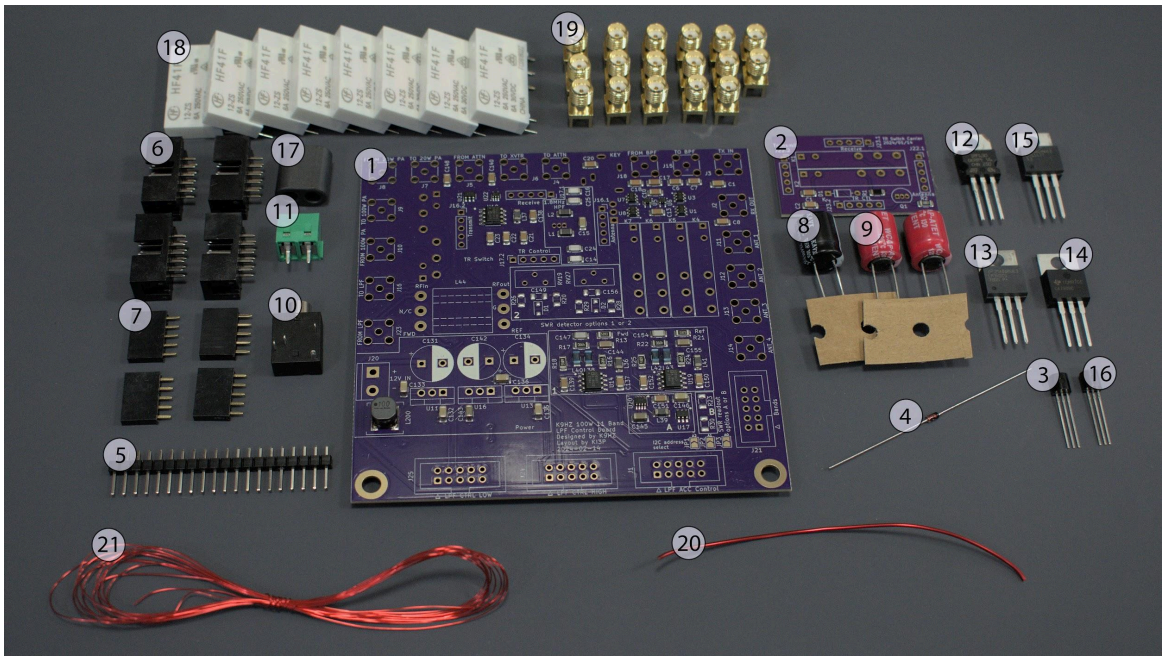
T41-EP SDT v12 LPF Control Module Assembly Manual



by Justin Giorgi (AI6YM) and Dr. Jack Purdum (W8TEE)

The T41 v12's LPF Control Board does far more than just control the relays on the LPF board. This module routes RF signals in and out of all other T41 modules, making room for several optional upgrades including a second-stage amplifier and a transverter. The module also incorporates a four antenna switch, transmit-receive switch, high-precision digital SWR meter, and (of course) digital control of the relays on the LPF board.

What's Included (Parts List)

1. (1) LPF Control Board
2. (1) TR Carrier Board
3. (1) BS170 Transistor
4. (1) 1N4148 Signal Diode
5. (1) 20pin 2.54mm Male Header
6. (4) 2×5 IDC Box Headers
7. (4) 5pin 2.54mm Female Headers
8. (1) 100uF 6v Electrolytic Capacitor
9. (2) 200uF 16V Electrolytic Capacitors

10. (1) ⅛” Audio Jack
11. (1) 2pin Molex Block
12. (1) IRF630 Transistor
13. (1) LM7805 5V Voltage Regulator
14. (1) UA7808 8V Voltage Regulator
15. (1) LM1117T-3.3 3.3V Voltage Regulator
16. (1) BN43-202 Transformer Core
17. (8) 12V Relays
18. (17) SMA PCB Connectors
19. 7cm (3”) of #20 Magnet Wire
20. 150cm (5’) of #30 Magnet Wire

Missing a part? Send an email to justin@ai6ym.radio.

You Will Need

1. Soldering Station, hot air or separate heat gun optional but recommended.
2. Multimeter
3. PCB Vise or Helping Hands
4. Jewelers Loupe
5. Wire cutters
6. Sandpaper or Hobby Knife
7. Solder of your preference, 60/40 tin/lead is recommended.
8. Flux Paste
9. Polyimide (Kapton) Tape
10. Solder Wick
11. NanoVNA (or comparable)

Safety Matters!

Soldering irons are hot. Everything they touch gets hot.

Have a fire extinguisher nearby!

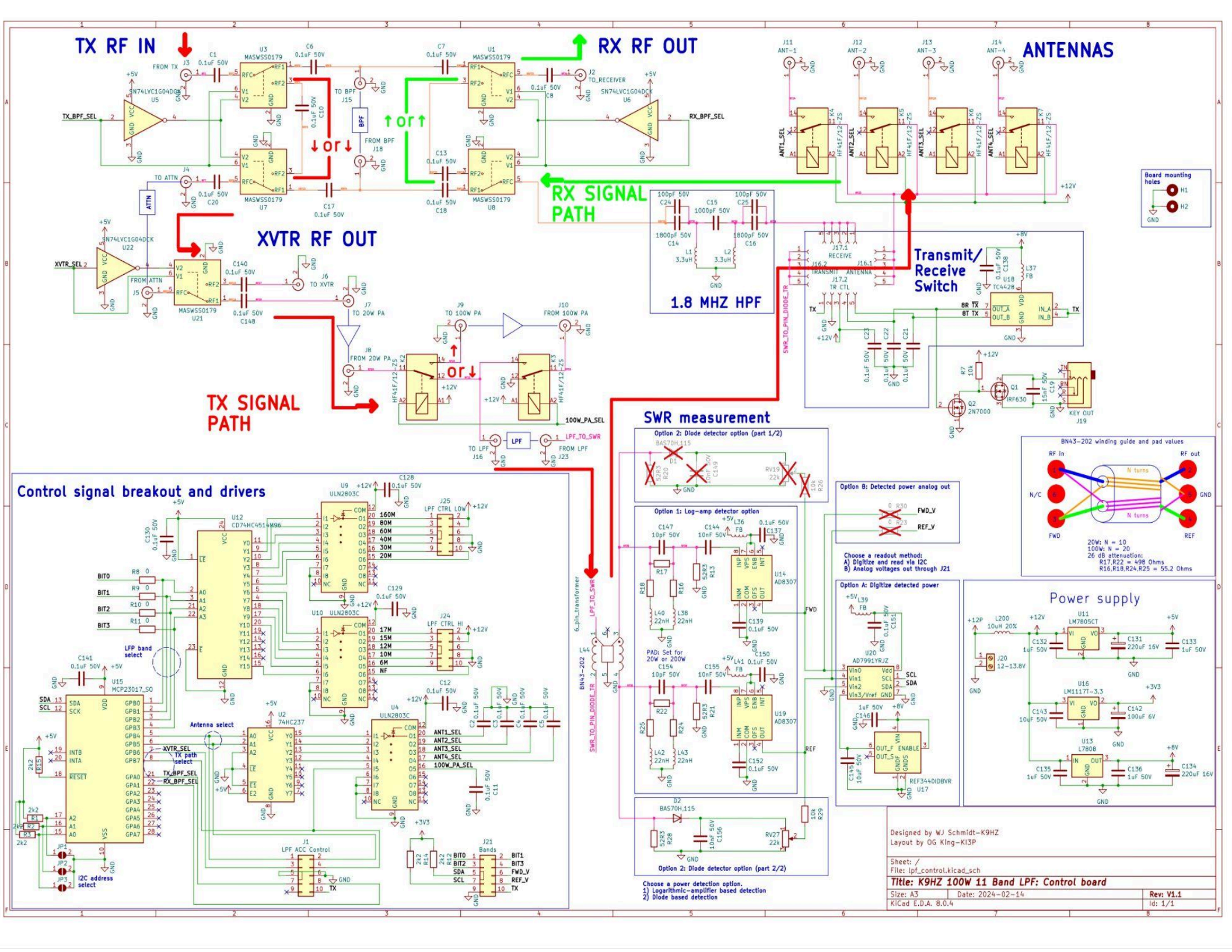
Solder splatters. Your eyes are not easily replaceable.

Wear your PPE!

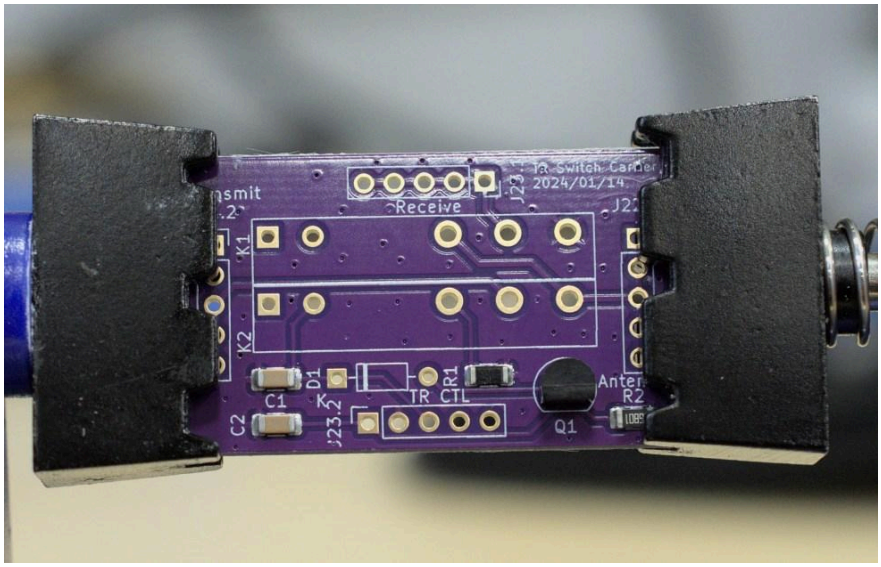
Fumes from heating the enamel coating on magnet wire can be dangerous.

