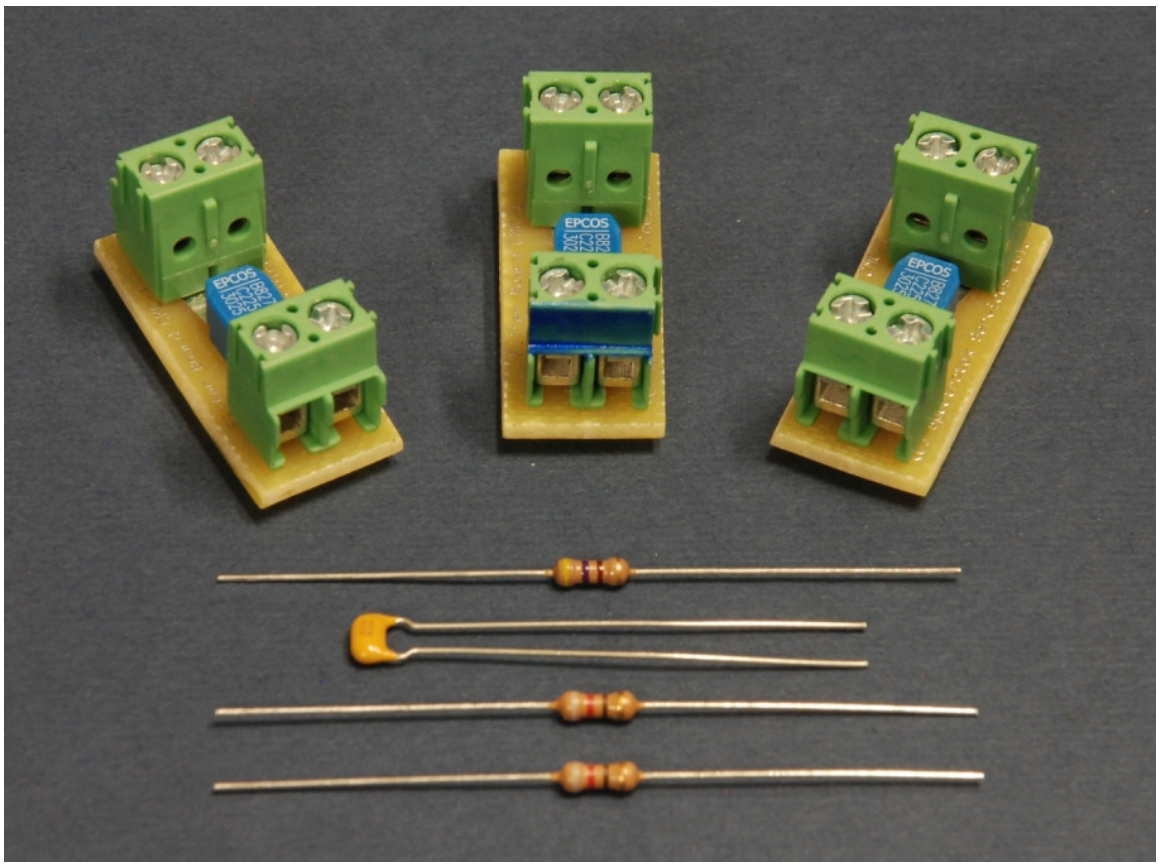
ECO-6 & Installation Manual

For the SPA4-RFR Upgrade Kit

To upgrade SPA4 amplifiers v1.00 & v1.01 to v2.0

Some sections also apply to the PA1, PA2, and PA3



14 August 2015

DISCUSSION

The modifications detained in this document will upgrade your SPA4 to the functional equivalent of the SPA4 version 2.0. This document incorporates all the information and modifications contained in ECO's 1, 2, 3, 4, and 5 for the SPA4 v1.00 and v1.01.

NOTE – Some of the modifications in this document also apply to the PA1, PA2, and PA3 amplifiers. These will be identified in **RED** letters next to the heading of each section.

One of the purposes of this modification kit is to install three outboard RF filter modules to the **B INPUT**, the **A GAIN**, and the **X1/X2** terminals. This will improve the performance of the SPA4 amplifier by reducing the sensitivity of the amplifier towards self interference that is caused by the connecting wires to the amplifier picking up an unwanted RF signal from the plasma tube. In extreme cases, this unwanted signal pickup may cause a malfunction of the amplifier which can result in an unstable duty cycle, erratic output pulses, or even destruction of the STW20KN50Z transistor

You will remove and replace two 4700 Ohm resistors that are located in the gate drive circuits of the IRF730 and the STW20NK50Z and replace them with new 82 Ohm 1.4 watt resistors. This will improve the gate drive waveforms and reduce the operating temperature of these transistors, as well as providing slightly higher power output.

