AUDIO BASICS

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Tire Testing Without A Pressure Gauge Re-visited!

Recently there have been a plethora of wildly enthusiastic subjective opinions that the Radio Shack Optimus CD-3400 Portable CD Player is just about God's gift to audiophiles. It is reported to have imaging and musicality equal to or better than many esoteric machines costing thousands of dollars. Leading audiophiles are building expensive power supplies for it. Reviewers are astonished that it sounds just as good as their favorite expensive home CD players. So we purchased one. (On sale this week for $129.00!)

Methinks that the tire testers not only have lost their pressure gauges - but that they are riding around on the rims.

The Radio Shack CD-3400 is a fine little inexpensive portable CD player. It does everything Tandy Corp claims for it. It is programmable, it has treble and bass boost functions, it pauses, it plays randomly, it cues, it has headphone outputs with a volume control and fixed level line outputs. It even lights up in the dark. If you want to hook up a set of low priced headphones and listen to tunes on the beach it fills the bill as good as any with a better and more convenient service network than most.

However, musically it is no better than any other 1-bit CD player we have evaluated on the bench and in our music system. It has all the flaws and signal artifacts we have grown used to observing and all the compressed transients, loss of high frequency definition, uninspired dynamic range, mumbly bass, and overall "fingernails on a blackboard" edges on loud highs that we hear with other 1-bit machines.

On the test bench we first notice that the audio output level of the CD-3400 is more than 6dB lower than that of our reference Philips 16-bit 4x oversampling design. We also notice over 5 mV of ultrasonic square wave artifacts riding on the wave form - the signature of many 1-bit machines. We find it kind of hard to consider subjective comments regarding inner resolution capability of a CD player when in fact any micro-details are going to be swamped by this distortion. The specification sheet for this machine tells us it has a 4 MHz clock frequency (nearly three times as slow as the standard 11 MHz clock in many full size 1-bit machines). This means that at 10 KHz, you don't get 1100 samples per cycle out of the 65536 samples on the CD, you only get about 400 samples from a one cycle snapshot. The low level artifacts we see on the test bench waveforms are evidence that our math (and subjective judgements) are correct. Of course if you average things enough and spread the distortion out so the analyzer cannot see it you can get impressive specifications.

The headphone output can boost the output signal level to normal levels, but with the addition of excessive noise. The headphone output adds about 40 mV of broadband noise to the right channel and 20 mV to the left channel of our sample player. This may go unnoticed with low resolution headphones in a noisy environment but it certainly does not improve the fidelity and certainly is not a 94 dB signal-to-noise ratio. All our testing was done with a freshly charged set of Ni-Cad

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batteries, so we were not evaluating AC converter artifacts or limitations.

So, go ahead and buy the CD-3400 if you need a simple and functional little portable CD player for the vacation home or bicycle. Don't buy it expecting it to be a musical enhancement to the ultimate higher fidelity of your home audio system. The Emperor has no clothes!

However, the golden ears may be correct in their evaluation of it – if they only get their context right. A proper observation may be that their esoteric megabuck specials really are no better than the CD-3400. We would not argue with that perspective.

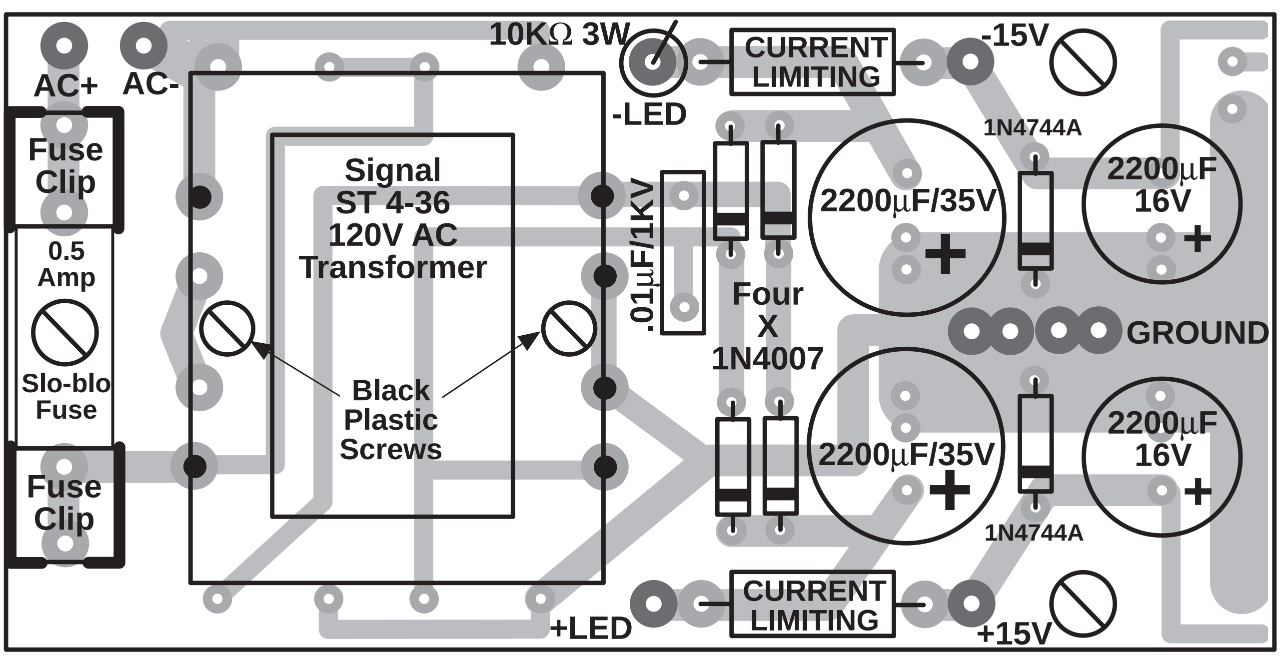
The PC-194 Versa-Kit II. A new AVA multi-purpose stereo circuit board project.

The remainder of this thick triple issue represents hundreds of man-hours of work and design time in your behalf. We present the new PC-194 multi-purpose stereo audio card and many of the possible circuit configurations for it. We explain the circuit designs in detail, with simple theory and math, so you will have a better understanding of op-amp audio design. We explain the power supply design and theory too. Even if you have no plans to build anything please read the rest of this. It is truly audio basics!

The PC-194 board allows you to build a very high quality and low cost phono preamplifier, buffered headphone amplifier, phase inverter, unity gain buffer, simple headphone amplifier, line preamplifier, and universal line preamplifier that will work with almost any linear op-amp (discover what sounds best to you and let us know too, please). It does not obsolete the original PC-392 Versa-Kit board, instead the PC-194 enhances the Versa-Kit by adding even more high quality circuit configurations.

Power Supply Parts List

1	AVA PC-392 R1 circuit board (truncated)
4	1N4007 silicon diode
2	1N4744A 1W 15V zener diode
1	Green LED
2	2W current limiting resistor (value varies)
1	10KΩ 3W resistor
1	.01µF/1KV ceramic disk capacitor
2	2200µF/16V axial lead electrolytic capacitor
2	2200µF/35V axial lead electrolytic capacitor
2	PC card fuse clips
1	3AG 1/2 amp slo-blo fuse
1	Signal ST4-36 PC card mount power transformer



Audio by Van Alstine PC-392 R1 Power Supply Stuffing Guide 5/25/94

2 sets #4-40 black plastic mounting hardware
3 #6-32 1/2" hex spacer
6 #6-32 1/4" pan head machine screw

Before we start the audio circuit descriptions we must have a power supply. This power supply will support any of the PC-194 circuit configurations shown. It is a shunt zener regulated power supply. Its advantages are that it is essentially short-proof, it is very stable and has a very wide bandwidth, and it is cool running, reliable, and economical. Because the regulating devices are not in series with the audio circuit, the bandwidth of the supply is not limited by the bandwidth of the regulators which are often much lower bandwidth than the audio design. In many active regulator designs fast audio circuits cause unhappy oscillations in the "half-fast" supply designs and these oscillations show up throughout the audio circuit too, contributing to "fingernails on the blackboard" bad solid state design. The only limitations of this shunt zener design is that it regulates well within a limited set of conditions. The secret to using it well is to ensure that it is used within its design limits.

The PC card is simply our Versa-Kit PC-392 R1 board with the audio circuit end eliminated to allow a fit into the Radio Shack chassis box along with a new PC-194 audio board. If you are building this into a larger chassis, then the whole PC-392 R1 board can be used to provide additional circuit functions in combination with the PC-194 board. Refer back to our original Versa-Kit designs in the 1992 *Audio Basics* issues for more options. Note that the "R1" revision was to enhance the board for alternate power transformer applications, and is not used for the discussions herein.

