A CW QRP Transceiver for 20 m band

The little QRP presented in this article may be built in a gradual manner, in fact it is divided in two main modules (plus VFO), you may also complete only a single part (RX or TX module).

Also the VFO module may be built with two complexity levels, as a conversion VFO or as a free oscillator, obtaining slightly different performances.

In other words the project looks completely modular, the tuning requires at least a frequency meter, a signal generator and an RF probe, if you have at your disposal an oscilloscope, this could make the job simpler.

How it is made

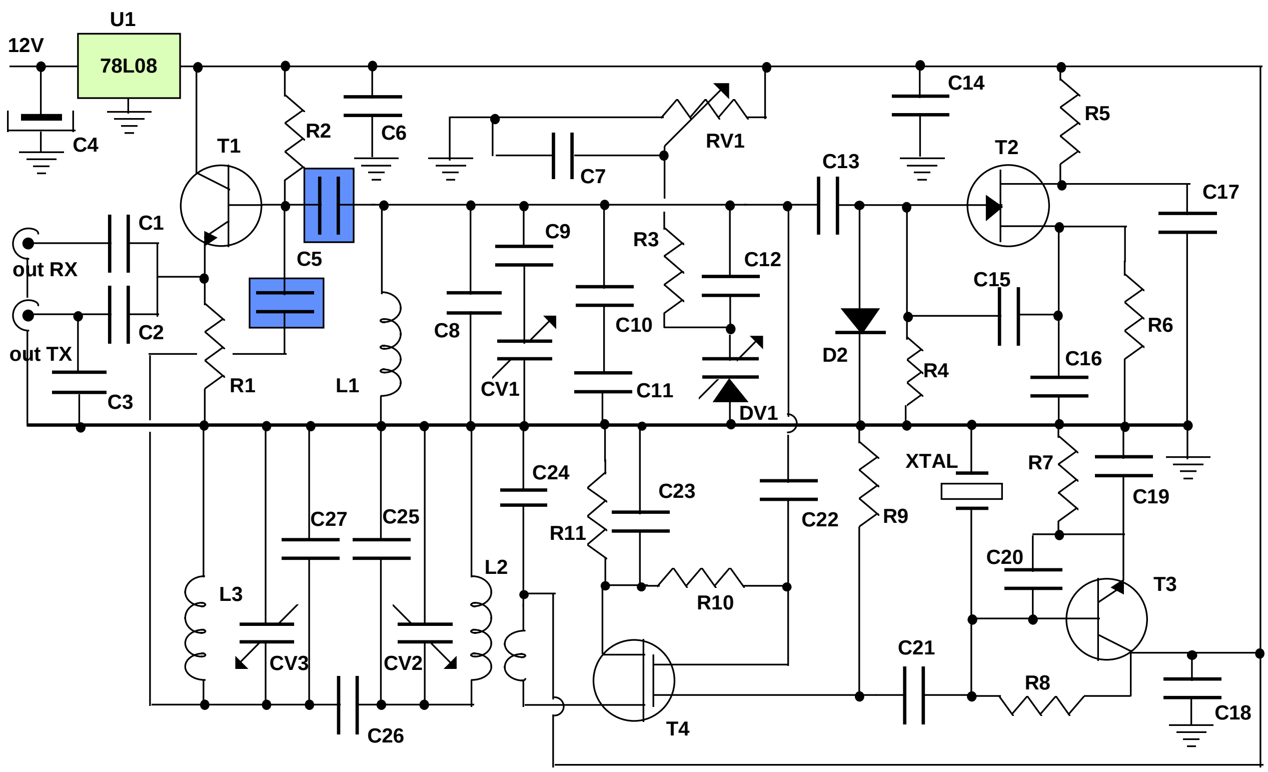
The transceiver is composed by three single sided printed boards 100x70 mm, theese may be stacked so as to reduce the overall size of the metal cabinet. I suggest to employ small size components (1/4 W resistors, 2,5 mm capacitors, …) wich should fit better on the PCB boards.

On the front panel you may place the tuning pot with its reductor gear, the gain and volume controls, the Key and earphone jacks. The power and antenna connectors may be housed on the back panel.

