Control your lights with the

Touch-lamp Dimmer

This completely new dimmer circuit uses a Siemens integrated circuit and a Triac to turn lamps on and off with just a light touch on a wall panel. Alternatively, you can dim or brighten the lamps to any desired level by merely touching the panel for two or three seconds — very classy! The circuit also has very effective EMI suppression and has optional remote sensing for two-way or multi-way lamp swtiching.

by JOHN CLARKE

Our last wall-mounted light dimmer was published in April 1973 (File 2/PC/18) but for the last six or seven years it has been cheaper to buy rather than build a light dimmer. To date, all commercially available domestic dimmers have been very similar in design to the above EA dimmer and have incorporated a separate switch and a knob for the dimming function. As such, they dim lamps effectively but most produce significant interference to AM radio.

Recently, at least one manufacturer has produced a touch-operated dimmer which is an attractive innovation. Just a light touch on the metal wall-plate switches the lamp(s) on or off and leaving your hand on the wall-plate for a couple of seconds lets you dim (or brighten) the lamps(s) to any desired level from full brightness to completely off. This occurs very smoothly.

The EA Touch-lamp Dimmer is functionally equivalent to this commercial touch dimmer but can be built for about half the cost and uses an improved design which we will detail later. From now on then, knobs are out and touching is in!

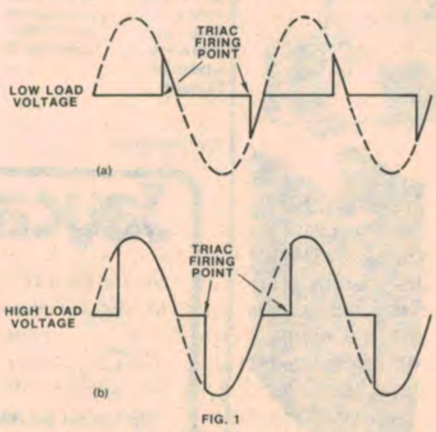
This new Touch-lamp Dimmer incorporates a facility which is not available or possible with any knob-operated dimmer. While all dimmers can be used in conjunction with two-way or multi-way switches, dimming of the lamps could only be done at the dimmer itself. This stands to reason. However, this new dimmer has optional remote sensing whereby additional wall plates can be used for multi-way switching or dimming.

In a large room or hallway it is possible to have two, three or more touchplates, any of which can switch the lamps on or off or dim them. In addition, this can be done with less wiring than is needed for a conventional multiway switch installation and the additional touch plates will probably cost less than the relatively expensive "intermediate" switches usually required.

The Touch-lamp Dimmer circuit is mounted on a small printed circuit board behind a blank face plate from the HPM Decorator range. This has the standard mounting holes of normal switch plates. On the front face is clipped a blank metallic plate which may be satin silver or gold finished aluminium or stainless steel, or brass. This gives a very good finish to the Dimmer.

Phase-controlled Triac

As with all other dimmer circuits, the Touch-lamp Dimmer employs a Triac.



These diagrams show how a Triac is used for phase control.

This is controlled by a new Siemens light dimmer IC, the S576A.