We have selected a Signal ST-4-36 basic power transformer for this application. *[Signal Transformer also makes a 240V version of this transformer. It has 8 pins instead of 6. If it is used the supply is automatically converted to 240V AC use].* It steps down the 120V AC power line to two 18V AC outputs with a center tap. After a full wave diode bridge rectifier (the four 1N4007 diodes) and the raw supply capacitors (the two 2200µF/35V electrolytics) this design provides a clean ±25V DC raw supply at 170 mA, the necessary voltage and current for the circuits downstream.

Because most linear op-amps suitable for audio applications are designed to operate properly with a ±15V DC power supply, this power supply uses 1N4744A 15V zener diodes as the main regulating devices. A combination of the current limiting resistors, the current demand from the audio circuits, and the 15V zener rating of the 1N4744A diodes drops the raw ±25V DC supply to a very quiet regulated ±15V DC supply.

The zener diode regulates by maintaining a steady voltage across it. If the supply voltage goes high, the zener conducts harder and drops the voltage, if the supply voltage drops the zener turns off thus raising the voltage. The zener's limits are its power rating and its voltage rating. Excess current through the zener can exceed its power rating and damage it. If the voltage of the supply goes below the voltage rating of the zener then the zener shuts off and does not regulate at all. The zener can also cause noise if allowed to turn off hard. A good design keeps the zener always turned on, never too hard, and never completely off.

There must be adequate headroom between the raw supply voltage and the regulated supply voltage to regulate. The current through the shunt zener diode must be set high enough to keep the zener turned on and regulating, but not so high as to exceed its power rating and damage it. The upper limits are about 100 mA of current available with this design, so it is fine for small signal applications, but not high enough capacity for heaver loads such as tube heaters or power amplifiers.

The only variable is the value of the current limiting resistor. This resistor sets the amount of idle current available to the 1N4744A shunt regulating zener diode and to the audio op-amps on the PC-194 board(s). The zener diode wants about 20 mA of current through it at 15 volts to regulate properly. Various op-amp designs have different idle current demands (from a small fraction of a mA for battery powered low current designs to 10 mA or more for high powered current drivers). The current limiting resistor on the power supply board is selected to provide the correct total current for the op-amp used. The lower the value of the resistor, the more current will flow, the higher the value the less current is supplied.

The value of the resistor is calculated by dividing the voltage drop (the difference between the raw supply voltage and the desired regulated supply voltage) by the sum of the current draw of the zener diode and the idle current of all the op-amps in the circuit. For example, the proper value of the current limiting resistor when used with two AD845 op-amps in this application is 10V divided by (20mA + 5mA + 5mA) which equals 333 ohms. The power rating of the resistor is determined by dividing the voltage drop squared by the resistance ($P=V^2/R$). In this case the power dumped across the resistor is about 1/3 watt, so we would choose a 1W rated resistor (or higher) to provide safe long term capability.

The 2200µF/16V electrolytic capacitors after the regulators and the additional supply capacitors on the audio boards themselves provide a enormous energy supply for peak demands. The shunt zener supply is like the pump that keeps the water tower full. The huge volume of the reservoir itself (the electrolytics after the zener regulators) keeps its level very constant. The big capacitors also provide a gentle turn-on and turn-off since they charge and decay slowly.

The indicator LED is supplied from the raw ±25V supply through a 10KΩ 3W current limiting resistor. These parts are unnecessary if the circuit is used in a neon lighted power switch application.

The board can be connected directly to a polarized AC power line for the simplest external wiring. The circuit will be on all the time it is plugged in. The plus side of AC goes to the AC+ eyelet, the ground side of AC (the wide blade on the power cord) goes to the AC- eyelet.

The wiring diagram example shown is specific and complete for installing the AVA PC-194 circuit built as a buffered headphone amplifier along with the AVA PC-392 R1 power supply in the Radio Shack 270-253 chassis.

In addition to the two completed circuit boards, this design requires a dual 100KΩ volume control, a switched output headphone jack, four panel mount RCA jacks, a green LED, and support hardware.

The design provides a voltage gain of 5 and adequate current drive for most any headphones. It can be connected directly to the audio outputs of a CD player, tuner, or tape deck and it will drive a power amplifier in addition to the headphones, eliminating the need for a preamplifier.

When the headphones are plugged in, the signal to the output jacks on the back panel is disconnected. When headphones are not used, the signal is connected to the output jacks and on to a stereo power amplifier if desired.

There are too many possible wiring iterations to allow us to show them all here. You will need to use common sense in selecting and wiring the correct hardware assortments for your specific application.

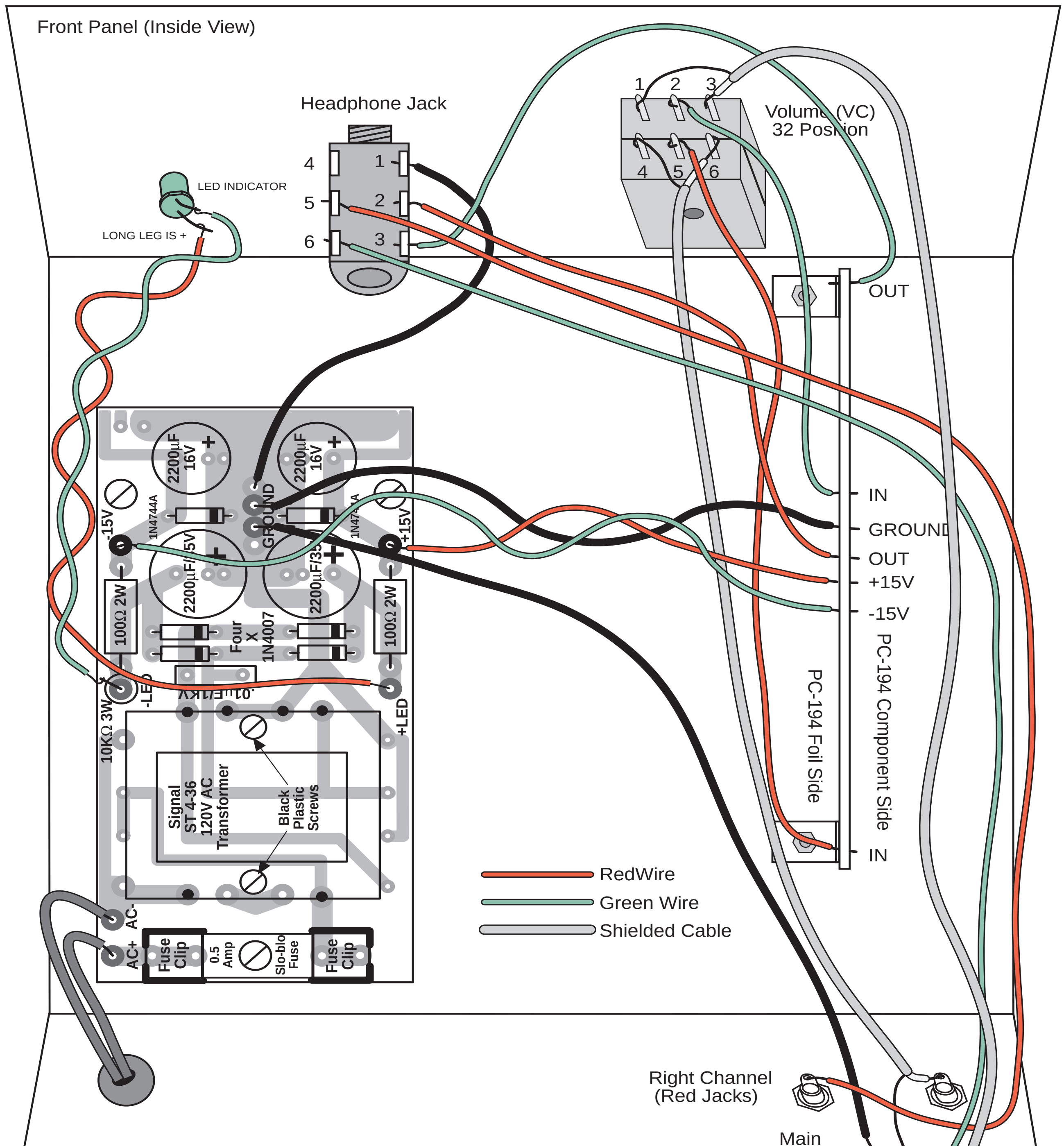
The following is a listing of assorted combinations of hardware, boards, and parts that are likely to be useful to you. If you purchase the package we will include an overall wiring diagram for that specific application. The packages include all necessary parts including wire and solder.

