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BEST OF MAPLIN PROJECTS BOOK FOUR

EDITORIAL

■ 'Best of Maplin Projects Book Four is a compilation of the most popular projects from 'Maplin Projects Book Thirteen to Sixteen', which are now out of print. Other issues of 'Maplin Projects Books' will be replaced by 'Best of' projects books as they go out of print. Back issues of 'Electronics - The Maplin Magazine' are available until they, too, go out of print and will then be replaced by projects books. For kit prices, please consult the latest Maplin catalogue and free price change leaflet, order as CA99H or the latest Maplin price list, order as XF08J. The price list also contains details of how to obtain a year's subscription to 'Electronics - The Maplin Magazine'.



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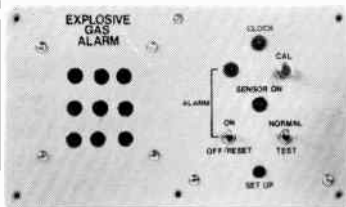
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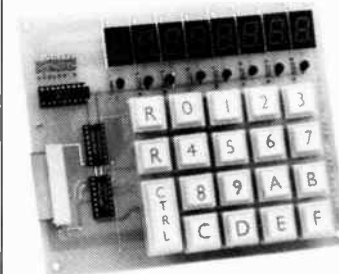
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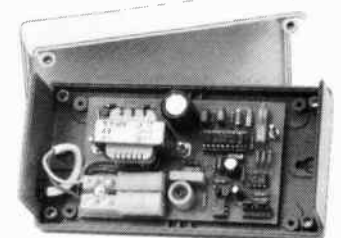
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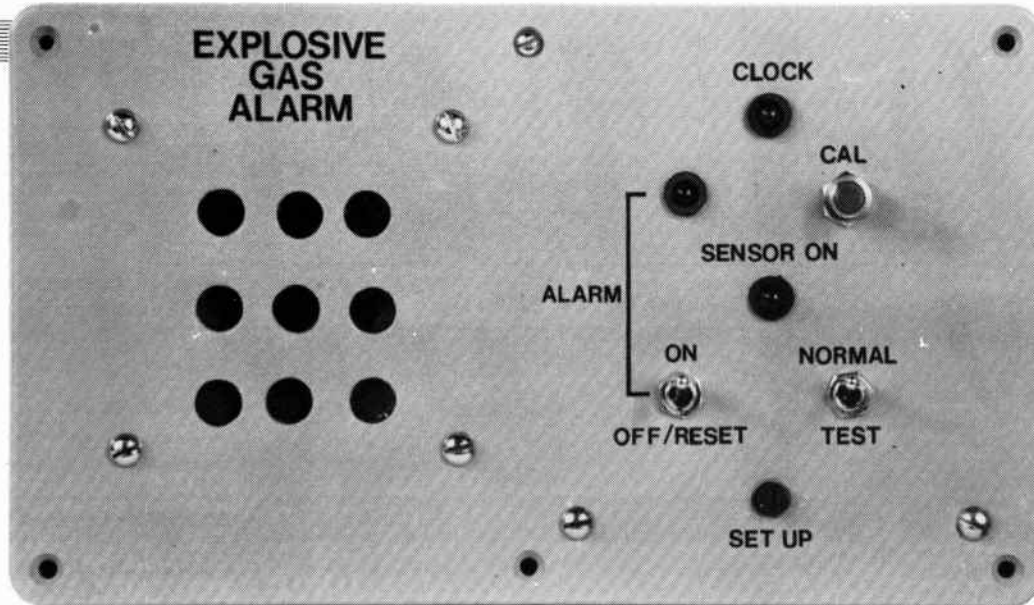
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- ★ Operates from 12V battery
- ★ Very low average current consumption
- ★ Detects all common explosive or inflammable gases
- ★ Loud strident alarm

Dangerous gas leaks, particularly in confined spaces, causing explosions and fires, are becoming a more common occurrence, usually damaging property and often maiming or even killing people. The Maplin gas detector has been designed to prevent the build-up of these gases by sounding a loud alarm before sufficient gas has leaked to cause a damaging explosion. The sensor used consists of two separate units, the sensor itself and a reference compensator. Both elements are connected in series and used to form two legs of a Wheatstone bridge. The two elements have similar resistance under normal conditions and vary equally with changes of ambient temperature, maintaining the bridge in balance. The presence of an inflammable gas causes the sensor element to increase in temperature, due to the oxidization of the gas on the surface of its platinum heating element. This increase in temperature causes an increase in resistance of the element and thus the bridge becomes unbalanced, the detection of which causes the alarm to sound.

The fairly high current (about 400mA) required by the sensors and their associated circuitry make it undesirable to have the sensors permanently energised, particularly when installed in a boat or caravan where the power is supplied from a 12V battery. This problem is overcome by testing for gas once every 5 or 6 minutes and latching the alarm on when gas is detected. This test period is adequate because in most cases the build up of gas, due to a leak, is fairly slow and the alarm should operate well before a dangerous level is reached.

The system will detect all common explosive or inflammable gases such as Butane, Propane, Methane, Town Gas, Natural Gas, and Petrol Vapour. The sensors are enclosed in double wire mesh housings to prevent any chance of the sensor itself igniting any gases encountered.

by Robert Kirsch

EXPLOSIVE GAS ALARM

How It Works

The Wheatstone bridge, previously mentioned, consists of R2, R4, RV1, and the two sensing elements. The balancing of the bridge is performed by adjusting RV1. The CAL switch (S1) is used to unbalance the bridge by a small amount, simulating the presence of a small amount of gas, this being used in setting up the alarm for maximum sensitivity. The state of the bridge is monitored by the dual op-amp, IC1a and IC1b, whose output is used to turn on TR3 under alarm conditions. IC4 forms a dual oscillator to produce the warbling alarm tone, and its output is fed to TR4 which drives the Piezo tweeter which provides the audio output. The alarm, when activated, latches on and sounds continuously until reset by the action of S3, which also disconnects the speaker for testing purposes. Latching is performed by connecting the positive voltage fed from the collector of TR3 (under alarm conditions) back to the inverting input of IC1a via D3, D4 and R5.

The sequence timing of the alarm is carried out by IC3, which is a 14 stage ripple counter with built in oscillator. The frequency of the oscillator is determined by R17, C3 and C4 running at about 1 cycle every 4 seconds. The various outputs from IC3 are used to control the switching regulator TR1 and to enable the monitor circuit via IC2, R13 and D5. The sensors require at least 20 seconds to settle down after power is applied before a test can be made and for this reason the sensors are powered for about 80 seconds per test cycle, but the alarm is only enabled for the last 40 seconds of this period. The time between tests can be altered by selecting various straps but under normal conditions the shortest period is recommended. (Link A to B). The sensors require a stable supply independent of variations of the incoming supply voltage, this is achieved by the 5V regulator (REG1) which provides the

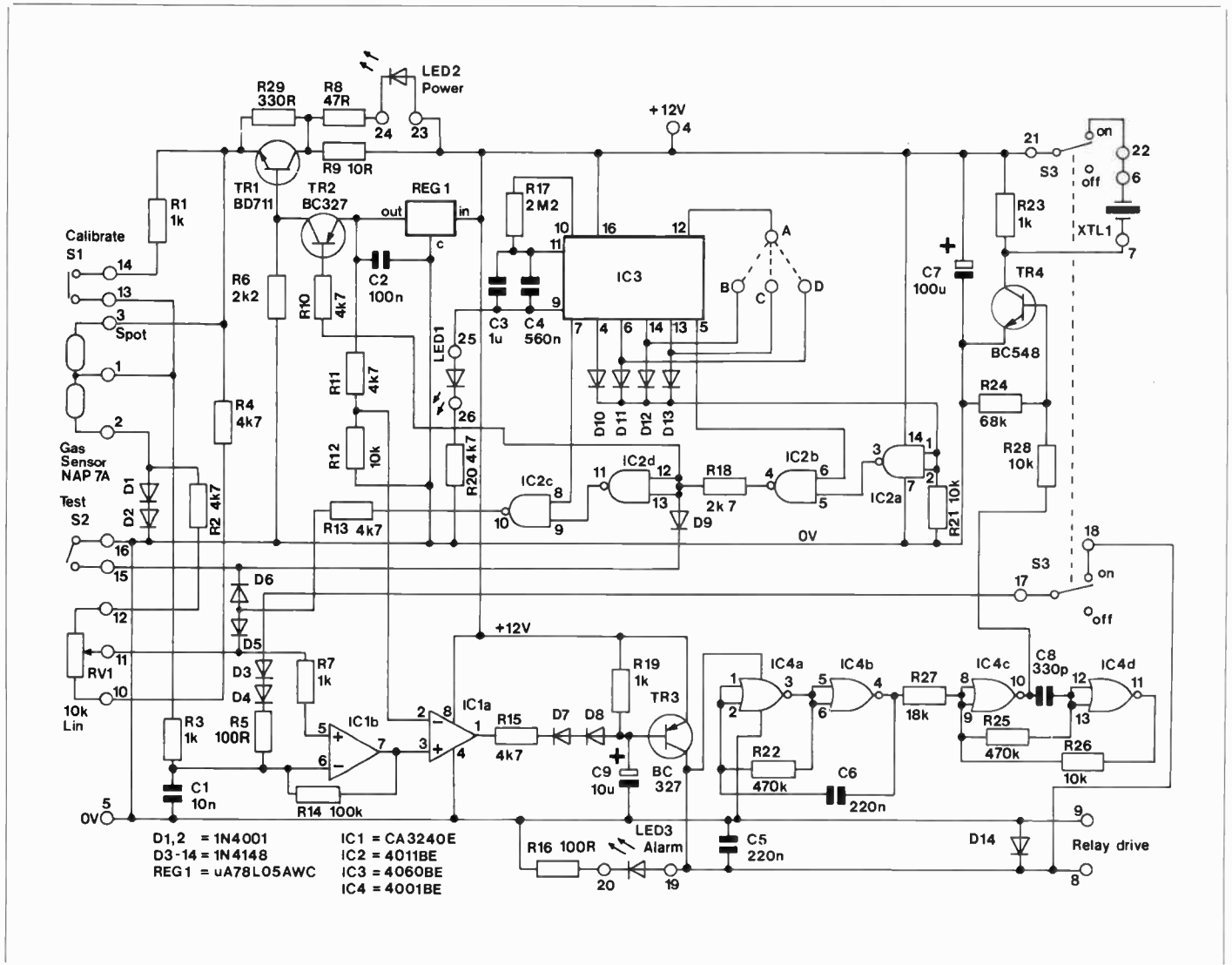


Figure 1. Circuit diagram of Gas Alarm

base current for the power switching transistor (TR1) via TR2, which forms part of the control circuit, fed from IC3.

The TEST switch (S2) overrides the timer connecting power to the sensors and also enabling the alarm circuit. LED2 lights whenever current is drawn by the sensors and will be on continuously when S2 is in the TEST position. Note that when the alarm is working, LED2 will only be on for the 80 seconds of the test period during each test cycle. LED3 gives an indication of an alarm even when the ALARM CANCEL switch (S3) is operated and is used for setting up purposes. LED 1 flashes at clock rate and is an indication that the timer is running.

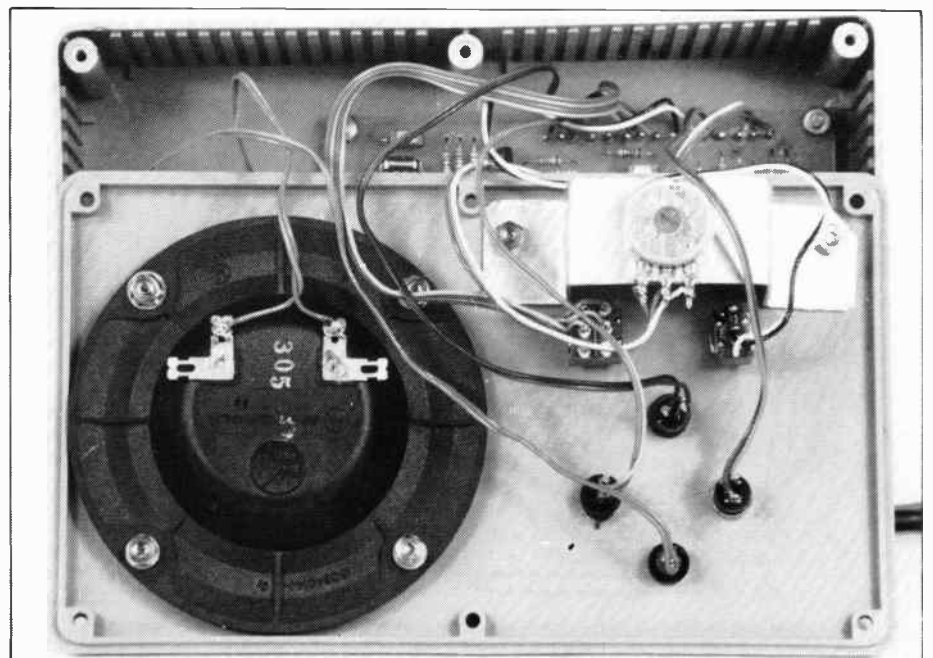
Construction

Construct the circuit board referring to the Parts List and component overlay on the board. Ensure the correct polarity of all diodes, transistors, integrated circuits and electrolytic capacitors. The sensors should be mounted carefully on their board, avoiding excessive heat and making sure that the one marked with the spot is in the correct position. The required amount of cable should be connected to the sensor board at this stage but not terminated on the main board before testing.

Setting Up and Testing

Connect the 10 ohm test resistor provided with the kit in place of the sensors (between pins 2 and 3). Switch S3 to ALARM OFF and S2 to TEST. Connect 12-24V to the unit and observe LED1; this should flash regularly at about once

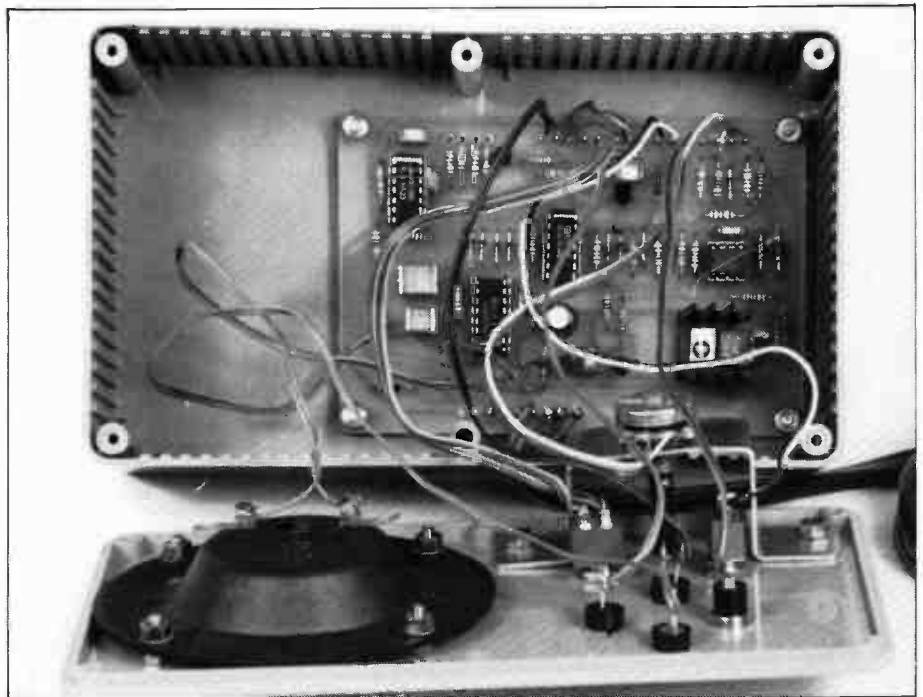
every 4 seconds. Connect a multimeter; set to a range that reads up to 10V, between -V battery supply (pin 5) and pin 3 (also connected to one end of test resistor). A reading of between 4.1 and 4.6 volts should be obtained at this point. Transfer the meter to pin 2; a reading of 1.4 to 1.8 volts should be measured.



NOTE, if these readings are not correct DO NOT connect the sensors. WARNING, the test resistor will become HOT during this test.

When the above conditions are correct, disconnect the supply and remove the test resistor. Connect the sensor cable ensuring correct location of wires. Re-apply power and check that LED2 (Green) is on. When current is first applied to the sensors, a slight smell of burning may be noticed; this is quite normal. Turn RV1 fully clockwise; in this position LED3 (Red) should be out. Wait 20 seconds then rotate RV1 slowly anti-clockwise until LED3 is just on. Very carefully rotate RV1 clockwise again until the LED is just extinguished but can be made to light by pressing the CAL button. This process must be done with extreme care if maximum sensitivity is to be obtained.

Disconnect the power for about 1 minute. When the power is re-applied, the ALARM LED should light immediately but go out after a maximum of 30 seconds. If the LED remains on after this period, slightly re-adjust RV1 anti-clockwise but make sure the above test conditions are met. Check that the alarm sounds when the ALARM LED is alight and S3 is normal. The unit is now ready for use, but a further test may be carried out under actual working conditions. Place the



sensor board in a container of about 5 litres capacity (e.g. a large ice-cream container) and arrange a loose fitting card lid to cover it. Fill a small container of about 65cc (e.g. a small aerosol lid) capacity with butane from an ordinary

gas cigarette lighter and cover with card or a sheet of paper. With the alarm set, carefully slide the lid from the small container and pour the gas (Butane is heavier than air) into the large container; then cover this container. The alarm

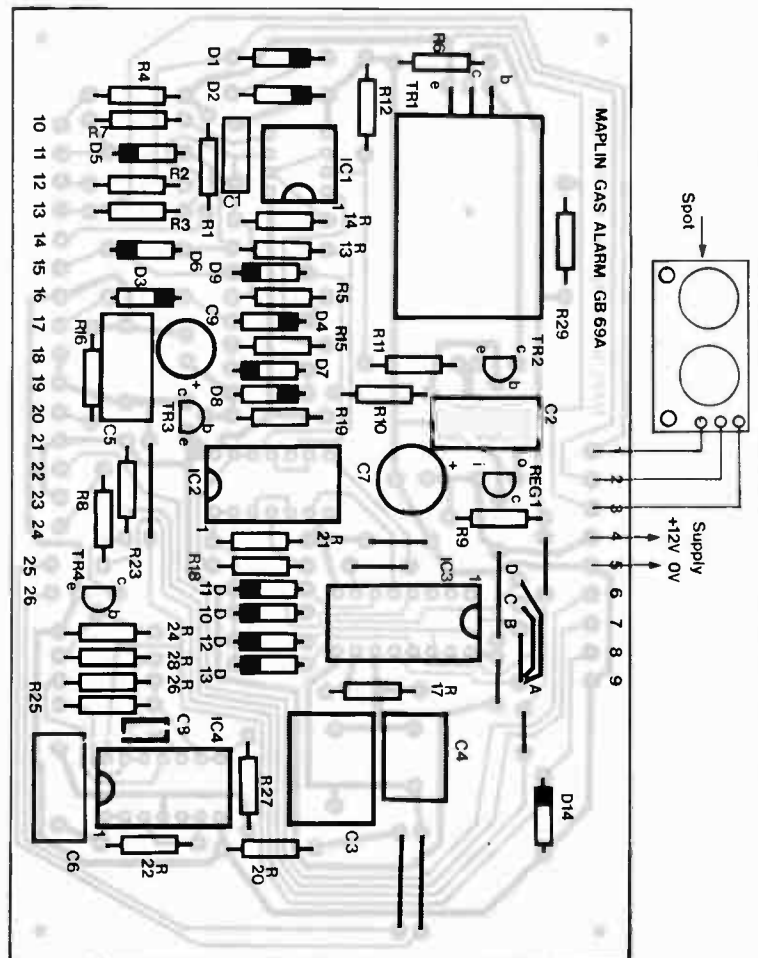
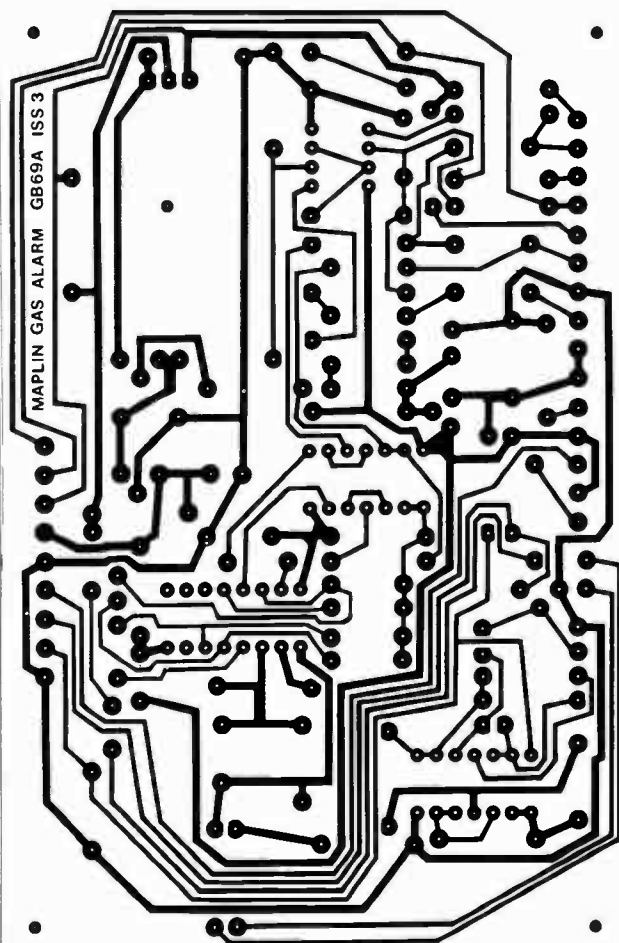


Figure 2. Track layout of main PCB

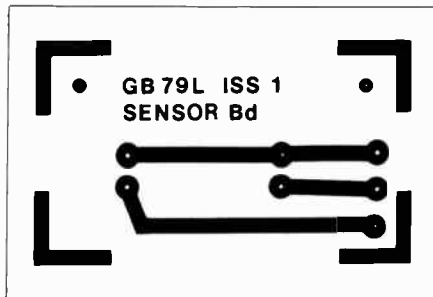


Figure 3. Gas Sensor PCB

should sound within a maximum of 6 minutes and remain latched until reset by S3. **WARNING**, do not carry out this test near a naked flame, near incandescent material or when smoking!

Installing the Alarm

The sensor board may be located up to 5 metres from the main alarm unit. Most common explosive gasses are heavier than air and therefore the sensors should be located at the lowest point where gas will collect. A free flow of air must be provided around the sensors and they must be kept free from contamination by oil or water. This alarm system is primarily designed for use in boats where power is supplied from a battery,

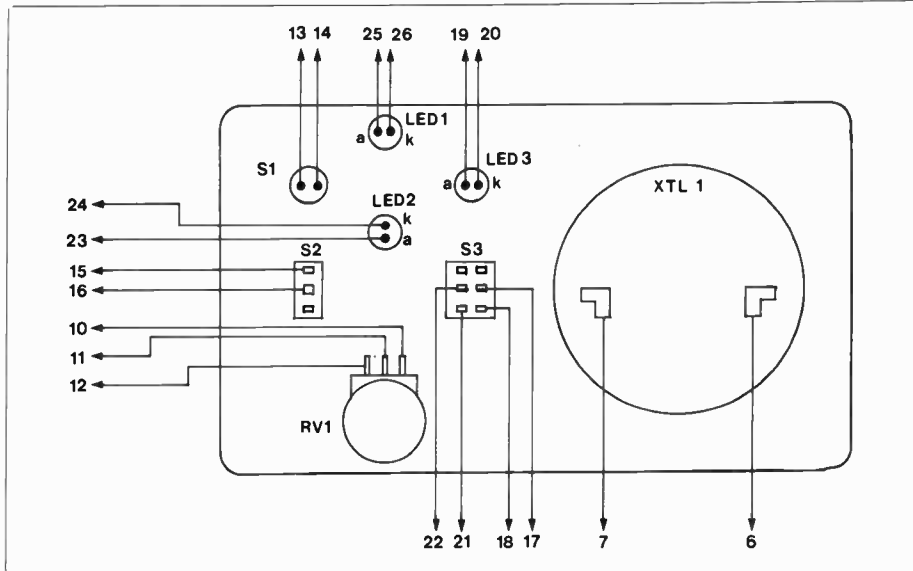
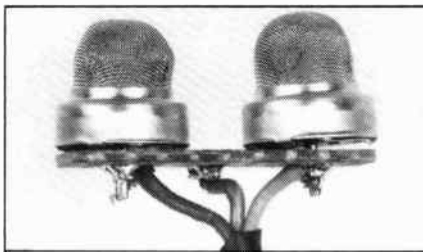


Figure 5. Wiring diagram



but it could also be used in the home when fed from a suitable mains power supply (requiring about 800mA at 12 volts). Finally, when gas is encountered, remember to ventilate the area well and beware of any form of ignition from naked flames, cigarettes, hot surfaces, sparks from electrical switching or other causes.