Some amplifiers occasionally exhibit slightly low output or a fall-off in output during normal operation. This effect is most often seen when using DC voltages above 133 volts. The use of an oscilloscope will reveal a distorted gate drive signal present on both the IRF730 and the STW20NK50Z. The distortion becomes more severe ad the DC operating voltage is increased.

You will add a new 470 Ohm ¼ watt termination resistor to the **A INPUT**. This will improve the audio waveform and provide better modulation stability when using the **A INPUT** of the SPA4.

Successful installation of this modification kit

COMPONENTS

The filter kit contains the following items:
3 ea. – common mode RF filter boards, type CMC-1. NOTE – One filter board is position sensitive. It has a painted marking on one end to identify it.
6 ea. – 15mm lengths of #12 AWG bare copper wire for connecting the filter boards to the terminal strips of the SPA4.
2 ea. – 82 Ohm ¼ watt resistors.
1 ea. – 470 Ohm ¼ watt resistor.
1 ea. – 0.1 uF 50 volt ceramic capacitor.

PREPARATION FOR INSTALLATION

Disconnect all wires from the SPA4 and remove the amplifier from its enclosure. You will need access to both sides of the board. You will need soldering and desoldering tools.

ADD NEW COMPONENTS SPA4

1) Solder the new 470 ohm resistor between the **+A IN-** terminals as seen here. (The new filter boards are shown installed.)

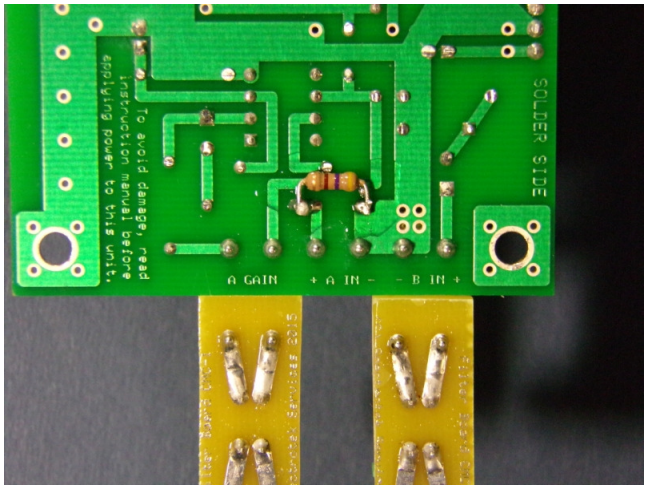


Figure 1.
470 Ohm resistor added between the **+A IN-** terminals.

2) Solder the 0.1 µF capacitor between the **SW3 TTL/RF** terminals as seen here. (The new filter board is shown installed.)

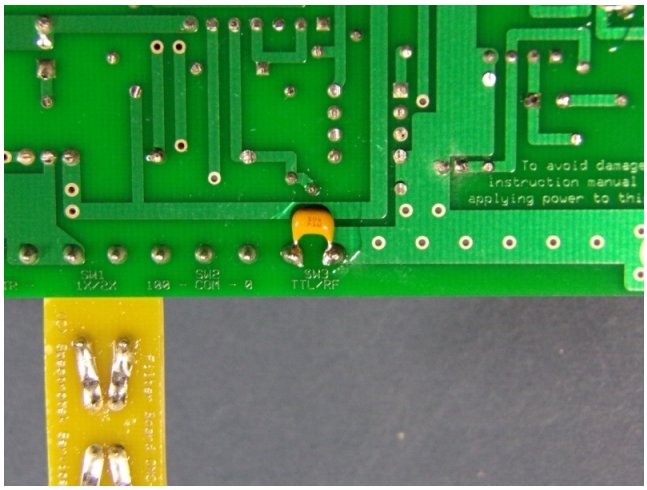


Figure 2.
0.1 uF capacitor added between the **SW3 TTL/RF** terminals.

3) If you are not able to solder the resistor and capacitor to the circuit board, you may install them by inserting their leads into the appropriate terminal strip connections along with the existing connecting wires.

CHANGE TWO GATE RESISTORS SPA4 PA3 PA2 PA1 - (1 resistor only)

4) Next, you will remove the existing gate resistors for the IRF730 and the STW20NK50Z and replace them with the new 82 Ohm resistors. Depending on the particular version and serial number of the amplifier, the resistor will be 4700 Ohms (4.7 k) or 18,000 Ohms (18 k).

5) Please refer to **Figure 3**, (next page,) for the location of the gate resistors.

