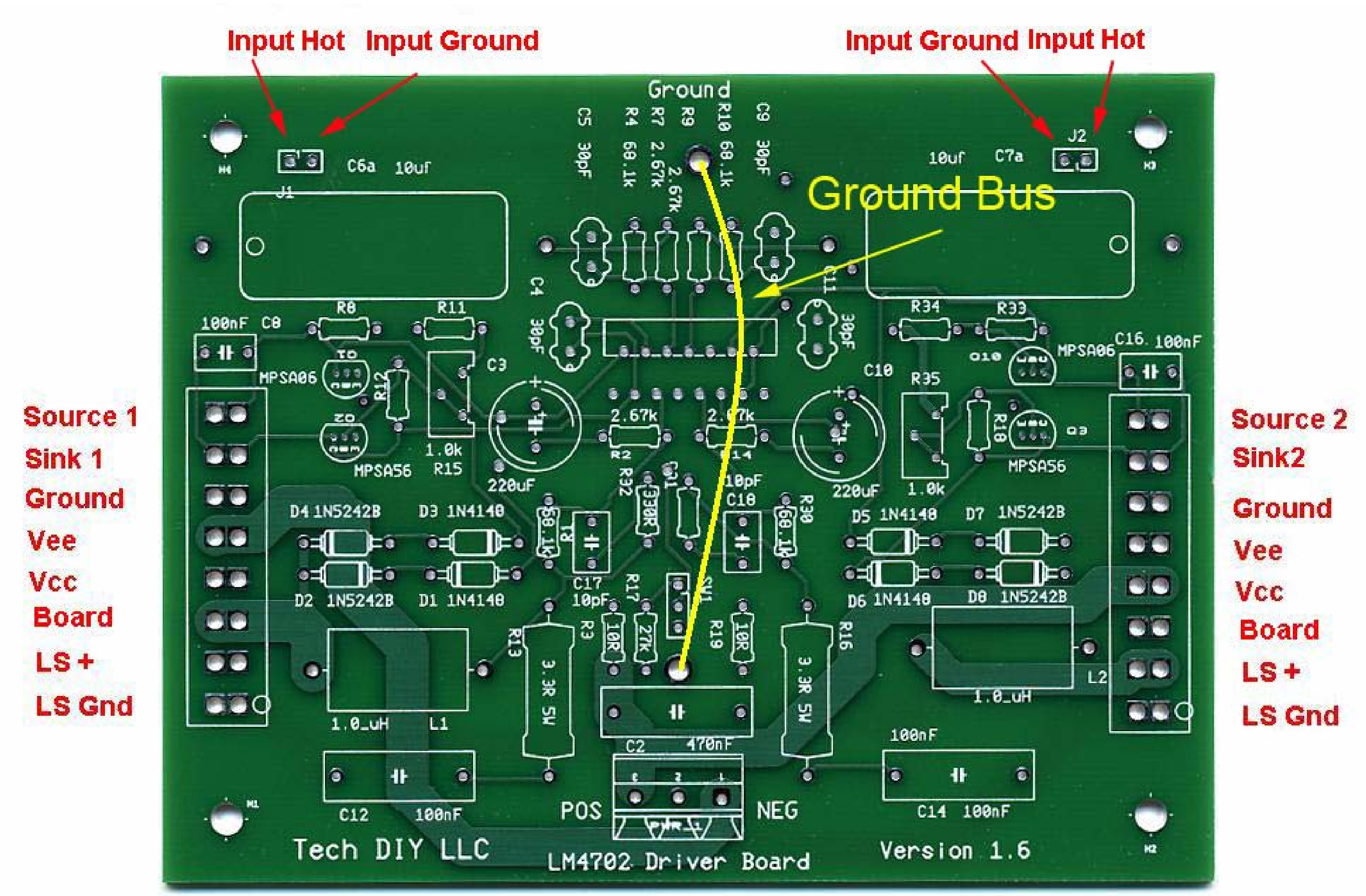
Instructions: Tech-DIY LLC LM4702 Driver Board

Background: National Semiconductor introduced the LM4702 Audio Driver chip in 2006. After several iterations we were able to produce a printed circuit board which incorporates many of the design features described in National's Application Notes AN-1645 "LM4702 Driving a MOSFET Output Stage" by Troy Huebner and AN-1490 "LM4702 Power Amplifier" by Mark Brasfield. These application notes, together with other materials from the product file are ***required reading***.

The Tech-DIY LM4702 Driver Board measures 4.900 x 3.800 inches. There are 4 mounting holes which will accommodate 6-32 threaded standoffs at 0.300 inches from each board edge. Provisions are made for standard connectors, or connections can be directly soldered to the board.

