Power Supply Board for Avantek 6GHz Amplifier and other GaAsFET Power Amplifiers

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The Avantek AWP-64100 amplifiers provide a solid 10+ watts at 5760 MHz, with lots of heat sink so they can run continuously at a comfortable temperature. They are long obsolete, but there were thousands of them surplus at reasonable prices, so there are probably many of them floating around. The only drawback is that they run on –24 volts[1], inconvenient for portable operation.

The amplifier uses a series of GaAsFET to amplify from ~0 dBm to 10 watts. GaAsFETS normally operate on positive voltages, so the amplifier includes an internal inverter to convert from –24 volts to +10.5 volts used by a bias board feeding appropriate voltage to each amplifier stage. This PC board replaces the inverter, dropping a +12 volt source to a regulated +10.5 volts and generating –12 volts needed by the internal bias board.

Recently there has been renewed interest in the 5760 MHz band, so I dug out my 5760 transverter. I found that the power amplifier had died, so it was time for an update. I had a couple of the Avantek amps in the barn that I have been meaning to convert to +12V, and I remembered buying a kit from C3i for the conversion. I located the amps and the kit, amazingly stored together, and found that the kit was actually a complete assembled PC board.

For the second amp, I considered duplicating the PC board, but I wasn't happy with the PC design. It looked like it had been done by a really bad auto-router, with no regard for high currents – a heavy wire had been added for the output current. I also found that the PTT line switching current is about 75 milliamps into the device pulling down, enough to smoke the switching transistor in most transverters.

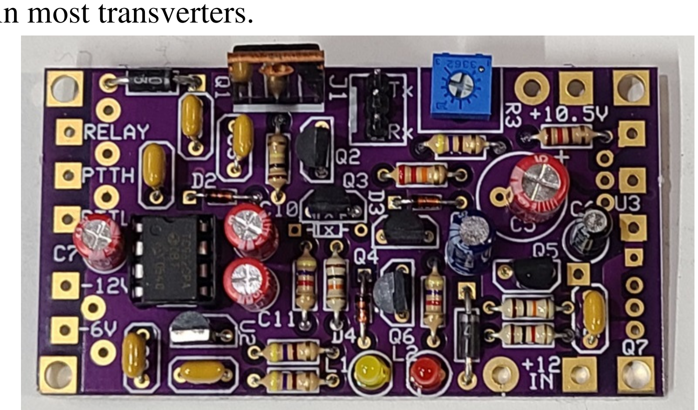

Figure 1 – New power supply board for Avantek 6 GHz Amplifier

I consulted Terry, W8ZN, since he had been involved with C3i. He suggested that it be redesigned to use solid-state switches instead of relays, and that it include TR relay switching that could handle a proper coax relay, instead of the “kicker” circuit that might switch a small 28 volt SMA relay.

Circuit

The hard part is the high currents. The amplifier draws about 5.3 amps at 10.5 volts. With a 12 volt supply, this only leaves 1.5 volts headroom for the voltage regulator, and common ones need about 3 volts. A low-dropout regulator is required, and the only one that will handle more than 5 Amps is the obsolete LT1083CP. Fortunately, there are many offered on ebay at prices comparable to the new price; choose the larger TO3P package. There are other, more complicated ways to do this, but the LT1083CP worked fine in the C3i version.

The 12 volts to the regulator is switched with a P-channel power FET. The IRF4905PBF has a low ON-resistance of 0.02 ohms, dropping perhaps 0.1 volts at 5 amps. The alternate IRF9Z34NPBF has a higher low ON-resistance of 0.1 ohms, dropping 0.5 volts, so a higher input supply voltage would be required. Since the LT1083 regulator needs up to 1.5 volts headroom, a 12 volt battery supply would need the lower ON-resistance. Either would work fine with a 13.6 volt supply.

