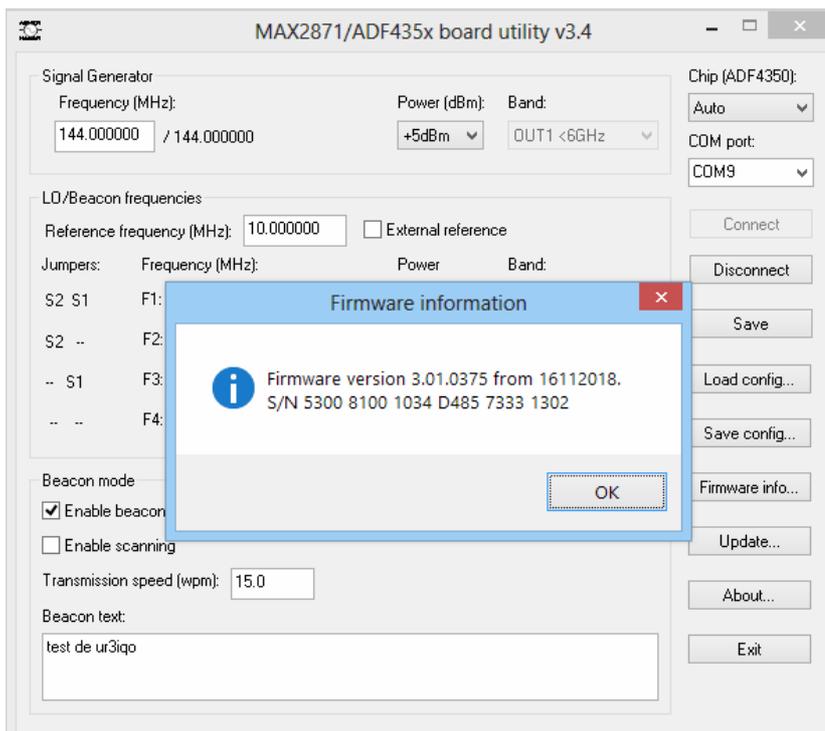
programmed values in the module. The *Chip* field will be updated with the chip type used in the module:



## 4.2 Checking module firmware and SynProg utility versions

You can check module's firmware version, build date and module's serial number when module is connected to PC and connection between SynProg utility and module is established (see Section 4.1). Also you can check the **SynProg** utility version by pressing the *About* button.

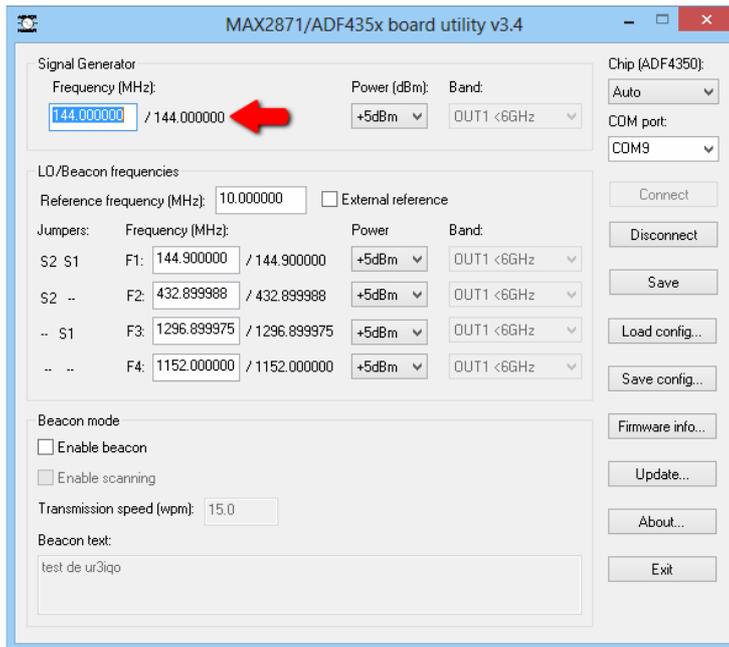
Press the *Firmware info* button to get the module's firmware information:



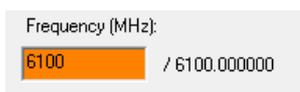
### 4.3 Signal source controlled from the PC mode

You have to connect module to the PC to use it in the signal source controlled from the PC mode (see Section 4.1). When the connection between **SynProg** utility and module is established it will switch to the signal source controlled from the PC mode.

The frequency can be set in the *Signal Generator* -> *Frequency* field. The real programmed frequency is shown just at the right of the frequency field. There is a special algorithm in the module's control utility which programs the synthesizer chip optimally minimizing the possible frequency error. The synthesizer uses 10..15MHz PFD frequency, but it is able to achieve tuning steps as small as tens of Hz in many cases:



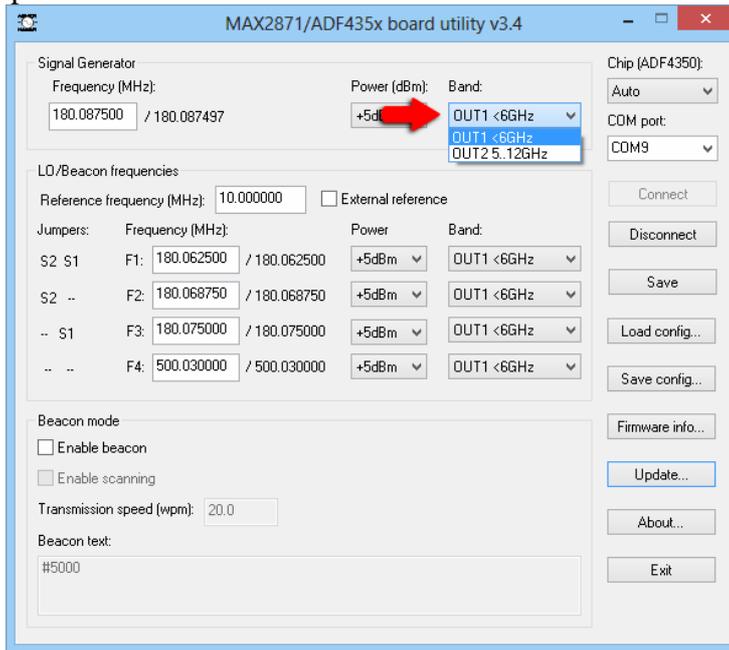
If the frequency is outside of the synthesizer chip frequency range the background color of the *Frequency* field will change to orange:



