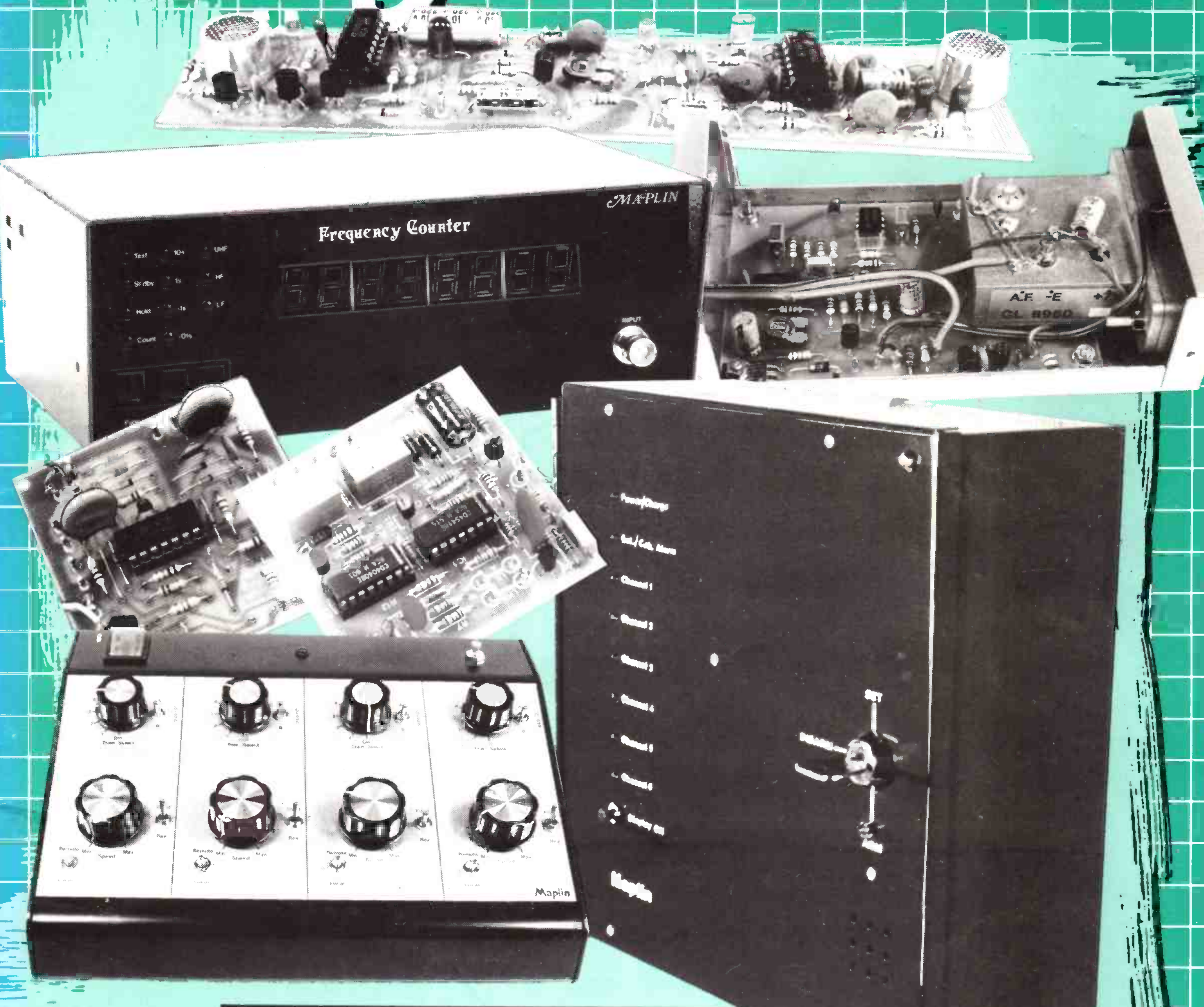
Best of Maplin PROJECTS

XC01B BOOK 1



- ★ Burglar Alarm System
- ★ Radar Intruder Alarm
- ★ Panic Button
- ★ Ultrasonic Alarm
- ★ External Horn
- ★ Multi-train Controller
- ★ Model Train Circuits
- ★ Frequency Counter

CONTENTS

BEST OF MAPLIN PROJECTS BOOK ONE

EDITORIAL

■ 'Best of Maplin Projects Books One and Two', are compilations of the most popular projects from 'Maplin Projects Books Two to Eight', which are now out of print. Other issues of 'Maplin Projects Books' will be replaced by 'Best of' projects books as they go out of print. Back issues of 'Electronics – The Maplin Magazine' are available until they, too, go out of print and will then be replaced by projects books. For kit prices, please consult the latest Maplin price list, order as XF08J. The price list also contains details of how to obtain a year's subscription to 'Electronics – The Maplin Magazine'.

R.T. Smith

■ **Editor** Roy Smith ■ **Compiled by** Robert Ball.
■ **Contributing Authors** Dave Goodman, Robert Kirsch and Chris Barlow.
■ **Technical Editors** Dave Goodman, Chris Barlow, Gavin Cheeseman, Tony Bricknell, Alan Williamson
■ **Technical Author** Robert Ball
■ **Technical Artists** John Dudley, Lesley Foster, Paul Evans, Ross Nisbet.
■ **Art Director** Peter Blackmore
■ **Art Editor** Jim Bowler.
■ **Art Assistants** Eugene Francis, Phillip Fey, Paul Owen
■ **Print Co-ordinators** Brian Lauezzari, Martin Needs, Ken Wakefield.
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■ **Trade Sales:** (0702) 554171
■ **Cashtel:** (0702) 552941
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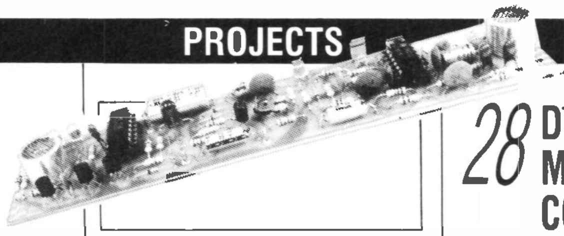
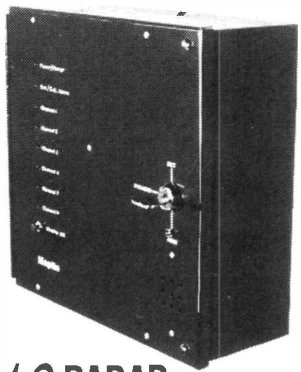
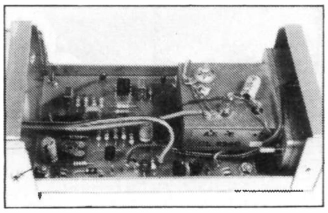
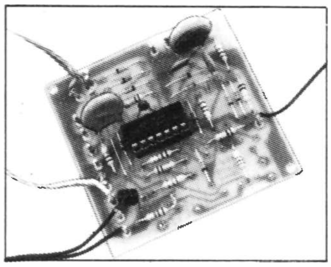
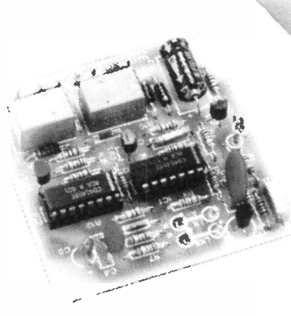
PROJECTS

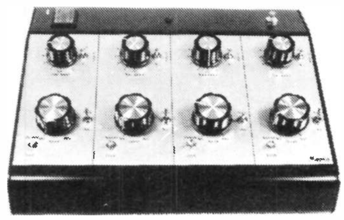


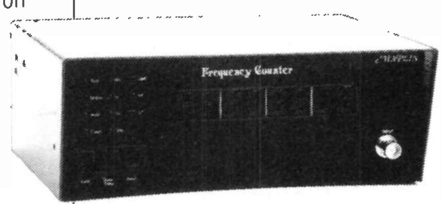








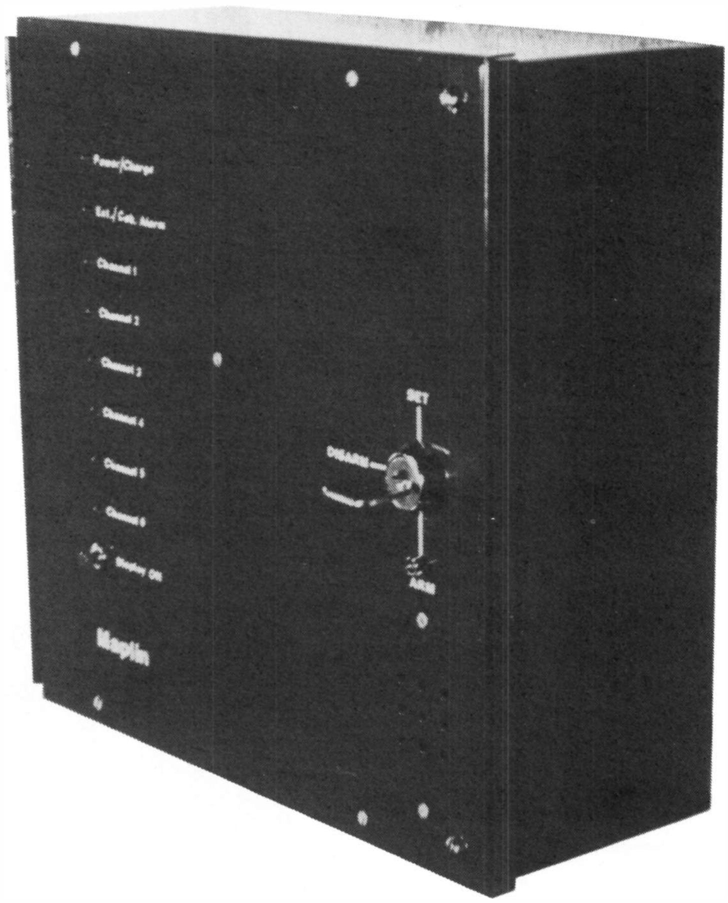




HOME SECURITY SYSTEM

by Dave Goodman

- ★ **Six independent channels with two groups per channel**
- ★ **Two or four wire operation with line sensing of open or short circuit or resistance change (jumping)**
- ★ **Tamper-proof main cabinet**
- ★ **External horn loop control has its own open/short circuit and jumping protection**
- ★ **Presettable entry and exit delay timers**



This new home security system offers a high degree of protection for domestic or commercial premises coupled with excellent long-term reliability. The unit is mains operated, but will run off its small internal nickel-cadmium rechargeable battery pack for 2 to 3 days depending on the size of the system. The internal battery is continuously charged when the mains is present and changeover from mains to battery and vice-versa has no effect on the system. CMOS circuitry is used throughout to minimise current drain.

There are sockets for six separate plug-in channels so that for example all downstairs windows could be connected to one input, all downstairs doors to another, all upstairs windows to another and perhaps shed and garage doors and windows to another. When setting the system you know immediately where to look for the window left open accidentally if the system will not set. Or parts of the system only may be set. For example, during the late evenings, the shed and garage circuit only could be set. Whatever your requirements this system offers the fullest possible flexibility for complete security.

The external horn is also fully protected when fitted with dry batteries. Its prominent position alone will deter most burglars, but any attempt to tamper with it will set it off. If the wires to it are cut or tampered with, the horn will sound. Even ripping the box off the wall will not stop the alarm. The recommended dry batteries will sound the alarm at full power for at least four hours even if the wires are cut.

The alarm is extremely easy to build, with internal wiring kept to an absolute minimum. Operation is by a single keyswitch and exit and entry delays may be preset to suit your requirements. There is an LED for each channel, giving monitoring facilities and an internal sounder giving 'alarm condition' tones. Even the main cabinet is protected, by a microswitch fitted to the PSU pcb.

Circuit Description

Mains PCB

The key switch S9, which is shown in Figure 1 with its contacts made, controls the 'disarm' and 'set' conditions of the alarm unit. TR1 is conducting and thus inhibiting the exit delay timer oscillator IC1c and d, and IC2, a 14 stage counter/divider, is held reset.

The oscillator IC1c and d is frequency variable between 25Hz (40ms) and 10kHz (100μs). This clock signal is divided down by IC2 by 8192 giving a minimum time out period of 0.8s and a maximum period of 5.5 mins. So allowing for variations in tolerances, IC1c, d and IC2 function as an exit delay timer presettable by RV1 giving periods of between 0 and 6 mins.

IC1a, b and IC3 function as described above but are used as an entry delay timer, presettable by RV2.

In the disarm mode IC2 pin 3 is at 0V and D2 is conducting. Consequently exit delay tone modulator IC5 c and d is inhibited. IC10a output is high, holding TR5 and LED9 ('ARM' LED) off. Latch IC10 b and d output is high. Entry delay timer is held off via D4 and IC10b output low. Counter IC3 pin 3 is low and alarm tone modulator IC5a and b is inhibited via D7 conducting.

Latches IC7, 8 and 9 have normally high outputs connected to LED buffer IC11 preventing channel LEDs 3 to 8 from turning on. A positive trigger pulse greater than 25ms in duration present at any of the inputs to the latches from switches S3 to 8 allows the channel LEDs to turn on for the duration of the triggering signal.

Switch S2 operates TR7 which discharges C13 and operates TR6, the LED display. TR6 remains on for the time constant set by R43 and C13, approximately 90s.

Operating switch S9 (contacts open) in the 'set' mode turns TR1 off. This removes the inhibit on the exit delay oscillator IC1c and d allowing it to run at the frequency determined by RV1. IC2 divides this signal and IC2 pin 3 goes high. While IC2 is counting, D2 is not conducting and IC5 c and d run at a frequency of approximately 8Hz. The inhibit on the tone generator IC6 b and c is removed allowing it to run at approximately 3kHz modulated at 8Hz.

At the end of the timing period, IC2 pin 3 goes high, inhibiting IC5d and IC6d. IC10a goes low, TR5 conducts and the 'ARM' LED turns on. IC10d inhibit is removed and a positive trigger pulse from switches S3 to 8 latches

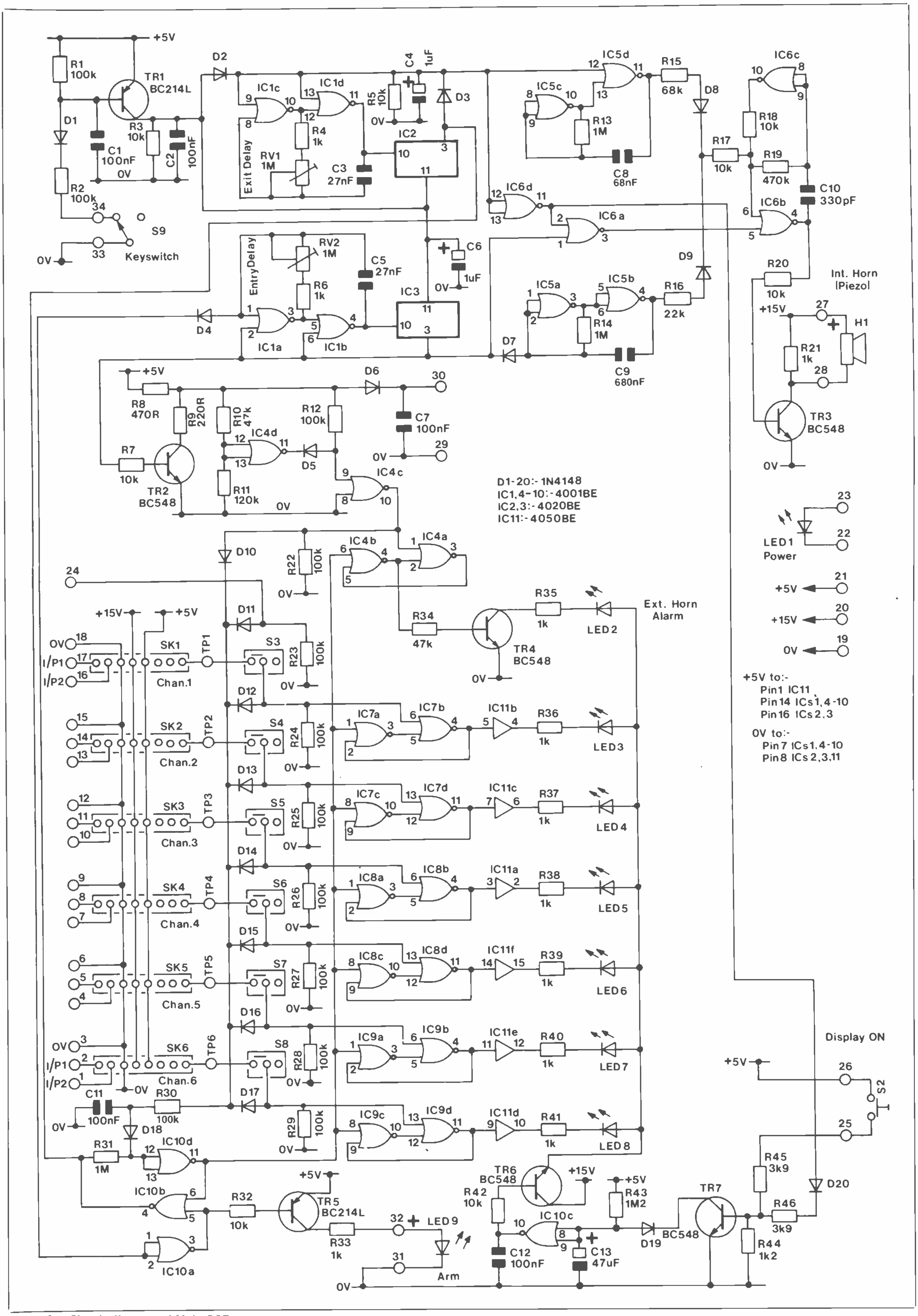


Figure 1. Circuit diagram of Main PCB.

IC10d low. The appropriate IC7, 8 or 9 goes low and latches, operating a channel LED.

This same trigger pulse also removes the inhibit on the entry delay oscillator IC1a and b via IC10 b and d. Consequently it begins to run at the frequency set by RV2. IC3 divides the clock signal and when pin 3 goes high the oscillator stops running, TR2 conducts, latching IC4 a and b, and operating LED 2.

Alarm tone modulator IC5a and b runs at 0 to 5 Hz and modulates the 3kHz tone oscillator IC6b and c developing the alarm tone signal at H1.

Power Supply

The power supply is shown in Figure 2. T1, BR1 and C2 provide 15V to the LED arrays, speaker output stages and charging circuit. C1 is a 0.1uF interference suppressor, which removes transient spikes from the mains.

LED1, R3, R1, TR1 and D1 form a constant current source for charging the six 1.2V nickel cadmium batteries used for power failure standby. The alarm current requirement is very low so that fully charged batteries will provide enough power for a few days. The trickle charge is set by R1 to 4mA and is temperature stabilised by LED1.

The supply voltage at pin 7 is approximately 15V and the battery supply is 7.5V. D2 will normally be reversed biased when mains voltage is applied and REG1 will deliver +5V at 100mA. LED1 also serves as a mains pilot light.

Removing the mains supply extinguishes LED1, removes the charging current and forward biases D2. Pin 7 drops to +7.5V while pin 8 remains at +5V. C3 and 4 ensure that no spurious spikes are produced during changeover to battery standby. The batteries should be checked periodically. If standby power is not required, short circuit pins 4 and 5 together to light LED1.

Break Contact Module

The break contact module shown in Figure 3 works on a balanced line system. The line (contact) inputs, 1 and 2, are set for +2.5V measured on TPA and TPB and adjusted with RV1 and RV2.

Up to five switch contacts (and 22k resistors) are used on each input allowing ten contacts per module as shown on Figure 18. The number used is dependant on the system mode chosen.

IC1 has R3 connected between input and inverting output. The gate is therefore used in its linear region and the output (at the test points) will be balanced at half the supply.

A high or low voltage swing, at the inputs, is detected by IC1a and d, and the output, normally low, will pulse high for the duration of the input change.

External Horn

The external horn circuit is shown in Figure 4. R1 terminates the security loop connected from pins 1 and 2 to pins 30 and 29 on the main PCB. A current, set at 3mA, is generated in the loop and cutting, short circuiting or reversing, will bias TR1 into conduction. TR2 will switch on and the battery pack then supplies H2. Note that TR1 supplied in the kit has been especially selected with suitable electrical characteristics, another 2N4393 sourced from elsewhere may not operate properly.

Returning the loop back to its normal condition would appear to bias TR1 off and prevent H2 from operating. This does not happen, owing to detection circuit IC4c, d (Figure 1) R10, 11, 12 and D6 switching, and dropping the loop current down to 1mA. The horn will continue to sound until the main alarm key switch is turned off.

Please note that with internal batteries connected, the horn will sound immediately, until the security loop is connected. So when fitting the system, the loop must be wired to the main alarm first, and then connect the batteries (see Figure 9).

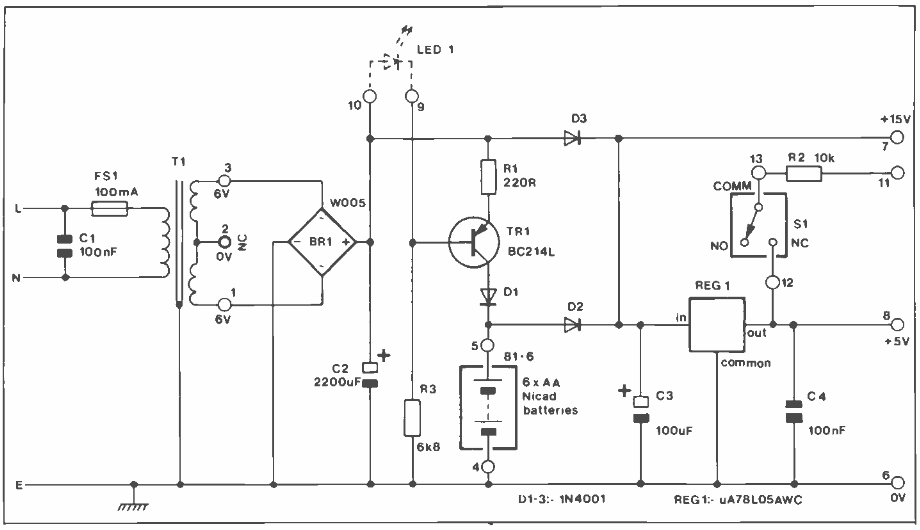


Figure 2. Circuit diagram of PSU.

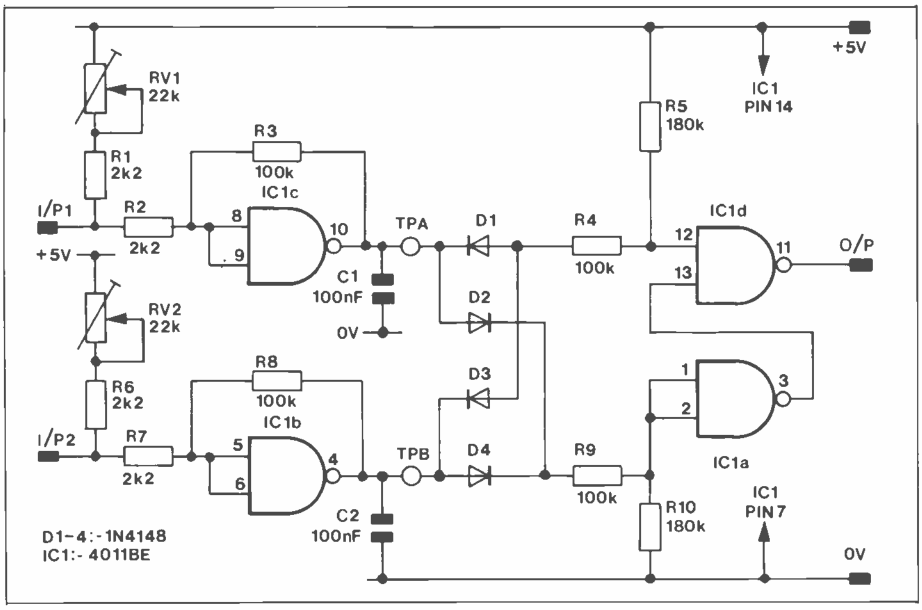


Figure 3. Circuit diagram of Break Contact Module.

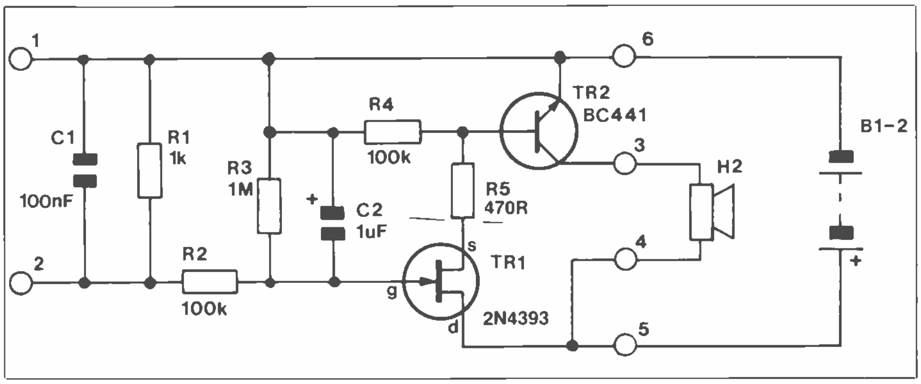


Figure 4. Circuit diagram of External Horn PCB.

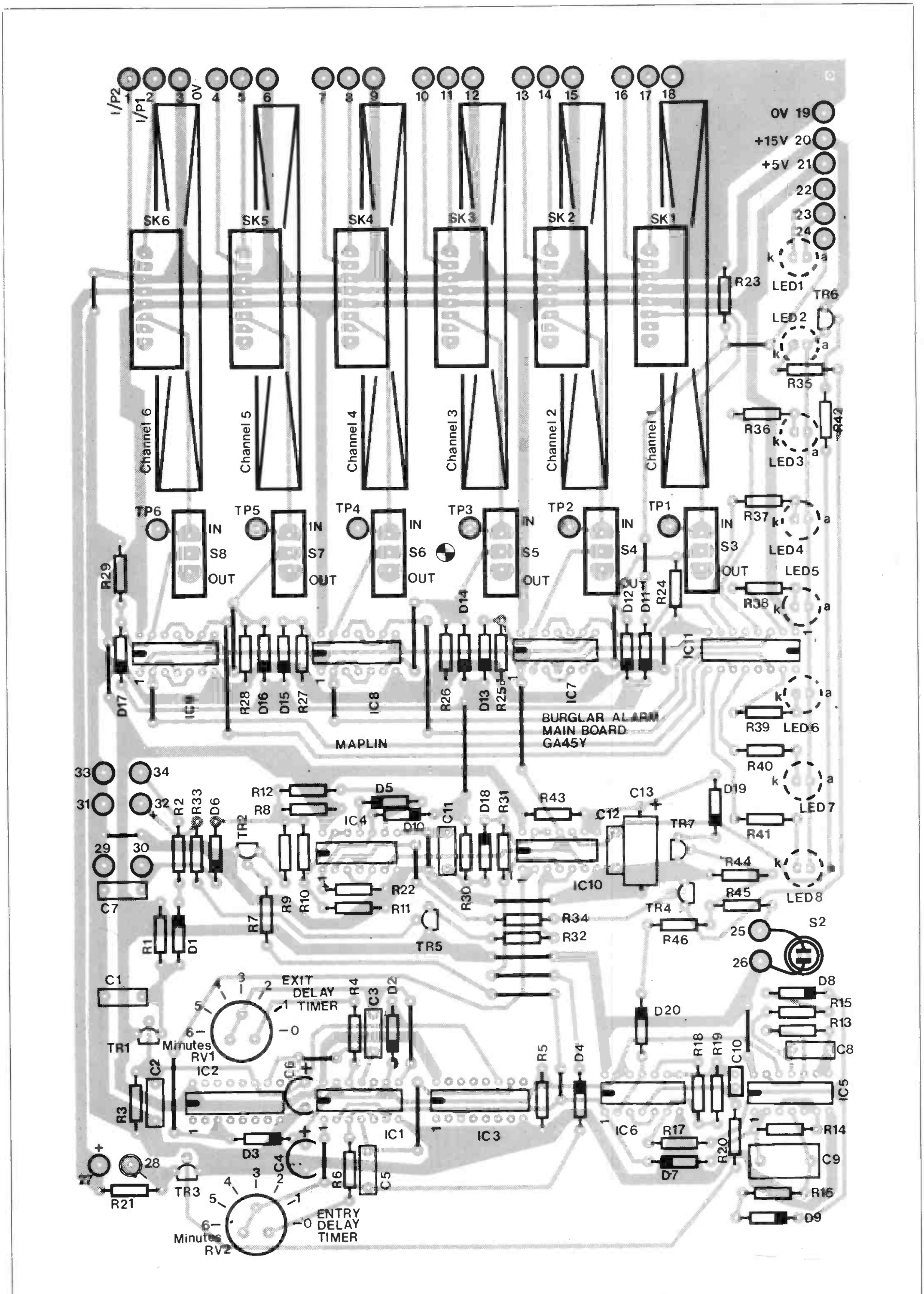
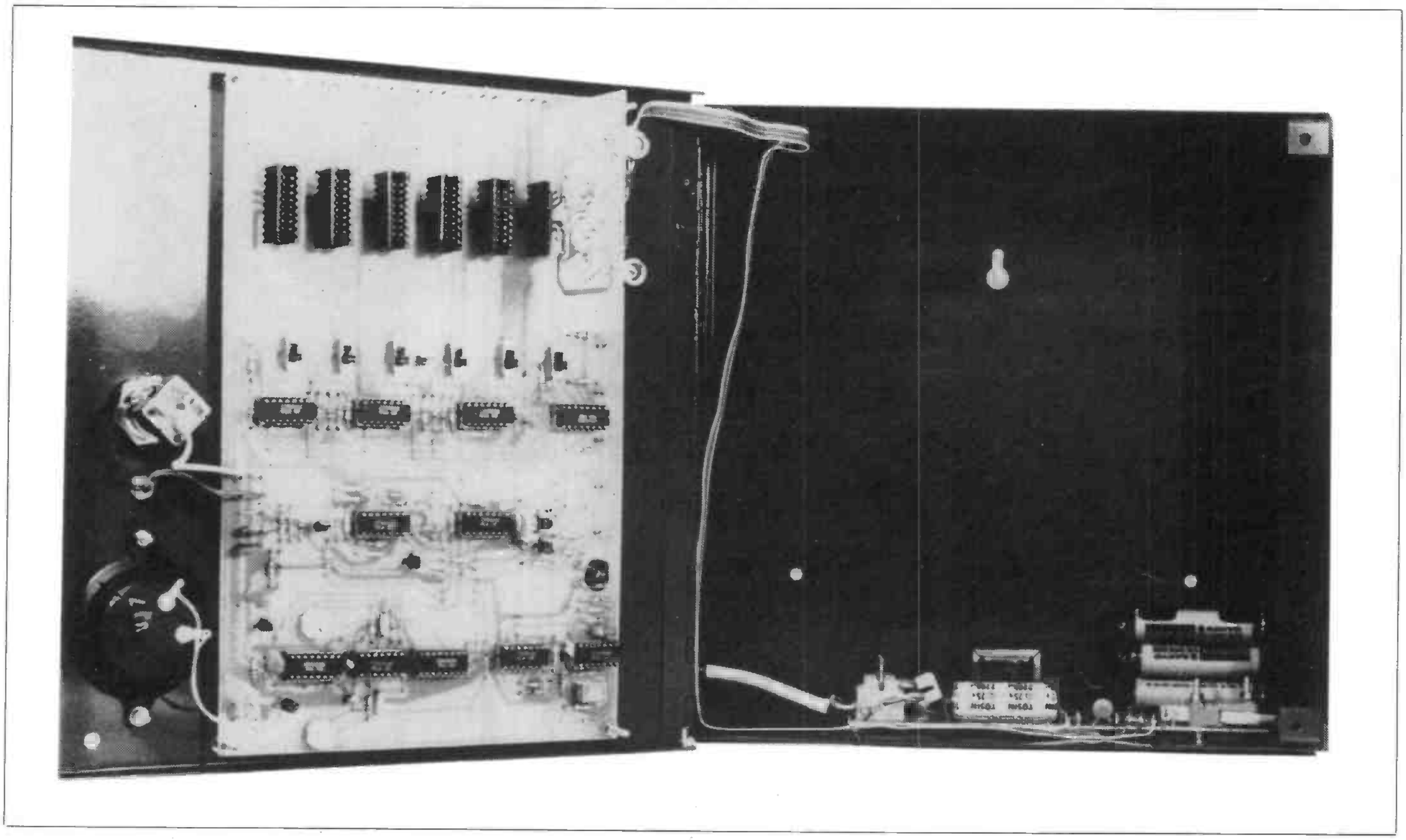


Figure 5. Component overlay of Main PCB.



Pic. A Internal view of control box with Main PCB fitted to the door and the PSU mounted in the base of the box.

Construction

Assembly and Setting Up Main PCB

Refer to the parts list 1 and Figure 10. Use 24 swg BTC (or E/C) wire to make the 28 link straps and fit these first. Next, fit the Veropins and the diodes. (The black tips are shown as white blocks on the legend.) Fit all resistors and capacitors. Note that electrolytic and tantalum types are polarised and have a '+' sign which must be correctly orientated. Fit transistors and IC sockets. Fit the two cermet presets RV1 and 2, and turn fully-clockwise, to 0 on the legend. Connect a 1k0 test resistor RT across pins 29 and 30. (Note - this will be removed when using the external horn PCB, but must remain in place if the external PCB is not in use.)

Refer to Figures 11 and 13 when mounting the channel LEDs. LEDs 1 to 8 are mounted to the PCB from the track side. Figure 13 shows the lead designations. Place the correctly orientated LED into position and insert a spacing strip 8mm x 1.5mm (spare Veroboard etc) between the legs. Bend the legs under the PCB, to hold in position and solder one leg only. Repeat for all eight LEDs.

Figure 12 shows the mounting procedure for fitting the PCB to the inside cabinet lid. Place five 1" x 6BA CSK screws through the lid, tighten down with five 6BA nuts and washers. Place five 6BA x ¼" spacers over the screws and offer the PCB to the lid, positioning the channel LEDs in the holes provided. With LEDs correctly positioned, remove the PCB and solder the eight remaining LED legs. Re-check all component values and positionings. Check for dry joints, solder splashes and short circuits on the track face. If all is in order, mount the PCB on to the lid and hold with five 6BA washers and nuts.

Push switch S2 mounts through the PCB and lid and is wired to adjacent pins 25 and 26. Mount LED 9 and connect to pins 31 and 32 (Figure 10). Mount key switch S9 and piezo horn H1 using two ¼" x 6BA CSK nuts, bolts, washers. Wire H1 to pins 27 and 28.

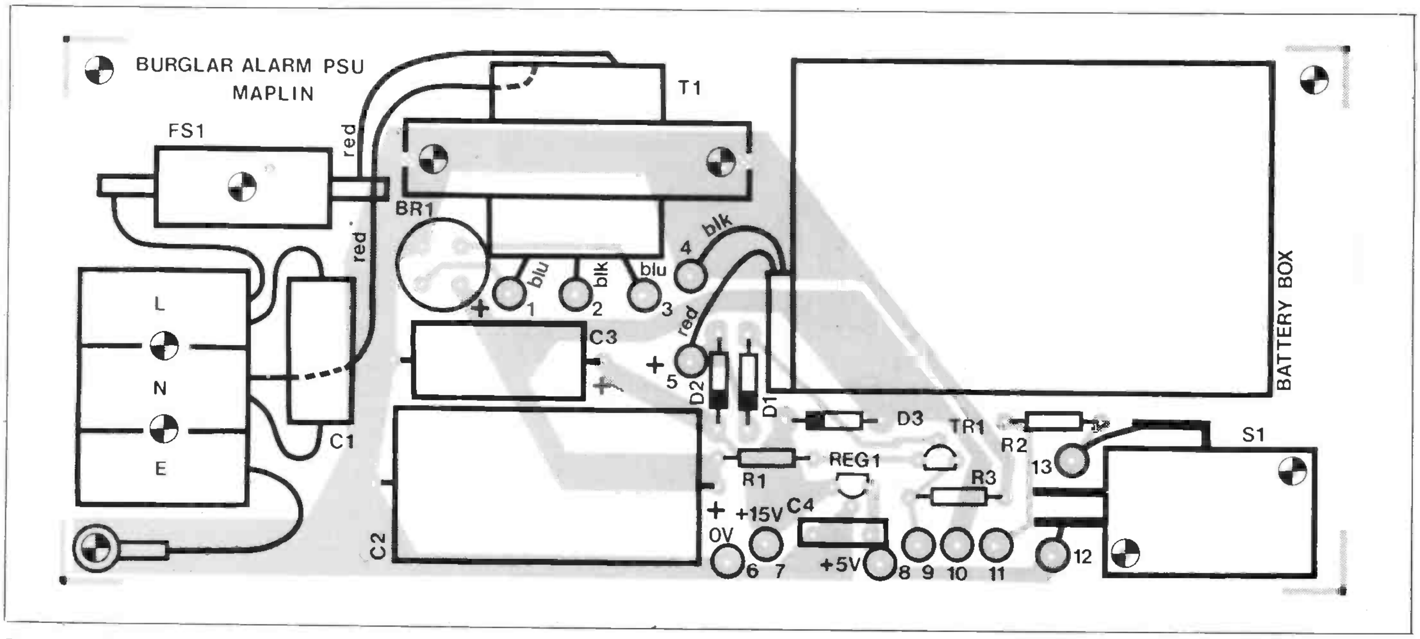


Figure 6. Track layout and component overlay of PSU PCB.

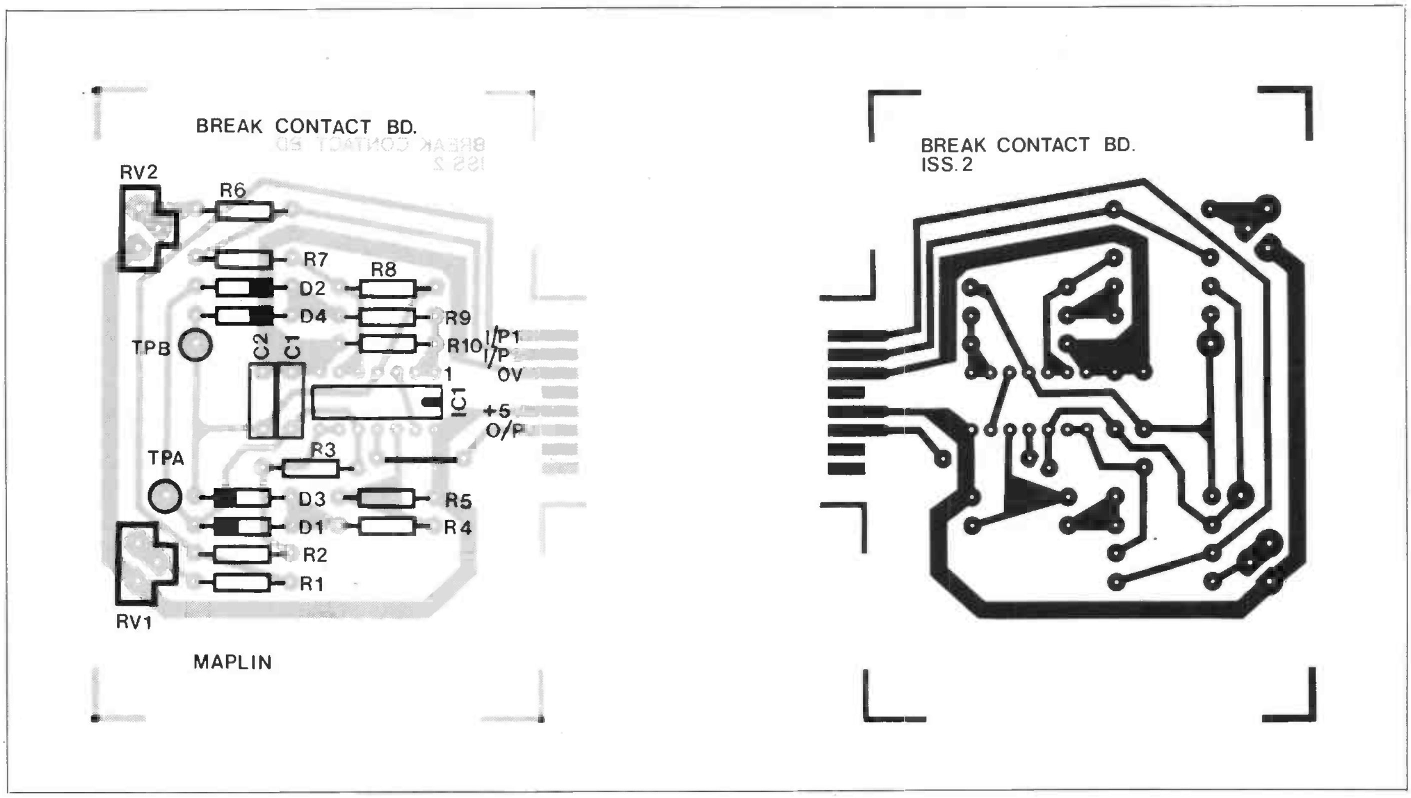


Figure 7. Track layout and component overlay of Break Contact Module.

Power Supply Unit

Next refer to the parts list and Figure 12 and 13 for the PSU assembly. Mount the three resistors, three diodes, BR1, TR1, and REG1. Ensure correct orientation of these components before soldering. Fit the 13 Veropins, C2 and C3 noting the polarity. Mount T1 with two 6BA ¼" bolts, nuts and washers. Mount FS1 using a ¼" x 6BA nut and bolt and three-way terminal block, using two 1" x 6BA bolts, nuts and washers. Wire T1 to FS1 and the terminal block 'N'. Wire the opposite end of FS1 to terminal block 'L'. Place systoflex sleeving over C1 leads, and fit to terminal block 'N' and 'L'. The battery clip (PP3) is connected to pin 5 (+ve lead red) and pin 4 (-ve lead black). The T1 secondaries connect to adjacent pins 1, 2 and 3.