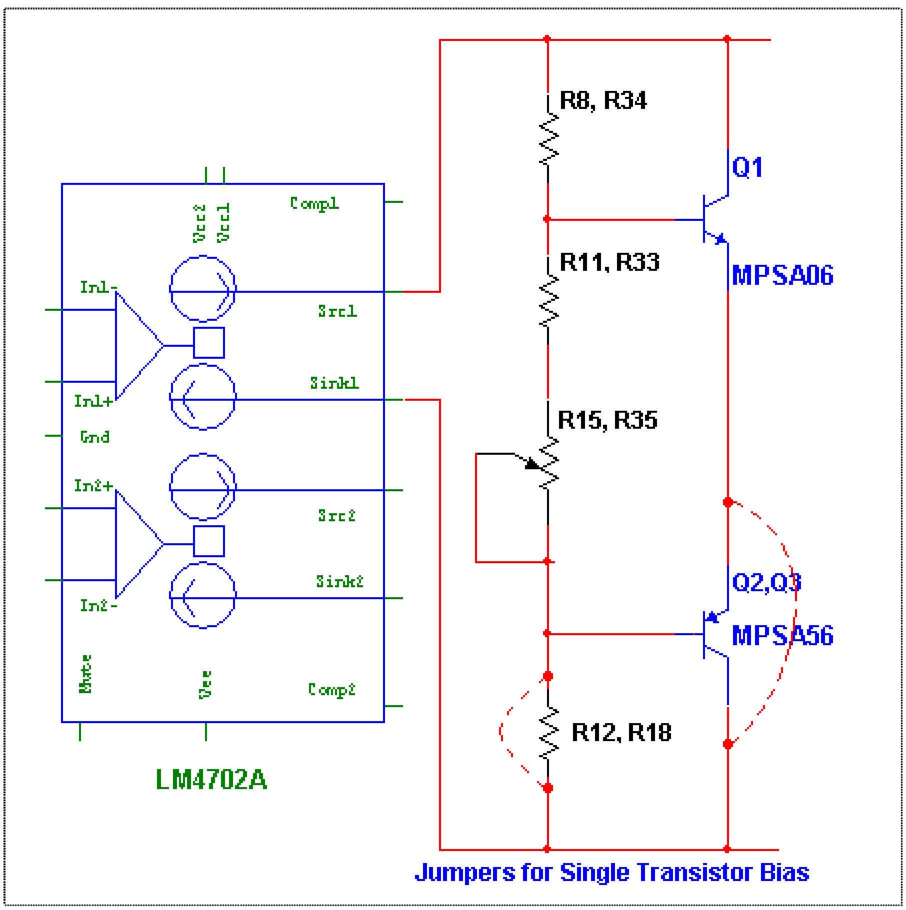


As you can see from the picture above, connections to the output board are made on the right and left hand with an 8 position connector. I used an On-Shore Technology ED1562 Terminal Block with 5.00mm lead spacing. This connector is quite sturdy, can accommodate wire as large as 12 gauge and will handle 15 amps D.C. The power connector is a standard 200 mil Power Pole type connector. The input connections are spaced so that a 100 mil Molex type male header can be used, but soldering directly to the input position is preferable.

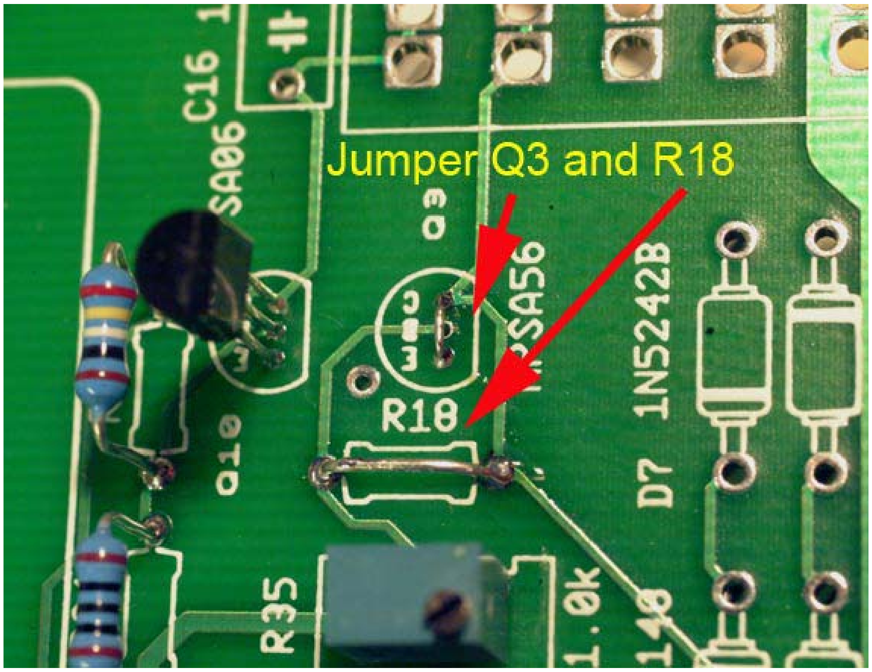
Assembly:
The board is assembled by first soldering the resistors and protection diodes (if required), then the silver mica capacitors, bias trimpots, ceramic capacitors, followed by the power resistors, and output inductors. The last item soldered into place should be the LM4702 itself. The large solder pads for the signal ground connections and power ground connections (shown as a yellow jumper "Ground Bus" in the photo above) are connected together with #14 or #16 wire, or 2 strands of #18 wire.