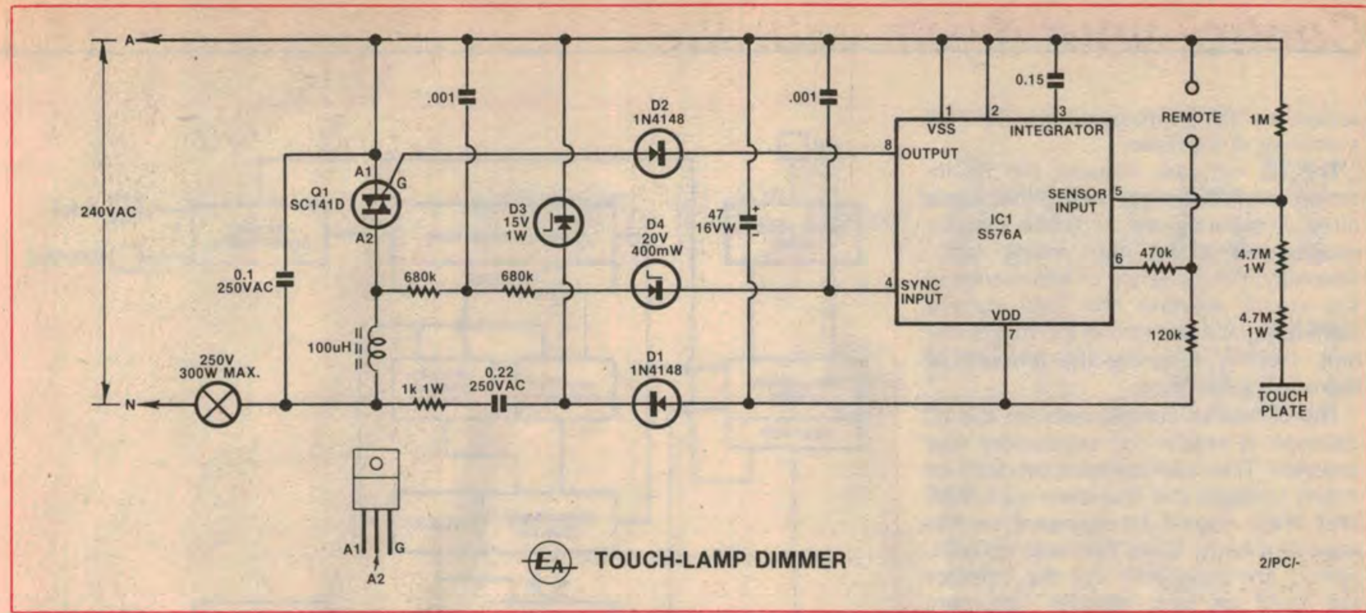
The Triac is an AC power control device originally developed by General Electric about 18 years ago. It is a bidirectional thyristor (SCR) device which can be triggered into conduction for both voltage polarities by a signal applied to its gate.

After being triggered into conduction, the Triac remains in conduction until the supply voltage decreases to zero or reverses in polarity, when it turns off. Used with AC, a Triac can be triggered into conduction at any point on either half of the mains cycle by a low voltage signal of either polarity applied between the gate and terminal one of the Triac.

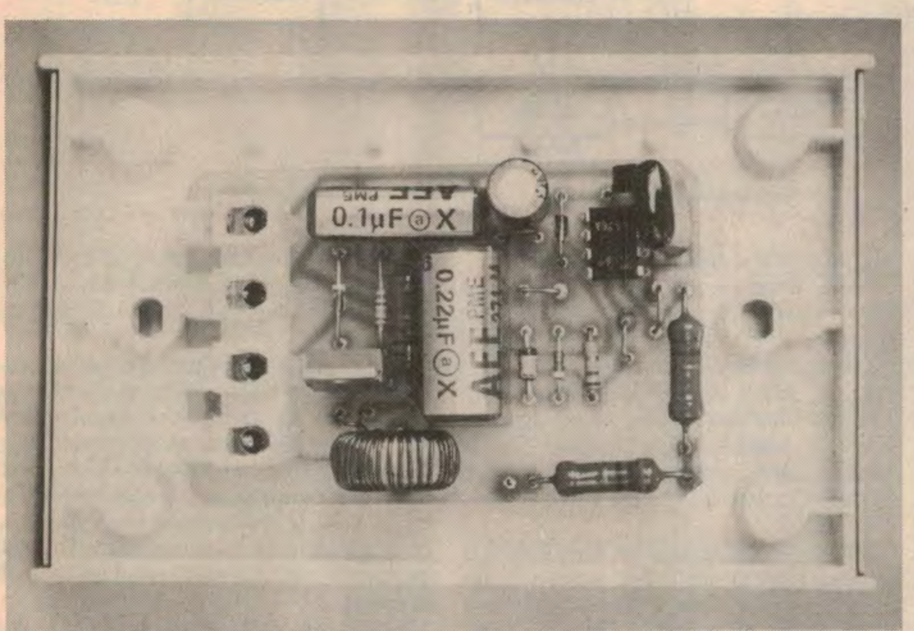
Since the Triac is only a switching device which is either fully conducting or open circuit, the only means of power control is to apply variable periods of mains voltage in each half wave mains cycle. This is called phase control. The later in the half-cycle the Triac fires, the less the average voltage applied to the lamp and the dimmer the lamp. This can be seen in Fig. 1a. If the mains is switched early in the mains cycle, then the proportion of voltage applied to the lamp is high and the lamp will appear fully on. This can be seen in Fig. 1b.

To trigger the Triac at the requisite period in the mains cycle some form of phase detection of the mains voltage is necessary as well as a trigger signal to fire the Triac. This is where the light dimmer IC, the Siemens S576, comes into the picture.

