miniHFPA HF Packer Amp Construction Manual

miniHFPA PACKER –AMP REV 1

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The first release of the miniHFPA HF Packer Amp (R1) is a new design physically but has its roots from the HF PackerAmp V4 R6

The major emphasis in this design is to reduce the need for complexity in builder efforts to make this project. As a result, we have one circuit board and no cables to fabricate. The builder is left with the comparatively simple task of installing through hole parts

Contents

Section One - Introduction

Welcome all builders to the homebrew Hfpacker-Amp miniHFPA 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 selected 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 miniHFPA HF Packer Amp. 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 optimized to permit lower skilled radio amateurs to complete the project with minimal use of special tools and test equipment. You do not need to:

- Fabricate a case and finish it.
- Drill and/or Tap a Heat Sink
- Install Surface Mount Components
- Wind and measure inductors for low pass filters.
- Make Internal Cables
- Supply test equipment or tools to measure inductance or crimp connections for cables.

Your building and testing tasks include:

- Soldering through-hole components
- Follow a step-by-step construction manual
- Measure current when called for in the procedure to set the bias.
- Measure Voltage to confirm the correct DC-DC Output Voltage reading.
- A dummy load, 100W 50 ohm
- Your transceiver, your power source, your two RG58 cables for RF connections.

You can take advantage of offered fabricate options available to you:

- Fabricate and install Amp circuit board Inductors and transformers.
- Through hole assembly

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 receive the construction manual in a pdf format. You can also download 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 circuit board is a four-layer design optimized to allow logic and RF to exist in the same world. The technique used is to put the RF devices on the top layer with a ground plane directly below the top layer. The 3rd and 4th layers are for signal routing of the control system.

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 50 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 to Q1's gate. The other signal is routed 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 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. VR2 works similarly for Q2 via R2. 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 standard network attenuates the RF Input by 9dB which is a 8:1 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 bias current is 100mA per MOSFET while transmitting. Two additional sets of pi-resistive networks are supplied for 2.5W and 1W max RF input. These additional sets let you customize your miniHFPA max RF input to match your transceiver output. You do not want to over-drive the miniHFPA. The standard is the 5W pi-resistive network.

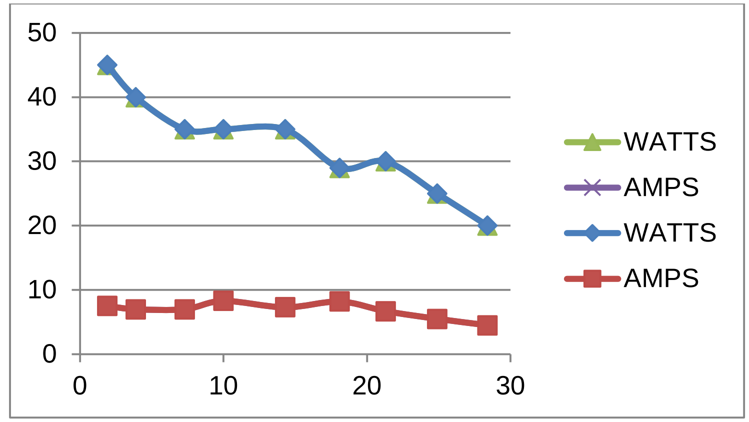
The switch-mode power supply circuits boost the nominal 12 VDC input to 29 VDC at 3-4 amperes during voice peaks. The power supply is normally off unless commanded to be on by the Controller IC, U2. During receive or standby current is very low. There is an approximate 76 mA current draw when power supply is off, and 295 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.

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

The Controller , U2 is a Microchip PIC16F688 device. RF input at J2 is tapped by U6, a dual Schmitt Trigger circuit 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 (Q9) operates the T/R relays K1 and K4 to switch from the RX state to the TX state. The controller is asleep during receive mode to inhibit controller noise..

Terms used in the descriptions

- PSU – Power Supply Unit
- IPS – Intelligent Power Switch
- SWV – Switch voltage for MOSFETs
- SWR – Standing Wave Ratio
- PTT – Push To Talk
- AMP – Amplifier

- TX - Transmit
- On/Standby – TX Enable
- LPF – Low Pass Filter
- XCVR – Transceiver
- BOM – Bill of Material

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. CW and SSB post delay time is selected by SW4. A front panel switch, SW2 sets the miniHFPA for Bypass/Operate. In Bypass, the transceiver signals are routed directly from J2 to J1.

LPF Selection Circuit Description

The miniHFPA has two removable side panels on the case which allow field access to the LPF Modules. The modules slide and plug in to a header strip.You were supplied with two LPF of your choice when you ordered and you have the option to purchase more. Each module covers two adjacent band segments. The choices are:

1. 160 M
2. 80/75 M
3. 60/40 M
4. 30/20 M
5. 17/15 M
6. 12/10 M

The most popular LPF choices are the 60/40M and 30/20M. A front panel toggle switch, SW1, selects the active LPF and indicated by the appropriate LED.indicator. Each LPF has a personality jumper that provides the ID to miniHFPA panel. The modules plug-in to either J5 or J6 on the miniHFPA board.

SWR Detection, Indication and Response

The miniHFPA incorporates a SWR detection and feedback circuit to shut down the miniHFPA transmit operation if a high SWR is detected. The reflected current through T4 is processed by the detection and filtering circuit to Q3. In the presence of a high SWR, Q3 will conduct providing a momentary signal to the controller, U2. The SWR state will tell U2 to shut down and light the SWR indicator. The amp will switch to bypass operation. To recover, the user should investigate what could have caused the high SWR. You can return to normal operation by cycling the STANDBY/ON switch, SW3 to OFF and then back to ON.

DC Power In and Battery Power Switching

Power enters through J3 and passes through CB1, an electronic circuit breaker. If you have sustained current greater than 10A, the part will purposely get hot and open circuit for a thermal time constant and thereby protect the miniHFPA from an over-current situation. This could happen if you connect the battery up backwards causing a heavy current flow through

D5, the reverse polarity protection circuit. The battery input voltage (nominal 12VDC) also flows through F1 a tiny surface mount electronic fuse that allows current to flow through Q5 if SW3 (STANDBY/ON) is closed (ON position). The 12V on the collector of Q5 is the source voltage for the low current circuits on the miniHFPA. In the ON position of SW3, the regulated 5V (VCC) will be the output of U1 (voltage regulator). The regulated 5V supplies the source voltage to the bias adjustment pots, VR1 and VR2. U2 and U6 are powered by this switched 5V source. In the OFF position, the standby current is very low and all electronics is switched OFF.

Over-Current Limiting Circuit

The U5 chip passes current from the DC-DC Converter circuit (29VDC in TX) through the Intelligent Power Source, U5. In the event of over-current within U5, the chip will reduce the DC-DC Converter.output voltage. Sustained over-current will cause U5 to get hot and create a thermal time delay to cease the over-current situation. After the thermal time delay passes, the U5 circuit activates again. When U5 is off, the TX LED is off and is a good trouble shooting tool to determine whether the miniHFPA is receiving the MOSFET drain supply voltage.

miniHFPA Power Supply Timing Signals

The Controller Chip, U2 sequences the operation of the power supply and the availability of the MOSFET drain voltage. The described sequence below happens in real-time with agility to not impede the operation of the miniHFPA amplifier.The sequence is:

1. The TX signal from U2 activates the T/R relay, switching the miniHFPA from receive to transmit.
2. After allowing the T/R relays to switch, the PSU signal is energized to power up the DC-DC converter and present 29VDC to the input of U5, the intelligent power switch.
3. The IPS signal from U5 passes the SWV (voltage for MOSFET is present at the OUTPUT of U5.
4. The SWV is present at the transformer T2 to supply the current required by Q1 and Q2.
5. Upon cessation of the transmit signal, a reverse sequence occurs allowing the miniHFPA to gracefully transition from Transmit to Receive.

PTT Operation

The miniHFPA can be controlled and driven by the transceiver directly from the Push-To-Talk circuits of the transceiver. This will bypass the RF Carrier detect circuits of the miniHFPA. The same internal timing sequence is in play but there is no hang-time delay involvement. The PTT input from the transceiver operates U3 which is a control input on U2.

Preparation

The most important preparation step before building is to 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. 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 Virgil via email or phone.

Inspection of Surface Mount Components

The circuit board back side has all the surface mount parts pre-installed by machine and/or by hand. We have some early experience where certain resistors are soldered on one end only. In particular, R31 and R32 have been spotted with solder on one end only. For this reason, it would be a good idea to spend a few minutes inspecting the surface mount parts under a light with a magnifier.

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 de-soldering, 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

- use a 12-25 watt soldering iron with a clean, non-corroded, well-tinned, fine tip
- keep the tip clean by frequently rubbing it along a wet sponge
- keep the tip tinned
- 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)
- let the contact zones heat before applying only electronics grade rosin cored solder (usually 3-6 seconds will do)
- apply the solder to the two surfaces (not the iron tip) and only enough solder to coat both surfaces
- ensure that the joint does not move after you remove the soldering iron tip and until the solder has solidified
- the resultant good solder joint should be shiny, in perfect contact with pad and wire and often has a concave upwards appearance
- 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. The project provides 2 sizes of magnetic wire #22 AWG (thickest), 24 AWG (thinnest).

Suggested Tools

- 12-25 watt electronics soldering iron, electronics grade solder, iron stand and sponge. You might want a small iron for tiny joints and a larger wattage iron when soldering to a ground plane.
- De-soldering braid and/or desoldering pump or bulb
- fine needle nose pliers, small fine wire cutters, wire stripper
- small screwdrivers including jewelers screwdrivers, small file

- multi-meter
- higher wattage soldering iron. I recommend a Weller WES51 which has nice features.

Included Speciality Tools

- 7/64 Hex Head tool

Component Installation

For each component, our word *"Install"* always means:

- 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 BOM.
- 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.
- 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.
- Install all low profile components first: usually resistors, capacitors, diodes, then electrolytics and active components.
- Resistors should be mounted flush to the board.
- Mount all capacitors, relays and connectors as flush to the board as possible.
- Bend the wires of the components at the bottom side slightly outwards in order to hold the component in place for soldering.
- Solder as per techniques described above.
- 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 120 seconds with 60 seconds between cycles to prevent overheating. Operating at 29VDC does not press the MOSFET to their limits. The ceramic washer TO220 mounting kit has excellent thermal performance and provides a robust 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 or denatured alcohol and Q tips or a combination.

Section Two – Amplifier Module Construction

Circuit Board ID is miniHFPA R0

Circuit Board Assembly, miniHFPA R1

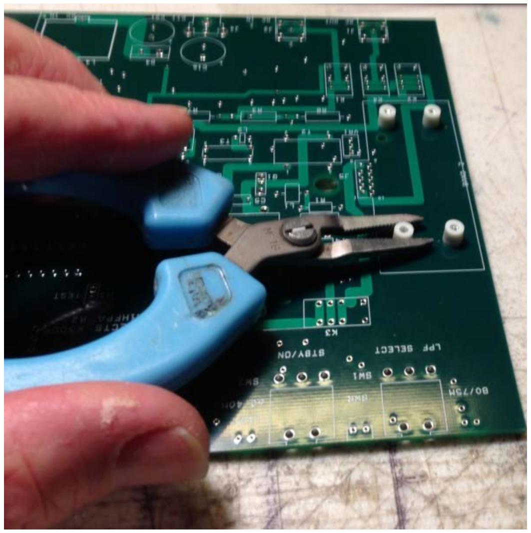
Assembly Steps

The circuit board is assembled in a sequence from low profile to high profile components. In addition, mechanical alignments are confirmed in this procedure.

- Install LEDs. LED1 (SWR) is RED. All other LEDs are green. The diameter of the holes on the circuit board is 0.024 inch. The LED lead size is 0.02 inch square. A measurement across the diagonal of a LED lead is 0.028 inch To solve the fitting problem use a tiny flat file or Exacto-Knife to scrape the diagonal edges of each LED. It does not take much; about 0.005 inch off each diagonal edge will do it. Resistance to seat the part is highest in the last 1/16 inch (closest to the body of the LED). Concentrate more in this area. Concentrate on the diagonal edges to minimize your time modifying these eight LEDs.After you have all the LEDs installed. Make sure they are all flat against the circuit board.. Install ❒
- Insert the four toggle Switches.With the part tight in the circuit board pattern, solder the back middle pin from the top side just enough to tack it in place.Examine the placement of the switches a second time and reheat the soldered pin while pressing down on the switch to properly seat the switch in the holes.Solder all the pins from the back side. A higher wattage iron is recommended.
- With the switches and LEDs mounted it is time to do a test fit with the top cover to confirm that the circuit board fits in the front panel and lines up the holes on the circuit board with the spacers on the heat sink.
  a. The hole on the circuit board at U4 should align with the 6-32 spacer. That spacer should pop into place into that hole and be flush with the top of the circuit board
  b. The four mounting holes for the circuit board should align with the four heat sink spacers and be in contact with the back side of the circuit board.
  c. If you are having some registration problems, try loosening the four 4-40 screws attaching the heat sink to the top cover panel.
  d. Everything is precisely drilled so the fit should be good. Allowing for some settling time, the case and circuit board fit normalizes for the variances.

- Attach the eight nylon spacers with eight 4-40 screws to provide bumpers to help guide the Low-Pass Filters into place on the amp board.

- You will need to grip the spacer with your hand tool pliers while screwing the silver color 4-40 self-tapping screws into the nylon.