Work in a well ventilated area!

Schematic


TX RF IN
RX RF OUT
ANTENNAS
RX SIGNAL PATH
XVTR RF OUT
TX SIGNAL PATH
1.8 MHZ HPF
Transmit/ Receive Switch
SWR measurement
Control signal breakout and drivers
Power supply
Board mounting holes
Option 2: Diode detector option (part 1/2)
Option 1: Log-amp detector option
Option B: Detected power analog out
Option A: Digitize detected power
Option 2: Diode detector option (part 2/2)
BN43-202 winding guide and pad values
Designed by WJ Schmidt-K9HZ
Layout by OG King-KI3P
Title: K9HZ 100W 11 Band LPF: Control board
Size: A3
Date: 2024-02-14
Rev: V1.1
KiCad E.D.A. 8.0.4
Id: 1/1

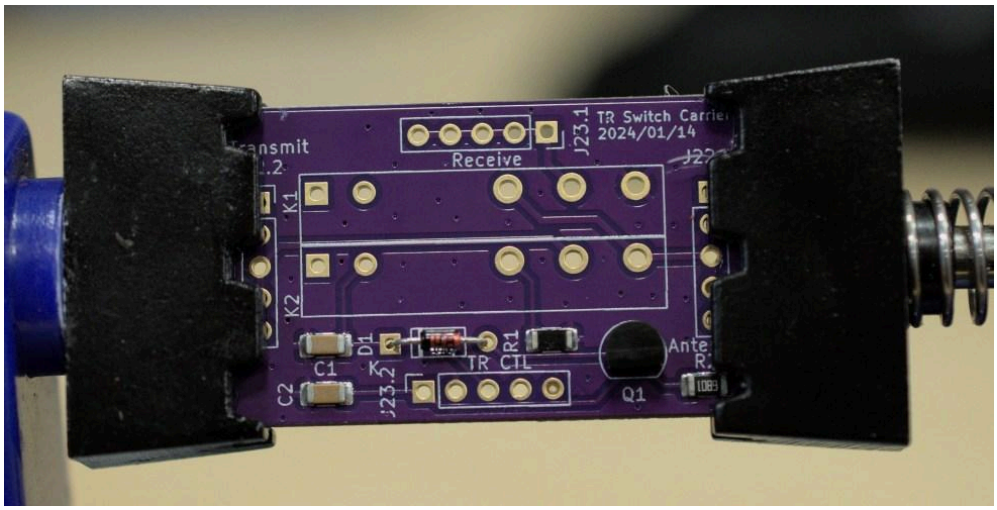
Assemble the TR Carrier Board

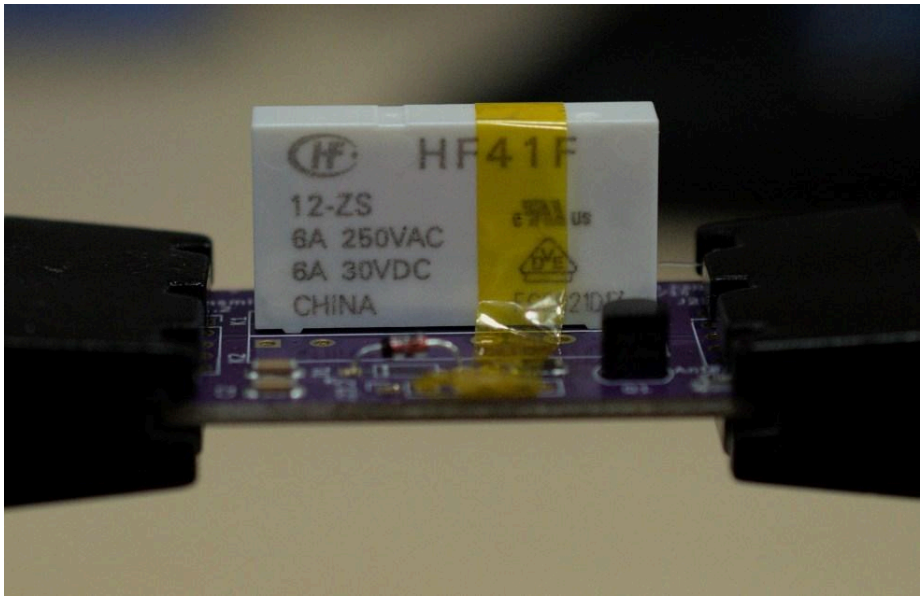


Start by assembling the TR Carrier Board. Place the BS170 transistor at *Q1* and secure it with tape. Solder from the back side of the board. Inspect the solder joints carefully with a loupe, these pins are closely spaced and very easy to bridge with solder. If you see any bridging remove the excess solder with a solder sucker or solder wick. Trim excess length from the leads.

Pro-Tip: Use a jeweler's loupe or a digital camera with a good lens to read the part numbers on small packages. This kit contains multiple different parts in TO-92 packages. They are not interchangeable!

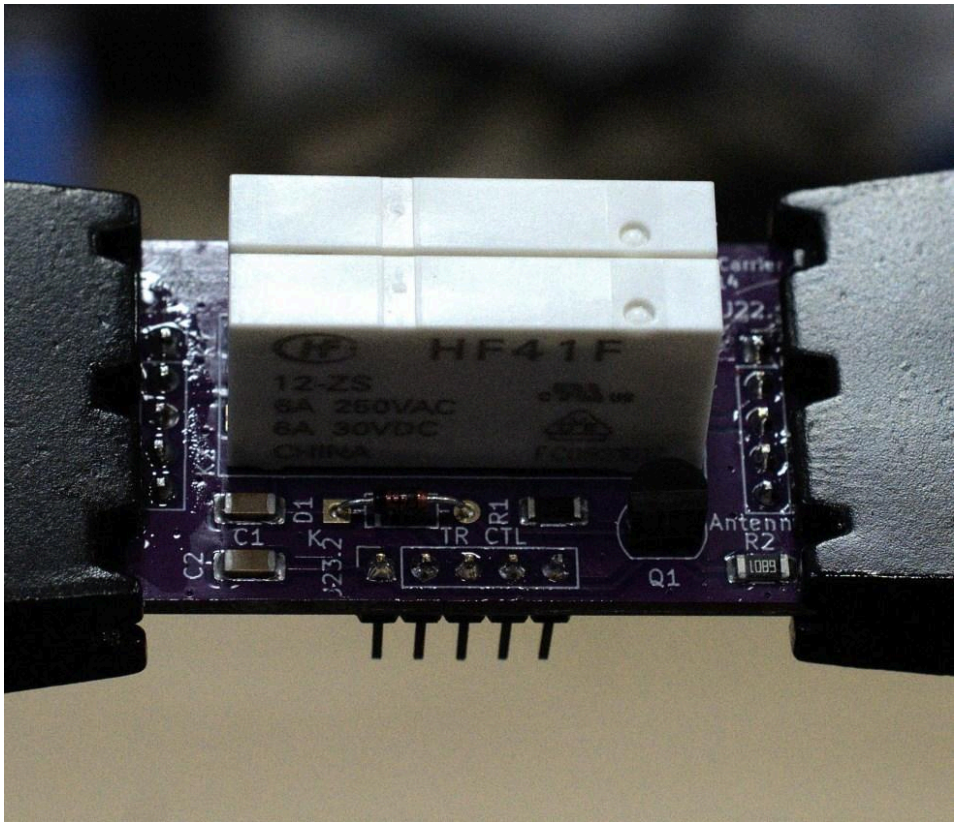
Place the 1N4148 diode, align the black strip on the diode with the white line on the board's silkscreen. Solder the diode in place and trim excess length from the leads.

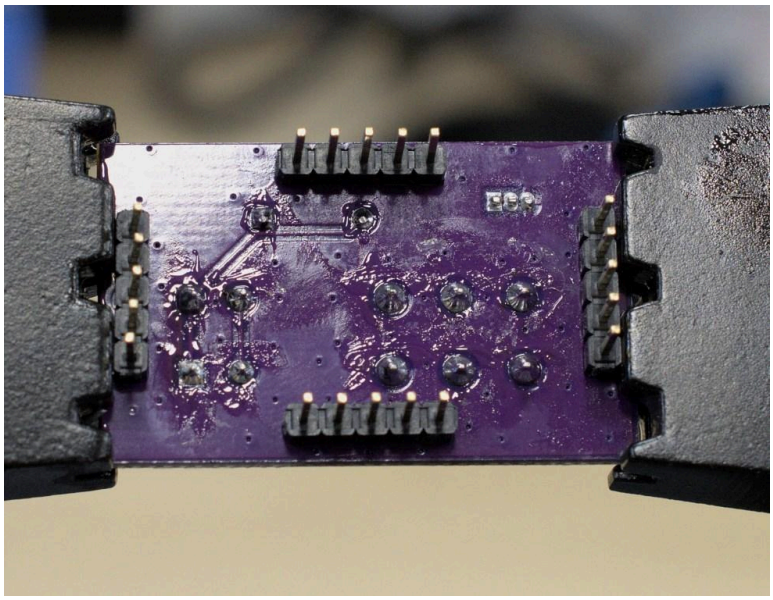




Place one relay on the board at location K1 and secure it with tape. Solder one pin and check alignment of the relay. It should be seated snugly against the board. Solder a second pin, double check alignment, and then solder the remaining pins. Repeat for the second relay, placing the second relay at location K2..