Upon receiving a sensor or extension input signal via the touchplate on the



TOUCH-LAMP DIMMER



This photograph shows the dimmer circuit mounted on the back of the face plate.

Touch-lamp Dimmer or slave remote switch, analysis of the signal is made. Signals shorter than 50ms are regarded as a disturbance and are ignored by the circuit; signals of between 50 and 400ms duration are considered as on/off control; and signals which last longer than 400ms are considered as up/down dimming control.

S576 dimmer IC

Fig. 2 shows a simplified block diagram of the S576A light dimmer/switch IC. This comprises the functional logic to decode whether an on/off or dimming function is required and to provide a constant brightness previously set by dimming. Three external connections to the IC are shown. These are the frequency reference, Fref; sensor and extension inputs; and the Triac output driver.

The brightness counter is an up/down digital counter which provides information about the required phase angle for the Triac gate pulse. The on/off control sets the phase angle for maximum brightness when "on" is selected and the minimum phase angle for "off". The up/down dimming control starts the brightness counter cycling through its dimming cycle of dark-to-bright-to-dark phase angle counting.

The cycle counter covers the same counting range as the brightness counter and counts over the full range once every half mains cycle in synchronism with the mains. When the count of the brightness counter and cycle counter are equal, the Triac driver sends a 40μs gate pusle to the Triac. If the brightness counter value equals the cycle counter late in the mains cycle then the Triac also fires late in the mains cycle and a dim lamp results. Conversely, if the brightness counter equals the cycle counter early in the mains cycle a bright lamp results.

The firing angle limiter blocks the comparator if the cycle counter is outside the phase angle control range; nominally set at 35 degrees (minimum brightness) and 152 degrees (maximum brightness).

Synchronisation with the mains frequency is derived from the Fref input. A phase locked loop (PLL) is used to multiply the mains frequency to 102.4kHz and operates as follows: A voltage controlled oscillator (VCO) generates a 102.4kHz signal that is divided by 2048 to the mains frequency of 50Hz with the frequency divider. The divider frequency is compared with the incoming mains frequency and an error voltage is generated by the PLL. This is filtered and controls the frequency of the VCO such that the divided output of the VCO is kept in phase with the mains frequency.

The frequency divider is tapped at several division ratios and these clock signals are used for timing the remainder of the circuit.

Touch-lamp Dimmer circuit

The circuit for the Touch-lamp Dimmer is relatively simple and consists of the 576 IC, a Triac, several diodes, capacitors and resistors and a choke. The remote switch circuit consists of two low cost transistors, a capacitor, several resistors and three diodes. We shall discuss the Touch-lamp Dimmer circuit first.

The Triac, serving the purpose of the mains switch, is connected between the mains active and the lamp via the 100μH choke. This choke, in conjunction with the 0.1μF capacitor, is used to suppress the considerable electromagnetic interference (EMI) produced by the fast switching of the Triac.

The LC network reduces the RF interference in two ways. Firstly, it acts as a filter, attenuating any RF which may be propagated along the mains lead. Secondly, the presence of inductance in the circuit prevents the load current from rising at a fast rate at the trigger instant, thereby reducing the amount of harmonic generation.

The choice of components for the LC network is critical for satisfactory suppression. The capacitor must be rated for mains voltages and that means 250VAC and 50Hz should be stamped on the capacitor body. Capacitors with 600VDC ratings are unsuitable. For the inductor we used an iron powder ring core manufactured by Neosid, type 17-132-10, which is specifically intended for EMI suppression.

We are particularly pleased with the effectiveness of the resulting EMI suppression in this new dimmer circuit. While many commercial dimmers do contain components for EMI suppression they are largely ineffective. The effectiveness of the EMI suppression is largely due to the Neosid iron powder toroid. This has a number of advantages compared with coils wound on ferrite rods that we have specified for previous Triac circuits.

First, because the coil is wound on a toroid instead of a rod, there is negligible radiation of flux and hence there is no strong field of interference in the immediate vicinity of the dimmer. Second, because there are relatively few turns and they can be tightly wound, the coil winding does not buzz audibly which can be obtrusive if you are close to the dimmer.

Third, because the iron powder is a lossy material which does not have the high Q of the ferrite rod material, there is less likelihood of ringing occurring in the circuit which can make the interference worse in some frequency bands.

