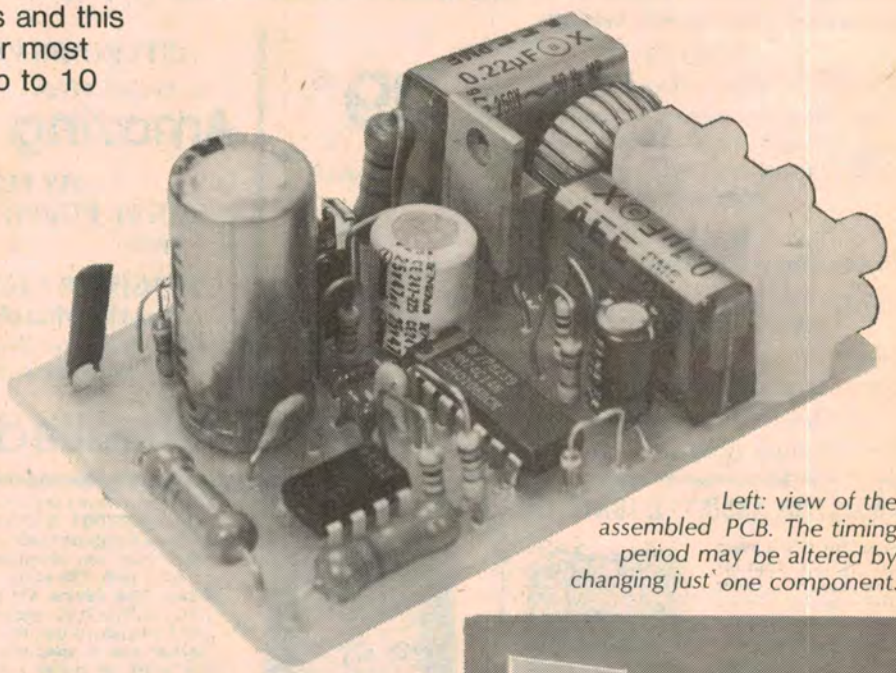
Control lamps and fans with the

TOUCH-LAMP TIMER

Just a quick dab with the fingers and this touch switch will turn on lights or most mains-powered appliances for up to 10 minutes.

by COLIN DAWSON



Left: view of the assembled PCB. The timing period may be altered by changing just one component.

If you have ever tried to operate one of the mechanical type delay switches with your hands full, you'll realise just how tricky this can be. The usual method is to make desperate stabs at the button with your elbow and hope for the best. This usually only succeeds in partially depressing the button, leaving you stranded half way up the stairs when the light goes out.

Once activated, this timer will remain on for the full duration of its delay – every time. Stairwell lighting is not the only possibility for the timer – it may also be used with lights in the hallway, garage or porch. It would be most suitable for use in those situations where there is more than one existing light. One could be switched in the normal way for long term use and the timer could be used for when you're "just passing through".

When this project was first conceived, our primary objective was to come up with a design that could function as a direct replacement for any normal mains switch. This meant a "two wire" device – one connection to the mains active and one to the load. We considered that it would be unacceptable for the circuit to require its own neutral connection as this would, in many cases, necessitate extra wiring.

As it happens, our Touch-lamp Dimmer (April '83) is such a device, requiring only one connection to the active line and another to the load. By making a few modifications, we were able to change the circuit from a touch-activated dimmer to a touch-activated timer.

