Receiver Noise Canceller

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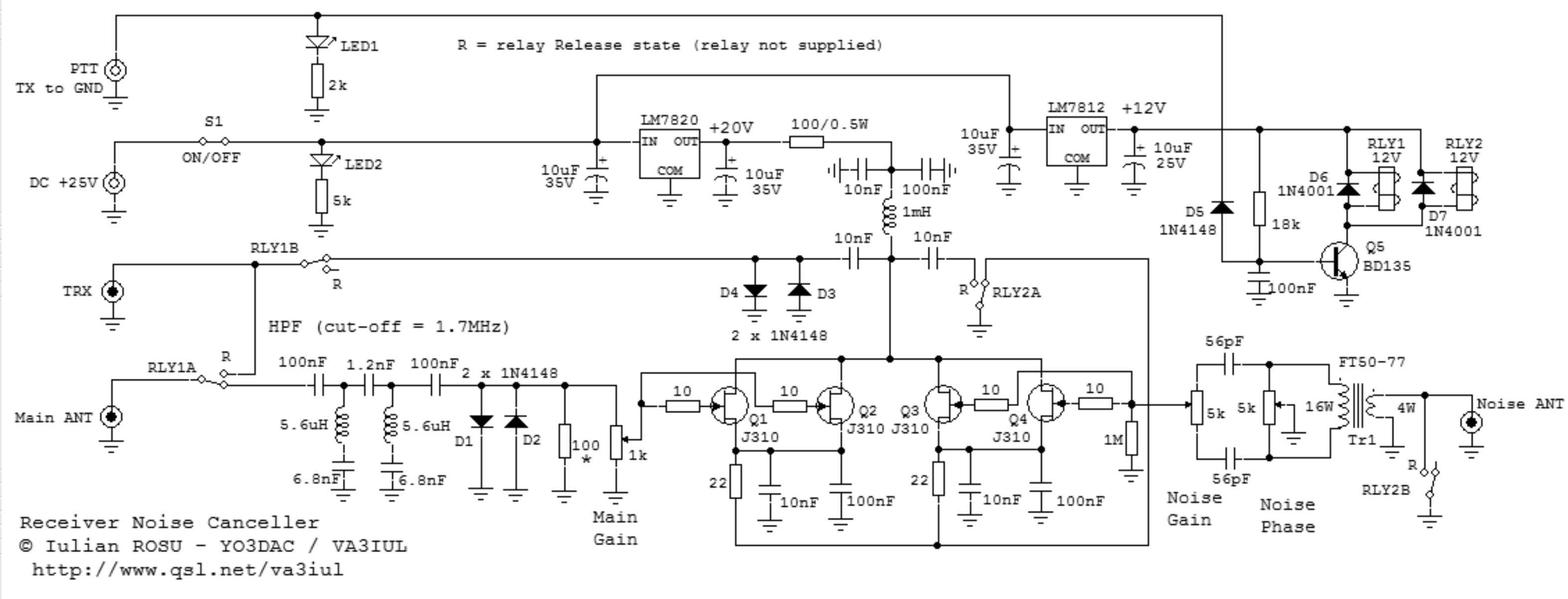


Receiver Noise Cancellers, using an additional receive antenna (diversity antenna) to phase out the local noise, were invented during the tube era, before WW2.

The main antenna receives both, the desired signal and the noise. The noise canceller works by combining the noise received from the Main Antenna and the noise received from the Noise Antenna (which is 180° out of phase with the desired received signal), thus canceling the noise and leaving only the desired signal.
Important to mention that the two antenna outputs (main and noise) are combined after modifying their phase AND amplitude (the relative signal levels).
The interference waveform must be continuous and reasonably stable in its shape and amplitude, as most of the noise from industrial, residential, computers, and power lines is.

Finding the most effective Noise Antenna for a required frequency band and your specific situation is experimental.

Several manufacturers make this kind of noise cancellers for radio amateurs (S.E.M., MFJ, WiMo, Timewave, DX Engineering). Their block diagram is almost the same, but the approach of the circuit implementation is different. Whatever complexity their circuit has, the noise canceling performances are pretty similar.

Unfortunately all of these devices suffer from dealing with high input signals.

The noise canceller presented bellow mainly improves the IP3 linearity of the circuit.

Improved linearity is done by using on each antenna path (main and noise) two J310 JFETs in parallel which are supplied at relative high DC voltage (+20V).
Compared to a single J310 JFET supplied at +12V, a stage using two JFETs in parallel supplied at +20V have more than 6dB better IP3 performance. Also this approach has higher gain and lower noise figure, parameters which are important for a first stage amplifier in a receiver system.
The signal from the main antenna is routed to the circuit through a steep elliptic High Pass Filter with cut-off at 1.7 MHz, filter which rejects strong broadcast stations and high noise levels below that frequency. Further, the signal is amplified by the Q1, Q2 stage.
The signal from the Noise antenna it goes initially to the phase changer circuit, and later amplified by the stage Q3, Q4 JFETs.
Drains of all JFETs Q1, Q2, Q3, and Q4 are connected together, connection where we get the sum of the Main and Noise signals.