Locate the strip of header pins and break off two 5-pin pieces. Place these pins at the locations marked “Receive” and “TR CTL”. Apply tape to hold them in place as you solder one pin on each header. Check to make sure they sit on the PCB surface and are properly aligned. Solder the remaining pins on each header.

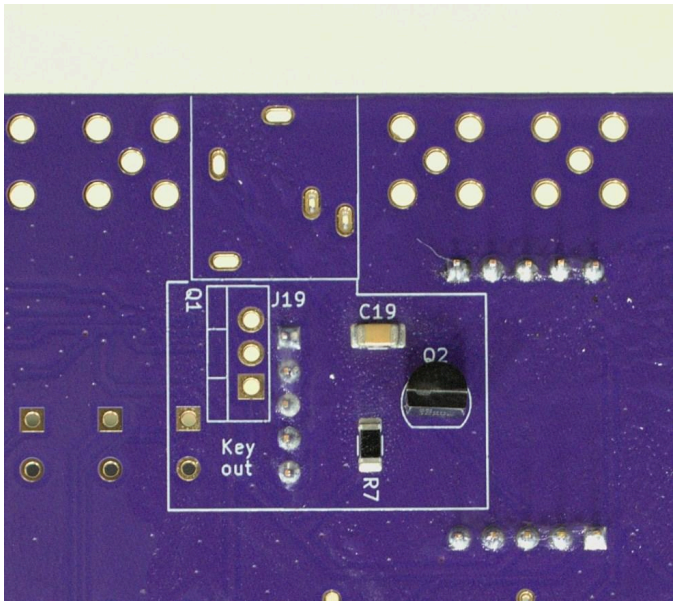




Assemble the PTT Circuit

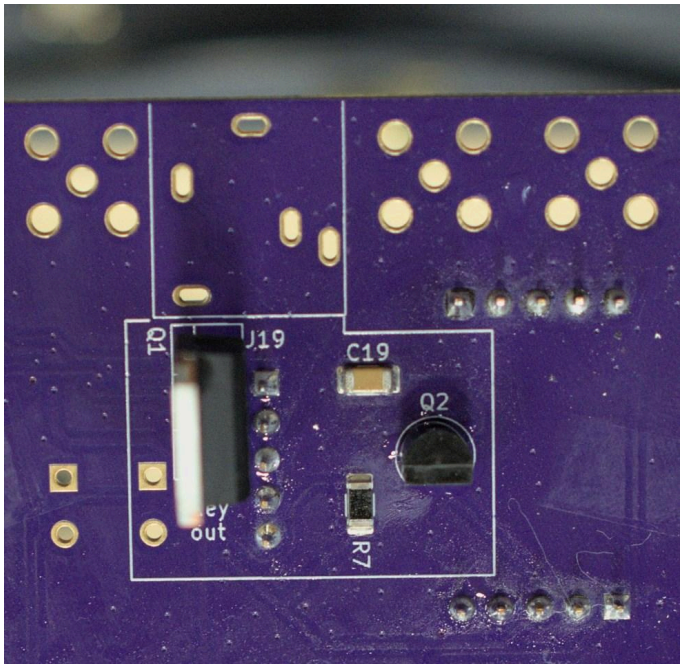
The LPF Control Board itself has several components on the back side. The solder joints for these components will become difficult to access once components are installed on the front side so assemble the back side first.

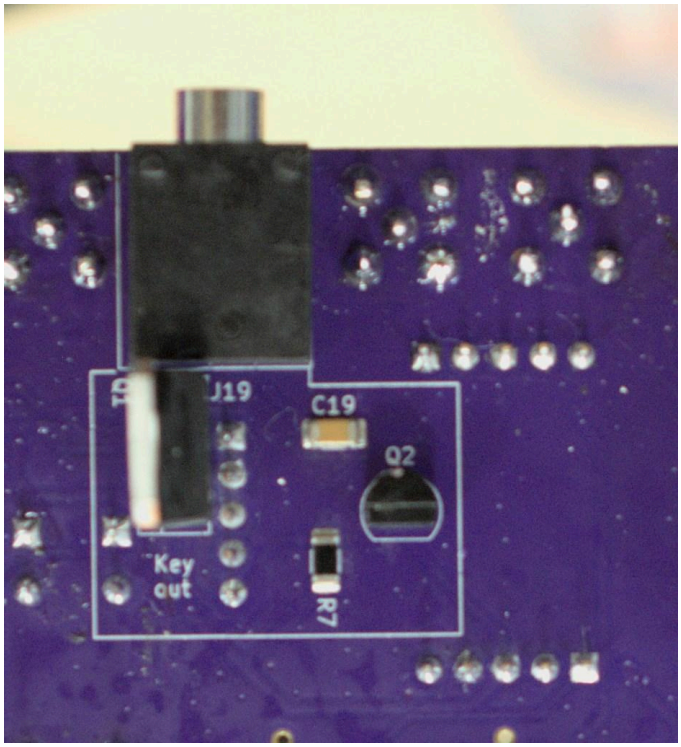
Note: These photos show me assembling components in a different order than is the order in this assembly manual. Following the order in the manual is strongly recommended!



Place the 2N7000 transistor at *Q2* and secure it with tape. Solder from the front side of the board. Inspect the solder joints carefully with a loupe and remove any solder bridging. Trim excess length from the leads. Check for continuity with an ohmmeter between the leads of Q2. All combinations should show an open circuit.

Place the IRF630 transistor at *Q1* and secure it with tape. Solder from the front side of the board and trim excess length from the leads.

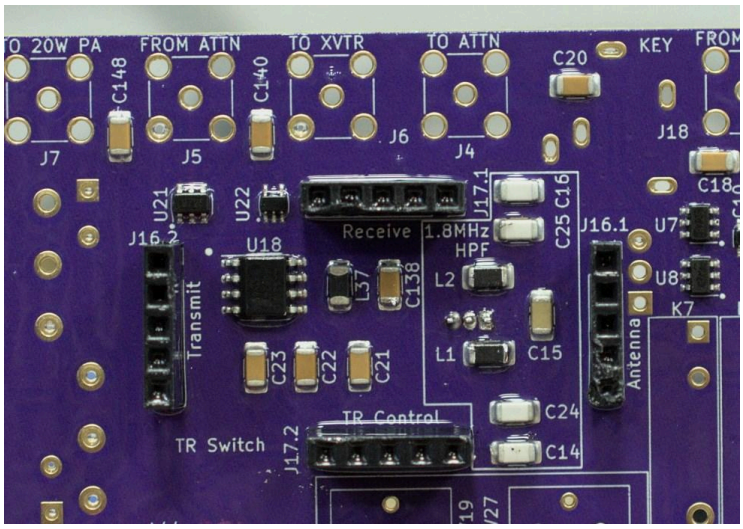




Place the audio jack at *J19* and secure it with tape. Solder a single pin from the front side of the board, check alignment of the part (it should be sitting flat against the board) before soldering the remaining pins.

The TR Carrier Headers

Install 5pin female headers at *J16.1*, *J16.2*, *J17.1*, and *J17.2* in whatever order is most convenient for you. For each header place the component on the board and secure it with tape, solder a single pin from the back of the board, and check alignment of the header. Solder a second pin and double check alignment before soldering the remaining pins. Repeat this procedure for all four headers.]



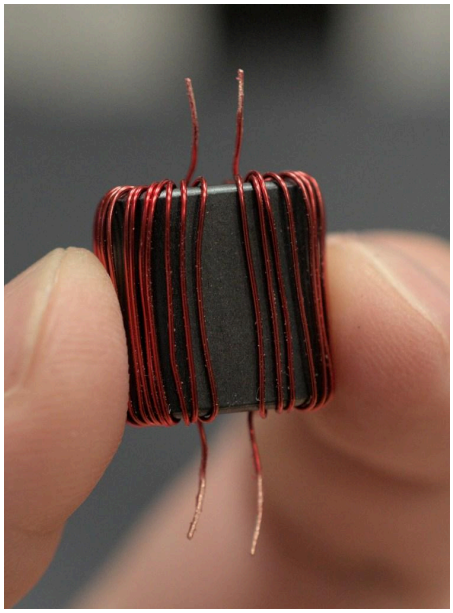
The SWR Bridge Transformer

The SWR bridge transformer consists of two separate 10:1 transformers on a single BN43-202 core. Instead of winding turns through both holes, turns are wound through one hole and around the outside of the core.

