

A NEW LIFE FOR THE FT-290R TRANSCEIVER !

By F5RCT

The FT-290R is an old amateur radio workhorse which was a very popular transceiver during the 80's. It is a 2-metre multimode portable which can run with or without an external 12 V power supply unit. Still quite favoured as an exciter for transverters or linear amplifiers, it is built like the proverbial brick outhouse. Large numbers were sold and they are now commonly available for around 150€. They seem to be reliable in general and most components are discreet and can be replaced. The following article proposes a list of modifications "à la carte" to improve their performance.



The Yaesu FT-290R is a multi-purpose, multi-mode FM / CW / USB / LSB portable 2-metre transceiver. With 13.8 VDC input, output power is 2.5 watts. Coverage is 144 to 146 MHz. FM steps are 12.5 or 25 kHz for the European version. CW/SSB steps are 100 or 1000 Hz. It has a built-in telescopic antenna. The radio operates from eight alkaline/NiCad C cells (not supplied) or from an 8.5 to 15.2 VDC power supply. It measures 6 x 2.5 x 7.9 inches (150x58x195mm) and weighs 1.3 kg.

For modifications you need the schematic diagram and the alignment procedure described in the user manual [1]. The minimum equipment required to align the transceiver is a power metre and a frequency counter (or better: a spectrum analyzer).

I have tested four devices: on some of them PLL and SSB modulator frequency crystals drifted due to ageing. Aluminium capacitors had aged too and showed an equivalent series resistance of more than 3 Ohms on 10µF capacitors. Some of them can leak, block the AGC line and have an effect of "heating up" when power is turned on.

Internal antenna removal and Pi filter improvement:

The FT-290R has a reputation of low sensitivity when the transceivers from the 90s came on the market. Mutek Ltd offer the SLNA290s [2] preamplifier but the internal antenna system will bring losses anyway.

This present modification has two advantages:

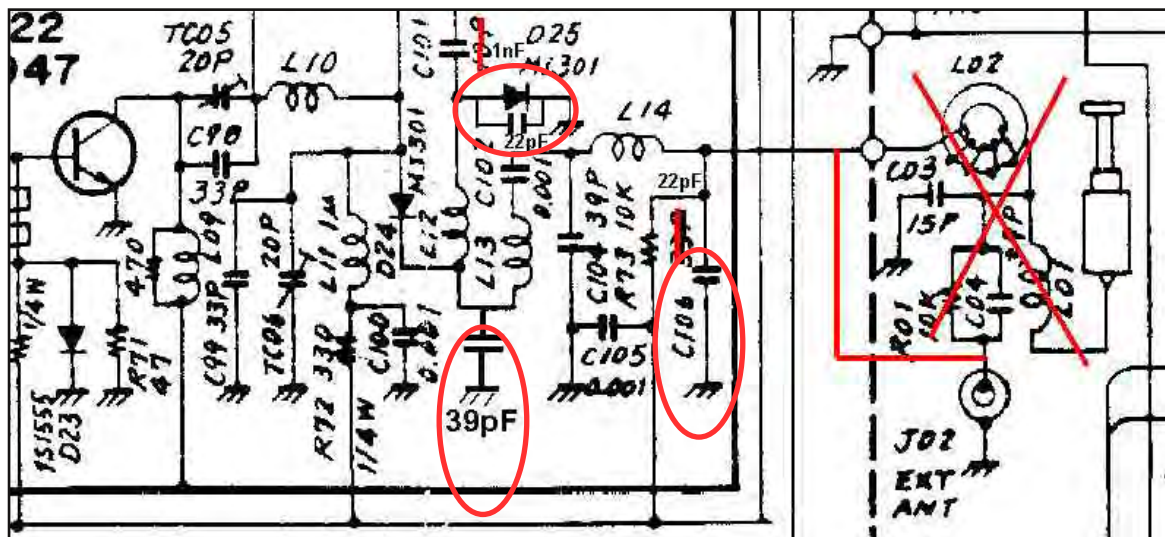
- It reduces the loss on the system by 2dB, improves the output power (x1.5) and sensitivity is better.
- For OMs who don't like the antenna socket connection at the back, it is possible to replace the antenna by a BNC socket on the front panel. Removing the inserted ring can be done by drilling it carefully through with a 10.5 mm diameter tool. On one device, I used the hole to place a 3.5mm stereo phone socket. Very useful for common headsets!

