Infrared Remote Control for the Touch-lamp Dimmer

by JOHN CLARKE & GREG SWAIN

Fancy infrared remote control for your Touch-lamp Dimmer? This circuit can turn the lights on and off or dim them to any desired level, all at the touch of a single button.

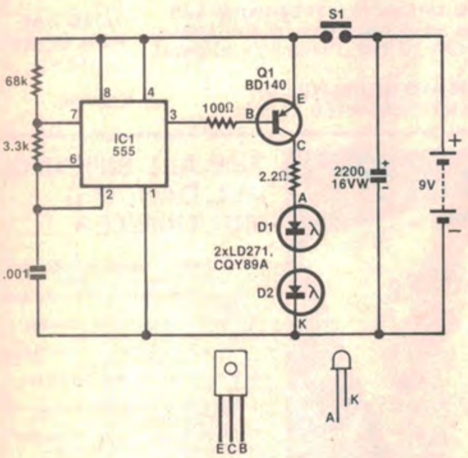
In many instances, the location of light switches is far from practical. In most rooms, for example, switches are located near the doorway. This is the obvious position for switching the light on and off upon entry or exit, but if you are seated in the room the doorway location is usually not convenient. With this infrared control, the lights can be switched on and off or dimmed to suit the mood without moving from your chair.

In the bedroom, the same advantages apply. You can now turn the light on and off or dim from the convenience of your bed. You will not need to walk around in the dark again. Just press the single button on the hand-held transmitter and the light will turn on or off. Or by holding the button down, you can dim (or brighten) the light to any desired level from full brightness to completely off.

You don't even have to point the transmitter directly at the wall-mounted receiver/dimmer unit. The circuit is so effective that wall reflections of the transmitted infrared light are quite sufficient to activate the receiver. Naturally, the user still has full control over the Touch-lamp Dimmer in the usual way – that is, by touching it.

The Touch-lamp Dimmer was originally described in April 1983 and consists of an HPM blank grid with a metallic cover plate. Mounted on the back of the grid plate is a small printed circuit board (PCB) which contains the dimmer circuitry. By lightly touching the front plate for between 50 and 400ms, the unit will switch lights on and off. Alternatively, touching the plate for longer periods initiates up/down dimming.

All these features are duplicated by the Remote Dimmer, although you actually have to go to the trouble of pressing the



REMOTE DIMMER TRANSMITTER

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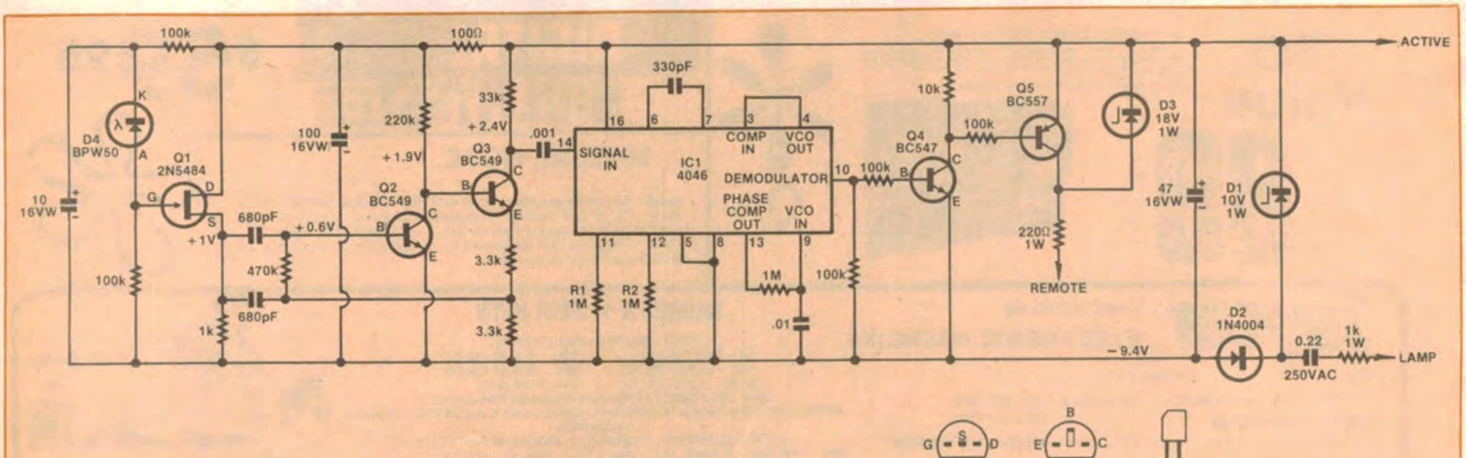

REMOTE DIMMER RECEIVER

The remote control receiver PCB and the dimmer PCB are both mounted on the back of the switch plate. At left is the hand-held infrared transmitter.

switch on the hand-held transmitter unit. Even so, the burden should not be too great!