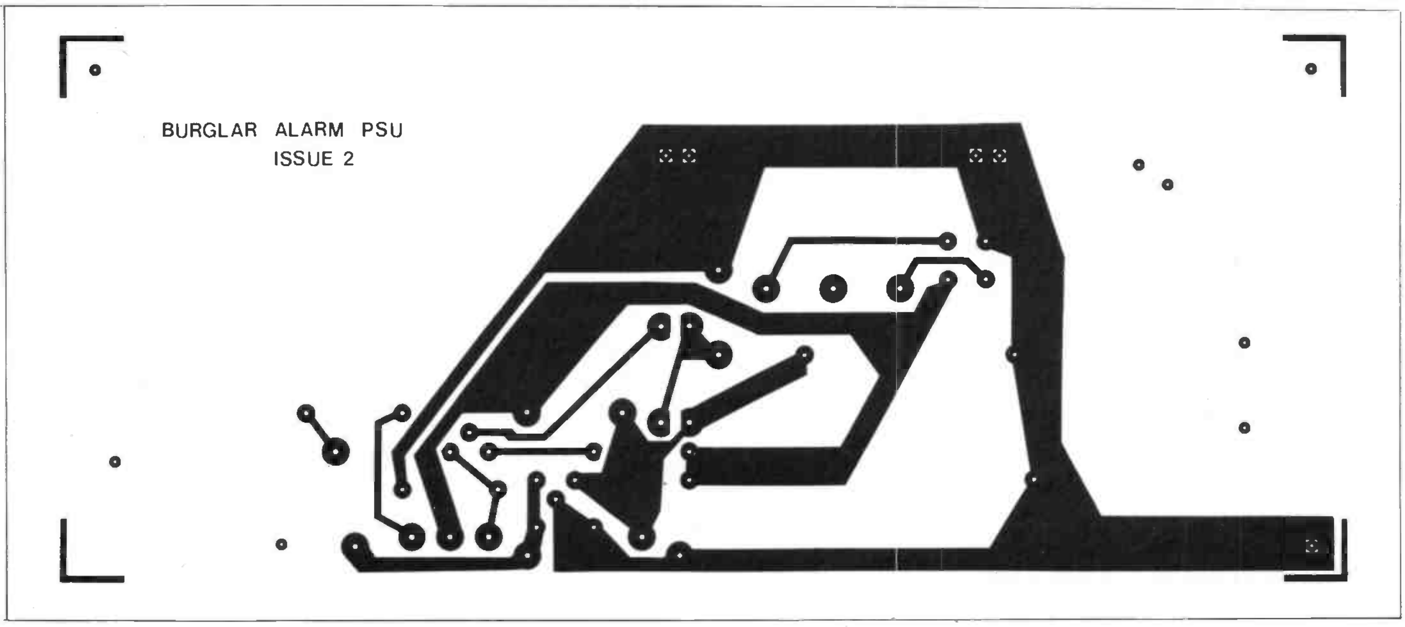
Insert three 6BA x ½" CSK screws through the cabinet base holes (Figure 15), at front left, rear left and rear right hand side. The two front right hand side holes are for mounting the micro switch. Insert two 1" x 6BA CSK screws and tighten all five with 6BA washers and nuts. Place the PSU PCB over the five screws and position the micro switch with the roller arm behind the angle bracket. Tighten down with two 6BA washers and nuts. Place a 6BA tag washer over the front left screw, and two 6BA washers over the remainder. Tighten down with three 6BA nuts. Connect a piece of wire from the 6BA (chassis earth) tag washer to terminal block 'E'. Wire the micro switch (S1) to adjacent pins 12 and 13.

Break Contact Module

Refer to the parts list and Figure 7 for the break contact PCB. The board is very simple to construct and requires no explanation. Once assembled, and checked, plug into any one of the six channel sockets on the main PCB. Ensure switches S3 to S8 are 'out' of circuit.

External Horn

Refer to the parts list and Figures 8, 9 and 17 for the external horn PCB and wiring. Again, the construction is simple. Note the orientation of the tantalum C2 and FET TR1. The crinkly heatsinks fits over TR2. Do not connect to main PCB at this stage.



Testing

Place a 20mm, 100mA fuse into FS1 position. Connect a length of three-way mains cable to the PSU terminal block. Ensure S1 is fully operated, and that no other wiring is connected to the PSU.

Place a voltmeter between 0V pin 6 and +15V pin 7. Apply mains power to the PSU, and check for a reading of 15V DC. Check for +5V between pin 6 (0V) and pin 8 and between 0V and pin 11 when S1 (micro switch) is released (slacken 2BA bolt). Re-operate S1 and check for 0V on meter. Remove the mains supply.

Connect 22" of six-way ribbon cable between the PSU and main PCB as follows:

	PSU	To	Main PCB
(0V)	P6		P19
(+15)	P7		P20
(+5)	P8		P21
LED1	P9		P22
	P10		P23
(S1)	P11		P24

Set the meter to 'amps' range and connect to pins 4 and 5 (or battery clip). Re-apply mains power and check for a reading of approximately 4mA and ensure LED 1 lights up. Remove the meter and LED 1 should extinguish. If the standby batteries are to be used, connect the nicad pack to the PP3 clip.

A voltmeter connected across pins 4 and 5 should indicate a reading of between 7.2 to 7.8V depending on the batteries state of charge. Note that LED1 will stay on with the batteries part or fully charged, also an incorrectly placed battery, within the pack, will allow LED1 to stay on, but the reading across pins 4 and 5 will be lower than +7V. (Rectify immediately as nicads do not like short circuits or reversed connections placed on them.)

For reliability, ensure that the battery pack is fully charged before use. The trickle charger keeps them topped up over a period of time and is not a fast charger.

Main PCB

With power on, and keyswitch disarmed, LED1 only should be on, and no alarm tones heard. Ensure RV1 and 2 are both fully clockwise, and turn key to 'set'. A high pitched tone will sound immediately lasting for no more than two seconds. When the tone stops, LED9 ('ARM') comes on, showing that the alarm is now primed and ready. Note that the warble tone, sounds for the duration of the exit timer delay period and is presettable by adjusting RV1 anticlockwise. The PCB legend has 'scaled' from 0 to 6 minutes and the small circle, on top of the cermet pot, acts as a pointer. If the exact time out periods are required, check the calibration scale with a watch or clock.

Once LED9 has come on, further adjustment of RV1 will only be effective when the key is turned to 'disarm' and then back to 'set', starting the exit timer again.

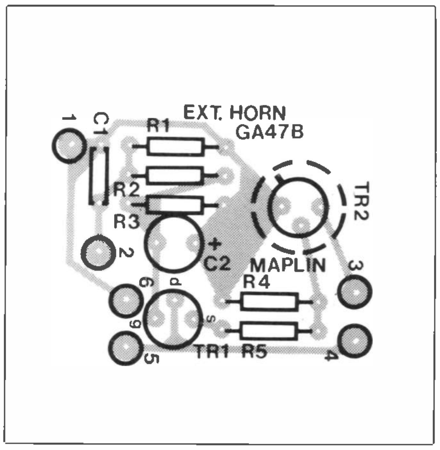


Figure 8. Track layout and component overlay of External Horn PCB.

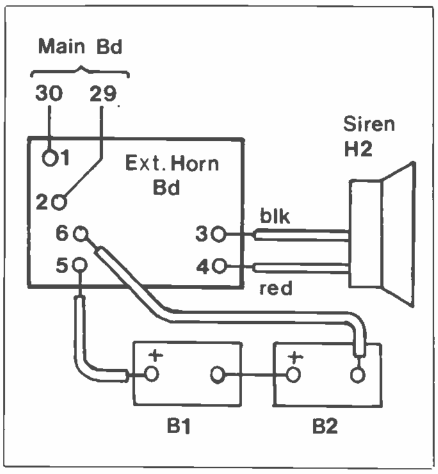


Figure 9. External Horn wiring diagram.

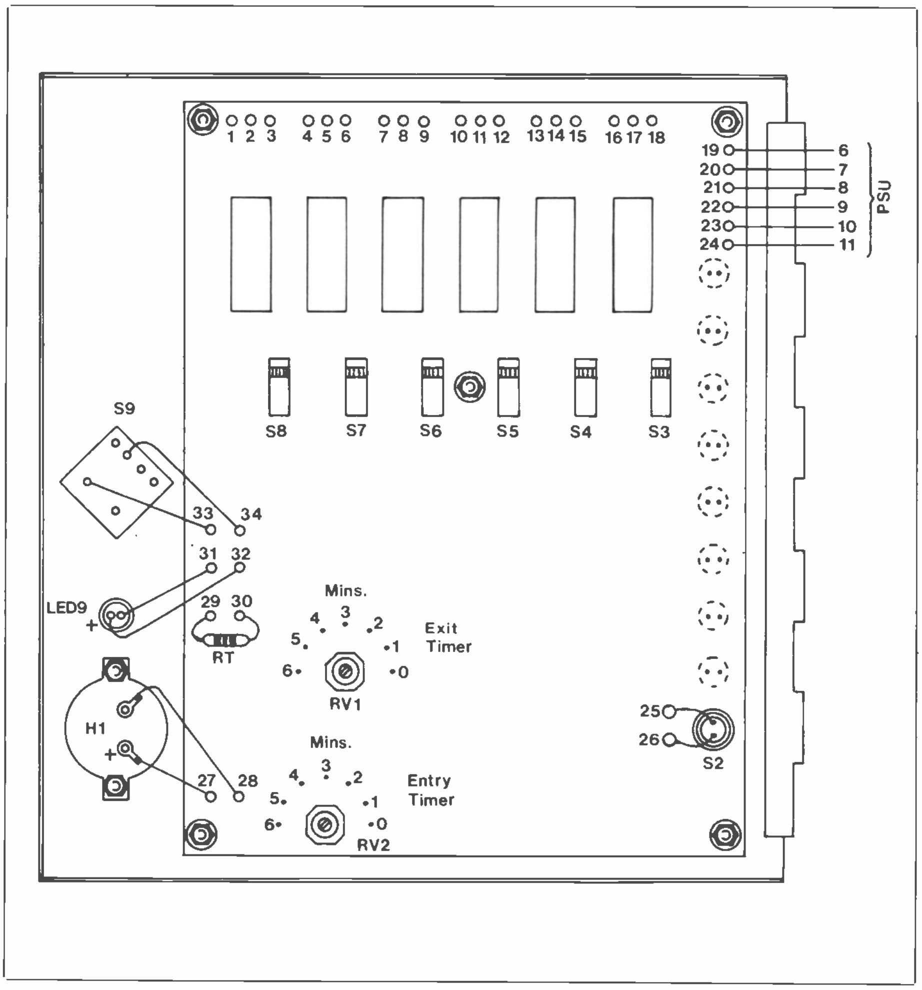


Figure 10. Main PCB wiring diagram.

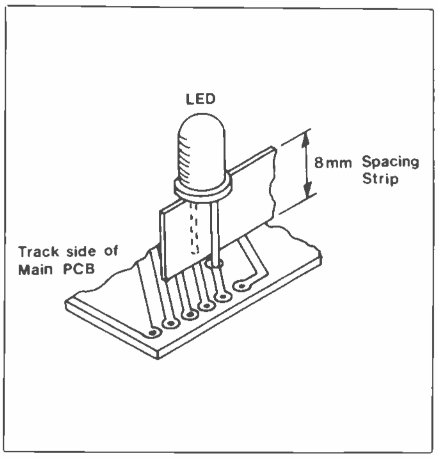


Figure 11. Indicator LED mounting.

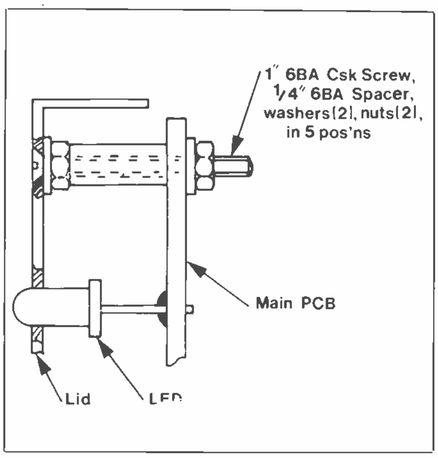


Figure 12. Mounting of Main PCB to cabinet door.

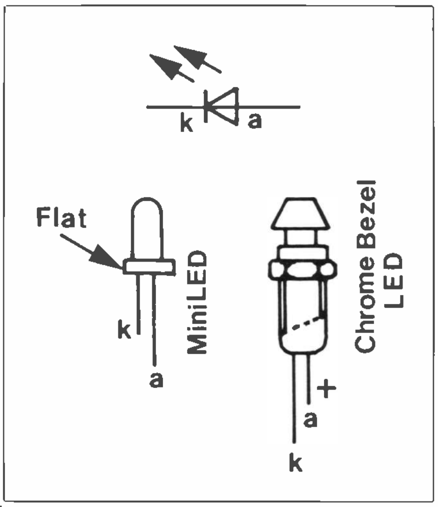


Figure 13. LED lead outs.

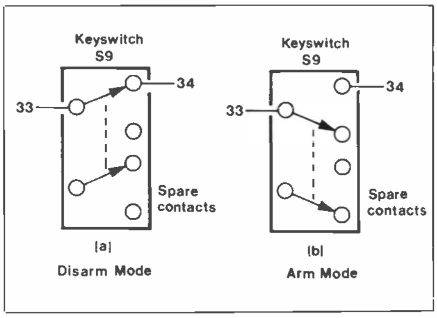


Figure 14. Key switch wiring.

Points

Connect a length of wire from P21 (+5V) to test point 1 (TP1). Operate S3 to the "IN" position. Press S2, display on and release. Channel 1 LED 3 will come on. Place S3 to the "OUT" position. LED 3 will go out. Repeat the above tests from +5V to TP2 to 6 and S4 to 8 checking channel LEDs 4 to 8. Note that pressing S2 allows the channel LEDs to light up, once triggered, for approximately 90 seconds. S2 will have to be re-operated for a continued display etc.

Remove the test lead from the test point, but leave attached to +5V. Turn the key switch to "set". Once the "armed" LED has come on, place switches S3 to S8 to the "IN" position (note — remove any plug-in PCBs). Check that no tone is heard and that LEDs 1 and 9 only are on. Touch the +5V test lead to test points 1 to 6 in turn, all channel LEDs should come on, followed by a slow, two-tone alarm signal. Ext/Cab alarm, LED 2, will come on, indicating tht the external horn trigger circuit has been operated. This alarm tone continues until the key switch is set to "dis-arm". Leave the alarm sounding and check that after 90 seconds the display goes off (preserving batteries on standby). The alarm tone should still continue. Press S2, check original display is returned.

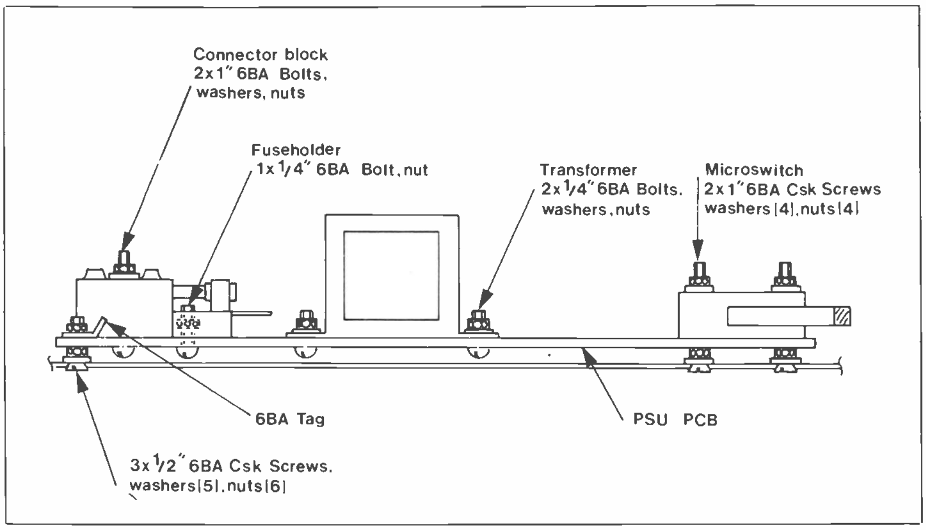


Figure 15. Mounting PSU PCB and components.

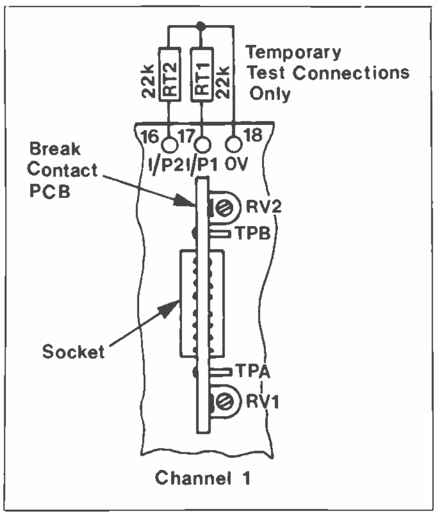


Figure 16. Testing Break Contact Module.

Circuit Monitor

Turn the key switch to "dis-arm". The tone and all displays will be cancelled. Note that in the dis-arm mode and with S2 pressed, the unit gives a useful monitor facility of doors, windows etc, which can be checked before arming the system. Loosen the 2BA bolt holding off micro switch S1. Ensure the roller arm releases, and turn the key switch to "set". After the time out period and LED 9 has come on, the Ext/Cab alarm LED 2 will light, showing that the cabinet has been tampered with, and the alarm tone will sound. Reset the key switch to "dis-arm". The alarm tone will cancel, but LED 2 will remain on for 90 secs; display time out. Re-operate S1 by tightening the 2BA bolt and LED 2 will go out.

Ext. Alarm

Place a short circuit across test resistor RT (1k0) between pins 29 and 30. Press S2, LED 2 will light, indicating that the external loop sensing circuit has been tampered with. Remove the short circuit; LED 2 will go out. Remove one end of resistor RT and press S2. LED 2 will, again, come on. Re-connect RT and LED 2 should go out.

Turn the key switch to "set" and replace the short circuit across resistor RT. When the alarm sounds, remove the short circuit. LED 2 will stay on and the alarm will continue to sound. Return key switch to "dis-arm".

Power Failure

Note that if standby batteries are fitted and mains power is removed, LED 1 will go out. If the alarm unit is set and armed prior to removal of mains power, the system will stay armed, unless triggered appropriately. When running on standby power, the alarm tones will be slightly quieter than normal.

Entry Timer

Set RV2, entry delay timer, for the required time out period. Turn the key switch to "set" and trigger any channel (+5V to a test point). The selected channel LED should come on and stay on. The alarm tone will not be present until the time out period has been reached, then the alarm tone will sound and LED 2 will light. Reset the key switch.

Break Contact PCB

This module may be plugged into any of the sockets in channels 1 to 6 on the main PCB. Note correct orientation of the module, when fitting; the component side is to the right and the track side, to the left.

Remove *all* power to the system, turn the key switch to "dis-arm" and S3 to S8 to the "OUT" position. Connect two test resistors, RT1 and RT2 (22k) between pins 17 and 18 and pins 16 and 18, as shown in Figure 16. These resistors are used for test purposes only and will be removed when the circuit is to be used.

Connect a voltmeter between TPA, on the module, and a convenient 0V point, with the +ve lead to TPA. Apply power to the system, and adjust RV1 for a reading of half the supply rail, i.e. +2.5V.

Repeat the test on TPB using RV2, and remove meter. Re-connect the meter between 0V and TP1 to 6 (main PCB) depending on channel chosen for setting up the module, and check for 0V. Short circuit resistor RT1, and check for +5V on the appropriate test point (main PCB). Remove the short circuit and repeat the test for RT2. Set the chosen channel switch (S3 to S8) to the "IN" position. Turn the key switch to "set" and remove one end of RT1. The appropriate channel LED will come on etc. Re-connect RT1; reset the key switch and repeat the test for RT2.

Reset the key switch and remove test resistors RT1 and 2.

External Horn PCB

Figures 8 and 9 show the connections for using an external horn. For test purposes remove *all* power from the system (disconnect all batteries) and wire the PCB to pins 29 and 30 (remove resistor RT). Any changes made to these connections will trigger the alarm so ensure correct wiring. Connect the electronic siren to pins 3 and 4; the black lead is negative and the red +ve. Since the siren is inside a box, its own cover is not required and should be removed to assist wiring and make the sound output as great as possible. Connect batteries B1 and B2 to pin 5 (+ve) and 6 (-ve). The battery supply should be 12V and various types of dry cell (6V each) are available. Note that no charging current is available to these batteries.

The horn (H2) will sound immediately, so return power to the alarm unit as soon as possible. Place a short circuit across pins 29 and 30 (main PCB); H2 will sound. Remove the short circuit and H2 will cease.

Turn the key switch to "set" and repeat the test. Both internal and

Continued on Page 27

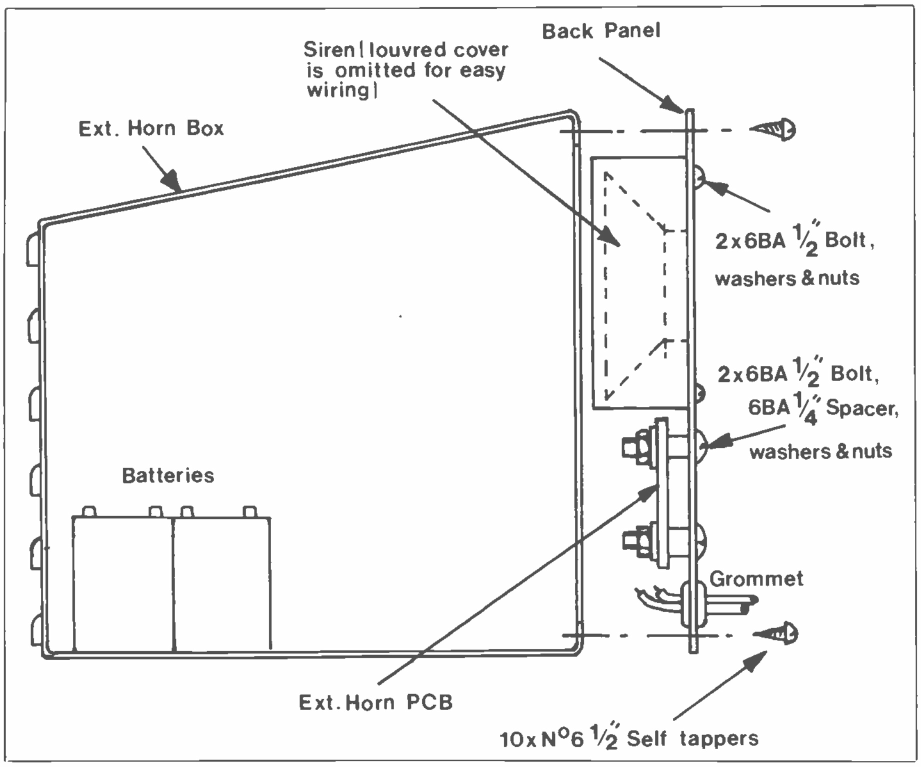


Figure 17. Assembly of External Horn Box.

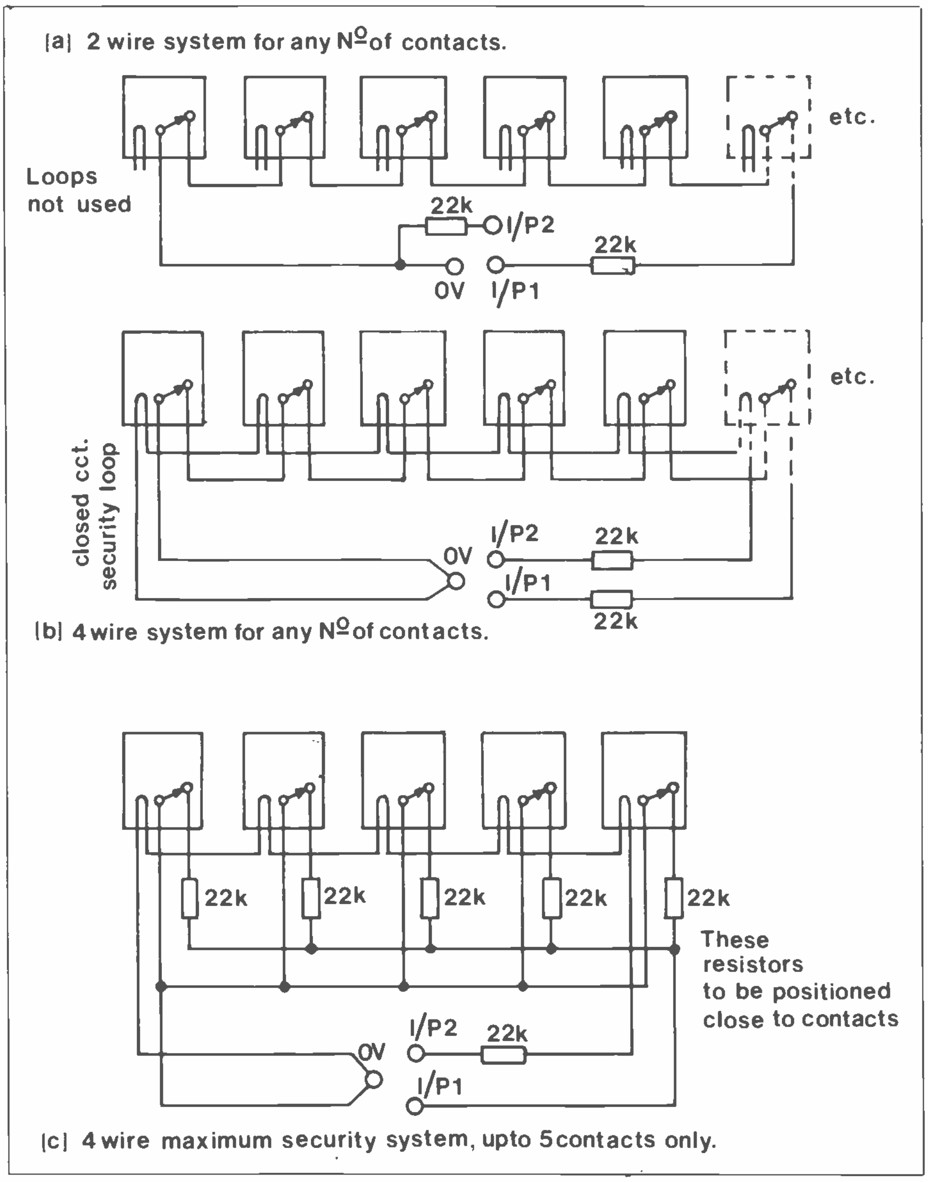


Figure 18. Methods of wiring alarm contacts.

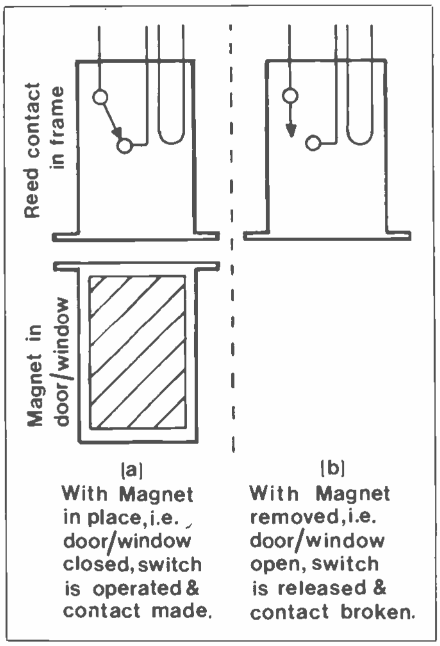


Figure 19. Reed switch connections.

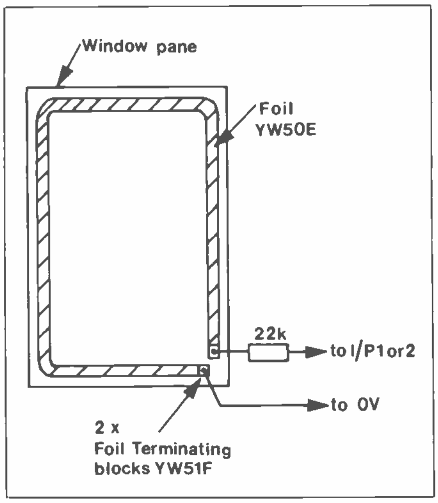


Figure 20. Window foil connections.

BURGLAR ALARM MAIN PARTS LIST

Resistors – all 0.6W 1% metal oxide unless specified

R1,2,12,22-30	100k	12	(M100K)
R3,5,7,17,18, 20,32,42	10k	8	(M10K)
R4,6,21,33,35-41	1k	11	(M1K)
R8	470Ω	1	(M470R
R9	220Ω	1	(M220R)
R11	120k	1	(M120K)
R13,14,31	1M	3	(M1M)
R15	68k	1	(M68K)
R16	22k	1	(M22K)
R19	470k	1	(M470K)
R10,34	47k	2	(M47K)
R43	1M2	1	(M1M2)
R44	1k2	1	(M1K2)
R45,46	3k9	2	(M3K9)
RT (test resistor)	1k	1	(M1K)
RV1,2	1M cermet	2	(WR45Y)

Capacitors

C1,2,7,11,12	100nF disc ceramic	5	(BX03D)
C3,5	27nF polylayer	2	(WW34M)
C4,6	1µF 35V tantalum	2	(WW60Q)
C8	68nF polylayer	1	(WW39N)
C9	680nF polylayer	1	(WW51F)
C10	330pF ceramic	1	(WX62S)
C13	47µF 10V axial electrolytic	1	(FB38R)

Semiconductors

D1-20	1N4148	20	(QL80B)
TR1,5	BC214L	2	(QB62S)
TR2,3,4,6,7	BC548	5	(QB73Q)
IC1,4-10	4001BE	8	(QX01B)
IC2,3	4020BE	2	(QX11M)
IC11	4050BE	1	(QX22Y)

Miscellaneous

LED 1-8	Mini LED red	8	(WL32K)
LED 9	Chrome LED small	1	(YY59P)
S2	Push switch	1	(FH59P)
S3-8	SP slide	6	(FF77J)
S9	Keyswitch	1	(FH04T)
H1	Piezo Tweeter	1	(YW52G)
SK1-6	Edge conn 108	6	(FL83E)
	Burglar alarm main PCB	1	(GA45Y)
	6BA x 1" csk screw	5	(BF13P)
	6BA washer	12	(BF22Y)
	6BA nut	12	(BF18U)
	6BA x ¼" spacer	5	(FW34M)
	6BA x ½" csk screw	2	(BF12N)
	2BA x 1" bolt	2	(BF01B)
	Grommet small	2	(FW55P)
	Burglar alarm box	1	(XG06G)
	Veropin 2141	1 Pkt	(FL21X)
	Ribbon cable 10-way	1 Mtr	(XR06G)
	14 pin DIL skt	8	(BL18U)
	16-pin DIL skt	3	(BL19V)

As required

	Door contact reed	As reqd	(YW46A)
	Window foil	As reqd	(YW50E)
	Window foil terminals	As reqd	(YW51F)
	Surface mounting reed	As reqd	(YW47B)
	Door loop	As reqd	(YW48C)
	Pressure mat	As reqd	(YB91Y)

For kit see under PSU parts list

BURGLAR ALARM PSU PARTS LIST

Resistors – all 0.6W 1% metal oxide unless specified

R1	220Ω	1	(M220R)
R2	10k	1	(M10K)
R3	6k8	1	(M6K8)

Capacitors

C1	100nF IS Cap	1	(FF56L)
C2	2200µF 35V axial electrolytic	1	(FB90X)
C3	100µF 35V axial electrolytic	1	(FB49D)
C4	100nF disc ceramic	1	(BX03D)

Semiconductors

D1,2,3	1N4001	3	(QL73Q)
BR1	W005	1	(QL37S)
Reg 1	µA78L05AWC	1	(QL26D)
TR1	BC214L	1	(QB62S)

Miscellaneous

T1	Transformer 6-0-6 100mA	1	(WB00A)
S1	Microswitch	1	(HF01B)
FS1	20mm Fuse 100mA	1	(WR00A)
	Chassis Fuseholder	1	(RX49D)
	Terminal block 5A (3 sections)	1	(HF01B)
	Burglar Alarm PSU PCB	1	(GA44X)
	6BA Tag	1 Pkt	(BF29G)
	6BA x 1" bolt	1 Pkt	(BF07H)
	6BA x ¼" bolt	1 Pkt	(BF05F)
	6BA x 1" csk screw	1 Pkt	(BF13P)
	6BA x ½" csk screw	1 Pkt	(BF12N)
	6BA washer	2 Pkts	(BF22Y)
	6BA nut	2 Pkts	(BF18U)
	Heatshrink CP24	1 Mtr	(BF87U)
	Veropin 2141	1 Pkt	(FL21X)

Standby Power if required

B1-6	Nicad 'AA' cells	6	(YG00A)
	9V Batt holder	1	(HQ01B)
	PP3 clip	1	(HF28F)
	Construction guide	1	(XH79L)
	Home security instructions	1	(XK15R)

A complete kit is available which includes all the parts in the PSU parts list (including standby power parts) and all the parts in the main parts list excluding those listed under "As required".
Order As LW57M (Burglar Alarm Kit)

EXTERNAL HORN PARTS LIST

Resistors – all 0.6W 1% metal oxide

R1	1k	1	(M1K)
R2	10k	1	(M10K)
R3	1M	1	(M1M)
R4	100k	1	(M100K)
R5	470Ω	1	(M470R)

Capacitors

C1	100nF disc ceramic	1	(BX03D)
C2	1µF 35V tantalum	1	(WW60Q)

Semiconductors

TR1	2N4393	1	(RA99H)
TR2	BC441	1	(QB70M)

Miscellaneous

H2	Electronic siren	1	(XG14Q)
B1,2	6V lantern battery	2	
	Heatsink 5F	1	(FL78K)
	PCB	1	(GA47B)
	Veropins 2141	1 Pkt	(FL21X)
	Ext Horn Box	1	(XG07H)
	Grommet small	1	(FW59P)
	Screws self tapping No 6 ½ inch	1 Pkt	(BF67X)
	Bolts 6BA ½ inch	1 Pkt	(BF06G)
	Washers 6BA	1 Pkt	(BF22Y)
	Nuts 6BA	1 Pkt	(BF18U)
	Spacers 6BA ¼ inch	1 Pkt	(FW34N)
	Constructors Guide	1	(XH79L)
	Home security instructors	1	(XK15R)

A complete kit of all the parts listed above (excluding batteries) is available.
Order As LW58N (External Horn Kit)

BREAK CONTACT MODULE PARTS LIST

Resistors – all 0.6W 1% metal oxide unless specified

R1,2,6,7	2k2	4	(M2K2)
R3,4,8,9	100k	4	(M100K)
R5,10	180k	2	(M180K)
RT1,2 (test resist.)	22k	2	(M22K)
RV1,2	22k vert encl preset	2	(UH17T)

Capacitors

C1,2	100nF disc ceramic	2	(BX03D)

Semiconductors

D1-4	1N4148	4	(QL80B)
IC1	4011BE	1	(QX05F)

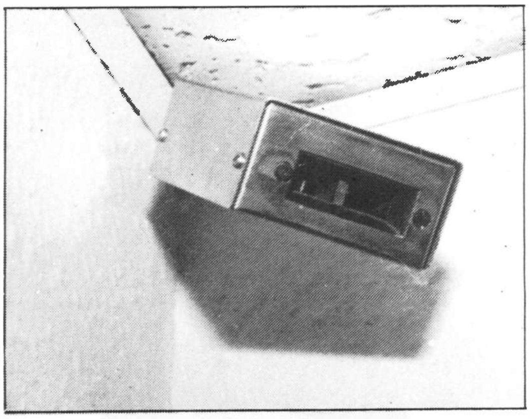
Miscellaneous

TPA,B	Veropin 2141	1 Pkt	(FL21X)
	Break contact PCB	1	(GA46A)
	14-pin DIL skt	1	(BL18U)
	Constructors Guide	1	(XH79L)

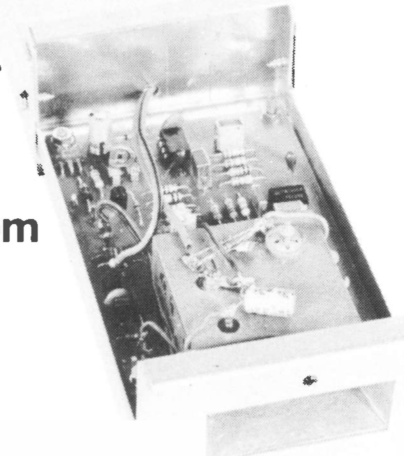
A complete kit of parts is available.
Order As LW59P (Break Contact Kit)

RADAR DOPPLER INTRUDER DETECTOR

THE MAPLIN RTX3



by Dave Goodman



- ★ **Home Office type-approved microwave Doppler detection system with up to 20m range**
- ★ **Single unit covers a wide area**
- ★ **Not susceptible to instability or interference from sound or light**
- ★ **Complete unit in 133 x 70 x 38mm box can be placed anywhere in area to be scanned**
- ★ **Unit may be hidden behind thin card or plastic**

The Maplin RTX3 movement detector utilises a specially manufactured microwave transceiver module, the CL8960. The module is assembled and preset to transmit at the required legal frequency of 10.687GHz ±12MHz (10,687,000,000Hz) with a peak transmission power of 10mW.

The extremely small wavelength (2.8cm) makes a very sensitive movement detector with coverage of quite a large area. In this design the range is adjustable from about 2m to 20m and the edge of the range is fairly well-defined wherever it is set.

The unit when triggered operates an internal LED and switches on a transistor which could switch up to 15V at 1A, but does not latch. Normally the unit will be used with our controller unit to which up to four of the radar modules could be connected. This control unit can then be used to connect to our Home Security System via the standard Break Contact Module. The control interface is described later in this issue.

Circuit Description

The heart of the system is the CL8960 radar module which consists of two tuned cavities or waveguides and a separate antenna which when fixed to the module gives a gain of around 5dB. One waveguide contains a Gunn diode which produces X-band microwave energy. This diode requires an extremely precise and stable power supply which should be 7V ±100mV at 160mA. This is derived from the 12V power supply by IC1, a precision voltage reference IC and two 1% resistors R3 and R4 that monitor the 7V rail. The current is supplied by TR3, an emitter follower driven by TR1. C1 decouples any hf component in the power supply.

The other waveguide contains a mixer diode which acts as a receiver. There is a small hole between the two waveguides so that some of the transmitted signal passes directly to the

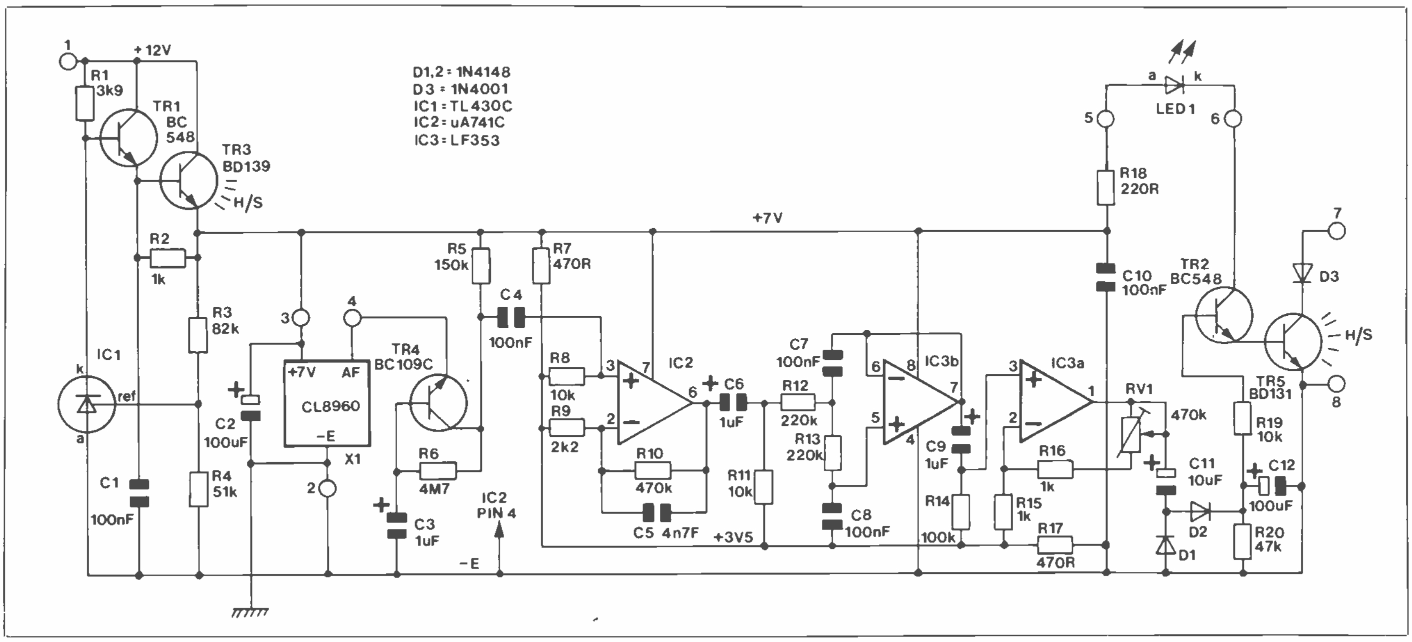


Figure 1. Circuit diagram of Doppler unit.

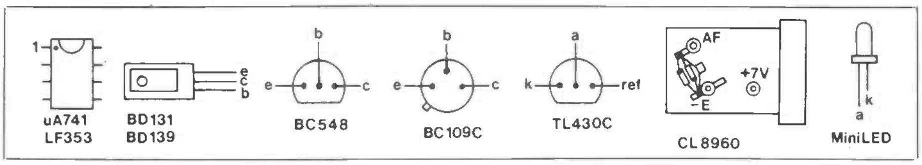
receiver. The reflected signals from the environment are at exactly the same frequency as the transmitted signal as one would expect. However, if an object moves within the sensitive area, the reflected frequency changes slightly due to the Doppler effect (see box). Even a small movement at this extremely high frequency can make changes of up to 50Hz (although of course this is only a minute change in percentage terms — less than 1 part in a hundred million). For example a movement of 1 metre per second will change the frequency by about 70Hz.

This slightly changed frequency will interfere with the transmitted frequency in the receiver cavity and produce a beat frequency equal to the change. This low frequency beat is output from the mixer diode at the terminal marked 'AF'. The mixer diode requires biasing at about 38uA with a low impedance (600Ω), therefore TR4 is required to be a common base amplifier with the bias current supplied by R5.

The AF signal is then AC coupled to IC2, a non-inverting amp and C5 ensures that only low frequencies are amplified. IC3b is a low-pass filter with a cut-off frequency around 40Hz. If higher frequencies are allowed to pass, the unit is prone to false triggering from for example mains-operated lighting, especially fluorescent lamps. The combined filtering in IC2 and IC3b eliminates this possibility.

