Speaker protection unit saves a saddening experience

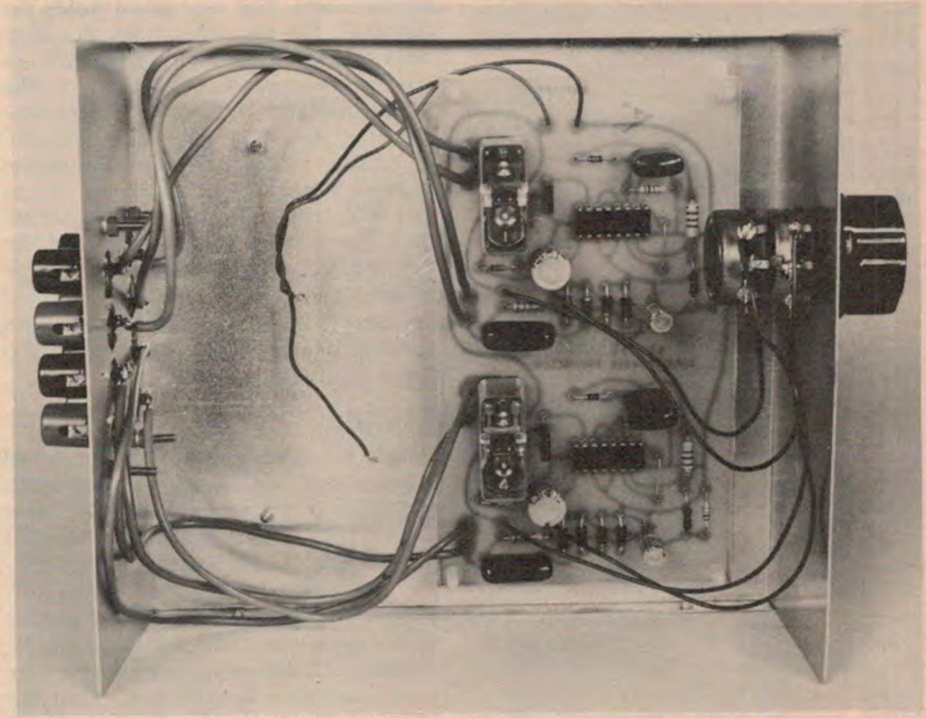
An expensive speaker system can be readily destroyed by a 20 watt amplifier. Carelessness with a high power amplifier (like the ETI-466 for example) can melt voice coils like cheese on toast. We know . . .

David Tilbrook

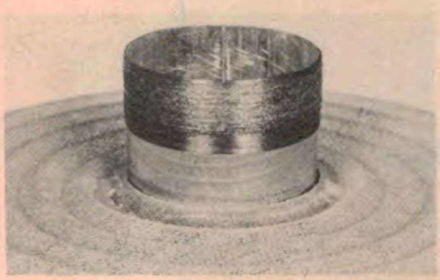
MODERN TRANSISTOR power amplifiers use the technique of dc coupling between the low level amplifier stages and between the output stages and the loudspeaker. This has the advantage of removing coupling capacitors from the signal path, decreasing parts count and improving performance at low frequencies.

Older transistor amplifiers used a single supply rail so the transistors operated between the supply voltage and ground. Since an ac signal has both negative and positive excursions the power amp was designed so that a dc voltage was present on the output stage. Positive excursions would cause an increase of this dc voltage while negative excursions decrease the voltage. Since dc cannot be applied directly to a loudspeaker it was necessary to insert a capacitor, called a blocking or output capacitor, between the output stage and the loudspeaker. The load impedance of the loudspeaker is around eight ohms so the capacitor has to be 5000 μF to 10 000 μF before an acceptable low end performance can be obtained.

The solution to these problems was dc coupling. The power amp is run from a 'split supply' so that the output transistors are supplied from a positive and negative supply voltage. The average of these supply rails is zero volts, so the output can be connected directly to the loudspeaker. Both positive and negative excursions are possible due to the split power supply.



Internal view of the speaker protector. We mounted the unit in a 'Deluxe Metal Cabinet" from Dick Smith measuring 184 x 160 x 70 mm, but you can choose any similar size cabinet to suit your equipment or even mount single units in your loudspeaker enclosures with preset controls.



What happens *without* the speaker protector.