Buffered Headphone Amplifier Package ($175 plus shipping). Includes PC-194 and parts for buffered headphone amp design, truncated PC-392 R1 power supply board and parts, Radio Shack 270-253 chassis box, Noble stepped precision volume control, knob, switching headphone jack, green LED, four gold plated RCA phono jacks and hardware, AC power cord and strain relief, board stuffing guides and wiring diagram.

Universal Line Preamplifier Package ($150 plus shipping). Includes PC-194 and parts for universal preamp design, truncated PC-392

R1 power supply board and parts, Radio Shack 270-253 chassis box, Noble stepped precision volume control, knob, DPDT switch (for selecting either of two sets of inputs), green LED, six gold plated RCA phono jacks and hardware, AC power cord and strain relief, board stuffing guides and wiring diagram.

RIAA Phono Preamplifier Package ($150 plus shipping). Includes PC-194 and parts for RIAA phono preamp design, truncated PC-



Versa-Kit II Buffered Headphone Amp in Radio Shack Chassis Box
© Audio by Van Alstine, Inc. 5/25/94

392 R1 power supply board and parts, Radio Shack 270-253 chassis box, green LED, four gold plated RCA phono jacks and hardware, AC power cord and strain relief, board stuffing guides and wiring diagram.

The Unity Gain Buffer, Basic Headphone Amplifier, and Phase Inverter versions of the PC-194 board can also be implemented on the full length PC-392 R1 circuit board when used as complete free standing units. The complete packages in the Radio Shack chassis for these applications include the full length PC-392 R1 layout as described in the March, 1994 *Audio Basics* issue. The PC-194 applications **($75 plus shipping for audio board and parts)** are most useful as "add-ons" in existing preamplifiers. For example they can provide inverted outputs or buffered tape outputs in an existing Ωmega II preamplifier (in either our chassis or a Dyna Pat-5 or Pat-4 chassis). An observant reader might notice that the buffered version could work in a Dyna Pas-3 vacuum tube preamp too - but we already have a specific dedicated board for that application - and we will offer it as a low cost add-on update kit for the Super Pas Three as soon as design time allows.

Unity Gain Buffer Package ($150 plus shipping). Includes PC-392 R1 and parts for unity gain buffer design, Radio Shack 270-253 chassis box, green LED, six gold plated RCA phono jacks and hardware, AC power cord and strain relief, board stuffing guide and wiring diagram.

Basic Headphone Amplifier Package ($150 plus shipping). Includes PC-392 R1 and parts for basic headphone amp design, Radio Shack 270-253 chassis box, Noble stepped precision volume control, knob, headphone jack, green LED, two gold plated RCA phono jacks and hardware, AC power cord and strain relief, board stuffing guide and wiring diagram.

Phase Inverter Package ($150 plus shipping). Includes PC-392 R1 and parts for phase inverter bridge design, Radio Shack 270-253 chassis box, green LED, six gold plated RCA phono jacks and hardware, AC power cord and strain relief, board stuffing guide and wiring diagram.

The phase inverter, headphone amp, and line preamp continue to be available with the larger, more attractive, and more sophisticated PFT chassis boxes instead of the Radio Shack chassis. Add $45 to the package price for the PFT chassis and alternate wiring diagrams.

Add $10.00 shipping in the continental USA for shipping on all these kit packages. Add $75 for shipping to the rest of the world. Boards and parts alone (no chassis) ship for $4 USA, $30 foreign. In Minnesota, add 6.5% sales tax to your payment.

Buffered Headphone Amp Parts List

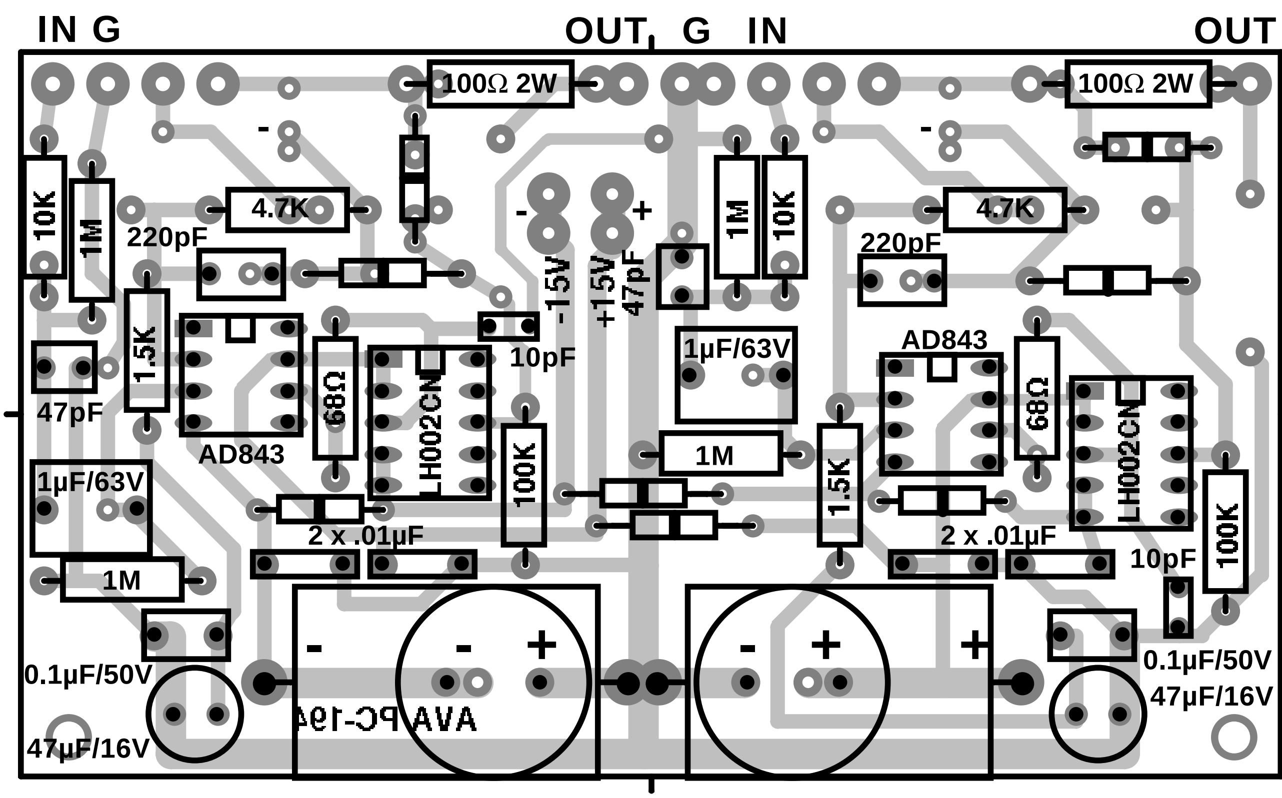
1	AVA PC-194 circuit board
2	Analog Device AD843 fet op-amp
2	National LH0002CN current buffer
2	8-pin IC socket
8	Zero Ohm jumper
2	68Ω 1/2W resistor
2	100Ω 2W resistor
2	1.5KΩ 1/2W resistor
2	4.7KΩ 1/2W resistor
2	10KΩ 1/2W resistor
2	100KΩ 1/2W resistor
4	1MΩ 1/2W resistor
2	10pF mica capacitor
2	47pF mica capacitor
2	220pF film capacitor
4	.01µF/100V ceramic disc capacitor
2	0.1µF/50V film capacitor
2	1µF/63V film capacitor
2	47µF/16V non-polar capacitor
2	3300µF/16V axial lead OR
2	4700µF/16V radial lead capacitor
2	L-Brackets and mounting hardware

This circuit provides a very fast and musical non-inverted LH0002CN buffered headphone amplifier with a voltage gain of five. It enhances the output drive capability of the excellent AD843 from 50 mA peak to 500 mA with a 100 V/µS internal slew rate. It can make the dynamic range of your headphones come alive.

Because there is no offset output voltage with the AD843 fet input op-amp the entire circuit has DC coupled outputs. The input is AC coupled to eliminate DC from sources upstream and the circuit is feedback driven to unity gain at subsonic frequencies to enhance stability and provide superior bass definition and damping.

Because the LH0002CH draws 10 mA of idle current the proper value of the current limiting resistor on the power supply board should be set to about 100 ohm 2 watt for this application.

