

HFPA V4 CONSTRUCTION MANUAL

HF PACKER –AMP VERSION FOUR

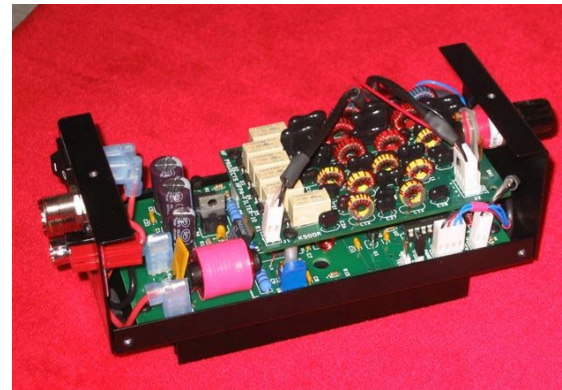
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Square Heat Sink with Fan



Rectangle Heat Sink, No fan



HF Packer-Amp V4 Options and Views

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Section One - Introduction

Welcome all builders to the homebrew Hfpacker-Amp V4 Project. This project parts and your efforts will eventually provide you with a compact 5 watt input to 30-35 watt output linear amplifier for use with QRP SSB/CW transmitters on the amateur bands 160 through 10 meters and which can be powered from a 12 volt DC supply. In this section, you are introduced to the building of the HF Packer Amp Version 4. The design is a good balance between output power, physical size and battery power consumption. The completed amplifier will reward the builder with a clean, more powerful output signal for a QRP rig when radio conditions become marginal.

This project is not a beginner's project and requires a medium skill level to complete it successfully unless you take advantage of some of the fabricated options. Builders require soldering, hand tool, basic electronics and component identification skills. This project manual is not included with the kit in order to keep kit costs to a minimum. All builders will thus require Internet access to download this PDF document file from the hfprojects site: <http://groups.yahoo.com/group/hfprojects/> Membership is free. The manual is produced in landscape format to allow more readable text per screen. This manual provides all you will need to successfully complete the amplifier project, however, some additional PDF files are provided at the above website for those interested in seeing more pictures of the project at various stages of construction.

The genesis of the basic amp circuit is fully described in the 2001 ARRL Handbook and in reprint articles from the ARRL. If you are an ARRL member, you can view the amplifier articles on-line. Full amplifier circuit design credit is given to Mike Kossor, WA2EBY. The amplifier module is mounted to the inside bottom of the chassis box and its MOSFETs are attached to a heat sink. The power supply unit is an integral part of the amplifier module while the filter board is mounted above the amplifier module.

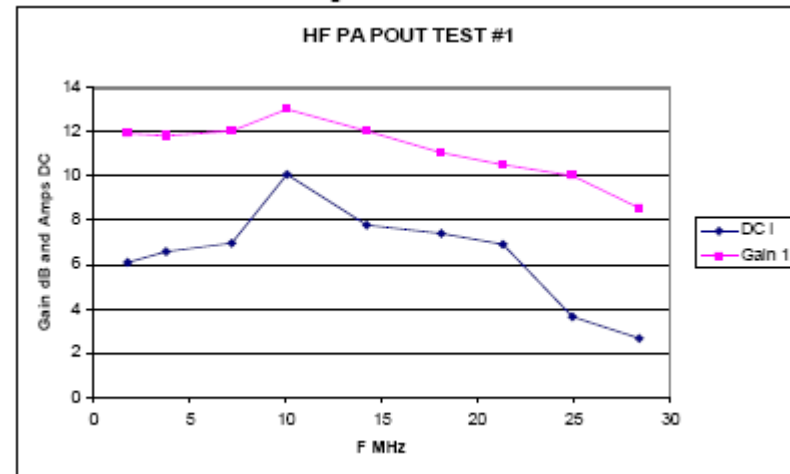
Circuit Details

The amplifier module is a push-pull design, biased for Class AB linear operation and uses low-cost power MOSFETs in its output stage. Maximum efficiency is at 10 MHz and develops over 70 watts output. QRP transmitter RF input is first sensed, which trips a relay, feeding RF through an RF attenuator pad. The signal is then applied to the primary of T3 via an input impedance-matching network consisting of L2. T3 is a 1:1 balun that splits the RF signal into two outputs 180 degrees out of phase. One of these signals is applied by C3 to Q1's gate. The other signal is routed via C7 to Q2's gate. The drains of Q1 and Q2 are connected to the primary of output transformer T1, where the two signals are recombined in phase to produce a single output. T1 also provides impedance transformation from the low output impedance of the MOSFETs to the 50Ω antenna port. DC power is provided to the drains of Q1 and Q2 by phase-reversal choke, T2. This is a very effective method to provide power to Q1 and Q2 while presenting a high impedance to the RF signal over a broad range of frequencies. The drain chokes for Q1

and Q2 are wound on the same core, and the phase of one of the chokes is reversed. C5 increases the bandwidth of impedance transformation provided by T1, especially at 21 MHz. The 5 V bias supply voltage is derived from a 78L05 regulator. Bypass capacitors C4, C6, C8 and C1 remove RF voltages from the bias supply voltage. Gate bias for Q1 and Q2 is controlled independently. VR1 adjusts Q1's gate-bias voltage via R1 and L1. VR2 works similarly for Q2 via R2 and L3. At low frequencies, the amplifier's input impedance is essentially equal to the series value of R1 and R2. L1 and L3 improve the input-impedance match at higher frequencies. The low value of series resistance provided by R1 and R2 also reduces the Q. A Resistive Pi Network comprised of R3, R7 and R8 provide a 50 ohm impedance to the transceiver and to the AMP. The network attenuates the RF Input by 6dB which is a 4:1 power ratio. The maximum RF input of 5W is reduced to 0.63W to the gates of the MOSFETs. The attenuation matches the popular FT817 power setting of 5W. The maximum of 0.63W is below the distortion level of the MOSFETs. This is important for distortion free SSB operation.

The switch-mode **power supply circuits** boost the nominal 12 VDC input to 29 VDC at 3-4 amperes during voice peaks. The power supply is normally off unless commanded to be on by the Controller IC, U2. During receive or standby current is very low. There is an approximate 26 mA current draw when power supply is off, and 95 mA current draw when power supply is on and 3-10A current draw when the amplifier is keyed by a transceiver.

Performance



The chart shows the typical gain vs frequency you can expect from the HF Packer-Amp. The average power out is approximately 35W. The fall off in performance at 30MHz is due to the MOSFET characteristics. This chart was made with a constant RF drive input.

The Controller , U2 is a Microchip PIC16F688 device. RF input at J3 is tapped by step-up transformer T4 to provide a signal to the controller for Carrier Operated Sensing. This signal causes the controller to sequence the PSU signal, the IPS signal and TX signal for correct operation. The PTT input may also be used to activate the amp independent of RF sensing. The TX signal (Q6) operates the T/R relays K2 and K3 to switch from the RX state to the TX state.

Terms used in the descriptions

- PSU – Power Supply Unit
- IPS – Intelligent Power Switch
- PTT – Push To Talk
- AMP – Amplifier
- TX - Transmit
- On/Standby – TX Enable
- LPF – Low Pass Filter
- XCVR - Transceiver

The IPS signal passes the PSU voltage to the MOSFETs through the IPS electronic switch U5. The PSU signal activates the DC-DC converter on from a standby state. The IPS device acts as a power switch and a over-current sensor to protect the DC-DC converter IC, U4. The U5 device purposely heats up rapidly to provide a thermal time constant circuit breaker if the current exceeds 5A. After the U5 device cools, the circuit breaker automatically resets.

A TEST jack, H3, provides a means to set the bias current. A jumper is provided to activate during calibration. A CW jack, H4, is provided to optimize the timing between CW and SSB operation. Install the jumper when using CW. A front panel switch through J5 sets the AMP for ON/STANDBY. In STANDBY, the amp is in standby and the Transceiver is routed directly to the antenna jack via J4.

Preparation

You may have purchased configurations not described here. The rectangular heat sink is a substitute for the square heat sink with fan. You may have purchased a fabricated set or the fabricated

inductor and transformer set. Skip over the sections that don't apply. The most important preparation step before building is to completely and thoroughly read this section of the manual. This will familiarize you with the circuitry, building requirements and components.

After reading this document and prior to assembly you should do an inventory of parts (Appendix A). In the unlikely event that you appear to have missing parts, duplicates or wrong parts please first double check for the parts in all bags, recheck the inventory and if this fails please contact the project organizers. This might also be the time to re-acquaint yourself with how to identify resistors and capacitors by the standard codings (Appendix E), if you have forgotten.

Construction Techniques

It is a fact that 90-95% of problems with completed electronics/radio kits are due to either component misplacement or soldering faults. We cannot stress highly enough the importance of double checking component installation before soldering and then good soldering technique in order to have a working amplifier at the end of this project. Other builder faults are active component damage due to over-heating and damage to circuit board pads and tracks caused by poor desoldering, too high a wattage of soldering iron or carelessness. It is very rare to have initially faulty components or printed circuit boards (PCBs).

Good Soldering Technique

- ⑩ use a 12-25 watt soldering iron with a clean, non-corroded, well-tinned, fine tip
- ⑩ keep the tip clean by frequently rubbing it along a wet sponge
- ⑩ keep the tip tinned
- ⑩ ensure all circuit board pads and component leads are clean (not a problem with this project because boards and components are new)
- ⑩ ensure the soldering iron tip is at its working temperature and is in contact simultaneously with both surfaces to be soldered (the pad and the component)
- ⑩ let the contact zones heat before applying only electronics grade rosin cored solder (usually 3-6 seconds will do)
- ⑩ apply the solder to the two surfaces (not the iron tip) and only enough solder to coat both surfaces
- ⑩ ensure that the joint does not move after you remove the soldering iron tip and until the solder has solidified
- ⑩ the resultant good solder joint should be shiny, in perfect contact with pad and wire and often has a concave upwards appearance
- ⑩ toroids and inductors you will wind and solder in this project use enamel coated magnet wire. The enamel wire used is designed to be stripped by a soldering iron at 750 deg F. This makes it much easier to tin the wire before insertion into the circuit board holes.

Suggested Tools

- ⑩ 12-25 watt electronics soldering iron, electronics grade solder, iron stand and sponge
- ⑩ desoldering braid and/or desoldering pump or bulb
- ⑩ fine needle nose pliers, small fine wire cutters, wire stripper
- ⑩ small screwdrivers including jewelers screwdrivers, small file
- ⑩ multi-meter
- ⑩ LCR meter
- ⑩ Crimp tools for Molex pins and Power Pole Terminals

Included Speciality Tools

- ⑩ 1/16 and 7/64 Hex Head tool


Component Installation

For each component, our word “*Install*” always means:

- ⑩ Pick the correct part to start with – in the assembly notes that follow we often provide a part number only. You must match this part number with the correct component using the parts lists (Appendix A).
- ⑩ Insert the component into the correct PCB position. Refer to the PCB component outline (silkscreen). Orient it correctly, following the PC board outline. This is vital for active components, electrolytic and tantalum capacitors and diodes. Also, it is good practice to mount resistors and capacitors in identical orientations (for resistors normally read color code left to right in same direction as the silkscreen on the PC board). This makes component checks easier.

- ⑩ Arrange the resistors on the table before you from left to right with the lowest values on the left progressing to higher values on the right. Use the multi-meter to confirm the resistor values.
- ⑩ Install all low profile components first: usually resistors, capacitors, diodes, then electrolytics and active components.
- ⑩ Resistors should be mounted flush to the board.
- ⑩ Mount all capacitors, relays and connectors as flush to the board as possible.
- ⑩ Bend the wires of the components at the bottom side slightly outwards in order to hold the component in place for soldering.
- ⑩ Solder as per techniques described above.
- ⑩ Flush cut excess wire leads and reflow the solder connection for assurance and a better looking solder joint.

Mark off each installation step in sequence as you complete it, in the box provided (e.g.).

Warnings and important points are posted with a  symbol.

Care of the IRF-510 MOSFET's

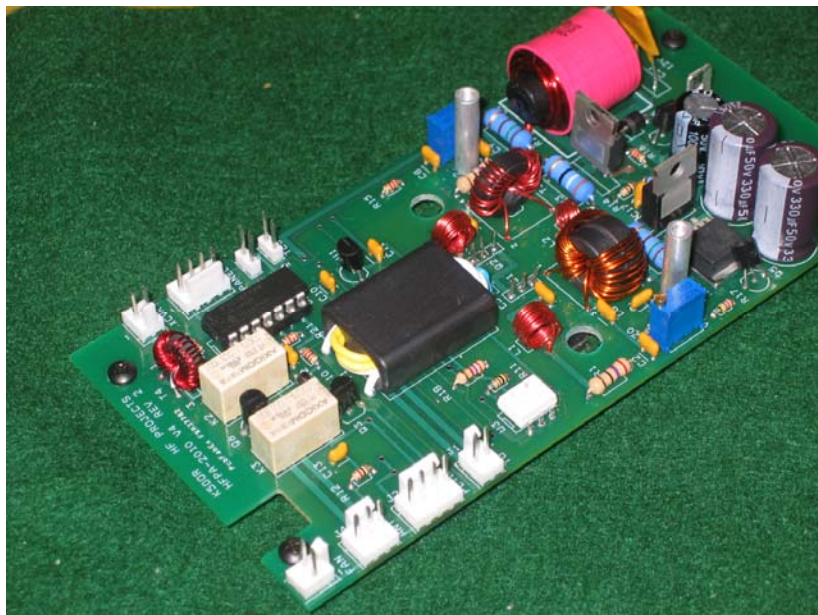
MOSFETs are susceptible to electrostatic discharge damage (ESD). It is important to use proper grounding techniques while handling the amp circuit board and the MOSFETs in particular. While working with MOSFETs you should wear a grounding strap and have an antistatic mat at your feet. At the very least you should frequently ground your hands to the nearest ground point. The IRF510 is a good compromise MOSFET that will work up to 30 MHz but has poor thermal characteristics of 3.5°C/Watt. When used in intermittent SSB and CW service forced-air cooling is not required.

Tuning time with full power should be limited to less than 30 seconds with 1-2 minutes between cycles to prevent overheating. Operating at 29VDC does not press the MOSFET to their limits. The Sil-Pad TO220 mounting kit has excellent thermal performance and provides a greaseless thermal interface between the MOSFET and the heat sink. Users report that this amplifier can be safely used for contest CW operation without further cooling. For PSK/RTTY forced air cooling is necessary or a reduction of power by reducing the input drive.

Other Construction Notes

1. Follow the sequence given to locate the next component in a series to install.
2. The header parts are installed by matching the part to the outline. Start by soldering one pin and then while reheating, align the part flush and perpendicular to the board. Solder the remaining pins.
3. The IPS511S, U5 component is pre-mounted since it is a surface mount part.
4. The reference numbers used are not in sequence and some references are skipped.
5. The circuit boards should be cleaned after soldering to remove solder flux residue. I recommend "TechSpray BLUE SHOWER" available in a can: 1630-16S. Use in a ventilated area following instructions on the can.

Section Two – Amplifier Module Construction



Circuit Board Assembly, HFPV V4 (rev 2 shown)

Assembly Steps

- Install 0.1 uF capacitors (104): C22, C4, C1, C9, C2, C6, C8, C3, C7 Install
- Install 47 pF (470J): C5
- Install 0.01 uF capacitors (103): C11, C10, C12
- Install 1000 pF capacitor (102): C13 Install
- Install 1 uF capacitor (105): C17. The long lead is (+) and goes in square pad marked (+)

- Insert 1N4007 diode at D2 (smaller of two axial components with cathode stripe at one end). Bend leads very close to the body to match the component outline on the board. Make sure cathode bar on the part matches the cathode symbol on the silk screen outline. Install
- Insert RL251 diode at D5. The leads are bent approximately 1/8 inch away from the body to fit the component outline on the board. Make sure cathode bar on the part matches the cathode symbol on the silk screen outline. Install
- Install six 1K 1/8W resistors (BRN BLK RED): R14, R20, R15, R10, R21, R12. Install

i Note: you may have an extra 1K on the first run due to a part change after parts were pulled.

- Insert two 4.7K 1/8W resistors (YEL VIO RED): R17, R19. Install
- Insert two 27 ohm ½ w resistors (RED VIO BLK): R1,R2 Install
- Insert three 10K 1/8w resistor (BRN BLK ORN): R4,R5,R9 Install

i Note: the remaining 10K resistor (R6) will be added to the bottom of the board later.

- Insert one 27K 1/8w resistor (RED VIO ORN): R13. Install
- Insert one 3K 1/4W resistor (ORN BLK RED): R18. Install
- Insert one 1.2K 1/8W resistor (BRN RED RED): R16. Install
- Insert one 1M 1/8w resistor (BRN BLK GRN): R11 Install

i Note: if you did not purchase the PINET 100-PI Option Module, install R3, R7 and R8 next. Otherwise wait until instructed to install alternate values for R3, R7 and R8 in the 100-PI section.

