Constructional Project

HANDCLAP SWITCH

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Let there be light – quick as the clappers!

THIS circuit has been designed to give you an easy life. No need to bend down to turn on awkwardly positioned switches, just clap your hands and the controlled appliance will be turned on for you.

The block diagram in Fig.1 shows how the circuit is split up into separate sections. The sound made by a handclap is picked up by an electret microphone, amplified by an op.amp, half-wave rectified and then cleaned up by a Schmitt trigger.

There is then a switched choice of either using the Timer circuit, which turns on a relay for a predetermined time set by a potentiometer, or using the Latching circuit, which turns on the relay until another handclap is received to turn it off.

CIRCUIT DIAGRAM

The circuit diagram for the Handclap Switch is shown in Fig.2.

The electret microphone is shown as MIC1 and is powered via resistor R1. Incoming sounds are a.c. coupled by C1 and fed to the non-inverting input (pin 3) of op.amp IC1. This input is d.c. biased at half the supply voltage by the potential divider formed by resistors R2 and R3.

The op.amp's gain is set at about 471, as determined by the values of resistors R4 and R5, i.e. (R4/R5) + 1. Capacitor C2 provides d.c. stability of the feedback path. The amplified output signal at IC1 pin 6 is a.c. coupled by C3 and fed to the preset amplitude control VR1.

From the wiper of VR1, the signal is rectified by the diode pump circuit comprising C4 and diodes D1 and D2. The resulting output voltage from D2 is smoothed by the *CR* network formed by C5 and R6.

From C5, the rectified voltage is fed to the Schmitt trigger circuit formed around NOR gates IC2a and IC2b. This circuit "cleans-up" the amplitude changes from C5 so that well-shaped logic level changes are output from IC2b pin 4.

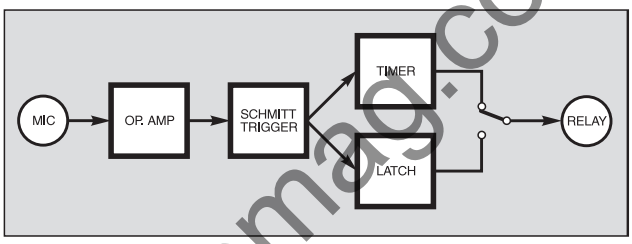


Fig.1. Block diagram for the Handclap Switch.

The voltage input to IC2a via R7 has to rise to well over half of the supply voltage before the output at IC2b will switch to logic 1. The output will only revert to logic 0 when the input falls to well under half the supply voltage. This helps to prevent false triggering of the circuit.

The latching part of the circuit is based on a D-type bistable, IC3a, which is configured as a T-type (toggle), by tying pin 2 to pin 5. This enables its output Q to latch high when a high-going trigger pulse from IC2b is received at pin 3. It then latches low again when it receives the next pulse. After which the next pulse toggles the output high again, and so on.

TIMING CIRCUIT

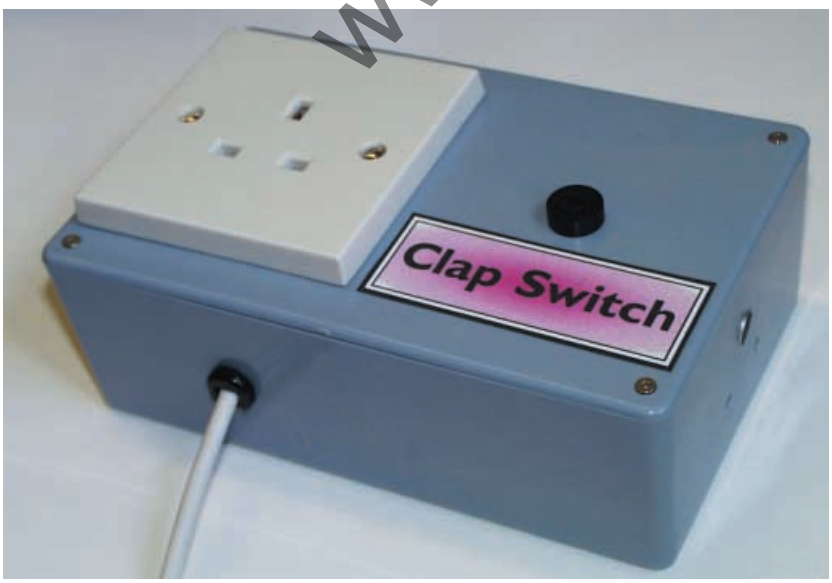
The Timing circuit is based around NOR gates IC2c and IC2d, configured as a monostable. The circuit's time constant (the time that its output stays high once triggered) is set by the value of capacitor C7 and the total resistance through preset VR2 and resistor R9.