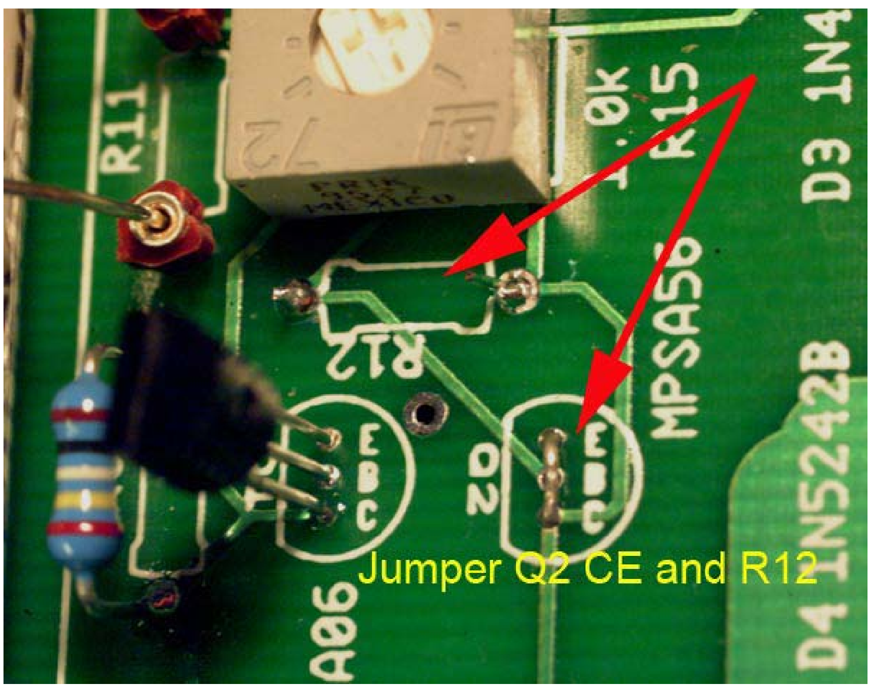
The output protection zobel consists of a 0.7uH coil in parallel with a 10 ohm-3 watt resistor AND a 10.0 OR 3.3 ohm resistor in series with a 100nF capacitor from the LS+ terminal to ground. The values of the output resistor and capacitor network can be adjusted to provide the best level of stability for your situation.

One word about the BIAS NETWORK. The board is designed to allow you to use a 2-transistor bias network consisting of a small signal transistors like the MPSA06 and MPSA56. You can use a single transistor and resistor by jumpering a couple of the holes on the board. I have illustrated the "totem" VBE bias generator below, along with a photo of how these connections may be jumpered connections. I used the single transistor bias generator and it works quite well.



You will find it best to mount certain passive components on the bottom side of the board. In particular, I found that it was convenient to mount the resistors which are wired in parallel with the output inductor onto the bottom of the board. In addition, connections for the bypass capacitors for the LM4702 are best made on the bottom as it is possible to make very short connections.





With lateral MOSFET's such as the 2SK1058/2SJ162 devices from Renesas it is possible to eliminate the transistor bias generator and connect a potentiometer directly across the Source and Sink connections. In this case the Sink bus should be connected to ground via a 47k resistor as Huebner demonstrates in Application Note 1645.

With standard bipolar Darlington transistors it is necessary to mount the bias generator transistor on the output device heatsink. In this case the VBE multiplier is located on the output device board.

Setup and Testing: After making sure that all connections are correct you can hook up the driver board to a power supply. For testing my amplifiers I use a supply capable of +/- 80 VDC at 10 amps. The a.c. line input to this transformer is connected to the supply with a GenRad Variac capable of delivering 10 amps.

