10 Watt RF Power Amplifier for 2.4 GHz

Overview

With high–power 2.5 GHz Multichannel Multipoint Distribution Service (MMDS) systems being removed from the air, their components are starting to show up a ham radio swapfests. While the high–gain omnidirectional antenna systems may be useful in certain WiFi applications, the most sought after compoents will be the RF power amplifiers and their pre–driver chains. I managed to find several 10 watt pre–driver amplifiers for sale (only $20!) at the Chicago FM Club's Radio Expo 2010 in Belividere, Illinois. These types of amplifiers don't include any type of input or output RF switching, so they can't easily be used in bi–directional (WiFi) applications. Don't worry, though! We're working on that one...

The units appear to be made by Comwave (the exact model is unknown) and they put out around 10 watts (+40 dBm) with a 100 milliwatt (+20 dBm) RF input at 2.4 GHz. These amplifiers were designed for the 2.5–2.7 GHz MMDS frequency range and will drop to around 4 watts output (+36 dBm) at 2.3 GHz. They quickly roll–off below that. Internally, the amplifier uses a Fujitsu FLL171 driving a Fujitsu FLL100 high–power GaAsFET. The amplifier needs +15 VDC at around 2.7A and a –15 VDC gate bias at 12 mA. The amplifier even has an internal directional coupler with a diode detector pick–off for a rudimentary RF power detector. The higher the voltage output of the detector, the higher the amplifier's RF output power. 5 watts of RF output gives a reading of around +8.5 VDC.

For this project, we'll be using a Xentek switching power supply from Fair Radio Sales in Lima, Ohio (Part Number SX200–81605). This $12 power supply puts out +5 VDC at 20A, +15 VDC at 2.5A, –15 VDC at 1.0A, and +24 VDC at 4.0A. The power supply will need to be modified slightly, as switching power supplies always need to see a load, so the unused +5 & +24 VDC outputs will have resistors soldered across their outputs.

A simple negative voltage sequencer will also need to be constructed for this amplifier to ensure that the –15 VDC gate bias voltage is applied ***before*** the +15 VDC drain voltage. This sequencer circuit will be very simple, and consists of just about any P–channel MOSFET, a 1N4743 13V Zener diode, a 2N2222A transistor, and some 10 kohm resistors.

On the RF amplifer's output, we'll add a protective ferrite isolator (Teledyne T–2S63A–3, 2–4 GHz, 20 dB iso.) and a 20 dB directional coupler (Miteq CD–262–522–20S, 2.6–5.2 GHz), both of which cover the 2.4 GHz range. These two items are optional, but will make testing the amplifier much easier.

Comwave Amplifier's RF Specifications

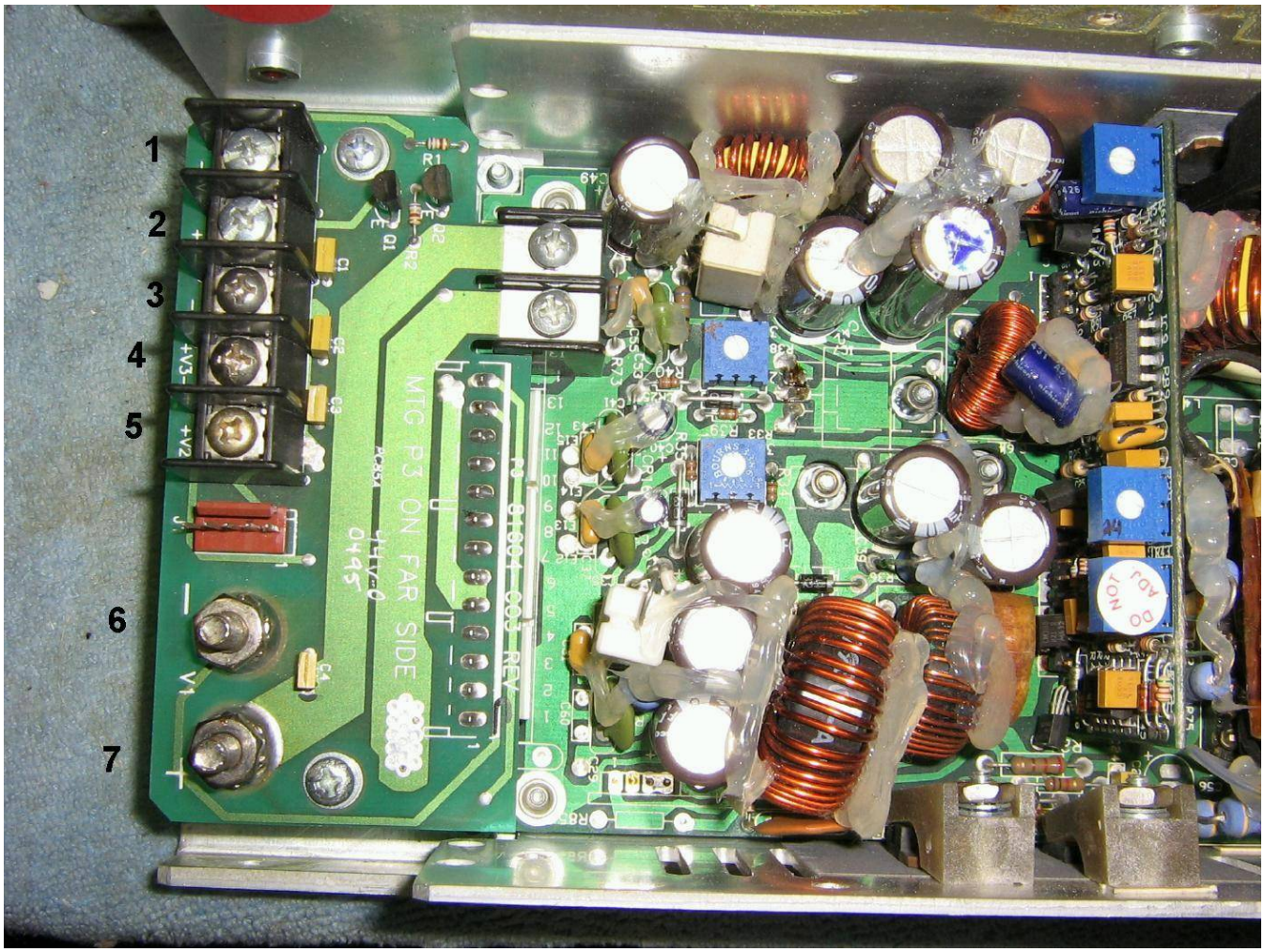
Frequency (GHz)	Input Power (dBm)	Output Power (dBm)
2.00	+20.0	+30.3
2.08	+20.0	+31.0
2.16	+20.0	+34.1
2.24	+20.0	+35.2
2.32	+20.0	+35.3
2.40	+20.0	+39.1
2.48	+20.0	+39.5
2.56	+20.0	+40.6
2.64	+20.0	+39.0
2.72	+20.0	+35.6
2.80	+20.0	+28.0

Pictures & Construction Notes

Internal view of the Xentek switching power supply, Fair Radio part number SX200-81605.

The low-voltage outputs are via the terminals on the left.

The 120 VAC mains input is via the terminals on the lower-right.