The overall signal path is as follows: From the input, the 10KΩ series resistor and 47pF capacitor to ground prove a low pass filter, designed to knock ultrasonic garbage out of the signal (the pole point is about 340KHz). The 1µF film capacitor keeps DC garbage from the circuit (the pole point is about 0.16Hz). The 1MΩ resistor to ground after the 1µF capacitor provides a uniform load and eliminates DC drift at the input. The signal is applied to the non-inverting input of the op-amp. At the output of the op-amp the signal is coupled into the input of the LH0002CN unity gain current buffer through a 68Ω resistor with a 10pF compensation capacitor to ground to enhance stability. The current buffer acts as a miniature high powered output stage for the op-amp, providing 10 times as much drive current and protecting the op-amp from excessive loads. A 100KΩ resistor provides a uniform output load at the output of the current buffer. A portion of the output is fed back to the inverted input of the AD843 through a 4.7KΩ resistor followed by a 1.5KΩ resistor and 47µF non-polar capacitor to ground. These parts set the overall gain of the circuit (a voltage gain of about 5) but set the gain to zero at very low frequencies (pole point 5 Hz) to ensure DC stability and very low distortion. The 220pF capacitor in parallel with the 4.7KΩ feedback resistor drives the circuit to unity gain at ultra-sonic frequencies (pole point about 150KHz) to ensure good high frequency stability and to keep ultrasonic garbage from unhappy sources from getting to your amplifier and speakers. Inside the op-amp, the inverted and the non-inverted signals (as modified by the feedback compensation parts) are summed and the resultant



PC-194 Buffered Headphone Amplifier Stuffing Guide FVA 5/23/94 signal is amplified. The output is DC coupled through 100Ω 2 watt resistor to limit output current to within safe limits for the op-amp current buffer. The zero ohm jumpers serve to configure the board for the various options and to eliminate the need for a more expensive double sided board design.

The .01µF/100V ceramic disk capacitors provide necessary power supply decoupling. The two large electrolytic capacitors are raw power supply capacitors after the regulators (see the power supply board layout for more power supply design details).

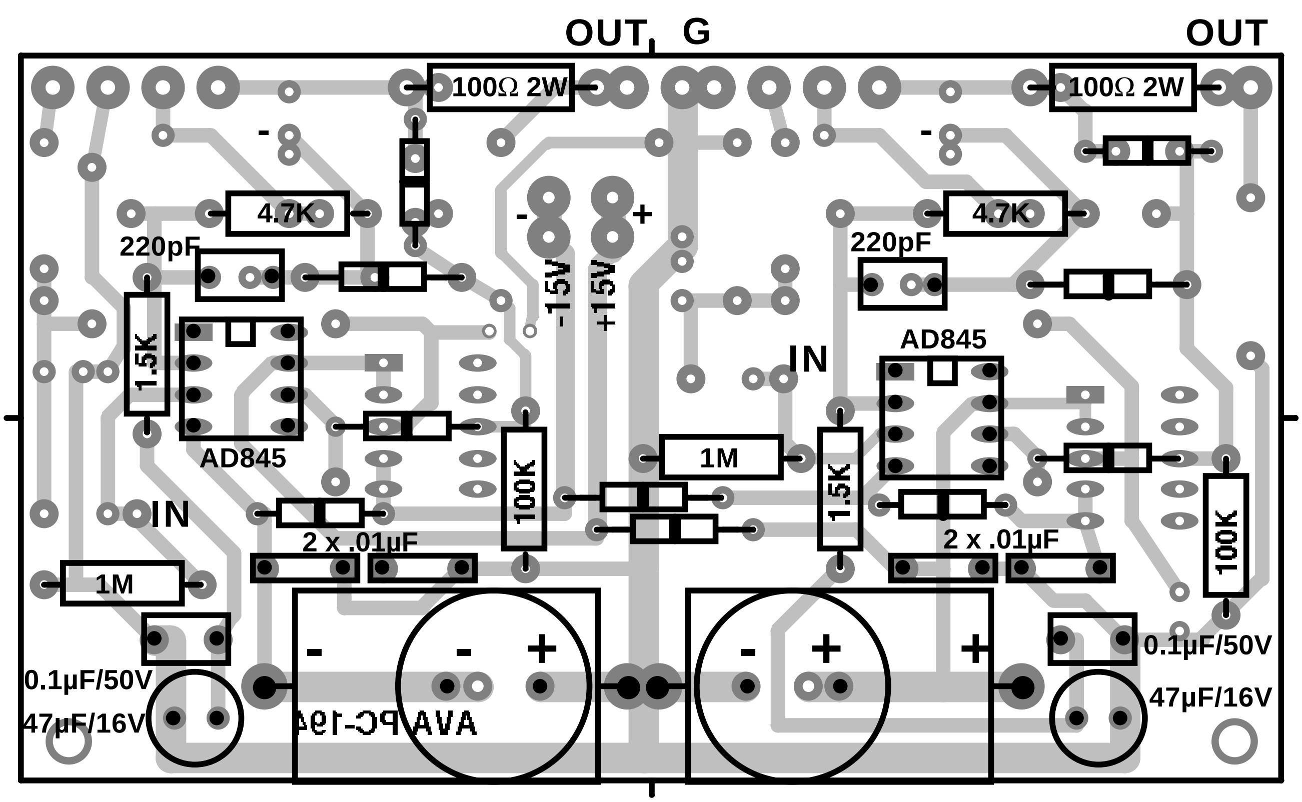
If desired, you can set the gain of this circuit higher by simply changing the 4.7KΩ resistors to 10KΩ, changing the 1.5KΩ resistors to 1KΩ, and changing the 220pF compensation capacitors to 100pF. This will double the voltage gain to a gain of 10 (20dB standard line level gain). If your wiring layout causes stability problems, substitute AD845 op-amps for the AD843s and avoid long leads and daisy chained grounds. The 845s have a gentler turn-on transient but in our opinion are not quite as musically transparent in this particular application.

Basic Headphone Amp Parts List

1 AVA PC-194 circuit board
2 Analog Device AD-845 fet op-amp
2 8-pin IC socket
10 Zero Ohm jumper
2 100Ω 2W resistor
2 1.5KΩ 1/2W resistor
2 4.7KΩ 1/2W resistor
2 100KΩ 1/2W resistor
2 1MΩ 1/2W resistor
2 220pF film capacitor
4 .01µF/100V ceramic disc capacitor
2 0.1µF/50V film capacitor
2 47µF/16V non-polar capacitor
2 3300µF/16V axial lead OR
2 4700µF/16V radial lead capacitor
2 L-Brackets and mounting hardware

This circuit is a simplified but still great performing AD845 based basic headphone amplifier.

It is designed to enhance existing preamplifier designs by adding headphone amplifiers where



PC-194 Basic Headphone Amplifier Stuffing Guide FVA 5/23/94

none existed before. It is particularly useful in the Dyna Pat-4 and Pat-5 chassis with Ωmega II audio circuits already installed.

Because we assume it will be driven from the output of an already DC stable AVA line circuit, it is DC coupled in directly to the AD845 non-inverting input. The 1MΩ resistor to ground after the 1μF capacitor provides a uniform load and eliminates DC drift at the input. At the output, a 100KΩ resistor provides a uniform output load. A portion of the output of the op-amp is fed back to the inverted input through a 4.7KΩ resistor followed by a 1.5KΩ resistor and 47μF non-polar capacitor to ground. These parts set the overall gain of the circuit (a voltage gain of about 5) but set the gain to zero at very low frequencies (pole point 5 Hz) to ensure DC stability and very low distortion. The 220pF capacitor in parallel with the 4.7KΩ feedback resistor drives the circuit to unity gain at ultra-sonic frequencies too (pole point about 150KHz) to ensure good high frequency stability and to keep ultrasonic garbage from unhappy sources from getting to your headphones. Inside the op-amp, the inverted and the non-inverted signals (as modified by the feedback compensation parts) are summed and the resultant signal is amplified. The output is DC coupled through a 100Ω 2 watt current limiting resistor. The zero ohm jumpers serve to configure the board for this option and to eliminate the need for a more expensive double sided board design.

The .01μF/100V ceramic disk capacitors provide necessary power supply decoupling. The two large electrolytic capacitors are raw power supply capacitors after the regulators (see the power supply board layout for more power supply design details).

If used with our existing circuits, it will be necessary to locate the + and - 15V DC power supply feeds and power supply ground wires and connect them to this board too. In addition, the current limiting resistors on the power supply board will require re-calibration for the additional load (another + and - 10mA).

