diyAudio™ Speaker Delay and DC Protector Board Build Guide

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Build Guide revision 1.0 for use with diyAudio Speaker Delay and DC Protector PCB

Introduction:

Speakers are usually one of the most expensive components in an audio system. And like any other investment we spend our hard earned money on, it's always a wise move to provide some sort of “insurance” to protect them and ensure their safe operation.

Power amplifiers more often than not make a nasty transient noise when powering up. This can be due to various factors including the circuit design of the power amp and power supplies. Usually the only solution is to delay the connection of the speakers to the power amplifier just long enough for the power amplifier circuitry to normalize.

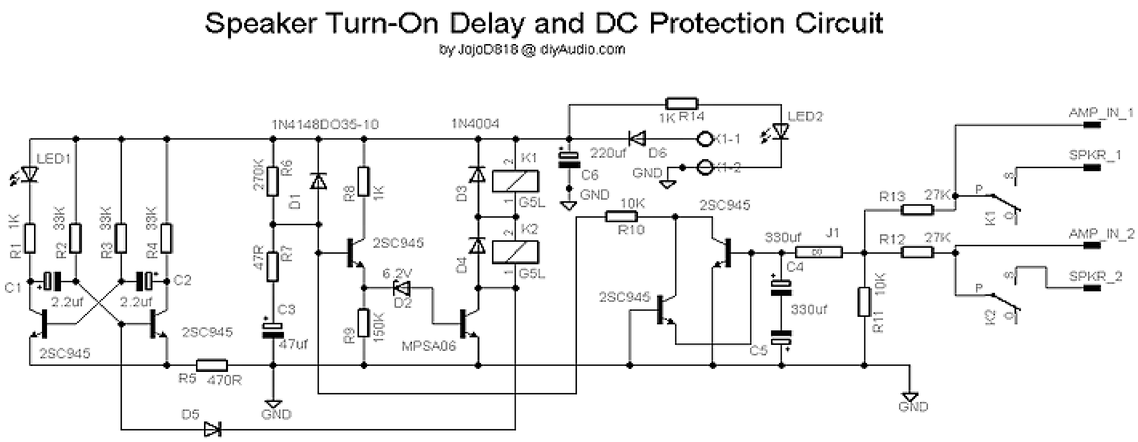
Another issue to worry about is the presence of any potentially dangerous DC at the output of the power amplifier which could flow to the speakers and destroy them. This is happens most often if there's a fault in the amp output section. These destructive DC voltages should be interrupted as quickly as possible.

Many commercial power amplifiers employ sophisticated protection schemes to protect the speakers in case of any power amplifier fault conditions, and to delay the connection of the speakers to the power amplifier output and those nasty power-on transients. While this sort of circuit can't guarantee the safety of your speakers, it can give them a fighting chance.

The project described here has both a turn on delay and DC protection, and can easily be incorporated to any power amplifier project you may have. It has an LED indicator that blinks while on delay mode or fault mode. Once the delay time passes or the fault is removed, the LED stops blinking and lights up steadily.

About the circuit:

Shown below is the schematic of the diyAudio Speaker Delay and DC Protector.



Circuit operation is simple and straightforward. To understand how it works, let's divide the circuit to 4 sections:

- Visual Indicator
- Time Delay and Relay Driver
- Speaker Switch
- DC Detector

How each of these sections works is briefly described below:

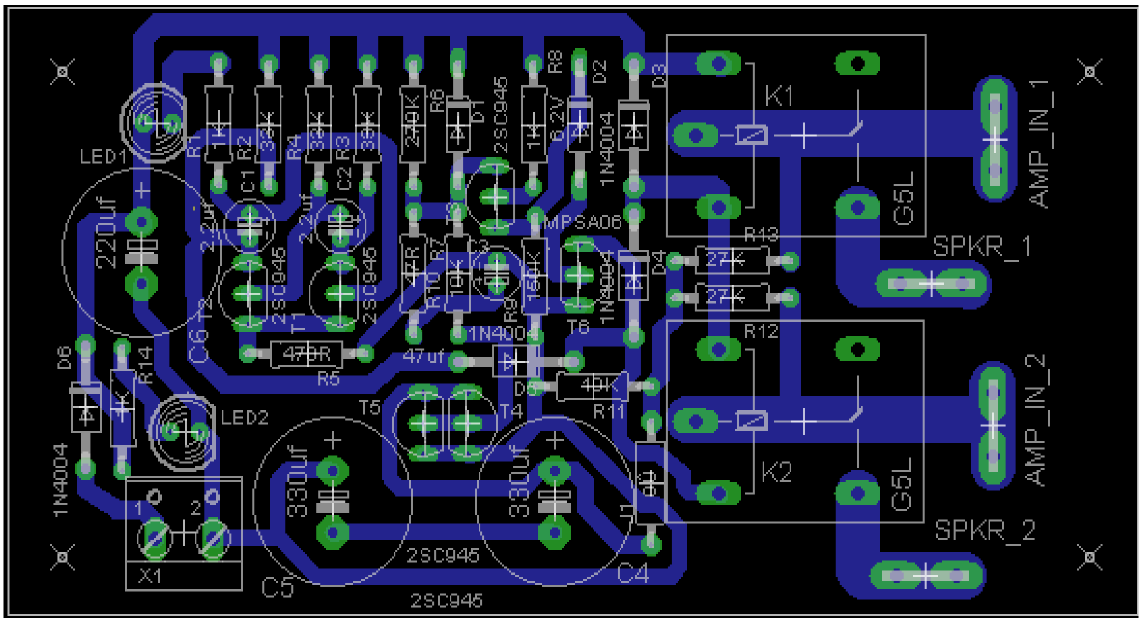
Visual Indicator – This section is primarily composed of a classic two-transistor flip flop circuit (T1 and T2) that flashes LED1. This section monitors the state of the relay coils. Once the relay coils are energized, the free-running flip flop is stopped and LED1 will be constantly lit.