Uncoil the supplied #30 magnet wire taking care not to kink it. Divide the supplied #30 magnet wire into two equal lengths. On each side of the core wind 20 turns of wire going through the

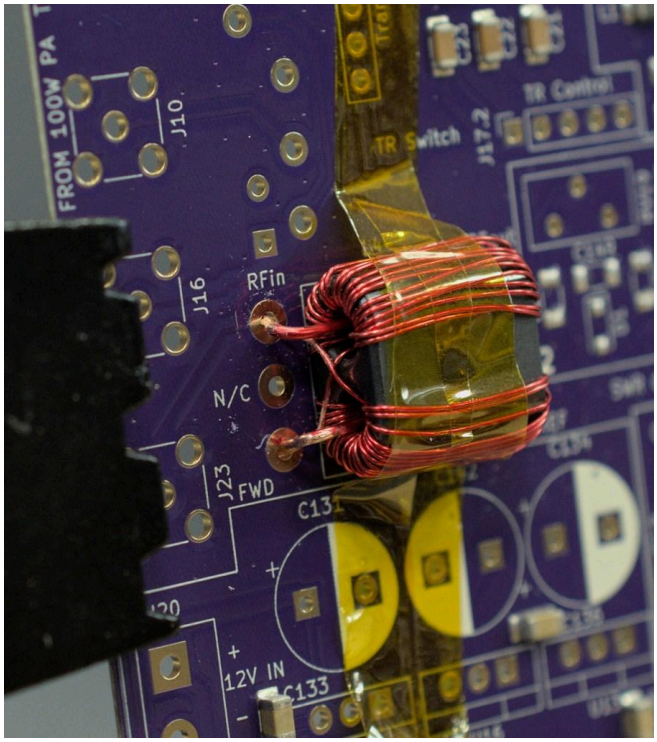
hole and then around the outside. Each pass through the hole counts as one turn. Space these turns evenly around the outside of the core as if winding a toroidal inductor. Leave at least 2cm (¾”) of wire on the ends of each coil. Use light pressure on the wire. Do not pull too hard or the wire will break and you will have to start all over again. It is OK if the turns overlap.

Strip the ends of each wire with a bit of sandpaper or a sharp knife. If using a knife be careful not to nick the copper wire.



Divide the supplied #20 magnet wire into two equal lengths. Pass one length through each hole of the transformer core, trim and strip the ends to 2cm (¾”). **These wires do not wrap around the outside of the core. They simply pass through the core.**

Before continuing check for continuity through each coil and wire. None of the cores or wires should have continuity to each other but they should all show near-zero resistance between their ends.

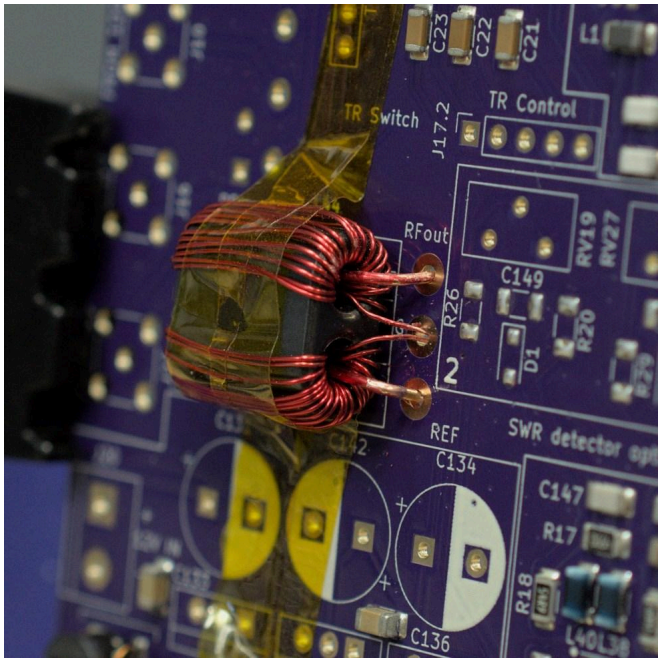


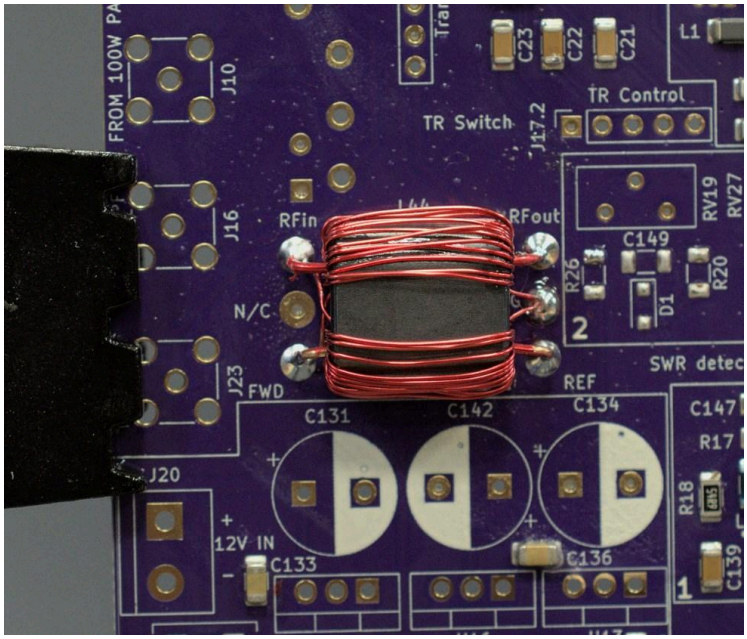
Place the transformer on the board. The #20 wires go straight through the core – the wire in the upper hole of the core goes into the upper hole on the board on each side of the transformer core, the wire through the lower hole of the core goes into the lower holes on the board.

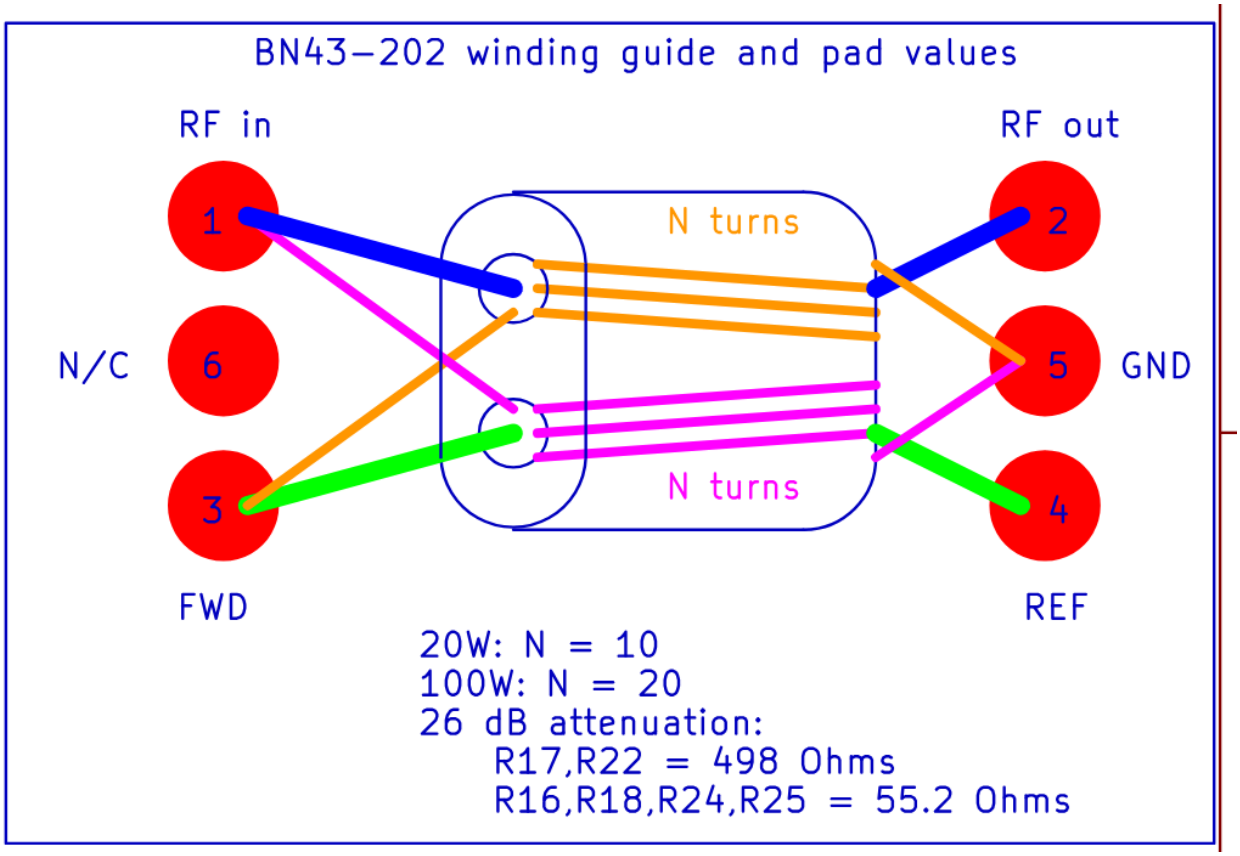
On the left side of the core the #30 wires cross. The wire coming out of the upper hole in the core goes through the lower hole in the board, the wire coming out of the lower hole in the core goes through the upper hole in the board. The center hole in the board is empty. Be sure that the wires cross without shorting to each other (they should both still have an enamel coating at the point they cross).

On the right side of the board the two #30 wires both go through the center hole in the board.

Pro-Tip: If the enamel coating has been removed or damaged a short can be prevented with a product like Liquid Electrical Tape. DO NOT use nail-polish or similar products, these are not durable and are often flammable even when dry!