The other high current is -12 volts, where the amplifier draws around 60 mA. The easiest way to do this is with a charge-pump converter, but most of the common ones can only supply 50 mA or less. The TC962 used in the C3i version can supply 80 mA, so I simply copied that circuit. It might be prudent to add a small stick-on heatsink to the chip. If -12 volts is already available in your transverter, connect it to the -12V terminal and leave out the TC962; bias protection will still work. Or you might consider an inexpensive ebay module using an MC34063A which can supply higher current.

The rest of the circuit is simple – I copied the PTT and TR relay switching from my Simple, Yet Fool-Resistant Sequencer (http://www.w1ghz.org/seq/Simple_yet_Fool-Resistant_Sequencer_Rev_B.pdf). Hundreds of these have been used for more than 20 years. From the C3i version, I borrowed the negative bias protection which prevents the amplifier receiving positive voltage unless the negative bias is available.

Switching for a TR relay is provided by Q1, am N-channel power FET, which pulls the bottom end of the relay to ground. The high side is from a separate supply, often 28 volts. Inexpensive small switching supplies may be found on ebay. This FET isn’t a particularly critical part, but it should be rated for at least twice the relay voltage. Heat sinking should not be needed unless the relay draws a lot of current. Don't forget to put a diode across the relay.

Most operators use the NC contact of the TR relay for receiving, to minimize power; add a jumper on J1 from Tx to the center pin so that the relay is active on transmit. Others chose to connect the receiver to the NO contact of the relay, so that it is powered on when receiving but not connected when the rig is powered off; a jumper on J1 from Rx to the center pin is used for this configuration.

The voltage to the amplifier is sequenced to switch on after the TR relay, with delay provided by R2, C4 and D3. Increase the capacitor to prolong the delay. If you are driving the relay from somewhere else, like a better sequencer, Q1, C4, and D3 may be omitted.

The schematic diagram is shown in Figure 2.