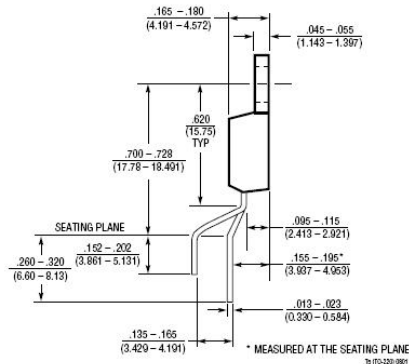
- Insert two 100 ohm 2W resistors at R7 and R8. Install
- Insert one 62 ohm 2W resistor at R3. Install

- Insert one 78L05 regulator (3 pin TO92 package) at U1. Match the outline.
- Insert four 2N5089 transistors (3 pin TO92 package) at Q3, Q4, Q5, Q6 Match the outline. Install
- Insert two 2-pin headers (no rib back) at H3, H4. Install
- Insert Diode D3 between the outside posts on the backside of the board at H3 and H4. The cathode (stripe) goes to H3 and the anode goes to H4. Make one wrap around the post and solder. Install
- Insert three 2-pin headers at J1, J3, J6. Install
- Insert one 3-pin header at J4. Install
- Insert two 4-pin headers at J2 and J5. Install
- Insert two Power Tabs at H1 and H2. Solder one pin, reheat and align perpendicular. Solder both pins of each tab Install
- Insert one Circuit breaker, CB1. Leave leads long. Insert just the tips through the board. Install
- Insert Inductor (Red 50 uh coil) at L4. The ends are not symmetrical. Install the over-hanging end away from CB1. Press the component flat on the circuit board. Solder the pins, flush cut and re-solder the connections. Install

- Insert two 10K- potentiometers, VR1 and VR2, on the board. The lead under the adjustment screw is inserted in the square pad in the circuit outline. Do not bend the leads. Solder one pin, reheat and align part perpendicular and flat on the board. Solder all pins Install
- Turn the 25-turn potentiometers CCW at least 20 turns. You will not hear a click and there is no mechanical stop.
- Install the 14 pin DIP socket for U2. Align the notch on the socket with the notch shown on the component outline. Solder one corner pin. Reflow connection while pressing the socket flat. Solder the other corner pin. Reflow the pin while pressing the socket flush. Solder the remaining pins. Install
- Insert U2, PIC16F688 Integrated Circuit in the socket Install
- Insert two relays at K2, K3. Do not bend or cut the leads. Solder one corner pin. Reflow while pressing the relay flat to the board. Solder the other corner pin. Reheat pin as necessary to make the relay flat to the board. Solder all pins Install
- Insert two 330 uF Capacitor at C21 and C16. The long lead (+) goes to the square pad of outline near the (+) symbol on the board. Solder one pin, reflow and align part flush. Solder other pin repeating reflow and alignment. Flush cut leads and reflow. Install
- Insert one 100 uF Capacitor at C15. The long lead (+) goes to the square pad of outline near the (+) symbol on the board. Solder one pin, reflow and align part flush. Solder other pin repeating reflow and alignment. Flush cut leads and reflow. Install

- Insert a MBR1060G diode (2 pin package) in the outline for D4. The part is mounted vertically. Press the part down until the body is resting on the circuit board. Install
- Insert a LT1270A Switching Regulator U4 is mounted vertically into the 5 holes on the circuit board outline for U4. With the part vertical, Solder the three pins. Make certain the part is still perpendicular and then solder the remaining two pins.

i Note: the LT1270A may or may not have the pins bent in a stagger pattern. If your part has straight legs you will have to approximate the shape for proper part insertion. See picture for details.



LT1270 Lead Bending Detail

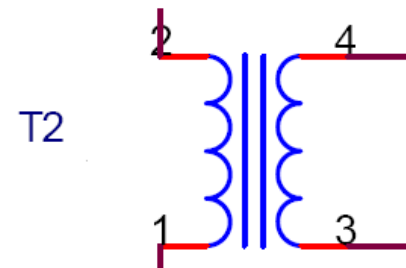
- Install 4N33, 6-pin IC at U3. Make sure the round depression dot on the package is closest to the notch in the component outline. Install

Spacer Assembly

- Locate four 4-40 x ¼ inch threaded hex spacers and four 4-40 x 3/16 inch length screws.
- Install the spacers on the bottom side of the circuit board. Tighten the screws extra snug so they will not come loose when removing the circuit board from the case in the future.
- Locate two 4-40 x ¾ inch threaded round spacer and two 4-40 x ¼ inch length screws.
- Install the spacers on the top side of the circuit board near VR1 and VR2. Tighten the screws extra snug so they will not come loose when removing the filter module in the future.

i Note: Identify the correct size wire for T2 and T3

Fabrication and Assembly of T2

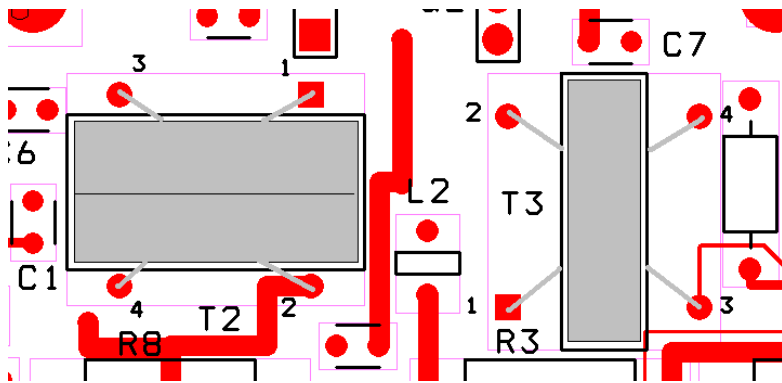


Schematic of T2

- Two stacked FT50-43 torroid cores are used for this transformer. Cut two #22 AWG wire (0.026 inch diameter) 15 inches long. Do not twist the wires. Insert the two wires through the cores. Bend the wires into a U-shape. Holding the

two wires together in one hand with the cores at the bottom of the U-Shape, grasp the wires in the rear and insert the wires on right side through the core four additional times. Pull each wrap snug keeping the wires parallel without crossovers.

- After completion of the loops on the right side, pass the remaining wires through the cores on the left side 5 times.
- Pull each wrap snug keeping the wires parallel without crossovers. You will now have 10 turns passing through the core.
- Separate and scrape the ends of the wires so you can measure continuity and determine the start and finish of each wire.



Circuit board showing cores with wire exits for T2 and T3

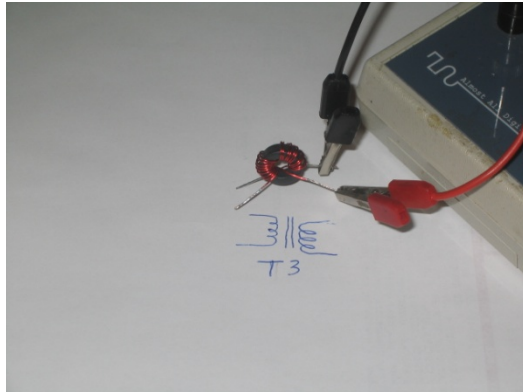
- Winding # 1 goes to pins 1 and 2. Winding #2 goes to pins 3 and 4.
- Insert the wires through the appropriate holes and pull snug to form the leads in the shape required.

- Pull T2 from the mounting holes and use a soldering iron to heat the insulation at the points where you will be soldering to the board. You need at least 750 degrees F to remove the insulation. Tin the leads removing excess accumulated Install
- Re-insert T2 on the board at the T2 outline. Pull the leads tight and Install
- Trim the excess lead length and reflow connections.

Adjust the wire spacing to match the picture. The top and bottom of the core should be clear so T2 and T3 will be minimum height to not create a clearance problem with the board above.

Fabrication and Assembly of T3

- One FT50-43 torroid core is used for this transformer. Cut two #24 AWG wire (0.022 inch diameter) 11 inches long . No twist is required or desired. Insert the two wires through the core. Bend the wires into a U-shape. Holding the two wires together in one hand with the cores at the bottom of the U-Shape, grasp the wire in the rear and insert the wires on the right side through the core four additional times. Pull each wrap snug. Avoid crossover of the leads.
- After completion of the loops on the right side, pass the remaining wires through the core on the left side 5 times. Pull each wrap snug. You will now have 10 turns passing through the core.
- Separate and scrape the ends of the wires so you can determine the start and finish of each wire. Use the multi-meter to measure continuity.



Identify T3 Windings

- Winding # 1 goes to pins 1 and 3 Winding #2 goes to pins 2 and 4.
- Insert the wires through the appropriate holes and pull snug to form the leads in the shape required.
- Pull T3 from the mounting holes and use a soldering iron to heat the insulation at the points where you will be soldering to the board. You need at least 750 degrees F to remove the insulation. Tin the leads removing excess accumulated
Install
- Re-insert T3 on the board at the T3 outline. Pull the leads tight and solder. Install
- Trim the excess lead length and reflow connections.

Fabrication and Assembly of L1 and L3

- L1 and L3 are identical and require 12 inches each of the remaining #24AWG wire.
- Use a ¼ inch drill bit as a winding form and wrap 10 complete turns of the wire tightly around the drill bit.
- Trim the excess lead length to ½ inch and tin the leads.
- Insert L1 and L3 into the L1 and L3 positions on the circuit board. Install
- Use the end of a ball point pen to push into the end of the air coils slightly to reform the wires should they become deformed during soldering.

Fabrication and Assembly of L2

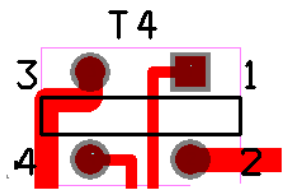
i Note: If you purchased the PINET 100-PI Module with your Amp, it is not necessary to install L2. Leave the holes clear. Instead, refer to the page for the PINET 100-PI Module option.

- L2 require 4 inches of the #24AWG remaining wire.
- Use a 3/16 inch drill bit as a winding form and wrap 4 complete turns of the wire tightly around the drill bit.
- Trim the excess lead length to ½ inch and tin the leads.
- Insert L2 into the L2 position on the circuit board. Install
- Use the end of a ball point pen to push into the end of the air coils slightly to reform the wires should they become deformed during soldering.

Fabrication and Assembly of T4

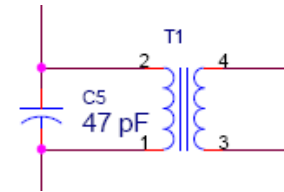
- T4 uses a F37-43 core and #30 AWG enamel wire.

- A 14 inch length of #30 red wire is wrapped 26 turns around the F37-43 core. Note the start and end wire positions on the core. It is important that your wire top/bottom positions are the same as the picture. Otherwise, it will not fit the pattern on the circuit board.
- Insert the leads through holes 1 and 4. Pull the wires tight and then remove T4. Scrape the wire where the leads will be soldered when T4 is re-inserted. Tin the leads at these positions on the wire.
- Prepare a 1 inch length of #20 AWG Yellow Teflon coated wire by stripping $\frac{1}{4}$ inch of insulation from each end. Tin the ends of the wire.
- Insert one end of the yellow wire into hole #2. The wire should be now straight up coming off the board. Solder
- Insert the tinned wires on the core into the holes marked 1 and 4 threading the yellow wire through the center of the core. Pull the leads tight. Poke the yellow wire into hole #3. Solder the three leads

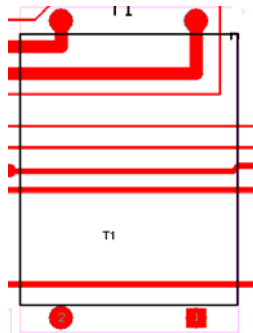


Fabrication and Assembly of T1

- T1 is fabricated using a Binocular core with a primary and secondary winding.
- The primary is a 7 inch yellow #20AWG Teflon coated wire. There will be 2 loops through the cores.
- The secondary is a 10 inch white #20 AWG Teflon coated wire. There will be 3 loops through the cores.
- Run the primary wire through first. Make sure to keep the wires from crossing over and unnecessarily blocking the wiring tube.
- Start with the other end and run the secondary wire through.
- Strip and tin the wires within $\frac{1}{4}$ inch of the tube hole.
- Insert the primary wires at holes 1 and 2. Pin 1 is the square pad.

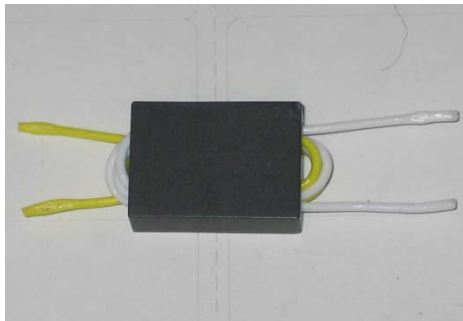


Schematic T1



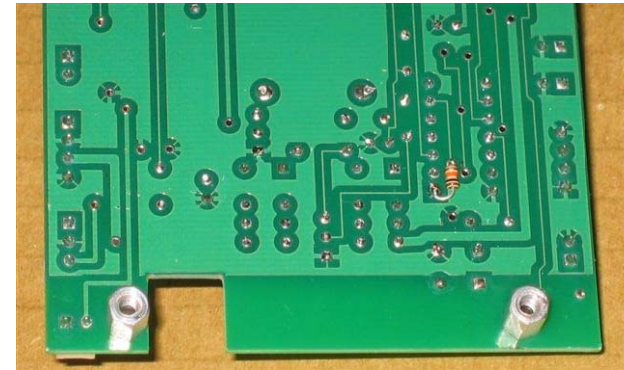
Circuit Board Showing T1

- Insert the secondary into holes 3 and 4
- Pull leads snug and solder. Install

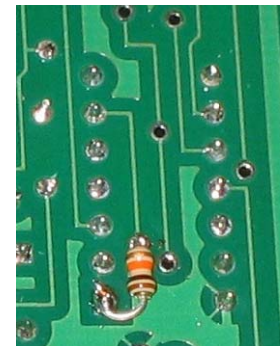


T1 with Yellow Primary, White Secondary

Resistor R6 Addition



- Add a 10K 1/8W resistor (R6) from pin 1 to 6 on the circuit side of U2. (added resistor)
- Clip the end of one end of the 10K resistor to ¼ inch length. Bend at right angle and insert in the hole near pin 1 (square pad). Solder on the circuit side.
- Wrap the other end partially around pin 1, clip excess lead and solder.

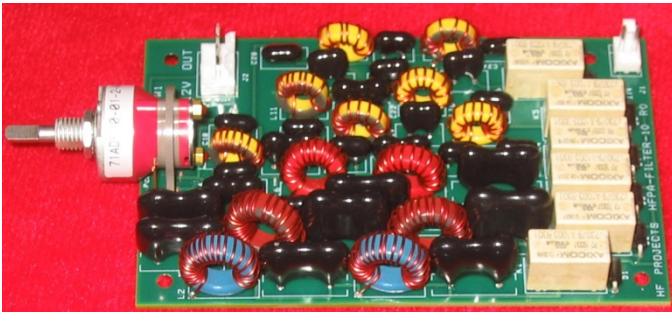


Clean and Inspect the Board

- Remove the flux from the circuit board with a flux removal spray in a ventilated space.
- Inspect the solder joints for the entire board

This completes assembly of this module. The MOSFETs will be installed in a later assembly.

Section 3 - Low Pass Filter Module Assembly



This is the 10-Band Filter Module for the HFPA V4

- ⑩ Size: 3.8 x 2.4 inch; Bands: 160-10M Power Rating: 50W; Control: Front panel switch
- ⑩ Design: Four-Layer Ground Plane with greater than -40dB rejection in the stop band;
- ⑩ Relay Front End controlled by front panel switch.

Organize for Assembly

- ⑩ Place on the table in front of you all the capacitors ranging from smallest value to largest value from left to right.
- ⑩ Organize the cores and relays into like groups.
- ⑩ Two Blue Cores – T68-1
- ⑩ Two Larger Red Cores – T50-2
- ⑩ Two Smaller Red Cores – T44-2
- ⑩ Seven Yellow Small Cores – T37-6
- ⑩ Wind the cores referring to the core winding table

Install Relays and Diodes

Install the six diodes on the circuit board observing that the stripe on the diode matches the board silkscreen for the part. Be careful that your tools do not damage the circuit board. The diodes require that the leads are bent very close to the body of the diode. Before installing, scrape the leads near the body to remove any oxidation on the leads. Install

Install six relays. Solder one pin, reheat and align flat. Install

Capacitor Assembly

i Install the capacitors in the sequence given and soldering when called for. If the part doesn't fit, you have it in the wrong place! Double check your work.