Externally, the appearance of the Touch-lamp dimmer with remote control is identical to the original except for a small hole in the touch plate (see photo). This is to admit infrared light pulses generated by the transmitter to an infrared photodiode in the receiver circuit. The receiver PCB and the existing Touch-lamp Dimmer PCB are stacked together, with the receiver PCB mounted directly on the grid plate.

The transmitter consists of a small box containing the necessary circuitry and a 9V battery. Two infrared LEDs protrude through the end of the box and a small momentary contact switch on the lid switches power to the transmitter when lamp control is required.

When the switch button is pressed, the transmitter emits pulses of infrared light and these are detected by the infrared detector diode in the receiver. The signal is then amplified and fed to a phase lock loop (PLL) IC which immediately locks onto the incoming frequency. The PLL drives a transistor output stage which, in turn, activates the dimmer circuit via the existing "Remote" input on the dimmer PCB terminal strip.

Since the receiver PCB carries its own power supply components, only two further connections are required between the receiver and dimmer PCBs. These are "Active" and "Lamp". As before, these connections are made directly to the terminal strip on the dimmer PCB.

How it works

The remote dimmer transmitter consists of a 555 timer IC, several resistors, two capacitors, a 9V battery, two infrared LEDs and a BD140 driver transistor. The 555 IC is connected in the astable mode, operates at 20kHz, and provides a 2.3μs negative going pulse at its pin 3 output. This signal switches on the BD140 transistor which supplies 1A current pulses to the two infrared LEDs. The 2.2Ω resistor limits the current to prevent damage to the LEDs.

Even so, the peak current is more than the battery could supply on its own. For this reason, a large storage capacitor (2200μF electrolytic) has been included to supply the peak current. The battery keeps the capacitor topped up with charge while the capacitor supplies the LED current pulses.

The average current drawn by the circuit is around 60mA giving a battery life of several months under normal use.

Note that two infrared LEDs have been used in the transmitter to double the infrared light output. These LEDs are either Philips CQY89A or Siemens LD271 types. They are similar in appearance to the more usual red LEDs except that they are encased in a very dark blue encapsulation which is transparent to infrared light.

Let's now turn to the receiver circuit. It can be broken down into four sections: an amplifier, a phase lock loop (PLL), an output driver stage, and a power supply.

The infrared light generated by the transmitter LEDs is received by an infrared photodiode (D4). This is a Philips BPW50 type which incorporates an integral infrared filter and which is specially designed to match the infrared LEDs.

The photodiode has its cathode connected to the positive supply rail via an RC decoupling network consisting of a 100kΩ resistor and a 10μF capacitor.

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This ensures that the supply line does not modulate the anode voltage of the diode, with subsequent amplification in the following stages. In operation, the photodiode acts as a current source such that it generates a current proportional to the incident infrared light. This current signal is converted to a voltage by the 100kΩ resistor at the anode.

The signal from the photodiode is fed to the input of Q1, an N-channel FET connected as a source follower. This stage has a gain of about 0.5 and drives a bandpass filter consisting of transistors Q2 and Q3. The centre frequency of the filter is about 20kHz while the bandwidth is wide enough to allow for some mistuning of the transmitter frequency. At the same time, it effectively eliminates interference from other sources such as fluorescent and incandescant lights.

Q2 and Q3 form a two stage inverting amplifier. Both transistors operate as common emitter stages, with the second stage providing two separate outputs: one from the junction of the two 3.3kΩ resistors and the second from Q3's collector. The first output has a relatively low impedance and is used to drive the filter and to provide DC feedback via the 470kΩ resistor to bias Q2.