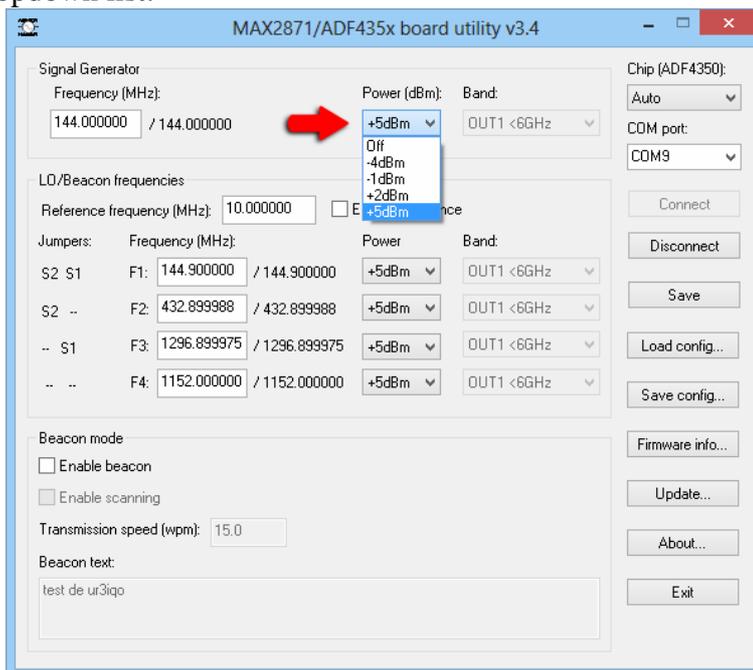
Usually there are some margins at the band edges, so the **SynProg** utility will allow you to program out of band frequencies to the module (but since the correct operation is not guaranteed it will warn you, see Section 4.4).

You can also use mouse wheel and UP/DOWN keys to tune frequency. Set the caret at the digit you want to change and rotate mouse wheel or press UP/DOWN keys. The frequency part to the left of the caret will change.

You can select the active output and frequency band for the SHF module using the *Band* dropdown lists:



The synthesizer chip output level can be changed using the *Signal Generator-Power* dropdown list:



The values in the list corresponds to the signal level at the output of the synthesizer chip, the real module output signal level is much higher (there is an amplifier on the module's board), also the output level depends of the frequency. You can find the typical output signal values in the Table 5 and Table 6. You should avoid setting output levels which lead to the output amplifier overload (setting output levels marked with red color in tables may degrade synthesizer phase noise and spurious signals level performance). The synthesizer chip output level is fixed at -1dBm when using the second output on the SHF module (5..12GHz band) to conform with the specifications of the doubler chip. This will result in more than +10dBm signal level on the board second output.

The module change frequency and output level (and switches outputs on the SHF module) shortly after the values in the *Frequency* field and *Power* dropdown list in the PC software were changed.

**Table 5 Typical ADF4350 based module output levels depending of frequency and output power settings**

Output level settings, dBm	Frequency, MHz					
	200	500	1000	2000	3000	4000
-4	12,8	12,5	11	7,3	7,2	6,2
-1	15,0	14,9	13,3	9,4	9,3	7,9
+2	16,1	16,5	14,9	11,1	11,2	9,5
+5	16,5	17,2	16,2	12,5	13,0	10,5

**Table 6 Typical MAX2871 based module output levels depending of frequency and output power settings**

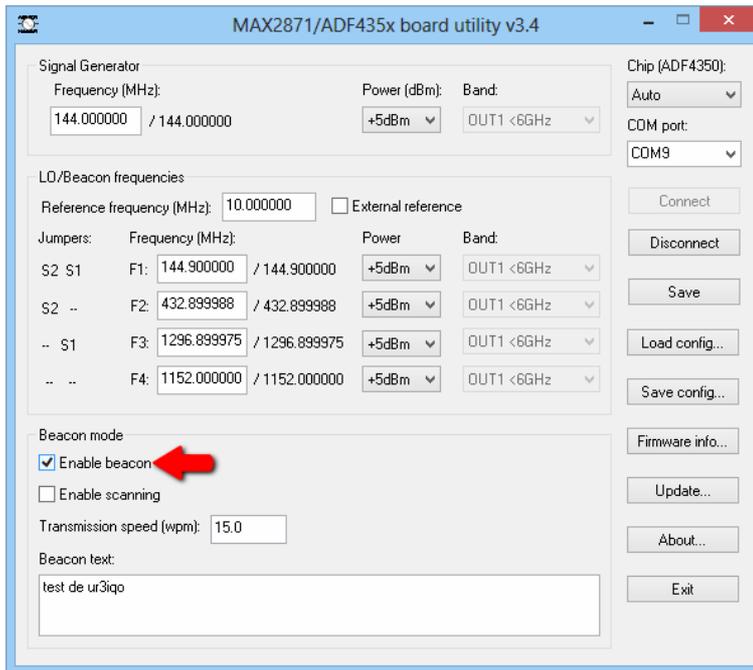
Output level settings, dBm	Frequency, MHz							
	50	100	200	500	1000	2000	3000	6000
-4	6,8	10,8	14,7	14,4	12,7	8,3	9,8	-0,5
-1	7,8	12,0	16,0	16,2	14,6	10,3	11,8	2,8
+2	8,4	12,5	16,5	17,1	16,1	12,1	13,0	4,5
+5	8,4	12,5	16,5	17,3	16,9	12,5	13,6	5,2

#### **4.4 Setting autonomous and beacon mode parameters**

You have to connect module to the PC to use it in the signal source controlled from the PC mode (see Section 4.1). When the connection between **SynProg** utility and module is established it is ready to program autonomous mode and beacon parameters.