Time Delay and Relay Driver – This section is responsible for switching on the relays (T6). This is also where the delay turn-on happens (T3). A capacitor connected to the base of T3 is slowly charged by R6. When T3 conducts, this gives T6 enough base voltage (via zener diode D2) to turn on the relays. Diode D2 is used as a fast off feature to turn off the relays as quickly as possible when power is removed or when a DC fault occurs.

Speaker Switch – This is simply a pair of 5-pin relays that connects (or disconnects) the amplifier output to the speakers.

DC Detector – Comprised mainly of T4 and T5, this monitors the amplifier's output for any presence of DC voltage. In the event a DC voltage is detected, it sends a signal to the Relay Driver that cuts-off the relays and disconnects the speakers from the amplifier's output.

As a reference, the parts placement guide of the Soft Start board is shown below:



Bill of Materials:

Transistors:

T1 - 2SC945 – Please see **Ideas and Alternatives** Section
T2 - 2SC945 – Please see **Ideas and Alternatives** Section
T3 - 2SC945 – Please see **Ideas and Alternatives** Section
T4 - 2SC945 – Please see **Ideas and Alternatives** Section
T5 - 2SC945 – Please see **Ideas and Alternatives** Section
T6 – SS9013 – Please see **Ideas and Alternatives** Section

Diodes:

LED1 – Your favorite 3mm or 5mm LED
LED2 – Your favorite 3mm or 5mm LED
D1 – 1N4148
D2 – 1N4735A 6.2V Zener Diode

D3 – 1N4004 or 1N4007
D4 – 1N4004 or 1N4007
D5 – 1N4004 or 1N4007
D6 – 1N4004 or 1N4007

Resistors: All resistors are 1/4W 5% (1% can also be used) unless specified.

R1 – 1K
R2 – 33K
R3 – 33K
R4 – 33K
R5 – 470R
R6 – 270K
R7 – 47R
R8 – 1K
R9 – 150K
R10 – 10K
R11 – 10K
R12 – 27K
R13 – 27K
R14 – 1K

Capacitors:

C1 – 2.2uf 50V Electrolytic
C2 – 2.2uf 50V Electrolytic
C3 – 47uf 50V Electrolytic
C4 – 330uf 50V Electrolytic
C5 – 330uf 50V Electrolytic
C6 – 220uf – 470uf 50V Electrolytic

Miscellaneous Parts:

K1 – Standard 5-Pin SPDT Relay - Please see **Ideas and Alternatives** Section
K2 – Standard 5-Pin SPDT Relay - Please see **Ideas and Alternatives** Section

Euroblock Terminal (2-pins)
FastOn Terminals
Standoffs for mounting

Printed circuit boards are available from the DA Store.

Tools Required:

Screwdrivers - Phillips and Flat
Miniature Screwdrivers - Phillips and Flat
Small Diagonal Cutters
Insulation Strippers
Needle-nose Pliers
Solder 60/40 Rosin cored or better
Soldering iron about 30 - 40 Watts
Digital Multi-Meter

Additional Useful Tools:

Electric Hand Drill
Assorted Files
Solder Sucker and/or Solder Remover Braid (Solder Wick) - To remove solder so components can be removed
Extra Flux - Useful if the solder doesn't flow well into a connection
Lacquer Thinner - to clean flux off the board after soldering.

Ideas and Alternatives:

Choosing your Transistors

As specified in the BOM Section, T1 to T5 are general purpose 2SC945 types. Any general purpose NPN transistors can fill in this job as long as they have a pin orientation of ECB (flat-face facing you for TO-92 packages) and a V_{CEO} of about 50V. As an example, 2SC828 types can used for T1 to T5.

As for T6, CS9013 can be substituted with an MPSA06 or any general purpose NPN transistor with a collector current of around 500mA. This transistor is what drives the relays so paying attention to it's collector current rating is a must. Using NPN transistors with 1A collector current is not a bad idea either, just remember to choose ones with a pin orientation of EBC (flat-face facing you for TO-92 packages).