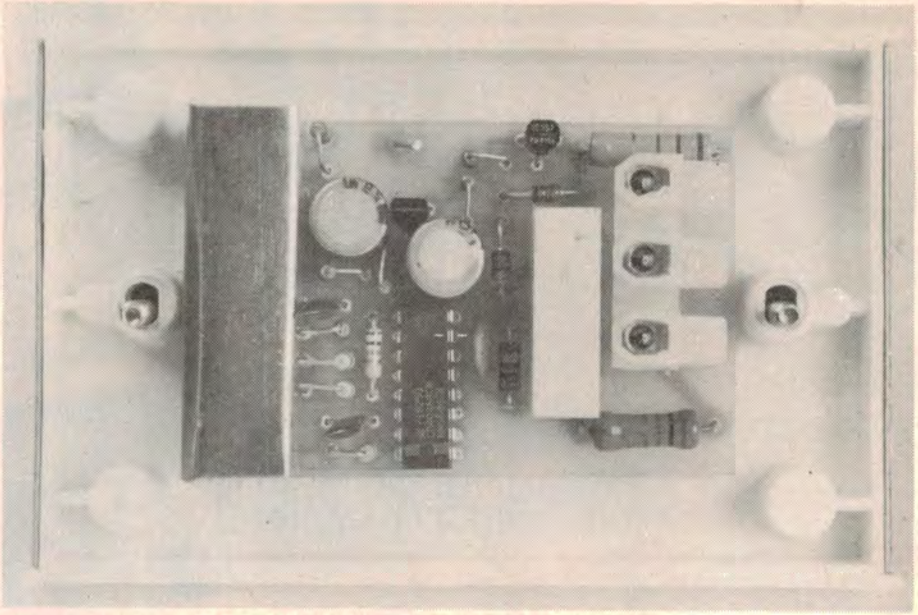
The filter components are the two 680pF capacitors and the 470kΩ bias resistor which, together with the output impedance of the previous FET stage, determine the centre frequency and Q of the filter.

Phase lock loop

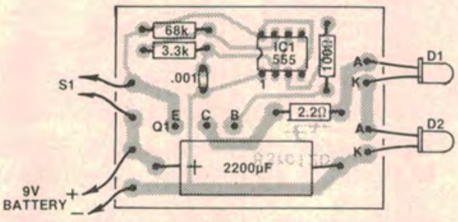
The amplified signal at the collector of Q3 is AC-coupled to the signal input of the 4046 PLL (IC1). This input has a sensitivity of about 200mV when AC-coupled which means that it can lock on to signals at or above this level.

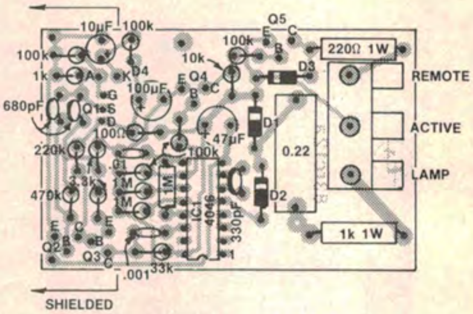
Inside the PLL is a voltage controlled oscillator (VCO), a phase comparator, a filter and a demodulator. The frequency of the VCO can be varied over a certain range by applying a DC control voltage to the VCO input (pin 9). R1 and R2, together with the 330pF capacitor (pins 6 and 7), set the range of the VCO from 10kHz to 20kHz.

What happens is that the phase comparator compares the signal frequency with the VCO and produces a control voltage to bring the VCO into lock (ie, to the same frequency). If there is no signal input, the VCO simply free runs at its minimum frequency (10kHz) and the filtered output from the phase