The new 82 Ohm gate resistor for the STW20NK50Z is directly above the diode marked “4148”.

The new 82 Ohm gate resistor for the IRF730 is located to the lower left and directly left of the large electrolytic capacitor with the aluminum top. It is directly below the diode marked “4148”.

6) Remove the old resistors and replace them with the new 82 Ohm ¼ watt resistors. In the event that you are not able to remove the resistors, the new resistors may be soldered directly across the existing old resistors. In this case, it is not necessary to remove the old resistors.

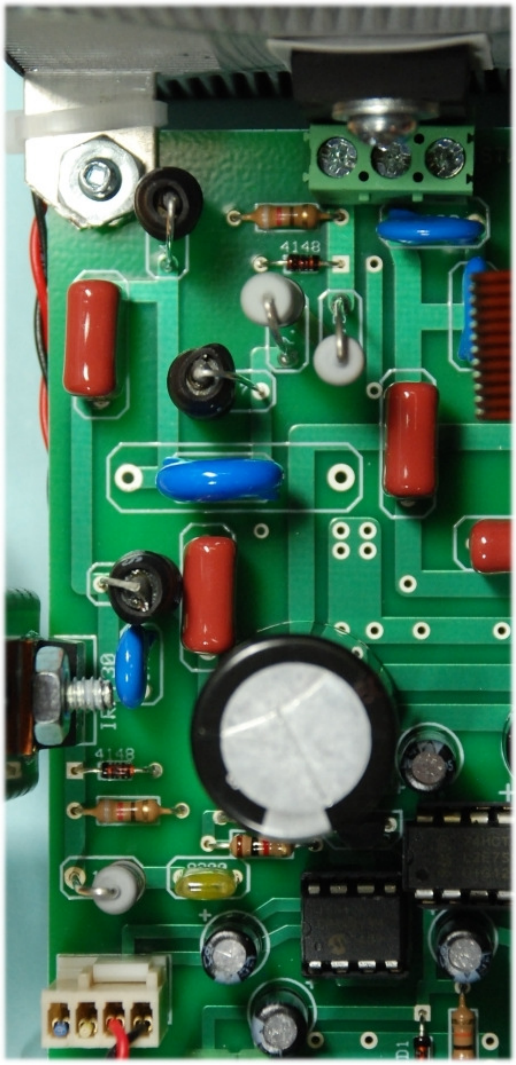


Figure 3.
Location of the gate resistors on the SPA4 and the PA3 amplifiers.

INSTALL FILTER BOARDS SPA4

7) Next, install the new filter boards to your SPA4 amplifier. The filters will be installed at these terminal strip locations: **A GAIN, B INPUT,** and **X1/X2.**

8) **One of the three filter boards has a blue paint mark on the outside of one of the terminal strips.** There is also a small 220 pF ceramic capacitor soldered to the bottom of the filter board at the end of the circuit board. This is the end of the board that has the blue paint marking.

9) Take one piece of 15mm copper wire and insert it as far as it will go into one of the holes in the terminal strip that has the blue paint mark.

10) As seen in the **Figure 4**, below, use a small screwdriver to gently tighten the terminal-strip screw just enough to prevent the wires from falling out of the terminal strip.

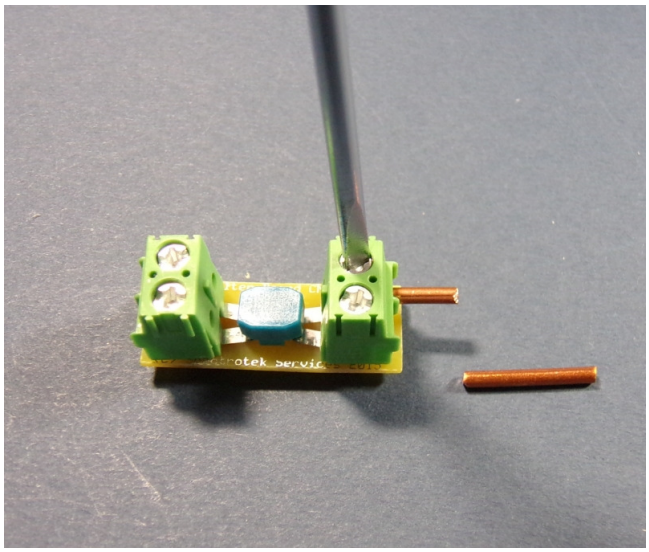


Figure 4.
Inserting a connecting wire to the filter board.

11) Using a second piece of 15mm copper wire, insert the wire as far as it will go into the other hole of the blue paint marked terminal strip.

