A 40 meters CW QRP Transceiver

The Project in few words

This project describes a little QRP transceiver "full legal power" (5 W at 12 V) for the 40 meters band. The RIG may be built in a gradual manner, in fact it is divided in two main modules, or you may also complete only the RX module. The RX section is designed so as to allow receiving both SSB and CW signals on the whole 7 MHz band. The tuning may be done using only an HF receiver, but if you have at your disposal a frequency meter and a signal generator, you could do a better job.
If you are interested in further informations, or to get the PCB masters, please contact me at my E-mail box.

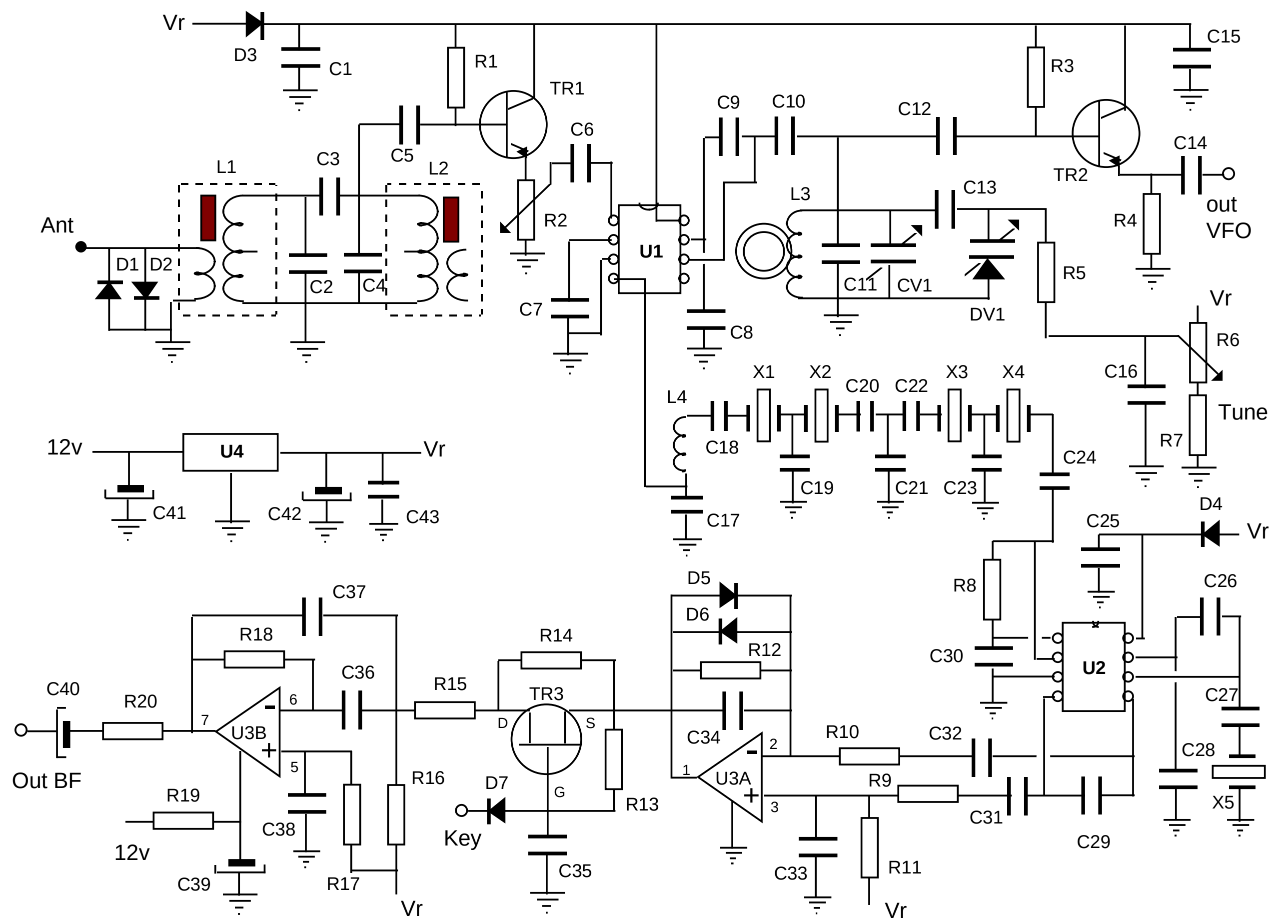
How it is made

The transceiver is composed by two single sided printed boards 100x66 mm. These should be fixed on a metallic ground base, and possibly enclosed in a little metal cabinet. On the front panel you may place the tuning potenziometer (a 10 turns model or a single turn device with a reductor gear) and the gain control. The frequency reading may be obtained with a 200 μA panel connected to the tuning pot. The Key and earphone jacks, like the power and antenna connectors may be housed on the back panel. You may give a nice look to the panel by drawing a 1:1 mask with a common graphic tool (I use the MS POWERPOINT), and then printing it on a self-adhesive transparent. The whole process may seem to be a little laborious but the result is very attratctive.

The Receiver circuit

It uses a classic superetherodyne design, for simplicity purpose I didn't implement an IF stage with a related AGC circuit, this is a compromise choice and implies some manual sensitivity adjusting in presence of strong QSB. The overall sensitivity and selectivity are very good and so also the capability to handle strong overloading signals, proving the effectiveness of the preselector stage and XTAL filter.

