Add a Phono Adapter to your Home Stereo

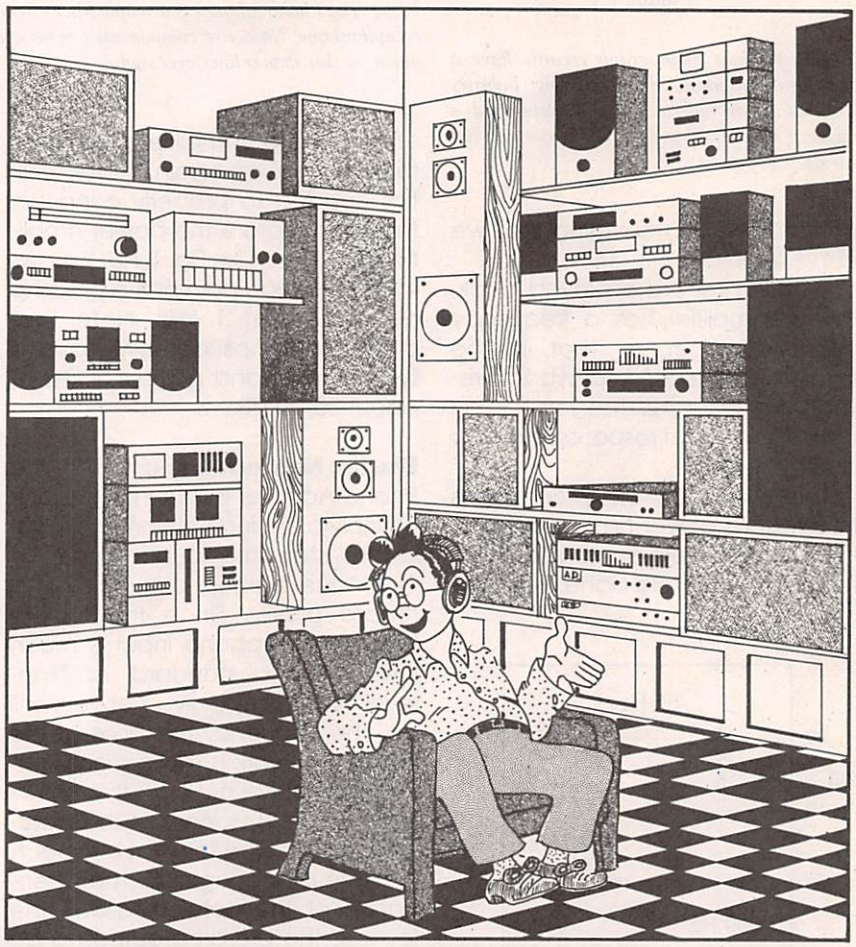
Reclaim that unused phonograph input on your amplifier with this simple adapter.

JOE GUSTAINIS

Although the era of the phonograph record has been over for more than a decade, stereo receivers and amplifiers still have phonograph inputs. Unless you have an extensive collection of "black vinyl" and still enjoy listening to them, the phono input on your home stereo is probably just sitting there unused.

On the other hand, you probably have a large collection of audio gear from CD and DVD players to cassette decks and component television. The audio outputs of those units are all fighting for an input to your amplifier, yet there is that phonograph input, sitting there unused. If there were a way to use that input with a modern piece of audio gear, the pressure to find jacks for everything in your home theatre would ease off that much more.

To the rescue comes the Phono Adapter described here. This simple circuit will let you use a standard audio source with an unused phono input. With the Phono Adapter plugged in between a piece of audio gear and the phono input of an amplifier, an additional auxiliary input for your sound system is gained. Electronics projects such as this one don't get much easier. Not only is it the perfect project for someone that has little skill in construction, it can be completed in less than two hours at very low cost and is a project that can be used every day.