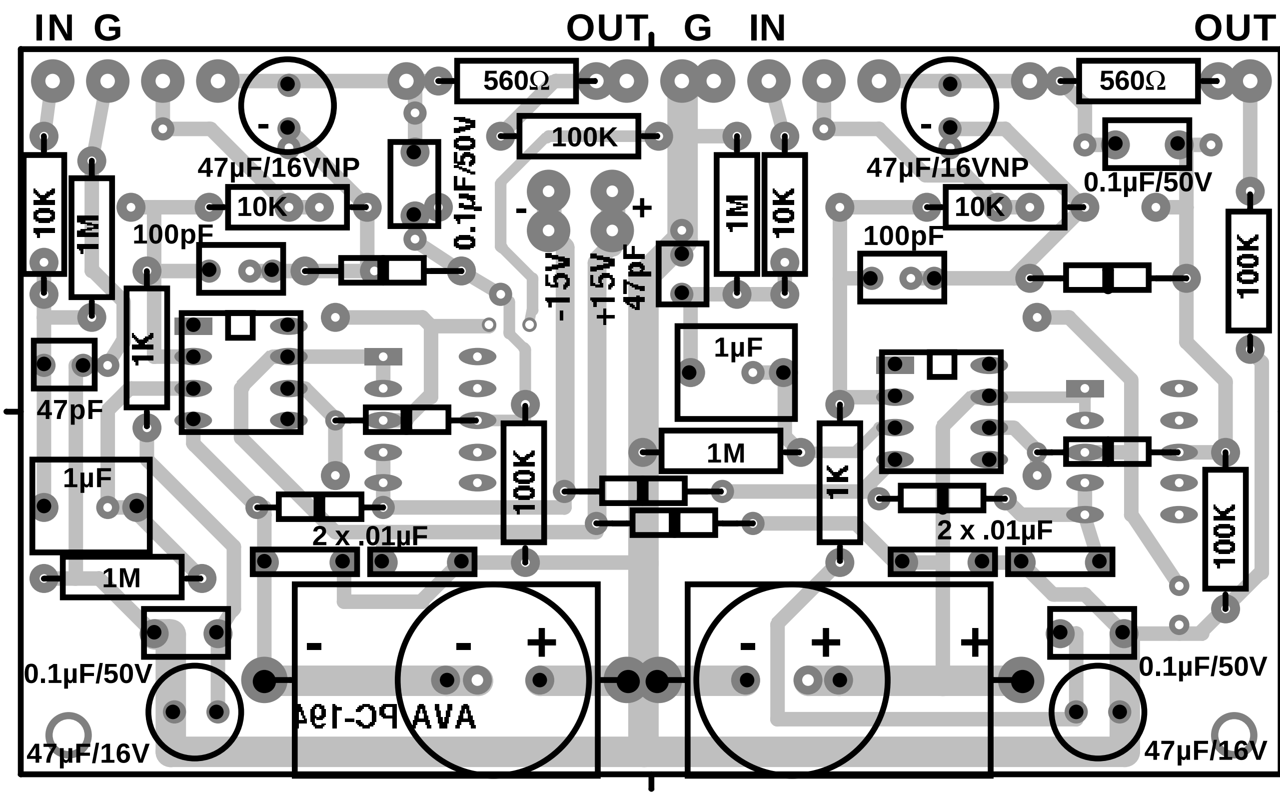
For severe duty use, the output section of this circuit can be enhanced with the LH0002CN current buffers and compensation parts along with the appropriate re-calibration of the power supply current limiting resistors (another 20mA idle current added).

Universal Line Preamp Parts List

1	AVA PC-194 circuit board
2	8-pin Linear op-amp (see below - you supply)
2	8-pin IC socket
8	Zero Ohm jumper
2	560Ω 1/2W resistor
2	1KΩ 1/2W resistor
4	10KΩ 1/2W resistor
4	100KΩ 1/2W resistor
4	1MΩ 1/2W resistor
2	47pF mica capacitor
2	100pF film capacitor
4	.01μF/100V ceramic disc capacitor
4	0.1μF/50V film capacitor
2	1μF/63V film capacitor
4	47μF/16V non-polar capacitor
2	3300μF/16V axial lead OR
2	4700μF/16V radial lead capacitor
2	L-Brackets and mounting hardware

This circuit provides a non-inverted 20dB gain line preamplifier that works with a wide variety of off-the-shelf linear op-amps. The purpose of this variation is to let you safely experiment with nearly any linear single 8-pin op-amp you care to try. The only requirements are that the device works on a + and - 15V supply and that it has a standard industry pin-out (pin 2 inverting input, pin 3 non-inverting input, pin 4 negative power supply, pin 6 output, and pin 7 positive power supply). Pins 1, 5, and 8 are not connected. The device selected must be internally compensated (and preferably unity gain stable). No external compensation capacitors connections are provided because there is too much variation in device compensation schemes to accommodate in a universal board design.

Because many ICs will generate some DC offset even when a capacitor in the feedback loop is used to prevent DC amplification, this circuit uses a film bypassed non-polar output coupling capacitor to ensure that no DC leakage reaches equipment downstream.



PC-194 Universal Line Preamplifier FVA 5/23/94

It will be necessary for you to experiment with the value of the current limiting resistors in the power supply depending upon the idle current specification for the op-amps you choose to use. If the resistor value is too high for the op-amp selected, the regulated + and - 15 volt supply will droop low. If the resistor value selected is too low, the power supply voltage will rise towards a hard 16 volts and possibly overheat and damage the 1N4744A zener diodes. In general, 300 ohm 2 watt resistors are a good starting point for typical 2 - 5 mA current draw ICs, while the value may need to go as low as 100 ohm 2 watt for a 20 mA device. If several audio boards are supplied from the same supply, the resistor values must be adjusted for the combined load. The final measured regulated power supply voltage will be between 14.5 and 15.5 volts DC if the resistors and total IC current idle current load are properly matched.

The speed, stability, and noise level of the op-amp selected are the most important characteristics determining the musical value of this circuit. It will work with an old 741 (and measure just fine in the audio band) but because the transient characteristics and current drive of those devices are poor, you will hear lots of "IC" sound - hard, bright, grainy, and non-dimensional. Pick a fast and stable low-noise device for good audio results. Let us know if you find something that appears to have better musical fidelity than the AD843 in this application.

Although the LH0002CN buffer variation is not spelled out here, it will work with many devices if you need greater load driving capability. Refer to the buffered headphone amp design and add the LH0002CN current buffers, the 68Ω resistors, and the 10pF compensation capacitors to this layout (eliminating two zero ohm jumpers, of course). The power supply will require re-calibration because of the additional 10mA idle current drawn by each LH0002CN.

The overall signal path is as follows: From the input, the 10KΩ series resistor and 47pF capacitor to ground prove a low pass filter, designed to knock ultrasonic garbage out of the signal (the pole point is about 340KHz).

The 1µF film capacitor keeps DC garbage from the circuit (the pole point is about 0.16Hz assuming the use of a high input impedance Fet op-amp – with a bi-polar op-amp this could go up to about 2Hz - no big deal). The 1MΩ resistor to ground after the 1µF capacitor provides a uniform load and eliminates DC drift at the input. The signal is applied to the non-inverting input of the op-amp. At the output, a 100KΩ resistor provides a uniform output load. A portion of the output of the op-amp is fed back to the inverted input through a 10KΩ resistor followed by a 1KΩ resistor and 47µF non-polar capacitor to ground. These parts set the overall gain of the circuit (a voltage gain of about 10) but set the gain to zero at very low frequencies (pole point 3 Hz) to ensure DC stability and very low distortion. The 100pF capacitor in parallel with the 10KΩ feedback resistor drives the circuit to unity gain at ultra-sonic frequencies (pole point about 150KHz) to ensure good high frequency stability and to block ultrasonic garbage. Inside the op-amp, the inverted and the non-inverted signals (as modified by the feedback compensation parts) are summed and the resultant signal is amplified. The output is AC coupled through a 47µF NP capacitor (pole point about 0.3Hz into a typical 10KΩ load). The 560Ω resistor limits current to within safe limits for the op-amp and enhances stability. The last 100KΩ resistor eliminates DC output drift at turn-on or while the circuit is not connected to a load. The zero ohm jumpers serve to configure the board for the various options and to eliminate the need for a more expensive double sided board design.