IC3a is a variable gain amplifier which is preset by RV1 to allow you to adjust the overall receiver sensitivity so that areas from 2m to 20m can be covered reasonably accurately. C11 and 12 and D1 and 2 remove the AC component from the audio signal and provide a DC bias to switch TR2 and LED1. If no further movement is detected, LED1 turns off after about 3 to 4 seconds as set by R20.

Pins 7 and 8 will normally be left unconnected, but if the unit is not being used with our control interface then these two pins can be wired to an external switching system and an external power supply not exceeding 15V at 1A must be used. See Figure 5.



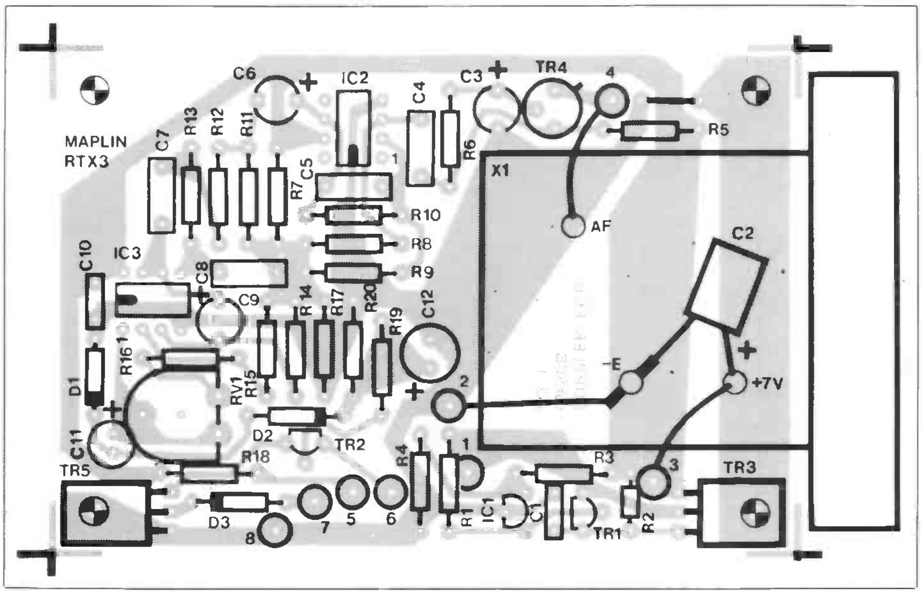


Figure 2. Component overlay of Doppler unit.

THE DOPPLER EFFECT

In 1842 an Austrian physicist, Christian Doppler discovered that the velocity of a sound source can change the frequency of that sound as perceived by an outside observer. For example if a car sounding its horn rapidly approaches an observer, the observer will note that as the car passes him the frequency of the horn drops. Although this is sound radiation, the same effect occurs with electro-magnetic radiation.

The reason for this is that for sound or electro-magnetic radiation, the speed of propagation (in the same medium) does not change. For electro-magnetic radiation this speed is about 300 million metres per second and generally denoted as 'c'. This speed remains the same regardless of the velocity of the source of the radiation relative to the observer.

Thus if a stationary source radiates for one second, the wave train produced will be 300 million metres long. Now imagine that the source moves away from the observer during the second when the radiation is emitted. The leading edge of the wave train will be 300 million metres from where the source was when the radiation started, but the end of the wave train will be where the source is at the end of the second.

So the length of the wave train is now 300 million metres plus the distance travelled by the source in that second. Since the transmitted frequency did not change, there must still be the same number of waves in this longer wave train as in the first one. If the observer now "listens" to this radiation for precisely one second, he will of course receive 300 million metres worth of both wave trains. The first wave train will contain all the waves transmitted, but the second wave train will not contain all the waves transmitted (because as we've seen there is actually more than 300 million metres worth of them). If there are fewer waves in the same distance then the distance between each wave must be greater. In other words the wavelength is longer and if the wavelength is longer then the frequency is lower.

In fact the observer would never know (unless he had other information) that it was not a stationary source that transmitted both signals. In the second case he would think that the source actually transmitted a lower frequency signal for a slightly longer time.

If the source had moved towards the observer during the transmission period, then the wave train would be shorter, the wavelength shorter and the frequency higher.

Construction

Insert the links and the 8 pins on the pcb, then taking care with the orientation of the diodes, IC's, transistors and C2, 3, 6, 9, 11 and 12 place the rest of the components except TR3 and TR5 and solder them all in position. Carefully align TR3 and TR5 above the holes in the pcb and then solder them in position, noting that no insulating washer is required. Drill the box and make the cut-out as shown in Figure 3, then place a 6BA ½in bolt in each of the four corner holes in the base and tighten a nut and washer on each bolt. Then sit the pcb on the nuts and fix with another nut and washer as shown in Figure 4.

Fix the antenna to the front plate of the box using two 6BA bolts. Now fix the CL8960 to this and tighten up. The CL8960 is supplied with two back-to-back diodes and a capacitor connected across the mixer diode for protection. These components must NOT be removed. Mount C2 from the +7V pin to the 0V pin as shown in Figure 2. Fix the LED either directly to pins 5 and 6 or to the hole marked 'A' in Figure 3. Connect the two wires between the pcb and the CL8960 as shown in Figure 2.

The 12V supply wires can now be connected; the positive to pin 1 and the negative to the CL8960 as shown in Figure 4. Make absolutely certain that you have connected the supply the right way round. Temporarily disconnect the wire from pin 3 on the pcb and connect a voltmeter between that pin and the chassis (0V). Connect the power supply. The voltmeter should read within ±1% of 7V, but many lower cost multimeters have far less accuracy than TL430C and in fact if your multimeter reads within ½V of 7V then it is very unlikely that there is a fault in the circuit. If all is well, remove the power supply, reconnect the wire to pin 3 and switch on again. The unit is now functioning.

The completed module is ideally situated in the corner of a room, but could be placed almost anywhere and may be disguised by covering the front. Any such covering should be thin paper, card or polystyrene and must be positioned not less than 2.5cm (1in) from the front of the box.

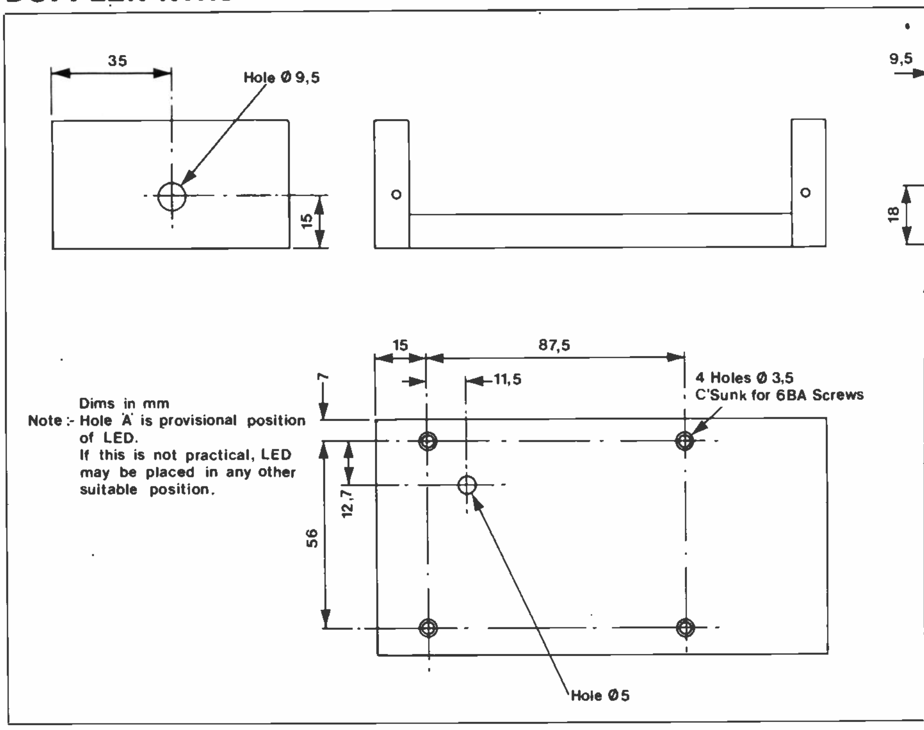
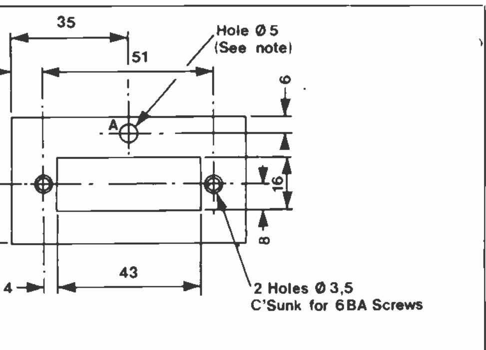



Figure 3. Box cut-out and drilling.

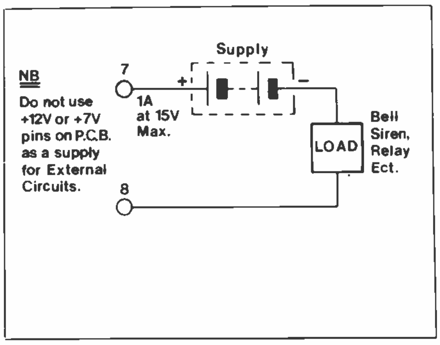


Figure 5. Wiring of external alarm if not used with control unit.

Licensing Requirements

The Maplin RTX3 radar intruder detector has been approved by the Home Office if built from our kit of parts. The licence will only be issued if the following requirements are met:

i. The unit must be built from our kit and our construction details must be followed implicitly.
ii. The equipment must be clearly and permanently marked "MAPLIN RTX3" and the kit includes the adhesive label required.
iii. The equipment must only be used indoors.
iv. The equipment must not be used for any purpose other than intruder detection within buildings.
v. Any technical changes made to the design will render the equipment unacceptable for licensing.

Provided that the above conditions are met, the Home Office will issue a licence and the cost is only £3 for five years (at time of writing). You should note that it is illegal to operate the unit before you have a licence and to this end an application form is supplied with the kit. Otherwise application forms are available from:

Home Office,
Radio Regulatory Dept.,
R2 Division — Licensing Branch,
Waterloo Bridge House,
London SE1 8UA.
(Telephone 01-275 3058).

The application form must state that the equipment to be licensed is the MAPLIN RTX3 intruder detector otherwise a licence will not be issued.

We should like to thank those concerned at the Home Office for their assistance and for the prompt way in which our application for type-approval was dealt with. *Continued on Page 27.*

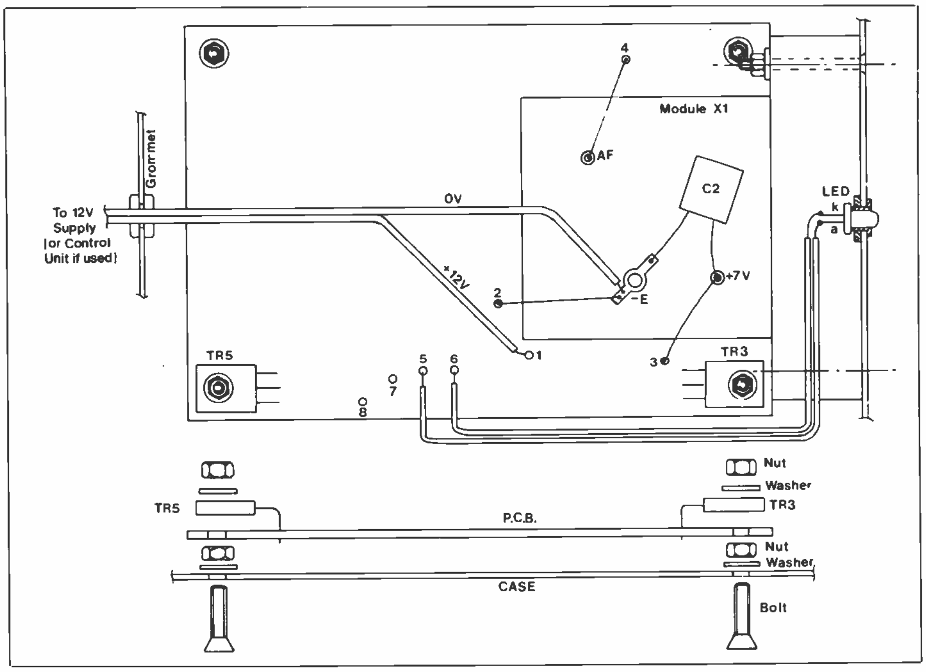
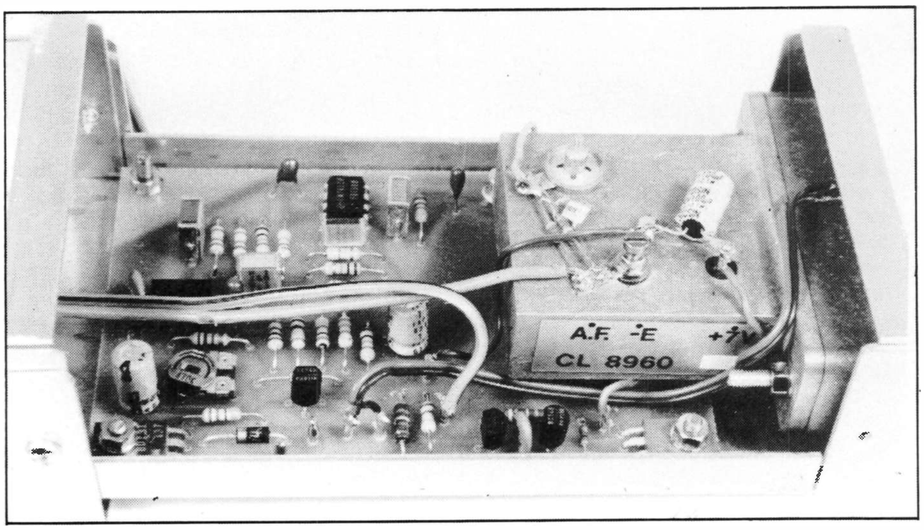
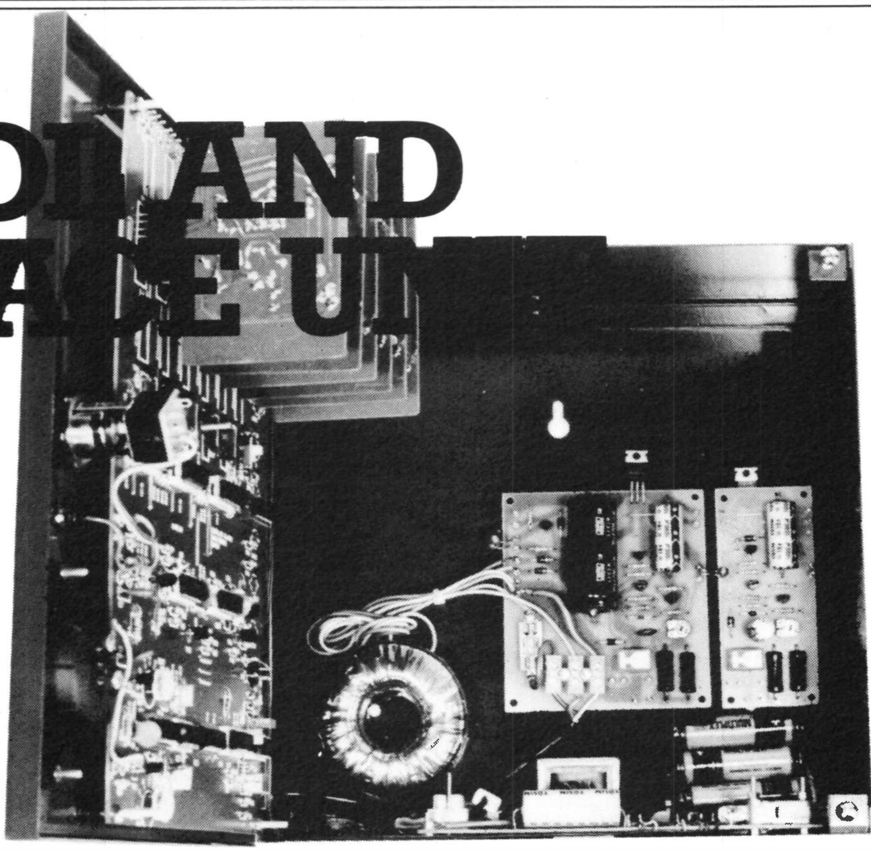


Figure 4. Assembly.



CONTROL AND INTERFACE UNIT

by Dave Goodman



This unit provides a power supply for up to four radar modules and an interface for one radar module. Additional "extra channel" pcb's can simply be wired on to the side of the main pcb. Thus each interface module could be wired to individual channels on the Home Security System (described in issue 2) so that after triggering, the actual unit that fired would be indicated. Alternatively if that facility is not required then simply connect the relays in series as shown in Figure 1a and connect them to just one channel on the Home Security System.

The module provides the facility to connect a standby battery pack. Twelve nickel cadmium batteries are required and they are trickle-charged all the time mains is present. When mains fails, the batteries take-over without triggering the alarm. The size of battery used will depend on how many radar units are being used and how long you wish standby to last after mains fails.

The current drain from the battery for each radar module is 170mA. Thus with 12 fully charged 'C' cells (1800mAh types), four modules would run for about three hours and a single module for about 12 hours. Alternatively, a single module would run from 12 'AA' cells (500mAh) for about 3 hours.

If standby batteries are not used then although when mains fails the radar units cease to function and the alarm is not triggered, when mains returns, the radar units, in taking a few seconds to settle, will trigger the alarm. So it is a considerable advantage to have standby batteries and avoid this kind of false triggering.

This unit could be used with any alarm system, but note that the relay contact does not latch. The maximum contact rating is 1A at 24V DC.

Circuit Description

The unit runs directly from 240V AC mains via a 15V 30VA toroidal transformer. The secondary voltage is half-wave rectified and smoothed by C1 producing about 24V off-load. TR1 forms a constant current charger for the standby battery with the current set to 6mA by R2. Diode D3 is reverse

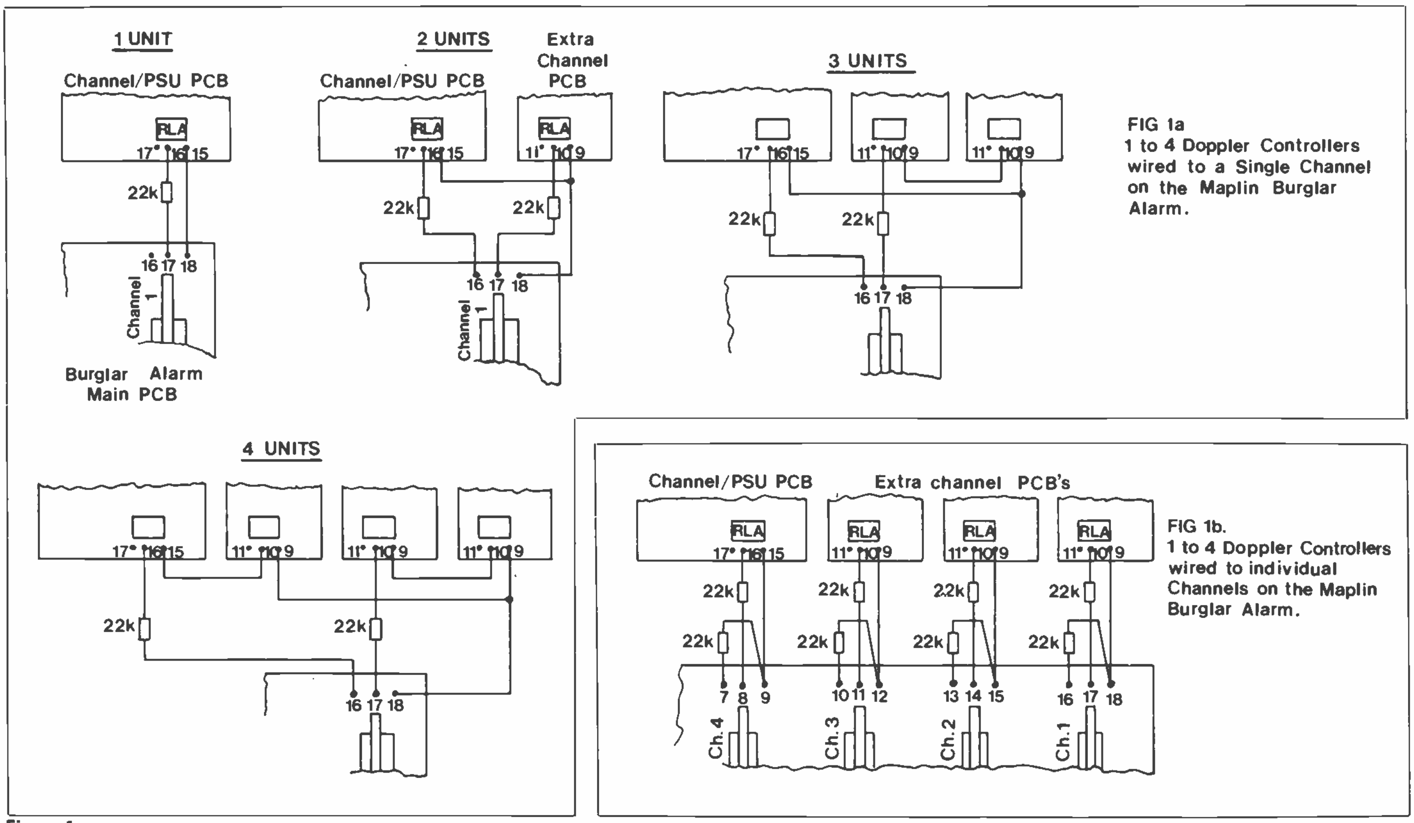


FIG 1a
1 to 4 Doppler Controllers wired to a Single Channel on the Maplin Burglar Alarm.

FIG 1b.
1 to 4 Doppler Controllers wired to individual Channels on the Maplin Burglar Alarm.

Figure 1.

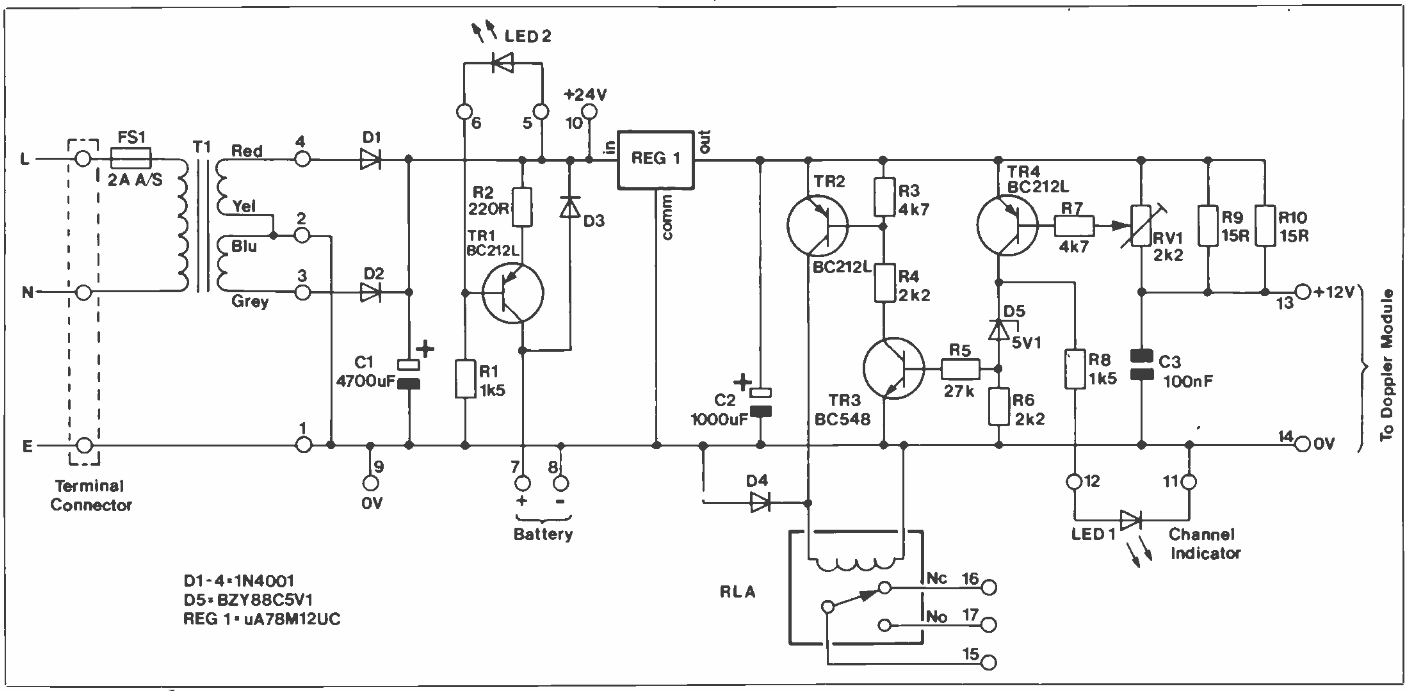


Figure 2. Circuit diagram of Channel/PSU PCB.

biased when mains and batteries are present, but when mains fails it becomes forward biased and the +24V rail drops to +15V. This is just sufficient to maintain the output of Reg 1 at 12V.

With a Doppler module connected to pins 13 and 14, the current through R9 and R10 in parallel provides a biasing voltage across RV1. With RV1 correctly adjusted, TR4 will be just turned on enough to light LED1, but not enough to operate TR3. TR2 will therefore not conduct and the relay will remain unoperated. If the Doppler module is triggered, the LED in the Doppler module lights and causes a tiny current change through R9 and R10. This change turns TR4 fully on and TR3 will turn on. This operates TR2 and the relay switches. The relay will only remain operated whilst the LED in the Doppler module is on.

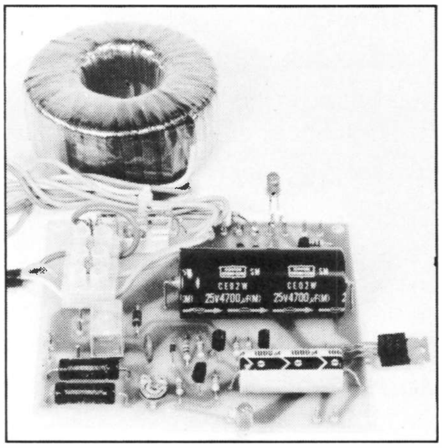
The advantage of this system is that only two wires are required and the wires themselves are constantly monitored. The alarm will fire if the wires are cut or short-circuited.

The extra channel pcb's as shown in Figure 3 are identical except that the power supply prior to the regulator is not included.

Construction of Channel/PSU PCB

Fit all the resistors, R1 to R10 and fit RV1 and solder. Fit and solder diodes D1 to D4 and Zener diode D5 taking care with orientation. Fit and solder the 17 Veropins and the disc capacitor C3, then C1, C2 and TR1 to 4 taking care with the orientation.

Relay RLA will only fit one way round, but be careful not to force the terminals, they should be carefully straightened and should then fit easily. Reg 1 can now be fitted below the pcb, then soldered and bent up so that it lies parallel with the pcb as shown in Figure 5.



Bolt the 3-way connector block to the pcb using two 6BA ½in bolts and nuts, then bolt the fuseholder to the pcb using a 6BA ¼in bolt and nut. LED1 and LED2 can now be connected as shown in Figure 4. These can be mounted directly to the pcb or externally depending on your requirements. LED2 shows that power is on and must be included if standby batteries are used. LED1 is used during testing, but can be omitted in use. If fitted, it lights when a Doppler module is connected.

Wire up the six colour-coded leads from the transformer as shown in Figure 4. Cut 8cm (3in) off the piece of mains cable (note that this is not

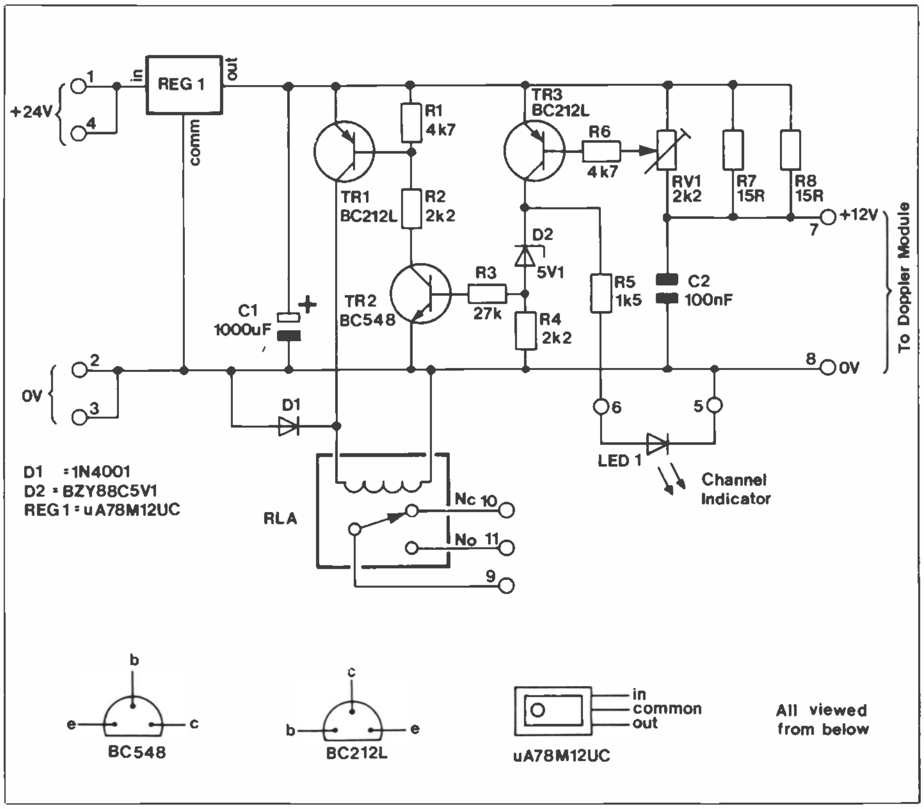
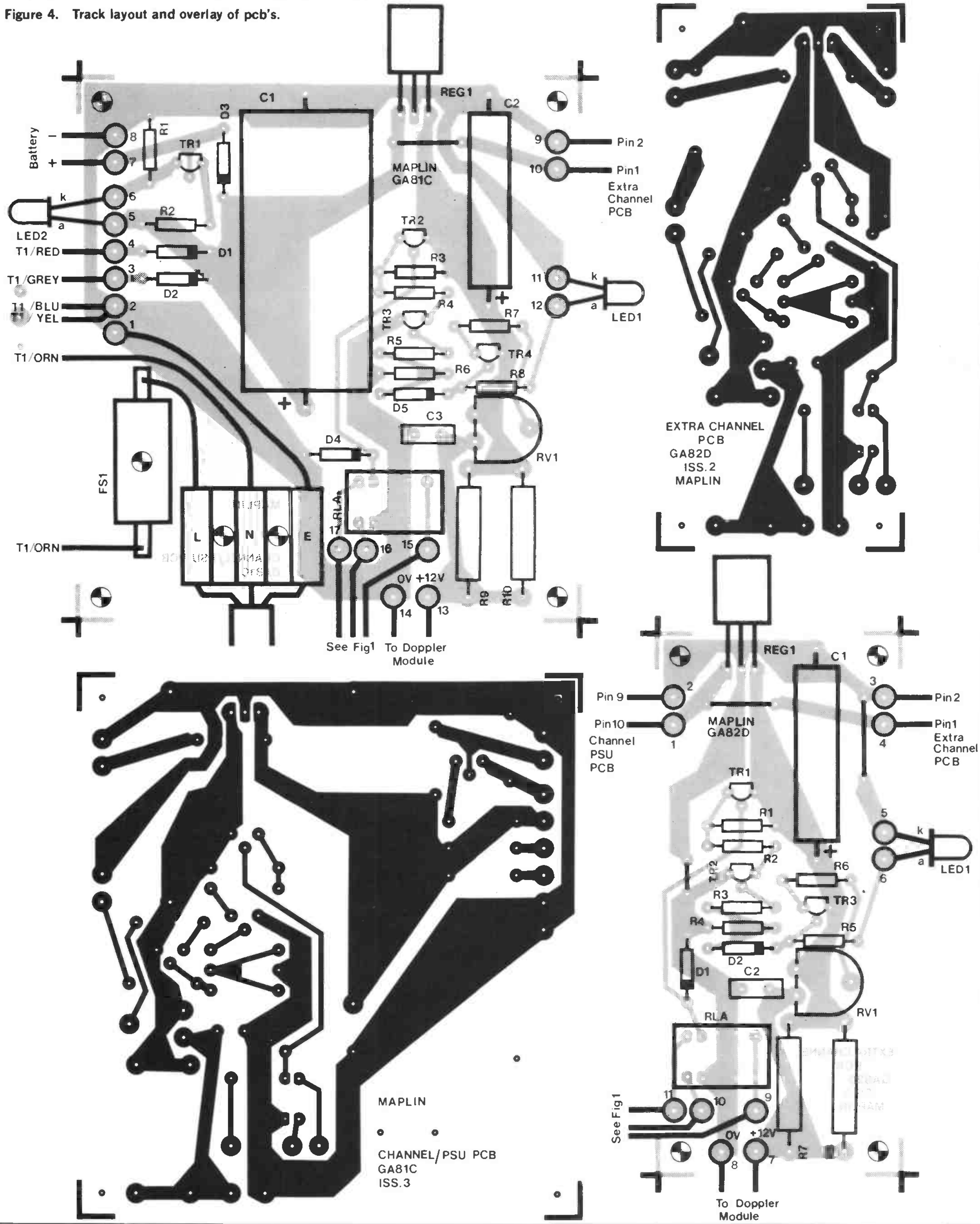
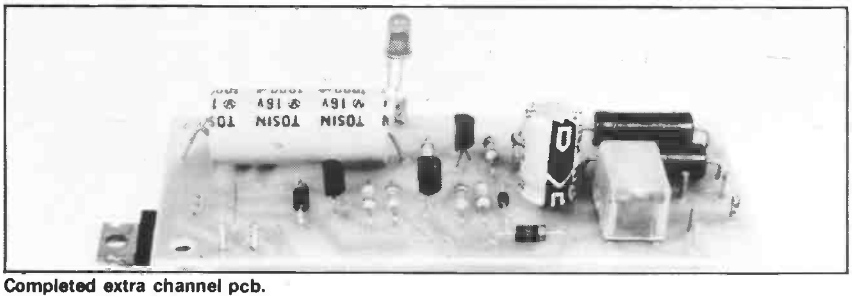


Figure 3. Circuit diagram of Extra Channel PCB.

Figure 4. Track layout and overlay of pcb's.





Completed extra channel pcb.

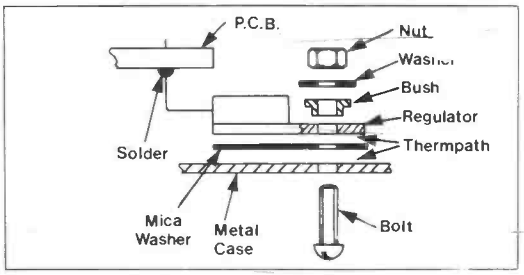


Figure 5. Mounting regulator 1.

supplied in the kit) and use the piece of brown wire to connect from the terminal block live to FS1. Use the piece of green/yellow to connect from the terminal block earth to pin 1. These connections are shown in Figure 4. The mains cable itself can now be connected to the other side of the terminal block and this is also shown in Figure 4.

Construction of Extra Channel PCB's

Extra channel pcb's can now be constructed in the same way as the channel/psu pcb's, though of course there are less components. The LED on this board is exactly the same as LED1 on the channel/psu pcb and again although required during testing, it can thereafter be omitted if not required.

Assembly

Mount the transformer with the mounting kit supplied with the transformer and then fix the pcb's side-by-side (if extra channel pcb's are in use) so that pin 9 on the channel/psu pcb is adjacent to pin 2 on the extra channel pcb and, if further extra channel pcb's are in use, so that pin 3 on the left-hand one is adjacent to pin 2 on the right-hand one.

Fix the boards using four ½in spacers and four 6BA ½in nuts, bolts and washers. With reference to Figure 5, bolt the regulator to the metal box using the mounting kit smeared with silicone grease e.g. Thermpath (not supplied in kit) and a 6BA ¼in bolt, nut and washer. The size of metal box in which the unit is mounted will depend on how many channels you require and whether you are having standby batteries, but whatever the size this will be a sufficient heatsink for the regulator.

When choosing a box, remember to leave room for the standby batteries. These can be fitted using our battery holders e.g. for 'C' cells use three HF95D or HF96E and for 'AA' cells use two HQ01B or YR62S. There may be sufficient room for everything in the main box of the Home Security System in which case the back of the box will form the heatsink for Reg 1.

If more than one channel is in use, then wire the pcb's together with strapping wire by linking the pins as follows:

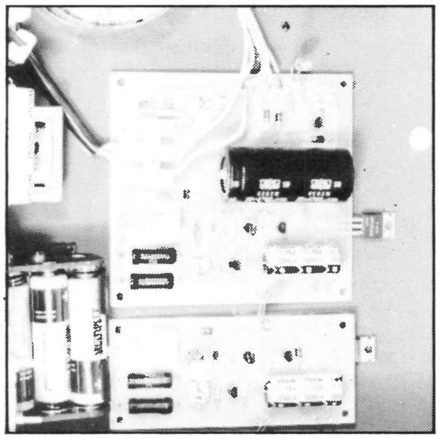
Channel/PSU PCB		Extra Channel PCB
pin 9	to	pin 2
pin 10	to	pin 1

The extra channel pcb can then be extended on again as follows:

1st or 2nd Extra Channel PCB		2nd or 3rd Extra Channel PCB
pin 3	to	pin 2
pin 4	to	pin 1

Setting-up

Switch the mains on and measure the voltage between pin 13 and 14 on the channel/psu pcb and between pin 7 and pin 8 on the extra channel pcb. The meter should read approximately 12V. Note that pins 14 (and 8) are 0V and the +12V should be on pins 13 (and



7). The pin numbers in brackets are for the extra channel pcb.

If all is well, connect a Doppler module to pins 13(7): +12V and 14(8): 0V. Adjust RV1 so that LED1 lights and check that if the Doppler module is removed the LED extinguishes. Reconnect the Doppler module and continue adjusting RV1 until the relay operates i.e. the LED and relay are now both operated.

Now turn the preset back until it is roughly in the middle of the region between the LED operating and the relay operating, i.e. the LED is now operated and the relay released. Connect a 2k to 3k resistor across pins 13(7) and 14(8) with the Doppler module still connected and check that the relay operates. Otherwise further adjustment of RV1 will be necessary. Remove the resistor. The output can now be wired as shown in Figure 1. ■

CHANNEL/PSU PARTS LIST

Resistors – All 0.6W 1% metal oxide unless specified

R1,8	1k5	2	(M1K5)
R2	220Ω	1	(M220R)
R3,7	4k7	2	(M4K7)
R4,6	2k2	2	(M2K2)
R5	27k	1	(M27K)
R9,10	15Ω(7W wirewound)	2	(L15R)
RV1	Hor Enclosed preset	1	(UH01B)

Capacitors

C1	4700µF 25V axial electrolytic	1	(FB96E)
C2	1000µF 16V axial electrolytic	1	(FB82D)
C3	100nF disc ceramic	1	(BX03D)

Semiconductors

D1,2,3,4	1N4001	4	(QL73Q)
D5	BZY88C5V1	1	(QH07H)
LED1,2	LED red	2	(WL27E)
TR1,2,4	BC212L	3	(QB6QQ)
TR3	BC548	1	(QB73Q)
REG 1	µA78M12UC	1	(QL29G)

Miscellaneous

T1	Toroidal 30VA 15V	1	(YK11M)
RLA	Ultra min relay 12V	1	(YX94C)
FS1	20mm A/S fuse 2A	1	(WR20W)
	Chassis fuseholder 20mm	1	(RX49D)
	Mounting kit (P) plas	1	(WR23A)
	Channel/PSU pcb	1	(GA81C)
	Terminal block (5A)	1	(HF01B)
	Veropin 2141	1 Pkt	(FL21X)
	Bolt 6BA ¼in	1 Pkt	(BF05F)
	Bolt 6BA ½in	1 Pkt	(BF06G)
	Spacer 6BA ¼in	1 Pkt	(FW34M)
	Washer 6BA	1 Pkt	(BF22Y)
	Nut 6BA	1 Pkt	(BF18U)
	TC wire 24swg	1 Mtr	(BL15R)
	*Mains cable	as Reqd	(XR01B)
	*Thermpath	as Reqd	(HQ00A)

A complete kit of parts containing all the above items except those marked * is available.
Order As LW74R (Radar Channel/PSU Module)

EXTERNAL HORN PARTS LIST

Resistors – All 0.6W 1% metal oxide unless specified

R1,6	4k7	2	(M4K7)
R2,4	2k2	2	(M2K2)
R3	27k	1	(M27K)
R5	1k5	1	(M1K5)
R7,8	15Ω(7W wirewound)	2	(L15R)
RV1	2k2 Hor Encl preset	1	(UH01B)

Capacitors

C1	1000µF 16V axial electrolytic	1	(FB82D)
C2	100nF disc ceramic	1	(BX03D)

Semiconductors

D1	1N4001	1	(QL73Q)
D2	BZY88C5V1	1	(QH07H)
LED1	LED red	1	(WL27E)
TR1,3	BC212L	2	(QB6QQ)
TR2	BC548	1	(QB73Q)
REG 1	µA78M12UC	1	(QL29G)

Miscellaneous

RLA	Ultra min relay 12V	1	(YX94C)
	Mounting kit (P) plas	1	(WR23A)
	Extra Channel pcb	1	(GA82D)
	Veropin 2141	1 Pkt	(FL21X)
	Bolt 6BA ¼in	1 Pkt	(BF05F)
	Bolt 6BA ½in	1 Pkt	(BF06G)
	Spacer 6BA ¼in	1 Pkt	(FW34M)
	Washer 6BA	1 Pkt	(BF22Y)
	Nut 6BA	1 Pkt	(BF18U)
	*Thermpath	as Reqd	(HQ00A)
	Constuctors Guide	1	(XH79L)

A complete kit of parts containing all the above items except that marked * is available.
Order As LW75S (Radar Extra Channel Module)

THE ULTRASONIC INTRUDER DETECTOR

by Dave Goodman

- ★ **Range up to 20 feet (400 sq. ft. area)**
- ★ **Adjustable sensitivity**
- ★ **Direct connection to the Maplin Home Security System via our ultrasonic interface plug-in module**
- ★ **Single PCB construction with no setting up required**
- ★ **Up to three may be used on any Maplin Home Security System**

The new ultrasonic intruder detector is a worthwhile addition to your Maplin Home Security System. It will function over a much wider area than conventional switch contacts, it is highly portable, can be used almost anywhere, and can offer total security of a fairly large room.

