MAPLIN PROJECTS BOOK THREE

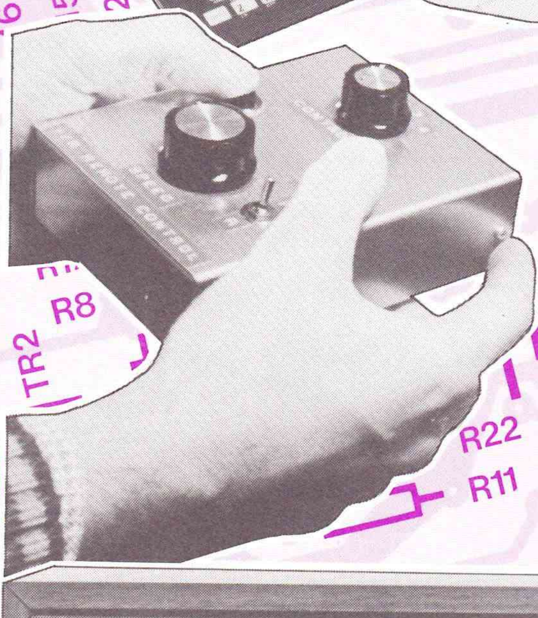
DOPPLER INTRUDER DETECTOR

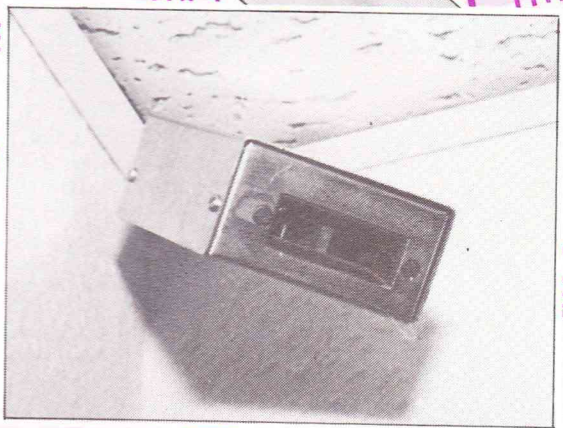
DOPPLER CONTROL AND INTERFACE UNIT

25W MOSFET AMPLIFIER

TRAIN REMOTE CONTROLLER

ZX81 KEYBOARD



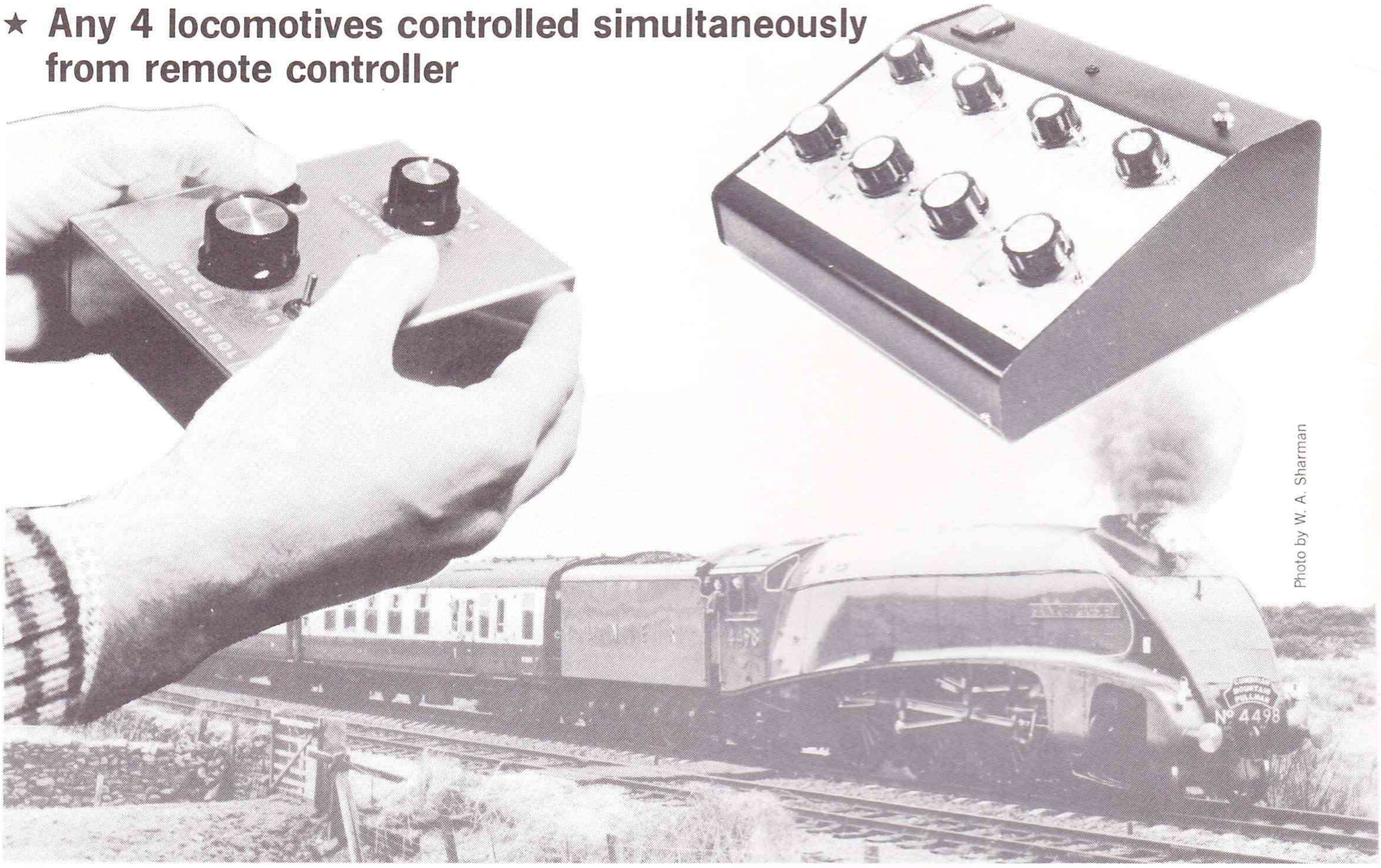


REMOTE CONTROL

for Digital Multi-Train Controller

★ Infra-red, radio and wire remote control systems described

★ Any 4 locomotives controlled simultaneously from remote controller



The second in this series of articles on model railway projects describes the addition of remote control facilities to the train controller described in the previous issue. This addition enables any or all of the four control boards to be commanded by an 8-bit digital input either from the remote controller or a computer. The data for each controller is latched and thus one train can be set running and the command changed to another controller to enable up to four trains to be controlled simultaneously by the external input. Figure 1 shows the block schematic diagram of the remote control system.

Additions To Control Board Circuit

Figure 2 shows the complete circuit of the control board with the extra parts added. As described previously, the board works by allowing a group of TS pulses to be sent to the 6 common lines depending on the direction and train to be controlled. The length of this group of pulses determines the speed of the train; thus with no pulses the train is stationary and with a full ten pulses per group, the train is at maximum speed.

In the local mode, the number of pulses in the group is set by selecting one of the ten outputs from the 4017 decade counter (IC1) and using this to trip the output gate after the appropriate number of pulses have been sent. The same applies in the remote mode, except that in this case the output gate is tripped when the output from the binary counter (IC101) is the same as the 4-bit input from the external source. This is detected by the 4-bit magnitude comparator (IC102), The direction in travel in the remote mode is controlled by simply gating the TS pulses fed to the appropriate line

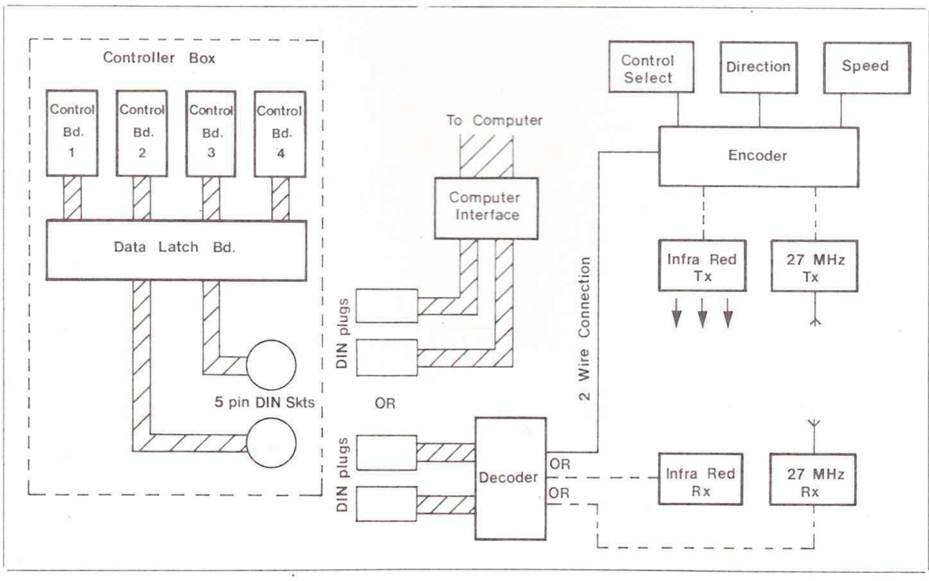


Figure 1. Block schematic showing all options.

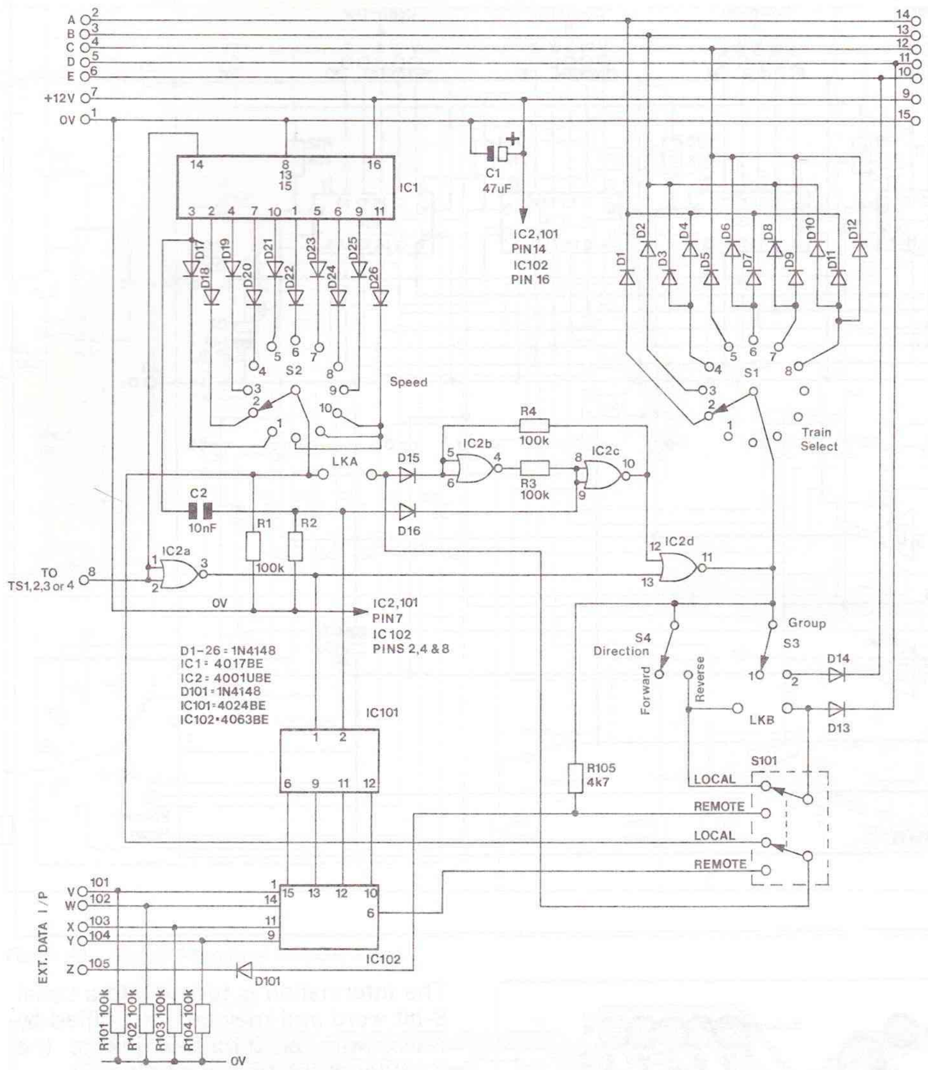


Figure 2a. Circuit diagram of complete Control board.

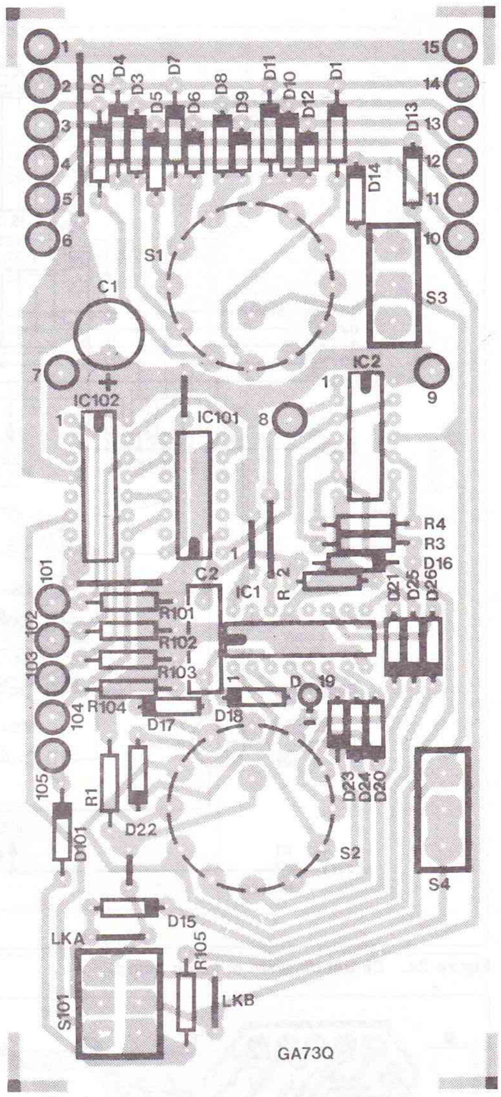
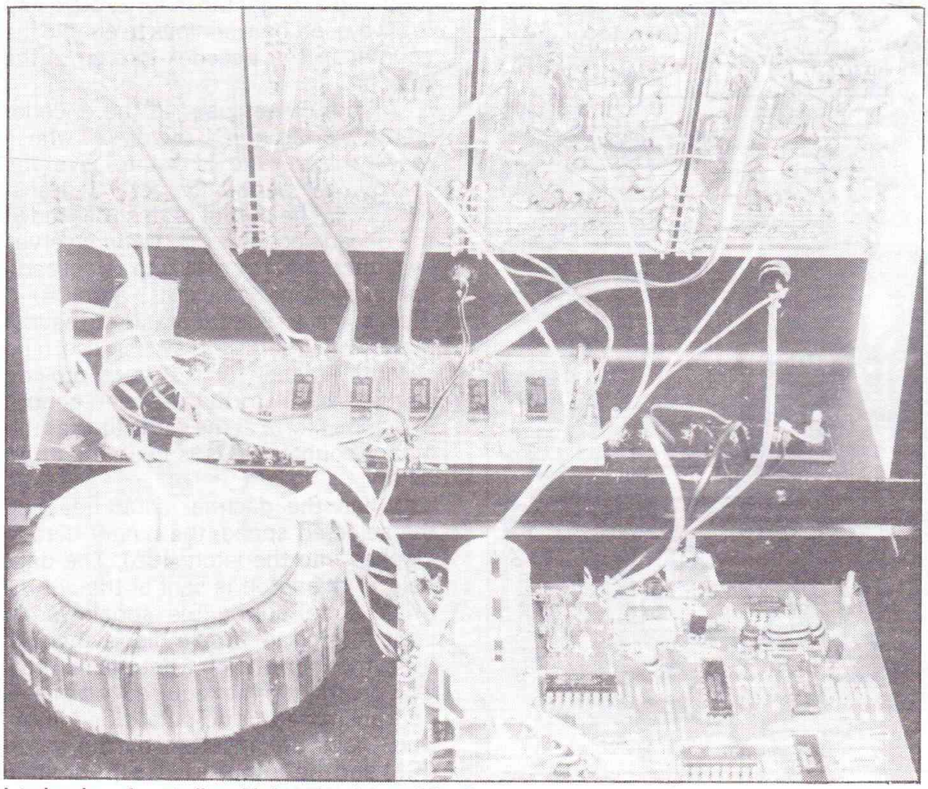


Figure 2b. Component layout of Control board.



Interior view of controller with Data Latch board fitted.

under control of the fifth bit of external data.

Remote Data Latch Board

The data for each of the four control boards is stored by one of the four latches (IC1 to 4); see Figure 3. The control board to be commanded is selected by the conditions applied to the input lines B5 and B6, and this is decoded by IC5 and the diodes D2 to D9 allowing the TS pulse to clock only the required latch.

The eighth bit of the control word may be used for any function required, but we have shown it connected to the power reset circuit. This requires an output only when the button on the remote controller is pressed, so no latch is needed.

Remote Control Data Encoder Board

This board enables any one of the four control boards to be selected and the speed and direction of the train selected by that board to be controlled.

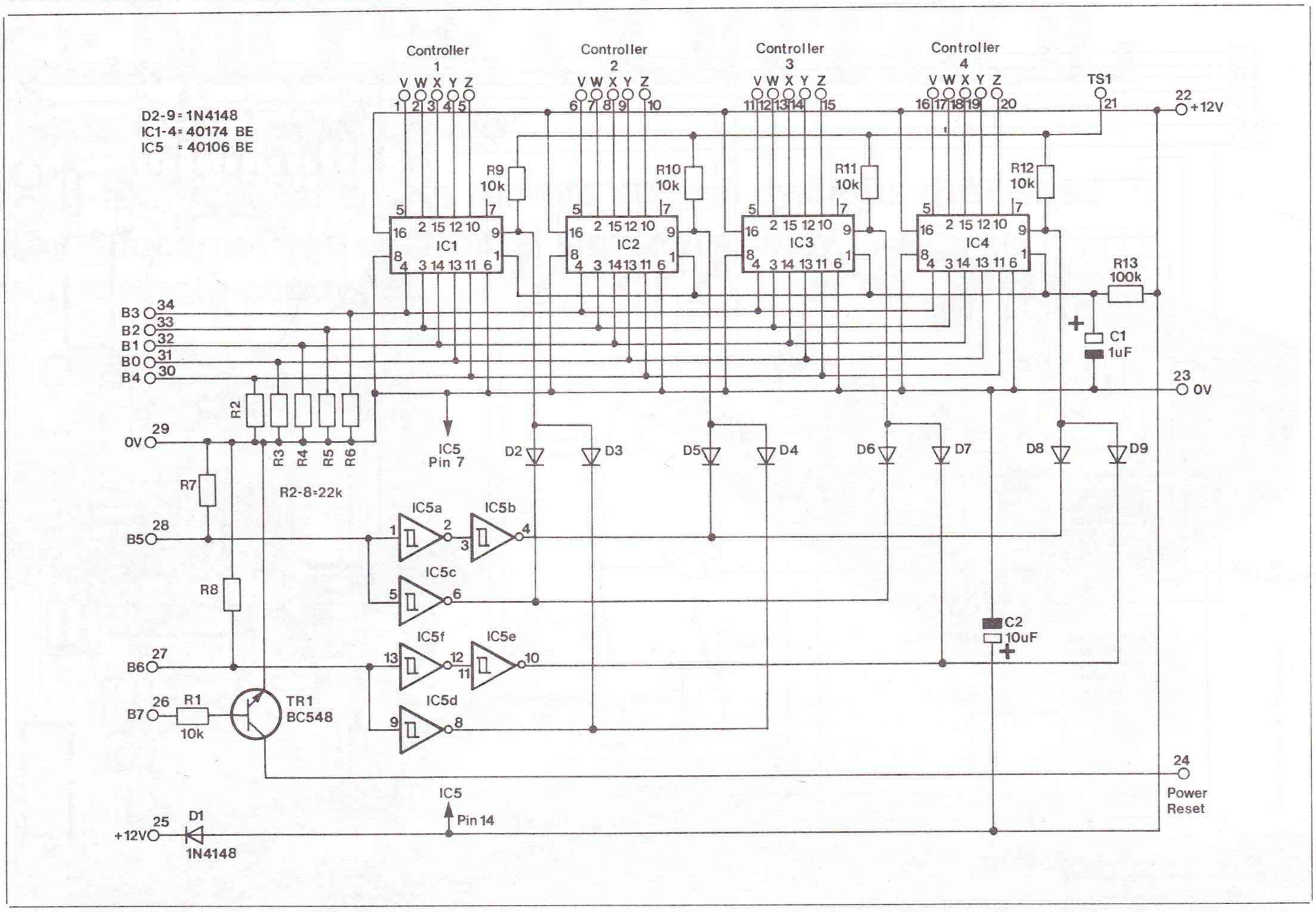


Figure 3a. Circuit diagram of Latch board.

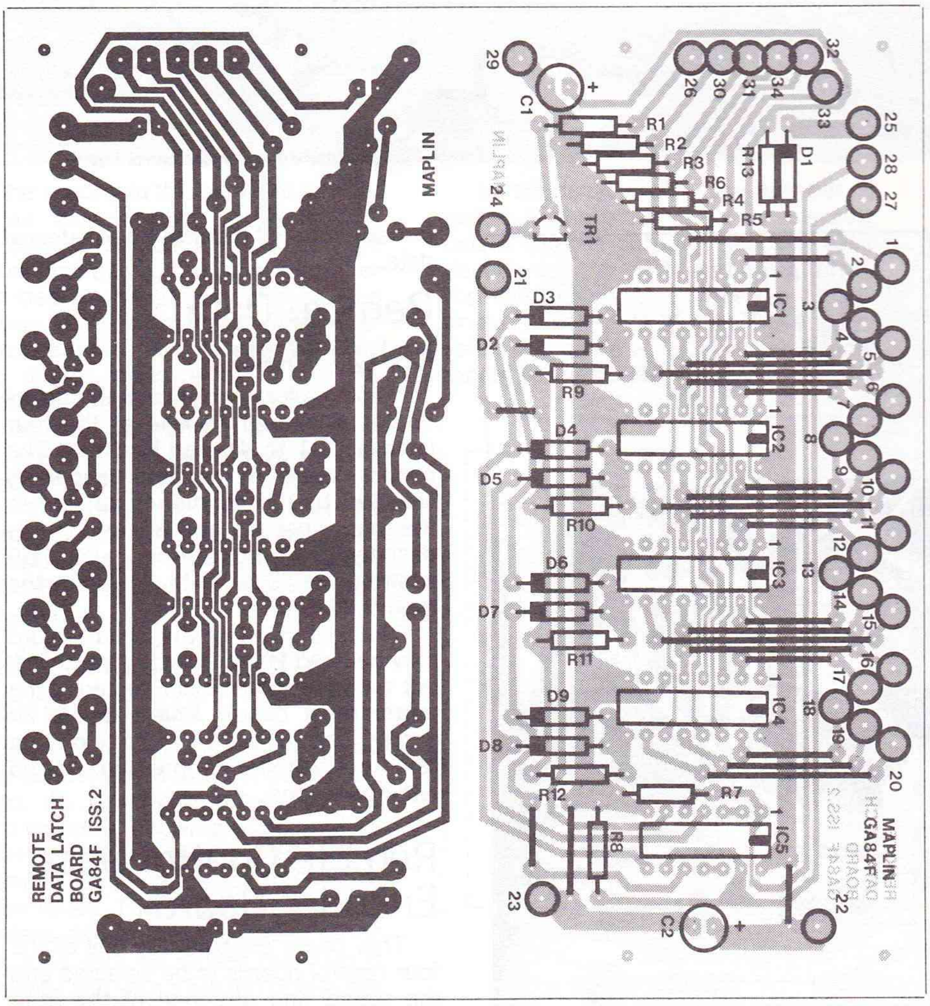


Figure 3b. Component layout of Latch board.