12) As seen in the **Figure 1**, use a small screwdriver to gently tighten the terminal-strip screw just enough to prevent the wires from falling out of the terminal strip.

13) Repeat steps (2) through (5) with the other two filter boards. Note that these filter boards do NOT have a blue dot or a capacitor installed, so you may put the wires into the terminal strip at either end of these filter boards.

14) Take one of the filter boards **WITHOUT** the blue paint mark and insert the end of the copper wires as far as they will go into the terminals on the SPA4 that are marked **A GAIN**. Note that it may be necessary to loosen the screws on the SPA4 terminal strip to insert the wires. The filter board should be placed as close as possible to the SPA4 circuit board, as shown in the picture.

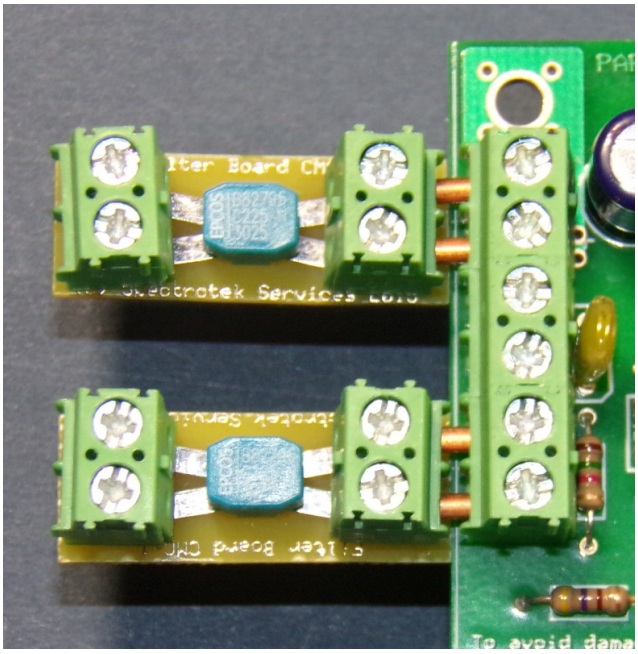


Figure 5.
Filter boards installed on B INPUT and A GAIN terminals.

15) Tighten the terminal-strip screws on the filter board and the SPA4 enough to clamp the copper wires firmly in place. Do not tighten the screws so much that they strip the screw threads.

16) Take the other filter board **WITHOUT** the blue paint mark and insert the end of the copper wires as far as they will go into the terminals on the SPA4 that are marked **B INPUT**. Note that it may be necessary to loosen the screws on the SPA4 terminal strip to insert the wires. The filter board should be placed as close as possible to the SPA4 circuit board, as shown in the picture.

17) Tighten the terminal-strip screws on the filter boards and the SPA4 enough to clamp the copper wires firmly in place. Do not tighten the screws so much that they strip the screw threads.

18) Take the third filter board **WITH** the blue paint mark and insert the end of the copper wires as far as they will go into the terminals on the SPA4 that are marked **X1/X2**. Note that it may be necessary to loosen the screws on the SPA4 terminal strip to insert the wires. The filter board should be placed as close as possible to the SPA4 circuit board, as shown in the picture. **Be sure end of the filter board with the blue paint mark is against the SPA4 or the filter will not work properly.**

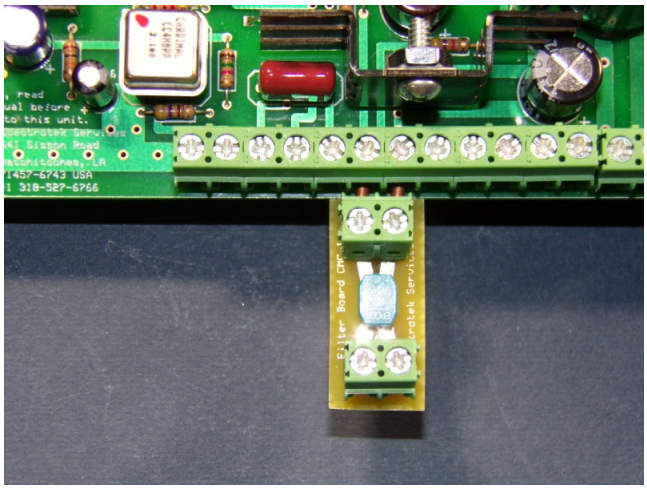


Figure 6.
Blue paint marked filter board installed on the XI / X2 terminals.

19) Tighten the terminal-strip screws on the filter board and the SPA4 enough to clamp the copper wires firmly in place. Do not tighten the screws so much that they strip the screw threads.