How it works

I'll describe individually the three boards and the relative tuning devices.

a) The VFO circuit



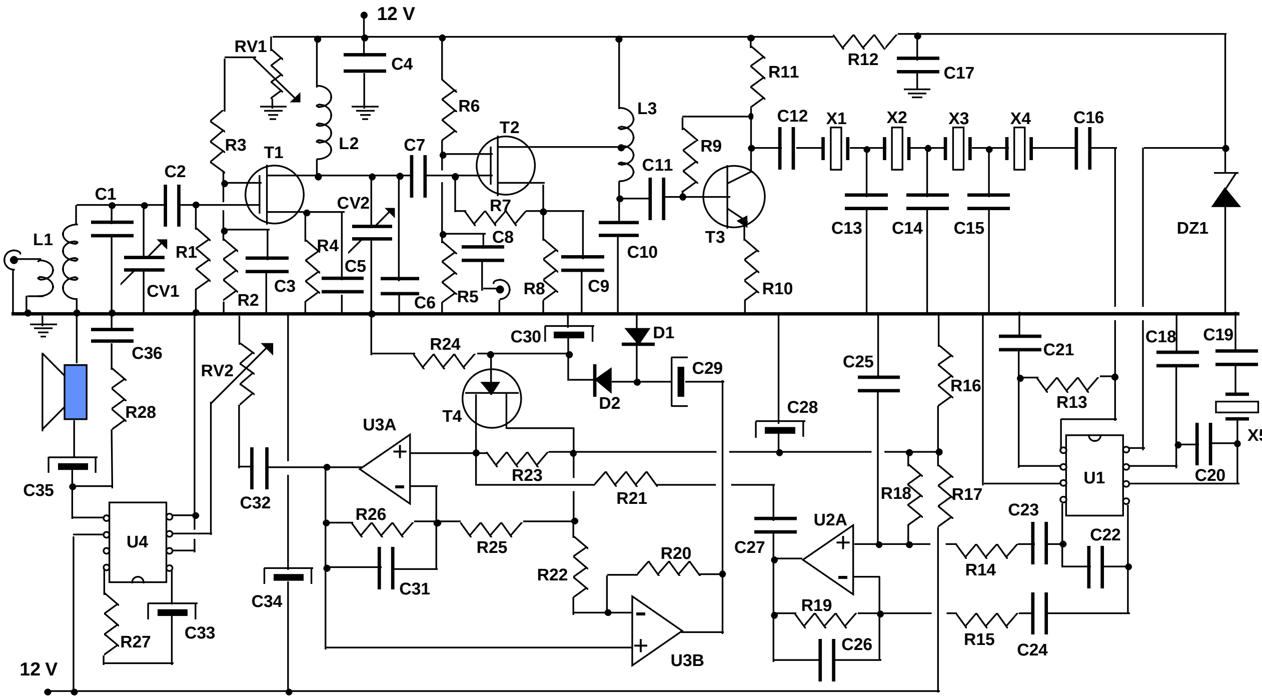
R1 : 470 Ω - 1/4 W	C1 : 68 pF	C12 : 56 pF NPO	C23 : 1.2 nF	T4 : BF960 mosfet
R2 : 180 KΩ	C2 : 12 pF	C13 : 150 pf N150	C24 : 33 nF	DV1 : BB204
R3 : 56 KΩ	C3 : 82 pF	C14 : 33 nF	C25 : 47 pF	D2 : 1N4148
R4 : 270 KΩ	C4 : 47 µF	C15 : 120 pF NPO	C26 : 2.2 pF	XTAL : 16 MHz
R5 : 100 Ω	C5 : 6.8 pF	C16 : 470 pF	C27 : 47 pF	U1 : 78L08
R6 : 390 Ω	C6 : 10 nF	C17 : 10 nF	CV1 : 35 pF trimmer	RV1 : 10 KΩ lin.
R7 : 330 Ω	C7 : 33 nF	C18 : 33 nF	CV2 : 60 pF trimmer	L1 : see text
R8 : 220 KΩ	C8 : 120 pF NPO	C19 : 82 pF	CV3 : 60 pF trimmer	L2 : see text
R9 : 270 KΩ	C9 : 27 pF NPO	C20 : 33 pF	T1 : 2N2222	L3 : see text
R10 : 270 KΩ	C10 : 150 pF N150	C21 : 150 pF	T2 : BF245	
R11 : 390 Ω	C11 : 120 pF NPO	C22 : 6.8 pF	T3 : 2N2222	