The information is turned into a serial 8-bit word and may be transmitted by radio, wire or infra-red link to the decoder at the train controller.

The serial data sent consists of one long sync pulse followed by eight pulses whose length is determined by whether the bit is at '1' or '0'. A short pulse is sent for 0 and a longer pulse for 1, but a gap is always left between bits to enable the counter in the decoder to step to the next bit.

All the pulses used in the encoder are derived from IC1 (Figure 4) whose mark/space ratio is set to give the critical 'on' period for data '1' transmissions. The output of this IC is fed to the decade counter (IC2) which serves two functions. The first is to select each one of the eight gates (IC3 and IC4) in their correct sequence and at the last two counts, send the sync pulse. The second function of IC2 is to provide sequential pulses to the speed control in decimal form at the same time as the binary counter (IC7) is counting up in binary.

When the decimal count reaches the selected speed, the binary data is clocked into the latch (IC6). The data held in this latch is sent at the appropriate time during the serial word's transmission. A simple diode encoder turns the information from the controller selector into the required two bits to be transmitted. Sync pulses and inter-word gaps are inserted by the gates (IC8) and the output is fed to the emitter follower (TR1).

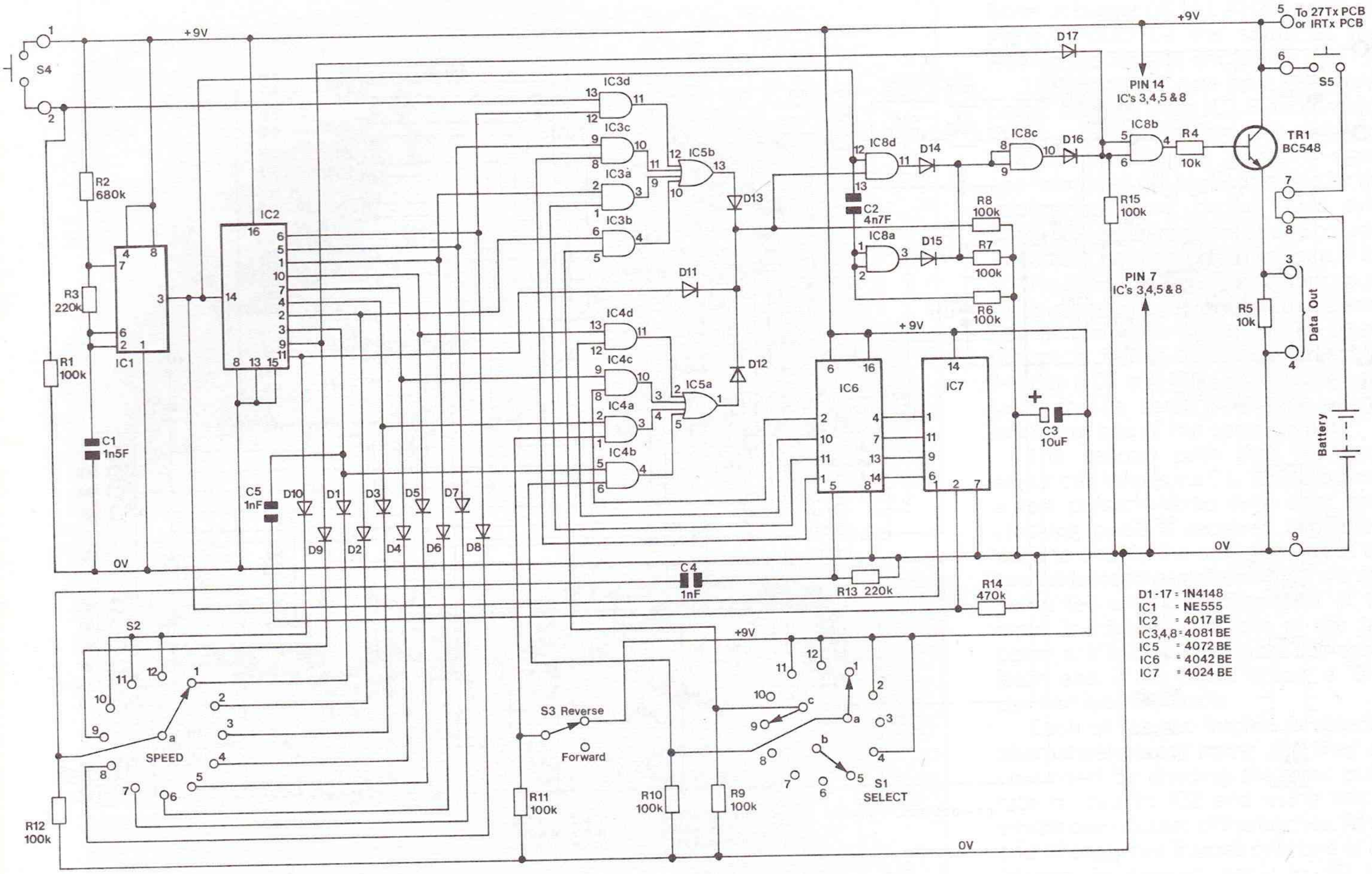


Figure 4a. Circuit diagram of Encoder board.

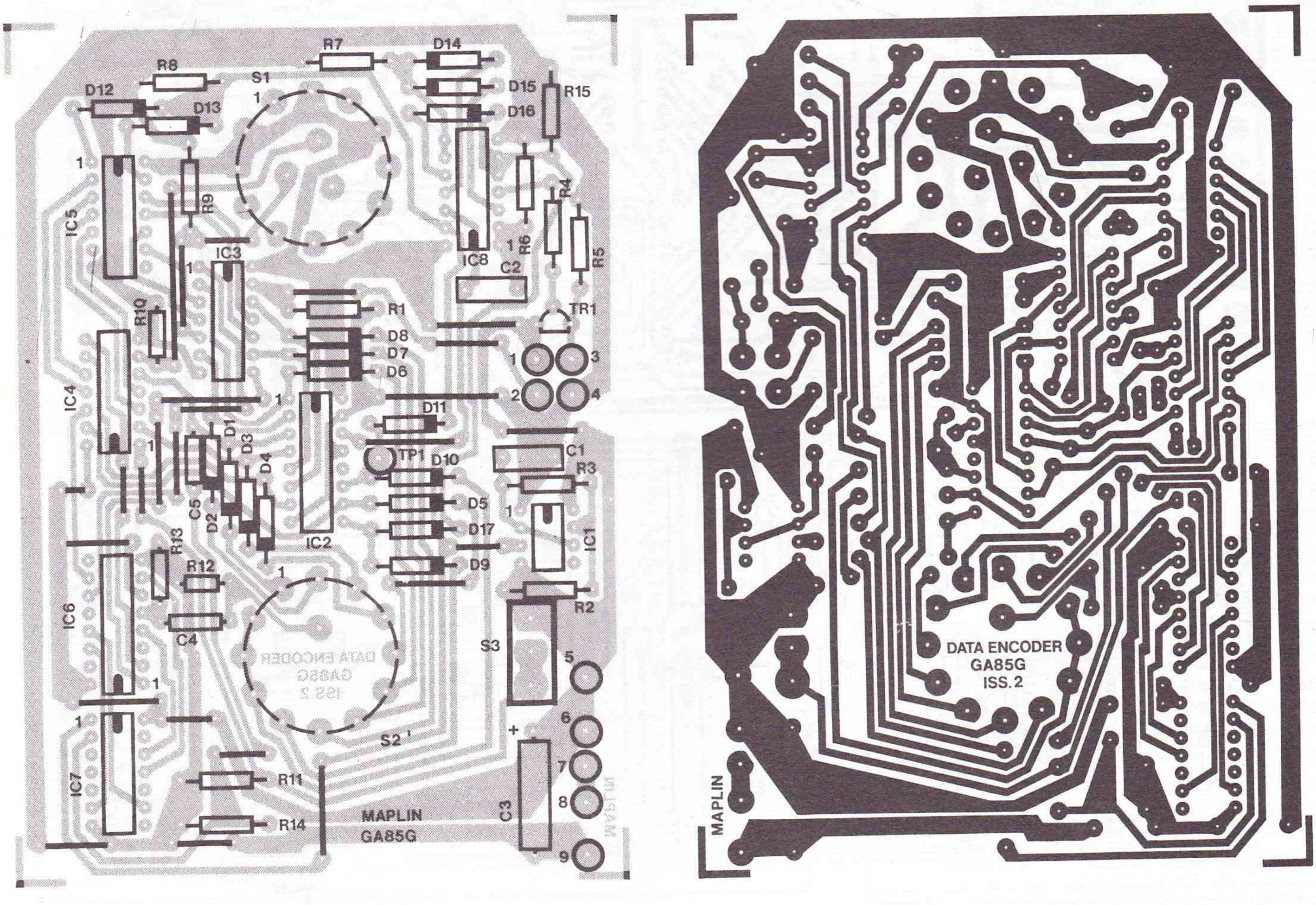


Figure 4b. Component layout of Encoder board.

27MHz Radio Data Link

Transmitter

The transmitter is a low-powered 27MHz crystal-controlled circuit of fairly conventional design. TR1 forms an untuned crystal oscillator which runs all the time that the controller is in operation. The output of this oscillator is fed to the base of TR2 which acts as an output amplifier and modulator. Incoming data is fed to the base of TR3 whose emitter is connected to the emitter of TR2. Thus, when the data is low, TR2 is turned on and passes the rf signal to its collector and the aerial circuit and when the data is high TR2 and TR3 turn off and little or no rf is transmitted.

Receiver

This is built on a standard board designed for model control purposes. Due to the relatively short range required for this application, the rf amplifier in the receiver is not used and is strapped out. This reduces the effect of high levels of external interference. The local oscillator is crystal controlled at 455kHz below the incoming rf frequency and fed to the mixer where it meets the incoming signal from the aerial tuned circuit L1. The 455kHz intermediate frequency is amplified and fed to the detector (D1) via two tuned circuits (IFT1 and IFT2). The signal at the output of the detector is fed via C16 to the data decoder and its DC level is used for controlling the receiver gain (agc).

Licensing Requirements

Please note that a licence is no longer required to transmit and receive signals in the 27MHz band being used for model control. Since the radio link described here meets all the requirements for transmitters and receivers in this band, it is perfectly legal to use it without a licence. Indeed, a licence for this use is simply not available any more.

Infra-Red Data Link

Transmitter

IC1 forms an oscillator running at about 30kHz with a very short, but high amplitude, pulsed output. This output is used to switch TR2 and thus pass high current pulses of about ½A through the four infra-red emitting diodes (D2 to D5) for a very short period. These pulses are turned on and off by TR1 which is controlled by the data input from the encoder.

Receiver

The infra-red signal is received by the diodes D3 and D4 and the 30kHz modulated pulses are amplified by TR1 and TR2. D1 and D2 form a detector and provide a signal relative to the modulation. This signal is amplified by TR3 and any 30kHz is filtered out by its feedback circuit. This signal now feeds TR4 which forms an inverter and output stage.

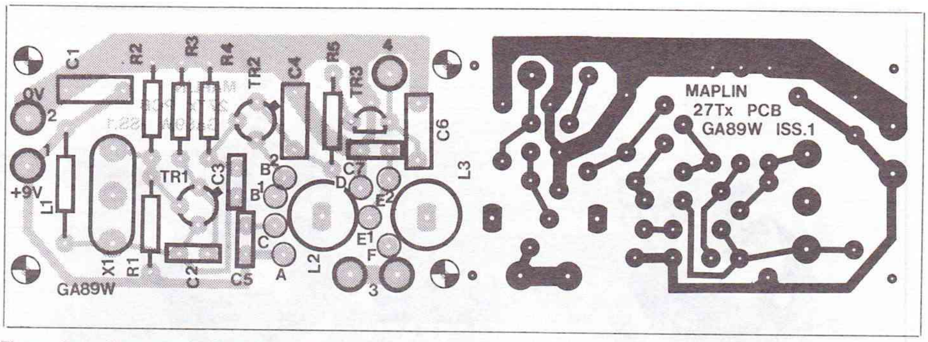
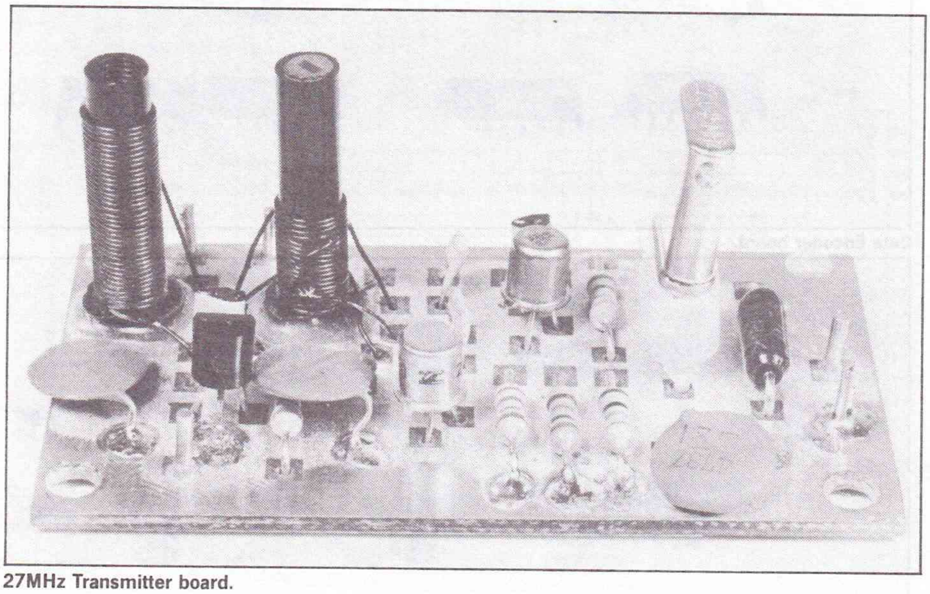


Figure 6c. Component layout of 27MHz transmitter board.



27MHz Transmitter board.

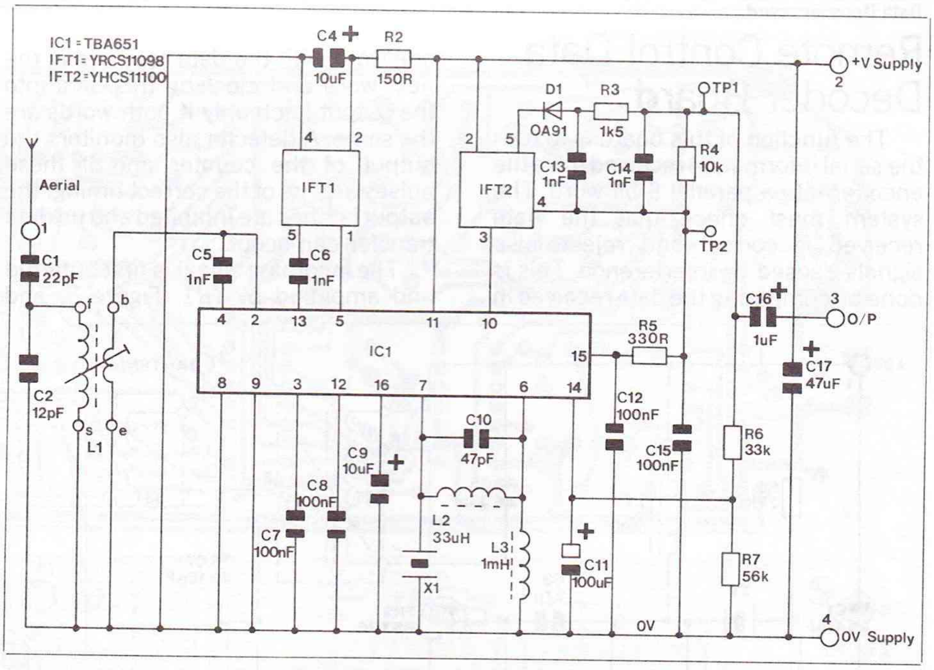


Figure 7a. Circuit diagram of 27MHz receiver.

Construction

Construct all boards referring to the board legend and the appropriate parts list, leaving the insertion of the IC's until last. Refer also to the special instructions below. Add the extra parts to whichever of the control boards you wish to control remotely.

Data Encoder Board

On this board, the Veropins have to be inserted from the component side to aid wiring when the board is mounted in the box. Ensure that the two rotary switches are in the correct positions. S2 is the switch without the click-stops.

27MHz Transmitter Board

This is a double-sided board with an earth-plane on the component side of the board. All the wires should be soldered on both sides of the board except where a clearance hole is provided for component leads on the earth plane side. Insert and glue the two

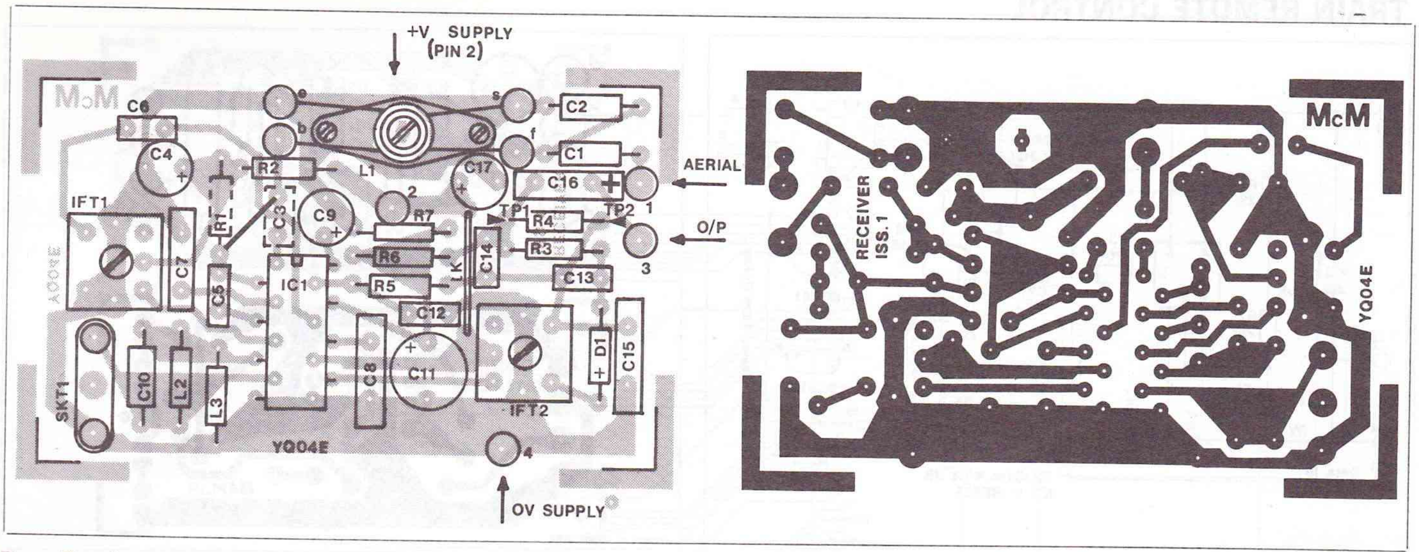
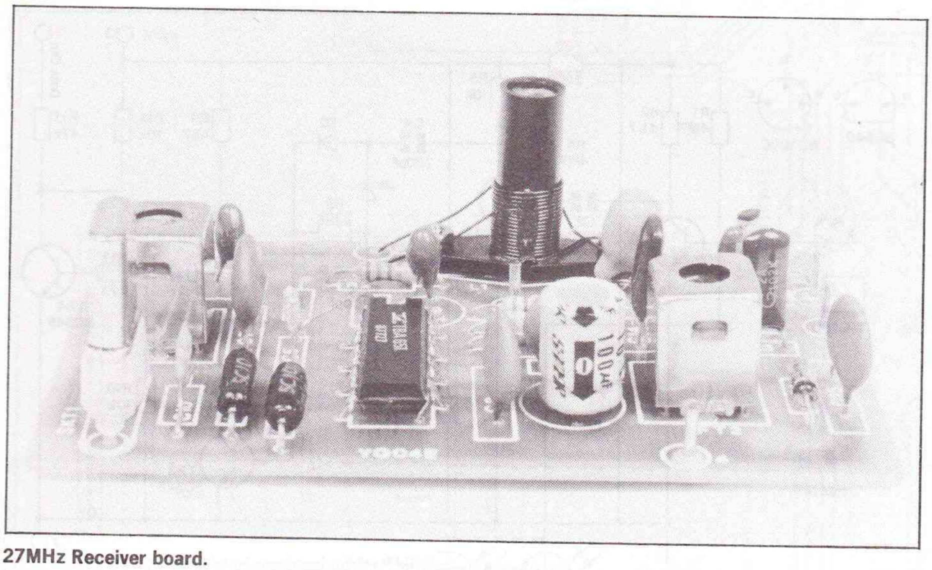


Figure 7b. Component layout of 27MHz receiver board.



27MHz Receiver board.

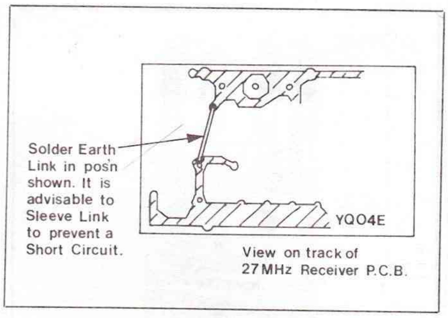


Figure 7c. Addition of earth link to 27MHz receiver board.

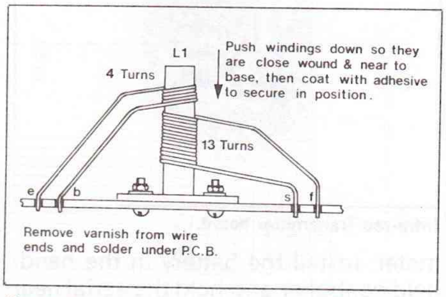


Figure 7d. Coil winding details for 27MHz receiver.

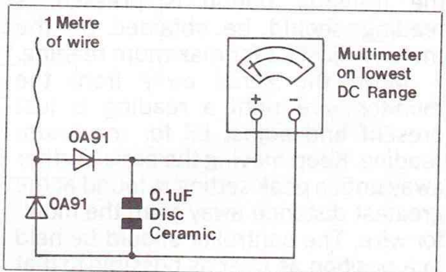


Figure 8a. RF monitor for transmitter alignment.

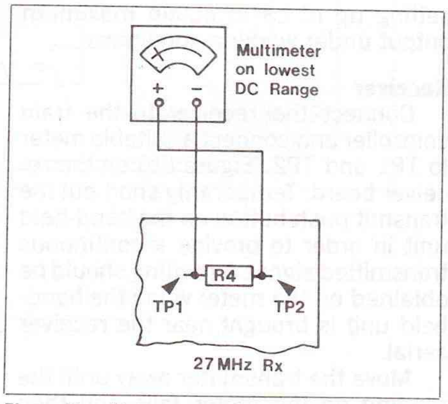


Figure 8b. Meter connections for receiver alignment.

formers for L2 and L3 into the board and wind the coils using 28swg enamelled copper wire referring to Figure 6B.

Start the windings at points A and D and wind up the formers. When the windings are completed they should be fixed with cyanoacrylate adhesive and allowed to dry before setting up the transmitter. The aerial consists of a length of palladium wire about 45cm long connected to pins.

27MHz Receiver Board

Ensure correct positioning of the two i.f. transformers IFT1 and IFT2, and also the two chokes L2 and L3. The positive end of D1 is the end with the band. Note that R1 and C3 are not used in this application and are replaced with a link as shown in Figure 7B. An additional earth strap should be added under the board using a short length of tinned copper wire as shown in Figure 7C.