The timing formula is $T = 0{\cdot}7 \times R \times C$, where T is the time for which the circuit remains triggered, in seconds, R is the resistance in Ohms and C is the capacitance in Farads.

This circuit uses values of R = 1M + 15k = 1015000 ohms, and C = 100μF = 0·0001F. In theory, therefore, the maximum time the circuit can remain on is: $0{\cdot}7 \times 1015000 \times 0{\cdot}0001 = 71{\cdot}05$ seconds. In practice, component tolerances will produce somewhat different timings, but the formula provides a guide to expectations.

If a longer time is required then a larger capacitor can be used, but it should not exceed 2200µF as timings will begin to be unpredictable, due to current leakage through the capacitor. The fixed resistor R9 ensures that the total resistance can never be zero, even if VR2 is set to zero resistance. The value for R9 was chosen so that the minimum timing period is approximately one second.

Switch S1 selects whether the latching or timed circuit is used, the chosen output feeding via resistor R10 to transistor TR1. When the output is high, the transistor is turned on, so activating the relay, RLA. Diode D3 prevents back-e.m.f. (voltage spikes) from being generated at the moment that the relay is turned off.



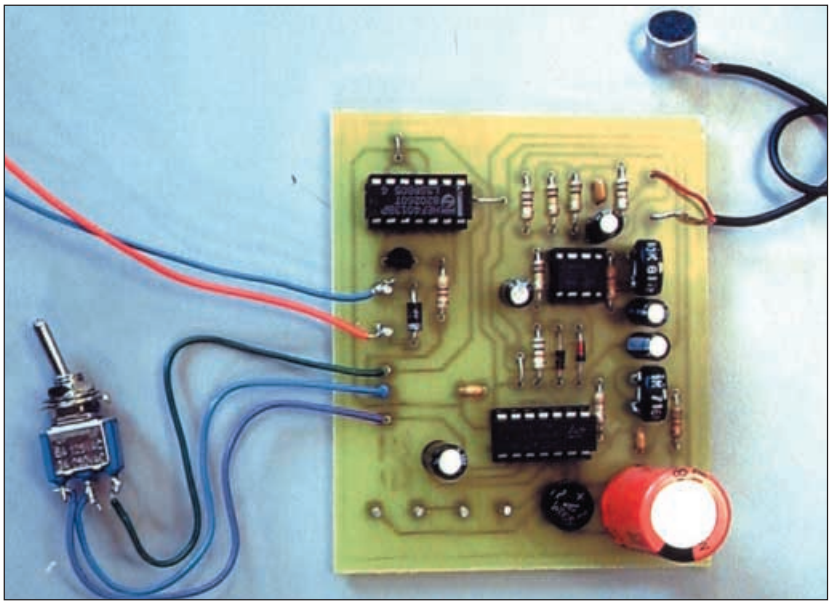
POWER SUPPLY

The power supply circuit is also shown in Fig.2. Power is derived from the a.c. mains and transformer T1 provides an isolated output voltage of 9V a.c., at up to about 100mA. A higher-current transformer may be used if preferred. The 9V a.c. supply is bridge-rectified by REC1 and smoothed by capacitor C9, producing a d.c. supply of about 12V.