The output Pi filter shows losses and needs to be modified.

Remove the antenna and the tube along the flange and the components wired to the main board.

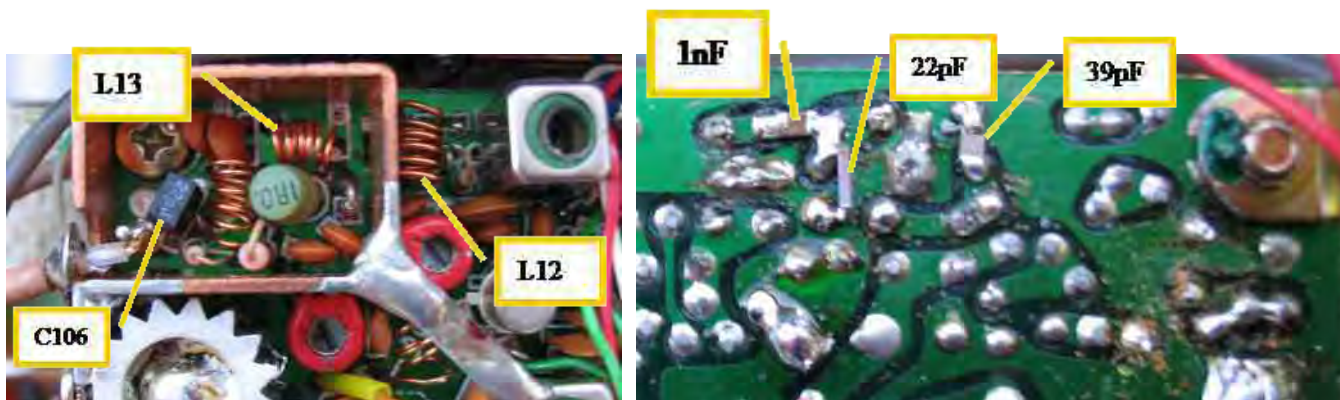
Remove all external components located outside the main PCB : From small toroid L02 to L01.





It is possible to replace the capacitors with 1206 or 0805 SMD 50V COG soldered directly on the bottom of the board. : it's easier and quicker than removing solder from holes.

- Now replace C106 (33pF) to 22 pF with a good ceramic capacitor (located in the corner near the screw).
- Replace L12 with 6 turns on 3 mm diameter using 0.5mm enamelled wire.
- Add a 39 pF capacitor between L12 and L13 (a location is foreseen).
- Add a 22 pF capacitor parallel to D25.
- Replace C101 with a 470pF to 1 nF capacitor.
- Reassemble the turns of L13 as shown on picture.



The Tx output stage needs to be tuned. Select the high power switch position. Adjust VR2003 to maximum power, and then adjust TC05 and TC06 to maximum power at 145 MHz in FM mode. The current is approximately 1.1A at 12.5V and maximum power is 4.5 W on my sample. Then reduce the power to 3.5 W by adjusting VR2003 again. This is necessary to stay linear in SSB mode. Select low power switch position, and then adjust VR2006 to 500 mW. The insertion loss on Rx is improved from 2.7 dB to 0.7 dB. On Tx the loss is improved too: from 2.5dB to 0.6dB and allows more than 1W in additional power.).

Using the FT-290 as a transverter or a PA:

The FT-290R has two power levels: 2.5W and 500 mW.

The low power mode may only be used for power consumption reduction. In low power mode ALC is not working and modulation compression is not present. The low level depends on a gate voltage of the Tx IF chain, this will imply large tolerance on this level, depending on temperature and frequency.

To use the transceiver with a PA or a transverter I recommend using it in 2.5 W mode. It is possible to adjust the level with VR2003 down to 1 W.