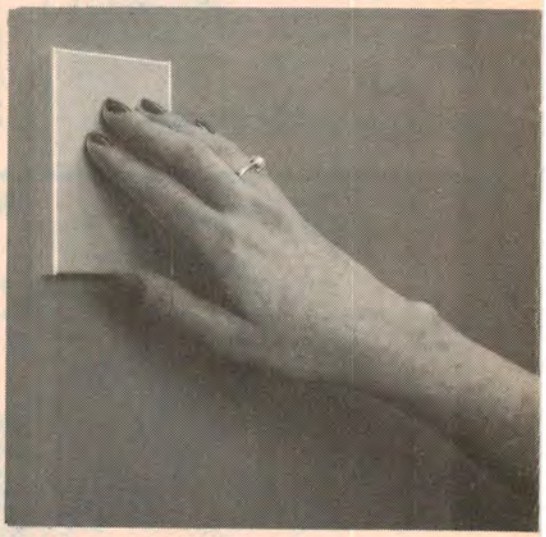
In fact, out new Touch-lamp Timer closely resembles the Touch-lamp Dimmer, both in circuit configuration and appearance. Like the Touch-lamp Dimmer, it is built on a small printed circuit board which is mounted on the back of a blank grid plate from the HPM Decorator range. This has the standard mounting holes of normal switch plates. A metallic panel is clipped over the front face to form the touch plate.

The touch plate is available in a variety of finishes. We chose gold-finished aluminium for our touch plate but you can also choose from satin silver aluminium, stainless steel and brass.

With some minor component changes to the timer, it can also be used to run a fan instead of a lamp. This makes it suitable for use with exhaust fans, such as those used in bathrooms. The fan would operate for the predetermined period and then switch off automatically.

If the Touch-lamp Timer is used for a stairwell or porch light timer, it may need to be operated from several different locations. To this end, we have made the circuit compatible with the remote extension of the Touch Lamp Dimmer. This relatively simple and inexpensive circuit is already available in kit form and could conveniently be added to the timer.

In common with light dimmer and fan speed controller circuits, the timer employs a Triac to interrupt the supply to the load. The Triac, a device capable of switching both positive and negative mains half cycles, is triggered by a low voltage pulse of either polarity applied between its gate and terminal one. Once triggered, it continues to conduct between terminals one and two until the mains voltage waveform crosses zero.



A quick touch with the fingers turns on the lights for up to 10 minutes.

By triggering the Triac early in each mains half cycle, virtually the full mains voltage is applied to the load and it functions normally. Triggering the Triac later in each half cycle will cause a progressively lower average voltage to be applied to the load. This results in the familiar dimming effect for lamps and

reduced speed for a fan, although this function is not employed in this circuit.

The delay between the zero voltage crossing and firing the Triac is referred to as the phase angle. If the Triac were to be fired instantly at the zero crossing, the phase angle would be 0° and if it were not fired at all, the phase angle would be 180°. In this circuit, the Triac is controlled by an S576A light dimmer IC and is operated such that the minimum phase angle is 35°. Although a lamp will appear to be operating at very nearly full brightness, it will always have slightly less than the full mains cycle applied to it.

During the first 35° (or 2ms) of each mains cycle the lamp does not have any voltage applied to it. Instead, the full mains voltage appears across the Triac circuit. Charge pump circuitry enables the voltage present during this 2ms period to power the timer for the remainder of the mains cycle and this allows the circuit to operate without a separate neutral connection.