Note: Readers wishing to adapt this filter network to suppress intereference from commercial light dimmers should be aware that our circuit is rated for a total of 300W incandescent lamp load. Circuits handling bigger loads will require a suitably large toroid. Neosid toroids are available from Watkin Wynne Pty Ltd, 32 Falcon Street, Crows Nest, 2065.

A low voltage supply for the S576 IC is derived directly from the mains via the 0.22μF current limiting capacitor and a 1kΩ resistor. By using the capacitor reactance to limit the current rather than a large value resistor, heat dissipation is minimal. Diodes D1 and D3 operate in conjunction with the 0.22μF capacitor as a "charge pump" for the 47μF capacitor while D3 performs the additional function of limiting the supply voltage to about 15V.

The 0.22μF capacitor acts as an impedance of 15kΩ at 50Hz and limits the current to an average of about 16mA when the full mains voltage is impressed across the Triac; ie, when the Triac is off. The minimum phase angle when the Triac fires is 35 degrees and the low average current thus developed is still sufficient for zener regulation and filtering.

Incidentally, while current is drawn by the circuit at all times, even when lamps are off, the actual power consumption (with lamps off) is of the order of 0.25W which is too small to be registered by the

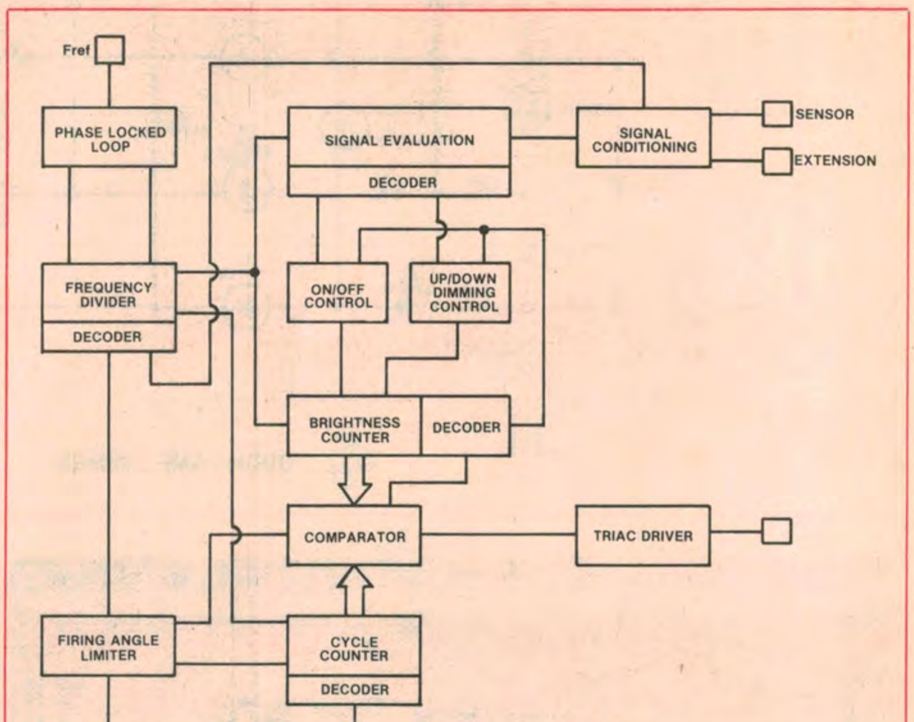
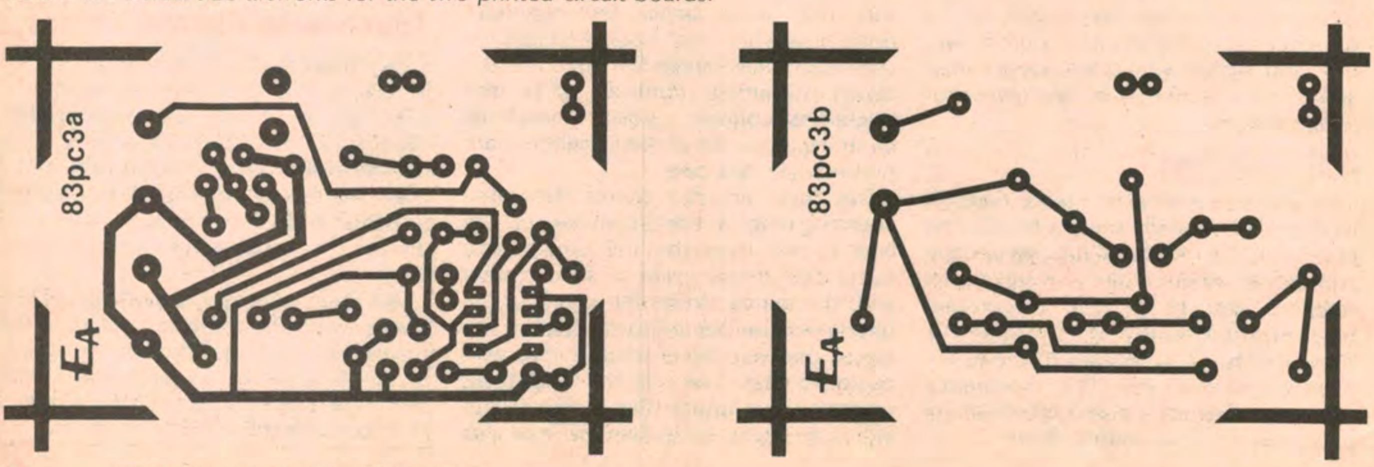
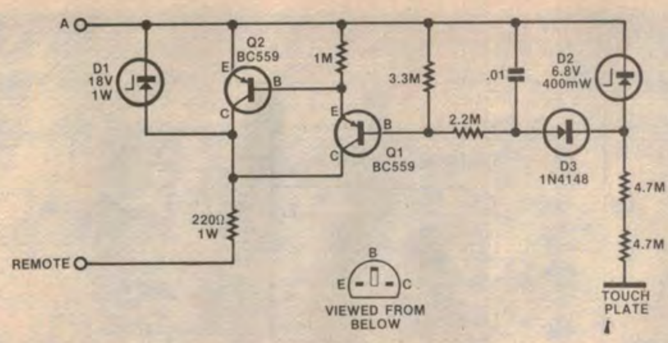


