

**Issue #1, Receiver front-end oscillation on VHF.**

Noticed while listening to NOAA weather service on 162.400mHz. The radio would break into oscillation with my hand near the antenna. This oscillation has been verified on at least one other UV-5R. Radio must be tuned to a fairly strong signal in the upper part of the VHF band for this to occur.

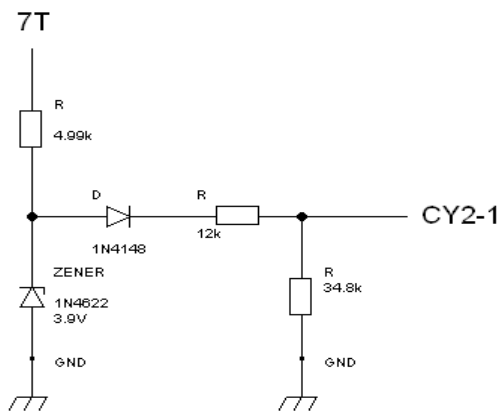
Problem was tracked down to a poor impedance match between the output of the preamp and the input of the SDR chip. I originally set out to place a 3dB resistive “pie” attenuator between the preamp and the SDR chip, but I couldn't find room on the board for three resistors. Instead, I decided to place a single resistor from C95 to ground. The oscillation was easily quenched with a couple hundred ohms of resistance. Values ranging from 100 to 200 ohms were tried. I settled on 110 ohms. The resistor is placed from node C95/U2-15 to ground.

BTW, it is common in the high gain RF designs to place resistive pads (isolators) between gain stages. The output stage then sees a nice non-reactive impedance and the following input stage also sees a nice non-reactive impedance. Amplifiers like that.

**Issue #2, Receiver off frequency.**

When transmit frequency is netted, receive frequency is approximately 2.5kHz to 3.0kHz high on UHF and about a third of that (also high) on VHF. This has been verified on several other UV-5R's.

I don't know if this issue is due to an error in the MCU code or the SDR code, but it really doesn't matter – I can't do anything about either of those. So I decided to design a workaround based on shifting the reference oscillator during transmit. Nice that the reference oscillator has a “pullability” pin. After trying several different circuits I settled on the one below. The selection of the Zener and diode is critical. The Zener chosen has several important characteristics – Vz is specified at 250uA and the Vz has a -0.06%/deg C coefficient that nicely tracks the -2mV/deg C coefficient of the diode. The net effect of the two parts combined in the circuit below should result in a circuit that is stable over temp. This is important for transmit frequency stability. Another concern is the change in Vz caused by the battery starting at 8V and decaying to 5V. The change in Vz is significant (I curve traced the Zener) but should represent less than a 200Hz shift in transmit frequency over battery discharge at UHF. This acceptable for my applications (I'm only an Amateur). If you need better frequency stability, a precision reference will be needed in place of the Zener. Unfortunately, most precision references are hungry (>0.5mA) and expensive and big.



Circuit is wired to the 7T node that goes to batter voltage during transmit, and CY2-1, pin 1 of the reference oscillator. I used a combination of SMT and leaded parts tacked onto the RF side of the board.

Once the circuit is tacked in, adjust the transmit frequency with VR1 as before. The receive frequency should now be pretty close. On my sample, I'm within 1kHz on UHF, and much better on VHF. In future experiments, I may make the 12k resistor a 20K pot and drill

a hole in the metal backing plate to allow me to adjust both the transmit and receive frequencies - obviously with some interaction – the receive frequency will need to be adjusted first, then the transmit frequency. That's OK with me...YMMV.

BTW, you can hear the 26mHz reference oscillator move approximately 180hZ with an HF receiver when going between receive and transmit.  $26 \times 17 = 442\text{mHz}$ . So near 442mHz, the shift is  $170 \times 17 = 2.8\text{kHz}$ . I'm not real picky so please don't tell me I'm not correcting the frequency enough – that might be true, but this works for me. If you need more correction, lower the 12k or use a 20K pot.

Of interesting note, we have all been describing this issue as the receiver being off frequency. In reality, I believe the **code error is in the transmit side of things**. With the reference oscillator set to 26.000.000 exactly, the receiver is dead nuts on frequency – the transmitter is then off. Hmm. Makes you think. Did the designers know about this problem and tailored the values of the trim divider to enable them to get the transmit frequency dead nuts? Got the design out the door.

There's many other ways to achieve the function of this circuit with additional active components that would retain using the existing on-board 3.3V regulator. I'm just presenting one of many possibilities. No attempt is made to show where the parts are installed – that is left up to you and will depend on the part types you have or decide to buy. Mouser carries the 1N4622 Zener. Hopefully someone will come up with a better fix than this or maybe someone with more time will come up with detailed instructions on how to implement this circuit. YMMV.