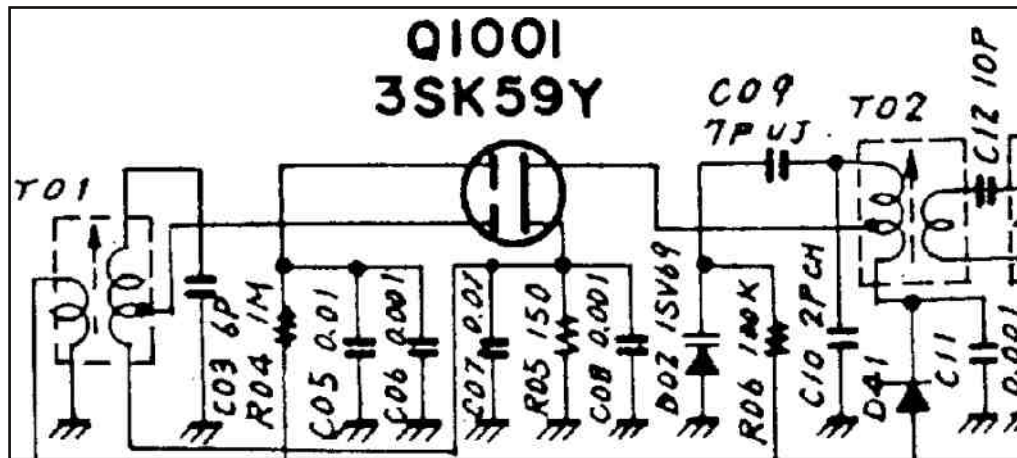
Receiver sensitivity improvement :

Sensitivity of initial circuit with modifications of Pi input filter and internal antenna system removed. Connection direct to S0239 antenna socket:

- 120 dBm measured (0.22 μ V) at squelch threshold in FM with CW signal.
- 115 dBm measured (0.39 μ V) for 20 dB (S+N)/N in SSB with CW signal. (0.5 μ V specified on datasheet).

The poor sensitivity comes from different design reasons and from the input transistor:

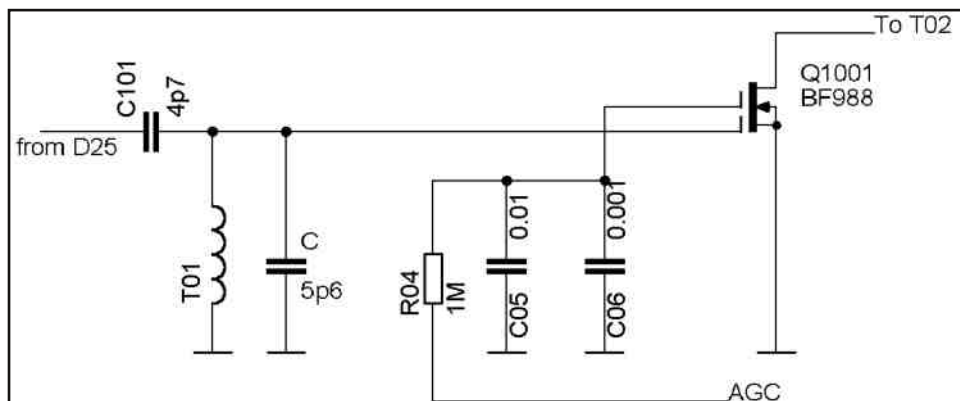
- Antenna switching from antenna socket to receiver input has high loss. The last modification reduces the loss by 2dB.
- The input transformer T01 has loss too. Having a transformer with very thin winding wire introduces loss compared to a direct matching circuit.
- The input transistor Q1001 has a poor noise figure even if the gain is sufficient. A quick modification consists in grounding the source resistor to increase gain (+1 or 2 dB) and drain current: but there is no improvement in sensitivity (signal to noise). This will increase G2 voltage and gain. This transistor is located close to the power jack.

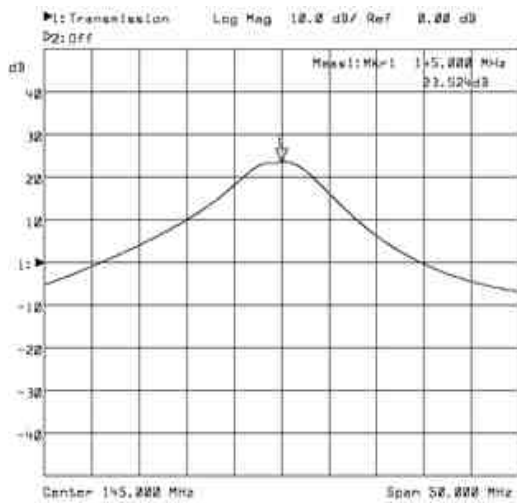


De-soldering of T01 is easy by using a large tip and adding a lot of solder tin to heat all leads together. Remove Q1001, C03, and C07. Clean holes with a de-soldering pump.

Replace Q1001 with a BF988 soldered on back side with reference facing the PCB. It is possible to use a BF690, BF961 or BF964 (or the SMD versions: BF998, BF994, ..)