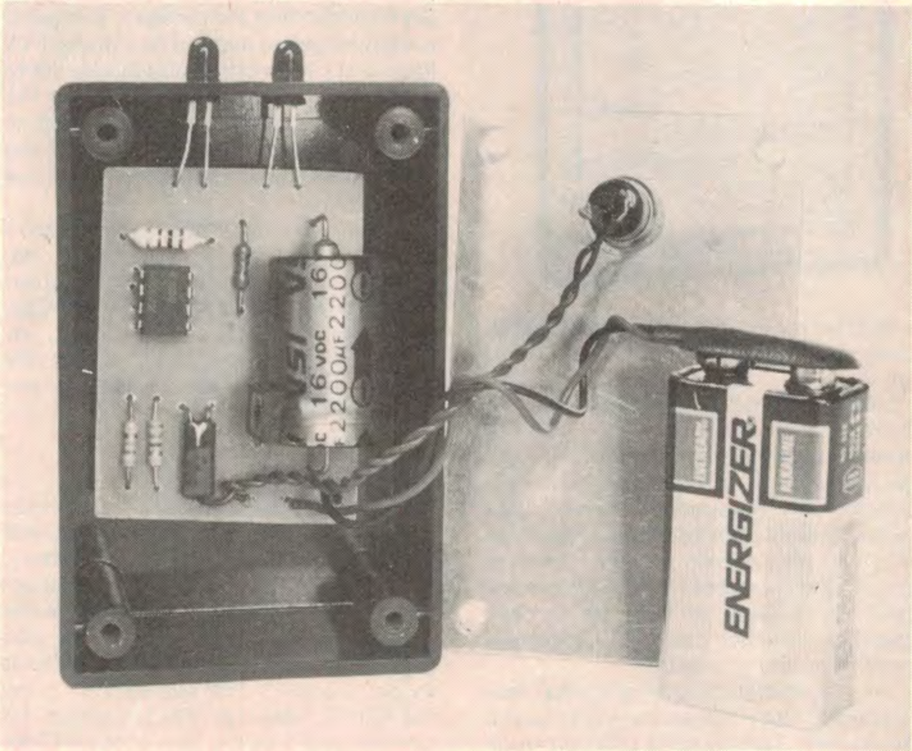


This view shows the receiver PCB mounted on the switch plate. Note the metal shield covering the sensitive input circuitry (see text and diagrams).





Install all parts exactly as shown on these overlay diagrams. Figs. 1 & 2 show the details for the metal shield.



View inside the hand-held transmitter. Use a small piece of foam insulation to prevent shorts between the battery and the PCB.

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comparator is low. This means that the demodulator output (pin 10) will also be low, since it follows the voltage on the VCO input, and that transistor Q4 will be off.

When the signal frequency is higher than the VCO, the phase comparator increases the duty cycle of its pulsed output with pin 13 remaining high for a greater proportion of time. This output is filtered by a 1MΩ resistor and a .01µF capacitor to produce a smooth control voltage on pin 9. Thus, when a 20kHz signal is received, pin 9 and the demodulator output (pin 10) both go high, turning on transistor Q4.

Q4, in turn, drives transistor Q5 which turns on and pulls the Remote input of the dimmer circuit high via a 220Ω resistor. Zener diode D3 protects Q5 from excessive collector-emitter voltages.

Note that for incoming frequencies much below 20kHz, the demodulator output will not go high enough to trigger Q4. IC1 thus provides an additional measure of filtering against frequencies below 20kHz.

Power for the circuit is derived from the mains via a 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 kept to a minimum. Diodes D1 and D2 operate in conjunction with the 0.22µF capacitor as a "charge pump" for the 47µF capacitor, while D1 performs the additional function of limiting the supply voltage to about 9.4V (ie, 10V minus the voltage across D2).

The 0.22µF capacitor acts as an impedance of 15kΩ at 50Hz and thus limits the current to an average of 16mA when the full mains voltage is applied across the Lamp and Active terminals (ie, at minimum brightness). When the lamp is at full brightness, the first 35 degrees (or 2ms) of each mains cycle is still available for the power supply (see EA, April 1983). The lower average voltage thus developed is still sufficient for zener regulation and filtering.

Construction

The Remote Dimmer receiver circuitry is constructed on a PCB coded 83rc12a and measuring 47x72mm. This PCB mounts directly onto the rear of the HPM grid plate. The transmitter circuitry is constructed on a PCB coded 83rc12b and measuring 52x39mm. This PCB, along with the 9V battery, is housed in a small plastic utility case measuring 54x29x83mm (WxDxH).