Fuse FS1 is included in the 9V a.c. supply line and should be rated to suit the maximum current that is permitted to be drawn from the transformer.

Although not included in the prototype, a fuse should also be included in the mains a.c. live supply line before the connection to the relay and transformer. This should be rated to suit the maximum load that the relay is required to switch, plus about 1A margin for the current through the primary winding of the transformer.

A neon lamp, LP1, is wired across the mains supply, following fuse FS2, indicating when mains power is connected.



CONSTRUCTION

Since this unit contains mains voltage, great care should be exercised in its construction. If in any doubt about construction consult a qualified electrician. Mains voltage can be lethal if abused.

Apart from the electret microphone, switch, relay and transformer, all the components are contained on a single printed circuit board (p.c.b.). The topside component layout and the full size underside copper foil track master are shown in Fig.3. This board is available from the *EPE PCB Service*, code 270.

Begin construction by soldering in the resistors and wire links. Ensure that the electrolytic capacitors, transistor, diodes and bridge rectifier are connected the right way round. Use sockets for the three i.c.s, but do not insert the i.c.s until construction has been completed (ensure their correct orientation when they are fitted).

If you choose not to use the timer circuit, VR2, R9, C6 and C7 can be omitted and a wire link inserted to join IC3 pin1 to R10. If you choose to omit the latching circuit, IC3 and C6 can be omitted and a wire link inserted to join IC2d pin11 to R10. In both cases S1 is omitted.