Four frequencies for the autonomous mode are set in the *LO/Beacon frequencies* group. You can program up to four frequencies. Each frequency corresponds to one state of the S1/S2 jumpers. The frequencies, signal level and band/output port (for the SHF module) are set in the same way as described in Section 4.3 for the PC controlled signal source mode.

The beacon mode is enabled by setting the *Enable beacon* checkbox, the beacon mode controls are activated after the beacon mode is enabled:

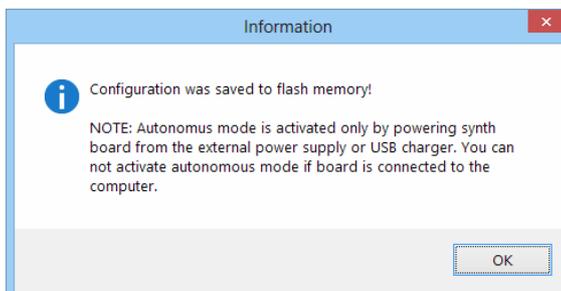


The scan mode can be enabled by setting the *Enable scanning* checkbox. Frequencies with the *Power* set to *Off* will not be scanned. The CW transmission speed can be set in the *Transmission speed* field. The message text is set in the *Beacon text* field (you can program CW messages up to 100 characters length).

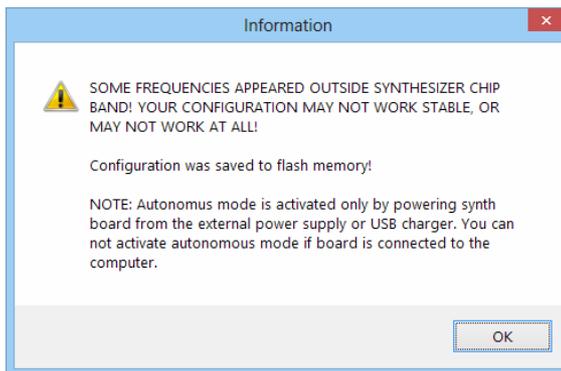
The English and Russian letters, digits, space and , . = / ? symbols can be used. There are also several special commands:

1. **@XY** sends two characters after the @ symbol without standard character pause. For example **@DN** will send the / symbol.
2. **#xxxx** sends the tone with **xxxx** milliseconds duration (add space after the delay number as a separator, it will not be sent, for example **#5000** will send tone for the 5000ms)
3. **&xxxx** sends the pause with **xxxx** milliseconds duration (add space after the delay number as a separator, it will not be sent, for example **&1000** will send pause for the 1000ms)

When all parameters for the autonomous mode are set you should save them to the module's flash memory. Press the *Save* button to do it. The program will inform you if the parameters was successfully saved or there were any problems:

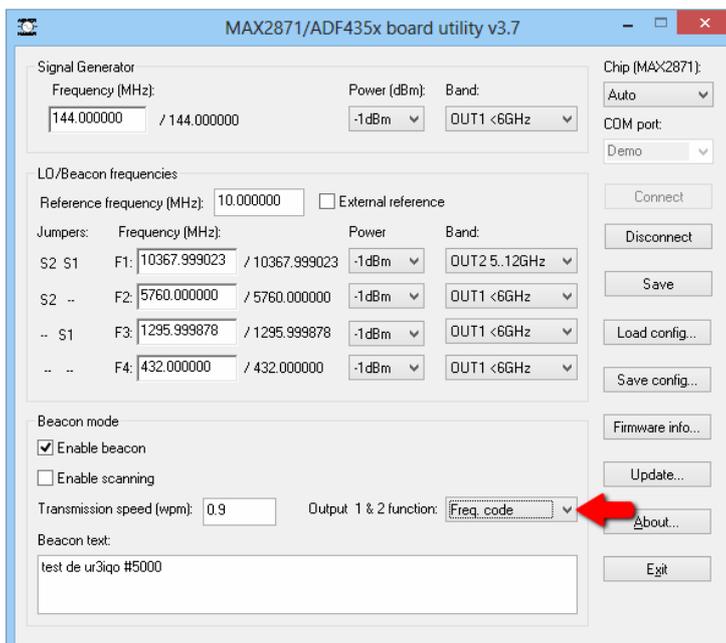


As was said before the **SynProg** utility will allow to program out of band frequencies. If you save configuration with such frequencies the program will warn you:



## 4.5 Configuring 1 & 2 outputs

You can configure 1 & 2 outputs for either frequency code or PTT and keying signals. Select the desired configuration using the *Output 1 & 2 function* dropdown list:



## 4.6 Saving and Loading module configuration

You can also save the module configuration to the file and load it to the program/module later. Use *Save config* and *Load config* buttons and select the necessary file for saving/loading configuration.

## **4.7 Using external reference signal**

You can use external reference signal. If you want to use the external reference signal you should check the *External reference* checkbox to disable internal 10MHz reference oscillator. This option is available only for the boards v2.0 and higher. When you use **SynProg** utility with the board v1.0 the checkbox will be disabled. If you use reference oscillator with the frequency other than 10MHz you should set the correct frequency in the *Reference frequency* field.

