Load Protection for Audio Amplifiers

Joseph Kreutz (Germany)

In order to be effective, any protection device connected between an audio amplifier output and the speakers needs to connect the load only after a few seconds' delay, disconnect it immediately the mains supply is turned off, and prevent any high-level DC component from being able to damage the loudspeakers. As the circuit suggested here can readily be 'grafted' onto any existing circuit, it merits the title 'universal'. The circuit diagrams in **Figures 1** and **2** relate to a prototype fitted to an amplifier producing 50 W into 8 Ω, with a ±35 V power supply. This circuit can be readily adapted to other supply voltages, and hence to other audio power outputs. The appropriate values for R1, R2, R8, R15, and R19, along with the operating voltages for C1 and C3 and the choice of semiconductors D9, D10, T1, T2, and T3 are given in **Table 1**.

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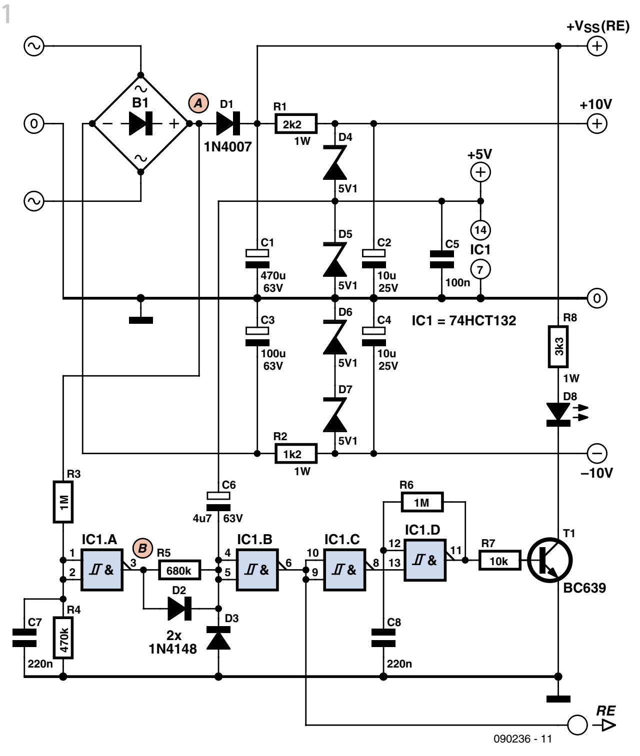

Circuit operation is simple: when the amplifier is turned on, the voltage at the junction of bridge rectifier B1 and diode D1 quickly charges capacitor C7 via resistor R3. Capacitor C7 avoids mains zero crossings causing spurious triggering. When the upper threshold voltage of IC1a is reached, its output goes low. At this moment, C6 is gradually charged via R5, and once the voltage across it reaches the required value, IC1b output goes high and turns relays RE1 and RE2 on via transistors T2 and T3. This process produces a delay of around 5 s. In order for us to be certain that IC1b output starts off low, the initial voltage across C6 must be zero. So this capacitor is connected directly to the +5 V rail. This circuit works by determining voltage thresholds: this means that we need to choose an SN74HCT132 quad Schmitt NAND gate for IC1.

Gate IC1c inverts the relay control signal and feeds it to one input of IC1d, which then operates as an oscillator, making LED D8 flash at around 4 or 5 Hz during the delay period.

As soon as the relay control signal goes high and the relays turn on, the IC1d oscillator is disabled and LED remains constantly lit. The LED is powered directly from the HT rail across C1, and 3.3kΩ resistor R8 limits the current through it to 10 mA. As shown in **Table 1**, the value of R8 depends on the supply voltage and hence on the power of the amplifier to which the protection circuit is to be connected.

As soon as the mains is turned off, IC1a output goes high and capacitor C6 discharges rapidly through D2, which then causes IC1b output to go low and the relays RE1 and RE2 to turn off almost immediately. So the amplifier load is isolated instantly and the circuit re-armed so as to produce the required delay next time mains power is applied.

Detection of any DC component is performed by IC2, an LM339 quad comparator. The networks C9/R12 and C10/R16 act as low-pass filters: they attenuate the audio signal very heavily, but if any DC voltage is present on the amplifier output, it will be fed to IC2's comparator inputs. If it exceeds ± 3.75 V, at least one of the comparators will output a 'low' signal, and thus turn off the corresponding relay control transistor. The load will remain isolated as long as the fault condition continues. This signal will also cause current to flow in the LEDs D11 or D12, indicating that the protection has been activated. Zener diodes D13 to D16 provide over-voltage protection for the comparator inputs. It's wise to make sure that R12 and R16 are indeed correctly connected to the amplifier outputs and not to the relay contacts feeding the loudspeakers. The choice of relays is not really critical: any