Wind the coil L1 referring to Figure 7D using 28swg enamelled copper wire. A length of tinned copper wire about 1.5cm long should be soldered to each end of R4 to form TP1 and TP2. The aerial is made from a length of palladium wire about 45cm long connected to pin 1 on the receiver board.

The crystals used in the transmitter and receiver must be a pair, though any colour will do. The crystal with the higher frequency is fitted in the transmitter. The receiver should be sited as far away from the layout as possible in order to reduce electrical interference problems.

Infra-red Receiver

The positioning of the infra-red receiver diodes will affect the range of the system. They should be shielded from direct light both artificial and sunlight. A simple reflector behind the diodes and a lens system will improve the range. Nevertheless, a range of about 6 metres can be expected with no additions with the transmitter pointing directly at the receiver diodes. The receiver must be mounted in a metal box with the box connected to 0V, otherwise the very sensitive circuit will pick up radio interference.

Setting-up 27MHz Transmitter & Receiver

Transmitter

Construct the rf monitor as shown in Figure 8a and connect to a suitable

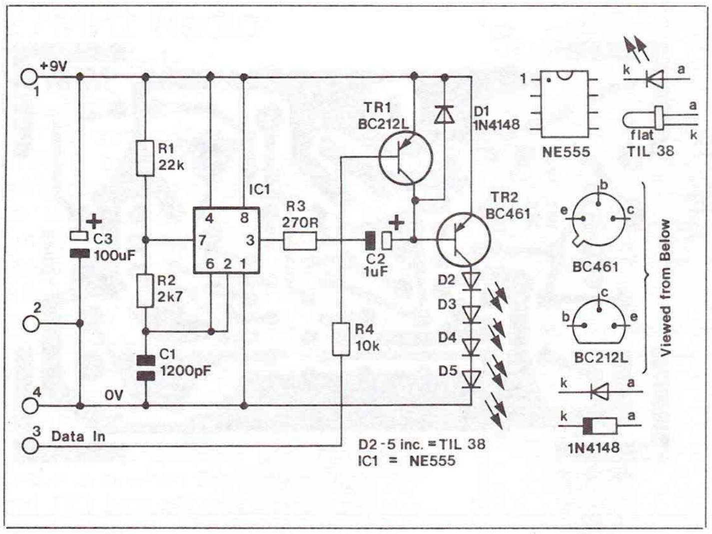


Figure 9a. Circuit diagram of Infra-red transmitter.

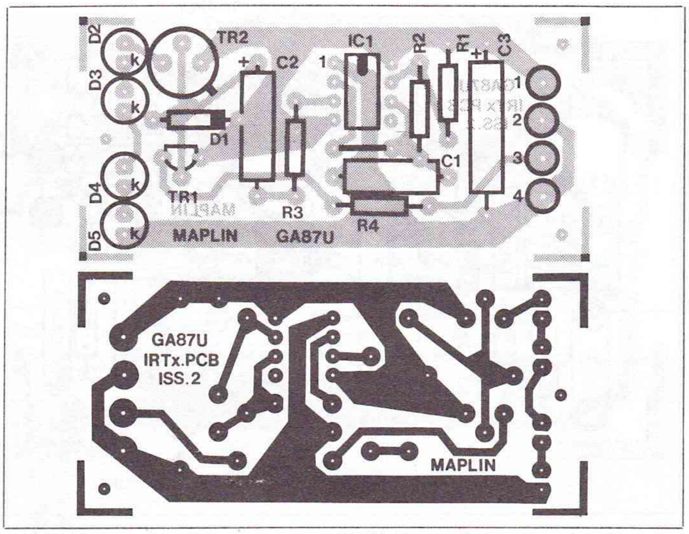
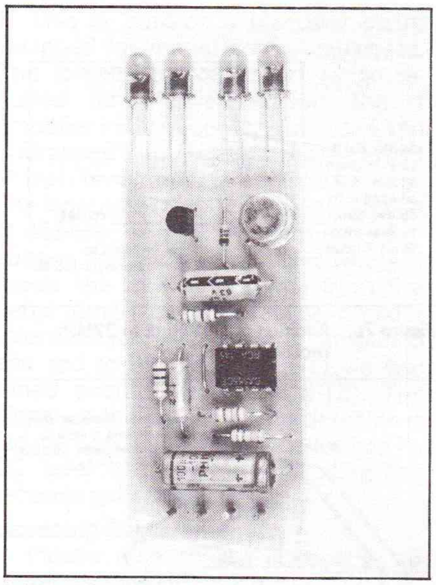


Figure 9b. Component layout of Infra-red transmitter board.



Infra-red Transmitter board.

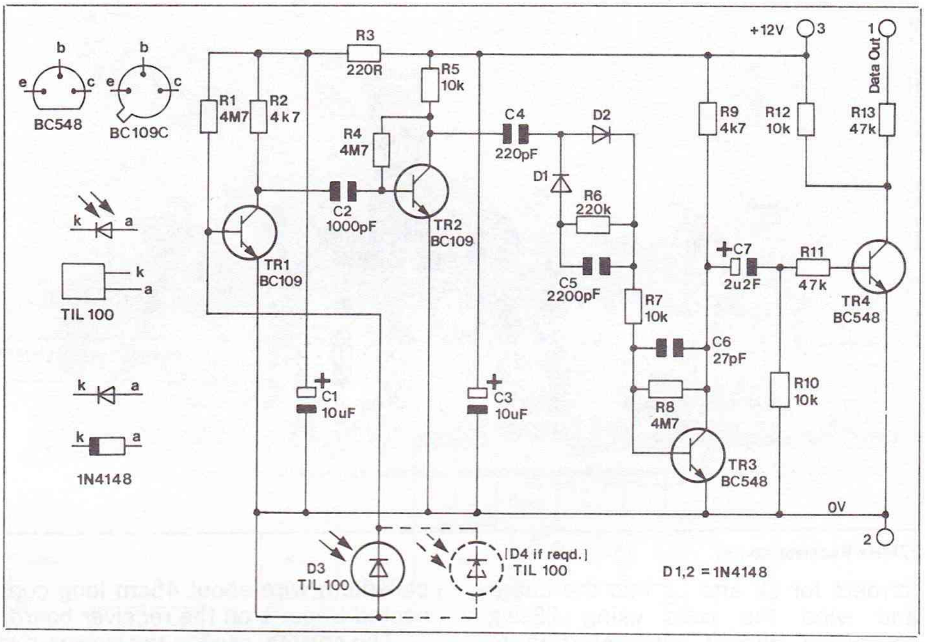


Figure 10a. Circuit diagram of Infra-red receiver.

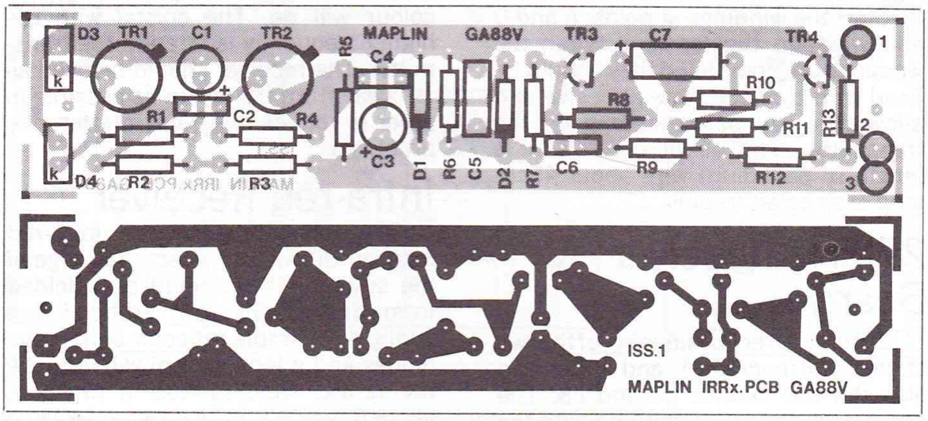
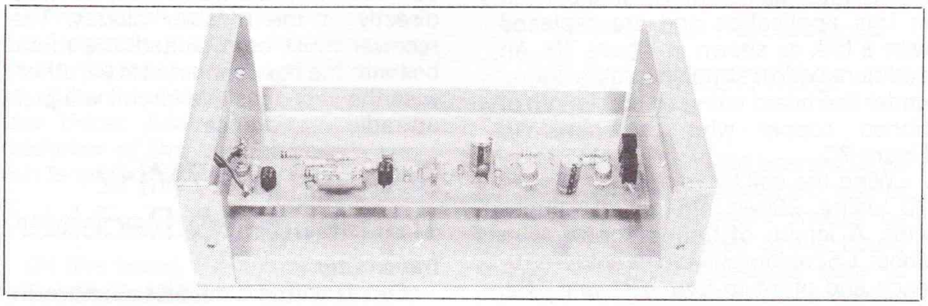


Figure 10b. Component layout of Infra-red receiver board.



Infra-red Receiver board.

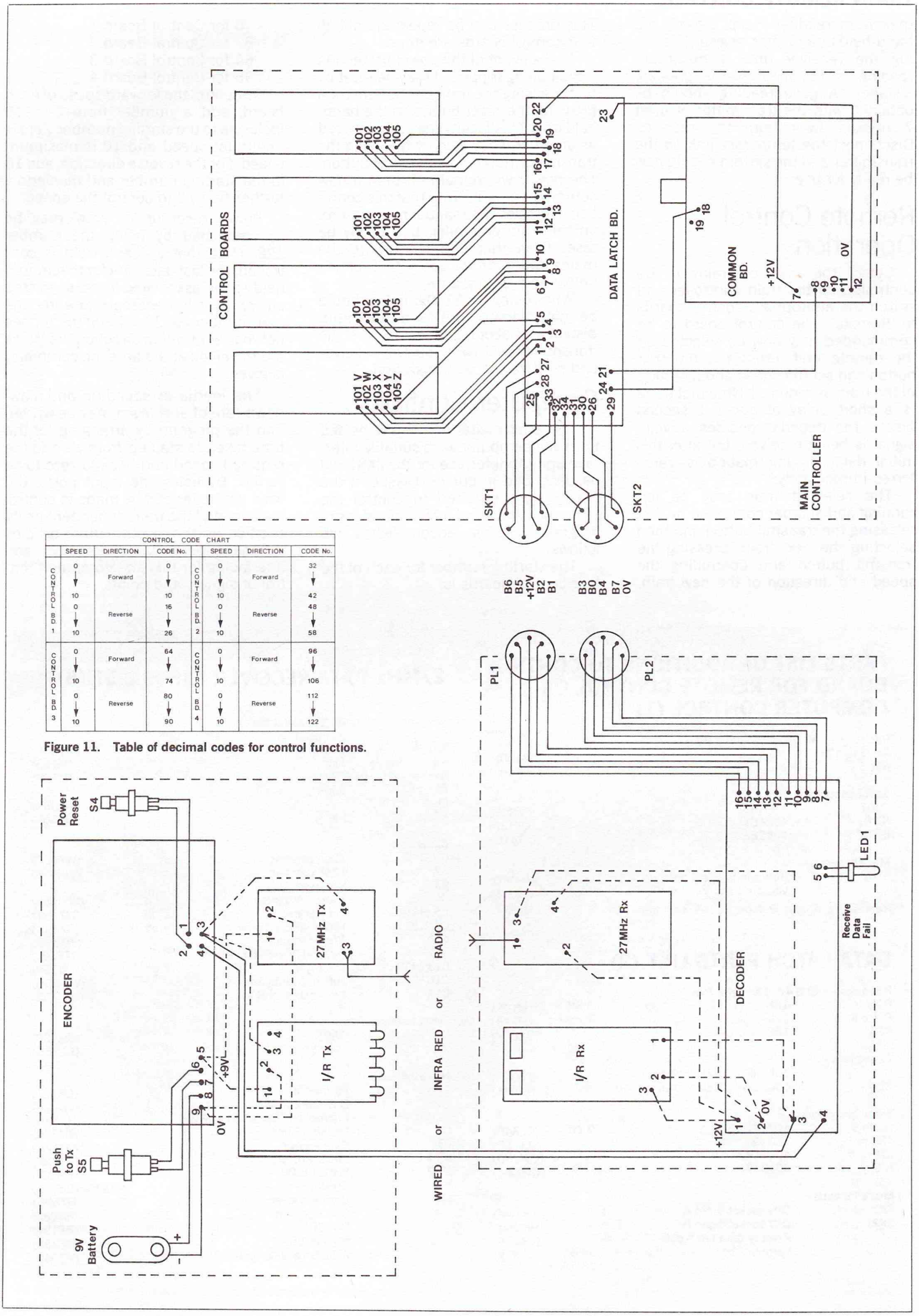
meter. Install the battery in the hand-held controller and hold the aerial near the wire attached to the monitor. When the transmit button is pressed, a reading should be obtained on the meter. Adjust L2 for maximum reading.

Move the aerial away from the monitor wire until a reading is just present and adjust L3 for maximum reading. Keep moving the aerial further away until a peak setting is found at the greatest distance away from the monitor wire. The controller should be held in a position as near as possible to that in which it will be used during the setting up of L3 to obtain maximum output under working conditions.

Receiver

Connect the receiver to the train controller and connect a suitable meter to TP1 and TP2 (Figure 8b) on the receiver board. Temporarily short out the transmit push button on the hand-held unit in order to provide a continuous transmitted signal. A reading should be obtained on the meter when the hand-held unit is brought near the receiver aerial.

Move the transmitter away until the reading on the meter falls and then adjust L1, T1 and T2 in turn for



CONTROL CODE CHART

	SPEED	DIRECTION	CODE No.		SPEED	DIRECTION	CODE No.
CONTROL BD. 1	0 ↓ 10	Forward	0 ↓ 10	CONTROL BD. 2	0 ↓ 10	Forward	32 ↓ 42
	0 ↓ 10	Reverse	16 ↓ 26		0 ↓ 10	Reverse	48 ↓ 58
CONTROL BD. 3	0 ↓ 10	Forward	64 ↓ 74	CONTROL BD. 4	0 ↓ 10	Forward	96 ↓ 106
	0 ↓ 10	Reverse	80 ↓ 90		0 ↓ 10	Reverse	112 ↓ 122

Figure 11. Table of decimal codes for control functions.

Figure 12. Interwiring diagram.

maximum reading. Keep moving the hand-held unit further away and retuning the receiver until a maximum reading is obtained at the greatest distance. A good reading should be obtained with the transmitter at least 7 metres away from the receiver. Disconnect the temporary link on the transmitter and the system should now be ready for use.

Remote Control Operation

Select the train or trains to be controlled on the train controller and switch the appropriate control boards to 'Remote'. The control board to be commanded may now be selected on the remote unit. Press the transmit button and set the speed and direction of the train as required. Note that there is a short delay of about 1 second before the decoder decides a valid signal is being received, but after this initial delay all information is transferred immediately.

The selected train may be left running and another controlled by first releasing the transmit button and then selecting the next train, pressing the transmit button and controlling the speed and direction of the new train. This process can be repeated until all four control boards are in use.

In the event of the power protection circuit being tripped, it may be reset by first pressing the transmit button, then pressing the reset button on the hand-held unit. This facility may also be used as an emergency stop by releasing the transmit button before the reset button. The power will remain off until a new command is sent. Note that this condition overrides the manual reset control on the train controller, but it may be reset from that end by turning the mains switch off for about 10 seconds before re-applying power.

When using the 27MHz link it should be noted that there is a minimum distance of about 2 metres where the transmitter will overload the receiver and no data will be transferred.

Computer Control

The 8-bit digital input may be fed from any computer via a suitable interface unit. An interface for the ZX81 will be described in our next issue. If the binary word required to control the system is converted into decimal form, programming is accomplished as follows.

The starting number for each of the four control boards is:

0 for Control Board 1
32 for Control Board 2
64 for Control Board 3
and 96 for Control Board 4

To control the forward speed of each board, add a number from 0 to 10 inclusive to the starting number. Zero is minimum speed and 10 is maximum speed. For the reverse direction, add 16 to the starting number and then add a further 0 to 10 to control the speed.

Power reset or 'all stop' may be accomplished by using the number 128. Note that as each train is controlled, the last data sent for that train is held in the associated latch, so to stop all trains, it is necessary to enter the four numbers 0, 32, 64 and 96. It does not matter in which direction the trains are travelling at the time the command is given.

The inertia or speed-up and slow-down rate of each train may be written into the program by arranging for the time taken to step up from zero to the required speed and back to zero to be varied. By using the input ports, the train controller can be made to control the speed of the train dependent on its position on the layout. Future articles will describe suitable detectors and interfacing for this and computer control of signals and points.

PARTS LIST OF ADDITIONS TO CONTROL BOARD FOR REMOTE CONTROL OR COMPUTER CONTROL (1)

Resistors — all 0.4W 1% metal film			
R101 to 104	100k	4 off	(M100K)
R105	4k7		(M4K7)
Semiconductors			
D101	1N4148		(QL80B)
IC101	4024BE		(QX13P)
IC102	4063BE		(QW41U)
Miscellaneous			
S101	Sub-min toggle 2-pole		(FH04C)
	Veropin 2141	5 off	(FL21X)

Note. Links 'A' and 'B' must be removed from pcb.

DATA LATCH PARTS LIST (2)

Resistors — all 0.4W 1% metal film			
R1,9 to 12	10k	5 off	(M10K)
R2 to 8	22k	7 off	(M22K)
R13	100k		(M100K)
Capacitors			
C1	1uF 100V pc electrolytic		(FF01B)
C2	10uF 35V pc electrolytic		(FF04E)
Semiconductors			
D1 to 9	1N4148	9 off	(QL80B)
TR1	BC548		(QB73Q)
IC1 to 4	40174BE		(QW73Q)
IC5	40106BE		(QW64U)
Miscellaneous			
SK1	DIN socket 5-pin A		(HH34M)
SK2	DIN socket 5-pin B		(HH35Q)
	Remote data latch pcb		(GA84F)
	Veropin 2141	34 off	(FL21X)

27MHz DATA RECEIVER PARTS LIST (8)

Resistors — all 0.4W 1% metal film			
R1	Not used		
R2	150R		(M150R)
R3	1k5		(M1K5)
R4	10k		(M10K)
R5	330R		(M330R)
R6	33k		(M33K)
R7	56k		(M56K)
Capacitors			
C1	22pF ceramic		(WX48C)
C2	12pF ceramic		(WX45Y)
C3	Not used		
C4,9	10uF 16V tantalum	2 off	(WW68Y)
C5,6	1nF ceramic	2 off	(WX68Y)
C7,8,12,15	100nF disc ceramic	4 off	(BX03D)
C10	47pF ceramic		(WX52G)
C11	100uF 10V pc electrolytic		(FF10L)
C13,14	1nF mylar	2 off	(WW15R)
C16	1uF 35V tantalum		(WW60Q)
C17	47uF 10V tantalum		(WW75S)
Semiconductors			
D1	OA91		(QH72P)
IC1	TBA651		(BL35Q)
Miscellaneous			
L1	Former 351		(LB17T)
	Dust core type 6		(LB42V)
	Enamelled copper wire 28swg		(BL39N)
L2	Choke 33uH		(WH38R)
L3	Choke 1mH		(WH47B)
IFT1	YRCS 11098		(HX42V)
IFT2	YHCS11100		(HX43W)
X1	Crystal		(see transmitter)
SKT1	Crystal socket		(HX60Q)
	Bolt 8BA ¼in.	2 off	(BF08J)
	Nut 8BA	2 off	(BF19V)
	Washer 8BA	2 off	(BF23A)
	27MHz receiver pcb		(YQ04E)

DATA DECODER PARTS LIST (3)

Resistors — all 0.4W 1% metal film			
R1,7,8,10,13,18,19	100k	7 off	(M100K)
R2,11,12,17	10k	4 off	(M10K)
R3,15	1M	2 off	(M1M)
R4,5	47k	2 off	(M47K)
R6	820k		(M820K)
R9	330k		(M330K)
R14	220k		(M220K)
R16	820R		(M820R)
Capacitors			
C1,2,4,5	1.5nF polycarbonate	4 off	(WW23A)
C3,9	1nF polycarbonate	2 off	(WW22Y)
C6,8,11	100nF polycarbonate	3 off	(WW41U)
C7	1uF 35V tantalum		(WW60Q)
C10	10uF 35V pc electrolytic		(FF04E)
Semiconductors			
D1 to 21	1N4148	21 off	(QL80B)
LED1	Red LED		(WL27E)
TR1	BC548		(QB73Q)
IC1	40106BE		(QW64U)
IC2	4013BE		(QX07H)
IC3	4024BE		(QX13P)
IC4,5	4099BE	2 off	(QW57M)
IC6,7	4077BE	2 off	(QW47B)
IC8,9	4042BE	2 off	(QX19V)
Miscellaneous			
PL1	DIN plug 5-pin A		(HH27E)
PL2	DIN plug 5-pin B		(HH28F)
	Data decoder pcb		(GA86T)
	Veropin 2141	20 off	(FL21X)

DATA ENCODER PARTS LIST (4)

Resistors — all 0.4W 1% metal film unless specified			
R1,6,7,8,9,11,15	100k	7 off	(M100K)
R2	680k		(M680K)
R3	220k		(M220K)
R4,5★	10k	2 off	(M10K)
R10,12	100k (⅛W)	2 off	(U100K)
R13	220k (⅛W)		(U220K)
R14	470k		(M470K)
Capacitors			
C1	1.5nF polycarbonate		(WW23A)
C2	4.7nF polycarbonate		(WW26D)
C3	10uF 25V axial electrolytic		(FB22Y)
C4,5	1nF ceramic	2 off	(WX68Y)
Semiconductors			
D1 to 17	1N4148	17 off	(QL80B)
TR1	BC548		(QB73Q)
IC1	NE555		(QH66W)
IC2	4017BE		(QX09K)
IC3,4,8	4081BE	3 off	(QW48C)
IC5	4072BE		(QX27E)
IC6	4042BE		(QX19V)
IC7	4024BE		(QX13P)
Miscellaneous			
S1	Rotary switch 3 pole 4 way		(FH44X)
S2	Switchpot 1 pole 12 way		(XX45Y)
S3	Sub-min toggle 'A'		(FH00A)
S4	Push switch		(FH59P)
S5	Press switch		(FH91Y)
	Knob K7B (for S1)		(YX02C)
	Knob K7C (for S2)		(YX03D)
	Battery clip		(HF28F)
	PP3 battery		—
	Data encoder pcb		(GA85G)
	Veropin 2141	10 off	(FL21X)

★If this is to be used with the 27MHz data link then make R5 a Min Res 1k even if you are using IR or wired links as well.

To make the function shown below, you will require all the parts shown in the parts list indicated.

Computer interface	: 1, 2.
Wired remote control	: 1, 2, 3, 4.
Infra-red remote control	: 1, 2, 3, 4, 5, 6.
Radio remote control	: 1, 2, 3, 4, 7, 8.

Note that parts list 1 will be required for each control board that you wish to modify.

As there are so many possible different combinations of these parts, it is not possible to offer kits.