Remove carefully the shield from T01 and the ferrite cap, cut the wire and clean the coil support. Then T01 is wound with 4.5 turns of 0.25 mm enamelled wire. Start the winding at the top second slot from G1 pin connection to finish at ground connection. Place the 6pF or 5.6pF capacitor from ground S to G1. Add a 4.7 pF capacitor from G1 to input close to C101, or replace C101 with 4.7 pF and make a short jump to G1. Solder non used pins of T01 to ground.





The front end stage T01 and T02 need alignment at 145 MHz using an RF signal generator, based on maximum deviation of Smeter.

Tests:

Sweeping the stage from antenna input to output of T02 gives a gain of 23.5 dB. The AGC voltage of 2.1V is sufficient to get the maximum gain.

-123 dBm measured (0.16 μ V) at squelch threshold in FM with CW signal.

-118.6 dBm measured (0.263 μ V) for 20 dB (S+N)/N in SSB with CW signal. With -128.6 dBm measured (0.083 μ V) for 10 dB (S+N)/N it is possible to decode a good CW signal.

The sensitivity measurement shows a 2.6 dB improvement, with the modification of the Pi filter it is about 5 dB better!

Calculating the approximate noise figure from output S/N to input S/N:

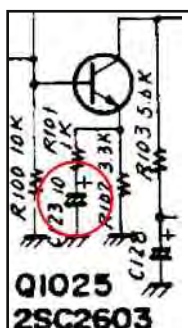
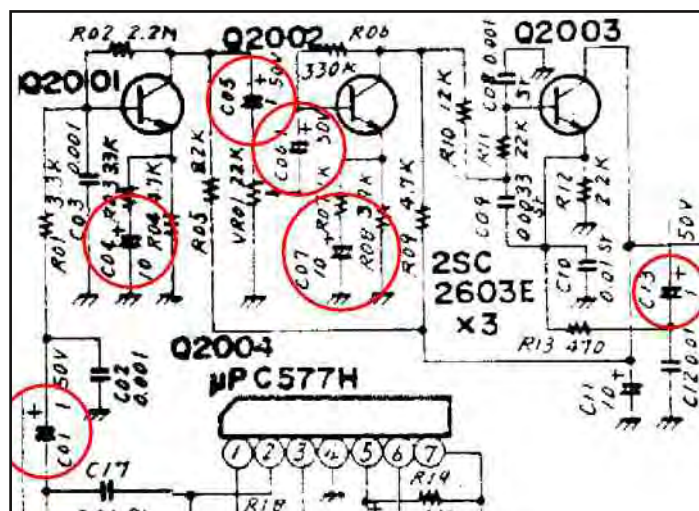
$$NF = (-128.6 \text{ dBm}) - (-174 \text{ dBm/Hz} + 10\log(2400 \text{ Hz}) + 10 \text{ dB} [(S+N)/N]) = 1.6 \text{ dB (Not bad!)}$$

Modulation improvement :

If you have a low pitched voice and reduce plops effects it is necessary to cut off audio low frequencies by changing some capacitors. This modification improves the quality of modulation by cutting low frequencies under 300 Hz. A slight emphasis of 3dB is introduced from 300 to 1000 Hz to make the voice clearer.

The original SSB microphone preamplifier has a low frequency cut-off near 10 Hz. This will not improve the rejection of residual side band under 300 Hz and produces a scratchy modulation.

Located on board near VR2001, change the C01, C04, C05, C06, C13 capacitors for 100nF X7R ceramic capacitors. See capacitors marked in red circles on picture below. The C07 capacitor is replaced by a 1 μ F aluminium.



Audio quality of reception :

On earlier versions of FT-290R the audio gain is too high and the volume control range is too straight.

The change had been made by Yeasu during production. Check if capacitor C123 and resistor R101 on the board are mounted, if it is the case remove them. See location marked with a blue circle on picture below.



Battery replacement :

Check the voltage of the battery: If measured voltage is less then 2.8V the battery is at the end of its life.

It is difficult to find a lead type battery the same as the original. On old computer motherboards you can find a good CR2032 battery holder. Just drill a hole on the PCB ground plane and place the holder to solder it. Before placing a new battery check the small 10µF capacitor on the CPU board (located near the CPU chip): if oxidation is visible, clean the PCB and replace the capacitor with a 100nF or 1µF ceramic if possible for less leakage current.