TR Switch
J17.2
TR Control
C23
C22
C21
L1
RFout
C149
R26
RV19
RV27
R20
D1
2
REF
C142
C134
C147
R17
R18
C136
L40L30


FROM 100W PA
J10
TR Switch
J17.2
TR Control
C23
C22
C21
L1
RV19
RV27
RFin
RFout
J16
C149
R26
D1
R20
N/C
2
J23
FWD
REF
C131
C142
C134
C147
R17
J20
R18
12V IN
C133
C136
C139
1

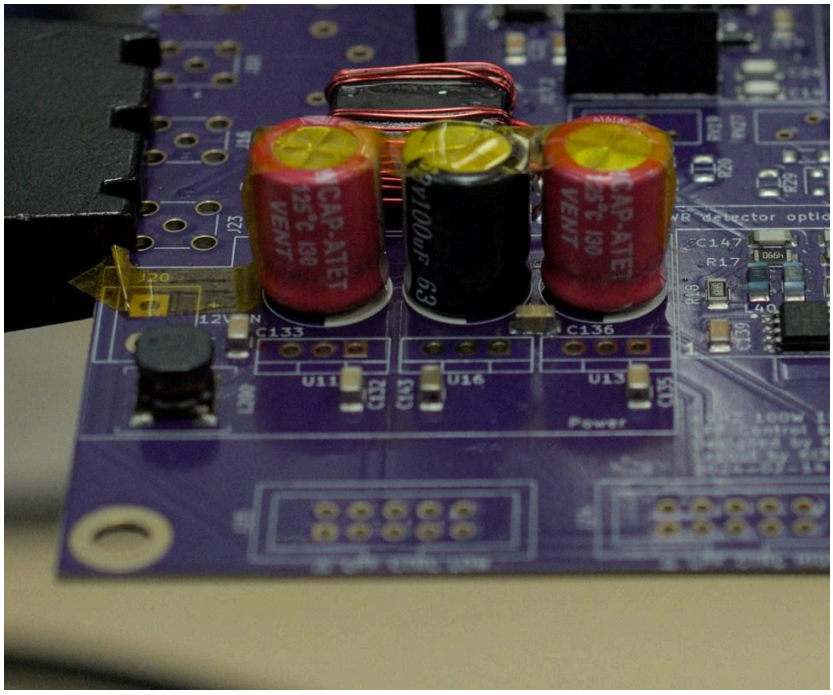


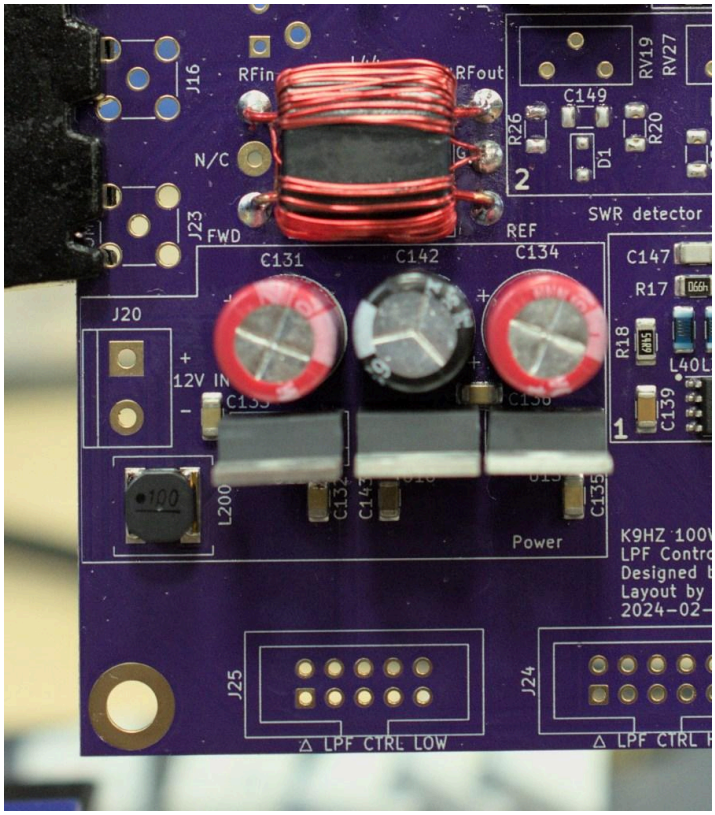
Secure the core with tape and solder each wire. Check for continuity across the two #20 wires and the combined 10T coils. Trim excess length from the wires.

The Power Supply Circuitry

Install *C131*, *C142*, and *C134* in whatever order is most convenient for you. *C131* and *C134* are 200uF 16V electrolytic capacitors while *C142* is a 100uF 6V electrolytic capacitor. For each, place the component with the stripe on its case aligned with the white marking on the board's silkscreen, secure the component with tape, solder both pins from the back side of the board, and trim excess length from the leads.

Note: The capacitors are not all oriented in the same direction!



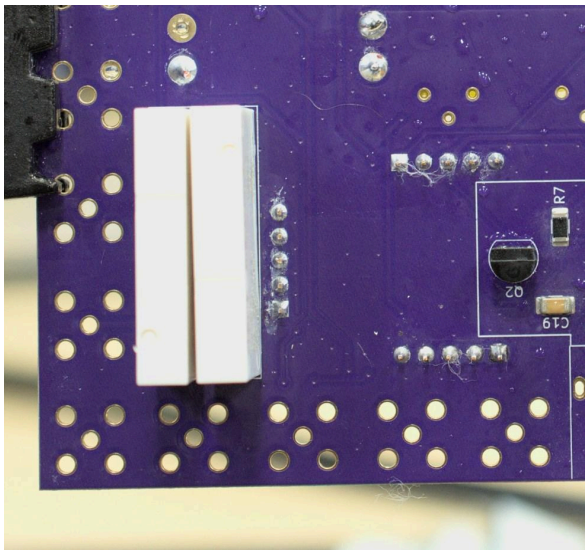


Likewise install *U11*, *U16*, and *U13* in whatever order is most convenient. *U11* is an LM7805 (5V) voltage regulator, *U16* is an LM1117T-3.3 (3.3V) regulator, and *U13* is a UA7808 (8V) regulator. For each place the component on the board with the metal tab aligned with the markings on the silkscreen, secure with tape, solder all three pins from the back side of the board, and trim excess length from the leads.

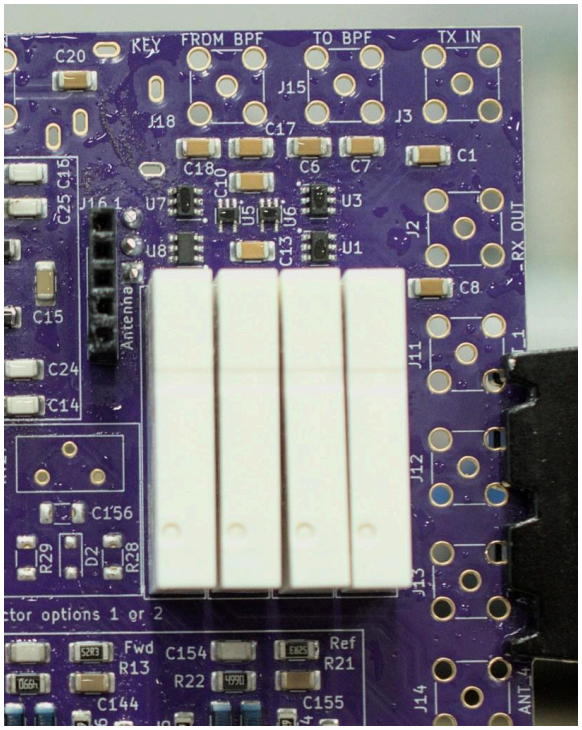
Pro-Tip: The center pin of each voltage regulator is connected to the metal tab on its package. This makes the center pin harder to solder. Use extra heat and flux as necessary.

Relays

Install the relays on the back side of the board first. Place one relay at *K2* or *K3* and secure it with tape. Solder a single pin from the front side of the board, check alignment of the relay, solder a second pin, double check alignment, and then solder the remaining pins. Repeat for the second relay.



Pro-Tip: After you have applied the tape to hold the relays in place, solder the middle relay pin on each relay. With your index finger on a relay and your thumb pinching the board, re-heat the middle pin while squeezing the top of the relay and the PCB. Often you can feel the relay seat itself snug to the PCB. Repeat with each relay. Once all the relays are re-seated, solder the remaining pins.



One at a time install the remaining four relays at *K4*, *K5*, *K6*, and *K7*. For each place the relay on the board, secure it with tape, solder a single pin on the back side of the board, and check the alignment of the relay. Relays should sit flat against the board. Solder a second pin on the back, double check alignment, and then solder the remaining pins. Repeat for all four relays.

Note: *K5*, *K6*, and *K7* are optional. If you don't plan to use the antenna switching function you may leave these relays unpopulated. *K4* connects to *J11* (*ANT_1*) and so must be installed or bypassed.