Choosing your Relays

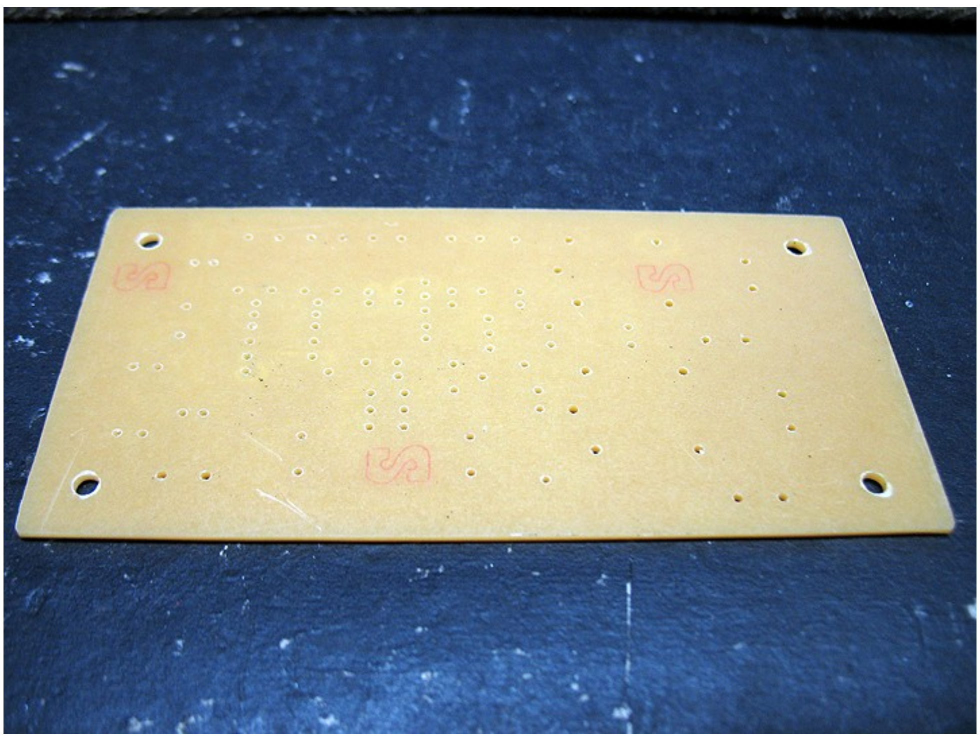
Coil ratings of relays K1 and K2 must be chosen depending on the AC voltage that you have available. The coils of the relays are in series, so you add them to get the voltage rating requirement to power up the project.

For example, if your power transformer has a spare 9VAC or 12VAC secondary winding, choose 6V relay coils for K1 and K2. Or if the spare secondary winding is 18VAC to 24VAC then a 12V relay coil must be used for K1 and K2.

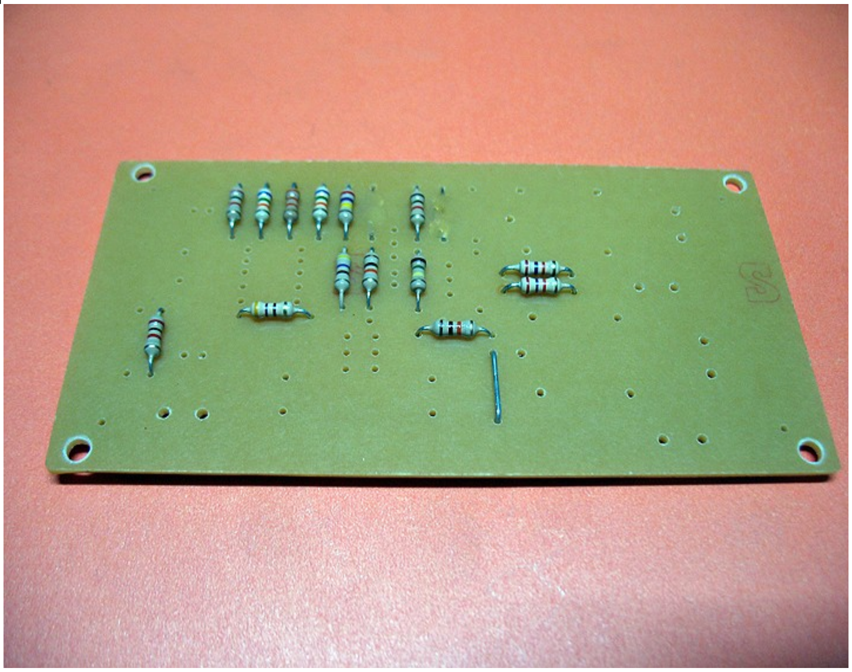
K1 and K2 contacts must also be considered when choosing/buying the relays. Omron™ and other brands have models that have 10A contacts which should be more than enough for mid to high power amplifier duties. Try not to skimp on the relays, you get what you pay for so choose wisely.

Construction:

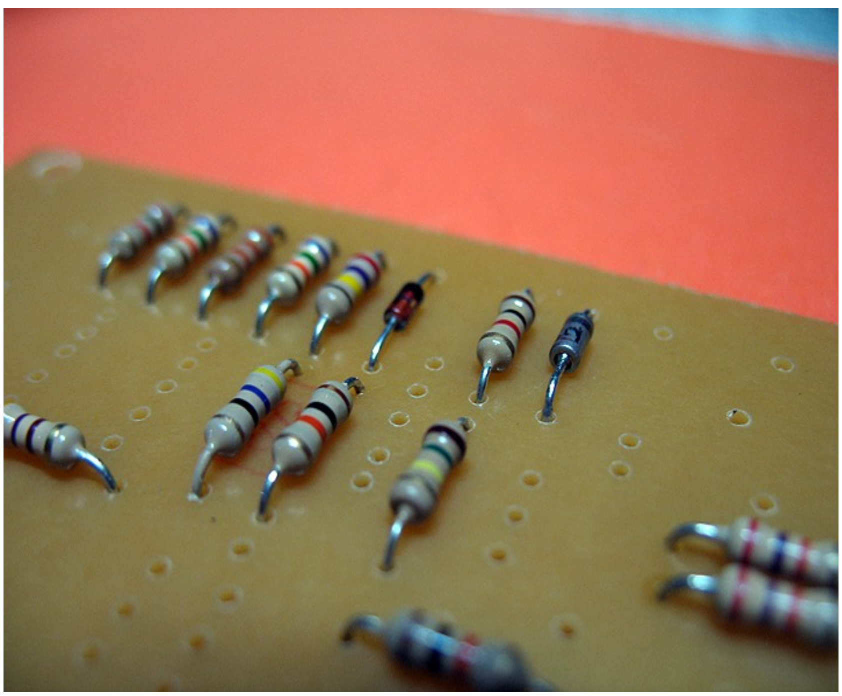
It's always good practice to inspect for cracks, hairline shorts or other errors in your PCB before doing any major construction with it. Check the actual PCB against the Parts Placement Guide and the bottom Foil Pattern Layout and make sure all vias and holes are in place and properly drilled.



