BRIDGE MODE FOR THE STEREO 120

Preface to Everything

PLEASE READ THIS FIRST! YOU MAY SAVE YOURSELF A LOT OF TROUBLE!

At some point I made 4 Ohm 1 kHz output power tests of single channels of the updated Stereo 120 with super heat sinks. I was kind of thrilled to find that single channel would deliver more than 100 Watts into 4 Ohms. On that basis, I did quick tests of a bridging configuration.

In the bridging configuration, the channels are driven out of phase, with the speaker connected between the left and right channel outputs. If you drive an 8 Ohm speaker in that fashion, each amplifier channel effectively sees a 4 Ohm load. On the basis of my earlier test, there should be prodigious output power available. Indeed, my early 1 kHz tests into a bridge tied 8 Ohm load showed that the amp could deliver almost 160 Watts!

Eventually, I came to write this white paper. In the course of doing so, I checked output power using 50 Hz, rather than 1 kHz. Much to my dismay, the power wasn't quite so impressive, and it faded quickly as even the super heat sinks warmed up. What was going on?

It seems that the LM3886 has built-in Safe Operating Area protection. That protection limits the power that can be delivered at low frequencies. That limiting was cutting in, lowering the power that could be delivered at below about 100 Hz.

As a result, we conclude that the bridging mode is only useful if:

- The impedance of your bridge tied load is nominally 16 Ohms, or
- You aren't producing low frequency power...e.g. the midrange and/or tweeter channel of a bi or tri-amped system

Warnings

Understanding the above, and assuming you want to go on: Before making any of the indicated modifications, make sure that both channels of your amplifier are working correctly.

Reread the previous section to understand the limitations of bridged mode operation!

There are potentially lethal voltages inside the Stereo 120. Work safely:

1. ***always remove the AC plug from the wall before working on the amplifier***
2. ***allow 1 minute for charge in the power supply capacitors to dissipate before commencing work***

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Revision 1p7, January 26, 2012

About Bridging

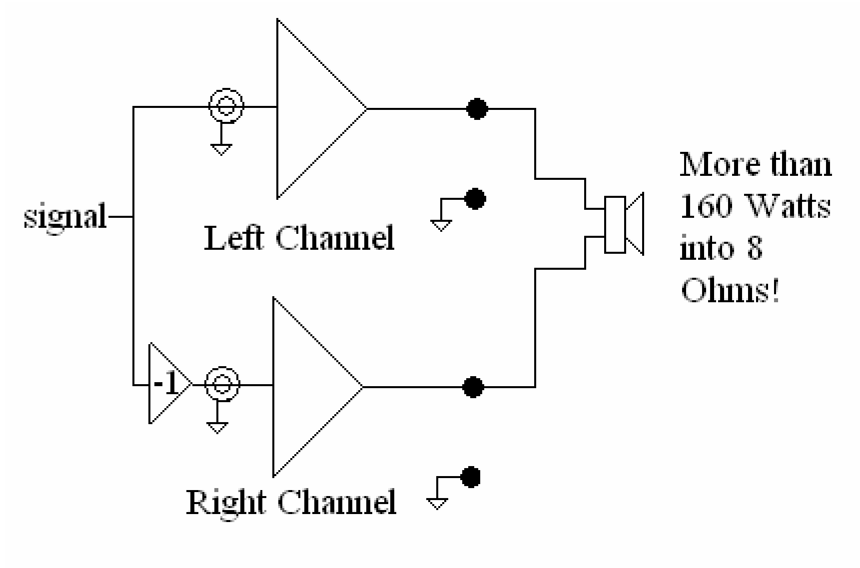

Figure 1-Bridging Mode Concept

In bridging mode, you drive the channels out of phase, and connect the speaker between the two red binding posts. This doubles the available open circuit voltage to drive the load. Ideally, that would turn a 60 watt per channel stereo amp into a 240 Watt mono amp.