The .01µF/100V ceramic disk capacitors provide necessary power supply decoupling. Some op-amps may require additional supply bypassing with 1µF tantalum capacitors or similar for best stability. The two large electrolytic capacitors are raw power supply capacitors after the regulators (see the power supply board layout for more power supply design details).

Have fun with this universal design and you too can become an audio design technician.

RIAA Phono Preamp Parts List

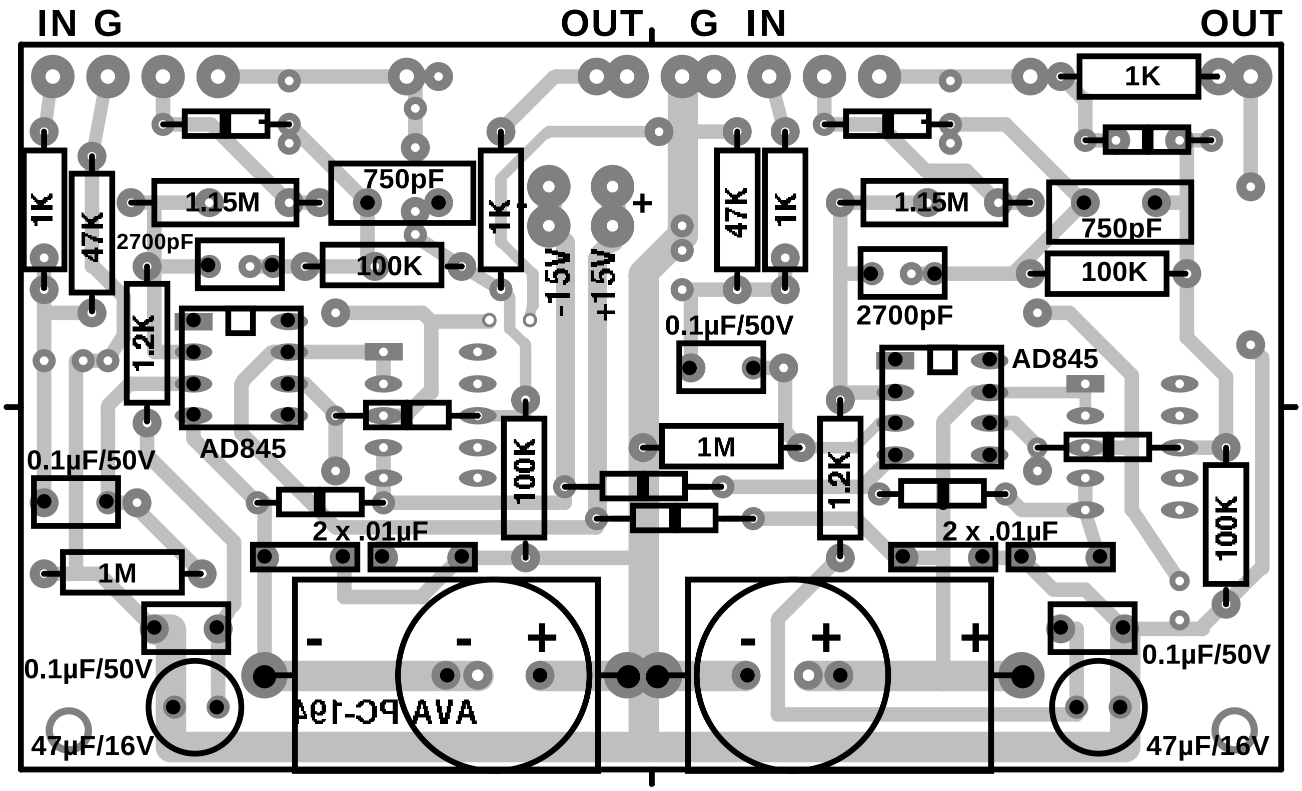
1	AVA PC-194 circuit board
2	Analog Device AD845 fet op-amp
2	8-pin IC socket
9	Zero Ohm jumper
4	1KΩ 1/2W resistor
2	1.2KΩ 1/2W
2	47KΩ 1/2W resistor
4	100KΩ 1/2W resistor
2	1MΩ 1/2W resistor
2	1.15MΩ 1W
2	750pF mica capacitor
2	2700pF film capacitor
4	.01µF/100V ceramic disc capacitor
4	0.1µF/50V film capacitor
2	47µF/16V non-polar capacitor
2	3300µF/16V axial lead OR
2	4700µF/16V radial lead capacitor
2	L-Brackets and mounting hardware

Here we have a complete very high quality RIAA phono preamp section based upon the fast fet input AD845 op-amp. This circuit provides a fast and musical non-inverted 40dB of gain at 1KHz and exact phono equalization. It is suitable for any normal output magnetic phono cartridge down to about 2mV output.

You can add this circuit board to any preamp not now containing a phono preamp where there is room and ±15V supply feeds are available. You can also build it as a free standing unit in the Radio Shack chassis box along with the PC-392 R1 power supply to work with any line preamplifier.

Note that the phono input jacks should have their ground connections isolated from chassis ground. The signal should connect from the input jacks to the PC card with shielded cable (the inner conductor is the hot side, the shield the ground side). At the input jacks, the ground side of the phono signal should also be AC coupled to the chassis through a .01µF disk capacitor to eliminate RFI and hum. Provide a ground terminal on the outside of the chassis at this point for easy connection to the turntable ground wire if supplied.

Because there is no offset output voltage with the AD845 fet input op-amp this circuit has DC coupled outputs. The input is AC coupled



PC-194 RIAA Phono Preamp Stuffing Guide 5/23/94 FVA

to eliminate DC from sources upstream and the circuit is feedback driven to unity gain at subsonic frequencies to enhance stability and provide superior bass definition and damping.

The overall signal path is as follows: From the input the 1KΩ series resistor provides high frequency input stability and isolation. The 47KΩ resistor sets the desired resistive phono load. The 0.1µF film capacitor keeps DC garbage and record warps from the circuit (the pole point is about 2Hz). The 1MΩ resistor to ground after the 0.1µF capacitor provides a uniform load and eliminates DC drift at the input. The signal is applied to the non-inverting input of the op-amp. At the output of the op-amp a 100KΩ resistor provides a uniform output load. A portion of the output is fed back to the inverted input of the AD845 through a frequency shaping network consisting of a 100KΩ resistor in parallel with a 750pF capacitor, the pair in series with a 1.15MΩ resistor in parallel with a 2700pF capacitor. A 1.2KΩ resistor and 47µF non-polar capacitor to ground completes this feedback loop. These parts set the overall gain of the circuit and determine the RIAA feedback pole points and set the gain to zero at very low frequencies (pole point 5 Hz) to ensure DC stability and very low distortion. Inside the op-amp, the inverted and the non-inverted signals (as modified by the feedback compensation parts) are summed and the resultant signal is amplified. Because the op-amp selected is very fast (100V/µS slew rate) and has high open loop gain and excellent current drive, the 60dB of gain at low frequencies can be provided and still allow good phase and feedback margins for superior stability, low noise, and low distortion (sounds damn good too!). The output is DC coupled through a 1KΩ resistor to limit output current to within safe limits. The zero ohm jumpers serve to configure the board for this option and to eliminate the need for a more expensive double sided board design.

The .01µF/100V ceramic disk capacitors provide necessary power supply decoupling. The two large electrolytic capacitors are raw power supply capacitors after the regulators (see the power supply board layout for more power supply design details).

If desired, you can set the phono load to any desired value by changing the 47KΩ resistors to the value you need. The input impedance of the fet op-amp is very high (>1MΩ) and is free of input bias currents so it does not interact with the load.

It might occur to some of you about now that we have now provided everything you need to make a complete preamplifier. Just start with a full sized PC-392 R1 supply and line circuit board and two PC-194 boards and you can have phono, line, headphones, and power supply in one tidy package. Tell us about your application.