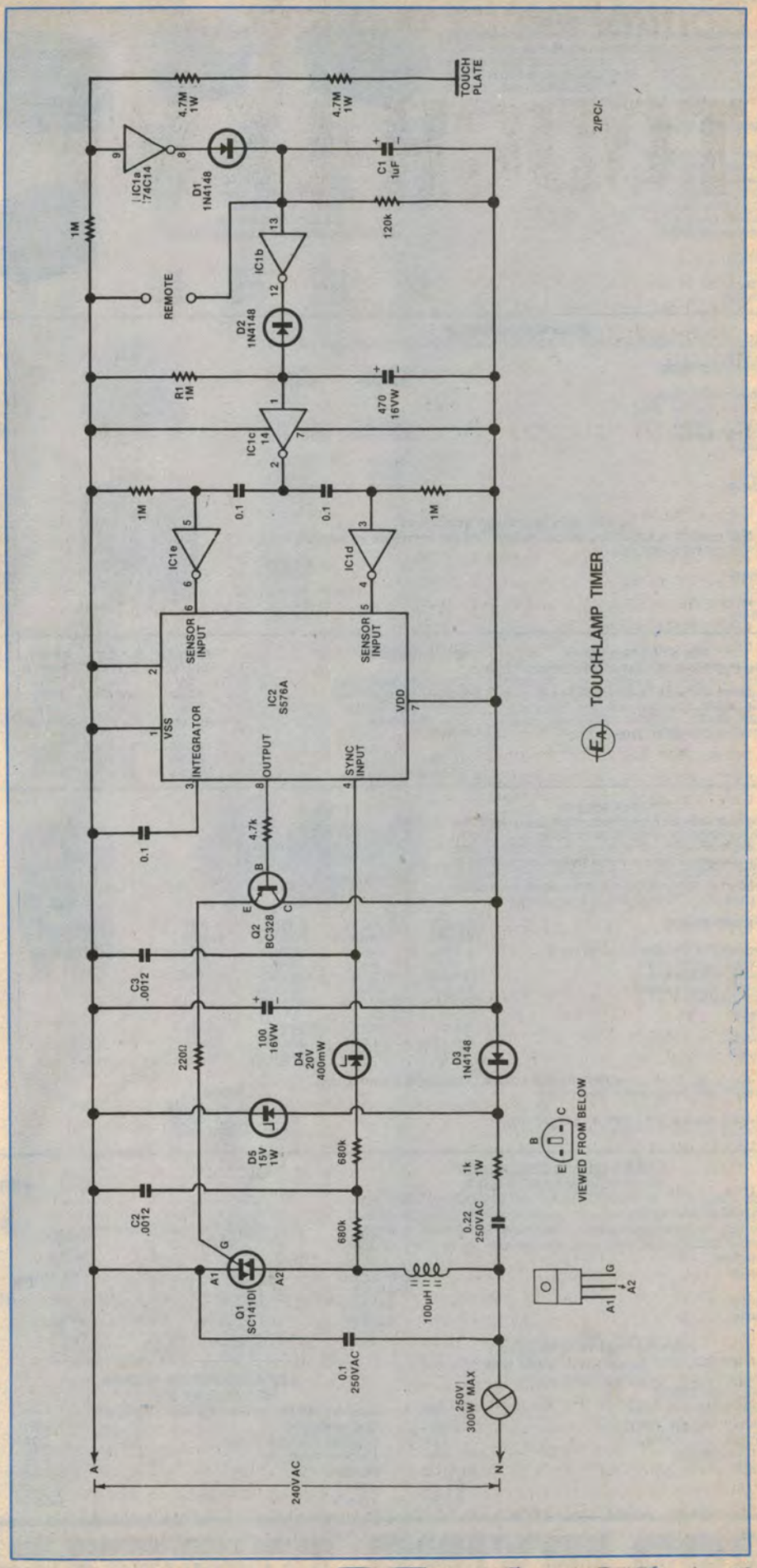
The lamp is switched off when the S576A stops supplying trigger pulses to the Triac. Normally, the input of this IC is connected to the touch plate and the duration of the touch determines the mode of operation. Any input signal of less than 50ms is regarded as spurious and is ignored. A signal of between 50 and 400ms causes the IC to operate in the on/off mode and signals of longer than 400ms initiate the dimming mode. Since we are not utilising the dimmer function, all input signals are conditioned such that they are about 100ms in duration so that the IC operates only in the on/off mode.

The circuit incorporates a toroidal inductance which provides effective suppression of radio interference from the circuit. This is particularly important because the rapid switching of the Triac can generate an unacceptable level of electromagnetic interference.

How it works

Operation of the circuit is actually quite straightforward if we consider it as a chain of events controlled by the touch plate. When somebody touches it, the touch plate supplies a signal which is processed by a series of inverter stages. This enables a 100ms pulse to be presented to the S576A at the beginning of each time period and another at the finish. Trigger pulses from the S576A are supplied to the Triac via a transistor buffer (Q2) and are timed such that the Triac operates with a 35° phase angle.

The main functional blocks of the S576A's internal circuitry are a phase locked loop, and ignition angle limiter and signal conditioning/evaluation. We have already discussed the operation of the signal evaluation section, ie, determining the required mode of operation.