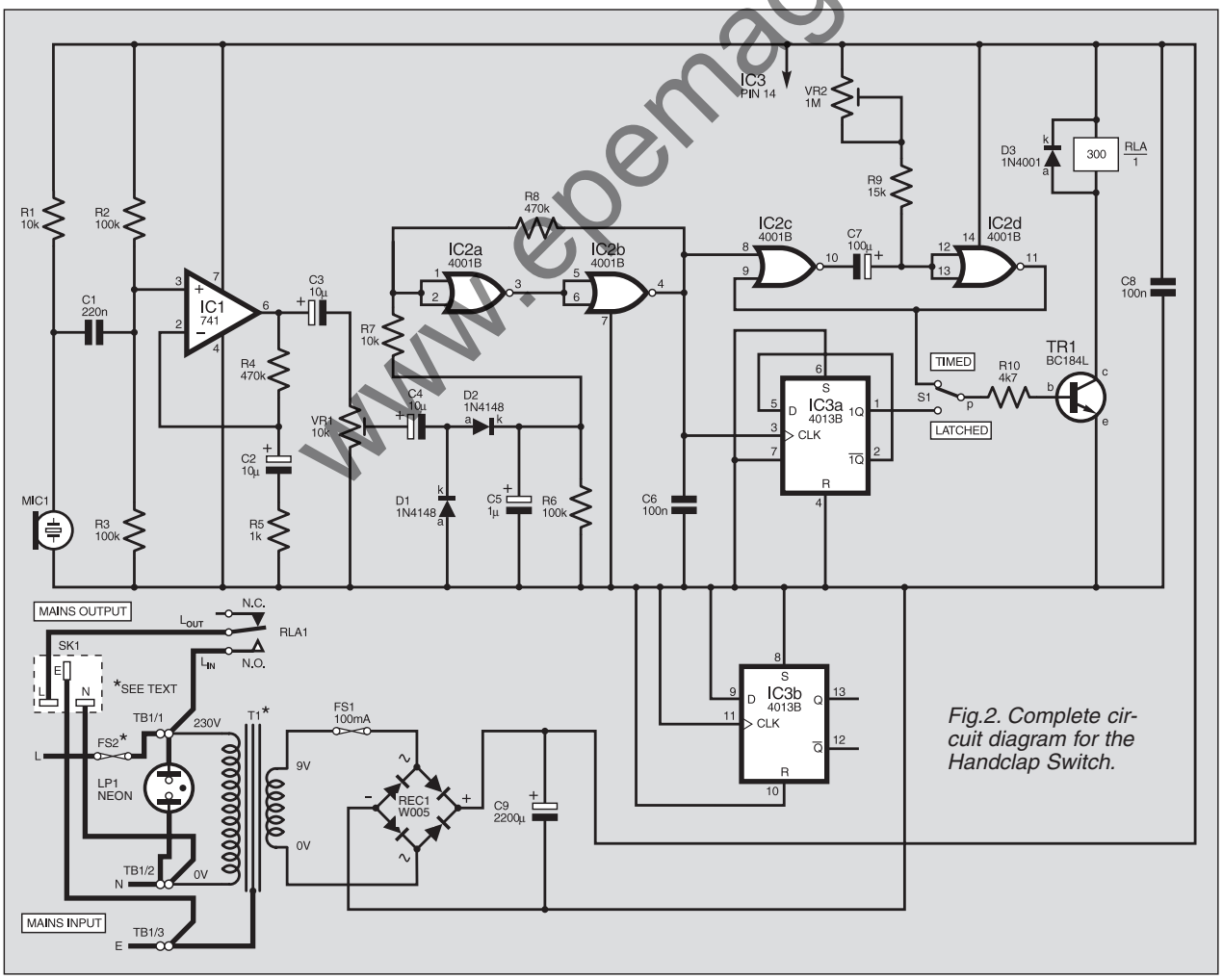


Fig.2. Complete circuit diagram for the Handclap Switch.