20) At this point, your SPA4 should look like this:

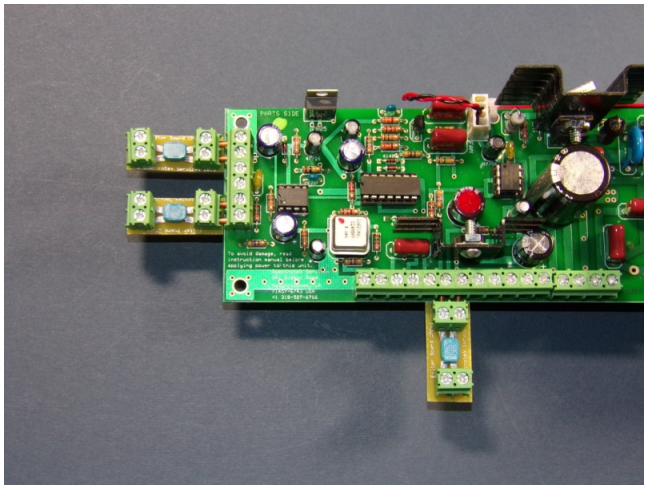


Figure 7.
All filter boards installed on SPA4 amplifier.

HEAT SINK FAN MODIFICATION SPA4 PA3 PA2 PA1

PROBLEM

The STW20NK50Z in the SPA4 may become too hot when operating under the following conditions:

1) The SPA4 is operating with a DC voltage greater than 133 volts, and;

2) The duty cycle of the input signal is greater than 60%, and;

3) The ambient air temperature is above 25ºC.

4) Under some operating conditions, RF interference from the IRF730 may be picked up by the power wires going to the heat sink cooling fan. This may cause the cooling fan to change speed and run too slowly when some modulation frequencies are used. The slow fan speed can result in failure of the STW20NK50Z due to overheating.

5) The built-in temperature sensor in the cooling fan does not sense the heat sink air temperature; instead, it senses the temperature of the incoming ambient air. As far is as known, only those fans with part number 1A02C3W00 are affected, however, it is suggest that all fans should be modified.

SOLUTION

Reversing the direction of the cooling fan will reverse the direction of air flow through the STW20NK50Z heat sink. This will enable the temperature sensor in the cooling fan to sense the actual heat sink air flow temperature. The fan speed will automatically increase as the heat sink becomes warmer, which will lower the temperature of the STW20NK50Z. The addition of a covering or shroud to enclose the heat sink will confine the air flow to the interior of the heat sink and assist the cooling process.

To eliminate the RF pickup problem, two wires will be removed from the fan power wire harness.

After these changes, the SPA4 will safely operate at voltages up to 152 volts with a duty cycle up to 100%. Above 152 volts, the duty cycle should be limited to 70% or less for safe operation.

To accomplish this modification, follow these steps:

21) Cut and remove the two plastic zip ties that hold the power wires that run from the cooling fan to the white plug that connects to the circuit board connector on the SPA4.

22) Remove the four screws that attach the cooling fan to the front of the heat sink.

23) The cooling fan wires will have either two or four wires. The four wire colors are **red, black, yellow** and **blue**. If there are only two wires, go to Step (25).

24) If there are four wires, cut and remove both the **YELLOW** and **BLUE** wires. Cut the wires at the white plastic plug and cut the wires as close to the fan circuit board as possible. Be careful not to damage the fan circuit board or the red and black wires.

25) Look at the back of the cooling fan that was mounted against the heat sink. **(See Figure 9, LEFT.)** If the back side of the fan has four corner standoffs that space the fan slightly away from the heat sink, then cut away the standoffs to make the back of the fan smooth. If this is not done, the mounting screws will be too short to reinstall the fan on the heat sink.

26) After removing the standoffs, use the four mounting screws that were removed in Step (2) to reinstall the cooling fan against the heat sink facing the opposite direction from which it was originally installed. Attach the fan so that the red and black power wires are visible. **(See Figure 8, RIGHT.)**

27) Use some adhesive backed tape, such as plastic electrical tape, and carefully wrap the outside of the heat sink so the heat sink is completely covered. This ensures that no cooling air can escape through the sides and edges of the heat sink. Overlap the tape between the heat sink and the cooling fan to prevent air leaks at the junction between the heat sink and the fan. **(See Figure 11.)**

28) Replace the fan power plug on the circuit board connector.

29) For neatness, you may replace the plastic zip ties that hold the cooling fan power wires to the SPA4 circuit board. It is not necessary to replace the plastic zip ties for the SPA4 to function correctly.

After this modification, the speed of the cooling fan will be controlled automatically by the thermal sensor in the fan. As the heat sink becomes warm, the speed of the fan will increase as necessary to maintain the proper temperature.

