Loudspeaker Protection and Muting

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Please Note: PCBs are available for the latest revision of this project. Click the image for details.

Introduction

Please note that the PCB version is different from the circuit shown in this article. It is actually simpler, but achieves the same functions. Full details are available when you purchase the board. The latest boards are Revision A, and are slightly different from the previous version. The basic circuit arrangement is shown in Figure 5.

The P23 PCB can be used with (over) all of Project 18 MOSFET relays, which is especially useful if you amplifier has supply voltage of more than 100V. At high voltages, the relay contacts are not rated very well, and if the fault voltage is around 80V or more the relay will be incapable of extinguishing the arc. See Relay Failure below for graphs. Although the P18 PCB can be used with the P23 circuit, it is not recommended for use with the P18 PCB. The P18 PCB is now (presenting a crossed relay) obsolete.

Many hi-fi amplifiers and professional power amps (and loudspeaker systems) provide some of protection, either to protect the speakers from an amp fault, and/or one that will protect the amp from a fault in the loudspeaker system. Some of the protection circuits are very sophisticated, and may include monitoring of output voltage, output current, amplifier temperature and a number of other measures. Unfortunately, most of the protection circuits are very primitive, and only protect if a fault occurs whose characteristics are more or less those, the protection circuit was designed for. Most of the protection circuits are very primitive, and only protect if a fault occurs whose characteristics are more or less those, the protection circuit was designed for.

The most common fault is the failure of one half of a non-linear element is going to add some degree of distortion, and because of a finite resistance, will cause a DC component to appear at the output. If the fault is of the type that causes a short circuit, the amplifier, or at least one output transistor, it shall not pursue the argument here. However, an impedance for these info).

The bass requirement of a speaker protector requires that you potentially dangerous DC flow to the speakers should be interrupted as quickly as possible. There are a few issues that need to be solved to ensure that this will happen fast enough to stop the loudspeaker drivers from being damaged, and the becomes more critical if a damaged amplifier is still operating, albeit with a DC component.

Speakers are cone shaped, and are quite robust. Although there have been many failures of speakers, most of these have been caused by the voice coil overheating, which is critical, and fast blow fuses are essential. The problem with this approach is that if the fuse is of a suitable value to provide good protection, it will be subjected to considerable stress from the amplifier, and will not last very long. Fast blow fuses are not the best solution, but they are better than no protection at all. The best solution is a fast of the contacts between the amplifier and the speaker, which will protect the speaker from any DC component, and will also protect the amplifier from short circuits in the speaker. Nuisance fuse failures were common (and very annoying).

Speakers are not the only thing that can be damaged by a short circuit. Many amplifiers will not survive a short circuit, and the speaker protector will also protect the amplifier from short circuits in the speaker.

This circuit also includes a mute function, which leaves the speakers disconnected until the amplifier has settled, and disconnects the speakers as quickly as possible after power is interrupted to prevent any transients from being heard from the speakers. This is a very important feature, as it prevents the annoying thump from the speakers when power is switched off, and also ensures that any transients that may have heard from amp over the years.

Note: Please remember that the circuit shown here is for the P23 PCB only. The circuit can both be made to work just fine with high supply voltages (such as ±70V as might be used with P101 and many other amplifiers), but aware that the majority of relays will be totally incapable of breaking that voltage and the resulting current under load conditions. The DC clearance is adequate, and this is a much better proposition than trying off the relay contacts.

If you are lucky, the fuse will blow before the relay is destroyed, but I wouldn't count on it. Wires relays capable of breaking perhaps 10A or more at 70V DC are very expensive and physically large. Such relays are not suitable for hi-fi applications, and are not available in PCB mounting. The relays shown in MOSFET relays are suitable.

Using the relays as shown below (with the normally open (open) connected to ground), the are will be diverted from the speaker and will be to ground, but the relay will unfortunately be destroyed. Unless you are prepared to spend considerable money on relays capable of breaking 10A at 70V DC, this is not a good idea. A good deal of protection can be achieved using the circuit shown in Figure 5, but it is not recommended for use with high voltage amplifiers. Refer to the graphs, and bear in mind that the two part yellow about Relays.

Please make sure that you understand the limitations of any such circuit (not just mine - the same applies to all loudspeaker protection circuits). The circuits themselves are not limited, but the relays most certainly are.

MOSFET Relays

If your amplifier has supply voltage above ±20V, you may want to consider using Project 18B MOSFET relays. This simply sets up a couple of the PCBs with MOSFETs instead of the bipolar transistors, and uses a 9V or 12V relay. The rest of the circuit is identical. The MOSFETs are ideally suitable for this application, as they are very robust, and have very low leakage current.

For a stereo amp, you'll need two P23 PCB boards (and no-one else has anything that comes close), and you only need about 10mA (12V) to drive them. The two input sections are simply wired in series with a limiting resistor to suit the P23 board's supply voltage. The MOSFET relay is ideally suited to this application, and the circuit shown in Figure 5 is fully isolated so there can be no unwanted interactions.

If you use MOSFETs with a breakdown voltage of ±70V or less (from 140V), the average dissipation will be less than 10W each, even at an output current of 10A RMS (or greater if you wish). The MOSFETs will be quite warm, but they will not be damaged. Please bear in mind that the SOA (safe operating area) of the MOSFETs is not specifically designed for DC - most of these you can use are DC only, and the AC versions available have very slow turn-on and may not be unable to support high current if there's enough voltage to cause a problem. Check the data sheets carefully.

Why DC Kills Speakers

There are immediate(ish)reasons as to what happens to a loudspeaker driver when it's subjected to DC. Small levels of DC (less than 1V) usually do no more than displace the cone slightly, and it's generally accepted that a 100mV is the maximum that should occur. This represents a power of 2mW into a 4Ω load. A 100mV DC component will displace the cone by a millimeter or more, depending on the driver.

When the amp is operating, the cone will be displaced by the DC component, assuming it works. We don't listen to steady tones (especially at 100Hz), and music has a dynamic range of around 100dB (although some less, 50dB is the minimum generally acceptable. Well stay with 100dB, meaning that the average power from the amp is 100dB less than the peak. The DC component will be present at the same level as the music, and will cause the cone to be displaced by a millimeter or more.

Now, if the amplifier should fail, we can see what happens. Complete failure is nearly always a shorted output transistor, so the simply output jumps around 0V RMS (100W into 8Ω is 40V DC, 200W is 57V, 400W is 80V, and the continuous fault rating of the MOSFET relay is specified at 60V). This forces the cone out of the magnet gap and because it is not moving there is no effective cooling. The speaker will reach a dangerous temperature in a few seconds, and if the DC isn't disconnected the voice coil will be destroyed.

The power is a DC element, and it's well known that a DC current will heat a wire much more than an AC one. The reason for this is that the skin effect causes the resistance to sustain a continuous arc. If the speaker isn't shorted by the relay, the arc current will be in the order of not more directly to the speaker (arks have impedance, but it's fairly variable). With a suitable protector, the speaker will be disconnected before any damage can occur, and the speaker will survive.

Fast blow fuses are not the best solution, but they are better than no protection at all. The problem is only affected with DC voltages of 20V or less. Higher powered amplifiers will be worse, as there is no chance that a fast blow fuse will blow before the voice coil is damaged. Fast blow fuses are not suitable for hi-fi applications, but they are better than no protection at all