The phase locked loop synchronises the IC's internal timing circuitry to the mains frequency to ensure stability. The ignition angle limiter prevents firing outside of the acceptable phase angle range (this is nominally 35° for maximum brightness and 152° for minimum brightness).

For a more detailed description of the S576A's operation, refer to the Touch-lamp Dimmer article in the April 1983 issue.

We have seen that when the load is activated the timer circuit derives its power supply from the first 2ms of each mains cycle. However, when the load is not activated, the full mains cycle is applied to the Triac and we need some method of limiting the "charge" delivered by the charge pump. This is achieved by the 0.22μF capacitor and 1kΩ/1W resistor in series with the circuit's ground connection. At 50Hz, the capacitor represents an impedance of 15kΩ and thereby limits the current to an average of 16mA. The 1kΩ/1W resistor limits the peak current during each pulse.

The voltage derived from this power supply is zener regulated to about 15V by diode D5 and rectified by D3. These diodes operate in conjunction with the 0.22μF capacitor as a "charge pump" for the 100μF electrolytic. Power consumption when the load is off is about 0.25W which is too small to be registered by the domestic watt-hour meter.

Touch plate operation relies on the impedance of the body to ground. Normally the touch plate is held at active potential (240VAC) and is taken to ground (ie, below circuit ground) when touched. This transition is used to initiate the timing sequence.

Note that the touch plate is not connected directly to the circuit – rather, it is coupled through two series 4.7MΩ resistors. There are two very important reasons for this, both related to the fact that the circuit is operating at mains active potential.

Primarily, the resistors isolate the circuit from anyone operating the touch plate, removing the hazard of electric shock. For this reason, each of the resistors must be rated at 500V (minimum). We recommend the use of Philips VR37 high voltage resistors for this application although Philips CR52 are also suitable.

The resistors also protect IC1 (a 74C14 CMOS hex Schmitt inverter) which actually detects the input transition. The potential of the touch plate, when a hand touches it, will be considerably lower than the circuit ground. Normally, this is an unacceptable condition, with the IC's internal protection diodes being triggered into conduction. However, the 9.4MΩ resistance in series with the input limits the current through these diodes to a safe level, permitting the IC to operate in this mode indefinitely.

Only one of the six inverters in the 74C14 is used to detect the input transition. This is IC1a, with pin 9 being its input. To prevent false triggering, pin 9 is normally held high by a 1MΩ resistor. Since the output of an inverter is always in the opposite logic state to its input,

PARTS LIST

1 PCB, 83pc8, 47 × 71mm
1 HPM Decorator blank grid, DR770/GF blank
1 HPM Decorator blank metallic finish cover plate (DR blank)
1 3-way insulated mains terminal block
1 Neosid iron powder ring core, 17-132-10
1 1.2m of 0.5mm diameter enamelled copper wire
1 compression spring, 3mm dia × 5mm long, solderable wire

SEMICONDUCTORS
1 SC141D Triac
1 15V 1W zener diode
1 20V 0.4W zener diode
1 BC328 PNP transistor
1 74C14 hex Schmitt inverter IC
1 S576A light dimmer IC
3 1N4148 diodes

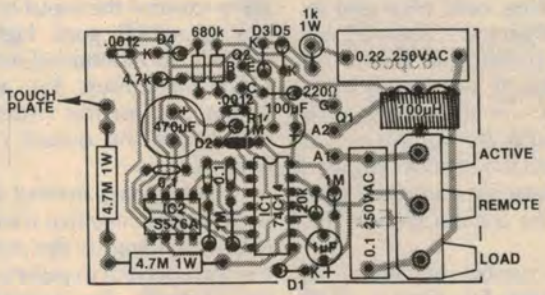
CAPACITORS
1 470μF/16VW electrolytic
1 100μF/16VW electrolytic
1 1μF/16VW electrolytic
1 0.22μF/250VAC metallised dieletric
1 0.1μF/250VAC metallised dieletric
3 0.1μF monolithic
2 .0012μF metallised polyester (greencap) – see text