C1 1500, C2 2700, C3 1500 Install

C4 1200, C5 1800, C6 1200 Install

C7 39, C8 110, C9 390, C10, 680, C11 330 Install

C12 27, C13 150, C14 100, C15 100, C16 220, C17 220, C18 47
Install

C19 12, C20 39, C21 150, C22 220, C23 100 Install

C24 12, C25 39, C26 82, C27 150, C28 68 Install

Core Winding Table

REF	TYPE	T	W	IN.	IND.	Clock
L1, L2	T68-1 (BLU)	20	22	19	5.08 uH	7-5
L3,L4	T50-2 (RED)	21	24	17	2.51 uH	7-5
L5	T44-2 (RED)	15	24	13	1.37 uH	7-5
L6	T44-2 (RED)	13	24	12	1.17 uH	7-5
L7	T37-6 (YEL)	12	24	9	580 nH	7-5
L8	T37-6 (YEL)	11	24	8	470 nH	7-5
L9	T37-6 (YEL)	10	24	8	430 nH	8-3
L10	T37-6 (YEL)	11	24	8	470 nH	7-5
L11	T37-6 (YEL)	10	24	8	430 nH	7-5
L12	T37-6 (YEL)	8	24	7	360 nH	10-2
L13	T37-6 (YEL)	7	24	7	280 nH	11-1

Where: T=turns; IN.=inches; IND= inductance; W=wire AWG

i Clock – Clock Face where winding occupy space on the core between a start time (7pm) and a end time (5pm) example. Evenly adjust the wire spacing to match the clock setting.

Core Winding Technique

The starting position: Divide the wire in half letting the core hang down. The wire passing through the core counts as one turn.

L3 Example:

Wind one side. Start with the wire in the back and wrap 10 turns on the right side.

Use a pair of needle nose pliers to aid in pulling the wire tight against the core as you wrap it around the core.

Wind the other side. Wrap 10 turns on the other side. You now have 21 turns through the core. I squeeze up the wraps to be tight. Your inductors must be wound with the wires on the sides shown or the inductor footprint will not match the circuit board layout.

i If the core does not fit the pattern (wound wrong), do not try to make it work, strip the wire and wind it again correctly. Spread the windings equally about the core using the clock code.

Core Installation

- ⑩ Install L1 and L2 last.
- ⑩ Install L3-13. Pull the leads tight. Align the core vertical and solder.
- ⑩ Repeat for each inductor one by one. Solder as you go. Install

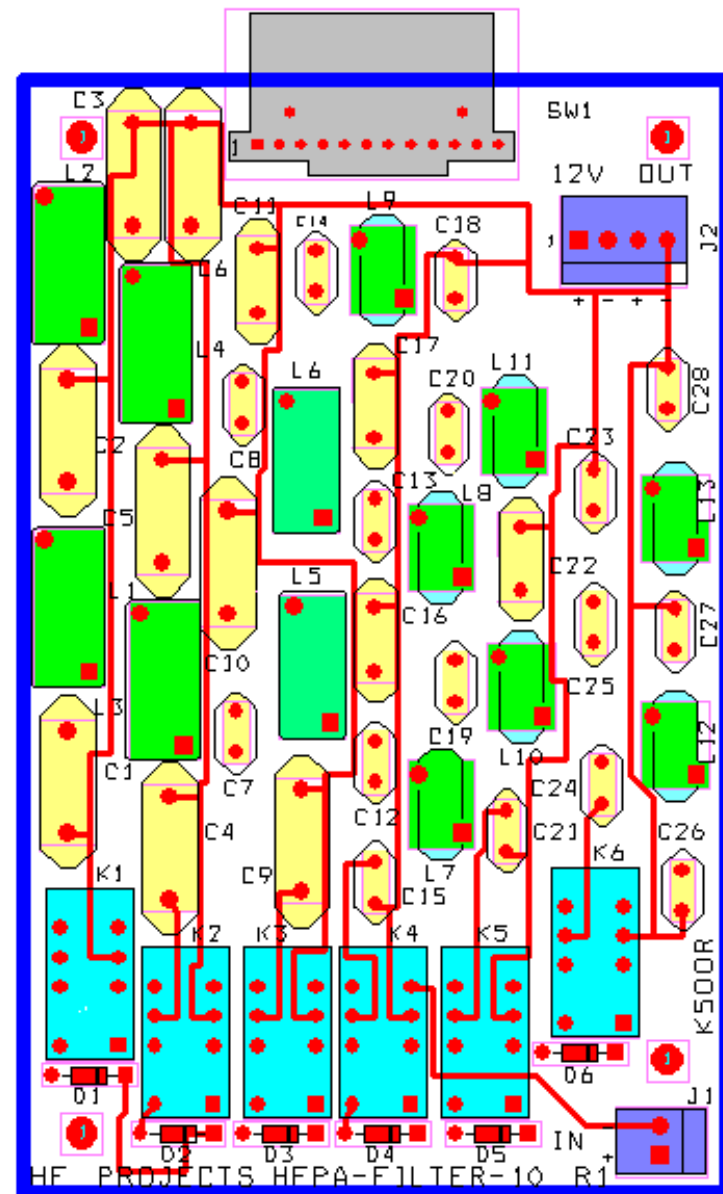
Switch Assembly

Insert the switch on the top side of the assembly. Make sure the leads are flush with the board. Install

Connector Assembly

Insert J1 and J2. Make sure the parts are flush and vertical. Solder one pin to start, reheat while making final alignment. Solder the remaining pins. Install

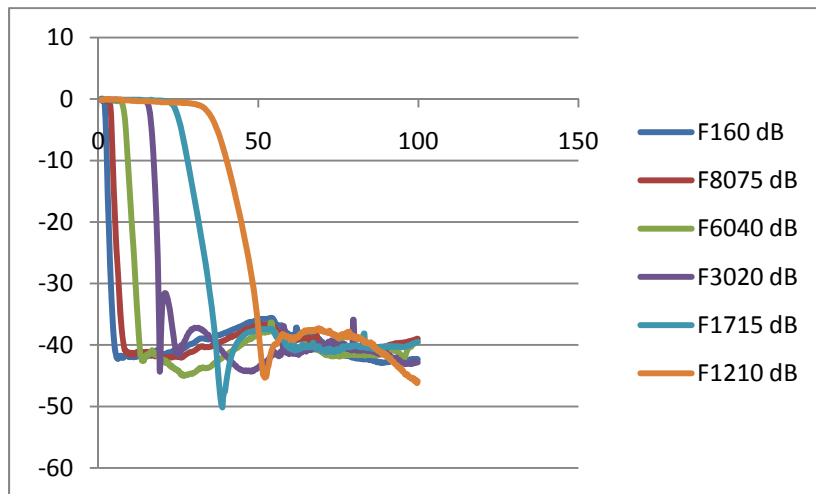
i the HFEPA-FILTER-10 circuit board depicted (right) and the picture has J1 and J2 oriented incorrectly. Rely on the silkscreen on the actual circuit board for proper part position.



In-Circuit Tuning Adjustments

If you have a miniVNA device for your PC you can adjust the filter in real-time for the best response curve. If you do not, you can use the clock method of lead spacing and you should be pretty close.

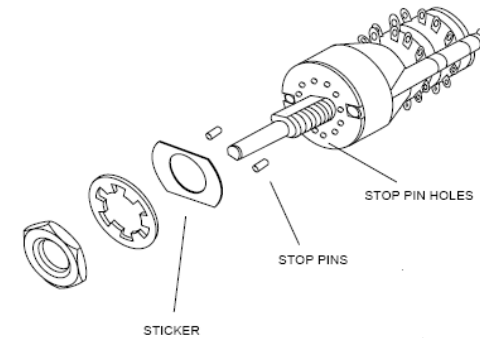
i Note: You must attach 12V to J2 in order to use a miniVNA. Observe polarity, pin 1 is +12V. You need power because only the energized circuit does not have the input and outputs grounded.



Consolidated Filter Response Where Y-axis = dB; X-axis = F MHz

The Plot was acquired using a miniVNA sweeping 1 – 100 MHz. Data was captured to an Excel spread sheet and graphed.

Selector Switch Stop Pins Installation



- The switch includes a little package that has two stop pins and a sticker. Your goal is to install the pins in the correct holes without losing the stop pins.



- Turn the shaft so the flat is on the right. Check ____
- Insert the pins at 12 and 6 o'clock. Cover with sticker.

Install

Section 4 – Case and Chassis Assemblies

Case Preparation

- Use a hobby knife to expose bare metal around the inside and outside of the holes for the RF IN, RF OUT and PTT so that when the panel part is inserted and secured, you will have a good case connection to the part body.

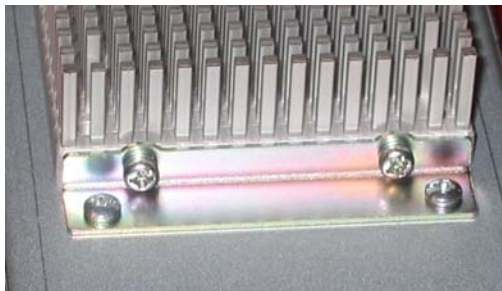
Heat Sink Assembly, no Fan

i Note: –You may have purchased the amp without the fan option. If true, install the black rectangular heat sink using four 4-40 x 5/16 inch screws and plastic wire clamps.

Heat Sink Assembly with Fan

- Locate the heat sink and F6020 Screw Set bag used with the heat sink and fan assembly.
- Attach brackets to each end of the heat sink with the metric screws and washers. The long screws will be used later to attach the optional fan to the heat sink.

Attach Heat Sink to Case

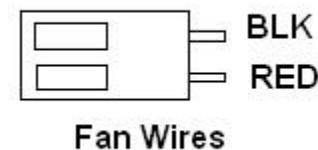


Heat Sink Bracket Attachments

- Attach the heat sink assembly to the case with four 4-40 x ¼ inch screws, plastic wire clamps and 4-40 nuts. Wires will be placed under the clamps during assembly so only loosely attach nuts at this time.

Fan Assembly Option

- The fan is assembled to the heat sink by the four long screws in the FS6020 Screw Set.
- Locate the black plastic fan guard and place on top of the fan (side with writing) and thread the four screws through the fan guard and fan.
- Orient the fan so the wires are close to the grommet hole on top of the case (towards front of case).
- Screw the fan on to the heat sink assembly. No washers.
- Cut the fan wire leads to 6 1/2 inch length.
- Insert grommet into hole on top of case.
- Feed the fan wires through the grommet hole.
- Crimp Molex pin to each wire. Insert into 2-pin Molex housing as pictured below.



i Note: – The mating hardware for the case wires are items referenced in the AMP assembly.

RF Input Cable

The RF Input cable is best fabricated on the bench and then installed in the amplifier.

- The cable type is RG174. Length is 11 inches.
- Thread four 23-43 cores over the coax sleeve. Adjust to mid position. Shrink $\frac{1}{2}$ inch length of black shrink over cores.
- Strip $\frac{3}{4}$ inch of the coax sleeve on each end. Comb out the shield and tightly twist into a pig-tail. Trim to $\frac{3}{8}$ inch.
- Prepare two $1\frac{1}{2}$ inch lengths of black TEF 24AWG wire by stripping $\frac{1}{8}$ inch from each end. Tin one end.



Heat Sink Shield

- The shields on both ends are connected to 1.5 inch TEF #24 black hookup wire. Heat sink the shield when soldering the wire to the shield so the inner conductor is not melted.
- Use $\frac{1}{4}$ inch black heat shrink on the wire ends to cover the bare shields.

- Attach the cable to the BNC connector being careful to keep the wire straight so the center conductor insulation is not melted. Thread a short length of $\frac{1}{8}$ inch red heat shrink over the center conductor. Form a hook in the black #24 TEF hookup wire and attach to the ground connection on the BNC. Solder this first. Next, solder the center conductor in the slot of the center pin of the BNC. Heat the $\frac{1}{8}$ inch red heat shrink with a heat gun to constrict around the wire.



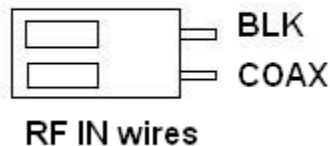
RF IN RF OUT and PTT Wires

- Tighten BNC to case with $\frac{1}{2}$ inch open wrench. A BNC T is useful to help hold the BNC in a fixed position while tightening.
- Position the Cores near the BNC connector. The cable is routed along one edge under the circuit board under the wire clamps to relieve cable congestion in the box.

RF Output Cable



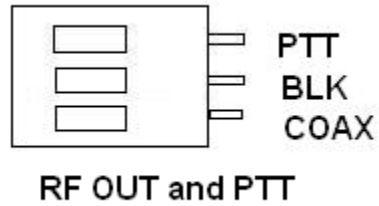
RF Input Cable



- Clamp the cable at the threads of the BNC with the 4 inch plastic Ty-wrap. See RF IN RF OUT and PTT Wires picture

The RF Output cable is best fabricated on the bench and then installed in the amplifier.

- The cable type is RG174. Length is 10.5 inches.
- The shields on both ends are connected to 1.5 inch TEF #24 black hookup wire. Heat sink the shield when soldering the wire to the shield so the inner conductor is not melted.
- Thread on four 23-43 cores on the wire near the end to be attached to a three pin Molex connector, J4. Cover with black heat shrink to hold the cores in place.
- Use 1/4 inch of black heat shrink on the wire ends to cover the bare shields.
- Attach the cable to the SO-239 connector being careful to keep the wire straight so the center conductor insulation is not melted. Thread a short length of red heat shrink over the center conductor. Heat the red heat shrink with a heat gun to constrict around the wire.
- Crimp the black #24 TEF hookup wire and attach to a red #4 ring terminal. Follow up by soldering the connection.
- Attach connector to rear panel using two 4-40 x 1/4 inch screws, one split lock washer and two 4-40 nuts.
- Attach a 10.5 inch length of #24AWG Teflon coated hookup wire to the PTT connector on the rear panel.
- This wire is routed along with the output cable and terminated into the 3-pin connector, J4.
- The cable is routed along one edge under the circuit board to relieve cable congestion in the box.



Low Pass Filter Input Cable Fabrication

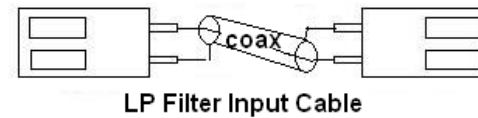
- Cut a 4.5 inch length of the RG174 cable. Twist the shields and cut to ¼ - 3/8 inch length.
- Cut two ½ inch lengths of the black ¼ inch heat shrink tubing for bare wire covering.
- Tin the end. Use a heat sink clamp next to the coax so the heat does not reach the center conductor.
- Cut two 1 ¼ inch lengths of black #24 AWG Teflon coated wire.
- Strip the insulation from both ends 1/8 inch or slightly longer. Tin one end. The other end is crimped to terminal pins.
- Solder the black wires to the shields. Use a heat sink clamp next to the coax so the heat does not reach the center conductor.



- Place the heat shrink over the coax end with both wires of each end exiting the tubing



- Crimp Molex pins on both ends of the cable
- Heat-shrink the cable bare connections with the ½ inch length of ¼ inch black heat shrink tubing.



Low Pass Filter Output Cable Fabrication

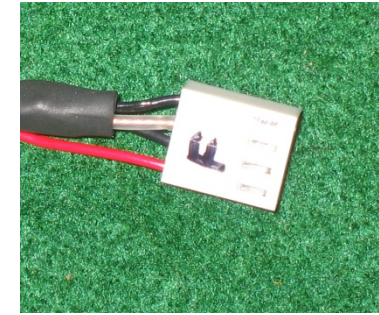
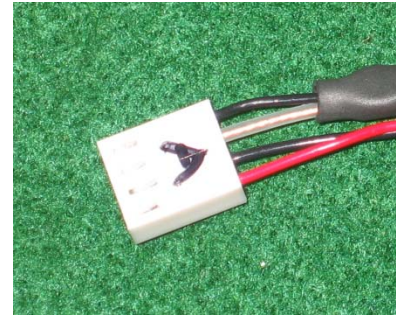
- The top cable is the finished Low Pass Filter Input Cable.
- Fabricate the Output cable in a similar manner.
- Cut the length of the RG174 cable to 4 inches.
- Prepare the ends with the crimp pins.
- Cut a 4 inch length #24 AWG Red and Black Teflon coated wire and attach crimp terminals to both ends.
- Attach the four wires to the four pin Molex connectors.

i This four wire cable is not symmetrical. The ends must be identified to show where they plug in.

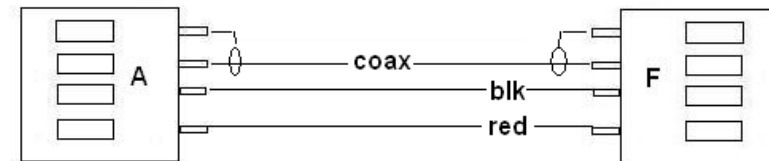
- Label one end of the four wire cable with the letter **A** using a Sharpie marker.
- Label the other end with the letter **F**.
- The end with the A designator plugs into the AMP. The end with the F designator plugs into the FILTER.



Filter Module Cable Fabrication



Connection Detail for AMP and FILTER ends



Cable between Amp and Filter

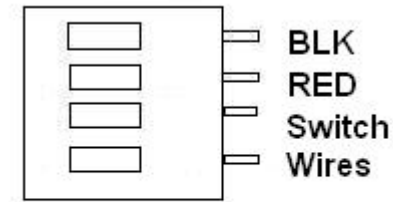


Front Panel Wires

On/Bypass Switch and LED Wiring

- Attach two 5 inch lengths of hook up wire to the small rocker switch. Shrink with ¼ inch red shrink tubing.
- Insert in the panel with the two connections away from the base of the case.
- Insert the LED into the hole adjacent to the rocker switch.
- Slip four 1/8 inch length of red shrink on the wires equally spaced. Shrink the tubings.