EXPLOSIVE GAS ALARM PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1,3,7,19,23	1k	5	(M1K)
R2,4,10,11,13,15,20	4k7	7	(M4K7)
R6	2k2	1	(M2K2)
R8	47Ω	1	(M47R)
R9,RT	10Ω	2	(M10R)
R12,21,26,28	10k	4	(M10K)
R14	100k	1	(M100K)
R5,R16	100Ω	2	(M100R)
R17	2M2	1	(M2M2)
R18	2k7	1	(M2K7)
R22,25	470k	2	(M470K)
R24	68k	1	(M68K)
R27	18k	1	(M18K)
R29	330Ω	1	(M330R)
RV1	Pot Lin 10k	1	(FW02C)

CAPACITORS

C1	Poly Layer 10nF	1	(WW29G)
C2	Poly Layer 100nF	1	(WW41U)
C3	Poly Layer 1μF	1	(WW53H)
C4	Poly Layer 560nF	1	(WW50E)
C5,6	Poly Layer 220nF	2	(WW45Y)
C7	PC Elect 100μF 25V	1	(FF11M)
C8	Ceramic 330pF	1	(WX62S)
C9	PC Elect 10μF 100V	1	(FF05F)

SEMICONDUCTORS

D1,2	1N4001	2	(QL73Q)
D3-14	1N4148	12	(QL80B)
TR1	BD711	1	(WH15R)
TR2,3	BC327	2	(QB66W)
TR4	BC548	1	(QB73Q)
REG1	μA78L05AWC	1	(QL26D)
IC1	CA3240E	1	(WQ21X)
IC2	4011BE	1	(QX05F)
IC3	4060BE	1	(QW40T)
IC4	4001BE	1	(QX01B)

MISCELLANEOUS

LED1	LED Yellow	1	(WL30H)
LED2	LED Green	1	(WL28F)
LED3	LED Red	1	(WL27E)
	LED Clip 5mm	3	(YY40T)
S1	Push Switch	1	(FH59P)
S2	Sub-Min Toggle A	1	(FH00A)
S3	Sub-Min Toggle E	1	(FH04E)
	Gas Detector Sensor	1	(FM87U)
	Gas Detector PCB	1	(GB69A)
	Gas Alarm Sensor PCB	1	(GB79L)
	Pin 2145	1 Pkt	(FL24B)
	Vaned Heatsink Plas Pwr	1	(FL58N)
	DIL Socket 8-pin	1	(BL17T)
	DIL Socket 14-pin	2	(BL18U)
	DIL Socket 16-pin	1	(BL19V)
XTL1	Direct Radiant Piezo	1	(WE54J)
	7/0-2 Wire 10m Blk	1 Pkt	(BL00A)
	Bolt 6BA 1/2in.	1 Pkt	(BF06G)
	Nut 6BA	1 Pkt	(BF18U)
	Instruction Leaflet	1	(XT47B)
	Constructors' Guide	1	(XH79L)

OPTIONAL

Case	1	(LH62S)
Knob K7B	1	(YX02C)
Fittings	As Req.	

The above items (excluding Optional) are available as a kit.

Order As LK60Q (Explosive Gas Alarm Kit)

The following items (which are included in the kit) are also available separately.

Gas Detector PCB Order As GB69A
Gas Alarm Sensor PCB Order As GB79L
Gas Detector Sensor Order As FM87U

LOW POWER RADIO CONTROL SYSTEM

- ★ 27MHz Operation For Ground-Based Model Control
- ★ Two Positive Pulse PWM Channels
- ★ Two Digital On/Off Channels

Since 1981 and the legalising of Citizens Band Radio on 27MHz, the licensing requirement for model radio control is no longer operative. However, certain conditions apply to both users of this band, and for RC modellers this means that signal transmissions must be within the frequency range 26.96MHz to 27.28MHz at a maximum mean power of 1.5W. Higher frequencies on this band are used for CB transmissions. The 35MHz band (35.005 to 35.205) is also available for radio control, but for use with model aircraft only – not ground-based models, and the 458MHz band would be complex for constructors to set up and align. Therefore a 27MHz system is used with limited power output and receiver sensitivity to avoid interference both to and from other users on the band.

Transmitter

The simple transmitter design of Figure 1, centres on IC1 which basically consists of three sections namely: frame and pulse timing; logic encoding and modulation; RF and output stage. Although capable of six channel operation the design utilises two channels (1 and 2) for pulse width modulation (PWM) and four channels for encoded digital

by Dave Goodman



(on/off) information. A train of six pulses (Figure 3) is generated every 20ms (50Hz) from the frame timer, C5 and R4 and 4.6V reference supply at IC1 pin 4. C5 is allowed to alternately charge and discharge by an internal comparator switch to generate the 20ms frame which starts the pulse timer C6 and R1 at IC1 pin 8.

The internal encoder provides six discharge paths for C6 at IC1 pins 18, 17, 16, 1, 2, and 3 – R2 providing a fixed time constant for channels 3 to 6 (pins 1 and 16 to 18) and RV1 and RV2 variable time constant for channels 3 to 6 (pins 1 and 16 to 18) and VR1 and VR2 variable time constants for channels 1 and 2. The serial pulse output from the encoder appears at pin 12 where C8 modulation filter capacitor is added to improve the transmitted carrier bandwidth. This is desirable where adjacent carrier channels are 10 to 15kHz apart instead of the more usual 50kHz separation. From IC1 pin 13, an internal emitter follower buffers the pin 12 modulation signal and supplies the collector of an internal NPN transistor at pin 11. IC1 pin 10 is the base connection for this transistor and drive current is supplied by R5. X1 is a third overtone crystal connected between base pin 10 and tuned circuit C10, C11, and L1 primary.

Aerials

When calculating wavelength for 27MHz, the optimum aerial length is approximately 17ft. – hardly practical for a hand-held portable transmitter! Aerials of half, quarter, or sixteenth wavelength are far more practical, these being some 8½ft., 4ft., and 2ft. in length, but do not radiate as efficiently. A dipole system could be used, where a telescopic aerial is connected to L2 and an equal length of wire connected to 0V is left to hang towards ground. The aerial's capacitance would change as the wire is moved and transmissions become irregular so either centre or base loading of the aerial becomes desirable. Centre loading requires a telescopic aerial to be centrally cut and a coil inserted between both halves, whereas base loading, although not as efficient, does allow the impedance of the load at the feed point of the RF output stage to be adjusted, thus improving signal strength. With the output stage components as Figure 1, distances of 50 to 100 yards are possible depending upon terrain or surroundings.

Construction

Refer to the overlay and Figure 6. Pin 6 on the overlay is not used, as L2 fits over this position. Identify and insert resistors R1 to R5. Next insert capacitors C1 to C11. C1 is polarised and its + lead must align with the legend. C10 and C11 are a little large and will require being offset slightly to facilitate fitting. Ensure these components are pushed down as close as possible to the PCB. Solder all leads and cut off excess wire ends. Insert the crystal holder and IC1. Pin 1 is immediately below the circular indentation close to one corner of the package. Insert Veropins 1 to 5 and 7 to 9 and solder these and all remaining components.

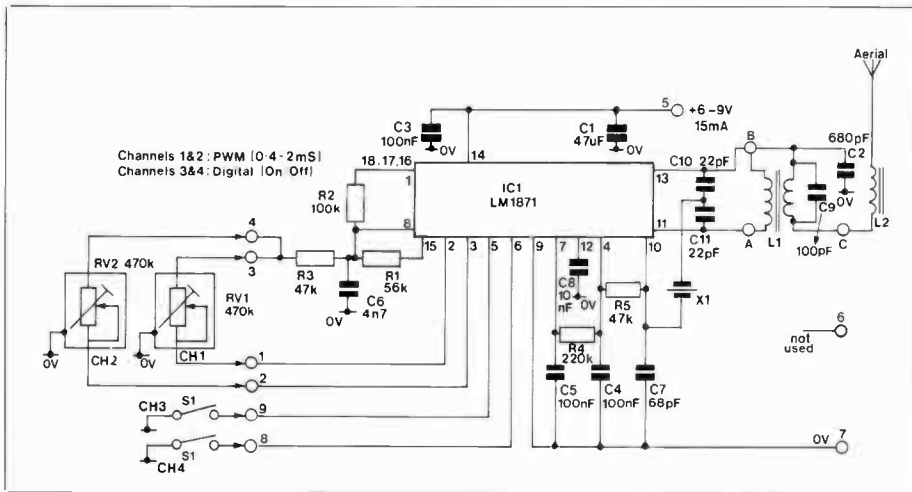


Figure 1. 27MHz Transmitter circuit diagram

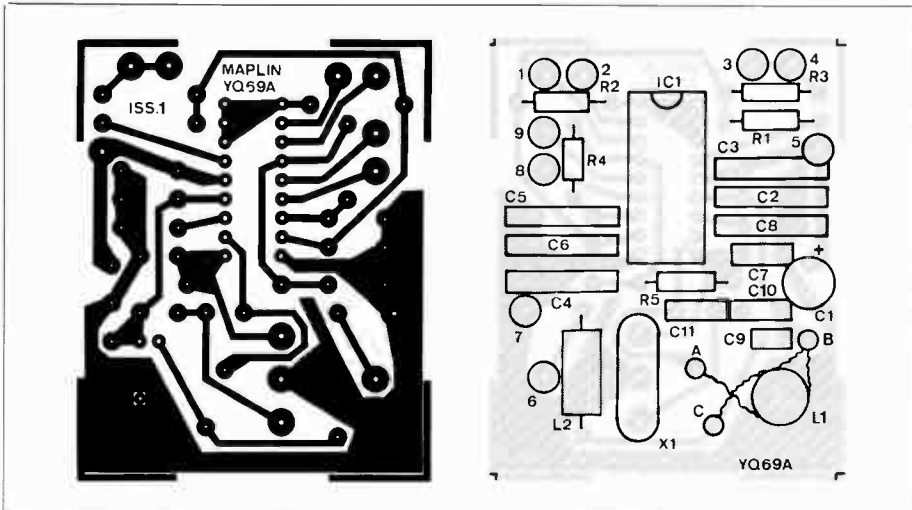


Figure 2. Track layout and overlay of Transmitter PCB

When the modulation output is high (+3.8V) at pin 13, the collector pin 11 and tuned circuit are pulled up into the active range of the internal transistor. RF feedback is via the crystal and pin 10, causing the tuned circuit to resonate at the desired frequency. Because third overtone crystals are used in this application a tuned collector load must be used to guarantee operation at the correct frequency. Tuning L1 by moving its dust core in and out of the former has very little effect on oscillator frequency, but does vary the angle of conduction and hence oscillator efficiency and harmonic suppression.

C3 and L1 secondary are also tuned to 27MHz and dust core adjustment determines coupling between both coils. For precise PWM detection it is necessary to produce a high on/off ratio when modulating the carrier. When modulation from pin 13 is low, crystal X1 continues to oscillate for some 500µs due to the high Q characteristics of the circuit. This 'ringing-on' would reduce the carrier modulation depth and C7 damps the crystal during this time; short carrier off times also help overcome this problem, but require X1 to be isolated from the aerial circuit, hence the split tuning capacitors C10 and C11. L2 further low-pass filters the transmitted carrier, thus reducing upper harmonic content and doubles as a base loading coil for the aerial.

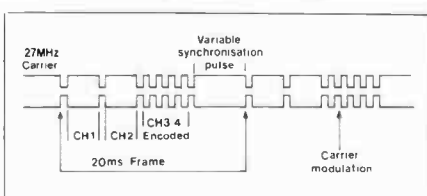
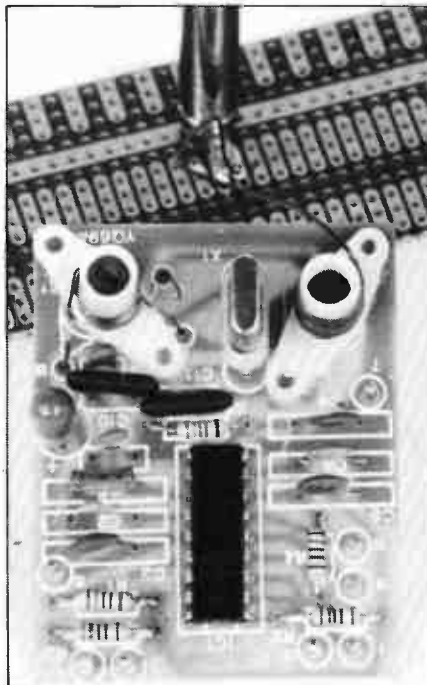


Figure 3. Transmitter envelope

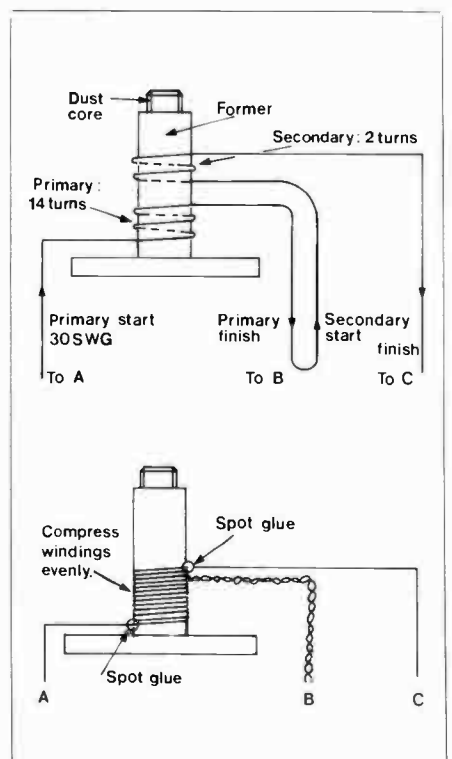


Figure 4. Winding details for coil L1



Good, accurate soldering is required if problems are to be avoided and cleaning the back face with thinners will help when inspecting the work.

Coil Winding (L1)

Both L1 and L2 have to be wound by hand. Although this may appear a daunting task, it is really not that difficult. For L1 you will need 1 metre (3ft.) of 30swg enamelled copper wire, a 7mm former and dust core and a tube of fast drying glue such as cyanoacrylate. Before construction examine Figure 4 to familiarise yourself with the turns requirements.

Primary winding A is begun at the base and fourteen complete turns wound up the tube. It does not matter which direction is chosen to wind the coil as long as both primary and secondary turns are in the same direction. It may be helpful to use the former's base mounting holes as wire anchor points when starting and finishing the coil as this will prevent the wire from unwinding until firmly glued. Once you have wound the primary coil, compress the windings together as shown and take up any slack by pulling the loose ends tight.

Apply a small amount of glue to the beginning and end of the coil and leave to harden. The finish wire from L1 primary is also the start for L1 secondary and allowance must be made for connecting it to point B on the PCB by looping the wire out a few inches. Continue winding up the tube in the same direction as before for two complete turns. There should now be two single wire ends (A & C) and a double wire (B) extending from the coil. Again, apply spots of glue to both start and end windings of L1 secondary and leave to harden.

Coil Winding (L2)

For L2 you will need 1 metre (3ft.) of 24swg enamelled copper wire and a 7mm former with dust core. Winding procedure is similar to L1 except that a single coil of 12 turns is wound up the tube starting 2mm from the base as shown in Figure 5. Because this wire is thicker, it will be necessary to remove any kinks by gently stretching the length before winding, else the coil will be difficult to compress neatly. The 2mm gap is not critical and the coil could be wound centrally along the tube if desired. A small allowance should be made though for tuning purposes. Glue the start and end windings as before and leave to harden.

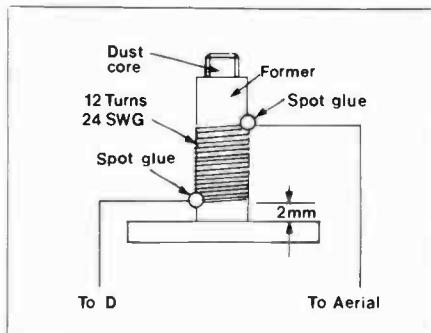


Figure 5. Winding details for coil L2

Mounting L1 & L2

Space is rather limited on the PCB, therefore both coils are mounted diagonally inwards from the right-hand corners as shown in Figure 6. Apply glue to each former base and stick the assembly in position. When mounting L1, be careful not to cover holes A and C and for L2 keep hole D clear. Leave both to harden before inserting the dust cores in case excess glue jams the threads. Insert a wire nearest to the base of L2 into hole D, then scrape off the enamel coating and tin with a soldering iron before soldering to the pad. On L1, insert the centre double wire into hole B, the primary start wire nearest the former base into hole A and the secondary finish, or topmost wire, into hole C. Each wire length from coil to terminating point should be kept short

and direct otherwise tuning may be affected. When soldering these connections, heat the wire close to its pad and apply solder. The enamel will melt allowing contact with the copper to be made, then solder in place. Finally remove excess wire ends and fit crystal X1.

Choice of Crystal

Table 1 lists six available channel frequencies. These crystals come as Tx/Rx (Transmit/Receive) pairs and the frequency is stamped on the body of each one. Choose the channel to be used and insert a crystal marked with the higher frequency into the socket on the transmitter PCB. The lower frequency fits into the receiver which is explained later.

Channel	Transmit frequency	Receive frequency	Code
Brown	26.995MHz	26.540MHz	HX30H
Red	27.045MHz	26.590MHz	HX31J
Orange	27.095MHz	26.640MHz	HX32K
Yellow	27.145MHz	26.690MHz	HX33L
Green	27.195MHz	26.740MHz	HX34M
Blue	27.245MHz	26.790MHz	HX35Q

455kHz IF and 50kHz channel spacing.

Table 1. Radio control matched crystal pairs.

Notes on Assembly

A close inspection of all components, assemblies and solder joints is worthwhile before applying power to the project. Ensure all components are fitted as closely to the PCB as possible and all leads are correctly soldered. Check for short circuits across the tracks and clean off any flux that may have accumulated. Many projects fail due to poor assembly detail and bad soldering, so be fastidious at this stage if problems are to be avoided!

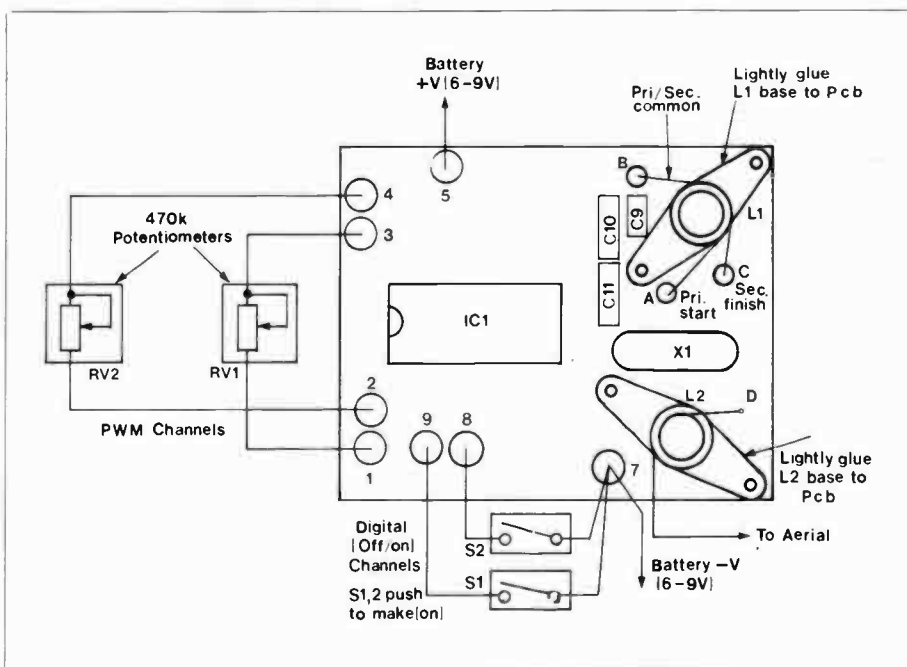


Figure 6. Wiring to Transmitter PCB

Wavemeter

Unfortunately, accurate adjustment of simple transmitters such as this does require test equipment other than a multimeter. A dedicated wavemeter, or grid dip meter that can be used as a wavemeter, is required for peaking L1 and L2. These items can be costly if not readily available so a simple circuit is given in Figure 7. If intending to build this circuit, it should be pointed out that no PCB is available and construction is a matter of choice. Figure 7B shows the prototype layout which was built on 0.1in. matrix Verostrip board. All components should be kept in close proximity with each other and the aerial soldered upright at its base. The coil is close wound on a 7mm former using 24swg enamelled wire (similar to L2, but without a dust core fitted). Make a small loop on top of the 18swg aerial wire and solder its base to the junction of L1, C1 and the diode. The circuit resonates at 27MHz and the meter indicates when a signal is being transmitted, but is not calibrated for field strength, and can only be used as a guide to maximum efficiency.

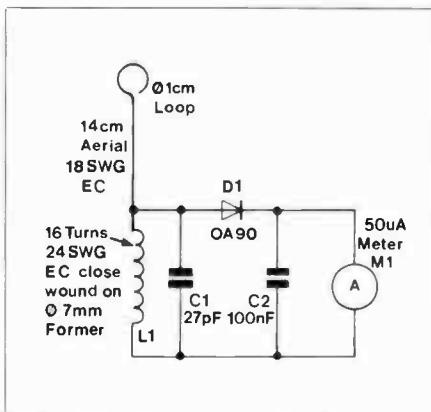


Figure 7A. Circuit diagram of a simple Wavemeter

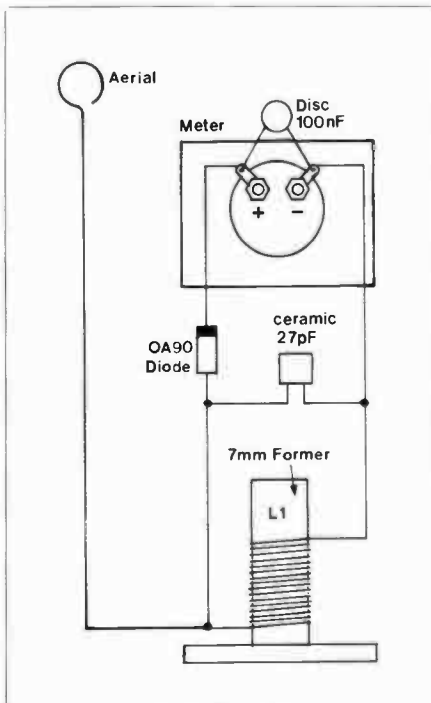


Figure 7B. Wiring diagram of simple Wavemeter

Testing the Transmitter

Connect RV1 between pins 1 and 3, and RV2 between pins 2 and 4 on the transmitter PCB (Figure 6). Connect the pot wiper to one of the resistance ends as shown in each case so that when turned its value is varied from 0Ω to 470kΩ. S1 and S2, if used, are wired between 0V (pin 7) and pin 8 or 9 as shown. These switches should be push-to-make and either latching or momentary action to suit requirements. Table 2 gives the result of S1/2 operation and approximate values for RV1/2. Current consumption of the transmitter is 10-15mA at 9V so a PP3 could be used for short periods. For preference use 6 AA size ni-cads (see Parts List) and a PP3 clip.