RESISTORS (¼W, 5% unless stated)
2 x 4.7MΩ 1W (Philips VR37 or CR52), 4 x 1MΩ, 2 x 680kΩ, 1 x 120kΩ, 1 x 4.7kΩ, 1 x 1kΩ 1W, 1 x 220Ω

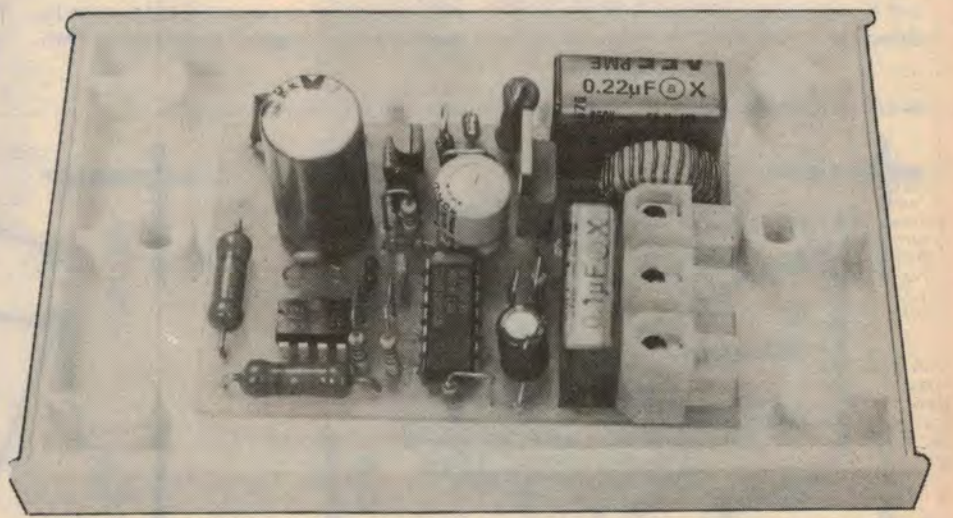
Remote extension

1 PCB, code 83pc3b, 47 × 72mm
1 HPM Decorator blank grid, DR770/GF blank
1 HPM Decorator blank metallic finish cover plate (DR blank)
1 2-way insulated mains terminal block
1 compression spring, 3mm dia, 5mm long, solderable wire
2 BC559 PNP transistors
1 18V/1W zener diode
1 6.8V/400mW zener diode
1 1N4148 small signal diode
1 .01μF metallised polyester capacitor

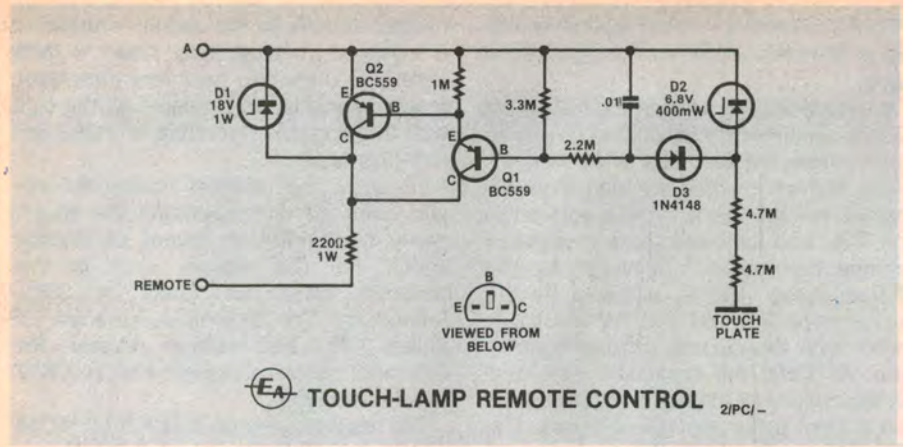
RESISTORS (¼W, 5% unless noted)
2 x 4.7MΩ Philips CR52 or VR37, 1 x 3.3MΩ, 1 x 2.2MΩ, 1 x 1MΩ, 1 x 220Ω 1W.



Make sure that all polarised components are correctly oriented.



The PCB is affixed to the back of the switch plate using epoxy adhesive. Contact with the metallic touch plate is by means of a small spring (see text).