Tuning the Noise Gain and Noise Phase potentiometers, attain the noise null.

Also, adjusting the amplitude and the phase of the signals coming from the Main and Noise antennas, you can get an enhancement of the desired received signals. This is an advantage which otherwise you get if using two paralleled receivers connected to different antennas. This is an option that some high-price transceivers have.

For any noise canceling circuit to work properly, very important is to use for the “Noise” antenna an antenna similar with the "Main" antenna. Some manufacturers mistakenly mention that the “Noise” antenna should be a simple wire or a simple loop antenna. Generally can be used any “Noise” antenna type (even a simple random length wire) but I found that the best performances were obtained when the antennas are similar in size and especially when they have the same polarization. The main explanation of that the antennas should be similar, is because the Noise doesn’t have to be local in origin; it can also arrive by ionospheric propagation from distant sources. This effect can allow noise from sources very far away to accumulate at the receiving location and "mask" the weak signals.

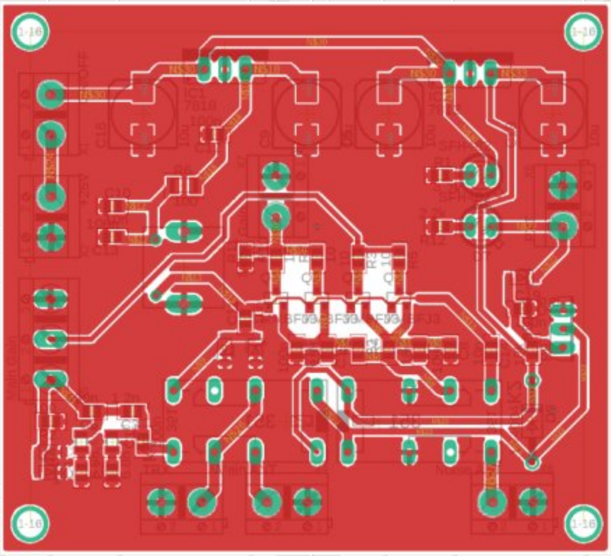
If both antennas (main and noise) are resonant antennas and not a simple wire, the distance between them should be λ/2 or greater. Sometime, due to limited space, this distance is hard to get in 80m and 40m, but the circuit it will work sufficient well even the antennas are closer.
The noise canceling performance is not affected much by the distance between antennas, but the desired signal enhancement option will be affected.

On the schematic, the two relays are shown in receive mode, which means: Switch 1 is closed, and the PTT of the transceiver is not pushed (PTT line not connected to the ground). R state of the relays means release state (when the circuit is not DC supplied, and Switch 1 is open).

For the reliability of the circuit it is very important to use fast signal relays, with switching (operate) time less than 5msec (most of the modern signal relays does this).
Important to don't damage the circuit with high RF power is: Never transmit with the transceiver if the PTT line from the transceiver is not connected to the circuit. If forget to do this connection and transmit 100W, the JFETs Q1,Q2,Q3,Q4 and diodes D3, D4 will be most probably damaged (due to high level of standing waves inside of the box). To prevent this situation I placed the LED1 into the circuit, to check always if the PTT cable coming from the transceiver is connected to the circuit. When the PTT from the transceiver is not pushed (RX mode), most of the transceivers put +8V on the PTT line. This DC voltage is used to light on the LED1.
For minimum loss of TX power when passing through the noise canceller circuit, on the back panel of the device place the TRX connector near the Main antenna connector, and place the relay RLY1 between them. Use short 50 ohms coax cables (4mm diameter with PTFE dielectric).
Never place the Noise Canceller circuit after a high power amplifier (more than 100W).
If use an external Transmatch, I would recommend placing the Noise Canceller circuit between the Transmatch and the Antenna, even some manufacturers recommend to be placed between the Transceiver and the Transmatch.
Also I recommend to tune the Transmatch (internal or external) with the Noise Canceller circuit not DC supplied (Switch 1 open), and switch ON the device after the tuning is done.

The phasing transformer Tr1 was made on a FT50-77 ferrite toroid, having 16 turns on primary and 4 turns on secondary. Another option is BN-43-3312.

Here is a short movie which shows the performance of the Noise Canceller device. Can be seen on the waterfall the noise reduction and improved signal readability when the device is active or is not.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