### **Issue #3, Poor squelch action.**

The squelch threshold has no hysteresis and it does not hold open with any discernible time constant. Very annoying in the car – otherwise OK. After trying various things, and in the process, blowing open Q19 (don't ask...but the test used several mosfets and a CD4460), I settled on placing a single 30 ohm resistor in series with the collector of Q19 and adding 10uF across C154 . This does not add hysteresis and only changes the mute timing a little. The effects are minor – a little less popping and a little smoother mute action. Probably not worth the trouble. FYI, in carrier squelch mode, the muting is controlled by the application and removal of power to U4. That means a big slug of current is needed to charge up the low ESR bypass caps. I wonder how Q19 likes that. Anybody out there encounter a failure of Q19? I couldn't find SOA curves for Q19 but second breakdown failure is a concern.

What I really would like to do is remove R103 and replace it with a 1N4148 and add a little capacitance across R51. That would open the squelch fast and delay the closing by the time constant of R51 and the added capacitance. I can barely see R51 (really really small)! So I decided not attempt this. I'm pretty sure it would be sweet. Maybe someone with better eyes will want to attempt this.

### **Issue #4, Intermod susceptibility in strong RF environments.**

I studied the RF front ends and noticed a schematic error – where does D15 and D16 get bias from in transmit mode? Must be an error. Regardless, when in receive, D15, D16, D18 and D19 have no reverse bias on them. And, maybe not even zero bias because large signals will tend to charge the floating node and modulate the capacitance of these diodes. A perfect mechanism for IMD. These diodes should have a negative bias on them or at least be forced to zero with a high resistance. If you use this radio hooked up to an external antenna, you may find improved IMD performance by placing a few kilo-ohms across these diodes. I have not tried this because I don't use an external antenna. An HT is portable use. If you need a base station, a better choice is a radio made for that use.

### **Issue #5, Display darkening from heat dissipated by the final RF device.**

Also noticed if I leave the radio in a hot car, I get the same thing - a dark display. The final transistor is heat sunk to the board by a solder tab and also from the top of the device by a "silpad" like material to a raised area on the chassis. The silpad is thick - .075"? The thermal resistance off the top of a plastic device through a thick silpad is very high. This heat path is useless. Might be a little better with some other lower thermal resistance material between the top of the device and the metal but probably not worth the trouble because you would still have the high resistance of the plastic package. Since I only use low power, I didn't pursue any changes here. If you try to improve the thermal path, beware of mechanical tolerance issues – the silpad was there to take up mechanical clearance between the top of the device and the heatsink, and also be wary of introducing a metallic mass above a plastic UHF RF device.

### **Issue #6, Terminals on the back of the battery.**

This need to be confirmed – there does not seem to be a diode between the rear battery terminals and the battery. And I don't know if there's an internal fuse (or something that will act like one) internally to the battery pack. So.....if I put this thing in my pocket with my keys or spare change, do I get a mini barbeque? I don't want to find out. Black electrical tape between charges may be prudent.

I have been testing the fixes for issue #1 and #2 for a week now. **The radio is quite enjoyable to use. I'm amazed at the quality of the components and workmanship. Top notch.** I don't plan on disassembling my radio again but if I do, I would change the 12K resistor to a 20K pot and drill a hole in the heat sink near VR1. I also would try to incorporate the proposed squelch changes.

If you don't want to tear into your new toy to fix issue #2, I offer the a few work arounds for the frequency issue:

1. Adjust the transmit frequency on UHF 0.5kHz low. No one will notice you are low in frequency that amount and it gets the receiver closer. I tested this solution for weeks – yes it has many pitfalls but for ham use – its a good compromise.
2. If you only use the computer program to set channels like I do, place a 30K-35K ohm resistor from CY2-1 to ground – there's extra pads and room next to CY2 that makes this easy to do, unlike the other parts needed for the full blown fix. Once the resistor is installed, adjust VR1 to get the receiver to be 0.5 to 1.0 kHz high on UHF. Then program your UHF transmit frequency in software 2.5kHz low. Use no correction for the transmit frequency on VHF. At least the receive frequency is displayed on the radio will be correct. I don't usually look at the transmit frequency when I'm talking so that wont bother me. Not a great idea but it might work. Needs testing....

I want to get a RDA1846 SDR chip and control it with my Aurdino. I thought I might be able to do that with the UV-5R but the physical implementation is not friendly for hacking into the serial paths or any of the T/R circuitry. It would be cool....everything is already there for \$65 bucks – the front ends, the SDR chip, the transmit RF chain....everything. Maybe Baofeng will sell me one of their engineering breadboards?

Comments and different ideas/solutions welcomed. And by all means, feel free to blow holes in anything presented here. This all does need peer review.....

73

Dave

kx3dx