Connect the battery negative (black lead) to pin 7 and a multimeter between battery positive (red lead) and pin 5. The remaining wire end from coil L2 should be cut off allowing three inches extending from the coil. Place the pick-up from a wavemeter close to L2 or twist two turns of L2 round the aerial wire if using the Figure 7 circuit. Apply power and monitor the current on the multimeter set

to read milliamps. Screw down the dust core of L1 in a clockwise direction and check the wavemeter reading which should gradually increase to a maximum field strength and minimum current which will be around 13mA. The Figure 7 meter should read close to half scale (10-30). Screw L2 core clockwise down into the former and the wavemeter reading should gradually increase then decrease. Finally readjust both L1 and L2 for maximum field strength and minimum current readings. As a guide, the prototype unit peaked at 12.98mA with 9V supply and a reading of 35 on the Figure 7 wavemeter. These figures will of course vary between different transmitters, but give an idea of what to expect.

If the current reading does not change when tuning and the wavemeter gives no indication, recheck RV1 and RV2 connections again as modulation stops if these connections are missing. No constant RF carrier is developed; it is only there when modulation is present. Check that crystal X1 is fitted correctly into its socket and L1 has been wired up correctly to the appropriate terminals. No

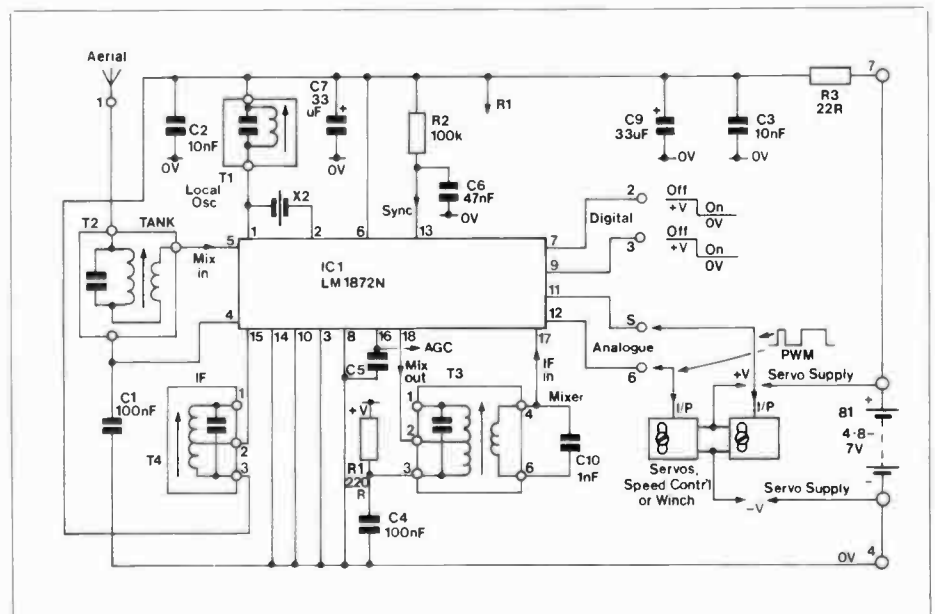


Figure 8. 27MHz Receiver circuit diagram

Best of Maplin

PROJECTS

XC04E

BOOK



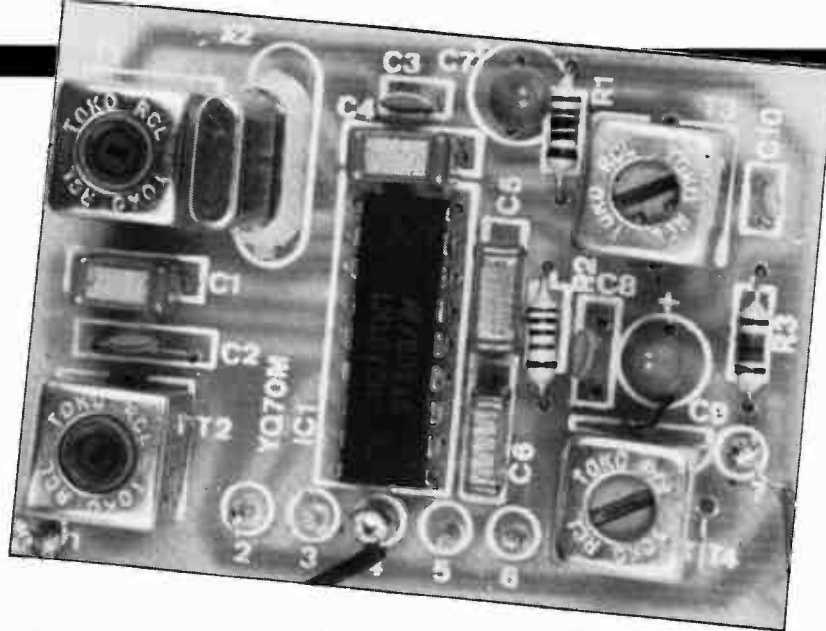
- ★ Explosive Gas Alarm
- ★ Low Power Radio Control System
- ★ Live-Wire Detector
- ★ Display Driver Module
- ★ Control-A-Train
- ★ Z80 CPU Module
- ★ Hex Keypad for Z80 Module
- ★ Ultrasonic Car Alarm
- ★ 3-Way Active Crossover
- ★ Mains Tx/Rx Driver Module
- ★ 16-Channel Logic Tester

current or excessively high current readings could indicate anything from flat batteries to faulty meter leads or more serious PCB faults and further assistance must be sought. For constructors with oscilloscopes, connect a high impedance probe – preferably below 10pF capacitance to the aerial wire from L2 or wind a few turns of insulated wire around L2 connecting one end to 0V and the other to the probe. A waveform similar to Figure 3 (without the 1ms channel 3 and 4 pulses) should be displayed. If the scope bandwidth is low then you will only see the modulation present from IC1 pin 13.

Receiver

Figure 8, the circuit diagram, shows the receiver and external connections. Transmitted 27MHz signals are picked up by the aerial and coupled to the mixer via tank coil T2. This coil effectively keeps strong out-of-band signals like TV and FM broadcasts from cross-modulating with the required signal. A local oscillator consisting of T1 and X2 connects via IC1 pins 1 and 2 to the internal mixer section where the local oscillator and aerial signals are mixed at T3 primary (pin 18). The stepped down signal appears on IC1 pin 17 which is the intermediate frequency (IF) input. IF tuning is performed by T4. In the case of using 'blue band' crystals for example, the transmitter frequency will be 27.245MHz and the receiver local oscillator will run at 26.790MHz. When these two signals are present at the mixer, a difference signal is produced, in this case 27.245 – 26.790MHz = 455kHz. This is true for all crystal pairs which is why matching is important. The 455kHz signal or IF (since it is intermediate between the input RF frequency and the desired audio frequency) is recognised by a tuned bandpass filter T4, which only responds to frequencies in the range 455kHz ±3.2kHz (3dB). Sum and difference signals above 460kHz and below 450kHz are not amplified and become ineffective. This is basically how superheterodyne receivers, of which this is an example, function.

Pulsing the transmitted carrier on and off at set intervals will result in the IF producing a DC pulse related to this carrier modulation from an internal-detector within IC1. The detected signal is compared with an internal voltage reference so that whenever the peak IF exceeds 25mV, a comparator resets the internal digital envelope circuitry. This threshold level can vary according to the distance between the transmitter and receiver, which can result in high IF signal levels being developed. To minimise this, automatic gain control (AGC) is used to regulate the peak carrier level to 100mV by comparing it with an internal 100mV reference. An error signal is then produced which determines the gain of the IF amplifier at C5 pin 16. Digital outputs pins 2, 3, 5 and 6 are decoded and generated within IC1. Both pin 2 (channel 3) and pin 3 (channel 4) are normally high



or positive and active low, so that a negative pulse is produced whenever S1 or S2 are operated at the transmitter end. See Table 2. Pin 5 (channel 1), controlled by RV1 (pins 1 and 3) on the transmitter, develops a positive pulse output, whose width is 0.3ms to 2.0ms, every 20ms. Similarly, pin 6 (channel 2) is controlled by RV2 (pins 2 and 4) with the same duration positive pulse variation. Both channels are independent of one another

and do not affect operation of channels 3 and 4 (see Table 3).

Construction

Identify and fit the three resistors R1 to R3. Insert IC1 and solder all leads onto their pads. Cut off excess wires and fit C2, 3, 8 and 10 followed by the remaining capacitors. C7 and 9 are both polarised and their positive leads must align with the PCB legend. Fit crystal socket for X2 and Veropins 1 to 7. Again solder all components and remove excess wire ends. Correctly identify T1 to T4. Identification codes appearing in the Parts List are printed on the side of the metal cans. These components can only be fitted one way round, but some may have extra wide screen terminals connected to the metal can. If so it will be necessary to trim a small amount from the width with a pair of cutters. Carefully solder the 20 coil terminals and 8 screen terminals onto the PCB. As mentioned in the transmitter construction, clean and inspect the back face of the PCB carefully before proceeding.

Transmit	Receive
RV1 or RV2 resistance	Pin 5 or 6 pulse width
0Ω	0.3ms
50kΩ	0.5ms
200kΩ	1.0ms
330kΩ	1.5ms
480kΩ	2.0ms
S1 open	Pin 2 high (+V)
S1 closed	Pin 2 low (0V)
S2 open	Pin 3 high (+V)
S2 closed	Pin 3 low (0V)
Frame rate = 20ms	
Repetition frequency = 50Hz	

Table 2. Transmit-to-receive characteristics

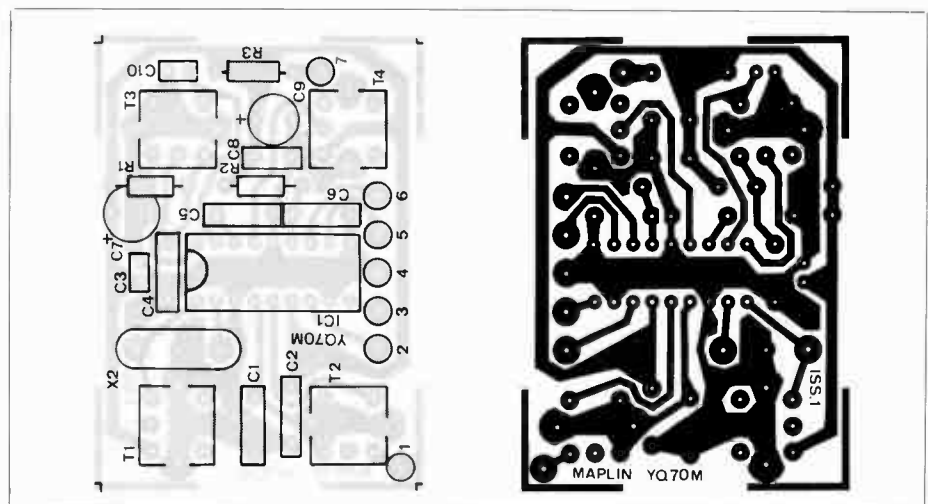


Figure 9. Track layout and overlay of Receiver PCB

Transmitter	Receiver	Description	Uses
RV1 – Pins 1 and 3	Pin 5	Channel 1 PWM O/P	Drives servo's, speed controllers and yacht winches.
RV2 – Pins 2 and 4	Pin 6	Channel 2 PWM O/P	
S1 – Pin 9 and 0V	Pin 2	Channel 3 Digital O/P	Active low operation, TTL compatible. Drives loads above 22kΩ.
S2 – Pin 8 and 0V	Pin 3	Channel 4 Digital O/P	

Table 3. Pin connections and channel functions

Testing the Whole System

It is likely that you will wish to use the transmitter as a hand-held device and operate a model of some kind. Therefore a suitable case is required in which to mount the transmitter PCB, batteries, pot's and switches. Although it is a matter of taste, it is suggested that a small plastic box be used, large enough to accommodate the hardware and small enough to hold comfortably. A static system could best employ a metal box for better ground plane effect and hence possible increased range, especially with a larger transmitting aerial (see Aerials section). Whatever system is employed, re-tuning of L1 and L2 will have to be done after boxing up as tuning will be altered according to the proximity of additional components and your hand. Repeat the transmitter setting up procedure as before for optimum results. Leave the transmitter operating at a level of three to four feet above ground. Hold the working receiver with aerial attached and battery

pack in one hand and move away from the transmitter. The earpiece buzz will most certainly stop after a while. Go back to the last working position and adjust T2 for maximum volume. Adjust T1 if necessary and continue moving away from the transmitter. Now T3 and T4 can be peaked for maximum. You will find that as the distance is increased, tuning becomes sharper and slug variations become smaller. In this way the optimum can be found for both transmitter and receiver.

Using the System

PWM output signals from either pins 5 or 6 (Rx PCB) will operate our servo and speed control projects for model boat and car applications. Because of the high power output from the transmitter, it is definitely not recommended that free-flying models be used as two or three pounds of balsa wood and aluminium hurtling out of the sky can be extremely dangerous! It is possible though for this

project to be used with robotics models, with a microcomputer replacing S1, S2, RV1 and RV2 via a digital or D to A interface.

Testing the Receiver

Insert the lower frequency crystal, from the selected pair, into the holder. Connect the PP3 clip with positive (red) to pin 7 and negative (black) to pin 4. Solder an M3 tag onto pin 1 and bolt a telescopic aerial to the lug with a 12mm M3 bolt. Aerials of 1 to 2 feet in length should be satisfactory for short distance use. 20swg wire could be used, but a telescopic aerial is easier to manage. With the recommended trimming tool, turn T1 and T2 tuning slugs until they are level with the can top plate. Screw T1 clockwise into the former for 2 full turns and T2 for 3 full turns. Carefully turn T3 slug anticlockwise as far as it will go, and then turn it clockwise - down into the former - for 1 1/4 turns. Do the same to T4. These settings are approximate to begin with and readjustment will be necessary

text and parts continued on back page

27MHz TRANSMITTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1	56k	1	(M56K)
R2	100k	1	(M100K)
R3,5	47k	2	(M47K)
R4	220k	1	(M220K)

CAPACITORS

C1	Tant 47µF 16V	1	(WW76H)
C2	Ceramic 680pF	1	(WX66W)
C3,4,5	Minidisc 0.1µF 16V	3	(YR75S)
C6	Ceramic 4700pF	1	(WX76H)
C7	Ceramic 68pF	1	(WX54J)
C8	Poly Layer 10nF	1	(WW29G)
C9	Ceramic 100pF	1	(WX56L)
C10,11	Mica 22pF	2	(WX05F)

SEMICONDUCTORS

IC1	LM1871	1	(YY71N)
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MISCELLANEOUS

	Former 351	2	(LB17T)
	Dust Core Type 6	2	(LB42V)
	PCB	1	(YQ69A)

OPTIONAL X1

Crystal Socket 25µ	1	(HX60Q)
EC Wire 0.315mm 30swg	1 Reel	(BL40T)
EC Wire 0.56mm 24swg	1 Reel	(BL28F)
Pin 2141	1 Pkt	(FL21X)
Instruction Leaflet	1	(XK09K)
Constructors' Guide	1	(XH79L)

MCR Crystal (see Table 1)	1	(HX30H-HX35Q)
Aerial 8-section	1	(RK48C)
Aerial 6-section	1	(RK49D)
PP3 Clip	1	(HF28F)
Battery Holder 9V	1	(HQ01B)
Battery AA Ni-Cad	6	(YG00A)
Trimming Tool TT5	1	(BR50E)
Pot Lin 470k	2	(FW07H)
Push Switch	2	(FH59P)

The above items (excluding Optional) are available as a kit.

Order As LK55K (27MHz Transmitter Kit)

The following item (which is included in the kit) is also available separately.

LM1871 Xmitter PCB Order As YQ69A

27MHz RECEIVER KIT PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1	220Ω	1	(M220R)
R2	100k	1	(M100K)
R3	22Ω	1	(M22R)

CAPACITORS

C1,4,5	Poly Layer 100nF	3	(WW41U)
C2,3,8	Monores Cap 10nF	3	(RA44X)
C6	Poly Layer 47nF	1	(WW37S)
C7,9	Tant 33µF 10V	2	(WW74R)
C10	Ceramic 1000pF	1	(WX68Y)

SEMICONDUCTORS

IC1	LM1872	1	(YY72P)
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MISCELLANEOUS

T1,2	Toko CSK3464	2	(YG31J)
T3	Toko YRCS12374	1	(YG30H)
T4	Toko YMCS17104	1	(YG32K)

OPTIONAL X2

PCB	1	(YQ70M)
Crystal Socket 25µ	1	(HX60Q)
Pin 2141	1 Pkt	(FL21X)
Instruction Leaflet	1	(XK09K)
Constructors' Guide	1	(XH79L)

MCR Crystal (see table 1)	1	(HX30H-HX35Q)
Aerial 8-section	1	(RK48C)
Aerial 6-section	1	(RK49D)
PP3 Clip	1	(HF28F)
Battery Holder 6V	1	(HF29G)
Battery AA Ni-Cad	4	(YG00A)
Trimming Tool TT5	1	(BR50E)
Crystal Earpiece	1	(LB25C)

The above items (excluding Optional) are available as a kit.

Order As LK56L (27MHz Receiver Kit)

The following item (which is included in the kit) is also available separately.

LM1872 Receiver PCB Order As YQ70M

LIVE WIRE DETECTOR



by Dave Goodman

The Maplin Live-Wire Detector is a fascinating and novel device which will detect the presence of mains electricity whether there's a current flowing or not. It's better than neon screwdrivers or multimeters because you do not have to make contact with the wire - it signals the presence of mains up to two inches (5cm) away and better than metal detectors, because it only indicates if the wire is live; also it's considerably cheaper.

A Most Useful Instrument

It's the sort of device every household should own and anyone can use it because you don't have to actually touch dangerous points with any part of the Live-Wire Detector. Even if the wires are not connected to anything at one end, Live-Wire will tell you if they're live. You could use it to find buried wires in dry plaster or plastic conduit or under floor or ceiling boards, though keep in mind that its sensitivity is only about two inches, so don't put a four inch nail where there was a negative reading! However, if you get a positive reading of a wire in a wall and there's nothing else electrical on

that wall, then you can hammer the nail home with confidence anywhere else. The message then is: beware of negative readings.

Other uses of Live-Wire include detecting breaks in cables or appliance leads. If you have a suspect mains lead, plug it into the mains; run Live-Wire along the cable and at the point where the live wire is broken, Live-Wire will cease to sound and flash. If a fuse blows, Live Wire will indicate mains present up to all

the fuses and mains present on the wires leaving every fuse except the dead one. If you're wallpapering and need to remove a switch plate, first check that you get a positive reading with the mains on, then switch off or remove the fuse from the circuit you think is the right one. With Live-Wire in the same position as before, it will no longer sound if you've found the right circuit. There are probably hundreds of other uses and one or two we've thought of include detecting ringing on telephone lines, detecting the EHT in TV sets (though Live-Wire will probably need to be desensitised).

Live-Wire will also detect static electricity but in this case, it must be moved into or through the static field and only while it is moving will the instrument sound.

Circuit Description

An AC electro-magnetic field is detected at IC1 pin 1. The 4069 inverter is connected in a linear by placing a feed-

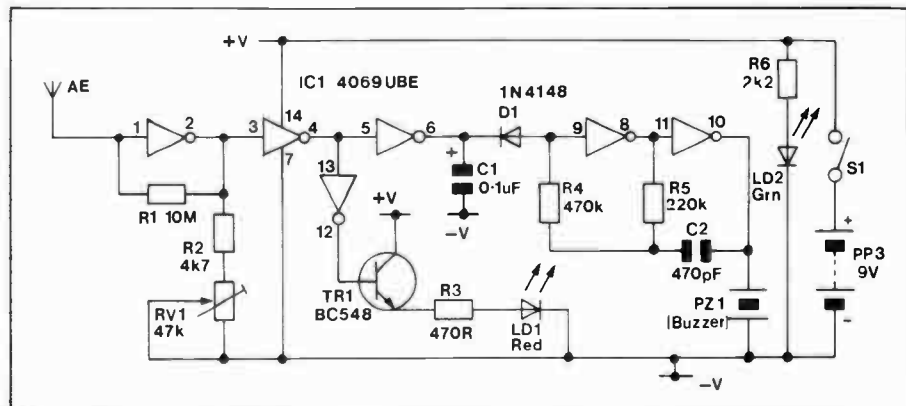


Figure 1. Circuit diagram of the Live-Wire Detector.



Inside view of the Live-Wire Detector prior to fitting the back panel.

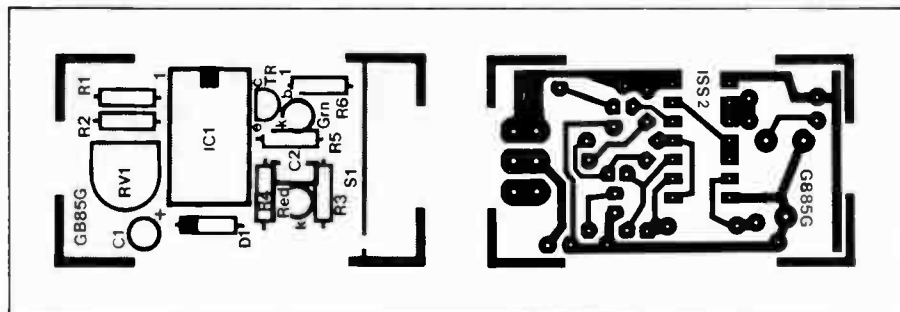


Figure 2. PCB legend and track.

back resistor between pins 1 and 2. The value chosen for R1 keeps the characteristics high CMOS input impedance so that changes in the surrounding electro-magnetic field produce a minute voltage change on the aerial track which are massively amplified in this stage.

RV1 sets the point at which the output from IC1 pin 4 will trigger the next two stages. This is necessary since the quiescent voltage at pin 2 will be different from one chip to another. Being a digital chip, this usually makes no difference but in linear mode, it is significant and RV1 has to be present to ensure that every Live-Wire can meet the specification. RV1, therefore, is adjusted to keep pin 4 high when not triggered.

Turning S1 on, lights LED2 which indicates that the circuit is active. If no electro-magnetic field is detected, then pin 4 will be high and the rest of the circuit is inactive. When an electro-magnetic field is detected, pin 4 goes low and pin 12 then goes high causing the emitter-follower TR1 to conduct, operating LED1.

At the same time, IC1 pin 6 goes high. D1 will now be reverse-biased which removes the continuous low 'hold-off' condition from pin 9 and allows the oscillator to run. The oscillator comprises the final stages of the 4069 and resistors R4,R5 and C2. The approximate frequency is 3.5kHz. The output of the oscillator drives the high impedance piezo-ceramic buzzer directly.

The circuit runs from a 9V PP3 battery. The current drain is approximately 10mA when the circuit is switched on and 17mA when it is detecting electricity.

An AC electro-magnetic field is one which is collapsing and re-establishing itself in phase with the frequency in the wire, e.g. for UK mains, it is 50Hz. This has the effect of turning D1 on and off, which stops and starts the oscillator, giving a characteristic buzzing sound. If the circuit was moved in a static electro-magnetic field, it will produce a pure high frequency tone.