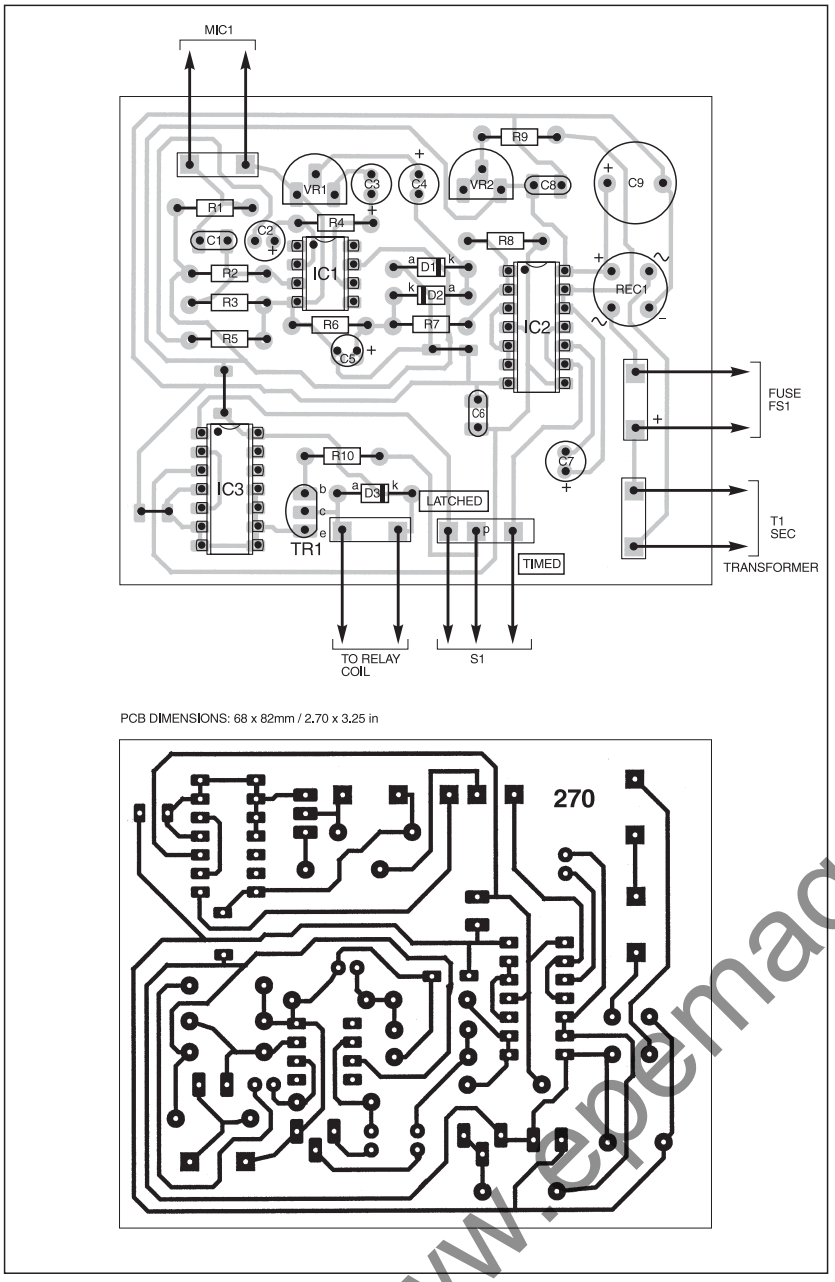


Fig.3. Printed circuit board component layout and full size copper foil track master pattern.

CASING

The mains voltage section of this unit should be kept in a separate compartment of the box to ensure that it is completely isolated from the low voltage circuit.

This is done by inserting a plastic partition inside the case. A small slot should be made at the bottom of it, allowing the *low voltage* wires from the relay and transformer to come through. The partition should be cut so that it fits securely in the slots provided in the side of the case.

The transformer should be firmly bolted to this partition. The relay is glued to it, using good quality adhesive that is suited to the plastic of the partition and of the relay's cover. *It is essential that the relay can never break its bond with the partition.*

Drill holes in side of the case to suit the positions of the electret microphone, switch S1, mains input cable grommet, neon and fuse FS2. In the lid, drill a hole for fuse FS1 and make a cut-out into which the 13A output socket will fit snugly, drilling holes for its mounting bolts as well.

Additionally, two holes are required to allow adjustment access to the two preset potentiometers using a small screwdriver.

The mains input cable used in the prototype is rated at 3A, which is fine for a low current item such as a desk lamp, for example. However, if you wish to switch higher current appliances, like an electric fire, then mains cable rated at **13A must** be used. (The relay must be capable of switching the voltage and current of the appliance to be controlled, i.e. 230V a.c. 13A.) A clamping grommet must be used with the mains input cable to prevent it being pulled out.

A set of three terminal blocks is used to connect up the mains to the wires for the transformer, relay and neon. This should be bolted securely to the base of the case, through holes drilled in a suitable position.

The mains wires connecting between the relay and the output socket must have the same rating as the mains input cable. They are soldered to the relay terminals.

TESTING

Once the p.c.b. has been assembled, fully check for any mistakes, and the quality of soldering.

COMPONENTS

See SHOP TALK page

Resistors

R1, R7	10k (2 off)
R2, R3, R6	100k (3 off)
R4, R8	470k (2 off)
R5	1k
R9	15k
R10	4k7

All 0·25W 5% carbon film.

Potentiometers

VR1	10k min. preset, vertical mounting
VR2	1M min. preset, vertical mounting

Capacitors

C1	220n ceramic disc
C2 to C4	10μF elect. radial, 25V (3 off)
C5	1μ elect. radial 25V
C6, C8	100n ceramic disc (2 off)
C7	100μ elect. radial, 25V
C9	2200μ elect. radial, 25V

Semiconductors

D1, D2	1N4148 signal diode (2 off)
D3	1N4001 rectifier diode
TR1	BC184L, or other gen. purpose *npn* transistor
REC1	W005 50V 1A bridge rectifier
IC1	741 op.amp
IC2	4001B quad 2-input NOR gate
IC3	4013B dual bistable (flip-flop)

Miscellaneous

LP1	mains neon, panel mounting
MIC1	electret microphone insert
RLA	min. 12V s.p.s.t. relay, contact rating to suit powered appliance
S1	s.p.d.t. toggle switch
T1	mains transformer, 9V a.c. 100mA secondary
FS1	100mA fuse, 20mm
FS2	mains rated fuse, value to suit powered appliance (see text)

Printed circuit board, available from the *EPE PCB service*, code 270; plastic case, 185mm × 115mm × 65mm; plastic insert to suit case (see text); fuseholder, panel mounting, 20mm (2 off); cable grommet, locking, panel mounting; 8-pin d.i.l. socket; 14-pin d.i.l. socket (2 off); 3-way mains rated terminal block, screw terminals, bolt mounting; nuts and bolts to suit; p.c.b. supports, self-adhesive (4 off); mains rated cable (see text); 13A mains socket, flush mounting; earthing solder tag; connecting wire; solder, etc.