Phonograph-Record Response. The phono jacks in your receiver or amplifier are connected to a special preamplifier circuit that provides the conditioning needed to deliver a flat frequency response for the extremely non-linear, low-level frequency characteristics of a phonograph. Since phonograph equipment never provided a truly linear frequency response, the effective dynamic range and signal-to-noise ratio of records was enhanced by intentionally recording non-linearly in accordance with a standard curve defined by the Recording Industry Association of America (RIAA). Figure 1 shows the typical frequency response of a phonograph-record playback, along with its pole/zero asymptotes. The response shown is normalized to 0 dB at 1 kHz and contains a zero at 50 Hz, a pole at 500 Hz, and a zero at 2120 Hz. Additional poles occur beyond the audio range; they are not shown since we are obviously

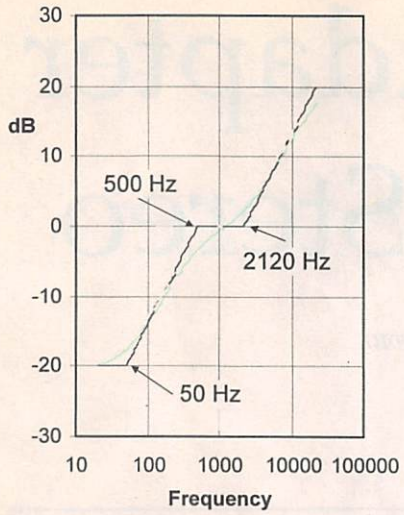


Fig. 1. Because phonograph records have a non-linear response, the Recording Industry Association of America (RIAA) developed a response standard that deals with those non-linearities.

not interested in anything that we can't hear.

When a record is played back, the preamplifier has a frequency equalization curve that is the inverse of the RIAA playback response; see Fig. 2. The result is an output with a flat response over the audio range.

The magnetic pick-up cartridges in a record player have extremely low output levels—typically only a few millivolts at mid-band. Because

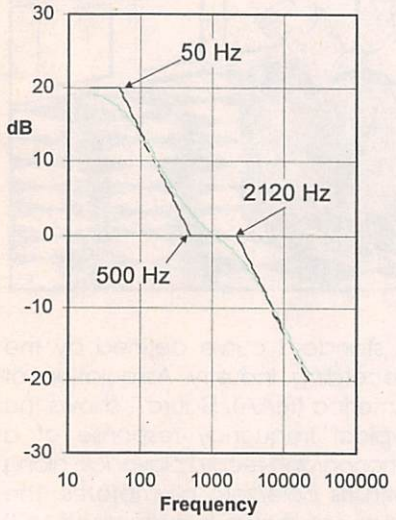


Fig. 2. An RIAA-compliant preamplifier has a frequency response that is the inverse of the RIAA curve. When an RIAA signal is played through the preamplifier, the result is a flat-frequency response.

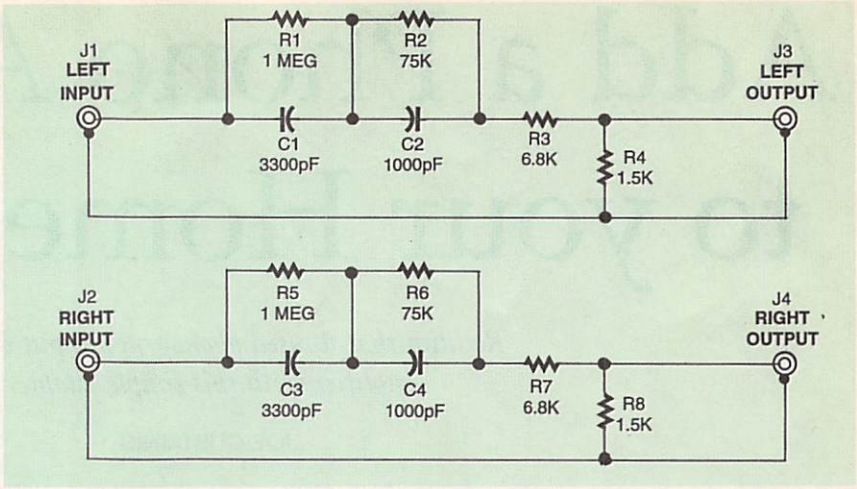


Fig. 3. The Phono Adapter is a simple filter circuit that changes a standard audio signal to an RIAA-compliant one. No active components are needed because the signal from a phonograph needle is much weaker than a line-level signal.

of that, the preamplifier must have the low-noise and gain characteristics needed to properly condition the signal before the power amplification stage. Like Fig. 1, Fig. 2 shows the magnitude gain of the preamp normalized at 1 kHz. Note that phono preamps actually have a typical mid-band gain at 1 kHz of about 30–40 dB.