The basic version makes use of a Colpitts fet oscillator and a buffer (2N2222) driving the RX and TX circuits. It works very well up to 7 or 8 Mhz, above this limit the stability may be impaired, therefore if you want to adapt this transceiver for a high-bands use (this is the case of 14 MHz band), it will be better to choose the conversion VFO version, wich makes use of the whole PCB board. You may shift from a version to the other simply by changing the connection of the C5 capacitor. The basic circuit version doesn't use the conversion components (located in the lower part of the schematic)
Where specified, the capacitors must be NPO type. The tuning coil must be wound very carefully.
A multi-turn pot may be employed for the tune control, but this will make the building of a frequency reading scale more difficult.

The L1 coil for the 14 Mhz band is made by 50 turns of enameled 0.40 mm wire wrapped on a 13 mm plexiglass core. The specified component values allow a frequency span of about 70 KHz (from 2,433 to 2,510 Mhz) and the output level will be 4V pp. The two varactor diodes contained in the BB204 must be parallel connected.
The L2 and L3 coils for the 14 Mhz band are obtained wrapping 12 turns of 0.50 mm enameled wire on a toroidal core T44-2. The link on L2 is made by 3 turns of plastic insulated wire.

To tune this module you may follow these instructions :
- remove the 16 MHz crystal so as the oscillator goes off
- remove the connection between C21 and the gate 1 of the mosfet
- input a 18.4 Mhz signal to the gate 1 of the mosfet
- tune CV2 and CV3 capacitors for the maximum output at 18.4 MHz frequency, using an RF probe (or better an oscilloscope)
- insert the crystal and C21 capacitor
- turn RV1 at the minimum value and tune CV1 so as to obtain a 18,433 Mhz (14 + 4,433) frequency

b) The Receiver circuit



R1 : 220 KΩ - 1/4 W R2 : 33 KΩ R3 : 82 KΩ R4 : 180 Ω R5 : 56 KΩ R6 : 150 KΩ R7 : 270 KΩ R8 : 330 Ω R9 : 180 KΩ R10 : 470 Ω R11 : 560 Ω R12 : 560 Ω R13 : 470 Ω R14 : 4,7 KΩ R15 : 4,7 KΩ R16 : 3.9 KΩ R17 : 3.9 KΩ R18 : 56 KΩ R19 : 56 KΩ R20 : 82 KΩ	R21 : 82 KΩ R22 : 4.7 KΩ R23 : 82 KΩ R24 : 560 KΩ R25 : 82 KΩ R26 : 820 KΩ R27 : 1.2 KΩ R28 : 10 Ω C1 : 68 pF C2 : 1.5 pF C3 : 10 nF C4 : 33 nF C5 : 10 nF C6 : 68 pF C7 : 6.8 pF C8 : 470 pF C9 : 10 nF C10 : 220 pF C11 : 10 pF C12 : 150 pF	C13 : 150 pF C14 : 150 pF C15 : 150 pF C16 : 150 pF C17 : 33 nF C18 : 47 pF C19 : 150 pF C20 : 47 pF C21 : 33 nF C22 : 33 nF C23 : 100 nF C24 : 100 nF C25 : 1.2 nF C26 : 1.2 nF C27 : 100 nF C28 : 10 µF C29 : 1 µF C30 : 10 µF C31 : 150 pF C32 : 1 µF	C33 : 10 µF C34 : 47 µF C35 : 220 µF C36 : 220 nF CV1 : 30 pF trim. CV2 : 30 pF trim. RV1 : 47 KΩ lin. RV2 : 22 KΩ log T1 : BF960 T2 : BF960 T3 : 2N2222 T4 : BF244 U1 : NE602 U2 : TL082 U3 : TL082 U4 : LM386 X1-X5 : 4.433 MHz D1-D2 : 1N4148 DZ1 : 6.8 V - 1W L1 : see text	L2 : see text L3 : see text

