

Very Simple, almost Universal, Speaker Protection Circuit

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Background

A friend bought a Class D amp recently with single supply (+52V). The output is, as expected, BTL. He wants to install speaker protection, so we did a search. The few versions we have made so far are not really designed for that.

Project 175 published by ESP fits the application 100%, but is rather complex (Fig. 3).

<https://sound-au.com/project175.htm>

Then I came across pictures of some very low-cost protection modules at AliExpress which look extremely simple and seem to support any configurations. I must have been really stupid not to think of something like this.

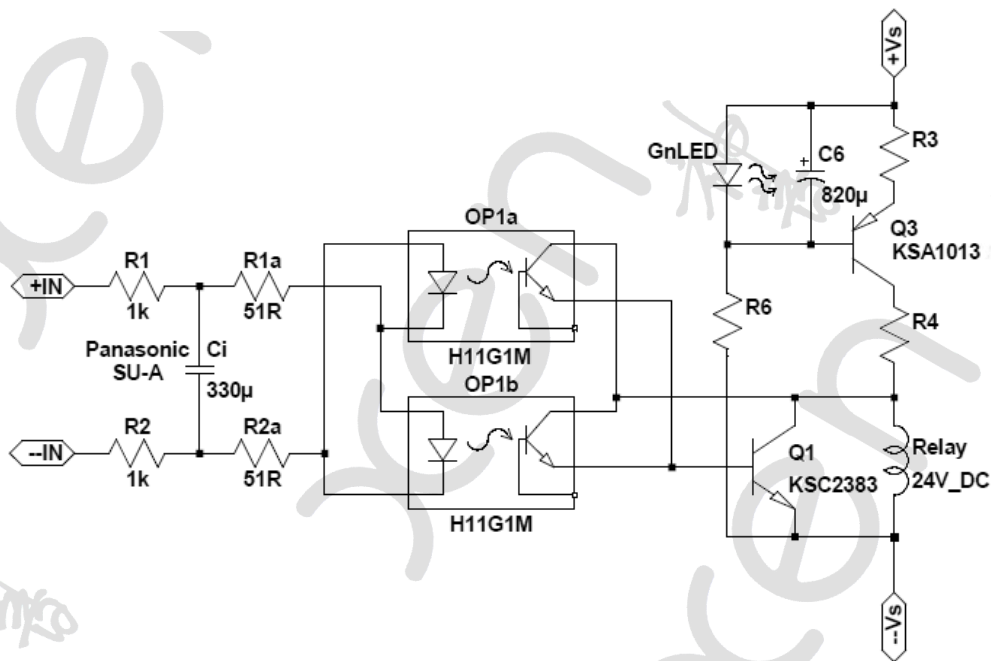


So why not just buy one, since they hardly cost more than a few bucks ?

Well, they can only be this low-cost because, more often than not, they are made from factory surplus parts. So there is no guarantee what exactly you get. For speaker protection, one wants it to be as near to 100% reliable as possible, and one also wants to choose his own type of relay for the purpose. On top of that, it would be desirable to be able to work with a wide range of supply voltages, to make the circuit as universal as possible.

The Circuit

So here is the first attempt. It has not been built, so it is only posted here to stimulate further discussions. Or build at own risk.



R3, Q3, R6, C6 & green LED forms a slow start current source to supply the relay coil. Except for some car amps, the total rail voltage is expected to be 30V or larger, so a 24V relay is used here. In case the total rail voltage is below 30V, one can choose 12V or even 5V relays accordingly. The disadvantage of low-voltage relays is their correspondingly higher coil current. Typically, a 24V relay coil requires some 22mA, a 12V 44mA, and 5V almost 110mA.

R3 determines the current, and is given by $(1.2V / \text{relay-coil-resistance})$. R4 is included in case of high rail voltages to take away some dissipation from Q3, and can also be a Zener diode. R6 is just a resistor to bias the green LED at say 1mA. It can also be a 1mA CRD (Semitech) so that no change is required for any rail voltages up to 100V (total) maximum. R6 / C6 determines the start-up delay time.

The amplifier supply rails were used deliberately to power this circuit, instead of a separate auxiliary supply. In case of a power failure of any supply rail(s), the relay will lose power and disconnect the speakers automatically.

Q1 is used to shunt the relay coil in case of a DC detection to switch it off. Because of the high relay coil currents, it is difficult to find low-cost optocouplers with very high current transfer ratio (CTR) at low input current. It is, in this design, important not to load the optocouplers excessively, so that the trigger voltage of the DC detection circuit can be closer to the forward voltage of the optocoupler LEDs. One should add a clamping diode across the relay coil, without showing.

This leads us nicely to the DC detection circuit. The inputs are from both amplifier outputs, whether single-ended or balanced. R1-R2-Ci forms a 1st order low-pass filter to remove most of the AC signals. R1a, R2a are optional, and are connected to optocouplers OP1a,1b. The LEDs of the latter are wired back-to-back, to enable activation by DC voltages of either polarity. (One can even argue that R2 is not necessary for maximum cost saving). The maximum reverse voltage of the said LEDs is larger than their forward voltage, so they protect each other.

With the values given above, the corner frequency of the low pass filter is 0.24Hz. Let's assume a worst-case AC input signal of 80V p-p at 24Hz. This will be reduced to 0.8V after the LPF, i.e. still below the trigger level. Some 40mA will flow through the optocoupler LEDs, but still within specification.

Let's now consider the worst case of a 5V relay with 110mA coil current. Q1 has a hfe of about 100, so that the base current is 1.1mA. That also means that the forward current at the optocoupler LED needs to be around 0.6mA. The voltage-drop across R1, R2 is 0.6V each and needs to be added to the LED forward current. That gives a trigger voltage of about 2.4V in either polarity.

There are AC optocouplers around with back-to-back LEDs already installed at the input. But the choice is rather restricted in terms of high CTR.

The circuit is so simple that it can be hard wired on a Vero board without much effort. The most-costly item is likely to be the speaker protection relay. The rest are low-cost, readily obtainable items. All resistors should be dimensioned generously according to their maximum dissipation, without saying.