Again, make sure that there are no dangerous conditions which could cause harm or injury to yourself. In particular, make sure that all passive component solder connections have been neatly snipped off. If you have used stranded wire make sure that all ends are also snipped. Check to make sure that you haven't left some little piece of bare wire across the power or output connections.

The initial test should be done with both driver board inputs shorted, and both outputs connected to 8 ohm resistive loads capable of dissipating at least 100 watts. I like to connect the output of the amplifier to an oscilloscope when setting the bias so that I can make sure that there is no oscillation. You can measure the bias current by inserting a DC ammeter between the power supply positive output and the positive input on the driver board, or by measuring the voltage across the output the current balancing resistor (if you have installed them in your output stage.)

Turn on the power supply and gradually bring the voltage up to its full setting. It sounds obvious, but if anything smokes you've got a problem.

As soon as about 1 milliamp flows into the mute pin the amplifier will begin to draw power. The amount of bias current in the output stage depends upon the class of operation and the type of output devices you use. In the amplifier which was described in Audio Express 100 milliamps of bias current allowed total harmonic distortion of 0.003% at 1 kHz on the prototype printed circuit boards used for the article. In the production boards the THD at 1 kHz should approach 0.001%

I run the amplifier for about 15 minutes and recheck the bias. With the Renesas Lateral MOSFETs there hasn't been much need to change the bias setting, if you use other output devices, however, you will probably have to readjust the bias potentiometer for your particular situation.

I have a wonderful oscilloscope functions on both my Tektronix 2465B and TDS3014 scopes – "Setup" or "Autoset" buttons which automatically sets up the instrument for the signal conditions which are present. When these buttons are engaged any oscillation will manifest itself immediately.

"It Oscillates, Now What?" [1]

Oscillation in an audio amplifier can result in catastrophic failure of your speakers. With this in mind we designed the driver board with a belt and suspenders low pass filter on the output. This filter consists of L1/L2 (0.7 µH in parallel with 10 Ω) and and C12/C14 in series with R13/R16. In addition we provide you with the ability of inserting a small RC network (C17/C18 in series with R31/R32) in parallel with the feedback resistors (R1/R30) to roll off the high frequency gain.

If the amplifier oscillates your first recourse is to change the values of the C12/C14 and R13/R16 – these are nominally stated as 100nF and 10 Ω. You may increase the value of C12/14 to 150nF, 220nF etc. to reduce the oscillation.

Capacitors C17 and C18, nominally 10pF silver mica, may be increased in value, bringing down the bandwidth of the amplifier. Unfortunately, increasing their value may also increase the THD% of the amplifier.

In the Audio Express article I showed 330pF capacitors from Gate to Source of the lateral mosfets. These increase the slew rate of the amplifier, but may also cause stability problems in certain circumstances. Remove these capacitors and instead, use 33pF from Gate to Drain.

[1] Apologies to Jan Didden and Walt Jung who coined this phrase to describe the somewhat problematic behavior of their Super Regulators.

Other Suggestions: Make sure that you place a heat sink on the LM4702. Without a heat sink it seems impossible to attain the THD% levels which Brasfield or Huebner discuss in their articles. The heat sink does not have to be particularly large, one that you would use to sink a TO-220 voltage regulator such as an LM317 should be adequate.

Best performance will be attained if you eliminate input coupling capacitors C6 and C7, directly coupling the amplifier from the source. This can create other problems if you're not careful including susceptibility to low frequency bumps from your vinyl analog sources (a.k.a. LP's), or D.C. offset on the output of the amplifier. (Discussed below.)

You can use the resistor and capacitor values suggested by Huebner in his article but the input impedance of the amplifier will be comparatively low. In this case you can eliminate the input capacitors C6 and C7 (10uF/50V polypropylene) and substitute a voltage follower with a high quality opamp. You will have to pick off power from Vcc/Vee and regulate it with a circuit capable of standing off the high voltage on Vcc and Vee.

I have not detected any D.C. offset on the output of any amplifier I have built with the LM4702 – but this doesn't mean that it might not be the case for you. Always check to see that there is no D.C. offset on the output as this will over-heat the voice coil of your speakers. D.C offset may arise from the D.C. present at the input source (which is multiplied by the gain of the amplifier) or bias current flowing through R4/R10. If the problem is related to the source material you will have to use the input blocking capacitors C6 and C7. If the problem relates to R4/R10 you may reduce their values, but once you venture down this path you will have to adjust the values of the feedback and gain setting resistors as well.