This optional circuit can be used for remote switching.

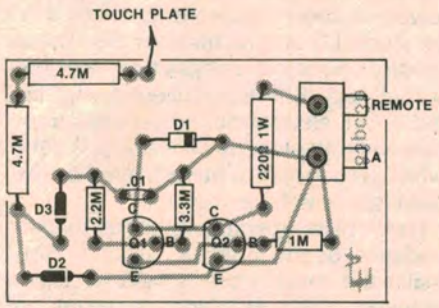
the output of IC1a (pin 8) will be normally low.

Notice that pin 8 is connected to the anode of diode D1 which will normally be reverse biased. This allows C1, a 1μF electrolytic, to be discharged by the 120kΩ resistor across it.

Suppose that the touch plate is now taken low. This will cause the output of IC1a to go high, forward biasing D1 and charging C1. As soon as the touch plate is released, C1 will begin discharging, providing a delay of about 125ms. The purpose of this network is to ensure reliable triggering – even with the lightest touch on the touch plate.

Whenever C1 is charged, the input of IC1b (pin 13) will be held high and its output (pin 12) will be low. Diode D2 will thus be forward biased and the 470μF capacitor on its anode will be discharged. This capacitor – in conjunction with resistor R1 – provides the control period of the circuit. When the hand is removed from the touch plate, the lamp will continue to operate for the duration of this period.

The maximum period of about 10 minutes is achieved by using a 1MΩ resistor for R1. Reducing the value of R1 will have a proportionate effect on the delay.



Above is the parts layout diagram for the remote switching option.

The charge of the 470μF capacitor is used to control the input of IC1c, the output of which goes high during "on" periods. As mentioned earlier, control of the S576A must be achieved using pulses, and for this reason, we can not simply use the output of IC1c as the control.

It is necessary instead to convert the positive and negative transitions of pin 2 (corresponding to the start and finish of the "on" period) to pulses of 100ms duration. Actually, the S576A has two inputs (pins 5 and 6) with opposite sense so that either positive or negative pulses can be used. In the original Touch-lamp Dimmer, pin 5 (which requires negative pulses) was used with the main touch plate and pin 6 to the remote sensor.

The output of IC1c is connected to two other inverters (IC1d and IC1e) via 0.1μF capacitors. Pin 3 of IC1d is normally held low by a 1MΩ timing resistor and thus receives a 100ms positive pulse when the output of IC1c goes high. This corresponds to a negative pulse on pin 4 which is fed to pin 5 of the S576A, causing it to activate the load.

Pin 5 of IC1e is normally held high by a 1MΩ resistor which means that it ignores the positive transition on pin 2 of IC1c but registers a 100ms negative pulse at the negative transition of pin 2. This is inverted and applied to pin 6 of the S576A, causing it to deactivate the load at the end of the timing period.

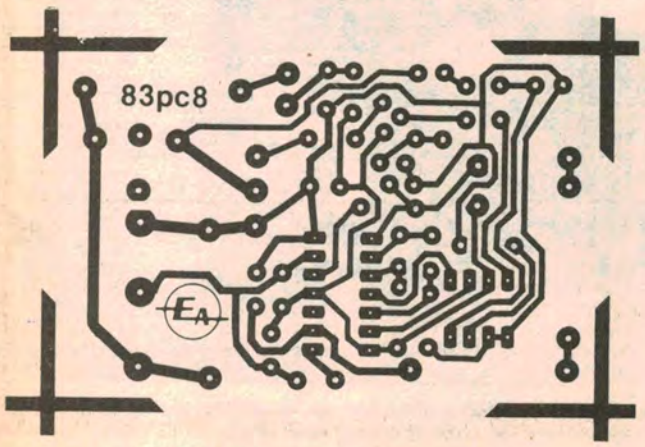
The output of IC2 is pin 8 which drives the base of transistor Q2 via a 4.7kΩ limiting resistor. In the Touch-lamp Dimmer, pin 8 was used to drive the Triac gate directly. We found that, under certain conditions, this would not reliably trigger the Triac for fan motor loads. The transistor buffer increases the drive to the Triac to solve this problem.

