Bridging Adapter For Power Amplifiers

Rod Elliott - ESP (Original Design / Basic Principles)

A stereo power amplifier is limited in its output power by two main factors - the impedance of the load and the internal power supply voltage. To obtain more power, one has very limited choices - other than the purchase of a more powerful amp.

The load impedance can be lowered, but if the load happens to be a pair of standard loudspeakers this is not viable, since the impedance is set by the drivers themselves. Increasing the power supply voltage is generally a bad idea, since most commercial amps do not have a wide safety margin with component ratings, and will probably be destroyed if the voltage were to be raised sufficiently to obtain even 50% more power.

The bridging adapter shown in Figure 1 can make an amplifier produce almost 4 times the power for the same impedance - but beware of the pitfalls. Basically, these are:

- The amplifier must be rated to drive a load impedance which is half that of the speakers to be connected
- Although some forms of distortion will cancel, the primary form of amplifier non-linearity - crossover distortion - will be worse ...
    - Both amplifiers in bridge will cross the zero volt point at the same time
    - The impedance is lower, there is more current, so each amplifier's contribution will be greater

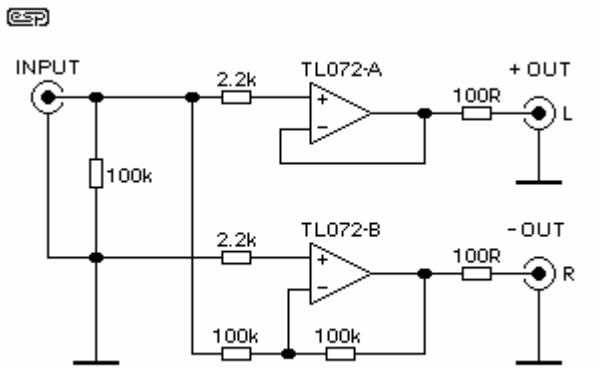

Figure 1 - Power Amplifier Bridging Adapter

Construction is not critical, and the adapter has unity gain for each output. Naturally, 1% metal film resistors should be used, and the choice of opamp is not too critical - the TL072 is perfectably acceptable in this configuration, and will have low noise and a wide bandwidth. Note that if interconnect leads are to be used from the adapter to the power amp, the 100 Ohm resistors shown must be placed in series with each output to prevent instability - this is important, as an oscillating adapter will inject an AC voltage of perhaps hundreds of kiloHertz into the amp's input, with the very real possibility of destruction of the output transistors.

The power supply may be taken from the preamp supply (this should be +/-12V to +/-15V). The preamp output is connected to the adapter's input, and for the sake of convention, connect the + OUT to the Left power amp's input, and the - OUT to the Right amp's input (as indicated in Figure 1). For opamp pinouts, go to the link on the main projects page, or have a look at one of the other projects (such as the Audio Preamp - Project 02) where this information is to be found.

Naturally, for stereo two circuits are needed, as well as a second (preferably identical) stereo power amp. This arrangement is also very useful to convert an otherwise mediocre stereo power amp into a perfectably acceptable sub-woofer amplifier, having plenty of power (depending on the power of the original, of course).

Quality is not so much of an issue for a sub, since only the low frequencies are reproduced, and amplifier distortion is as nothing to the distortion generated by a loudspeaker at low frequencies.

The loudspeaker is connected between the amplifier's + outputs only, and neither side of the speaker can be earthed or connected to any other amplifier output - either of these **WILL** blow up your amplifier.

Testing

I have had a few constructors who have had problems - mainly due to inexperience. I have been doing this stuff for so long that I often forget that many of my readers are novices, and this looks really simple, so off they go and promptly have problems I haven't covered. I shall attempt to remedy the situation forthwith!

When the unit is built, after checking that power is correct (no more than +/-15V), some basic tests need to be done.

- First, make sure that there is no appreciable DC offset at the outputs. Generally it should be no more than about 3mV, and will generally be less. More than about 100mV means you have a problem, so switch off immediately and check your work carefully.
- Apply a signal to the input, and measure the level (a signal generator is best for this). Try for an input of about 1V RMS.
- Measure the AC voltage at each output to ground. It should be exactly the same as the input for both outputs.
- Measure the AC voltage between the two "hot" (signal) outputs (at the connector or the 100 ohm resistors). It should be exactly double the input voltage.