Closeup view of the Xentek's power supply's output terminals.

Terminal 1 is an isolated ground for the +24 VDC output.

Terminal 2 is the +24 VDC output.

Terminal 3 is the –15 VDC output.

Terminal 4 is the ground for the +/– 15 VDC outputs.

Terminal 5 is the +15 VDC output.

Terminal 6 is the isolated ground for the +5 VDC output.

Terminal 7 is the +5 VDC output.

Terminals 1 & 4 should be tied together for a common ground in this application.

The +5 VDC output will not be used.

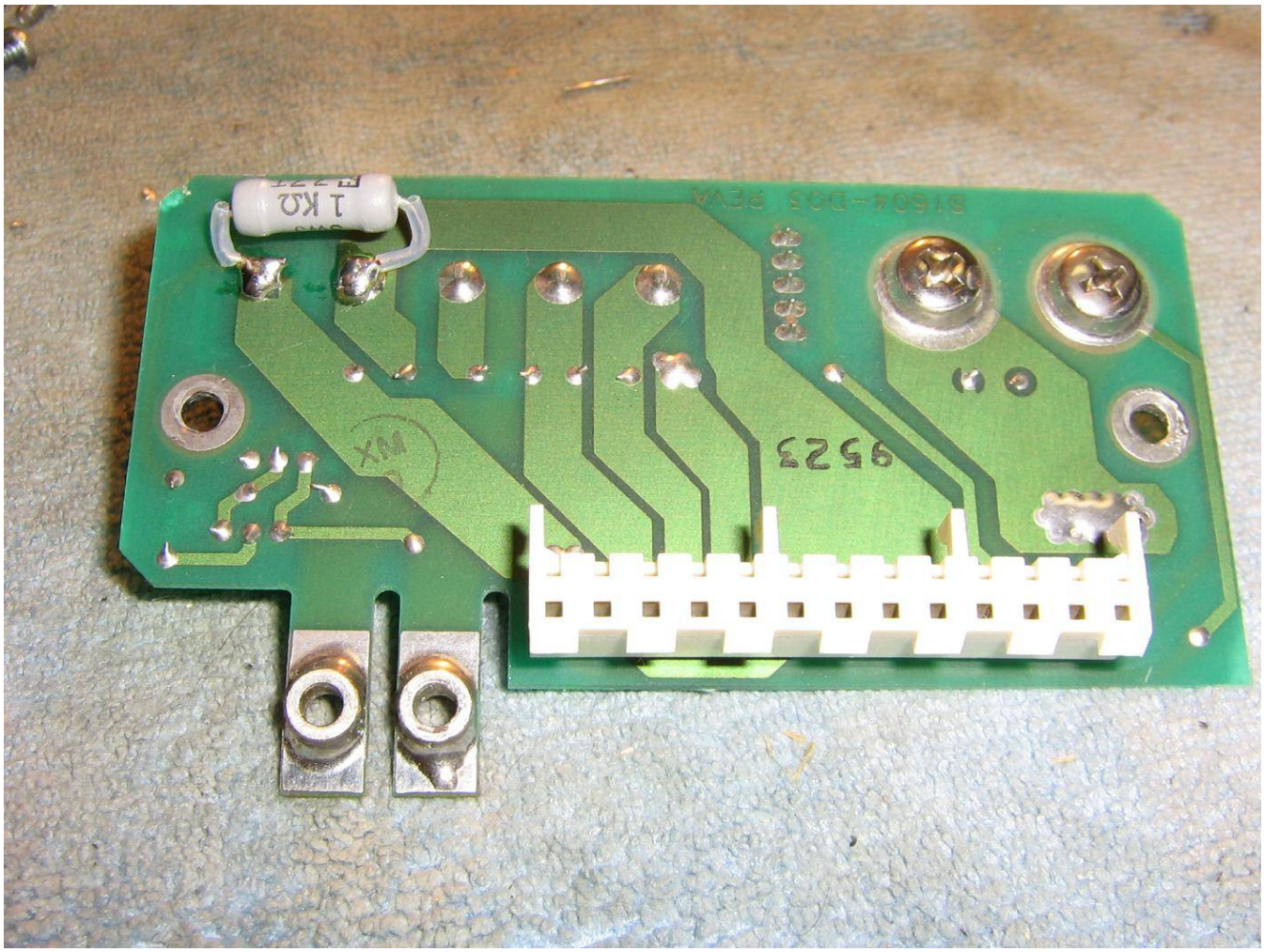
Overview of the 120 VAC input terminals.

Terminal 8 is Earth ground.

Terminal 9 is 120 VAC neutral.

Terminal 10 is 120 VAC live.

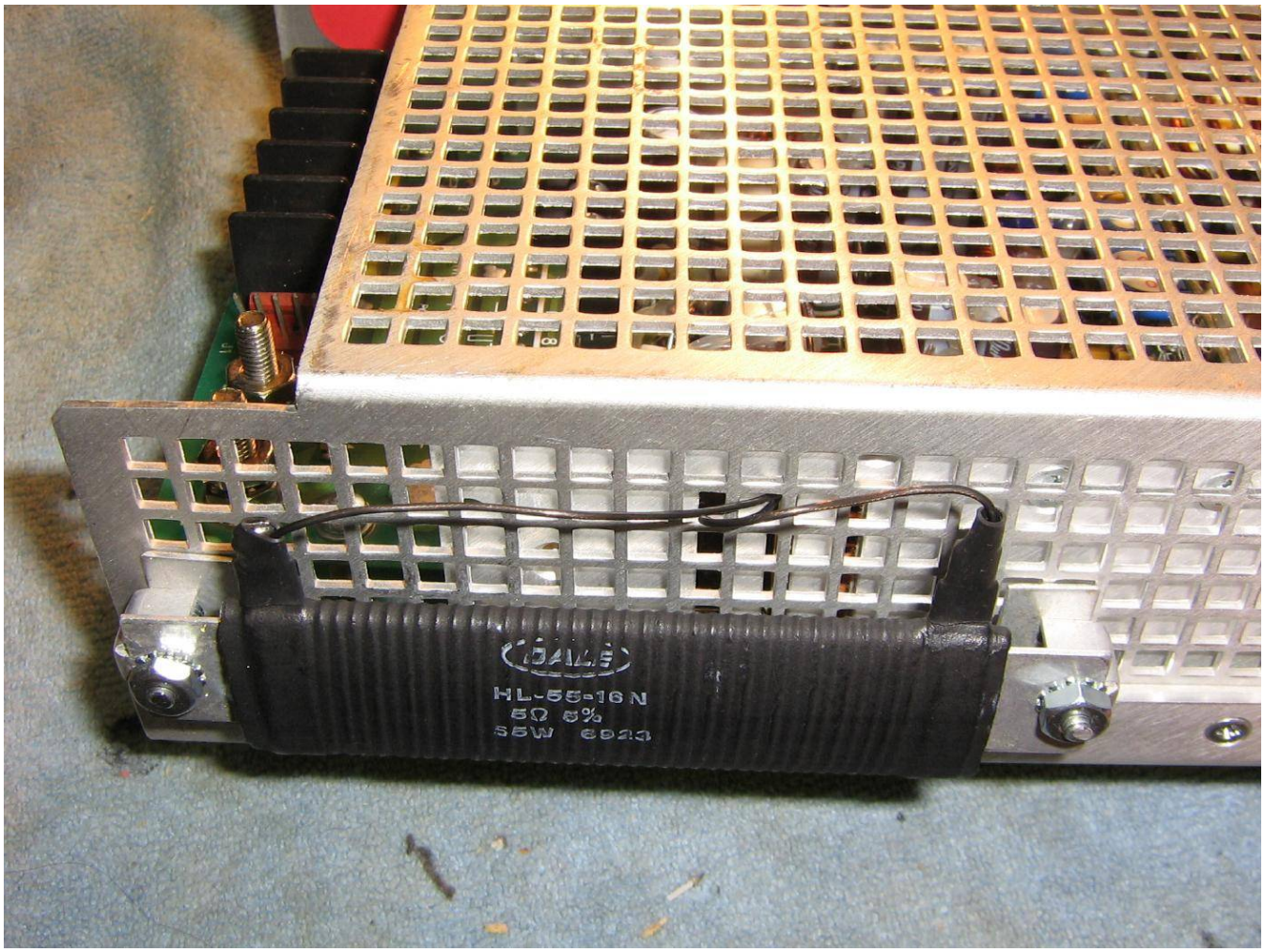
The 5A fuse was jumpered over, as a panel–mount fuse holder will be added to make replacement easier.