Begin construction by assembling the transmitter PCB according to the parts overlay diagram. The main point to watch here is that all polarised parts are correctly oriented. These include the 2200µF capacitor, the LEDs, the transistor and the IC. The two infrared

PARTS LIST

1 PCB, 83rc12a, 47x72mm
1 PCB, 83rc12b, 52x39mm
1 plastic utility case, 83x54x29mm
1 Scotchcal front panel, 50x79mm
1 momentary contact pushbutton switch
1 9V battery, Eveready 216 or equivalent
1 battery clip
1 3-way mains terminal strip
1 100mm length of 1mm-diameter tinned copper wire

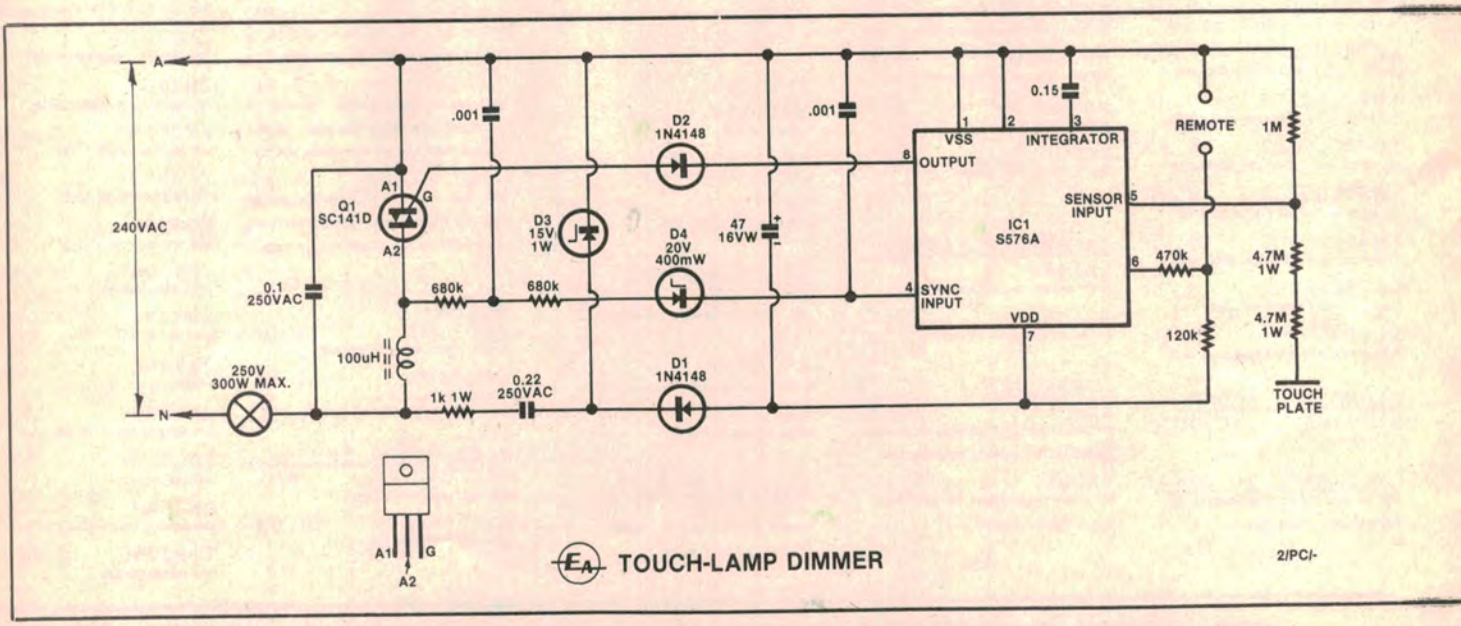
SEMICONDUCTORS
1 555 timer IC
1 4046 phase lock loop IC
1 BD140 PNP transistor
2 BC549 NPN transistors
1 BC547 NPN transistor
1 BC557 PNP transistor
1 2N5484 N-channel FET
1 18V 1W zener diode
1 10V 1W zener diode
1 1N4004 diode
2 CQY89A or LD271 infrared diodes
1 BPW50 infrared photodiode

CAPACITORS
1 2200µF/16VW pigtail electrolytic
1 100µF/16VW PC electrolytic
1 47µF/16VW PC electrolytic
1 10µF/16VW PC electrolytic
1 0.22µF 250VAC
1 .01µF metallised polyester
2 .001µF metallised polyester
2 680pF ceramic
1 330pF ceramic