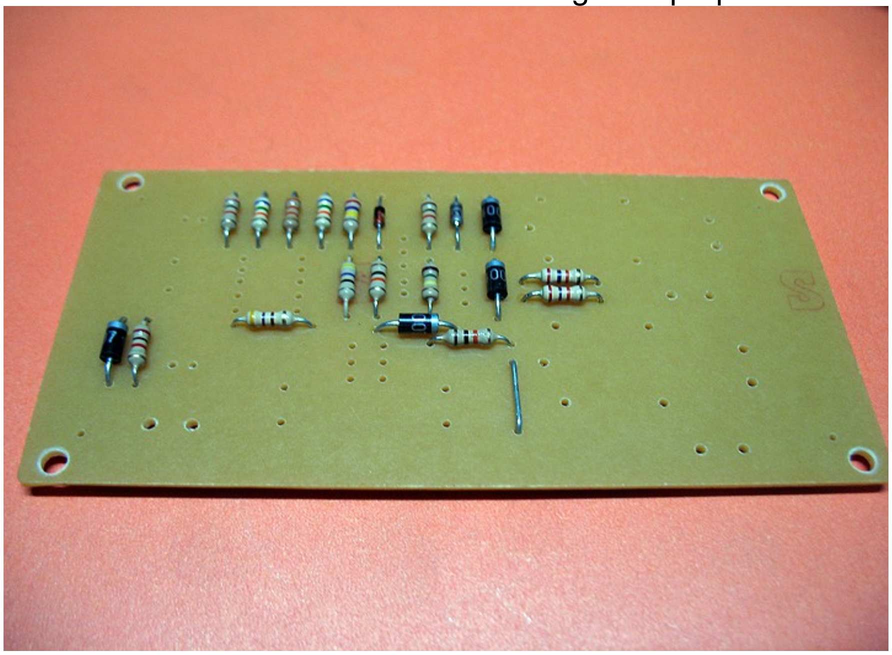
Start populating your board with the resistors first. A quick verification of their resistance using a DMM could save you a lot of time later on if a problem occurs because of a wrong value resistor! This is also a good time to install and solder all the jumpers in the board.



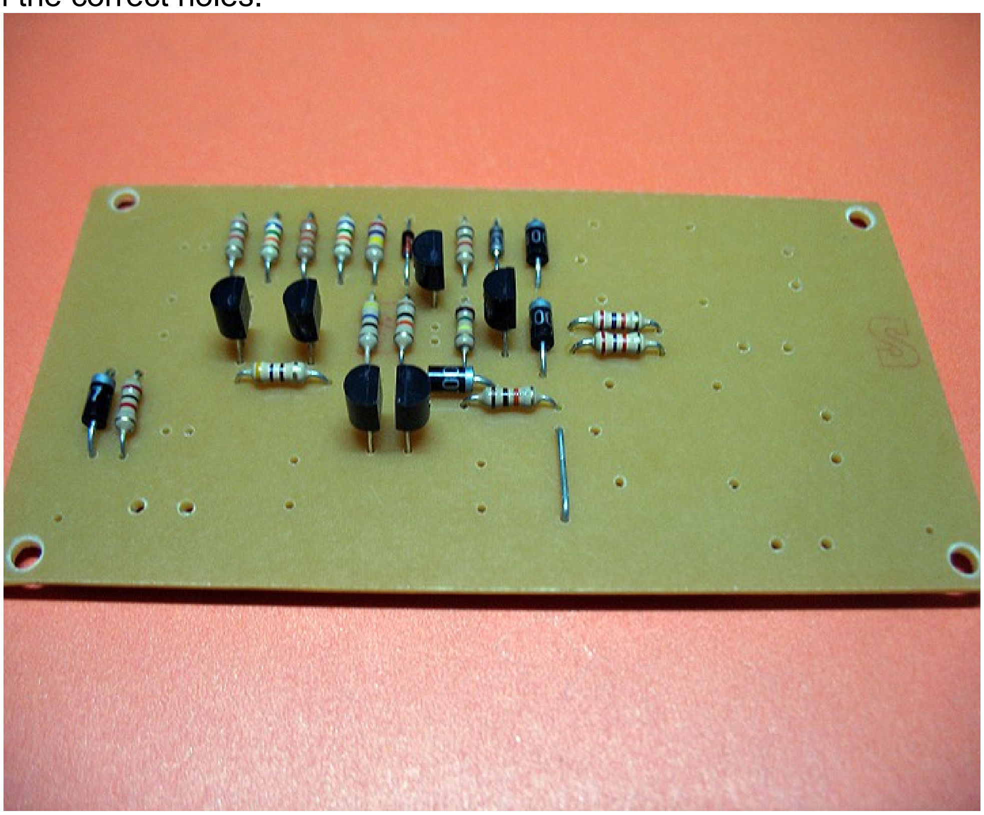
Insert and solder D1 (1N4148 diode) and D2 (Zener diode), paying particular attention to their lead orientation.