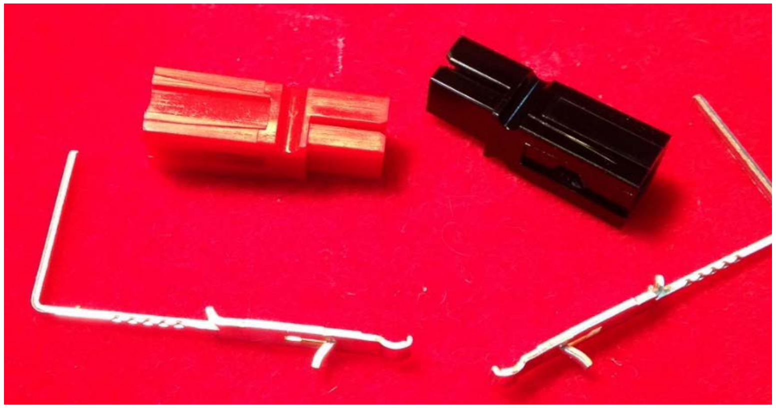


Hold the nylon bumpers while tightening with a screw driver.

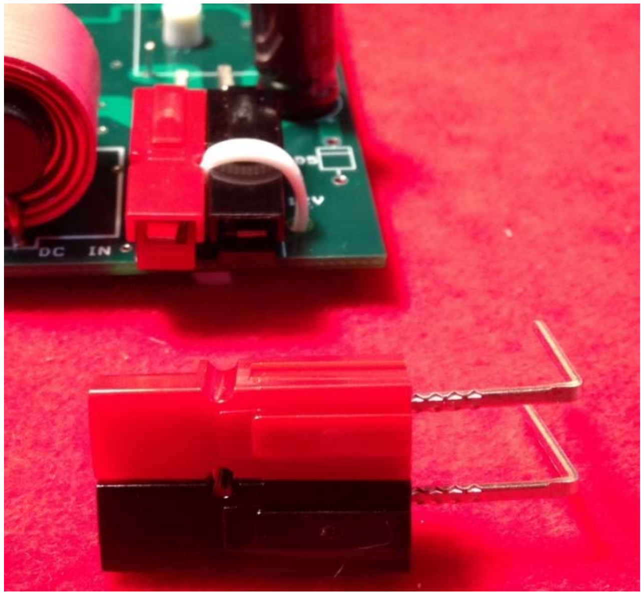
- Insert three relays (K1, K2 and K4) into the circuit board located near the bottom next to the J1 and J2 connectors.
    a. With the relays physically in the holes, flip the board over so the relays rest against the table. Solder one pin on each relay. I recommend a pencil iron (Weller WD1 or equivalent) for this work.
    b. After soldering, flip the board over and while pressing down on a relay, reheat the soldered pin to allow the relay to be fully seated on the circuit board.
    c. Solder all pins of the relays. Install ❒
- Install relay K3 into the circuit board and repeat the soldering steps above. Install ❒
- Locate the right-angle 10-pin headers that get installed into J5 and J6. Cut a slip of paper about ½ x ½ inch and slide the paper between the connector and the circuit board. The paper acts as a spacer to properly set the height of J5 and J6 above the circuit board.
- In addition to being the right height, you need to make certain that the pins are parallel with the circuit board surface. To do this:
    a. Tack solder a corner pin on the top side.
    b. Eye-ball the pins to insure the pins are parallel with the surface of the board and that the connector is spaced the thickness of the sheet of paper. Reheat the tacked joint while making any necessary adjustments of the connector.
    c. Insert a LPF Module to aid you with alignment evaluation.

d. Repeat tacking alignment for both J5 and J6.
e. Solder all the pins from the back side using a pencil iron.
f. Remove the paper spacers after soldering.
g. Remove the LPF module and save for later.

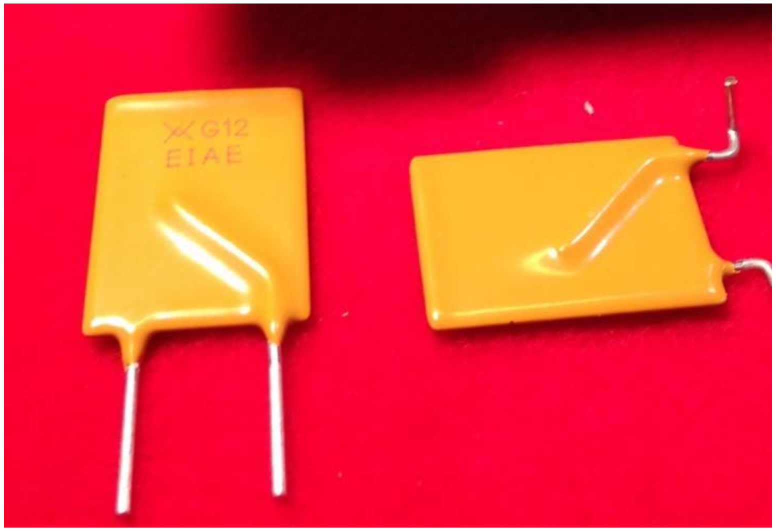
- Flip the circuit board over and install the 14-pin socket for U2. Note that the notch of the socket aligns with the silkscreen pattern.
  a. Tack-solder one corner pin by soldering from the top side of the circuit board.
  b. While pressing down on the socket, reheat the one pin you tacked into place. Avoid holding your finger on the pin being soldered!
- Solder all the pins of the socket. Install ❒
- Locate the Red and Black housing and the right angle pins.



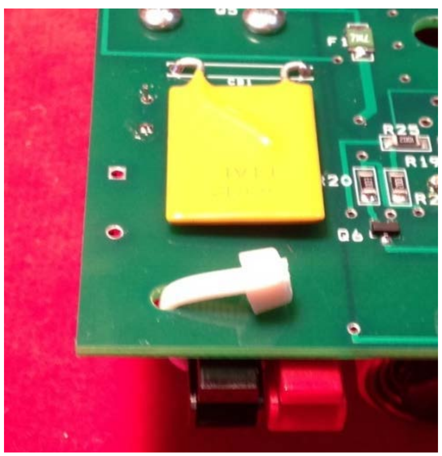
- Insert the pins into the housings. They will snap into place. Assemble the Power Pole connector pieces using the two PCB 25 Amp contacts (J3) and the plastic red and black housings pair P30-50. It is important that the red piece be on the left side when viewed from where you would plug in the power cable. The plastic pieces are tongue and groove to allow mating. Install ❒



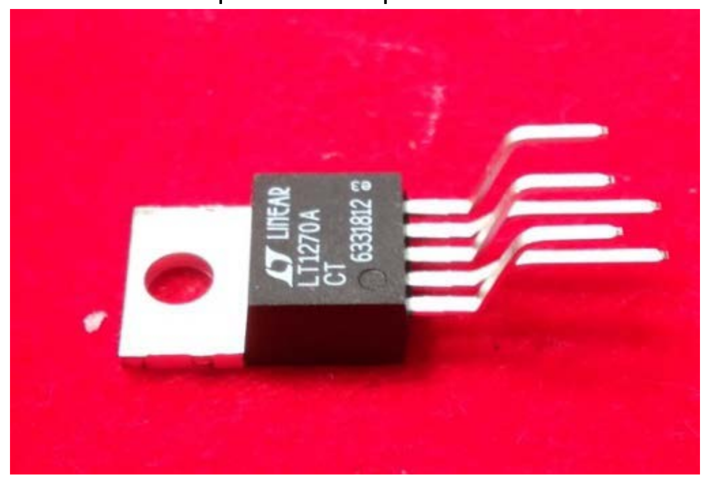
- Insert the J3 connector into the holes. The housing should lie flat on the top side of the circuit board with the leads parallel to the board and through the holes of J3. The red side inserts into pin 1 (+) of J3. Flip the board over and solder the pins. Cut the pins flush with the circuit board. You don't want any protrusion of the cut leads. You can reheat the solder connection and press the stubble with the soldering iron so that the soldered pin recedes leaving a flat surface on the back side of the circuit board. Install ❒



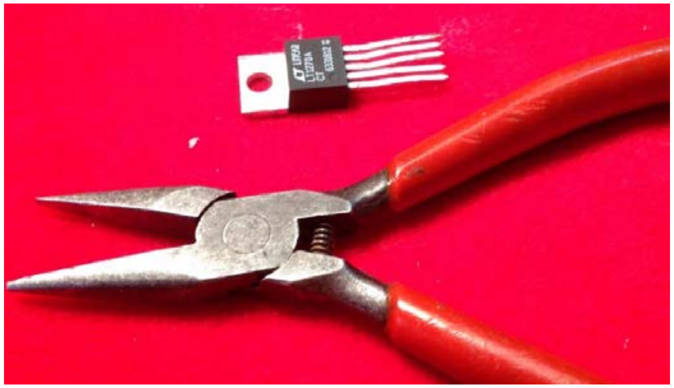
- Lead Form the Circuit Breaker, CB1 as shown in the picture above. Insert the part parallel and flat on the back side of the circuit board.   Install ❒



- Use the Plastic Ty-wrap to secure the connector to the circuit board. Cut excess length after you cinch the wrap through the two holes provided on the circuit board. Install ❒
- The DC/DC Converter chip, U4 has the leads bent for vertical assembly. We must have it mounted horizontally. It is necessary that we form the leads for our application. Start by flattening all the leads out straight. Don't cause stress in the process and break a lead. It is an expensive component.



- Next step is the re-bending of the leads for our application. In this procedure, we will hold the part in proximity to where it will be mounted and mark the leads with a ink marker to create two bend lines that will guide us in reforming the part five leads.



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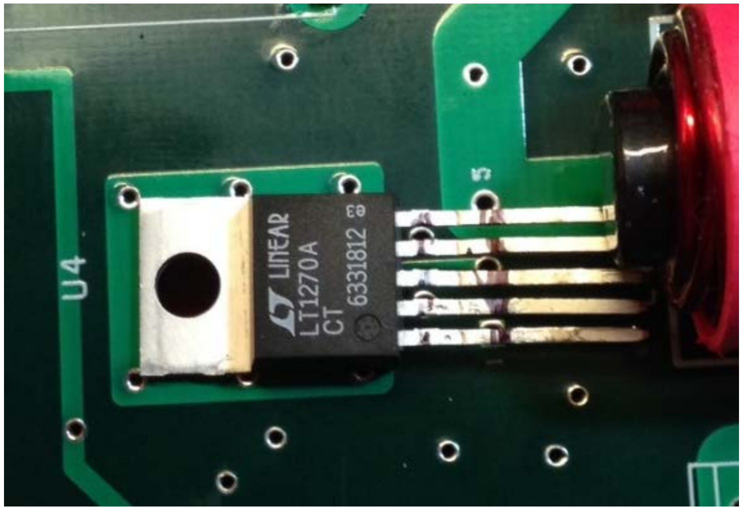
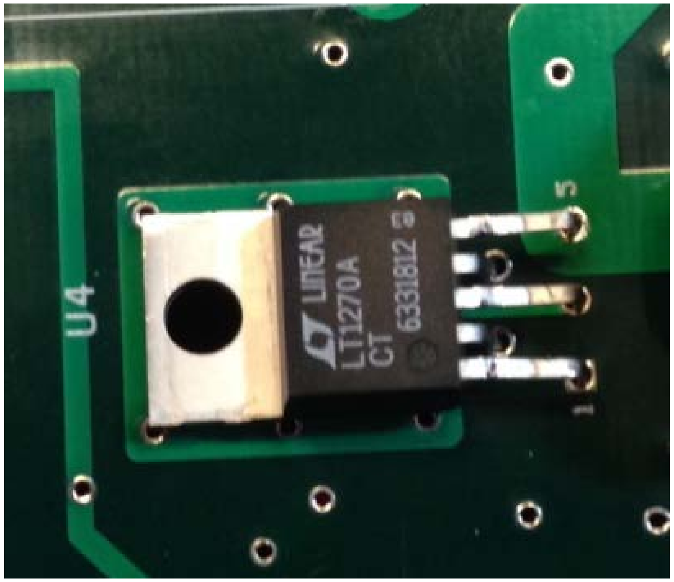
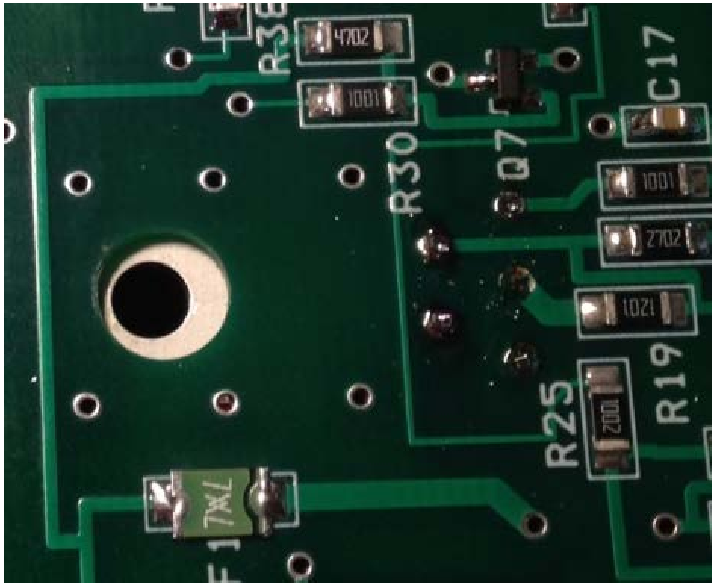


- A marker pin is scribed across the approximate locations where the leads need to be bent so that the part can be properly installed on the circuit board. Two of the five leads are bent close to the body of the part. The three remaining alternating leads are bent at the second line.

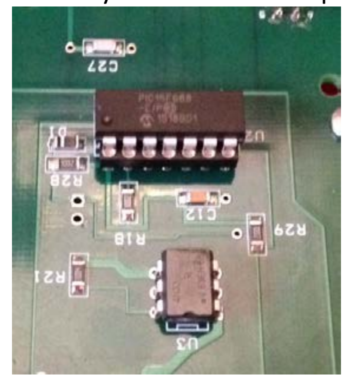


- Bend the second and forth lead first and the first, third and fifth leads last. Now, carefully feed the leads through the holes. You want the long leads of U4 to be parallel and even when inserted. Use the needle nose pliers to pull and position the leads. Your finished work should look like the picture above.