Fig. 2

Below are actual-size artworks for the two printed circuit boards.

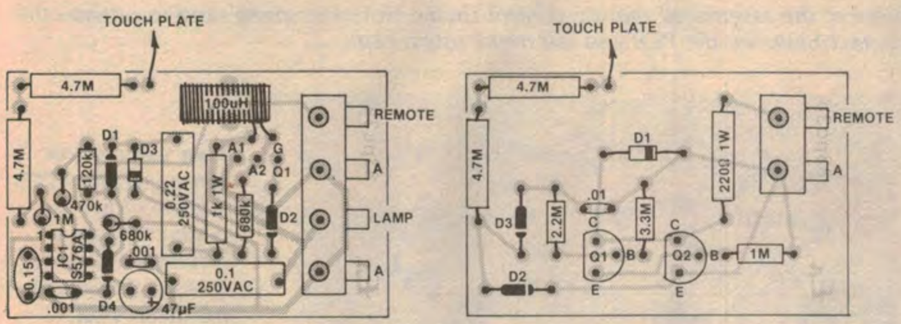




TOUCH-LAMP DIMMER REMOTE CONTROL

2/PC/–

This optional circuit can be used for multi-way switching.



Parts layout for the main circuit (left) and the remote switching circuit (right).

domestic watt-hour meter.

Negative gate triggering for the Triac is provided from pin 8 of IC1. Diode D2 reduces positive voltages which can be produced at the gate of the Triac during the triggered state by about 0.6V to prevent damage to the IC.

The phase locked loop input to IC1 (pin 4, the sync input) is derived from the Triac A2 terminal via two 680kΩ resistors and a series 20V zener diode, in conjunction with two .001μF capacitors. This relatively complex two stage filter was found necessary to make the circuit proof against the effects of mains control tones. Without the filter circuit, mains tones would cause the lamps to flicker badly.

Two 4.7MΩ resistors are used in series from the sensor input of the IC to the touch plate. These must be each rated at 500V to provide sufficient electrical isolation between the user at the touch plate and the mains active. We used Philips CR52 resistors which are 18mm long and 5.2mm in diameter, and which have a 0.67W rating. Better still, use two Philips VR37 resistors, which are smaller and have considerably better voltage ratings. The VR37 resistors have a light-blue body 10mm long and the 5% tolerance band is depicted in yellow paint rather than gold, because metal particles degrade the high voltage properties.

Touch plate operation relies on the resistance of the body to ground. Normally the sensor input, pin 5, is held at active potential (240VAC) until the touch plate is touched. This brings the sensor input to a sufficient level below active to trigger the IC.

