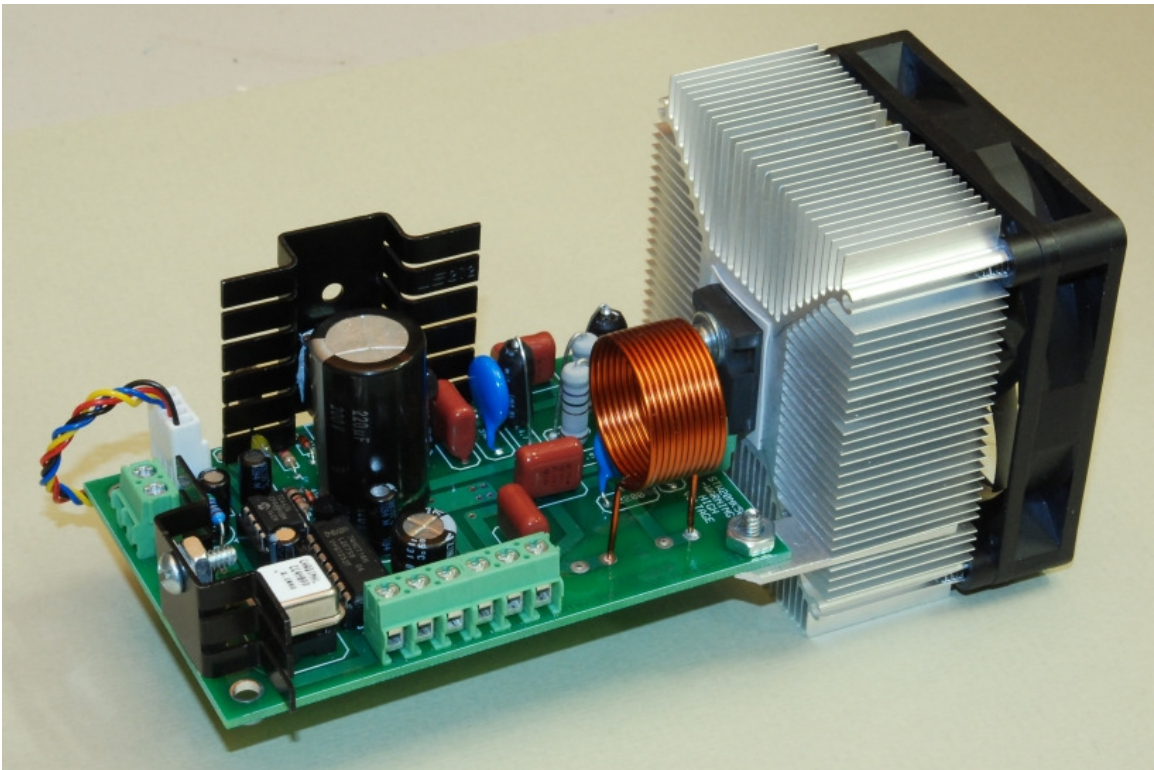


Assembly Instructions

for the

PA3 v2.0 Amplifier Kit



PA3 Amplifier shown mounted on HS2 Heat Sink
(The HS2 shown here is **not** included with this kit.)