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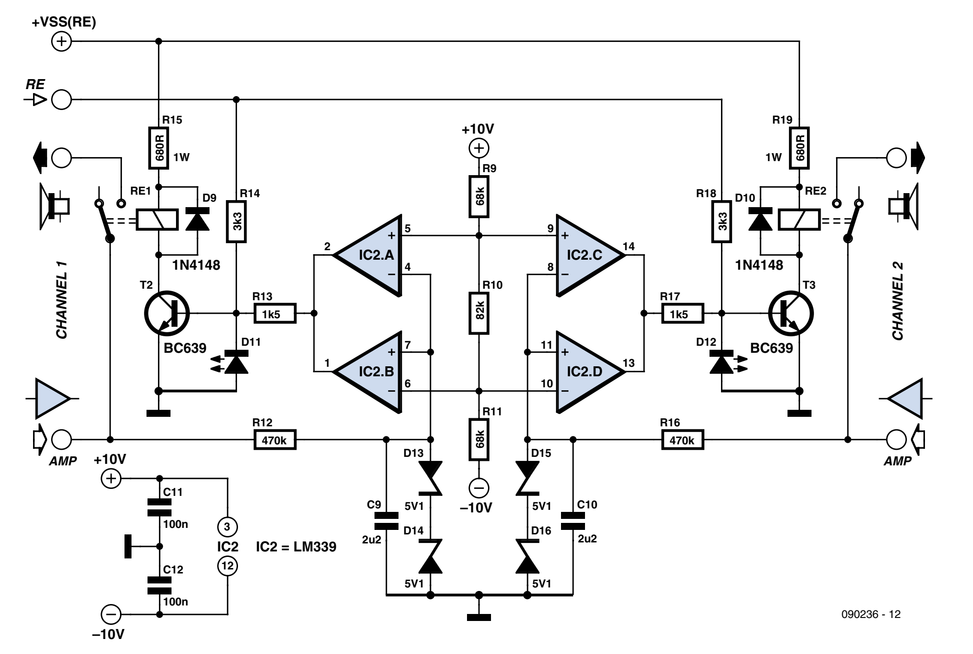

Table 1. Stereo (2-channel) amplifier

Supply voltage [V]	27	35	47	56	64	70	76
Power into 4 Ω [W]	50	100	200	300	400	500	600
Power into 8 Ω [W]	25	50	100	150	200	250	300
Working voltage for C1 (470 µF) & C3 (100 µF) [V]	40	63	63	80	80	100	100
Value for R1	1k8, 0,25 W	2k2, 1 W	3k3, 1 W	4k7, 1 W	4k7, 1 W	5k6, 1 W	5k6, 1 W
Value for R2	820 Ω, 1 W	1k2, 1 W	1k8, 1 W	2k2, 2 W	2k7, 2 W	2k7, 2 W	3k3, 2 W
Value for R3	2k7, 0,25 W	3k3, 1 W	4k7, 1 W	5k6, 1 W	6k8, 1 W	8k2, 1 W	8k2, 1 W
Value for R15 & R19 (*)	-	680 Ω, 1 W	1k2, 1 W	1k8, 1 W	2k2, 1 W	2k7, 2 W	2k7, 2 W
D9 et D10	1N4148	1N4148	1N4148	1N4148	1N4148	BAV21	BAV21
T1, T2, T3	BC639	BC639	BC639	BC639	BC639	2N5551	2N5551

* for 24 V relays drawing a current in the region of 15 mA.

type that has a high enough breaking capacity, works from 24 V, and only needs around 15–25 mA to drive it will do. The relays fitted to the prototype are RT 314024 ones made by the Austrian company Schrack [1]. They can switch 16 A, which is enough for amplifiers with pretty reasonable powers. The prototype is fitted to a 50 W per channel stereo amplifier, whose 35 V supply voltage is higher than the relays' rated operating voltage. So it was necessary to fit series resistors R15 and R19 in order to drop the excess 11 V. As the relay coil resistance is 1,450 Ω, these series resistors need to be 680 Ω and rated for a dissipation of 1 W. Naturally, the value of R15 and R19 depends on the type of relay chosen and the amplifier's supply voltage, as shown in **Table 1**. However, the value isn't critical, as the relays are pretty tolerant about their operating voltage. Besides, it's easy enough to find out the resistance of a relay coil: just measure it with an ohmmeter!

It's essential to pick up the power for the circuit directly from the amplifier's power transformer terminals, before the rectifier and smoothing capacitors, as shown in the connection diagram in **Figure 3**. This voltage is rectified by bridge rectifier B1 and applied via D1 to the 470 µF smoothing capacitor C1. The power for the relays and LED D8 is taken from directly across this capacitor. Diode D1 allows capacitor C1 to be isolated as soon as the mains power goes off: so when the amplifier is turned off, there is zero voltage at IC1a input , and the relays are guaranteed to be off. The +10 V and +5 V rails are regulated by zeners D4 and D5, while D6 and D7 stabilize the –10 V rail feeding IC2. Using two zeners in series limits the power each of them has to dissipate.