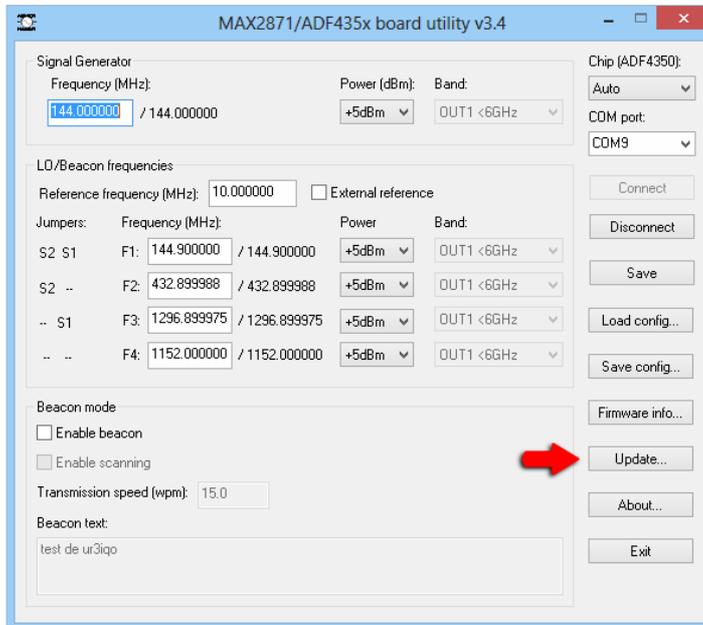
The External reference status LED (see Section 2) will lit if the module uses external reference.

## **4.8 Finishing**

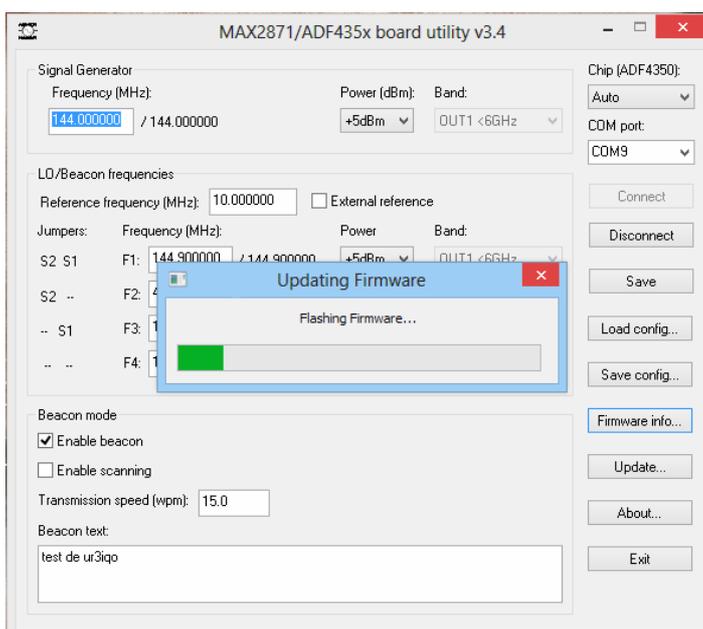
When you have finished module programming press *Disconnect* button. You can connect another module to the PC and continue, or you can finish the program by pressing *Exit* button.

## 5 Firmware update

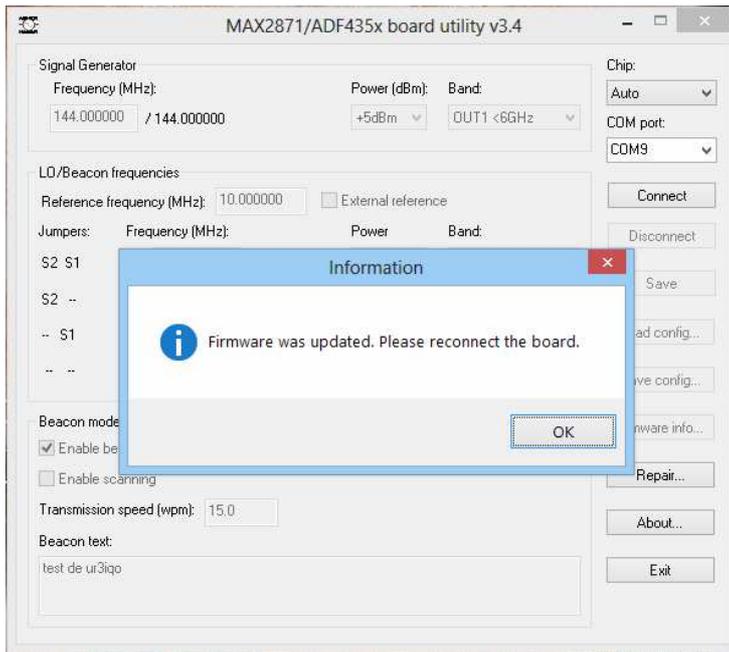
The module firmware is user upgradable and can be updated if needed. You have to download firmware image file (you can download firmware images from this page <https://vhfdesign.com/pll-lo/lo-pll-usb.html>). Connect module to the computer, run **SynProg** utility, and connect to module from the SynProg utility (see Section 4.1). Now save your module configuration to the file using the *Save config* button (you can skip this step, but module configuration will be erased during firmware update). Then press *Update* button:



Select firmware image file (**Note: the SHF modules and ADF435x/MAX2871 modules use different firmware, please select the correct firmware image**). The module will enter bootloader mode (the LED on the module board will start heartbeat flashing) and the update process will be started. **Do not disconnect module, power off the computer or terminate SynProg utility during firmware update!**