27 February 2016

© 2013-2016 by Ralph Hartwell
Spectrotek Services
All Rights Reserved

RADIO FREQUENCY WARNING NOTICE

- **The PA3 is a high-frequency switch mode power supply module designed to furnish a square wave modulated high voltage alternating current at a frequency of approximately 3.1 MHz across a 50 ohm load impedance.**
- **If the PA3 is installed incorrectly or used improperly, it is capable of causing severe radio frequency interference. To prevent this from occurring, observed the following warnings:**
- **The PA3 is to be used as a research device only, or as part of a complete system to drive a plasma tube.**
- **The PA3 is not intended to be used for any form of radio transmission in any manner whatsoever.**
- **The PA3 is not intended to be connected to an antenna or to any radiating element or to be used for any form of radio communications purposes in any manner whatsoever.**
- **The PA3 is designed solely to be a source of power to light a plasma tube.**
- **All electrical connections to the output terminals of the PA3 are to be made by the use of properly shielded 50 ohm coaxial cable capable of handling at least 500 watts at 3.1 MHz.**
- **All connections are to be made in such a manner as to minimize any RF radiation from the connecting wires to the PA3.**
- **The PA3 has been specifically designed to be driven by a TTL square wave signal that from a standard signal generator, such as the UDB-series of frequency generators or any other signal generator capable of producing a duty cycle modulated square wave signal with an amplitude of 0 to +5 volts.**
- **The operating frequency range of the PA3 has been restricted to a 1 MHz portion of the spectrum centered at 3.1 MHz.**
- **Any attempt to drive the PA3 with a radio frequency source such as a CB radio transmitter, will result in immediate destruction of the PA3.**

GENERAL ASSEMBLY INSTRUCTIONS

Arrange for a clean work surface with adequate lighting. You will be working with small parts, and you may need to use a magnifier for close work. Working on a soft surface, such as a short nap towel, prevents parts from rolling off the work area and falling on the floor.

You will be soldering small parts in place. If you are not used to soldering such items, it is suggested that you seek assistance from an experienced person before starting assembly.

The circuit board of the PA3 has been designed with ruggedness in mind. Extra-wide and thick copper traces have been used on the PA3. Because of this, the PA3 will withstand repeated soldering should repairs be necessary, such as if a part has been installed in an incorrect location. Nevertheless, it is strongly recommended that you take care in locating the position of the various parts when assembling your PA3.

You will require the following tools:

- Small needle-nose pliers to install the heat sink.
- Small flush-cut or side-cutter pliers to cut off the excess wire ends of parts after soldering them in place.
- A #1 Phillips head screwdriver to install the heat sink.
- A soldering iron, with a recommended wattage of between 30-70 watts, and a tip temperature of no more than 700° F. The tip should be a small conical point.
- Solder, 60/40, 63/37, or 62/36/2 grade, no larger in diameter than 0.032". rosin core flux only. Suitable types are Radio Shack 64-013 and 64-009.
- If you prefer, you may use a lead-free solder instead. The PA3 circuit board is compatible with all lead-free solders.

WARNING! DO NOT use acid core solder!!

Doing so will cause damage to the circuit board and will void any and all warranties. We will NOT warranty any circuit boards that have been assembled using any type of acid core solder.

WARNING! The STW20NK50Z is Static Sensitive!!

The STW20NK50Z MOSFET transistor in your PA3 kit has been tested before shipment. Your STW20NK50Z has been wrapped in aluminum foil to prevent damage from static electricity during shipment.

Please do not unwrap the STW20NK50Z until you are ready to install it. Be sure to use antistatic precautions while installing the STW20NK50Z in your PA3 circuit board.

The general assembly procedure outlined in these instructions has been laid out so as to have the builder install the smallest components, such as resistors and diodes, on the circuit board during the earliest stages of assembly. This procedure avoids the difficulty of attempting to install these small components onto the board after the larger parts have been soldered onto the board.

The wire leads of almost all of the parts will need to be carefully bent (usually at right angles to the body of the part) according to the assembly instructions. Bend the part leads using **ONLY** your fingers! Unless used very carefully, using pliers to bend the leads may cause the body of the part to break or crack where the lead attaches to the body of the part. This can result in outright failure of the PA3 to operate, or even worse, it may cause intermittent malfunctions during operation. Such problems can be very difficult to resolve.

Although you may assemble the various parts of the PA3 kit in almost any order, the following sequence allows you to “build up” from the surface of the board, making it easier to install the remainder of the parts as you assemble your PA3.

It is suggested that you take the time to inspect the blank circuit board and familiarize yourself with where the various parts will be installed. Please refer to the photograph of the complete PA3 in the back of this manual for help in locating the position of the parts.