Remote switch circuit

The remote switch circuit is designed to connect to the Remote terminal of the dimmer circuit. If this terminal is brought to active potential, the extension input, pin 6 of IC1, will provide control to the circuit in a similar manner to control with the pin 5 input. It is necessary to implement remote operation using extra circuitry since if pin 5 were just extended, the extra line capacitance would false-trigger the IC.

When the sensor input is touched, the resulting earth-going voltage at this input is sufficient to charge the .01μF capacitor until the voltage reaches the 6.8V zener voltage minus the drop across the 1N4148 diode. The first transistor (Q1) is switched on due to the base current through the 2.2MΩ resistor connected to the capacitor. This transistor in turn switches on transistor (Q2), which ties the remote input high.

When contact to the sensor input is released, the .01μF capacitor discharges via the 2.2MΩ and 3.3MΩ resistors. This removes the base current to transistor

Parts List

1 PCB, 83pc3a, 47 x 72mm
1 HPM Decorator blank grid, DR770/GF blank
1 HPM Decorator blank metallic finish cover plate (DR blank)
1 4-way insulated mains terminal block
1 Neosid iron powder ring core, 17-132-10
1.2m of 0.5mm diameter enamelled copper wire
1 compression spring, 3mm dia x 5mm long, solderable wire
1 SC141D 6A Triac
1 S576A light dimmer/switch IC
1 20V/400mW zener diode
1 15V/1W zener diode
2 1N4148, 1N914 silicon diodes

CAPACITORS
1 47μF/16VW PC
1 0.22μF/250VAC
1 0.15μF metallised polyester
1 0.1μF/250VAC metallised dielectric
2 .001μF metallised polyester

RESISTORS (½W, 5% unless noted)
2 x 4.7MΩ Philips CR52 or VR37, 1 x 1MΩ, 2 x 680kΩ, 1 x 470kΩ, 1 x 120kΩ, 1 x 1kΩ.

Remote extension

1 PCB, code 82pc3b, 47 x 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.

MISCELLANEOUS
Solder, insulating tubing, epoxy resin adhesive.

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

$20

for the Touch-lamp Dimmer and

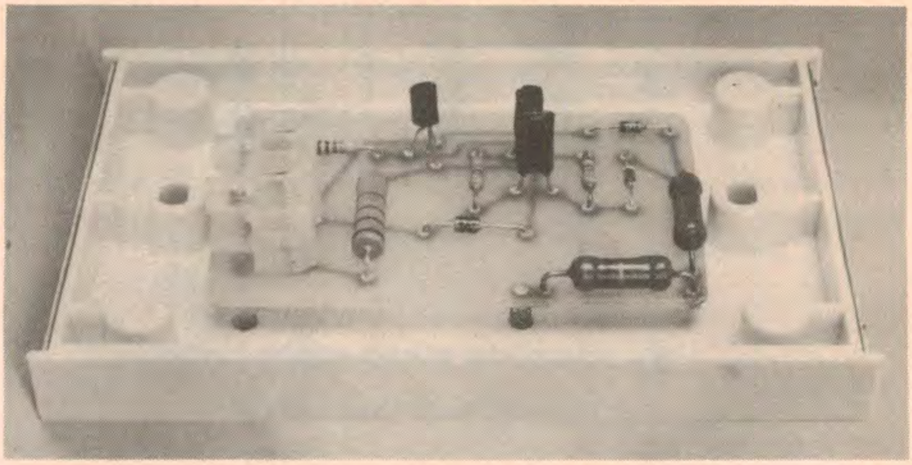
$9

for the remote extension. These figures include sales tax.

Q1 which in turn removes the base drive to Q2. The 1MΩ resistor at the base of transistor Q2 ensures that the transistor will be off. The response time of the circuit is dependent upon the .01μF capacitor and associated resistors. It takes approximately 2ms to switch on the transistors after touching the sensor input, and about 30ms to switch off after contact ceases.

The 18V zener diode and 220Ω resistor provide protection for transistor Q2 in the event that connections to the circuit are transposed, in which case the zener is forward-biased and acts as a normal diode. When connected correctly, the zener protects the transistors against excessive collector-emitter voltages.

The maximum lamp load which may be connected to the Dimmer is 300 watts although we imagine that most users will be content with far less than this. The maximum load rating is set partly by the size of toroid, as mentioned before, and by the maximum power due to conduction (IR) losses which the Triac can withstand without having an efficient heatsink fitted.