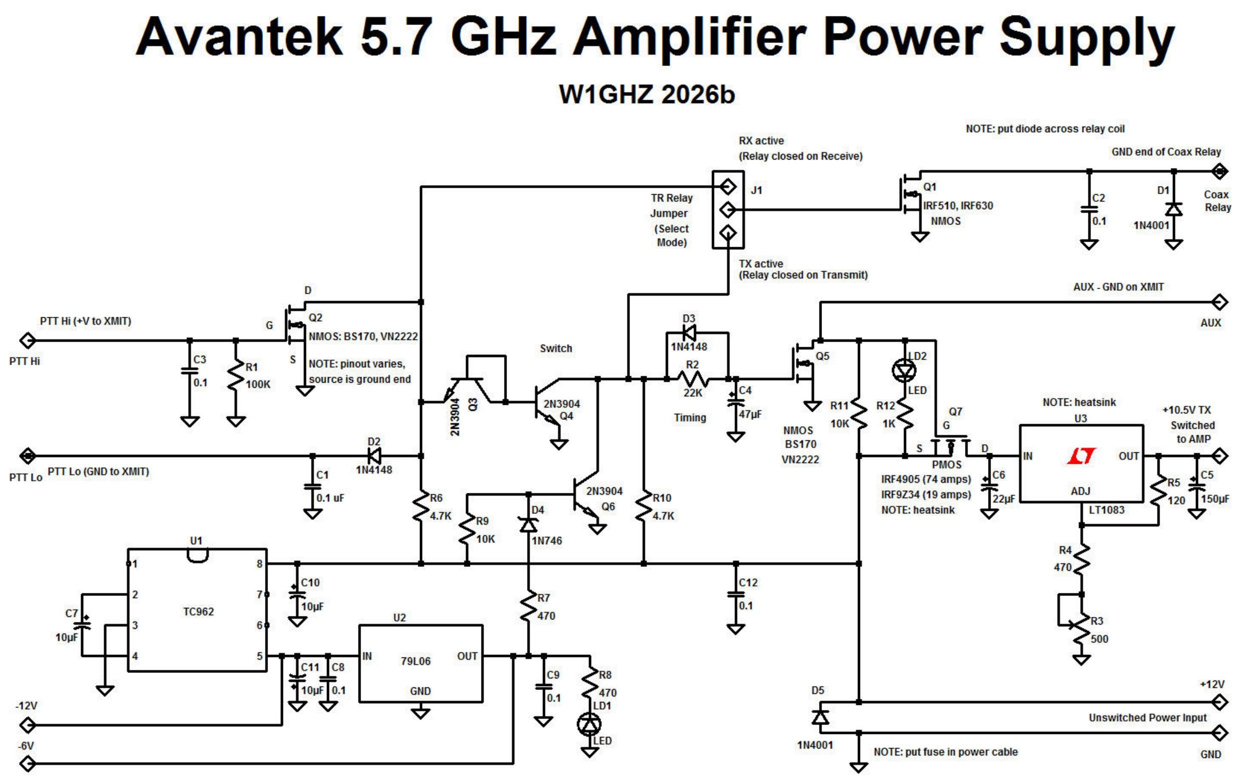

Figure 2 - Schematic of new power supply board for Avantek 6 GHz Amplifier

Construction

All the component locations are marked on the PC board shown in Figure 1; Figure 3 might also be useful for locating them. Reference designators (R2, C5, Q6, etc) start in the upper left, go across, then continue left to right in a lower row. Follow the part outlines for orientation. For polarized components, capacitors and LEDs, insert the longer lead in the square pad. All off-board connections are larger square terminals marked with function. The large round holes near them are for ground connections as needed.