If you look at the blank circuit board, you will see that one side of the blank circuit board has a serial number engraved on it. This is the Solder Side of the circuit board. The other side of the board, the Parts Side, has the part number “STW20NK50Z” placed next to the three mounting holes for the STW20NK50Z transistor. All of the parts are to be installed on the side of the board that has the STW20NK50Z identification. All of the soldering is done on the opposite (Solder Side) of the board.

The parts side of the board also has outline drawings of all the parts, as well as their the component value, (1500, 0.47,) thus making it easy to identify where the various parts should be placed.

For each assembly step, locate the listed part, and identify where on the circuit board it will be placed. Some of the parts in this kit may be furnished with the leads already pre-bent to the correct shape for insertion in the PA3 circuit board. However, some kits may include parts with leads that have not been pre-bent. If you have one of these kits, it will be necessary to carefully bend the leads of some of the parts to fit. When this is necessary, it will be in the assembly instructions.

After inserting the leads of each part through the proper holes in the PA3 circuit board, carefully tug on the free end of the wire lead to seat the part close to the circuit board. Do not apply excessive force trying to seat the part firmly against the board. If the part is positioned slightly above the board, that is OK.

Note that several parts must be installed so that they are sitting slightly above the surface of the circuit board, and not tightly in contact with it. This is done for proper heat dissipation when the PA3 is in operation. If these parts are not properly spaced above the board, it is possible for the PA3 to fail during operation.

After inserting each part, bend the free ends of the wire leads at a 45° angle to prevent the part from slipping out of the circuit board when the board is turned upside down to solder the part in place.

Solder the part in place, inspect the solder joint, and then cut off the excess lead wires with the flush cutter pliers.

As you assemble the PA3 circuit board, you will see that the instructions for installing the parts appear in the instructions similar to this:

4148 D2

As you install each part, put an “X” or a check mark in the “” box to the left of each part. Assembling the parts in sequence helps to prevent assembly errors.

The “4148” indicates the identifying text that is printed in white on the component side of the PA3 circuit board where the part will be installed.

The “D2” indicates the component number shown in the schematic diagram in this assembly manual and in the operating instructions for the PA3 amplifier.

INSTALLING THE PARTS ON THE PA3 CIRCUIT BOARD

Install (3) 1N4148 Diodes

Please be sure to orient the black cathode band on the 1N4148 diodes to match the markings on the circuit board.

4148 D2

4148 D3

4148 D4

Install (1) 5 Volt Zener Diode

Please be sure to orient the black cathode band on the Zener diode to match the marking on the circuit board.

ZD1 D1

Install (2) 82 Ohm Resistors

82 Ohm (Gray Red Black) R4 **Install at ORANGE PAINT location.**

82 Ohm (Gray Red Black) R7 **Install at ORANGE PAINT location.**

Install (1) 1000 Ohm Resistor

1000 Ohm (Brown Black Red) R2

Install (1) 10 K Ohm Resistor

10,000 Ohm (Brown Black, Orange) R1

Install (1) 51 or 470 Ohm Resistor at Location “TERM”

51 Ohm (Green Brown Black) **Install for Spooky2 or any TTL output generator.**

470 Ohm (Yellow Violet Brown) **Install for GB-4000.**

Install (1) 2.2 mHy Common Mode Choke

This is marked “EPCOS.”

CMC-1

Install (2) 8-Pin DIP Sockets

TC4426 U3

OSC 3.1 MHz

Install (1) 14-Pin DIP Socket

74HCT14 U5

Install (1) MC78L05 Voltage Regulator

78L05 U2

NOTE – Be sure to install the MC78L05 so that the flat side of the device is facing towards the mounting position of the large 220 uF 200V electrolytic capacitor that is marked “220” on the circuit board.

Install (1) 4-Pin White plastic connector for cooling fan

FAN

TERMINAL BLOCK INSTALLATION

When installing the terminal blocks, be sure to install them so that the holes for the connecting wires are facing away from the circuit board.