The ultrasonic detector works on the Droppler Effect Principle which in this case means transmission of a 40kHz carrier signal, and reception of the fundamental carrier along with the additional frequency shifted signals. These extra signals can vary in frequency by up to 200Hz either side of the fundamental, and are quite small in amplitude. Several stages of filtering are required to remove

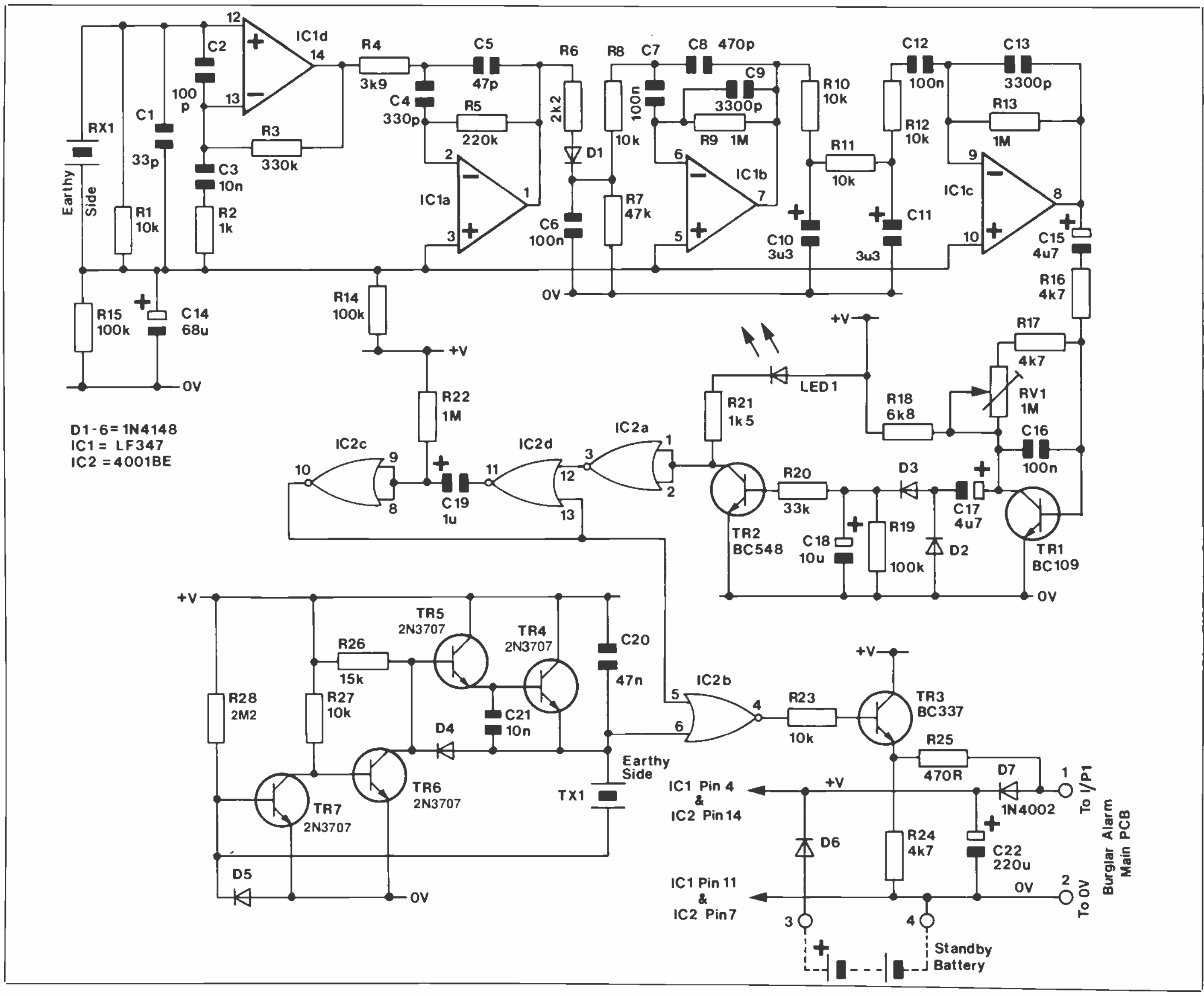


Figure 1. Circuit diagram of the Ultrasonic Transceiver.

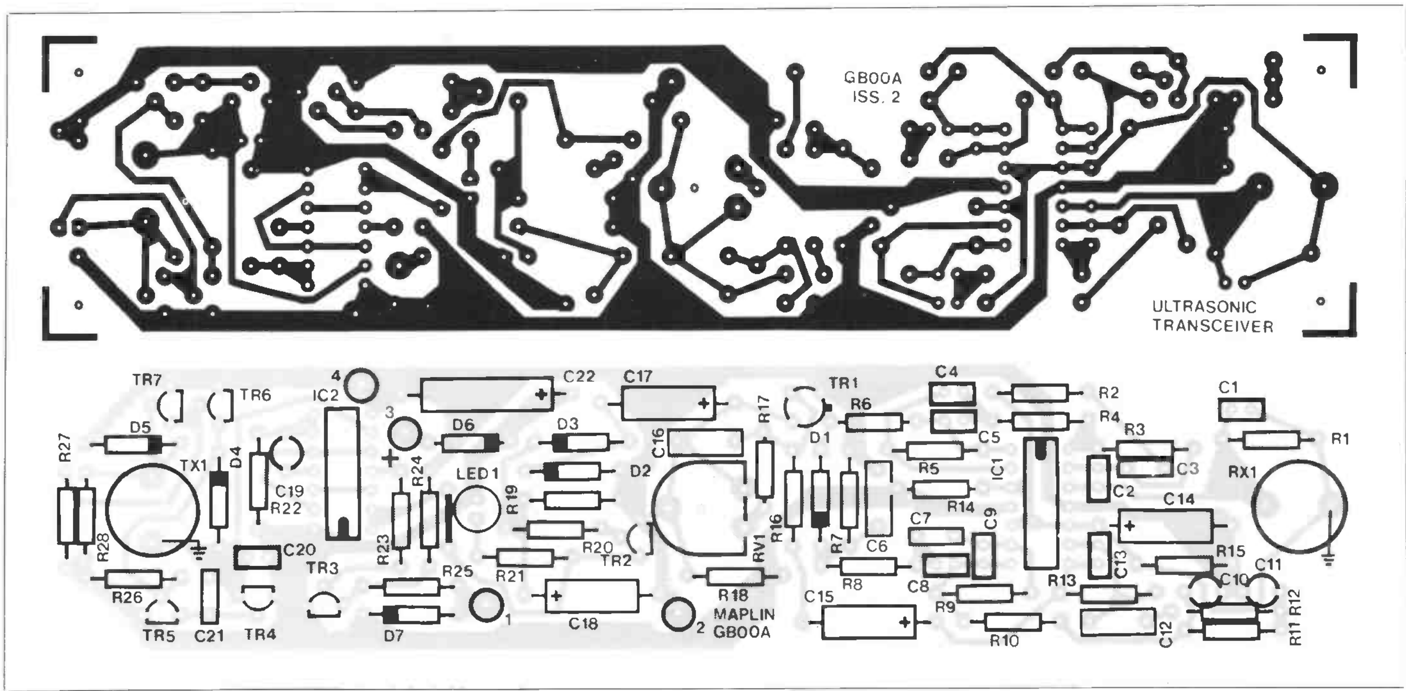
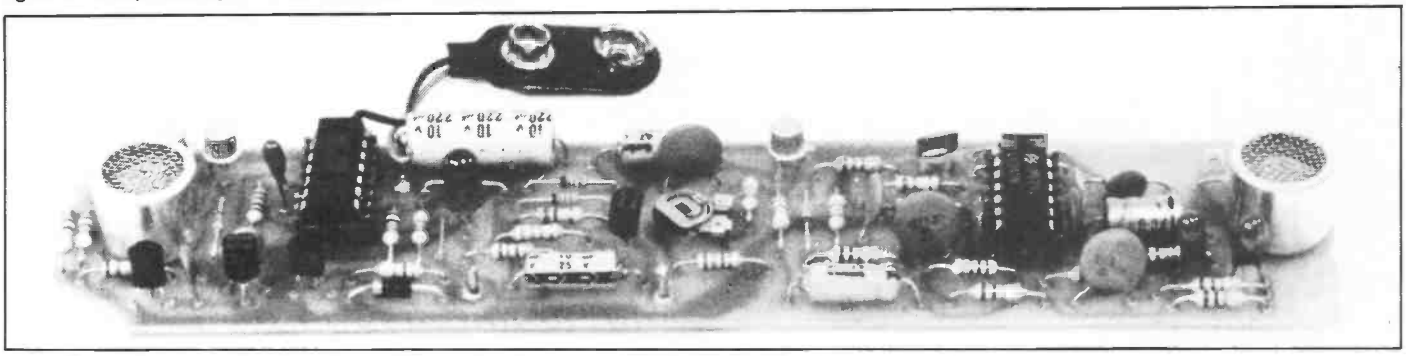


Figure 2. Component layout of the Ultrasonic Transceiver.



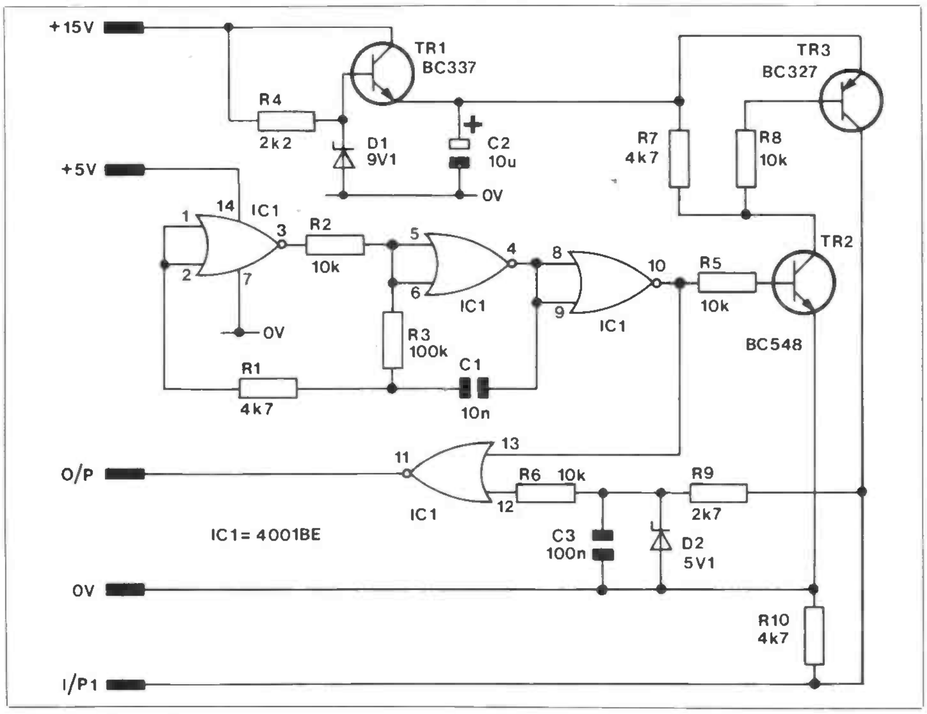


Figure 3. Circuit diagram of the Ultrasonic Interface.

the carrier, spurious r.f., and mains interference. The remaining signals are amplified, and, if they are sufficiently large, the alarm will be triggered. The level of triggering is dependent on the sensitivity setting. In this design the transmitter and receiver are both mounted on the same PCB along with their associated circuitry, and signals are 'bounced' around the room.

The Transmitter

As an improvement over conventional systems, in which the oscillator may require many tedious hours of alignment, we have designed a system in which the transducer determines the oscillator frequency, i.e. the circuit needs NO setting up at all.

The circuit TR4,5,6 and 7, allows the transducer to oscillate at its self-resonating point. C20 at switch-on discharges through the transducer, causing it to resonate. The produced signal is amplified by TR6 and 7, and a constant current circuit comprising TR4, 5 and D4, allows the necessary feedback for sustained oscillation. From this it can be seen that the normal operating frequency becomes dependent on the transducer.

The Receiver

Ultrasonic signals transmitted in an enclosed area will reflect and bounce off hard surfaces, and be absorbed by soft surfaces. A percentage of these signals (called nodes and anti-nodes) are reflected back at the receiver transducer. The transmitter and receiver being matched pairs means that the receiver has a greater affinity for signals transmitted by its partner than for those produced by anything else. Because we are dealing with audio signals, it is possible for low frequency signals of sufficient amplitude (e.g. the rumble of a lorry going past) to trigger the intruder system, so filtering is required. Tests have shown that beat frequencies of between 5Hz and 100Hz can be produced by objects moving through the ultrasonic field. C1 and C2 remove unwanted r.f. signals present at the input of IC1d. This stage has a gain of 300, and high rejection of signals above the ultrasonic band. IC1a amplifies the received ultrasonic signals only, and has a first order response. D1 allows only the positive portion of the signal through, and the carrier part of the signal is removed by C6/R7, leaving only the lower frequency content of the signal. IC1b amplifies all low frequency (l.f.) signals, also filtering any possible remaining high frequency (h.f.) content. R10/11/12 and C10/11 form a low pass filter, which only allows signals below 50Hz to pass through to the final amplifying stage of IC1c. We should now be looking (on pin 8) at what is a stable threshold voltage of about +3v. modulated by l.f. signals of 5-50 Hz, and up to 5v in amplitude.

The stage comprising TR1, RV1, and R16/17 determines the overall sensitivity of the receiver, with a range from unity to x100. Amplified signal peaks are coupled to the diode pump D2/3, C18, R19, so that when the voltage across C18 develops more than 0.7v, sufficient current is produced to bias TR2 into conduction. LED1 illuminates. This has been included to give the user a means of visibly testing the circuit range and coverage (see setting-up procedure).

IC2a inverts and buffers the output from TR2. IC2c and IC2d form a monostable triggered by IC2a. IC2b is a control gate switching the 40kHz carrier from the transmitter oscillator to TR3.

With the working system in a stable condition the 40kHz carrier is coupled via R25 to the incoming supply rail. If the system is triggered the carrier is removed. Note that the supply rails connect to the burglar alarm via a plug-in module (the u/s interface PCB, GB01B).

A standby battery (PP3-9V) is shown connected, positive terminal to pin 3, and negative terminal to pin 4. Charging or 'topping up' facilities have not been added to this part of the circuit, so periodical checks on battery conditions are advisable. Note that the battery will not be required when using the transceiver in conjunction with a u/s interface PCB and our Home Security System, although it will be necessary to increase the NiCad battery pack from 7.8v to 9v. This can be accomplished with a total of eight NiCads (1.2v nominal) and two 6v battery holders (HF29G).

Ultrasonic Interface PCB

This simple circuit identifies the carrier signals transmitted by the ultrasonics module. These signals appear between each 2ms current pulse (used for powering the transceiver), and allows monitoring of the two wire supply connection.

IC1a and b form a 500Hz CMOS oscillator, and switch the buffer transistor TR2 at this rate. The regulator D1, TR1, applies 8.6V d.c. to TR3, which is

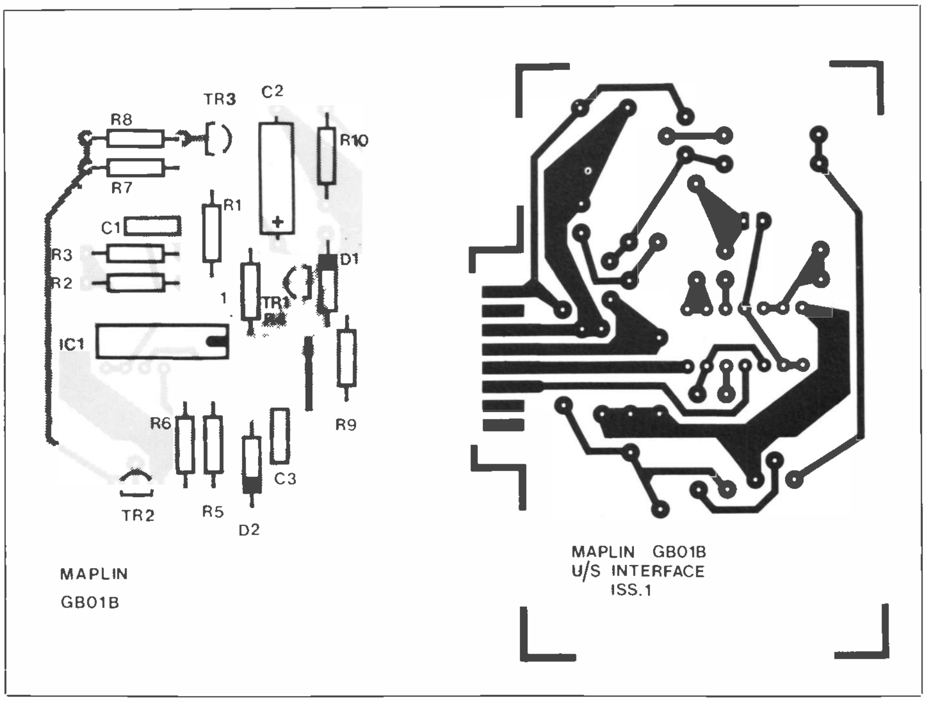
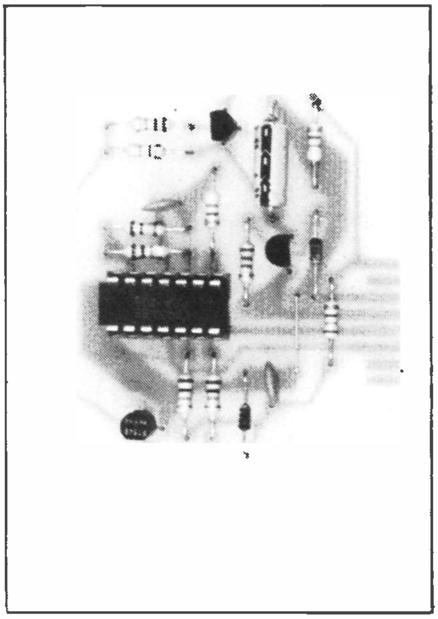


Figure 4. Component layout of the Ultrasonic Interface.



pulsed on and off by TR2, producing an 8.6V, 500Hz signal across R10. This signal is rectified by D7 and C22 (figure 1) in the transceiver, producing 8.2V on the positive rail.

IC1d has a 500Hz clock pulse on pin 13, and an in-phase signal of 500Hz on pin 12. The two signals cancel at the output, pin 11, producing an inverted trigger signal, which fires the burglar alarm. However, under normal conditions a carrier signal will be present across R10, appearing between each 2ms pulse. R6, R9, D2, and C3 filter and limit this composite signal, and IC1d output remains low. Either disconnection of the supply, or triggering the transceiver will remove the 2ms 'carrier' from across R10, sending IC1d output high (+5V), and setting off the alarm.

Constructional Details for Ultrasonic Intruder Detector

Refer to the parts list and Figure 2 Mount D1 to D7 ensuring correct orien-

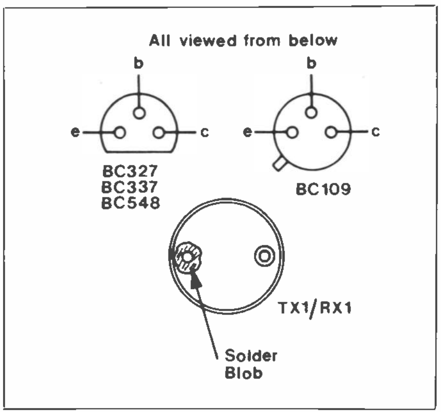


Figure 5. Pin Designations.

tation. Mount resistors R1 to R28, and capacitors C1 to C22. Check that the electrolytics C14, C15, C17, C18 and C22, also tantalums C10, C11 and C19 are mounted with correct polarisation. Electrolytics are marked at the negative end but tantalums at the positive. Fit the I.C. sockets, and all transistors. TR1, TR6, and TR7 have their emitters marked with a pip on the case, and should line up with the legend marked on the PCB. If a metal case is used, it is important that the transducers do not touch the chassis. The transducers each have one pin connected directly to their case, and this pin should be connected to the hole marked ⏚ (Figure 2).

Assembly of Ultrasonic Trigger

Observe the usual precautions when mounting components. Use an I.C. holder, for IC1, and double-check all solder joints. Plug the module into any channel on the main PCB of the Home Security System, and apply power. If you have a voltmeter, check across pins OV and I/P 1 on the main PCB. This sould read approx. 5.0V dc. Also the selected channel should trigger, and the monitoring LED will light.

Setting Up

Set RV1 anti-clockwise. Connect a 9V battery across pin 3 (positive) and pin 4 (negative). LED 1 should come on for a few seconds and then extinguish. Allow 30 seconds settling time, and then wave your hand about six inches away from the transducers. Response to movement should be indicated by LED 1 illuminating, and it should remain so for a few seconds. If there is no response, turn RV1 to approximately ¼ travel to increase sensitivity, and repeat check. If the LED now stays on, move away to a point where the LED is still visible, and keep completely still. After a few seconds the LED should go out. If the circuit still does not work, try disconnecting the battery, and repeating the above checks. If all is satisfactory remove the battery and connect the transceiver to the Maplin Home Security System main PCB.

Use either bell wire, or our 4-wire phone cable (XR66W) to connect the transceiver to the main PCB (burglar alarm). Pin 2 will connect to 0V and Pin 1 will connect to I/P 1.

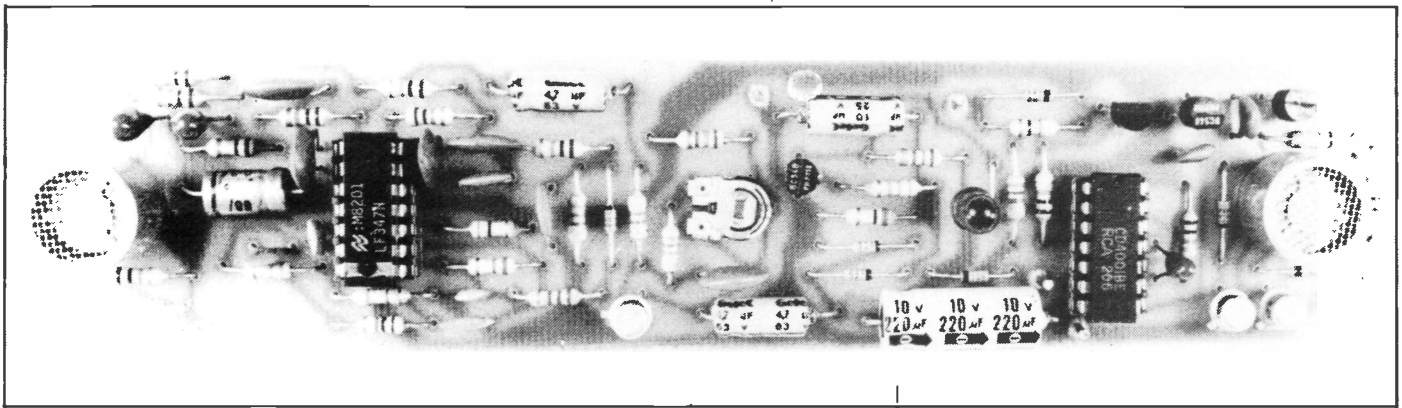
Whatever channel is used for this project, ensure that a u/s interface module is plugged in to this position only.

At switch-on the burglar alarm channel LED will flash. Allow about a minute for the transceiver to stabilise. Turn the sensitivity control RV1 clockwise, to suit conditions, and set the key switch for 'ARM'. Don't forget to switch in the selected channel (switches 3 to 8).

If stand-by batteries are to be used, remove the mains supply, then reconnect. Check that the system does not trigger. If all is well, experiment with RV1 settings for optimum results before putting into service.

Using Ultrasonics

The module is best placed in a corner of the room to be protected, preferably just below ceiling level, and inclined at an angle of 30 to 45 degrees downwards. Keep as far away as possible from windows, radiators, central heating thermostats, and telephones and bells. Remember that anything that moves (e.g. curtains, telephone bells) can set off the alarm, dependent on sensitivity. RV1 must now be adjusted for required sensitivity. Obviously, the more sensitive the system, the greater the possibility of false triggerings occurring. If areas greater than 400 square feet need covering, then two or more devices may be used. Note that each transceiver will draw 24mA, and up to three may be used on one system, dependent on what else is connected to the system.



ULTRASONIC TRANSCEIVER PARTS LIST

Resistors: All 0.6W 1% metal oxide

R1,8,10-12 inc,23,27	10k	7	(M10K)
R2	1k	1	(M1K)
R3	330k	1	(M330K)
R4	3k9	1	(M3K9)
R5	220k	1	(M220K)
R6	2k2	1	(M2K2)
R7	47k	1	(M47K)
R9,13,22	1M	3	(M1M)
R14,15,19	100k	3	(M100K)
R16,17,24	4k7	3	(M4K7)
R18	6k8	1	(M6K8)
R20	33k	1	(M33K)
R21	1k5	1	(M1K5)
R25	470Ω	1	(M470R)
R26	15k	1	(M15K)
R28	2M2	1	(M2M2)
RV1	1M hor encl preset	1	(WR64U)
Capacitors			
C1	33pF ceramic	1	(WX50E)
C2	100pF ceramic	1	(WX56L)
C3,21	10nF disc ceramic	2	(BX00A)
C4	330pF ceramic	1	(WX62S)
C5	47pF ceramic	1	(WX52G)
C6,7,12,16	100nF disc ceramic	4	(BX03D)
C8	470pF ceramic	1	(WX64U)
C9,13	3300pF ceramic	2	(WX74R)
C10,11	3µ3F 35V tantalum	2	(WW63T)
C14	68µF 6V3 axial electrolytic	1	(FB44X)
C15,17	4µ7F 63V axial electrolytic	2	(FB18U)
C18	10µF 25V axial electrolytic	1	(FB22Y)
C19	1µF 35V tantalum	1	(WW60Q)
C20	47nF minidisc	1	(YR74R)
C22	220µF 10V axial electrolytic	1	(FB60Q)
Semiconductors			
D1-6 inc.	1N4148	6	(QL80B)
D7	1N4002	1	(QL74R)
LED 1	LED RED	1	(WL27E)
TR1	BC109C	1	(QB33L)
TR2	BC548	1	(QB73Q)
TR3	BC337	1	(QB68Y)
TR4-7	2N3707	4	(QR31J)
IC1	LF347	1	(WQ29G)
IC2	4001BE	1	(QX01B)
Miscellaneous			
TX1/RX1	Ultrasonic transducers (pair)	1	(HY12N)
	Veropin 2141	1 Pkt	(FL21X)
	14-pin DIL skt	2	(BL18U)
	Ultrasonic Transceiver PCB	1	(GB00A)

A complete kit of all the above parts is available.
Order AS LW83E (Ultrasonic Xceiver Kit)

U/SONIC INTERFACE PARTS LIST

Resistors: All 0.6W 1% metal oxide

R1,7,10	4k7	3	(M4K7)
R2,5,6,8	10k	4	(M10K)
R3	100k	1	(M100K)
R4	2k2	1	(M2K2)
R9	2k7	1	(M2K7)
Capacitors			
C1	10nF mini disc	1	(YR73Q)
C2	10µF 25V axial electrolytic	1	(FB22Y)
C3	100nF mini disc	1	(YR75S)
Semiconductors			
D1	BZY88 C9V1	1	(QH13P)
D2	BZY88 C5V1	1	(QH07H)
TR1	BC337	1	(QB68Y)
TR2	BC548	1	(QB73Q)
TR3	BC327	1	(QB66W)
IC1	4001BE	1	(QX01B)
Miscellaneous			
	14 pin DIL Skt	1	(BL18U)
	U/S Interface PCB	1	(GB01B)

A complete kit of all the above parts is avilable.
Order As LW84F (Ultrasonic Interface Kit)

PANIC BUTTON

by Dave Goodman

★ **For use with the Maplin Home Security System**
★ **Will trigger External Horn even if system is disarmed**
★ **Can be reset with existing alarm unit keyswitch**

This project has been designed specifically in response to the many requests we have had for a 'Panic Button' addition to our Home Security System.

The requirement is for a button placed close to the front or back doors, inside the home, or even by the bedside. In any emergency pressing the button would trigger the alarm, setting off sirens, lamps, etc., and hopefully attracting attention and dissuading potential burglars. The Panic Button PCB caters for up to four switches, which should prove adequate for most applications, and complete instructions are given for connection to the Burglar Alarm PCB.

Circuit Description

With reference to Figure 1, two diodes, D1 and D2, are wired to the spare change-over contacts on the Burglar Alarm keyswitch (Figure 3). Either of these diodes will always be forward biased, allowing D3 only to conduct when the contact changes over. The keyswitch contacts are break-before-make, so that during switching a positive pulse appears at D3, which will, in turn, trigger the monostable IC1b and IC1c. This lengthened trigger pulse forward biases D4 and resets the latch IC1d and IC1e.

The output from IC1d is held low by R9 and a high output from IC1e. This may be thought of as a loop. IC1a and

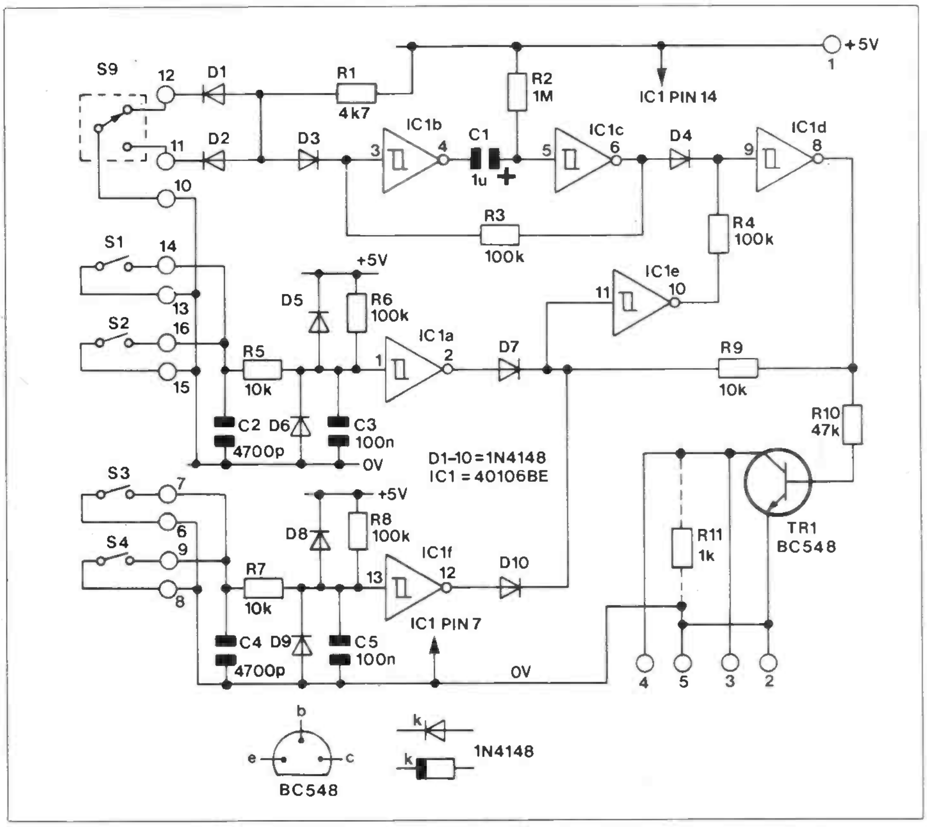


Figure 1. Circuit diagram

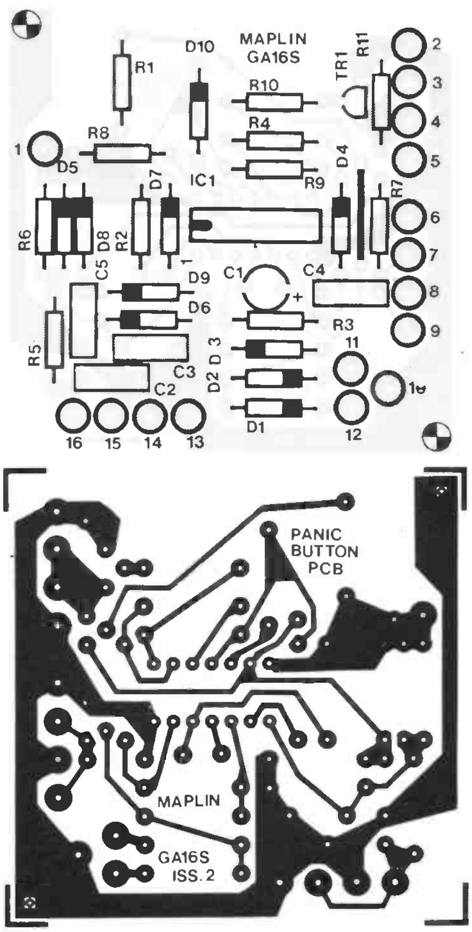


Figure 2. PCB layout and legend

IC1f are input buffers for the panic buttons. These are arranged into two input groups, with provision for two switches per group, allowing up to four switches to be connected. D5, D6, C2, and C3 slow the switching action to avoid contact bounce problems, and give protection from false triggering from RF voltages and spikes induced along connecting cable runs. D8, D9, C4 and C5 perform the same function for the other group.

Both buffer inputs are held high, by R6 and R8, and D7 and D10 will be reverse biased. Pressing button 1 will take IC1a input low and D7 will conduct. IC1e output will go low and IC1d output will switch high. TR1 will then conduct and remain in this state, due to the latching action of IC1d and e, even when button 1 is released. TR1 collector and emitter are wired across the external horn pins on our Burglar Alarm PCB (Figure 4), and will now trigger the external horn. If the burglar alarm is in 'set' mode this too will be triggered. To reset the panic button and/or the main alarm/external horn keyswitch S9 must be switched from one position to the other, but it does not matter which way or how many times this is done. Associated circuitry for buttons 2 to 4 functions in the same way.

Assembly

Bend and insert the one link, between D4 and R7, and insert resistors R1 to R11. All ten diodes can now be fitted, making sure that their black tips align with the white bar on the legend. Fit the five capacitors, noting that C1 is polarised. Finally place TR1 and the 14-pin IC socket in position and solder all components carefully. If you are using

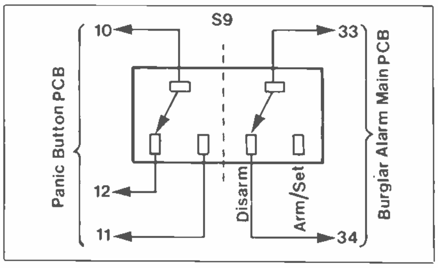
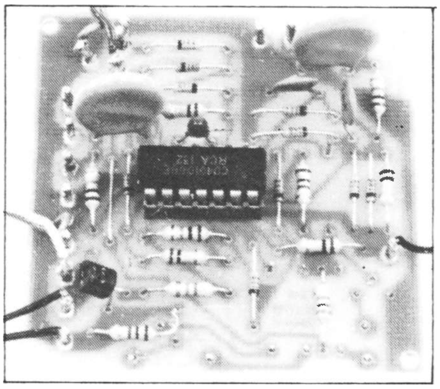


Figure 3. Keyswitch connections



them, fit all sixteen veropins and solder those too. Cut all excess leads and check for dry joints and short circuits. Insert IC1 into the holder and proceed with testing the board.

Testing

Refer to Figure 4 before attempting to connect the PCB to your alarm unit, first switching off mains and removing batteries, if fitted. This will cause the external horn to trigger, so disconnect the external wiring from pins 29 and 30 (if used), and reconnect the wire ends to a 4.5V battery. If the horn still sounds, reverse battery connections to these wires and the horn will stop. Of course, the batteries may be removed from the external horn cabinet, but this may prove to be inconvenient in practice.

Connect three wires from the Panic Button PCB to the Burglar Alarm PCB as follows:

Panic Button PCB		Burglar Alarm PCB
pin 1		+5V
pin 4	to	pin 30
pin 5		pin 29

also connect pins 10, 11, and 12 to keyswitch S9, as shown in figures 3 and 4.

Re-apply power to the alarm system and turn key-switch S9 to SET. After any time out period the alarm should not trigger. If it does you may have left the micro switch (mounted on PSU) released. Simulate the panic buttons with a piece of wire connecting pins 13 and 14. The alarm will trigger, and continue to sound until the keyswitch is turned to DISARM. Remove the short on pins 13 and 14. Now return the keyswitch to SET and short pins 6 and 7 together. Again, the alarm should sound continually. Remove the short on pins 6 and 7.

The next check is made with an external horn connected to the panic button PCB. Either the external horn or the programmable timer PCBs can be used. Figure 4 shows wiring connections for both, so choose the one appropriate to your system. On the panic button PCB R11 must be completely removed, remembering to remove all power sources before you do so.

Reconnect power, sirens, etc., and turn the keyswitch to SET. Short circuit pins 15 and 16 on the panic PCB. Both internal and external horns should sound. Turn key to DISARM. Remove short from pins 15 and 16 and short pins 8 and 9. This time only the external horn should sound, and it should continue sounding until the short is removed. Turn the keyswitch to SET and then back to DISARM to reset the external horn. Tests are now complete and the system is ready for use.

The System In Use

Mount the PCB in the burglar alarm cabinet and connect the wiring as shown in Figures 3 and 4.

The type of switches used for the panic buttons will depend on personal preference, but switches ideal for this purpose appear in the parts list. A make-when-pressed action is required, and up to four buttons can be used.

Some points to remember are:—

1. Connect the external horn circuitry direct to the panic PCB, and *NOT* to the burglar alarm PCB as it was previously.
2. The normal burglar alarm functions have not changed in any way.
3. The panic facility will function whether the burglar alarm is set or not. The only difference between the two modes is that although both internal and external horns sound in the ARMED mode, only the external horn will sound in the DISARMED mode.
4. Either type of external horn PCB will function with this project.

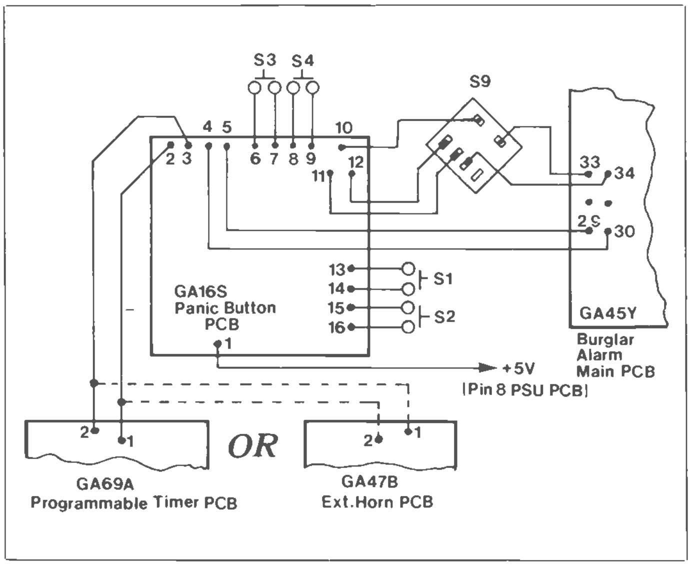


Figure 4. Wiring to Burglar Alarm and External Horn PCBs

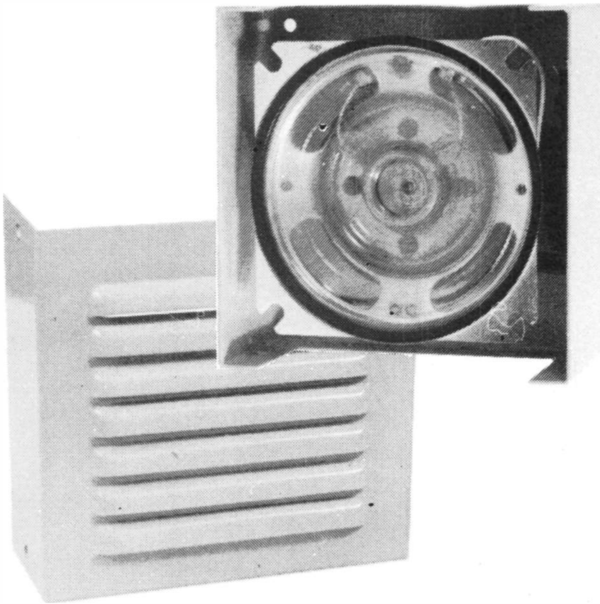
PANIC BUTTON PARTS LIST

Resistors – All 0.6W 1% metal film			
R1	4k7	1	(M4K7)
R2	1M	1	(M1M)
R3,4,6,8	100k	4	(M100K)
R5,7,9	10k	3	(M10K)
R10	47k	1	(M47K)
R11	1k	1	(M1K)
Capacitors			
C1	1μF 35V Tantalum	1	(WW60Q)
C2,4	4700pF 1000V Disc	2	(HY18U)
C3,5	100nF Disc Ceramic	2	(BX03D)
Semiconductors			
TR1	BC548	1	(QB73Q)
IC1	40106BE	1	(QW64U)
D1-10 inc.	1N4148	10	(QL80B)
Miscellaneous			
	Panic Button PCB	1	(GA16S)
	Veropin 2141	1 Pkt	(FL21X)
	14 pin DIL skt	1	(BL18U)
S1,2,3,4	Lge red push button	as Reqd	(RK82D)
	Constructor's Guide	1	(XH79L)

A complete kit of parts, including one panic button, is available.
Order As LW97F (Panic Button Kit)

EXTERNAL HORN PROGRAMMABLE TIMER

by Dave Goodman



- ★ **Three timing settings from 2 minutes to 2½ hours**
- ★ **Switch over from sounder to flashing beacon when time is up**
- ★ **Directly replaces the previous external horn PCB**
- ★ **Two wire control with tampering detection**

New recommendations concerning the use of burglar alarm sounders have recently been introduced, and apply only to sirens or bells fitted outside protected premises, not to those used internally, unless they are likely to be audible outside. The ruling comes under the noise pollution title, and requires that alarm sound indicators cease to function after a seventeen minute running period from switch-on. Presumably the alarm would, or should, have been raised within this time, and the appropriate authorities notified, making further ear-blasting and nerve-shattering decibels unnecessary. So that it is not forgotten that the alarm system has been activated a flashing lamp or beacon can be switched on which will flash away until reset. Perhaps eye pollution will become a problem in the future!