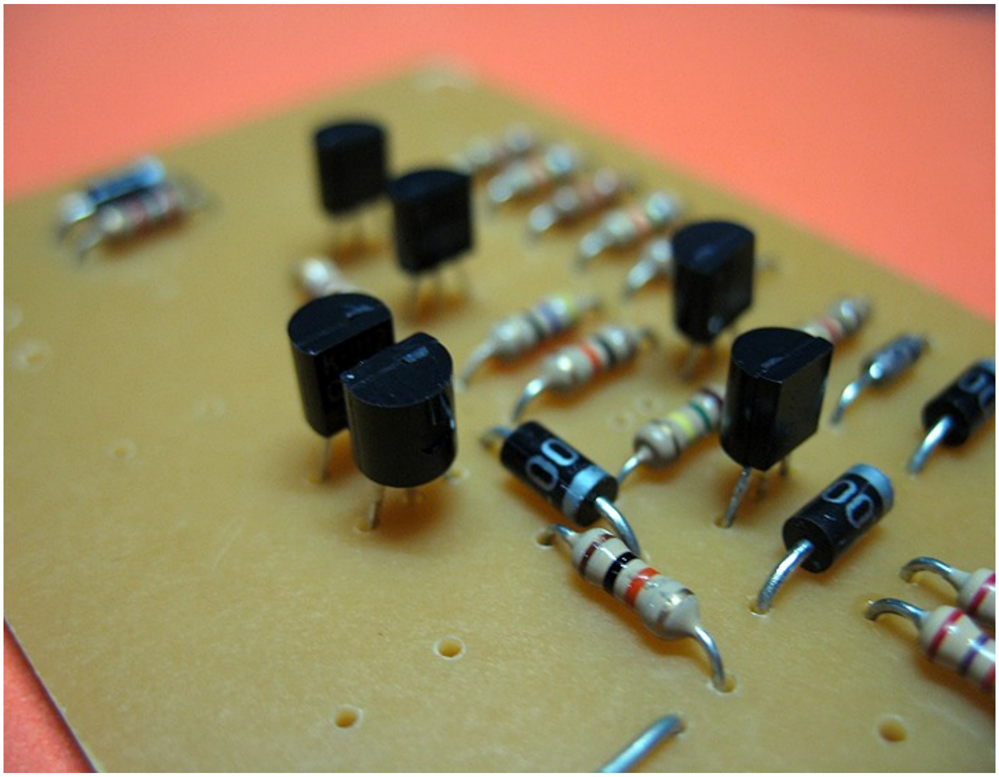


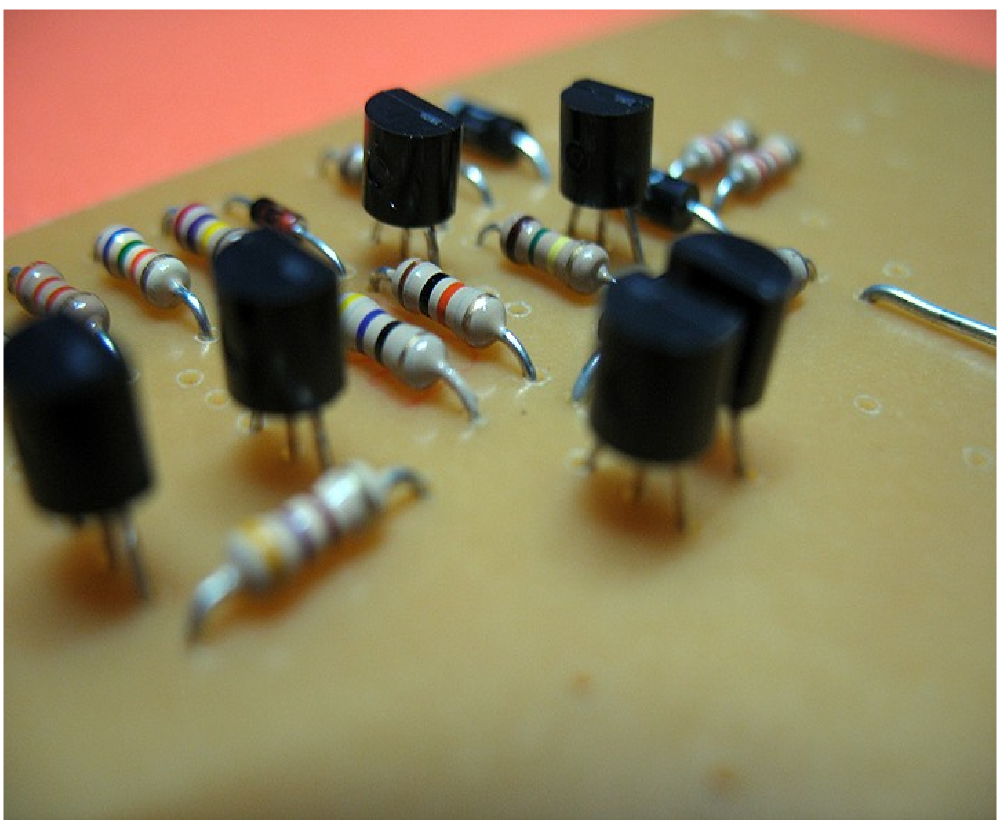
Insert and solder the 4 1N4004 diodes while noting their proper lead orientation.