Practically, limitations in the power supply and losses and power limits in the amplifier modules limit the Stereo 120's bridging mode power to about 160 Watts into 8 Ohms. That power is only available for reasonable lengths of time for frequencies of 1 kHz and above. 16 Ohm speakers work out well, with 120 Watts available to a single 16 Ohm speaker. 8 Ohm bridge tied speakers trigger the SOA protection circuits at a low enough level to make the technique inadvisable for this amplifier.

Our Bridge Mode Conversion

We will produce the same result as shown in Figure 1, but get there by a slightly different path. In our modification, we will:

- connect the input signal to the left channel
- not use the right channel input
- add a resistor that adds a gain of 1 inverting input to the right channel

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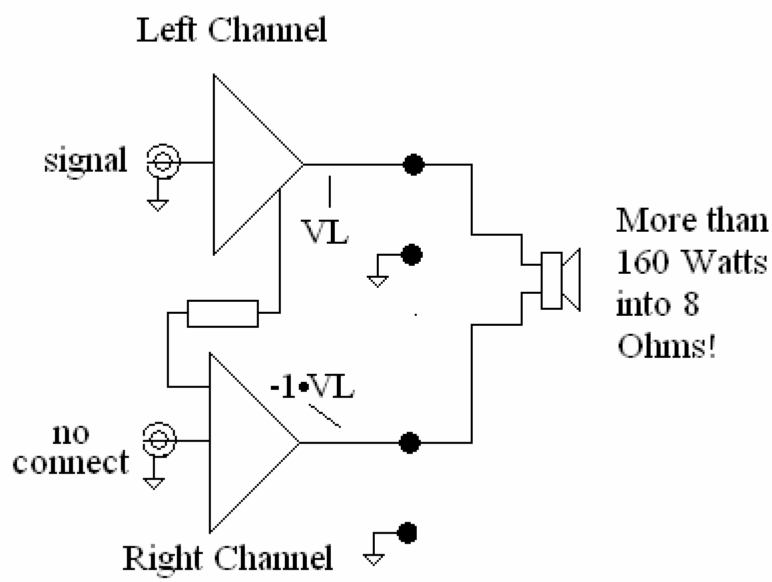

Figure 2-Bridge Mode by converting right channel to unity gain inverting amplifier

Detailed Directions

Here are the step by step directions to guide you through the conversion. These directions show how to make this as a permanent modification. The following section discusses an alternative whereby you can make Bridge Mode switchable.

Before You Begin

1. Remove the Stereo 120 from your system. Disconnect the AC power plug from the wall socket. Let the amplifier sit for 1 minute.
2. Remove the 4 screws from the bottom of the amp that hold on the top cover.
3. Remove the top cover.

Build the Bridging Harness

4. Prepare a 9” length of black/white twisted wire as follows, so the result looks like Figure 3.
    a. Remove ¼” of insulation on both the black and white wires on one end.
    b. Twist the exposed conductors.
    c. Remove ¼” of insulation on the white wire at the other end.
    d. Wrap the insulated black wire around the end of the white wire as shown in the left side of Figure 3
    e. Tin both ends of the white wire.

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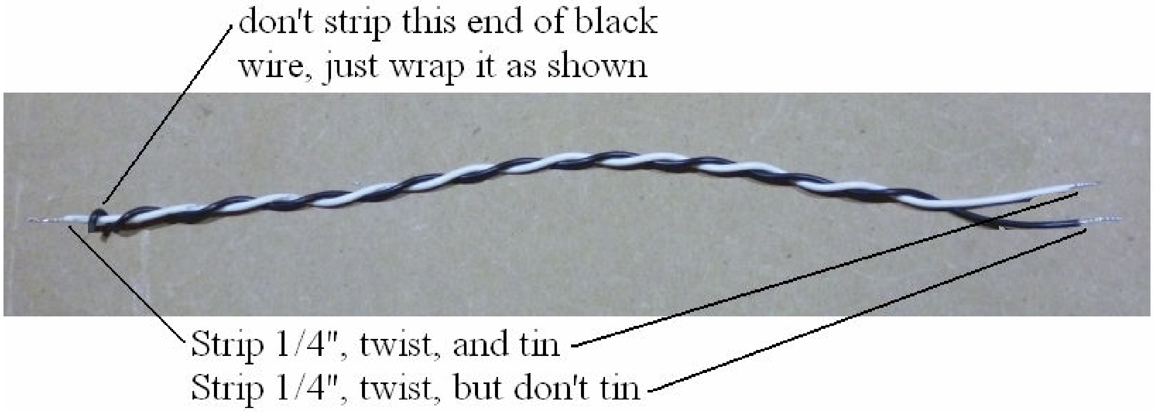