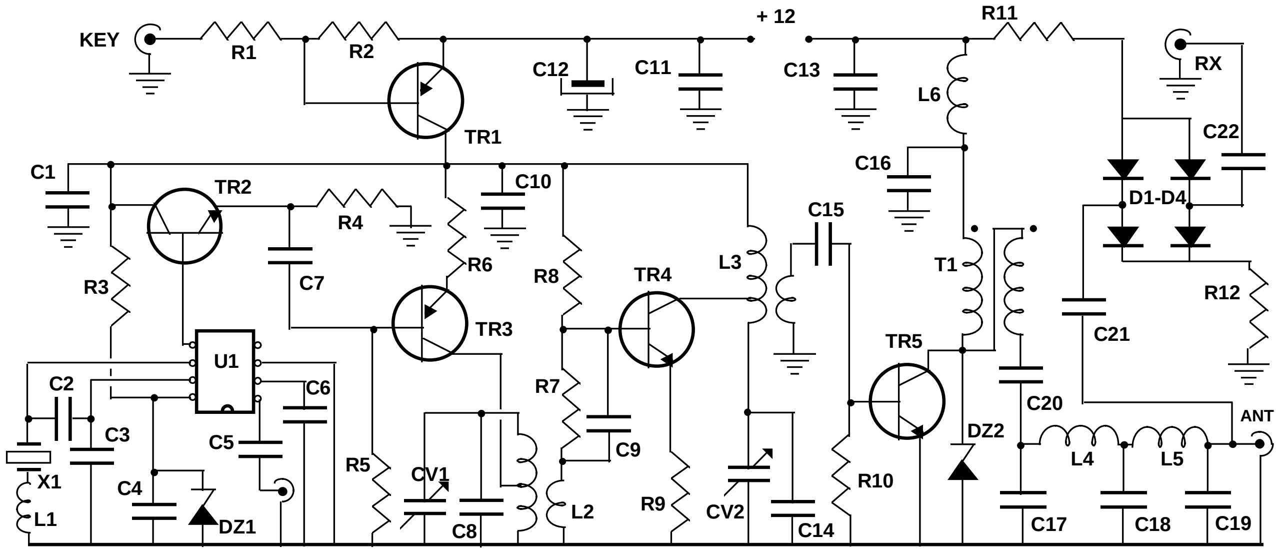
It uses a classic superetherodyne design, employing mosfets in the front end and in the mixer stage, so as to obtain a good immunity towards overloadig signals and a few dB of RF gain.
The XTAL ladder filter makes use of 4 crystals, it exhibits about 600 Hz of bandpass and a good out-of-band rejection. You may employ any set of crystals, provided that their frequency is near 4 MHz. An NE602 IC is used as a product detector, producing also the beat frequency by another (same frequency) crystal. A capacitor, series connected to the crystal, raises slightly the beat frequency, so producing the required shift to demodulate the CW.
The BF circuit makes use of a first pre-amplifier and filtering stage followed by an AGC circuit. This BF automatic gain control partially compensates for the lack of a true IF section and the relative RF derived AGC. Please notice that the RX circuitry is working also in TX mode, so the trasmitted CW, whose amplitude is reduced by the diodes bridge and the AGC control, can be heard from the loudspeaker while keying (full break-in and monitor functions).
An LM386 IC works as a power amplifier delivering about 1 W into an 8 Ω loudspeaker. Be careful while connecting this IC on the PCB board, an effective ground bypass is needed for the Vcc supply line, I suggest to insert two 47 μF capacitors immediately near the IC pins (see C34 in the assembly schematic), also the connections to volume control must be shielded.

The L3 coil is made by 30 turns of enameled 0.30 mm wire wrapped on a 5 mm plastic support with ferrite core, the tap is obtained at the 6^{th} wire from the Vcc (cold side).
The L1 and L2 coils, for the 14 Mhz band, are obtained wrapping 16 turns of enameled 0.40 mm wire on a T44-2 toroid. The link on L1 is made by 3 turns of plastic insulated wire.