INFRA-RED TRANSMITTER PARTS LIST (5)

Resistors — all 0.4W 1% metal film			
R1	22k		(M22K)
R2	2k7		(M2K7)
R3	270R		(M270R)
R4	10k		(M10K)
Capacitors			
C1	1200pF 1% polystyrene		(BX57M)
C2	1uF 63V axial electrolytic		(FB12N)
C3	100uF 10V axial electrolytic		(FB48C)
Semiconductors			
D1	1N4148		(QL80B)
D2 to 5	TIL38	4 off	(YH70M)
TR1	BC212L		(QB60Q)
TR2	BC461		(QB72P)
IC1	NE555		(QH66W)
Miscellaneous			
	Infra-red transmitter pcb		(GA87U)
	Veropin 2141	4 off	(FL21X)

INFRA-RED RECEIVER PARTS LIST (6)

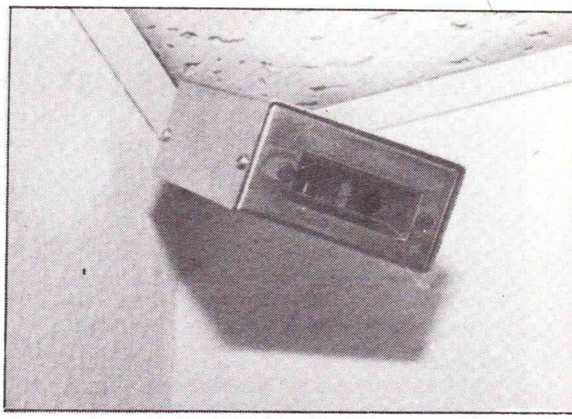
Resistors — all 0.4W 1% metal film			
R1,4,8	4M7	3 off	(M4M7)
R2,9	4k7	2 off	(M4K7)
R3	220R		(M220R)
R5,7,10,12	10k	4 off	(M10K)
R6	220k		(M220K)
R11,13	47k	2 off	(M47K)
Capacitors			
C1,3	10uF 35V pc electrolytic	2 off	(FF04E)
C2	1000pF ceramic		(WX68Y)
C4	220pF ceramic		(WX60Q)
C5	2200pF polycarbonate		(WW24B)
C6	27pF ceramic		(WX49D)
C7	2.2uF 63V axial electrolytic		(FB15R)
C8	100nF 35V tantalum		(WW54J)
Semiconductors			
D1,2	1N4148	2 off	(QL80B)
D3 (D4 if req'd)	TIL100		(YH71N)
TR1,2	BC109C	2 off	(QB33L)
TR3,4	BC548	2 off	(QB73Q)
Miscellaneous			
	Infra-red receiver pcb		(GA88V)
	Veropin 2141	3 off	(FL21X)

27MHz DATA TRANSMITTER PARTS LIST (7)

Resistors — all 0.4W 1% metal film			
R1	22k		(M22K)
R2	10k		(M10K)
R3	150R		(M150R)
R4	2k2		(M2K2)
R5	22R		(M22R)
Capacitors			
C1,4,6	47nF disc ceramic	3 off	(BX02C)
C2	10pF ceramic		(WX44X)
C3	27pF ceramic		(WX49D)
C5	33pF ceramic		(WX50E)
C7	18pF ceramic		(WX47B)
Semiconductors			
TR1	BC109C		(QB33L)
TR2	BSX20		(QF32K)
TR3	BC212L		(QB60Q)
Miscellaneous			
L1	Choke 15uH		(WH36P)
L2,3	Former 722/2	2 off	(LB20W)
	Dust Core	2 off	(LB41U)
	Enamelled copper wire 28swg	½m	(BL39N)
X1	Crystal (supplied in pairs) (any one of HX30H to HX35Q)		
	Crystal socket		(HX60Q)
	27MHz transmitter pcb		(GA89W)
	Veropin 2141	3 off	(FL21X)

RADAR DOPPLER INTRUDER DETECTOR

THE MAPLIN RTX3



- ★ 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 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. 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.

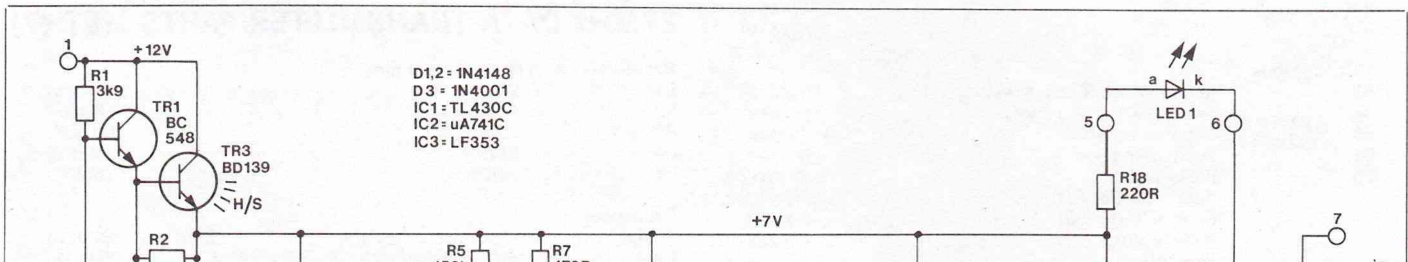
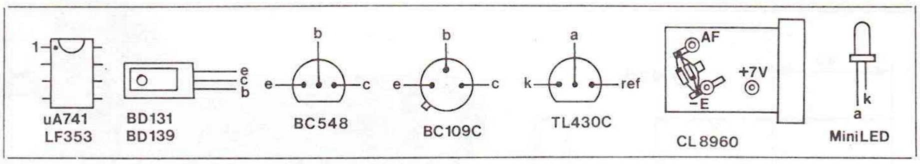


Figure 1. Circuit diagram of Doppler unit.

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.



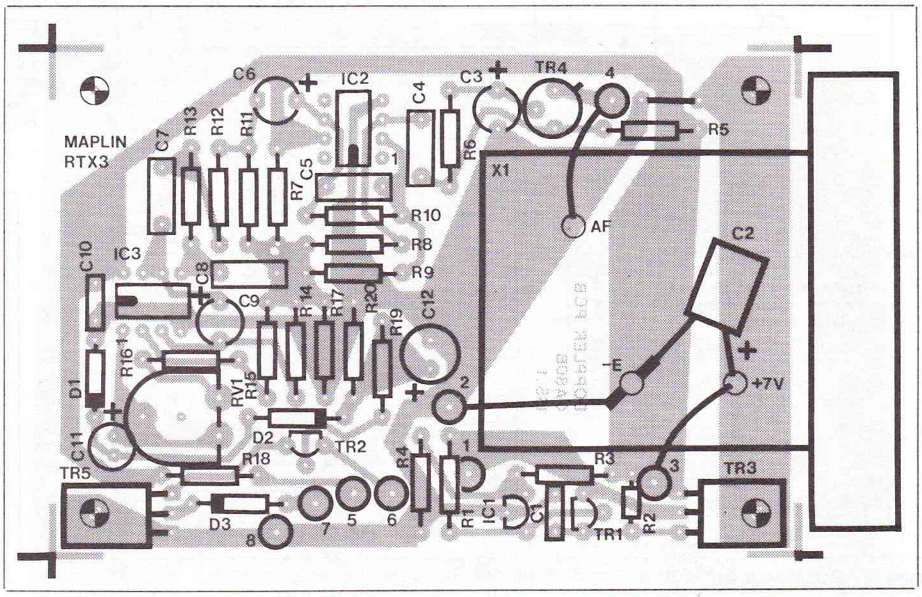


Figure 2. Component overlay of Doppler unit.

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.

DOPPLER MODULE PARTS LIST

Resistors — all 0.4W 1% metal film unless specified

R1	3k9	
R2	1k (⅛W)	
R3	82k	
R4	51k	
R5	150k	
R6	4M7	
R7,17	470R	2 off
R8,11,19	10k	3 off
R9	2k2	
R10	470k	
R12,13	220k	2 off
R14	100k	
R15,16	1k	2 off
R18	220R	
R20	47k	
RV1	470k horiz sub-min preset	

Capacitors

C1,10	100nF minidisc	2 off
C2,12	100uF 10V pc electrolytic	2 off
C3,6,9	1uF 35V tantalum	3 off
C4,7,8	100nF polycarbonate	3 off
C5	4n7 polycarbonate	
C11	10uF 35V pc electrolytic	

Semiconductors

D1,2	1N4148	2 off
D3	1N4001	
LED1	Mini LED red	
	Mini LED clip	
TR1,2	BC548	2 off
TR3	BD139	
TR4	BC109C	
TR5	BD131	
IC1	TL430C	
IC2	uA 741C (8-pin)	
IC3	LF353	
X1	Radar module	

Miscellaneous

Doppler PCB	
Veropin 2141	8 off
Box AB7	
Grommet small	
Label Maplin RTX3	
Countersunk bolt 6BA ½in	4 off
Countersunk bolt 6BA 1in	2 off
Washer 6BA	10 off
Nut 6BA	10 off
Hook-up wire	½m

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

DOPPLER RTX3

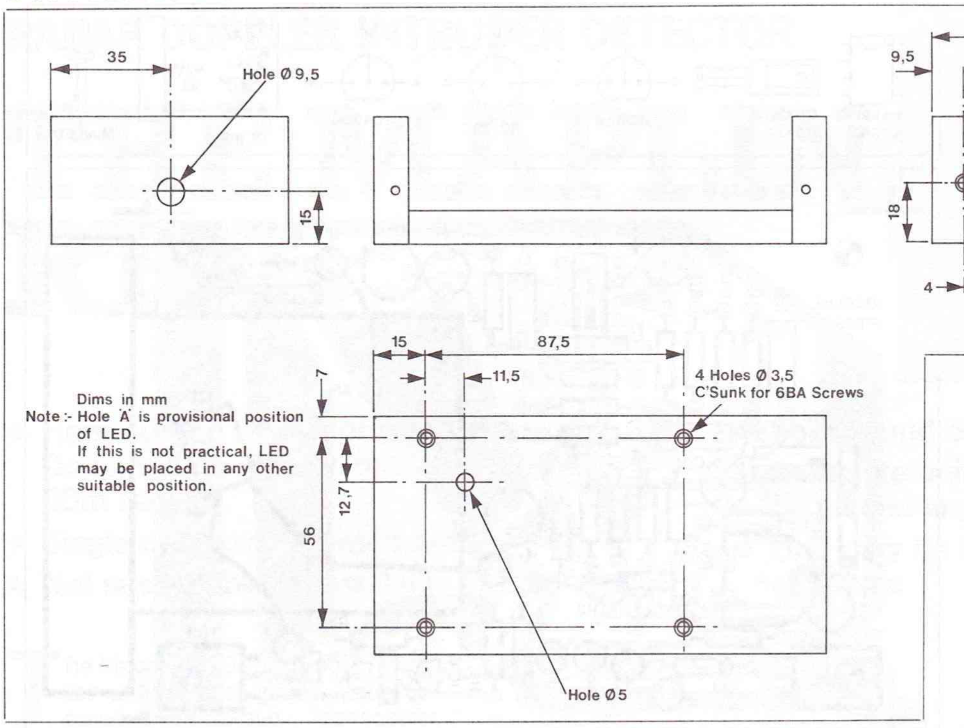
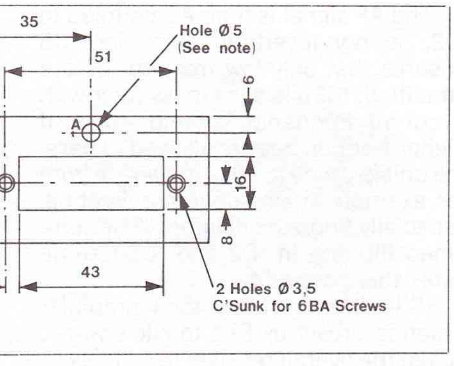



Figure 3. Box cut-out and drilling.

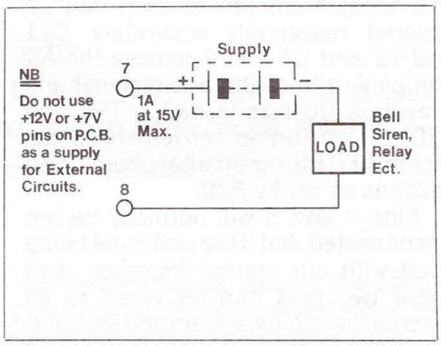


Figure 5. Wiring of external alarm if not used with control unit.

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.

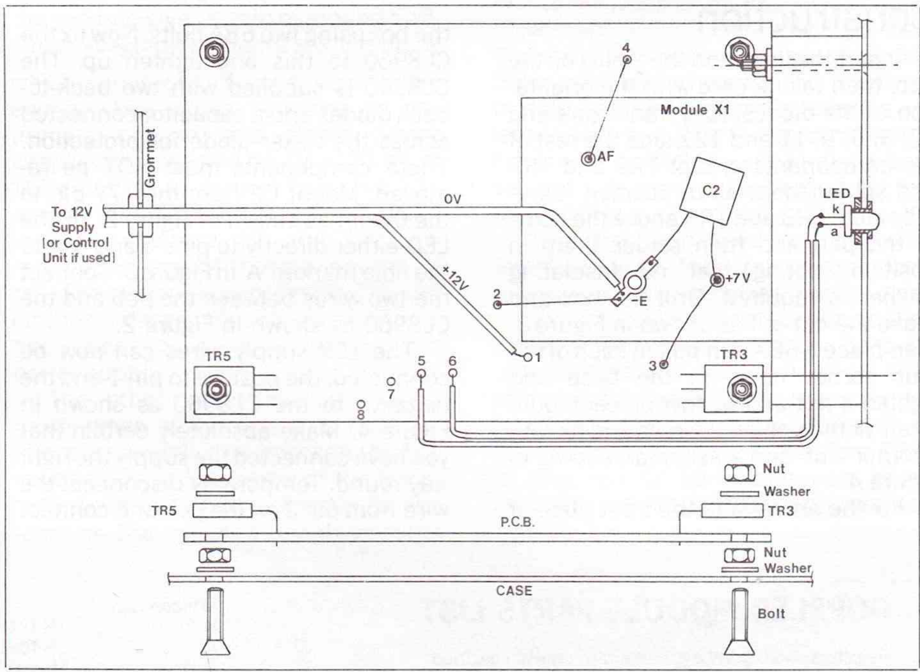
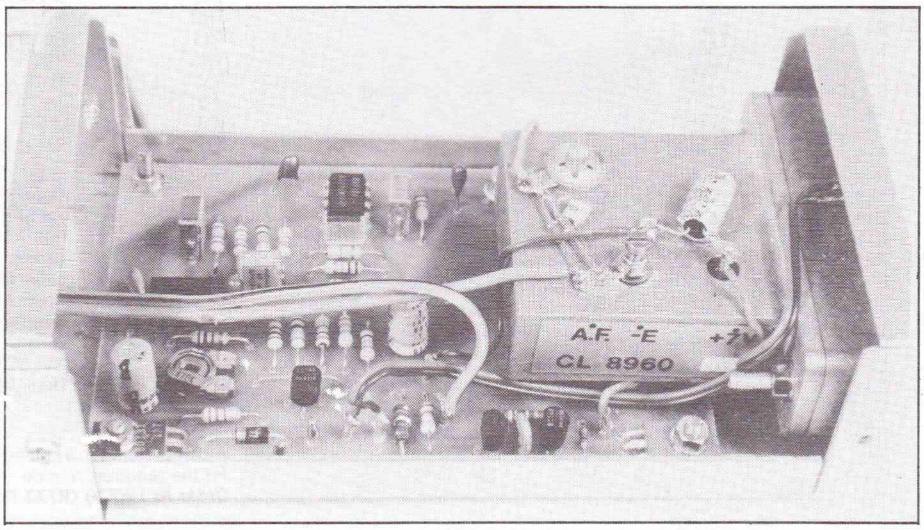


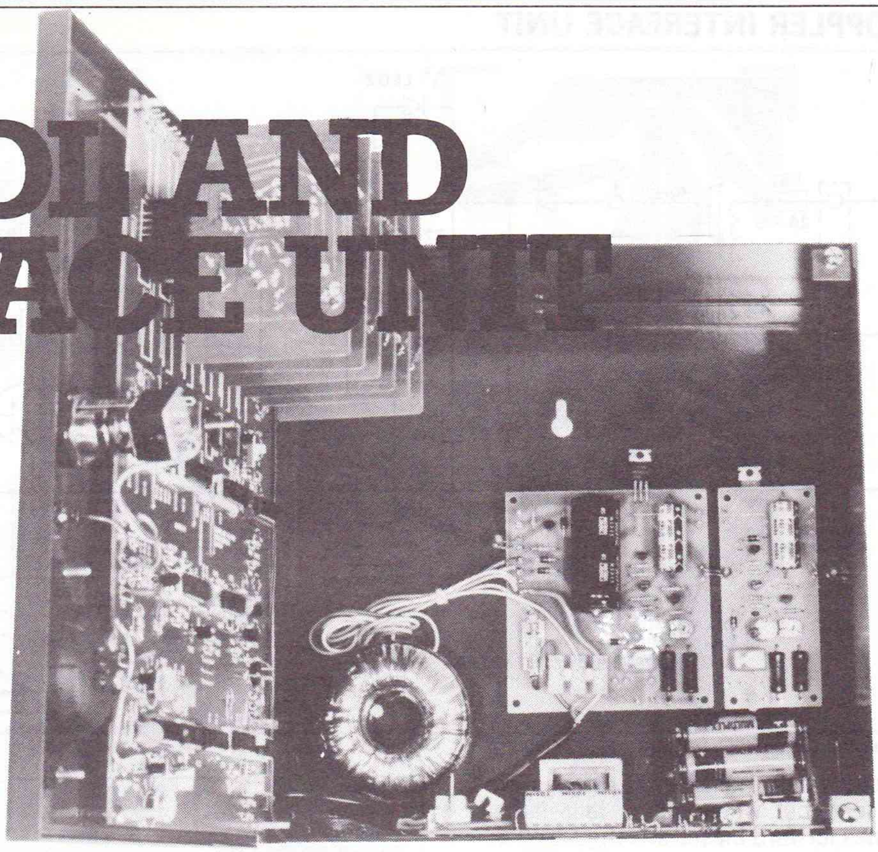
Figure 4. Assembly.



DOPPLER MODULE

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

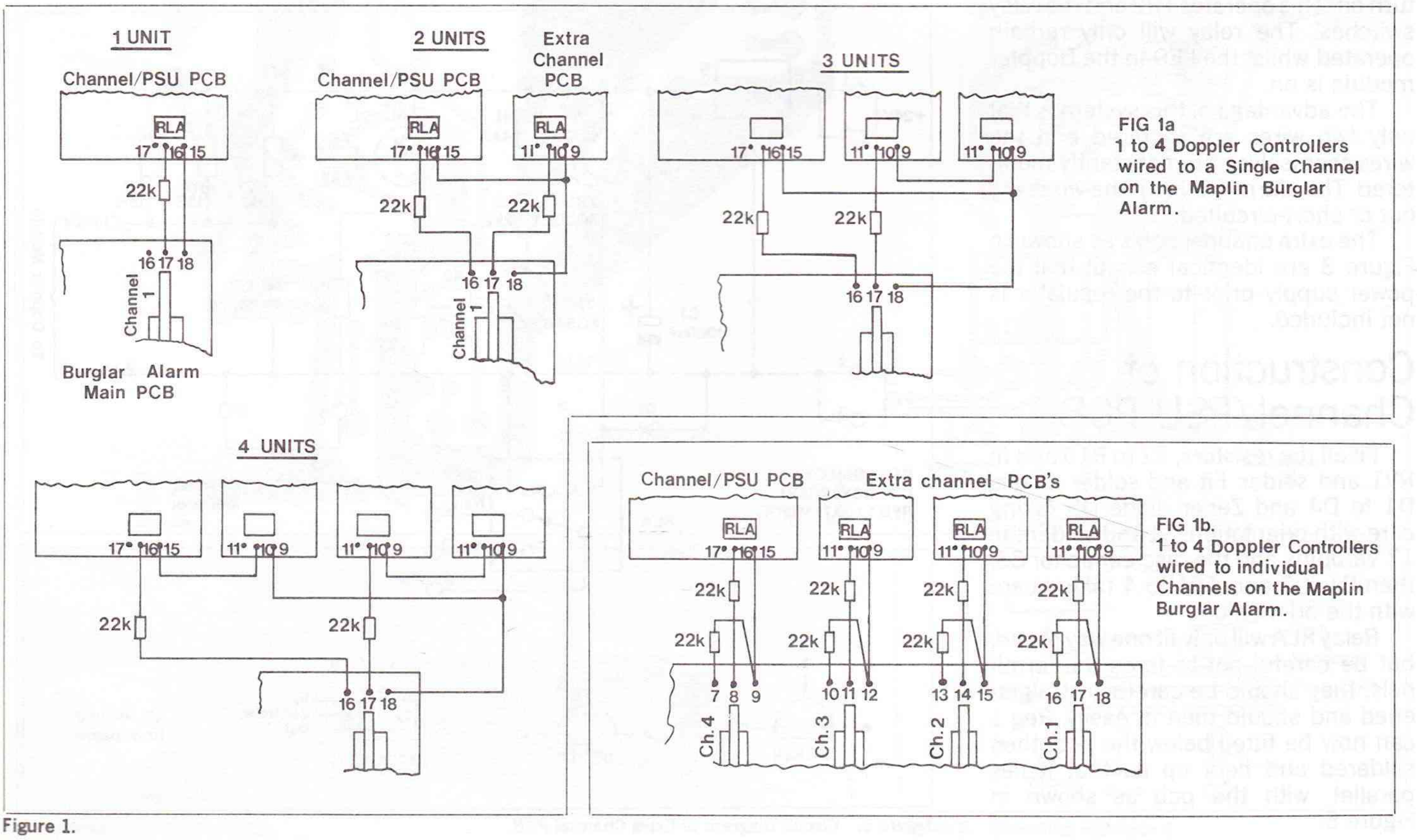


FIG 1a
1 to 4 Doppler Controllers wired to a Single Channel on the Maplin Burglar Alarm.

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

Figure 1.

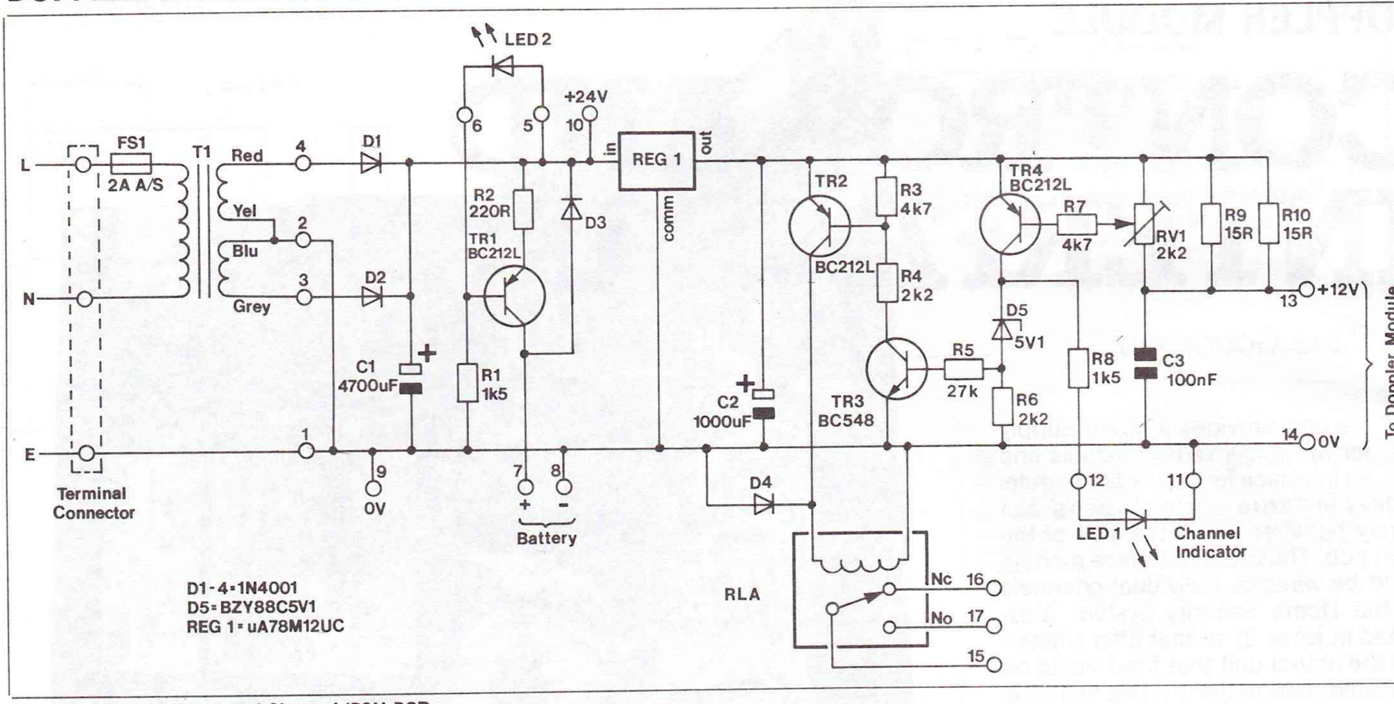


Figure 2. Circuit diagram of Channel/PSU PCB.