- The picture above shows the U4 component properly aligned with the large hole on the circuit board. Note the slight offset from dead center. This is correct for this application. It allows the 6-32 screw to pass through the U4 part into the spacer threads below. In final assembly when the U4 part is attached to the spacer, there will be a thermal bond that transfers the heat from the component into the heat sink.
    a. We will also apply thermal grease to improve the thermal bond between the backside of U4 to the circuit board under U4 and the spacer attached to the heat sink. Install ❒
- Insert the rear panel connectors. To complete the assembly of these items, make sure they are flush and straight in their mounting position on the circuit board. After you are satisfied, solder them in place.

- Finish the socket assembly by soldering all pins and then installing the chip for U2, PIC16F688, in the socket. You will probably have to roll the pins slightly on each side to make the pins perpendicular to the U2 body for easy insertion. Install and make sure you do not have a pin bent under.



- Install the fabricated RF transformer kit or fabricate from the provided raw materials.

- The Fabricated Transformer Set will now be installed. The package contains all the RF transformers and coils used on the miniHFPA. The next few steps will describe their installation.
  1. The leads are preformed to fit each of the component location. To identify further:

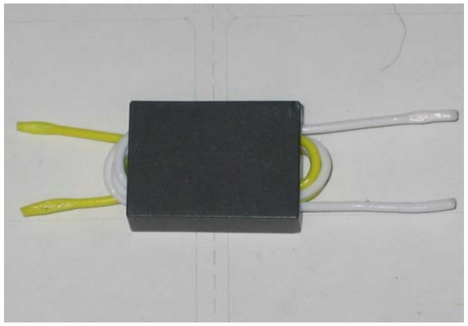
• T3 is the single core bifilar wrapped core with windings marked 1-2 and 3-4
• T2 is the double core bifilar wrapped core with windings marked 1-2 and 3-4
• L1 and L3 are two identical air ¼ inch air=core coils
• L2 is a smaller 3/16 inch air core inductor.
• T1 is a binocular output ttansformer color coded with yellow primary and white secondary. The
white wire secondary is closest to the relay, K3
• T4 has multi-turn secondary with a single-turn primary

Fabricated Magnetics Step By Step

Ite	Qty	Ref	Description	Mfg and Part
1	20	L1,L3	INDUCTOR	#24 wire 10 in. x 2
2	4	L2	INDUCTOR	#24 wire 4 in
3	1	T3	Transformer, Input	FT50-43 .
4	22	T3 #24 wire	wire 24 awg	11 inch x 2
5	2	T2	Transformer, DC	FT50-43 .
6	30	T2 #22 wire	wire 22 awg	15 inch x 2
7	1	T1	Balun Core	BN-43-3312 + silver plate wires
8	1	T1 Yellow 7 inch PRIMARY	Wire 20 AWG Yellow Silver Plate Marvec Electronics	GPW T20-04-25 SKU: 1968
9	1	T1 White 10 inch SECONDARY	Wire 20 AWG White Silver Plate Marvec Electronics	GPW T20-04-25 SKU: 1973
10	1	T4	Transformer, SWR	Mouser: Fair-rite 623-5961000201 or FT37-61
11	12	T4 wire	Transformer, SWR	#28 wire 18T 12
12	1	T4 wire	Transformer, SWR	#22 wire 1T

Fabrication 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.
- Make a U shape of the 7 inch yellow wire and insert into the two tubes. Equal distance the wires.
- Make a U shape of the 10 inch white wire and insert into the same end of the two tubes. Equal distance the wires. At this point, you have 2 yellow and two white wires coming out the same end.
- Push one of the yellow wire leads through the adjacent tube. Push the other yellow wire lead through the other adjacent tube. Pull the leads tight. You are finished with the yellow wire.
- Push the white wires through in the same manner. Pull the wires tight. Push the white wires through a final time through the adjacent tubes. You now have the yellow wire leads on one end and the white wire leads on the other.
- You are done winding the core.
- Trim about 3/8 inch length off each lead. Strip each wire about 3/8 inch and lightly tin the tip. You are now ready to install the transformer into the board. The yellow primary (input) and white secondary (output).
- Insert the primary wires at holes 1 and 2. Pin 1 is the square pad.
- Insert the secondary into holes 3 and 4
- Pull leads snug and solder. Install ❒



T1 with Yellow Leads Primary and White Leads Secondary

Fabrication and Assembly 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. To prevent chaffing of the wire on the edge of ceramic cores, insert a common soda straw (same length as the thickness of the two stacked cores). Through the stacked cores, insert the two parallel wires. 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 front 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 front 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 isolation to determine the start and finish of each wire.
- 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.
- Remove 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 insulation and excess solder. ❒
- Re-insert T2 on the board at the T2 outline. Pull the leads tight and solder in place. Install ❒
- Trim the excess lead length and reflow connections.
- This is a typical spot where you can have a poor solder connection. Inspect and re-solder if necessary.

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 front 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 front 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.
- 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 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

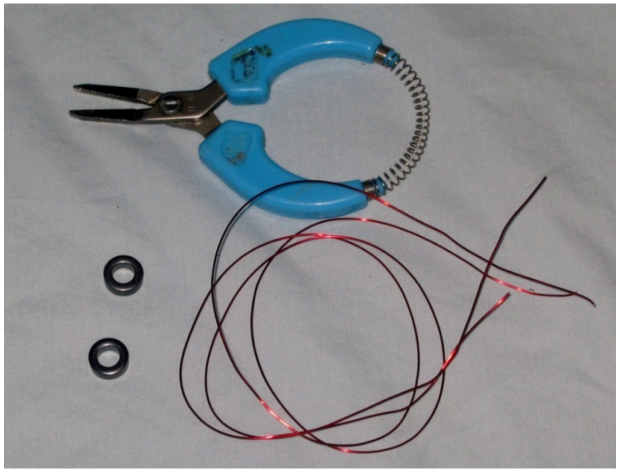
- L1 and L3 are identical and require 12 inches each of the remaining #24AWG wire.
- Use a ¼ inch drill bit as a winding form and wrap 10 complete turns of the wire tightly around the drill bit.
- Trim the excess lead length to ½ inch and tin the leads.
- Insert L1 and L3 into the L1 and L3 positions 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.

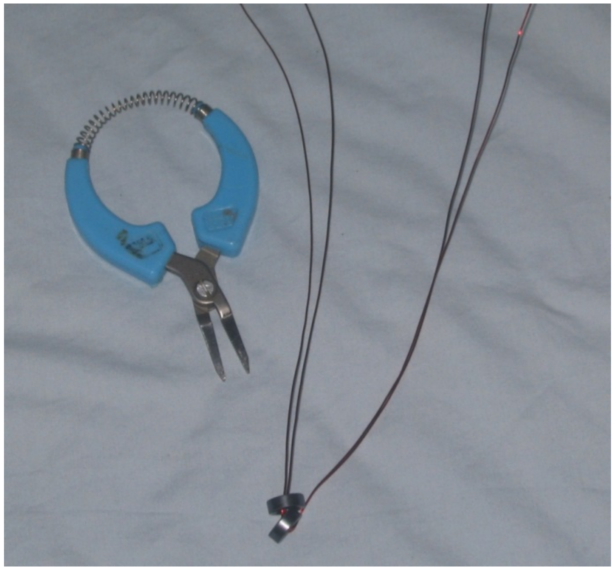
Fabrication and Assembly of L2

- 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.

Fabricating miniHFPA Magnetics

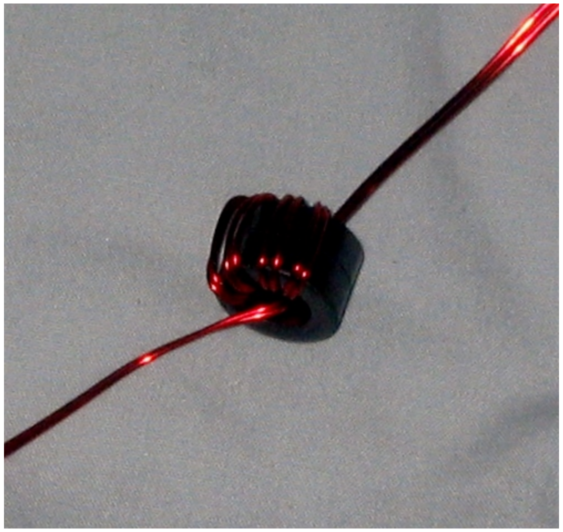


You start with the cores, two wires and pliers



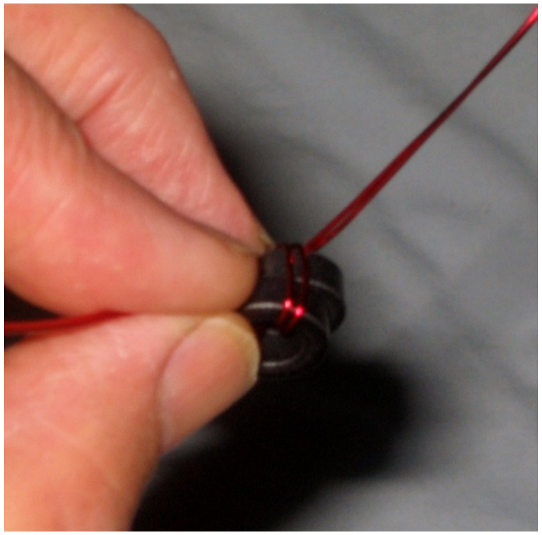
Place the cores in the center of the two wires.

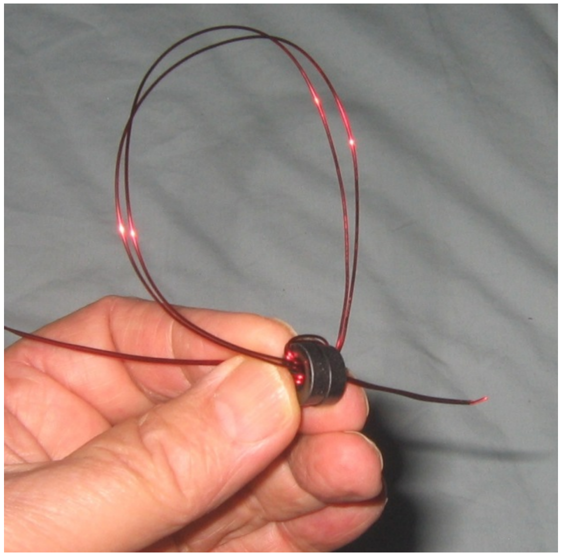
Start with the wire in back by wrapping it around and through the core. At this point the individual wires have passed through the core two times.



Continue wrapping the free wire through the cores on the right side until you have passed the wires through the cores a total of five times (include all passes through the core).

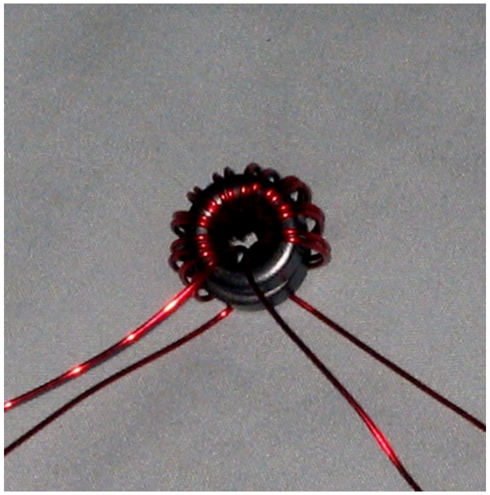
At this point, you are finished with the right side and done nothing with the left side. Use the same winding technique for the left side.





You will soon be half way done. I prefer to not twist the wires as that causes unnecessary abrasion on the enamel.

Pull the end of the wires with the pliers to keep the windings tight. I prefer to not let the wires cross each other.



Now continue with the wire end on the left to pass the wires through the center of the cores until the wires have made a total of ten passes through the core.

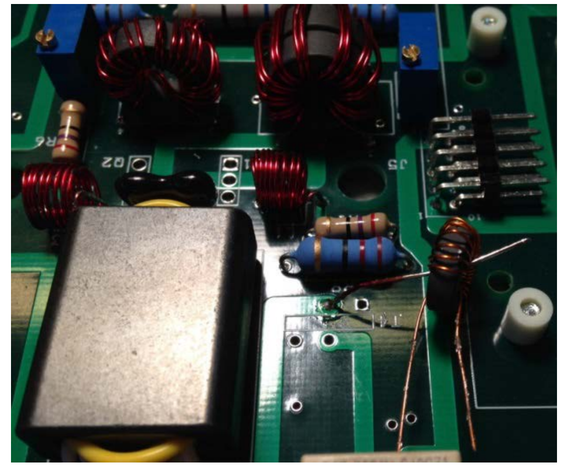
In this picture, all ten passes through the cores have been completed.

The next task is to organize the wires so that one winding is on the left side and the other winding is on the right side.

Scrape the end of the wires and use an ohmmeter to determine the two windings.

Strip insulation and a tin the leads. Put the transformer through the board and form the leads.

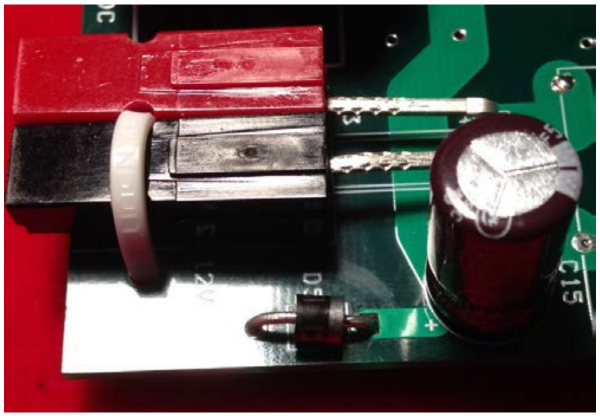
T4 is constructed using a FT37-61 and 18 turns of #28 enamel coated wire. Use the same technique as described in the pictures above to wind the wire. This transformer has a one-turn primary and an eighteen turn secondary.