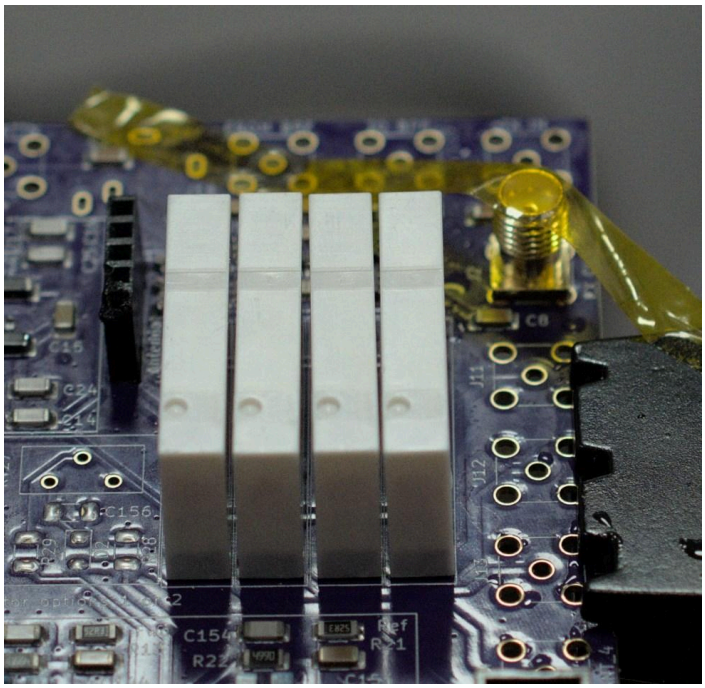
Headers & SMA Connectors

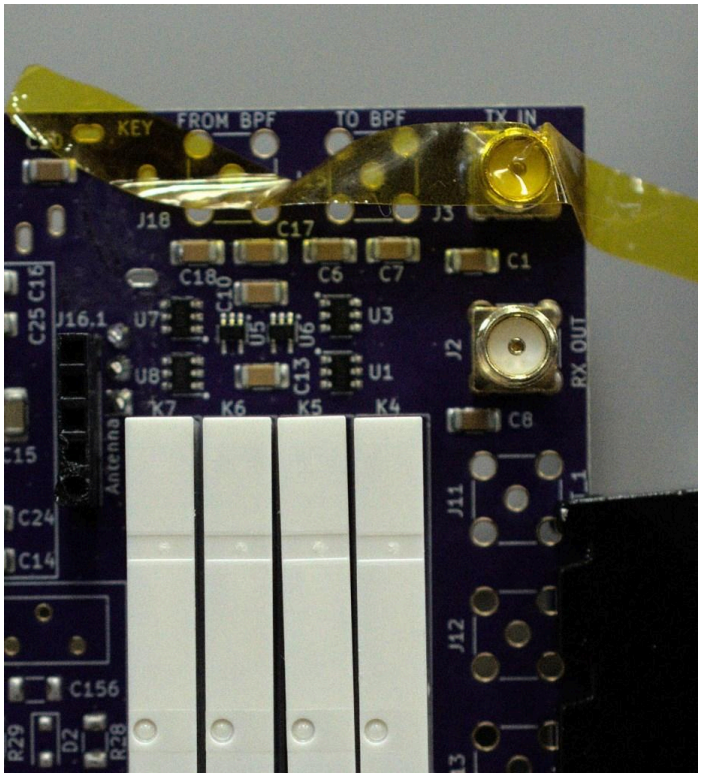
Install the off-board connectors starting with the SMA connectors since these require the most heat. Work in whatever order is most convenient for you.

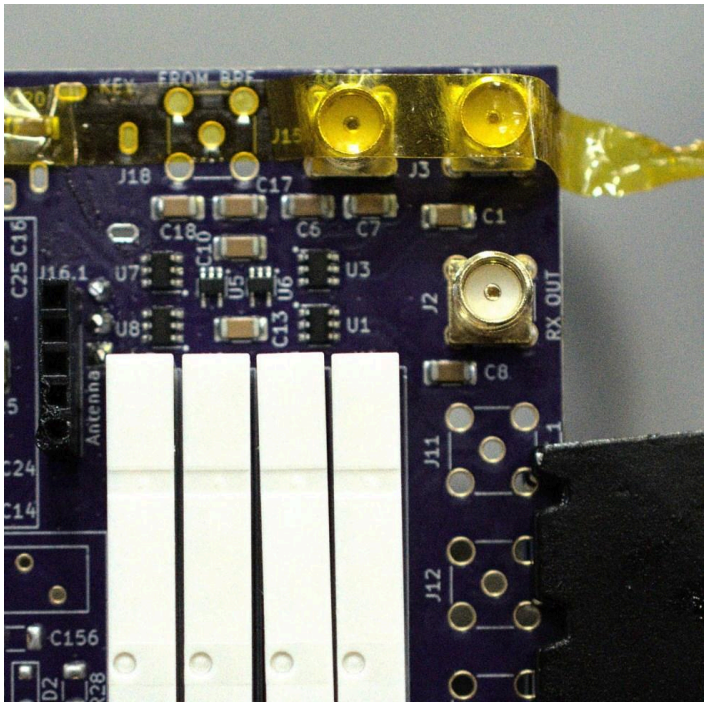
Note: For a standard T41 v12 build *J9* & *J10* (for the 100W amplifier) and *J6* (for the transverter) are not required. Feel free to leave these parts off the board if you don't plan to add those components in the future. *J4* & *J5* are used for an optional attenuator but must be populated so that a jumper can be installed.

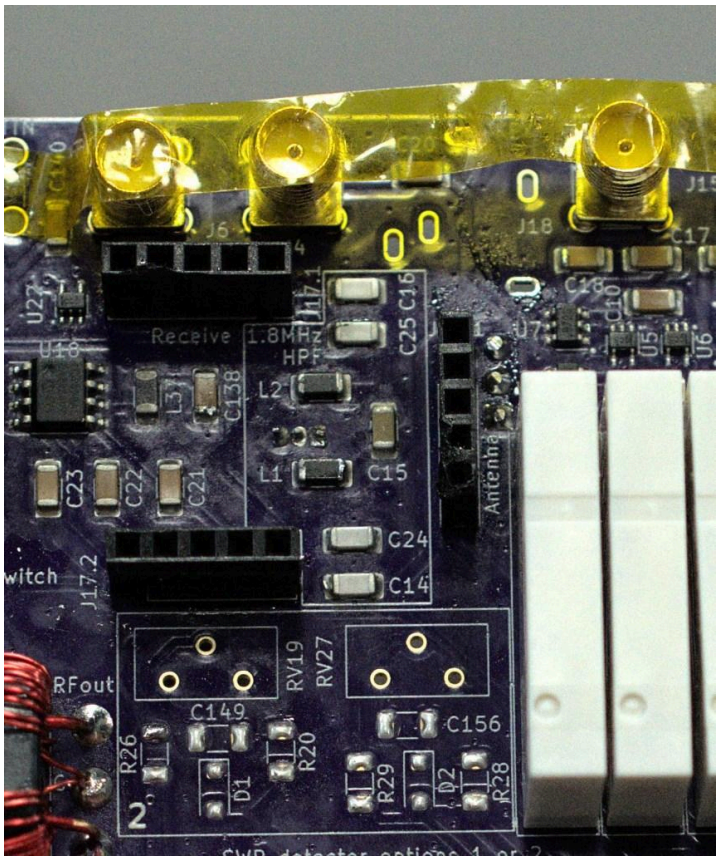
For each SMA connector that you install, place the part on the board and secure it with tape. Solder a single pin (the center pin is easiest) from the back of the board and check alignment of the connector before soldering the remaining pins. Extra heat and flux may be necessary to solder the ground pins since these lose heat quickly through the connector itself. To insure the

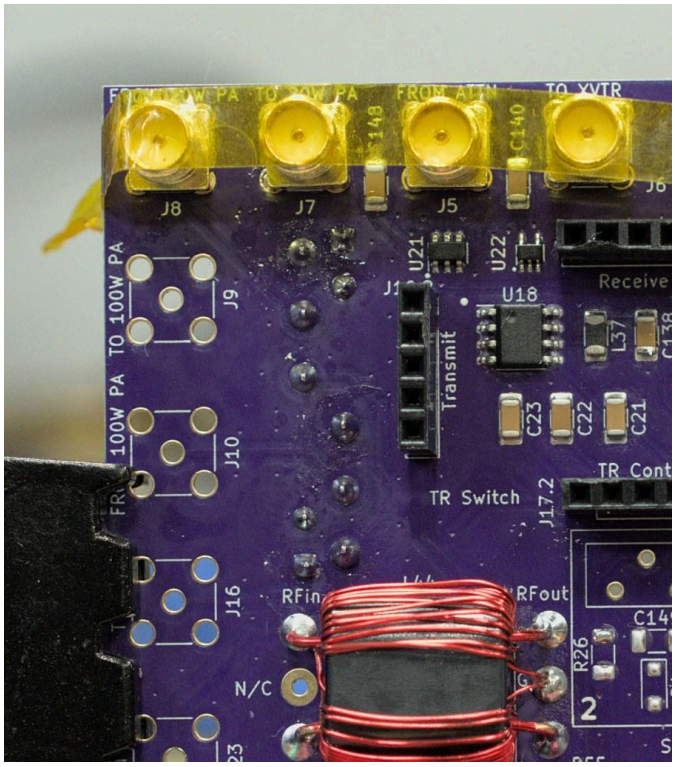
connector is fully seated, use some kind of insulating material between your index finger and the SMA connector (I used a 1/2” square of cardboard taped to my index finger), then flip the board over and reheat the center pin while squeezing with your thumb and index finger.

