The K290R Project

Steve Kavanagh, VE3SMA, December 2017

Background

I have been using a pair of Yaesu FT-290R 2m transceivers as IF rigs for microwave transverters for many years. My 2.3, 3.4, 5.7, 10 and 24 GHz transverters have been designed to interface with the FT-290R (operated in low power mode) using a single coaxial cable for transmit/receive IF signals and transmit/receive switching control. The FT-290Rs are set to about 100 mW output and they provide 6.8 V DC (through a large resistance) at the antenna socket in transmit. But the FT-290Rs are showing their age and are becoming unreliable. I purchased the first one in 1983 – 34 years ago. The purpose of this project was to produce a replacement for the FT-290R as a 2m IF radio.

The approach selected was to install a low power 2m transverter inside an Elecraft K2, a QRP HF transceiver which I enjoy operating. This provides a much better receiver than the FT-290R, but does not provide FM capability, which can occasionally be useful. It also does not have internal batteries like the FT-290R. An internal battery is an option for the K2 but the transverter takes up the space which would otherwise be available for the battery. The K2 is bigger than the FT-290R but not as heavy. Because the modified K2 is emulating an FT-290R, I called it the K290R.

This article describes how the modification was accomplished. It is probably difficult to reproduce exactly what I did, as some of the parts have become hard to find. Nevertheless, I hope it will help anyone thinking about microwave IF rig alternatives.

2m Transverter Selection

I acquired at a flea market an old used DEMI 144-28DC low power transverter board. Or so I thought. It seems, after some headscratching and email exchanges about small differences from the published schematic and layout, that it may actually be an unauthorized (and not quite identical) copy of the DEMI board. No matter…it does work, though with a bit less output than a real DEMI, and provides the same interfaces.

K2 Configuration

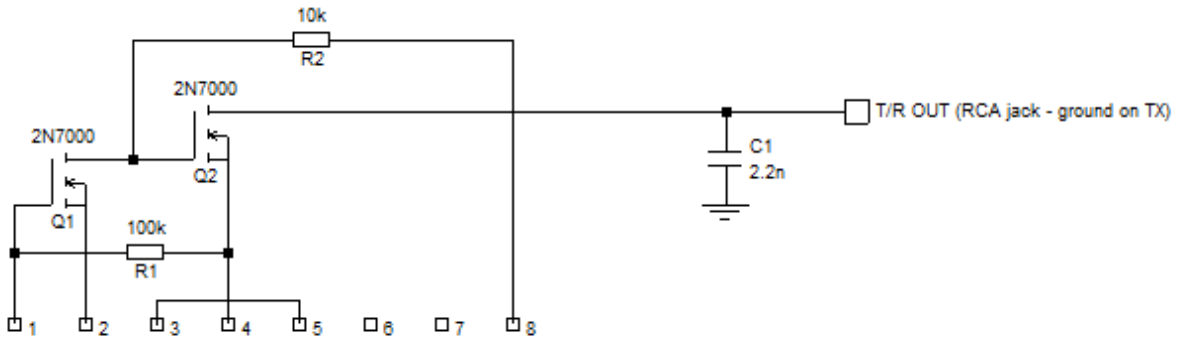
It was necessary to fit the K2 with the K160M module from Elecraft, which adds the 160 m band and, more importantly for this application, a separate receive-only antenna input. This input is then used for the receive IF at 28 MHz. In the primary menu “RANT” must be set to “ON”.

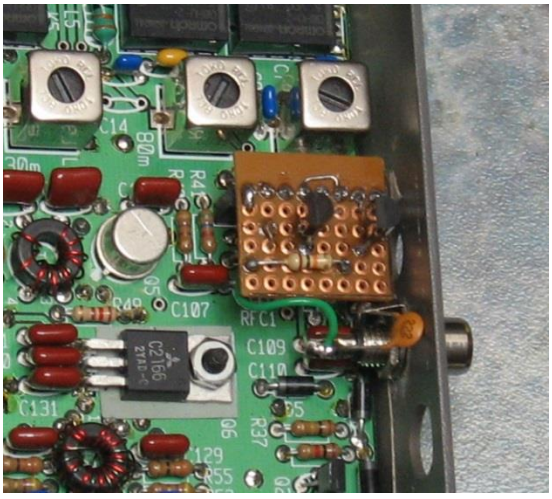
The normal QRP antenna jack is used for the transmit 28 MHz IF output from the K2. The lowest power at which I thought the signal quality and output power control would be good is 1

watt. I activated one transverter band in the K2 menu, set the IF to 28 MHz and the RF to 144 MHz and set the power limit to 1 watt. If the IF rig is to be devoted to a single band, you can set the K2 MHz readout on a transverter band to whatever you want.