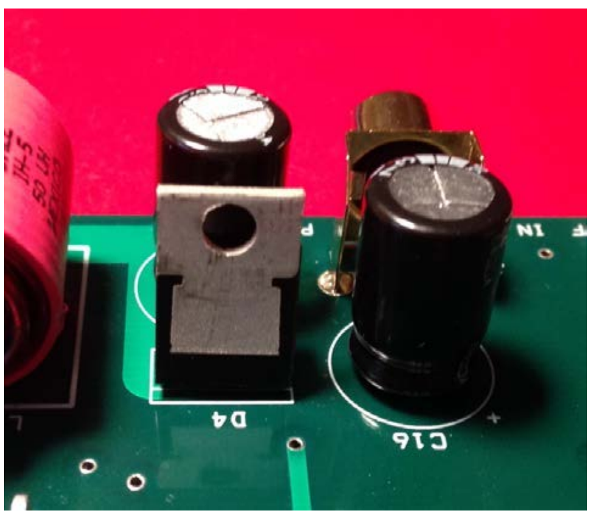


The picture above shows a length of #24 enamel wire (primary) that has about ½ inch of the wire with the enamel still intact that will pass through the core. Each end will be stripped to accept solder. Solder one end in place to the circuit board as you see in the picture above. You are now going to pass this free end of the enamel #24 wire through the wound core. A word of caution concerning insulation on the wire. It is very important to scrape the insulation off the ends of the wire that will pass through the circuit board and be soldered. The enamel on this #28 wire is hard and takes diligence to make sure you can solder it to the circuit board. If your solder joint looks like the wire nub is an island in a sea of solder, you have not actually soldered it.

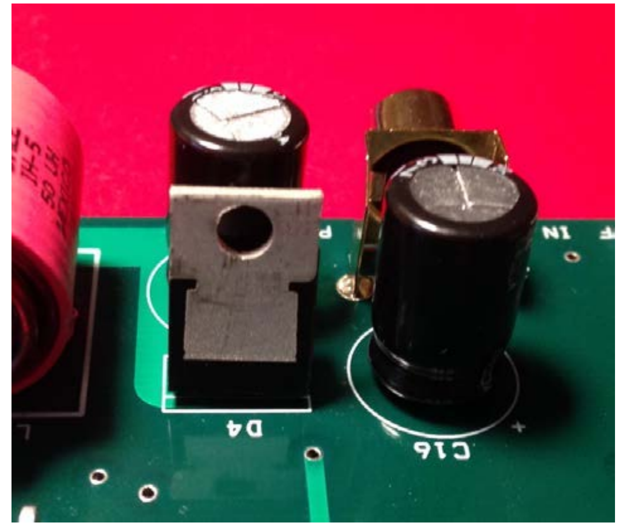
Insert the free through the center of the T4 core. Insert the wires wound on T4 through the diagonally placed holes on the circuit board for T4.

- Insert D5 as shown. Observe polarity. Install





- Insertl D4 as shown. Observe polarity. It will snap into place allowing it to be flush with the surface. Install ❐



- Insert the three capacitors. Observe polarity marks and the long lead of the capacitor. . Install ❐

PI-Resistive Network Installation

- Choose to build your miniHFPA for the desire maximum RF Input that your transceiver supplies. The miniHFPA output power is the same for any case. Overdriving the amp will cause excessive current. Although the miniHFPA has max current sensing and shutdown, you are putting your amp in harm's way and therefore susceptible to a possible failure. Protection devices are much slower to operate than the electrons flowing through your circuits. It depends upon the amount of over-current and the internal temperature build up exceeding the capacity for the MOSFET case to drain that heat away from the device.

1. This option is available so you can match the amplifier input requirements to the transceiver output characteristic. You may find it advantages to use a lower power on the transceiver, if you have a choice, to improve on battery life.

   5.0 W Max RF Input (standard)
   - R3 62 ohm, 2W (BLU-RED-BLK)
   - R7/R8 100 ohm, 2W (BRN-BLK-BRN)

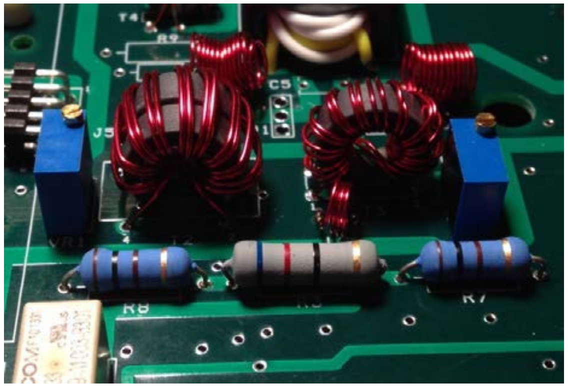
   2.5W Max RF Input (option)
   - R3 39 ohm, 2W (ORN-YEL-BLK)
   - R7/R8 160 ohm, 2W (BRN-BLU-BRN)

   1.0W Max RF Input (option)
   - R3 12 ohm, 1W (BRN-RED-BLK)
   - R7/R8 430 ohm, 2W (YEL-ORN-BRN)

- Install the version that you want to use. I suggest using an ohmmeter to be certain about the resistor values chosen. Install ❐

PI-Resistive Network and Bias Pots

- In the picture below, the standard 5.0W max RF Input resistor values are installed.



- Note the location of the adjustment screw in the picture above. The square pin on the circuit board is your indicator of the pot adjustment position. Turn the pots about 10 turns counter clockwise. You will not hear a click at the end of the travel range.

Bottom Cover Assembly

The bottom cover has the holes for the connectors on the end.

- Install four Rubber Bumpers. You will need small hand tool pliers and a tiny screw driver during this assembly. Locate the four black rubber bumpers. On the outside of the bottom cover, insert the rubber bumpers one at a time through the four corner holes. You will find it difficult to do unless you use a technique to get the rubber through the hole. A tiny blade screw driver can be used to push the rubber into and through the hole while you are pressing down with your thumb on the bumper head.
  1. Place the bumper at the hole and press firmly down with the thumb.

2. With the tiny screw driver or equivalent, push in on the side of the rubber that is not going into the hole. You may have to work around the perimeter pressing the rubber into the hole while maintaining pressure on the bumper head.
3. Once you start seeing some rubber passing through the hole. After you get about 1/8th inch passing through the hole, you can use small hand tool pliers to grasp the rubber and pull the rubber further through the hole. You will have to tug in all lateral directions to make the rubber enter into the hole.
4. Pull and work the rubber until the rubber bumper body is flush with the bottom of the bottom cover.
5. Install ❐

Set the bottom cover aside for future use during final assembly.

Heat Sink Assembly

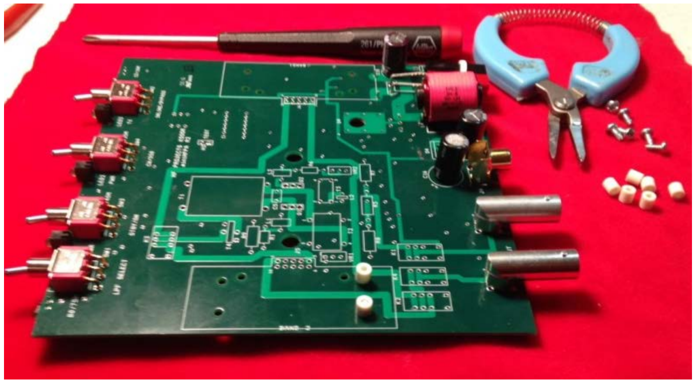
Top Cover Assembly

Heat Sink Attachment

There are four outer perimeter 4-40 tapped holes used to attach the heat sink to the top cover. The heat sink is physically mounted to the outside of the cover with the four mounting holes in the top cover aligning with four corresponding threaded 4-40 holes on the heat sink.

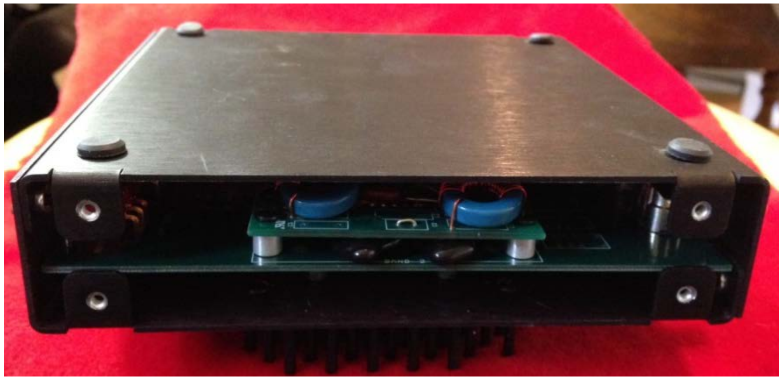
1. Attach the heat sink with four 4-40 x ¼ inch screws to the top cover assembly. Do not fully tighten during this step.
2. The next inner perimeter set of four holes on the heat sink are used to attach the heat sink to the circuit board. This procedure installs the four 4-40 x ½ inch male-female aluminum spacers to these inner perimeter holes. Do not over tighten the spacers since you could break off the threads in the hole, leaving you a problem.
3. Place two #6 washers over the threads of the 6-32 x ½ inch male-female aluminum spacer.
4. Insert the spacer, with washers, into the 6-32 tapped hole near the top cover cutout. The washers will displace to the side enough to allow the spacer to be tightened without washer binding with the top cover. The washers provide additional 1/16 inch length so that the top of the spacer will be flush with the top of the

circuit board clearance hole when the circuit board is inserted.



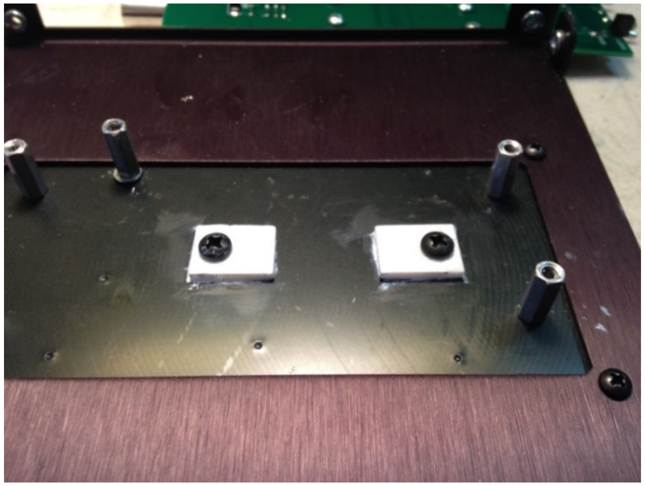
Install of Nylon bumpers broad view

Circuit board fitted into the case view



Side View showing the LPF Module plugged in

MOSFET Mounting and Bias Setting



- The ceramic washers are greased up with a thin layer of thermal paste. The washers are held by two temporary 6-32 x ¼ inch screws to set the parts in proper position. Allow a few minutes for the thermal washers to get settled in. You will remove these two temporary screws before continuing.

- The MOSFET are attached to the back side of the circuit board. The MOSFET pins are bent 90 degrees just where the width of pins reduces from the MOSFET connections. The thermal paste is applied in a thin layer to the rear of the MOSFETs.. Solder both sides to insure a good electrical connection of the high current passing through the MOSFETs.

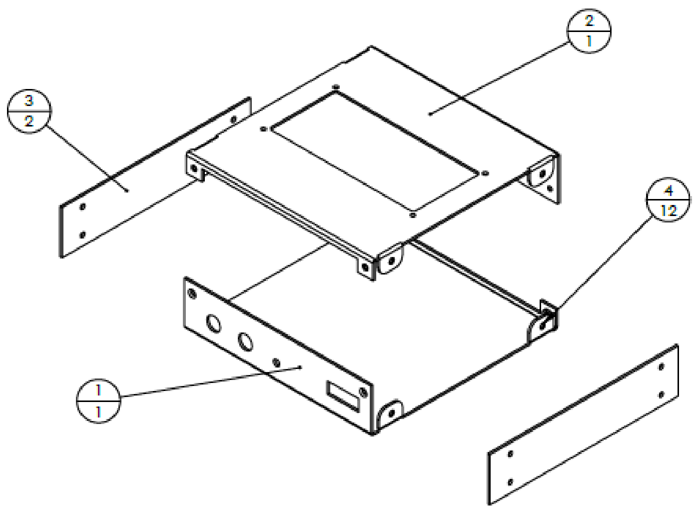
- This is a view of the connection area for Q1 and Q2. The bare minimum tips of the MOSFETs just barely break the surface in the holes of Q1 and Q2.

Final current value after bias set and no drive: 338 mA
I am using the 5W pi-resistive network so my RF input is a constant 5W. I have a 160M and 80/75M LPF installed.

RF TEST

BAND	OUTPUT	CURRENT
160M	45W	8.2A
75M	48W	8.5A

Mechanical Drawings



This is an overview of the top, bottom and sides of the miniHFPA case assembly.

Section Five – Adjustment and Testing

- Turn the pots fully CCW so we can test the RF functions without generating power output.

Ohmmeter Test

- Resistance from Red to Black DC Input with switch ON should be about 500 - 1K ohm.
- Online/Bypass Switch placed in Bypass position
- Attach a watt meter and dummy load in series to the BNC RF Output connector.

Test Mode Setup

- Connect XCVR to the BNC RF Input Connector.
- 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. Power Poles are on each end. Plug the test cable into the multi-meter set to read amps. The current passing through the red wire registers on the meter.