The electrical schematic



R1 : 150 KΩ	C1 : 100 nF	C21 : 56 pF	C41 : 47 µF
R2 : 1 KΩ - pot.	C2 : 82 pF	C22 : 270 pF	C42 : 22 µF
R3 : 270 KΩ	C3 : 2.2 pF	C23 : 47 pF	C43 : 100 nF
R4 : 1 KΩ	C4 : 82 pF	C24 : 47 pF	CV1 : 35 pF
R5 : 56 KΩ	C5 : 2.2 pF	C25 : 100 nF	D1-D7 : 1N4148
R6 : 10 KΩ - pot.	C6 : 1 nF	C26 : 68 pF	DV1 : BB204
R7 : 1 KΩ	C7 : 10 nF	C27 : 18 pF	L1-L2 : 2th MF 10.7 Mhz ✹
R8 : 470 Ω	C8 : 470 pF	C28 : 68 pF	L3 : 64 turns - ϕ 0.25 mm on T50/6 ✹
R9 : 10 KΩ	C9 : 150 pF	C29 : 33 nF	L4 : 22 µH
R10 : 10 KΩ	C10 : 150 pF	C30 : 33 nF	X1-X5 : 4.433 MHz
R11 : 470 KΩ	C11 : 47 pF	C31 : 100 nF	TR1 : BF199
R12 : 470 KΩ	C12 : 15 pF	C32 : 100 nF	TR2 : 2N2222
R13 : 1 MΩ	C13 : 68 o 33 pF ✹	C33 : 150 pF	TR3 : BF245
R14 : 1 MΩ	C14 : 1 nF	C34 : 150 pF	U1 : NE602
R15 : 22 KΩ	C15 : 100 nF	C35 : 0.47 µF	U2 : NE602
R16 : 470 KΩ	C16 : 33 nF	C36 : 2.2 nF	U3 : NE5532
R17 : 1 MΩ	C17 : 39 pF	C37 : 470 o 820 pF ✹	U4 : 7808
R18 : 1 MΩ	C18 : 47 pF	C38 : 10 nF	
R19 : 10 Ω	C19 : 47 pF	C39 : 47 µF	
R20 : 10 Ω	C20 : 270 pF	C40 : 22 µF	

✹ see text, all resistors ¼ W, all electrolytic capacitors 25 V

The front-end circuit

It employs a double tuned circuit, made using two common 10.7 MHz FM transfomers. In this manner a good withstanding was obtained against overloading signals and inter-modulation. The input is protected against over-voltages by two opposed diodes. An emitter-follower transistor transfers the signal to the mixer stage, so obtaining a real 10 dB gain. A linear 1 KΩ potenziometer on the TR1 emitter is employed as an effective RF gain control.