Figure 8.
LEFT – Fan in original mounting configuration.
RIGHT – Fan in reversed air flow mounting configuration after modification.

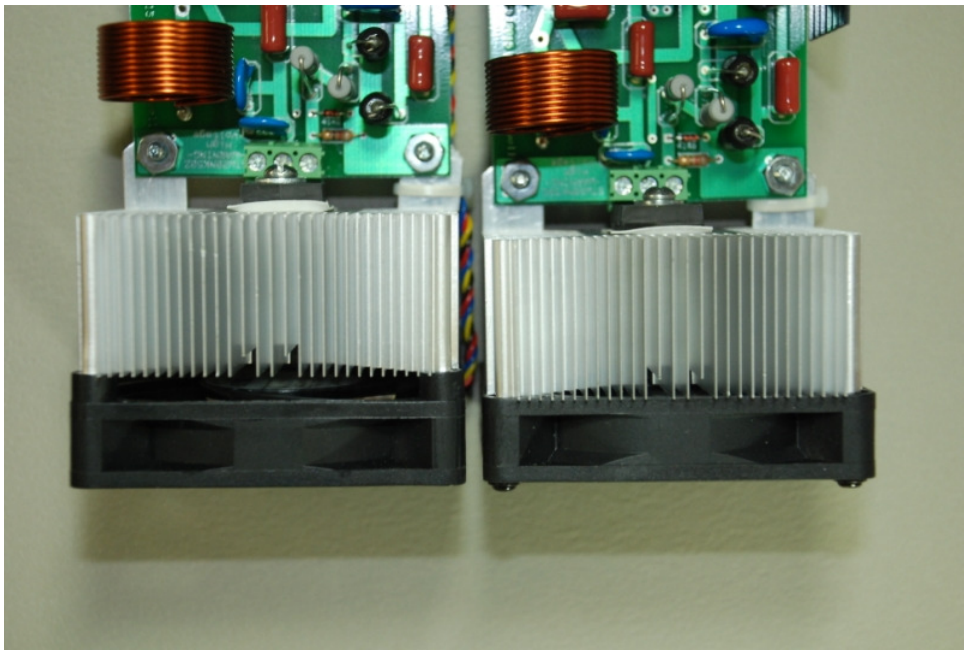


Figure 9.

LEFT – Original mounting configuration. Fan is spaced away from heat sink by plastic standoffs. Air discharge is towards the circuit board.

RIGHT – New mounting configuration shows fan mounted against heat sink. Air discharge is away from the circuit board.

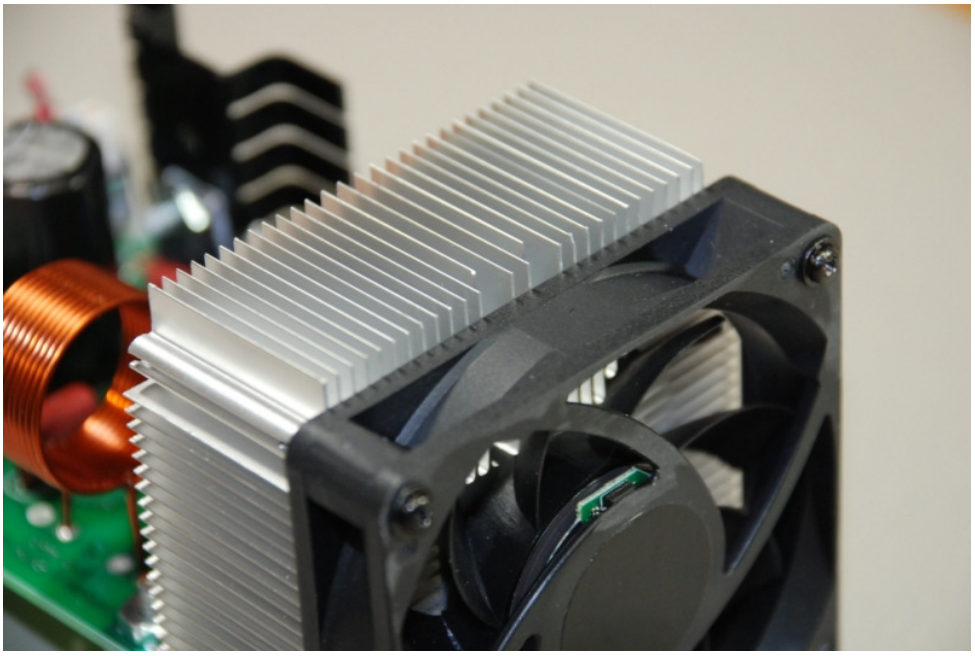


Figure 10
Fan in new reversed airflow mounting configuration.