As the circuit moves into a field, LED1 may operate before the buzzer starts to sound. It will gradually increase in brightness and during this time, at some point, the buzzer will sound before or just as the LED reaches full brightness.

Construction

With reference to Figure 2 and the Parts List, fit the components, with the exception of the slide switch, as follows: start by fitting each of the resistors into the positions shown. Next, insert the diode in position D1 ensuring that the device is correctly orientated. It is important that each of these components

lies flat to the PCB as shown in the photographs.

Fit the two capacitors in their respective positions, noting that C2 is a polarised device which needs to be installed the correct way round. Carefully solder all these components in place and clip off the excess lead ends. Now insert IC1 and TR1 (so that their orientation matches up with that shown in the corresponding board legends), and fit preset RV1 in the position indicated. Carefully solder all the leads of these three components and cut off the excess leads of the lead-lengths.

The red LED (LD1) is inserted into the position marked on the pcb as 'Red' in Figure 2. Likewise, the green LED (LD2) is placed in the 'Grn' position. Correct positioning of these items is also critical, and the cathode (marked as 'k' in Figure 2) is the shorter lead of the LED. Adjust the two LEDs until the base of each coloured package is 6mm above the top surface of the board. Holding the LEDs absolutely vertical in that position, solder the four leads and clip off the excess lead-lengths.

Cut the two wires from the battery connector (black = -Ve; red = +Ve) so that they are 50mm (2in.) long, tin them, and referring to Figure 3, insert each in the appropriate hole and solder in place. Cut the wires from the buzzer so that about 25mm (1in.) of each remains, tin them, insert in the two remaining holes on the PCB and solder them in position. Note that buzzer polarity is uncritical. With a small screwdriver or trim tool, adjust RV1 until its wiper points to C1 as arrow in Figure 2, and finally check that all components have been inserted and soldered correctly.

Final Assembly and Testing

Referring to Figure 4, place the switch in the box so that its lever protrudes through the rectangular cut-out in the case. Ensuring that the two LEDs protrude through the appropriate round holes, insert the M2 bolts through the two holes on either side of the switch cut-out, pass them through the mounting holes of the switch and terminate with M2 nuts. When the bolts have been sufficiently tightened, position the PCB on the switch

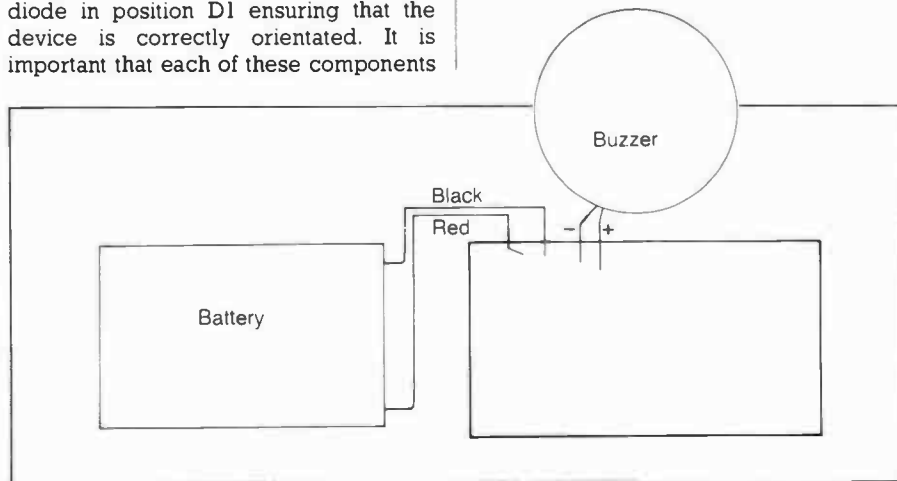


Figure 3. Live-Wire Detector wiring diagram.

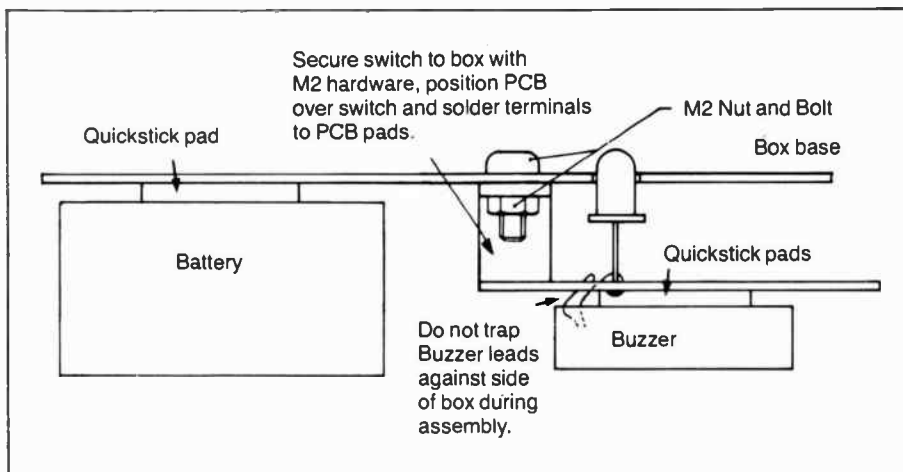


Figure 4. Overall assembly of the Live-Wire Detector.

terminals exposed within the case and solder in place. It must be checked that the board is mounted flush against the switch prior to soldering, otherwise undue strain could be placed on the PCB tracks. Please bear in mind that the switch effectively holds the PCB in place. Now solder the switch terminals to the PCB.

Stick the buzzer centrally onto the soldered side of the PCB using a quickstick adhesive pad, as shown in Figure 5, so that the mounting ears of the buzzer point to the corners of the PCB and the buzzer lead-out wires are nearest the edge of the board. Ensure that the adhesive pad is fixed to the base of the buzzer, and not the top (which has a large central hole on it, from which the sound is emitted). Please note that the diameter of the buzzer may vary slightly. If it is found that it is too large to fit into the box, carefully remove some of the plastic casing of the buzzer with a sharp knife.

Install a new PP3 battery, preferably of the alkaline type, ensuring that it is fitted to the battery clip the right way round, even a momentary incorrect connection could cause damage. Depending on the position of the on/off switch the Live-Wire Detector may already be switched on, indicated by the green LED

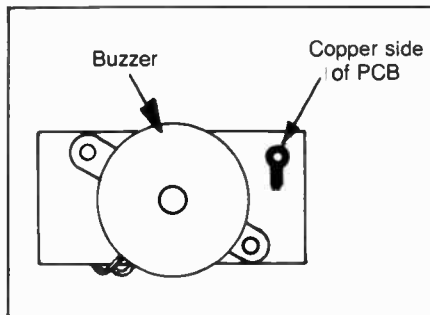


Figure 5. Buzzer mounting.

glowing, if this is the case, switch the unit off.

Plug an appliance into a mains socket and switch it on. Bring the assembly up to the cable, holding the battery end of the box. Switch the Live-Wire Detector on. The green LED should light and stay on. As you approach the appliance's cable, the red LED should light and the buzzer should sound.

RV1 must now be adjusted so that the unit starts to operate about 2 inches (5cm) from the cable. To increase the sensitivity, turn RV1 clockwise; vice versa to decrease the sensitivity. Do not try to make the unit too sensitive or you will find that it is occasionally triggered by your body, or for no apparent reason.

When RV1 is correctly adjusted, fix the battery into the box using the other sticky-pad, see Figure 4. Finally, screw the box lid on using the four screws provided.

Uses

This unit is extremely useful around the home, and because the user does not have to make actual contact with any part of a live circuit, it is perfectly safe to use. Even if the wires are not connected to anything at one end (i.e. no current is flowing), Live-Wire will reveal if they are live. Some of the many uses that we have identified include the following:

Finding wires concealed by plaster, plastic conduit, floor boards or ceiling panels. However, please bear in mind that the sensitivity of the unit is only about two inches, so do not hammer a four inch nail into a wall where there was a negative reading! However, if you get a positive reading and there is nothing else electrical on that wall, then you can confidently fix the nail anywhere else. Generally, negative readings should be treated with caution.

The detection of breaks in cables or appliance leads. If a mains lead is suspect, it is plugged into the mains and Live-Wire is run along its length. At the point where the live wire is broken, Live Wire will cease to sound and flash.

If a particular mains circuit needs to be isolated, for example, when a switch plate needs to be removed (e.g. for wallpapering a wall), first check that you get a positive reading with the Live-Wire Detector when the mains is switched on, then remove the lighting fuse and use Live-Wire Detector, *in the same position*, to verify that the correct fuse has been removed.

Detecting ringing on telephone lines.

Detecting the presence of EHT within a TV set (in this case, Live-Wire will probably need to be desensitised).

Live-Wire will also detect static electricity, but only when it is being moved into, or through, the static field.

LIVE-WIRE DETECTOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1	Econ Res 10M	1	(B10M)
R2	4k7	1	(M4K7)
R3	470Ω	1	(M470R)
R4	470k	1	(M470K)
R5	220k	1	(M220K)
R6	2k2	1	(M2K2)
RV1	Hor Encl Preset 47k	1	(UH05F)

CAPACITORS

C1	Tant 100nF 35V	1	(WW54J)
C2	Ceramic 470pF	1	(WX64U)

SEMICONDUCTORS

TR1	BC548	1	(QB73Q)
D1	1N4148	1	(QL80B)
IC1	4069UBE	1	(QX25C)
LD1	Mini LED Red	1	(WL32K)
LD2	Mini LED Green	1	(WL33L)

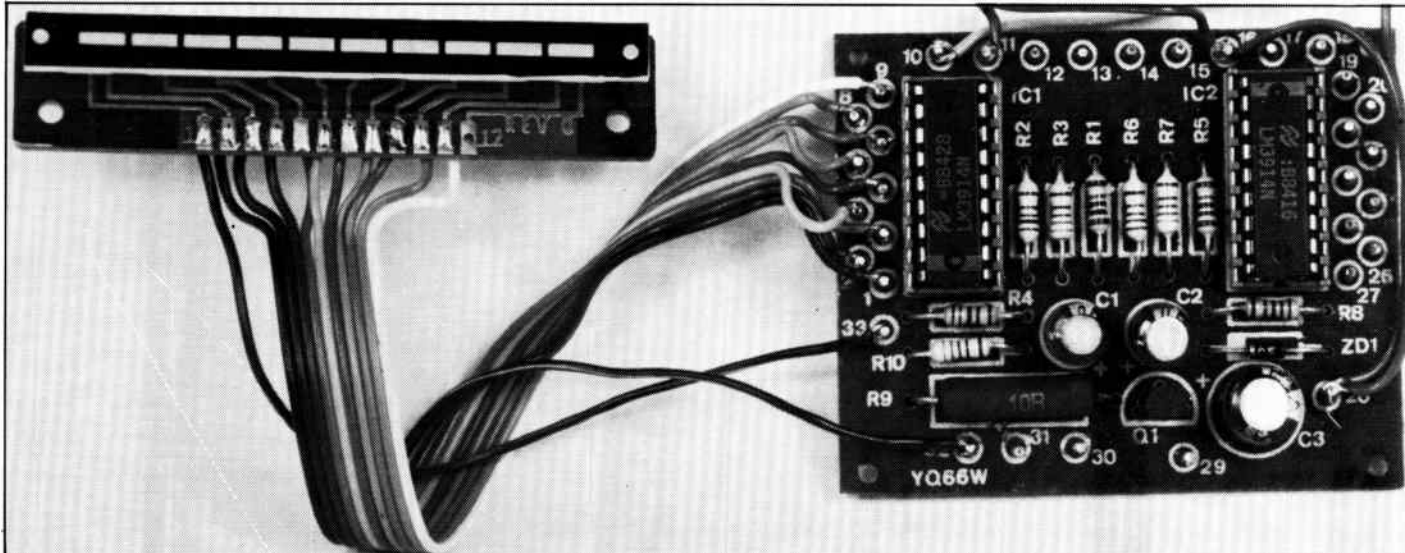
MISCELLANEOUS

S1	Sub-Min Slide	1	(FH35Q)
	PP3 Clip	1	(HF28F)
	Min Piezo Sounder	1	(FM59P)
	Poziscrew M2 6mm	1 Pkt	(BF41U)
	Steel Nut M2	1 Pkt	(JD63T)
	Live Wire Det Case	1	(FT39N)
	Quickstick Pad	1 Strip	(HB22Y)
	PCB	1	(GB85G)
	Instruction Leaflet	1	(XK07H)
	Constructors' Guide	1	(XH79L)

OPTIONAL

B1	Battery PP3	1	(FK62S)
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The above items (excluding Optional) are available as a kit.
Order As LK63T (Live Wire Detector Kit)



DISPLAY DRIVER MODULE

by Dave Goodman

- ★ Many Types of Display can be Driven
- ★ Choice of Driver Chips
- ★ Flashing Option
- ★ Easy to Build

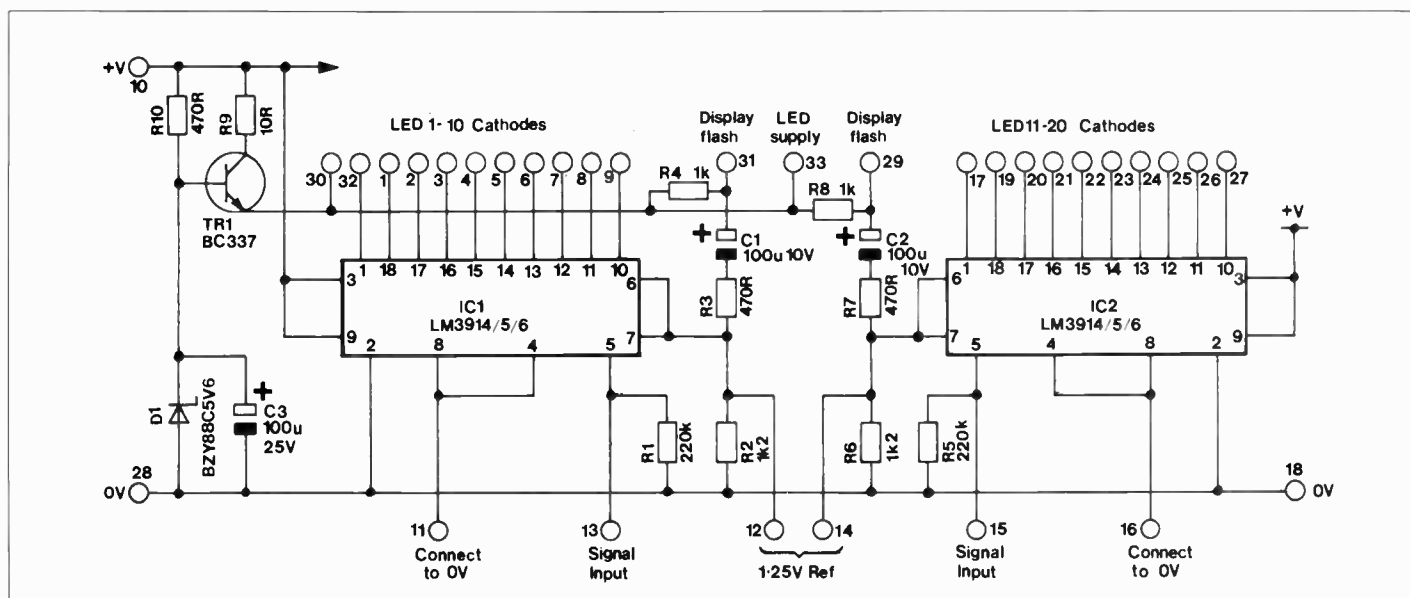


Figure 1. Circuit diagram

Many projects built by the Home Constructor require a LED display to give an indication or show a response to a set of circumstances. This article will describe a module which will drive up to 20 LED's and also show how to make those LED's flash on and off. Many different types of LED display can be used with this module and in addition to this, different driver chips can be used to give varying displays.

A dual display driver PCB for the LM3914-16 range of display driver IC's can be used for single DOT or sequential BAR mode control of the 20 LED's. Display brightness is adjustable and FLASH can be determined from any desired LED position. Three types of IC are available from MAPLIN's range which have identical operating characteristics but offer different response of input voltage to display output. Figure 5 is a graphic representation which shows the response curves of these IC's in BAR mode. Each of the LED's (1 to 10) are sequentially operated in turn as the input DC voltage is increased from approximately 50mV to 1.3V, and for the LM3914 a linear scale can be observed. For a logarithmic scale, the LM3915 is chosen, which increments each LED in 3dB steps and the LM3916 is suitable for VU displays.

Circuit Operation

IC1 (2) requires very little external components as all LED controlling elements are internal to the IC (see figure 7). Ten comparator output stages control each LED via an internal resistor ladder network, referenced to a 1.25V constant voltage source, and an increasing signal voltage applied to the high impedance voltage follower, switches each comparator in turn. Figure 1 shows the 5V regulator: R10, D1 and TR1, which feeds each anode of LED's 1 to 20. Either single LED's or common anode 10 LED displays can be used here, and R2 determines LED current or brightness. Reducing the value of R2 increases LED current (and vice-versa) and with the recommended value of 1k2, approximately 10mA flows through each LED. PCB pins 4 and 8

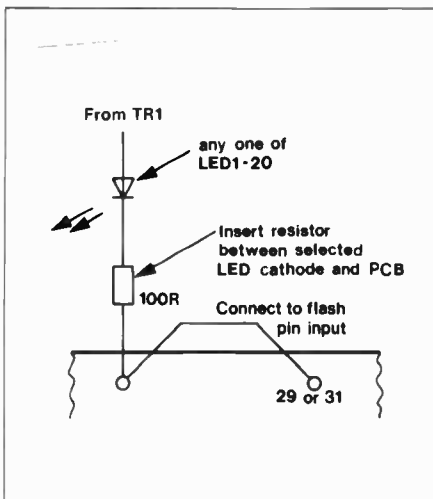


Figure 4. Connection for flashing mode

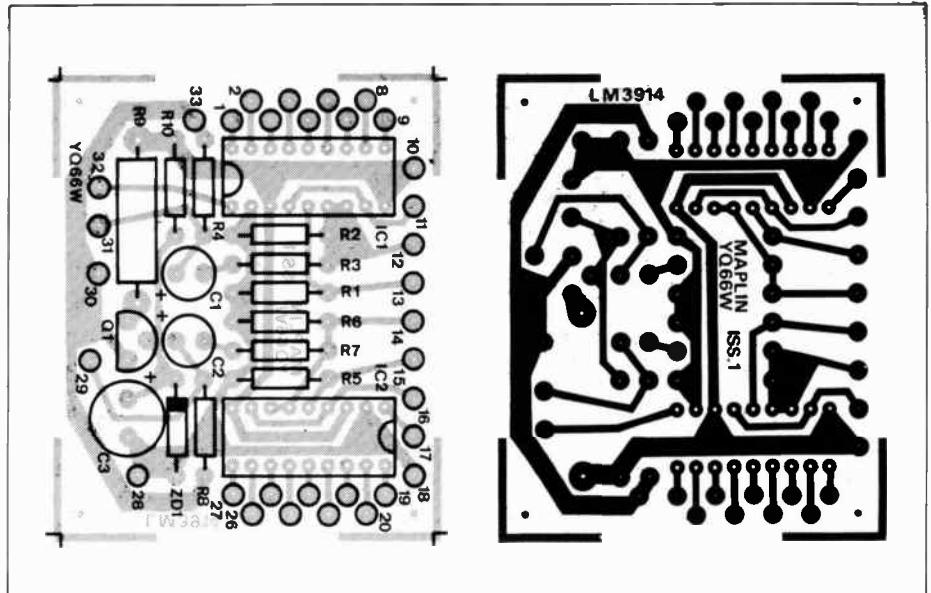


Figure 2. PCB track layout and overlay

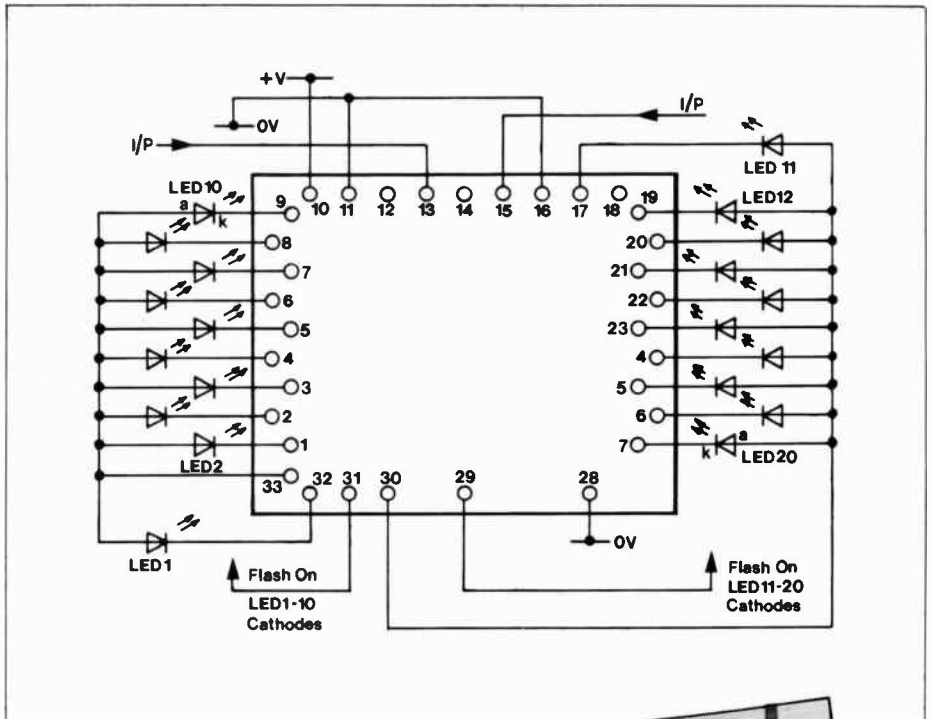
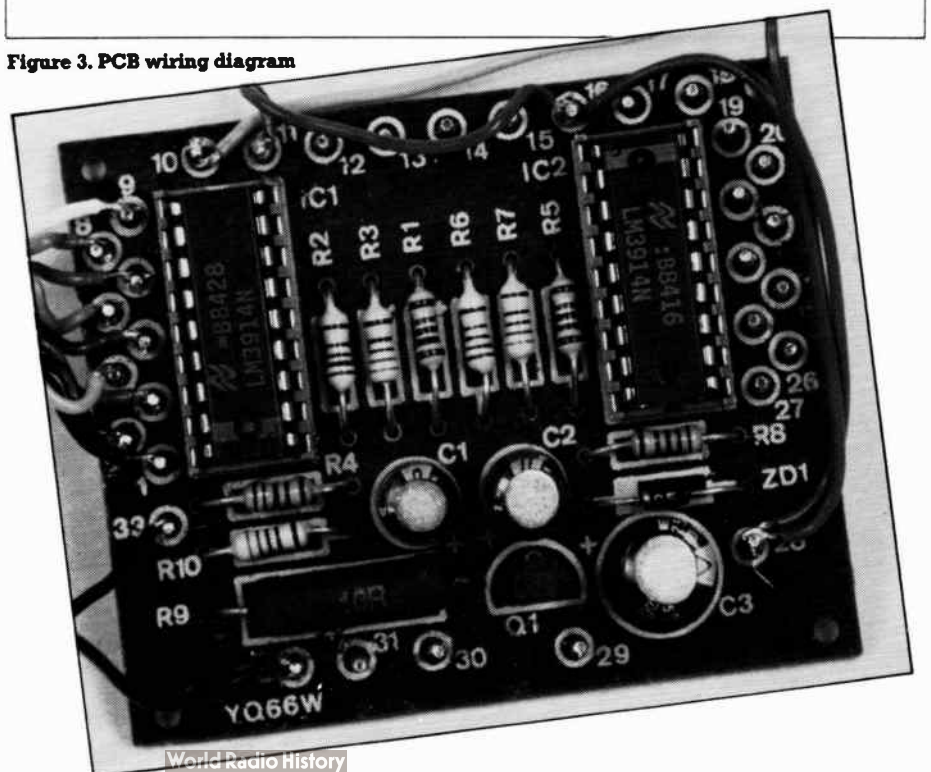


Figure 3. PCB wiring diagram



should be connected to 0V, although these inputs could be referenced positively above ground, thus changing the point with which input signals start to switch the LED's. LED 1 output will normally be active with input signals $\approx +0.1V$ when pin 11 is at 0V. Connecting pin 11 via a resistor to 0V raises the comparator threshold so that a higher input voltage will be required to drive the display. Figure 8 shows the appropriate connections to those pins and Table 1 indicates resistance values and the approximate minimum input voltage required to operate the first LED of the display.