Depending on manufacturing tolerances, the terminal blocks may be a tight press fit into the circuit board. Be sure to seat the terminal block completely against the circuit board before soldering. Double check to make sure the wire holes in the terminal blocks are facing the outer edge of the circuit board before soldering the terminal blocks in place.

To make soldering the terminal boards onto the circuit board an easier task, insert the terminal blocks onto the circuit board and hold them in position with your hand. Now, turn the board upside down and carefully place it down on the surface of your workbench. The PA3 circuit board should now be laying flat against the back of each of the terminal blocks. It is now an easy task to solder the terminal blocks into position.

Install (1) 2 Position Terminal Strip at This Location:

AF IN

Install (1) 6 Position Terminal Strip at This Location:

GND / +19, GND / + HV, GND / RF OUT

Install (1) 3 Position Terminal Strip at This Location:

STW20NK50Z

Install (4) 47 uF 16 V Electrolytic capacitors

47 C2

47 C3

47 C4

47 C5

Install (1) 1000 pF Disc Capacitors

1 nF C7

Install (2) 2200 pF Disc Capacitors

2200 C13

2200 C14

Install (1) 8200 pF Poly Film Capacitor

8200 C6

Install (1) 15 Ohm 1 Watt Resistor

15 R3

Bend one of the leads of the resistor down towards the body of the resistor so that both leads point in the same direction. . The bottom end of the resistor should be standing about 1/4 inch or 6 mm above the surface of the circuit board.

Install (3) 4.7 uH Ferrite Core Inductors

NOTE: Your amplifier kit contains a new style inductor which replaces the black inductors that are shown in the photograph at the back of this assembly manual. Although these new inductors look different, they are identical in function to the black inductors. The lead wires of the new inductors are pre-bent to fit into the mounting holes of the circuit board. Please see the photographs at the back of this assembly manual for correct orientation of these inductors before soldering them in place.

Mount the inductors vertically with the inductor bodies placed against the PA3 circuit board against the solder holes that do not have traces visible on the Parts Side of the circuit board. The folded over wire lead should pass through the hole in the circuit board which has a copper trace connecting to the solder pad.

4.7 L1

4.7 L2

4.7 L3

Install (2) 7.5 Ohm Resistors

Please see the photographs at the back of this assembly manual for correct orientation of the resistors before soldering them in place.

Bend one of the leads of the resistor down towards the body of the resistor so that both leads point in the same direction.

Mount the resistors vertically with the resistor bodies centered over the outermost holes in the mounting pads. There is a diagonal trace connecting the two solder holes where the unbent lead of each of the resistors will be soldered. The bottom end of each resistor should be standing about 1/2 inch or 12 mm above the surface of the circuit board. Mounting the resistors in this manner allows the maximum cooling airflow between the resistors.

7.5 Ohm (Violet Green Gold Gold) R5

7.5 Ohm (Violet Green Gold Gold) R6

Install (4) 0.47 uF capacitors

0.47 C8

0.47 C9

0.47 C11

0.47 C1

Install (1) 3900 pF Ceramic Capacitor

2200 C10

Install (1) 470 uF 25 V Electrolytic Capacitor

470 C1

Install (1) 220 uF 200 V Electrolytic Capacitor

220 C12

Install (1) MC7812 Voltage Regulator

7812 U1

NOTE – Be sure to install the MC7812 so that the exposed metal side of the device is facing away from the circuit board.

Install (1) IRF730P MOSFET Transistor

IRF730

NOTE – Be sure to install the IRF730P so that the exposed metal side of the device is facing away from the circuit board.

Install (1) L4 Air Core Inductor

L4

Please see the photographs at the back of this assembly manual for correct orientation of this inductor before soldering it in place.

The air core inductor L3 in your PA3 kit is supplied with leads that are cut to the proper length. Make sure that the enamel insulation is removed from the outermost ¼” of each connecting wire on L3.

If necessary, carefully bend the wires on L3 so that they pass through the mounting holes in the PA3 circuit board. Be careful not to bend the leads too far so as not to split the plastic insulation that holds the coil turns together. Insert the leads of L3 through the holes in the circuit board and carefully solder them in place.