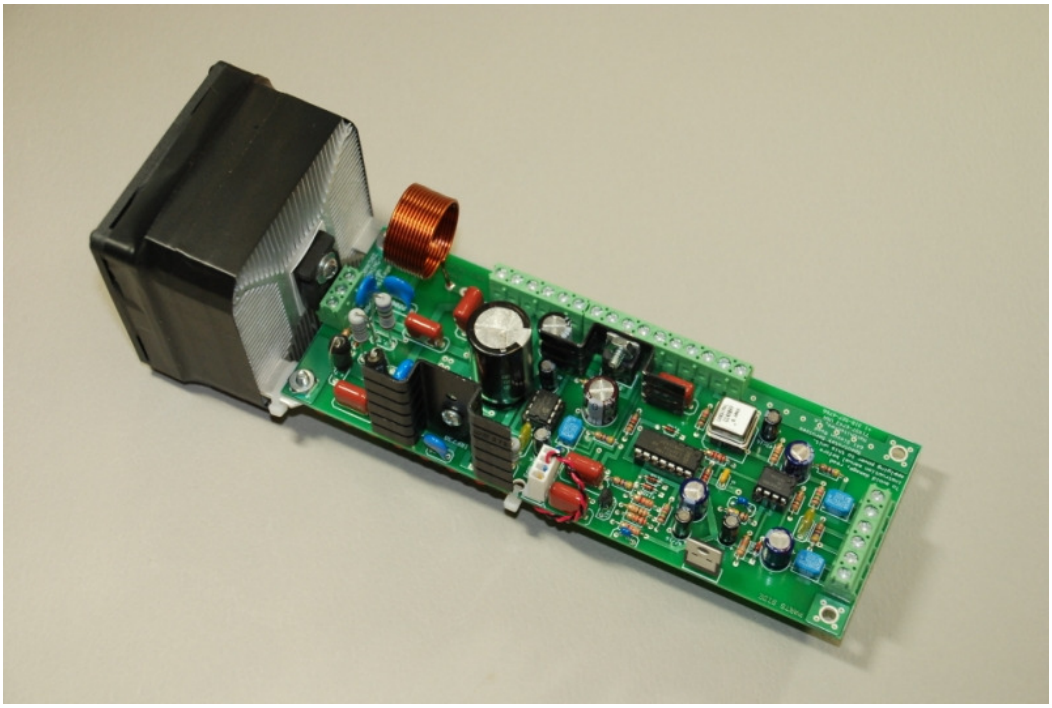
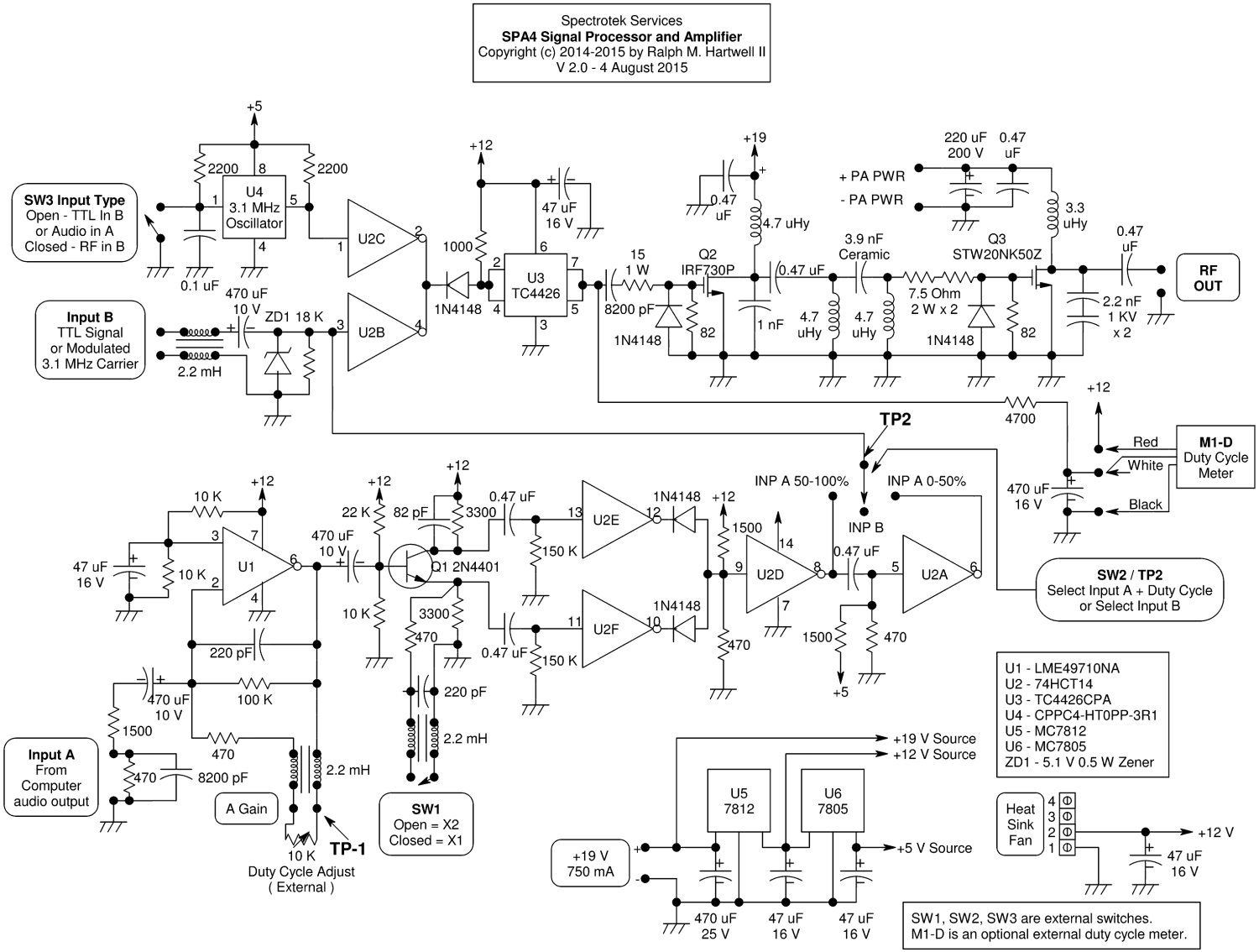