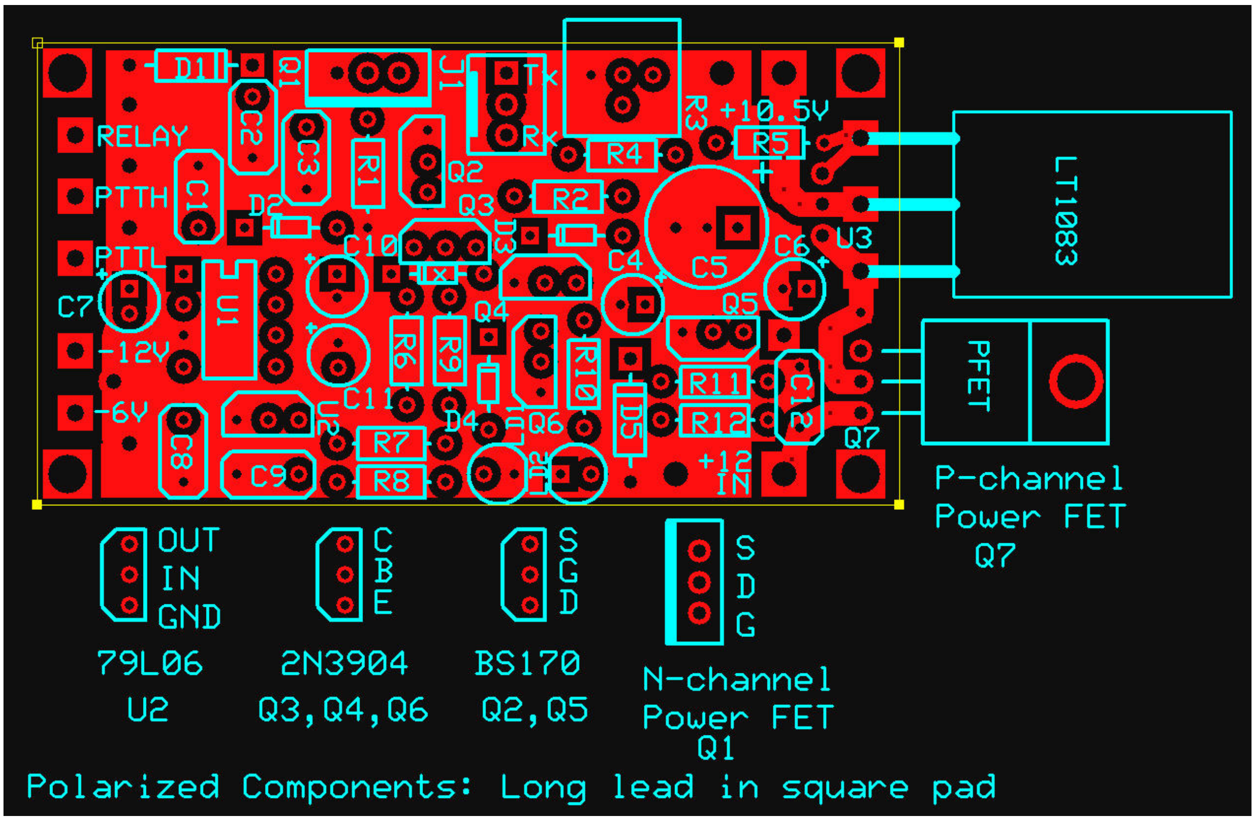

Figure 3 – Component locactions and orientaitions on the PC board

The high current components, U3 and Q7, should be mounted on a heat sink or on the amplifier chassis with an insulating pad – check for shorts to ground before powering up. The PC board is designed to fit in the compartment which housed the original switching power supply board, as shown in Figure 4.