Approx. Cost Guidance Only **£23** *excluding case and mains socket*

In the prototype, the p.c.b. is secured to the base of the case using self-adhesive p.c.b. supports. However, it is advisable not to fully secure the p.c.b. until testing is complete.

The first thing to check is that the d.c. output from the rectifier circuit is the correct voltage, of around 12V. If it is not, immediately disconnect the circuit from the mains and check that the transformer, bridge rectifier and capacitors have been connected correctly.

To start testing, adjust preset VR2 for its minimum resistance in series with resistor R9. To adjust preset VR1 to its correct setting, first adjust it for maximum signal output at its wiper, then turn it back about ten degrees.

These two settings should give you a sensible level in respect of the amplified electret microphone signal, and also a time delay of one second for the timer circuit.

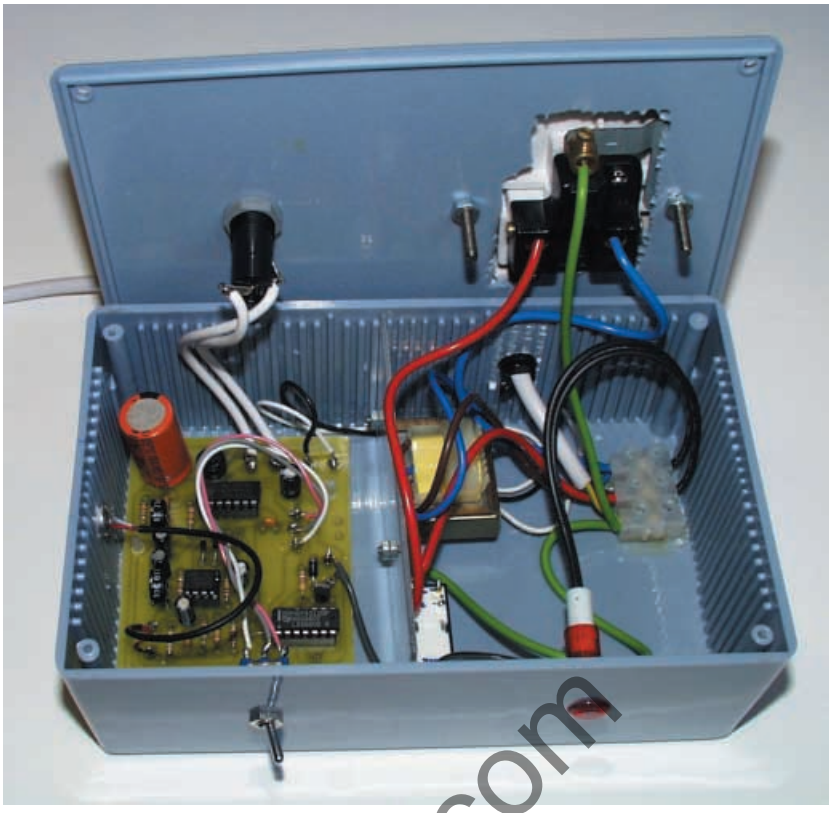
COMMON PROBLEMS

Typical constructional mistakes include dry solder joints and adjacent p.c.b. track pads accidentally bridged together with solder. Other problems include failure to insert wire links.

Also check that the components are correctly placed, and the correct way round.