Install (2) TO220 Mini Heat Sinks

NOTE: It is advisable to apply a small amount of heat sink compound (“thermal grease”) to the heat sink before attaching the heat sink to the transistor or voltage regulator.

- Install on MC7812 Voltage Regulator **Install SMALL heat sink here.**
- Install on IRF730P MOSFET Transistor **Install LARGE heat sink here.**

Install (1) TC4426 Integrated Circuit in its socket.

- 4426 socket (Previously installed.)

Install (1) 74HCT14 Integrated Circuit in its socket.

- 74HCT14 socket (Previously installed.)

Install (1) 3.1 MHZ oscillator module in its socket.

- OSC socket (Previously installed.)

Install (1) STW20NK50Z Transistor

Using the 3-connector terminal block for mounting the STW20NK50Z, simply insert the pins of the STW20NK50Z as far as they will go into the holes of the terminal block and gently but firmly tighten the clamping screws of the terminal block.

Note that when you mount the PA3 circuit board in its final location, it may be necessary to bend the pins of the STW20NK50Z in order to obtain the proper clearance of the PA3 circuit board from the heat sink.

When installing the transistor on the heat sink, be sure to use the supplied Bergquist thermal pad (white in color) or a good quality, high thermal transfer insulating sheet between the transistor and the heat sink.

The heat sink used should be able to dissipate a heat load of 100 watts or more. The part of the heat sink where the MOSFET is mounted must be at least 3/8 inch / 9.25 mm thick. This is necessary so that it will be able to spread out the heat from the MOSFET. Using a heat sink with less thickness risks damage to the MOSFET due to overheating at high power levels,

□ STW20NK50Z

FINAL INSPECTION

Using a magnifying glass and a bright light, carefully inspect the top and bottom of the finished circuit board for any unwanted solder splashes between connections, short wire clippings, or anything else that may cause problems during operation of the PA3.

Should you wish to remove the solder flux residue from the finished circuit board, you may use a commercial flux remover or 100% Isopropyl alcohol. Use only 100% Isopropyl alcohol. Rubbing alcohol is NOT suitable for removing the flux residue due to its high water content and the denaturing ingredients contained in rubbing alcohol. After cleaning the board, allow it to dry thoroughly before continuing.

This completes the assembly of the PA3 circuit board.

