Smart Chocolate Block

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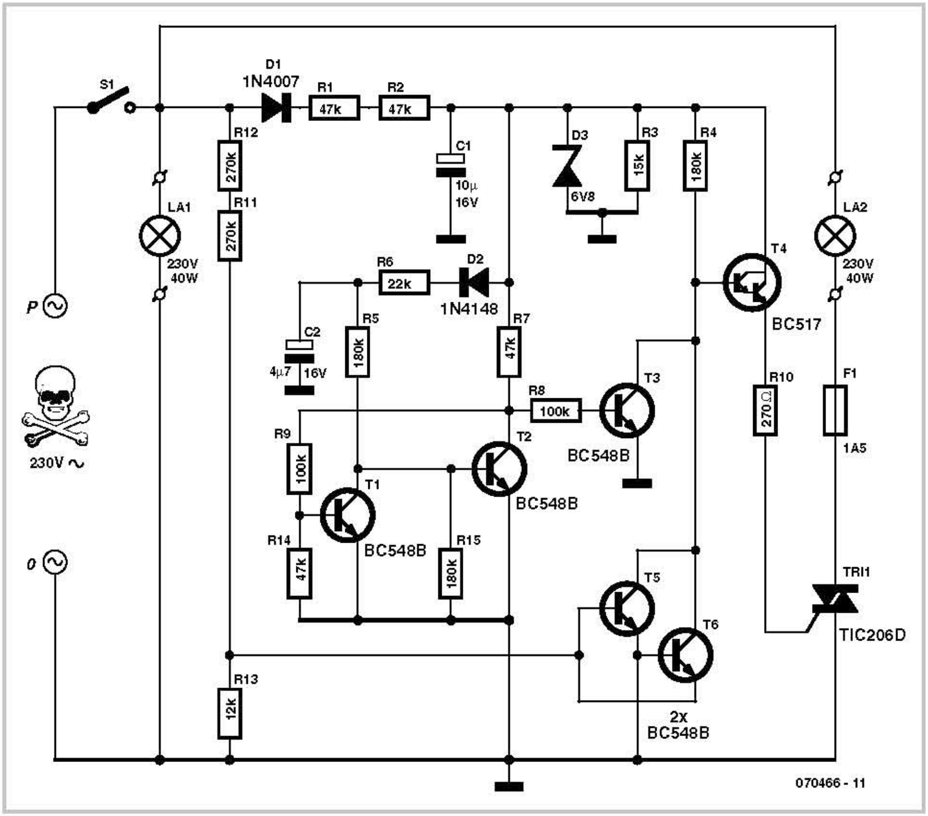
What can be done, when two light bulbs in one light fitting are to be switched separately, but only one switch circuit is available? Simple: build a 'smart chocolate block' into the ceiling rose! The circuit is built from discrete components and with a bit of ingenuity can be fitted onto a printed circuit board measuring just a centimetre or two square.



When light switch S1 is operated for the first time lamp La1, which is connected in the usual way, lights; La2 remains dark. Electrolytic capacitor C1 starts to charge via rectifier diode D1 and resistors R1 and R2 until zener diode D3 conducts, limiting the voltage to about 6.8 V. This voltage is used as a supply for the rest of the circuit. The second lamp is connected via a triac and a fuse (1.5 A, medium speed recommended). The triac is triggered by T4, which can only happen when T3 does not pull its base down to ground. The first time the circuit is switched on this is the case, as we shall see below.

Transistors T1 and T2 form a bistable flip-flop with a well-defined power-up state. R14 and R15 cause both transistors to be initially turned off. As the voltage across C1 rises, transistor T1, driven via resistors R7 and R9, turns on. The base drive for transistor T2, which is provided via D2, the low-pass filter formed by R6 and C2, and R5, would arrive a little later, but when T1 turns on it diverts the base current away from T2, which therefore remains turned off. This situation is stable: the base of T3 is not pulled down and so this transistor conducts.

To turn the second lamp on, switch S1 is opened and then, within a second or so, closed again. The effect of this action on the flip-flop is as follows.
When the switch is opened the voltage across C1 falls more rapidly than the voltage across C2. The main reason for this is resistor R3, which is directly responsible for the discharge of C1; C2 can only discharge through the relatively high resistance of R5,

since the other path is blocked by diode D2. This means that T2 is driven via R5 for one or two seconds longer than T1 is driven via R7 and R9. If during this time the supply voltage reappears, it can no longer drive the base of T1 via R7 as T2 is conducting all the current to ground. This situation is also stable, as C2 is recharged via D2 and R6. When T2 conducts it pulls the base of T3 to ground, so that this latter transistor turns off. Darlington transistor T4 now conducts as its base is pulled high via R4. T4 now provides the trigger current for the triac via current limiting resistor R10, and the second lamp lights.

T5 and T6 together form a zero-crossing detector. It ensures that the triac is never triggered at a moment when the AC mains supply is at a high voltage point in its cycle. This avoids a rapid inrush current into La2, which would give rise to considerable radio interference. Also, trigger current is only required for the triac for a small fraction of the period of one cycle of the mains supply. If this current were drawn continuously from the low voltage supply, C1 would rapidly discharge; R1 and R2 would have to be considerably reduced in resistance, which would increase the heat dissipation of the module, perhaps making it infeasible to build the circuit into a plastic ceiling rose.

Using the component values shown the triac is only driven when the instantaneous mains voltage is less than about 15 V in magnitude. The voltage divider formed by R11, R12 and R13 switches on the transistors T5 and T6 when the voltage is greater than +15V or less than –15 V respectively. The collectors of these transistors, which are connected together, pull the base of T4 down to ground or to a slightly negative voltage when the mains cycle is outside the desired phase window.

Any resistors across which mains voltages will be dropped are formed from two individual resistors wired in series to ensure that the maximum voltage specifications of ordinary 0.25 W components are not exceeded. This applies to R1 and R2, as well as R11 and R12. The whole circuit is at mains potentials and great care must be taken to observe all relevant safety precautions in construction and installation.

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