Figure 11.
SPA4 v2.0 processor-amplifier shown with fan configured for reversed airflow with heat sink shroud tape installed.

This completes the installation and upgrade of your SPA4 amplifier to Version 2.0.

Please replace the old schematic diagram in the instruction manual for your SPA4 amplifier with the revised schematic diagram found on the next page.

Edited by  CAT


Spectrotek Services
SPA4 Signal Processor and Amplifier
Copyright (c) 2014-2015 by Ralph M. Hartwell II
V 2.0 - 4 August 2015
SW3 Input Type
Open - TTL In B
or Audio in A
Closed - RF in B
Input B
TTL Signal
or Modulated
3.1 MHz Carrier
U4
3.1 MHz
Oscillator
2200
2200
0.1 uF
470 uF
10 V
ZD1 18 K
2.2 mH
U2C
U2B
1000
1N4148
U3
TC4426
47 uF
16 V
+5
+12
+19
0.47
uF
4.7 uHy
15
1 W
8200 pF
1N4148
Q2
IRF730P
82
1 nF
0.47 uF
4.7
uHy
3.9 nF
Ceramic
4.7
uHy
7.5 Ohm
2 W x 2
Q3
STW20NK50Z
1N4148
82
220 uF
200 V
0.47
uF
+ PA PWR
- PA PWR
3.3
uHy
0.47
uF
2.2 nF
1 KV
x 2
RF
OUT
TP2
4700
+12
Red
White
Black
M1-D
Duty Cycle
Meter
470 uF
16 V
INP A 50-100%
INP A 0-50%
INP B
SW2 / TP2
Select Input A + Duty Cycle
or Select Input B
10 K
+12
47 uF
16 V
U1
10 K
220 pF
470 uF
10 V
100 K
1500
470
470
8200 pF
2.2 mH
Input A
From
Computer
audio output
A Gain
10 K
TP-1
Duty Cycle Adjust
(External)
22 K
82 pF
470 uF
10 V
Q1 2N4401
10 K
3300
470
220 pF
2.2 mH
SW1
Open = X2
Closed = X1
3300
0.47 uF
150 K
U2E
U2F
1N4148
1N4148
150 K
0.47 uF
1500
U2D
U2A
470
1500
470
0.47 uF
+5
U1 - LME49710NA
U2 - 74HCT14
U3 - TC4426CPA
U4 - CPPC4-HT0PP-3R1
U5 - MC7812
U6 - MC7805
ZD1 - 5.1 V 0.5 W Zener
+19 V Source
+12 V Source
+19 V
750 mA
U5
7812
U6
7805
+5 V Source
470 uF
25 V
47 uF
16 V
47 uF
16 V
Heat
Sink
Fan
+12 V
47 uF
16 V
SW1, SW2, SW3 are external switches.
M1-D is an optional external duty cycle meter.