Pocket Radio HF SDR: $18 DX

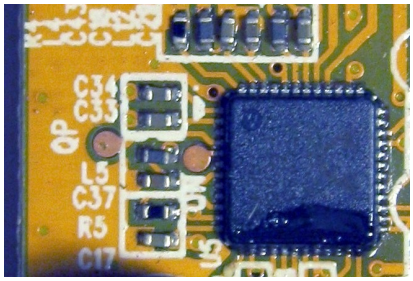
MW, SW, FM, AIR, VHF, UHF

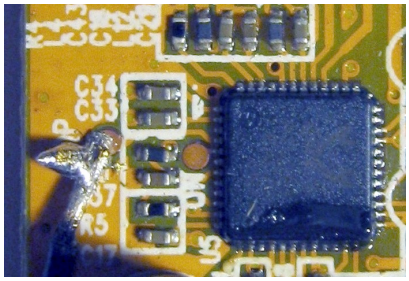
VERSION 1 ©2015

CAUTION: Wear eye protection when soldering.

1. HARDWARE: 24 MHz to 1.7 GHz

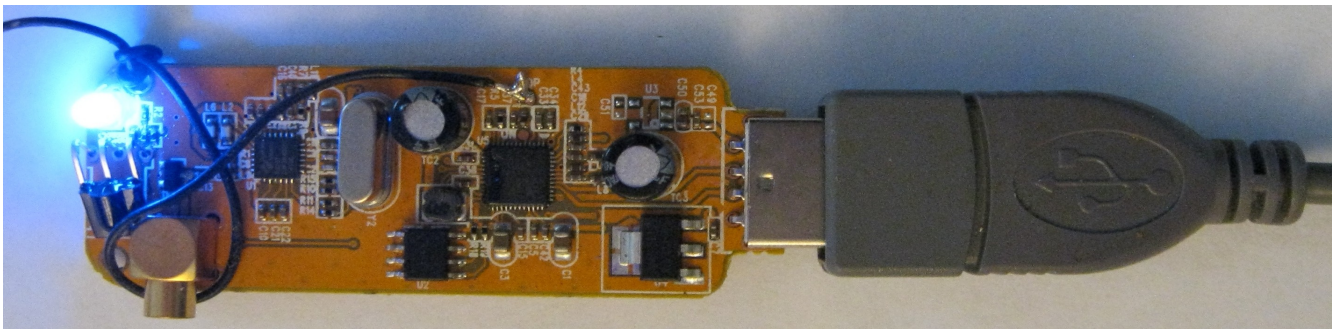
A NESDR Mini USB DVB-T & RTL-SDR receiver was purchased on eBay for $18.00 (shipped) from NooElec. A magnetic 4.75” antenna (diode protected; male MCX jack) was included. The NESDR Mini dongle can be used as an RTL-SDR. SDR refers to a software defined radio. RTL refers to the Realtek RTL2832U interface chip. The RTL2832U uses an ADC (Analog-to-Digital Converter) to accept an IF, low IF, or Zero-IF signal and convert it to 8-bit I/Q samples. The samples are sent via the universal serial bus (USB 2.0), at rates as high as 3.2 MS/s (mega-samples per second). The NESDR Mini's Rafael Micro R820T tuner chip covers from 24 to 1766 MHz. It consists of a low noise amplifier (LNA), I/Q mixers, and I/Q amplifiers. A 28.800 MHz crystal is utilized by both chips.





2. HARDWARE MODIFICATION: DC to 28.8 MHz

This mod takes soldering one piece of wire. The NESDR's plastic shell can be pried apart using a jewelers screwdriver. A wire was tied to a PCB hole (picture below) to prevent damage from pulling. One side of the wire was soldered to a circular, copper pad near the RTL2832U chip. The pad (Q+) is located between the markings C33 and L5 (picture above). The other side of the wire was fished through an existing case hole (see top picture). The wire was hooked to a 50 foot indoor antenna via an alligator clip. **A safer setup**: use a 10 nF capacitor to block DC and back-to-back diodes (to ground) to dump voltages over 0.7V. *Elsewhere* see other ways of presenting RF to the chip: ex. via a toroid. Ideally the other pad would be connected to ground using a 10 nF capacitor.



3. SOFTWARE

Stations from DC to 1766 MHz, including MW, SW, and FM DX, can be heard using software. Popular programs include: GQRX (Linux), SDR# (Windows), and SDR Touch (Android). An Android-OS based phone or tablet can use the NESDR Mini via a USB-to-microUSB cable and SDR Touch.