Figure 3-Preparing the 9" black/white twisted pair for the briding harness

5. Cut one lead of the 20K resistor to 3/8" length. Form that lead into a hook as shown in Figure 4.
6. Slip a 1" long piece of 1/8" diameter heat shrink tubing over the white wire.
7. Form a hook in the white wire.

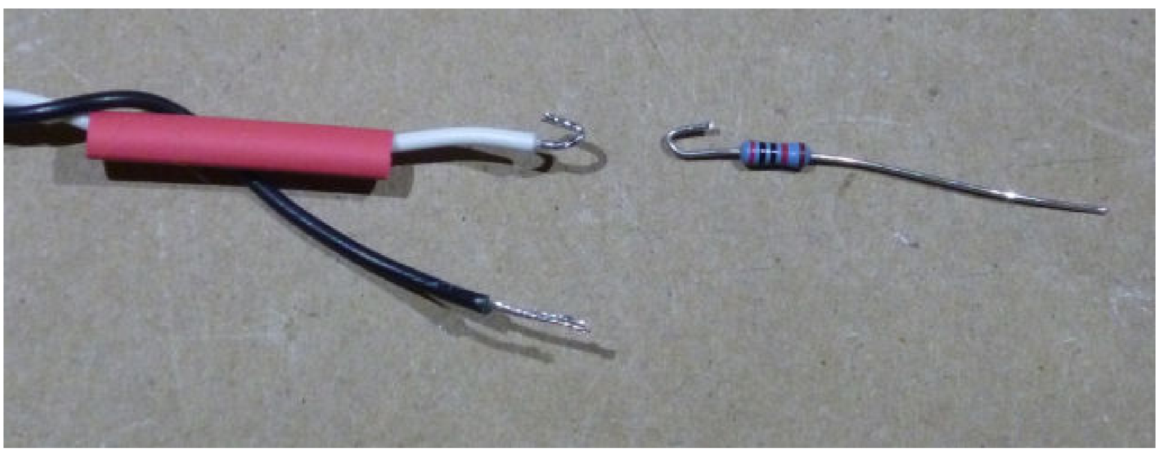

Figure 4-preparing to install the 20K resistor

8. Interlock the hook in the white wire and the resistor, crimp both hooks, and solder the resistor to the wire as shown in Figure 5. Keep the joint relatively compact, and keep the soldering iron heat away from the heat shrink tubing.