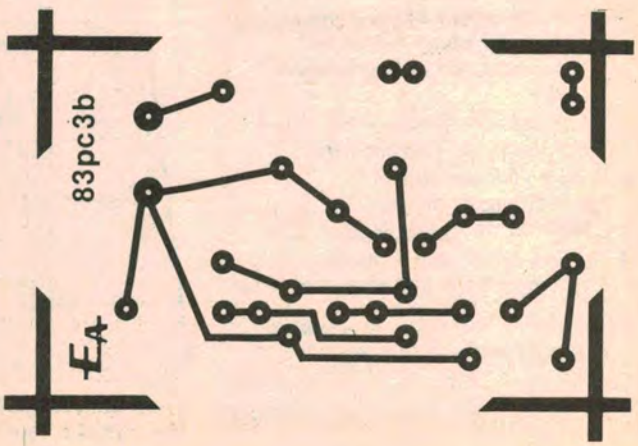
With some types of fans – particularly those with larger motors – it may also be necessary to change capacitors C2 and C3. If the fan does not start reliably, increase the value of C2 and, if necessary, C3. Neither of these two capacitors should need to be larger than .0047μF and it is preferable to use the smallest values which will permit reliable starting as larger values cause the fan to operate at reduced speed.

Triac Q1 drives the load via the 100μH toroidal choke. This choke, in conjunction with the 0.1μF capacitor, is used to suppress the considerable electromagnetic interference which is usually generated in this type of switching circuit.

The phase locked loop input to IC2 (pin 4, the sync input) is derived from the Triac A2 terminal via two 680kΩ resistors and a series 20V zener diode. Together

Below are actual size reproduction of the two printed circuit boards.





with the two .0012μF capacitors, this network forms a two-stage filter which makes the circuit proof against the effects of mains interference. Without this filter network, mains borne interference (such as control tones) could upset the operation of the circuit.

The Touch-lamp Dimmer remote extension required only a single connection to the main dimmer circuit and one to the mains active. If necessary, the active connection could also be made at the dimmer terminal block. We have designed the timer to be compatible with this system.

The extension feeds into the main timer circuit at the cathode of D1. Recall that this is normally low, going high only when the circuit is triggered. The remote extension output is normally floating and also goes high when triggered, thus making it directly compatible with the timer circuit.

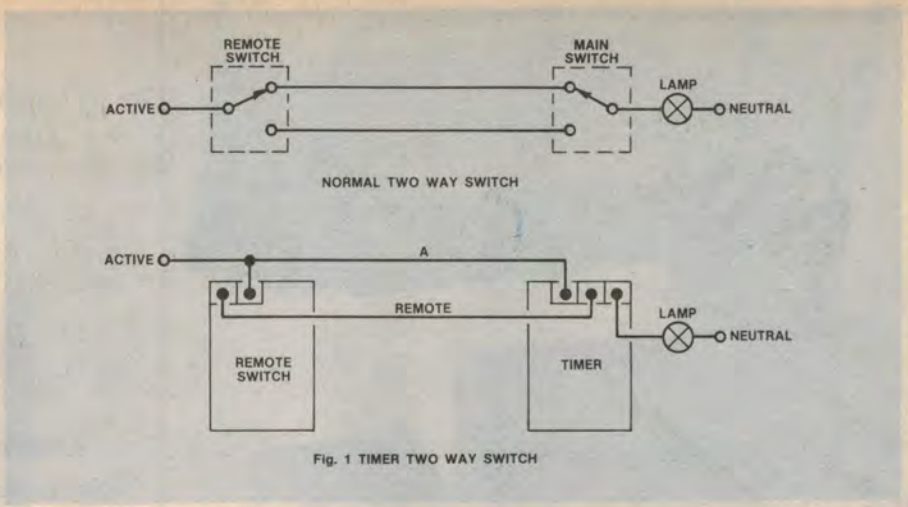


Fig. 1 TIMER TWO WAY SWITCH

This diagram shows how the timer and remote switch can replace an existing two-way switch installation.