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.

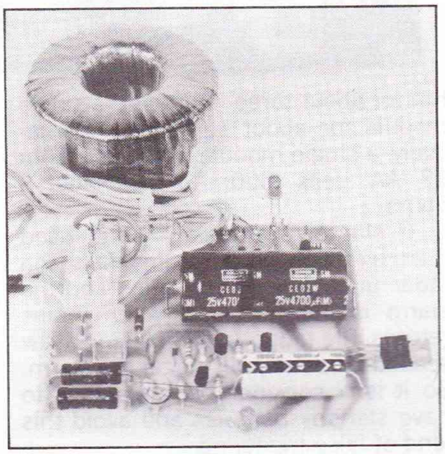
The advantage of this system is that only two wires are required and the wires themselves are constantly monitored. The alarm will fire if the wires are cut or short-circuited.

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

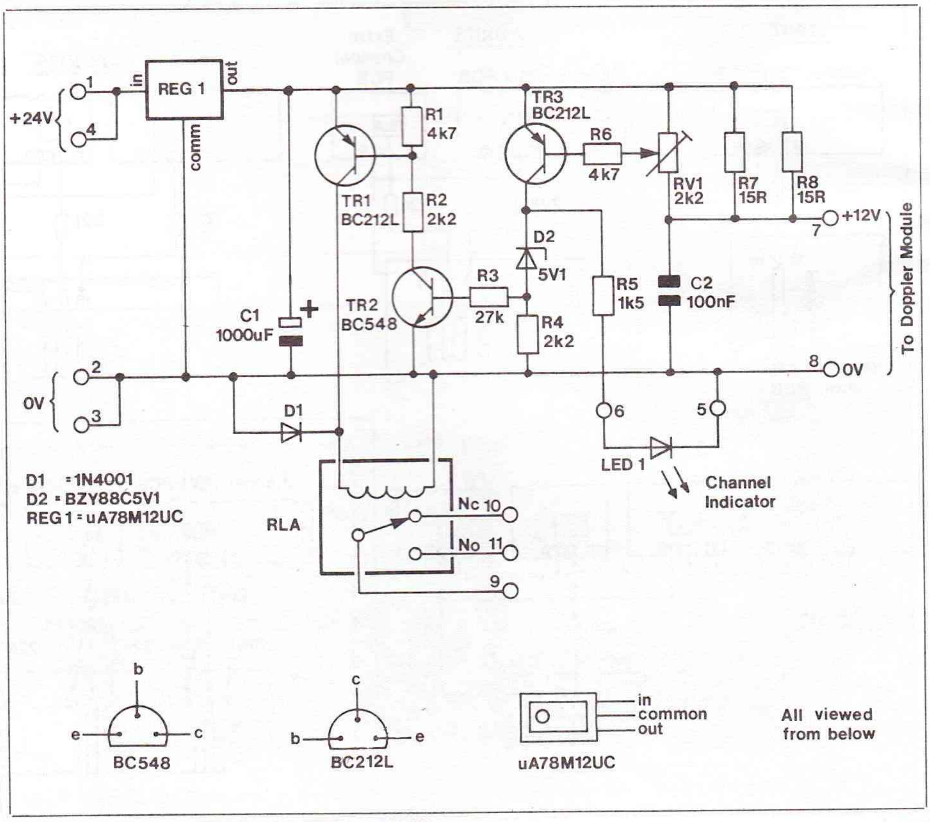


Figure 3. Circuit diagram of Extra Channel PCB.

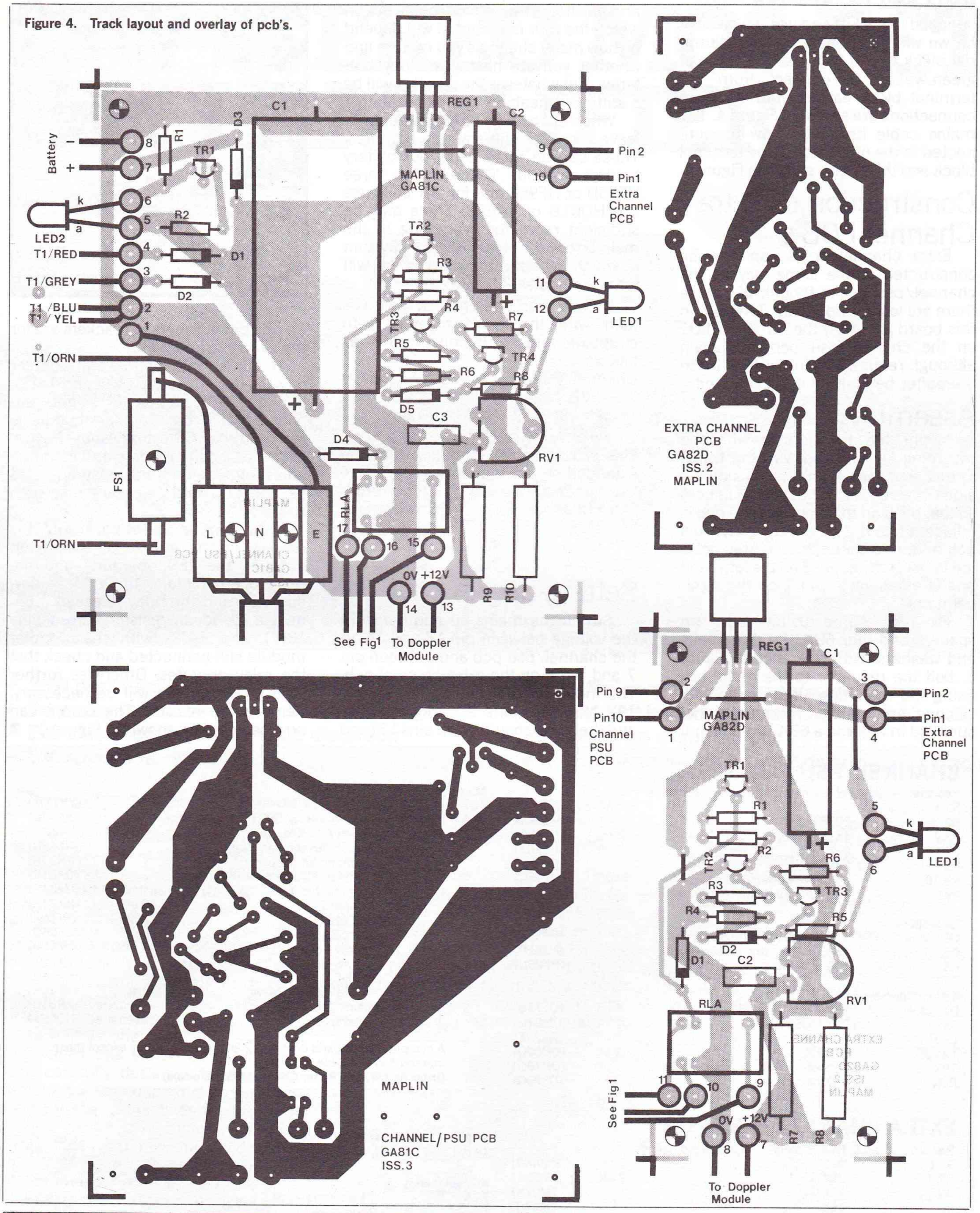
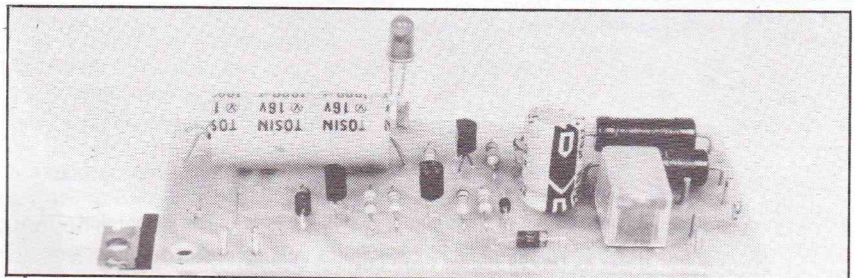


Figure 4. Track layout and overlay of pcb's.



Completed extra channel pcb.

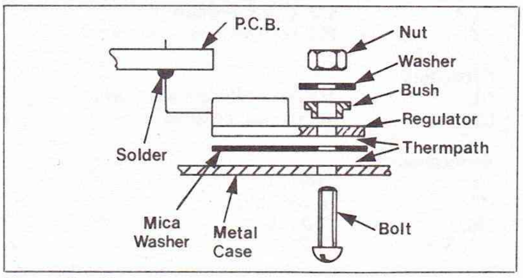


Figure 5. Mounting regulator 1.

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:

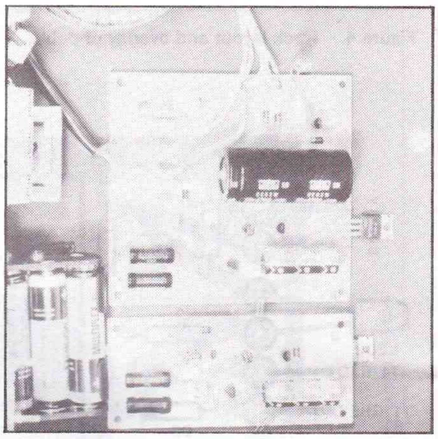
Channel/PSU PCB		Extra Channel PCB
pin 9	to	pin 2
pin 10	to	pin 1

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 0.4W 1% metal film unless specified			
R1,8	1k5	2 off	(M1K5)
R2	220R		(M220R)
R3,7	4k7	2 off	(M4K7)
R4,6	2k2	2 off	(M2K2)
R5	27k		(M27K)
R9,10	15R (7W wirewound)	2 off	(L15R)
RV1	2k2 horizontal sub-min preset		(WR56L)
Capacitors			
C1	4700uF 25V axial electrolytic		(FB96E)
C2	1000uF 16V axial electrolytic		(FB82D)
C3	100nF disc ceramic		(BX03D)
Semiconductors			
D1,2,3,4	1N4001	4 off	(QL73Q)
D5	BZY88C5V1		(QH07H)
LED1,2	LED red	2 off	(WL27E)
TR1,2,4	BC212L	3 off	(QB60Q)
TR3	BC548		(QB73Q)
REG 1	uA78M12UC		(QL29G)
Miscellaneous			
T1	Toroidal 15V 30VA		(YK11M)
RLA	Ultra min relay SPDT		(YX94C)
FS1	20mm A/S fuse 2A		(WR20W)
	Chassis fuseholder 20mm		(RX49D)
	Mounting kit (P) plas		(WR23A)
	Channel/PSU pcb		(GA81C)
	Terminal block (3-way)	part of	(HF01B)
	Veropin 2141	17 off	(FL21X)
	Bolt 6BA ¼in	2 off	(BF05F)
	Bolt 6BA ½in	6 off	(BF06G)
	Spacer 6BA ¼in	4 off	(FW34M)
	Washer 6BA	5 off	(BF22Y)
	Nut 6BA	8 off	(BF18U)
	Strapping wire 24swg	1m	(BL15R)
	*Mains cable	as required	(XR01B)
	*Thermpath	as required	(HQ00A)

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

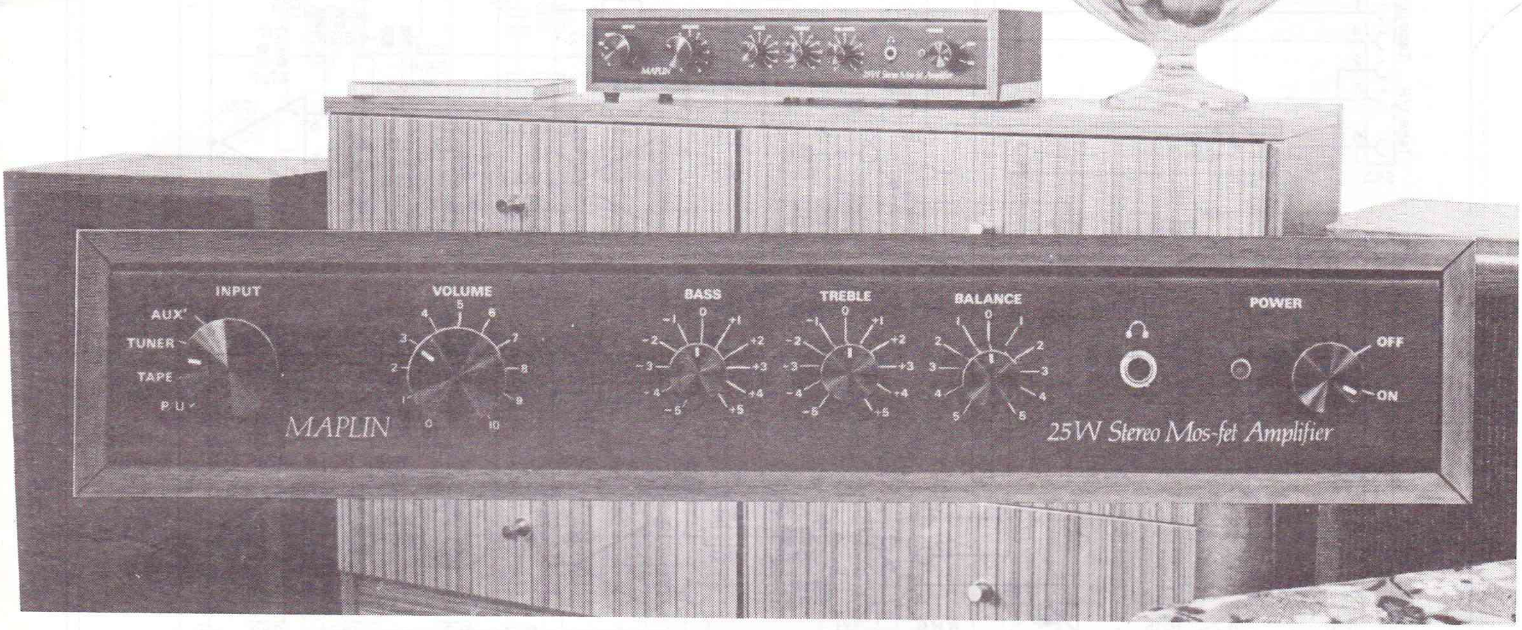
EXTRA CHANNEL PARTS LIST

Resistors — all 0.4W 1% metal film unless specified			
R1,6	4k7	2 off	(M4K7)
R2,4	2k2	2 off	(M2K2)
R3	27k		(M27K)
R5	1k5		(M1K5)
R7,8	15R (7W wirewound)	2 off	(L15R)
RV1	2k2 horizontal sub-min preset		(WR56L)
Capacitors			
C1	1000uF 16V axial electrolytic		(FB82D)
C2	100nF disc ceramic		(BX03D)
Semiconductors			
D1	1N4001		(QL73Q)
D2	BZY88C5V1		(QH07H)
LED1	LED red		(WL27E)
TR1,3	BC212L	2 off	(QB60Q)
TR2	BC548		(QB73Q)
REG 1	uA78M12UC		(QL29G)
Miscellaneous			
RLA	Ultra min relay SPDT		(YX94C)
	Mounting kit (P) plas		(WR23A)
	Extra channel pcb		(GA82D)
	Veropin 2141	9 off	(FL21X)
	Bolt 6BA ¼in		(BF05F)
	Bolt 6BA ½in	4 off	(BF06G)
	Spacer 6BA ¼in	4 off	(FW34M)
	Washer 6BA	5 off	(BF22Y)
	Nut 6BA	5 off	(BF18U)
	*Thermpath	as required	(HQ00A)

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

25W STEREO MOS-FET HI-FI AMPLIFIER

by Dave Goodman



- ★ **25W per channel rms with power MOSFET output**
- ★ **Very easy to build — only 7 interconnecting wires**
- ★ **Extremely low total harmonic distortion**
- ★ **Extremely low noise**
- ★ **High efficiency toroidal transformer**
- ★ **Complete kit includes wooden cabinet & chassis**
- ★ **No setting-up required**
- ★ **All components except 5 mount directly on main pcb**

One of the most popular projects we have ever produced is the MOSFET amplifier described in the June 1981 issue of "Electronics and Music Maker". Its popularity is doubtless due to the virtues of the MOSFET transistors — as the article says: they are "virtually bomb-proof — like the best valve amps." For reliability, freedom from thermal runaway and extremely low harmonic distortion there's nothing to touch the MOSFET transistor for audio power output stages.

As well as offering these essential advantages this stereo amplifier has been carefully designed for absolute ease of construction; this in its turn adding to the reliability and repeatable quality for all constructors. All the components, bar five, mount directly on to the main pcb and only seven interconnecting wires are required and they are for the headphone socket and LED.

The inputs and outputs are on pcb mounting DIN sockets and provision has been made on the pcb for connecting a graphic equaliser, though you will need to drill the rear panel to make connection. Otherwise the kit contains everything you need including a punched chassis finished in matt black with legends printed on the front and rear panels. A wooden cabinet is also supplied which has to be glued together with a woodworker's PVA adhesive (e.g. Resin W) and this glue is not supplied in the kit.

No setting-up is required. If the building instructions are carefully followed then the amplifier will work correctly as soon as it is switched on. However, a preset is provided for each input (except auxiliary) which can be adjusted if desired, so that when switching between inputs, the volume control does not have to be altered to keep the output volume constant. In addition, a remote control unit for volume, bass, treble and balance will be published shortly — hopefully in the next issue.

Circuit Description

T1 is a toroidal transformer and was chosen as it has several advantages over conventional types. It is much more efficient as it runs cooler and has lower radiated magnetic fields keeping stray hum to a minimum. Its small size

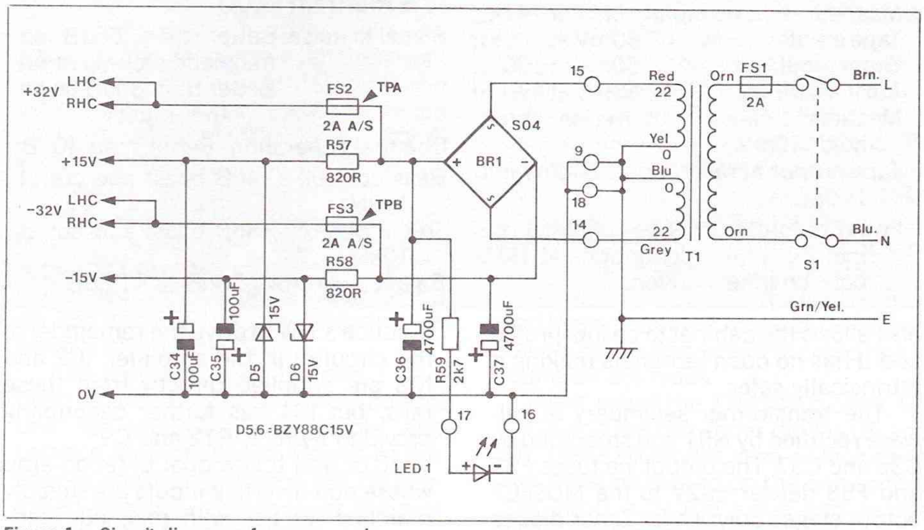


Figure 1. Circuit diagram of power supply.

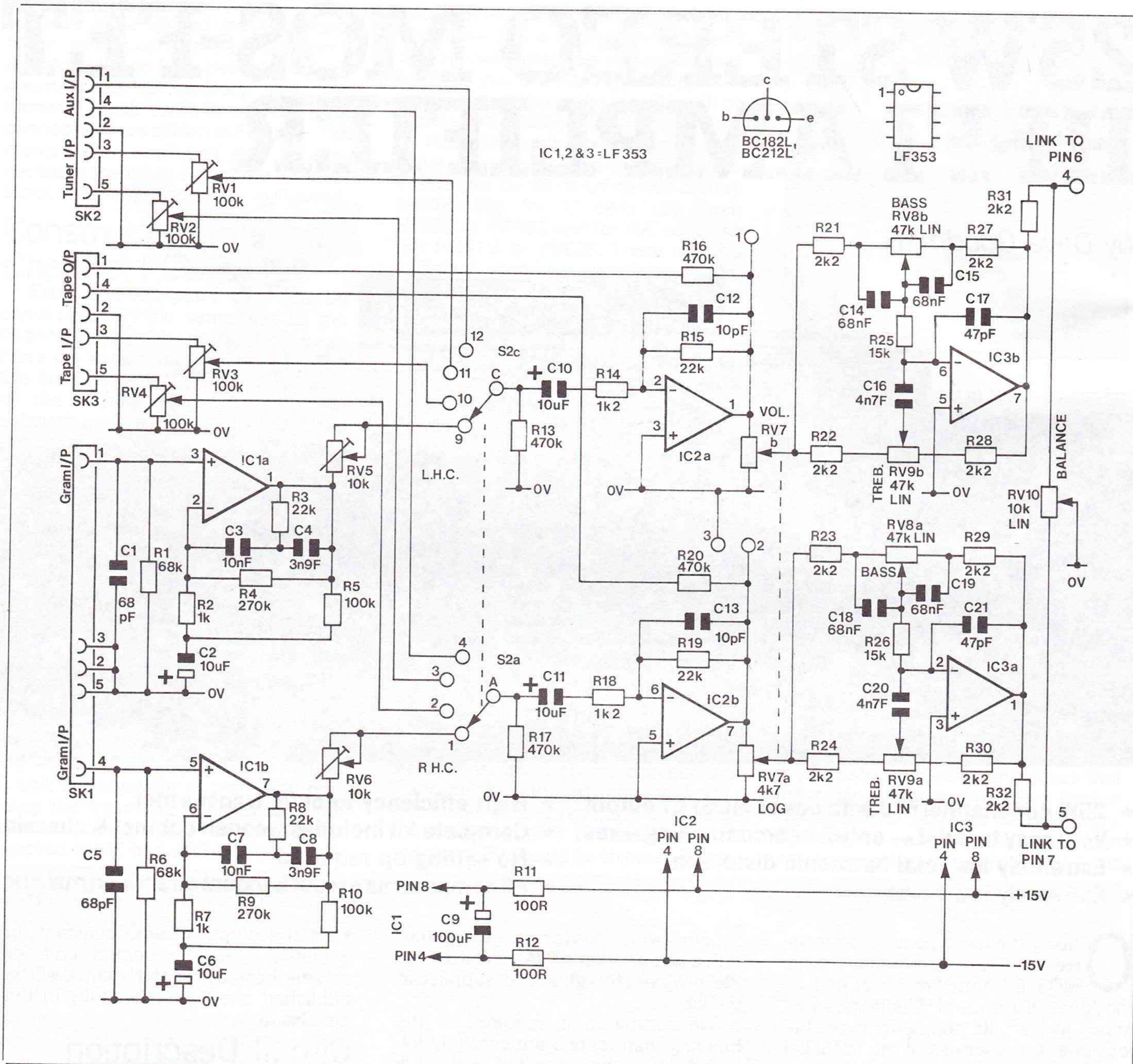


Figure 2. Circuit diagram of pre-amp and tone controls.

Specification of prototype

Input sensitivities for max. output (with preset adjusted for max. sensitivity).