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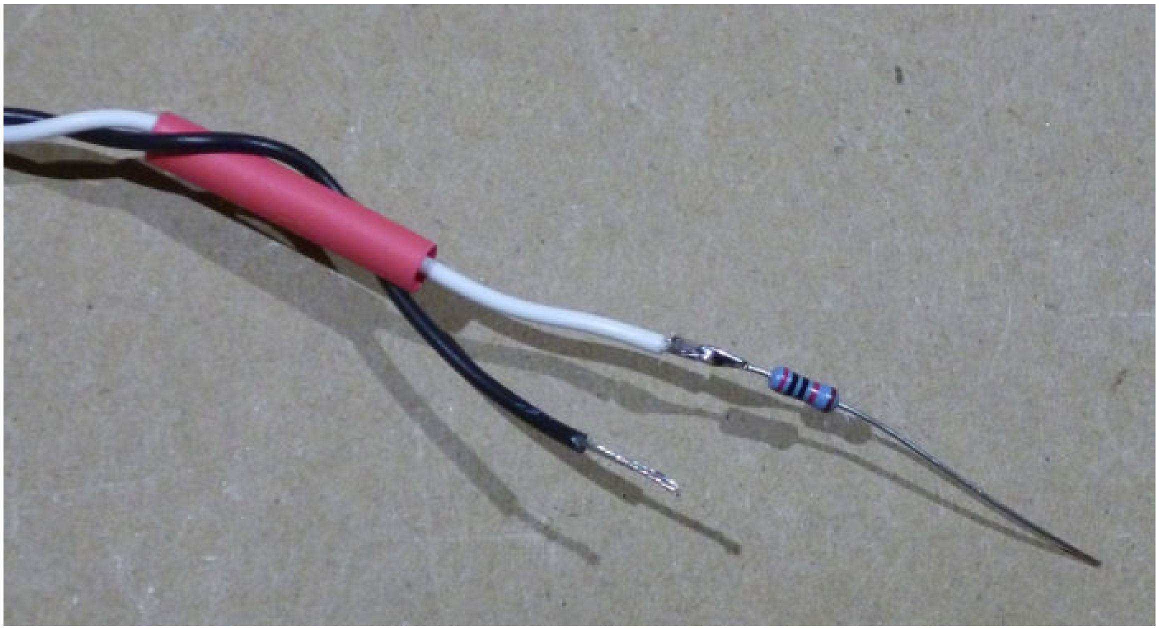

Figure 5-crimping and soldering the resistor in place

9. Slide the heat-shrink tubing so that its right-most end hangs just beyond the body of the resistor.
10. Slide the soldering iron back and forth over the length of the heat shrink tubing as you work your way around the diameter (Figure 6). This causes the heat-shrink tubing to contract, making a trouble-free assembly (Figure 7).