1k ohm / 3 watt load resistor across the +24 VDC output.

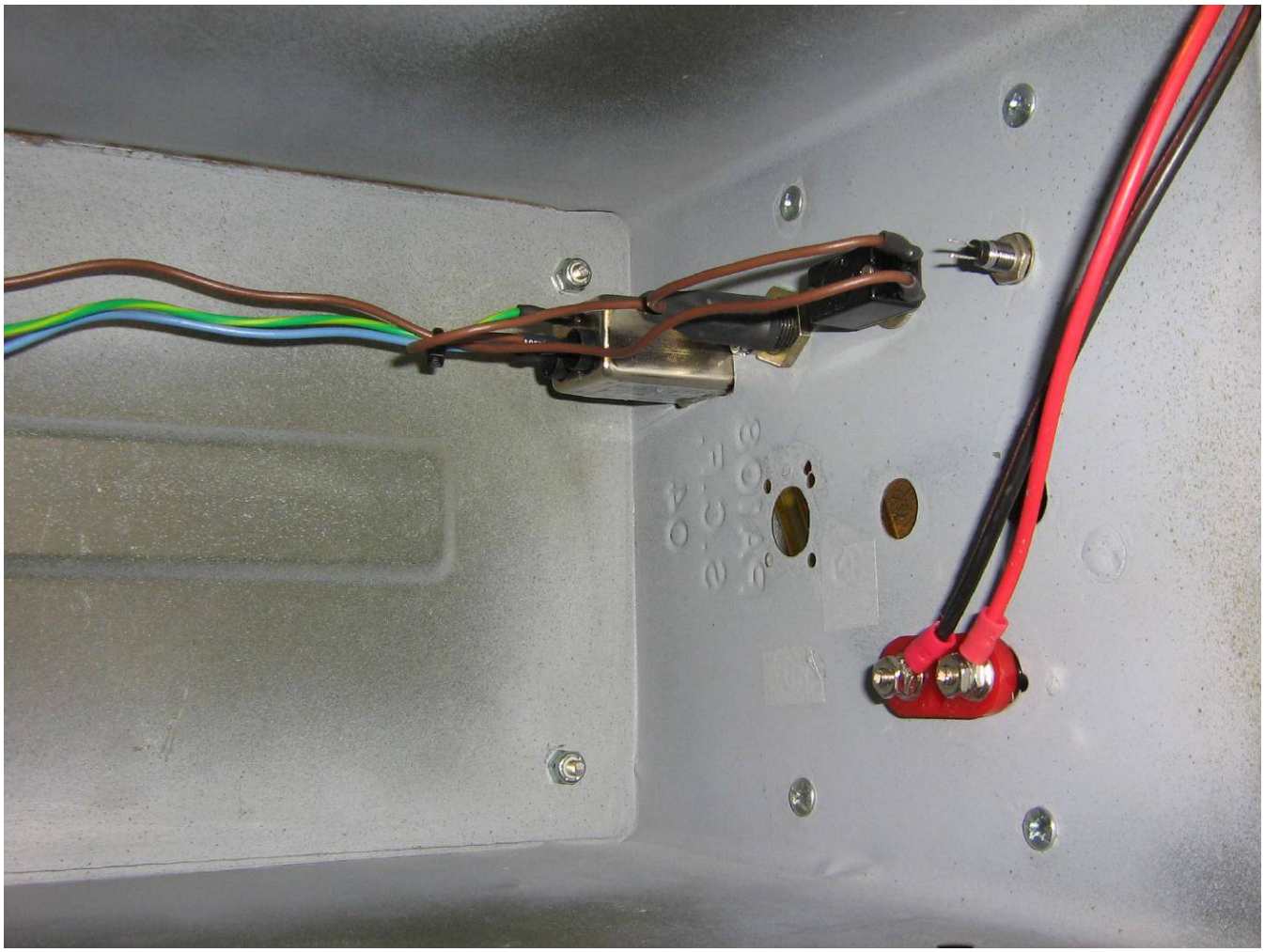
Switching power supplies (usually) need to see a small load in order to operate properly. Adding a simple resistor across the output is an easy solution to this problem.

This resistor was added to the bottom of the terminal board to keep it out of the way.



5 ohm / 55 watt load resistor across the +5 VDC output.

This resistor is overkill, but its body made it easy to mount to the side of the power supply's case.