Magnetic pick-up input: 2mV at 47kΩ
Tape input: 50mV at 100kΩ
Tuner input: 50mV at 100kΩ
Auxiliary input: 50mV at 470kΩ
Magnetic pick-up input overload threshold: 40mV
Tape output at rated input: 100mV into 100kΩ
Power output: >26W per channel rms into 8Ω or 4Ω continuous at 1kHz both channels driven.
Total harmonic distortion: Better than 0.075% at 1kHz at >25W output.
Frequency response: 20Hz to 40kHz ±1dB (from magnetic pick-up input ±1dB from RIAA)
Signal to noise: Better than 60dB on magnetic pick-up input. Better than 80dB on all other inputs
Channel separation: Better than 40dB
Bass control: ±14dB boost and cut at 100Hz
Treble control: ±8dB boost and cut at 10kHz
Balance control: -50dB to +1.5dB

also allows the cabinet to be low-profile and it has no open terminals making it intrinsically safer.

The transformer secondary is full-wave rectified by BR1 and smoothed by C36 and C37. The output via fuses FS2 and FS3 deliver ±32V to the MOSFET output stages only, whilst Zener diodes D5 and D6 and resistors R57 and R58 produce ±15V to drive the remainder of the circuitry in the amplifier. IC2 and IC3 are supplied directly from these rails, but IC1 has further decoupling provided by R11, R12 and C9.

IC1a and b is a dual bi-fet op-amp whose non-inverting inputs are suitably matched for use with magnetic cartridges. A degree of protection from stray rf is also provided. The feedback circuitry about each input produces a response to within ±1dB of the recommended RIAA curve. This is achieved by using frequency selective feedback to boost the lower and cut the upper frequencies. Presets RV5 and RV6 control the gain of the pick-up input and allow fine adjustment of channel balance or reduction of volume of high output magnetic cartridges.

RV1 and RV2 perform the same function for the tuner input and RV3 and RV4 for the tape input. If not required simply turn them to the end that gives maximum volume. The auxiliary input level is not presettable, but is selected along with the other inputs by S2. IC2 is a mixer stage supplying the tape output and has an almost perfectly flat response over the audio spectrum.

The volume control, RV7, supplies the selected input signal to IC3 which looks after the tone compensation. RV8 gives boost or cut of the bass frequencies while RV9 controls the gain of

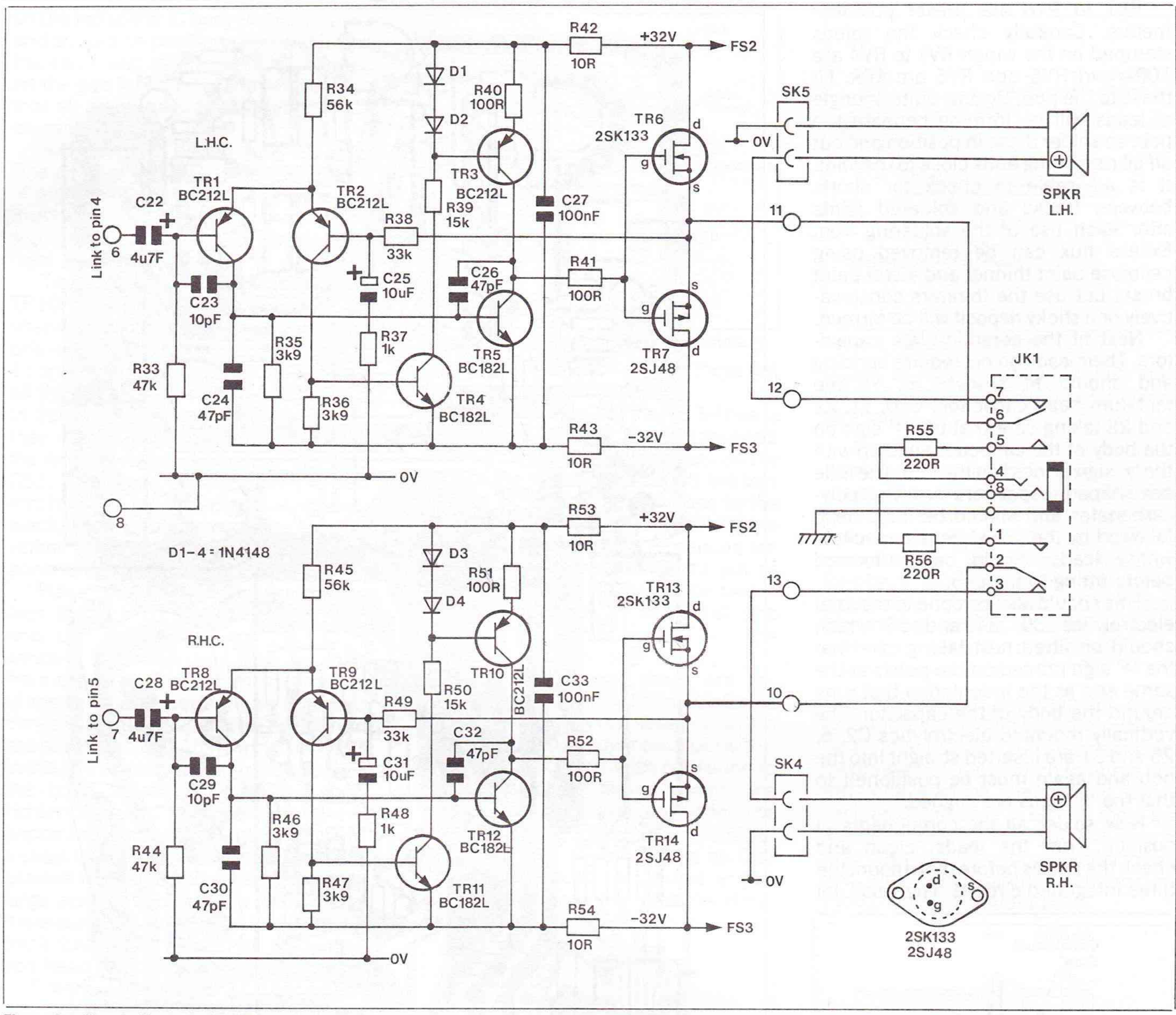


Figure 3. Circuit diagram of MOSFET power amp.

the treble frequencies. In their centre positions, this stage too has an almost perfectly flat response over the audio range. The balance control, RV10, simply shunts the audio signal to ground of the channel it is turned from.

Pins 4 and 5 are strapped to pins 6 and 7, but these straps can be removed if you wish to insert a graphic equaliser.

TR1 and 2 form a differential amplifier whose output is fed to TR5, a voltage amplifier/driver stage. TR3 is a constant current and impedance source which is controlled by TR4. The output of TR5 drives the power MOSFET's TR6 and TR7.

Power MOSFET's have a very low 'on' resistance and an extremely high 'off' resistance and display the characteristic channelling effect when driving into near short-circuits, since the forward resistance increases as the temperature of the device rises, unlike a bipolar transistor, where the opposite effect causes the destruction of the device. The effect allows circuit design to be simple and this in turn improves the distortion and noise figures.

Even further simplicity of design is achieved because the gates of MOSFET's having such a high impedance allows them to be connected and biased together without suffering from cross-over distortion. A small bias voltage is applied from a constant current set to around 20mA, though this is not critical and hence no setting-up is required.

The overall gain of the power amplifier is 33 as set by the ratio of R38 to R37. The power amp has a virtually perfectly flat response over the entire audio range with excellent stability and very fast switching or slew rate which gives an extremely wide power bandwidth, yet the damping factor is still very good.

The output of the power amp is fed to DIN sockets SK4 and SK5 which supply the external speakers, while JK1 disconnects this output and connects it via R55 and R56 to a stereo headphone when a plug is inserted.

The additional pins 1, 2 and 3 have been included so that a remote control unit for volume, bass, treble and balance may be added. Details of this easy-to-construct addition will be published shortly — hopefully in the next edition if space is available.

Construction

Main pcb

With reference to Figure 4 insert the 28 Veropins from the track side, then push them firmly home with the tip of a hot soldering iron and solder to the pcb. Fit the thirteen links using 24 swg tinned copper wire as shown in Figure 4. This Figure also shows how to fit and solder the two straps required between pins 4 and 6 and between pins 5 and 7 and again this should be done with the tinned copper wire and soldered.

Resistors R1 to R54 and R57 to R59 can now be fitted to the pcb. Bend the leads before insertion and push them down on to the pcb. If you cannot read the colour code directly, use the chart in the resistor section of our catalogue or the colour wheel (XL05F). Note that R3, 4, 8 and 9 must be 1% tolerance types and these are either marked 1% or they have a brown ring where the gold ring is found on 5% types.

Next insert the 1N4148 diodes, D1 to D4 and the two Zener diodes D5 and D6. These six diodes have a black band and must be placed on the pcb so that this band is at the same end as the white band printed on the pcb.

25W MOSFET AMPLIFIER

RV1 to RV6 are preset potentiometers. Carefully check the values stamped on the wiper: RV1 to RV4 are 100k and RV5 and RV6 are 10k. Fit these to the pcb. By now quite a jungle of leads will be forming beneath the pcb, so solder these in position and cut off all remaining ends close to the joint. It is advisable to check for shorts between tracks and soldered joints after each use of the soldering iron. Excess flux can be removed using cellulose paint thinner and a stiff paint brush, but use the thinners conservatively or a sticky deposit will be formed.

Next fit the ceramic plate capacitors. Their leads do not require bending and should fit straight in. Fit the tantalum bead capacitors C10, 11, 22 and 28 taking care that the '+' sign on the body of the capacitor lines up with the '+' sign printed on the pcb. The little box-shaped capacitors are the polycarbonates and should be fitted next, followed by the polystyrene capacitors whose leads should be pre-formed before fitting to the pcb.

This should also be done to the axial electrolytics C9, 34 and 35 which should be fitted next taking care that the '+' sign printed on the pcb is at the same end as the indentation that runs around the body of the capacitor. The vertically mounted electrolytics C2, 6, 25 and 31 are inserted straight into the pcb and again must be positioned so that the '+' signs are aligned.

Now solder all the components in position, trim the leads, clean and check the pcb as before then mount the three integrated circuits. The small dot

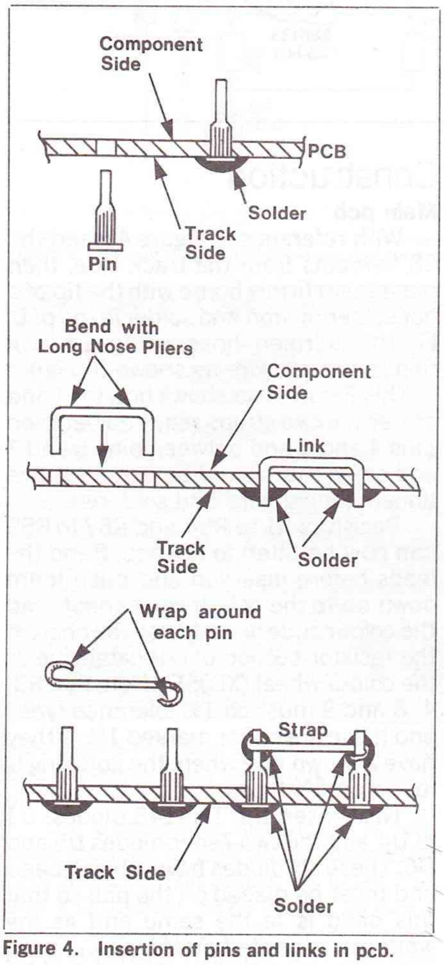
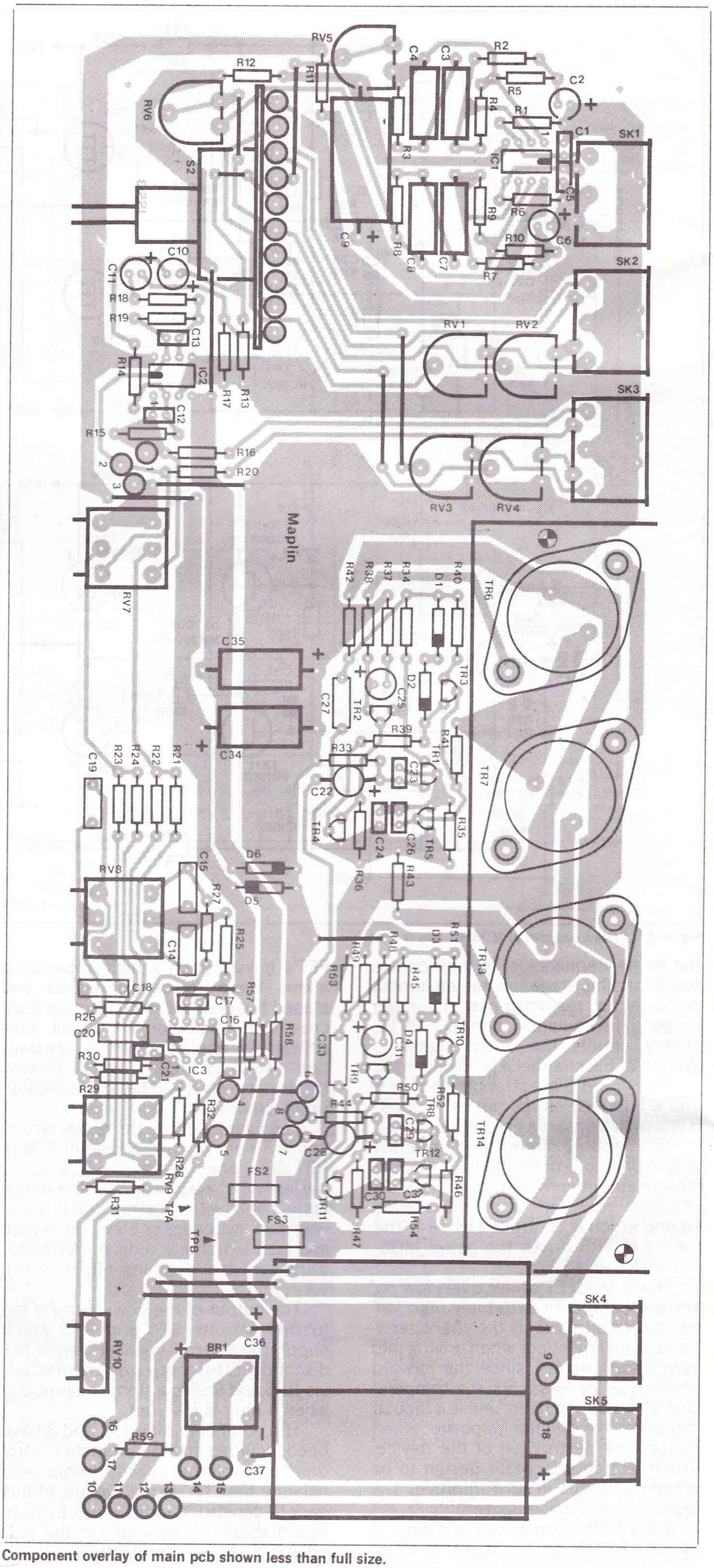


Figure 4. Insertion of pins and links in pcb.



Component overlay of main pcb shown less than full size.

on the top of the IC body indicates pin 1 and should be positioned so that it is at the same end as the 'D' shape formed on the pcb legend. Take care to ensure that all eight leads fit through the pcb on each IC.

Next, fit the bridge rectifier BR1. One edge of the plastic package has a '+' sign painted on it and as before this must be positioned to align with the '+' sign on the pcb. Push the plastic body right down onto the pcb.

Transistors TR1 to TR3 and TR8 to TR10 are type BC212L and their 'D' shaped package must line up with the pcb legend. The same applies to TR4, 5, 11 and 12 which are type BC182L. Push all these transistors down to about 0.5 to 1cm (¼in) from the pcb otherwise they can be easily bent or broken. Fit the two polyester capacitors C27 and C33. These are usually colour coded and from the top the colours are brown, black, yellow, black or white, red or yellow. Now solder all these components as before.

Place the FET mounting bracket over the pcb on the component side and bolt in position with two nuts, washers and 6BA ¼in bolts inserted from the track side. Ensure that the top of the bracket is perfectly smooth and clean. Carefully adjust the position of the bracket so that 16 holes (4 per FET) in the pcb are exactly centralised under the holes in the bracket, and then tighten the bolts. This operation is very important as misalignment will result in a short circuit between the FET and the bracket (0V). One bolt passes through a large area of track and to ensure that there is a good connection between this track (0V) and the bracket, solder the bolt head to the track.

Smear a thin layer of Thermpath over both sides of a mica insulator and place it on one of the power FET's then repeat with the other three. Place each FET with its insulator over the mounting bracket noting that the two leads on the 2SK133's are towards the rear of the pcb (the bracket itself is on the rear edge) and on the 2SJ48's they mount towards the front.

With reference to Figure 5 insert two 6BA ½in bolts from the track side up through each MOSFET and tighten up with 6BA washers and nuts. Solder the FET leads to the pcb and then solder all eight bolt heads to the pcb.

The four small fuseholder clips may now be fitted. The easiest way to do this is to clip a fuse between each pair and then place and solder the whole assembly to the pcb. Remove the fuses when this is completed.

Fit the three 5-pin DIN sockets, SK1 to SK3, ensuring that all seven pins (2 are securing pins) go through the pcb and none are left bent underneath. Sockets SK4 and SK5 should be fitted in the same way. The last two axial electrolytic capacitors C36 and C37 can now be fitted. They mount with polarities in opposite directions so take care to ensure that the indentation around the body is at the same end as the '+' sign on the pcb. Solder these last seven items to the pcb.

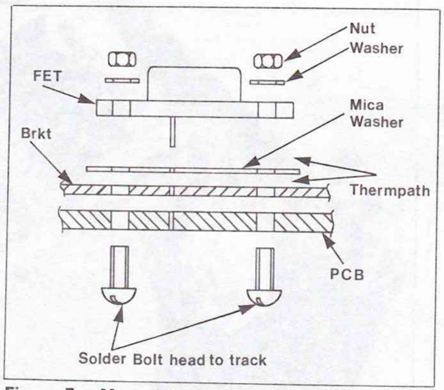


Figure 5. Mounting the MOSFET transistors.

The four-way rotary switch S2 has to be prepared before it can be mounted. Firstly, straighten all fifteen tags on the back of the switch then cut off the tags marked B, 5, 6, 7 and 8 close to the plastic moulding. Secondly, cut off the loops on the ends of the remaining ten tags leaving as much straight pin as possible. Refer to Figure 6. The switch can now be fitted to the small pcb ensuring that all ten pins have come through and solder them in position.

On the main pcb there are ten Veropins situated near the front left side of the board. Lightly tin these pins with a soldering iron (i.e. cover each pin with a *thin* layer of solder). With reference to Figure 7, place S2 facing towards the front of the main pcb and offer the switch pcb up to the ten pins so that they align with the ten tracks on that pcb. Hold the board as upright as you can and solder one pin. Resolder if the board is not perfectly upright, then when satisfied, solder the remaining nine pins.

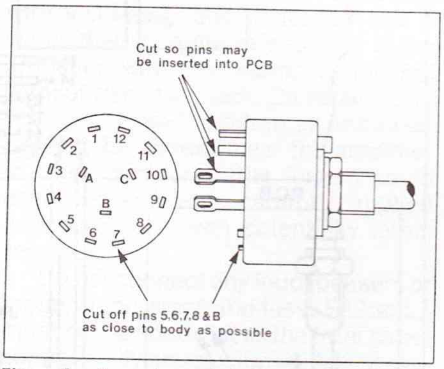


Figure 6. Preparing switch S2.

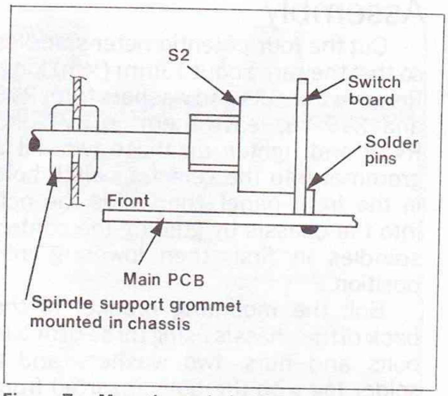


Figure 7. Mounting switch S2.

Finally, mount the four rotary potentiometers on the pcb checking the resistance values against the RV numbers to ensure correct placement, before soldering. The pcb is now complete and should be cleaned up. Re-check all components for correct values and correct orientation of polarised components. Check for dry joints and short circuits and carefully resolder any suspect joints.

If you possess a multimeter, check for short circuits between the pins and case of the MOSFET transistors and the mounting bracket. Switch to ohms and with one lead on the bracket check each lead and case in turn. If there are any short circuits then you will have to strip down the mounting bracket to find out why, but careful construction should have prevented this.

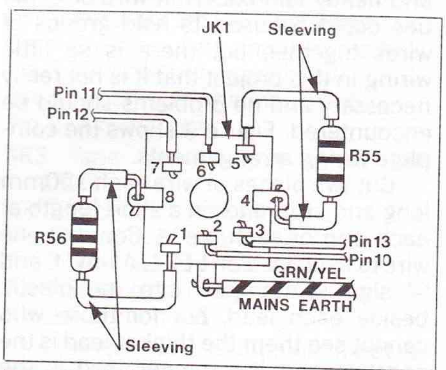
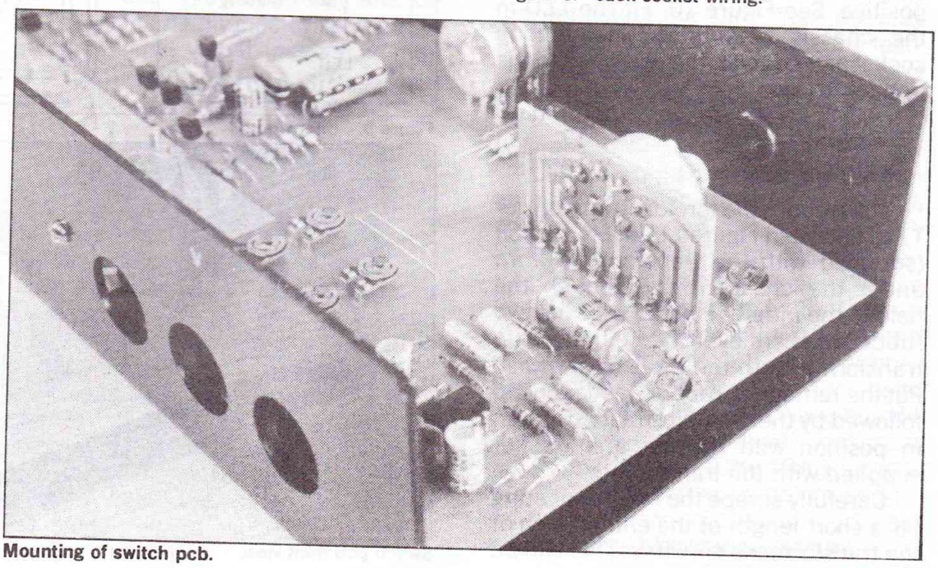


Figure 8. Jack socket wiring.


Mounting of switch pcb.

Assembly

Cut the four potentiometer spindles so that they are about 13mm (½in) long. Remove the nuts and washers from RV8 and RV9 but leave them on RV7 and RV10 and tighten up these two. Fit a grommet into the selector switch hole in the front panel, then slide the pcb into the chassis by guiding the control spindles in first, then lowering into position.

Bolt the mounting bracket to the back of the chassis using three 6BA ¼in bolts and nuts, two washers and a solder tag with the bolts inserted from the outside. The tag washer fits on the bolt nearest to the two 2-pin speaker sockets. The two remaining pot mounting washers and nuts fit onto RV7 and RV10 and tighten up on to the chassis. Make sure that all five DIN sockets line up with the holes in the chassis and readjust to suit.