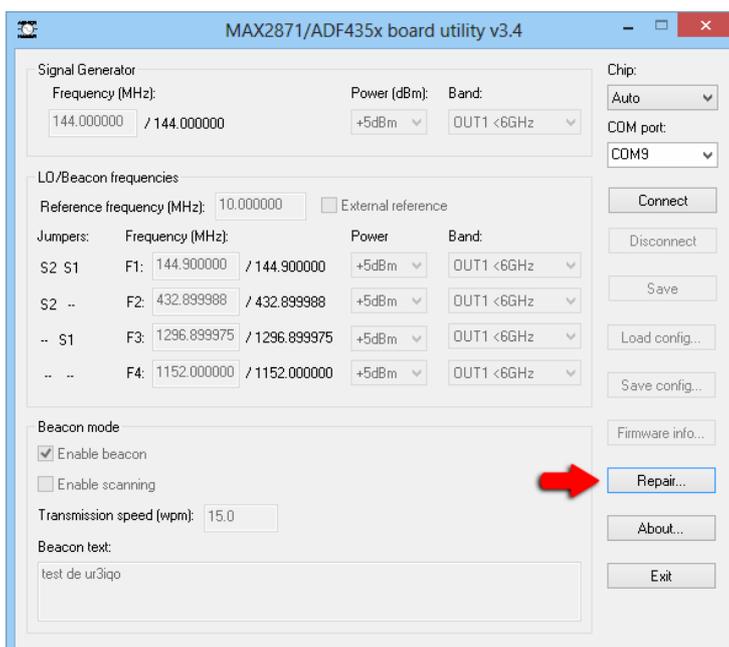
The program will show a message after the firmware was flashed:



Now you should disconnect the module from the computer USB port. Reconnect module to the computer, restore saved configuration (using the *Load config* button) and save it to the module flash memory (using the *Save* button). Now you can disconnect module from the computer - the module is ready to use updated firmware.

## 5.1 "Debricking" the module

When you power up the module it will check the firmware integrity and will stay in the bootloader mode if the firmware does not pass integrity test (the bootloader mode is indicated by heartbeat module LED flashing). If it happened (probably as a result of the unsuccessful firmware update) the module firmware can be repaired. Connect the module to the computer USB port, run **SynProg** utility, select correct COM port (see Section 4.1), but do not try to connect to the module from the SynProg utility (do not press *Connect* button). Press the *Repair* button instead and then select firmware image file:



The firmware repairing process will start (it is the same as the firmware update process, see Section 5).

## **5.2 Forcing bootloader to activate**

If the module firmware does not work properly or you can not update firmware using standard method the bootloader mode can be activated manually. You have to remove the S1 and S2 jumpers and short the S1 and S2 contacts (see Section 2). Then use the instructions for the module "debricking" (see Section 5.1).

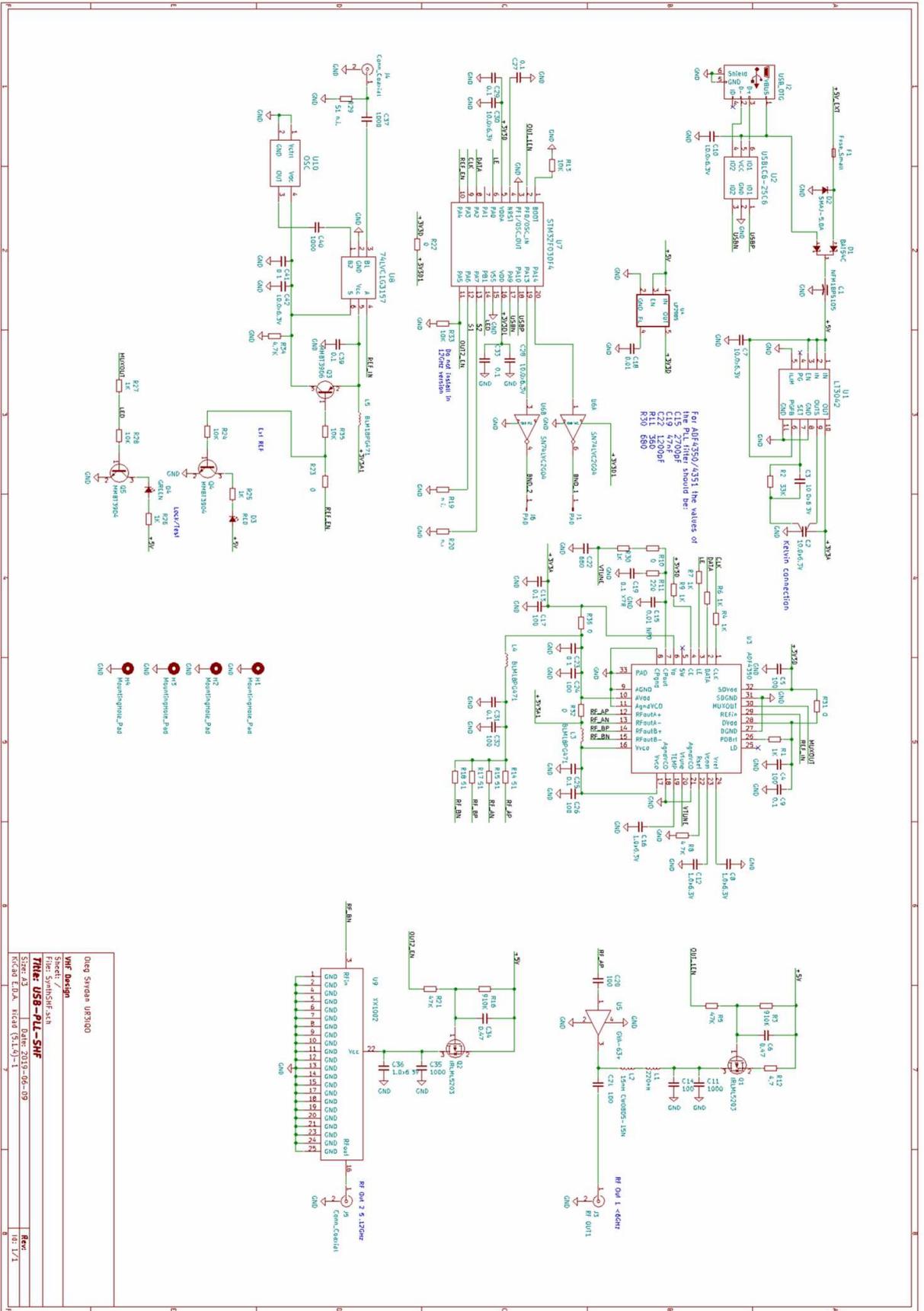
Remove the short and install jumpers back after the firmware repair.