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

- Connect for Current Measurement on the 10A scale.
- 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. If your meter does not have high resolution, you may have to use a smaller scale to measure mA. **There can be a current surge when power is first applied that can blow the low current fuse in your meter**. Use a jumper across the meter during turn on to shunt the current around the meter. Remove the jumper after a second or two.

DC Current Test and Bias Adjustment

- TX LED should be OFF. Record: _______mA
- Use small screw driver to short TEST pins. The TX LED should light.
- Current is about 68 mA while the pins are shorted together and the LED is on. Record: _______mA .
- Utilize the provided jumper to hold the TX LED ON. (note: multiple transitions may confuse the controller and the TX LED does not stay lit. If so, remove the jumper, cycle power and try again)
- Turn VR1 clockwise while monitoring the current. Raise the current by 100mA. Record: _______mA reading.
- Turn VR2 clockwise while monitoring the current. Raise the current by 100mA Record _______mA reading.
- Remove the test jumper. You should have increased the current by a total of 200mA with your adjustments.
- Bias setting is now complete. Stow the jumper on one of the TEST pins for future use.

Install two LPF Modules

- Insert the 60/40 Module on one side and the 30/20 Module on the other side. It does not matter electrically which side you install the modules.
- The selected LPFmodule will light the LED for that LPF.

RF Signal Testing

- Switch the Online/Bypass Switch to ON. Key the XCVR. The LED lights. (1W RF drive)
- Release XCVR KEY. The LED is OFF .
- Measure from case ground to the metal case of diode D4. Key the XCVR. The voltage switches from 0.0VDC to about 29.2VDC.
- Tap CW/SSB toggle switch controls the hang time of the amp when using RF keying. Note the time difference that the TX LED is ON in CW vs SSB.
- 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. Open the PTT test switch. The TX LED is off

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 29.2VDC. Record _____VDC

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

LT1270ACT Alert Notice

"Be careful when probing around the DC -DC Converte
have received one user report of the chip arcing and going violently up in flames when grounding pin 2, the fly back sensor to control output voltage. The voltage divider R13 and R16 is used to tell the sensor the output voltage. The LT1270A will try to increase voltage on pin 4 until voltage on pin 2 from the voltage divider reaches 1.24V. This can result in dangerously high voltages on pin 4, when pin 2 is mistakenly grounded. Also note, that the middle pin 3 is at ground while pin 4 carries output voltage of about 30V.

Those two pins can be easily shortened when probing. Better, measure input voltage (pin 5) at the cathode of D5, measure output voltage (pin 4) at the anode of D4, measure fly back voltage (pin 2) at R13, and measure the control state (pin 1) at R14 (converter off when at ground). Be very careful!"

RF Power Testing

- Attach 12VDC power source capable of supplying 10A continuous current. The 12VDC source should be fused at 20A.
- Monitor Current
- Your amp was built for 1W, 2.5W or 5W max RF input. You do not want to exceed the max RF input because of the over-current situation this wll cause.

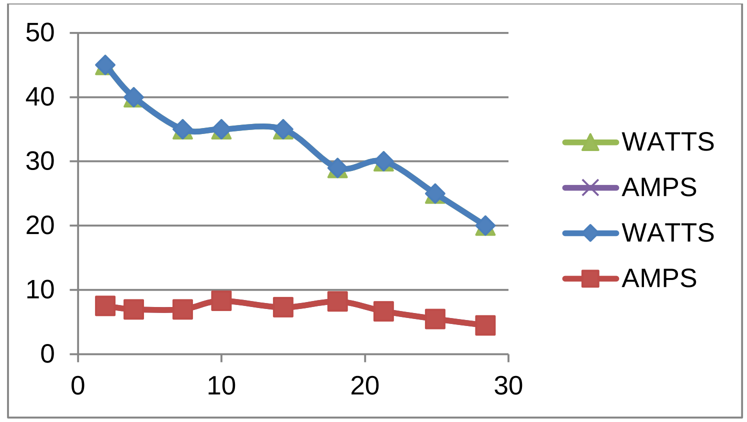
- For the purposes of discussion, we are using the 5W setting
- Select a LPF band that matches the transceiver band.
- In BYPASS mode, adjust the power out to 5W _______
- Switch to the ONLINE position and key down for a few seconds, Observe the power output and DC current.
- Record your power output 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. This may cause the SWR LED to light and switch the amp to bypass.

This chart was recorded on an earlier model but applies also to the miniHFPA.

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



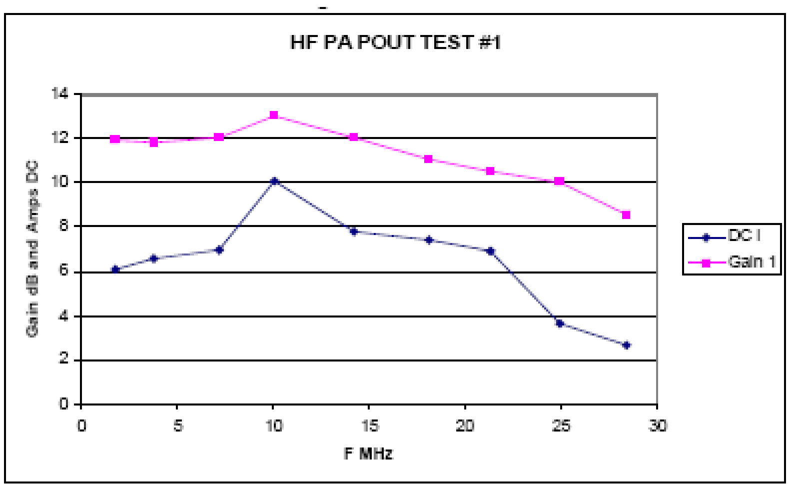
Frequency vs Watts vs Amps Plot

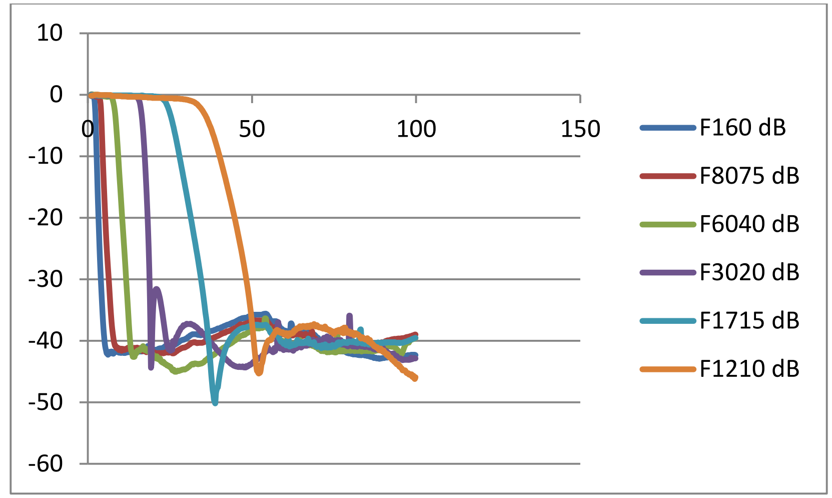
ⓘ Power Input Constant at 5W set for each band

PTT Connections FLEX 1500 and FT817

FLEX 1500 – Connect the center wire from the PTT jack to pin pin 3 of a serial connector which corresponds to the Flex 1500 Flexwire connector on the back of the radio. This connection allowed the Flex 1500 to key the Packer Amp. Do not connect the ground connection as the Amp and Radio are already referenced to the same ground. Using an additional ground connection has been reported to cause distortion.

FT817 – Connect the center wire from the PTT jack to pin 1 of the ACC jack on the FT817 (PTT). Do not connect the ground as the Amp and Radio are already referenced to the same ground. Using an additional ground connection has been reported to cause distortion.

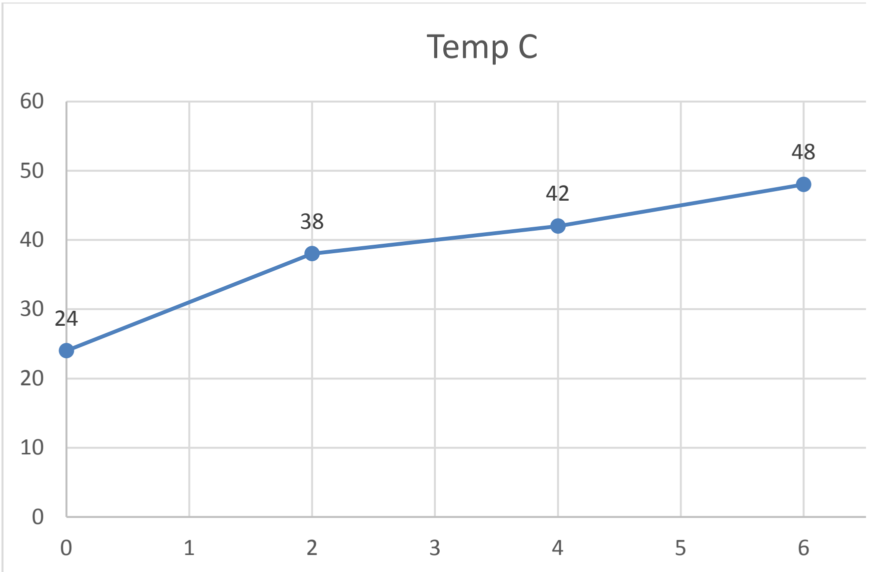




Consolidated Filter Response Where Y-axis = dB; X-axis = F MHz

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

The test was running CW in three two minute sprints with only a moment to read the temperature before continuing with the next run. The probe is placed on the metal edge of a MOSFET right after a 2 minute sprint is complete.



Time in Minutes vs Temperature in Degrees C

At the end of the test, the heat sink measured approximately 40 degrees C.

I also measured a DC/DC Converter Temperature of 64 degrees C. I only measured the end temperature after 6 minutes. The DC/DC Converter is connected to the heat sink by a ½ inch 6-32 threaded spacer.

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)
- Standy current: 73-79mA
- Chassis mount Power Pole Connector 30A contacts
- Power Switch: (Standby – On)
- RF In: BNC 5W Max Input (if 9dB pi-network installed)
- RF Out: BNC
- Power Out: nominal 30-35W Average 160 - 10M.
- 100% Modulation without distortion (according to 2-tone tests)
- Weight: 1lb 15 oz.
- Case Size: 6 x 6 x 3 inch
- Front panel toggle switchs: 0.5 inch additional length
- Rear panel controls: 0.5 inch additional length
- Heat sink Size: 2.25 .2.25 x 0.8 inch
- Front panel Switch: LPF, Standby –On, CW-SSB, Inline - Bypass
- LED Indicators: TX, 80/75, 60/40, 30/20, 17/15, 12/10, Power, SWR
- Case black anodize with white silkscreen legends front and rear.
- Case: Top, Bottom, Side (2),
- Rubber Feet
- 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 100mA per transistor. Easy pot adjustment.
- A test Jumper activates the PSU for adjustment.
- Spurious products -40 dB or better @ 35 watts
- Harmonic content -45 dB or better @ 35 watts
- Load tolerance 2:1 or better SWR recommended
- High SWR detect and switch to bypass
- Over current detect with thermal shutdown

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 1W up to a practical 5W limit. Resistor sets provided for 1W, 2.5W and 5W RF full scale input.

CW and Digital Modes: The AMP provides excellent operation for digital modes including PSK. Monitor the temperature. Adjust drive accordingly.

Do's and Don'ts for Successful Operation

- Do set the band switch to match the XCVR band
- Do not exceed the max RF drive limit.
- 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

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

ⓘ 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 HF Projects.
- Remove Power, unplug cables.
- 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.

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

- Follow the installation procedure in this manual.

- Re-install MOSFETs using the non metallic 6-32 x 5/16 cap head screws.

CW/SSB Selection

The front panel toggle switch selects CW or SSB hang time. CW hang time is 0.15 seconds while the SSB hang time is 0.50 seconds.

If you are using PTT, CW/SSB selection is not active and timing is solely dependent upon the PTT signal.

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 from2.5 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. 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. The kit is supplied with the power in cable.

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. The thermal circuit breaker is the tan colored tab that is mounted on the bottom layer of 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.

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, there are only a few components to make this chip work. We have the high current inductor, L4 50uH, the high current series diode D4 and the two resistors. The LT1270A 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 three electrolytic capacitors. The two resistors in the circuit 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. Your voltage may vary due to the tolerance of the resistors and other subtle variances. I find a typical of about 29.2V.. 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 29.2VDC.

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 29.2V 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 29.2V 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 29.2V 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.

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.

CONTROL

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

Big Picture

RF enters at the case mount BNC connector

U6 is a RF Module that provides RF detection for the amp without impacting the Input SWR. It consists of a dual CMOS Schmidt trigger device.

K2, K3 and J4

Relays K1 and K4 form the T/R (transmit/receive) function controlled by the control signal TX. K1 is used to divert the RF output from the transceiver to the AMP input. (Signal name RF_IN). If not in transmit, the signal passes through the normally closed contacts of K1 to K4. The also normally closed contacts of K1 (when not in transmit) are routed directly to J2 which is connected to the BNC RF Out connector on the rear panel. So in receive mode, the BNC Connector is connected to the other BNC connector. This is the bypass mode where you can operate the transceiver with the AMP out of the circuit. When K1and K4 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 and K2 back to K4. The diodes, D6 and D8, clamp the transient voltage that occurs when current stops flowing in K2 and K3. Without the diodes you will have a large spike voltage introcing noise into the system.

TX Signal Generation

The TX signal comes from the collector of Q9. This transistor output is either at 12V (receive) or 0V (transmit). Q9 is controlled by U2 pin 5 through R11. 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, R29.

PTT Control

We have discussed that the presence of RF through R23 can trigger TX. There is an additional way to achieve TX. It is by the Push-To-Talk input sensed on pin 3 of U2. 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

CW or SSB is selected by switch SW4. If you are using SSB, the amp will optimize the hold time for SSB operation. For CW operators, the default power up condition optimizes the hold time for CW..