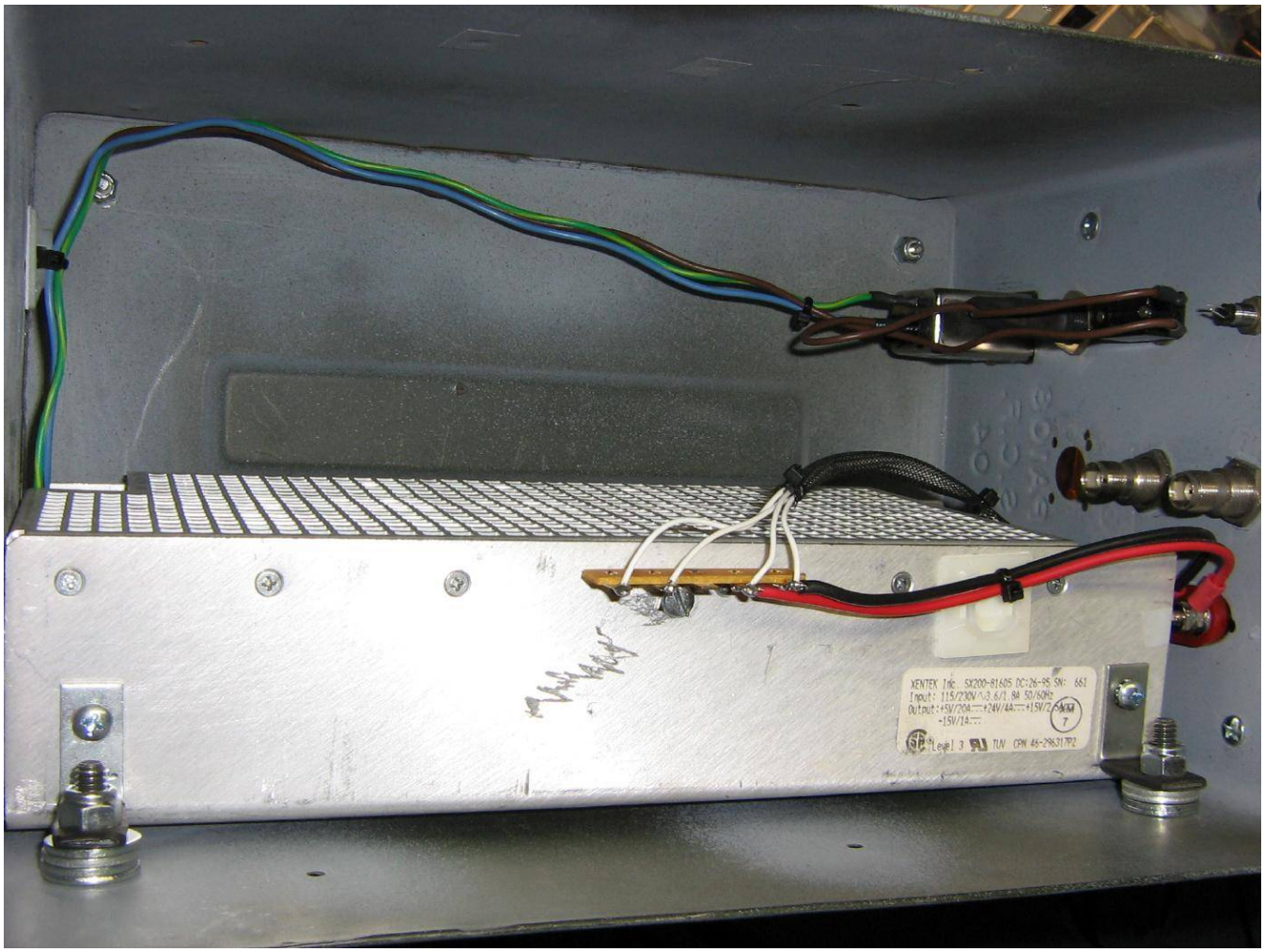


Project case overview and behind the front–panel.

The 120 VAC input filter, 5A fuse holder, and power switch are installed.

There is a green LED for a "power on" indicator.

The banana jacks are for an external +24 VDC output. This is optional, but could be useful for powering other projects.

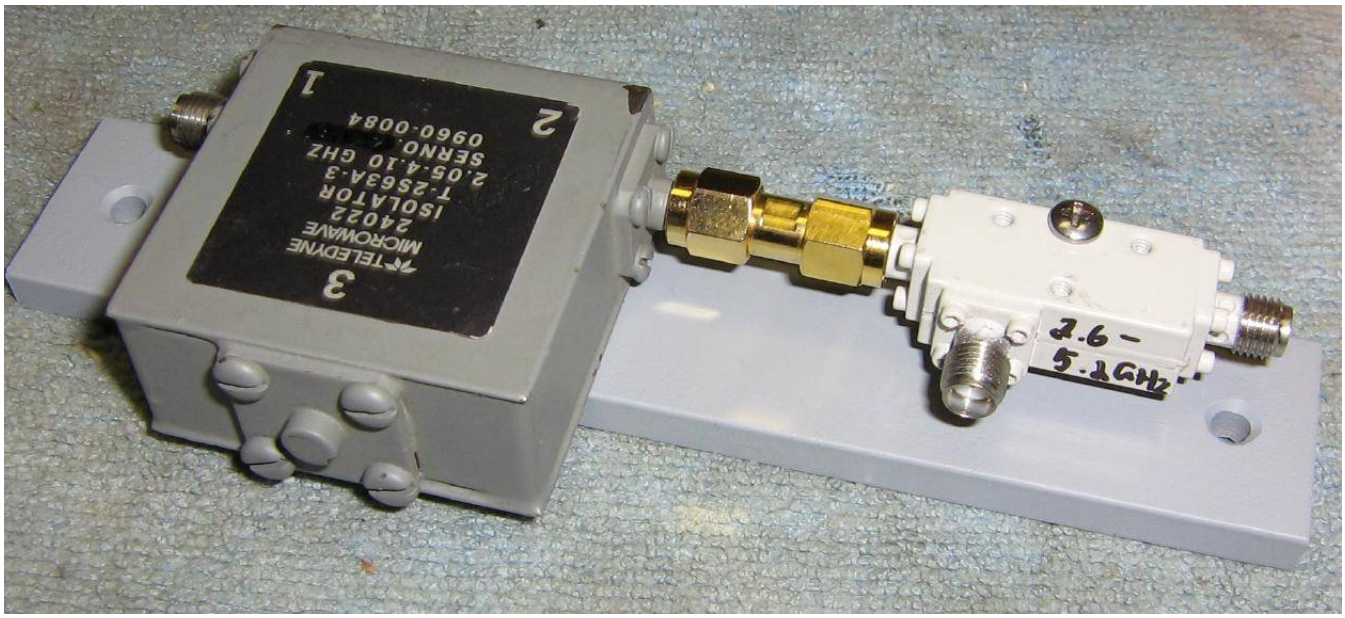


Mounting the switching power supply inside the project case.

Two L–brackets are attached using the #8 threaded mounts on the power supply's case.