If you want to use SSB on the microwave bands, the K2 should also have the Elecraft KSB2 SSB module installed.

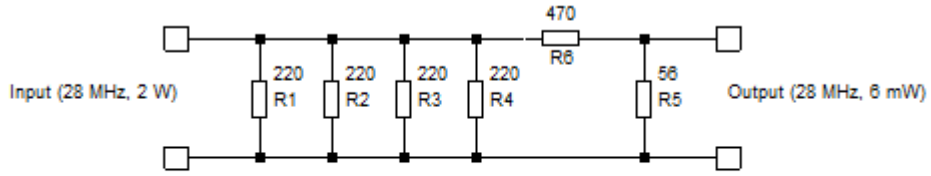
The basic K2 does not have a PTT output. In order to switch the 2m transverter (and the microwave transverter) between receive and transmit it is necessary to add one. One option is to buy the K60XV module, which provides such an output, for which you need to install an extra jack. This would also provide a receive input, so the K160M would not be needed. But I opted to add a separate simple homebrew PTT output board along with the K160M. Mine is a modified version of the one described on the Elecraft website at http://www.elecraft.com/Apps/Amp_keying_ckt.htm , which would work just as well, I think. The schematic and a photo of my PTT output board installed are shown below. It plugs into J13 on the RF board. I used one of the transverter in/out jack holes (for the K60XV) to mount the RCA jack to provide this output. The centre pin is switched to ground in transmit mode. In the K2 primary menu, under "T-R", you must set "8r hold" to avoid too much relay chatter.





Transmit IF Interfacing

The 28 MHz output power from the K2 is considerably more than the 2m transverter board requires, so an attenuator is needed to dissipate most of the RF. I opted to build the attenuator into the (QRP) top of the K2, with a BNC input jack installed in one of the holes intended for the antenna tuner option.



R1-R4 are 1 watt (1/2 watt would do)
R5 & R6 are 1/4 W

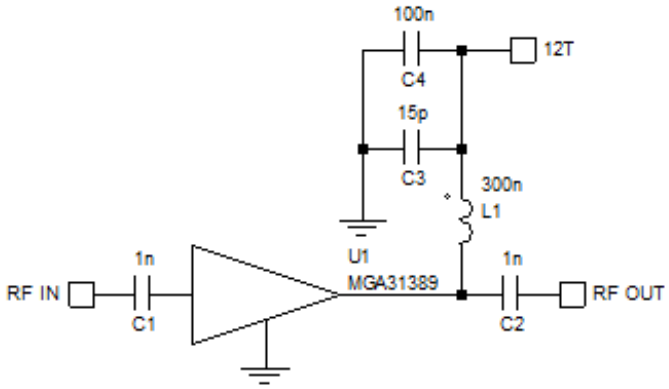
2m Transverter Configuration

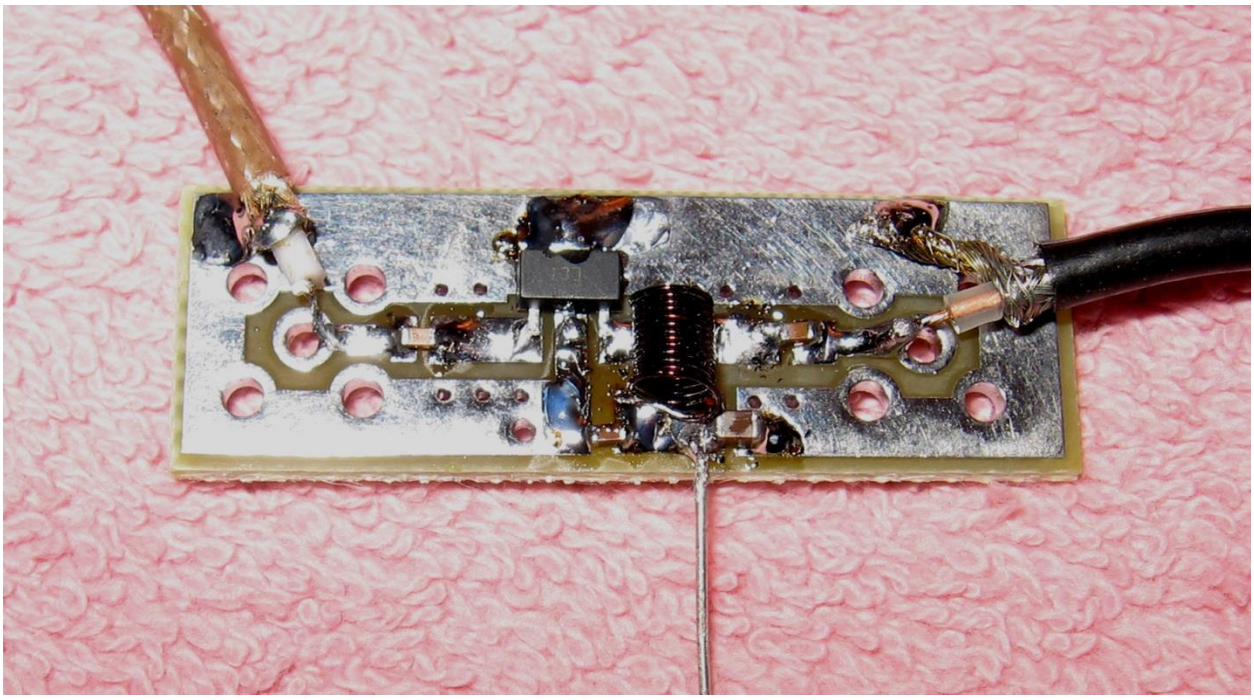
The 2m transverter board offered a variety of alternative connections. I arranged it to use separate IF and RF transmit and receive connections and ground-to-transmit PTT, and I wired the spare relay contacts to provide +12 V output when the transverter is switched to transmit mode. This voltage is then used to toggle the RF interface and power amplifier circuitry between receive and transmit. The transverter board is mounted in the K2 top cover, on small standoffs.