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 front panel switch in the BYPASS position for the TEST jumper to function. If in bypass 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.

Note: The TEST jumper is transition sensitive since you are waking the processor when applying the jumper. Multiple transitions will cause the U2 chip not to respond. If this occurs, try again. You may have to cycle power and try again to get the LED to light.

5V Regulator

While we are on the CONTROL 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. (Vcc = 5V).

TX LED

The front panel houses the TX LED. This LED is powered by the transmit voltage (29.2V) 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 R24, the 3K 1/4w resistor.

MOSFET AMP 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 lower right 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 accidently 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

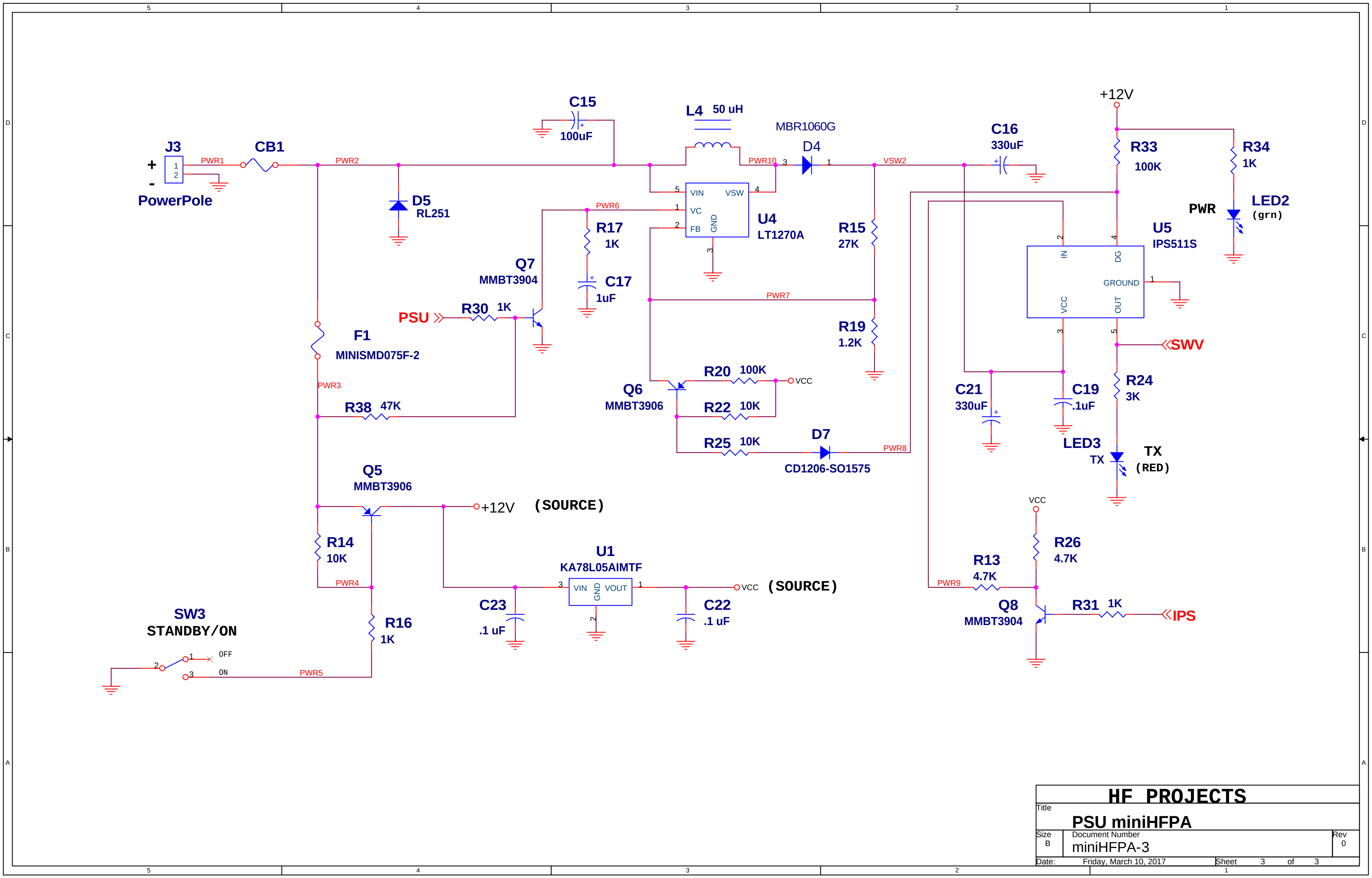
The 5 V bias supply voltage is derived from a 78L05 regulator. Bypass capacitors C3, C4, and C11, C13 and C22 remove RF voltages from the bias supply voltage. Gate bias for Q1 and Q2 is controlled independently. VR1 adjusts Q1's gate-bias voltage via R1 and L1. VR2 works similarly for Q2 via R2 and L3. 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 100mA 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 100mA. Now turn VR2 until you increase the current an additional 100mA. You may find the setting sensitive at the 100mA 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. Ceramic washers are used for an effective thermal solution. 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 is intimate contact with the ceramic washers below. Apply a thin layer of thermal compound (supplied in kit) to all surfaces from the metal on the MOSFET to the ceramic washers and the heat sink. 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.



J3
+
-
PowerPole
PWR1
CB1
PWR2
C15
100uF
L4 50 uH
MBR1060G
D4
PWR10
VSW2
C16
330uF
+12V
R33
100K
R34
1K
PWR
LED2
(grn)
D5
RL251
PWR6
R17
1K
C17
1uF
U4
LT1270A
VIN
VSW
VC
FB
GND
R15
27K
U5
IPS511S
IN
DG
GROUND
VCC
OUT
Q7
MMBT3904
PSU
R30 1K
PWR7
R19
1.2K
SWV
F1
MINISMD075F-2
PWR3
R20 100K
VCC
Q6
MMBT3906
C21
330uF
C19
.1uF
R24
3K
R38 47K
R22 10K
R25 10K
D7
CD1206-SO1575
PWR8
LED3
TX
TX
(RED)
Q5
MMBT3906
+12V (SOURCE)
R14
10K
PWR4
U1
KA78L05AIMTF
VIN
GND
VOUT
VCC (SOURCE)
C23
.1 uF
C22
.1 uF
R13
4.7K
PWR9
R26
4.7K
Q8
MMBT3904
R31 1K
IPS
SW3
STANDBY/ON
OFF
ON
PWR5
R16
1K
HF PROJECTS
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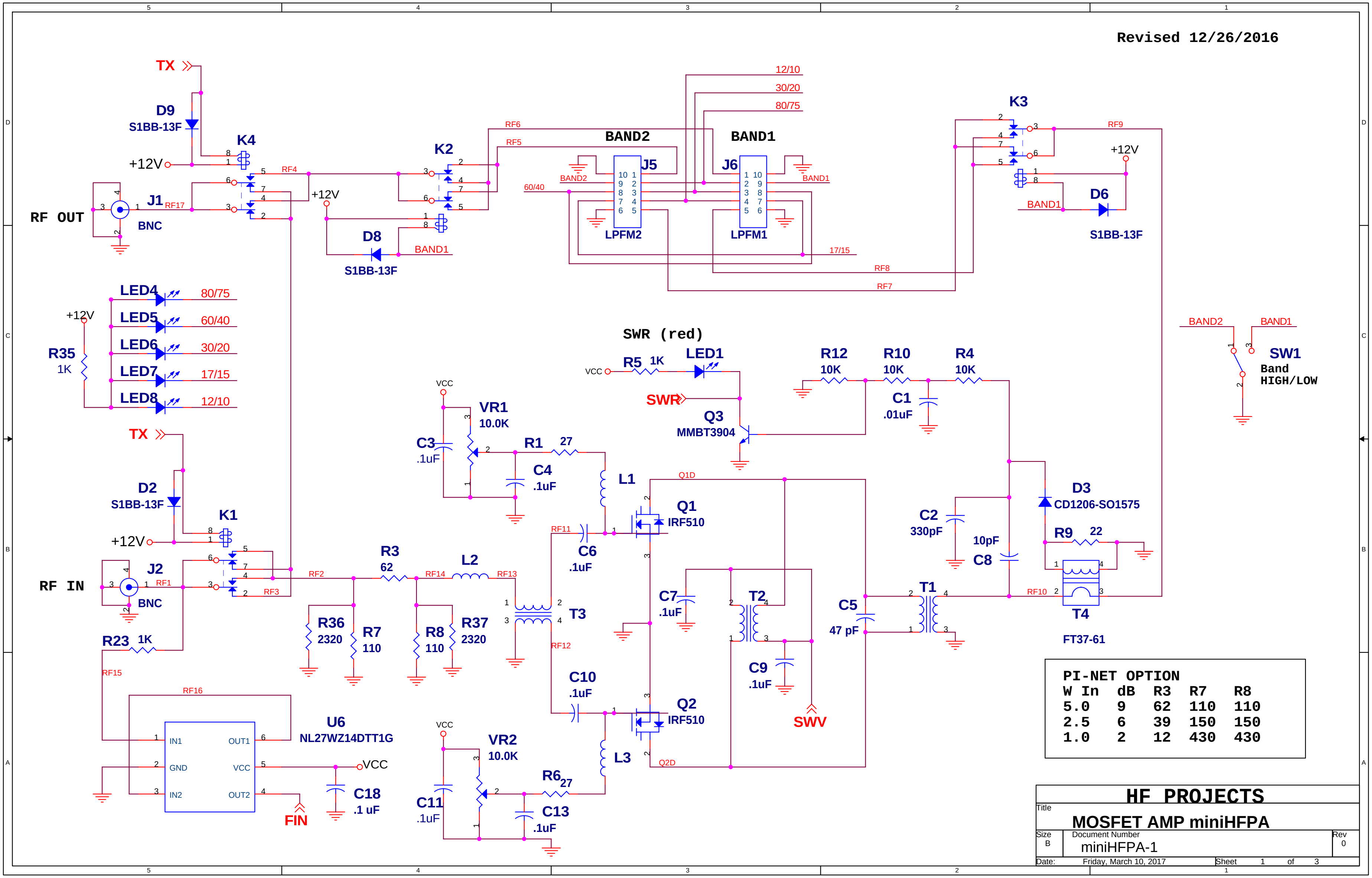
Size
B
Document Number
miniHFPA-3
Rev
0
Date: Friday, March 10, 2017
Sheet 3 of 3



Revised 12/26/2016
TX
D9
S1BB-13F
K4
+12V
RF OUT
J1
BNC
K2
D8
S1BB-13F
BAND1
BAND2
BAND1
J5
J6
LPFM2
LPFM1
12/10
30/20
80/75
60/40
17/15
K3
+12V
D6
S1BB-13F
LED4
LED5
LED6
LED7
LED8
80/75
60/40
30/20
17/15
12/10
+12V
R35
1K
SWR (red)
R5 1K
LED1
SWR
Q3
MMBT3904
R12 10K
R10 10K
R4 10K
C1 .01uF
BAND2
BAND1
SW1
Band
HIGH/LOW
TX
D2
S1BB-13F
K1
+12V
RF IN
J2
BNC
VR1 10.0K
C3 .1uF
R1 27
C4 .1uF
L1
Q1 IRF510
C6 .1uF
R3 62
L2
T3
D3
CD1206-SO1575
C2 330pF
10pF
C8
R9 22
T1
T4
FT37-61
C5 47 pF
C7 .1uF
T2
C9 .1uF
SWV
R36 2320
R7 110
R8 110
R37 2320
R23 1K
C10 .1uF
Q2 IRF510
L3
U6
NL27WZ14DTT1G
IN1
GND
IN2
OUT1
VCC
OUT2
VCC
C18 .1 uF
FIN
VR2 10.0K
C11 .1uF
R6 27
C13 .1uF
PI-NET OPTION
W In dB R3 R7 R8
5.0 9 62 110 110
2.5 6 39 150 150
1.0 2 12 430 430
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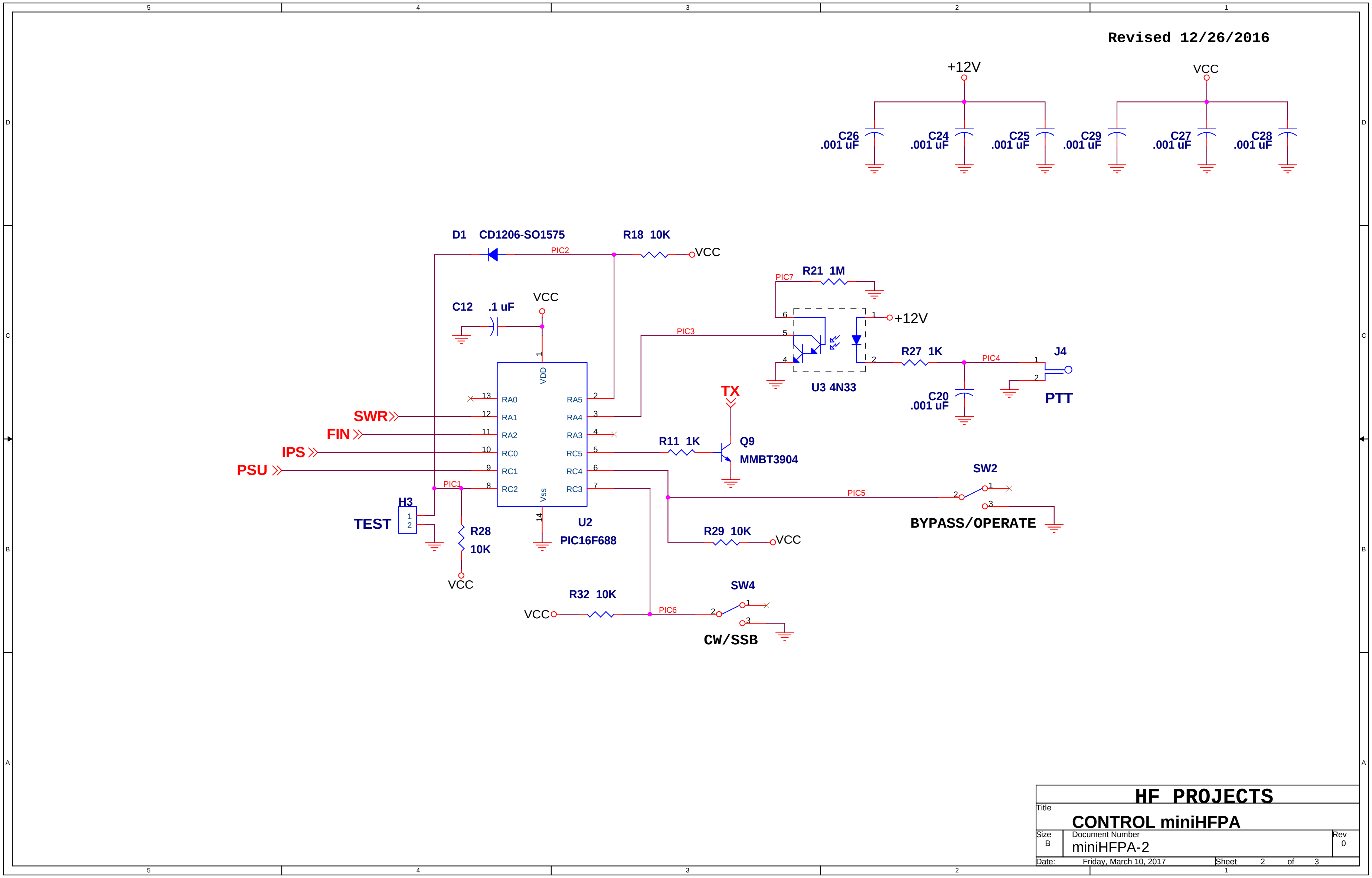
Size B
Document Number
miniHFPA-1
Rev 0
Date: Friday, March 10, 2017
Sheet 1 of 3