Flashing

Flash input pin 31 (29) can be connected to any one (only) of LED's 1 to 10 (11 to 20) as shown in Figure 4. It is important to connect a 100Ω resistor in series with the chosen LED otherwise insufficient discharge current for C1 (C2) is developed. For example, connecting LED 10 via a 100Ω resistor to pin 9 on the PCB and connecting pin 9 to pin 31 flash input, will cause all ten LED's to flash twice a second and could signify display over voltage in a voltmeter project.

PCB Connections

Figure 3 shows external connections to the module. A power supply of 5 to 15V is required with 150mA current handling capability. Pins 1 to 9 and 33 are LED cathode connections to IC1 and pin 30 is the common anode +5V supply. Pin 31 is the flash input and can be wired to any one of the 10 pins previously mentioned. Pins 18 and 28 are common 0V connections and pin 10, the 5 to 15V supply. Pin 12 has a 1.25V reference output voltage available, pin 13 is the signal input terminal and pin 11 should be connected either directly to 0V or via a resistor (see Figure 8). Corresponding pins associated with IC2 perform the same functions as their counterparts on IC1 and operation of both sections is identical.

LED Displays

Figure 9 shows five of the most useful displays available from MAPLIN's Catalogue, along with terminal notations. The Parts List has stock codes of these components if required. These displays are suitable for use as voltmeter indicators, alarm flashers, sensor indicators, amplifier power level meters, graphic equaliser response, VU meters and the module could be used to replace panel meters in these applications.

Operation

So far, all input specifications refer to positive DC signals and not to AC signals. Sinewaves can be fed directly to the signal input for display, but problems may arise when calculating average or peak levels, or the amount of dampening required to ensure a readable display.

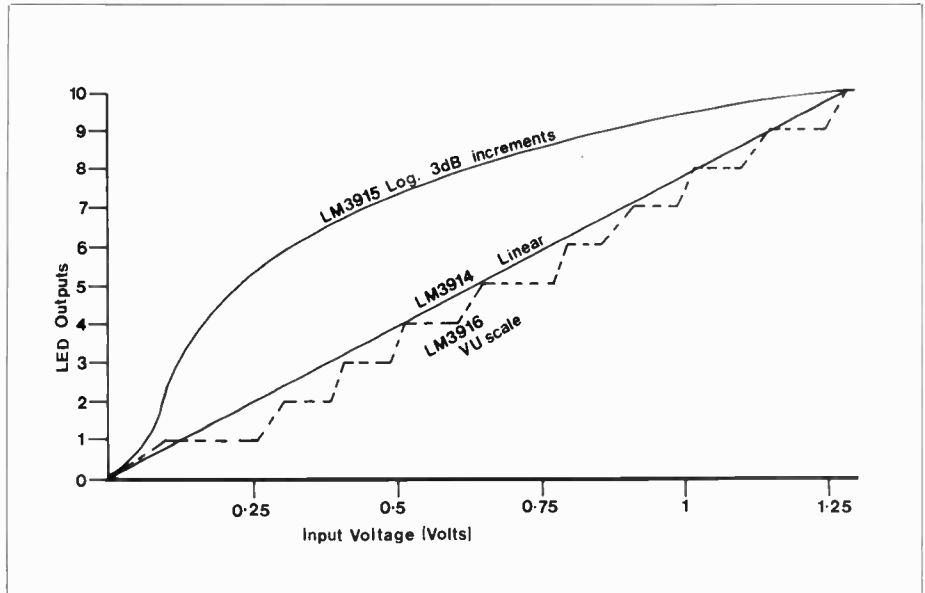


Figure 5. IC response curves

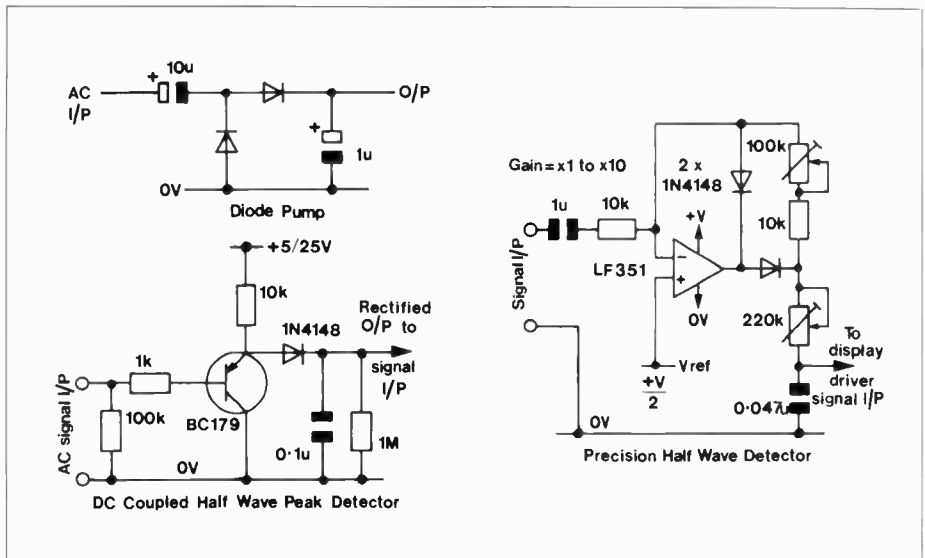


Figure 6. Input AC detector circuits

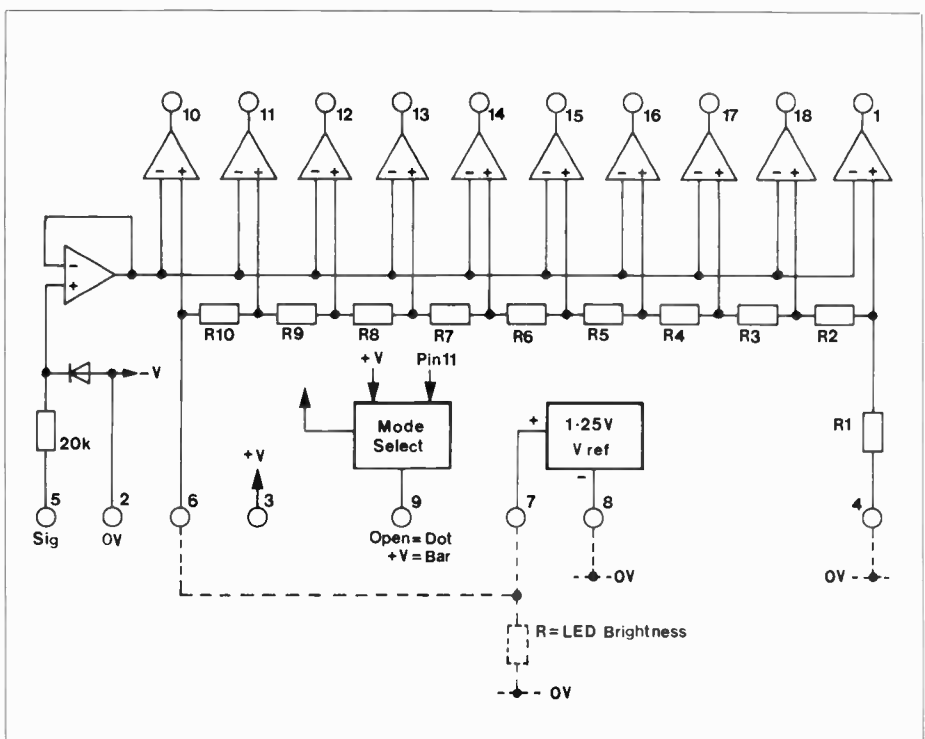
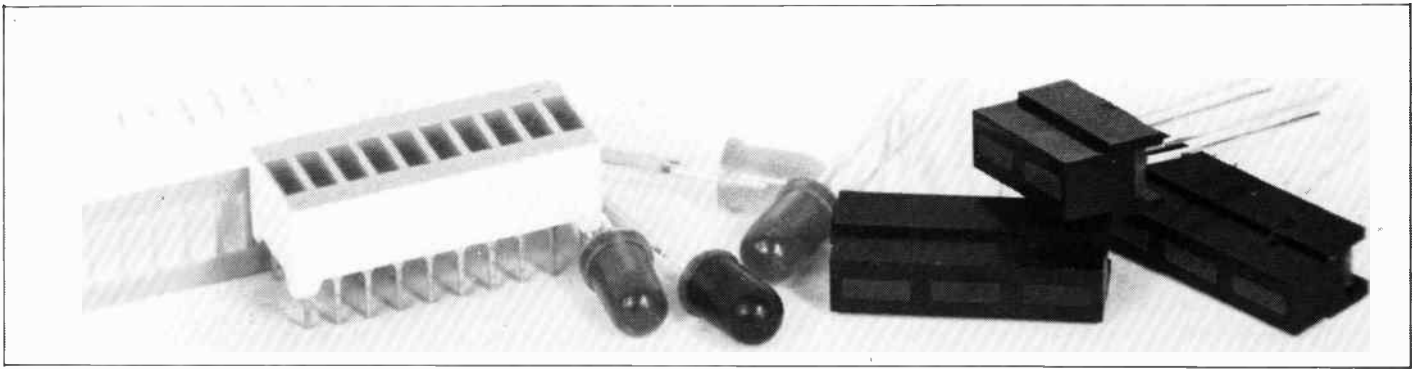


Figure 7. Internal circuit of LM3914/5/6



Some example circuits are given in Figure 6 which convert AC signals to DC voltages suitable for driving the module. The diode pump is the simplest to use, although its input impedance is low, and diode forward voltage drop must be considered. A capacitor at the output damps the display for a slow response reading and values are chosen accordingly.

Absolute maximum input signal voltages should be kept below 35V peak and wiring from LED's to module must be as short as possible to avoid HF noise radiation causing interference in audio equipment. DOT or single LED mode is simply produced by not inserting pin 9 on IC1 (2) into the PCB and is left floating.

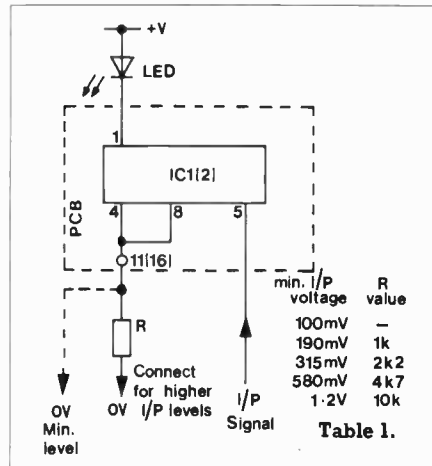


Figure 8. Input level reference

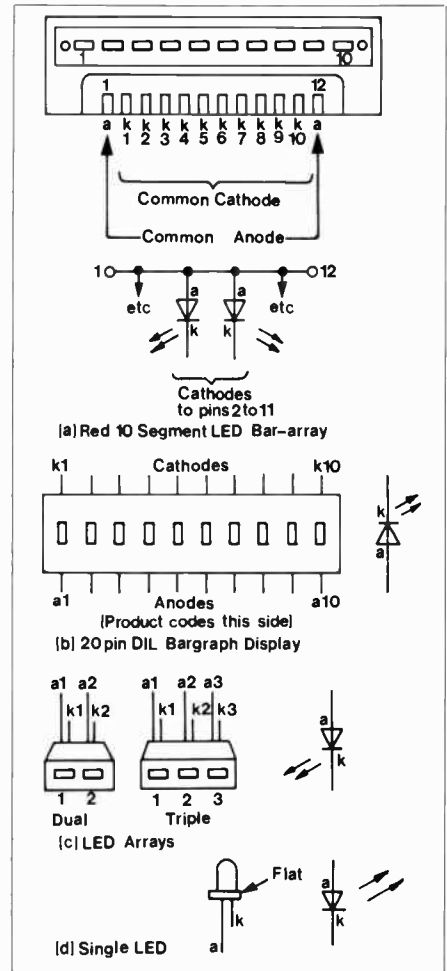
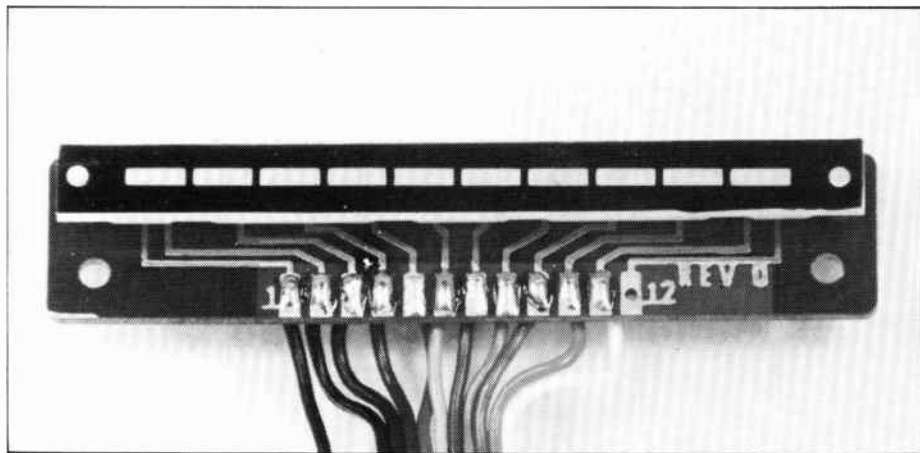


Figure 9. Pin connections of various displays

BARGRAPH DISPLAY DRIVER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1,5	220k	2	(M220K)
R2,6	1k2	2	(M1K2)
R3,7,10	470Ω	3	(M470R)
R4,8	1k	2	(M1K)
R9	10Ω 3W Wirewound	1	(W10R)

CAPACITORS

C1,2	PC Elect 100μF 10V	2	(FF10L)
C3	PC Elect 100μF 25V	1	(FF11M)

SEMICONDUCTORS

ZD1	BZY88C5V6/X55C5V6	1	(QH08J)
TR1	BC337	1	(QB68Y)
IC1,2	LM3914 or LM3915 or LM3916	2	(WQ41U)*
		2	(YY96E)*
		2	(YY97F)*

* Select device as appropriate, see text.

MISCELLANEOUS

PCB	1	(YQ66W)
Pin 2145	1 Pkt	(FL24B)
Instruction Leaflet	1	(XT48C)
Constructors' Guide	1	(XH79L)

OPTIONAL - Choose as required:

Red 10-Seg Bargraph	As Req.	(YH76H)
Red Bargraph Display	As Req.	(BY65V)
Green Bargraph Display	As Req.	(YG33L)
Dual LED Array Red	As Req.	(YH77J)
Tri LED Array Red	As Req.	(YH78K)
Dual LED Array Green	As Req.	(YH79L)
Tri LED Array Green	As Req.	(YH80B)
Dual LED Array Yellow	As Req.	(YH81C)
Tri LED Array Yellow	As Req.	(YH82D)
LED Red	As Req.	(WL27E)
LED Green	As Req.	(WL28F)
LED Orange	As Req.	(WL29G)
LED Yellow	As Req.	(WL30H)

Because of the many different applications possible for this project, none of the above parts are available as a kit. Select and make up a list to order the parts required.

Control-a-Train

- ★ Pulse Width Modulated For Excellent Low Speed Performance
- ★ Inertia Control of Momentum and Braking
- ★ Box or Panel Mounted
- ★ Easy To Build
- ★ Low Cost

by Robert Penfold



We make no apologies for using three of Mr W. Sherman's superb photographs of steam engines with his kind permission in this article about model trains, but we're all steam train nuts here at Maplin and we just loved the pictures!

Things have moved on from the days when model train controllers were little more than a rectifier and a high power potentiometer (called a 'rheostat'), and using modern electronic devices it is possible to produce a simple controller that has quite advanced facilities. This design is based on just two operational amplifiers but it has a pulsed output for good starting and low speed performance, plus simulated inertia, momentum and braking. It also has output current limiting which protects the circuit when the inevitable overloads and short circuits occur. The unit is designed to operate from the 15 volt AC output from a train transformer or the 15 volt AC auxiliary output of a train controller but it could easily be built as a self contained unit having a built-in mains transformer if preferred. It should also run properly if powered from the 12 volt DC output of a train transformer or controller.

Pulsed Control

Obtaining good results from a model train controller is more difficult than it might at first appear. Simply varying the voltage fed to the motor by means of a voltage regulator type circuit or a series rheostat might seem to offer excellent performance but in practice, the characteristics of the electric motor leads to problems. Starting tends to lack realism as a fairly high voltage is needed by the motor before it will start to operate but once it does start to run, only a relatively low voltage is needed in order to move the train slowly. As a result the train suddenly jumps to a high speed instead of having slow and realistic acceleration.

Another problem is that of poor low speed performance. This tends to be worse in the rheostat type of controller where the output impedance of the controller is inevitably quite high at low and medium speeds due to the high series resistance of the rheostat. This results in the output voltage actually decreasing slightly if the train comes to an incline and the current consumption rises as the motor is loaded more heavily. This prevents the motor from obtaining the increased power that it requires for stable running. If the train goes down an incline, the opposite occurs with the motor requiring less power, drawing less current but receiving increased voltage and a power level that is little changed. The practical result of this is a tendency for the train to run fast down the slightest of gradients and to stall when climbing a gradient.

A constant voltage type controller uses a voltage stabiliser circuit to eliminate these unwanted output voltage variations. This does not totally eliminate the problem though since the power level received by the motor still does not vary in a way that exactly matches its requirements. One way around the problem is to use an over-compensated voltage stabiliser, which is the method of

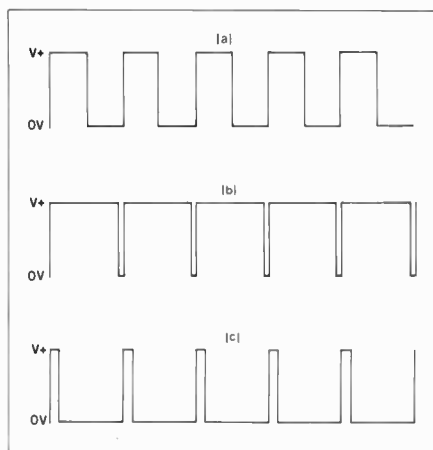
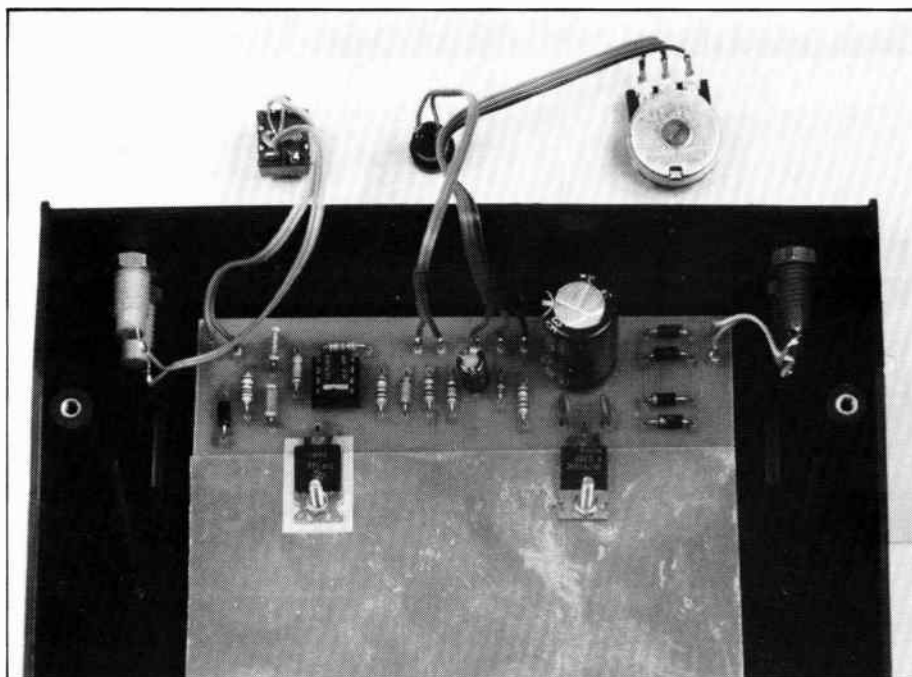


Figure 1. Output Waveforms;
(a) Half, (b) Max & (c) Min Power Output
speed stabilisation used in applications such as cassette recorders. What is probably a more simple and practical solution for the present application and the one which is used here, is a method of pulse control.

The idea of a pulsed output controller is to provide a series of output pulses that drive the motor at full power. The average output voltage (and thus the speed of the train) is varied by altering the mark-space ratio of the output signal. Figure 1 helps to explain the way in which this system operates.

This diagram shows typical output waveforms at various output powers. In figure 1 (a), the waveform is a square-wave having a 1 to 1 mark-space ratio. The average output voltage is therefore equal to half $V+$ and this gives half maximum output power. In figure 1 (b), the mark-space ratio of the signal is very high and the output is at $V+$ for the vast majority of the time. This gives an output power which is virtually equal to that obtained if the output was at $V+$ continuously. There is obviously a small power loss due to the brief periods when the output goes low but these are too short to give a significant power loss in practice and can be ignored. Finally, in figure 1 (c), the output consists of very brief pulses and most of the time the output is at zero volts. This gives a very low average output potential and would in fact fail to turn-over the motor at all.

Although small DC electric motors are not designed to operate from a pulsing supply, they will do so perfectly well provided the output frequency is not very low or very high. A frequency of a few hundred Hertz is satisfactory. In a train controller application, excellent results are obtained as the brief but powerful pulses nudge the train into movement and overcome the starting problem and the tendency to stall at slow speeds.

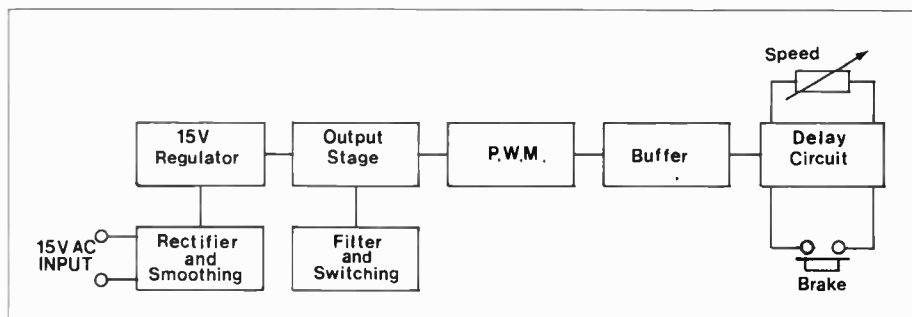


Figure 2. Block Diagram

Operating Principle

The block diagram for the controller appears in figure 2. The 15 volt AC input is rectified and then smoothed. A 15 volt regulator circuit is used to give a reasonably well smoothed and stabilised supply for the main circuit, although such a well smoothed and regulated supply voltage is by no means essential. The main reason for including the regulator is that it incorporates current limiting which protects the unit as a whole in the event of a short circuit or other overload on the output.