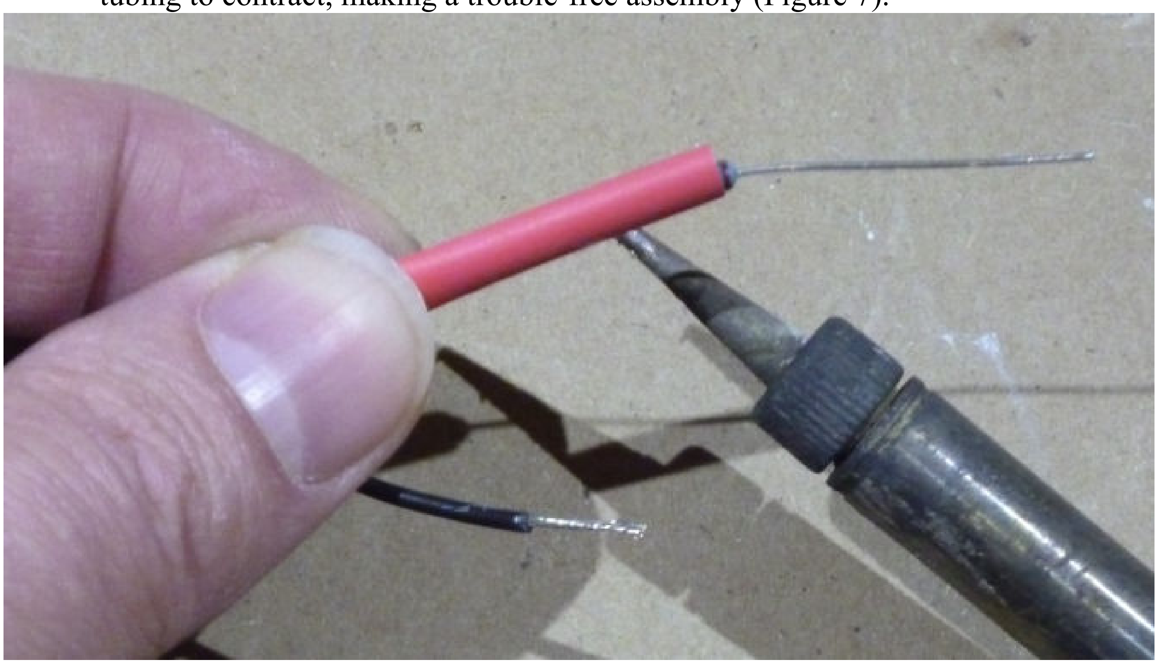

Figure 6-shrink the tubing with heat from the soldering iron

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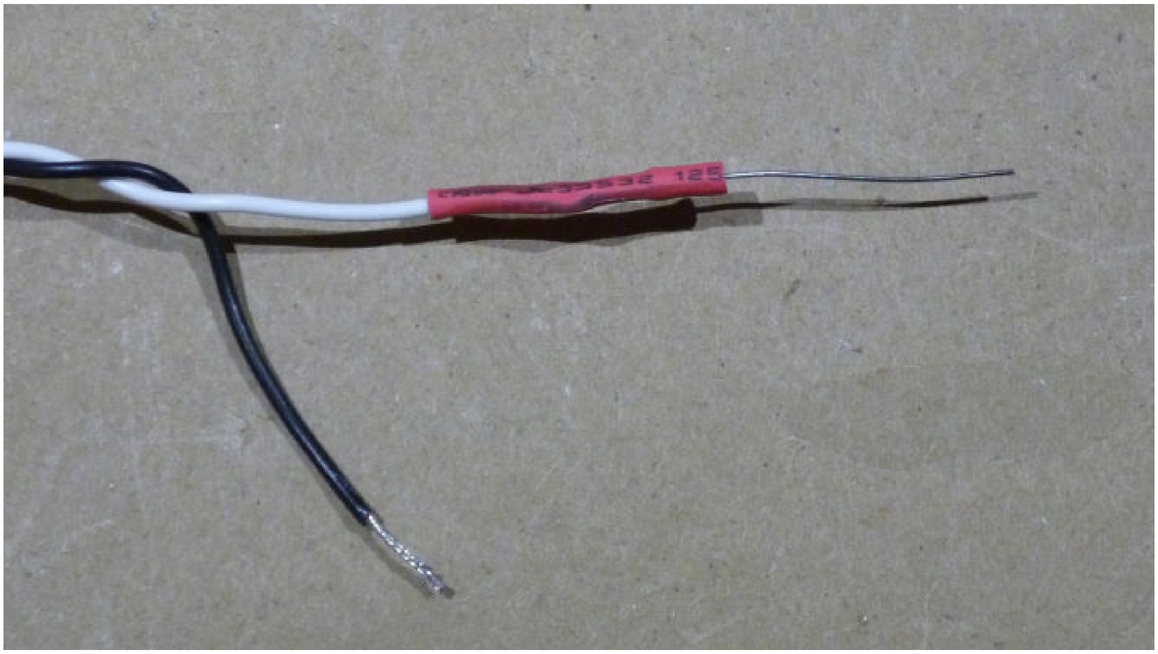

Figure 7-completed harness assembly. Note that the heat shrink extends slightly beyond the end of the resistor body

<u>Right Channel Modifications</u>

11. Remove the two screws from the bottom of the chassis that hold the RIGHT channel super heat sink in place. This gives you access to the PCB.
12. Insert the free end of the 20K resistor into the RIGHT channel circuit board, from the component side, at the location shown in Figure 8. Solder the resistor on the solder side of the board. The heat-shrink and resistor we end up at about a 45 degree angle to the plane of the board (Figure 9).