S- meter and LCD panel lamp replacement :

The main weak point of the FT-290 is the small incandescent backlight that has to be replaced periodically. This lamp does not handle a voltage greater than 12.5 V and blows at 14 V. It is a real pain in the neck if you do your own repairs: do the replacement once and for all.

It is possible to replace the light bulb by two white LEDs side by side in series with a 470 Ohms resistor.

This modification depends on surface mounted LEDs picked up from mobile phones. The procedure is lengthy due to the removal of the front panel and the stack of printed circuits.



Reverse polarity protection :

The protection against reverse polarity of supply is not sufficient: F5AEG burned the CPU board of his device. By studying the schematic diagram and the device structure we spot a diode (D01 10D1) located on the power jack and PL socket that will shortcut the supply if reverse polarity is applied. This diode is a silicon junction (0.7V) diode and is too weak for strong power. A fuse follows the switch and the diode to protect the device against inside shortcircuits.

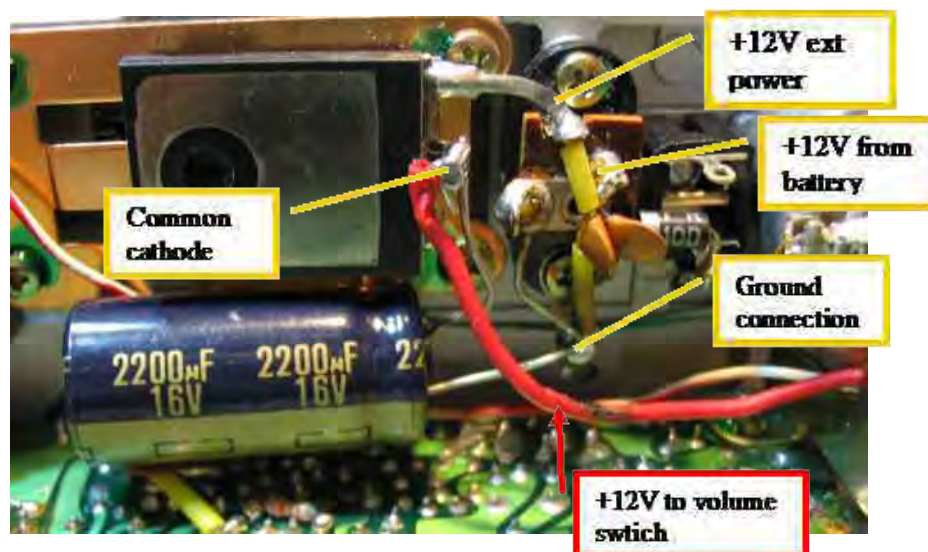
The recommended improvement is to remove the input diode and add a Schottky series diode on +12V of the device. This change adds a voltage drop of 0.3 V max but protects the device absolutely without any trouble. The Schottky diode may be found in a computer power supply, it is the +5V rectifier diode, generally a double 30 A to 60 A 45 V diode.

Remove the parallel diode on power jack and PL socket.

Connect the two anodes of the Schottky diode together. Then solder the anode to the power jack and the cathode to the red wire and +V pole of the capacitor.

Check the capacitor and replace it if necessary with a 1000 μ F 16 V minimum. This capacitor protects the device against voltage spikes present on vehicles.

Another idea is to connect the Schottky diode in parallel to the supply after the fuse. In this case the fuse will blow if reverse polarity is applied. If you do this the anode ground connection must be connected to the frame near the fuse on the power supply board. Bear in mind that if the ground impedance is too high the protection will be not sufficient.



PLL phase noise and spurious.

The signal at Rx mixer gate 2 was measured with an R&S FUP spectrum analyzer and phase noise system measurement.