A pulse width modulator circuit is at the heart of the unit and this is an oscillator which has the mark-space ratio of its output signal controlled by an input voltage. Within the operating limits of the control voltage, the higher the control voltage, the higher the mark-space ratio of the output signal. A buffer stage at the output of the pulse width modulator enables the fairly high currents required by the motor to be comfortably accommodated. The speed of the train can be controlled by varying the input voltage to the pulse width modulator.

For straightforward speed control, a potentiometer to provide the control voltage is all that is required. In order to give simulated inertia and momentum a delay circuit must be added. This should give a fairly long attack time so that the acceleration of the train is restricted to a realistic level. With the power removed, a real train will coast for a considerable distance and an even longer decay time is required. However, the simulated braking is provided by a push button switch that can greatly reduce the normal decay time of the delay circuit.

Although the output signal is a pulsed signal there is little problem with radio frequency interference being generated due to the low voltages and low fundamental frequency of the output signal. A simple filter is included at the output to attenuate the weak high frequency harmonics that are generated and the direction control (a switch that controls the polarity of the output signal) is also included.

Circuit Operation

For a unit of this type, very few components are required as reference to the circuit diagram of Figure 3 will reveal. In this circuit, IC2b is used as virtually an ordinary operational amplifier relaxation oscillator. The motor will require a fairly high current of typically about 500 milliamps and Darlington power transistor TR1 is used as an emitter follower buffer stage to enable suitably high output currents to be supplied. D6 and C6 are suppression components and S1 is the direction control.

The basic action of this type of oscillator is for C5 to charge to a little over half the supply voltage via R7 and so on, with a squarewave being generated

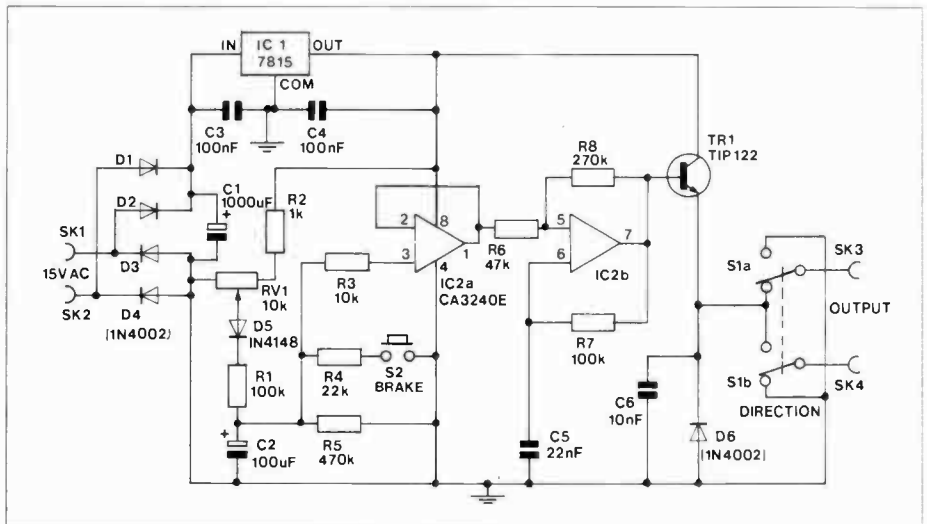


Figure 3. Circuit Diagram

at the output of the operational amplifier. This assumes that the input bias voltage to R6 is half the supply voltage but in this case, the bias can be varied and variations in this potential have the effect of altering the output waveform. In fact the effect on the waveform is to give an average output voltage that is roughly equal to the bias voltage. Thus the speed of the train can be controlled simply by controlling the bias voltage to the oscillator and the required pulsed output is obtained.

IC2a is used as a buffer in the bias voltage circuit and RV1 is the speed control. D5, R1 and C2 are a timing circuit which limit the acceleration of the train, giving the simple simulated inertia effect. When RV1 is backed-off, the only significant discharge path for C2 is through R5 and the train only reduces speed very gradually, giving the simulated momentum. Closing S2 shunts R4 across R5, giving a much faster reduction in speed and S2 therefore gives the simulated braking action. The specified



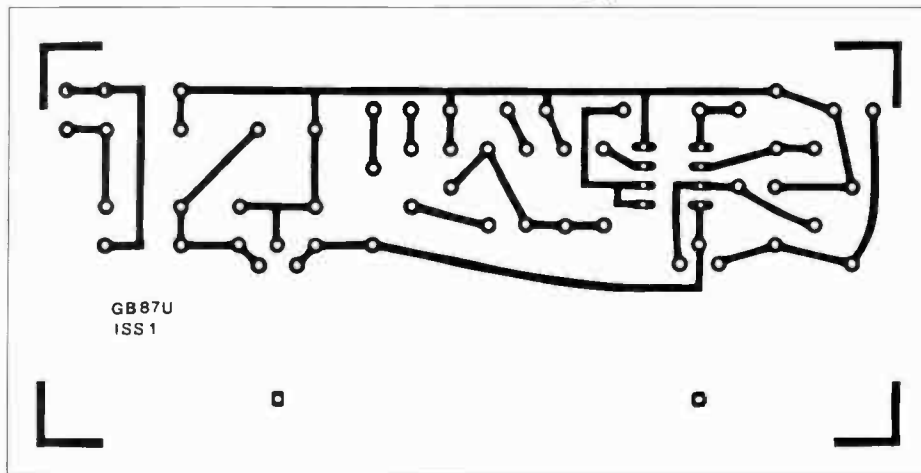


Figure 4. PCB Artwork

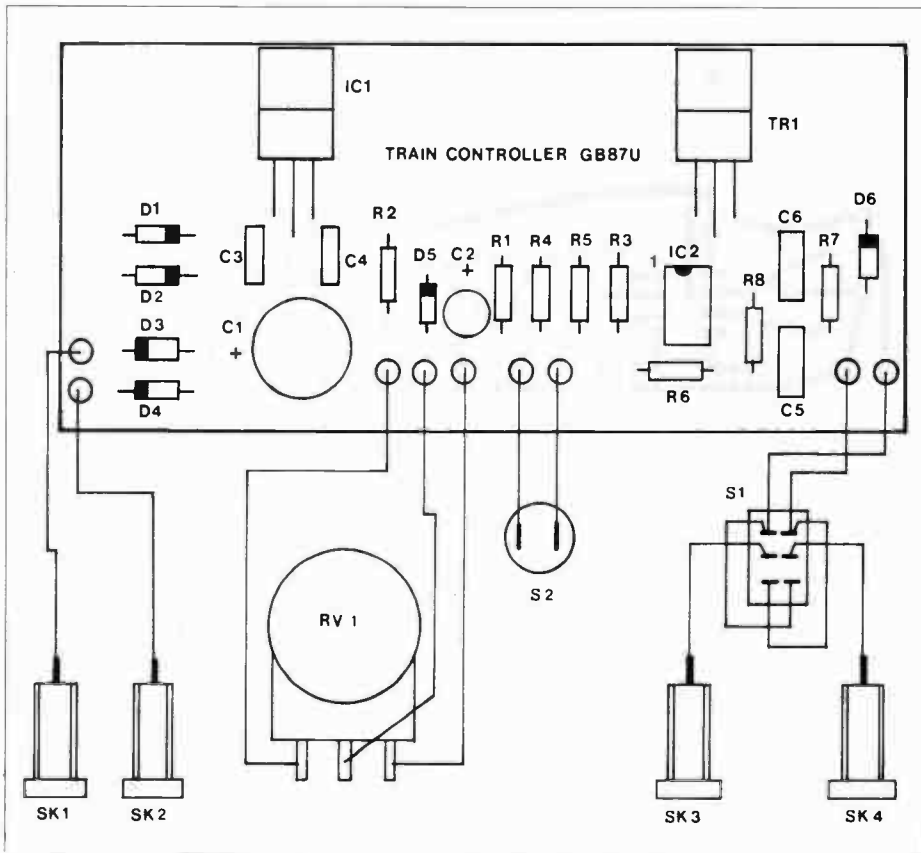


Figure 5. PCB Wiring and Legend

values will give excellent results but by altering the values of R1, R4 and R5, the inertia, momentum and braking characteristics can be tailored to suit individual requirements.

As explained previously, power is obtained from a 15 volt AC output of a train transformer or controller and this output should be rated at about 1.4 amps or more. The rectifier is a bridge type (D1 to D4) and C1 is the smoothing capacitor. The supply stabilisation is provided by the monolithic voltage regulator IC1 and this enables output currents of up to 1 amp to be provided. This is adequate for any of the popular small model railway gauges but owners of large gauge layouts should note that it might not be adequate for their purposes.

Construction

Start by making up the printed circuit board. Figure 4 and Figure 5 gives full details of both the printed circuit board and the hard-wiring. IC2 is a MOS input device and it would be prudent to observe the basic anti-static handling precautions when dealing with this component. Leave it in its protective packaging until the unit is otherwise complete and it is time for it to be connected into circuit. The device should then be fitted in a holder and handled as little as possible. Fit Veropins at the point where connections to the controls and sockets will be made and take care to fit the electrolytic capacitors and semi-conductors the right way around.

TR1 and IC1 are both mounted horizontally on the board and a piece of (approximately) 18 s.w.g aluminium is sandwiched between these components and the board. This aluminium fin should have dimensions of about 112 by 85 millimetres and it acts as a heatsink for TR1 and IC1. As TR1 operates in a switching mode, it actually dissipates only a modest amount of power but IC1 does have to dissipate several watts when the train is run at speed and without adequate heatsinking, it could be damaged. The printed circuit board can be used as a sort of template when marking the positions of the mounting holes in the heatsink. Position the piece of aluminium so that the metal undersides of TR1 and IC1 are fully in contact with it but the aluminium fin should not overlap the board so far as to risk it short circuiting to the leadout wires of either device.

IC1's heatsink-tab connects internally to its common terminal and thus to the negative supply rail of the controller. The heatsink-tab of TR1 connects internally to its collector terminal and therefore to the +15 volt line. In order to prevent a short circuit on the 15 volt stabilised supply, one or both devices must be insulated from the heatsink using a standard plastic TO-66 insulating kit. Probably the best solution is to insulate only TR1, leaving the heatsink at the negative supply potential. The insulating

washer fits between TR1 and the heatsink with the plastic bush fitted on top of TR1 and into its mounting hole. In other words, the washer must insulate TR1 from the heatsink and the bush must insulate TR1 from the mounting bolt.

The board is secured to the base panel of the case by means of the mounting bolts for TR1 and IC1, which should be 1 inch long 6BA types. Also, 1/4 inch spacers are included on the mounting bolts between the base panel and the printed circuit board. The assembly is mounted with the board well to the rear of the case leaving sufficient room for the heatsink in the front part of the case. Once the board and heatsink have been mounted in the case, use a continuity tester to check that the insulating kit on TR1 is effective.

It is obviously not essential to use the sloping front case specified in the Parts List but this is the ideal type of case for a train controller and the suggested type is about the optimum size. The three controls are mounted on the front panel. SK1 and SK2 are mounted at one end of the rear panel while SK3 and SK4 are fitted at the opposite end of this panel. (See Figure 5.) To complete the unit the point to point style wiring is then added using ordinary multi-strand connecting wire.

If the controller is to be constructed as a mains powered unit with a built-in mains transformer, a substantially larger case will be required. The mains transformer should have a rating of 15 volts at 1.4 amps or more and the Maplin TR34V HP type (Order Code WB22Y) would be suitable. The 15 volt tapping of one secondary winding would feed the controller circuit while the other winding could be used to provide a 15 volt AC auxiliary output. An important point that must be emphasised here is that the



normal safety precautions for mains powered equipment must not be ignored. The case should be a type having a screw fitting lid so that easy access to dangerous mains wiring is not possible. Also, the negative supply rail of the unit plus any exposed metalwork such as fixing screws should be earthed to the mains earth lead.

Using the Controller

SK1 and SK2 connect to the 15 volt output of the train controller. SK3 and SK4 connect to the power rail. Make quite sure that you do not accidentally reverse these two sets of connections as this would almost certainly damage some of

the components. When set for minimum power, there is actually a low output power to the train and a slight hum might be produced from the motor. The train should not move though and should be well below the start-up threshold power level.

Excellent starting and low speed performance should be achieved but only if the track is kept clean so that the engine is always in good electrical contact with the track. Controllers of this type can be a little difficult to master if you have previously only used a simple type but so would driving a real train and the higher level of skill required is the whole point of inertia type controllers.

CONTROL-A-TRAIN PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1,7	100k	2	(M100K)
R2	1k	1	(M1K)
R3	10k	1	(M10K)
R4	22k	1	(M22K)
R5	470k	1	(M470K)
R6	47k	1	(M47K)
R8	270k	1	(M270K)
RV1	Pot Lin 10k	1	(FW02C)

CAPACITORS

C1	PC Elect 1000µF 35V	1	(FF18U)
C2	PC Elect 100µF 25V	1	(FF11M)
C3,4	Minidisc 100nF 16V	2	(YR75S)
C5	Poly Layer 22nF	1	(WW33L)
C6	Poly Layer 10nF	1	(WW29G)

SEMICONDUCTORS

D1-4,6	1N4002	5	(QL74R)
D5	1N4148	1	(QL80B)
TR1	TIP122	1	(WQ73Q)
IC1	µA7815	1	(QL33L)
IC2	CA3240E	1	(WQ21X)

MISCELLANEOUS

SK1,2	4mm Socket Red	2	(HF73Q)
SK3,4	4mm Socket Blue	2	(HF70M)

S1	Sub-Min Toggle E	1	(FH04E)
S2	Push Switch	1	(FH59P)
	PCB	1	(GB87U)
	DIL Socket 8-pin	1	(BL17T)
	Kit (P) Plas	1	(WR23A)
	Pin 2145	1 Pkt	(FL24B)
	Knob K7B	1	(YX02C)
	Bolt 6BA lin.	1 Pkt	(BF07H)
	6BA Spacer 1/4in.	1 Pkt	(FW34M)
	Nut 6BA	1 Pkt	(BF18U)
	Ribbon Cable 10-way	1m	(XR06C)
	Front Panel	1	(FT40T)
	Heatsink	1	(FT93H)
	Instruction Leaflet	1	(XT50E)
	Constructors' Guide	1	(XH79L)

OPTIONAL

	ABS Console M6006	1	(LH66W)
	4mm Plug Red	2	(HF86W)
	4mm Plug Blue	2	(HF63T)

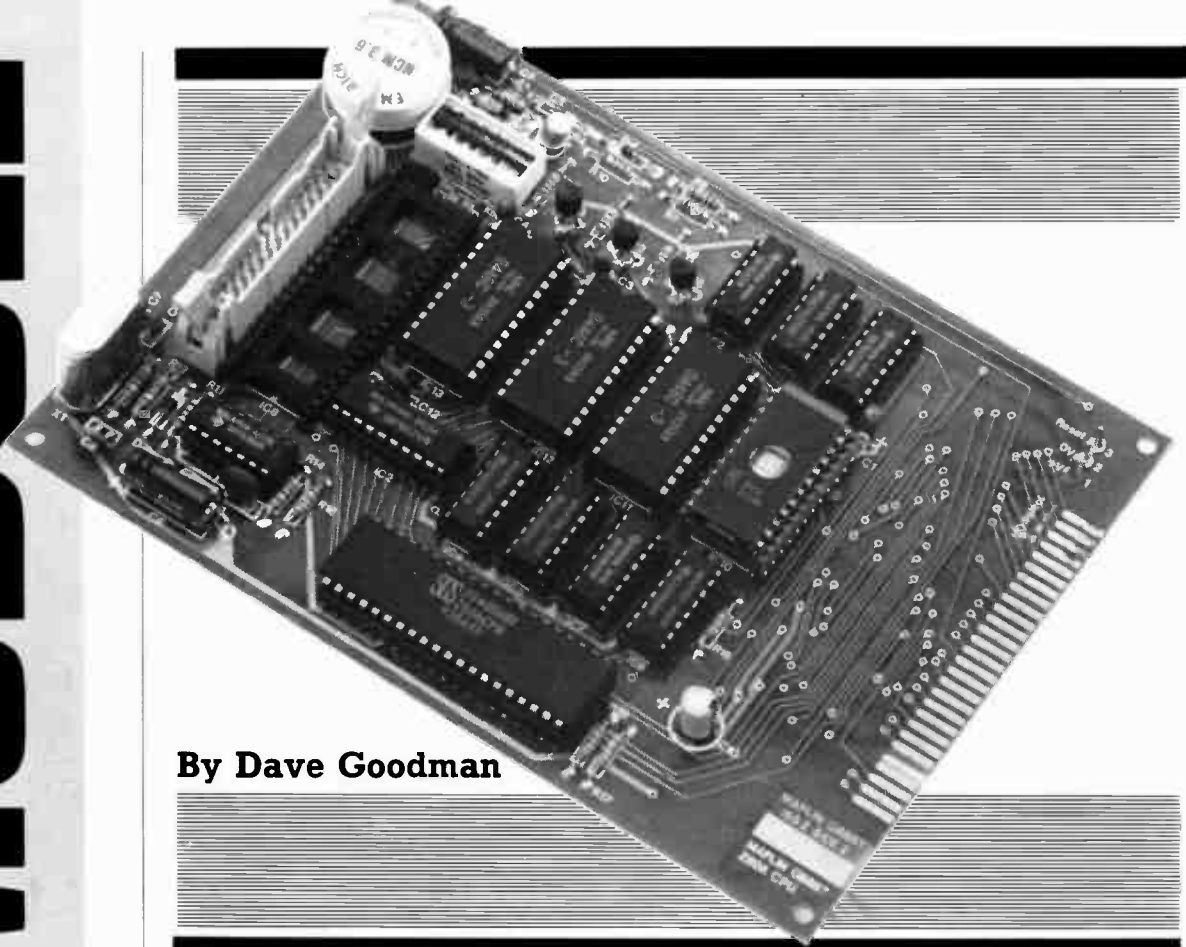
The above items (excluding Optional) are available as a kit.

Order As LK64U (Control-A-Train Kit)

The following items (which are included in the kit) are also available separately.

Control-A-Train Front Panel Order As FT40T
Control-A-Train PCB Order As GB87U
Control-A-Train Heatsink Order As FT93H

Z80 CPU MODULE



By Dave Goodman

- ★ Accepts up to 8K of on-board memory
- ★ Has facilities for keyboard and displays
- ★ 4 decoded I/O select lines
- ★ Battery back-up available for CMOS RAMS

The Z80 microprocessor has been with us for many years and is still proving successful, with many new computer developments giving evidence of this fact.

Practical applications of this CPU require a module with memory, Input/Output, clocks and facilities for further expansion.

The Maplin CPU Module can accept up to 8K of memory which is decoded in 2K (2048 bytes) blocks. The first block contains the operating system in ROM or EPROM and the second, third and fourth blocks can be either RAM or ROM. Static or CMOS 2K RAMS may be fitted (totalling 6K) and battery back-up is available, via switches, for CMOS data retention, if required. Both Z80 or Z80A processors can be fitted, and the system clock has facilities for different size crystals to suit, e.g., 1MHz crystal for Z80 or 2.4576MHz crystal for Z80A.

A keyboard/display decoding IC can be fitted allowing for small key or large (64-key) type keyboards (or sensors) for data input. This IC can also drive seven segment LED displays.

Four decoded I/O select lines are available and all data, address and common control lines are buffered before being brought out to an expansion edge connector.

Circuit Description

Figure 1 shows the circuit of the Z80 module. IC1 is the CPU 'heart' of the system and is driven by the system clock, IC7, with frequency set by crystal X1. Resistors R12, R13 and capacitors C7 to C9 are chosen for 1MHz and 2.4576MHz operation and can be varied to suit higher frequency crystals of 3 to 4MHz (for Z80A). Power up reset components R11, C6 and IC7 hold the Z80 in a reset condition for approximately 500ms when power is first applied. Further resets can be performed by taking the SYSTEM RESET input pin low (0V) at any time after power up. Data lines D0 to D7 and address lines A0 to A15 are buffered by IC2 to IC5, then extended to the ROM, IC10; ROM or RAM, IC11 to IC13 and keyboard/display decoder IC8. Switches S1 to S3 connect the back-up battery B1 to IC's 11-13. If back-up is not required then S1-S3 should be set in the '+5' position. B1 is trickle charged from the +5V rail when power is applied at a low 2mA, set by R8. Diode D1 supplies both battery and RAM IC's when the power is turned on, whereupon diode D2 becomes reversed biased. TR4 is turned on during normal operation and its collector provides base current for TR1, TR2 and TR3. These three transistors have their emitters controlled by IC9, which decodes in 2K

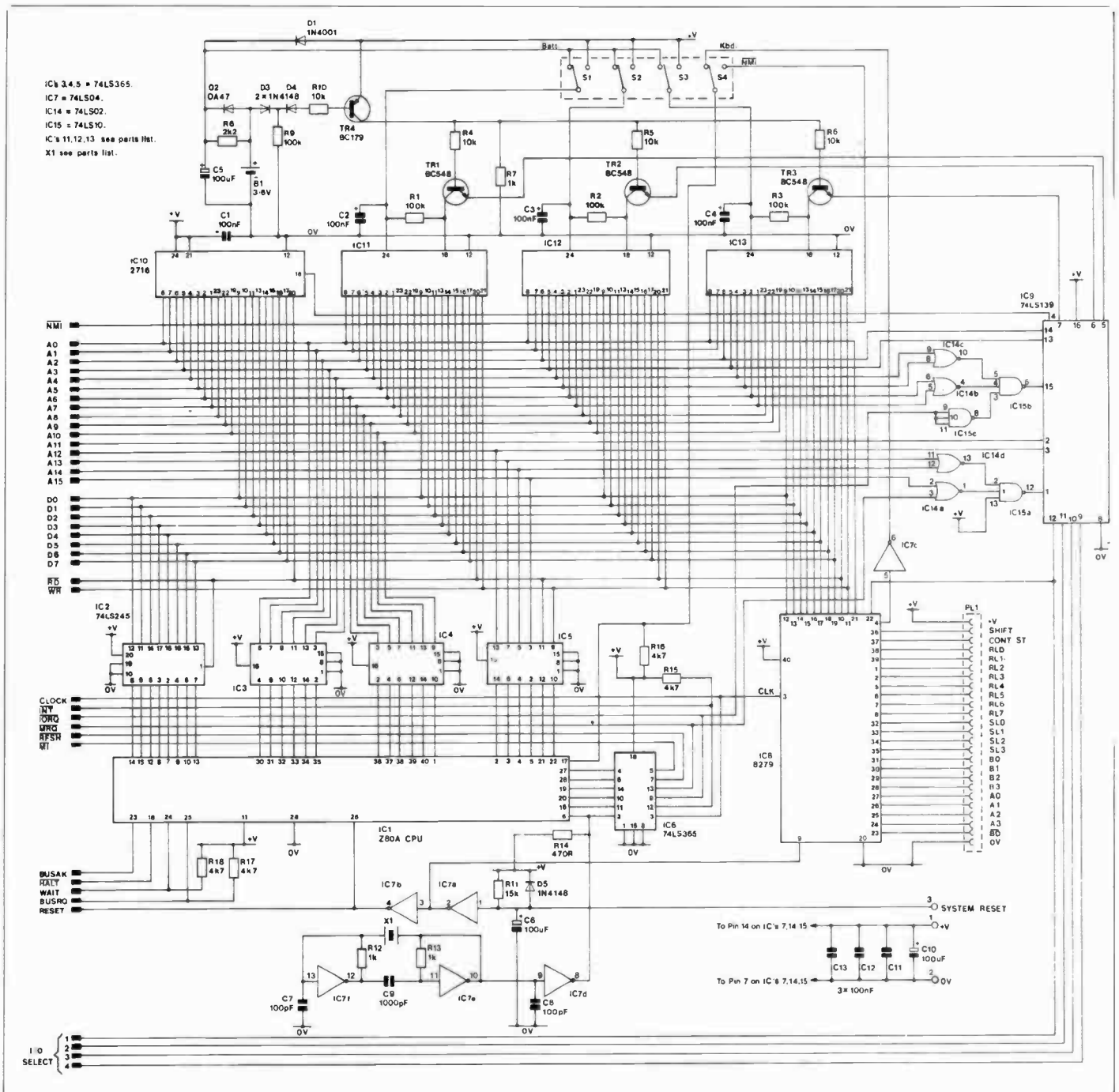


Figure 1. Circuit Diagram

blocks when addressed by the CPU. With IC9 outputs not selected, all three transistor emitters are held close to their base potential and no current flows. The chip select \overline{CE} (pin 18 of IC's 11, 12 and 13) are also held high by pull-up resistors R1 to R3, thus none of the RAMs are selected at this time. For the CPU to read or write data at a valid RAM location, the appropriate address must be set up on A0 to A15. For example, address 2048 is valid at IC11; this is found by taking address lines A0 to A10 low, A11 high and A12 to A15 low. During a memory read cycle, \overline{MREQ} is taken low and IC9 gives a decoded LOW output on pin 5. TR1 emitter voltage drops and collector current flows pulling IC11 pin 18 chip select low. The read \overline{RD} line going low will enable all data output buffers within IC11 and stored data will be presented on the data bus D0 to D7. Two way communication between data bus and CPU is

then determined by IC2. This IC allows data to be transferred from the bus to the Z80 when the read line (IC2, Pin 1) is active, or when read is inactive all Z80 data is sent out to the bus. This method of buffering, along with IC3 to 6, effectively isolates the CPU from external devices, thus keeping its power requirements low and preventing possible damage from short circuits.