Unfortunately, dc coupling also has its disadvantages. The biggest of these is the possibility of damage to the loudspeakers in the case of power amp failure. Since all the stages are dc coupled, a fault anywhere in the power amp can cause the output stage to swing hard against one of the supply rails. The most common power amp fault is a condition in which one or several of the output or driver transistors is destroyed, and this almost always causes the full dc voltage from one of the supply rails to be applied directly to the loudspeaker. The loudspeaker cone is slammed against the suspension and the power dissipation in the voice coil causes a rapid increase of voice coil temperature. In this condition most woofers will survive for only a few seconds. The most dramatic example of this fault I have seen was in a very expensive pair of three-way loudspeakers. They had been connected to a high power tuner-amplifier (150 W/channel) when the output stage had gone faulty. The entire inside of the speaker was one charcoal mass (much to the horror of the owner). The temperature increase in some of the crossover components had set fire to the stuffing inside the box, totally destroying the crossover and drivers.

This type of fault is all too common and is the most expensive fault likely to ▶

occur in a modern hi-fi system. Some top line amplifiers have built in protection circuits with relays that disconnect the loudspeakers should this condition occur, but these are the minority.

This project is an attempt to remedy this situation. The circuit 'looks' at the loudspeaker wires and protects the loudspeakers in two ways. The presence of any dc automatically trips the relay and disconnects the loudspeaker. The protector also looks at the amount of power applied to the loudspeaker. It allows high power transients but will disconnect the loudspeaker if the applied power exceed the loudspeaker rating form more than about 50 milliseconds. In this way the advantage of the improved high power amplifiers is not lost but the loudspeaker is still protected. The circuit includes a two-second monostable delay circuit so that the loudspeaker is automatically reconnected approximately two seconds after the 'fault condition' has been removed.

The project is designed around two standard CMOS ICs. This ensures a very low current consumption and obviates the need for a power switch. This is important since a fault with an amplifier could well occur at the moment of turn-on and it is essential that the loudspeaker protector is already on. When the relay trips, the circuit pulls around 50 mA for each relay so it is important that battery is capable of supplying 100 mA during relay operation. For this reason, the battery specified for this project is an Eveready 276-P or equivalent. There should be no problem with the battery lasting for its shelf life, providing the relays are not tripped more than very occasionally.

Construction

Start construction with the pc board. Solder the resistors capacitors, diodes and relay first. The diodes and electrolytic capacitors must be inserted the right way round as shown on the pc board overlay. Lastly; solder the transistors and ICs on the board. Again, these devices must be oriented correctly.

The prototype was constructed in a general purpose steel box but this is not critical. The front panel is fitted with a stereo 100k potentiometer. This sets the trip point of the protector so that it can be adjusted for your particular loudspeakers. The rear panel holds the terminals for the wires from the amplifier and loudspeakers. I used two four-way spring terminals. The wiring to the rear panel and to the front potentiometer is shown in the wiring diagram.

Finally, make the connection to the battery. Probably the best way to do this is to screw two self-tapping screws into the battery terminals and solder the wires between these and the pc board. The pc board should be mounted on spacers in the case. Plastic pc board stand-offs are ideally suited for this project as the pc board is small.

Testing

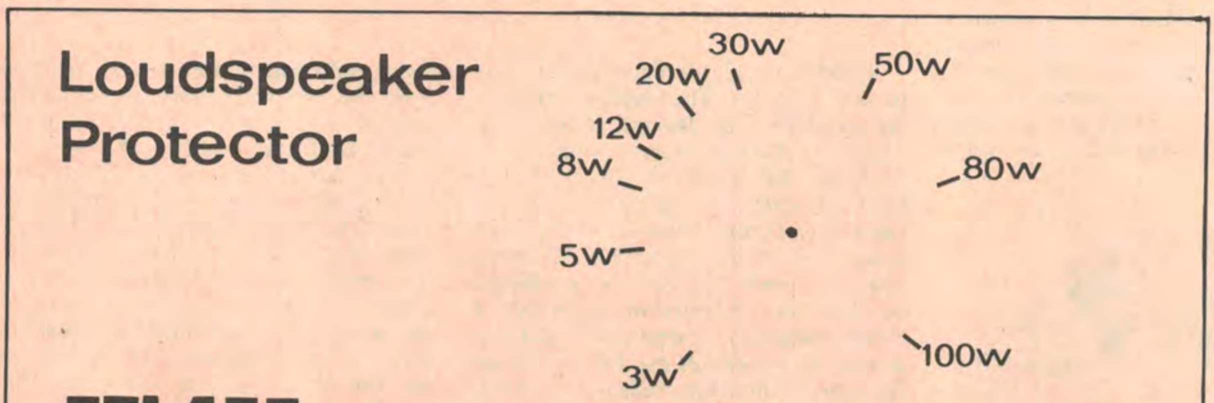
Check the orientation of all polarised components including the transistors and ICs. If all is well cut two short lengths of speaker cable and connect the output of the amplifier to the input of the loudspeaker protector. Connect the speaker cables to the output of the protector. Now switch on the hi-fi system. Choose music with reasonably even amplitude for this test. Turn the front panel level control on the loudspeaker protector for the lowest power and slowly increase the amplifier volume. When the power to the loudspeakers exceeds that set by the potentiometer the protector should trip in and disconnect the loudspeakers.