FAULT FINDING

To assist in fault finding, temporarily disconnect the wires between the p.c.b. and the relay coil. Connect a light emitting diode (l.e.d.), with a 1kΩ ballast resistor in series, to the p.c.b. terminals provided for the relay coil connection. The l.e.d. will provide you with a way of knowing if the circuit is working.



Interior of the assembled Handclap Switch. Note that the mains connections are well isolated from the low voltage circuit and that the central partition fully separates the two sides of the box. This prototype does not include the mains fuse FS2.

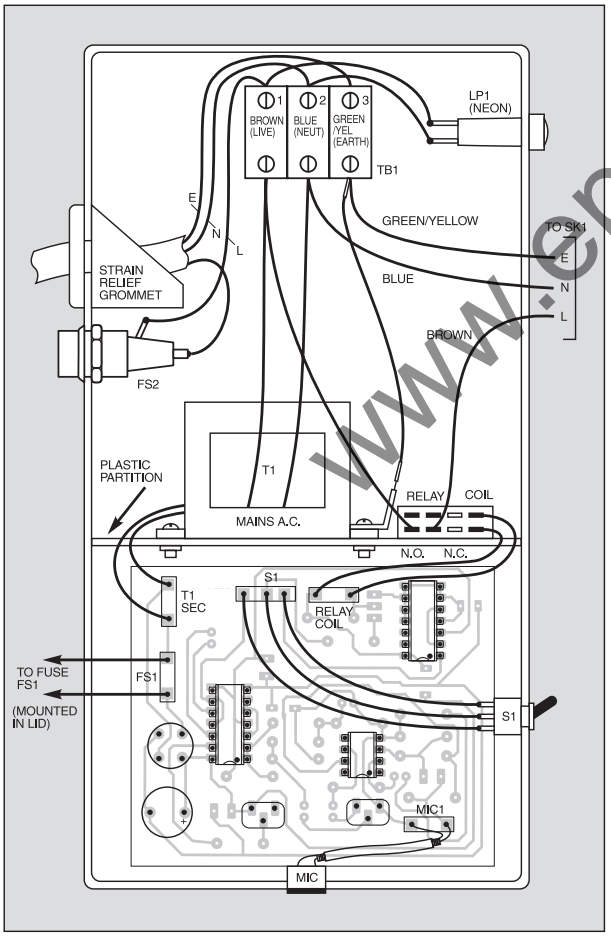


Fig.4. Interwiring between the two partitioned areas and the off-board components.

Testing can be done using a multimeter but it is preferable to use an oscilloscope as the signal sometimes fluctuates. Start by again testing the power supply, which should still be around 12V. Next connect the oscilloscope to the positive side of the electret microphone (junction with resistor R1) to see if sounds are being received when you clap hands.

After that, check that the voltage at pin 6 of IC1 is at 6V when no sound is occurring, and that the sound signal is amplified when it is present. If a suitably amplified signal is present, check that the voltage at IC2a pins 1 and 2 is above 6V. If this is not so, check that diodes D1, D2 and capacitors C4, C5 are connected the correct way round, and that VR1 is not set to minimum gain.

If all is well the output at IC2b pin 4 should be 12V when a sound signal is present.

Connect a meter to switch S1 pin 1 then to S1 pin 3. Pin 3 should remain high until you clap your hands again, which should cause it to go low.

Pin 1 of switch S1 should remain high for the period set by VR2, R9 and C7 and then go low. If it does not, check that C7 is connected the correct way round.

SETTING UP

Both presets, VR1 and VR2, can be adjusted to suit the user's particular needs. The following is a summary of their functions:

VR1: Sets the sensitivity of the circuit to sound.

VR2: Only used if the timer circuit has been selected by switch S1. It sets the time for which the timer remains active. Reducing the resistance reduces the timing period.

IN USE

This design can be used to turn on any normal mains powered domestic appliance, within the limits of the cabling and value of fuse FS2.

Plug the appliance into unit's output socket, clap hands or shout and it will turn on, either:

1) for a timed period up to about 70 seconds, or

2) until you clap or shout again.

These options can be chosen with the selection switch S1. □