With reference to Figure 8 slide a piece of sleeving over each wire on R55 and R56 then solder them between tags 4 and 5 and tags 1 and 8 of the jack socket. Cut four pieces of wire each 125mm long, and strip and tin a short length at each end of each piece. Solder these four wires to tags 2, 3, 6 and 7 on the jack socket. Fix the jack socket to the front panel then connect the four wires to the pcb as follows:

JK1 tag	to	pcb pin
2		10
3		13
6		11
7		12

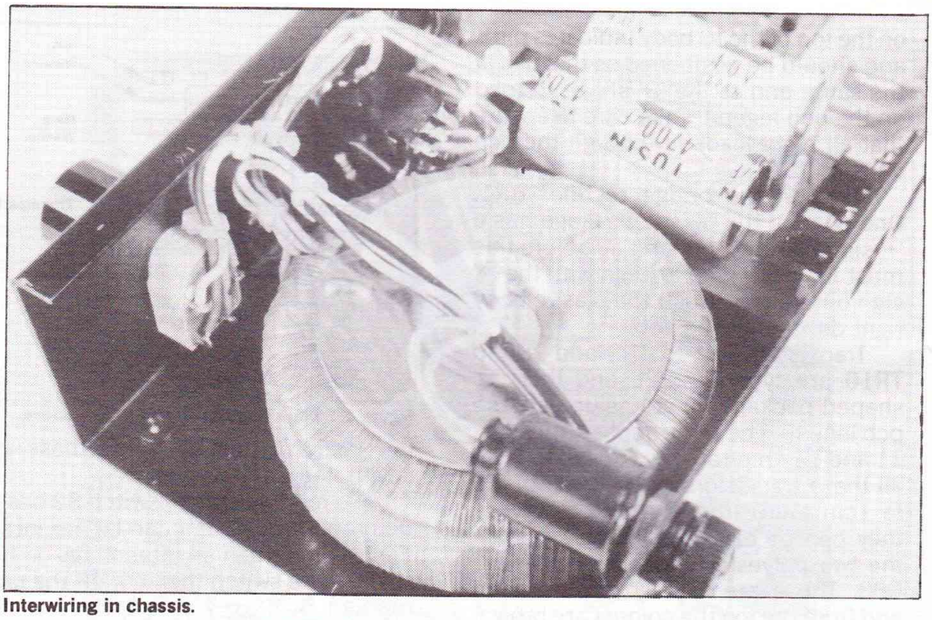
Keep all wiring as short as possible and neatly laid out. Thin wire or cable ties could be used to hold groups of wires together, but there is so little wiring in this project that it is not really necessary and no problems should be encountered. Figure 9 shows the complete wiring arrangements.

Cut two pieces of wire each 150mm long and strip and tin a short length at each end of each piece. Connect one wire to each lead on LED1. A tiny '+' and '-' sign is stamped into the plastic beside each lead, but for those who cannot see them the thicker lead is the negative and the thinner lead is the positive. See Figure 10. Fit the LED in the chassis next to the headphone socket and connect the two wires to the pcb as follows:

LED1	to	pcb pin
+ (thin)		17
- (thick)		16

Now mount the toroidal transformer T1 as shown in Figure 11. Insert the bolt (supplied with the transformer) from under the chassis base through the hole in the indent. Place one of the two rubber washers over the bolt, then the transformer with the wires uppermost. Put the remaining rubber washer on top followed by the clamping plate. Tighten in position with the nut and washer supplied with the transformer.

Carefully scrape the enamel coating off a short length of the end of each of the transformer's six wires. This can be



Interwiring in chassis.

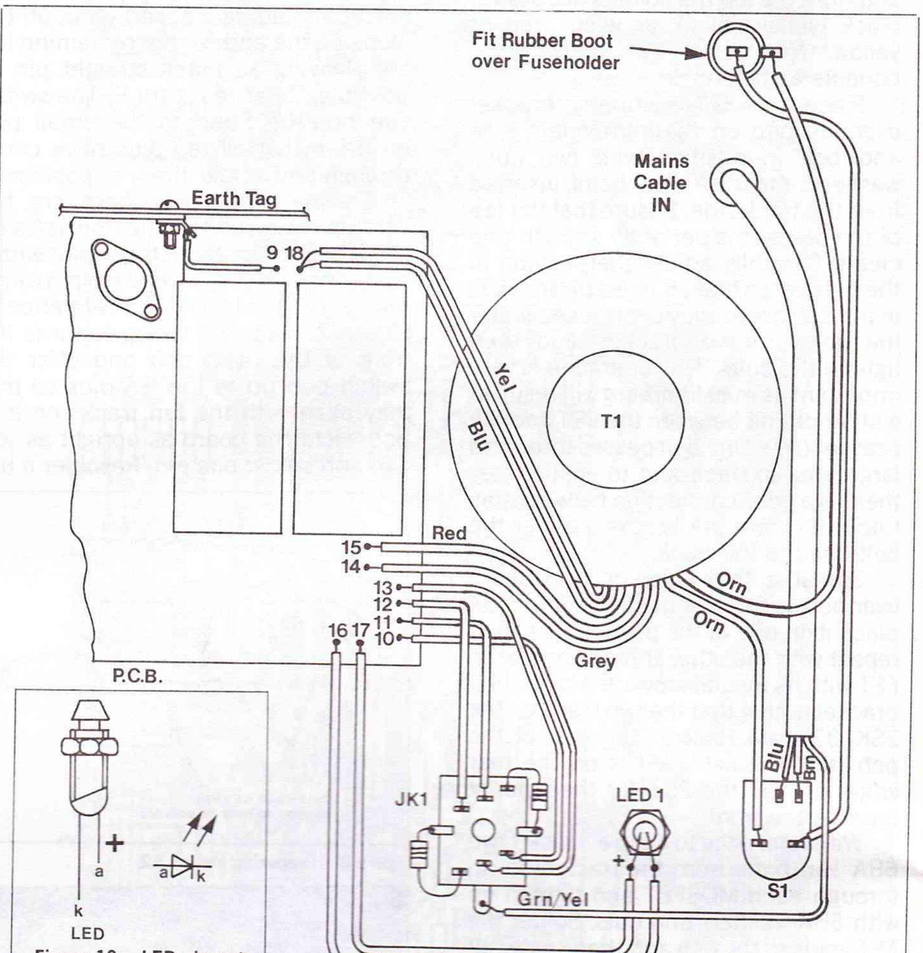
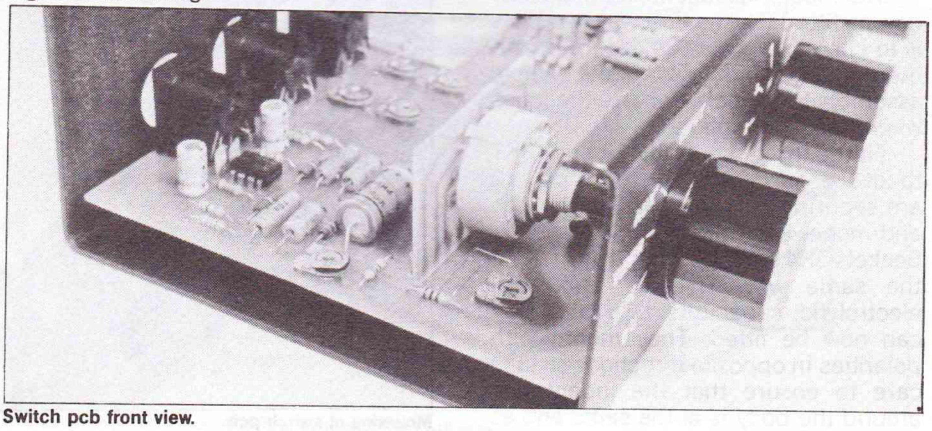
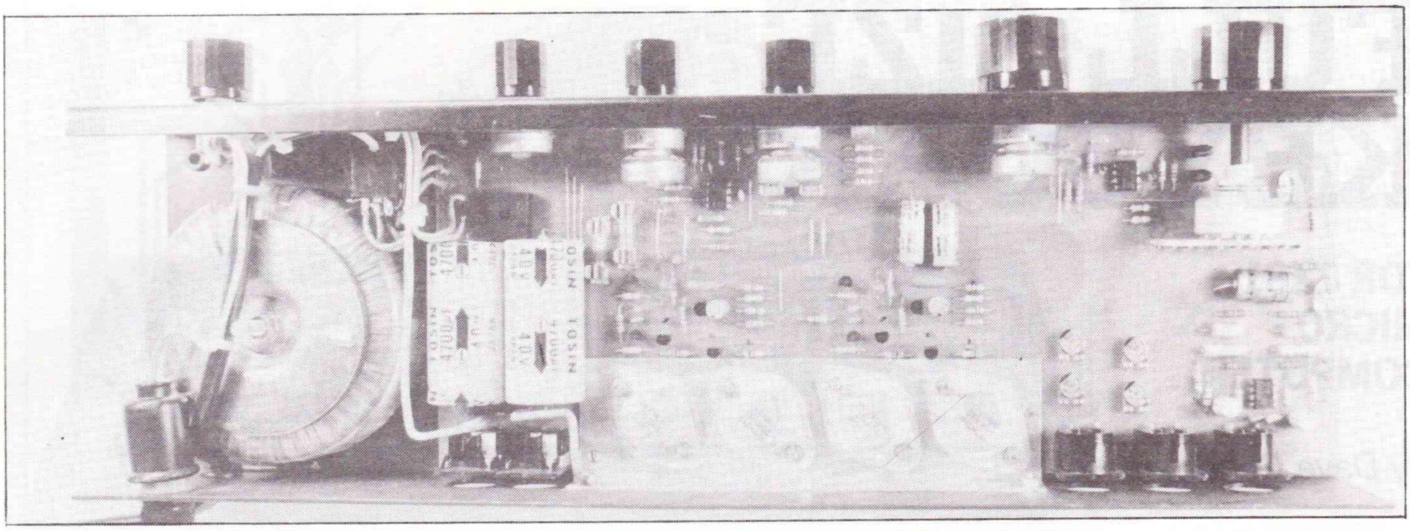


Figure 10. LED pin-out.

Figure 9. Interwiring.



Switch pcb front view.



Internal view of completed amplifier.

done with a sharp knife or a piece of fine emery cloth or wet and dry. Twist together the blue and yellow wires and connect both to pin 18 on the pcb. Connect a short length of wire between pin 9 and the earth tag as shown in Figure 9. Form the red and grey wires around to the bridge rectifier and solder on to pins 14 and 15 on the pcb. It makes no difference which wire goes to which pin.

Fix the chassis fuseholder to the rear panel above T1 and fit a rubber grommet in the hole beneath it. Fix the rotary mains switch S1 to the front panel taking care that the small spigot fits into the matching hole. Cut the spindle to the same length as the other spindles. Also trim the spindle on S2 to this length.

Connect one of the orange wires from T1 (it doesn't matter which one) to the side tag on the fuseholder FS1, after sliding the rubber boot over the wire first. Cut a piece of wire about 150mm (6in) long, strip and tin each end then pass it through the rubber boot and connect it to the rear tag on FS1. Solder both wires, then push the rubber boot forward so that it completely covers the body of the fuseholder.

Connect the other end of this wire to one of the top two terminals on switch S1. Then connect the other orange wire from T1 to the other top terminal on S1. Strip 80mm (3in) of the outer covering of the piece of mains lead and strip and tin a short length of each of the three internal wires. Put the mains lead through the grommet in the rear panel and terminate the blue wire to the tag on S1 immediately below the orange wire from T1 and terminate the brown wire to the tag on S1 immediately below the piece of wire from FS1.

The mains earth (green and yellow wire) should be connected to the earthing tag on the top of JK1. Ensure that all the connections you have made are properly soldered. Check carefully for dry joints and short circuits. Insert the 2A antisurge fuse into FS1 and ensure that the other two fuses are NOT inserted into their clips on the main pcb. Fit the control knobs on to the spindles as shown in the photographs.

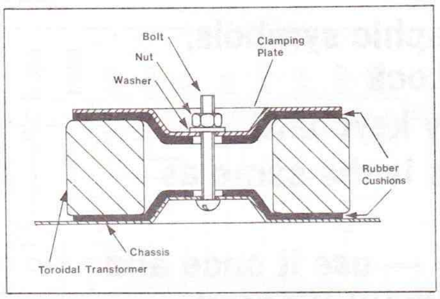


Figure 11. Mounting the toroidal transformer.

Finally check that the last section of wiring is identical to all the diagrams. The amplifier is now ready for testing.

Testing

Fit the 13A mains plug to the mains cable. The rear of S1 could be covered with insulating tape if desired and it would then be quite safe to work in the amplifier with the mains connected without risk of a shock. On no account, however, should children or untrained persons be allowed near the amplifier in this condition. Little fingers could easily unpeel your carefully applied insulating tape with potentially lethal results.

Do not connect any loudspeakers or inputs at this stage and fuses FS2 and 3 must not be fitted. Set all the front panel controls fully anticlockwise. Adjust presets RV5 and RV6 to half-way and set RV1, 2, 3 and 4 fully clockwise. Give the project a final visual inspection then connect the mains plug to the mains and switch the amplifier on by turning S1 clockwise.

LED1 should light up. If it does not switch off, remove the mains and check fuse FS1. If it is still intact, try reversing the wires on pins 16 and 17 on the pcb. Switch on again. If all is well switch a multimeter to 50V DC or 100V DC or thereabouts, connect the negative lead to the metal chassis or the tag on the top of JK1 and the positive lead to pin TPA on the pcb. The meter should read around +32V (±5V). Now put the meter's positive lead to the chassis and connect the negative lead to pin TPB on the pcb. Again the meter should read the same voltage as before i.e. -32V (±5V).

Switch off. If all is well the other two 2A fuses can now be fitted into the fuse clips on the pcb. If desired and you have sufficient knowledge, two further checks can be made. The +15V rails can be checked on D5 and D6 and you should obtain a reading of above 100mV DC between the cases of the four power MOSFET's and the chassis.

The treble, bass and balance controls can now be set centrally. Speakers may now be connected and inputs as required. The input connections are as follows:—

SK1 Magnetic pick-up input (5-pin DIN 180°)
Pin 1 Left channel input
Pin 4 Right channel input
Pins 2, 3, 5 Common (0V)
SK2 Tuner/Aux input (5-pin DIN 180°)
Pin 1 Auxiliary left channel input
Pin 4 Auxiliary right channel input
Pin 3 Tuner left channel input
Pin 5 Tuner right channel input
Pin 2 Common (0V)
SK3 Tape input/output (5-pin DIN 180°)
Pin 1 Tape left channel output
Pin 4 Tape right channel output
Pin 3 Tape left channel input
Pin 5 Tape right channel input
Pin 2 Common (0V)

If when any particular input is selected there is an obtrusive hum, try disconnecting the earth from the plug at one end of the interconnecting lead. Check out the remaining functions of the amplifier and adjust the six presets RV1 to 6 to suit your equipment if desired.

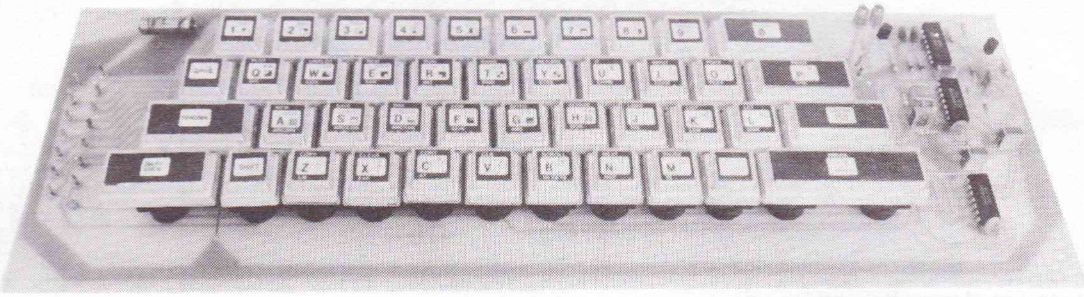
Carefully fold the wooden cabinet glueing the corners together with a PVA adhesive such as Evostik's "Resin W". Slide the chassis into the wooden sleeve when the glue is properly set, so that the four holes in the bottom line up with the four holes in the base of the chassis. Then bolt on the four rubber feet using the four 4BA ¾in bolts supplied in the kit. If you have bought the parts separately, you will need to cut the excess length off the 4BA 1in bolts. The amplifier is now complete and its reliable, superb quality should give many years of listening pleasure.

Continued on page 30.

FULL~SIZE KEYBOARD

FOR ZX81 MICRO-COMPUTER

by Dave Goodman



- ★ **Single key selection of Graphic symbols, Function mode and Shift Lock**
- ★ **Full size, full travel, 43-key keyboard**
- ★ **Two-colour legend for keys is the same as the ZX81 keyboard**
- ★ **Faster, more reliable entry — use it once and you won't be able to do without it again!**

S1 = 1	S15 = R	S29 = J
S2 = 2	S16 = T	S30 = K
S3 = 3	S17 = Y	S31 = L
S4 = 4	S18 = U	S32 = New Line
S5 = 5	S19 = I	S33 = Shift Lock
S6 = 6	S20 = O	S34 = Shift
S7 = 7	S21 = P	S35 = Z
S8 = 8	S22 = Func'	S36 = X
S9 = 9	S23 = A	S37 = C
S10 = 0	S24 = S	S38 = V
S11 = Grps 2	S25 = D	S39 = B
S12 = Q	S26 = F	S40 = N
S13 = W	S27 = G	S41 = M
S14 = E	S28 = H	S42 = ·
		S43/44 = Space

Table 1. Key function chart.

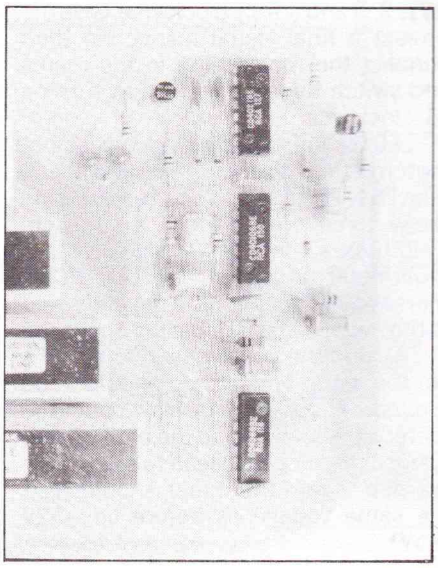
Support systems for the Sinclair ZX81 are very much in demand at the moment and an add-on keyboard with full size keys can offer a great improvement over the existing unit. Operation becomes more positive, unlike the ZX81's touch-keyboard where the only way to be sure you've pressed the key correctly is to check on the screen. With this keyboard, the feel is similar to that of a typewriter and thus entry speed is far higher and much more reliable.

On the ZX81's touch-keyboard, to select a graphic symbol — first the "shift" key must be operated and held and then the "graphics" key operated, then the "shift" key held and the actual graphic symbol required pressed. On this keyboard simply press and release the "graphics 2" key. An LED gives an indication that the mode is selected and the screen cursor changes to [G] as normal. Now any desired graphics symbol may be selected directly without pressing or holding any additional keys. Press and release "graphics 2" key again to return to normal mode. The LED will extinguish and the screen cursor will return to [K or L].

On the ZX81's touch-keyboard selecting a function requires a similar operation to selecting a graphics symbol. On this keyboard simply press and release the "function" key. The screen cursor changes to [F] and an LED flashes once to indicate that this mode is selected. Now any of the operator keys may be selected directly without pressing or holding any additional keys. After selection the LED is extinguished and the screen cursor returns automatically for normal entry.

Finally, this keyboard has a "shift lock" key that electronically holds the keyboard in shift mode after that key is momentarily pressed. A second LED lights to indicate that this mode is selected. Pressing the "shift lock" key again, extinguishes the LED and returns the keyboard to normal entry mode.

Our own experiments have proved that this keyboard is invaluable. No-one who tried it wanted to go back to using the touch-keyboard. Relief from neck-ache was one often cited advantage! Users described how with the touch-keyboard one looks down to the left or right to read the program to be entered, then at the keyboard to select the key, then up at the TV to check the symbol has gone in, then often, back to the keyboard to roll the finger around a little more because the symbol hasn't been entered (apparently a common occurrence), then up to the TV again, then back to the program. When entering with our keyboard, operators rarely needed to move at all.



Children who used it, found they could perform complicated operations easily — often they could not do the same thing on the touch-keyboard at all! Everyone agreed that there was no alternative on the market and almost lynched the author to get their hands on the prototype.

Construction

Begin by straightening and forming thirty-three wire links, and fit these first. Insert the six diodes, taking care to align the black band printed around the body with the white line printed on the PCB. Insert all resistors. For those unfamiliar with the new colour code a chart is printed in the resistor section of our 1983 catalogue.

Next fit all three ICs (see Figure 3). It is advisable to fit IC sockets when using CMOS ICs. Fit all capacitors, noting that C11 should be mounted with the negative end towards the left hand side of the PCB. Align TR1 and TR2 with the legend and fit in place.

Carefully solder all components and links to the PCB and cut off the remaining ends. Before inserting the forty-four keys fit a white plastic top to each one. Switches S33, 32, 22, 21, and 10 are doubles and S43, 44 may be either a treble or two singles (see Figure 4).

Now put each key in position on the board, place a book or stiff card over the top, and turn the whole assembly over. Solder all the keys in place and check

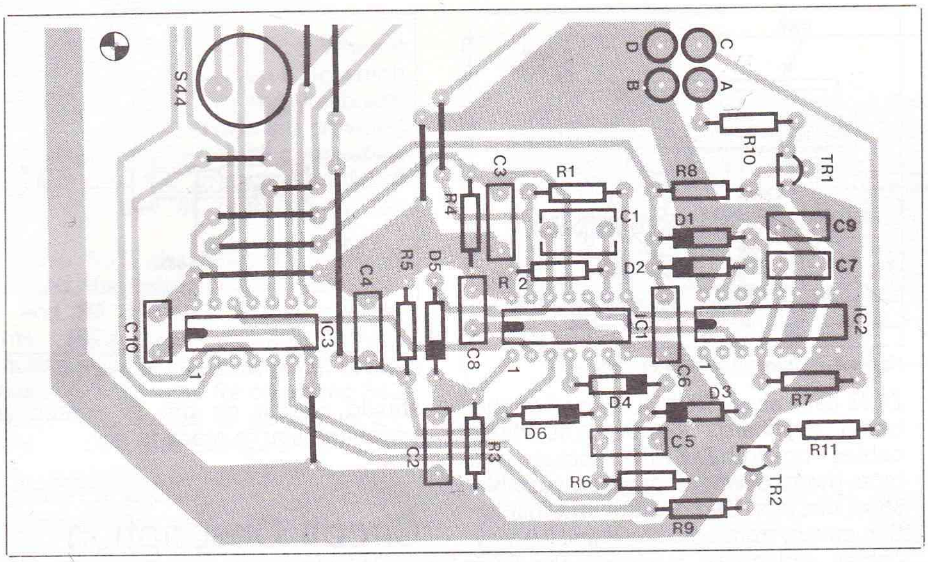


Figure 1. Component overlay of electronics section of pcb.

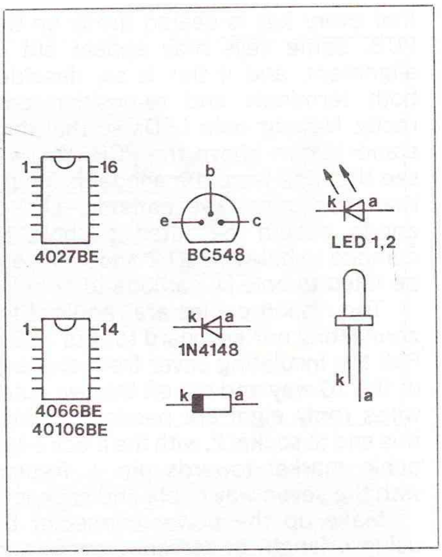


Figure 3. Pin-outs of components.