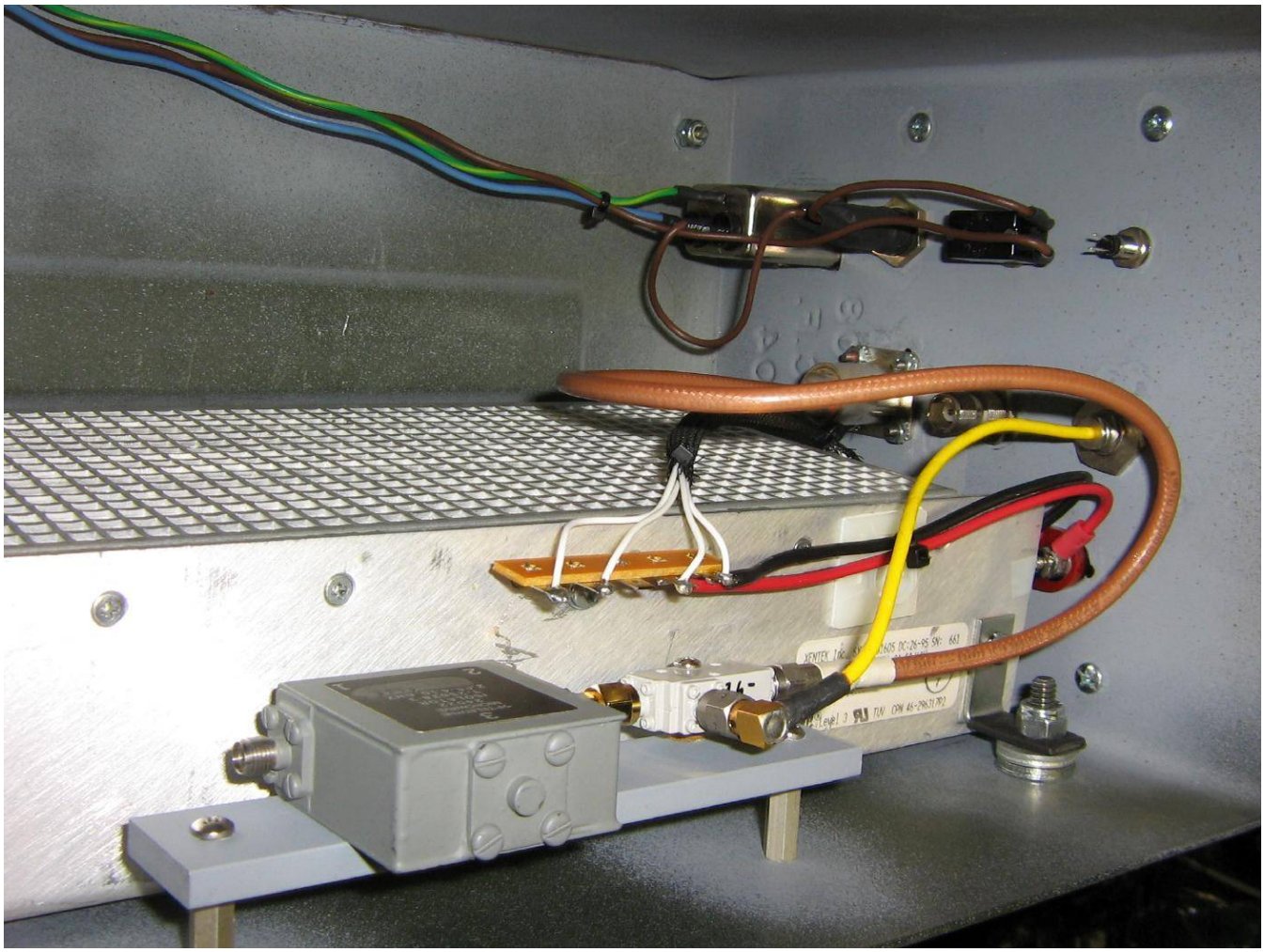
The various outputs from the power supply were brought out to a solder terminal strip for easy access.

The red/black wires are for the panel–mounted banana jacks which provide an optional +24 VDC output.



An optional ferrite isolator and a 20 dB directional coupler are added to RF output of the amplifier.

The ferrite isolator will protect the amplifier in case of a SWR mismatch and the directional coupler is for sampling the output RF power or for driving the local oscillator port on an external mixer.



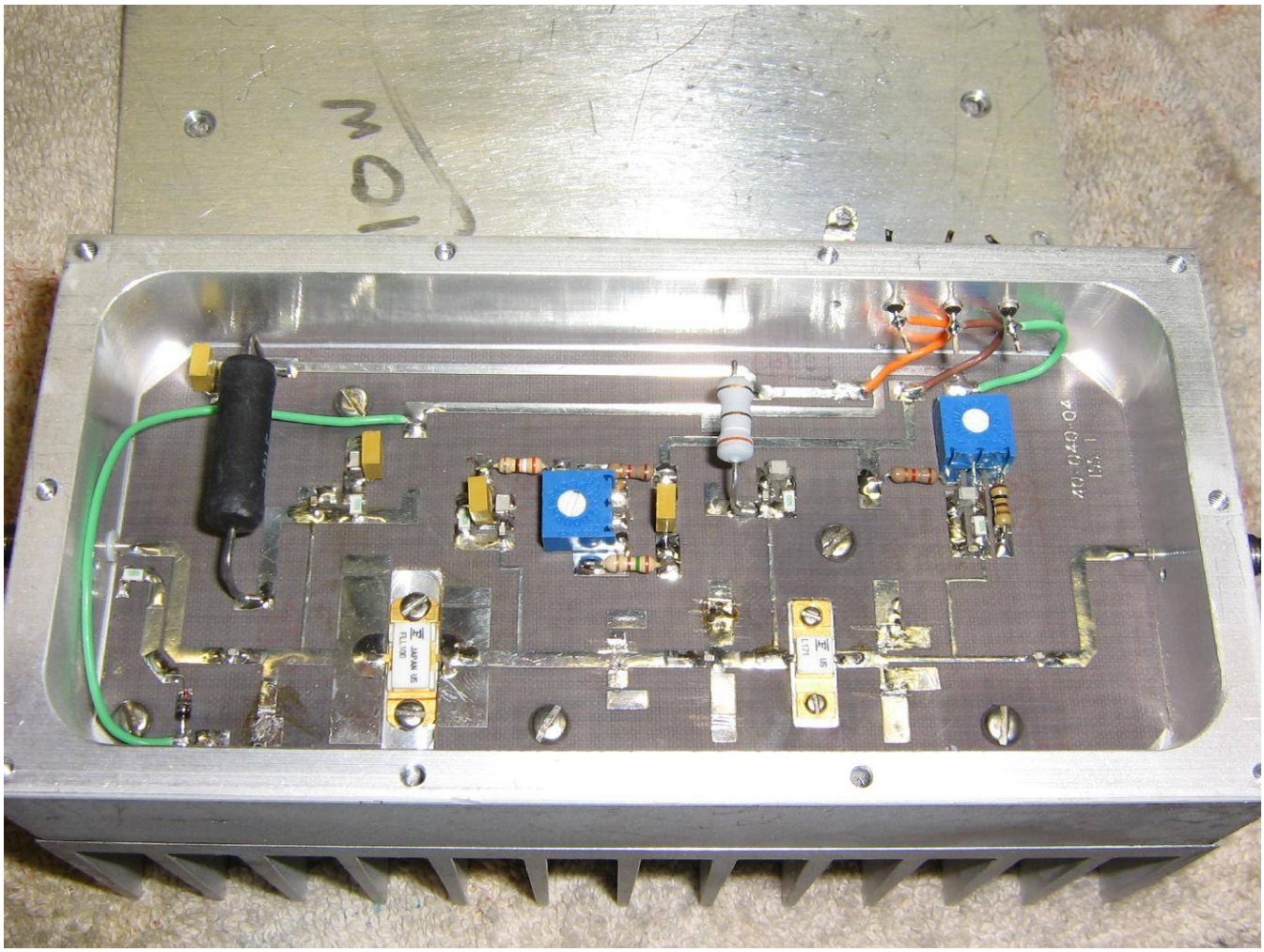
Mounting the ferrite isolator and directional coupler.

Because ferrite isolators ***can not*** be mounted near anything magnetic, the isolator and directional coupler are mounted to a small piece of aluminium bar stock, which is then attached to the side of the case using threaded aluminium stand−offs.

The final RF output from the directional coupler goes to a panel−mount N connector (bottom).

The 20 dB tap (yellow coax) from the directional coupler goes to a panel−mount TNC connector (top).