Diode D2 becomes forward biased if the 5V supply is removed. Battery B1 will then supply 3.8V to switches S1 to S3 thus obtaining low power data retention, providing that IC11 to 13 are not selected - and TR4 turning off at this time ensures this does not happen! IC9 is a dual decoder - one half of which decodes RAM and the other half decodes INPUT/OUTPUT. Four I/O select lines are available, one of which also selects IC8, the Keyboard/Display interface. S4 selects the NMI (Non Maskable

Interrupt) input from CPU to edge connector, or CPU to IC8 interrupt output. As the pin 4 output of IC8 is active high, this would mean that the Z80 is always interrupted, so an inverter has been added to prevent this from happening.

Construction

The PCB has tracks on both sides connected together with plated through holes. This type of layout allows for higher component density and more accurate solder joint connections. Also, a solder resistant layer has been applied to reduce the chance of tracks shorting together during soldering operations and for greater isolation between components.

Begin construction by identifying resistors R1 to R18 and inserting these into their correct positions. Fit both large diodes, D1 and D2 and the three smaller diodes, D3 to D5. Diodes must be fitted

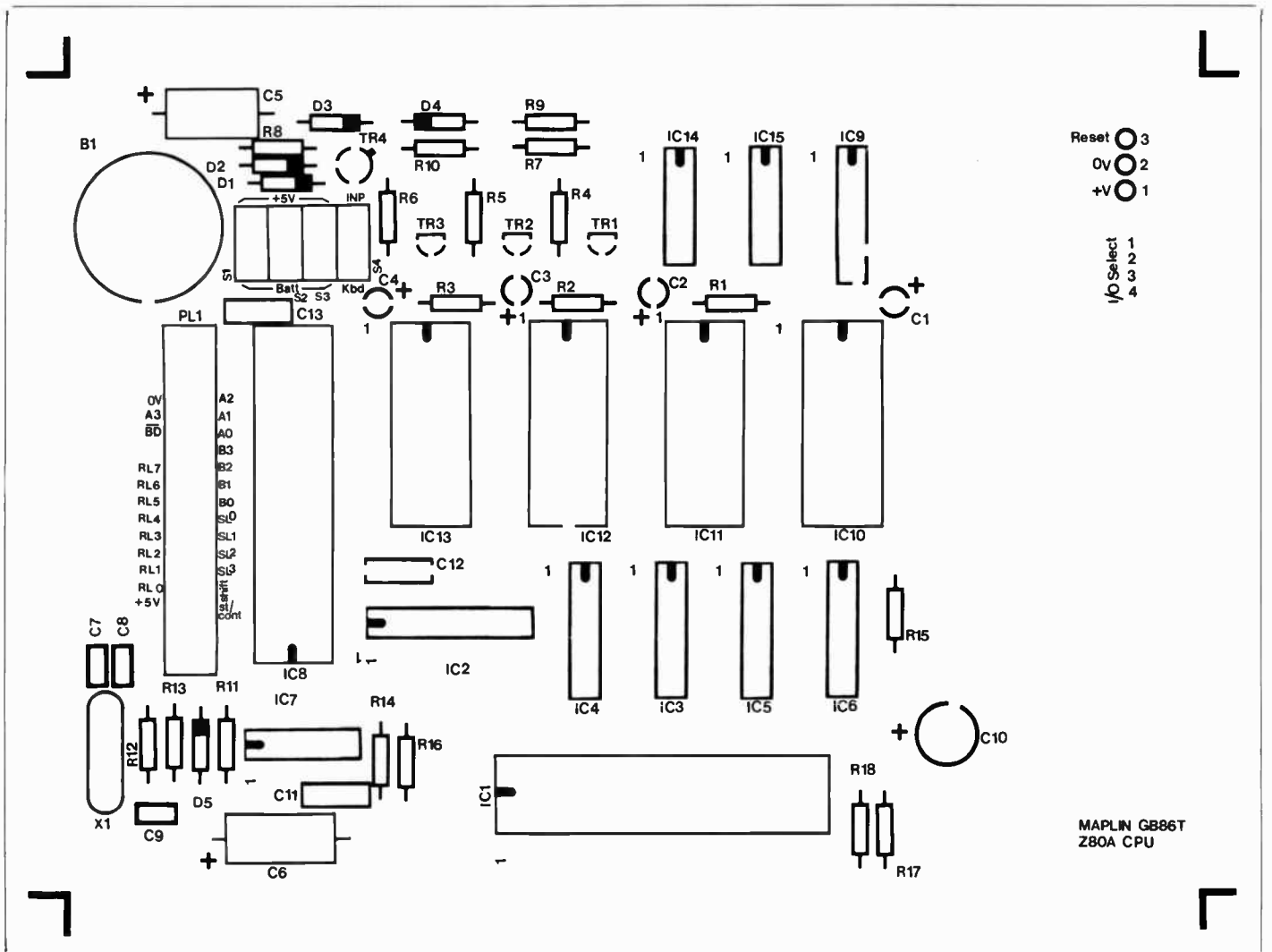


Figure 2. PCB overlay

the correct way around, and to assist with orientation, line up the end marked with a large band (cathode) to the bar on the PCB legend. Insert transistors TR1 to TR3, with the flat face of the 'D' shaped body in line with the legend, and fit TR4. Identify and fit capacitors C1 to C4. They are small tantalum bead types and one lead is marked with a '+' symbol which must be inserted into the hole marked '+'. Now carefully insert the three small ceramic C7, 8 and 9 and disc capacitors C11, 12 and 13. Keep all component bodies close to the PCB and not 'standing off' above it, and bend each lead-end underneath, to help prevent the component from falling out before soldering.

Fit the two axial capacitors C5, C6 and PC type C10. Unlike the tantalum types, these three components have their negative lead marked with a -V symbol, so *don't* insert this end into the PCB hole marked +! Solder all components fitted so far and cut off excess wire ends. When soldering, it is not necessary to build up a mound of solder around each terminal on this board as all holes are plated through. Ensure enough solder is applied to fill the gap between terminal and hole, and check on the opposite side for 'over-flow', which may cause a short circuit.

Proceed with inserting the 4-way switch bank. All sixteen leads must go through the board and this may take a

little patience and re-adjustment to complete. Hold in place by bending the four corner leads down to the board. Mount IC sockets for IC's 1 to 7, IC's 9, 10, and IC's 14 and 15. If adding the keyboard/display interface or ROM/RAM chips then these sockets (for IC's 8, 11 to 13) should also be fitted. One end of the socket has a reference slot moulded into the plastic and this should be aligned with the legend when inserting. Now solder all socket legs in place being careful not to bridge solder between adjacent pins, as this will spell disaster when powering up the module. Finally, fit the PCB nicad battery B1, M.P.U. crystal X1, and solder these in position. Clean up the board, by cutting off excess wires and use a PCB cleaner with a stiff paint brush to wash off flux before inspecting the module. A close inspection of all tracks, joints and components is especially recommended on this board, as very little information can be given as to where faults may lie if the module does not function properly later on.

Initial Testing

A multimeter set to read high ohms (x 10K or more) should be used to check for shorts *between* the address, data and control line connections along the edge connector. Then use the lowest resistance range to check for continuity along these connections. For example,

with reference to Figure 1, it can be seen that D0 to D7 is common from IC2, IC8 to IC10 and the connector. Check for shorts between these data lines and also check for continuity from the furthest point (IC8) to the data output pads on the edge connector. Repeat these checks on Address/Control busses from IC's 3 to 6 and the edge connector.

If all is well, power can be applied to the module, but *do not* insert the IC's at this stage. A +5V supply, well smoothed and regulated, is required and should be connected to terminals 1 (+5V) and 2 (0V) at the top corner of the expansion connector. Set each switch (1 to 4 in the switch bank) up towards D1 and D2. This is notated on the legend as '+5V' and 'INP' for the NMI input line. Switch on the supply, and with the meter set to a suitable DC volts position, check for +4.7 to 5V across C5. A negative reading could mean reversed meter connections or a reversed supply connection. If the correct voltage is given, leave the supply on and check the battery voltage between 0V and D2 anode, which is the opposite end to the one marked with a band. The voltage reading may be low at this stage (possibly +1 to +3 volts). Let the battery charge, and watch the voltage rise towards +4V, which will take a little while.

Now check the collector of TR4 to 0V. With power on, the reading will be

IC	Address	(&H)	IC9 PIN	Function
10	0-2047	0000-07FF	4	2K ROM only
11	2048-4095	0800-0FFF	5	2K ROM or RAM
12	4096-6143	1000-17FF	6	2K ROM or RAM
13	6144-8191	1800-1FFF	7	2K ROM or RAM

Table 1.

I/O Select	Address	(&H)	IC9 PIN	Function
1	0 to 3	00-03	12	KBd/Display
2	4 to 7	04-07	11	I/O Select
3	8 to 11	08-0B	10	I/O Select
4	12 to 15	0C-0F	9	I/O Select

Table 2.

about +4.8V while the battery voltage is low, and approximately +2V when the battery has charged to +4V. This is due to TR4 being biased partly off, when the battery is at full potential. Switch off the power, and TR4 collector voltage should drop to 0V. Now take a reading on IC13 pin 24, re-connect the power and check that with S3 in the '+5' position, a voltage of +5V is present on this pin. Set S3 to 'BATT' and the reading should drop to +4.3V. Repeat this test on IC12/S2 and IC11/S1.

Leave the switch-bank set in their present positions, and check each collector of TR's 1 to 4 in turn - a reading of +3.5V should be found here. Switch off the supply and repeat the tests, noting that the voltage will have dropped to approximately +3V. These voltage readings are much dependent upon the type of equipment used to take the measurements. An oscilloscope with 1M Ω impedance probe and a digital multimeter were used to take measurements for this procedure. Lower impedance equipment such as 20K Ω /VOLT moving coil meters will naturally give lower readings and this must be kept in mind if large differences are apparent.

Memory and I/O Map

Four memory select lines are internally decoded by IC9 as shown in Table 1. Each IC9 output shown decodes a 2K (2048 bytes) block starting at 0000. The first block should contain ROM or EPROM and the operating system is resident here (IC10).

The next three IC's can be either ROM or RAM, with switched options available for 2716 type EPROMS, 4116 static RAM or 6116 (μ PD446) CMOS RAMs. Further memory decoding above & 1FFF (8192) is not available and should be added externally.

Four I/O decoded outputs are available from the expansion connector as shown in Table 2. I/O select lines occupying the first sixteen addresses are decoded in blocks of four. This means

that each I/O line has four addresses associated with it, and I/O select line 1 is also common to the KBd/display interface IC. Further decoded I/O lines are not available above & 0F (15) and must be added externally in conjunction with IORQ and M1.

Control Lines

All of the Z80 control lines are available, most of which are buffered, including a system CLOCK output, RESET output, SYSTEM RESET input and a switched NMI input. The NMI can be taken from either KBd/display interface IC8 or directly from the expansion connector.

If the system bus is to be used by external devices during BUSRQ-BUSACK time then problems will be encountered due to IC2. Normally, the Z80 data bus will be high impedance at this time, thus freeing the bus for external device use. IC2 will be in WRITE mode and this means that its data bus outputs will always be at TTL level, thus the bus will not be free! If required, IC2 could be omitted and links connected between each of the eight input to output pins to allow external BUS use.

Keyboard/Display

The 8279 is a very comprehensive IC capable of scanning keyboards or sensors, and also driving 7 segment LED displays. The interface can scan up to 64 keys - expandable to 128 with suitable decoding - and sensors or strobed keys may be used. Two key lockout and 'N' key rollover can be programmed, and keyboard entries generate an interrupt (NMI) to the Z80. Either four or eight (programmable) 7 segment displays can be added with blanking facilities, and all connections are made via a 26-pin IDC socket (PL1).

Further information on the use and programming of the 8279 is unfortunately well outside the scope of this article, but data sheets are available to assist in hardware/software design (see end of this article).

Expansion

This module is intended for use as the central processing section of either a complete microcomputer system, or used purely for experimental/educational purposes, or it can be used on its own as a 'simple' M.P.U. based control system. Z80 physiology and architecture is not detailed in this article as such a complex subject requires a great deal of careful study. A great many books, some of which are listed for reference, are available to assist in the development of this subject, but for the more initiated, further testing routines follow.

Further Testing

Figure 3 shows a simple LED indicator using the four I/O lines. The cathode of each LED is connected directly to the four I/O select lines 1 to 4 and each anode is connected via a current limiting resistor to the +5V supply. With the power off, insert all IC's and either a ready programmed EPROM or an interface such as SOFTY or a 'ROMulator'.

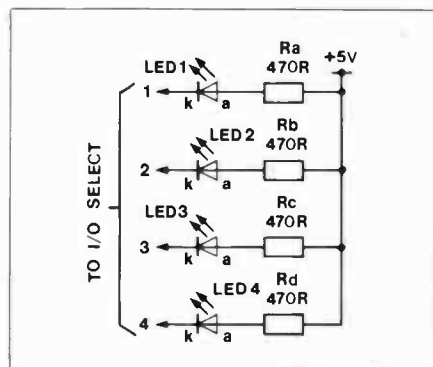


Figure 3. Test LED Display

There is no 'easy' way to test CPU modules, as instruction sequences must be made available to the Z80. For development purposes, a SOFTY programmer was used and the ROMulator cable link modified as per the User Manual. Failing this important item, an EPROM must be programmed with either

Machine Code Listing Examples

Listing 1. I/O Port test.

```
Ld A,N      3E,FF      : DATA TO OUTPUT
OUT (n),A   D3,00      : n = (00-0F) PORT
JR          18,FA      : REPEAT
```

Listing 2. 6K RAM test.

```
Ld DE, NN   11 00 00   RESET COUNTER
Ld C, N      0E 0F     PORT #4 (0F)
Ld HL, NN   21 FF 1F   RAM TOP = 8191
Ld B, N      06 00     INITIALISE DATA (*)
Ld (HL), B   70        WRITE DATA (*)
Ld A, (HL)   7E        READ DATA
CPB         B8         IS RAM O.K?
JRNZ        20 21     NO - GO FAULT RTNE
Ld A, B      78        YES - STORE COUNTER
OUT (c), A   ED 79     OPERATE LED
Ld B, A      47        RESTORE COUNTER
DJNZ        10 F5     REDUCE COUNTER (*)
DEC HL      2B        NEXT ADDRESS
INC DE      13        COUNTER +1
```

```
Ld A, N      3E 08     END OF CURRENT RAM?
CP D         BA        (2048 BYTES TESTED)
JRNZ        20 EB     NO - GO INITIALISE DATA
Ld DE, NN   11 00 00   YES - RESET COUNTER
DEC C       0D 0D 0D 0D SELECT NEXT LED
Ld A, N      3E 07     6K TESTED?
CP H        BC
JRNZ        20 E0     NO - INITIALISE DATA

Ld HL, NN   21 00 10   FAULT ROUTINE
OUT (c), A   ED 79     INDICATE WHICH RAM
OUT (n), A   D3 00     INDICATE 'FAULT'
DEC HL      2B
Ld A, N      3E 00     FLASH BOTH LEDS
CPH         BC
JRNZ        20 F6
Ld HL, NN   21 FF 10
DEC HL      2B        AND REPEAT
CP H        BC
JRNZ        20 FC
JR          18 EA
```

test routines or your development program, using the memory and I/O information given or taken from Machine Code listings 1 and 2.

Listing 1 is a 6 byte routine which operates one of LEDs 1 to 4. The particular LED I/O address 00-0F is determined by the fourth byte. If IC8 is fitted, set S4 to 'INP'. Listing 2 is a 6K RAM test routine which assumes IC's 11 to 13 are fitted and switched to standby (BATT) mode. With a 1MHz crystal, X1 clock frequency, the routine shown in Listing 2 tests every bit combination (0-255) in every memory location (3 x 2048 bytes). Each RAM test takes ≈30 seconds and the complete routine takes 90 seconds.

LED 4 indicates IC13 being tested; LED 3 indicates IC12 being tested; LED 2 indicates IC11 being tested. LEDs 2 and 3 together indicate a successful test. LED 1 + (LED 2 to 4) together and flashing indicate a fault in the RAM designated previously.

When using CMOS RAMs a data retention test can be made as follows:-

1. Set S1 - 3 to 'BATT'.
2. Run the 6K RAM TEST routine.
3. Switch off supply.
4. Change the following bytes in routine 2:

Address (*)	From	To
09	00	01
0A	70	00
13	10	00
14	F5	00

5. Switch supply on again and run routine 2.

This time the test looks for data 01 previously stored before the first power down and checks all 6K locations. LEDs 4, 3 and 2 step sequentially, then all three turn on together if the test is successful. Otherwise faults are indicated as before.

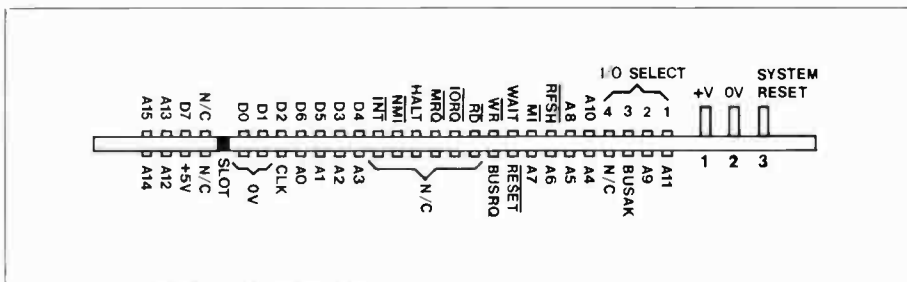


Figure 4. Expansion Connector

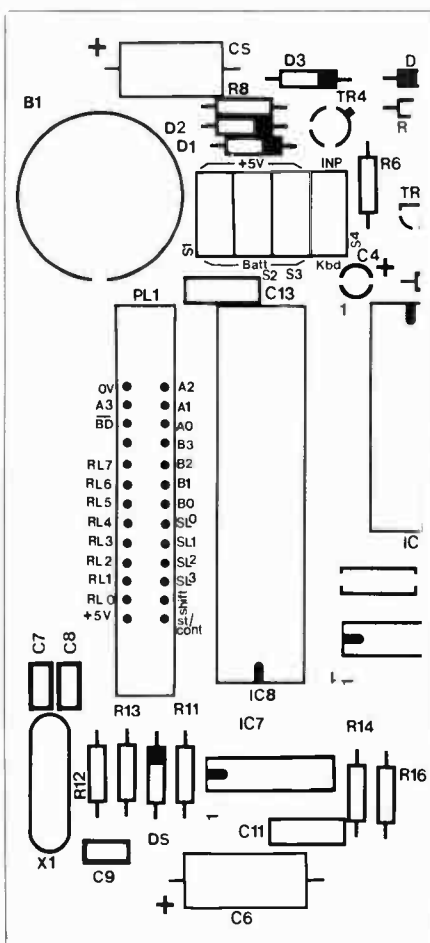


Figure 5. PL1 connections

The four LEDs in Figure 3 serve as a simple indicator and will only work if the I/O decoding section is fault-free. They will not give a meaningful indication if either the routine, bus connections or I/O decoder are faulty.

DATA SHEETS for a range of Z80 peripheral devices are available from Maplin and are listed below. A charge of 75p per copy applies at time of print only. Also shown are some selected Z80 related books which can be purchased from Maplin.

Data Sheets	Description
Z80A-CTC	Counter-Timer.
6116-3 (446-3)	2K CMOS RAM.
Z80A-DART	Serial Controller.
Z80A-PIO	Parallel Controller.
8255A	Peripheral Adaptor.
8279	Keyboard/Display Interface.
6402	U.A.R.T.
8251	Communication Interface.
8250	U.A.R.T.
2716	2K EPROM.

Reference Books

A Z80 Workshop Manual (WA54J).
Programming the Z80 (XW72P).

Z80 CPU MODULE PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1,2,3,9	100k	4	(M100K)
R4,5,6,10	10k	4	(M10K)
R7,12,13	1k	3	(M1K)
R8	2k2	1	(M2K2)
R11	15k	1	(M15K)
R14	470Ω	1	(M470R)
R15-18	4k7	4	(M4K7)

CAPACITORS

C1-4	Tant 100nF 35V	4	(WW54J)
C5,6	Axial 100μF 10V	2	(FB48C)
C7,8	Ceramic 100pF	2	(WX56L)
C9	Ceramic 1nF	1	(WX68Y)
C10	Minelect 100μF 10V	1	(RK50E)
C11-13	Minedisc 100nF 16V	3	(YR75S)

SEMICONDUCTORS

D1	1N4001	1	(QL73Q)
D2	OA47	1	(QH70M)
D3-5	1N4148	3	(QL80B)
TR1-3	BC548	3	(QB73Q)
TR4	BC179	1	(QB54J)
IC1	Z80A CPU	1	(QW00A)
IC2	74LS245	1	(YF91Y)
IC3-6	74LS365	4	(YH11M)
IC7	74LS04	1	(YF04E)
IC9	74LS139	1	(YF54J)
IC14	74LS02	1	(YF02C)
IC15	74LS10	1	(YF08J)

MISCELLANEOUS

S1-4	DIL Switch SPDT Quad	1	(XX29G)
B1	PCB Mounting 3.6V Bat	1	(RK46A)
	PCB	1	(GB86T)
	DIL Socket 14-pin	3	(BL18U)
	DIL Socket 16-pin	5	(BL19V)
	DIL Socket 20-pin	1	(HQ77J)
	DIL Socket 40-pin	2	(HQ38R)
	Pin 2141	1 Pkt	(FL21X)
	Instruction Leaflet	1	(XT51F)
	Constructors' Guide	1	(XH79L)

OPTIONAL

PL1	25-Way IDC Header Plug	1	(XX29G)
	2 × 28-Way PC Edge Conn	1	(FG23A)
X1	2.4576MHz Crystal	1	(FY81C)
or	1MHz Crystal	1	(FY79L)
IC8	8279 Kbd/Display I/F	1	(YH51F)
IC10	2716 2K EPROM	1	(QQ07H)
IC11-13	6116 (μPD446)	3	(UF33L)
or	2716	3	(QQ07H)

TEST COMPONENTS

Ra,b,c,d	470Ω	4	(M470R)
LED1-4	LED Red	4	(WL27E)

The above items (excluding Optional) are available as a kit.