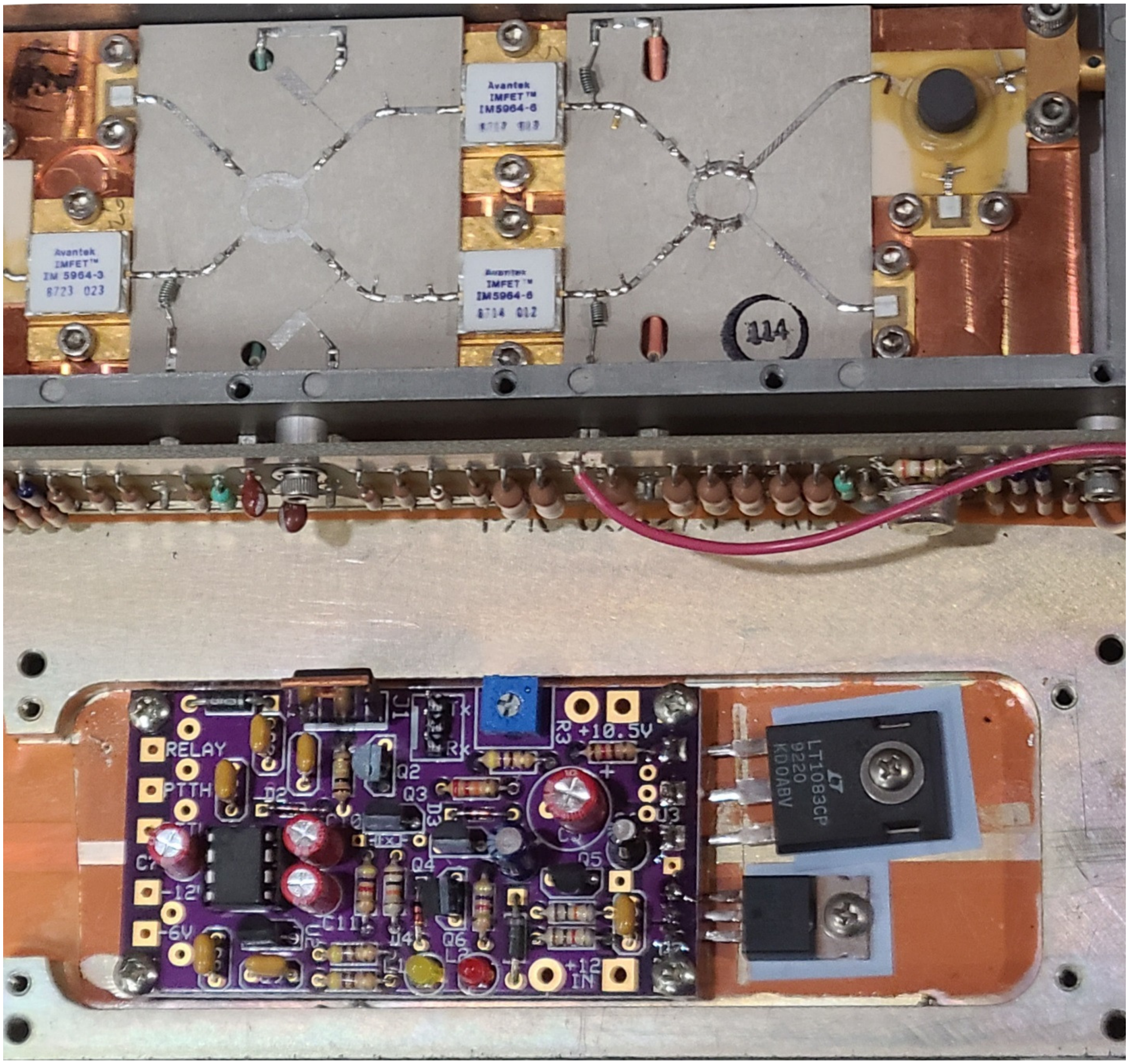

Figure 4 – Power supply board mounted on amplifier heat sink ready for smoke test

Test

The completed board can be tested before adding the high current components, U3 and Q7. With +12 volts supplied, the LED LD1 (I like yellow) should light. Ground the PTTL and LD2 should light. Connecting PTTH to +12V should also light LD2. Short out the -6V to ground and the PTT should no longer operate – LD2 will not light.

Connect an ohmmeter between the RELAY terminal and ground. It should change between high and low resistance with PTT, with the low resistance direction selected by J1 activating the relay.

Finally, Q7 and U3 are added, bolted to a heat sink with insulating pads and a nylon shoulder washer for Q7 – check for shorts. The output voltage may be adjusted to +10.5 volts with R5, but it will be slightly lower with high current and will need a final adjustment with the amplifier.

The RF smoke test was successful. Input current was about 4.8 amps at +12.6 volts with no drive increasing to about 5.5 amps at 12 watts out. A finger test on Q7 and U3 found them to be running cool.

Parts

The parts list at the end is for two sets of parts. Small cheap parts have a quantity of 10, since 10 pieces cost about the same as two. A Mouser project is available.

Parts not on the list area the obsolete LT1083CP, but many are listed on ebay. The other problem part is the 79L06 regulator,U2, – one ebay listing says they are used for Tesla repair, which must have depleted the domestic supply. Many are listed from overseas sources, and mine came quickly with no tariff nonsense. Unless you are working with the 3.4 GHz Avantek amplifier which requires -6 volts, a common 79L05 will work fine.

Finally, LEDs are ubiquitous, so I didn't chase down part numbers. And I haven't been able to find a part number for the nylon shoulder washer for Q7, so save one from the original switching power supply.

Summary

This board should make it easier to get one of these amplifiers operational and providing good power. Get it on the air and make some contacts on a fun band. See you on 5760.

Other Amplifiers

This board can also be used with other GaAsFET amplifiers. I've heard that there was an Avantek version usable at 3.4 GHz, but I've never seen one -- unless there is one in my barn. Other GaAsFET amplifiers, regardless of frequency, typicall require +6 to 10 volts and a negative voltage. The negative voltage may be adjusted by changing the negative regulator, U2. The positive output from this board is adjustable over the range. If less current is needed, the positive voltage regulator, U3, can be changed to the readily available LT1084, 5 amps max, or the LT1085, 3 amps max. A footprint for the TO-220 package used by those devices is also on the board.