144 MHz Medium Power Amplifier

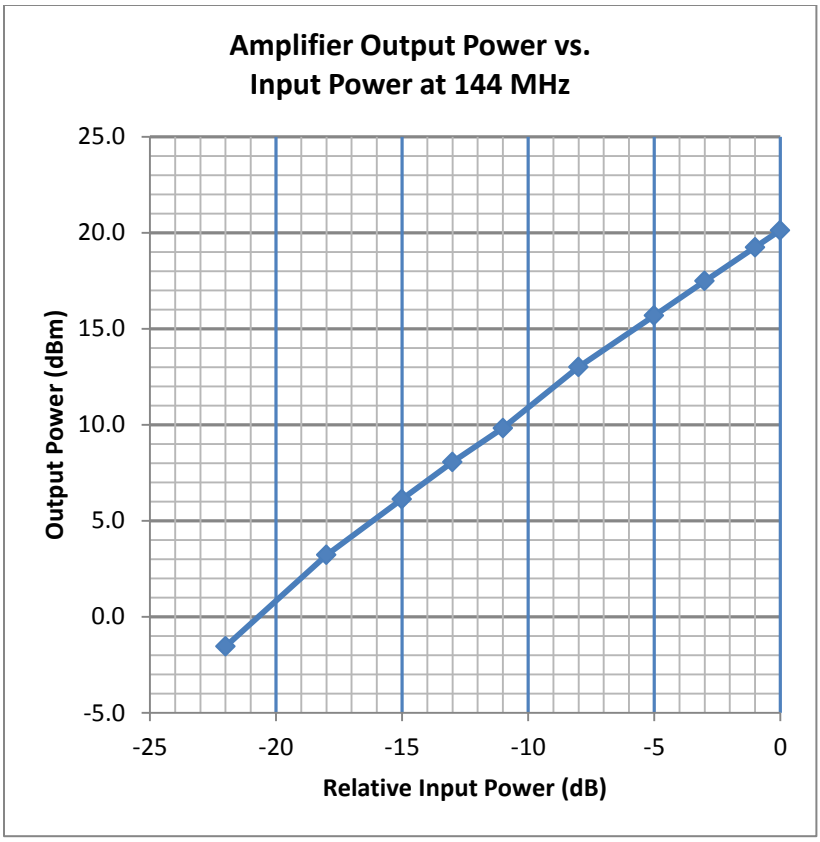
The maximum 2 m output power from the transverter board was only about a milliwatt. So an amplifier was needed to get the same 100 mW output as the FT-290R. I selected the MGA-31389 MMIC as it had the appropriate gain, excellent advertised DC-to-RF power efficiency and was available from Digi-Key. The amplifier was built on a W1GHZ board, as used for his GVA-84 and ADL5534 amplifiers described at http://www.w1ghz.org/small_proj/GVA-84_amplifier.pdf . See the schematic and a photo of the amplifier under test, below.