The mixer and VFO stages

The mixer stage employs a double balanced NE602 IC and provides about 18 dB of gain. The local oscillator coil is made by 64 turns of of enameled 0.25 mm wire on a T50-2 Amidon toroid. The overall frequency span is controlled by the C13 capacitor; with a 68 pF value you may cover the entire 40 m band, so exploiting the SSB reception capability, while a 33 pF capacitor will limit the coverage to the only CW segment. A 1 KΩ resistor (R7) is series connected to the potenziometer so as to get a better linearity of the tuning control. A little capacitor (C12) is employed to drive a buffer stage, delivering an adequate RF level for the TX mixer and a possible frequency reader.

The XTAL filter

A particular care was dedicated to the filter design, in fact I wanted to obtain a device suited also for SSB reception. I chose a ladder 4 poles design, employing some cheap 4.433 MHz crystals for TV use. In this manner I obtained a 1.8 KHz bandpass, an acceptable compromise to receive both the CW and SSB modes. The filter in/out impedance is about 500 Ω, so a matching network (C17 - L4) is employed at the input, while the output is loaded with an adequate resistor (R8).

The Demodulator

This stage employs another NE602 IC as a double balanced product detector, providing further 18 dB of gain. A 4.433 MHz crystal is used for the oscillator, while a little capacitor (18 pF) series connected raises the crystal frequency about 1 KHz allowing the demodulation both for the CW and for the LSB.
You may also replace C27 with a little 22 pF variable capacitor (5 mm pin spacing) so obtaining a better control of the demodulation.

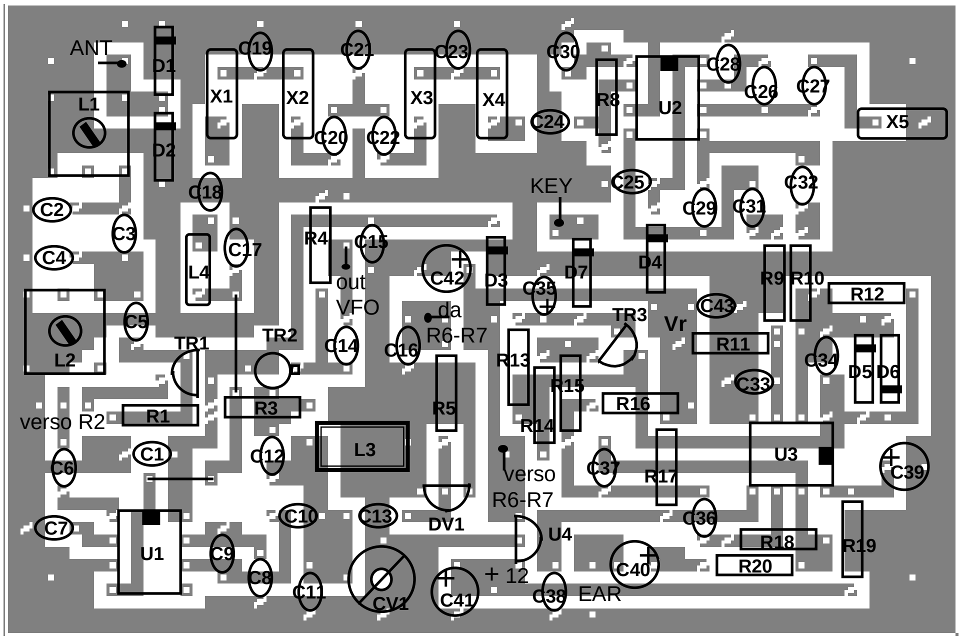
The AF section

Employs the two halves of an NE5532 operational amplifier, this device is equipped with an internal corrent limiter, so it cannot be replaced with other models (TL082 or LM358). The overall gain should be about 60 dB. The U3b stage is configured as a passband filter, and modifying the value of C37 you may adapt the central frequency for CW only (820 pF) or mixed CW & SSB (470 pF). An inter-stage FET (TR3) works as an attenuator while transmitting (break-in function), this is obtained by grounding the gate and consequently lowering the FET channel conductivity. I suggest to series connect the tho earphone halves, so as to obtain an higher impedance (64 Ω).