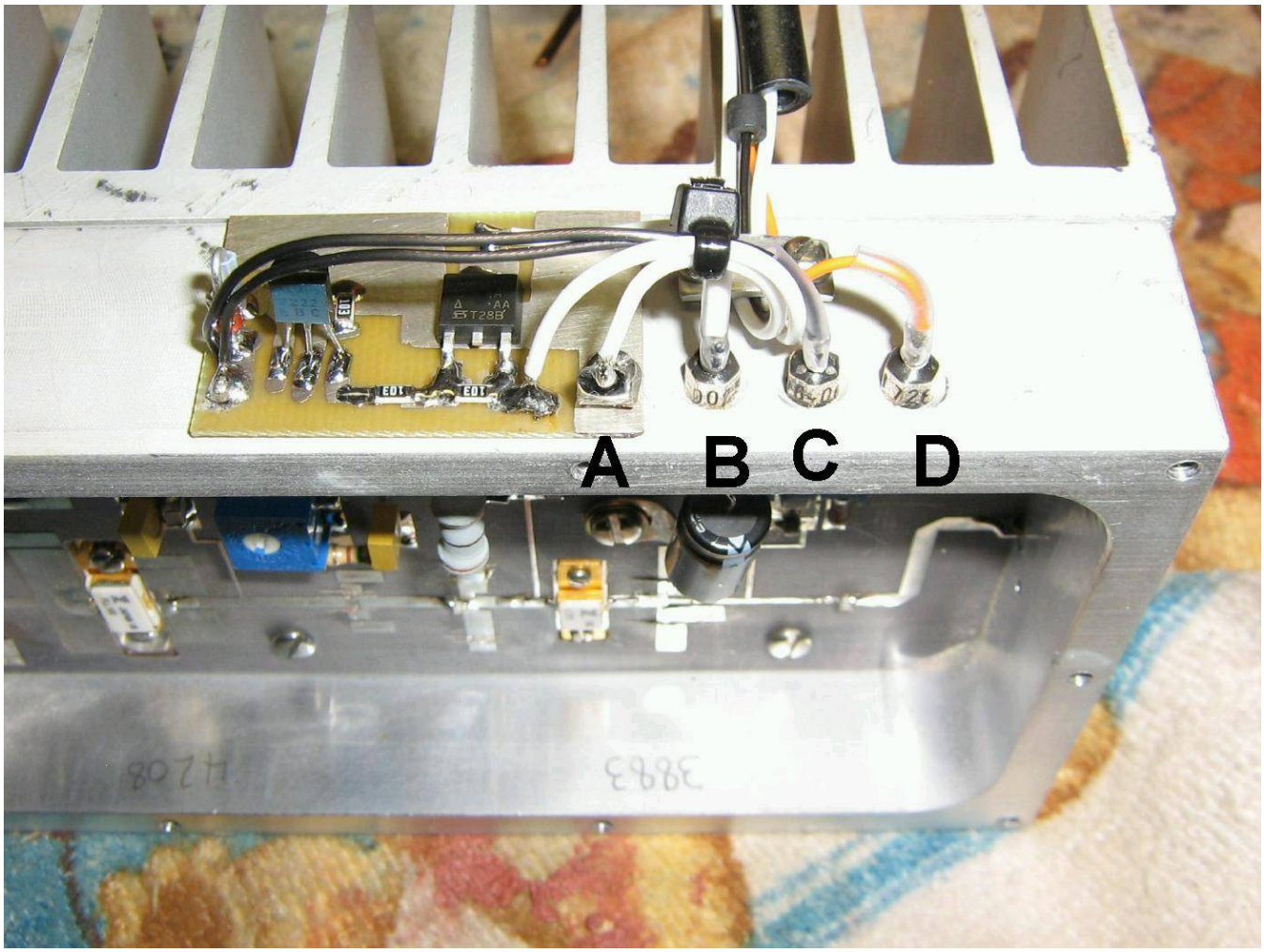
The RF input to the amplifier will also be via a panel−mount TNC connector (middle).



Internal view of the Comwave 10 watt MMDS amplifier.

The RF input is on the right−side, RF output is on the left−side.

+/− 15 VDC power, ground, and the detector output are via the feed−through capacitors on the upper−right.



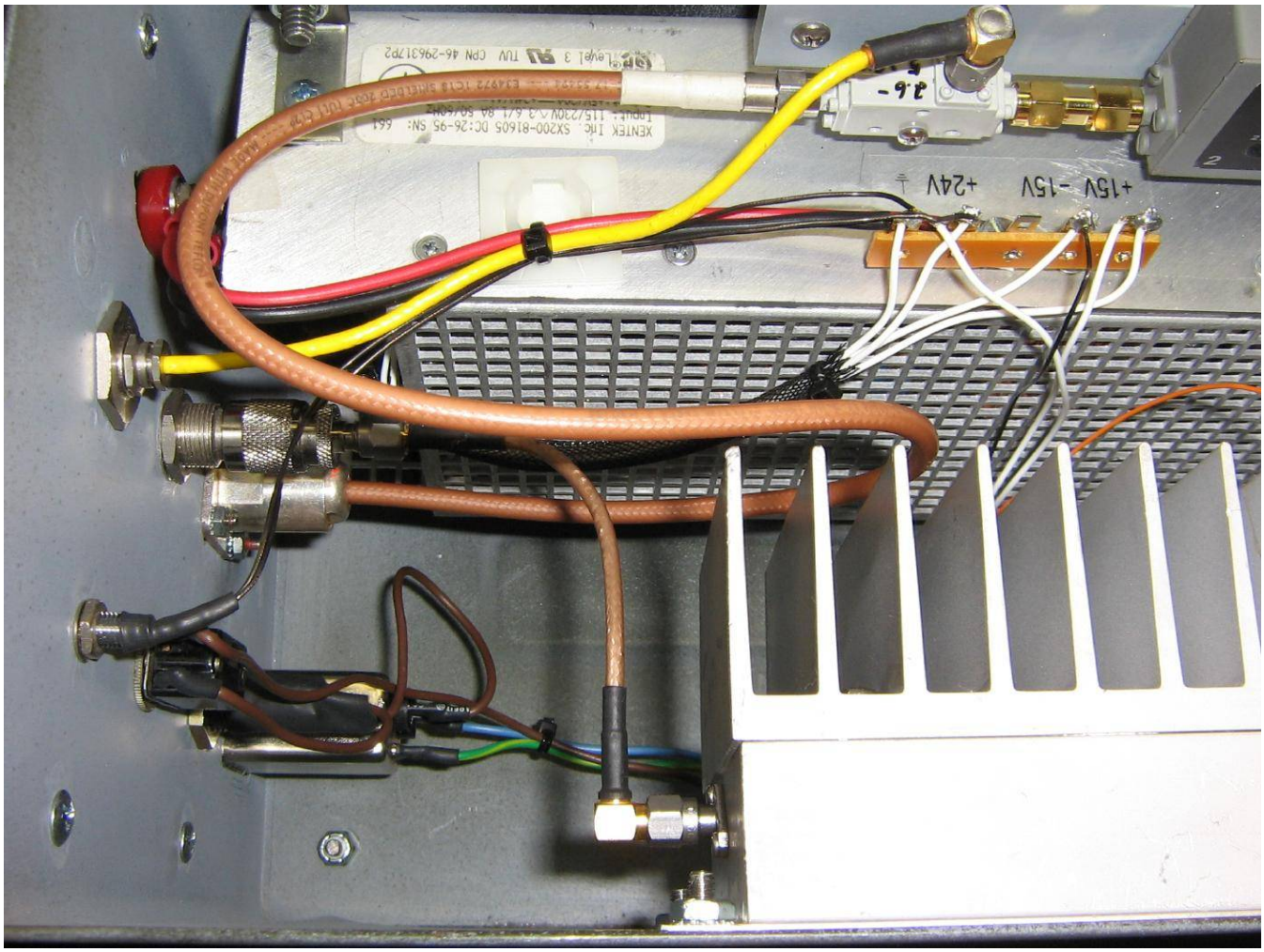
Closeup view of the negative voltage sequencer circuit board and the amplifier's DC power connections.