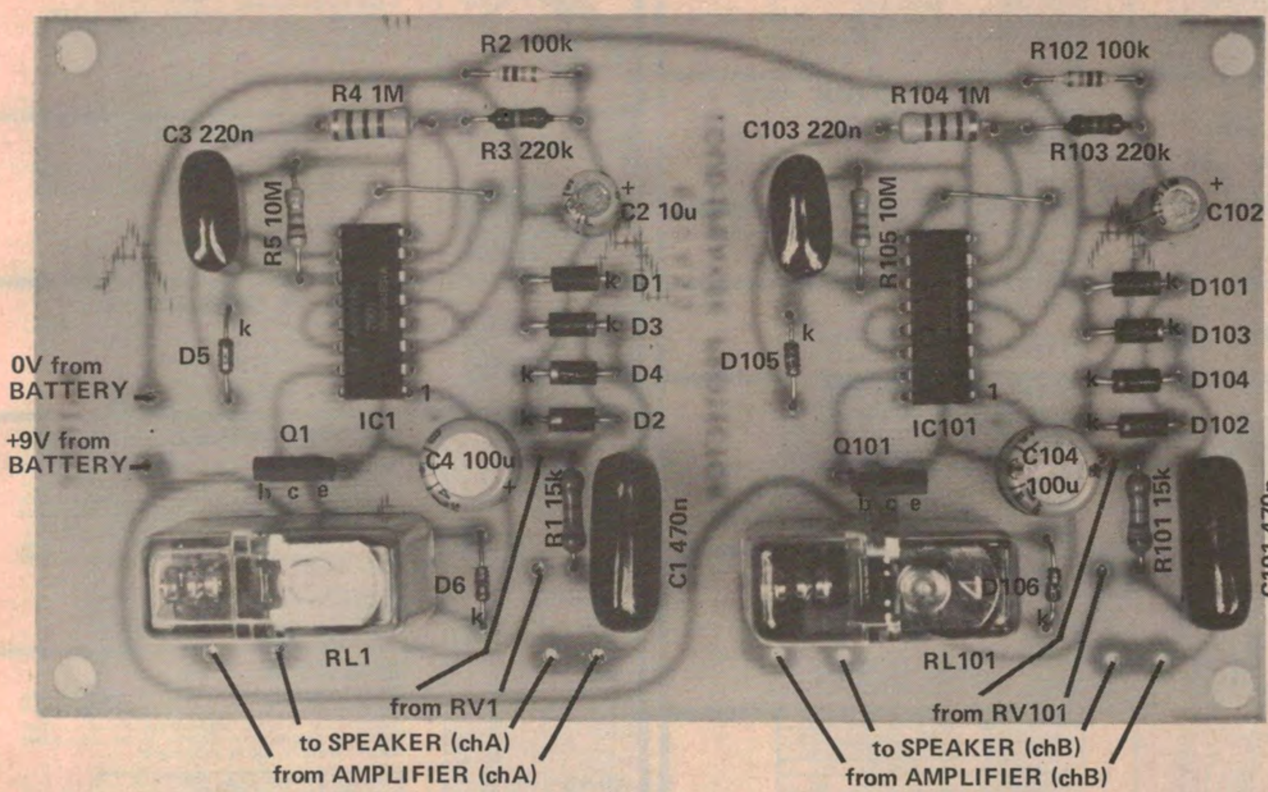
Turn the amplifier down, and the loudspeakers should be reconnected after about two seconds. Since loudspeaker power figures are a rather dubious quantity, it is probably best to establish the correct setting for the