- Cut the wires to be equal length for termination into a four pin Molex connector.
- Strip 1/8 inch insulation from each wire and crimp Molex pins on the wires.
- Insert the wires in the 4 position Molex Housing.



Switch and LED Wires

Power Pole Physical Installation

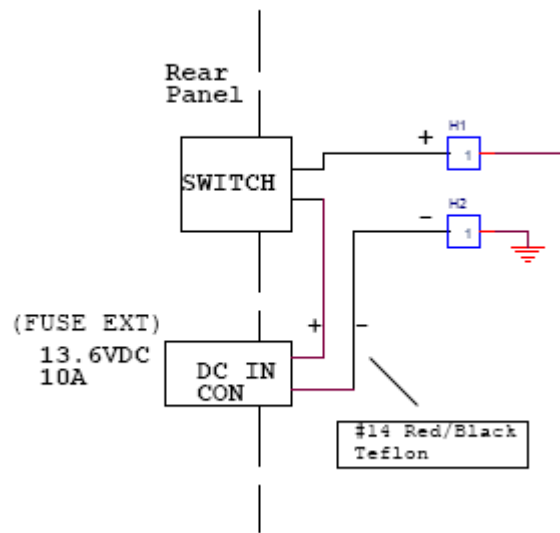
- Locate the two notched keepers used to retain the Power Pole Housing in the panel.
- Locate the Red and Black Power Pole pieces.

i The Power Pole housing can be joined in various ways. There is one standard that is used on the HF PACKER-AMP. Looking at the front of the red/black housing, mate the two pieces side to side with the red on the left and the contacts in the lower position.

- Install the top keeper in the top mounting hole with the tab extending into the hole between the red/black housing. Use a black 4-40 x ¼ inch screw with split washer and nut.

- Install the bottom keeper in the bottom mounting hole with the tab extending up into the hole between the red and black housing. Use a black 4-40 x ¼ inch screw with split washer and nut.
- Secure the screws tight while keeping the keeper pieces level. When complete, the power pole housing will be able to move around a bit (float).

Power Wiring Connections



Connection of Power Wires

Install Rear Panel Power Switch

- Snap in the power switch with the “1” label towards the outside.

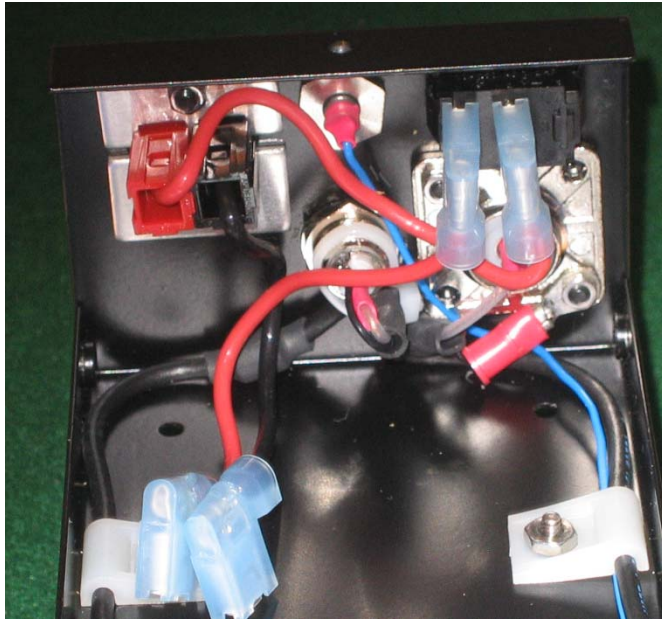
Install Wiring for Power

- Crimp one end of a 4 inch length, #14AWG RED Teflon coated wire to a Blue Flag Terminal.
- Crimp the other end to a Power Pole (PP) 30A Terminal.
- Insert PP Terminal into the RED PP housing.

i Note: Use the end of a thin flat blade screw driver to press the PP terminal into the PP housing until you hear it click. Use a pull test to be certain the wire is firmly seated in the PP housing.

- Plug the Blue Flag Terminal on the Power Switch outside terminal.
- Crimp both ends of another 4 inch length , #14AWG RED Teflon coated wire to a Blue Flag Terminal
- Plug the Blue Flag Terminal on the remaining Power Switch terminal.
- The other end of this 4 inch RED wire will plug on the circuit board at H1 during circuit board and case assembly.
- Crimp one end of a 4 inch length, #14AWG BLACK Teflon coated wire to a Blue Flag Terminal.
- Crimp the other end to a PP 30A Terminal.
- Insert PP Terminal into the BLACK PP housing.
- Use a pull test to be sure wire is firmly seated in PP housing.

- The other end of this 4 inch BLACK wire will plug on the circuit board H2 during circuit board and case assembly.



Power Connections and Cable Routing

Heat Sink and Screw Depth Test

- Check the heat sink at the drilled and tapped holes for the MOSFETs. Make sure there are no burrs at the site. A ¼ inch drill bit hand turned can remove the sharp edges.
- Check the cleanliness of the holes and heat sink area. Cutting oil was used in the tapping process. Remove any residue with alcohol.
- Screw in the Nylon 6-32 x 5/16 cap screws to make sure that they do not bottom out with a MOSFET under the head.

TO-220 THERMASIL III with adhesive back

- The heat sink area should be clean and dry. Use a touch of alcohol
- Peel and stick the Heat Sink adhesive back insulators over the threaded holes on the heat sink. Neatly align in the space provided.

IRF510 MOSFET Lead Bend



- Prepare the IRF510 MOSFETs for insertion on the board by bending the leads at right angle so the bare metal of the MOSFET is opposite the bends.
- Hold the leads near the body with long nose pliers. Adjust the long nose pliers' position just below where the leads from the body reduce in width. Bend the leads with a sharp right angle.

MOSFET Attachment to the Circuit Board

- Insert the MOSFET leads through the AMP board from the bottom. Set the board flat on the table so you can see through the large access holes on the circuit board and target the holes of the MOSFETs directly below.
- Hold the board component side down and insert the MOSFETs through the mounting holes from the bottom side of the board.
- Put the AMP Module into the case placed over the spacers .
- Attach the circuit board from the top of the case using four black 4-40 x 3/16 inch screws. Adjust the alignment of the circuit board so the MOSFET mounting holes are centered in the access holes on the circuit board. Tighten screws.
- The MOSFETS should now lie flat on the Thermasil pads (SIL-PAD).
- Line up the mounting holes on the MOSFETS and the heat sink and secure with the nylon screws.
- The MOSFETS should be straight, flat and positioned with the holes aligned with the circuit board. Solder the MOSFET pins in place.
- Remove the amp board from the heat sink and reflow the pins on the MOSFETS on top and bottom.

Circuit Board and Case Assembly Procedure

- Place the PSU End of the AMP Module back into the case towards the rear panel and then lower the remainder of the

circuit board down to the case. The slot in the circuit board fit easily over the front panel switch and fan cable wires.

- Route the FAN cable so it passes through the slot area.
- Arrange the other cables to not interfere with board mounting.
- Attach the circuit board from the top of the case using four black 4-40 x 3/16 inch screws.

MOSFET Alignment over Heat Sink Holes

- Micro-adjust as necessary by moving the body of a MOSFET so that the hole in the MOSFET matches the threaded mounting hole in the heat sink.



do not damage the SIL-PAD hole under the MOSFET. Do not over-tighten the nylon screws. You could shear off the head with too much torque.

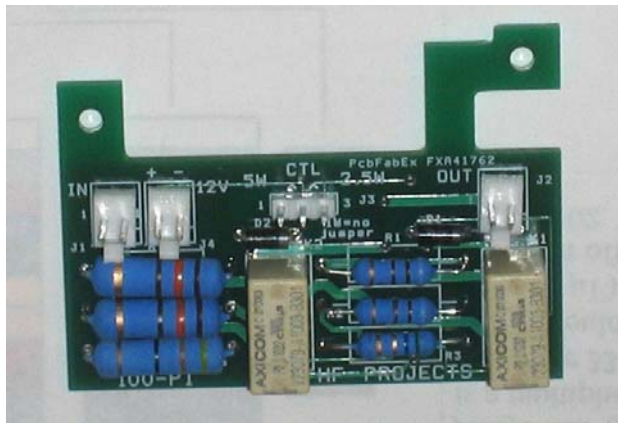
- Insert the two black Nylon 6-32 x 5/16 inch length Socket Head Cap Screws through the MOSFET holes into the tapped holes on the heat sink using the 7/64 inch hex head tool.
- Tighten the screw until resistance is encountered. Inspect the screws to make certain that they are firmly in contact with the MOSFETs. Peering into the heat sink, the tips of the nylon screws should barely be visible if properly installed.
- Use the multi-meter to measure ohms. Connect one probe to chassis ground and the other probe to any pins on the MOSFETs. You should have a very high megohm or infinite reading on the meter. This measurement is made before any cables are attached to the board.

PINET 100-PI Option Module

i section is for those who purchased the PINET 100-PI Option Module.

100-PI Assembly

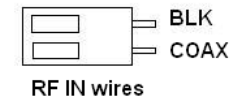
- Install Diodes D1 and D2
- Install Relays K1 and K2
- Install Connectors J1, J2, J3 and J4 according to silkscreen pattern.
- Install Resistors R1, R2, R3, R4, R5 and R6
- Clean circuit board and set aside after inspection.



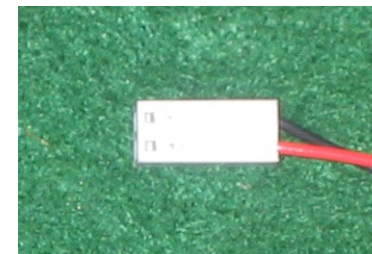
100-PI Cable Fabrication

- Fabricate two 3-inch cables. Use the supplied RG174 cable, black 1 ¼ inch hook up wire and shrink tubing.
- Strip ½ inch insulation from each end. Twist the braid and trim to ¼ inch. Tin the braid and attach a black hookup wire to the braid. Cover with heat shrink tubing. The wires are positioned as shown.

- Attach a 2-pin connector on one end of each cable. Note in the picture that the openings for the terminal tabs are up in the picture. Attach the coax center wire to the pin indicated in the picture.

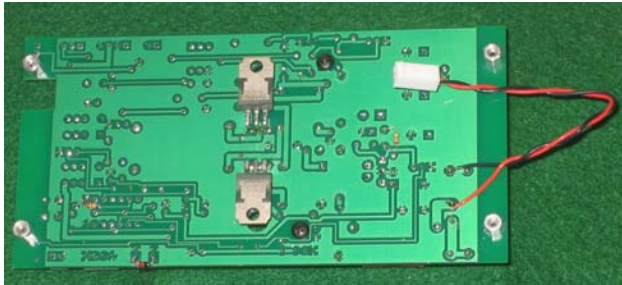


- Fabricate a five inch 2-wire cable from the red/black wires supplied. Attach a crimp terminal to one end of each wire. Strip 3/8 inch insulation from the other ends and tin the wire lightly.
- Insert the crimp terminals in the 2-pin housing as shown below. Note in the picture that the openings for the terminal tabs are up in the picture.

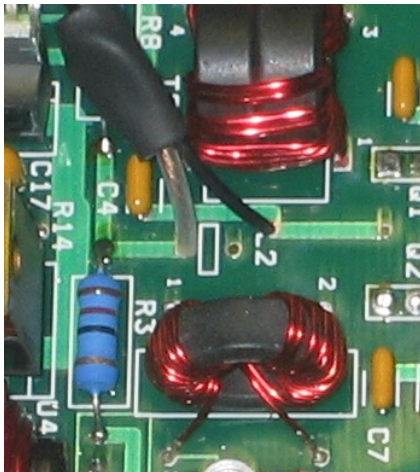


- Install a 430 ohm resistor at R7 and R8. Install a 12 ohm resistor at R3. This is the new 2dB pi-resistive network.
- Attach a red/black wire 5 inch power cable to the Amp module. Solder the wires to the bottom side of the amp at

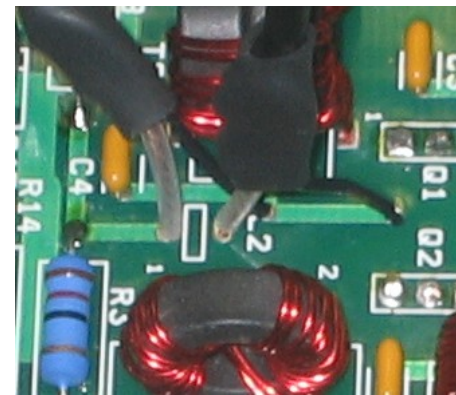
the H2 terminal and at CB1. Reheat CB1 connection and push CB1 leads further into the holes to expose a ¼ inch stub. Wrap the tinned stranded wire ends around the points on H2 and CB1 and solder. This cable will plug into J4 on the 100-PI Module when installed.



- Remove L2 from the circuit board if installed. It will not be used. We will attach the PI-networks to these holes.
- Connect one of the two 3-inch cables at L2 and ground as shown in picture.



- Note that the coax center goes into the hole on the left in the L2 position. The shield wire connects to a ground plane hole next to the number 2 in the photo.
- This cable will connect to J1 on the PINET 100-PI module. Identify the cable as J1 with a marking pin on the 2-pin connector.
- Connect the remaining 3-inch cable at the open hole of L2. The shield also connects to the ground plane. See photo below.



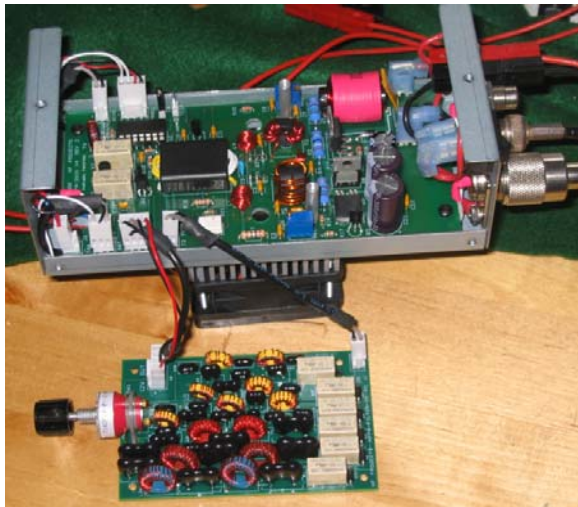
- Note that the coax center goes into the hole on the right in the L2 position. The shield wire connects to a ground plane hole further to the right in the photo.
- This cable will connect to J2 on the PINET 100-PI module. Identify the cable as J2.
- Attach a peel and stick rubber bumper to the top of C16, a 330uF capacitor.

Section Five – Adjustment and Testing

- Turn the pots fully CCW so we can test the RF functions without generating power output.
- Place the LP Filter to the side and cabled up as shown.

Ohmmeter Test

- Resistance from Red to Black DC Input with switch ON should be about 1K ohm.
- Online/Bypass Switch placed in **Bypass** position
- Attach a watt meter and dummy load in series to the SO239 RF Output connector.



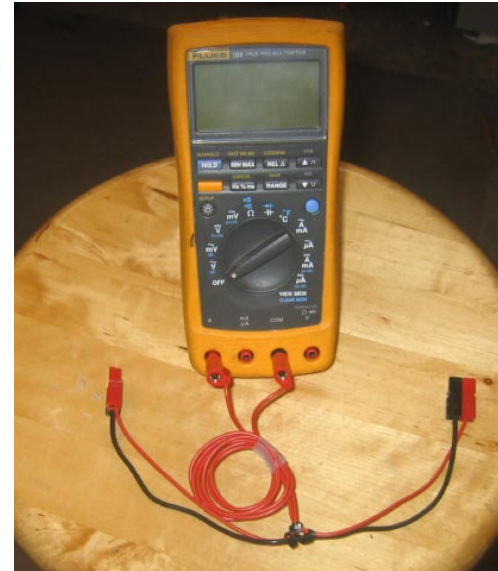
Test Mode Setup

- Connect XCVR to the BNC RF Input Connector.
- Set LPF for 160M. Set the XCVR for 160M.

- Set the XCVR Power Setting for Low Power (about 1W).
- Key XCVR. The 1W of power should be displayed on Watt meter and SWR should 1.0:1 Record ____ W

Basic Current Test

- I recommend a special cable that allows you to easily measure current.



Test cable puts the meter in series with the Red wire.

- Connect for Current Measurement.
- Online/Bypass Switch placed in Bypass position.

- Connect to a DC 12V source and Power Up. The current is less than 30mA.

❗ if the Meter reading is negative, reverse the meter leads.

- LED should be OFF. Record: _____ mA
- Use small screw driver to short TEST pins. The LED should light.

❗ If jumper on CW pins, it must be removed for TEST to work.

- Current is about 85 mA while the pins are shorted together and the LED is on. Record: _____ mA .