Revised 12/26/2016
+12V
VCC
C26 .001 uF
C24 .001 uF
C25 .001 uF
C29 .001 uF
C27 .001 uF
C28 .001 uF
D1 CD1206-SO1575
R18 10K
PIC2
VCC
R21 1M
PIC7
C12 .1 uF
VCC
PIC3
+12V
U3 4N33
R27 1K
PIC4
J4
PTT
C20 .001 uF
VDD
RA0
RA1
RA2
RC0
RC1
RC2
RA5
RA4
RA3
RC5
RC4
RC3
Vss
SWR
FIN
IPS
PSU
TX
R11 1K
Q9
MMBT3904
SW2
PIC5
BYPASS/OPERATE
PIC1
H3
TEST
R28 10K
VCC
U2
PIC16F688
R29 10K
VCC
R32 10K
VCC
PIC6
SW4
CW/SSB
HF PROJECTS
Title
CONTROL miniHFPA
Size B
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miniHFPA-2
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BUILD LIST

revised
1/29/2017

LPF160, jumper none JP1
L1:T68-1=5.08uH, 20T , L2=open
L3:T68-1=5.08uH, 20T,
C1=open, C2=jumper, C3=open
C4L=1500pF, C5L=2700, C6L=open, C7=1500pF
19 inch x 2 Belden 8051

LPF8075, jumper 1-6 JP1
L1:T50-2=2.65uH, 21T , L2=0 ohm
L3:T50-2=2.65uH, 21T,
C1=open, C2=open, C3=open
C4L=1000pF, C5L=1800, C6L=open, C7=1000pF
17 inch x 2 Belden 8051

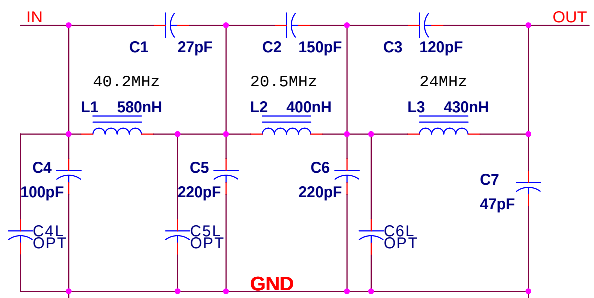
LPF6040, jumper 2-6 JP1
L1:T50-2=1.37uH, 21.8MHz, 15T 13 in.
L2:T50-2=1.17uH, 14.0MHz, 13T 12 in.
L3=0 ohm
C1=39pF, C2=110pF, C3=open
C4=390pF, C5L=680pF, C6=330pF, C7=open
12 inch x 2 Belden 8051

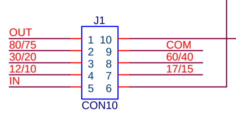
LPF3020, jumper 3-6 JP1
L1:T50-10 580nH, 40.2MHz, 10T
L2:T50-10 =400nH, 20.5MHz, 9T
L3:T50-10 =430nH, 24.4MHz, 10T
C1=27pF, C2=150pF, C3=120pF,
C4=100pF, C5=220pF, C6=220pF,
C7=47pF
8 inch x 3 Belden 8051

LPF1715, jumper 4-6 JP1
L1:T50-10 =470nH, 67MHz, 11T
L2:T50-10 =430uH, 37.2MHz, 10T
L3=0 ohm
C1=12pF, C2=39pF, C3=0 ohm
C4=150pF, C5=220pF, C6=100pF, C7=open
8 inch x 2 Belden 8051

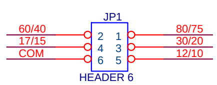
LPF1210, jumper 5-6 JP1
L1:T50-10 =380nH, 67.2MHz, 8T 9in.
L2:T50-10=330nH, 44.8MHz, 7T 8in.
L3= T50-10=330nH 53.5 MHz, 7T 8in.
C1=18pF, C2=47pF, C3=33pF
C4=68pF, C5=150pF, C6=150pF, C7= 82pF
7 inch x 2 Belden 8051

Note: C4, C5 and C6 have an alternate footprint identified as C4L, C5L and C6L. Refer to Build List.





30/20 Value shown as reference



JP1 Programming:
Insert wire jumper between pin 6 and another pad to set the board identity
See Build List

HF PROJECTS		
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Size: B	Document Number: <Doc>	Rev: 0
Date: Friday, March 10, 2017	Sheet 1 of 1	

		miniHFPA Assembly		Update: 2/24/2017	
Item	Quantity	Reference	Description	Mfg and Part Number	
1	1	Circuit Board	Circuit board blank		
2	1	SMT Assembly	SMT assembly services		
		SMT Components	MACHINE PRE-INSTALLED		
Item	Quantity	Reference	Description	Mfg and Part Number	
1	1	C8	Multilayer Ceramic Capacitors MLCC - SMD/SMT 1206 10pF 50volts C0G 5% Vishay / Vitramon	77-VJ1206A100JXAPW1BC	
2					
3	1	C2	Multilayer Ceramic Capacitors MLCC - SMD/SMT 1206 330pF 25volts X7R 10% Vishay / Vitramon	77-VJ1206Y331KXXCBC	
4	7	C20,C24,C25,C26,C27,C28,C29	Multilayer Ceramic Capacitors MLCC - SMD/SMT 200V 1000pF C0G 1206 10% Tol AVX	581-12062A102K	
5	1	C1	Multilayer Ceramic Capacitors MLCC - SMD/SMT .01uF 50volts 10% X7R Vishay / Vitramon	77-VJ1206Y103KXAAC	
6	13	C3,C4,C6,C7,C9,C10,C11,C13,C19,C12,C18,C22,C23	80-C1206104K5RAC7867 C1206C104K5RAC7867 .1uF Kemet Multilayer Ceramic Capacitors MLCC - SMD/SMT	80C-C1206104K5RAC7867	

7	1	C17	Multilayer Ceramic Capacitors MLCC - SMD/SMT 1.0uF 10V X7R 10%	603-CC805KKX7R6BB105 case 0805	
8	3	D1,D3,D7	Diodes - General Purpose, Power, Switching IO=150mA VR=75V HIGH SPEED	Bournes: 652-CD1206-S01575	
9	4	D2,D6,D8,D9	Diodes - 100V, 1A S1BB--13F	Diodes, Inc 621-S1BB-F	
10	1	F1	Resettable Fuses - PPTC .75A 13.2V 100A Imax	650-MINISMDC075F-2	
11	4	Q3,Q7,Q8,Q9	Bipolar Transistors - BJT SOT-23 NPN GEN PUR	512-MMBT3904 Fairchild	
12	2	Q5,Q6	Bipolar Transistors - BJT PNP General Purpose	512-MMBT3906 Fairchild	
13	10	R5,R11,R16,R17,R23,R27,R30,R31,R34,R35	Resistor, Thin Film Resistors - SMD 1/4W 1K ohm 1% 50ppm	Yageo: RT1206FRE071KL	
14	1	R19	Thin Film Resistors - SMD 1/4W 1.2K ohm 1% 50ppm	Yageo: RT1206FRE071K2L	
15	2	R36, R37	Thick Film Resistors - SMD 1/4watt 2.32Kohms 1%	Vishay 71-CRCW1206-2.32K-E3	
16	1	R24	Thick Film Resistors - SMD 1206 3Kohms 1% Tol AEC-Q200	Panasonic 667-ERJ-8ENF3001V	
17	2	R13,R26	Thin Film Resistors - SMD 4.7K Ohm 1% 1/4W 200 Volts 50ppm	Yageo: RT1206FRE074K7L	
18	10	R4,R10,R12,R14,R18,R22,R25,R28,R29,R32	Thin Film Resistors - SMD 1/4W 10K ohm 1% 50ppm	Yageo: RT1206FRE0710KL	
19	1	R15	Resistor, 27K Thin Film Resistors - SMD	Yageo: RT1206FRE0727KL	
20	2	R33,R20	Thin Film Resistors - SMD 1/4W 100K ohm 1% 50ppm	Yageo: RT1206FRE07100KL	
21	1	R21	Thin Film Resistors - SMD 1/4W 1M ohm 1% 50ppm	Yageo: RT1206FRE071ML	
22	1	R38	Thin Film Resistors - SMD 1/4W 47K ohm 1% 50ppm	Yageo: RT1206FRE0747KL	

23	1	U5	IC, Intellegent Power Switch IPS511S Series 35V 135mOhm Fully Protected High Side Power Mosfet Switch D2PAK-5	IPS511S	
24	1	U6	IC, Dual Schmidt Trigger	863-NL27WZ14DTT1G	
25	1	U1	IC 3-TERM 0.1A 5V POS REG	512-KA78L05AIMTF	

		Through-hole parts			
Item	Quantity	Reference	Description	Mfg and Part Number	
1	1	C15	. Aluminum Electrolytic Capacitors - Leaded 50V 100uF 105C 10x16 mm	Lelon RXJ101M1HBK-1016P	
2	2	C21,C16	Aluminum Electrolytic Capacitors - Leaded 35volts 470uF 10x16x5 mm, LOW ESR	667--EEU-FR1V471	
3	1	D4	Schottky Diodes & Rectifiers 10A 60V	ON Semiconductor 863-MBR1060G	
4	1	D5	Diode, 2.5A 100 PRV DO41 RL251-B Rectron	583-RL251	
5	1	H3	Header .100 K.K. Connector 2 CKT	Molex 538-22-03-2021	
6	2	J1,J2	Connector, 50 ohm PCB Jack	PN: 5413631-2	
7	2	J3	Printed Circuit Board (PCB) 25 Amp Contact	1377G1	
8	1	J4	Connector, RCA Jack PC Mtg R/A	Right Angle 534-900	
9	2	J5,J6	Header Assembly: Harwin, M20-9740546 05+05 2.54 pitch SIL Horizontal PC Tail PIN Header Assembly	Harwin: 855-M20-9740546	
10	4	K1,K2,K3,K4	Relay, 12VDC Non-latching Single coil P2 Tyco Electronics/ Axicom V23079A1003B301	655-V23079A1003B301	
11	7	LED2-LED8 GRN	LED, Circuit Board Indicator - GRN	Dialight 551-0209F	
12	1	L4	NDUCTOR 70-IH-5-50 RADIAL HI CUR 50uH DALE/VISHAY	70-IH-5-50	
13	2	Q2,Q1	MOSFET, TO-220AB N-Ch Power Fairchild IRF510	844-IRF510PBF	
14	1	R9	Metal Oxide Resistors 22ohms 5% Tol RED-RED-BLK	282-22-RC Xicon	

15	2	R6,R1	Carbon Film Resistors - 27ohms RED-VIO-BLK	293-27-RC	
16	1	LED1 (SWR)	LED, Circuit Board Indicator - RED	645-551-0409F	
17	1	R3 (for 5W Full Scale) 9dB pi network	Resistor, 62 ohm 2W BLU-RED-BLK	282-62-RC	
18	2	R7,R8 (for 5W Full Scale) 9dB pi network	Resistor, 100 ohm 2W BRN-BLK-RED	282-100-RC	
19	4	SW1,SW2,SW3,SW4	Toggle Switches Mini Toggl SP PC MNT ON-NONE-ON	Carling 2M1-SP1-T2-B4-M6RE	
20	1	U2	IC, Microchip PIC16F688-E/P Microchip Microcontrollers (MCU) 7KB 256 RAM 12 I/O	579-PIC16F688-E/P	
21	1	U2	Socket, 14 pin DIP D2814-42 Harwin	855-D2814-42	
22	1	U3	Transistor Output Optocouplers Photodarlington Out 4N33 Vishay	78-4N33 Vishay	
23	1	U4	Integrated Circuit, LT1270ACT 10 AMP PWR SWITCH	LT1270ACT#PBF	
24	2	VR2,VR1	Pot, 10K 652-3362P-1-103 10K	72-T93YA-10K Vishay	
25	1	Used with J3	Cable Ties *PAN-TY* CABLE TIE Panduit	644-PLT1M-M69	
26	1	Used with U2	SHUNT OPEN TOP	538-15-38-1024 Molex	
27	1	U4 Stick on Heat Spreader	BNTECHGO 8.8mm x 8.8mm x 5mm Black Aluminum Heatsink Cooling Fin 8.8mm x 8.8mm x 0.5mm Silicone Based Thermal Pad	BNTECHGO order through AMAZON	
28	8	Round Spacer #2 Nylon 3/16 x 3/16 inch .	.BIVAR: 9913-187	Digi-Key 492-1048-ND	
29	8	Self Tapping Screw 4-40 x 1/4 in	4-40 Screw: Philips Pan Head Self tapping	MS-ST-4-40-1/4 TubeDepot.com	