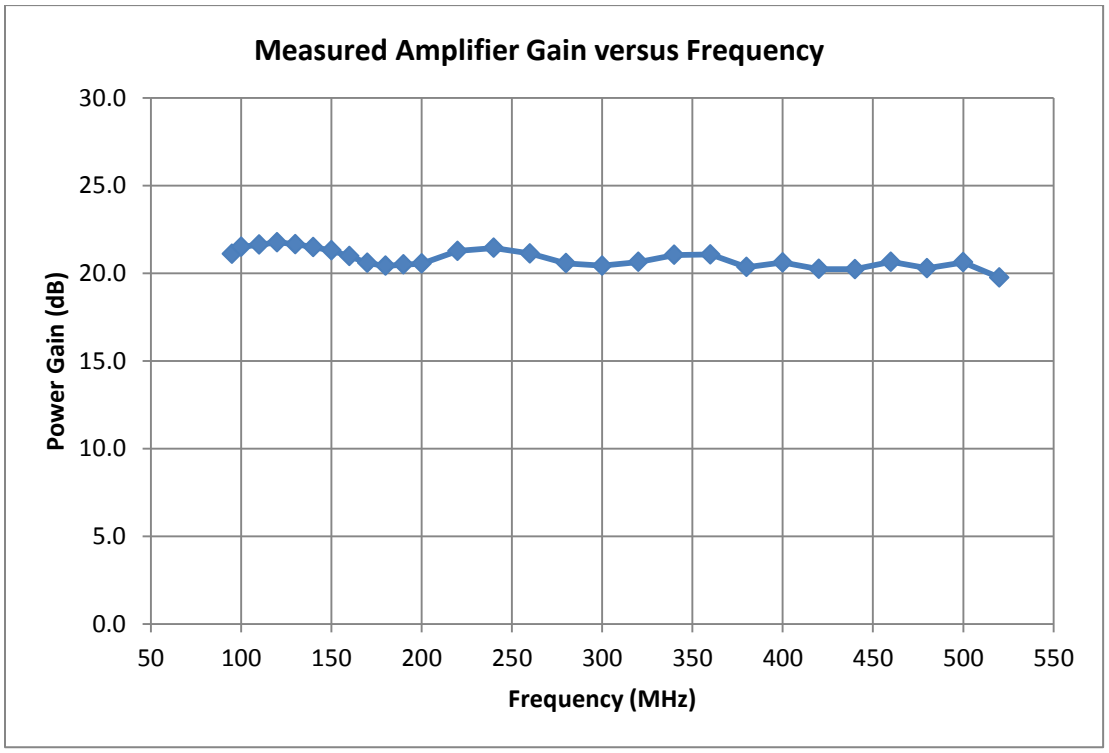
The real DEMI output should be closer to 10 mW, I believe, so a lower gain MMIC choice might be preferred if the DEMI 28-to-144 MHz transverter board was used.





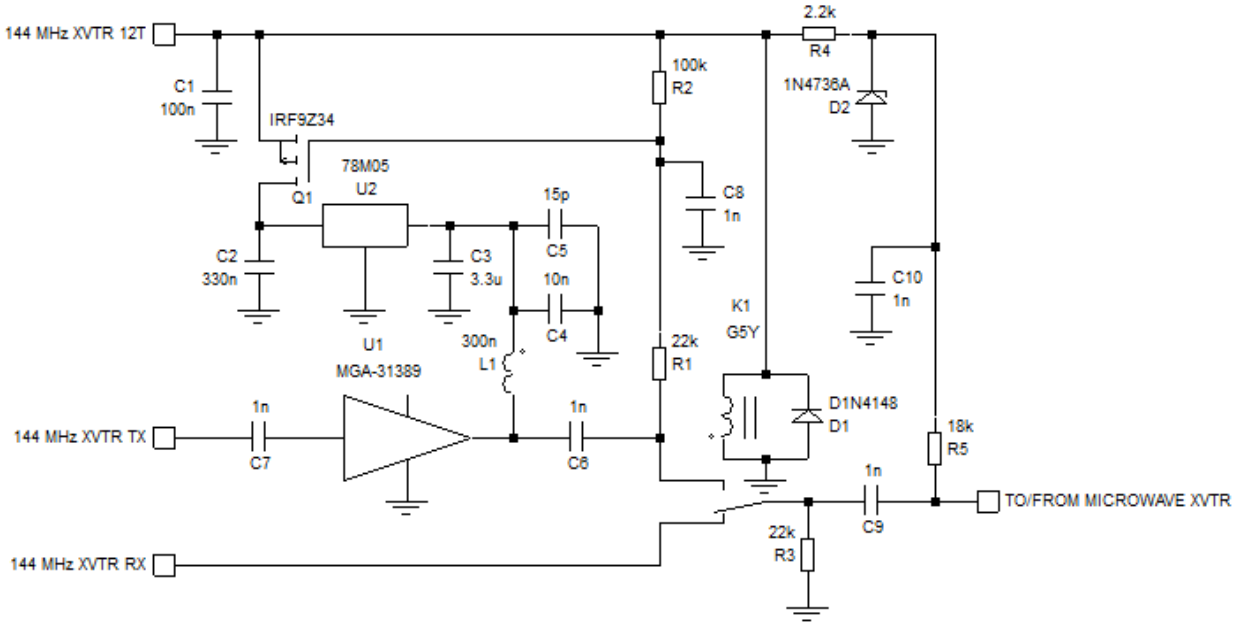
I measured the basic performance of the amplifier, with the following results, showing good linearity up to 100 mW (20 dBm) RF output power at 144 MHz and pretty flat gain over more than 100-500 MHz. It looks like a very useful general purpose medium power amplifier. I'd suggest substituting a surface mount inductor for the hand-wound coil I used, as I found it was easily knocked out of shape when handling, soldering and installing the board.