How to tune the RX stages

First of all you have to tune the local oscillator, you may employ a general coverage receiver or, better, a frequency meter. By adjusting the CV1 capacitor you should obtain a frequency span from 2567 to about 2667 KHz. By varying the C13 value you may modify this span amount. Then, connecting the antenna, you should try to tune a weak signal, adjusting the L1 and L2 cores for the better sensitivity.

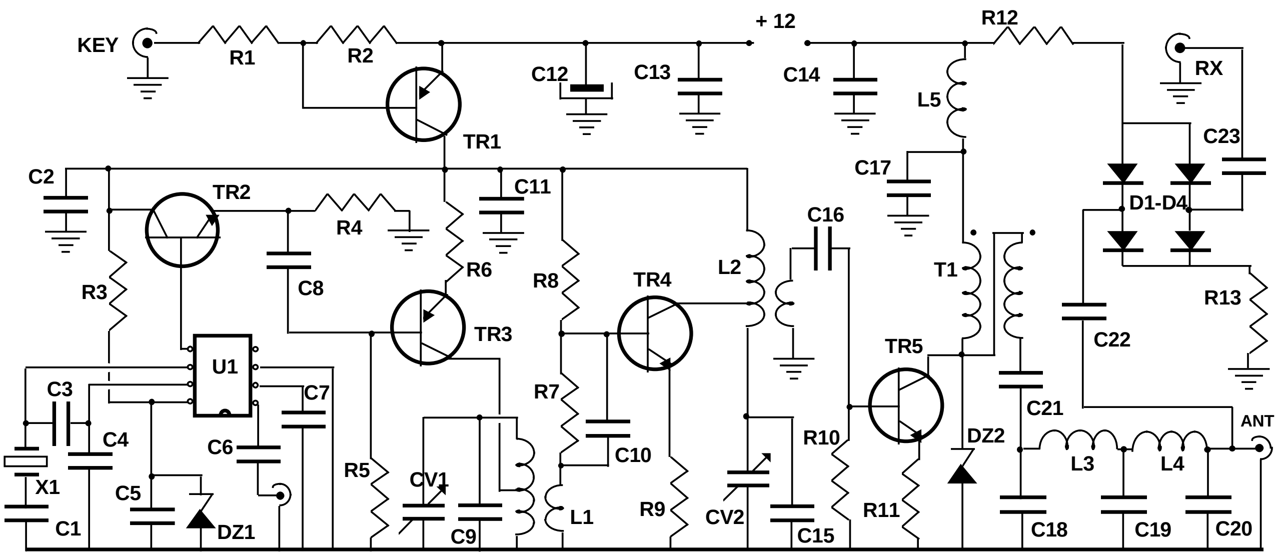
Receiver Layout - real dimension 100x66 mm



The Transmitter circuit

I employed a frequency conversion approach, in this manner it is possible to receive and transmit on the same frequency using a single VFO. An automatic RX/TX switching circuit implements the full break-in and monitor function. The assembly is not particularly critical, however some care must be dedicated to align carefully the amplifier stages, so as to avoid possible instability.

The electrical schematic



R1 : 3.9 KΩ	C2 : 47 nF	C16 : 47 nF	L3 - L4 : 17 turns - ϕ 0.7 mm
R2 : 33 KΩ	C3 : 47 pF	C17 : 47 nF	on T50/6 ✷
R3 : 1 KΩ	C4 : 150 pF	C18 : 470 pF	L5 : VK200
R4 : 1 KΩ	C5 : 10 nF	C19 : 2 x 390 pF parallel	TR1 : 2N2907
R5 : 47 KΩ	C6 : 33 pF	C20 : 470 pF	TR2 : 2N2222
R6 : 180 Ω	C7 : 10 nF	C21 : 47 nF	TR3 : BF324
R7 : 100 Ω	C8 : 1 nF	C22 : 10 nF	TR4 : 2N2219 heat sink
R8 : 820 Ω	C9 : 56 pF	C23 : 47 pF	TR5 : 2SC1969/2SC2166 ✷
R9 : 15 Ω	C10 : 390 pF	CV1 : 35 pF	D1-D4 : 1N4148
R10 : 47 Ω	C11 : 47 nF	CV2 : 35 pF	DZ1 : 6.8 V - ½ W
R11 : 3 x 1 Ω parallel ✷	C12 : 47 µF	L1 : 33 turns - ϕ 0.4 mm on T44/2	DZ2 : 33 V - 1 W
R12 : 1 KΩ	C13 : 100 nF	tap at 10^{th} turn - link 3 turns ✷	X1 : 4.433 MHz
R13 : 1 KΩ	C14 : 100 nF	L2 : 33 turns - ϕ 0.4 mm on T44/2	U1 : NE602
C1 : 100 pF	C15 : 68 pF	tap at 7^{th} turn - link 2 turns ✷	T1 : 6 bifilar turns - ϕ 0.5
			on ferrite balun ✷