Biasing Network. The circuit for the Phono Adapter is shown in Fig. 3. It is simply a biasing network that conditions standard audio signal to "look" like a signal coming from a record player. Since the typical level for the phono input is much lower than a standard, or "line-level" input, a passive network will do. The frequency response of the biasing network is the same as the response curve of Fig. 1, thus skewing the "flat" response of the external audio source to what is expected from a phonograph. The attenuation of the network allows the level of the pre-amp output to be similar in amplitude to a standard auxiliary input; the volume of your system won't have to change when listening to a piece of audio gear though the phono input.

The network was selected to provide relatively high input impedance to accommodate a variety of audio sources. The input impedance of the network at any frequency will always be greater than the sum of R3 and R4 (R7 and R8 for the right channel). If the sum of those resistors is kept significantly higher (over ten times) than the output impedance of whatever audio source you are using, the frequency response and the scaling of the network will not be significantly affected.

Likewise, the output impedance of the network must be kept significantly lower than the input impedance of the phonograph preamplifier. The output impedance of the network will always be less than R4 (R8 in the right channel); an RIAA standard phono preamplifier has

TABLE 1
ALTERNATE COMPONENT VALUES

Component	Value	Alternate 1	Alternate 2	Alternate 3
R1, R5	1 Meg	1.2 Meg	2.2 Meg	3.3 Meg
R2, R6	75K	91K	160K	270K
R3, R7	6.8K	10K	10K	4.7K
R4, R8	1.5K	1.5K	3.3K	4.7K
C1, C3	3300 pF	2700 pF	1500 pF	1000 pF
C2, C4	1000 pF	820 pF	470 pF	270 pF

$$\frac{Vout(s)}{Vin(s)} = (0.001385)\frac{\left(\frac{s}{2\pi 50}+1\right)\left(\frac{s}{2\pi 2120}+1\right)}{\frac{s^2}{(2\pi 500)(2\pi 26555)}+\left(\frac{1}{(2\pi 500)}+\frac{1}{(2\pi 26555)}\right)s+1}$$

$$\frac{Vout(s)}{Vin(s)} = \left(\frac{R_4}{R_1+R_2+R_3+R_4}\right)\frac{\left(R_1C_1s+1\right)\left(R_2C_2s+1\right)}{\left(\frac{R_1R_2\left(R_3+R_4\right)}{R_1+R_2+R_3+R_4}C_1C_2\right)s^2+\left(\frac{R_1\left(R_2+R_3+R_4\right)C_1+R_2\left(R_1+R_3+R_4\right)C_2}{R_1+R_2+R_3+R_4}\right)s+1}$$

Fig. 4. Although the Phono Adapter circuit is very simple, the math needed to design it properly can get quite involved.

an input impedance of 47,000 ohms. Cable and input capacitance of the preamplifier can also affect the network's response. That capacitance can be on the order of 100 to 1000 pF, so it is necessary to keep the output impedance of the network less than about 4700 ohms in order not to create an additional in-band pole.

The simplicity of the Phono Adapter's circuit does an excellent job of hiding the complex mathematical equation that designed it. That equation, called a *Laplace Transform*, is shown in Fig. 4; the equivalent representation in terms of component values is included. While the zeroes at 50 Hz and 2120 Hz, and the pole at 500 Hz are required by the RIAA standard, the pole at 26,555 Hz is not. That pole can be any frequency as long as it is outside of the audio band (above 20 kHz). The 26,555-Hz pole shown is specific to our circuit.

For additional information concerning the design of RIAA circuits, see National Semiconductor's application note AN-346, titled "High-Performance Audio Applications of the LM833."