Amplifier Output Power vs.
Input Power at 144 MHz
Output Power (dBm)
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-25
-20
-15
-10
-5
0
Relative Input Power (dB)


Measured Amplifier Gain versus Frequency
Power Gain (dB)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
50
100
150
200
250
300
350
400
450
500
550
Frequency (MHz)

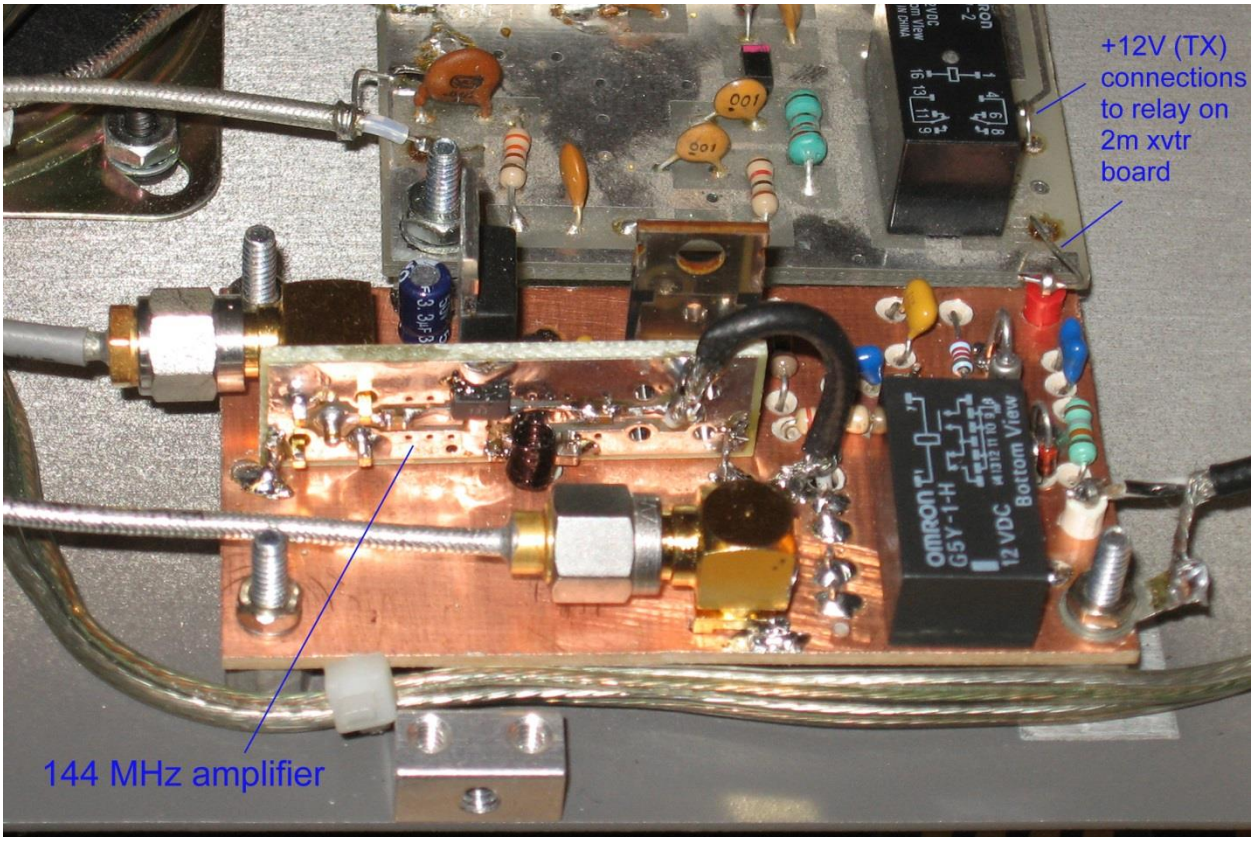
Control Circuitry

The 144 MHz interface to the microwave transverters uses a single coax cable for both transmit and receive signals and also carries a DC control signal to switch the microwave transverter between receive and transmit. The control board schematic below implements these requirements. It is shown including the 2 m power amplifier, since that board was piggy-backed on the control board.