Phase noise:

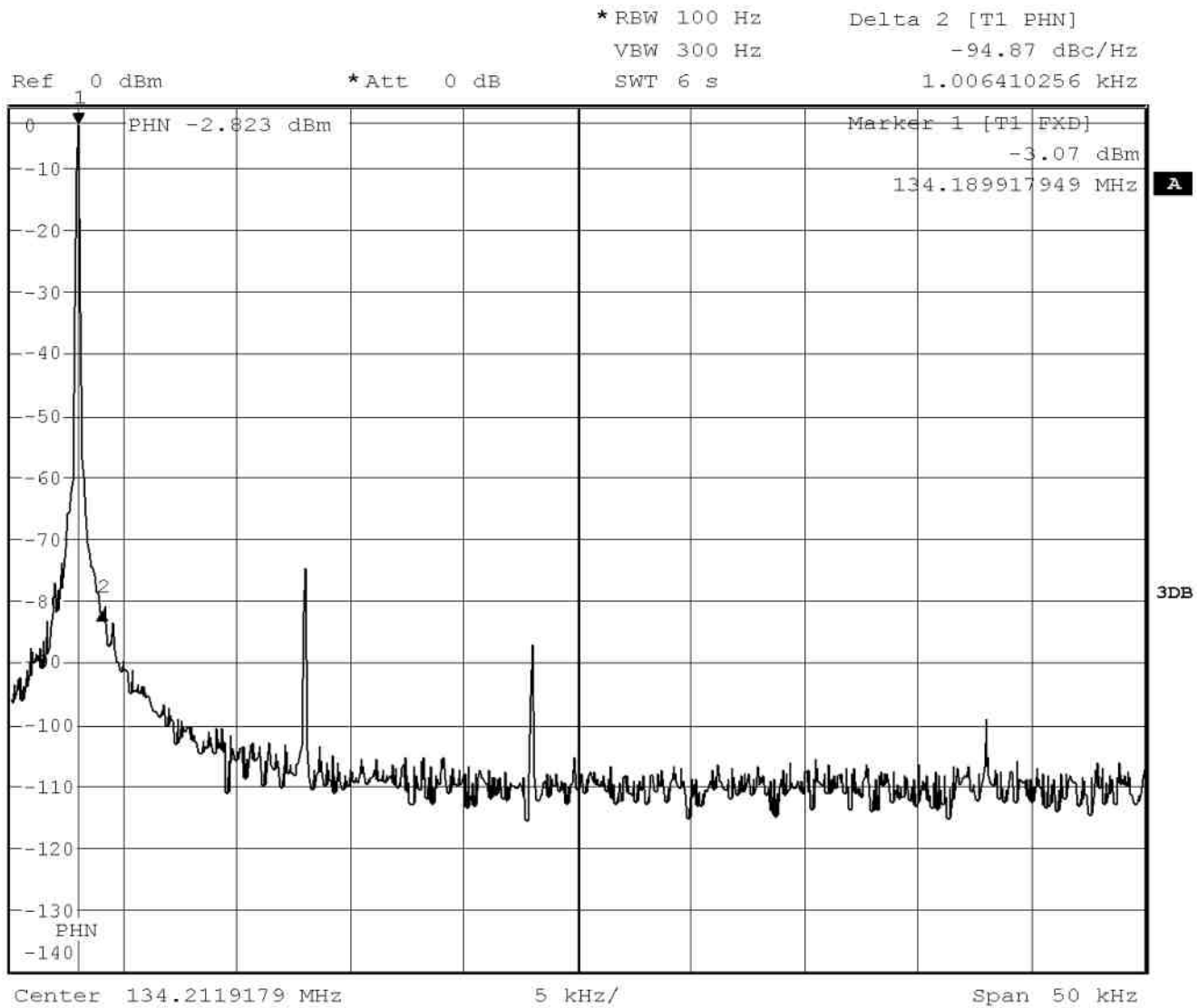
- 95 dBc/Hz at 1 kHz offset
- 111 dBc/Hz at 3 kHz offset
- 122 dBc/Hz at 10 kHz offset

Spurious:

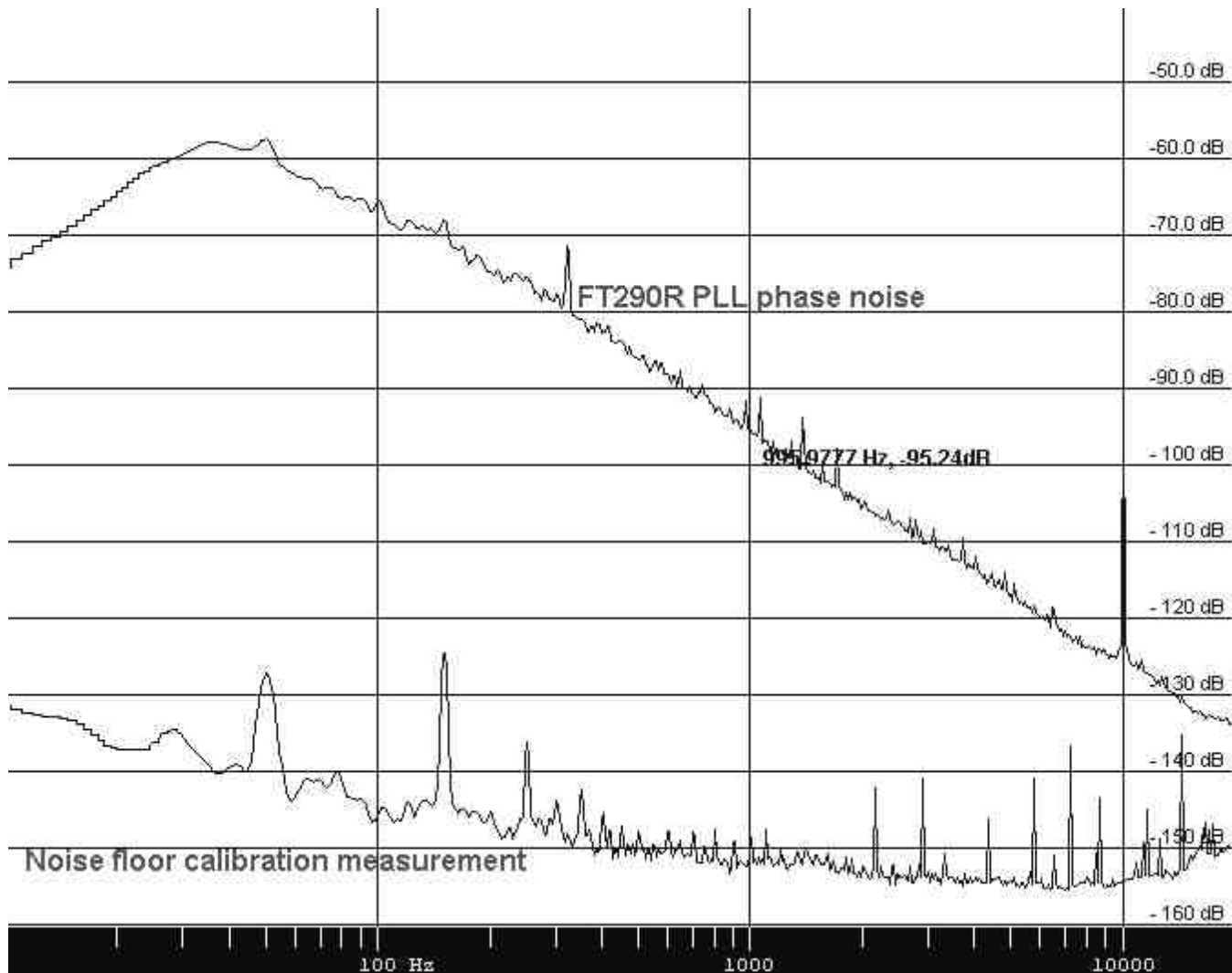
some residuals from the comparison frequency of the PLL

- 70 dBc at 10 kHz offset
- 80 dBc at 20 kHz offset
- 95 dBc at 40 kHz offset

Spectrum measurement:



PLL phase noise measurement: -95 dBc/Hz at 1 kHz offset



It is possible to reduce PLL noise:

- Limit the frequency range to 144-145 MHz with the jumper configuration on the CPU board. Then adjust the TC01 trimmer capacitor of the PLL's VCO (see alignment procedure) at 3.5 V for 145 MHz. The RF filters on receiving (T1001-T1004) and transmitting (T2001-T2006) section need tuning too.
- Remove the PLL shield and cut the track from pin 8 of PLL circuit to resistor R27 (1k), then add SMD 4k7 to 10k resistor. This modification decreases the noise on tuning voltage.
- On earlier versions the -6.8V voltage is provided by ICL7660 (8 pins DIL IC). Noise is generated on +5.6V, audible in FM mode. It is very easy to improve by connecting a 10µF capacitor between pin 8 and ground.

More information and modifications can be found on the web [3]. I hope these will help you!

73 de F5RCT Jean-Mathieu STRICKER f5rct.jm<at>gmail.com

References:

- [1] : <http://www.mods.dk/>
- [2] : <http://www.mutekrf.com/index.html>
- [3] : <http://www.whelan.me.uk/radio/mods290i.htm>