RF Signal Testing

- Switch the Online/Bypass Switch to **ON**. Key the XCVR. The LED lights. (1W RF drive)
 - If Fan option, fan is ON. Current = 0.25A.
 - Else, Current = 90mA
- Release XCVR KEY. The LED is OFF and the FAN turns off after the hold time expires.
- Measure from case ground to the right side of R18. Key the XCVR. The voltage switches from 0.0VDC to about 29.5VDC.
- Place a jumper on CW pins, H4 (if not already jumpered).
- Tap the key on XCVR. Note the time that the LED is ON and that the fan runs. Observe the CW hold time (0.5 sec).
- Remove the jumper on CW pins, H4.
- Tap the key on XCVR. Note a longer LED ON time and fan runs. Observe the SSB hold time (1.5 sec)

- Rig a toggle switch and RCA plug to test the PTT function. Plug into the RCA Jack.
- Close the PTT test switch. The LED lights and the fan runs.
- Open the PTT test switch. The LED is off and fan stops running.

DC Current Test and Bias Adjustment

- Insert the jumper plug over the TEST pins of H3.
- Start with either potentiometer and turn clockwise while measuring current. You may have to turn the pot screw about 15 turns CW before the current starts to climb. It will climb sharply when the MOSFET begins to conduct. Adjust the current to increase the current by 10mA. New current reading: _____ mA.
- Turn the other potentiometer clockwise to increase the current by an additional 10 mA. New current reading: _____ mA.
- Remove the jumper plug from H3.

Voltage Test

- It is handy to have a second multi-meter to make a voltage measurement s while monitoring current. If a second meter not available, reconfigure meter to measure voltage.
- Re-connect DC power if not connected as this time.
- Measure from Case to the rectifier tab, D4, next to the electrolytic capacitors. The voltage is the DC Input Voltage. Approximately 13.6V. Record _____ VDC

- Use the screw driver again to jumper the TEST pins of H3. The LED lights and you measure about 29.5VDC. Record _____VDC

i At this point, you have proven the functionality of the AMP and you have completed the adjustments.

- Remove Power. Install CW jumper on H3. Install LPF into the case. Secure with two 4-40 x ¼ inch screws.
- Attach front panel nut and tighten. Install Knob and tighten.

LPF RF Testing

Although not as good as a VNA, you should be able to tweak the band edges. This procedure also provides a way to test signal continuity from the LPF IN to the SO239 connector out.

These steps describe a method to test the LPF for signal continuity and performance at the band edge. In this test the AMP output is bypassed and the transceiver is used as a signal source.

1. The RF In cable normally at J3 on the amp board is rerouted to plug instead into the LPF input connector, J1. You will have to physically free this cable up to re-route to the LPF input.
2. Attach transceiver to BNC connector on the case. Set the transceiver RF out to about 1W.
3. Attach a watt meter and dummy load to the SO239 connector.

4. Jumper the PTT input to cause the LED to light. You must be ONLINE for this to work.

5. Set the band switch to 160M and the rig to 160M at the top of the band.

6. Key the transceiver. You should see your 1W (or slightly less) on the watt meter.


7. If the watt meter is attenuated, try in the middle of the band. If the signal comes up, you need to adjust your 160M inductor. Try spreading the turns. If still no joy, you may have to remove 1 turn.

8. Repeat this process for all bands. Removing a turn probably only applies to 160 - 40M. All other bands are adjusted by spreading or squeezing the coils (stop RF while adjusting).

9. After satisfactory completion of the tests and adjustments, restore the RF In cable back to J3 on the AMP board.

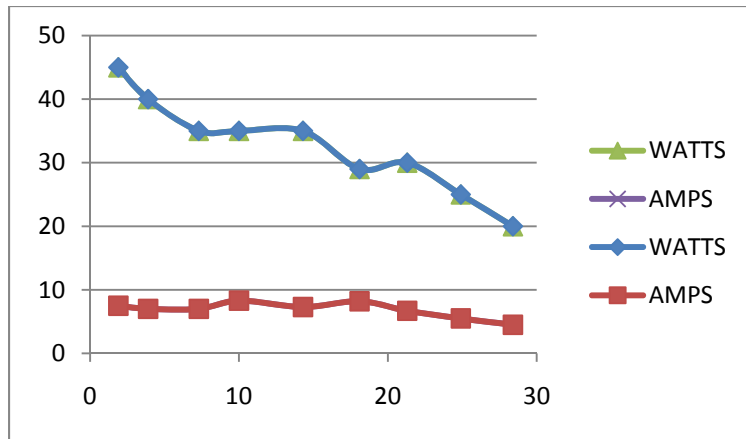
RF Power Testing

- Attach 12VDC power source capable of supplying 10A continuous current. The 12VDC source should be fused at 20A.
- Monitor Current
- Connect XCVR set for 160M and 5W setting
- Set Band Switch for 160M.
- In BYPASS mode, adjust the power out to 5W _____
- In ONLINE mode and key down for a few seconds, observe the power output and DC current.
- Record your power output and DC current for each band in the Frequency vs Watts vs Amps Table.
- Plot your Power Out and Amps results vs Frequency.

 If you see an unusual spike up in DC current or drop in power, your LP filter may be suspect.

FREQ MHZ	WATTS	AMPS
1.9	45	7.5
3.9	40	7
7.3	35	7
10	35	8.3
14.3	35	7.3
18.7	29	8.2
21.3	30	6.7
24.9	25	5.5
28.4	20	4.5

Frequency vs Watts vs Amps Table



Frequency vs Watts vs Amps Plot

i Power Input Constant at 5W set for each band

Section SIX – Specifications and Operation

Specifications

- The drive is 0.1 - 5W RF 160-10M
- Input impedance: 50 ohms
- Control: Carrier operated or PTT (RCA jack)
- DC Input: 12VDC, 10A max (9-16V range)
- Standby current: 23-29mA
- Chassis mount Power Pole Connector 30A contacts
- Power Switch: Rocker Power Switch
- RF In: BNC
- RF Out: SO-239
- Power Out: nominal 30-35W Average 160 - 10M.
- 100% Modulation without distortion (according to 2-tone tests)
- Weight: 1lb 15 oz.
- Case Size: 6.5 x 3 x 2.25 inch
- Front panel band switch knob: 0.75 inch additional length
- Rear panel controls: 0.5 inch additional length
- Heat sink Size: 2.25 .2.25 x 0.8 inch
- Fan Size: 2.25 x 2.25 x 1.2 inch (60mm) 12V, 24 CFM
- LP Filter Switch: 6 position 160, 80/75, 60/40, 30/20, 17/15, 12/10
- Front panel Switch: ON/BYPASS
- TX LED Indicator
- Case painted black with white silkscreen legends front and rear.
- Two piece 20ga galvanized steel case,
- Rubber Feet
- CW/SSB Mode Jumper for optimized hold time of T/R relay
- Digital control, RF sense and sequencing of T/R relay and Intelligent Power Switch and fan control.
- Amplifier: IRF510 MOSFET Push-Pull Class AB1 Linear Amplifier.
- Bias set to 10mA per transistor. Easy pot adjustment.
- A test Jumper activates the PSU for adjustment.
- Fan option not required for intermittent SSB operation.
- For high duty cycle CW or digital modes, either reduce drive or include the fan option. An easy add-on option.
- Fan Operation SSB and CW at full speed.
- Spurious products -40 dB or better @ 35 watts
- Harmonic content -45 dB or better @ 35 watts
- Load tolerance 2:1 or better SWR recommended

Operation

Amplifier operation theory is described in Section One with the practical aspects expanded on in this section.

Choice of XCVR: The HFPA V4 Amp is compatible with most QRP XCVR's but accommodates the FT817 RF Power Input choice of 5W RF drive as the default power input setup. The pi resistive network on the amplifier front end can be customized for other attenuation levels to work from the range of 0.1W up to a practical 5W limit. Contact HF Projects for more specific details.

CW and Digital Modes: The AMP provides excellent operation for digital modes including PSK. Monitor the temperature. Adjust drive accordingly. Install a jumper on the CW H4 Jack to tell the controller you are operating CW or digital modes.

Temperature is not measured by an active sensor. The temperature control algorithm is simply, the fan runs during transmit. For intermittent SSB operation, no fan is required.

Do's and Don'ts for Successful Operation

- Do set the band switch to match the XCVR band
- Do not exceed 5W drive
- Do tune the antenna only in the BYPASS position
- Do not touch up antenna tuning in the ON position
- Do not operate with an SWR > 2.0:1
- Do install CW jumper for CW operation. Remove it for SSB.

Maintenance Issues

- If your power drops to near zero or the TX LED does not light during transmit or you hear a squealing noise from the amp, you have probably blown a MOSFET

i Warning, the surface mount chip, U5, can be hot to the touch if you short a MOSFET. The hot U5 chip purposely gets hot acting as a thermal controlled circuit breaker for the DC power to the MOSFETs.

- Replace both MOSFETs: Always replace both. Spares are available from Radio Shack or HF Projects.
- Remove the four top screws and two MOSFET Socket Cap screws to allow the circuit board to be removed. Also disconnect the two flag terminals for the 12VDC input.

- Unplug the cables to the board. Remove the circuit board from the case.
- Clip out the MOSFETs and remove the pins remaining in the board. Tweezers and soldering iron works.
- Remove excess solder. Clean up flux.

i The most important issue is to save the board circuit connections by carefully removing the old pins.

- Follow the installation procedure outlined in Section Four
- Re-install MOSFETs using the non metallic 6-32 x 5/16 cap head screws.

Section 7 Theory of Operation and Troubleshooting

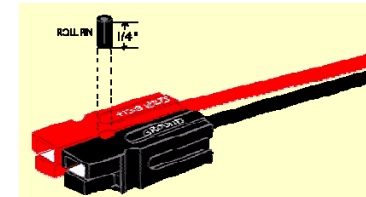
Power Supply Unit

The PSU has the job of converting the 12V DC Input (8-16V range) to 29.5V for the MOSFET transistor drains. Why do we do that? Several reasons, the state of the battery no longer affects operation until all useful energy in the battery is expended. Operating the MOSFETs at a higher voltage overcomes IR (current and resistance) losses in a 12V system. The higher the voltage the more the gain is possible. Why stop at 35W? Why not 100W? Well have you tried lugging around the heavy car battery on your back pack trip? When you boost your 2.5W signal up to 40W, you go from 2.5 to 5 to 10 to 20 to 40W. Each time you double you increase your received signal by 1 S-Unit. A signal increase from in the noise to a S4 means your signal is readable. Your power pack to do this can be a 7AH Gel Cell or some of the newer light weight Lithium Ion battery packs. I used to fabricate 25, 50, 75 and 100WH battery packs from harvested cells in DEWALT power packs. But that is another story. The point is that you can operate from a light weight power source and only be down 1 or 2 S-units from a 100W rig. Many can testify how effective this is.

Power Input

The 12V is input through the 30A contacts of the Power Pole connectors. There is a right way and a wrong way of putting the little plastic pieces together to insure your connectors are polarized correctly. The industry has a certain way of joining the pieces together to be compatible with everybody else. Make sure you set

up your jack to receive plugs that are configured according to the drawing below.



"Housings should be mated according to the diagram above, viewing from the contact side (opposite the wire side), tongue down, hood up, RED on the LEFT, BLACK on the RIGHT. Also notice the 3/32-inch-diameter roll pin, 1/4 inch long, is used to keep the housings from sliding apart

Reverse Voltage Protection

No one can stop a lightning bolt from wrecking havoc but we attempt it with our reverse polarity diode and thermal circuit breaker. If you ever apply voltage in reverse, there will be enough time to fuse the reverse protection diode into a lump of metal before the thermal circuit breaker from kicking in to open the circuit. It will do its job however and save the other components in the amp. The thermal circuit breaker is the tan colored tab that is mounted by its tips to the circuit board. Why is mounted this way? It is done on purpose so that the thermal mass of the circuit board

traces will not unduly influence the reaction time of thermal circuit breaker. It must get hot in order to open the circuit. It will remain open until it cools down again. So in that sense, it is self-resetting. It is designed so that it takes a sustained 10A or more to trigger the circuit breaker. There are no recorded cases where this part fails. In case of reverse voltage, you will have to replace the diode with a similar high current diode. We have spares.

DC-DC Converter, U4

The DC-DC Converter is operated on demand (when we transmit) otherwise, it is off and silent during receive. If you follow along by looking at the schematics page **PSU HFPA 10**. There are only very few components to make this chip work. We have the high current inductor, L4 50uH, the high current series diode D4 and the two resistor R13 and R18. We will touch on the controls a little later. TheLT1270A is a 10A device. Meaning the device is rated for 10A current. It operates under the principal that if you ground one end of the inductor the current flowing through the inductor will attempt to keep flowing at its current level when the ground is removed. Pin 4 provides that ground. The inductor, following the laws, will raise the voltage to near infinity to attempt to keep the same current flowing. As a result, we get a step up of voltage. On the anode side of D4, you will see a switching waveform between ground and about 30V. On the cathode side you will see a constant DC thanks to the electrolytic capacitors C16 and C21. So how do we regulate this beast? Glad you asked. The resistors R13 and R18 form a voltage divider which sends a small sample of the output voltage back to the U4 chip pin 2 (FB) or feedback pin. The sampled voltage on pin 2 is internally compared to an internal voltage reference of 1.244V. The U4 chip will adjusting the switching duty cycle of the

output on pin 4 to make the voltage on pin 2 equal to 1.244V, the internal reference. So now the output voltage is set by the ratio of R13 and R18 using simple ohms law principals. To figure it out, you have 1.244V across R18, a 1.2K resistor. That will set a known current flowing through R18. $I=E/R$ or $1.244/1,200$ or $0.001037A$. This current is also flowing through R13, the 27K resistor. So what is the voltage across R13? $E=I*R$ or $0.001037 * 27,000 = 28V$. The voltage at the top of R13 is equal to $1.244V + 28V$ or $29.25V$. Your voltage may vary due to the tolerance of the resistors and other subtle variances. I find a typical of about 29.5V in several amps. If you are trouble shooting this circuit you want to measure the voltage on the tab of D4 (cathode). When the PSU is off, you will essentially measure your battery input. When the PSU is on, you will measure approximately 29.5VDC.

Timing Sequence of Control Signals

The PSU, IPS and TX are three control lines which are synchronized by the Controller, U2. When RF input is detected, the PSU is turned on first to get the 29.5V ready for use. Next the TX line is switched from receive to transmit with no power to MOSFETs at the time of switching. Next the IPS line is asserted by U2 which operates the switch, U5 and delivers the 29.5V to the drains of the MOSFETs. When RF goes away, a reverse sequence is followed. First, the IPS control line is made inactive which removes the 29.5V from the MOSFET drains and then the PSU control line is made inactive and finally the TX control is made inactive which switches the AMP from transmit to receive. This can be visualized (somewhat on the timing diagram shown on the **PSU HFPA 10** drawing. The waveforms shows that the RF signal may come and go due to keying or speaking but the PSU is active until a hold time has been exceeded.

U4 Control

U4 is controlled by the digital on/off control labeled **PSU**. When PSU measures 0V, the PSU is on. When PSU is 5V, the PSU is off. This control signal switches Q4 connected to pin 1 of U4 (VC) voltage control. You can learn more about U4 at:

<http://cds.linear.com/docs/Datasheet/lt1270afc.pdf>

Fully Protected High Side Power MOSFET Switch, U5

See <http://www.irf.com/product-info/datasheets/data/ips511.pdf>

This device is a combination power switch and circuit breaker. The IPS511S switch is controlled by the digital on/off control signal **IPS**. This signal is switched on (0V) when the PSU is already on and switches off (5V) before or at the same time that PSU is switched off. The device also acts as a thermal operated circuit breaker. The IPS511S is rated up to 5A. Above that, the switch will purposely heat up and the output will drop to zero volts. It will recover when it cools down. This part neatly switches voltage to the AMP drain connections when on. In the event of a short-circuit the circuit breaker will kick in. Because of the circuit breaker action you will keep from destroying the DC-DC converter chip, U4. Without the protection, the DC-DC converter will deliver the battery current into the short-circuit until the U4 blows up. How can you know if you have a short-circuit? The front panel LED will not light. You might hear a squeal from the amp and U5 will get hot. Don't worry; it is doing its job. What is the most likely thing to cause a short-circuit? The MOSFETs. We will get more into MOSFET failure in the AMP descriptions to follow.

At this point, you should sufficiently know how the PSU works, what controls it and what safe guards you have. What to measure? You

can use a volt meter probing R18 on the end closest to the PSU for the voltage measurements. This voltage is what lights the LED. It means, when lit, that the MOSFET has a transmit source voltage on the drain connections. You can see the control signals on U2 pins 9 and 10. Placing a jumper on H3 (TEST) will cause both of these control signals to have 0V outputs.

This concludes the PSU discussions. We will discuss the timing of the PSU and IPS signals when we talk about the controller chip, U2.

CONTROL HFPA 10

The next discussion is about signal flow through the AMP from RF IN to RF-OUT. Follow along by looking at **CONTROL HFPA 10** Schematic during this description.

Big Picture

RF enters at the case mount BNC connector and is attached via a cable to J3.