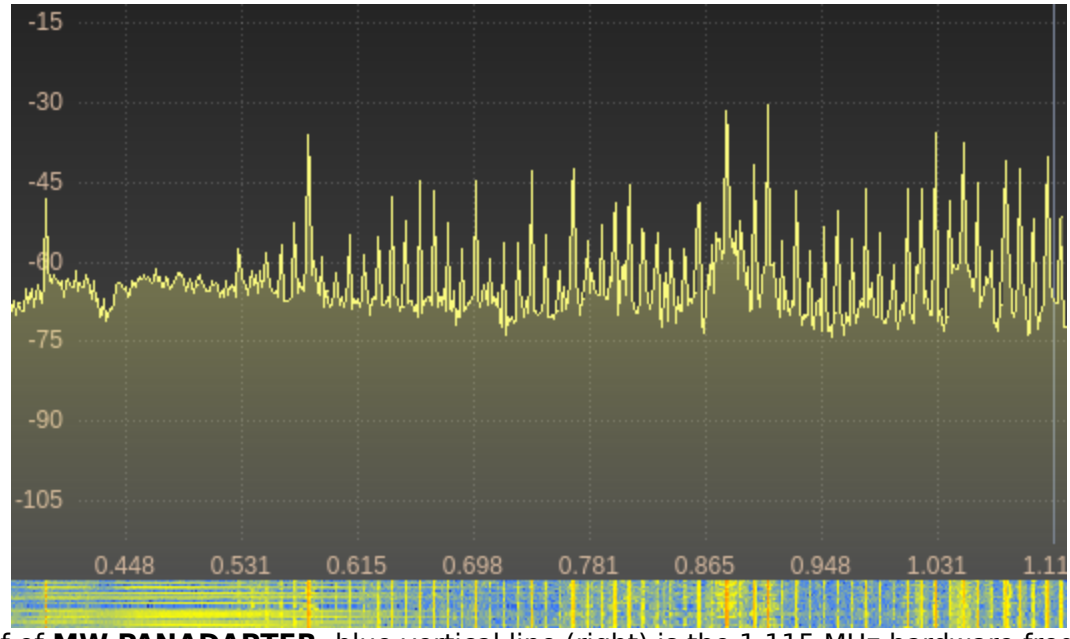
4. GQRX: UHF/VHF

GQRX utilizes rtl-sdr (free SDR) and gnuradio (free signal processing). From the terminal type: "sudo rmmod dvb_usb_rtl28xxu" each time the dongle is plugged into a USB slot. This uses root privilege to unload an auto-loaded module that will tie up the tuner and prevent its usage. From the terminal type: "gqrx" to start GQRX. To hear UHF/VHF set Device to Realtek RTL2832U; set Device string to rtl=0; set Sample rate to 2400000; set Bandwidth to 1 MHz; and set LNB LO to 0 MHz. The LNB LO is the low-noise block down-converter local oscillator. Use manual LNA gain. Proper manual LNA gain adjustment can be critical to VHF and UHF reception. The modulation used on VHF/UHF is often NFM (narrow-FM): WFM (wide-FM: mono or stereo) and AM are also used.