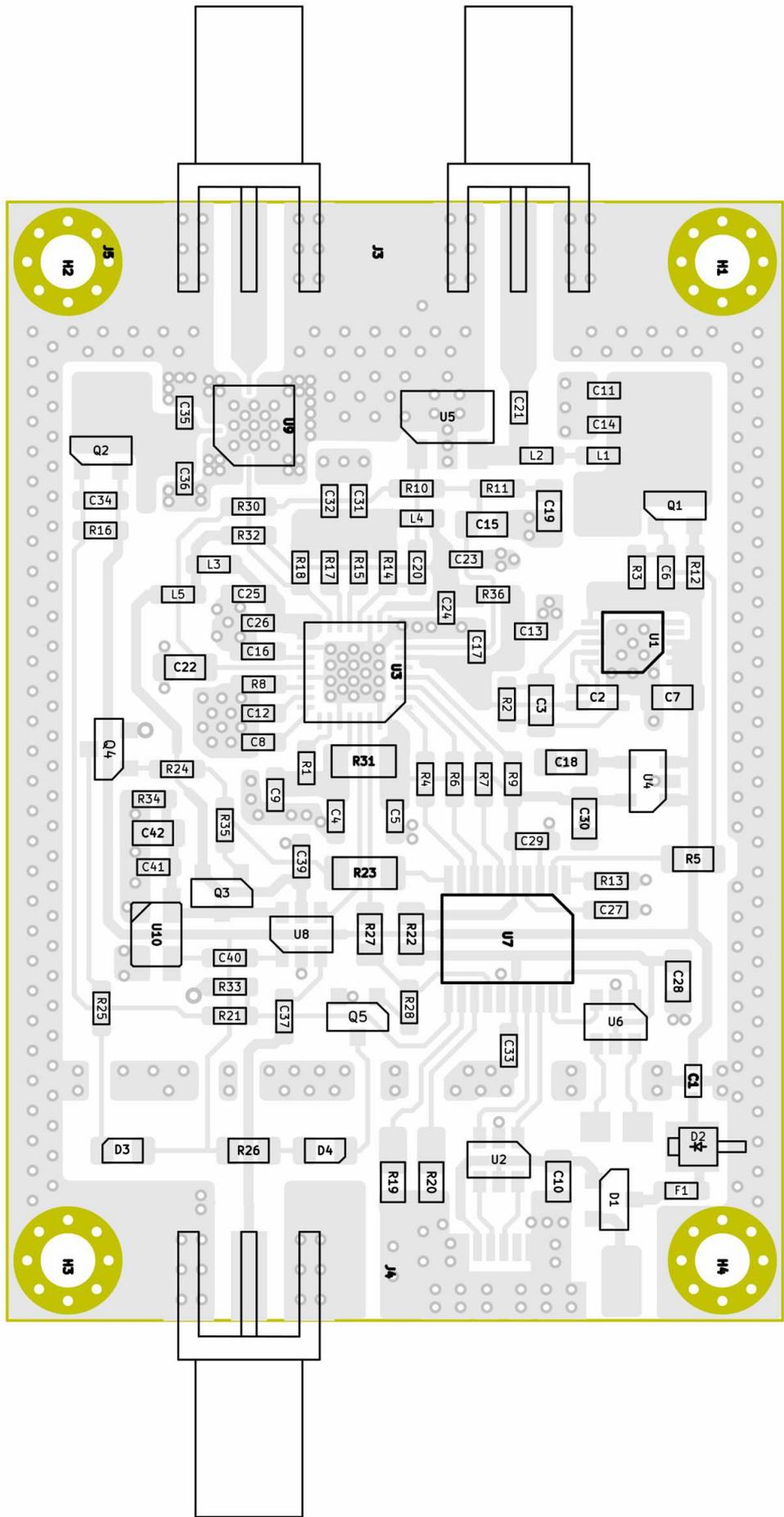
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# Appendix A

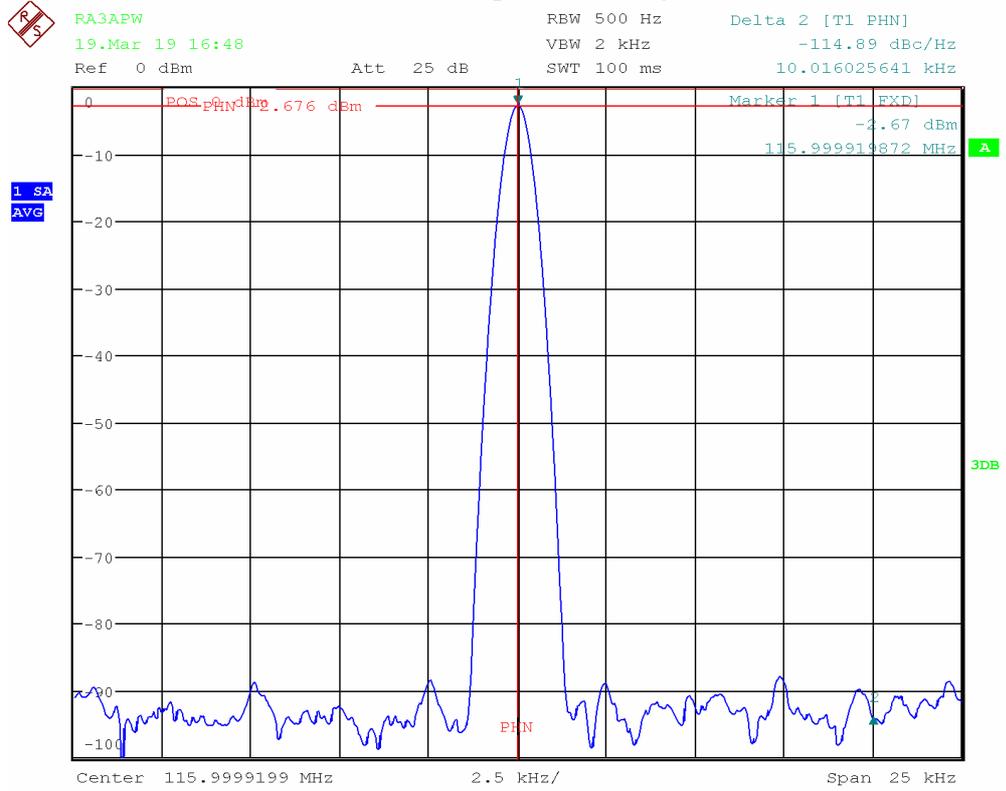
## Module schematics and parts placement