T4 is a RF-TAP that passes through the core of T4 as a single wire. The secondary of T4 has many turns to provide detection sensitivity to low level RF signals. The output of T4 becomes an input to U2, the controller. It is a low current sensitive input that will interrupt the processor on the slightest wisp of RF above the noise background. We will discuss this process a little later. The desired attributes of T4 is to not disturb the signal quality or have adverse affects on the SWR of the transceiver RF while alerting the controller, U2 that RF from the transceiver Transmit signal is present. Placing a scope on the U2 pin 11 may introduce too much probe capacitance and affect your measurement. To view the signal with a scope, get on the junction of R9 and T4.

K2, K3 and J4

The junction point after leaving T4's single wire through the core is the junction points of K2 and K3. These two relays form the T/R (transmit/receive) function controlled by the control signal TX. K2 is used to divert the RF output from the transceiver to the AMP input. (Signal name RF_IN). If not in transmit, the signal from T4 passes through the normally closed contacts of K2 to K3. The also normally closed contacts of K3 (when not in transmit) are routed directly to J4 which is connected to the SO239 connector on the rear panel. So in receive mode, the BNC Connector is connected to the SO239 connector. This is the bypass mode where you can operate the transceiver with the AMP out of the circuit. When K2 and K3 are closed (transmit mode), we divert the BNC signal to the AMP input where it is amplified. Further processing occurs in the LPF (low pass filter) which rejects the harmonics of the AMP output. The signal from the LPF is returned to J2 on the board where it passes through K3 to the SO239 connector. The diode, D2, clamps the transient voltage that occurs when current stops flowing in K2 and K3. Without D2, you might see voltage spikes of 25 to 50V when the relay is opened. It is best to prevent this transient noise from happening.

TX Signal Generation

The TX signal comes from the collector of Q6. This transistor output is either at 12V (receive) or 0V (transmit). Q6 is controlled by U2 pin 5 through R21. TX cannot occur unless the front panel switch is in the ON position. By placing the switch in the ON position, you are enabling the AMP to function. In the ON position you will have a ground signal on pin 6 of U2. Otherwise this signal will be 5V as provided by the pull-up resistor, R6.

PTT Control

We have discovered that the presence of RF through R4 can trigger TX. There is an additional way to achieve TX. It is by the Push-To-Talk input sensed on pin 3 of J4. This would be an external contact closure to ground (12V common or case ground). The contact closure is normally supplied by the transceiver or SDR (software defined radio). A current flows through an opto-isolation circuit in the 4N33 device, U3. The output of U3 on pin 5 becomes an input to the controller, U2 on pin 3. An internal pull-up resistor in U2 keeps pin 5 at 5V unless a valid PTT signal is detected. If detected, the pin 5 switches to 0V. With PTT control, you can hold the AMP in transmit mode without having to have RF excitation on the input. This is useful to reduce relay switching while pausing to speak in SSB. The base of the transistor in the 4N33 has a 1M resistor which reduces sensitivity and provides stable operation.

CW or SSB option

The controller has a sense pin (2) which provides a 0V or 5V input depending upon whether a jumper is installed on the two pin header, H4. Insert the jumper if you are a CW operator or remove if you are a SSB person. You might want to add a toggle switch to the case to allow easy selection. CW mode has the shortest hold-time for the T/R function while the SSB mode (no jumper) provides a longer hold time to bridge across pauses in normal speech patterns to lessen relay switching.

TEST Jumper, H3

A 2-pin header, H3 senses the users desire to test the AMP. The TEST mode is useful for setting the bias current or checking the DC-DC converter operation. You must have the Enable front panel switch in the BYPASS position for the TEST jumper to function. If

enabled and the jumper installed, the PSU and IPS signals will be at 0V while pin 5 of U2 will be +5V to activate TX. Removing the jumper at H3 TEST will return PSU and IPS signals to +5V and pin 5 of U2 will be 0V. The fan does not operate in the TEST mode.

FAN Option J6

The fan is controlled by an output on pin 7 of U2 connected to transistor, Q3. The fan is plugged into J6. The fan has red/black leads signifying the polarity of the leads. The plus lead is red. It must be connected to pin 1 of J6 with the black wire to pin 2 of J6. The fan is operated by the controller, U2. If carrier is detected or PTT is activated, you will have the fan activated. The fan is triggered on when carrier or PTT is present and goes off when the hold time has expired.

5V Regulator

While we are on the CONTROL HSPA 10 schematic, let us look at the voltage circuit, U1. This is a part which regulates the 12V input down to 5V for the controller, U2. ($V_{cc} = 5V$). The part requires bypass capacitors C10 and C11 as stated on the data sheet for the part to prevent instability.

Panel LED

The front panel houses the TX LED. This LED is powered by the transmit voltage (29.5V) and is a direct indication that you have this voltage. It will be LIT during actual transmit or during TEST when the H3 jumper is in place. Current is limited by the R18, the 3K 1/4w resistor. A common building problem is the connections from the panel to J6 on the wrong pins.

MOSFET AMP HSPA 10 Schematic

Follow along the descriptions as you view this schematic. **RF_IN** signal is shown on the extreme left side. This is the transmit output from the transceiver at this point. The signal reaches this point if **TX** is activated. The impedance of the transceiver is 50 ohms and the transceiver is happiest when it sees a 50 ohm impedance load.

Pi-resistive Network

That is where R3, R7 and R8 comes into play. This combination of resistors is actually a pi-resistive network that has two functions. First is the impedance termination and second is an attenuator for the amplifier input. The AMP is set up for a max RF input of 0.63W at the gates of the MOSFETs. Overdriving the amp will cause audio distortion at the least and failure of the MOSFETs at the most. We must transition between the max RF output from the transceiver to the 0.63W level with the pi-resistive network. The standard default network is set up for 9dB attenuation. This is equivalent to an 8:1 power ratio. Looking at the choice, $5W/8 = 0.625W$ at the gates of Q1 and Q2. The table in the upper left quadrant of the schematic shows values of the pi-resistive network for other max transceiver output levels. It is not physically possible due to size constraints to have each network on board and choose between them. This is a build option that the user must decide. What is the best network to match their transceiver? The FT817 has both a 2.5W and 5W output either the 6 or 9 dB network could be used but there is always a danger if using the 6 dB network that the user may accidentally operate with 5W. The overdrive will distort and blow the MOSFETs. So, for safety reasons, the 9 dB attenuator is the best choice.

L2 and T3

The signal out of the pi-resistive network next passes through L2 , an impedance matching, to reach T3. The function of T3, 1:1 BALUN is to provide two outputs with 180 degrees phase relationship. Each output is fed to one input of the Push-Pull Linear Amplifier.

T2

DC powered is supplied to Q1 and Q2 through a phase reversal dual choke designated T2. This is a very effective method to provide power to Q1 and Q2 while presenting a high impedance to the RF signal over a broad range of frequencies. The drain chokes for Q1 and Q2 are wound on the same core, and the phase of one of the chokes is reversed.

T1

The drains of Q1 and Q2 are connected to the primary of output transformer T1, where the two signals are recombined in phase to produce a single output. T1 also provides impedance transformation from the low output impedance of the MOSFETs to the 50Ω output connector, J1. C5 is important since it increases the bandwidth of impedance transformation provided by T1, especially at 21 MHz. It is responsible for low distortion at higher RF levels while the bias provides low distortion at low RF levels.

BIAS

The 5 V bias supply voltage is derived from a 78L05 regulator. Bypass capacitors C4, C6, C8 and C1 remove RF voltages from the bias supply voltage. Gate bias for Q1 and Q2 is controlled independently. VR1 adjusts Q1's gate-bias voltage via R1 and L1. VR2 works similarly for Q2 via R2 and L3. At low frequencies, the amplifier's input impedance is essentially equal to the series value of R1 and R2. L1 and L3 improve the input-impedance match at higher frequencies. The low value of series resistance provided by R1 and R2 also reduces the Q.

BIAS Adjustment

The bias adjustment puts the MOSFETs slightly into conduction for each half cycle. The amount of bias was chosen to eliminate low level cross over distortion that would exist otherwise. It is not necessary to increase or decrease the bias from the nominal 10mA

specification. Once you have removed the distortion, it is pointless to increase the bias further. To do so only increases self heating of the MOSFET. You cannot adjust the power level of the AMP by adjusting the bias. If you want to change the power level, which is best done by changing the DC volts on the drains of the MOSFETs. The bias level is set by first turning both pots (VR1 and VR2) completely CCW (counter clock wise). Monitor the DC input current. The pots are 25-turn and there is no mechanical stop or audible noise. So count the turns. You can measure ohms from the wiper to ground for zero ohms as a secondary means of determining you are fully CCW. Next, jumper the TEST pins of H3 to activate the PSU. Note the current and turn VR1 until you increase the current by 10mA. Now turn VR2 until you increase the current an additional 10mA. You may find the setting sensitive at the 10mA set point. Make tiny pot adjustments to raise/lower the current.

Heat Sinking the MOSFETs

The MOSFETs are thermally attached to while electrically isolated from the heat sink. SIL-PADs are used for a neat clean thermal solution. The little fiber washers traditionally used with the TO220 case are not used due to their possible failure to maintain isolation. In its place we use a 6-32 x 5/16 inch Nylon Hex Head screw to thermally couple the MOSFET to the heat sink. A hex wrench is provided with the project to aid in the assembly process. The wrench provides sufficient torque to hold the MOSFET in intimate contact with the SIL-PAD below. Things to consider are the cleanliness of the SIL-PAD installation (no burrs) and using alcohol to remove oily residue where the SIL-PADs are placed. It is important when installing the MOSFETs that the metal face of the MOSFET is flat against the pad and not be under strain with the AMP board

connections. The construction manual suggests a procedure to follow when installing MOSFETs.

Connecting this up backwards will cause a short on the 12V and may damage circuitry.

HFPA FILTER MODULE 10

To follow the circuit explanations, turn to the HFPA Filter Module schematic. This design uses Relay selection of the RF input and a rotary switch for RF output selection. The switch operates a single low pass filter path at a time. All other filter circuits have shorted inputs while not in use for minimal interaction between adjacent circuitry. The relay input selection provides a high degree of isolation and improved filter overall performance. All of the HF bands are selected with 6 choices from the front panel switch. It is very important that the filter choice equal the band of operation. For instance operating on 15M with the filter set to 80M is a recipe for MOSFET failure. There is no interlocking or cross checking provided except by the alert operation of the user.

J1, Filter Input

The AMP output is received at J1 and is routed to the circuitry of one LP filter circuits through relay K1-K6.

J2, Filter Output

The selected filter circuit output is routed through the contacts of SW1 to J2. Note that 12V is also on J2. This is the operating voltage for the relays.

Output Filter Cable

The cable is unique in that it is not the same pin out at each end. The cable housing has either the letter "A" or the letter "F" written on the face. "F" is for the Filter connection and "A" is for the AMP connection. You must plug this in correctly for the filter to operate.

APPENDIX A

Inventory of Parts: HFPA V4 R3 Amplifier Module

(revised 5/1/11)

HFPA 2010 V4 R3				
Item	Quantity	Reference	Description	Part Number
1	1	CB1	Circuit breaker 16V, 7A Hold 11.9A Trip	650-RGEF700
2	9	C1,C2,C3,C4,C6,C7,C8,C9,C22	CAP CER .1UF 50V 10% X7R 1206	581-SR201C104KAR
3	1	C5	CAP CER DISC 47PF 1KV SL RAD DEA1X3A470JC1B Murata	490-4161-ND
4	3	C10,C11,C12	Cap, .01uF SR151C103K AVX 100V 10% 581- SR151C103K AVX 100V 10% Mouser 581-SR151C103K; Allied stk 507-0210 1C10X7R103K050B Vishay	581-SR151C103K
5	1	C13	Cap 1000pF 100volts 10% X7R C315C102K1R5CA	80- C315C102K1R5CA
6	1	C15	Cap, 100 uF 50V LOW ESR 140- ESRL50V100	140- RXJ101M1HBK1016P
7	2	C21,C16	Cap, 330 uF 50V LOW ESR 140- ESRL50V330	140- RXJ331M1HBK1320P

APPENDIX A

8	1	C17	Cap, 1 uF 35V 10% Dip Radial Tantalum T350A105K035AT 80- T350A105K035AT Mouser; Allied stk 541- 0548	581- TAP105K035SCS
9	1	D2	Diode, 1N4007	512-1N4007
10	1	D4	Diode, MBR1060G	MBR1060G
11	1	D5	Diode, 2.5A 100 PRV DO41 RL251-B Rectron Mouser 583- RL251-B	583-RL251
12	2	H1,H2	KeyStone Electronics .25 PCB TAB 032TPBR Keystone 534-1287	534-1287-ST
13	1	J4	Connector 3P 22-23- 2031	538-22-23-2031
14	2	J2,J5	Connector, 4P 22-23- 2041	538-22-23-2041
15	3	J1,J3,J6	Connector, 2P 22-23- 2021	538-22-23-2021
16	2	H3,H4	Header .100 K.K. Connector 2 CKT Molex 538-22-03-2021	538-22-03-2021
17	2	K2,K3	Relay, 12VDC Non- latching Single coil P2 Tyco Electronics/ Axicom V23079A1003B301	655- V23079A1003B301
18	4	R4,R5,R6,R9	Resistor 10K 1/8W 5%	299-10K-RC
19	1	L4	INDUCTOR 70-IH-5- 50 RADIAL HI CUR 50uH DALE/VISHAY	70-IH-5-50
20	2	Q1,Q2	MOSFET, TO-220AB N-Ch Power Fairchild IRF510	512-IRF510

APPENDIX A

21	4	Q3,Q4,Q5,Q6	2N5089 Small Signal Transistors NPN Gen Pur SS Central Semiconductor 2N5089 610-2N5089 Mouser	610-2N5089
22	2	R1,R2	Resistor 27 ohm 1/2W 293-27	293-27
23	1	R3	Resistor, 62 ohm 2W	282-62-RC
24	2	R7,R8	Resistor, 100 ohm 2W	282-100-RC
25	6	R10,R12, R14,R15, R20, R21	Resistor 1K 5% 1/8W Carbon Film XICON 299-1K	299-1K
26	1	R11	Resistor, 1M 1/8W 5% Carbon Film Xicon 299-1M-RC Mouser	299-1M-RC
26	1	R13	Resistor, 27K 1/8W	299-27K-RC
27	1	U2	Socket, 14 pin DIP D2814-42 Harwin	855-D2814-42
28	1	R16	Resistor, 1.2K 1/8W	299-1.2K-RC
29	2	R17,R19	Resistor, 4.7K 1/8W	299-4.7K-RC
30	1	R18	Resistor, 3K 1/4W	291-3.0K-RC
31	3	T2,T3	Core, Grey (0.5" OD)	FT50-43
32	1	T1	Balun Core Binocular	BN-43-3312
33	1	T4	Core, Grey (0.38" OD)	F37-43
34	1	U1	5V Regulator, Fairchild 512-LM78L05ACZ Mouser 512-LM78L05ACZX	512-LM78L05ACZ
35	1	U2	IC, Microchip PIC16F688-E/P Microchip Microcontrollers (MCU) 7KB 256 RAM 12 I/O	579-PIC16F688-E/P

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36	1	U3	Optocouplers DIP-6 PHOTO DARL 4N33 Allied Stk 307-0194	4N33
37	1	U4	Integrated Circuit, LT1270ACT 10 AMP PWR SWITCH REG 5 TO-220	LT1270ACT#PBF
38	1	Wire, T4	#24AWG Any Color TEF 1 inch	
39	2	VR1,VR2	Pot, 10K 652-3362P- 1-103 10K	T93YA-10K
			Note: Items 40-44 used in case assembly	
40	3	mating parts	Headers & Wire Housings HSG 2P WITH LKG RAMP	538-22-01-2027
41	1	mating parts	Headers & Wire Housings HSG 3P WITH LKG RAMP	538-22-01-2037
42	2	mating parts	Headers & Wire Housings HSG 4P WITH LKG RAMP	538-22-01-2047
43	1	mating parts	Headers & Wire Housings SHUNT OPEN TOP 2P	538-15-38-1024
44	20	mating parts +spares	Headers & Wire Housings CRIMP TERM 22-30 TIN	538-08050-0114
45	1	Inductors (12T)	Wire #24AWG 5FT (0.022" OD)	566-8052
46	1	Inductors (7T)	Wire #22 AWG 3FT (0.026" OD)	566-8051
46	1	inductors	Wire, #20 TEF 7 inch	602-5856-100-05
47	1	inductors	Wire, #20 TEF 10 inch	602-5856-100-05
48	1	PCB	Circuit Board blank with IPS-511S Installed	HFPA 2010 V4 R3 with IPS511S
49	1	Wire, T4 (4T)	#30 AWG Enamel, 15	

APPENDIX A

			inch	
50	2	Spacer	Hex .187x.75 ALUM 4-40 tap	534-2029
51	6	Screw	4-40 x 3/16 inch	
52	4	Spacer	Hex .187x .25 ALUM 4-40 tap	534-1891
53	1	D3 (add on)	Diode, Signal	1N4148