PA3 CIRCUIT BOARD CHECKOUT PROCEDURE

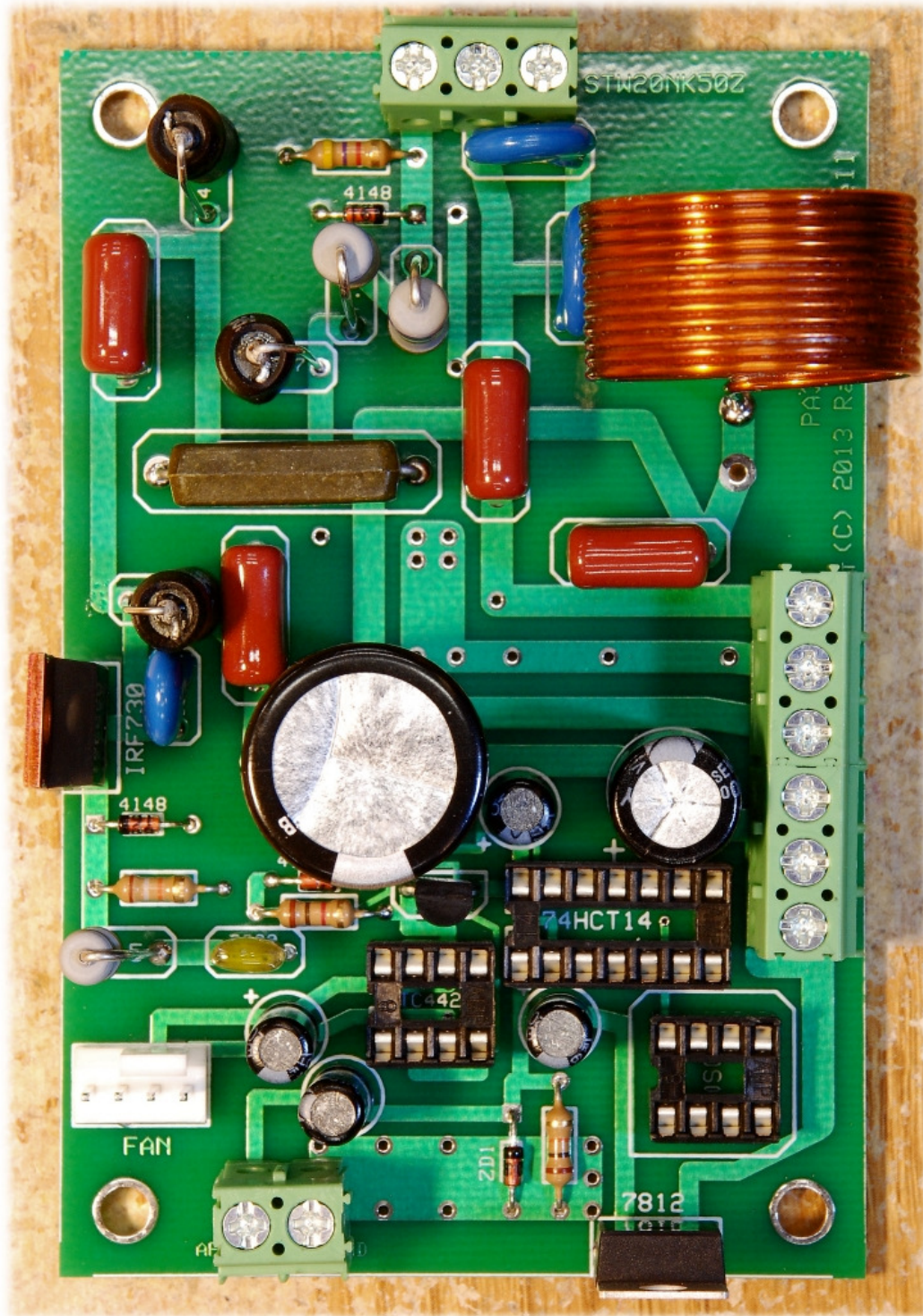
RESISTANCE CHECK

The following resistance checks are to be taken with no external connections to the circuit board.

Using an Ohmmeter, measure the resistance between the + 19 and GND terminals and between the + HV and GND terminals. The resistance readings should be greater than one Megohm. The resistance reading may be low at first when the Ohmmeter leads are connected, but the resistance reading will increase as the filter capacitors charge up from the Ohmmeter voltage,.