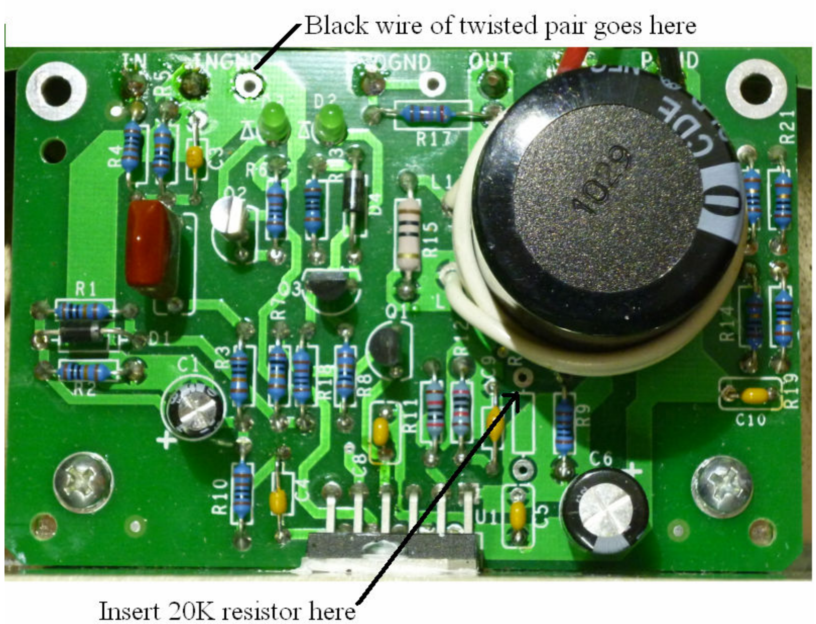

Figure 8-RIGHT channel circuit board connections

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13. Connect the black wire of the 9” black/white twisted pair to one of the unused INGND eyelets on the RIGHT channel pcb, inserting it from the component side, and soldering on the solder side.