View of the assembled remote control circuit. Note the spring used to provide the contact between the PCB and the metal touch plate.

Rear view of the remote control PCB, showing how the contact spring is mounted. A similar scheme is used for the main PCB.

Construction

We constructed our Touch-lamp Dimmer circuit on a PCB coded 83pc3a and measuring 47 × 72mm, while the remote switch is constructed on a PCB coded 83pc3b and measuring 47 × 72mm. The PCB layout for the dimmer is unusual in some respects. Some of the components are very cramped and three resistors are mounted vertically. The two 4.7MΩ resistors are mounted away from the copper tracks of the active mains circuitry to ensure high isolation between the touch plate and the mains.

We shall discuss construction assuming that the remote switch will be constructed as well. If only the dimmer is to be built, the comments relating to the remote switch PCB can be ignored.

Since safety of this circuit can be jeopardised by wrong components inserted in the touch plate resistive string, we expect that at least one kit supplier will provide the PCBs with the 4.7MΩ resistors already soldered into the boards. This will ensure that the correct values have been used. Apart from this, assembly of the remainder of the components will require insertion into the PCBs.

Follow the PCB overlay diagrams during construction. Note that the diodes, Triac, electrolytic capacitor and the IC must be oriented correctly.

The four-way insulated terminal block is secured to the PCB using short lengths of 1mm diameter wire inserted into the copper pads allocated for the terminals. Alternatively, PC stakes can be used in place of the wire.

The toroid is wound with 37 turns of 0.5mm enamelled copper wire. Wind each turn tightly so that it touches the next winding at the centre of the core. When winding is complete, twist the two ends together and, leaving about 10mm of free length, clean each end of the wire with a knife or file.

The wound toroid is secured to the PCB with a short piece of tinned copper wire strapping through the centre of the core and looped into the holes allocated in the PCB. The ends of this wire are soldered to the copper pads. Ensure that the wire is tight before soldering.

The metal touch plate simply clips into position over the grid plate.

The dimmer 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 be affixed with epoxy resin to the rear of the grid plate.

Installation

Installation involves removing the old switch plate and replacing it with the new Touch-lamp Dimmer. The size of the dimmer PCB and associated components are designed to fit within the cutout of a standard wall box. Wiring involves only inserting the two switch wires into the terminal block of the dimmer PCB. If the slave remote control unit is to be used, two extra wires are needed to connect between the main dimmer unit and the remote slave unit. These wires will already be in place if the dimmer is replacing a normal two-way switch.

Before installing the dimmer, 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, then these should be switched off.

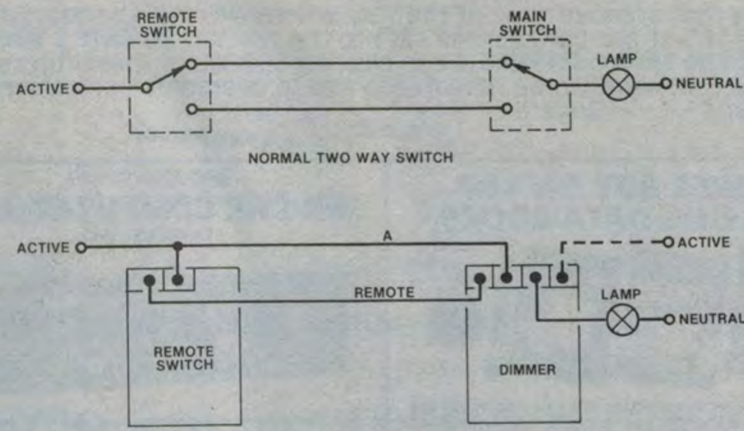


Fig. 3 DIMMER TWO WAY SWITCH

Note that when connecting the dimmer to the wiring, the active lead should be inserted into the outside 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 dimmer to the wall. Turn on the power and test the dimmer. If it does not function, disconnect the power and reverse the leads.

Fig. 3 shows the wiring normally used for two-way switches and the equivalent wiring for the Touch-lamp Dimmer and remote switch. Note that the outside active terminal on the Touch-lamp Dimmer is now spare and may be used for bridging or connections to additional remote switches. Note also that 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 remove connections.

After some period of usage, the light dimmer may collect dust and an oily film on the polycarbonate plate. This can decrease the resistance between the touch plate and earth and cause false triggering of the dimmer. 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.