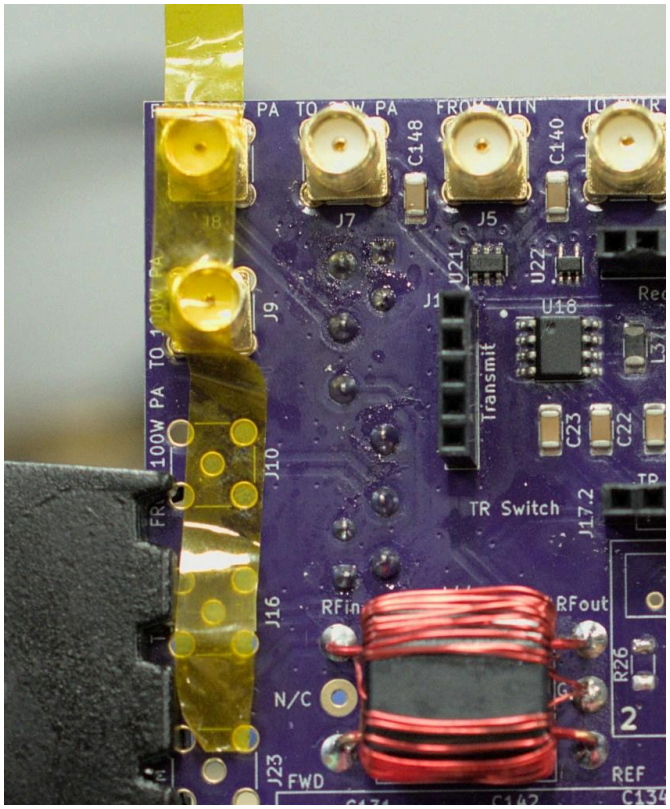


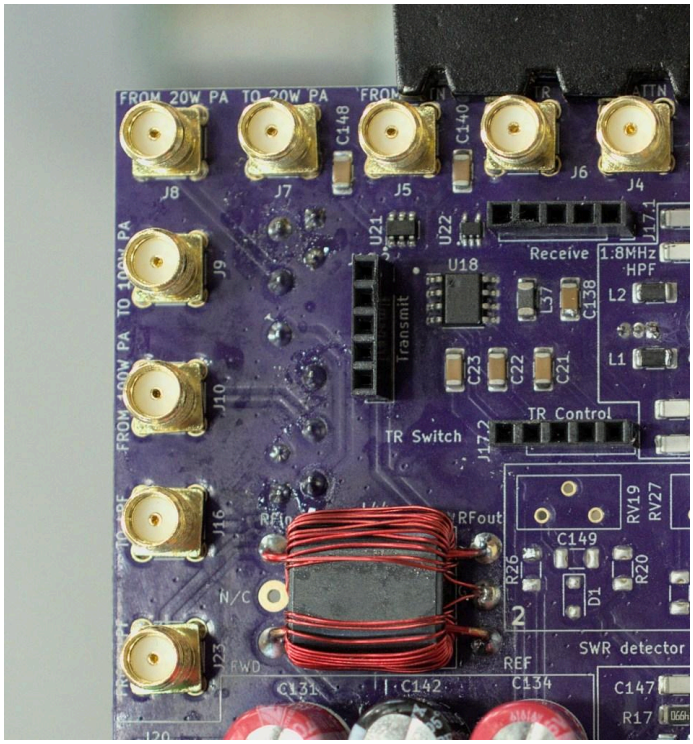


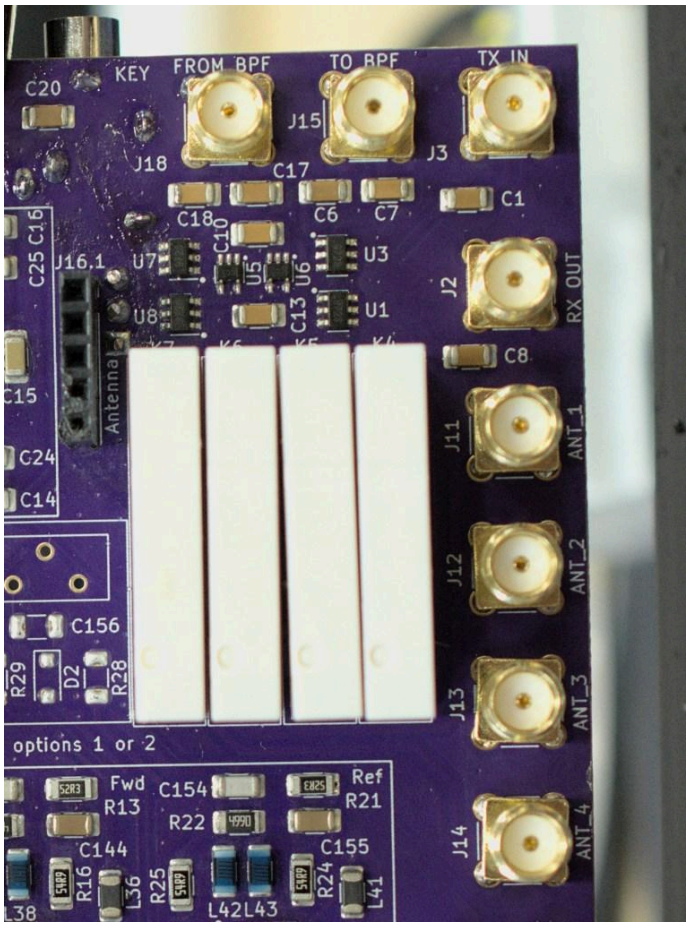

KEY
FROM BPF
TO BPF
J15
J18
J3
C17
C18
C6
C7
C1
C10
U7
U5
U6
U3
J16.1
J2
RX OUT
U8
C13
U1
C8
Antenna
J11
J12
C24
C14
C156

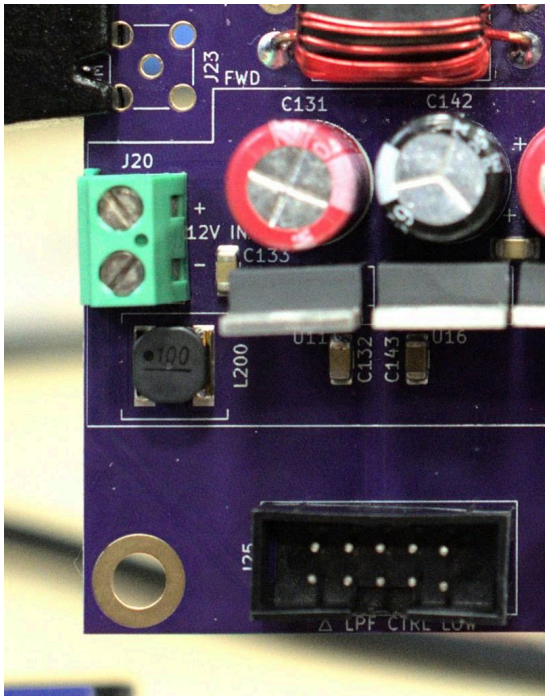

J6
J18
C17
C16
C25
U27
U18
Receive
1.8MHz
HPF
L2
L1
C15
C138
C23
C22
C21
Antenna
C24
C14
J17.2
RFout
RV19
RV27
C149
C156
R26
R20
R29
R28
D1
D2
2


TO XVTR
J8
J7
J5
C140
U21
U22
U18
Receive
Transmit
L37
C23
C22
C21
J9
J10
100W PA TO 100W PA
TR Switch
J17.2
TR Cont
J16
RFin
RFout
N/C
R26
2


C148
C140
J7
J5
U21
U22
U18
Transmit
L37
C23
C22
J9
J10
100W PA TO
TR Switch
J17.2
J16
RFin
RFout
N/C
R26
2
J23
FWD
REF

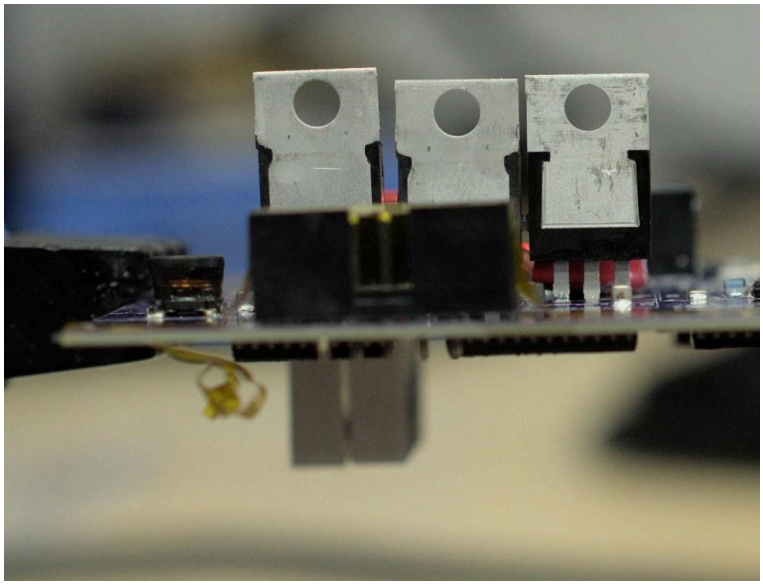

FROM 20W PA
TO 20W PA
J8
J7
J5
J6
J4
C148
C140
U21
U22
U18
Receive 1.8MHz HPF
Transmit
L37
C138
L2
L1
C23
C22
C21
TR Control
TR Switch
J17.2
RV19
RV27
C149
R26
R20
D1
RFout
N/C
J16
J23
FWD
REF
C131
C142
C134
C147
R17
SWR detector