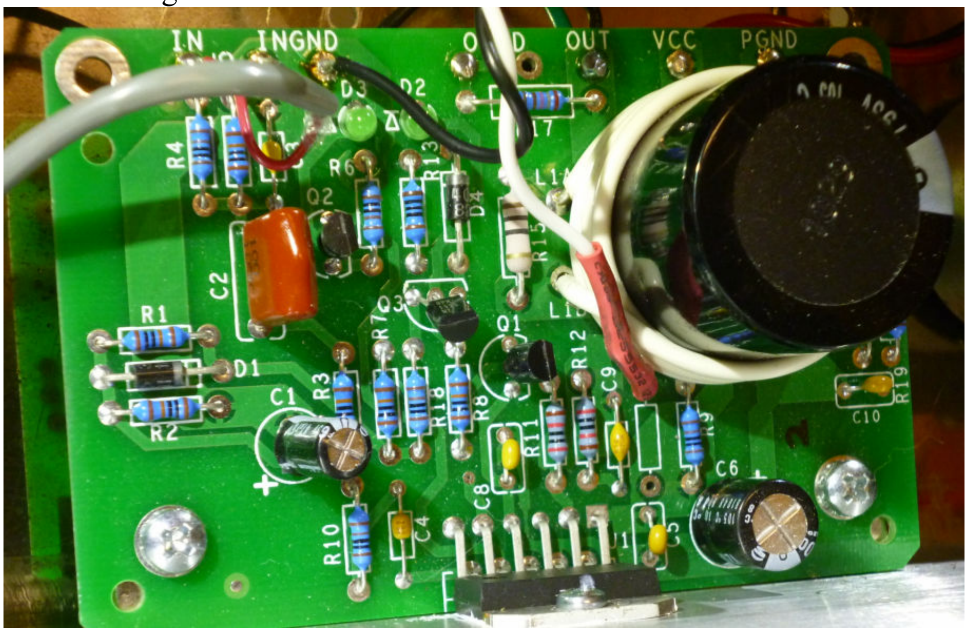

Figure 9-bridging harness connections to right channel circuit board

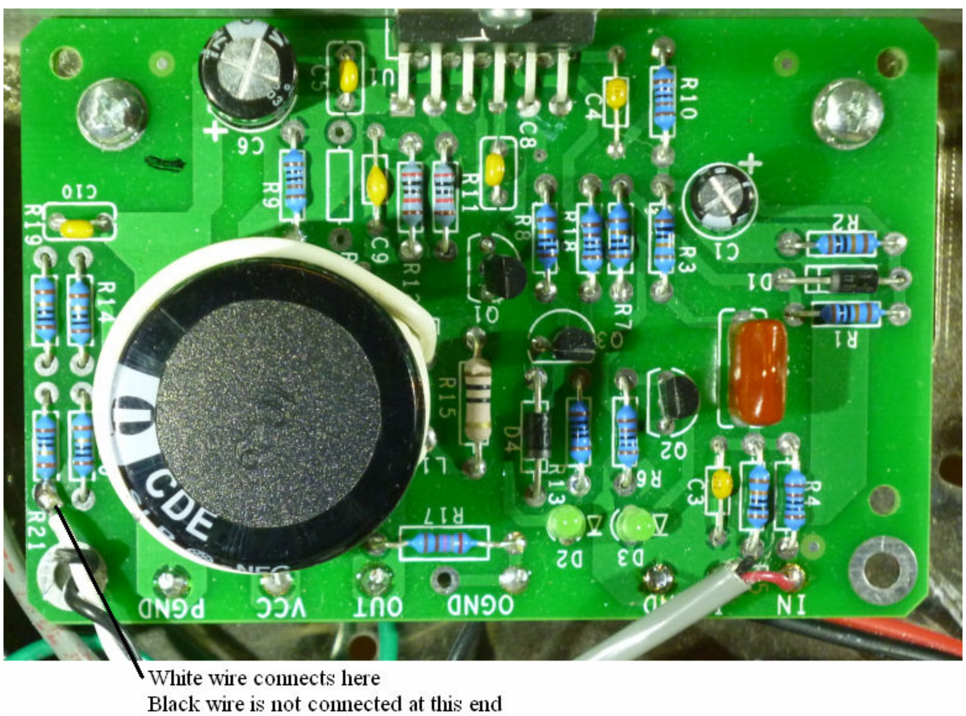

Figure 10-connecting bridging harness to LEFT channel circuit board

<u>Left Channel Modifications</u>

14. Form the white wire on the remaining end of the harness into a hook. Crimp that hook to the lead of R21 on the LEFT channel PCB, on the side of R21 furthest

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from the mounting brackets. Solder the wire to R21. It doesn't matter if it touches that same end of R20 also, as these resistors are both connected on that end.

<u>Final Assembly</u>

15. Neatly dress the bridging harness between the channels.
16. Reinstall the left channel super heat sink module.
17. You may find that you want to shorten the bridging harness at the end that connects to the left channel circuit board. If you do so, maintain the twisted arrangement. Note that if you shorten the wires, you may have to disconnect it from the left channel circuit board if ever you need to work on the bottom of either circuit board.
18. Reinstall the amplifier cover.

Figure 11 shows the completed amplifier with bridging. Note the funny shape of the harness. As we mentioned before, feel free to shorten the harness, making this a straight run. The only shortcoming of doing so is that it may need to be disconnected if you must work on an amplifier channel.