✷ see text, all resistors are ¼ W, all electrolytic capacitors 25 V

The transmission mixer

It makes use of an NE602 IC, the oscillator crystal is similar to those employed in the receiver filter, while a little series connected capacitor (C1, 100 pF) matches the oscillator's frequency to the center frequency of the filter.

A transistor (TR2) works as a buffer stage to adapt the high output impedance of the NE602 to the low input impedance of the following RF amplifier stage.

The 7 MHz amplifier chain

It employs two transistors (TR3-TR4), the first works as a class A amplifier, the output of this stage is tuned by the L1-CV1 circuit, so as to filter the spurious signals produced by the mixer. The second transistor is biased by a resistor divider, so as to obtain a class AB working with a current drain ranging from 40 mA (no signal) to 60-65 mA (full power). The coupling between the stages is made by links wrapped on the tuning coils. This stage can deliver an output power of about 150-200 mW on a 50 ohm load, a little heat sink is needed for TR4.

The L1 and L2 coils are made by 33 turns of of enameled 0.40 mm wire on a T44-2 Amidon toroid. L1 has a tap at the 10^{th} turn from the ground and a link made by 3 turns of of plastic insulated wire. L2 has a tap at the 7^{th} turn from the supply side and a link made by 2 turns of of plastic insulated wire. Both the links are wrapped on the coils starting from the cold side.

The final power stage

It is equipped with a transitor suited for the CB band (2SC2092, 2SC1969, MRF475, 2SC2166) in a broad band configuration. Employing an high gain model, such as the 2SC1969, I recommend to insert a low value resistor (R11, 2 or 3 parallel connected 1 Ω resistors) series connected to the emitter, so as to avoid a possible instability . This transistor works as a class C amplifier, exhibits about 60% efficiency and delivers about 9 W of input power, so it must be equipped with an effective heat sink.

The output impedance of this transistor (R_L) may be calculated from the following formula :

$$R_L = V_{cc}^2 / 2P_o$$

Where V_{cc} is the supply voltage and P_o is the output power, so assuming 12 V and 5 W we'll obtain $R_L = 14\ \Omega$. A broad-band 1:4 transformer (T1) matches the antenna load (50 Ω) to the transistor output impedance, it is made by bifilar winding 6 paired turns of enameled 0.5 mm wire on a ferrite TV balun (12x12 mm). A 5 poles Pi filter cleans the output signal before delivering it to the antenna. L4 and L5 coils are made by 17 turns of of enameled 0.70 mm wire on T50-6 Amidon toroids.

The RX/TX electronic switching circuit

This circuit is implemented by a diode bridge, so allowing the full break-in working, that is RX remains active while transmitting. In this manner it is possible to hear also the CW keying (monitor function). The TR1 transistor is biased so as to provide supply current to the TX driver stages only while Keying.

The PCB board is equipped with two supply points, one for the final stage and the other for the drivers, so doing it was possible to reduce the risk of possible instability. Two separate cables will connect theese points to the positive power supply.

How to tune the Transmitter

After connecting the VFO, you have to adjust the two CV1 and CV2 capacitors so as to obtain the maximum output power (about 5 W) on a dummy load (you may build it by parallel connecting nine 470 Ohm 1W resistors). The output power may be measured using a simple RF probe (made with a diode and a capacitor) and it is obtained from the formula $P = V^2/2R$.

The full power current required will be about 1 A.

The TX Layout - real dimension 100x66 mm