If all the above tests are OK, you can connect the output of your preamp to the input of the adaptor. Just for safety's sake, measure the DC output voltages again. If the +OUT terminal now shows a DC voltage where none was evident before, check the - OUT terminal. You will probably find that it has the same voltage, but of opposite polarity. This means that there is DC from the preamp, so use a capacitor in series with the input to get rid of it (or fix the preamp :-)

If the power amp has a volume control (or controls), make sure that both channels are set to maximum. Do not connect a speaker until you have verified that the amps' outputs are at zero volts (+/-100mV or so), and that there are no large voltage swings when the amp (or adaptor) are turned on or off. If possible, the power to the adaptor should be applied first. It is possible to leave it on permanently if powered from an AC adaptor, as current drain is very low.

Once these tests have been completed, you may connect the speaker. Remember that the power will be four times that from a single channel of the amp for the same impedance, so overdriving the speakers is quite possible. Use the utmost care, especially with expensive speakers.

Bridging Principles

For those who have not used bridging or who do not understand the principles, a short explanation of how the adapter is used and how this almost quadruples the output power is called for.

The adapter is connected between the preamplifier and the power amps. The power amps must be the same - power rating, minimum impedance rating, etc. Generally, a stereo power amp is used, so when connected in bridge mode we are assured that the amplifiers are more or less identical.

Normally, the speaker is driven from the amplifier output to ground, and the AC swing is limited by the supply voltages in the amp. Consider a 50 Watt per channel power amp - 50W into 8 Ohms requires a signal voltage of 20V RMS:

$$P=V^2 / R = 20^2 / 8 = 400 / 8 = 50 \text{ Watts}$$

To achieve this, the peak voltage is just over +/-28V (20 * 1.414), and a power supply voltage of about +/-35V will generally be used to allow for losses and mains voltage variations.

The same amplifier into 4 Ohms will deliver close to 100W - provided the power supply does not collapse under the load. For both these examples, only one side of the loudspeaker is driven, and the other is grounded.

Now, if a second amplifier is connected so that its output is exactly 180 degrees out of phase (inverted) with the first, and connected to the normally grounded side of the speaker, as one speaker terminal is driven positive, the other is driven negative by the same amount.

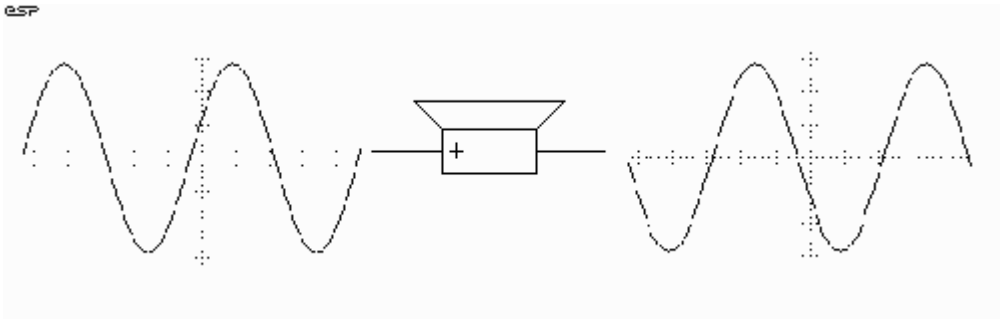

Figure 2 - Voltages Applied to the Loudspeaker Using Bridging

Figure 2 shows this, with the waveforms at each speaker terminal shown. As you can see, as one terminal is driven positive, the other is driven negative by the same amount, and although a sine wave is shown, the principle is not affected by the signal waveform. (Note that both waveforms should be viewed from left to right, otherwise the diagram would indicate zero output from the speakers - which is exactly what you **will** get if the adapter is not used.)

At maximum power, the 8 Ohm loudspeaker now "sees" double the voltage that it would receive from one amp alone. Using the formula above, we get:

$$P=V^2 / R = 40^2 / 8 = 1600 / 8 = 200 \text{ Watts}$$

Since the voltage across the speaker is doubled, naturally the current through it is also doubled, and that is the reason that each amplifier must be capable of driving 1/2 the normal speaker impedance. This technique is very common in car audio systems, because the nominal 13.8V of a car's electrical system is too low to obtain much power except into very low impedances.

Loudspeakers are very difficult to make if the impedance is too low, because there are too few turns of wire in the voice coil, and efficiency is lost. Four Ohms is a reasonable minimum, but even with this impedance an non-bridged car amplifier is still only capable of a maximum of about 5 Watts. By using bridging, close to 20W is now possible, with each amplifier driving the equivalent of 2 Ohms.

This is the reason for all the dire warnings about not grounding either speaker lead of a car audio system - because each lead is the output of an amplifier, shorting it to ground or another speaker lead will destroy the power amp.

The same principle applies to the bridged connection shown here - no connection other than to the speakers is possible without damaging the amplifier.