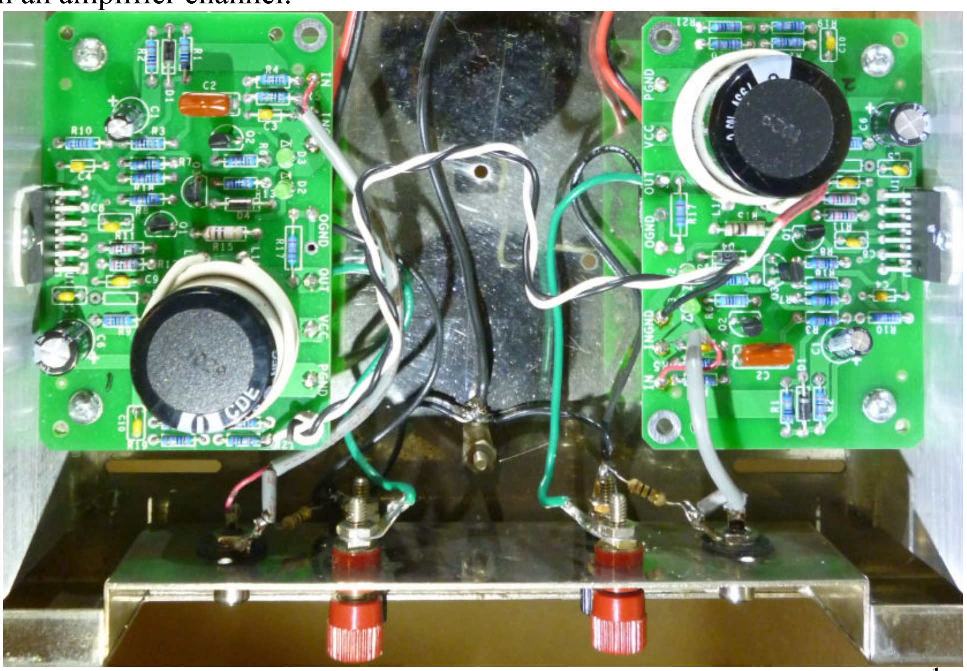

Figure 11-Harness connects left and right channels to provide bridging function[1]

<u>Using the Bridging Amplifier</u>

Speaker Connections: Connect an 8 Ohm or greater speaker between the red binding posts for the right and left channels.

Amplifier input: Connect the drive signal to the amplifier only to the LEFT channel input. Do not use the RIGHT channel input.

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[1] The resistors in the picture are for use with isolated input jacks and do not affect the bridging modification.

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Sensitivity: The bridged amplifier is twice as sensitive as an unbridged amplifier. You will probably significantly dial back your preamp's volume control. If your preamp is a PAT-4, this may degrade the signal to noise ratio a bit. At this writing, I'm working on a modification for the PAT-4 that disables the tone controls and places its volume control in a more favorable range.

Polarity: In bridged mode operation, the left channel red binding post has the same polarity as the input signal. The right channel binding post is inverted.

Optional Enhancements

More Power

The current limit in the standard power supply is a bit sloppy. In many cases, it will go into shut-down mode prematurely. To get more current out of the power supply, change R19 on the PC-15 power supply circuit board from its stock value of 6200 Ohms to a new value of 3300 Ohms. A ¼ Watt resistor is adequate. *Please note that doing the swap-out will require significant disassembly of the power supply and regulator assembly. Only make this mod if you can work slowly and methodically, so that you don't harm the power supply.*

Switchable Bridging

It is possible to make the bridging connection switchable, so the amp can be used as a powerful bridging mono amp or as a normal stereo amplifier. In a nutshell, one would just interrupt the connection between R21 on the left channel and the white wire of the bridging harness with a SPST switch.

TEMPERATURE BASED POWER LIMITATIONS

Here's a bit of data I took to characterize the bridge configuration's performance with a 6.9 Ohm bridge tied load. This is the equivalent of each channel driving a 3.45 Ohm speaker.

The mod worked out beautifully, initially tested driving a 6.9 Ohm speaker at low levels with a 50 Hz sinusoid. I then cranked up the output to look for any misbehavior. I found that the LM3886 SPIKE protection circuits kicked in at output levels that were low enough to make the bridging not particularly worthwhile with a 6.9 Ohm load[2].

The power supply delivered 75 volts to the amplifier under test. The following table reports the RMS voltage across a 6.9 Ohm bridge-tied load at the onset of SPIKE protection as a function of heat sink temperature.

[2] I did not measure the phase angle of the load.

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Heat Sink Temp ºF	Bridged Output Voltage at Protection	Watt at 6.9 Ohms
90	25.8	96.5
100	22.4	72.7
110	19.7	52.3
120	18.4	49.1
130	17.3	43.4
140	16.1	37.6
150	15.4	34.4
160	14.4	30
170	13.6	26.8
180	13.0	24.5

So why are these results so much less than my initial results on the web-site? As mentioned earlier, those results were taken at 1 kHz. The results reported here are for 50 Hz. I found that for low frequencies, say below 100 Hz, the Safe Operating Area protection of the LM3886 stopped it from delivering extreme amounts of power into a 6.9 Ohm bridge -tied load.

Note however, that the LM3886 delivered the rated power of 60 Watts into normally configured 8 Ohm loads, even with heat sinks so hot that you wouldn’t want to touch them.

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