30	1	CB1	Resettable Fuse - PPTC	lITTLEfUSE: 650-RGEF1200	
31	2	Housing - Power Pole	Red and Black pair	P30-50	
32	4	Screw 4-40 Pan	4-40 x 1/4 Pan Phil	MSPPK0404	
33	1	C5	Capacitor, 47pF dip silver mica		
34	1	Heat Sink used with U4	AAVID Thermalloy TO-220 HORZ 15.6 TR507102B00000G	532-507102B00	
35	0				
36	1	screw 6-32x1/4	PMSSS 632 0025 PH	MSPPK0604 MICRO	
37	1	R3 (for 2.5W Full Scale) 6dB pi network	Resistor, 39 ohm 2W ORN-WHT-BLK	282-39-RC	
38	2	R7,R8 (for 2.5W Full Scale) 6dB pi network	Resistor, 160 ohm 2W BRN-BLU-BRN	282-160-RC	
39	1	R3 (for 1W Full Scale) 2dB pi network	Resistor 12 ohm, 1W BRN-RED-BLK	281-12-RC	
40	2	R7,R8 (for 1W Full Scale) 6dB pi network	Resistor 430 ohm, 2W YEL-ORN-BRN	282-430-RC	

Fabricated Magnetics

Item	Quantity	Reference	Description	Mfg and Part Number
1	20 in.	L1,L3	INDUCTOR	#24 wire 10 in. x 2
2	4 in.	L2	INDUCTOR	#24 wire 4 in
3	1	T3	Transformer, Input	FT50-43 .
4	22 in.	T3 #24 wire	wire 24 awg	11 inch x 2
5	2	T2	Transformer, DC Feed	FT50-43 .
6	30 in.	T2 #24 wire	wire 24 awg	15 inch x 2
7	1	T1	Balun Core Binocular	BN-43-3312 + silver plate wires
8	1	T1 Yellow 7 inch PRIMARY	Wire 20 AWG Yellow Silver Plate Marvec Electronics through AMAZON	GPW T20-04-25 SKU: 1968
9	1	T1 White 10 inch SECONDARY	Wire 20 AWG White Silver Plate Marvec Electronics through AMAZON	GPW T20-04-25 SKU: 1973
10	1	T4	Transformer, SWR	Mouser: Fair-rite 623-5961000201 or FT37-61
11	12 in	T4 wire	Transformer, SWR	#28 wire 18T 12 inch
12	1 in.	T4 wire	Transformer, SWR	#22 wire 1T

miniHFPA CASE

Item	Quantity	Reference CASE	Description ASSEMBLY	Mfg and Part Number
1	1	special order 50 units	HEAT SINK including drill and tap. The interfering fins will be removed.	Alpha Novatech N13070B-20 customized for 0.6 inch height

2	1	Top Cover, bottom cover, side panels, black anodize and 2 screened panels	Fabricated Case Assembly (100 qty)	Gauthier Industries, Inc.	
3	1	Thermal Paste 1 oz.	Thermal Paste 1 oz	SPHINX LOT OF 5 PACK SILVER Thermal Grease CPU GPU PS2 PS3 XBOX HeatSink Compound Paste Syringe AMAZON	
4	1	Hex Key	Allen Long Arm 7/64 Hex Key	RESTOCKIT INC 023-58005	
5	4	Standoffs & Spacers PCB to Heat sink anchor	Standoffs & Spacers 3/16 HEX 1/2" LNGTH ALUM 440 THREAD M/F	FASCOMP FC4505-440-A	
6	1	3/16'' OD Hex #6-32 x 1/2'' Standoff Male to Female Aluminum Iridite	RAF Electronics Jameco	RAF Electronics 4505-632-AL-7	
7	4	4-40 x D1141/4 - Flat Head Machine Screws	FMPPK0404 - 4-40 x 1/4 - Flat Head Machine Screws - Phillips	FMPPK0404 - MicroFasteners	
8	13	screw - 4-40 x 1/4 - Pan Head	MSPPK0404 - 4-40 x 1/4 - Pan Head Machine Screws - Phillips - Steel with Black Oxide Plating	MSPPK0404 - MicroFasteners	
9	2	Hex Socket	Hex Socket 6-32 x 5/16	Fastnel 731384069	
10	2	Washer Lock	#6 SS	16028 Bolt Depot	
11	4	FEET		537-F2	
12	2	uses with Q1 Q2	Aluminum Oxide Insulator TO-220	4171G Aavid Thermalloy	

Fabricated Plastics

Item	Quantity	Reference	Description	Mfg and Part Number

		CASE	ASSEMBLY		
1	1	Impact resistant Polycarbonite Channel .490 x .400 legs .060 thickness	Switch Guard Assembly 4 inch	McMASTER-CARR 1753K13	

Item	Quantity	Reference	Description	Mfg and Part Number	
		LPF160			
1	1		Circuit Board	miniLPF	
2	2	C7, C4	1500Pf	Cap 500V (DSM) 5%	
3	1	C5	2700pF	Cap 500V (DSM) 5%	
4	2	L1,L2	T68-1	Core	
5	17	Belden: 8051 (18 inch each)	Wire #22 AWG 19 inch 20T 5.08uH	Belden 8051	
6	17	Belden: 8051 (18 inch each)	Wire #22 AWG 19 inch 20T 5.08uH	Belden 8051	
7	1	J1	Socket Assembly: Harwin M20-7880546L 2.54mm Pitch DIL PC Tail Horizotal Socket	HARWIN: 855-M20-7880546	
8	4	Spacer 1/4 in Standoff; 1/4 Round; Female; Threaded 4-40; Length .250; Alum/Clear Iridite	Standoff; 1/4 Round; Female; Threaded 4-40; Length .250; Alum/Clear Iridite	3478	
9	4	Screw 4-40 x 1/4 in	Pan Phil Black Oxide	MSPPK0404	
10	1	Label .5x.5	printed label - white gloss	ONLINELABELS.COM OL2050WG	

Item	Quantity	Reference	Description	Mfg and Part Number	
		LPF8075			
1	1		Circuit Board	miniLPF	

2	2	C4, C6	1000Pf	Cap 500V (DSM) 5%	
3	1	C5	1800pF	Cap 500V (DSM) 5%	
4	2	L1,L2	T50-2	Core	
5	17	Belden: 8051 (18 inch each)	Wire #22 AWG 17 inch 22T 2.65uH	Belden 8051	
6	17	Belden: 8051 (18 inch each)	Wire #22 AWG 17 inch 22T 2.65uH	Belden 8051	
7	1	J1	Socket Assembly: Harwin M20-7880546L 2.54mm Pitch DIL PC Tail Horizotal Socket	HARWIN: 855-M20-7880546	
8	4	Spacer 1/4 in Standoff; 1/4 Round; Female; Threaded 4-40; Length .250; Alum/Clear Iridite	Standoff; 1/4 Round; Female; Threaded 4-40; Length .250; Alum/Clear Iridite	3478	
9	4	Screw 4-40 x 1/4 in	Pan Phil Black Oxide	MSPPK0404	
10	1	Label .5x.5	printed label - white gloss	ONLINELABELS.COM OL2050WG	

Item	Quantity	Reference **LPF6040**	Description	Mfg and Part Number	
1	1		Circuit Board	miniLPF	
2	1	C1	39pF	Cap 500V (DSM) 5%	
3	1	C2	110pF	Cap 500V (DSM) 5%	
4	1	C4	390pF	Cap 500V (DSM) 5%	
5	1	C5	680pF	Cap 500V (DSM) 5%	
6	1	C6	330pF	Cap 500V (DSM) 5%	
7	2	L1,L2	T50-2 (RED)	Core T50-2 (Red) PartsAndKits	
8	13	Belden: 8051 (13 inch)	Wire # 22 AWG 13 inch, 15T: 0.37uH	Belden 8051	
9	12	Belden: 8051 (12 inch)	Wire # 22 AWG 12 inch, 13T: 0.17uH	Belden 8051	

10	1	J1	Socket Assembly: Harwin M20-7880546L 2.54mm Pitch DIL PC Tail Horizotal Socket	HARWIN: 855-M20-7880546	
11	4	Spacer 1/4 x 4-40 alum.	.25 x .25 alum round threaded spacer 4-40	Keystone 534-3478	
12	4	Screw 4-40 x 1/4 in	Pan Phil Black Oxide	MSPPK0404	
13	1	Label .5x.5	printed label - white gloss	ONLINELABELS.COM OL2050WG	

Item	Quantity	Reference LPF3020	Description	Mfg and Part Number	
1	1		Circuit Board	miniLPF	
2	1	C1	27pF	Cap 500V (DSM) 5%	
3	1	C3	120pF	Cap 500V (DSM) 5%	
3	1	C4	100pF	Cap 500V (DSM) 5%	
4	1	C2	150pF	Cap 500V (DSM) 5%	
5	2	C5,C6	220pF	Cap 500V (DSM) 5%	
6	1	C7	47pF	Cap 500V (DSM) 5%	
7	10	L1 Belden 8051 (11 inches each)	Wire # 22 AWG 10T	Belden 8051	
8	10	L2 Belden 8051 (11 inches each)	Wire # 22 AWG 9T	Belden 8051	
9	10	L3 Belden 8051 (11 inches each)	Wire # 22 AWG 10T	Belden 8051	
10	3	L1,L2,L3	T50-10 (Black)	Core T50-10 (Black) PartsAndKits	
11	1	J1	Socket Assembly: Harwin M20-7880546L 2.54mm Pitch DIL PC Tail Horizotal Socket	HARWIN: 855-M20-7880546	
12	4	Spacer 1/4 x 4-40 alum.	.25 x .25 alum round threaded spacer 4-40	Keystone 534-3478	
13	4	Screw 4-40 x 1/4 in	Pan Phil Black Oxide	MSPPK0404	
14	1	Label .5x.5	printed label - white gloss	ONLINELABELS.COM OL2050WG	

Item	Quantity	Reference	Description	Mfg and Part Number	
		LPF1715			
1	1		Circuit Board	miniLPF (qty=200)	
2	1	C1	12pF	Cap 500V (DSM) 5%	
3	1	C2	39pF	Cap 500V (DSM) 5%	
4	1	C4	150pF	Cap 500V (DSM) 5%	
5	1	C5	220pF	Cap 500V (DSM) 5%	
6	1	C6	100pF	Cap 500V (DSM) 5%	
7	10	Belden 8051 (10 inches each)	Wire # 22 AWG 11T 0.47uH	Belden 8051	
8	10	Belden 8051 (10 inches each)	Wire # 22 AWG 10T 0.43uH	Belden 8051	
9	2	L1,L2	T50-10 (Black)	Core: T50-10 (Black)	
10	1	J1	Socket Assembly: Harwin M20-7880546L 2.54mm Pitch DIL PC Tail Horizotal Socket	HARWIN: 855-M20-7880546	
11	4	Spacer 1/4 x 4-40 alum.	.25 x .25 alum round threaded spacer 4-40	Keystone 534-3478	
12	4	Screw 4-40 x 1/4 in	Pan Phil Black Oxide	MSPPK0404	
13	1	Label .5x.5	printed label - white gloss	ONLINELABELS.COM OL2050WG	

Item	Quantity	Reference	Description	Mfg and Part Number	
		LPF1210			
1	1		Circuit Board	miniLPF (qty=200)	
2	1	C1	18pF	Cap 500V (DSM) 5%	
3	1	C2	47pF	Cap 500V (DSM) 5%	
4	1	C3	33pF	Cap 500V (DSM) 5%	
4	1	C4	68pF	Cap 500V (DSM) 5%	
5	2	C5, C6	150pF	Cap 500V (DSM) 5%	
6	1	C7	82pF	Cap 500V (DSM) 5%	

7	9	Belden 8051 9 inch 8T .38uH	Wire # 22 AWG	Belden 8051	
8	8	Belden 8051 (8 inches X 2) 7T .33uH	Wire # 22 AWG	Belden 8051	
9	8	Belden 8051 (8 inches X 2) 7T .33uH	Wire # 22 AWG	Belden 8051	
10	3	L1,L2,L3	T50-10 (Black)	Core: T50-10 (Black)	
11	1	J1	Socket Assembly: Harwin M20-7880546L 2.54mm Pitch DIL PC Tail Horizotal Socket	HARWIN: 855-M20-7880546	
12	4	Spacer 1/4 x 4-40 alum.	.25 x .25 alum round threaded spacer 4-40	Keystone 534-3478	
13	4	Screw 4-40 x 1/4 in	Pan Phil Black Oxide	MSPPK0404	
14	1	Label .5x.5	printed label - white gloss	ONLINELABELS.COM OL2050WG	
		Power Cable			
Item	**Quantity**	**Reference**	**Description**	**Mfg and Part Number**	
1	1	2 ft of #14 AWG R/B cable	Red/Black Zip Cord (Guage: 14 Length: 2 ft)	Wire-RB-14-100 Powerwerx	
2	1	Red/Black Power Pole Connector bonded	Red/Black Power Pole Connector bonded	WP30-50 Powerwerx	