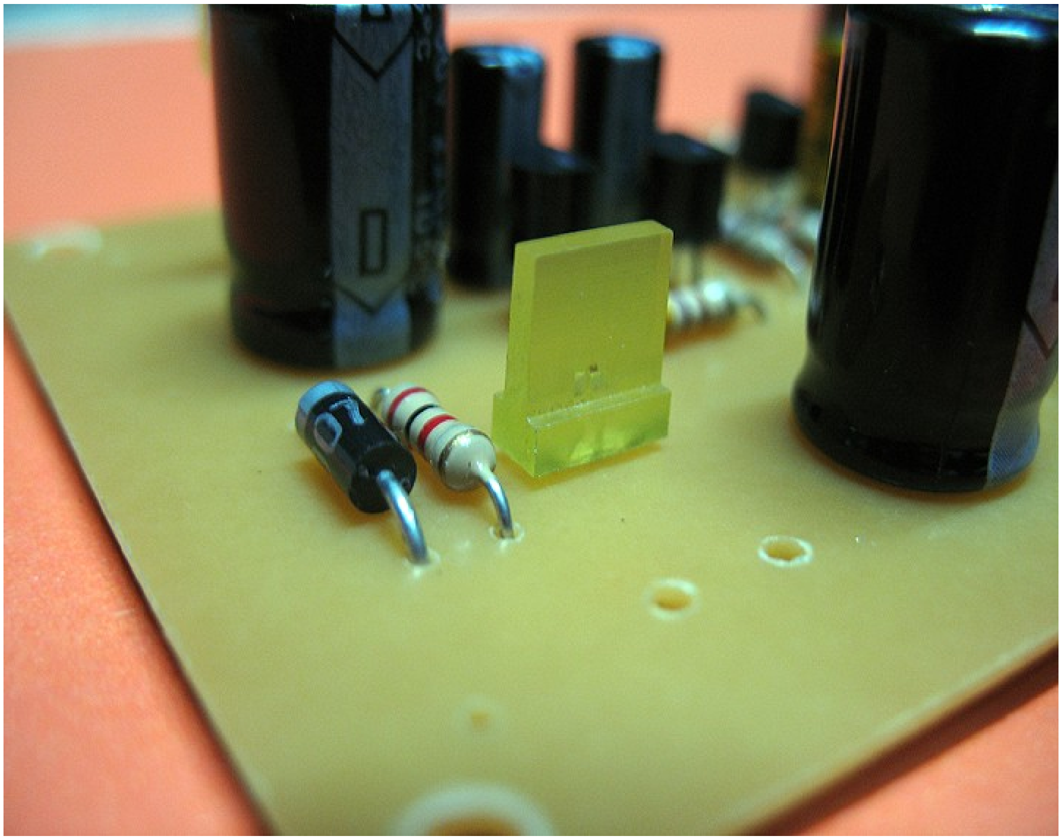
Next, insert and solder the 6 NPN transistors, pay particular attention to their proper lead orientation and make sure each is inserted properly with the correct pins in the correct holes.





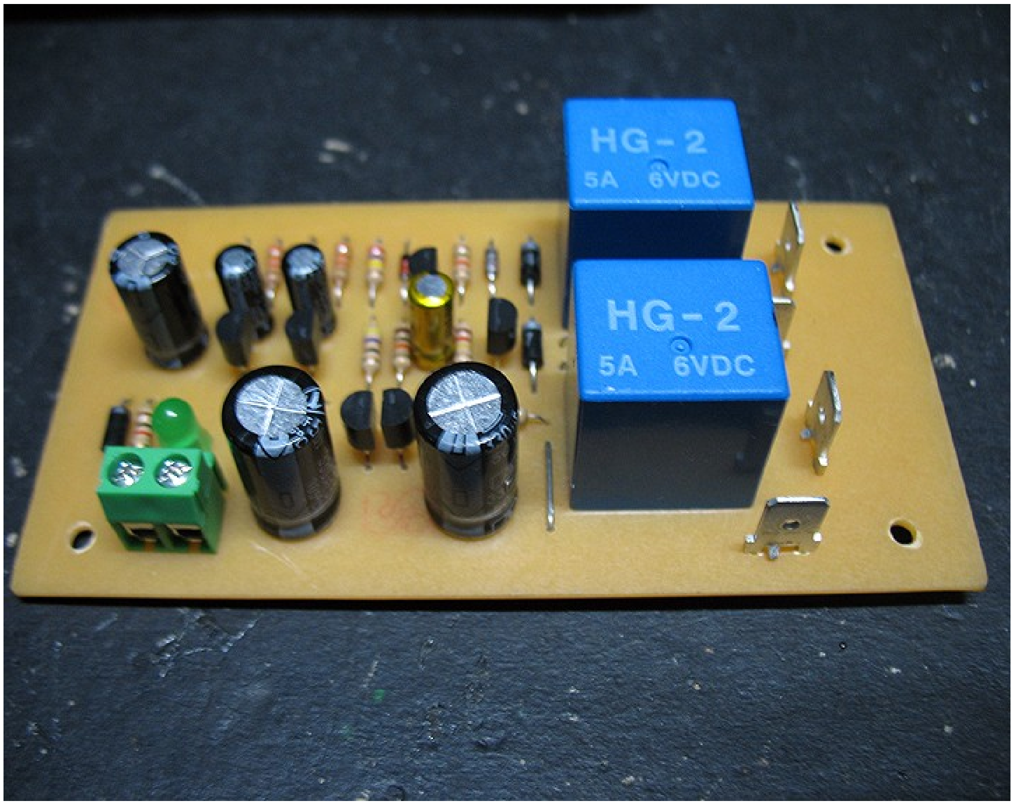


Next, insert the power indicator LED2, and the rest of the capacitors. Again, ensure that all components are inserted properly while noting their proper lead orientation. Note that LED1 can be installed with a length of wire if it's to be installed in the front of the chassis.