There are some Fujitsu amplifiers that run on +12Vand -12V. The power supply board can supply the +12 volts if R4 is increased to 560 ohms. Of course, the supply voltage must be enough above 12 volts to provide some headroom for the regulator, otherwise output power may be reduced,

Notes

1. Why –24 volts? These amps were used in AT&T Long Lines microwave links, big towers spaced every 30 to 40 miles all over the country – thousands of them. Each link was ~6 GHz in one direction and ~4 GHz in the other. That's how long distance calls were made before fiber, and why they were expensive. And all telephone equipment runs on negative voltage, probably since a decision by Alexander Graham Bell on how to connect his wet-cell batteries. Another reason cited is that it reduces corrosion of copper cables. [I'm not sure this makes sense if the current is on a pair of wires – then you get to choose which one corrodes.]

2. Paul Wade, W1GHZ, "A simple, yet still "fool-resistant," sequencer," http://www.w1ghz.org/seq/Simple_yet_Fool-Resistant_Sequencer_Rev_B.pdf

PS-6G

Mouser #	Mfr. #	Manufacturer	Description
579-TC962EPA	TC962EPA	Microchip	Switching Voltage Regulators High Out
512-BS170	BS170	onsemi	MOSFETs FET 60V 5.0 MOHM TO92
863-MC79L05ACPG	MC79L05ACPG	onsemi	Linear Voltage Regulators 5V 100mA N
512-2N3904TFR	2N3904TFR	onsemi	Bipolar Transistors - BJT NPN Transisto
594-K104K15X7RF5WH5	K104K15X7RF5WH5	Vishay	Multilayer Ceramic Capacitors MLCC -
710-860010472002	860010472002	Wurth Elektronik	Aluminum Electrolytic Capacitors - Rad Radial
667-ECE-A1CKA220	ECE-A1CKA220	Panasonic	Aluminum Electrolytic Capacitors - Rad (KA)
667-ECA-1CM470B	ECA-1CM470B	Panasonic	Aluminum Electrolytic Capacitors - Rad
710-860020373008	860020373008	Wurth Elektronik	Aluminum Electrolytic Capacitors - Rad Radial
652-3362P-1-501LF	3362P-1-501LF	Bourns	Trimmer Resistors - Through Hole 1/4I
512-1N4148	1N4148	onsemi	Small Signal Switching Diodes 100V Io/
603-CFR-25JB-52-10K	CFR-25JB-52-10K	YAGEO	Carbon Film Resistors - Through Hole 1
603-CFR-25JB-52-4K7	CFR-25JB-52-4K7	YAGEO	Carbon Film Resistors - Through Hole 1
603-CFR-25JB-52-22K	CFR-25JB-52-22K	YAGEO	Carbon Film Resistors - Through Hole 1
603-CFR-25JR-52100K	CFR-25JR-52-100K	YAGEO	Carbon Film Resistors - Through Hole 1
603-CFR-25JB-52-120R	CFR-25JB-52-120R	YAGEO	Carbon Film Resistors - Through Hole 1
603-CFR-25JB-52-470R	CFR-25JB-52-470R	YAGEO	Carbon Film Resistors - Through Hole 1
603-CFR-25JB-1K0	CFR-25JB-1K0	YAGEO	Carbon Film Resistors - Through Hole 1
863-1N4002RLG	1N4002RLG	onsemi	Rectifiers 100V 1A Standard
610-1N746A	1N746A TR PBFREE	Central Semiconductor	Zener Diodes 3.3V .5W
942-IRF4905PBF	IRF4905PBF	Infineon	MOSFETs MOSFT PCh -55V -74A 20mO
844-IRF510PBF	IRF510PBF	Vishay	MOSFETs TO220 100V 5.6A N-CH MO
567-175-6-210P	60-11-5791-1674	Wakefield	Thermal pad for Q7 (TO-220)
144-TO-218-70	60-11-D401-1674	Essentra	Thermal pad for U3 (LT1083CP)

DIGIKEY #			
1944-1291-ND	60-11-5791-1674	Chromerics	Tthermal pad for Q7 (TO-220)
1944-1355-ND	60-11-D401-1674	Chromerics	Thermal pad for U3 (LT1083CP)