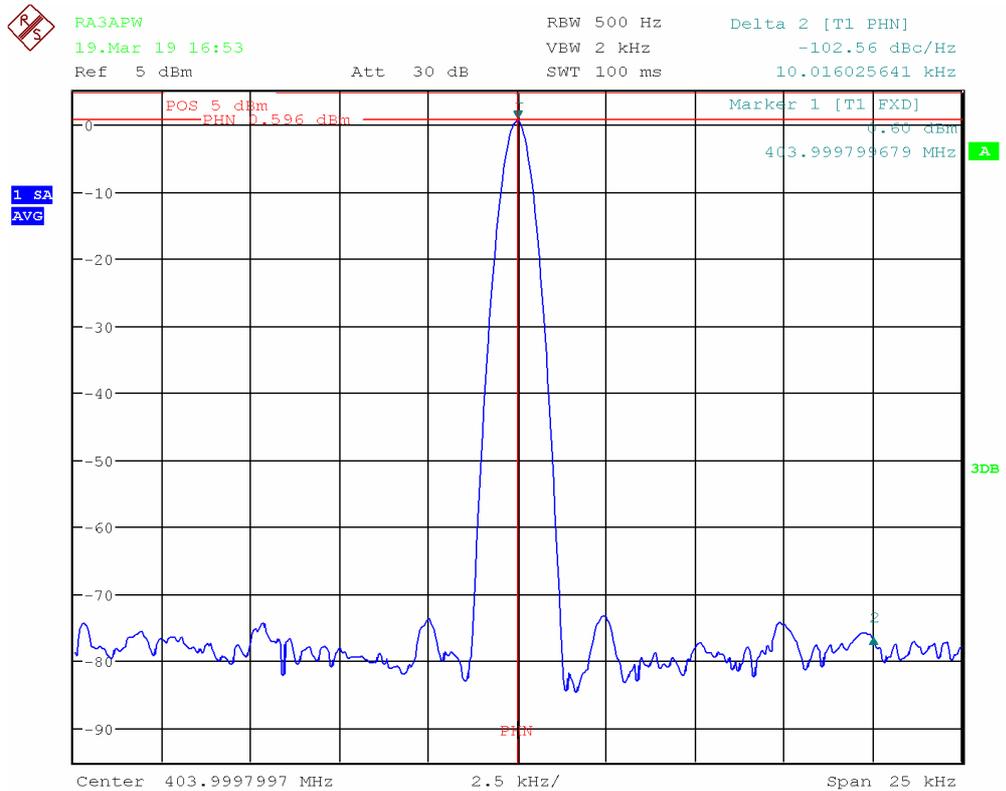


# Appendix B

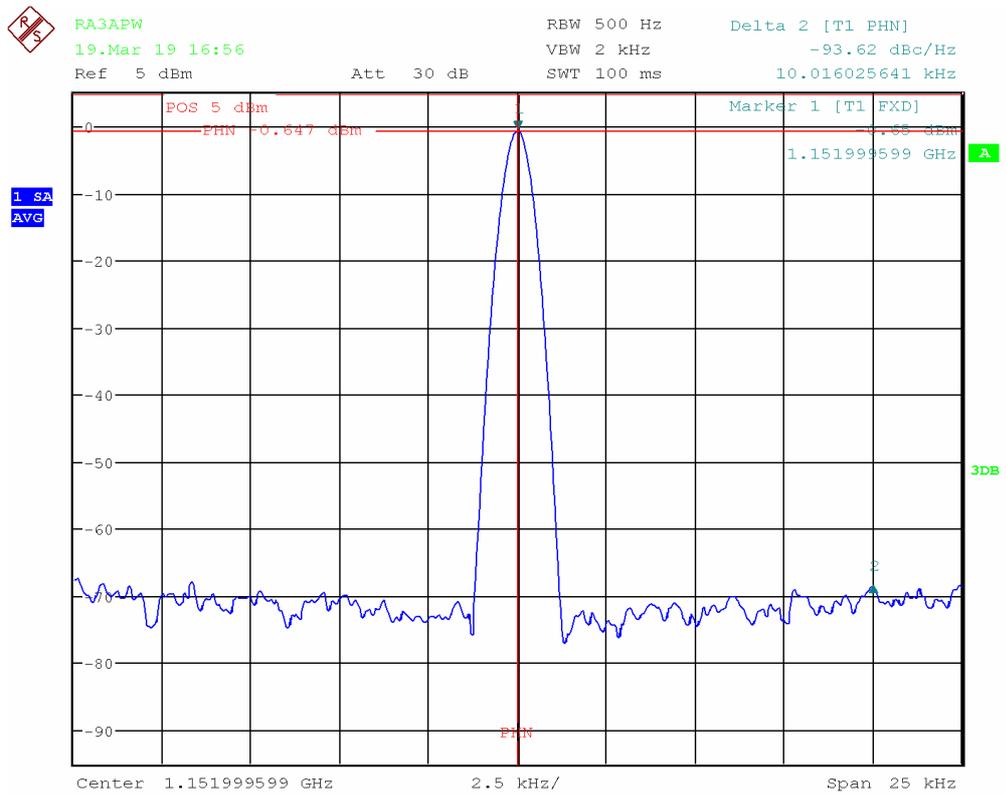
## Phase noise measurements of the ADF4351 module (R&S FSQ8 spectrum analyser)