Finally, install the relays and the Faston connectors to finish the build. You may install a euroblock connector if you wish for the power supply connection.

Shown here is a version with 6V coil relays for use with a 9 to 12VAC transformer secondary tap or a separate 250mA transformer.



Checking Your Work:

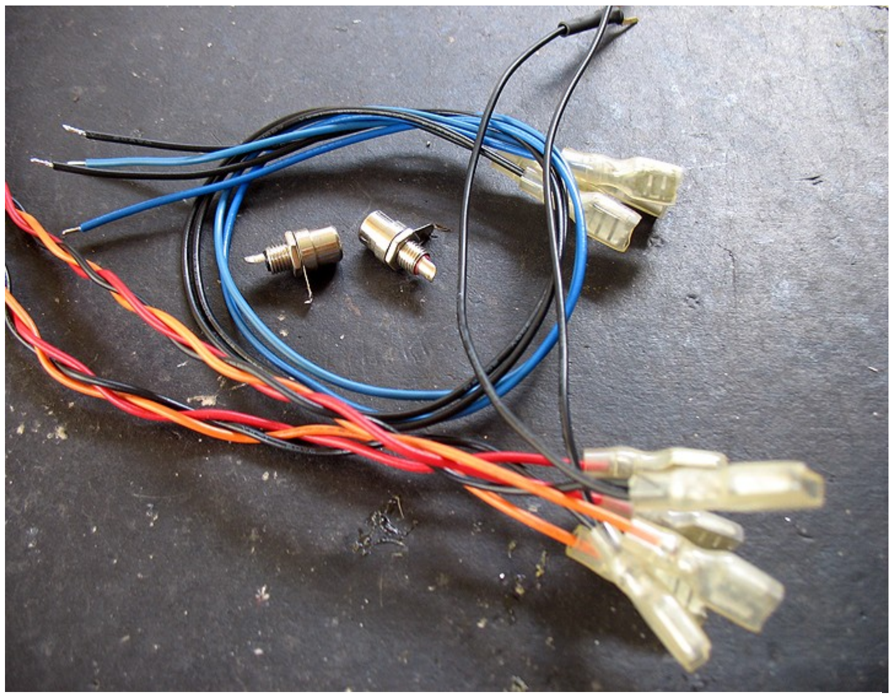
Building electronics stuff is fun up to the point when you are about to power it on for the first time. To help in reducing the risk of failures and boost a builder’s confidence, this is my usual procedure for checking a finished board.

Resistors – Visually check each resistor, cross reference it with the BOM and make sure that you placed the right value in the right spot. It's also good practice to do a quick resistance test of a resistor using a DMM before soldering it in place. It's very easy to mistake a 5-band 68K resistor with a 68R resistor!

Capacitors – electrolytic capacitors are polarized so check and pay careful attention to their pin orientation. Make sure the marking on the capacitor matches the polarity marked on the board.

Diodes – it is so easy to overlook the lead orientation of diodes, especially the small signal types and zener types. Check and make sure that their polarity matches the assigned polarity markings on the board.

Transistors – these devices have markings on their bodies that may require the use of a magnifying glass. Read and make sure that every transistor is properly oriented on the board and that the particular transistor installed is indeed the type of transistor that is required to be installed in that position. Catastrophic failure may occur if you misplace a transistor or install it the wrong way, so take your time to check and recheck.



Wiring – it helps if the wires you use are of different colors. For example, all V+ wires are Red, Ground wires are Black, and V- wires are Orange. That way, there won't be any confusion when doing tests and assembly of your amp. Also, make use of suitable thickness wires, but don't overdo it. Remember that it's harder to dress a thick wire. Use AWG #16 stranded hookup wires at least. Of course no one's stopping you from using those ultra high end cables for wiring the amp. Use shielded wire for all small signal carrying wires.