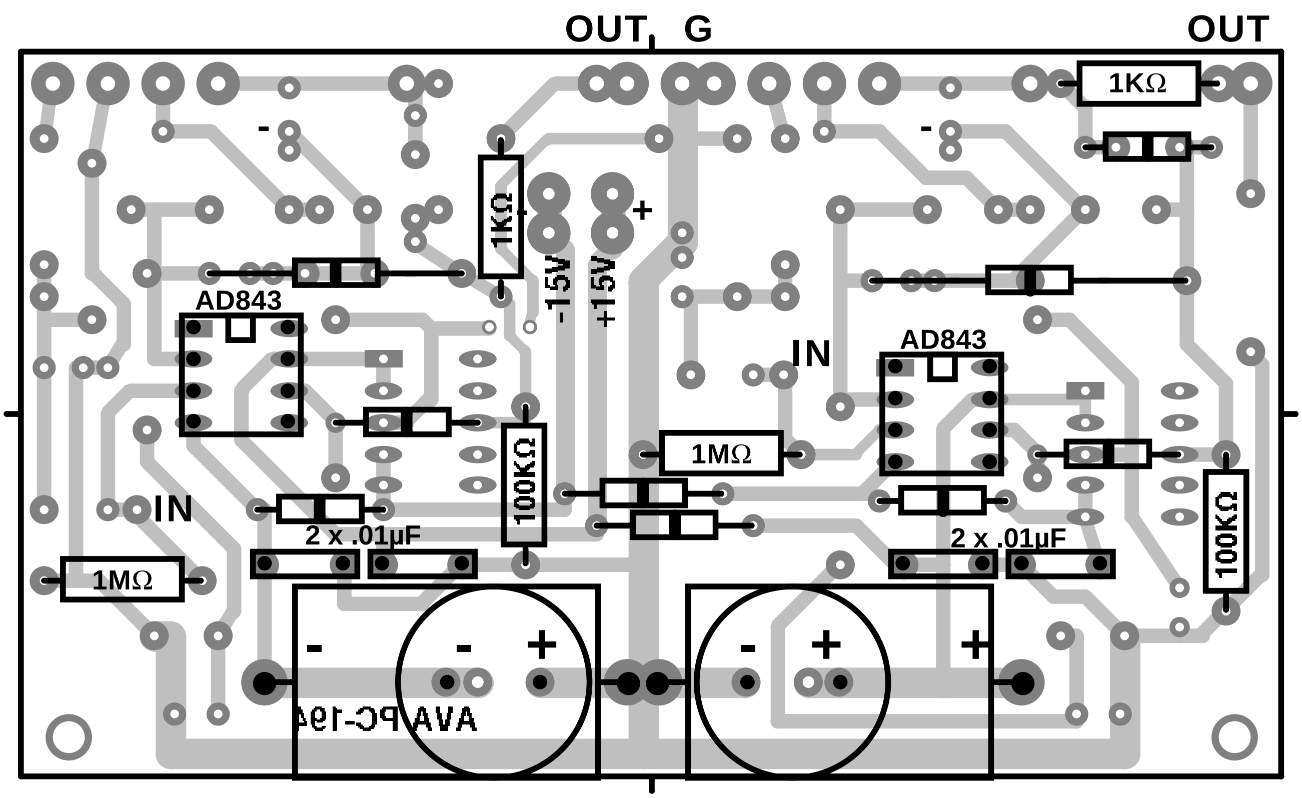
Unity Gain Buffer Parts List

1 AVA PC-194 circuit board
2 Analog Device AD-843 fet op-amp
2 8-pin IC socket
9 Zero Ohm jumper
2 1KΩ 1/2W resistor
2 100KΩ 1/2W resistor
2 1MΩ 1/2W resistor
4 .01µF/100V ceramic disc capacitor
2 3300µF/16V axial lead OR
2 4700µF/16V radial lead capacitor
2 L-Brackets and mounting hardware

This circuit is the same problem solving unity gain buffer shown in the March, 1994 issue of *Audio Basics* but re-configured on the PC-194 card for free standing use. Refer to that issue for a description of the circuit's capabilities.

This variation is designed to enhance existing preamplifier designs by adding an internal unity gain buffer to isolate tape output circuits. It is particularly useful in the Dyna Pat-4 and Pat-5 chassis with basic Ωmega II audio circuits already installed.

Because we assume it will be driven from the output of an already DC stable AVA line circuit, it is DC coupled in directly to the AD843 non-inverting input. The 1MΩ resistor to ground after the 1µF capacitor provides a uniform load and eliminates DC drift at the input. At the output, a 100KΩ resistor provides a uniform output load. 100% of the output of the op-amp is fed back to the inverted input through a zero ohm jumper. This sets



PC-194 Unity Gain Buffer Stuffing Guide FVA 5/23/94 the overall gain of the circuit to one and provides the maximum bandwidth for the device. Inside the op-amp, the inverted and the non-inverted signals (as modified by the feedback compensation parts) are summed and the resultant signal is amplified. The output is DC coupled through a 1KΩ current limiting resistor. The zero ohm jumpers serve to configure the board for this option and to eliminate the need for a more expensive double sided board design.

The .01µF/100V ceramic disk capacitors provide necessary power supply decoupling. The two large electrolytic capacitors are raw power supply capacitors after the regulators (see the power supply board layout for more power supply design details).

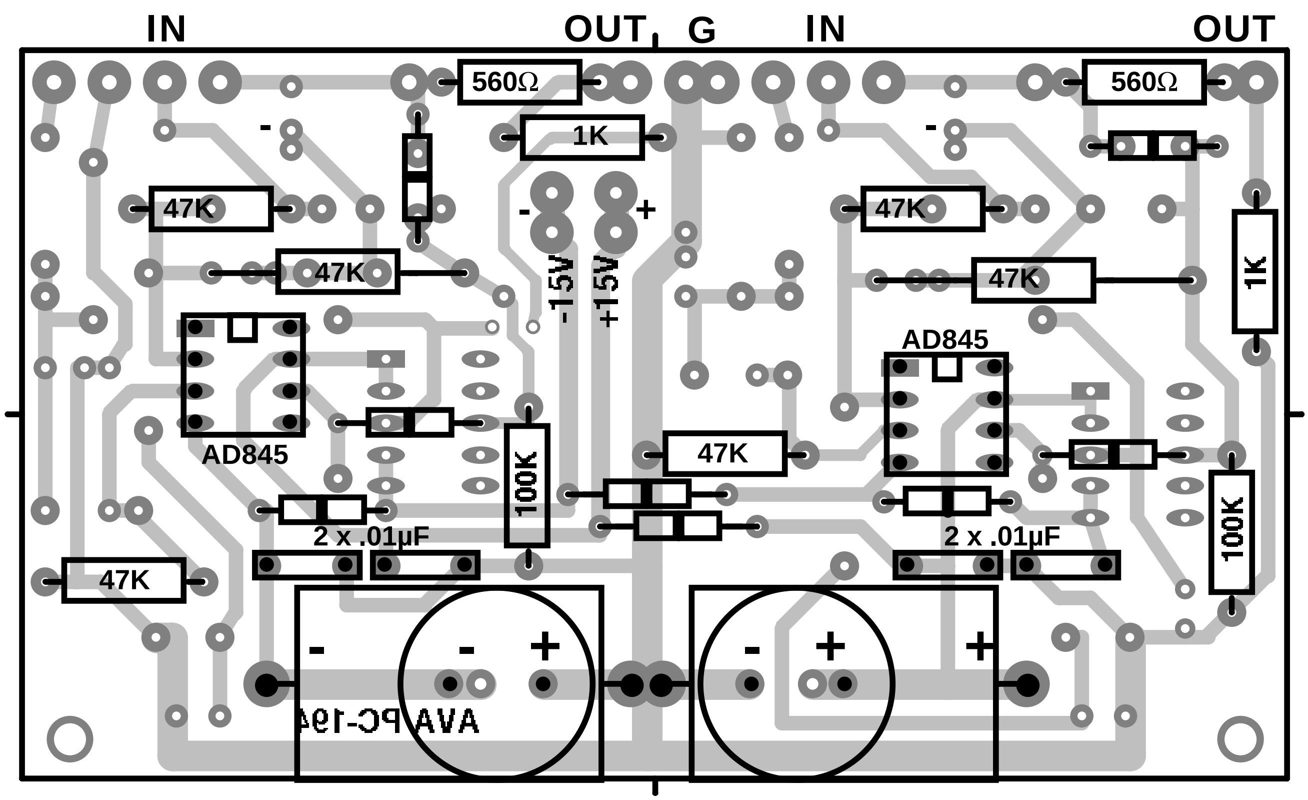
If used with our existing circuits, it will be necessary to locate the + and - 15V DC power supply feeds and power supply ground wires and connect them to this board too. In addition, the current limiting resistors on the power supply board will require re-calibration for the additional load (another + and - 10mA).

For severe duty use, the output section of this circuit can be enhanced with the LH0002CN current buffers and compensation parts along with the appropriate re-calibration of the power supply current limiting resistors (another 20mA idle current added).