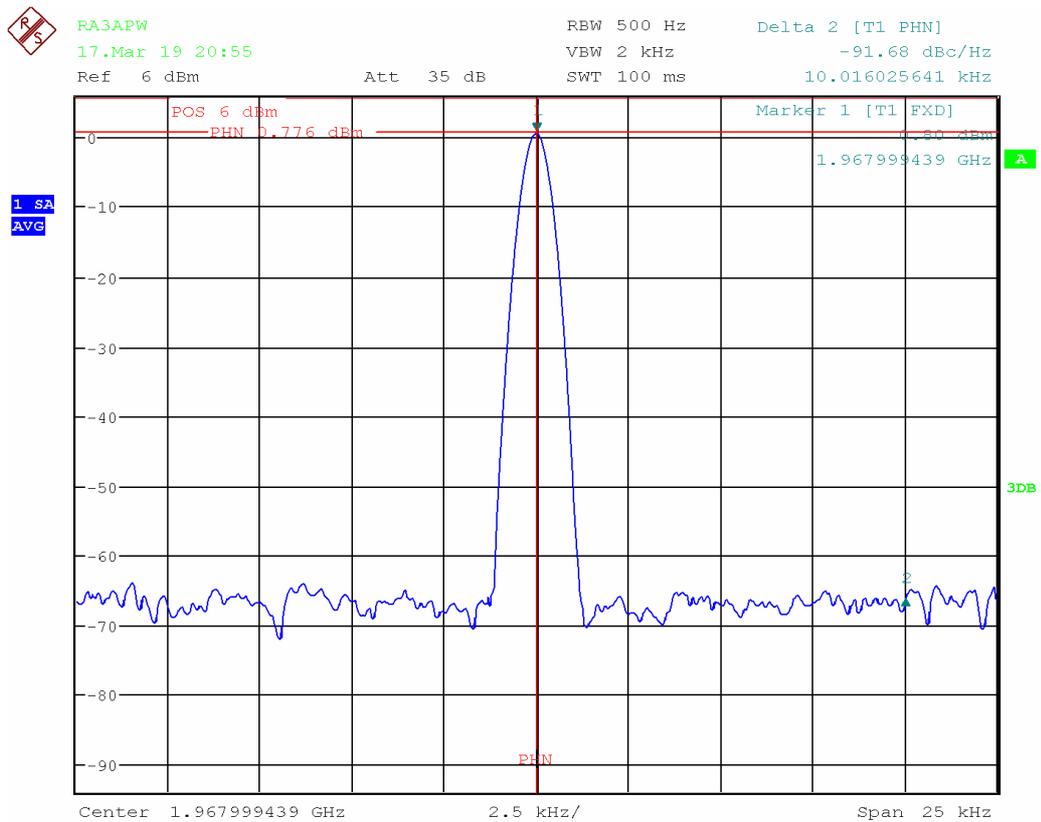
**Figure 1 PN measurements on the 116MHz frequency. Autonomous mode, power set to -4dBm, 10dB attenuator at the spectrum analyser input**



**Figure 2 PN measurements on the 404MHz frequency. Autonomous mode, power set to -4dBm, 10dB attenuator at the spectrum analyser input**



**Figure 3 PN measurements on the 1152MHz frequency. Autonomous mode, power set to -4dBm, 10dB attenuator at the spectrum analyser input**



**Figure 4 PN measurements on the 1.97GHz frequency. Autonomous mode, power set to +5dBm, 10dB attenuator at the spectrum analyser input**



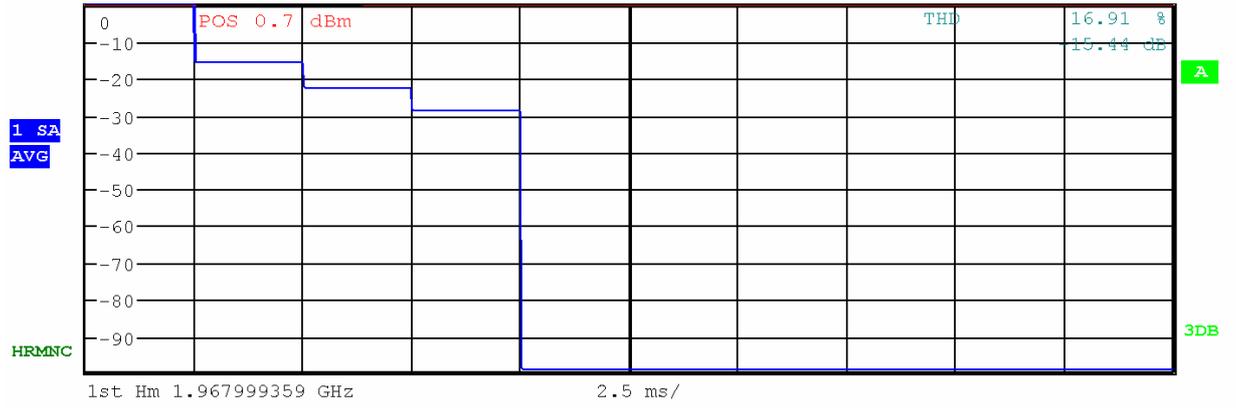
RA3APW

17.Mar 19 21:08

Ref 0.7 dBm

Att 15 dB

CMT 25 ms



No	Frequency	RBW	Power
1	1.97 GHz	200 kHz	0.61 dBm
2	3.94 GHz	500 kHz	-16.32 dBc
3	5.90 GHz	1 MHz	-23.12 dBc
4	7.87 GHz	1 MHz	-29.18 dBc
5	out of range		---
6	out of range		---
7	out of range		---
8	out of range		---
9	out of range		---
10	out of range		---

**Figure 5 Harmonic content at 1.97GHz frequency. Autonomous mode, power set to +5dBm, 10dB attenuator at the spectrum analyser input**