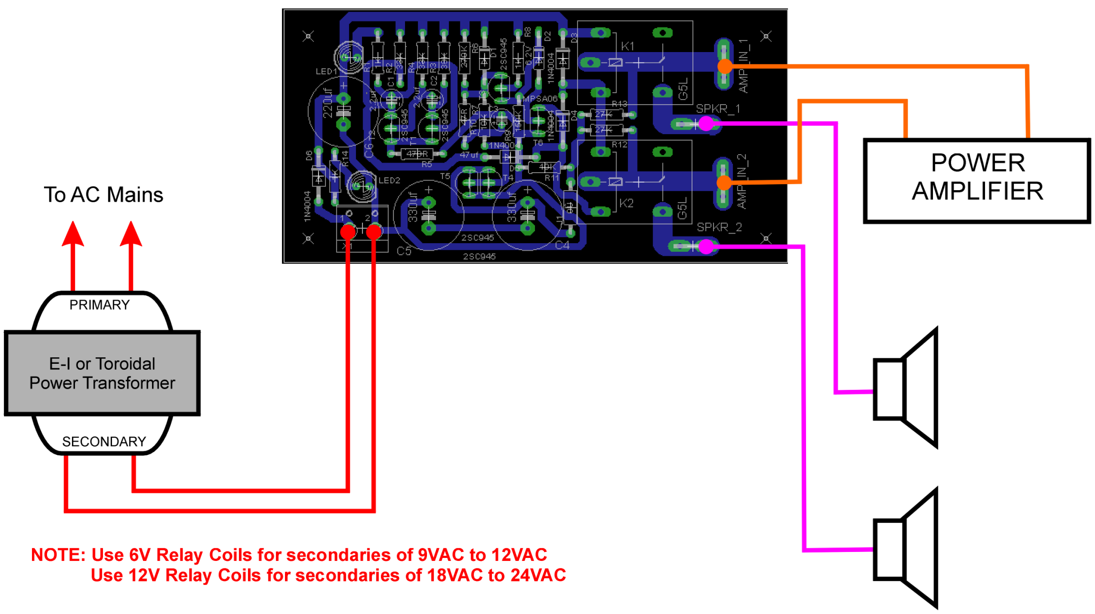
Testing and Calibration:

Things you'll need:

1. Digital Multi-Meter (DMM). Two of these would come in handy.
2. Suitable Power Transformer.
3. Piece of wire with alligator clips at both ends.

Shown below is the recommended wiring diagram for the diyAudio Speaker Delay and DC Protector PCB.

diyAudio™ Speaker Delay and DC Protector Board Wiring Guide



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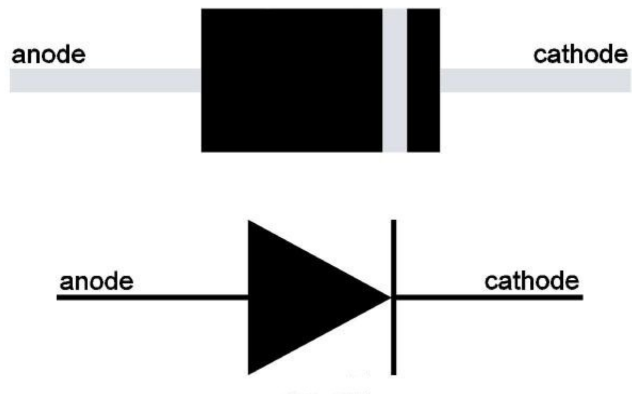
Testing Procedures:

1. Setup a suitable power transformer. You can use a 9VAC to 12VAC if you use 6V relay coils or 18VAC to 24VAC is you use 12V relay coils.
2. Connect the probes of your DMM to AMP_IN_1 and SPKR_1. Set to check for resistance. If you have another DMM, connect the other DMM's probes to AMP_IN_2 and SPKR_2, again, set to check for resistance. As it is, you should read infinite resistance or no connection between terminals AMP_IN_1 and SPKR_1, and AMP_IN_2 and SPKR_2.
3. Connect your power transformer to terminal X1 of the board and plug it in. Immediately, you will notice LED2 light up steadily and LED1 start flashing.
4. After about 4 to 8 seconds, LED1 should stop flashing and light steadily. At the same time, both DMMs should read zero resistance. Meaning AMP_IN_1 is connected to SPKR_1 and AMP_IN_2 is connected to SPKR_2.

5. To conduct a quick test for DC Protection, remove both DMMs but keep the board powered up.
6. Get your piece of wire with alligator clips on both ends and clip one end to the Cathode of Diode D6, it's the lead nearest to the band on the body of the diode. (See drawing)



7. Now connect the other end of the wire to either AMP_IN_1 or AMP_IN_2 and immediately you will notice (or hear) the relays will disengage and LED1 will start to flash again. Remove the alligator clip and after a few seconds, you will hear the relays re-engage and LED1 will stop flashing and lit up steadily.

Your Speaker Delay and DC Protector is now tested and ready for duty.

Special Note: Please make sure that the output of your Power Amplifier is connected to the board's AMP_IN_1 and AMP_IN_2 connectors because the DC Protection circuit monitors these terminals. Interchanging AMP_IN_1 and SPKR_1 terminals will not cause any faults but if any DC is present this will cause the circuit to disconnect, reconnect, disconnect, reconnect and cycle all over again even if the DC voltage is still present.

Listening Tests and Reviews:

Using The Speaker Delay and DC Protector board in my amplifier builds has always been a welcome addition. It saves my speakers from being exposed to nasty power amplifier turn-on or turn-off noises. I especially hate the “thump” I hear during power-on which is a normal thing for most power amplifiers whose VAS section stabilizes later than the rest of the amplifier circuitry does.

It's also worthwhile to note that in the years I've used these protection circuits, thankfully, they haven't affected the sound quality coming from my power amplifier. The use of quality relays is a must of course, as poor connection between the contacts will affect the sound.

Feedback and Final Notes:

Almost all commercial and professional power amplifiers I've seen employ the use of some sort of Speaker Delay and Protection, so why not use one in our DIY power amps? Power amplifiers that are properly designed and built using quality parts exhibit a long service life and excellent track record. Employing auxiliary protection circuits is added insurance for our speakers and makes us feel good knowing that they won't be exposed to any nasty thumps.

Enjoy!

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