Construction

The printed circuit board (PCB) used for this project is coded 83pc8 and measures 47 x 71mm. Components on the PCB are packed in rather tightly and this means it is important to solder them in the correct order. Put D2 and R1 in place first – if you leave them until later, it will be a matter of inserting them with tweezers!

The next component to install is IC1, followed by the rest of the resistors and diodes. The capacitors (greencaps, monolithics and electrolytic) can then be soldered in place.

Put the PCB aside for a moment and turn to the toroid. This must be wound with 37 turns of 0.5mm enamelled copper wire. Wind each turn tightly so that it touches the adjacent winding at the centre of the core. When the winding is complete, twist the two ends together (a few twists will do). Leaving about 15mm of free length, strip the enamel from each end of the wire.

The wound toroid is secured to the PCB with a short piece of tinned copper wire strapping which is passed through the centre of the core. This wire is soldered into two holes on the PCB (adjacent to the toroid) and should be pulled tight before soldering.

The remaining components may be installed in any order except for the three-way terminal block which should be fitted last. The best way to mount it is to first insert three short pieces of tinned copper wire and then solder these into their respective PCB holes.

The timer PCB is centrally located on the rear of the grid plate and a hole drilled in the grid plate directly opposite the touch plate pick-up point on the PCB. We used a small spring made from solderable wire to provide the contact between the PCB and the touch plate. This spring is soldered at right angles to the copper side of the PCB, and protrudes through the hole drilled in the grid plate to provide a reliable contact.

Note that the HPM grid plate has eight plastic cylindrical protrusions on one side of the moulding. Four of these will have to be trimmed with side cutters to provide clearance for the PCB.

An alternative to using the spring for contact to the metallic decorator plate is to flare out the strands of multistrand hook-up wire and sandwich these between the front panel and plastic grid.

Isolation of the touch plate should now be checked. Use a multimeter set to measure the highest range. The resistance between the active terminal of the circuit and the touch plate should be about 10MΩ or you should get a very small deflection on the meter if the meter does not resolve resistances this high. This test will ensure that there is no fault at the touch plate likely to cause electrocution.

If the circuit fails this test, check firstly that the correct value resistors are used and secondly that there are no solder bridges from the resistors to any other tracks on the PCB.

Finally, the PCB should be affixed with epoxy resin to the rear of the grid plate.

We estimate that the current cost of parts for this project is approximately

$21

for the Touch-lamp Dimmer and $9 for the remote extension. These figures include sales tax.

Installation

Installation is easy and involves removing the old switch plate and replacing it with the Touch-lamp Timer. All you have to do by way of wiring is insert the two existing switch wires in the terminal block on the timer PCB. If the remote control switch is used, two extra wires will have to be run to it from the main timer PCB. These wires will already be in place if you are replacing a normal two-way switch set-up but, if not, they should be installed by a licensed electrician.

Before installing the timer, it is important to disconnect the mains power. This should be done by switching off the power at the switchboard and removing the relevant fuse. Keep the fuse with you to prevent someone else reinserting it unexpectedly. If circuit breakers are installed in the switchboard, these should be switched off.

Note that when connecting the timer to the wiring, the active lead should be inserted into the inside terminal of the terminal block. In some cases it may be unclear which lead is the active and which lead is from the light socket. Try one combination first and screw the timer to the wall. Turn on the power and test the timer. If it does not function, disconnect the power and reverse the leads.

Fig. 1 shows the wiring normally used for two-way switches and the equivalent wiring for the Touch-lamp Timer and remote switch. You can have as many remote switches as you like – all you have to do is wire them in parallel, but be careful not to transpose the active and remote connections.

After some period of usage, the light timer may collect dust and an oily film on the polycarbonate plate. This can decrease the resistance between the touch plate and earth and may prevent reliable triggering of the timer. Generally a wipe over of the front surfaces with a clean cloth will remedy this. In stubborn cases it may be necessary to clean the entire plastic grid and between the metal touch plate and grid plate.