Terminal A is a common ground.

Terminal B is +15 VDC at around 2.7 amps.

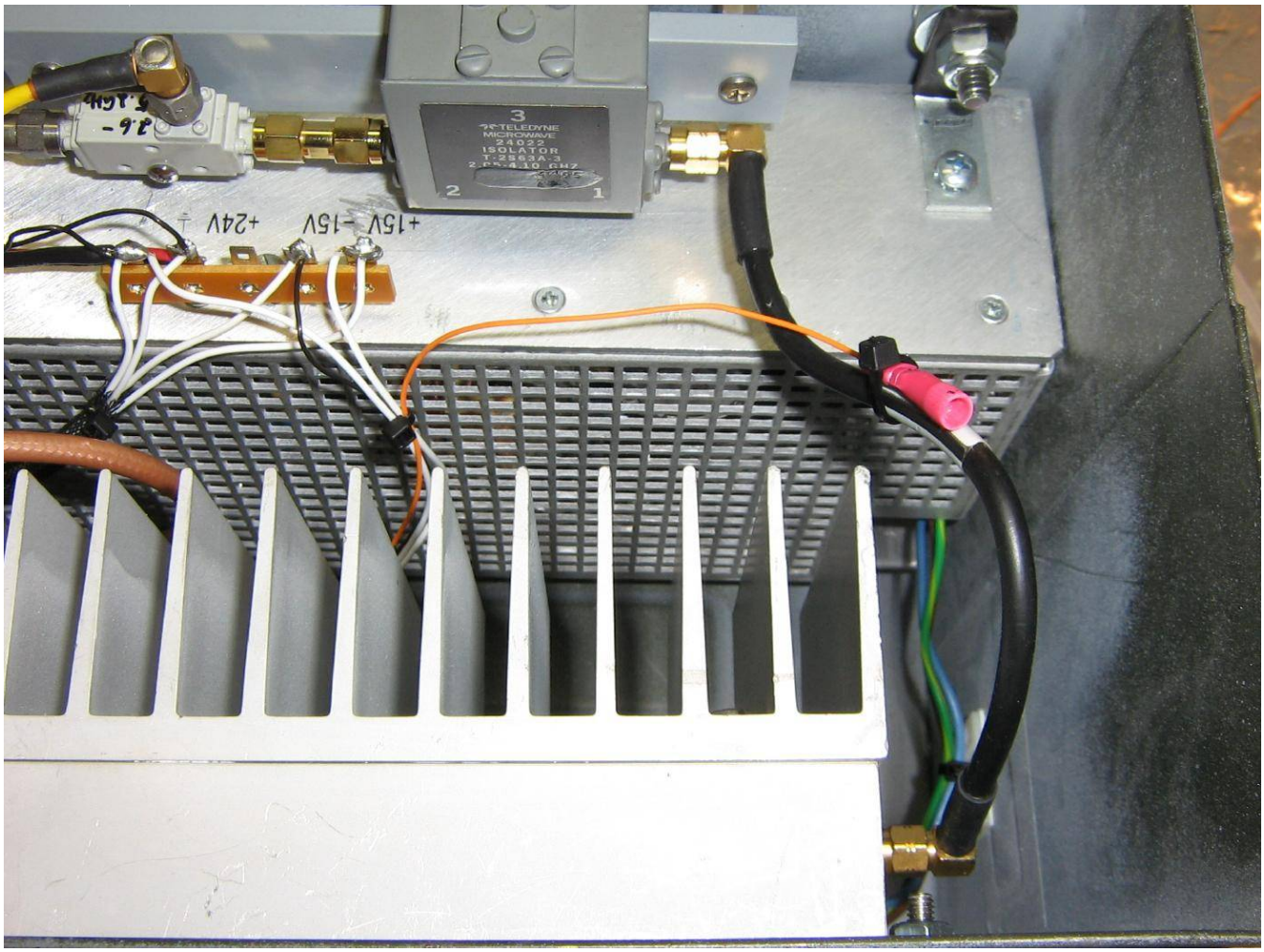
Terminal C is –15 VDC at around 12 mA and ***must*** be applied first.

Terminal D is the output of the diode detector.



Completed amplifier case overview.

RF input to the amplifier is shown in the lower–center.



Completed amplifier case overview, alternate view.

RF output from the amplifier is shown the lower–right.

The orange wire is the output from the diode detector and goes to an open crimp terminal for testing.

Completed amplifier front–panel overview.

120 VAC mains input on the right.

10 watt RF output is via the bottom N connector.

100 mW (+20 dBm) RF input is via the middle TNC connector.

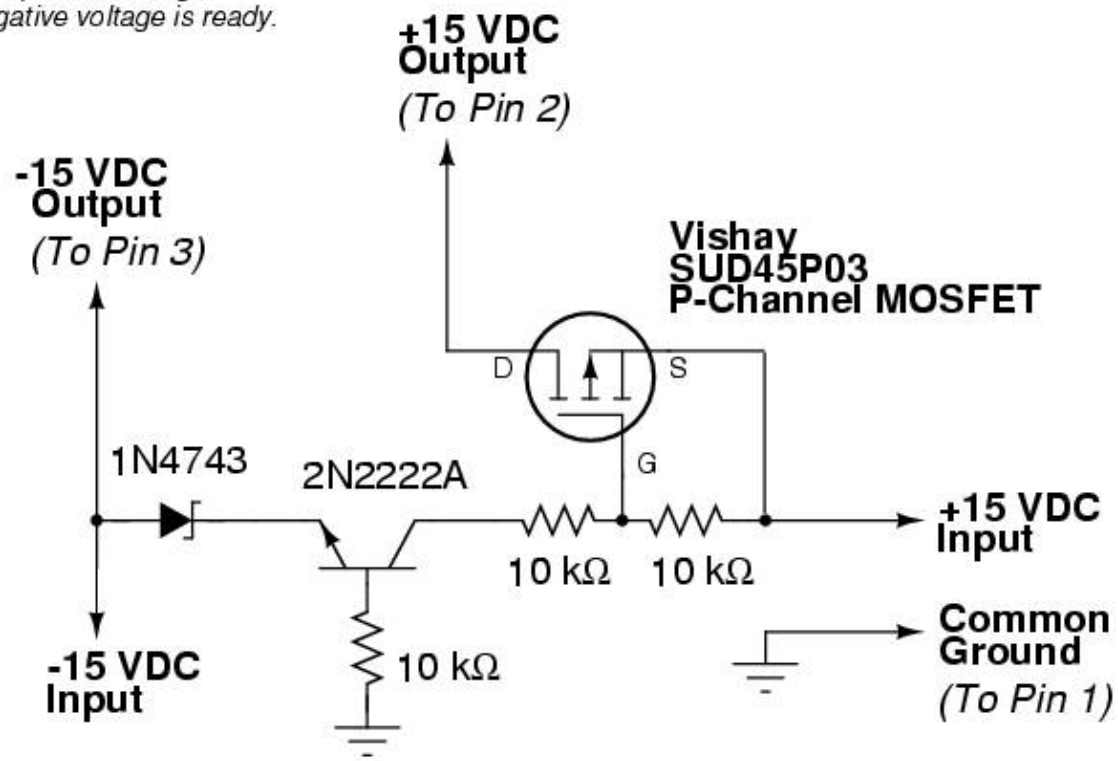
–20 dB tap of the RF output signal is via the top TNC connector.