Phase Inverter Parts List

1 AVA PC-194 circuit board
2 Analog Device AD845 fet op-amp
2 8-pin IC socket
8 Zero Ohm jumper
2 560Ω 1/2W resistor
2 1KΩ 1/2W resistor
6 47KΩ 1/2W resistor
2 100KΩ 1/2W resistor
4 .01µF/100V ceramic disc capacitor
2 3300µF/16V axial lead OR
2 4700µF/16V radial lead capacitor
2 L-Brackets and mounting hardware

The many useful applications for these phase inverter circuits have been previously described in the October, 1992 issue of *Audio Basics*. Here we have re-configured the circuit on the PC-194 card for free standing use.



PC-194 Phase Inverter Stuffing Guide FVA 5/23/94

This variation is designed to enhance existing preamplifier designs by adding an internal phase inverter to allow you to directly bridge two stereo amplifier for dual mono use or for balanced line out applications. It is particularly useful in the Dyna Pat-4 and Pat-5 chassis with basic Ωmega II audio circuits already installed, or of course as a companion to a line preamplifier built on another PC-194 board.

This circuit must be driven from the output of an already DC stable AVA line circuit, with the output taken ahead of any output current limiting resistors on the parent line preamp circuit. It is a completely DC coupled in-to - out circuit with no compensation.

The input feeds into the inverted inputs of the AD845 through a 47KΩ resistor. The non-inverted inputs are grounded through another 47KΩ resistor. The output of the op-amp is fed back to the input through another 47KΩ resistor providing 100% feedback, a 47KΩ input impedance, and fast inverting operation. The output is DC coupled through a 560Ω current limiting resistor. Because bridged use increases the system gain by 6dB, 1KΩ resistors to ground are added at both the inverted and the non-inverted outputs to attenuate the signal level back to normal and provide for lower noise operation. The zero ohm jumpers serve to configure the board for this option and to eliminate the need for a more expensive double sided board design.

The .01µF/100V ceramic disk capacitors provide necessary power supply decoupling. The two large electrolytic capacitors are raw power supply capacitors after the regulators (see the power supply board layout for more power supply design details).

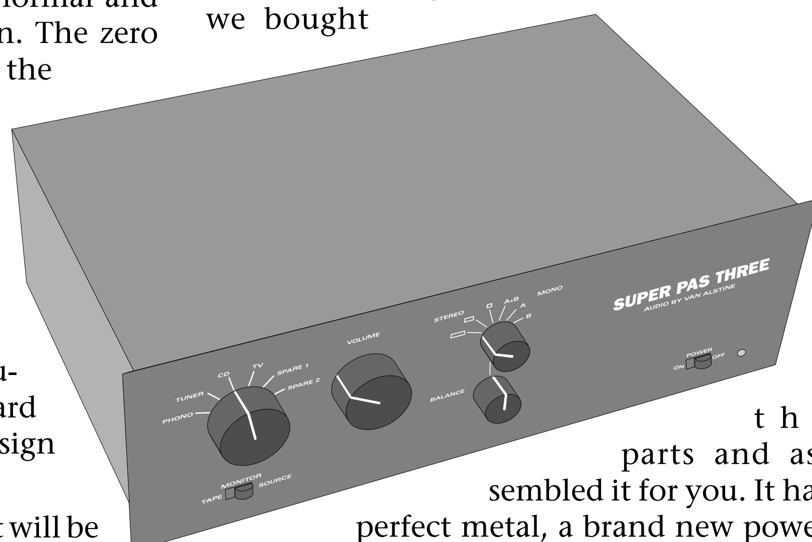
If used with our existing circuits, it will be necessary to locate the + and - 15V DC power supply feeds and power supply ground wires and connect them to this board too. In addition, the current limiting resistors on the power supply board will require re-calibration for the additional load (another + and - 10mA).

A Few New Reviews

The Ωmega II 440hc and the Super 70i amplifiers are thoroughly reviewed in issue #51 (Summer, 1994) of *The $ensible Sound*. The Super 70i amplifier circuits and Super Pas Three preamp circuits get brief, but positive, mentions in Tamara Baker's column in issue #95 (Late Spring, 1994) of *The Abso!ute Sound*. Finally, *Radio World* has both the Super Pas Three and Super 70i rebuild kits under construction for evaluation in an issue this coming fall. We appreciate the attention. The March, 1994 issue of *Sound Off* takes us to task because we are dubious of A-B switch-boxes. They claim that a reasonable way to quickly switch amplifiers is to simply pull the interconnect cables from the inputs while the amp is turned on and connected to the speakers! Golly crash-boom-bang! Don't you try that if you want to keep your speakers alive!

Used Equipment

Brand New factory wired Super Pas Three Preamp from old stock unassembled Dyna metal. This is likely your last chance at a really perfect Super Pas Three. A client got the chassis parts to build in our kit but never got around to doing it so we bought the parts and assembled it for you. It has perfect metal, a brand new power transformer, and our new circuits, new tubes, gold jacks, ceramic selector switch, and a new black AVA faceplate and knob set. The price is $495 plus $10 shipping in the continental USA with a one year parts and labor warranty.



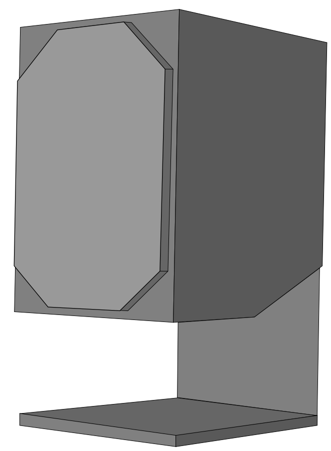
New Ωmega II Preamplifier circuits in excellent, clean, black recycled Pat-5 chassis, complete with new AVA black faceplate and knob set, gold jacks, and full functions (switchable tone controls, switchable EPL loop, dual tape monitors, low gain switch, and low filter). The unit is wired now for two sets of phono inputs (plus CD, Tuner, Spare, and two sets of Tape inputs and outputs). We can rewire it to convert the second set of phono inputs to line level inputs instead at no extra charge if you desire. The price is $395 with a new two year parts and labor warranty. The only function not connected is the original Dyna speaker switcher. If you need this (few do) add $75 for us to supply the necessary 5-way binding posts and wire it in. Shipping is $10 in the USA.

New Ωmega II 150 Amplifier circuits in used Dyna St-150 chassis. This is the same new high performance active feedback power amplifier circuit set that would go in a new Ωmega II 200 chassis, but installed in a good used Dyna St-150 chassis to save you $150. The price is $545 and it comes complete with a two year parts and labor warranty on our circuits, six months on the original Dyna metal. Add $15 for shipping in the continental USA.

New Δelta 150 Amplifier circuits in used Dyna St-150 chassis. This is the same clean and stable AVA power mos-fet circuit set that would go in a new Δelta 200 chassis, but installed in a good used Dyna St-150 chassis to save you $150. The price is $345 and it comes complete with a one year parts and labor warranty on our circuits, six months on the original Dyna metal. Add $15 for shipping in the continental USA.

Super 70i Vacuum Tube Amplifier with new AVA jack set, and all new signal tubes. This is as nice as a small vacuum tube amplifier gets and is a great match for speakers such as our B&W DM640i with AVA upgraded crossovers. We have several good chassis and can offer this package with our new insides for $645.00 plus $15 shipping in the continental USA. These units have a two year parts and labor warranty on our circuits, six months on the chassis and mechanical bits, and 30 days on the tubes. Add $100 for the AVA power transformer and solid state rectifier installed too.

New B&W CM-1 Loudspeakers (black finish). These are the best overall really small (13" high x 8.5" deep x 6.25" wide) loudspeakers I know of (I use a set myself in my video system and both my kids have them). The last retail price was $800 before they were discontinued last year (they got too expensive to make). We have one pair left at $595 including shipping to you complete with a 5 year parts and labor warranty. I have one used pair (black) in perfect like new condition too. They are available at $475 with our one year parts and labor warranty. If you are looking for ultimate resolution and imaging in a tiny space, these are the speakers for you. Allow $15 for shipping in the continental USA.



New B&W Acoustitune Sub-Woofer (black finish). This stereo sub-woofer is a perfect match for the CM-1s or most any small speakers. It has a built-in passive crossover (no extra electronics needed). It was purchased from us about 5 years ago and the client never opened the carton! (We did now to ensure every is in good working order). Your cost is $275.00 (or $225 if purchased with the CM-1s) with our one year parts and labor warranty. Allow $15 for shipping in the continental USA

This is the biggest issue of Audio Basics we have ever put together. We felt getting all of the information regarding these new circuits in one place was best. You will hear from us again in late July. Thanks for your interest.

Frank and Darlene Van Alstine