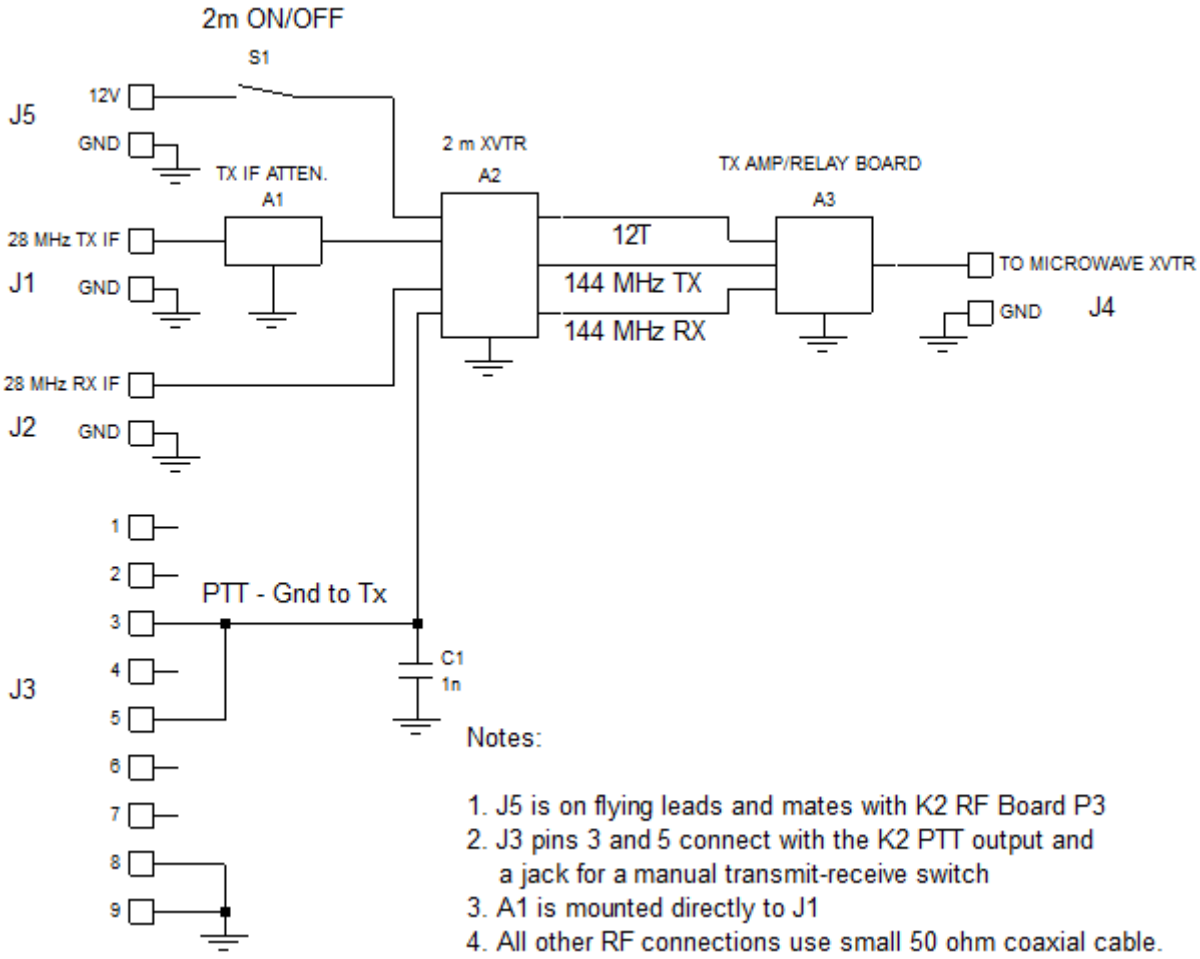
When the 2m transverter board switches to transmit it provides a +12V power supply to this circuit. That operates the RF relay K1 (Omron G5Y-12), which switches the 144 MHz port from the 2m transverter receive input to the 144 MHz power amplifier output, and provides a positive DC voltage (controlled by Zener diode D2) through R5 to signal the microwave transverter to switch to transmit. Once the K1 has closed in the transmit position, the combination of R1, R2 and R3 provide a suitable voltage to turn on the MOSFET switch Q1 and provide the operating voltage to the 144 MHz amplifier through a 5 V regulator U1.