APPENDIX A

PINET 100-PI Option Module

Bill of Materials

Item	Quantity	Reference	Part Description	Mfg/PN/Dist.
1	2	D1,D2	Diode, 1N4007	863-1N4007G Mouser
2	2		Jack Screw KeyStone 7228	839-0994 Allied
3	3	J1,J2,J4	Header .100 K.K. Connector 2 CKT Molex	538-22-23-2021
4	1	J3	Vertical PC Header .100 K.K. 3 CKT Molex 538-22-03- 2031	538-22-03-2031
5	2	K1,K2	RELAY DPDT	Relay, 12VDC Non-latching Single coil P2 Tyco Electronics/ Axicom V23079A1003B301 Mouser:
6	2	R1,R2	Resistor, 910 ohm 1W	281-910-RC
7	1	R3	Resistor, 5.6 ohm 1W	281-5.6-RC
8	1	R6	Resistor, 43 ohm 3W	283-43-RC
9	2	R4,R5	Resistor, 130 ohm 3W	283-130-RC
10	1	Amp 2dB PI	Resistor, 12 ohm 1W	281-12-RC
11	2	Amp 2dB PI	Resistor, 430 ohm 1W	281-430-RC
12	2	J1,J2	RG174 Coax Cable 3 inch length	
13	3	J1,J2,J4	Locking Ramp Housing 2P	MOLEX 538-22-01-2027
14	6	J1,J2,J4	Terminals, crimp	538-08-50-0114
15	1	J4	Wire, Black 5 inch	
16	1	J4	Wire, Red, 5 inch	
17	4	J1,J2	Wire, Black 1.3 inch for pig tails	

APPENDIX A

18	4	J1,J2	Black Shrink Tubing 1/2 inch length	
19	1		Bumper, peal/stick	517-SJ-5303CL
20	2		Screw, 4-40 x 3/16 inch	
21	1		Circuit Board	PINET 100-PI R1
22	1	J3	Jumper 2-pin	538-15-38-1024

Appendix B

Inventory of Parts: Low Pass Filter Module

Low Pass Filter Module				
Item	Qty	Ref	Size, Description and Typical Value Markings	P/N Mfg
1	2	C19,C24	DM10, Cap, 12pF 500V 5% [12J],[120J0]	TS23 Mica
2	1	C12	DM10, Cap, 27pF 500V 5% [27J]	TS23 Mica
3	3	C7,C20,C25	DM10, Cap, 39pF 500V 5% [39J]	TS23 Mica
4	1	C18	DM10, Cap, 47pF 500V 5% [47J],[470J0]	TS23 Mica
5	1	C28	DM10, Cap, 68pF 500V 5% [68]	TS23 Mica
6	1	C26	DM10, Cap, 82pF 500V 5% [82J]	TS23 Mica
7	3	C14,C15,C23	DM10, Cap, 100pF 500V 5% [100J]	TS23 Mica
8	1	C8	DM10, Cap, 110pF 500V 5% [110J]	TS23 Mica
9	3	C13,C21,C27	DM10, Cap, 150pF 500V 5% [150J]	TS23 Mica
10	3	C16,C17,C22	DM15, Cap, 220pF 500V 5% [220]	TS23 Mica
11	1	C11	DM15, Cap, 330pF 500V 5% [330]	TS23 Mica
12	1	C9	DM19, Cap 390pF 500V 5% [390]	TS23 Mica
13	1	C10	DM19, Cap 680pF 500V 5% [680]	TS23 Mica
14	2	C6,C4	DM19, Cap, 1200pF 500V 5% [1200]	DM19122J
15	2	C3,C1	DM19, Cap, 1500pF 500V 5% [1500]	DM19152J
16	1	C5	DM19, Cap, 1800pF 500V 5% [1800]	DM19182J
17	1	C2	DM19, Cap, 2700pF 500V 5% [2700]	DM19272J
18	6	D1,D2,D3,D4,D5,D6	Diode, 1N4007	
19	1	J1	Connector, CON2	538-22-23-2021
20	1	J2	Connector, CON4	538-22-23-2041
21	6	K1,K2,K3,K4,K5,K6	Relay, 12V DPDT	655-V23079A1003B301
22	2	L2,L1	Inductor BLUE	T68-1
23	2	L4,L3	Inductor RED (0.5 inch)	T50-2

Appendix B

24	2	L5,L6	Inductor RED (0.4 inch)	T44-2
25	7	L7	Inductor YELLOW	T37-6
26	1	SW1	Switch, Rotary, 18 Inch Shaft, Adjustable Stop, 1 Deck, 2 Pole, Non-Shorting	71ADF30-01-2-AJN
27A	1		Wire, 24 AWG, 10 ft (24T)	Belden 8052
27B	1		Wire, 22 AWG, 38 inch	Belden 8051
28	1	PCB	Circuit Board	
29	1	mating parts	Headers & Wire Housings HSG 2P WITH LKG RAMP	538-22-01-2027
30	1	mating parts	Headers & Wire Housings HSG 4P WITH LKG RAMP	538-22-01-2047
31	6	mating parts	Headers & Wire Housings CRIMP TERM 22-30 TIN	538-08050-0114

APPENDIX C

Inventory of Parts: Case Assembly

Reorganized by major groups 3/5/11

FAN Assembly Option

Item	Quantity	Reference	Description	Part Number
1	1		FS6020 Screw Set	S001Z80N
2	1		Heat Sink Alpha NovaTech FS6020PF	FS6030PF
3	1		Fan 60x25mm 12V 4500RPM 24CFM 35DB Ball Bearing Orion OD6025HB	OD6025-12HB
4	1		Finger Guard 60mm Plastic Orion Fans	G60-P
5	4		4-40 Hex Nuts	
6	4		Screw, 4-40 x 5/16	
7	4		Split lock Washer #4	
8	1		Grommet, Rubber .187	534-730

Finished Case

Item	Quantity	Reference	Description	Part Number
3	1		Case, fabricated, painted and screened	

APPENDIX C

Case Assembly and Special Tools

Item	Quantity	Reference	Description	Part Number
1	1	Omit if fan option ordered	Heat Sink AAVID (black rectangular finned)	
2	1		TyWrap 4 inch	644-PLT1M-M69
3	1	Mating Connector	Power Pole 30A Red/Black	PP30-50
4	1		Switch Power Rocker DA102J12S215HQF	676-0031
5	1		Knob BLK AL KNRLD IND LN	PKG50B1/8
6	4		Foot F2-ENCLOSURE-BLACK-FEET	537-F2
7	2	Q1,Q2	Nylon Socket Cap Head Screw 6-32 x 5/16 Black (1 spare)	McMaster Carr 95868A295
8	4		Eagle Cable Mounting & Accessories 1/8" HVY DTY CLIP	561-1250CC
9	2	Q1,Q2	Heatsinks TO-220 THERMASIL III with adhesive back Aavid Thermalloy 53-77-4ACG	532-53-77-4ACG
10	4		Screw 4-40 x 3/16	MSPPK0403
11	6		Screw 4-40 x 1/4 Pan Phil Black Oxide	PANPMS0404-10D4

APPENDIX C

12	8		Screw, 4-40 x 5/16	
13	4		4-40 Hex Nuts	
14	8		Split lock Washer #4	
15	4		4-40 flat washer used with 1/8" HVY DTY CLIP	
16	1		Powerpole Mounting Clamp Pair for 2 or 4 PP15/30/45 Powerpoles	1462G1
17	1		1/16 Hex Key-Long	116HK-L pointe- products.com
18	1		7/64 Hex Key-Long	764HK-L pointe- products.com

Fabricated Cable Set Option (if ordered, uses cable components in fabrication)

Item	Quantity	Reference	Description	Part Number
1	1		RF In Cable	
2	1		RF Out Cable	
3	1		DC Power Cable	
4	1		Front Panel Cable	
5	1		LPF RF In Cable	
6	1		LPF RF Out Cable	

APPENDIX C

Cable Components List (supplied if fabricated cable set not ordered)

Item	Quantity	Reference	Description	Part Number
1	8 inch	RF Cable finishing	Shrink Tubing 1/4 inch x 1/2 inch lengths as required	FIT221V1/4 BK103
2	2 inch	Bare Wire Covering	Shrink Tubing 1/8 inch x 1/4 inch lengths as required	
3	1	RF In Cable	Connector, BNC	530-CP-1094- AST
4	1	RF Out Cable	Connector, SO239	25-7350
5	1	Front Panel Switch Cable	Switch TX On/Bypass PRK22J5BBBNN Switch, Rocker, ULTRA Miniature, ON-OFF, NO LEGEND Cherry	908-0065
6	2	Front panel switch cable	Hookup wire, Gray, #24 5 inch length	
7	1	DC Cable	Power Pole Set 30A Red/Black	PP30-50
8	1	DC Power In	Wire Red #14AWG Teflon red 4 inch	Wire-TF-14-
9	1	DC Power In	Wire Red #14AWG Teflon red 4 inch	Wire-TF-14-

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10	1	DC Power In	Wire Black #14AWG Teflon black 4 inch	Wire-TF-14-
11	4	Power Wiring	Terminals FLAG RECP 16-14 BULK .250 x .032	571-35201332
12	1	RF Cable Ends	Hookup wire, Black #24 Teflon 17 inch Cut to 1.4 inch lengths for pig tails	
13	1	LPF Control cable	Hookup wire Black #24 Teflon 4 inch	
14	1	LPF Control Cable	Hookup wire Red #24 Teflon 4 inch	
15	1	PTT Wire, RF Output Cable	Hookup wire, White #24 12 inch length	
16				
17	1	PTT component RF Out Cable	Switchcraft Phono (RCA) Connectors REAR MOUNT JACK	502-3501FRX
18	1	RF Out Cable	RG174, 10.5 inch	
19	1	RF In Cable	RG174, 11 inch	
20	1	LPF RF Out Cable	RG174, 4 inch	
21	1	LPF RF In Cable	RG174 4.5 inch	
22	1	LED Front panel switch cable	LED Panel Mount Indicators HI EFF RED DIFFUSED 5in WIRE LEADS	645-558-0101- 007F

APPENDIX C

23	8	RF In, RF Out Cable	Core 23-43, 4 per cable with shrink tube covers	
24	1	RF Out Cable	Terminals RING 22-18 AWG 4	517-2204A

Appendix D LPF Coil Set

L1, L2

5.08uH



L3, L4

2.51uH



L5

1.37uH



L6

1.17uH



L7

580nH



L8, L10

470nH



L9, L11

430nH



L12

360nH



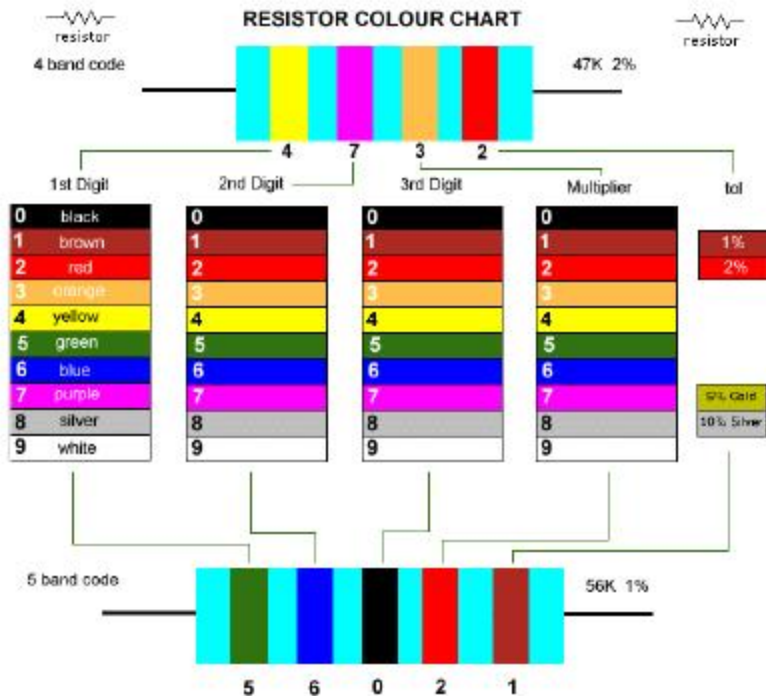
L13

280nH



Use the ZOOM feature to see greater detail

Appendix E: Resistor and Capacitor Identification

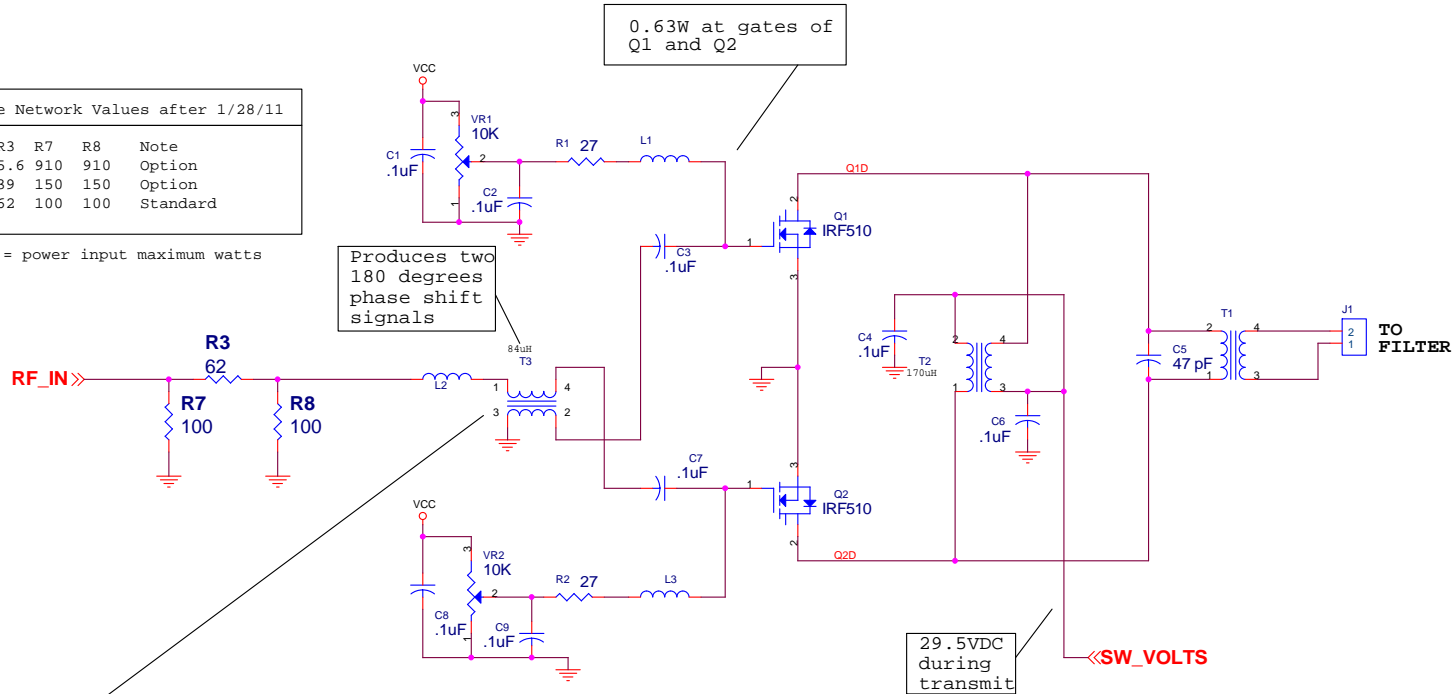


Identifying Capacitors

Small-value fixed capacitors (such as the silver mica capacitors for the filter module) are usually marked with one, two, or three digits and no decimal point. If one or two digits are used, that is always the value in *picofarads* (pF). If there are three digits, the third digit is a multiplier. For example, a capacitor marked "330" would be 33 pF (33 with a multiplier of 0). Similarly, "151" would be 150 pF, and "102" would be 1000 pF (or .001 μ F). Fixed capacitors with values of 1000 pF or higher often use a decimal point in the value, such as .001 or .02. This is the value in *microfarads* (μ F).