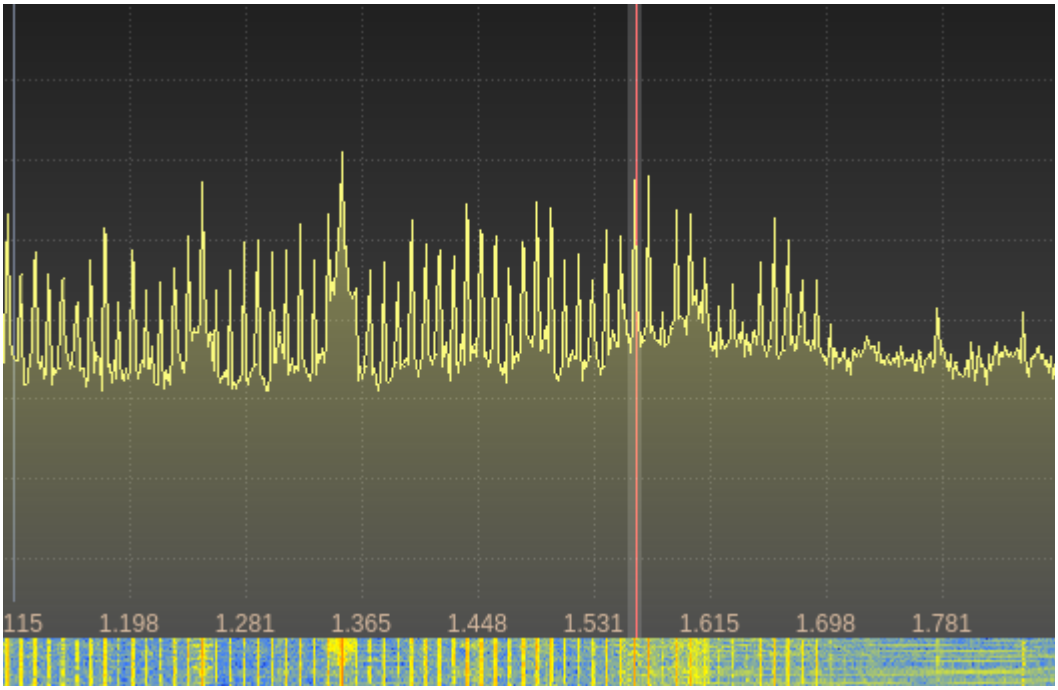
5. GQRX: MW/SW and MW PANADAPTER

After hardware modification, GQRX can be used as a MW and SW receiver using the direct sampling mode: input number **four**. For antennas, the outer metal ring of the MCX jack can be used as ground. To see the entire MW spectrum (from 448 to 1781 kHz); set Device to Other... ; set Device string to rtl=0,**direct_samp=4**; set Sample rate to 1500000; set Bandwidth to 1 MHz; and set LNB LO to 0 MHz. Enter an offset (upper right) of zero (0.000 kHz) to allow direct frequency entry. Enter a hardware frequency (upper left) of 1.115 MHz; the exact center of the MW band.

Turn the radio on by pressing the "Start DSP Processing" circle (upper left). Set the filter bandwidth: normal will suffice. Set mode to AM. Set AGC to fast for scanning (test medium for listening). Set the audio gain (volume). Adjusting the volume can be crucial for proper reception. Use the channel filter offset to change MW frequencies. Click the upper (or lower) part of the 10-kHz (XX#0.000 kHz) offset digit to increase (or decrease) the received MW frequency. Under "Input controls" set the LNA gain to zero and check "DC rem" (automatic DC removal). Before tuning on MW, center one station via the channel filter offset in kHz and tenths of kHz (XXX#.#00 kHz). The whole MW spectrum can be seen. The FFT size (display crispness) and rate can be set. Up to 3.2 Mhz of bandwidth can be seen at once. "No limits" may help switch into the direct sampling mode.



Left half of **MW PANADAPTER**: blue vertical line (right) is the 1.115 MHz hardware frequency. Spikes represent stations' carriers. The sidebands, beside each carrier, contain voice data.



Right half of **MW PANADAPTER**: red vertical line is the station currently being heard. Clicking on the waterfall (bottom; larger on the actual screen) changes stations.

To hear SHORTWAVE, use the MW settings but set Sample rate to 2400000. Standard bandwidths on AM are 4.8-kHz narrow (*2.4-kHz voice*), 9.6-kHz normal (*4.8-kHz voice*), and 24.2-kHz wide (*12.1-kHz voice*). User defined bandwidths are: 0.5-kHz to 40-kHz on AM and 260-Hz to 9.8-kHz on SSB. GQRX will tune in fine 1-Hz increments; allowing quality reception of ham radio operators on SSB. Demodulation also includes CW-U and CW-L or continuous wave (Morse code). A "configuration" file can be saved for UHF/VHF-mode, MW-mode, and SW-mode. Restart the terminal and/or use "gqrx --reset" to switch between the MW/SW mode and the UHF/VHF mode.

6. POCKET RADIO

Pocket Radio DX was started in 2002 using an $11 Sony ICF-S10MK2 and RadioShack loop to MW DX. It evolved into using sub-$20 radios, almost disposable electronics, to MW, SW, and FM DX. Now an $18 **DC to 1.7 GHz Software Defined Radio** can be added to your Pocket Radio DX arsenal. And it can be used as a MW panadapter or to DX on VHF and UHF (scanner frequencies). The NooElec NESDR Mini tuner has the easy-solder, copper pads for direct sampling. It contains the RTL2832U and R820T chips. It is available for $18.00 on Ebay: item number 151217088428 ("Improved Capacitors & Crystal"). Or buy it directly from NooElec Inc. for $17.95 as SKU: 100556.

The modification in this article uses a clean input on the RTL2832U chip. This is exploited via using "**direct_samp=4**" in the device string. I recommend tinkering with both the software and hardware. Try tuned SW loops, tuned MW ferrite antennas, and inductor-based inputs using both the Q+ (*pin 4*) and Q- (*pin 5*) branches. Ideally, band-pass filters or traps would keep local MW and FM energies out of the LNA and ADC. Considering the 48-dB dynamic range of the RTL2832U's 8-bit ADC and its 28.8 MHz sampling rate, this is a surprisingly useful software defined radio. With SDR you can both hear and see radio frequencies. Since most of an AM station's energy is in its carrier, stations can be seen (above the noise floor) before they can be heard. MW, SW, FM, VHF, and UHF DXing with this "$18 version of the $2000 IC-R8500" is both challenging and fun.

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Dr. Phil's Receiver Designs