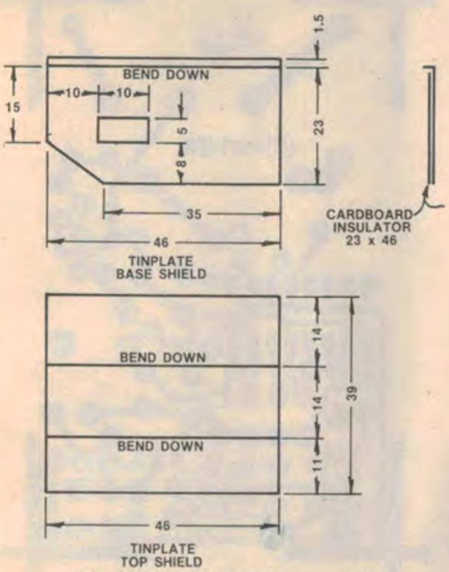
RESISTORS (¼W, 5% unless noted)
3×1MΩ, 1×470kΩ, 1×220kΩ, 5×100kΩ, 1×68kΩ, 1×33kΩ, 1×10kΩ, 3x3.3kΩ, 1x1kΩ, 1x1kΩ 1W, 1x220Ω 1W, 2x100Ω, 1x2.2Ω

MISCELLANEOUS
Clear plastic film, scrap tinplate, cardboard, solder, epoxy resin, solder etc.

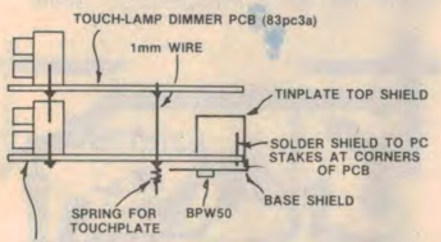
PLUS
All the parts required to build the Touch-lamp Dimmer (see April 1983)



EA TOUCH-LAMP DIMMER



DIMENSIONS IN MILLIMETRES Fig. 1



REMOTE CONTROL RECEIVER PCB (83rc12a) Fig. 2

LEDs are mounted at the extremities of their leads and bent at right angles after soldering.

Note that the body of the .001μF capacitor must be mounted flat against the PCB. This is to allow the battery to fit between the PCB and the lid of the case during final assembly.

With the PCB assembled, attach the Scotchcal label to the lid of the case and drill the switch mounting hole. You will also have to drill two 5mm holes at one end of the case to accept the infrared LEDs. These holes should be positioned so that the PCB will sit comfortably on the bottom of the case. The two infrared LEDs should protrude by about 5mm to ensure that their active areas are exposed.

The wiring to the switch and battery can now be completed according to the wiring diagram and the case assembled. We used foam insulation to isolate the battery from the PCB and to hold these items in place when the lid is screwed down.

Attention can now be turned to the remote dimmer receiver. As before, take care to ensure that all polarised components are inserted correctly and note that most of the resistors are mounted end on. Note also that alternative pad spacings have been provided for the 0.22μF capacitor. These are to suit the two different types of capacitor commonly available.

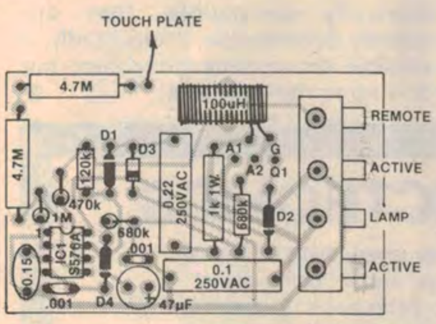
The three-way insulated terminal block is secured to the PCB using short lengths of 1mm diameter wire soldered to the copper pads allocated for the terminals.

The photodiode (D4) is mounted on the copper side of the PCB. Bend the leads at right angles adjacent to the diode body, then insert the diode so that it lies flat on the PCB with the active area facing outwards. In practice, this means that the diode body should lie under transistor Q1.

Shielding is required for the amplifier portion of the circuit and Fig.1 shows the dimensions required. Tinplate is the ideal material and this can be obtained cheaply by cutting up a tin can that previously contained Fido's dinner. The 5x10mm cutout in the base shield provides clearance for the photodiode.

A cardboard insulator is required between the base shield and the PCB, and this can be attached to the metal using double-sided tape or epoxy adhesive. This done, the two shield pieces can be attached to the receiver PCB by soldering them to earthed PC stakes (see Fig. 2). Note that the shield could touch the leads of some resistors — this is acceptable provided the leads are connected to earth. You will have no problem if you solder in the resistors exactly as shown in the parts overlay diagram.

Check the assembly carefully to ensure adequate clearance between the shield and the photodiode leads.



Left and above: reprinted from the April 1983 issue, these two diagrams depict the circuit and PCB parts overlay for the Touch-lamp Dimmer. As shown in the photos and Fig. 2, the dimmer PCB is stacked on top of the remote receiver PCB. Refer to April 1983 for a full circuit description.