Specification

A timer project has been designed for use with the Home Security System (see March issue) which will directly replace the previous External Horn PCB. Any type of siren, bell, or sounder requiring 12V at no more than 1A DC can be used, and in addition a lamp or beacon rated at 12V and less than 1A DC can be switched on after a preset time-out period has elapsed. One of three timing periods (see table 1) ranging from 2 minutes to 2½ hours can be programmed by removing or adding two wire links as required.

A 12V battery supply is needed to power this system, and batteries, siren, and PCB will all fit into an external horn cabinet. Unfortunately, this PCB is larger than the previous one, and the mounting holes in the cabinet lid will not align with it, so a further two 6BA holes are required. The lamp may be fitted to the cabinet, or wherever it will be readily visible.

Circuit Description

R1 terminates a two wire loop connection from the mother board in the main alarm. Removal of R1 from the circuit, either by shorting or open

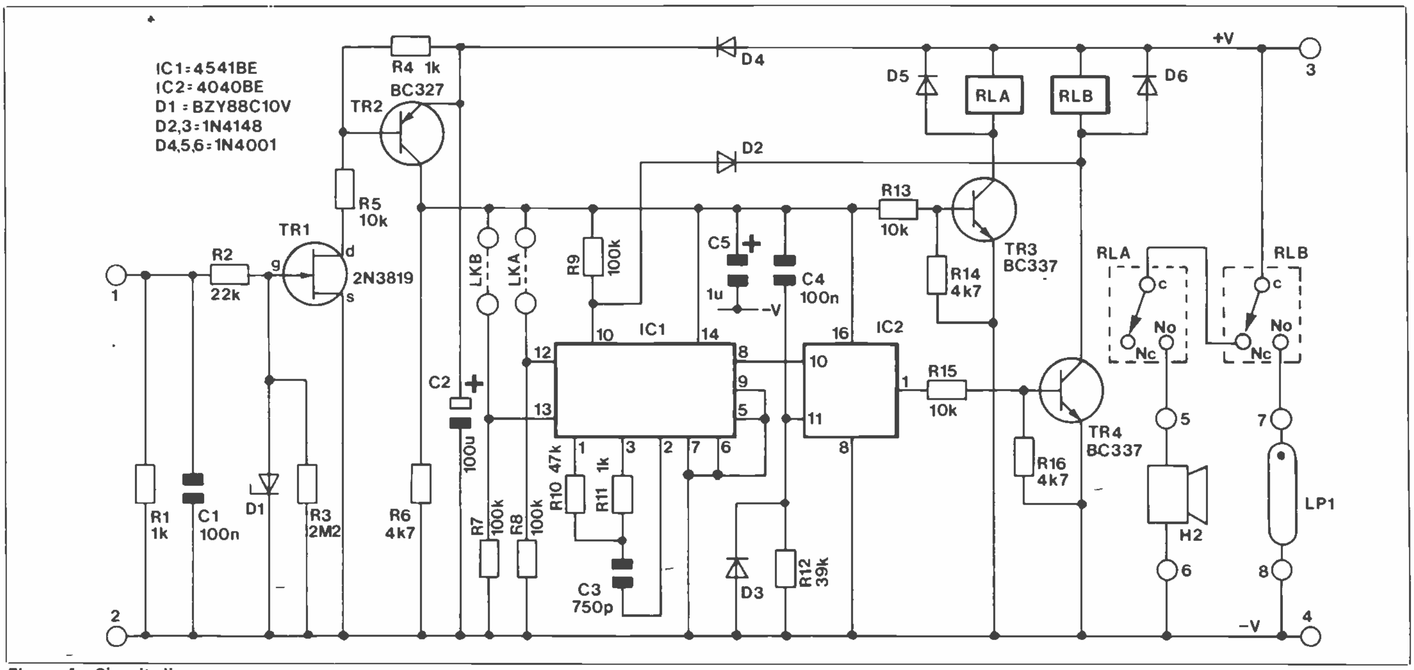


Figure 1. Circuit diagram.

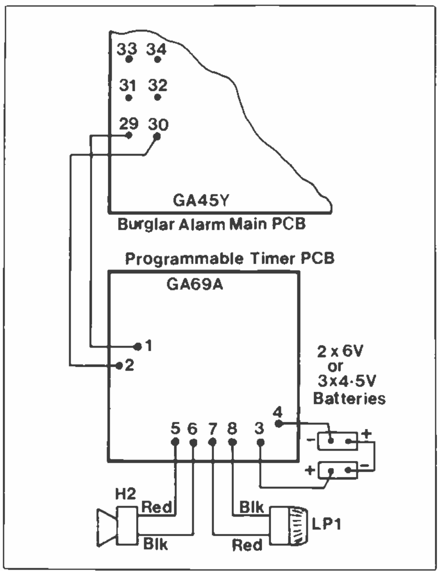
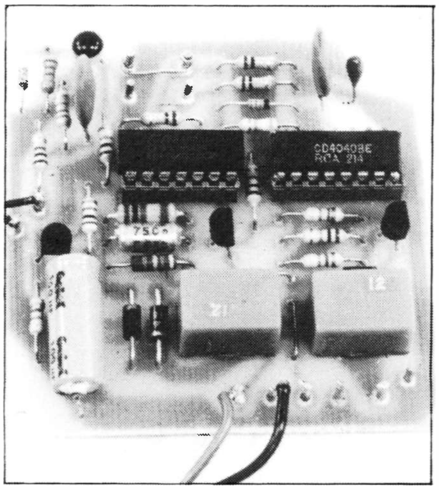


Figure 2. PCB layout and overlay.



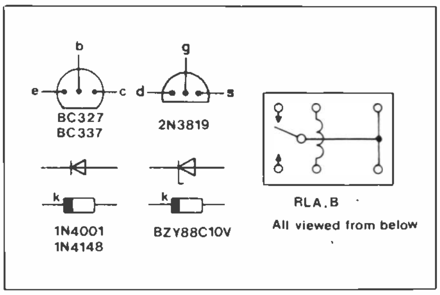
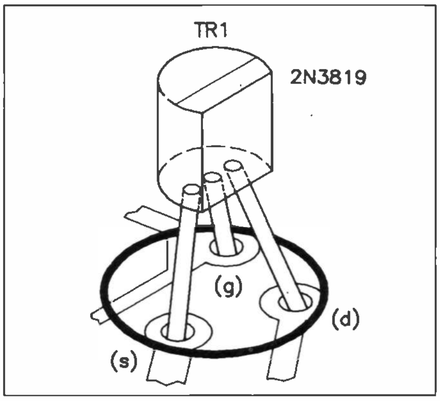


Figure 3. Wiring to main burglar alarm PCB.

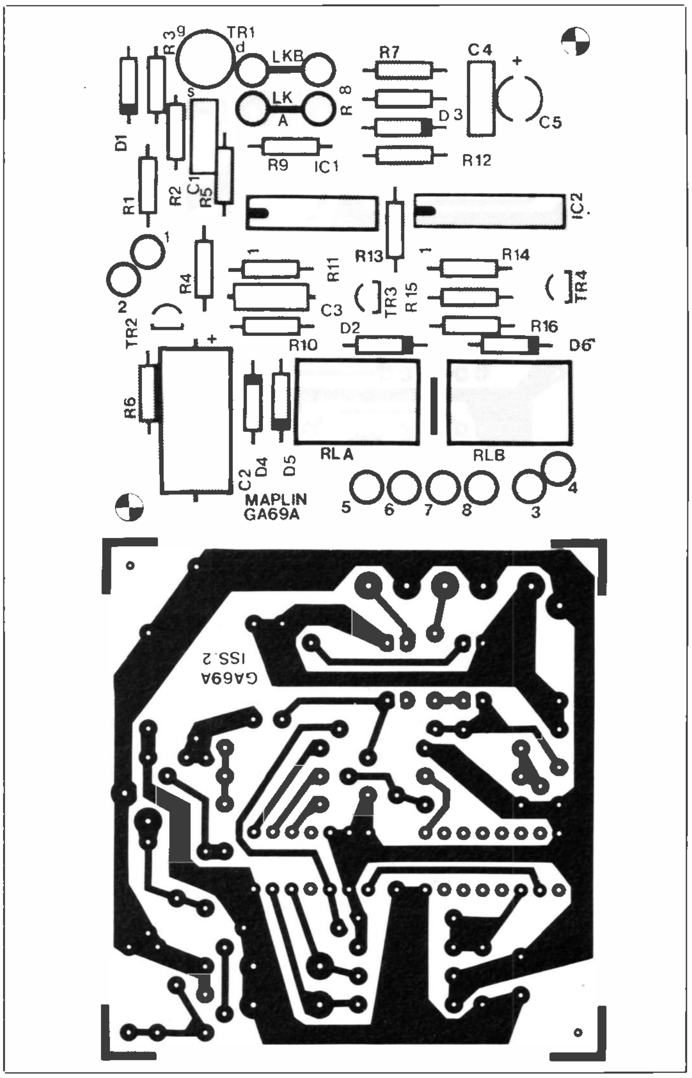


Mounting TR1.

circuiting the loop, will trigger the main alarm. TR1 is an N-type J-FET device, and requires a negative potential between gate and source to prevent drain current flow. With Pin 1 or 2 disconnected, R3 holds TR1 gate to ground, allowing drain current to flow.

C1, R2 and D1 help prevent RF and voltage spikes, that may be introduced along the length of connecting cable used, false triggering the timer. Now, with TR1 conducting, the voltage drop across R4 and R5 is sufficient to allow TR2 to conduct, and connect the battery positive rail, via D4, to the supply rail. R13 monitors the positive supply rail, and TR3 immediately conducts, switching RLA, and allowing the siren connected between pins 5 and 6 to operate for a period of time (generated by IC1 and 2.

IC1 is a programmable timer, with an internal clock and four dividing stages. Clock frequency is set by R10, R11 and C3 to 16.5kHz, which is divided down by one of three stages set by links from the positive rail to pins 12 and 13 (Table 1). The Q output at pin 8 requires further dividing, and is applied to a 12 stage ripple counter, IC2. C4 and R12 apply a reset pulse to IC2, ensuring that all twelve dividing stages will function, and a positive-going output at pin 1 operates TR4 and relay RLB.



PROGRAMMABLE TIMER PARTS LIST

Resistors – all 0.6W 1% metal oxide unless specified

R1,4,11	1k	3	(M1K)
R2	22k	1	(M22K)
R3	2M2	1	(M2M2)
R5,13,15	10k	3	(M10K)
R6,14,16	4k7	3	(M4K7)
R7,8,9	100k	3	(M100K)
R10	47k	1	(M47K)
R12	39k	1	(M39K)
Capacitors			
C1,4	100nF Disc Ceramic	2	(BX03D)
C2	100µF 25V axial electrolytic	1	(FB49D)
C3	750pF 1% polystyrene	1	(BX55K)
C5	1µF 35V Tantalum	1	(WW60Q)
Semiconductors			
D1	BZY88C10V	1	(QH14Q)
D2,3	1N4148	2	(QL80B)
D4,5,6	1N4001	3	(QL73Q)
TR1	2N3819	1	(QR36P)
TR2	BC327	1	(QB66W)
TR3,4	BC337	2	(QB68Y)
IC1	4541BE	1	(QQ47B)
IC2	4040BE	1	(QW27E)
Miscellaneous			
RLA,B	Ultra-min relay 12V SPDT	2	(YX94C)
	Programmable Timer PCB	1	(GA69A)
	Veropin 2141	1 Pkt	(FL21X)
	14-pin DIL skt	1	(BL18U)
	16-pin DIL skt	1	(BL19V)
	Construction Guide	1	(XH79L)
Optional			
LP1	12V Alarm Beacon	1	(YK39N)

*Printed below are the parts needed for the External Horn Case. (if required)

H2	Electronic siren	1	(XG14Q)
B1,2	6V lantern battery	2	
	Case	1	(XG07H)
	Grommet Small	1	(FW59P)
	No. 6 self-tapping screws x ½"	1 Pkt	(BF67X)
	Bolt 6BA x ½" (for P.C.B.)	1 Pkt	(BF06G)
	Washer 6BA	1 Pkt	(BF22Y)
	Nut 6BA	1 Pkt	(BF18U)
	Spacer 6BA x ¼"	1	(FW34M)
	Bolt 6BA x ¼" (for Siren)	1 Pkt	(BF05F)
	Wire to suit		

A kit of parts is available for this project. It does not include the Beacon which must be ordered separately if required, nor does it include any of the parts shown as*

Order As LW98G (Programmable Timer Kit)

The timing sequence must now be inhibited in this mode, otherwise RLB will switch off and on after each timeout period, and D4 stops this by preventing IC1 pin 8 from changing state. RLB contacts, changing over, will remove the battery supply from the siren and reconnect it to pin 7, hence the beacon will flash until the control loop is restored, either by resetting the main burglar alarm, or by the batteries running down.

Time Period	Link
2 mins	Link B
2hrs 30mins	Links A & B
17 mins	No Links

Table 1: Program Table

Assembly

Refer to Figure 2 and the parts list for building this project. You may commence construction by bending and inserting resistors R1 to 16 and diodes D1 to 6. Note that D1 is a zener diode, and different from the others. Fit capacitors C1 to 5, you will see that C2 and C5 are polarised, and must be fitted the correct way round. Finally, fit transistors TR1 to 4, and relays RLA and B, both IC holders, and all the Vero pins. Solder all the components into place, clean, and inspect the track for shorts and dry joints. When you are completely satisfied with your handiwork, proceed with testing before putting into use.

Testing

Preliminary checks can be made with a meter set to resistance range. Measure between pins 3 and 4 (supply rails), there should not be a shortcircuit here. Measure between one of the supply rail pins of LKA or LKB and pin 4, again there should not be a short circuit. Wire the PCB to the burglar alarm as shown in figure 3, and connect to a suitable 12V battery supply. Two 6V lantern type or three 4.5V batteries are recommended for use with the project, because quite high currents can be drawn by bells or sirens.

The beacon listed in the parts list gives a very bright flash once a second, but only draws 50mA, so battery life is extended. It is not necessary to make connection to a siren or lamp at this stage, as both RLA and B give an audible click when operated. Remove the wire from pin 1 and you should hear RLA click on. If you have placed a link in LKB you will have to wait two minutes before RLB clicks on. The next step is to connect both siren and lamp to repeat the tests after remaking the connection to pin 1. Ensure correct polarity of the four connecting wires, red is positive and black negative (Figure 3). The system is now ready for use.

Usage

Fit the timer PCB into your external horn cabinet. If you already have an external horn PCB it must now be discarded as this new system completely replaces the old unit. Two new holes are needed, but the existing spacers, nuts, and bolts can be used for mounting. If you do not possess our external horn cabinet, see parts list for details. Connect the batteries and siren, you will need a length of two-wire cable for connection to the lamp if fitted externally. Connect up to the Burglar Alarm and the system is complete.

HOME SECURITY SYSTEM

Continued from Page 10

external horns will sound along with LED 2. Turn the key switch to "dis-arm" and both horns should stop sounding. Note that the 12V external batteries supply the horn only, via TR2. When not in use, the current drain from B1 and B2 is approximately 5uA and will not effect the shelf life of the batteries greatly.

If problems are experienced in getting the external horn to work properly, replace R5 on external horn PCB with a wire link, and replace R9 on main burglar alarm PCB with a wire link.

USING THE SYSTEM

Various systems for sensing and triggering the alarm unit are available and are listed in the parts list. Typical connections are shown in Figures 18, 19 and 20. Note that for maximum security only five switches, each with a 22k resistor, should be used per input (10 switches per module) and connected as in Figure 18(C). With 6 modules in use, up to 60 switches can be accommodated, using a two wire system, or 30 switches using the 4 wire system. Whatever method is favoured, refer to the break contact setting up procedure and adjust RV1 and RV2 on each module for half the supply voltage. Any form of shorting, bridging, reversing or cutting connections will trigger the alarm.

If one input only, per module, is to be used, terminate the remaining input with a 22k resistor (see Figure 16) otherwise the alarm will keep sounding, with that channel switched in.

Magnetic reed switches can be mounted into door frames and the magnet into the door directly opposite. Surface type reeds are available for metal frame works.

Pressure mats should be placed under carpets etc ensuring adequate clearance from furniture and metal foil strip can be fitted to glass panels. There will shortly be ultra sonic and microwave doppler detectors available and those will interface directly to the break contact module.

Finally, remember that setting the modules to half (+2.5V) supply rail will allow detection of short circuits or open circuits, within the contact loop so make or break contacts may be accommodated, using suitably placed 22k resistors. ■

MAPLIN RTX DOPPLER UNIT

(continued from page 14)

DOPPLER MODULE PARTS LIST

Resistors: All 0.6W 1% metal oxide unless specified

R1	3k9	1
R2	1k	1
R3	82k	1
R4	51k	1
R5	150k	1
R6	4M7	1
R7,17	470Ω	2
R8,11,19	10k	3
R9	2k2	1
R10	470k	1
R12,13	220k	2
R14	100k	1
R15,16	1k	2
R18	220Ω	1
R20	47k	1
RV1	470k horiz sub-min preset	1
Capacitors		
C1,10	100nF minidisc	2
C2,12	100μF 10V pc electrolytic	2
C3,6,9	1μF 35V tantalum	3
C4,7,8	100nF polylayer	3
C5	4n7F polylayer	1
C11	10μF 50V pc electrolytic	1
Semiconductors		
D1,2	1N4148	2
D3	1N4001	1
LED 1	Mini LED red	1
	Mini LED clip 3mm	1
TR1,2	BC548	2
TR3	BD139	1
TR4	BC109C	1
TR5	BD131	1
IC1	TL430C	1
IC2	μA 741C (8-pin)	1
IC3	LF353	1
X1	Radar module CL8960	1
Miscellaneous		
	Doppler PCB	1
	Veropin 2141	8 pins
	Box AB7	1
	Grommet small	1
	Label Maplin RTX3	1
	Countersunk bolt 6BA ½in	4 bolts
	Countersunk bolt 6BA 1in	2 bolts
	Washer 6BA	10 washers
	Nut 6BA	10 nuts
	Hook-up wire	½ Mtr
	Constructors' Guide	1

A complete kit is available of all the above items plus an application form for the required licence. **Order As LW73Q (RTX3 Doppler Kit)**

DIGITAL MULTI-TRAIN CONTROLLER

by Robert Kirsch

★ **14 locomotives individually controlled on the same track**

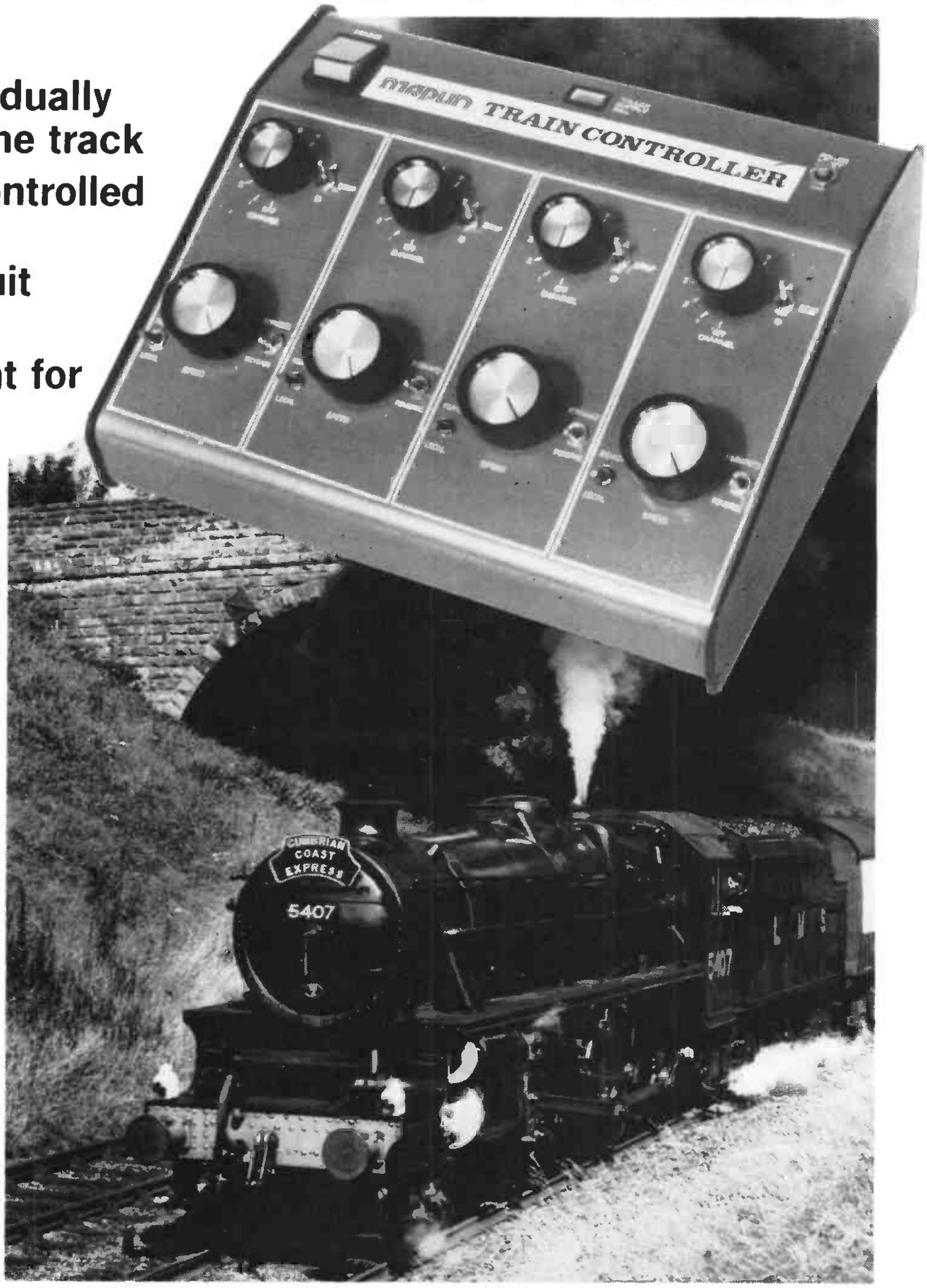
★ **Any 4 locomotives controlled simultaneously**

★ **Automatic short circuit protection**

★ **Supply always present for carriage lighting etc.**

★ **Remote control and computer interfacing**

★ **Low cost, two wire system**



Railway enthusiasts have for many years appreciated the need for a control system that enables trains to be driven as if the operator were in the driving cab of the locomotive. This not only means control of speed and direction of that locomotive, but also the ability to move anywhere on the layout without the need for track isolating or switching, thus making the wiring of the layout much simpler.

The system described in this article fulfills all these needs by producing a constant 18V DC on the track with digital information superimposed on it, to which only the selected train or trains will respond. The permanent track voltage also means that locomotive headlights, carriage lighting and many accessories may be used unaffected by the speed of the trains.

This system can control up to 14 locomotives all on the same track, and any four of these may be driven independently at one time. Provision is also made for any or all, of the four control units to be operated by a 7 bit digital input, thus enabling remote control either from hand-held units (using wire or radio) or from a home computer, giving full control of direction and speed.

Details of the remote control and computer interfacing will be described in later articles.

Circuit Description

Refer to Figures 1 to 5 when following the circuit description.

The most important consideration in the design of a system like this is to keep the receiver module as small as practicable to enable it to fit in as many locomotives as possible. This has been achieved by using a small 8 pin IC, the ML926/7, IC1 as the receiver. Decoding and control is accomplished by IC2, a 40106 CMOS IC leaving two transistors, TR2 and TR3 as input amplifiers, the six transistors TR4 to TR9 for motor control and one transistor, TR1 as a voltage stabiliser.

The ML926 and ML927 are pulse position modulation (PPM) receivers with built-in error detection circuits. There are four outputs from each IC, three of which are decoded by IC2 to control one of the seven receivers. (000 is used as the all off condition.) The fourth output is used to control the direction of travel. A fifth bit is transmitted by the control unit to select either the ML926 or the ML927 ICs, thus giving fourteen channels.

As it is only possible to decode one signal at a time the receiver is addressed for one period out of four (called its time slot) and it retains the information received until the next address is due.

The speed of a locomotive is controlled by allowing any number of coded time slots (from 1 to 10) to be transmitted during a period of 10 time slots (TS), thus controlling the on to off ratio of pulses fed to the motor. Minimum speed is with one TS pulse and nine

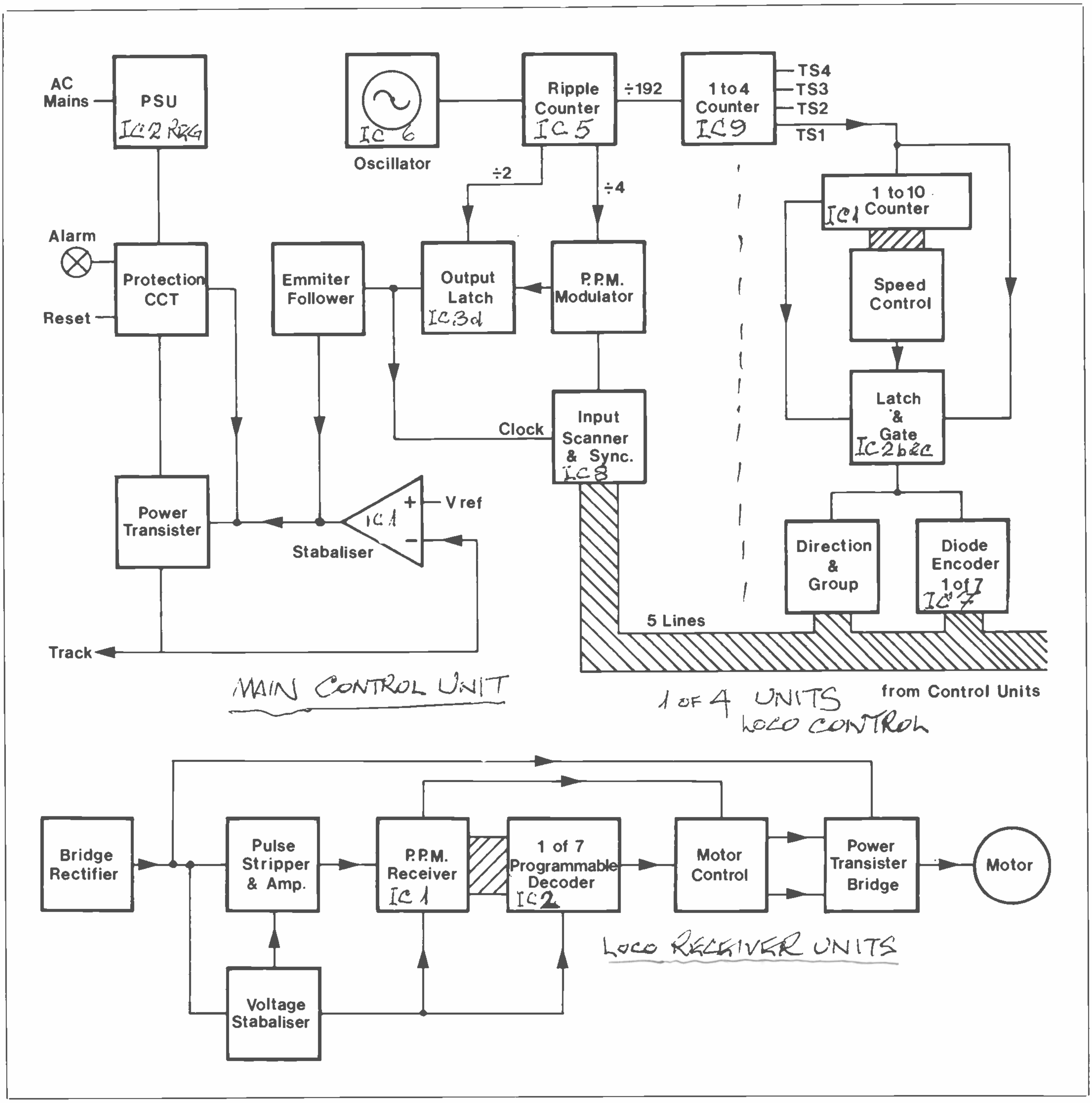


Figure 1. Block diagram. (a) Common and control boards. (b) Receiver.

blank periods, half speed is with five TS pulses and five blank periods and full speed is with a continuous string of TS pulses being sent thus keeping the motor driven at full power.

The transmitter IC normally used with the ML926/7 is the SL490 but several of the built in features of that IC make it undesirable to use in this application.

The PPM system uses a frame of six pulses followed by a sync period. Digital information is transmitted by varying the time between two consecutive pulses in the following ratio: DATA 1 = 2, DATA 0 = 3, SYNC = 6.

The pulse timing is controlled by resetting a counter IC4 after 2, 3 or 6 clock pulses have been received depending on whether the data to be sent is 1, 0 or sync. In order to transmit each one of the five data bits in their correct order another counter, IC8 scans the five AND gates IC3c and IC7 in turn and then at the sixth count causes the sync period to be sent at the same time resetting the counter for the next scan. The timing point of the pulse to be transmitted is detected by monitoring the resetting point of this counter. This causes the latch IC3d to be triggered which allows a pulse of twice the clock period to be sent.

The ripple counter, IC5 provides all timing pulses required by the controller. It is fed by the CMOS relaxation oscillator formed by IC6 a,b,c and d. This oscillator is divided by 192 by IC5 to produce a TS trigger pulse approximately every 850μs. Each frame of data takes about 380μs, so that two complete frames can be sent in one TS period.

The trigger pulse denoted above is used to clock the counter IC9 and produce four separate, consecutive output pulses, TS1-4 each approximately 850us long. Each of the four control boards is fed with one of these TS pulses and this pulse is used to step the counter IC1 (control board). The counter steps from one to ten and then resets itself for the next count. The first output from the counter sets the latch IC2b and c which is reset when the counter reaches the number set by the speed control thus holding the latch open for one to ten pulses. The latch gates TS pulses which are fed to the diode encoder. The pulses are connected onto one or more of the three data lines depending on the code of the receiver being addressed. If the reverse switch is operated or group 2 is selected the TS pulse is switched onto the appropriate data lines.

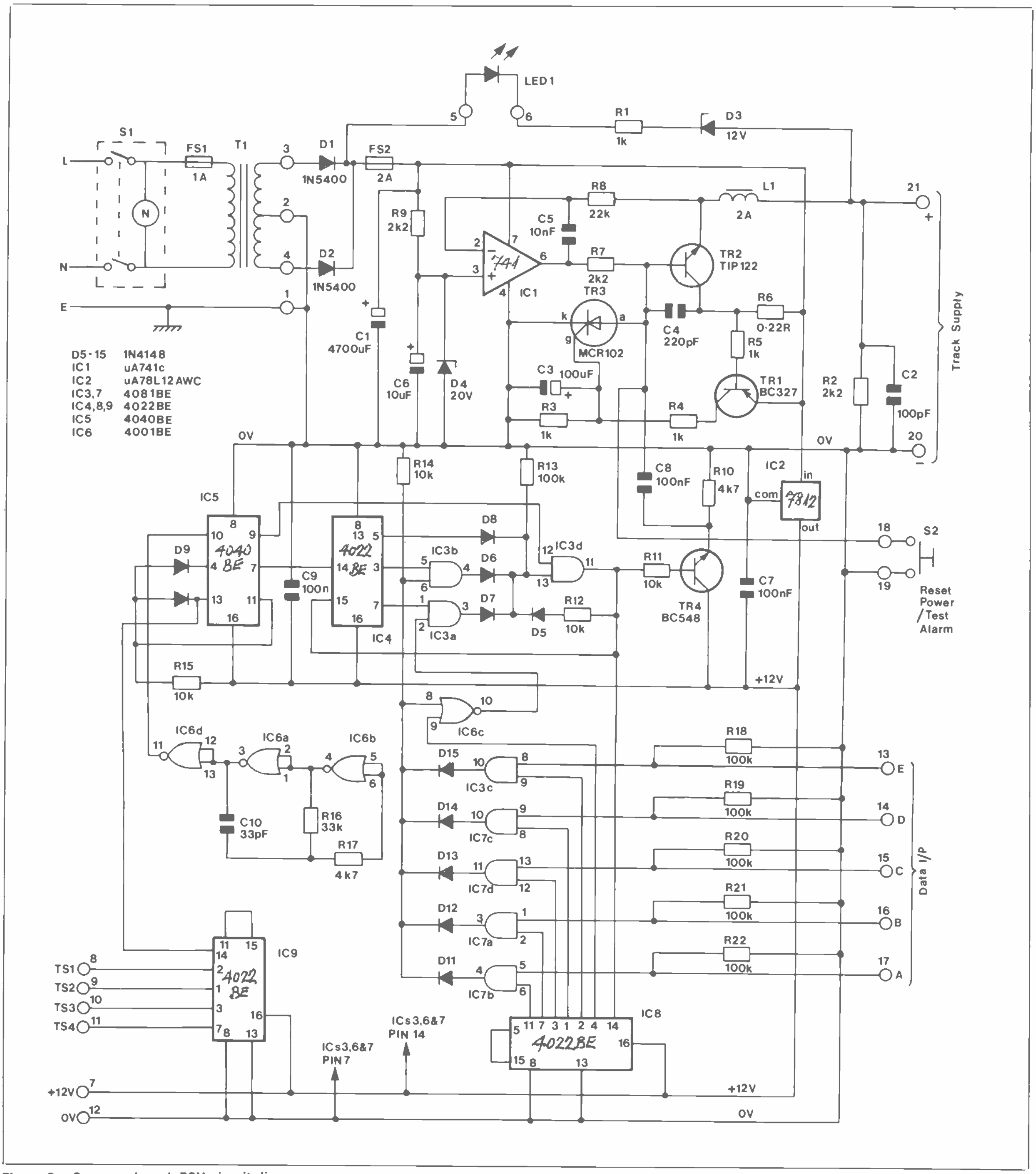
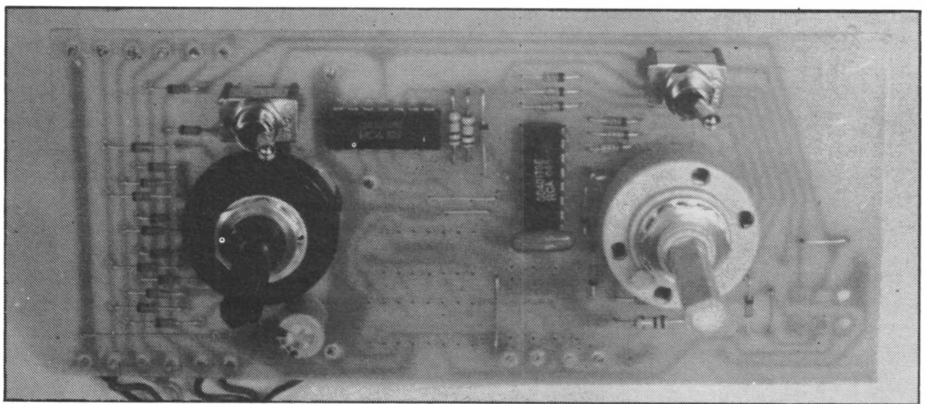


Figure 2. Common board. PSU circuit diagram.


Completed control PCB.

The DC supply fed to the track is stabilised by IC1 (common board) at about 18V and data signals from the emmiter follower TR4 are superimposed on it and used to control the power Darlington transistor, TR2 which supplies current to the track. In order to protect the controller from damage due to accidental short circuiting of the track the current flowing through R6 is monitored by TR1. When this current exceeds the preset limit the transistor conducts and fires the SCR TR3 thus removing the drive to TR2 and turning off the supply to the track.

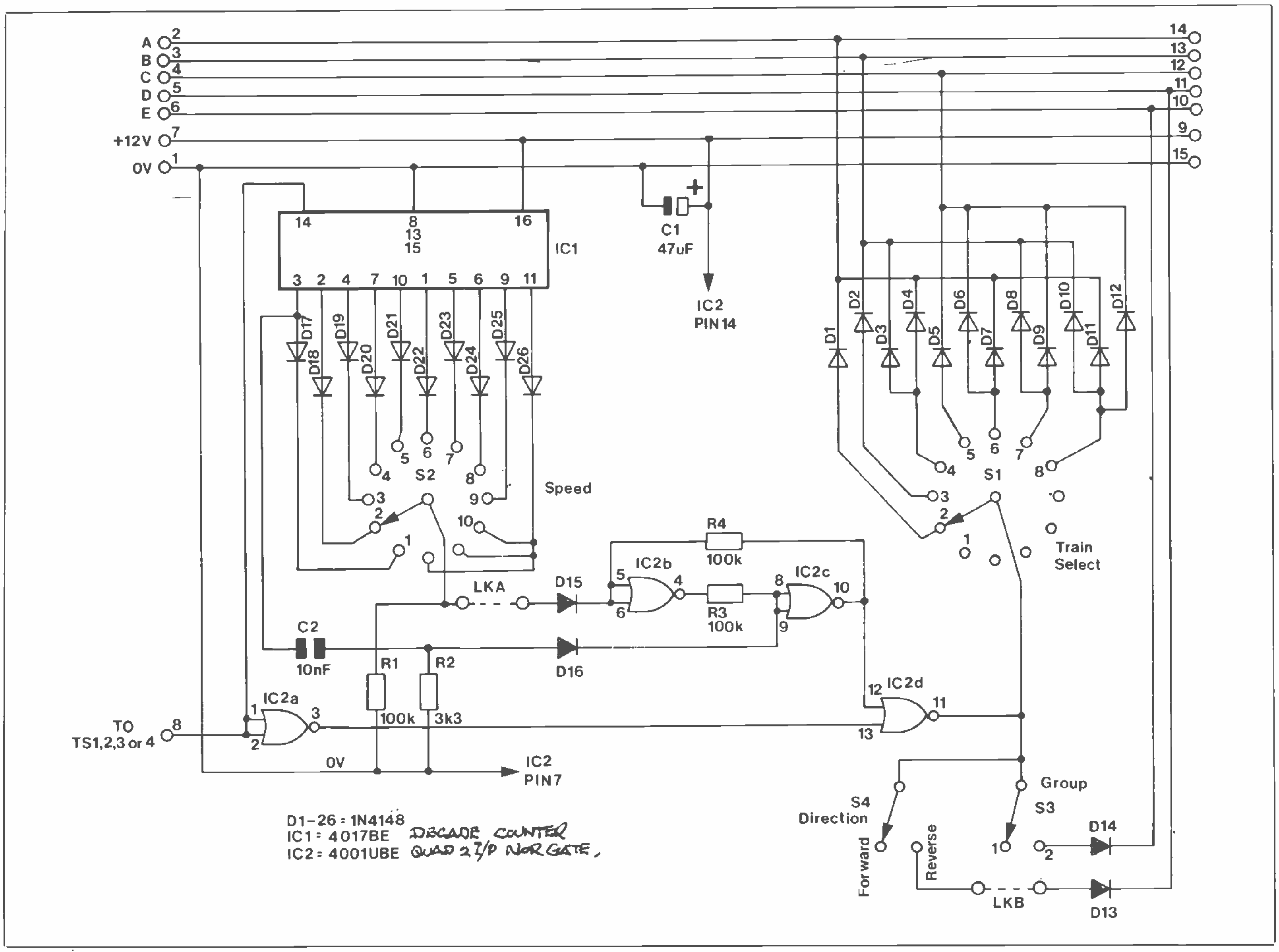


Figure 3. Control board circuit diagram.

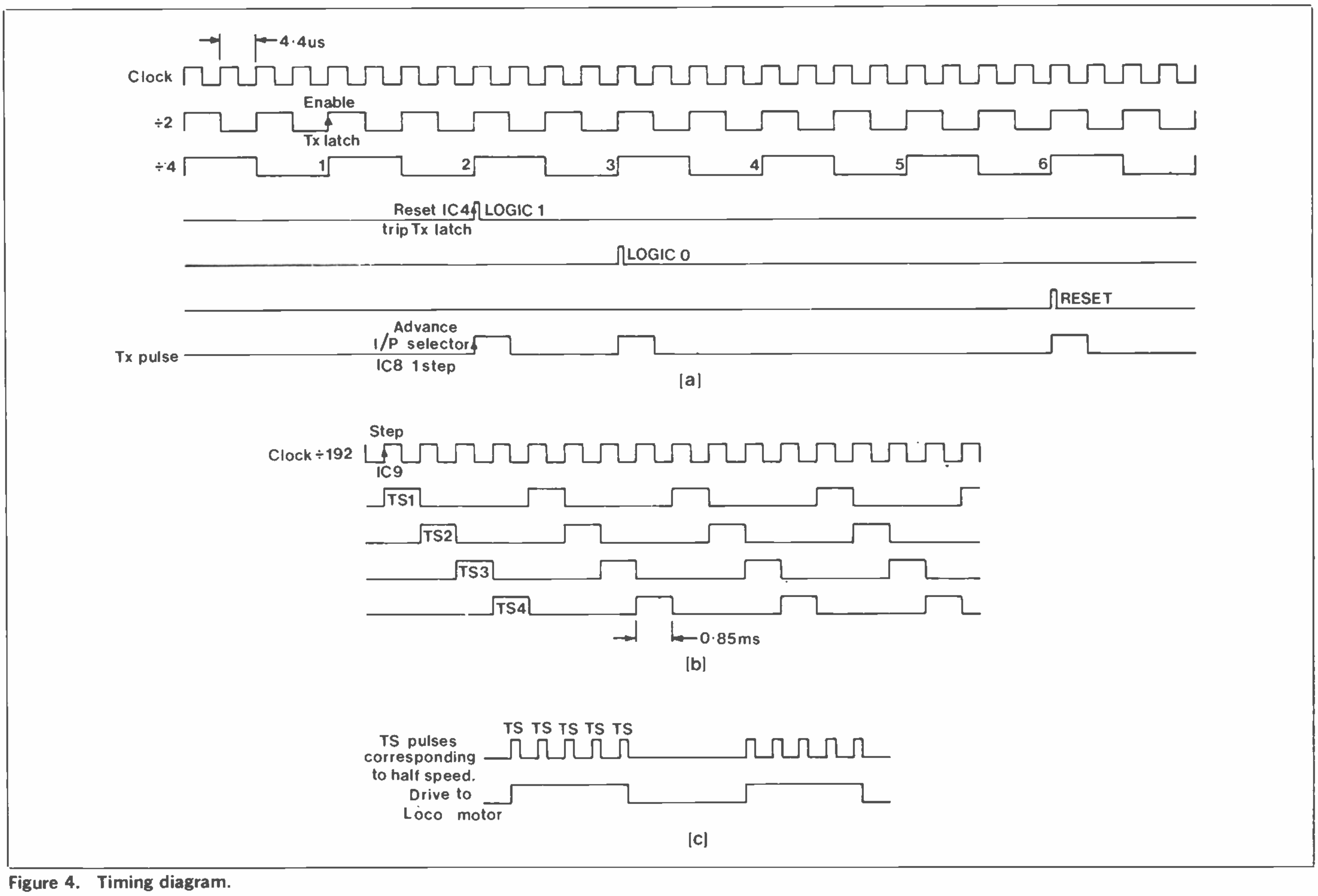


Figure 4. Timing diagram.