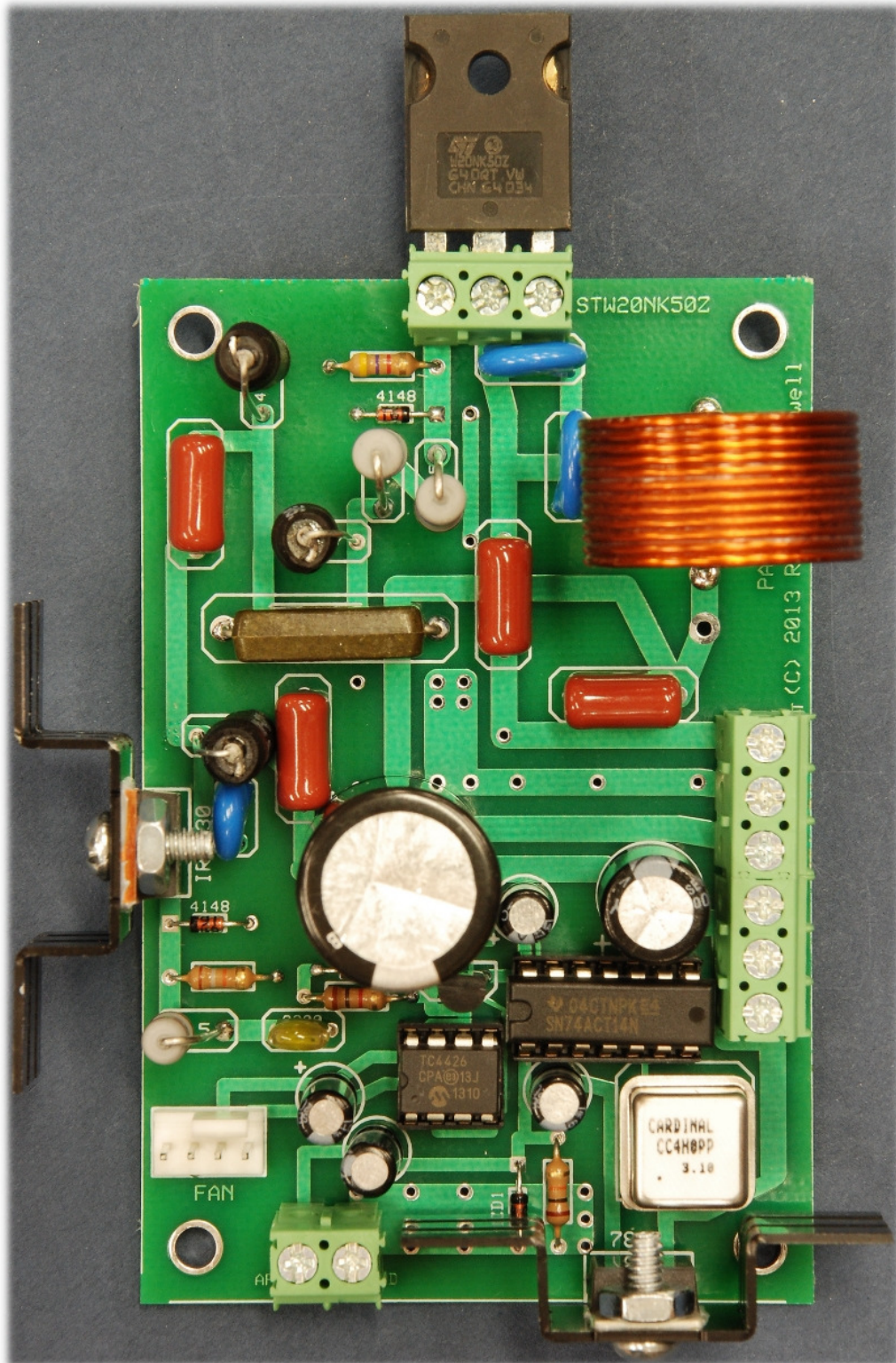
After the resistance reading stabilizes, reverse the Ohmmeter leads and make sure the resistance in the reverse direction also reads greater than one Megohm.

Your PA3 module is now ready for use. Please consult the PA3 Instruction Manual for final setup and operating instructions.



Partially Assembled PA3 - Showing Correct Orientation of Parts.