See the following photo of the board, mounted on standoffs in the K2 top cover. It was made using point-to point wiring on the non-foil side of a piece of single-sided PC board with the parts mounted on the foil side. The leads run through holes drilled in the board (and countersunk on the foil side to eliminate shorts, unless the lead is to be grounded). The 144 MHz medium power amplifier board is mounted on top.

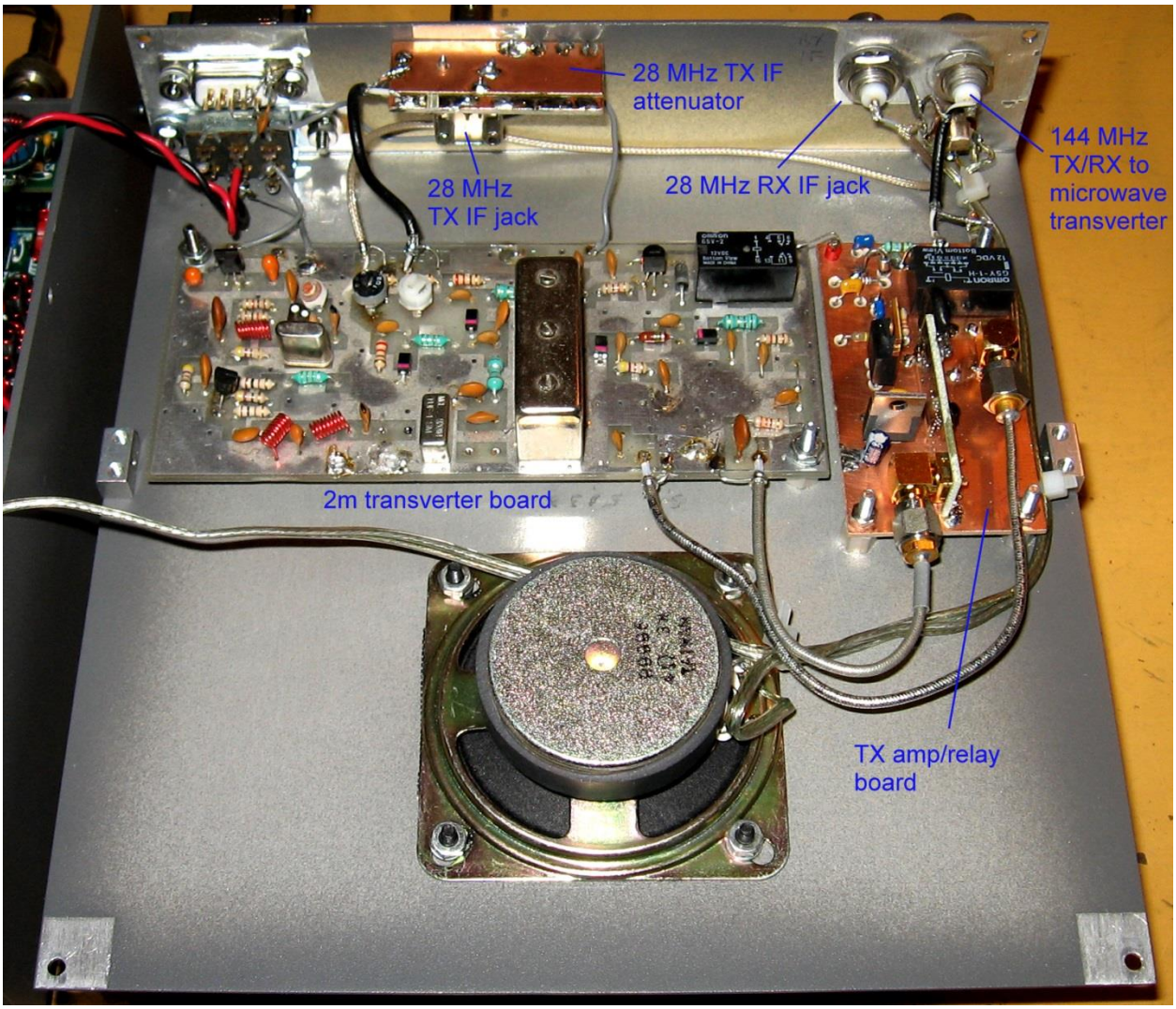

+12V (TX)
connections
to relay on
2m xvtr
board
144 MHz amplifier
OMRON
G5Y-1-H
12 VDC
Bottom View