To tune this module please follow these instructions :
- tune the mixer stage injecting a 4,433 Mhz signal into the VFO input and adjusting the L3 core so as to obtain the maximum output from the T3 collector
- connect the VFO and input a 14 Mhz singnal to the receiver, then alternate the tuning of CV1 and CV2 so as to obtain the maximum output from the XTAL filter
- connect the antenna and adjust slightly CV1 and CV2 so as to obtain the best reception of a week signal
- you may change the CAG decay time by modifying the R24 value (the higher the value, the longer the decay time)

If any instability is observed in the front-end stage, you may try to solve the drawback by parallel connecting a 470 Ω to the RX input, and/or loading the L2 coil with a 15-22 KΩ parallel connected resistor.

c) The Transmitter circuit



R1 : 3.9 KΩ - 1/4 W	R12 : 1 KΩ	C11 : 47 nF	C22 : 10 nF	CV2 : 30 pF trim.
R2 : 33 KΩ	C1 : 47 nF	C12 : 47 µF	TR1 : 2N2907	L1 : induct. 22 µH
R3 : 1 KΩ	C2 : 47 pF	C13 : 47 nF	TR2 : 2N2222	L2 : see text
R4 : 1 KΩ	C3 : 150 pF	C14 : 68 pF	TR3 : BF324	L3 : see text
R5 : 47 KΩ	C4 : 10 nF	C15 : 47 nF	TR4 : BFR36	L4 : see text
R6 : 47 Ω	C5 : 470 pF	C16 : 47 nF	TR5 : see text	L5 : see text
R7 : 100 Ω	C6 : 10 nF	C17 : 150 pF	X1 : 4.433 MHz	L6 : VK200
R8 : 1.2 KΩ	C7 : 1 nF	C18 : 330 pF	DZ1 : 6.8 V - 1W	T1 : see text
R9 : 5.6 Ω	C8 : 82 pF	C19 : 150 pF	DZ2 : 33 V - 1W	D1-D4 : 1N4148
R10 : 47 Ω	C9 : 390 pF	C20 : 47 nF	U1 : NE602	
R11 : 1 KΩ	C10 : 47 nF	C21 : 10 nF	CV1 : 30 pF trim.	

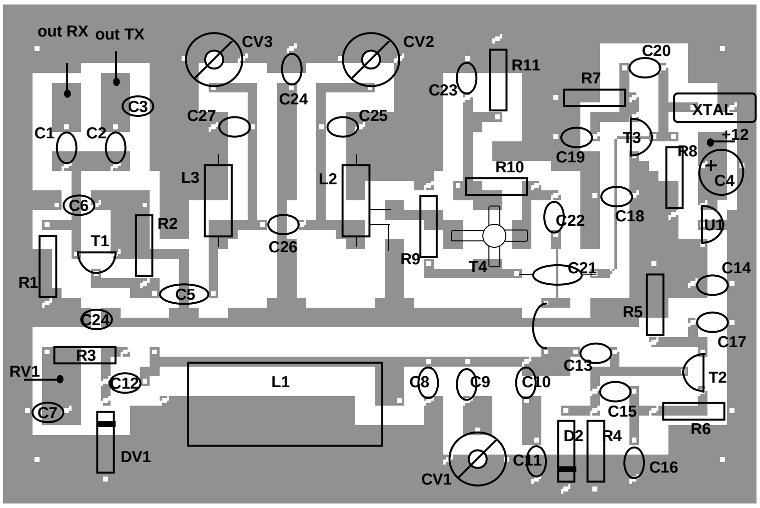
It employs a frequency conversion design, so you can operate the TX and RX using a single VFO. An NE602 mixer converts the VFO frequency up to the 14 MHz band using a crystal similar to those used in the RX, the little series connected inductance lowers the crystal oscillating frequency so as to produce the necessary shift. The power broadband stage is equipped with a transitor suited for the CB band (2SC2092, 2SC1969, MRF475, 2SC2166). The driver and final transistors must be adequately cooled. The T1 transformer has a 1:4 ratio and is made bifilar winding 6 paired turns of enameled 0.5 mm wire on a ferrite TV balun (12x12 mm). A double Pi filter cleans the signal before sending it to the antenna, while a diode bridge works as an electronic switch and implements the full break-in function. The power supply to the driver stages is inhibited while receiving, by means of TR1.