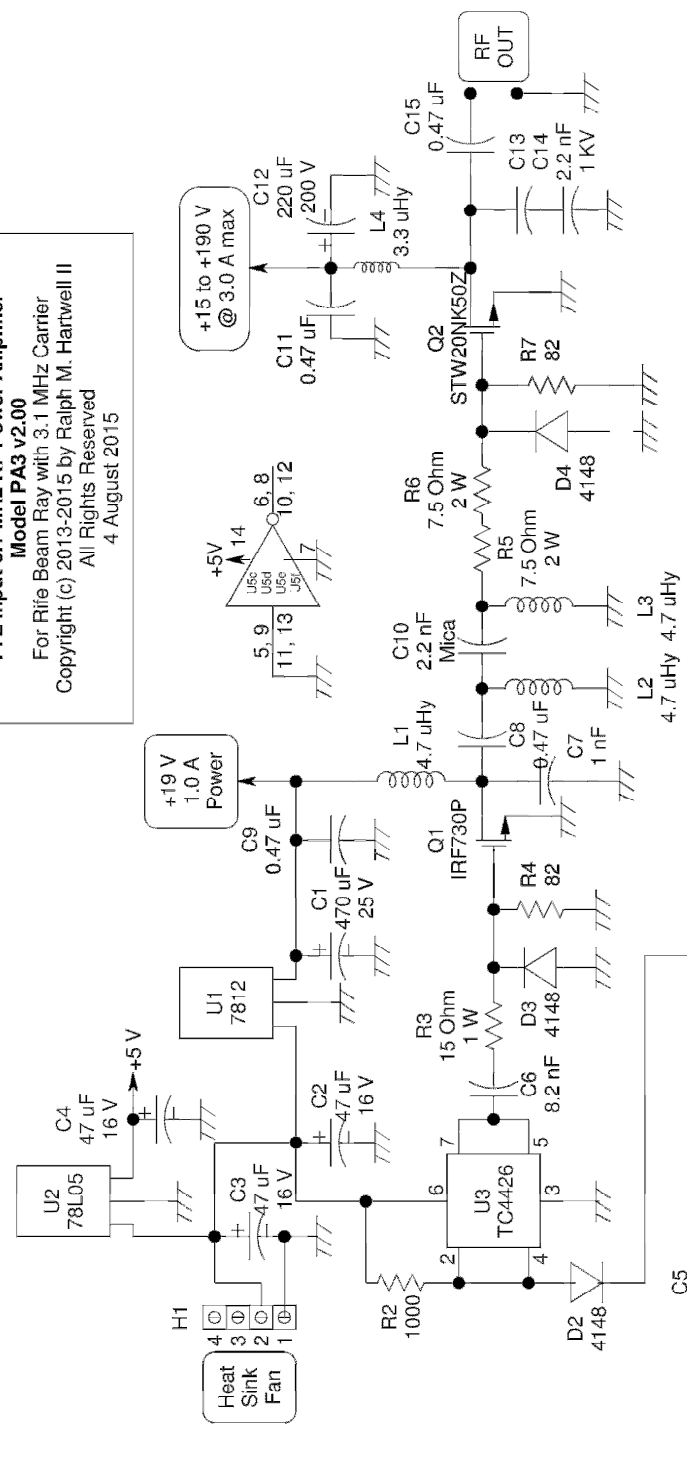
Inductor L4, Heat Sinks, TC4426, 74HCT14, oscillator module and STW20NK50Z are not yet installed.



Assembled PA3

Inductors L4, Heat Sinks, TC4426, 74HCT14, oscillator module and STW20NK50Z have been installed.

TTL Input 3.1 MHz RF Power Amplifier
Model PA3 v2.00
 For Rifle Beam Ray with 3.1 MHz Carrier
 Copyright (c) 2013-2015 by Ralph M. Hartwell II
 All Rights Reserved
 4 August 2015



NOTES:

- The STW20NK50Z must be mounted on suitable heat sink to dissipate 125 watts at full power.
- The STW20NK50Z is insulated from the heat sink with Bergquist SPA2000-0.015-00-104 Thermal Pad.
- The IRF730P and MC7812 both require a small heat sink.
- If it is mounted on a grounded heat sink, the IRF730P must be insulated from the heat sink with a Wakefield Thermal Solutions 175-6-280P Thermal Pad.
- The 4.7 uhy inductors are Bourns Inc. 5800-4R7-RC 4.7 uhy Ferrite Core RF Chokes.
- L3 is a 3.3 uhy air core coil. Do not use a ferrite core as it will slow the rise time of the waveform.

455 VPP / 500 Watts
 Maximum peak output
 @ 50 Ohms.

Absolute Maximum
 Drain voltage
 210 VDC at 1.70 A
 with a 50%
 duty cycle

Conversion efficiency
 80% minimum.

Schematic Diagram of the PA3