The optional +24 VDC / 4A output is via the banana jacks.

Negative Voltage Sequencer Schematic

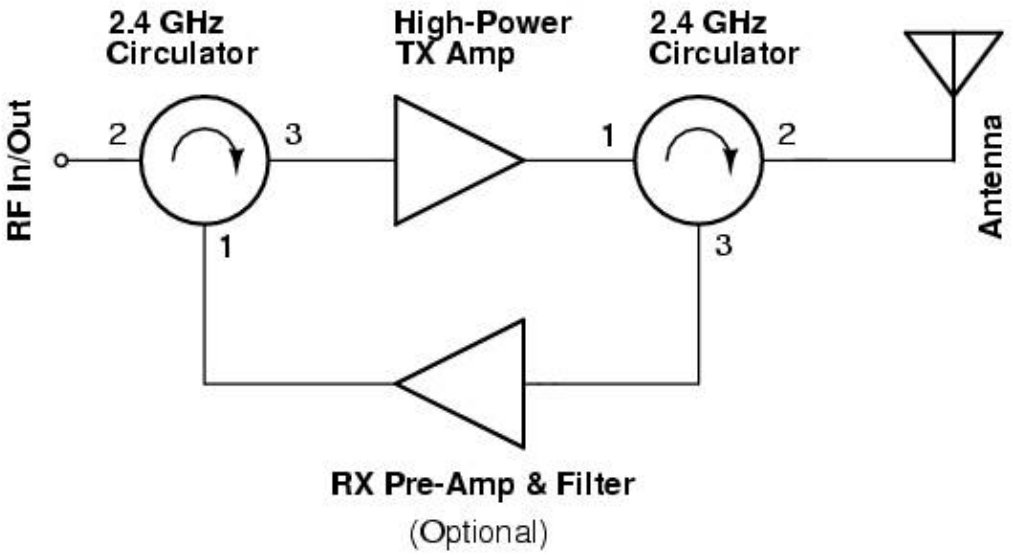
Negative Voltage Sequencer

Holds off postive voltage until negative voltage is ready.

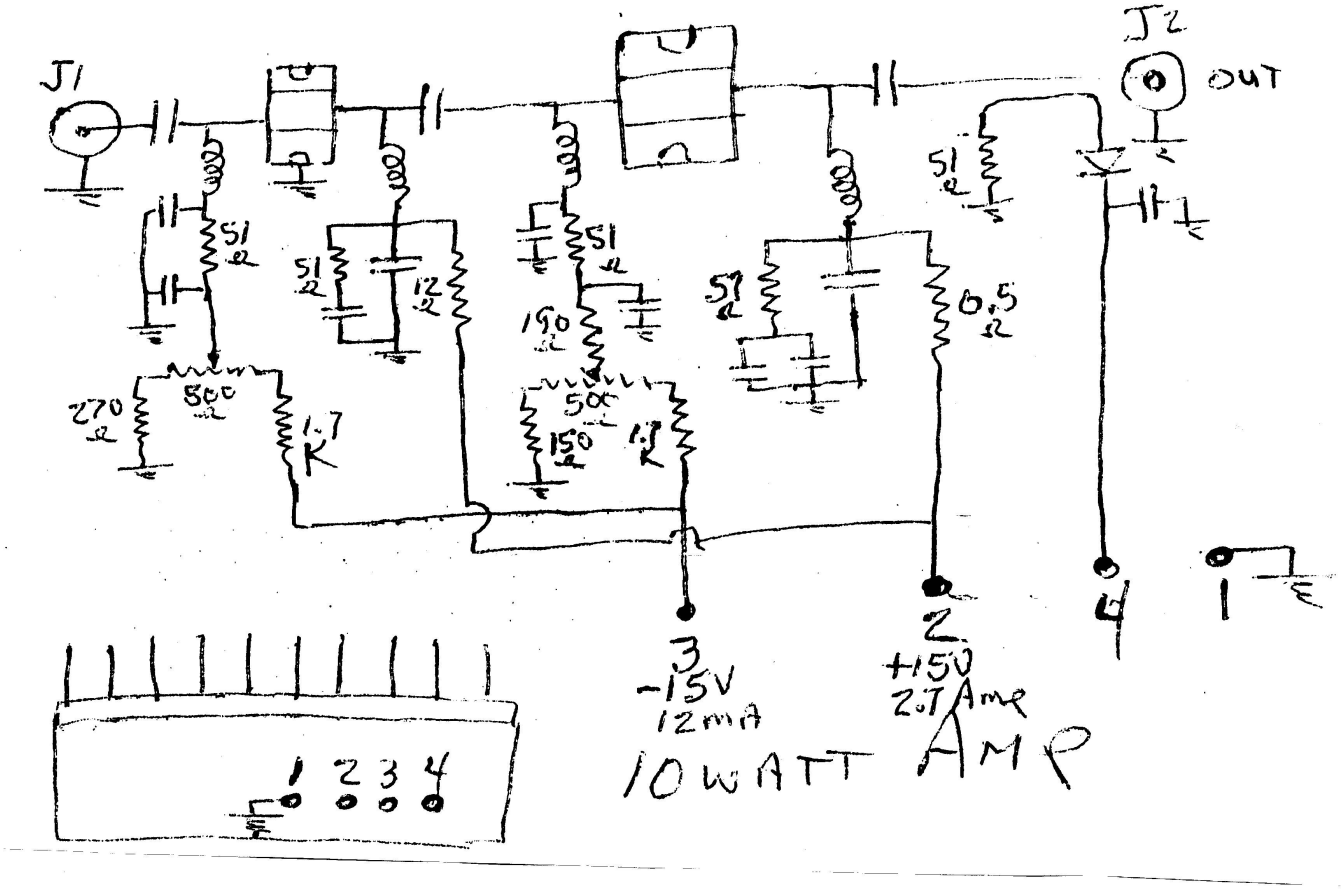


Experimental Bi-Directional Amplifier

Replace TX/RX switches with circulators.



Comwave 10 Watt MMDS Amplifier Schematic



Partial schematic, but is fairly complete.

RF input is on the left (J1), into a Fujitsu FLL171 which drives a Fujitsu FLL100.

The diode and 51 ohm resistor on the output directional coupler should be reversed.