The 14 MHz coils must be made in the following manner :
L2 and L3 : 16 turns of enameled 0.40 mm wire on a T44-2 toroid, tap at the 5th wire, link made by 2 turns of plastic insulated wire
L4 and L5 : 12 turns of enameled 0.50 mm wire on a T50-6 toroid

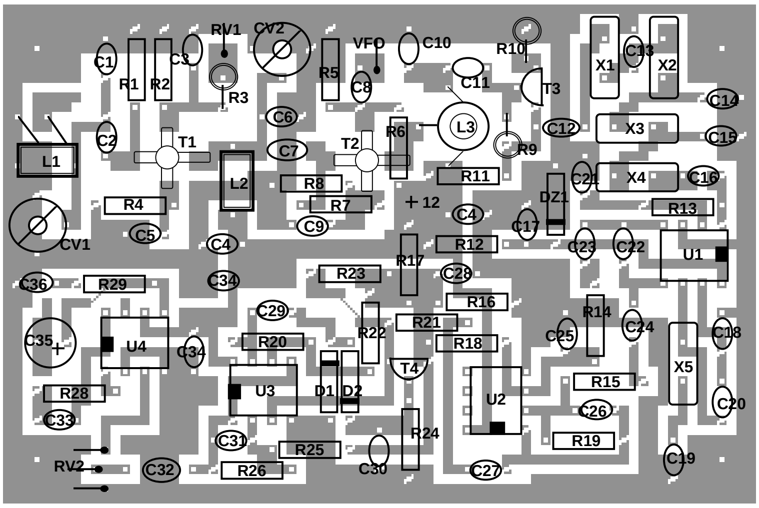
To tune this module connect the VFO, then alternate the tuning of CV1 e CV2 so as to obtain the maximum output (4 - 5 W) on a dummy load (you may build it by parallel connecting 9 resistors 470 Ω - 1W). The full power current required will be about 1 A. If any instability is observed, you may try to solve the problem by inserting a low value (0.5 Ω) resistor series connected to the emitter of TR5, and/or by raising the R6 value to 100 Ω or more.

d) The 1:1 scale PCB boards

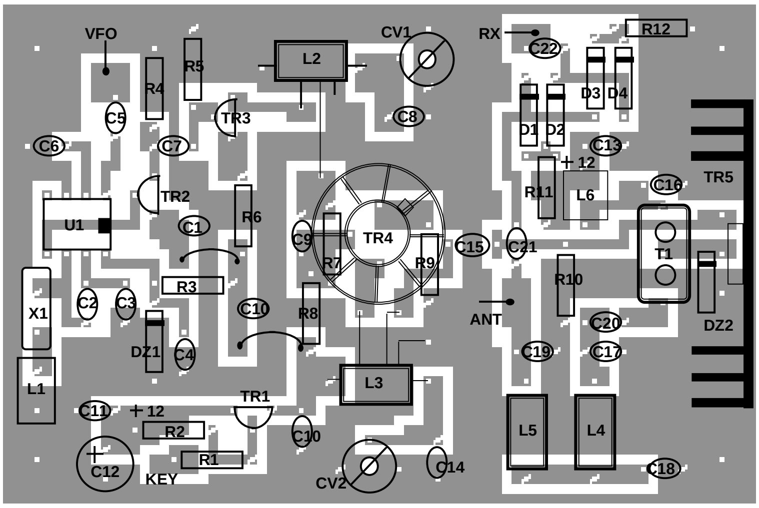
VFO



RECEIVER



TRANSMITTER



e) some final notes

The assembly is not particularly critical, however some care must be dedicated to the VFO and RX input stage, wich must be aligned carefully. The overall sensititivity and selectivity are very good, and so also the capability to handle strong overloading signals, in short the mixer and XTAL filter stages make well their job. Also the BF CAG system proved to be very effective, and the listening quality recalls a good IF system. Especially the CW envelope is very good, showing a very short attack and decay time.
If you are interested in further informations, or to get the PCB masters, please contact me at my E-mail box.