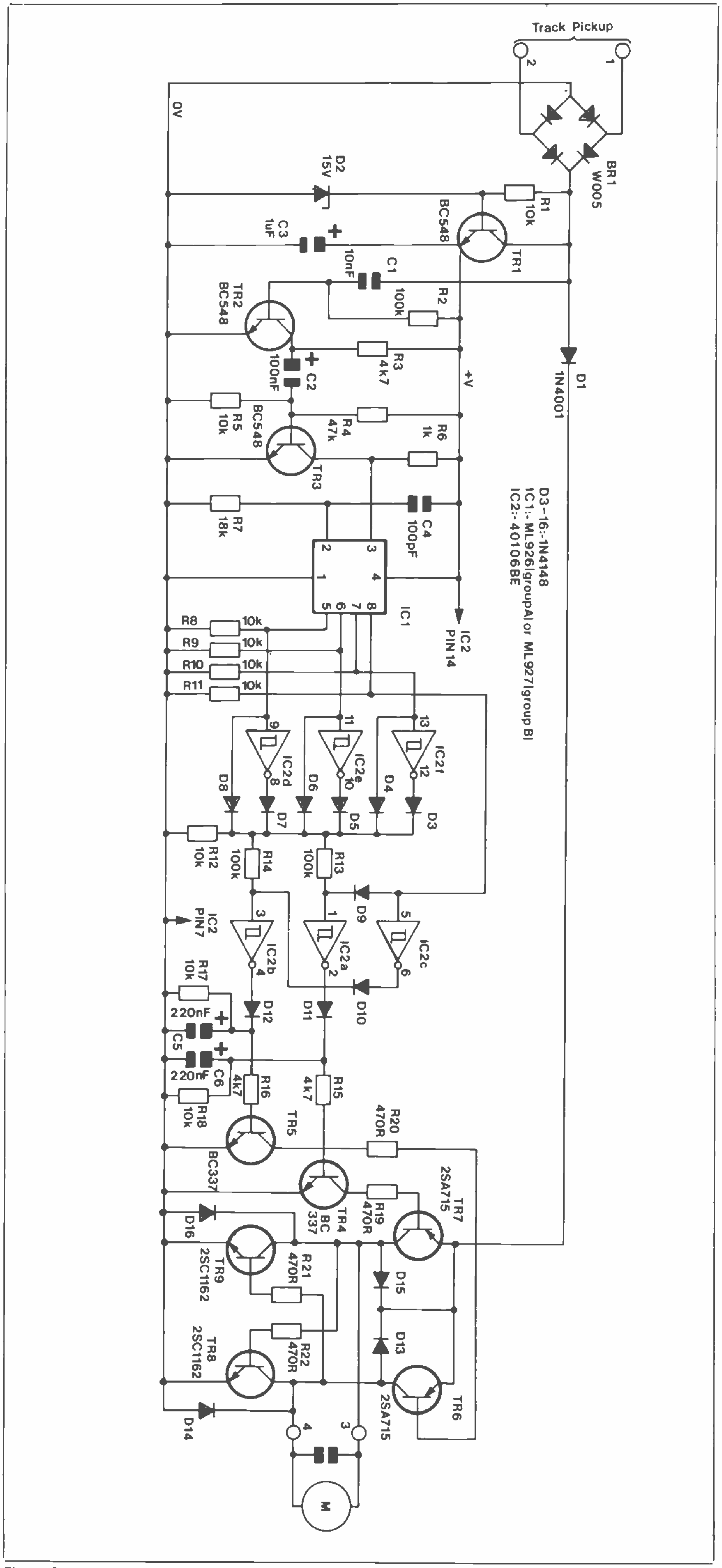


Figure 5. Receiver circuit diagram.

The SCR remains latched until it is reset by shorting it with S2. If the fault is still present the circuit will trip immediately and cause no damage.

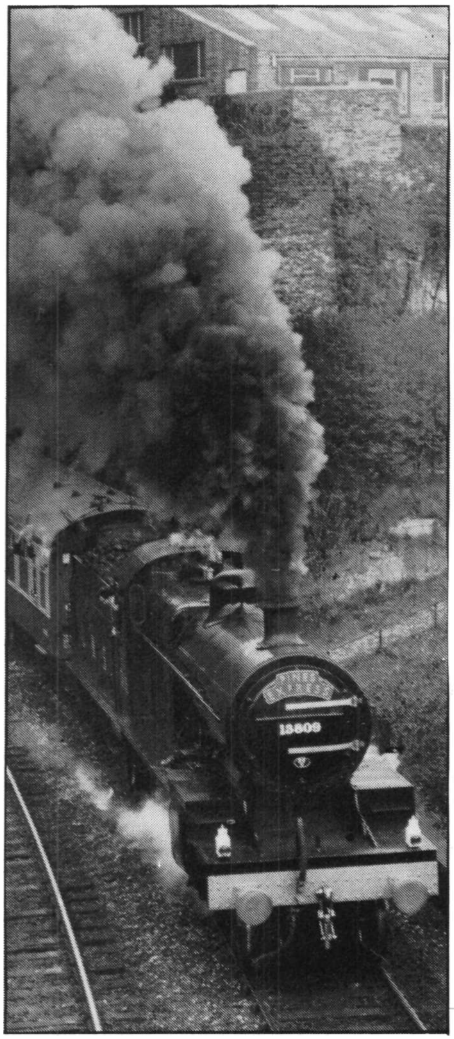
When the track supply falls more than 12V below the power units output, either due to the protection circuit being tripped or due to a fuse failure the indicator LED1 will light. Provision is also made for a buzzer to be fitted if an audible indication of track supply failure is required. A timer may be used to reset the protection circuit automatically after a short delay and this will be described in a later article.

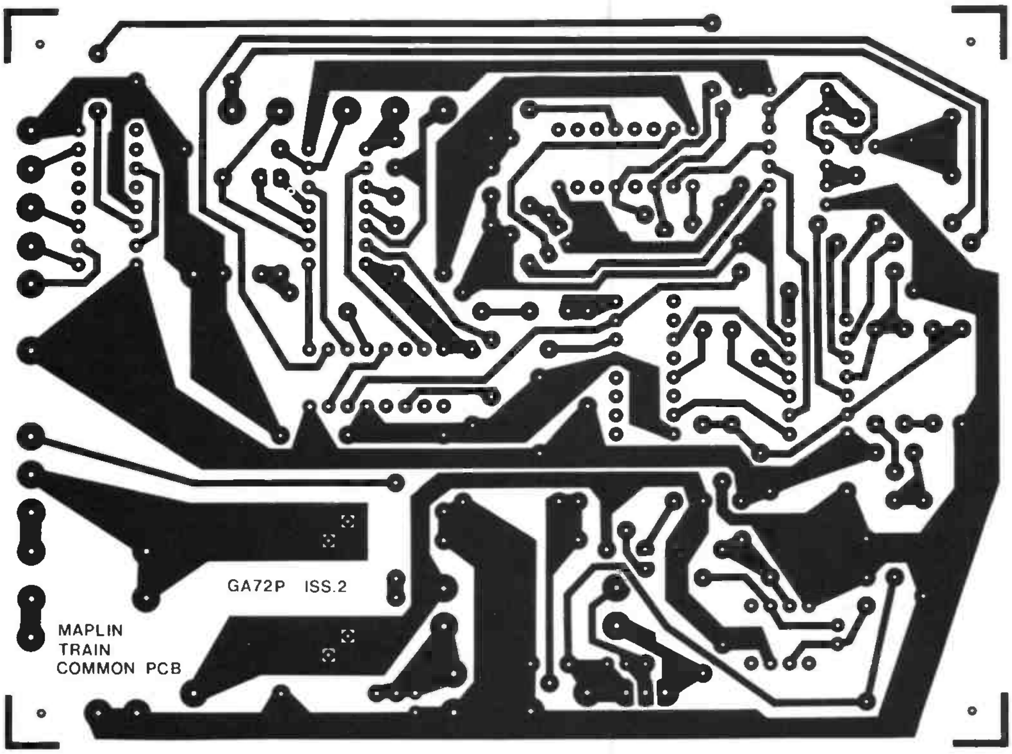
Construction

Build all PCBs referring to legends and parts list.

Common Board

The track layout and component overlay for the common board are shown in Figure 6. Fit Veropins and PCB mounting fuse holders and solder. Insert and solder all resistors, diodes, capacitors and the choke. Insert the two plastic transistors, regulator and SCR into their correct positions. Push the leads of the power transistor TR2 through the PCB just far enough to allow it to be soldered and bend the leads as shown in Figure 7. Finally, insert and solder all ICs observing the usual CMOS precautions and making sure that they are the correct way round.





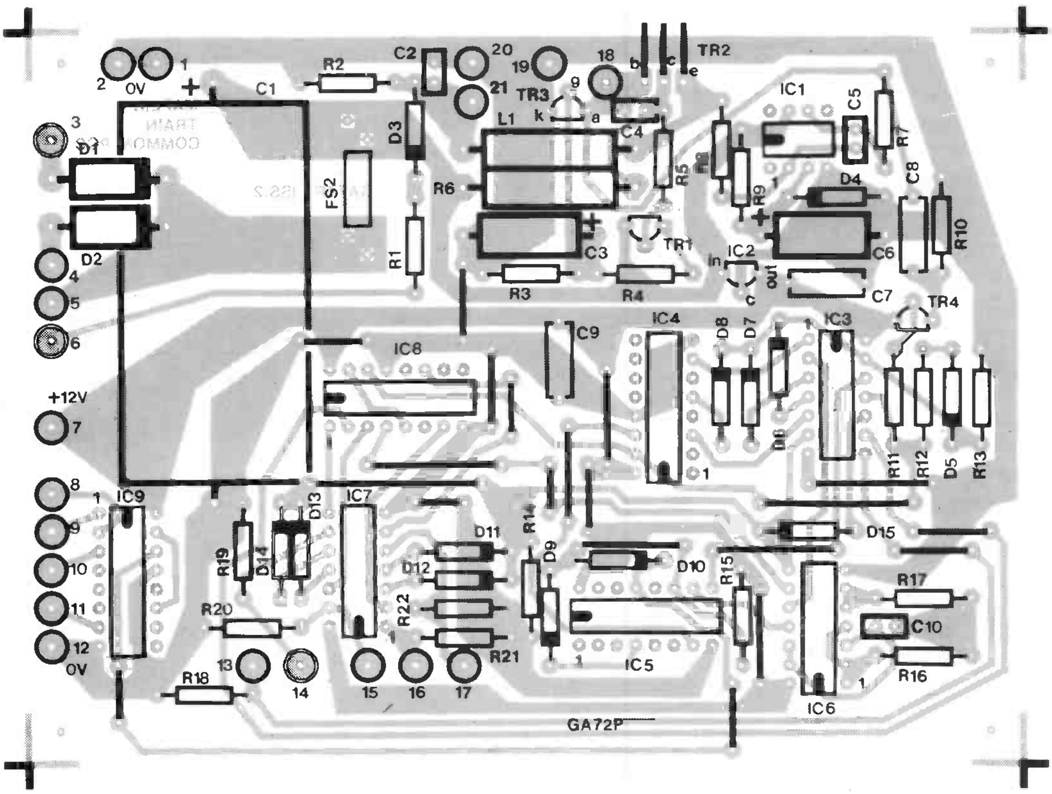
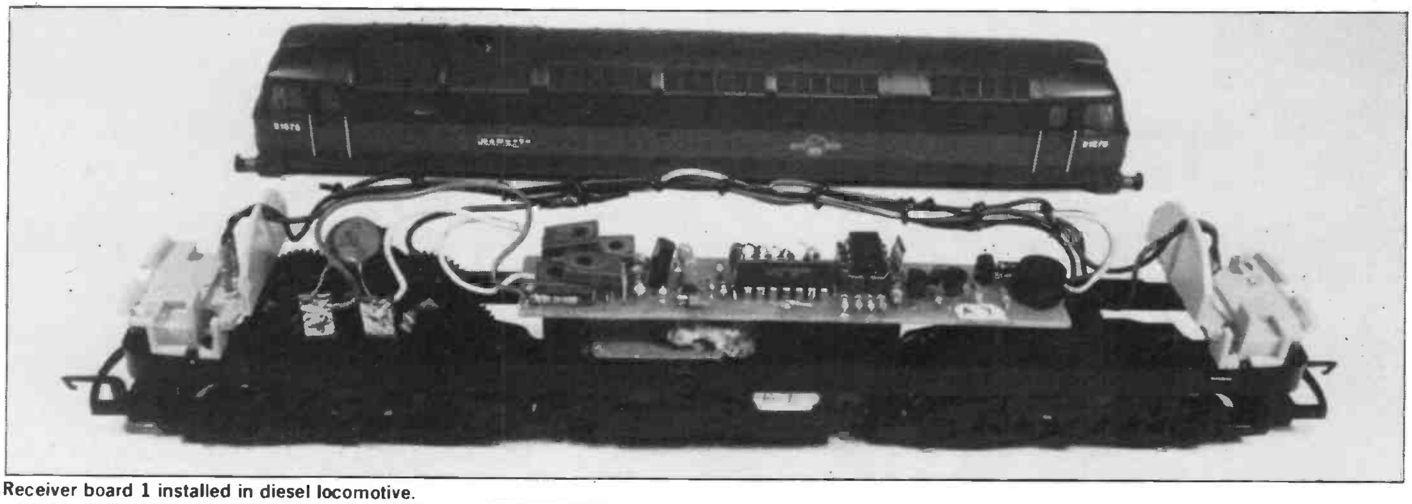
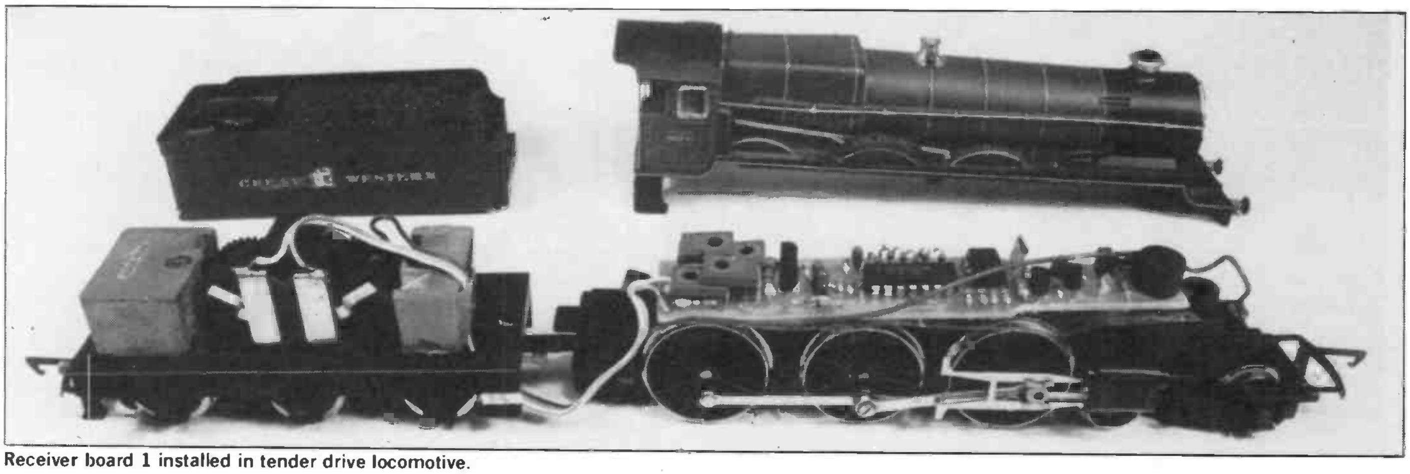


Figure 6. Common board track layout component overlay.



Receiver board 1 installed in diesel locomotive.



Receiver board 1 installed in tender drive locomotive.

Control Board

The track layout and component overlay for the Control Board are shown in Figure 8. Fit and solder all components in order as described above but in this case fit the Veropins from the component side of the PCB to enable ease of wiring when the boards are fitted to the front panel. The rotary switch without the click stops is mounted next to IC1. Note the unused component positions on the board are for the remote control option which may be added later.

Assembly

Mount the transformer, mains switch, fuse holder, LED, push button and terminals on the case. Fit the common board and control boards. (Note that only one control board need be fitted initially.) The self-adhesive penal legend may be used as a template for drilling the front panel or the ready drilled case XG09K may be used. Note that this is not included in the kit.

Wire all boards and components together referring to Figure 13. Insert the fuses noting that the 1 amp anti-surge fuse is fitted in the panel fuse holder.

Receiver board

There are initially two receiver boards available to fit varying size locomotives. See Figures 10 and 11. The dimensions of these boards are shown in Figure 9. Fit and solder all capacitors and resistors noting that some resistors do not lay flat on the board. Insert and solder all diodes other than D3 to D8 and fit all transistors taking special care with the positioning of TR6, 7, 8 and 9 as shown in Figure 10b/11b. Insert and solder IC2.

Decide which channel the receiver is to use and insert the appropriate diodes referring to Figure 12. If the receiver is to be group A then insert an ML926, if group B an ML927. Carefully check all soldering and positioning of components before testing.

Testing Procedure

Controller

Switch on power with nothing connected to the output terminals. The neon indicator in the mains switch should now be illuminated. Using a meter set to 20V DC or above check that there is approximately 18V at the output terminals.

Press the reset button and the "Track Supply Fail" LED should light and extinguish when the button is released. If this test is satisfactory, short circuit the output terminals and the LED should again light brightly while the short circuit is present and dimly when the short circuit is removed. Press the reset button. The LED should be extinguished and 18V restored to output terminals.

Receiver

Connect the receiver to the control unit as shown in Figure 14. Select the channel number and group of the receiver on a control unit and advance the speed control. One of the two lamps should light with its brightness depending upon the speed set. Switch over the reverse switch to the opposite position and repeat the test. In this case the other lamp should respond. Switch the control unit to the other channels and groups and ensure that the lights remain extinguished. If these tests are satisfactory the module is ready to be inserted in the locomotive.

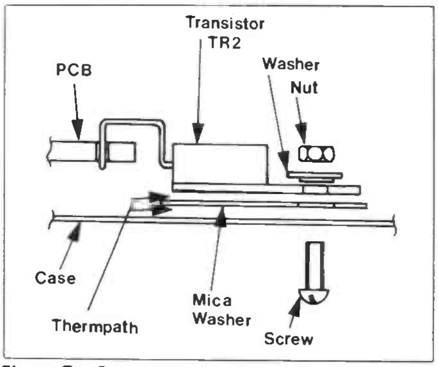


Figure 7. Power transistor mounting.

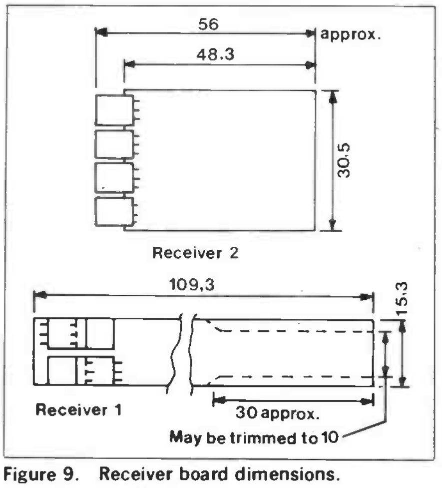


Figure 9. Receiver board dimensions.

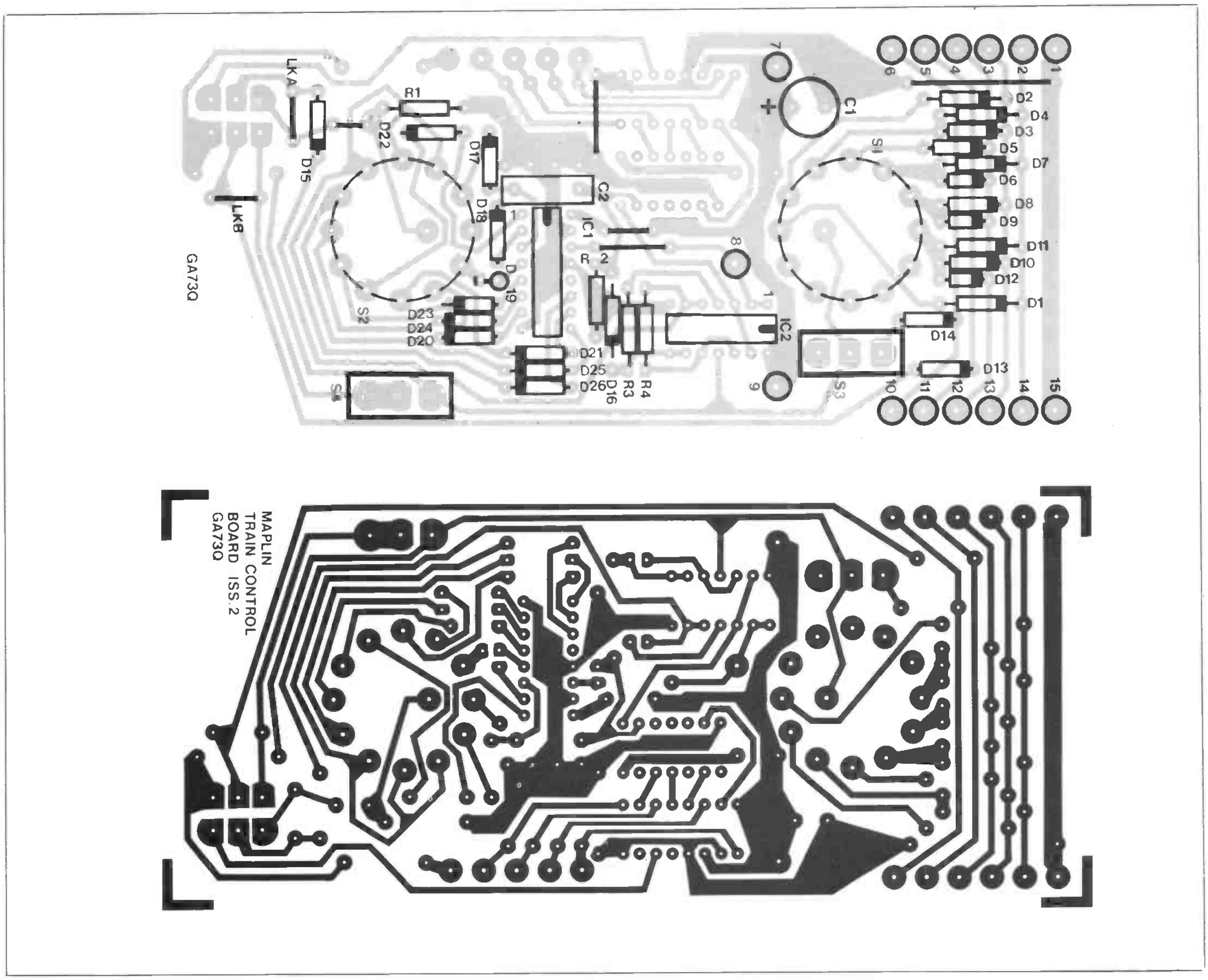
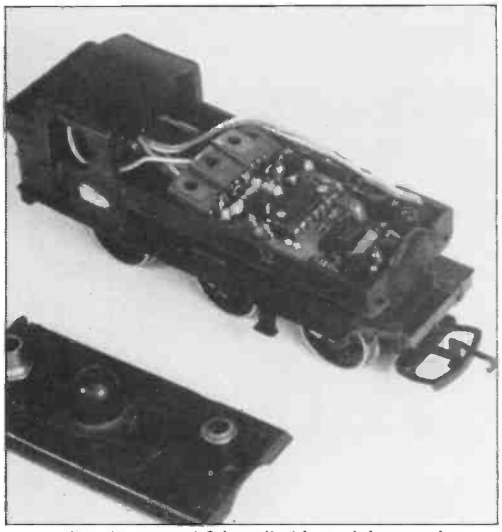
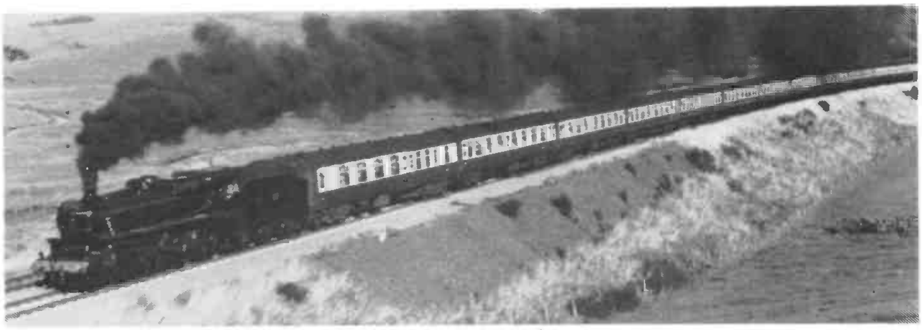


Figure 8. Control board track layout component overlay.



Receiver board 2 installed in tank locomotive.



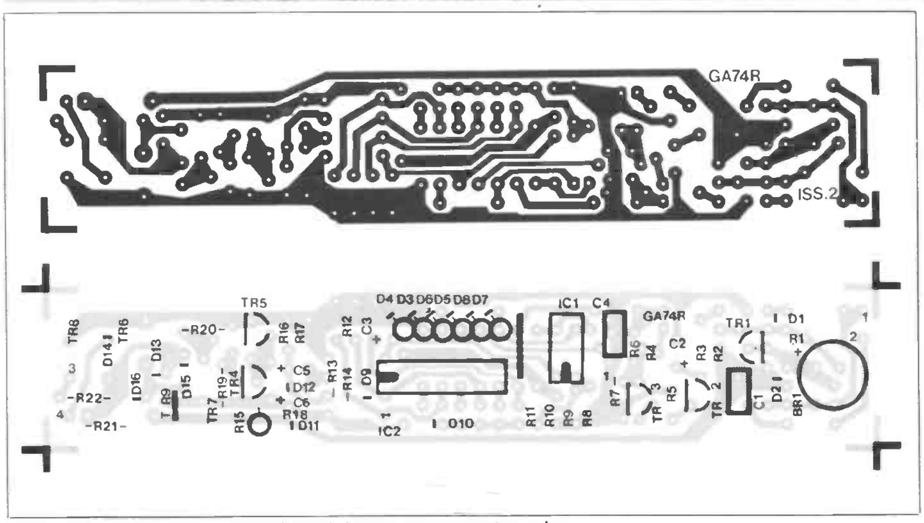


Figure 10(a). Receiver board 1 track layout component overlay.

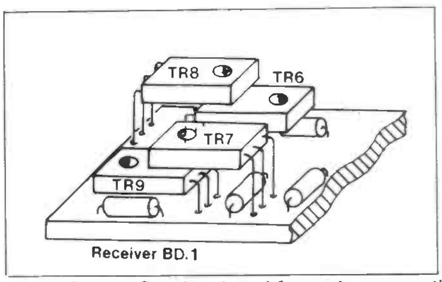


Figure 10(b). Receiver board 1 transistor mounting.

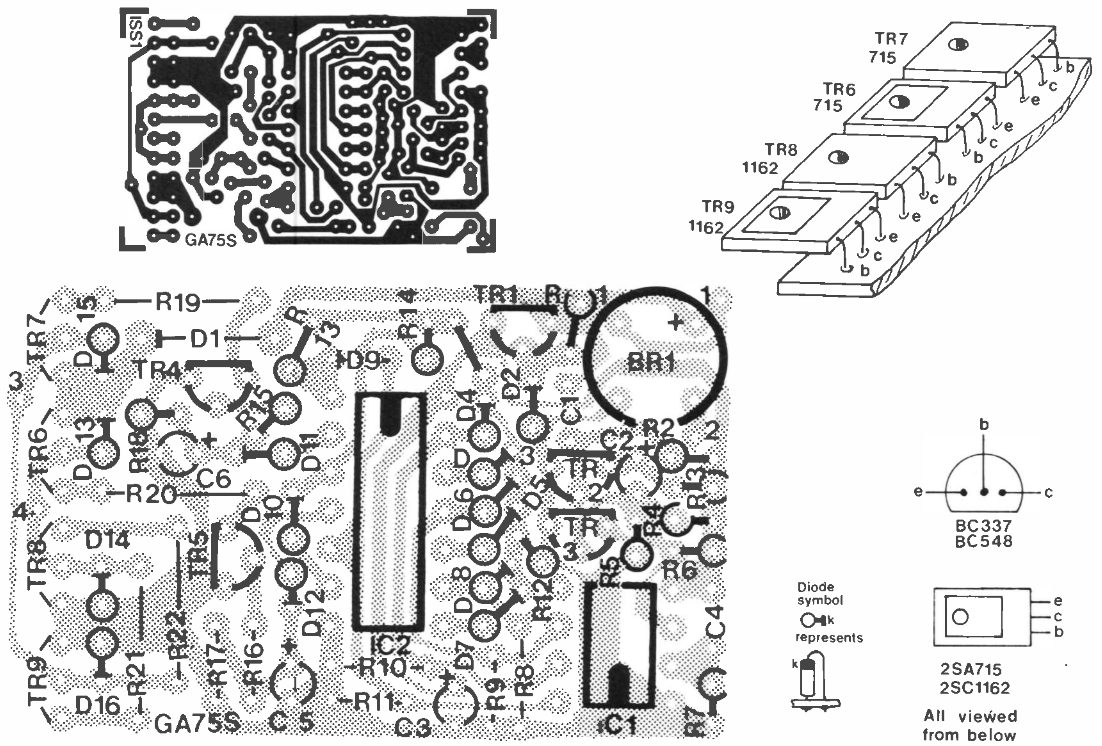


Figure 11(a). Receiver board 2 track layout component overlay. (b). Receiver board 2 transistor mounting.

Loco	Insert Diode		
1	D4	D6	D7
2	D4	D5	D8
3	D4	D5	D7
4	D3	D6	D8
5	D3	D6	D7
6	D3	D5	D8
7	D3	D5	D7
	Group A ML926	Group B ML927	

Figure 12. Receiver code chart.

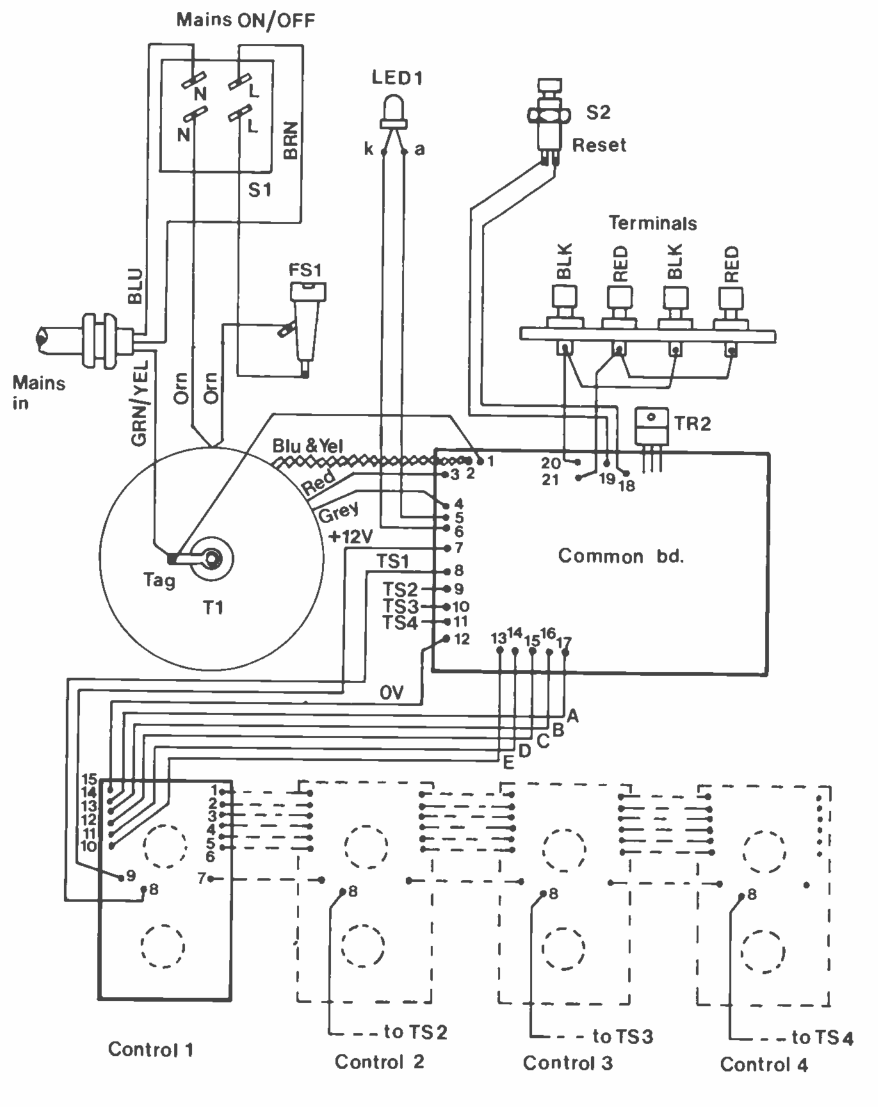


Figure 13. Controller wiring diagram.

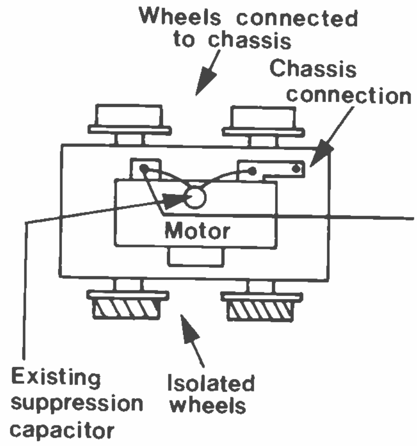


Figure 15. Wiring of conventional locomotive.

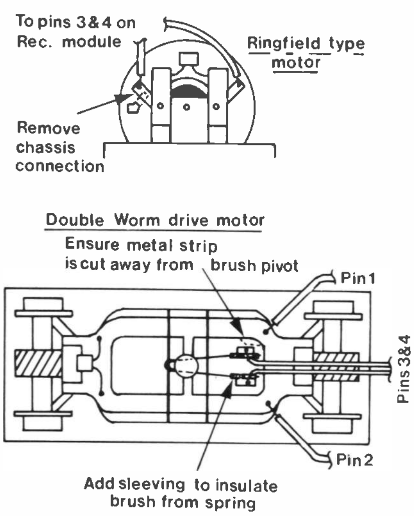


Figure 16. Modifications to various motors.

Installing Receivers in Locomotives

All locomotives designed for use with conventional control systems have the two sides of the motor connected directly to the wheels on each side of the locomotive Figure 15. To install the receiver module, the motor must be completely isolated from the wheels. In many modern models this is accomplished by removing a wire link but in some of the older models there is a permanent connection from one side of the motor to the chassis. In all cases by careful modification this connection can be removed. Some examples are shown in Figure 16. It is most important to ensure that the motor is completely isolated and it is worth checking this with a meter set to ohms before installing the module.

In most cases there will be a wire coming from one of the pickups, this is connected to one input of the module and the other input is connected to the chassis at a suitable point as shown in Figure 17. After installation, if it is found that the locomotive travels in the wrong direction in relation to the controller switch, the wires to the motor should be reversed.

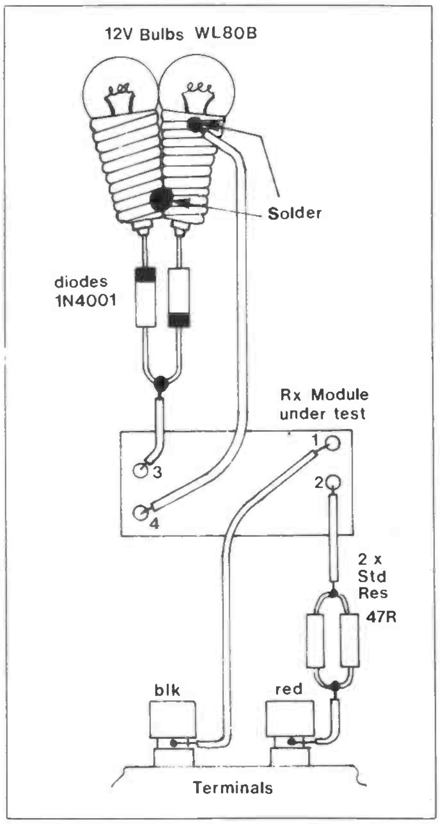
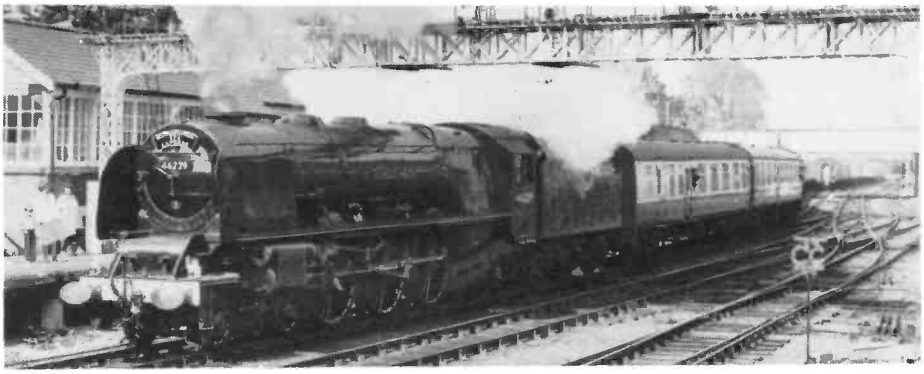
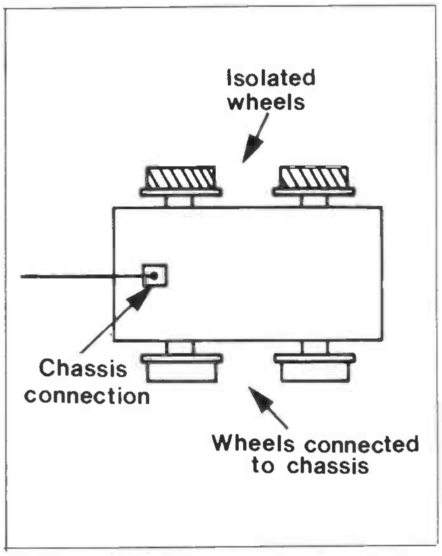


Figure 14. Receiver testing.





KITS

Complete kits are available for the train controller as follows:

All parts in Train Common/PSU Parts List excluding the case (XG09K).
Order As LW61R (Train Common/PSU Kit)

All parts in Train Control Parts List
Order As LW62S (Train Control Kit)

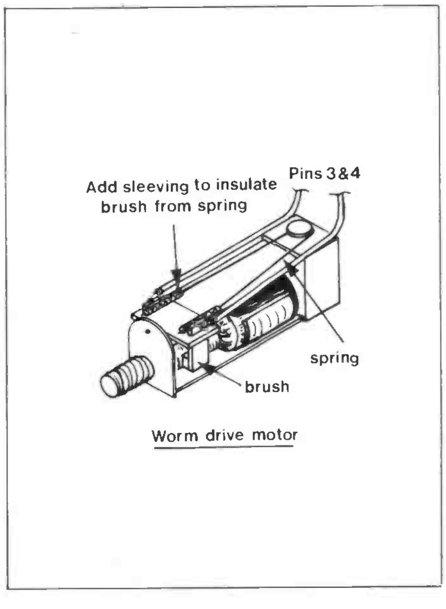
Four kits are available to make receiver modules as follows:

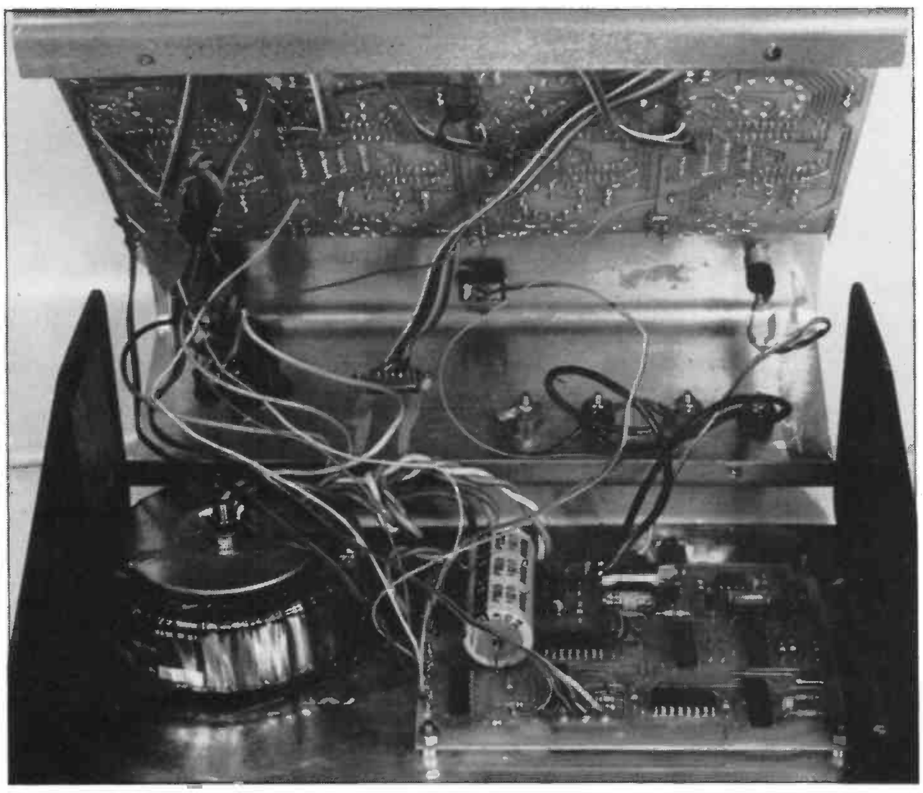
Kit for Group A with long PCB
Order As LW63T (Receiver 1-ML926 Kit)

Kit for Group A with square PCB
Order As LW64U (Receiver 2-ML926 Kit)

Kit for Group B with long PCB
Order As LW68Y (Receiver 1-ML927 Kit)

Kit for Group B with square PCB
Order As LW69A (Receiver 2-ML927 Kit)





Internal view of main control box.