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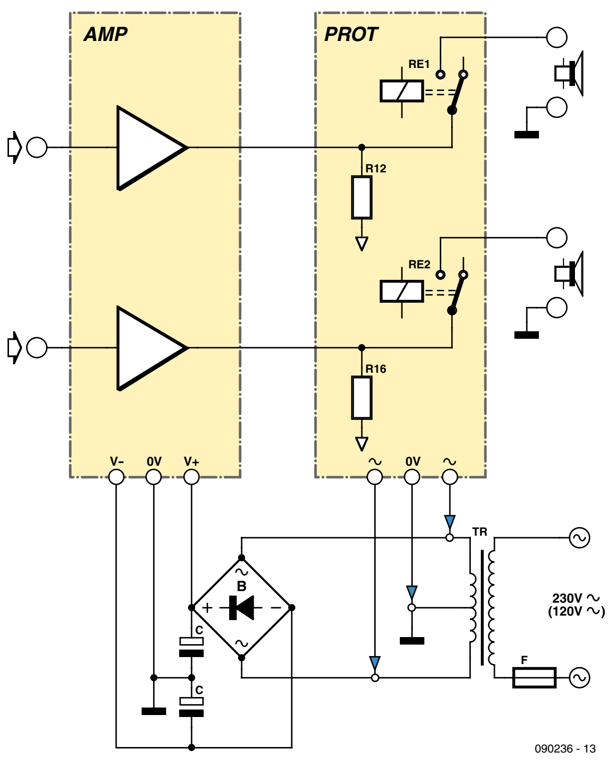

It is perfectly simple to extend the circuit for 5+1 or 7+1 channel audio systems, as used on an increasing number of computers. And it's all the more advisable because the sound cards often produce erratic signals when the computer

Table 2. System with 5+1 or 7+1 channels

Supply voltage [V]	27	35	47	56	64	70	76
Power into 4 Ω [W]	50	100	200	300	400	500	600
Power into 8 Ω [W]	25	50	100	150	200	250	300
Working voltage for C1 (2200 µF) & C3 (470 µF) [V]	40	63	63	80	80	100	100
Value for R1	820 Ω, 1 W	1k2, 1 W	1k8, 1 W	2k2, 2 W	2k7, 2 W	2k7, 2 W	3k3, 2 W
Value for R2	270 Ω, 2 W	390 Ω, 2 W	560 Ω, 5 W	680 Ω, 5 W	820 Ω, 5 W	820 Ω, 10 W	1k, 10 W
Value for R3	2k7, 1 W	3k3, 1 W	4k7, 1 W	5k6, 1 W	6k8, 1 W	8k2, 2 W	8k2, 2 W
Value for R15 et R19 (*)	-	680 Ω, 1 W	1k2, 1 W	1k8, 1 W	2k2, 1 W	2k7, 2 W	2k7, 2 W
D4 - D7	BZV85C5V1 or 5V1 device capable of dissipating 1 W						
D9 & D10	1N4148	1N4148	1N4148	1N4148	1N4148	BAV21	BAV21
T1, T2, T3	BC639	BC639	BC639	BC639	BC639	2N5551	2N5551

* for 24 V relays drawing a current in the region of 15 mA.

is powered up or down, which when amplified can be at best unpleasant, and at worst, damaging for the loudspeakers.

As shown in **Figure 4**, the +5 V supply rail present on the computer's USB bus is applied to one of the inputs of gate IC1a, the other input being used to check the presence of the amplifier supply voltage. So both the computer and the amplifier have to be running for the speakers to be connected after a 5-second delay. The 100 nF capacitor C13 avoids unwanted triggering. Turning off the computer or the amplifier disconnects the speakers immediately.

The **Figure 1** delay circuit, modified as per the circuit in **Figure 4**, is common to all channels, and provides the relay control signal for them all. But the DC component switching and protection unit shown in **Figure 2** has to be repeated 3 or 4 times, so as to be able to control the number of channels in the system. Refer to **Table 2** for the component values for a protection circuit for a 5+1 or 7+1 channel system. The modifications mainly affect the following points:

- The values of R1 and R2 are reduced, but their dissipation increased, as shown in **Table 2**;
- C1 and C3 are also increased to 2,200 µF and 470 µF respectively;
- Zener diodes D4 to D7 change to type BZV85C5V1 or equivalent, capable of dissipating 1 W.

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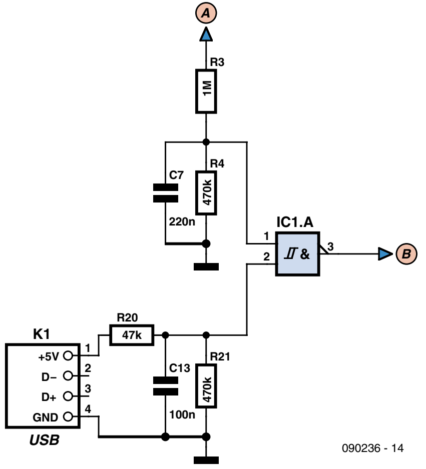

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Internet Link

[1] www.schrack.com