PI-Resistive Network Values after 1/28/11					
dB	PImax	R3	R7	R8	Note
1	0.8	5.6	910	910	Option
6	2.5	39	150	150	Option
9	5.0	62	100	100	Standard

where: PImax = power input maximum watts



0.63W at gates of Q1 and Q2

Produces two 180 degrees phase shift signals

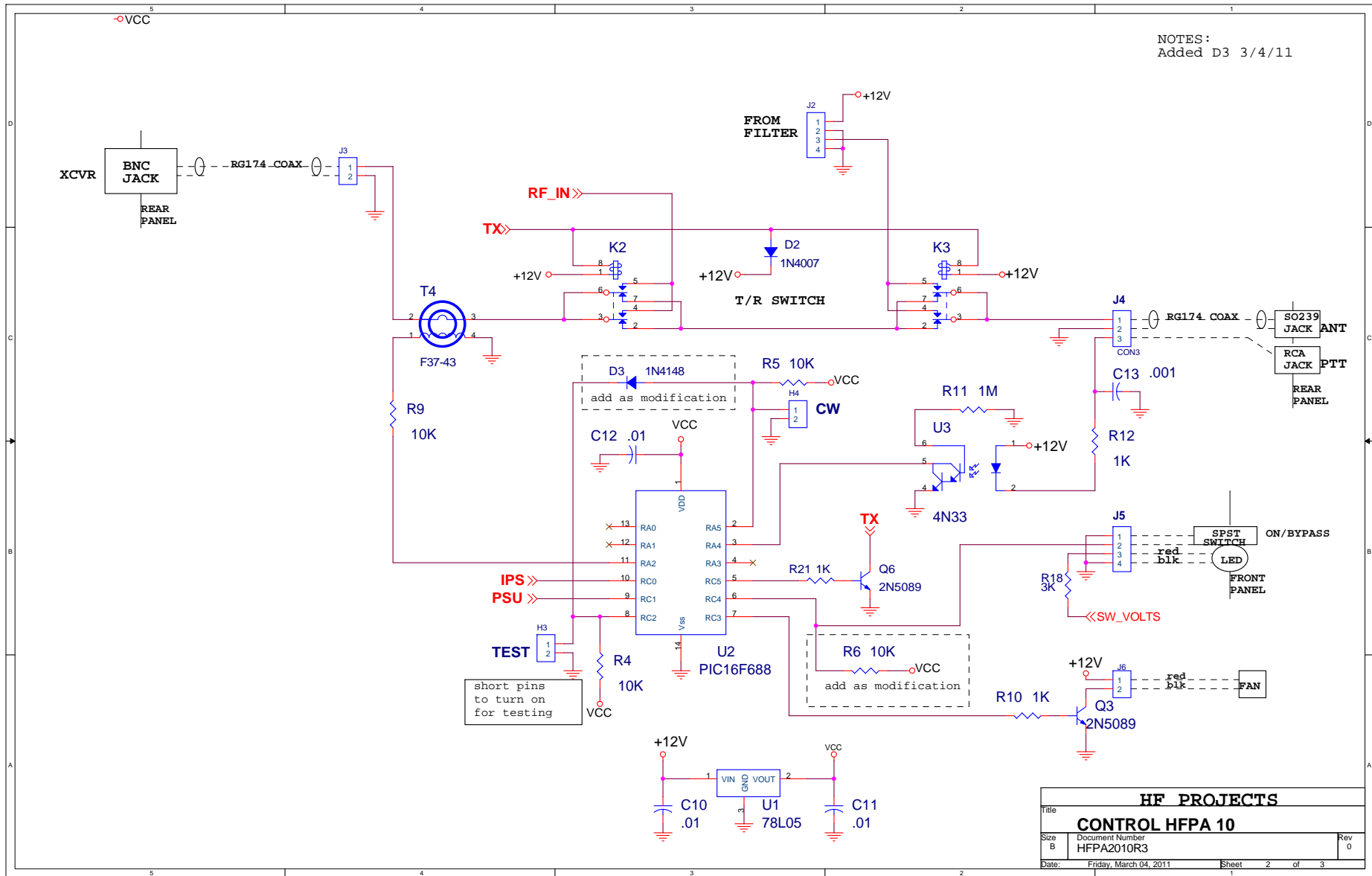
29.5VDC during transmit

T3 Schematic Correction 2/1/11
 To make the schematic agree with the artwork, T3 wires are renumbered to match the artwork. The orientation of T3 does not change and matches the silkscreen outline. The function of T3 remains unchanged.

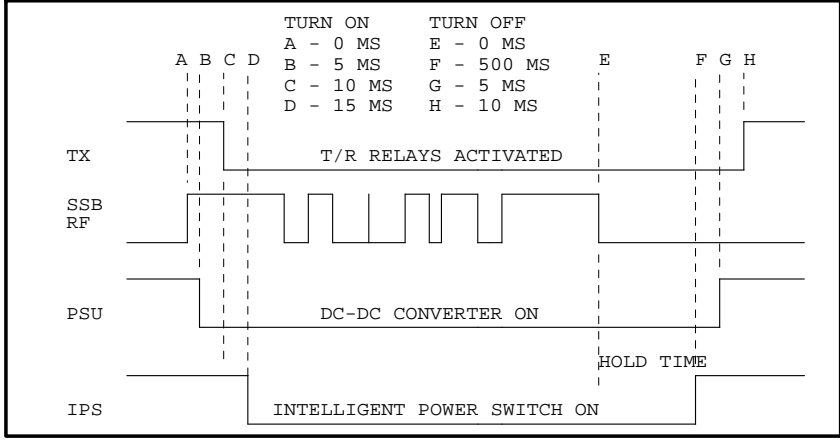
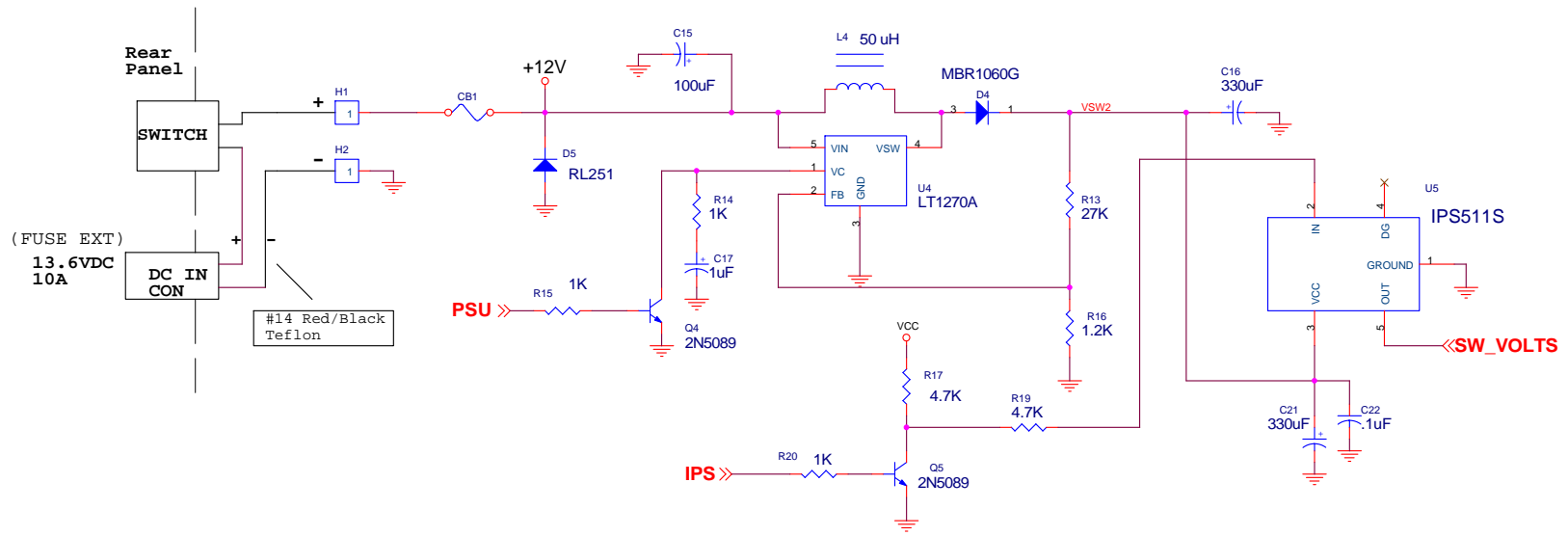
Revised: 2/1/11

HF PROJECTS		
MOSFET AMP HFP A 10		
Size B	Document Number HFP A2010R3	Rev 0
Date:	Tuesday, February 01, 2011	Sheet 1 of 3

NOTES:
Added D3 3/4/11

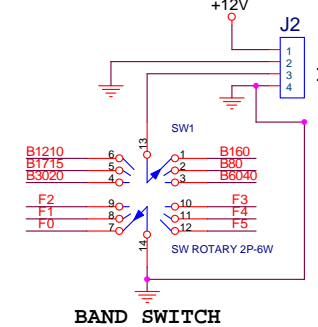
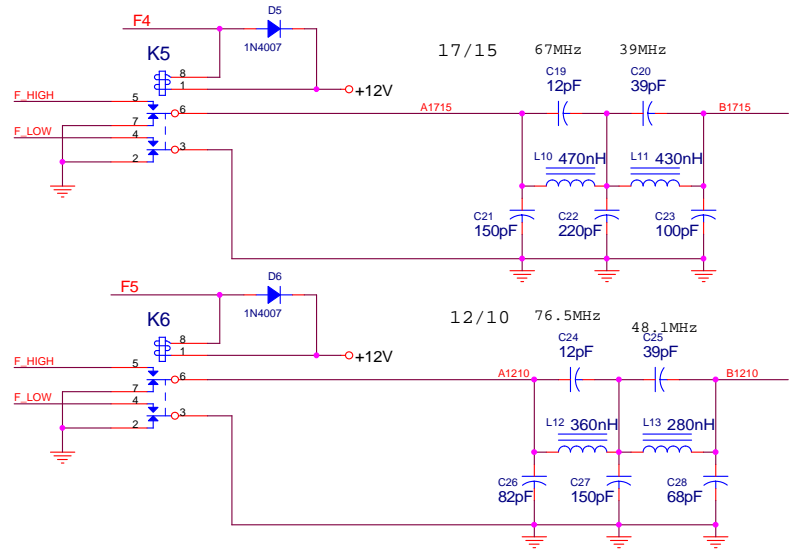
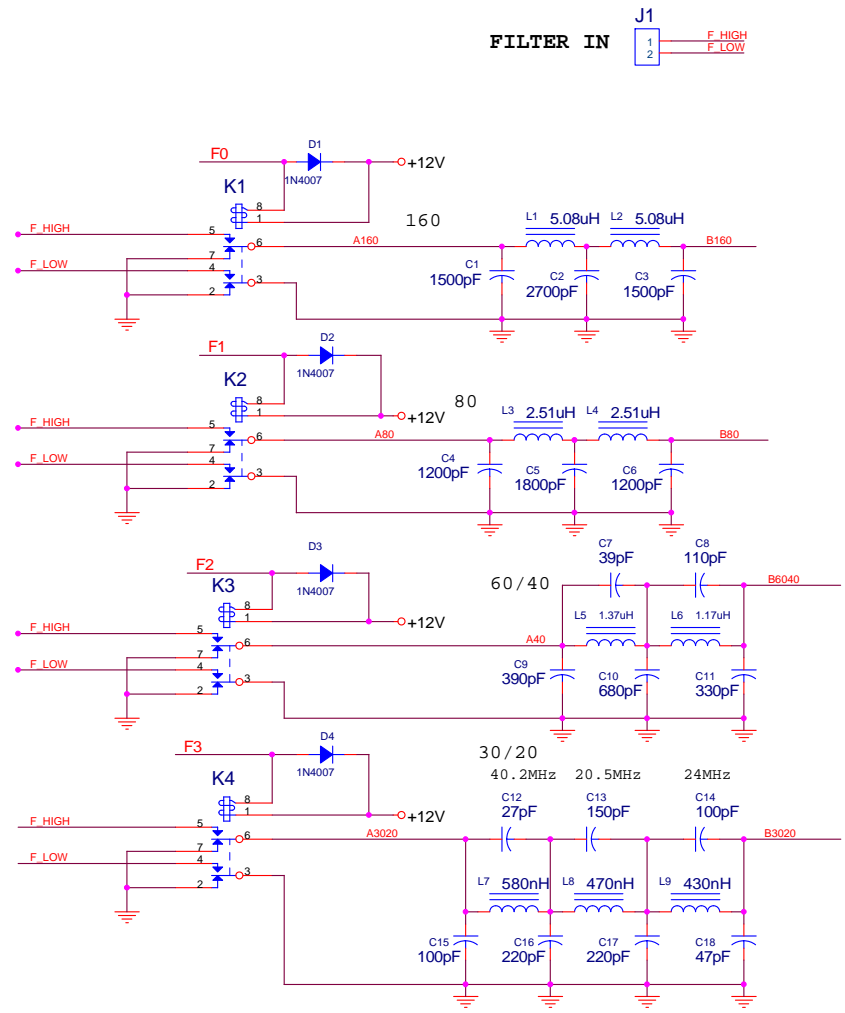


HF PROJECTS		
CONTROL HFPA 10		
Size B	Document Number HFPA2010R3	Rev 0
Date: Friday, March 04, 2011	Sheet 2	of 3



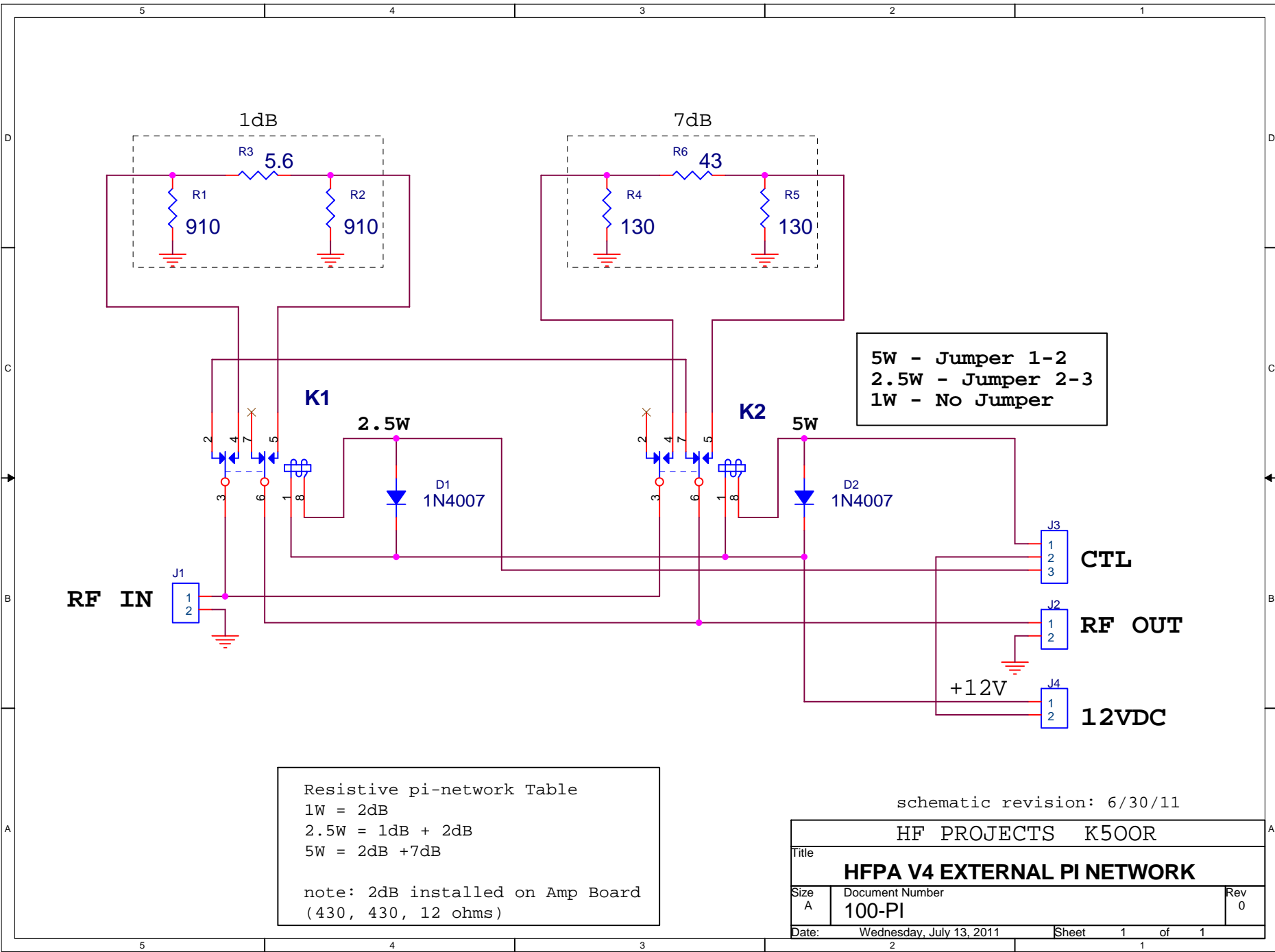
HF PROJECTS		
Title		
PSU HFPA 10		
Size	Document Number	Rev
B	HFPA2010R3	0
Date:	Wednesday, January 05, 2011	Sheet 3 of 3

4/4/11 Changed L1, L2 from T50-1 to T68-1



REF	TYPE	TURNS	INCHES
L1, L2	T68-1	20T	19
L3, L4	T50-2	21T	17
L5	T44-2	15T	13
L6	T44-2	13T	12
L7	T37-6	12T	9
L8	T37-6	11T	8
L9	T37-6	10T	8
L10	T37-6	11T	8
L11	T37-6	10T	8
L12	T37-6	8T	7
L13	T37-6	8T	7

HF PROJECTS K500R			
Title			
HFPA FILTER MODULE 10			
Size	Document Number	Rev	
B	HFPA FM V4	0	
Date:	Monday, April 04, 2011	Sheet	1 of 1



5W - Jumper 1-2
 2.5W - Jumper 2-3
 1W - No Jumper

Resistive pi-network Table
 1W = 2dB
 2.5W = 1dB + 2dB
 5W = 2dB + 7dB
 note: 2dB installed on Amp Board
 (430, 430, 12 ohms)

schematic revision: 6/30/11

Title		
HF PROJECTS K50OR		
HFPA V4 EXTERNAL PI NETWORK		
Size A	Document Number 100-PI	Rev 0
Date: Wednesday, July 13, 2011	Sheet 1	of 1