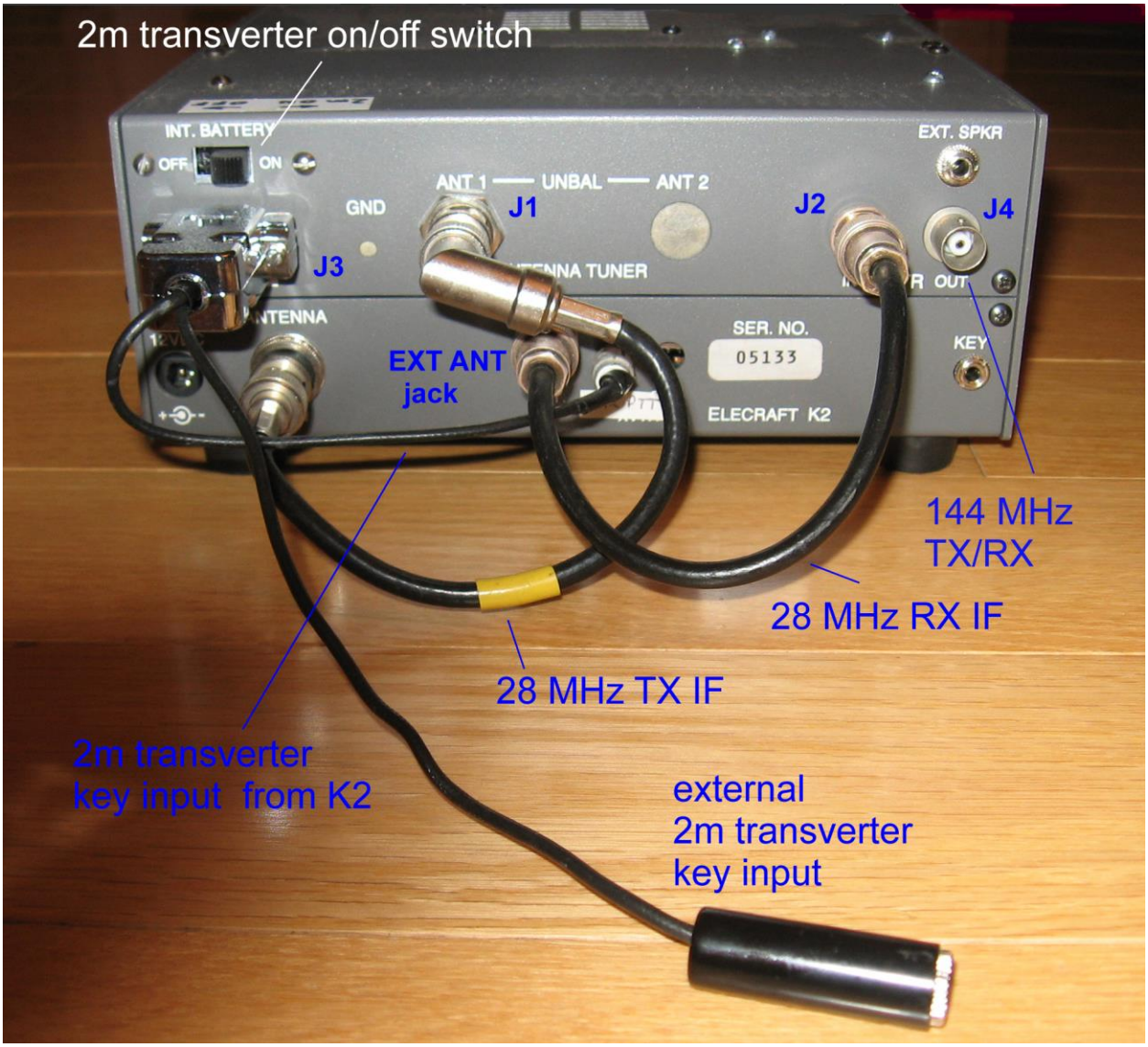
Overall Assembly

The top level wiring for the parts mounted on the K2 top cover is shown in the following schematic. It was not necessary to make any extra holes in the K2 case for connectors, just a few small holes for board mounting in the top cover. S1 was chosen to fit the existing hole for the battery switch, while J3 is a 9-pin D-connector which fits the existing hole for the computer interface connector.



The following photos show the inside of the K2 top cover with the 2m transverter installed, and a view of the rear panel connectors.


28 MHz TX IF attenuator
28 MHz TX IF jack
28 MHz RX IF jack
144 MHz TX/RX to microwave transverter
2m transverter board
TX amp/relay board



Results

This IF rig was used on CW and SSB in the 2017 ARRL 10 GHz and Up Contest with a Kuhne 10 GHz transverter and 2 watt amplifier and performed well with no issues or failures. I was always able to hear what others at the same site could hear. Manual T/R switching was used on CW to avoid losing the first dit or two of each transmission due to the delays through the various control relays and the sequencer in the 10 GHz transverter.