To ensure reliable operation of this system, as with any other, the locomotives should be in good condition, and it is often worth replacing brushes and cleaning wheels and pickups before use. The track needs to be kept fairly clean although the receiver will respond to signals as long as there is enough power to drive the motor.

Further articles in this book will describe track circuiting (train position detection) point control and detection of position, interlocking and control of signals, automatic loop switching, and many other useful circuits as well as constructional hints for the railway modeller.

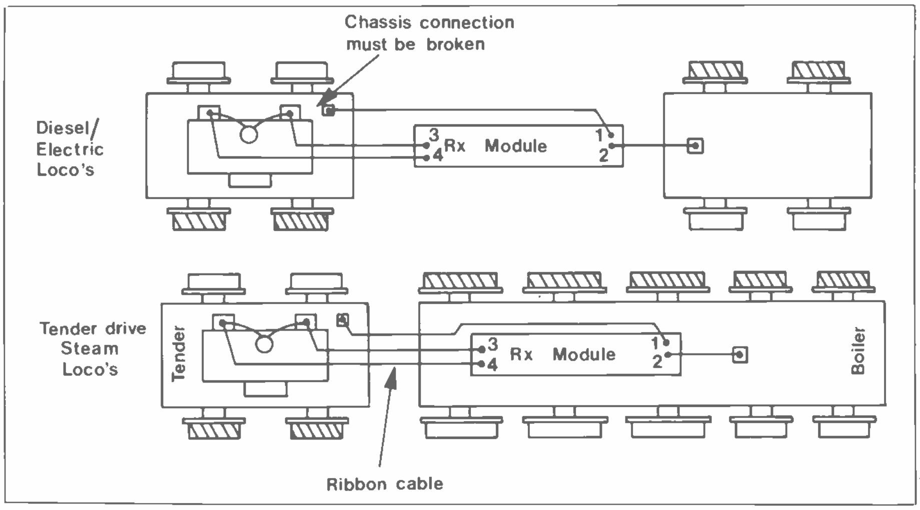


Figure 17. Installation of receiver in locomotive.

TRAIN CONTROL PCB PARTS LIST

Resistors: All 0.6W 1% metal film

R1,3,4	100k	3	(M100K)
R2	3k3	1	(M3K3)
Capacitors			
C1	47μF 25V PC electrolytic	1	(FF08J)
C2	100nF polyester	1	(BX70M)
Semiconductors			
D1-26	1N4148	26	(QL80B)
IC1	4017BE	1	(QX09K)
IC2	4001UBE	1	(QL03D)
Miscellaneous			
S1	Rotary SW12B	1	(FF73Q)
S2	Switch 1 pole 12 way	1	(XX45Y)
S3,4	Sub-min toggle 'A'	2	(FH00A)
	Veropin 2141	1 Pkt	(FL21X)
	Train control PCB	1	(GA73Q)
	Knob K7B (for S1)	1	(YX02C)
	Knob K7C (for S2)	1	(YX03D)
	Constructors' Guide	1	(XH79L)
Optional			
	Train control front panel	1	(XX47B)

TRAIN COMMON/PSU PARTS LIST

Resistors: All 0.6W 1% metal film unless specified.

R1,3,4,5	1k	4	(M1K)
R2,7,9	2k2	3	(M2K2)
R6	0.22Ω 3W wirewound	1	(W0.22)
R8	22k	1	(M22K)
R10,17	4k7	2	(M4K7)
R11,12,14,15	10k	4	(M10K)
R13,18-22	100k	6	(M100K)
R16	33k	1	(M33K)
Capacitors			
C1	4700μF 25V axial electrolytic	1	(FB96E)
C2	100pF ceramic	1	(WX56L)
C3	100μF 10V axial electrolytic	1	(FB48C)
C4	220pF ceramic	1	(WX60Q)
C5	10nF ceramic	1	(WX77J)
C6	10μF 25V axial electrolytic	1	(FB22Y)
C7,8,9	100nF polyester	3	(BX76H)
C10	33pF ceramic	1	(WX50E)
Semiconductors			
D1,2	1N5400	2	(QL81C)
D3	BZX61C12	1	(QF55K)
D4	BZY88C20	1	(QH21X)
D5-15	1N4148	11	(QL80B)
TR1	BC327	1	(QB66W)
TR2	TIP122	1	(WQ73Q)
TR3	BT149B	1	(YH94C)
TR4	BC548	1	(QB73Q)
IC1	μA741C (8-pin)	1	(QL22Y)
IC2	μA78L12 AWC	1	(WQ77J)
IC3,7	4081BE	2	(QW48C)
IC4,8,9	4022BE	3	(QW19V)
IC5	4040BE	1	(QW27E)
IC6	4001BE	1	(QX01B)
Miscellaneous			
L1	RF suppressor choke 2A	1	(HW05F)
T1	Torodial transformer 80VA 18V	1	(YK17T)
LED 1	LED red	1	(WL27E)
FS1	Fuse anti-surge 1A	1	(WR19V)
FS2	Fuse 20mm 2A	1	(WR05F)
S1	Dual rocker neon	1	(YR70M)
S2	Push switch	1	(FH59P)
	Safe fuseholder 20	1	(RX96E)
	Fuse clip	2	(WH49D)
	S/R grommet	1	(LR49D)
	Veropin 2141	1 Pkt	(FL21X)
	LED clip	1	(YY40T)
	Leverterm 4 way	1	(BW71N)
	Train common PCB	1	(GA72P)
	Mains lead	3 Mtr	(XR04E)
	10-way ribbon cable	1 Mtr	(XR06G)
	Wire 3202 black	1 Mtr	(XR32K)
	Wire 3202 red	1 Mtr	(XR36P)
	Train control case	1	(XG09K)
	Kit 'P' plas	1	(WR23A)
	Bolt 6BA x ½"	1 Pkt	(BF06G)
	Washer 6BA	1 Pkt	(BF22Y)
	Spacer 6BA x ⅛"	1 Pkt	(FW33L)
	Nut 6BA	1 Pkt	(BF18U)
	Tag 2BA	1 Pkt	(BF27E)
	Small thermpath	1	(HQ00A)
	Train control front panel	1	(XX47B)
	Stick-on feet	1	(FW38R)
	Constructors' Guide	1	(XH79L)

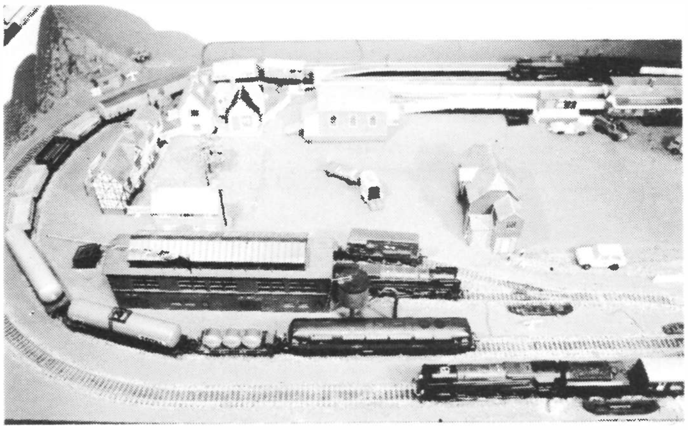
TRAIN RECEIVER MODULE PARTS LIST

Resistors: All ⅛W 5% carbon unless specified

R1,5,8-12,17,18	10k	9	(U10K)
R2,13,14	100k	3	(U100K)
R3,15,16	4k7	3	(U4K7)
R4	47k	1	(U47K)
R6	1k	1	(U1K)
R7	18k 0.6W 1% metal film	1	(M18K)
R19-22	470Ω 0.6W 1% metal film	4	(M470R)
Capacitors			
C1	10,000pF ceramic	1	(WX77J)
C2	100nF 35V tantalum	1	(WW54J)
C3	1μF 35V tantalum	1	(WW60Q)
C4	100pF ceramic	1	(WX56L)
C5,6	220nF 35V tantalum	1	(WW56L)
Semiconductors			
D1	1N4001	1	(QL73Q)
D2	BZY88C15V	1	(QH18U)
D3-16	1N4148	14	(QL80B)
BR1	W005	1	(QL37S)
IC1	ML926 (Group 'A')	1	(QR57M)
or	ML927 (Group 'B')	1	(QR58N)
IC2	40106BE	1	(QW64U)
TR1-3	BC548	3	(QB73Q)
TR4,5	BC337	2	(QB68Y)
TR6,7	2SA715	2	(QR56L)
TR8,9	2SC1162	2	(QR59P)
Miscellaneous			
	Train receiver 1 PCB	1	(GA74R)
or	Train receiver 2 PCB	1	(GA75S)
	Constructors' Guide	1	(XH79L)

Details on kits are given on page 37

MODEL TRAIN PROJECTS



★ Train Head and Tail Lamp Control
★ Automatic Loop Control
★ Track Circuiting

by Robert Kirsch

This article describes several circuits that may be added to a layout using the digital control system described previously. These circuits have been in use on the authors 00 gauge outdoor layout for some time, and have been found to improve the realism and enjoyment of the railway greatly.

Train Head and Tail Lamp Control

This circuit enables the head and tail lamps to be operated automatically from the receiver unit fitted in the locomotive and controlled by the direction of travel.

This unit may be fitted to dual ended locomotives to enable the headlamps to light only in the directioin of travel, or to a complete train that is to operate in both directions, for example an H.S.T. set, providing white lights at the front and red lights at the rear whichever way the train is moving.

The circuit is fed from the output of the decoder in the receiver module.

When a receiver is selected by the control unit and the speed control advanced, pulses appear at one of the two outputs of the decoder, the number of pulses being dependent on the speed setting. These pulses are fed via R1 and D1 (Figure1) to C1, causing it to charge rapidly. It is prevented from discharging when the input goes low by D1 being reverse biassed.

The voltage developed across C1 is used to turn TR1 on, via R2, and in so doing causes current to flow through the lamp in the collector circuit. R3 reduces the voltage to enable a 12V lamp to be used. The lamp and the LED are effectively in series across the supply, so that when TR1 is on the LED is extinguished, and when it is off the LED will light via the resistance of the bulb filament. The lamp will not light because the LED only draws about 10mA as R4 is in series with it.

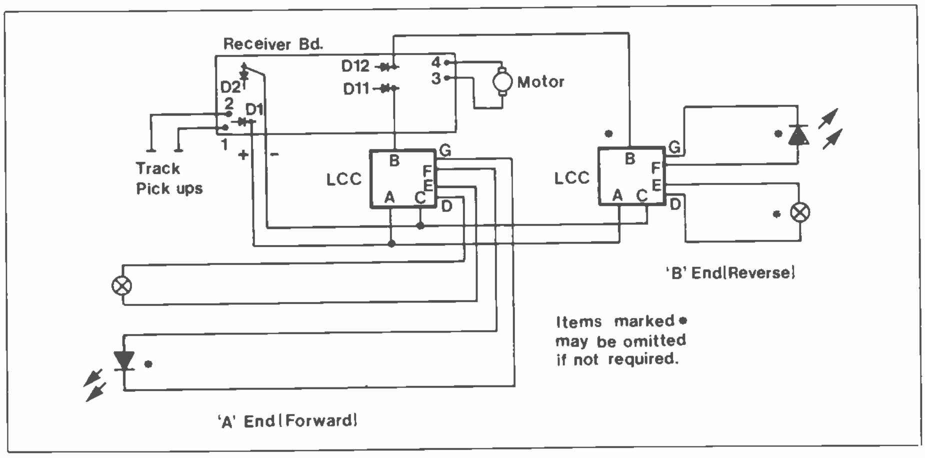


Figure 2. Typical locomotive installation

Installation

Examples of installation for various applications are shown in Figure 2 and 3. It will be seen that to control headlamps at both ends of a locomotive two control circuits will be needed. In the case of a complete train it is necessary to electrically couple all vehicles together. This is useful as it enables several track pick-ups to be made along the length of the train, also making carriage lighting possible.

Three wires are required to enable headlamp control. A bridge rectifier and control circuit are required at the non-driving end of the train, the pulse

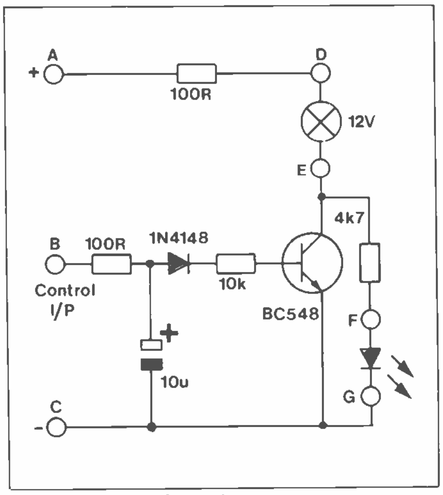


Figure 1. LCC schematic

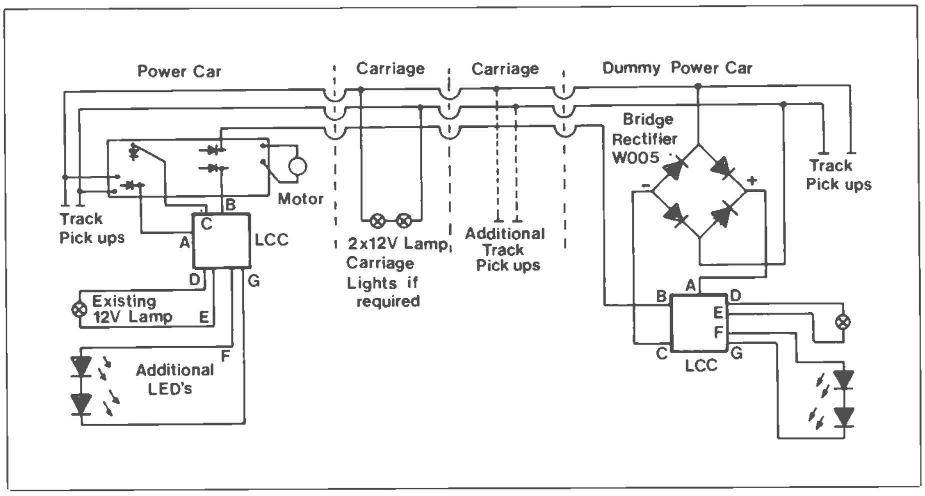


Figure 3. Installation in HST set

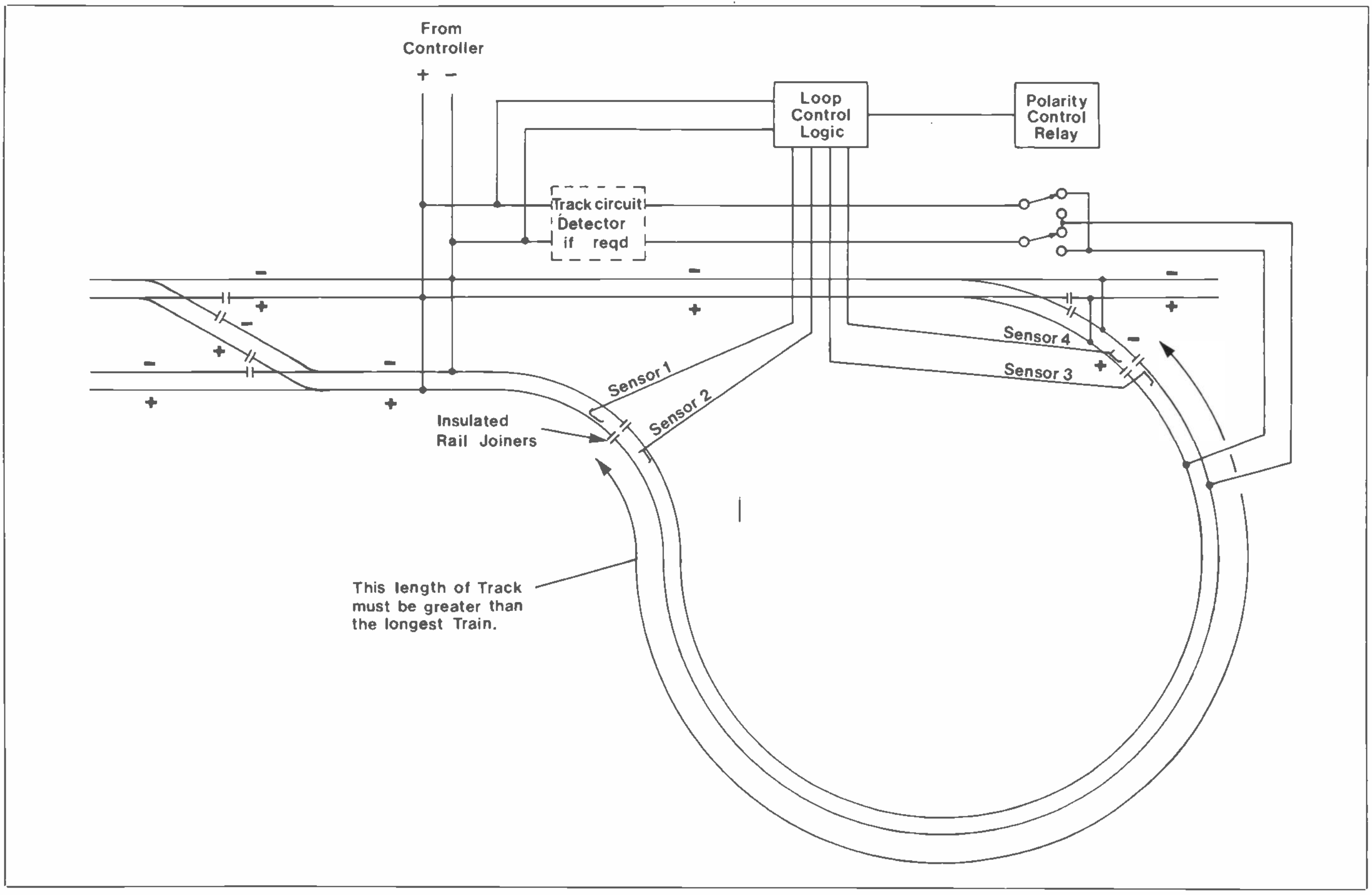


Figure 4: Loop control schematic.

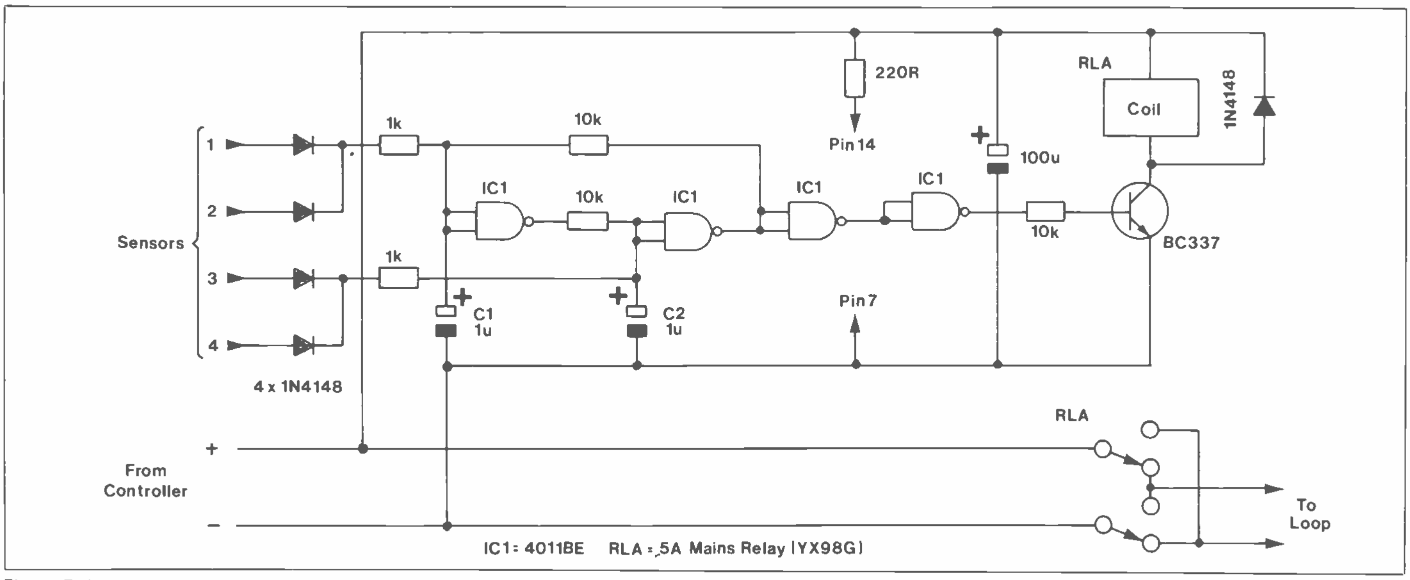
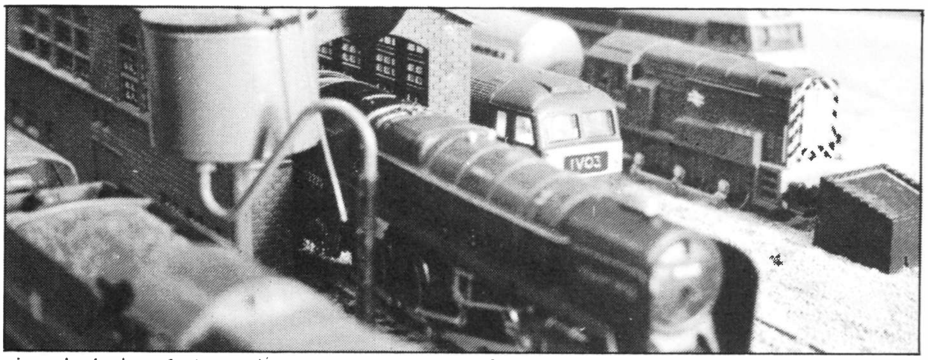


Figure 5: Loop control circuit.



signals being fed on the third wire. A very flexible type of wire should be used between carriages, and the wire used in telephone cords has been found suitable for 00 gauge applications. Enough slack must be left to allow for negotiation of sharp curves. A single lamp may be used for the headlamps, and flexible light guide (XR56L) can be used to transfer the light to the front of the vehicle. The ends of the light guide may be shaped into a lens by holding it near a heat source and allowing the plastic to melt and form a small dome. Two LEDs may be used if required by connecting them in series, although it may be necessary to try several LEDs before installation, to ensure that they are both of the same brightness.

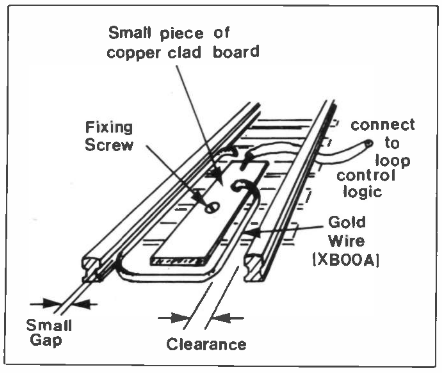


Figure 6: Track sensor detail.

Automatic Loop Control

Loops on model railway systems present a problem due to the confliction of track polarity when entering or leaving the loop. The system described here automatically detects when a train is entering or leaving the loop and sets the polarity accordingly. The receivers used in locomotives are fed from a bridge rectifier, and are therefore not affected by the change in polarity of the track, thus there is no pause during switching.

Figure 4 shows a typical loop arrangement with the four sensors, two placed at each end of the loop. These sensors are simply made from gold plated wire and arranged so that the wheel flanges of the train make contact between one running rail and the sensor wire. This arrangement has been found very reliable in practice, and may be used in other applications where accurate train position detection is required.

Figure 5 shows the circuit of the automatic loop control and it can be seen that a positive input from any of the track sensors will cause the bistable, formed by gates 1 and 2 of the IC, to change to one state or the other, depending on the sensor activated. The inputs from the sensors are decoupled by C1 and C2, to prevent false operation due to inevitable voltage spikes found on model railway systems.

Installation

The system should be installed referring to Figure 4 as a guide, but do not worry at this stage about the polarity of the connections to the loop section. When the sensors are in position check their operation by shorting them to the appropriate running rail with a screwdriver blade, to ensure that sensors 1 and 2 cause the relay to operate and 3 and 4 cause it to release.

The polarity can now be tested by driving a train into the loop, if the protection circuit on the controller trips as soon as the train enters the isolated section the connections to the loop must be reversed, and a further test carried out to ensure that all is now correct. It will be noted that the distance between the two inner sensors must be greater than the longest train that is likely to use the loop, to prevent both sets of sensors being activated at the same time.

Track Circuiting

The circuit shown in Figure 7 provides a means of detecting when a train is in a particular section of the track. This information may be used to provide an indication on a track layout diagram, as well as being interfaced with signalling equipment.

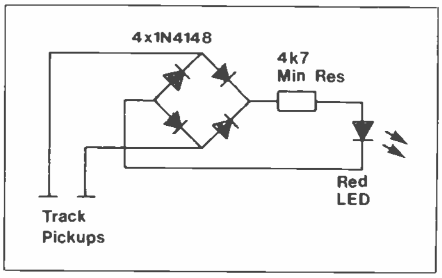


Figure 8: Tail lamp circuit.

The individual sections of track which need to be equipped must be isolated at both ends on the positive rail only, and fed by the common supply from the controller via the detector circuit. A single wire feeds from each detector and is connected via a 12V bulb to the negative supply (EARTH). The lamp lights when current is drawn from the track due to TR1 (Figure 7) being turned on by the volt drop across D1 and D2. The two diodes only allow a reduction of about 1.4V, and do not affect the operation of the system. It should be noted that only vehicles that draw current through their wheels will be detected by the track circuiting so it is necessary to provide track pickups at both ends of the train. This may be accomplished by connecting a resistor of about 470 ohms between both wheels on an axle of the last vehicle, or a tail lamp may be provided using the circuit shown in Figure 8.

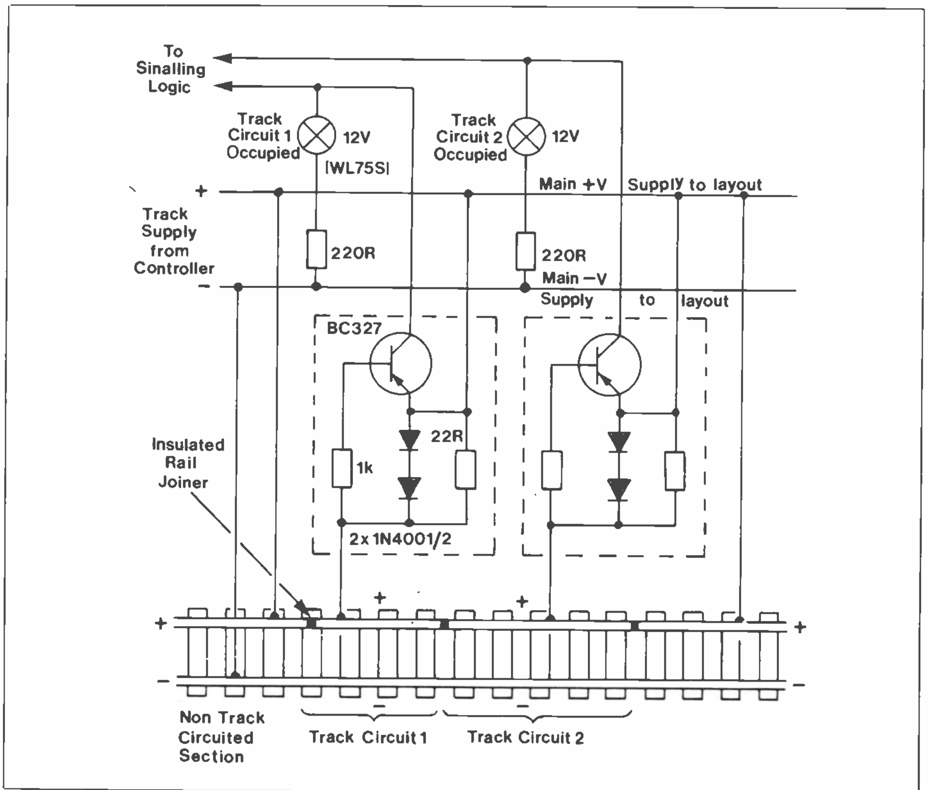
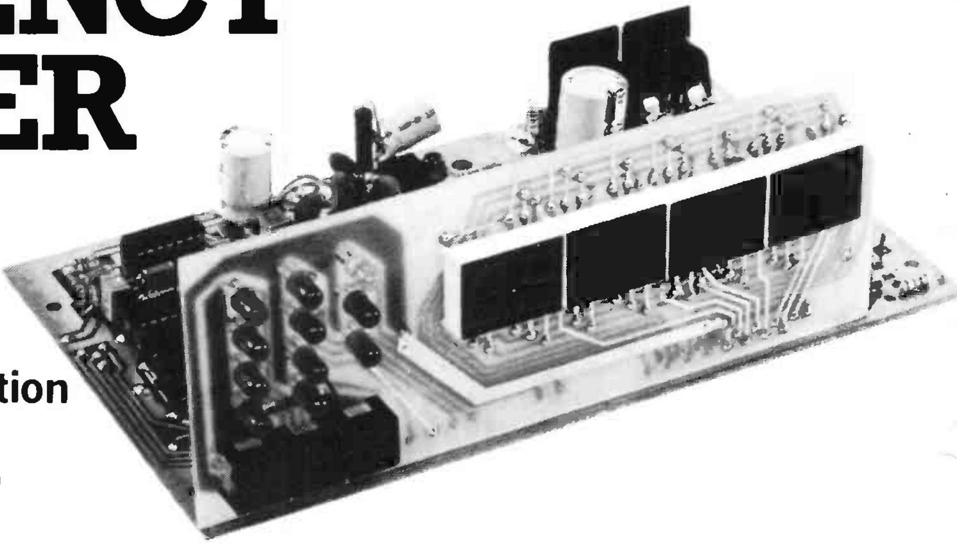


Figure 7: Track circuiting.

THE 8-DIGIT FREQUENCY COUNTER

by Chris Barlow



- ★ **Ranges from 100Hz to 500MHz**
- ★ **Mains or 12V DC operation**
- ★ **Clear 8-digit display**
- ★ **Easy to build - only two interconnecting wires**

This frequency counter offers a superior specification for the first time in kit form. The design is based on the Intersil ICM7216D, and includes electronically switched ranges for greater reliability and ease of construction. Provision has been made for possible future extensions, so this kit can be considered truly flexible.

The integrated circuits used are of an extremely advanced and sophisticated design, including CMOS, ECL, and Schottky TTL. The display uses multiplexed large red 7-segment LEDs for easy viewing. The functions and ranges are selected by computer-style key switches, and displayed on rows of different coloured LEDs. The input is a single BNC socket, and is switched automatically to the correct input amplifier. The counter will run off either an internal or an external reference oscillator, of either 1MHz or 10MHz (programmable). The power supplies are fuse protected on both DC and AC inputs.

The Frequency Counter

IC1 (ICM7216D) has multiplexed inputs for function and range select. It also has its own internal reference

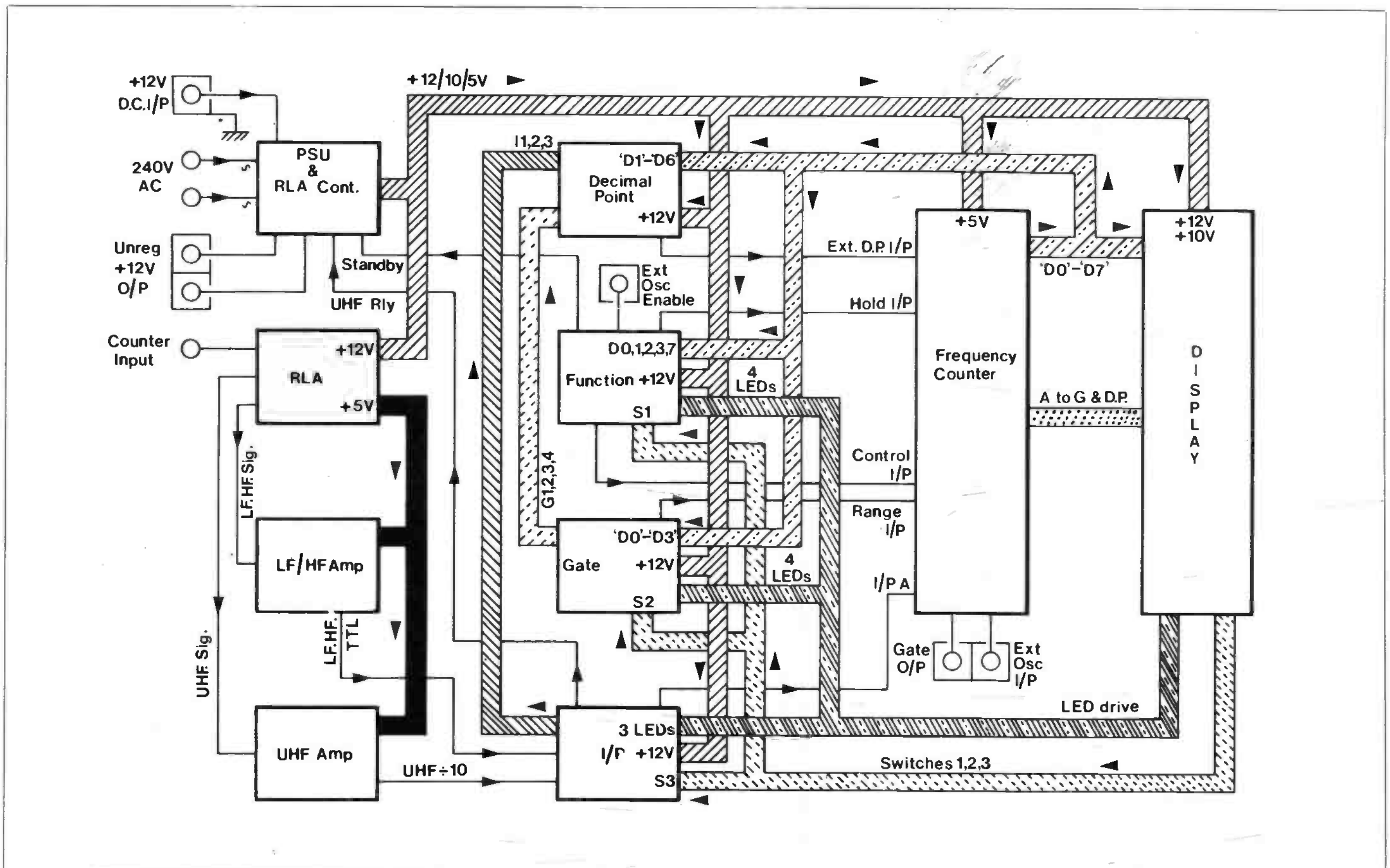


Figure 1. Block schematic of counter.

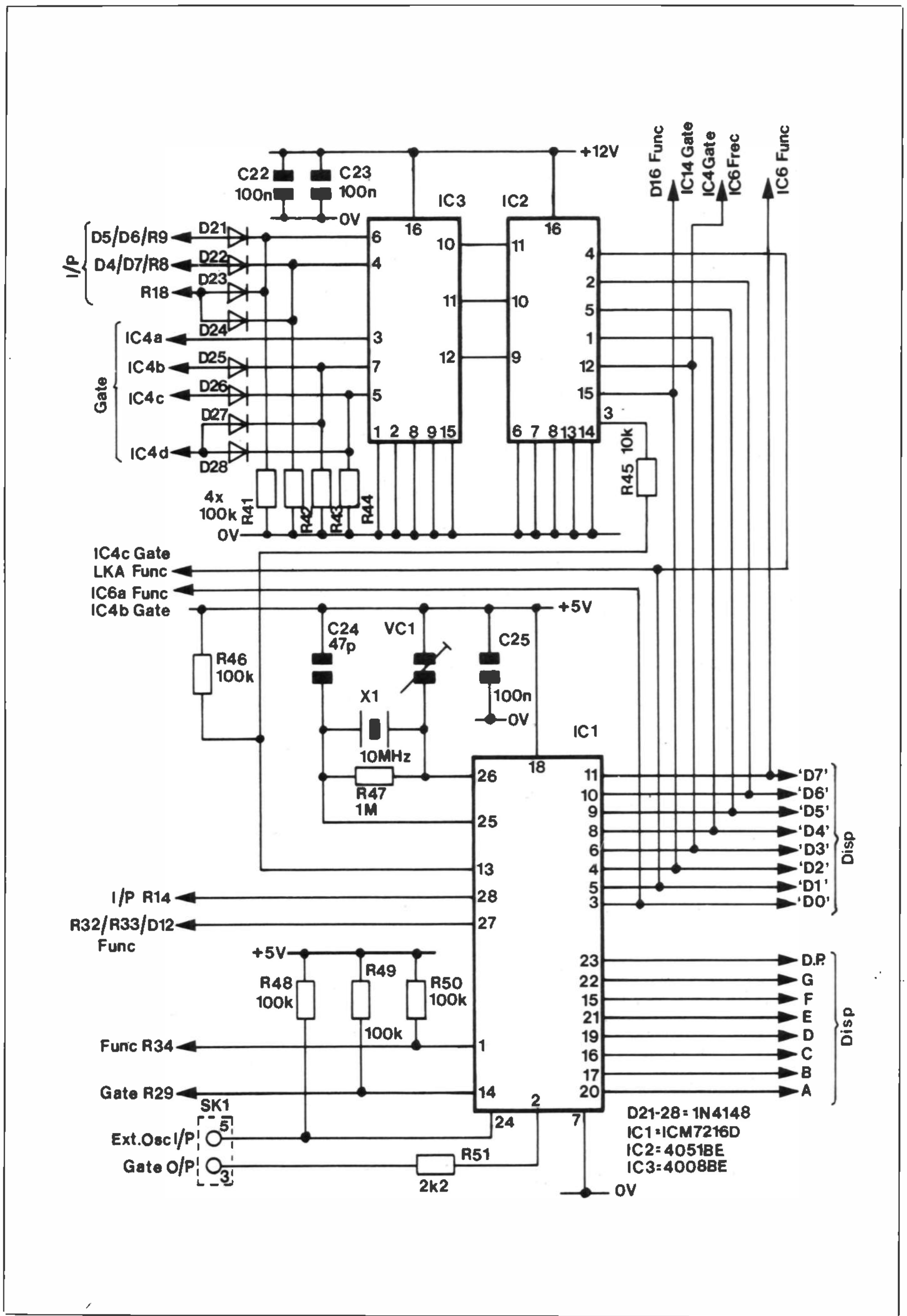
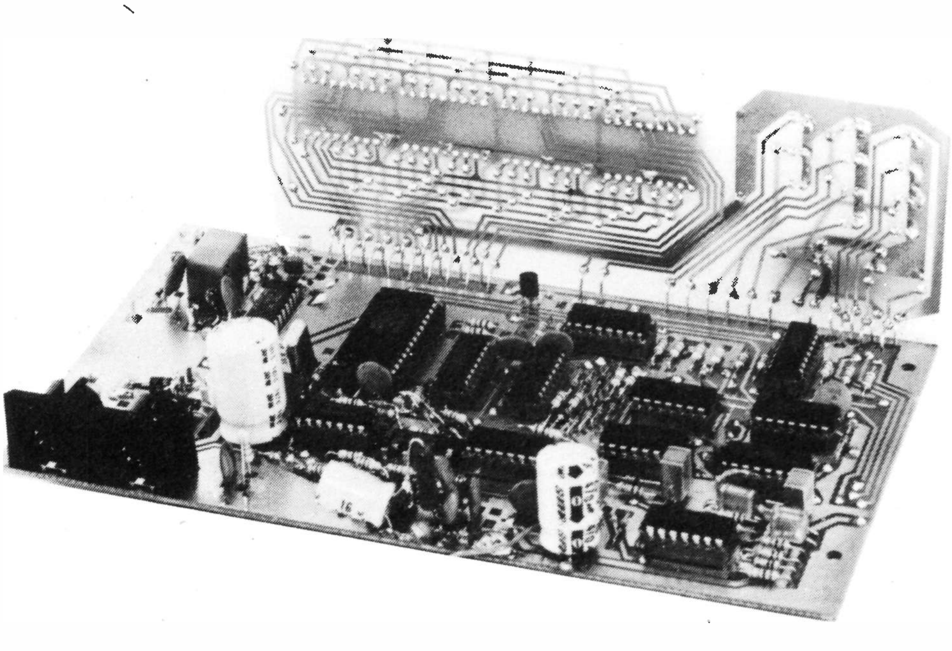


Figure 2. Frequency counter and decimal point logic counter.



oscillator, as well as provision for an external oscillator input (pin 24). Its internal oscillator is controlled by either a 10 MHz or a 1 MHz crystal. A 10 MHz crystal is supplied with the kit. Please note that if you wish to use the 1 MHz option, LKA on the PCB must be fitted. The crystal frequency is set by VC1. The setting of VC1 will determine the accuracy of the displayed frequency, and care should be taken in making this adjustment. IC1 provides the digit and segment drive for the 8-digit 7-segment displays. The digit drive multiplex signal is also used in the function and gate time selects circuits, to control the function and range inputs of IC1. Pin 2 of IC1 provides a gated signal output, which is fed to pin 3 of SK1, for possible future expansion to the system.

The Decimal Point

ICs 2 and 3 (CMOS 4051 and 4008) control the position of the decimal point. This is calculated by looking at the input range and gate time settings. The decimal point occurs at the transitional point between MHz and 100s kHz, except for the 10s gate time on L.F. range, where the decimal point occurs between Hz and tenths of Hz.

The Gate Time Function

This uses the CMOS 4093 (IC11) and 4017 (IC5) to select the gate times. The 4017 controls the CMOS bilateral switch CMOS 4016 (IC4). This selects the appropriate multiplex data line, which controls the range input (pin 14 of IC1). ICs 9 and 10 are the LED drivers for the four LEDs used in the display.