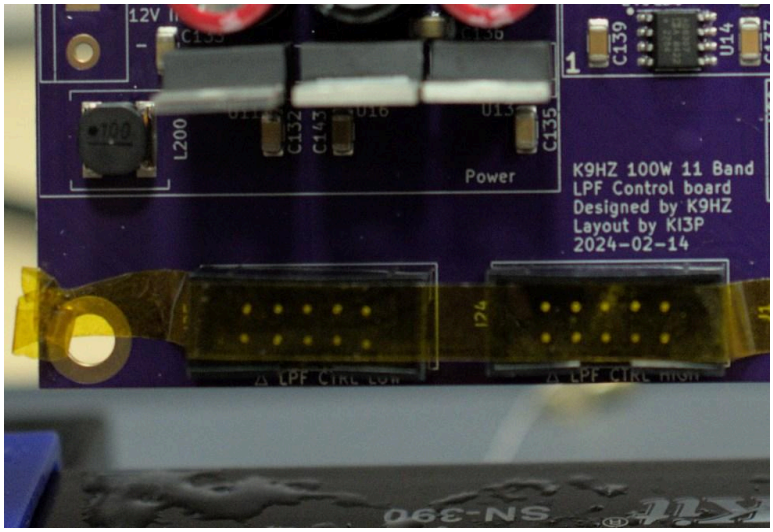

KEY
FROM BPF
TO BPF
TX IN
C20
J18
J15
J3
C17
C18
C6
C7
C1
C10
U3
U7
U5
U6
U8
U1
C13
J16.1
Antenna
J2
RX OUT
C8
J11
ANT_1
J12
ANT_2
J13
ANT_3
J14
ANT_4
C25
C16
C15
C24
C14
C156
R29
D2
R28
options 1 or 2
Fwd
R13
C154
Ref
R21
R22
C144
C155
R16
L36
R25
L42
L43
R24
L41
L38

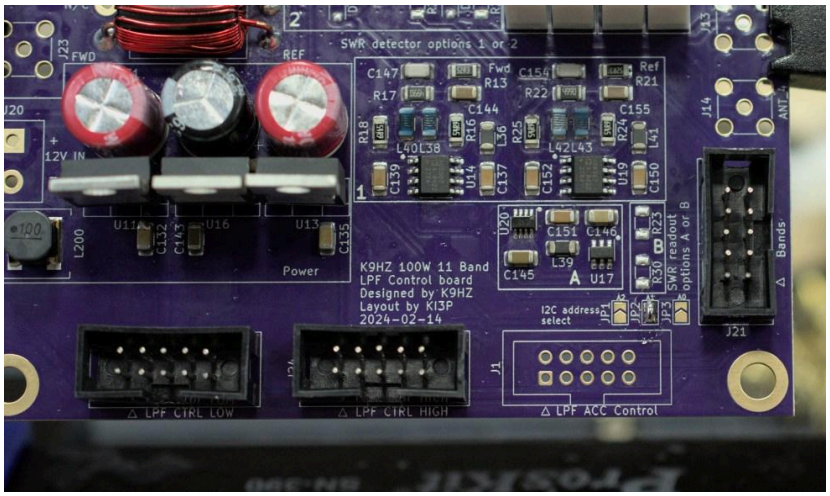


Place the 2pin molex block at *J20*, secure it with tape and solder a single pin from the back of the board. Check alignment of the part before soldering the second pin.

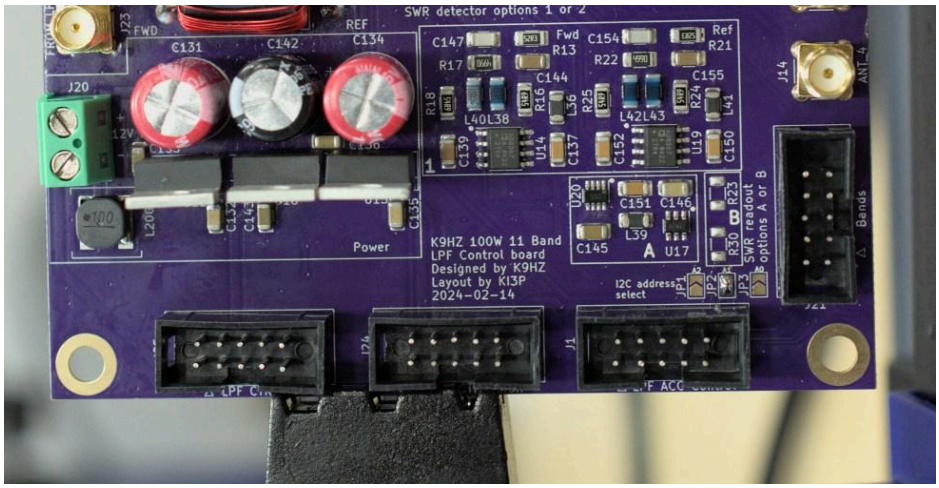
Install 2×5 box headers at *J1*, *J21*, *J24*, and *J25* in the order most convenient for you. For each header place it on the front of the board and secure it with tape. Be sure to align the key (the gap in the plastic box) with the marking on the board's silkscreen. Solder a single pin from the back side of the board, check that the header is properly aligned, solder a second pin, double check alignment, and then solder the remaining pins. Repeat for each box header.







Jumper the two pads together to set A1 at JP2 with a bit of solder as shown below.

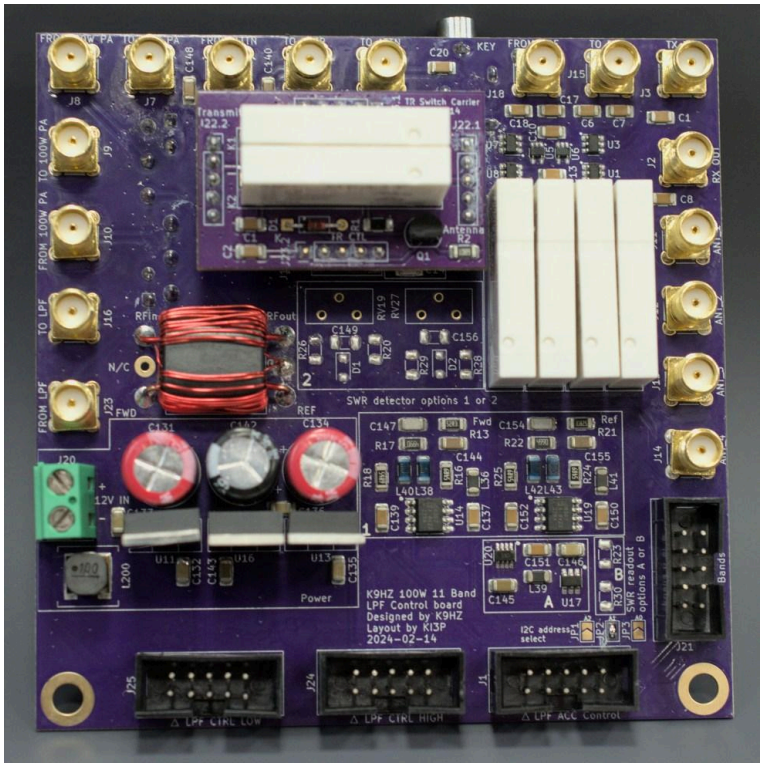


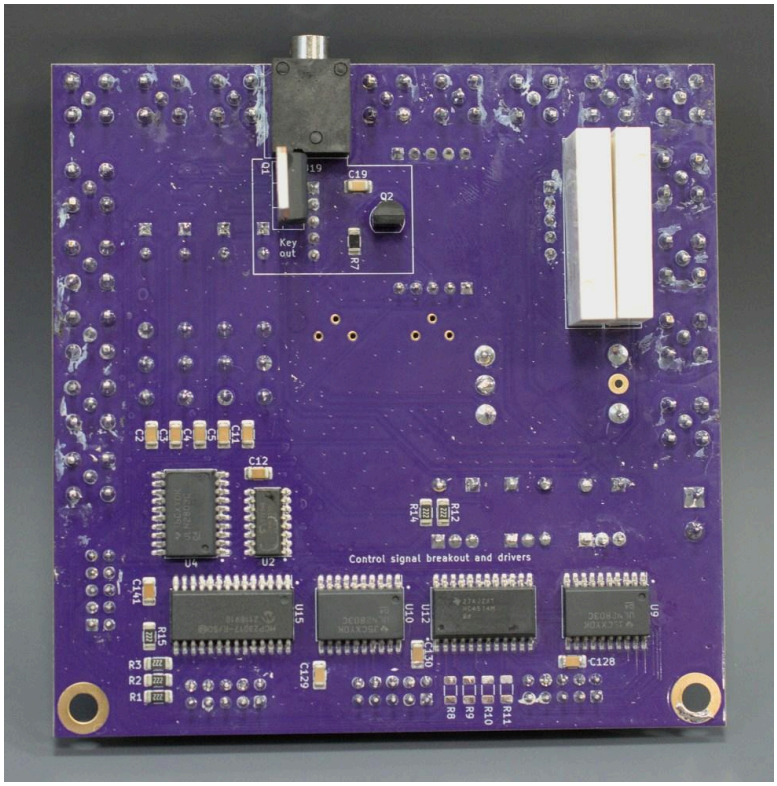
Note: *J1* is not required for a standard T41 v12 build. Feel free to leave it off the board. This header is intended for operation without the I2C digital control and may require rework of the board to function properly. Review the schematic carefully if you plan to control the board with this connection.

Finishing Up

Clean your board as necessary to remove excess flux and residue. After cleaning carefully inspect all of the solder joints on your board. Use a jeweler's loupe to get a good look, touch up any joints that are cold or incomplete.

Once the board is clean, dry, and thoroughly inspected, install the TR Carrier Board. The boards are mated such that *J23.1* on the TR Carrier connects to *J17.1* on the LPF Control Board (*J22.1* to *J16.1, J22.2* to *J16.2, J23.2* to *J17.2*).





Testing

An LPF control test sketch is available in my GitHub repo. This sketch allows you to test each of the functions of the LPF Control board (selecting filters, switching antennas, measuring SWR, etc). The T41 main board is required for this sketch.

Signal routing cannot be tested with a simple multimeter due to the use of RF switches as decoupling capacitors. Use a NanoVNA or similar device to generate test signals and measure performance.

Pro-Tip: Be sure to calibrate your test equipment for each frequency range you test!