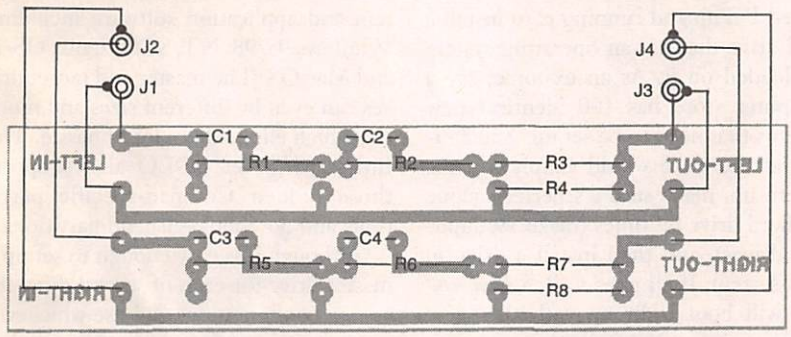
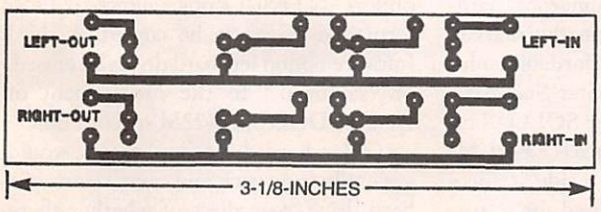


Fig. 5. If you want to build the Phono Adapter on a PC board, use this parts-placement diagram to locate the components.



Here's the foil pattern for the Phono Adapter. The circuit is simple enough to fit on a single-sided board without the need for jumpers.

Construction. As you can see from the schematic diagram, the Phono Adapter is an extremely inexpensive project. The most expensive item will be the project case itself—if you decide to use one.

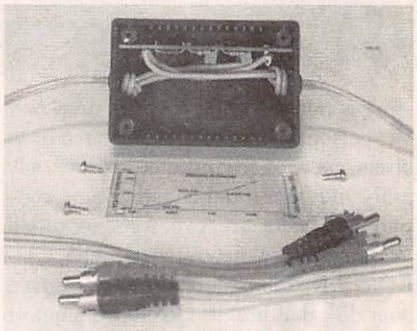


Fig. 6. The author's prototype used hard-wired cables instead of jacks. Note the overhand knots tied in the cables to act as strain reliefs.

It is not necessary to use an etched PC board; a small piece of perfboard can be used with standard construction techniques. On the other hand, a printed-circuit board makes for a neater assembly. If you'd like to use an etched board, a foil pattern has been included here; follow the parts-placement diagram shown in Fig. 5.

If you do not want to mount jacks on the case, you can substitute a dual phono-plug cable for J1–J4. Cut the cable in half and connect the inputs and outputs to the severed ends. Use vinyl grommets to protect the cables where they pass through holes in the case. Additionally, tie an overhand knot in the cable to act as a strain relief. As you can see in the photo of the au-thor's prototype (Fig. 6), the severed-phono-cable app-roach was used, as that was less expensive.

Component tolerances will effect the shaping characteristics,

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PARTS LIST FOR THE PHONO ADAPTER

RESISTORS

(All resistors are 1/4-watt, 5% units.)
R1, R5—1 megohm
R2, R6—75,000-ohm
R3, R7—6,800-ohm
R4, R8—1500-ohm

CAPACITORS

C1, C3—3300-pF, ceramic-disc
C2, C4—1000-pF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

J1–J4—RCA phono jacks, panel-mount
Audio cables, case, grommets, hardware, etc.

but to most ears, 10% ceramic capacitors and 5% carbon-composition resistors are acceptable. For fussier audiophiles, using tighter-tolerance components or hand selecting component values are ways to get the best accuracy. Additionally, the use of metal-film resistors will minimize any audio noise created by the Phono Adapter.

It is not necessary to use the component values indicated for your adapter network. Table 1 shows a few design alternatives in terms of component value. If you have these complete alternate-value sets lying around in your spare-parts box, the Phono Adapter will become that much less expensive to build!

If you notice that playback is too loud or soft compared with other stereo inputs, the attenuation provided by R3, R4, R7, and R8 may be modified, as long as the sum of the two resistors are kept constant. That changes the signal level without altering the frequency-response characteristics. Preamplifier gain variation in different models of receivers might make this "tweaking" necessary.

Happy listening! Ω