The Function Circuit

This is almost identical in operation to the Gate Time Circuit, but the multiplex data selected is fed to the control pin of IC1 (pin 1). In addition, the function circuit feeds signals to the input select, gate time select, and +10V control circuits. This disables the input select and gate time select in every mode except COUNT, also the +10V control is shut down in the DISPLAY OFF mode. A hold signal is generated in the function circuit which is fed to pin 27 of IC1, so that the frequency displayed can be stored for as long as is required. The display LEDs are driven by IC10 (CMOS 4049).

The Input Range Select Circuit

This functions similarly to the previous two, but features the control of Schottky TTL gates, which select either direct frequency, divide by ten, or divide by a hundred ranges. This is necessary because the maximum frequency that IC1 can handle is 10 MHz, therefore, for HF and UHF, division of the input signal is necessary. IC13 is the divide by ten chip used for HF and UHF ranges. In the UHF mode the prescaler IC14 divides by ten, which is then fed into IC13, making a total division of one hundred. IC9 drives the display LEDs.

The UHF Input Amplifier/Prescaler

The UHF input stage uses a ZTX326 (TR3) broad band, high frequency amplifier in the common base mode. The UHF signal is fed to TR3 via the input relay circuit. It is then fed to the input pins (15 and 16) of IC14. The IC divides the signal by a factor of ten, and the signal is then fed to the input select circuit.

The LF/HF Amplifier

The input to the amplifier is a FET source follower, TR5, to provide a high input impedance. This feeds the signal into pin 5 of IC16, a three stage broadband amplifier. The output on pin 15 is a 1V peak-to-peak signal, which is fed to the base of TR4. This then converts the signal into a TTL switching level, which is fed to pin 1 of IC15. This provides a clean switching waveform to drive the input select circuit. The output is on pin 8.

Power Supply and Relay Control

This consists of a standard transformer/bridge rectifier network, which provides an unregulated 12V supply for the CMOS circuits. REG 1 is a +5V, ½A regulator, and has a 1N4148 diode in its common return to increase the output voltage to +5.6V. This gives a brighter display and more reliable TTL switching. The 10V controlled output feeds the display LEDs on GATE TIME and INPUT ranges. The 10V is shut down in the DISPLAY BLANK mode, by IC11 controlling TR1. The relay RLA is controlled by TR2/IC9, and is active when UHF is selected. The relay controls the voltage and signal feed to either the LF/HF amplifier, or the UHF input amplifier/prescaler.

The Input Protection Circuit

This provides DC isolation to 500V, and AC protection up to a 5V peak-to-peak signal. This is achieved with limiting diodes and DC isolation capacitors on the input.

Construction

This project has been designed to fit into the aluminium instrument case XY45Y. Holes have to be drilled for the transformer, regulator, mains input socket, and fuse, as they are all mounted on the back of the box. Holes also have to be drilled to allow access to the PCB mounted power connector and auxiliary socket. The front of the case requires holes drilling for the BNC input socket, the three key switches, the

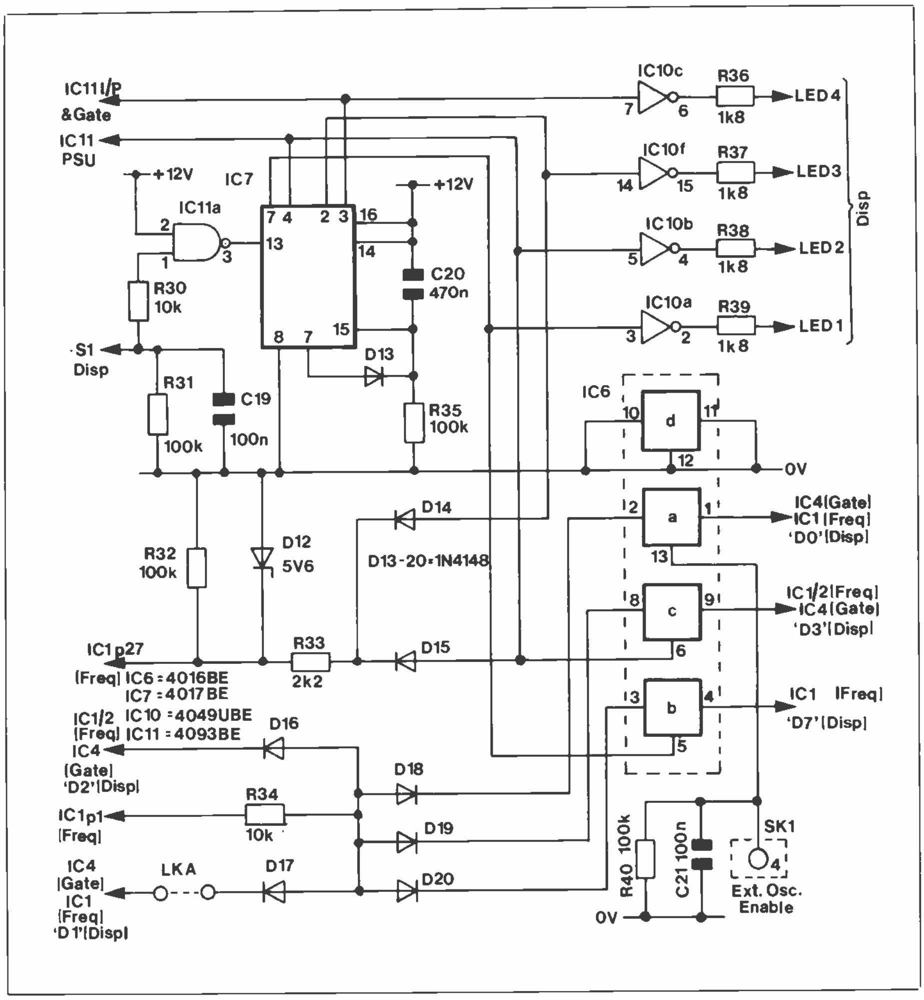


Figure 3. Function select circuit.

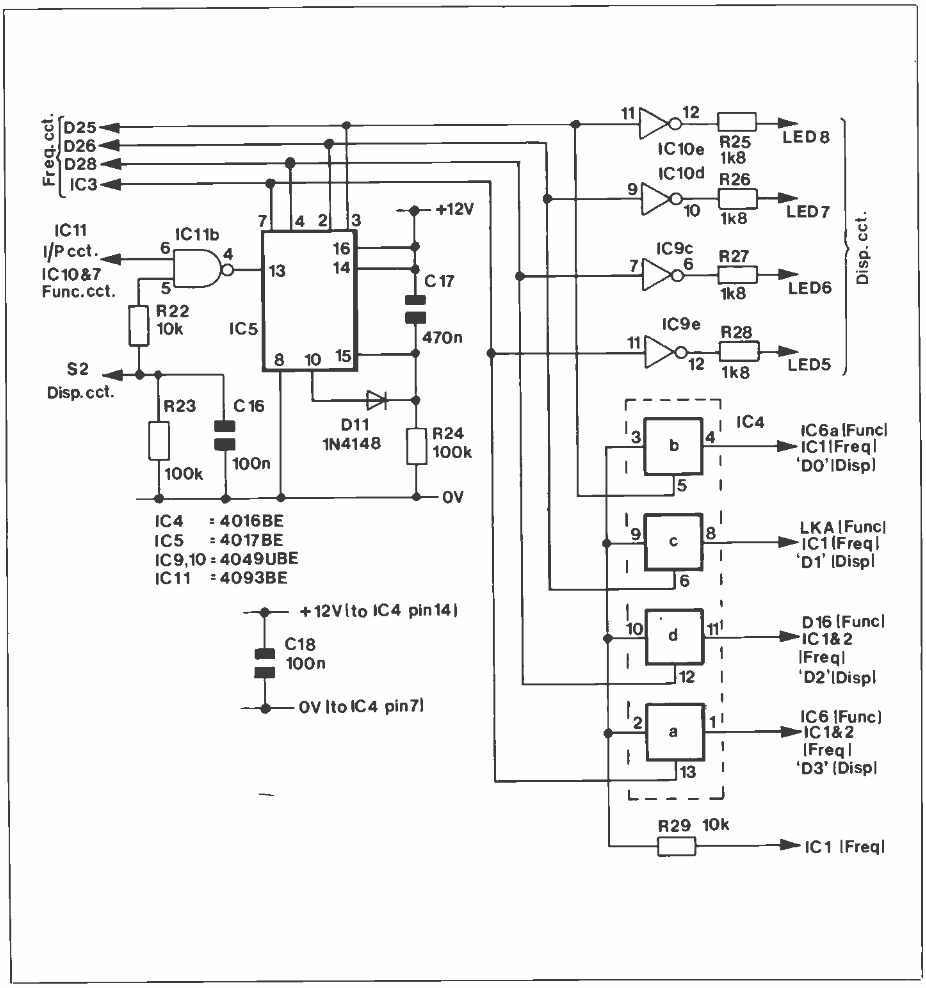


Figure 4. Gate time circuit.

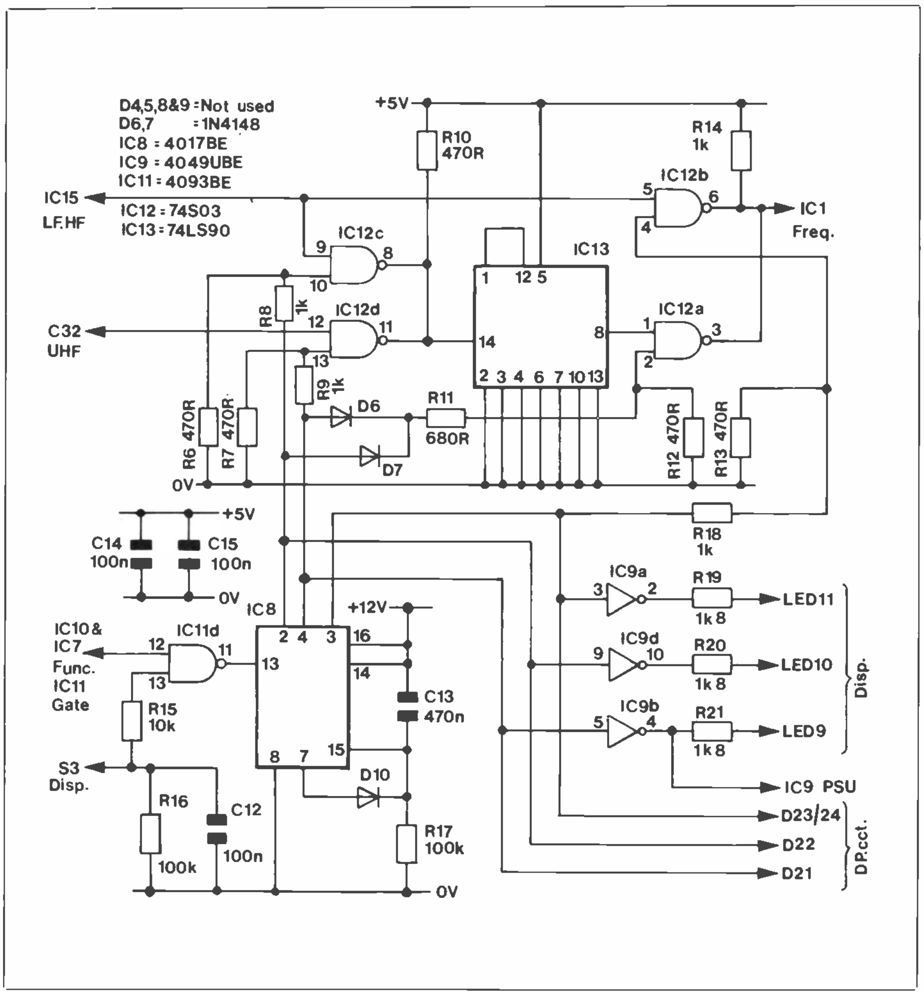


Figure 5. Input select circuit.

three rows of LEDs, and a rectangular window needs cutting for the display. The holes are already provided on the bottom of the box to fit the main PCB on ⅛" 6BA spacers. The CMOS ICs are all provided with sockets, and care should be taken when handling these devices.

The Main PCB

First, fit all track pins, making sure that they are all soldered on both sides. don't omit a track pin adjacent to R6. Then insert and solder the Vero pins into their correct positions, and fit all resistors and diodes, including BR1, checking for correct polarity on all the diodes.

Fit the two PCB mounting connectors and the fuse clips. Fit all capacitors, including VC1. Make sure that all the electrolytics and tantalums are correctly polarised. Fit the relay RLA and all IC sockets. These are *only* provided for CMOS ICs. Sockets should *not* be fitted to the ECL and TTL devices, as these can operate at frequencies that make the use of sockets undesirable. Fit the transistors, including the input FET, and solder the regulator into a position enabling it to be bolted to the back panel when the PCB is fitted into the case. Fit the crystal, taking care not to overheat this component. Clean the underside of the PCB, and check soldering for possible dry joints etc.

The Display PCB

Fit all track pins. Fit all 7-segment displays, ensuring correct orientation with markings towards the bottom of the board. Fit all display LEDs, and then the three push switches as shown in Figure 10. Check your soldering!

Fitting the Display PCB to the Main Board

The display PCB must be mounted at an angle of 90 degrees to the main board, and the bottom edge must run parallel to the front edge of the main PCB. Solder the inter-PCB connecting links to the main board.

All CMOS chips with the exception of IC1 should now be fitted. Normal CMOS precautions should be observed. Fit the BNC socket and glue the red filter to the front panel (as shown in Figure 11). The main PCB should now be tested (see the setting up procedure). After testing, mount the PCB with spacers (Figure 11), and bolt the regulator (using the mica washer), the mains transformer, the fuseholder, and the mains input socket to the back panel (Figure 12), and wire up as shown. Fit the capacitors to the back of the BNC socket as shown in Figure 11.

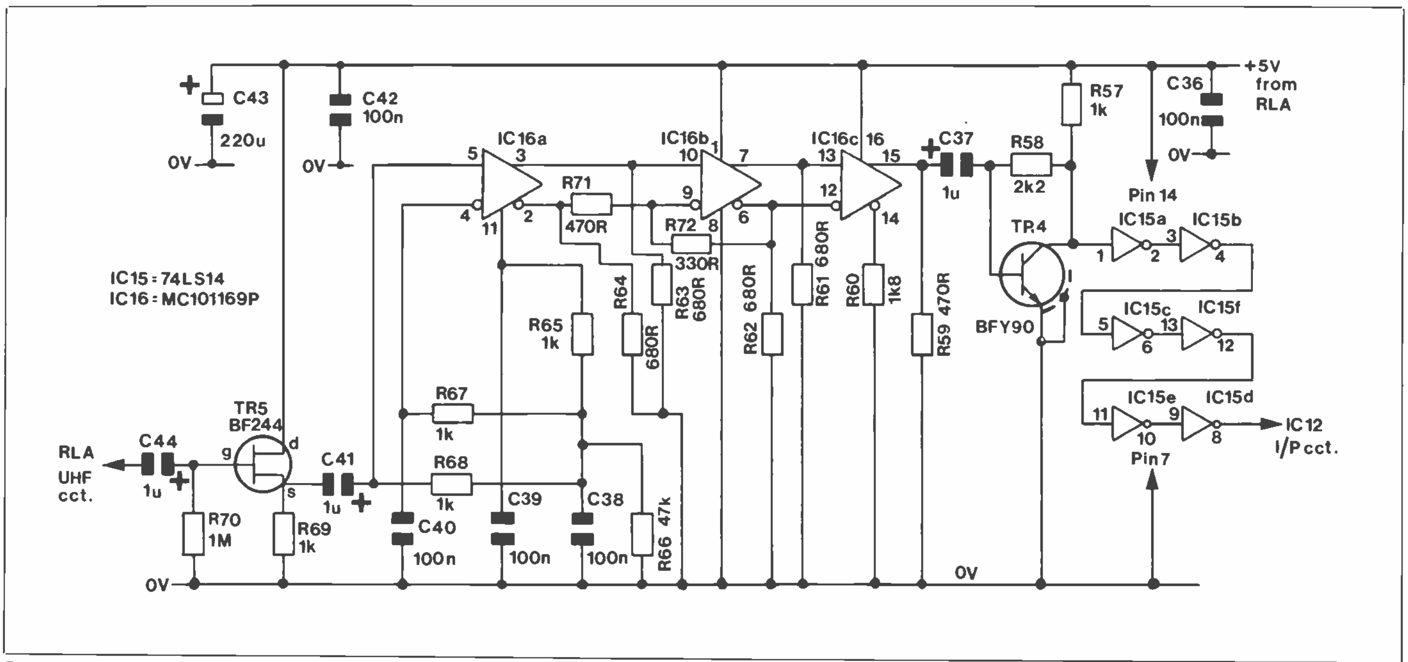


Figure 6. LF/HF input circuit.

Setting Up

Before fitting into the case, the voltage regulator and CMOS control logic can be tested. A 12V DC supply is needed. This can be a battery, C.B. power supply, or similar. Fit a meter capable of reading 1A fsd across the PCB fuseclips, with the negative lead on the side of the fuseclip which connects to the anode of D3. Fit a temporary heatsink (e.g. a croc clip) to the metal tab of the regulator. Connect the 12V supply via the PCB mounted power input socket. A current of no more than 200mA should be observed. If there is more than 200mA, disconnect immediately and check the construction. If there is zero current, you may have incorrect polarity on the power supply. If all is correct the bottom LED in each row should be lit, but none of the 7-segment displays. Press each switch in turn, and check that the LEDs illuminate in sequence. The function should be kept in COUNT mode whilst checking the ranges. When the function is in any mode other than COUNT, the other two switches should have no effect. In 'DISPLAY OFF' mode, the range LEDs will extinguish. Remove the meter and replace the fuse FS2. The regulator output should now be measured, using a voltmeter connected with the negative lead to 0V, and the positive lead to test point 1. A reading of approximately 5.5V should be obtained. Ensure that there is no more than +5V DV present on pins 1, 13, and 14 of IC1 holder, and that when the function is on HOLD, there should not be more than 6V on pin 27. Remove the power and carefully insert IC1. Re-apply the power and a display should be visible, as shown

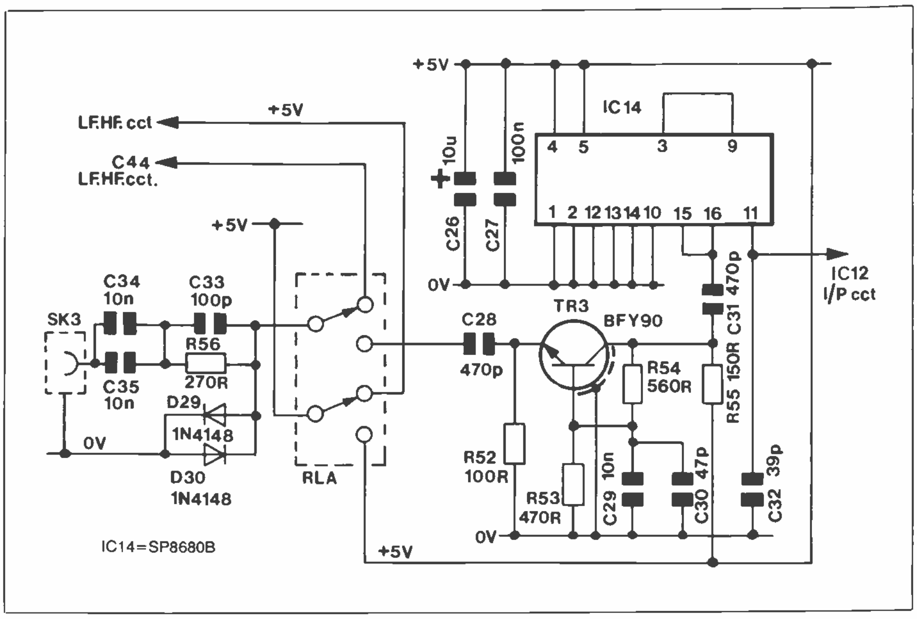
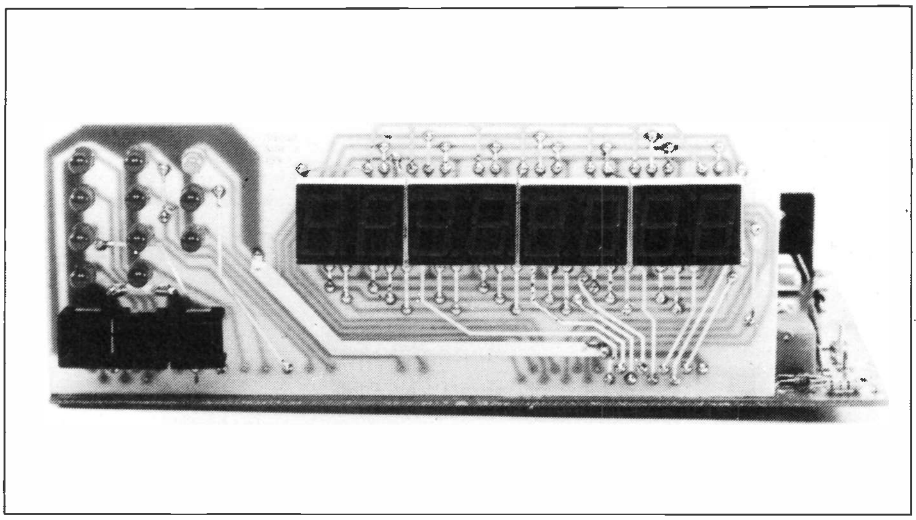


Figure 7. UHF input and relay circuit.



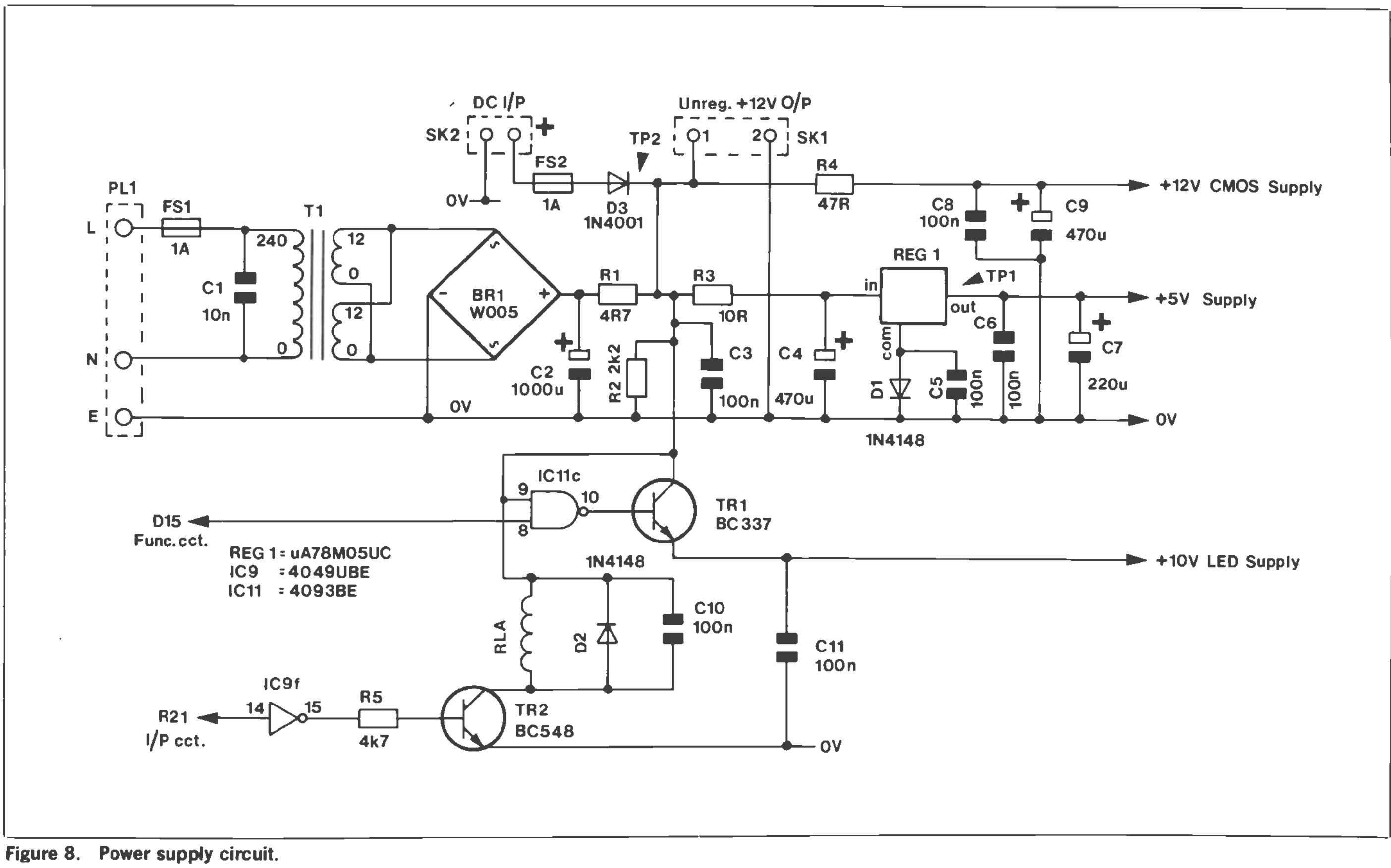


Figure 8. Power supply circuit.

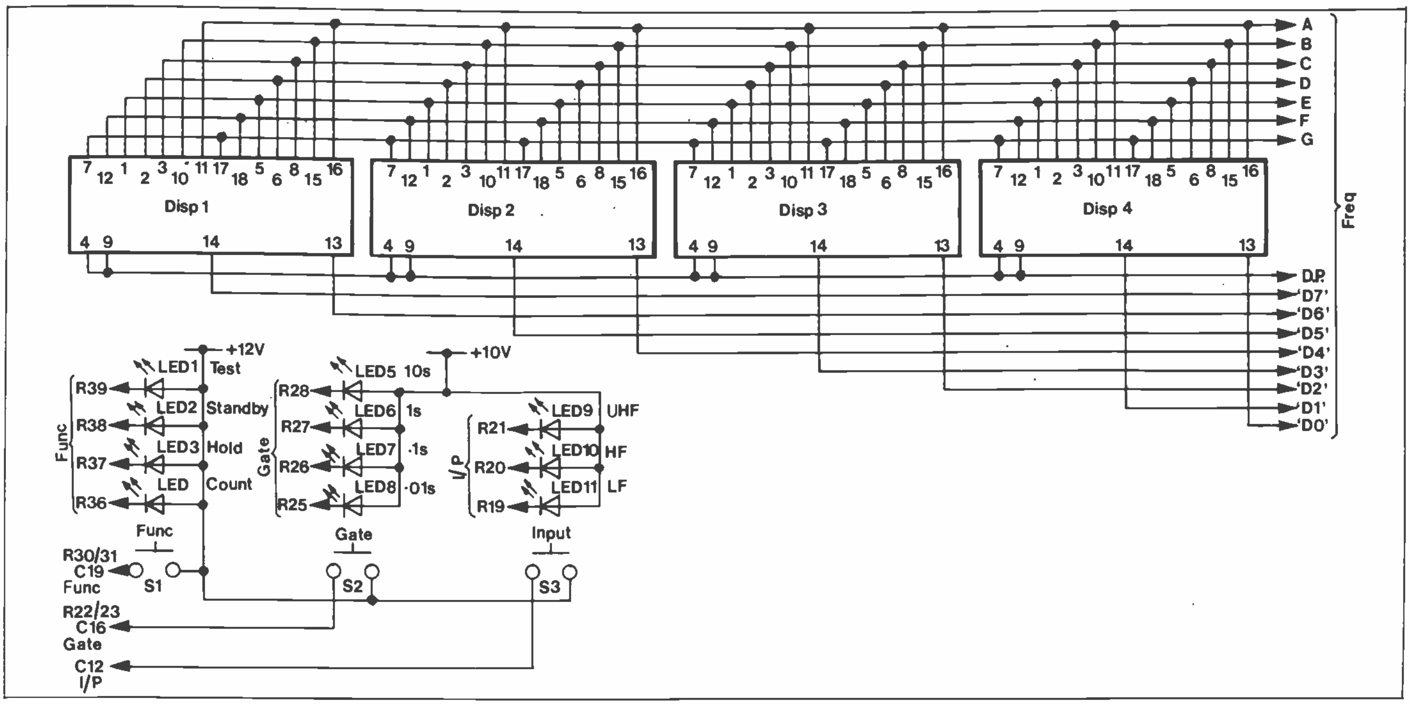


Figure 9. Display circuit.

MAIN PARTS LIST

Resistors: All 0.6W 1% metal oxide unless specified.

R1	4Ω7	1	(M4R7)
R2,33,51,58	2k2	4	(M2K2)
R3	10Ω (3W wirewound)	1	(W10R)
R4	47Ω	1	(M47R)
R5	4k7	1	(M4K7)
R6,7,10,12,13, 53,59,70	470Ω	8	(M470R)
R15,22,29,30 34,45	10k	7	(M10k)
R8,9,14,18,57, R67,68,69	1k	9	(M1K)
R16,17,23,24,31 32,35,40-44,46, 48-50	100k	16	(M100K)
R19-21,25-28, 36-39,60	1k8	12	(M1K8)
R47	10M	1	(B10M)
R70	1M	1	(M1M)
R52	100Ω	1	(M100R)
R54	560Ω	1	(M560R)
R55	150Ω	1	(M150R)
R56	270Ω	1	(M270R)
R11,61-64,72	680Ω	6	(M680R)
R66	47k	1	(M47K)

Capacitors

C1	10nF suppression Cap.	1	(FF53H)
C2	1000μF 25V P.C. Electrolytic	1	(FF18U)
C3,5,6,8,10,11,12 14,15,16,18,19, 21-23,25,27,36, 38-40,42	100nF Disc Ceramic	22	(BX03D)
C4,9	470μF 25V P.C. Electrolytic	2	(FF16S)
C7,43	220μF 16V P.C. Electrolytic	2	(FF13P)
C13,17,20	470nF 63V 5% Cap	3	(EF19V)
C24	47pF Silver Mica	1	(WX09K)
C26	10μF 16V Tantalum	1	(WW68Y)
C28,31	470pF Ceramic	2	(WX64U)
C29	10nF Disc Ceramic	1	(BX00A)
C30	47pF Ceramic	1	(WX52G)
C32	39pF Ceramic	1	(WX51F)
C33	100pF Ceramic	1	(WX56L)
C34,35	10nF H.V. Disc	2	(BX15R)
C37,41,44	1μF 35V Tantalum	3	(WW60Q)
VC1	Trimmer 65pF	1	(WL72P)

Semiconductors

D1,2,6,7,10,11 13-30 inc.	1N4148	24	(QL80B)
D3	1N4001	1	(QL73Q)
D12	BZY88C5V6	1	(QH08J)
TR1	BC337	1	(QB68Y)
TR2	BC548	1	(QB73Q)
TR3,4	BFY90	2	(QQ64U)
TR5	BF244A	1	(QF16S)
REG.1.	μA78M05UC	1	(QL28F)
IC1	ICM7216D	1	(YY94C)
IC2	4051BE	1	(QW34M)
IC3	4008BE	1	(QW14Q)
IC4,6	4016BE	2	(QX08J)
IC5,7,8	4017BE	3	(QX09K)
IC9,10	4049UBE	2	(QX21X)
IC11	4093BE	1	(QW53H)
IC12	74S03	1	(QY24B)
IC13	74LS90	1	(YF38R)
IC14	SP8680B	1	(QY18U)
IC15	74LS14	1	(YF12N)
IC16	MC101169P	1	(QY23A)
BR1	W005	1	(QL37S)

Miscellaneous

X1	10MHz crystal	1	(FY78K)
RLA	Ultra-min Relay DPDT	1	(YX95D)
SK1	P.C. Mtg. Power Skt.	1	(RK37S)
SK2	P.C. Din SKT 5-Pin 'A'	1	(YX91Y)
FS2	20mm Fuse 1A	1	(WR03D)
	Fuse clip	2	(WH49D)
	28 Pin Dil Skt	1	(BL21X)
	14 Pin Dil Skt	3	(BL18U)
	16 Pin Dil Skt	7	(BL19V)
	Veropin 2141	1 Pkt	(FL21X)
	Track Pin	2 Pkts	(FL82D)
	P.C.B.	1	(GB02C)
	Screw 6BA x ½"	1 Pkt	(BF06G)
	6BA Nut	1 Pkt	(BF18U)
	6BA Washer	1 Pkt	(BF22Y)
	6BA Spacer x ⅛"	1 Pkt	(FW33L)
	Kit (P) Plas	1	(WR23A)

DISPLAY PARTS LIST

Disp. 1-4	'DD' Display Type C	4	(BY68Y)
S1,2,3	Click Key Black	3	(HY34M)
LED 1-4,10	Red LED	5	(WL27E)
LED 5-8,11	Green LED	5	(WL28F)
LED 9	Yellow LED	1	(WL30H)
	Track Pins	2 Pkts	(FL82D)
	P.C.B	1	(GB03D)

ADDITIONAL PARTS LIST

T1	Transformer 12V 500mA	1	(YK28F)
FS1	20mm Fuse 1A	1	(WR03D)
	Chassis-Fuseholder	1	(RX96E)
PL1	Euro Conn. Lead set	1	(BW99H)
SK3	BNC Skt	1	(HH18U)
	Case	1	(XY45Y)
	Filter Red	1	(FR34M)
	Freq. C. Front Panel	1	(RK39N)
	Long Power Plug	1	(HH61R)
	13A Mains Plug	1	(RW67X)
	Mains Fuse 3A	1	(HQ32K)
	Mains inlet chassis plug	1	(HL15R)
	I/P cap Black	1	(FK93B)
	Wire 3202 Blue	1 Mtr	(XR33L)
	Wire 3202 Brown	1 Mtr	(XR34M)
	Wire 3202 Grn/Yllw	1 Mtr	(XR38R)
	Constructors Guide	1	(XH79L)
	Soldercons	1 Pkt	(XX14Q)

A complete kit of parts is available for this project including an attractive printed and punched adhesive aluminium front panel.
Order As LW79L (Frequency Counter Kit)

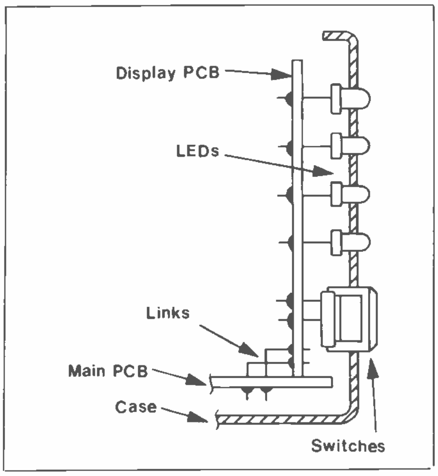


Figure 10. Mounting of switches and LEDs.

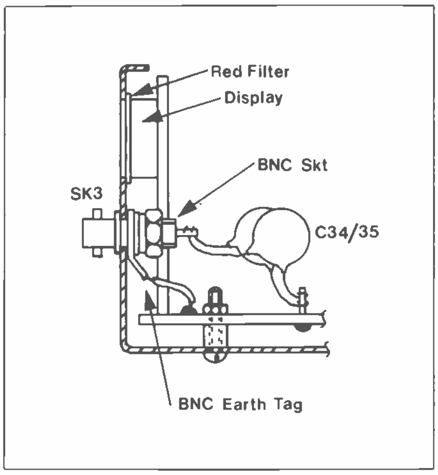


Figure 11. Suggested assembly.

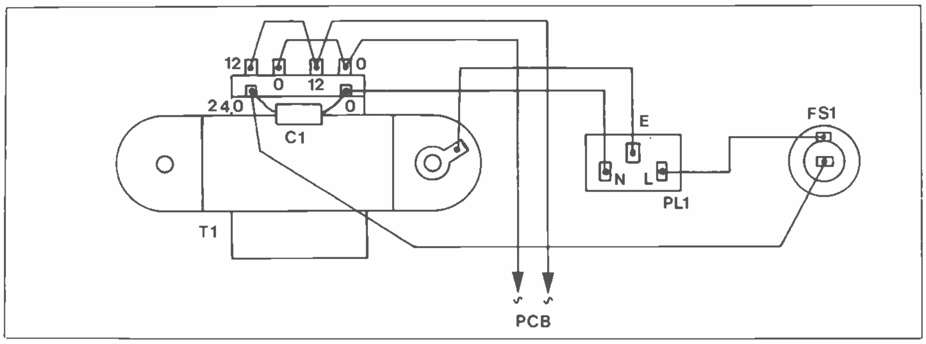


Figure 12. Back panel assembly.

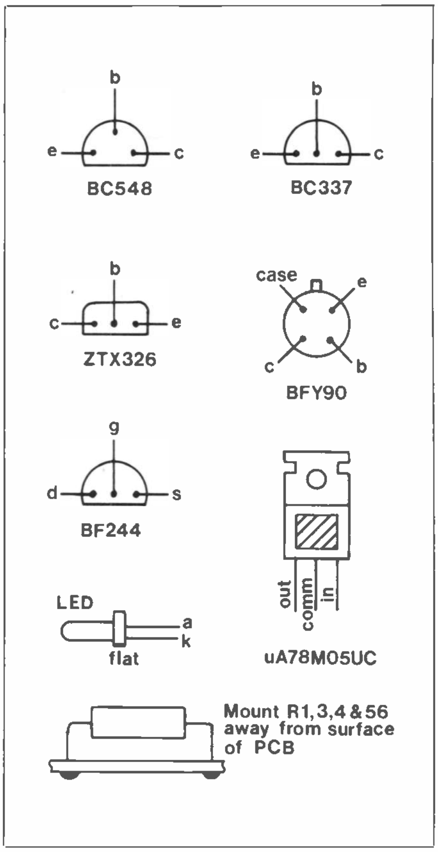


Figure 14. Pin designations.

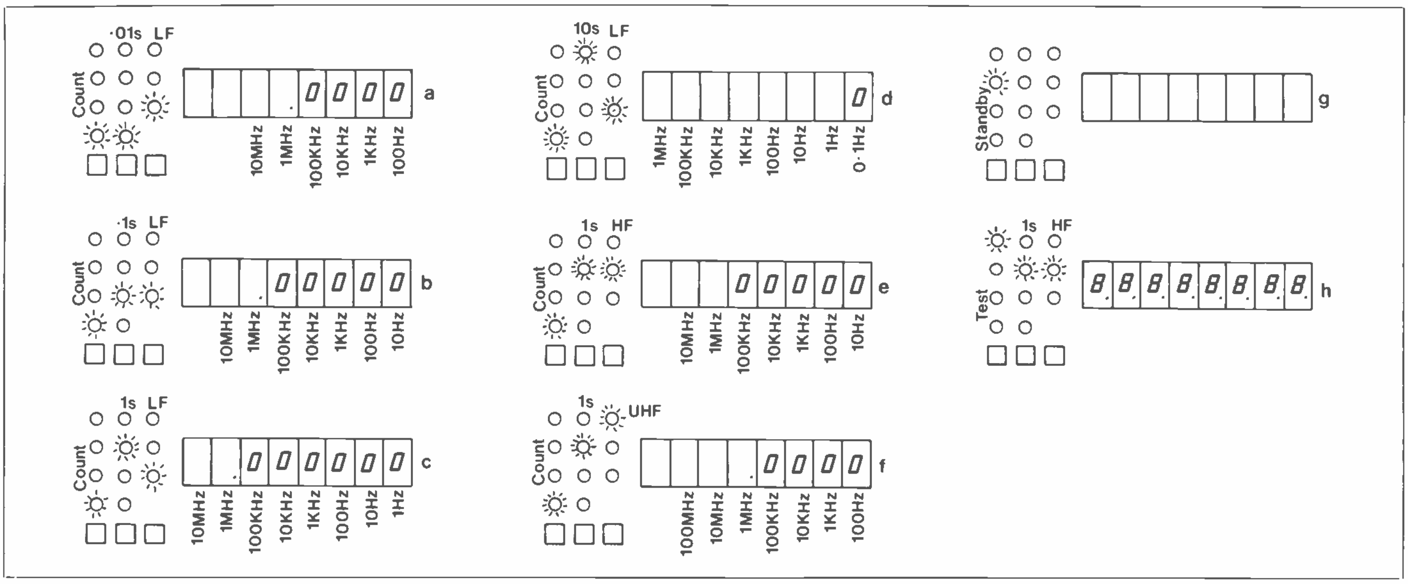
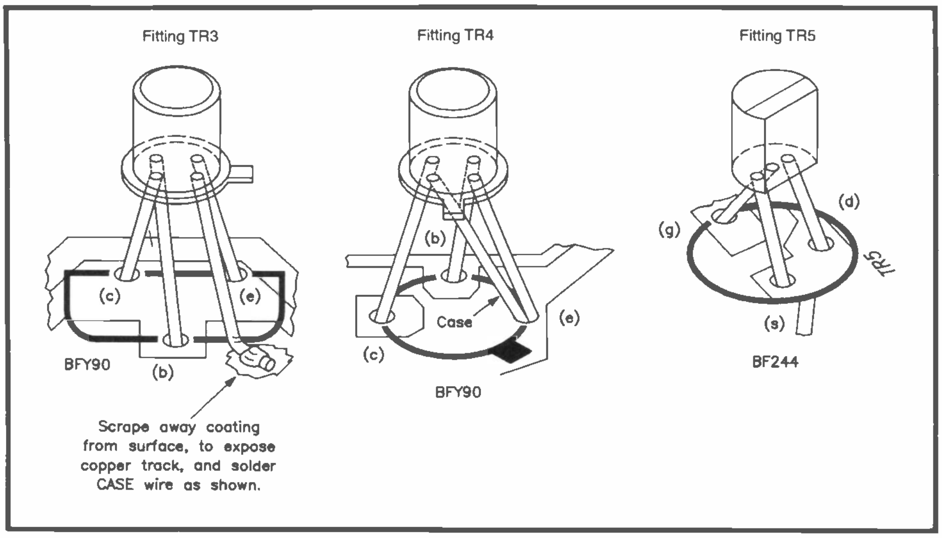


Figure 13. Display conditions.

in Figure 13a. Switch through the ranges, and check that the display varies as in Figures 13b to 13h. At this stage the counter is fully working, and frequency measurement is possible.

When the function is in the TEST position, no more than 320mA should be drawn from the DC supply. The counter should now be assembled as described in Construction Details, and the AC feed wires should be connected to the PCB.

Plug in the mains, and check that all functions are correct as before. A DC voltage measurement should be taken between 0V and TP2. Not more than +15V, and not less than +11V should be present. The trimming capacitor VC1 should be adjusted for correct reading using an input of known frequency.



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