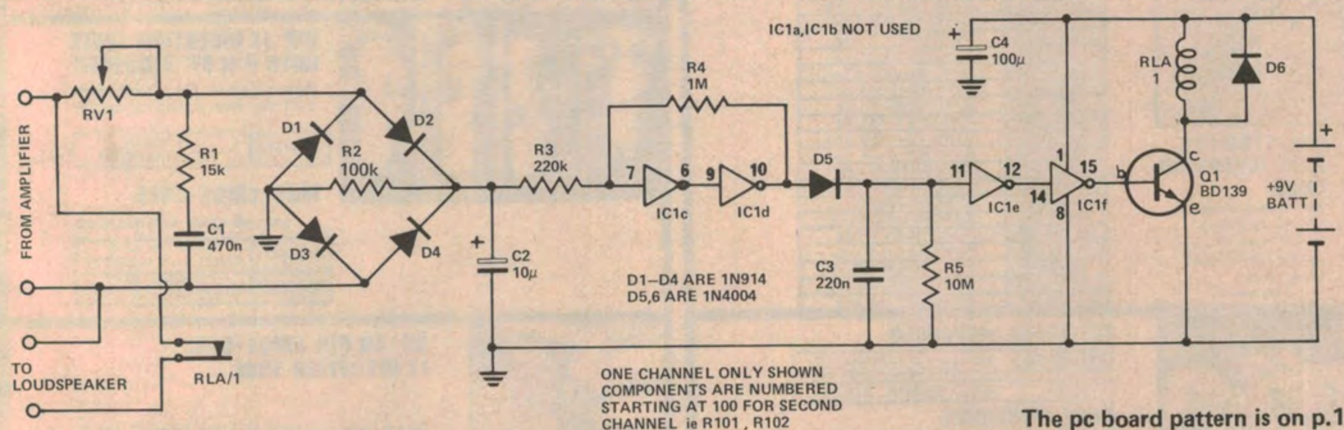
HOW IT WORKS – ETI 455

The signal voltage from the amplifier is rectified by a full-wave bridge consisting of diodes D1, D2, D3 and D4. The potentiometer RV1 and the resistor R1 and capacitor C1 form a potential divider that determines the sensitivity of the circuit. At normal signal frequencies C1 has a relatively low impedance and the resistance across the diode bridge becomes that of resistor R1, i.e: 15 k. As the frequency approaches dc however, the impedance of this capacitor increases, increasing the sensitivity of the circuit. If a dc voltage is presented to the input C1 acts as an open circuit and the protector is therefore at its most sensitive.

Signal voltges from the full wave rectifier are averaged by the capacitor C2 and R2, and then applied to a Schmitt trigger. The Schmitt trigger is formed from the resistors R3, R4, ICIc and ICId. This circuit will only respond to a voltage level greater than a preset amount. When this voltage is exceeded (around 6.5 V in this case) the output goes positive charging C3 through diode D5. This diode prevents C3 from being discharged by the Schmitt trigger when its output goes low again so the capacitor can only be discharged by the 10 M resistor R5. This takes about two seconds so this circuit is in reality a simple and effective monostable. Another two stages of the IC drive the transistor which is in series with the relay coil. Diode D6 protects the transistor from large back-EMF voltage spikes produced when the relay is turned off.







The pc board pattern is on p.113

loudspeaker protector experimentally rather than just setting it to the rated power handling of your loudspeakers. Your ears are the best indication that the system is being strained. Set the loudspeaker protector so that it trips just below that volume where distortion starts to occur.

We have done extended tests on the protector, even to the point of connecting expensive loudspeakers and inducing power amp faults that would otherwise destroy a loudspeaker in seconds. In all of these tests the loudspeaker protector has performed well and it is a comforting thought that should a power amp fault occur, it will not take your loudspeakers with it. ●

PARTS LIST - ETI 455

Two of each of the following is required for stereo.

Resistors all ½W, 5%
- R1 . . . . . . 15k
- R2 . . . . . . 100k
- R3 . . . . . . 220k
- R4 . . . . . . 1M
- R5 . . . . . . 10M

Potentiometers
- RV1 . . . . .100k lin. (dual for stereo)

Capacitors
- C1. . . . . . . 470n greencap
- C2. . . . . . . 10µ 25V electrolytic
- C3. . . . . . . 220n greencap
- C4. . . . . . . 100µ 25V electrolytic

Semiconductors
- Q1 . . . . . . BD139
- D1–D4. . . . IN4002, EM402 or similar
- D5, D6 . . . . IN914 or similar
- IC1 . . . . . . 4049B Hex inverter

Miscellaneous
Only one of each the following is required.

ETI 455 . . . pc board
12V relay with one C/O, Pye 265/12/C2, four terminals, case - Dick Smith H-2744, knob(s), screws, nuts, pc board spacers.