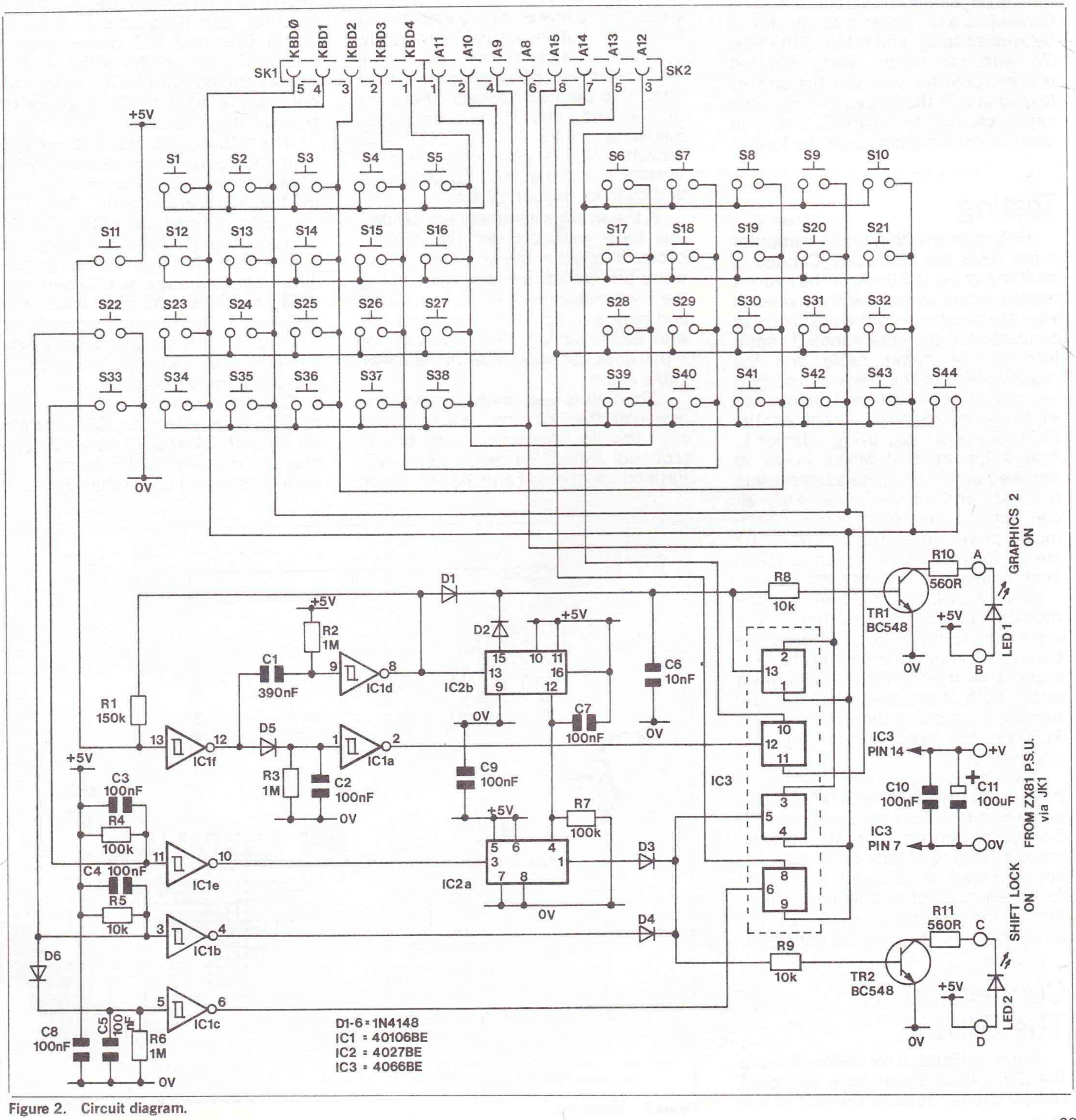


Figure 2. Circuit diagram.

that every key is seated firmly on the PCB. Some keys may appear out of alignment, and if this is so, desolder both terminals and re-position correctly. Now fit both LEDs so that they stand 10mm above the PCB. You will see that one lead, the anode, is longer than the other, the cathode. LED 1 anode should be fitted to hole B, cathode to hole A; LED 2 anode should be fitted to hole D, cathode to hole C.

Two ribbon cables are required for connecting our keyboard to your ZX81. Pull the insulating cover from one end of the 10-way and cut off the two outer wires (only eight are needed). Solder this end to socket 2, with the black edge cable marker towards pin 1. Repeat with the seven way cable and socket 1.

Make up the power connector by using a length of screened cable and fitting a 3.5mm plug at one end (Figure 5). The remaining end screen should be tinned (i.e. a thin layer of solder should be applied to it), and fitted to the PCB 0V, with the centre lead, +5V, left unconnected for now. Cut the printed legend and fit the pieces into the clear caps, referring to Figure 1, and then snap them into position on the keys.

Testing

Before connecting to the computer a few tests are necessary. Connect a multimeter set to 50mA, or the nearest measurement above that is possible on your multimeter, with the positive lead connected to the unterminated centre lead of the power cable and the negative lead to the track on the PCB immediately beneath the hole marked +V. Now connect the power cable to the ZX81 power supply, using adaptor L. Always ensure that Mains Power is removed before plugging adaptor L into the ZX81 and the keyboard. When all connections have been made, switch mains power on. Providing both LEDs are off, the meter should read less than 1mA, or about 20mA with both LEDs on.

If all is well, switch off, remove the multimeter, and connect the centre conductor to the PCB by passing the bare end through the hole in the PCB marked '+V' from above and soldering it underneath. Note that when disconnecting the system the mains should ALWAYS be switched off prior to unplugging.

Switch on again, and connect a meter set to read DC volts between 0V and pins 1 to 8 of socket 2 and pins 1 to 5 of socket 1 in turn. There should be no voltage reading at any time, with the keys pressed or released. Any faults found must be rectified before connecting to the computer, otherwise the Sinclair U.L.A. chip may be damaged.

Connecting To The ZX81

Refer to Figure 6 for connections to the ZX81 PCB. Insert both keyboard ribbon cables through the slot in the

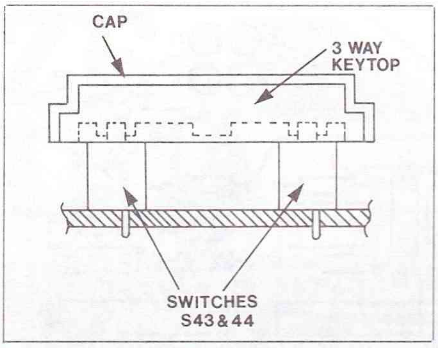


Figure 4. Fitting of 3-way key cap.

ZX81 case above RUBOUT key Ø on the touch keyboard. Remove the flexi-cables from both ZX81 PCB sockets and tape them down to prevent possible short circuits. Remove the end insulation covers from both the 8 and 10-way cables and gently push into the PCB sockets. The two extra wires on each cable help to make a firm connection in the socket, but are not used electrically.

Alternatively, two connectors can be soldered to the ribbon cables and then fitted into the PCB sockets. These are RK67X and YW18U minicon plugs. Soldering cables to the ZX81 PCB sockets is NOT recommended. Plug the adaptor L into the ZX81 power socket and connect to your TV set.

If the wrong characters are printed you have probably got the flexible cables plugged in the wrong way. Don't worry, this can't do any damage. Unplug the 7-way cable in the ZX81, turn it over and plug it in again. If it still does not work do the same for the 10-way cable. If this does not work, reverse the 7-way cable again.

When all is well, switch off and re-assemble the ZX81, the new keyboard can now be mounted in its box if required. Switch on again. LED1 will flash on and then off and the [K] cursor

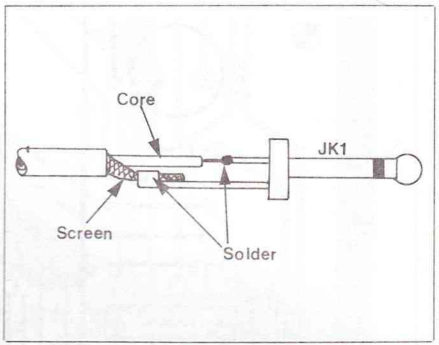


Figure 5. Wiring of 3.5mm jack plug.

should appear on the TV screen as usual and you're ready to go.

Circuit Description

S11, the 'graphics 2' key is connected to a buffer/inverter IC1f which together with IC1d acts as a monostable. Operating S11 causes the output of IC1f to go low which in turn causes the output of IC1d to go high, holding the input of IC1f high for the period set by C1, R2.

The output of flip-flop IC2b now goes high and turns on the bilateral switch IC3a which operates the 'shift' function in the keyboard matrix. Also TR1 conducts, turning on LED1. C2 discharges through R3 which delays the output from IC1a from changing state. When it does change over IC1a operates IC3d which connects 'graphics 2' in the keyboard matrix. Further operation of S11 repeats this sequence except that this time IC2b switches low and IC3a and IC3d are released.

S22, the 'function' key is connected to IC1b. When operated, IC3b operates via D4 with C4 and R5 acting as anti-bounce components. D6 becomes reverse biased and C5 discharges via R6,

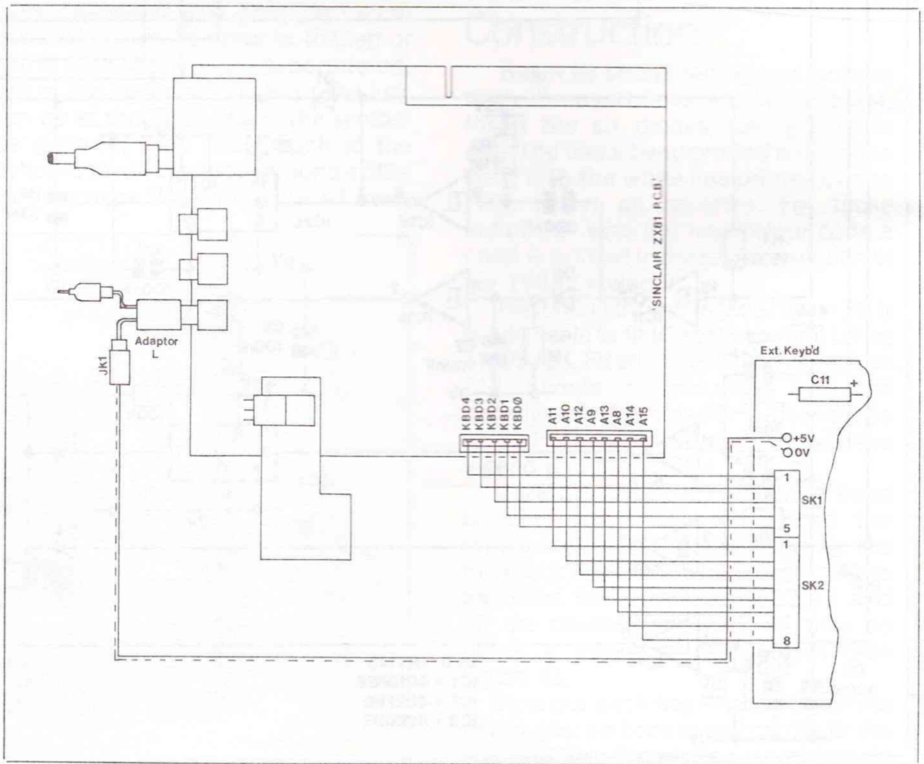
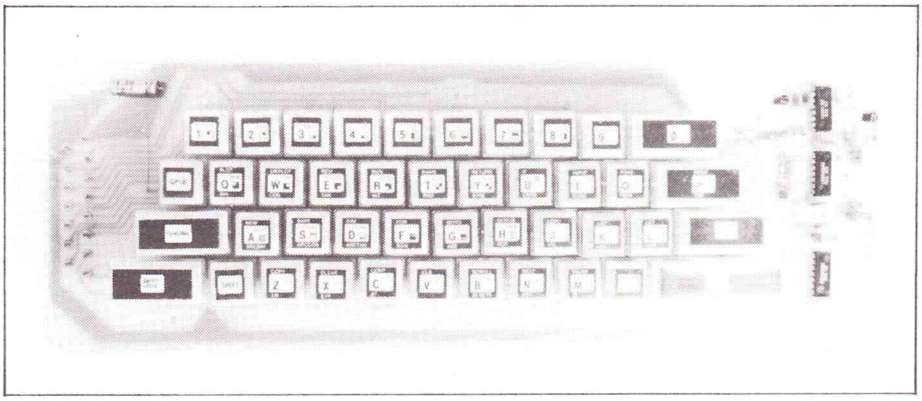


Figure 6. Interwiring.

delaying the operation of IC1c. When it finally operates, it turns on IC3c which connects 'function' in the keyboard matrix. These time delays are provided to ensure that the 'shift' connection occurs before the 'graphics' or 'function' connection as required by the ZX81.

When S33, the 'shift lock' key is operated, the output of IC1e goes high. C3 and R4 are anti-bounce components. IC2a now operates which switches on IC3b via D3 and TR2 which causes LED2 to light. Re-operating S33 causes IC2a output to go low which releases IC3b and extinguishes LED2. ■



PARTS LIST

Resistors — all 0.4W 1% carbon unless specified			
R1	150k		(M150K)
R2,3,6	1M	3 off	(M1M)
R4,7	100k	2 off	(M100K)
R5,8,9	10k	3 off	(M10K)
R10,11	560R	2 off	(M560R)
Capacitors			
C1	390nF polycarbonate		(WW48C)
C2,3,4,5	100nF polycarbonate	4 off	(WW41U)
C6	10nF polycarbonate		(WW29G)
C7,8,9,10	100nF minidisc ceramic	4 off	(YR75S)
C11	100uF 25V axial electrolytic		(FB49D)
Semiconductors			
D1-6	1N4148	6 off	(QL80B)
LED1,2	LED red	2 off	(WL27E)
TR1,2	BC548	2 off	(QB73Q)
IC1	40106BE		(QW64U)
IC2	4027BE		(QX16S)
IC3	4066BE		(QX23A)
Miscellaneous			
JK1	Plug 3.5mm plastic		(HF80B)
S1-44	Keyswitch	44 off	(FF61R)
	Keytop 1-position	37 off	(FF62S)
	Keytop 2-position	5 off	(FF63T)
	Keytop 3-position		(FF64U)
	Keytop print ZX81		(XH58N)
	ZX81 ext. keyboard pcb		(GA83E)
	Tinned copper wire 24 swg	2m	(BL15R)
	Adaptor L		(RK27E)
	Flexicable 7-way		(RK30H)
	Flexicable 10-way		(RK31J)
	Cable single black	½m	(XR12N)

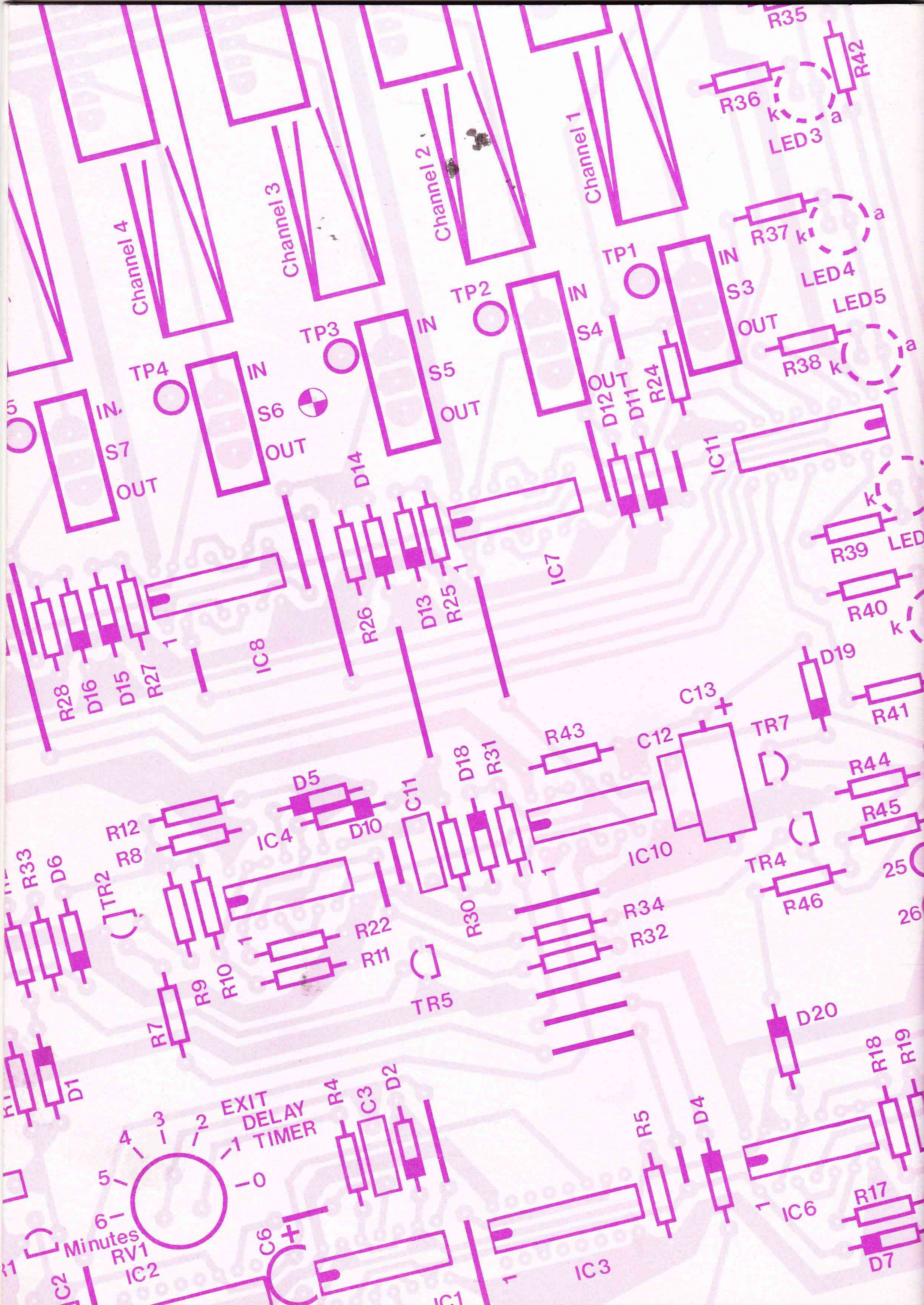
A complete kit for this project excluding a case is available.
Order As LW72P (ZX81 Keyboard Kit)
A case is also available.
Order As XG17T (ZX81 Keyboard Case)

25W STEREO MOSFET AMP Continued from page 44

PARTS LIST

Resistors — all 0.4W 1% carbon unless specified			
R1,6	68k	2 off	(M68K)
R2,7,37,48	1k	4 off	(M1K)
R3,8	22k	2 off	(M22K)
R4,9	270k	2 off	(M270K)
R5,10	100k	2 off	(M100K)
R11,12,40,41,51,52	100R	6 off	(M100R)
R13,16,17,20	470k	4 off	(M470K)
R14,18	1k2	2 off	(M1K2)
R15,19	22k	2 off	(M22K)
R21-24,27-32	2k2	10 off	(M2K2)
R25,26,39,50	15k	4 off	(M15K)
R33,44	47k	2 off	(M47K)
R34,45	56k	2 off	(M56K)
R35,36,46,47	3k9	4 off	(M3K9)
R38,49	33k	2 off	(M33K)
R42,43,53,54	10R	4 off	(M10R)
R55,56	220R (½W)	2 off	(S220R)
R57,58	820R	2 off	(M820R)
R59	2k7		(M2K7)
RV1-4	100k horizontal sub-min preset	4 off	(WR61R)
RV5,6	10k horizontal sub-min preset	2 off	(WR58N)
RV7	4k7 log dual pot		(FX08J)
RV8,9	47k lin dual pot	2 off	(FW87U)
RV10	10k lin pot		(FW02C)
Capacitors			
C1,5	68pF ceramic	2 off	(WX54J)
C2,6,25,31	10uF 35V PC electrolytic	4 off	(FF04E)
C3,7	10nF 1% polystyrene	2 off	(BX86T)
C4,8	3n9 1% polystyrene	2 off	(BX63T)
C9	100uF 40V axial electrolytic		(FB50E)
C10,11	10uF 16V tantalum	2 off	(WW68Y)
C12,13,23,29	10pF ceramic	4 off	(WX44X)
C14,15,18,19	68nF polycarbonate	4 off	(WW39N)
C16,20	4n7 polycarbonate	2 off	(WW26D)
C17,21,24,26,30,32	47pF ceramic	6 off	(WX52G)
C22,28	4uF 16V tantalum	2 off	(WW64U)
C27,33	100nF polyester	2 off	(BX76H)
C34,35	100uF 25V axial electrolytic	2 off	(FB49D)
C36,37	4700uF 40V axial electrolytic	2 off	(RK26D)
Semiconductors			
D1-4	1N4148	4 off	(QL80B)
D5,6	BZY88C15V	2 off	(QH18U)
LED1	Chrome LED small		(YY59P)
BR1	Bridge S04		(QL10L)
TR1,2,3,8,9,10	BC212L	6 off	(QB60Q)
TR4,5,11,12	BC182L	4 off	(QB55K)
TR6,13	2SK133	2 off	(QQ36P)
TR7,14	2SJ48	2 off	(QQ34M)
IC1,2,3	LF353	3 off	(WQ31J)
Miscellaneous			
S1	Rotary mains switch		(FH57M)
S2	Rotary 3-pole 4-way switch		(FH44X)
SK1,2,3	PC DIN socket 5-pin 'A'	3 off	(YX91Y)
SK4,5	PC DIN socket 2-pin	2 off	(YX90X)
JK1	DPDT jack socket		(BW80B)
T1	Toroidal transformer 22V 80VA		(YK18U)
FS1,2,3	2A antisurge fuse	3 off	(WR20W)
	Safuseholder 20mm		(RX96E)
	Rubber boot		(HL51F)
	Fuse clips	4 off	(WH49D)
	Mica insulator T03	4 off	(WR24B)
	Small thermpath		(HQ00A)
	Stereo amp heatsink		(RK25C)
	Stereo amp pcb		(GA71N)
	Stereo amp switch pcb		(GA78K)
	Stereo amp chassis		(XG15R)
	Stereo amp woodwork		(XG16S)
	Cabinet feet	1pk	(FW19V)
	Grommet small	2 off	(FW59P)
	Knob K44	3 off	(HB39N)
	Knob K45		(HB40T)
	Knob K46	2 off	(HB41U)
	Veropin 2141	28 off	(FL21X)
	Bolt 4BA 1in	4 off	(BF04E)
	Bolt 6BA ¼in	5 off	(BF05F)
	Bolt 6BA ½in	8 off	(BF06G)
	Nut 6BA	13 off	(BF18U)
	Washer 6BA	12 off	(BF26D)
	Tag 6BA		(BF29G)
	13A mains plug		(RW67X)
	Min mains cable	2m	(XR01B)
	Hook-up wire yellow	1m	(BL10L)
	Tinned copper wire 24 swg	1m	(BL15R)
	Systoflex 2mm black	10cm	(BH06G)

A complete kit of all the parts listed above is available.
Order As LW71N (25W Stereo MOSFET Amp Kit)



R35
R42
R36
LED3
Channel 4
Channel 3
Channel 2
Channel 1
R37
LED4
TP1
TP2
TP3
TP4
IN
S3
OUT
S4
S5
S6
S7
LED5
R38
D12
D11
R24
IC11
D14
IC7
R39
R40
R26
D13
R25
R28
D16
D15
R27
IC8
D19
C13
R41
R43
C12
TR7
D5
D18
R31
C11
R44
R12
D10
R45
R8
IC4
IC10
R33
D6
TR2
TR4
R30
R34
R46
R22
R9
R10
R11
R32
TR5
R7
D20
D1
R18
R19
EXIT
DELAY
TIMER
R4
C3
D2
R5
D4
IC6
Minutes
RV1
C6
IC2
IC3
R17
D7
C2