Final assembly

You are now ready for the final assembly. First, remove the dimmer PCB from the grid plate by prising it gently with a screwdriver blade (be careful though, otherwise the PCB could

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shatter). This done, remove the contact spring and the three short lengths of tinned copper wire from the Remote, Active and Lamp terminals (but not from the Active terminal adjacent to the 0.1μF 250VAC (capacitor).

Fig. 2 shows the stacking arrangement for the two PCBs. As shown, the touchplate contact spring is soldered to a pad on the receiver PCB and a 23mm length of 1mm tinned copper wire run to the contact (or touch) pad on the dimmer PCB. Connections between the two terminal blocks are made using three 20mm lengths of 1mm tinned copper wire – one each soldered to the Remote, Active and Lamp terminals of the dimmer PCB.

Solder in each 20mm length of wire so that it extends 8mm above the surface of the dimmer PCB, then insert the wires into the terminal blocks and tighten the screws. Provided that you use 1mm tinned copper wire for all connections, no further support will be required between the two boards.

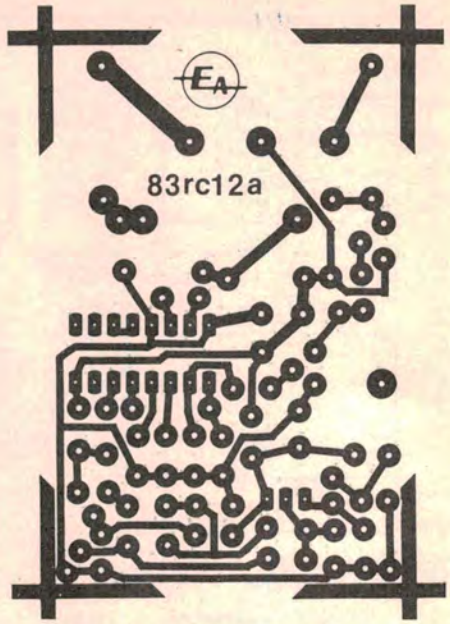
The PCB assembly is centrally located on the rear of the plastic grid plate. You will have to mark out and cut a hole in the grid plate for the photodiode, together with a matching hole in the metal faceplate. Make sure that these holes are large enough to admit light to the full active area of the photodiode. It will not be necessary to drill a new hole in the grid plate for the contact spring, since the existing hole can be re-used.

Because the photodiode leads are at mains potential, a rectangular sheet of stiff, clear plastic should be fitted over the cutout for the photodiode (the plastic used for shirt box lids is ideal). This should be glued directly to the plastic grid plate using a suitable adhesive (eg, "Airfix") so that, when the metallic cover plate is clipped into position, the plastic window is sandwiched between the two.

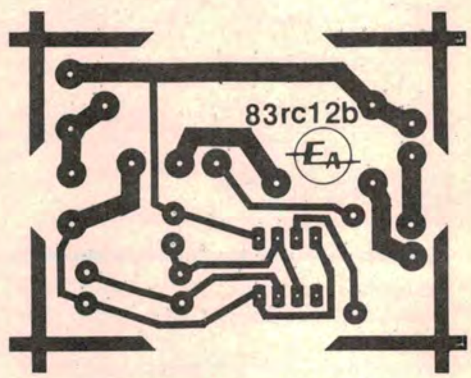
The PCB assembly can now be affixed with epoxy resin to the rear of the grid plate and the touchplate checked for correct isolation. Set your multimeter to the highest range and check that the resistance between the touch plate and the active terminal on the dimmer PCB is about 10MΩ. If the circuit fails this test, check carefully for faults and rectify any problem before proceeding.

Installation of the completed unit is exactly the same as for the original Touch-lamp Dimmer circuit in the April 1983 issue. The new unit is designed to fit a standard wall box and, just in case you're wondering, the remote switching option can be added as before.

Finally, some readers may be wondering if the remote control option can be fitted to the Touch-lamp Timer described in August 1983. The simple answer is that while the two circuits are electrically compatible, they are physically incompatible. Undoubtedly, it is possible to overcome this problem but that is up to the individual.



Here are actual size artworks for the PCBs and the transmitter front panel.



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

$26

This includes sales tax but does not include the cost of the Touch-lamp Dimmer.