Order As LK67X (Z80 CPU Module Kit)

The following item (which is included in the kit) is also available separately.

Z80 CPU Module PCB Order As GB86T

Keypad for the Z80

- ★ Type in your own code easily
- ★ Visual display aids checking
- ★ Simple construction

by Graham Dixey C. Eng., M.I.E.R.E.

PLEASE NOTE THAT THIS PROJECT WILL SHORTLY BE REVISED AND RE-DESIGNED

Introduction

The Maplin Z80 CPU card which was published in Issue 15 of 'Electronics' offers an inexpensive way to get to grips with computerised control systems for those who can write their own control programs and put them into an EPROM. The provision for 8K of on-board memory is generous for such applications, and input/output decoding for peripheral chips is also provided. Unfortunately the module is totally devoid of any kind of resident software and is completely inaccessible to the 'user' in its basic form. Provision is made for a keyboard to be added however, the suggested device is the 8279 programmable keyboard/display interface IC, which can look after a variety of input sources (keypads, full

keyboards, sensor arrays, etc.) and can control up to sixteen 7-segment displays if required. Thus, it is obviously possible to produce a small computer which can be programmed directly from a HEX keypad, with a 7-segment display to monitor addresses, status and data, both in and out.

In the design presented here, there are eight 7-segment displays, from left to right, the first four form the 'address field', the next two the 'status field' and the two on the right, the 'data field'. What is needed to achieve this simple objective is the module described here, a monitor resident in EPROM (which has been developed and is available - see Parts List), and some knowledge of Z80

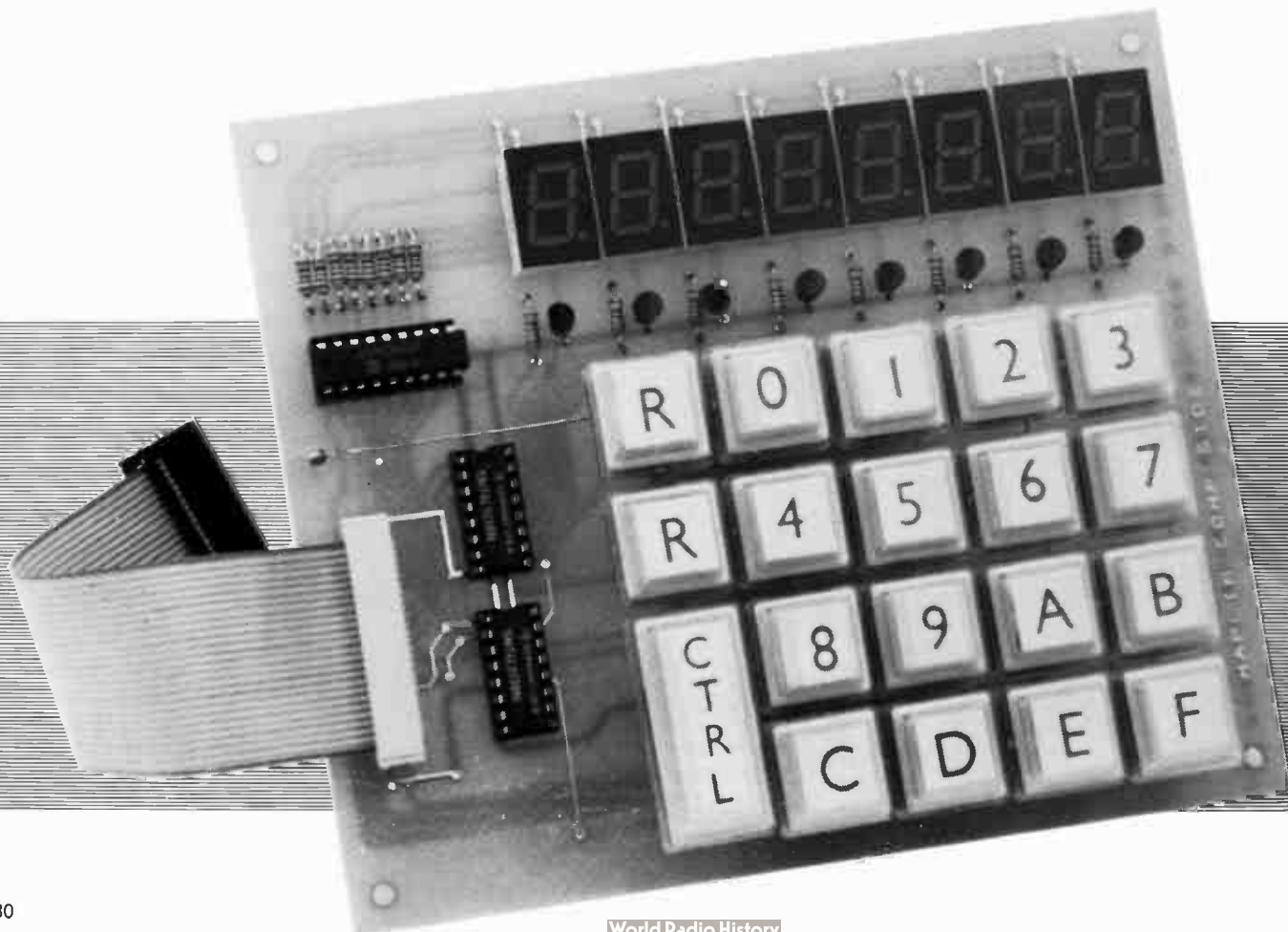
machine code or the desire to acquire it, which can be assisted by my current series on the subject.

Note that it is advisable to obtain a copy of Issue 15 of 'Electronics' to be sure exactly what is provided in the Z80 CPU kit and what is otherwise 'optional'.

The Keyboard Display Circuit

The circuit is shown in Figure 1, and is quite straightforward, largely due to the built-in sophistication of the 8279 IC.

The display is multiplexed at a rate determined by the system clock and a control word sent by the monitor. As a result, a binary counter output appears



Keypad for the Z80

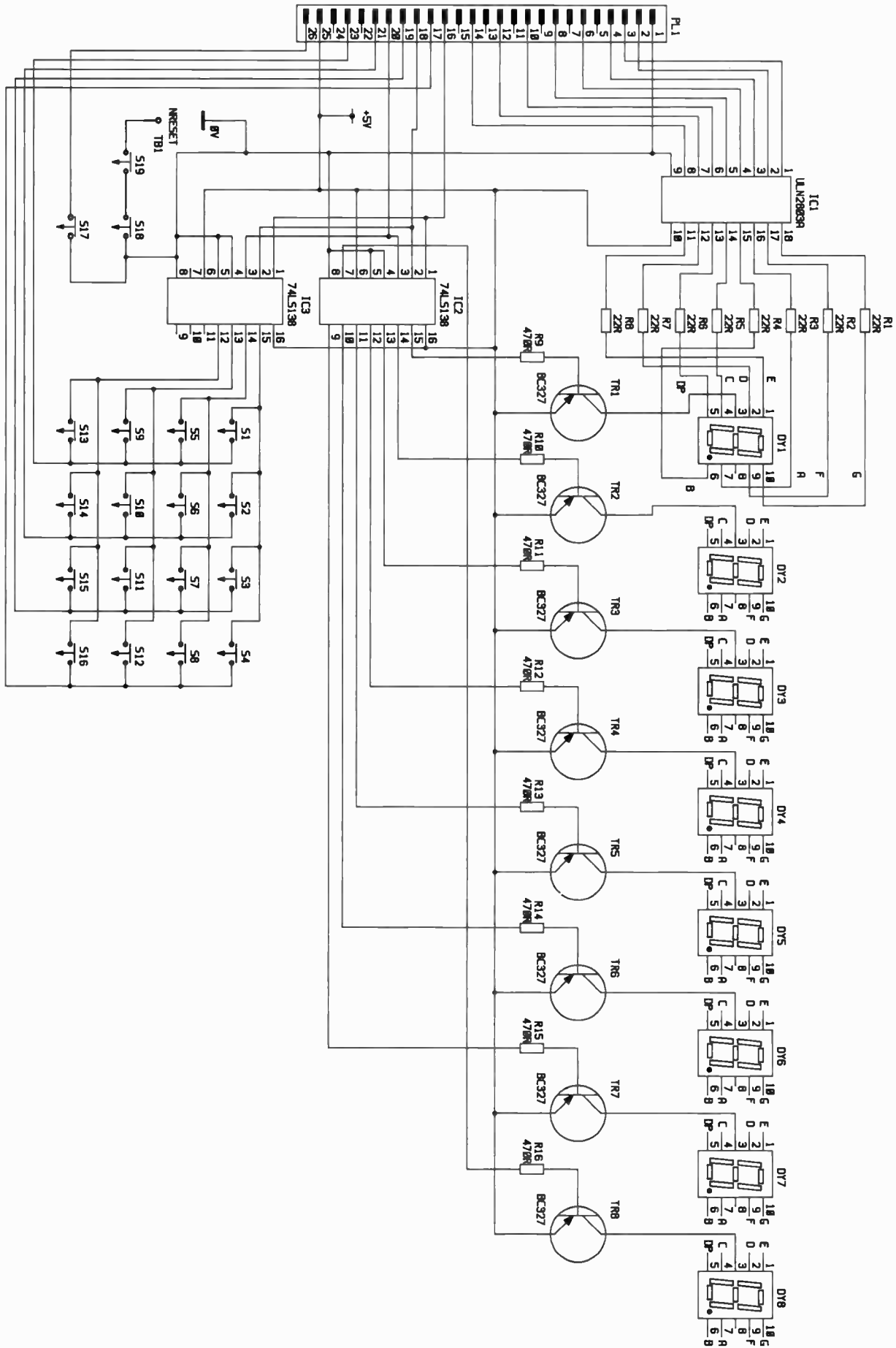


Figure 1. Circuit Diagram.

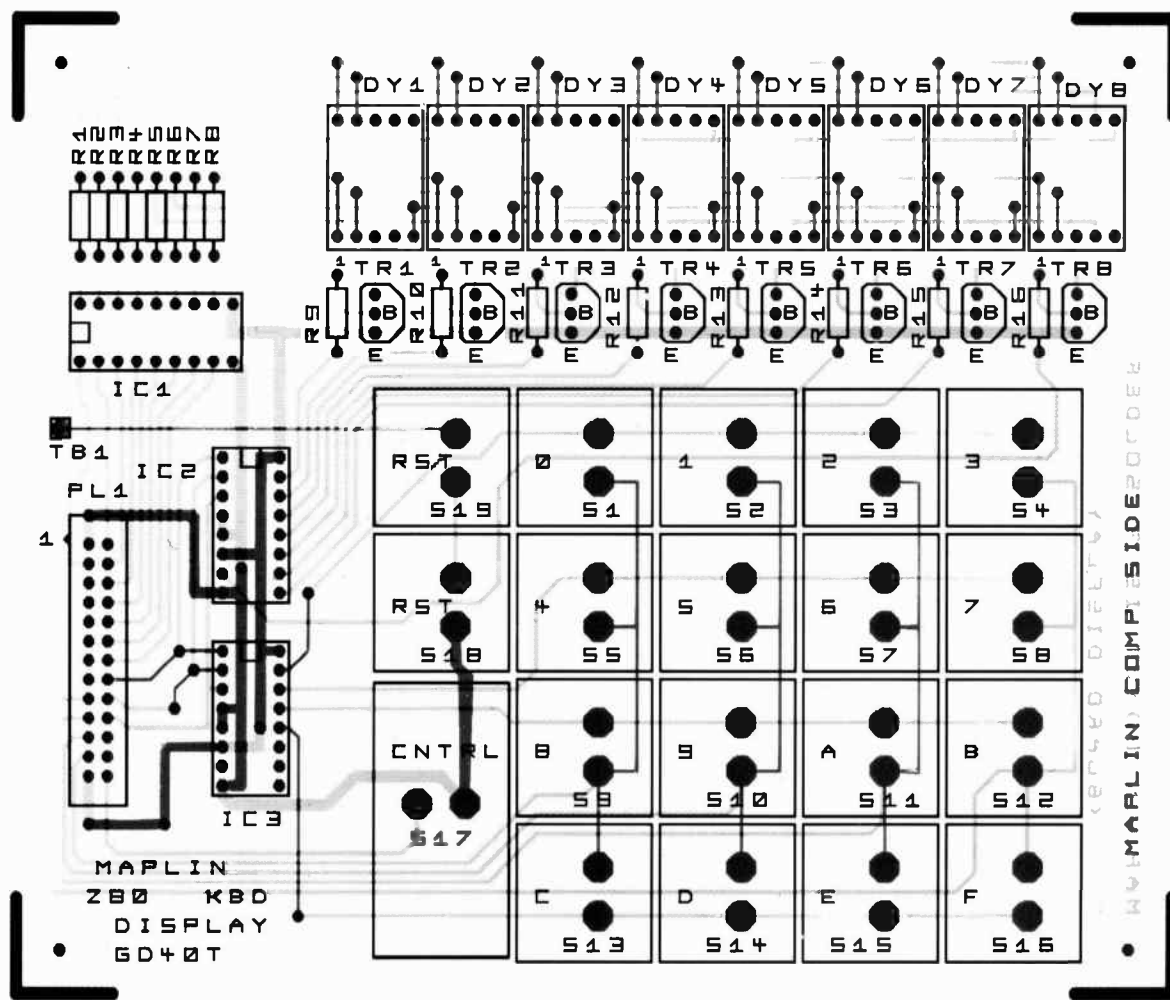


Figure 2. PCB Layout.

on the scan lines SL0-SL2, which is applied to both 74LS138 3-8 line decoders, IC2 and IC3. The eight output lines of IC2 drive the bases of driver transistors TR1-8, which are PNP types since common-anode displays are used. The ULN2803A, IC1, is an octal inverting buffer, that can sink more than enough current for the 7-segment displays. Its input is a set of eight data lines A0-A3, B0-B3 from the 8279 internal display RAM. The 22Ω resistors, R1-R8, limit the segment current to a value that will ensure reliability and long life for the displays.

The keypad consists of a 16-key HEX matrix and, to obtain additional functions, a further key, CTRL, is provided. This, used together with any other key, allows up to 16 control functions. Some of these are used in the system monitor, described later. The keypad returns four lines RL0-RL3, plus CTRL, to the 8279, which scans them to detect a key press and to identify its position in the matrix. It then sends an 'interrupt' signal to the Z80, to initiate a 'read keyboard input' routine.

Construction and Testing

No problems should be encountered provided that you negotiate the usual hazards of dry joints, bridged tracks, wrong polarity for IC's and transistors, etc. Refer to Figure 2 for assembly and afterwards carry out a visual examination for such defects and check with a meter for shorts across the supply. Some resistance checks with the power off will give an indication whether all is well or not. Where there are semiconductors in circuit, the reading will be different depending upon which way round the meter leads are applied to the circuit.

For example, a measurement between the 0V line and any of the lines A0-A3, B0-B3 should show high resistance one way and approximately 22Ω the other way. Similar results should be obtained between 0V and the lines SL0-SL2, but RL0-RL3 to 0V should show open circuit until a key is pressed, when the results are much the same as for the others.

These are all static tests, carried out

with the chips in place but no supply connected.

When the CPU and keyboard/display modules are connected together (a suitable cableform is available and its pin-outs are shown in Figure 3), and power is applied, the Z80 sends clock pulses to the 8279 IC which then generates the scan voltages on SL0-SL2. These can be detected by using a logic probe in the 'pulse' mode. Naturally, on power-up the display could show almost anything, unless the monitor ROM is fitted, in which case, if all is well, you'll see eight dots to tell you that the monitor's running. Pulse trains should also be found on pins 7, 9-15 inclusive of IC2 (and hence on the bases of TR1-8), and on pins 12-15 of IC3.

Pressing a key in any of the four vertical rows causes pulses to appear on RL0-RL3 respectively. Both CTRL and RESET should send logic low to the CPU card when pressed. To avoid the embarrassment of accidentally resetting the computer, two Reset Keys are provided, which have to be pressed at the same time to force a reset.

The Monitor EPROM

A simple monitor occupies rather less than half of a 2716 EPROM and provides the following facilities:

- (a) Access to any memory location to examine and/or modify data,
- (b) Step backwards or forwards through memory to examine, edit or enter program data,
- (c) Run a program from a given start location.

No sophistication is claimed for the monitor, but it is easy to use with a little practice. It operates as follows.

On power up, eight dots appear on the display to indicate that the monitor is running. Now press CTRL-A. CTRL-A means 'CTRL key plus A key, press down together'. OA now appears in the 'status field' to indicate 'address mode'. Type in an address, which you'll notice goes into the display in 'typewriter' mode, i.e. left entry. If you now enter CTRL-D, the status field changes to Od (data mode), though the dots remain in the data field. However, anything typed on the keypad now will appear in the data field and is entered into memory at the location stated in the address field. Entering CTRL-F takes you forward to the next location, while CTRL-B takes you back to the previous location. CTRL-F and CTRL-B only operate in data mode and always refresh the display, in other words, an address must be entered first before you can move forward or backward from that location. You can use this facility to only examine or edit memory rather than entering a program. Instead of typing in the actual start address, type in the one 'before it'; enter data mode and then use CTRL-F. This takes you to the location you want and brings up the data actually at that location on the display. Now as you step forward or back through memory, you will have a simultaneous display of memory and data. You can look anywhere in ROM or RAM in this way. CTRL-A and CTRL-D allow you to 'toggle' back and forth between the two modes, so you can nip about in memory quite niftily.

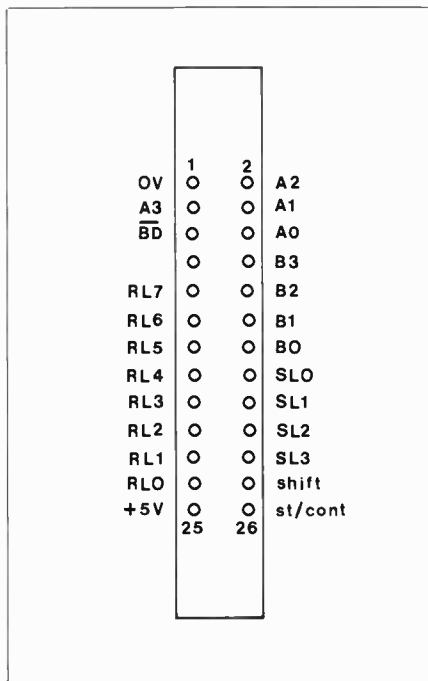


Figure 3. Connections to Z80 CPU.

Note that the data display is only refreshed by CTRL-F or CTRL-B, which means that whenever you toggle back to 'data' mode from 'address' mode the data shown is arbitrary. To see the correct data at the new location, type CTRL-F followed by CTRL-B (or vice-versa).

Thereafter, any memory locations examined by use of either of the latter control keys is correct.

To run a program that you have entered, type CTRL-E and OE appears in the status field. Enter the start address of the program, and operate CTRL-C. The program will now run and eight dashes on the display is the sign that it is doing so. If you put a HALT instruction at the end of your program, it will wait and you can then leave the program by using the 'reset' keys, which will take you back into the monitor. This, of course, allows you to examine any memory locations that might have been modified by the program simply by re-entering the sequence via CTRL-A.

Scratchpad RAM

As with all monitors, this one requires a small amount of RAM for its own use. This it uses for the storage of variables and also as a 'stack' during the running of certain monitor routines. The monitor ROM occupies the addresses &0000 to &07FF; the following area of the memory map is normally occupied by RAM, starting at address &0800. The monitor claims the bytes from &0800 to &085F for its scratchpad. This means that the lowest address at which user programs should be stored is &0860.

Summary of Control Functions

Command	Status Code	Mode & Action
Power-on	8 dots	Monitor ready
Reset	8 dots	Monitor ready
CTRL A	0A	Address mode. Enter address.
CTRL D	0d	Data entry mode, following Address mode only. Enter data.
CTRL F	0d	Step forward one location and refresh display. Data mode only.
CTRL B	0b	Step backward one location and refresh display. Data mode only.
CTRL E	0E	Enter start address of program to execute.
CTRL C	8 dashes	Execute program.

Z80 CPU MODULE HEX KEYPAD KIT PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1-8	22Ω	8	(M22R)
R9-16	470Ω	8	(M470R)

SEMICONDUCTORS

TR1-8	BC327	8	(QB66W)
IC1	ULN2803A	1	(QY79L)
IC2,3	74LS138	2	(YF53H)

MISCELLANEOUS

DY1-8	1/2in. Display Type 1	8	(FR39N)
	PCB	1	(GD40T)
S1-19	Keyboard Switch	19	(FF61R)
	Pin 2145	1 Pkt	(FL24B)
	Keypad 1 Position	18	(FF62S)

Keypad 2 Position	1	(FF63T)
DIL Socket 16-pin	2	(BL19V)
DIL Socket 18-pin	1	(HQ76H)
Constructors' Guide	1	(XH79L)

OPTIONAL PL1

Keypad Cableform	1	(FP63T)
EPROM 2716/M12	1	(UH87U)

The above items (excluding Optional) are available as a kit.

Order As LM18U (Z80 Hex Keypad Kit)

The following items (which are included in the kit) are also available separately.

Keypad PCB Order As GD40T
Keypad Cableform Order As FP63T
EPROM 2716/M12 Order As UH87U

Although a few years ago a couple of concealed switches provided a good and in most cases, adequate means of defeating car thieves, these days something a little more sophisticated is really required. One reason for this is that car thieves are generally familiar with simple forms of alarms, immobilisers, etc. and means of overcoming them. Perhaps of more relevance, it is common for quite expensive items to be left in cars, either in the form of loose items in the back of the car or as car accessories such as radios, cassette players, compact disc players, and the like. Many car alarms are of little or no use against someone who breaks or forces open a window and removes items from inside the car.

This burglar alarm design is basically the same as the ultrasonic movement detector type that is often used to protect homes and other buildings. By detecting movement inside the car, it renders the method of entry irrelevant, and even

someone reaching in through a window left slightly open should trigger the alarm.

The circuit incorporates an Exit Delay Timer which prevents the unit from being activated until several seconds after it has been switched on, giving the user an opportunity to leave the car without triggering the alarm. This is an important feature as it enables the on/off switch to be positioned inside the car, rather than having to rely on a concealed switch somewhere on the outside of the car. A short duration Entry Delay is also included so that the user can enter the car and deactivate the alarm before it sounds. However, for obvious reasons, this delay needs to be kept as short as possible and the on/off switch should obviously be concealed somewhere inside the car where it cannot easily be found.

by Robert Penfold

Once activated the alarm operates the car horn, and to make it more obvious that this is not merely some sort of electrical fault say, but genuinely an alarm, the horn is pulsed on and off at approximately 1Hz, creating an 'urgent' sound. Of course, some other alarm generator could be used if preferred.

To avoid unnecessary annoyance to others and to prevent excessive drain on the car's battery, the alarm is automatically switched off after about 2½ minutes (provided the unit is not still being triggered).

System of Operation

Alarms of this type rely on the well-known Doppler Shift effect. It is this effect which, for example, causes the pitch of a car engine to sound higher when approaching than it does when it has passed by and is moving away. In this case, an ultrasonic transmitter is used to generate high frequency sound waves that are inaudible to humans. A receiver circuit is used to detect the ultrasonic

ULTRASONIC CAR ALARM



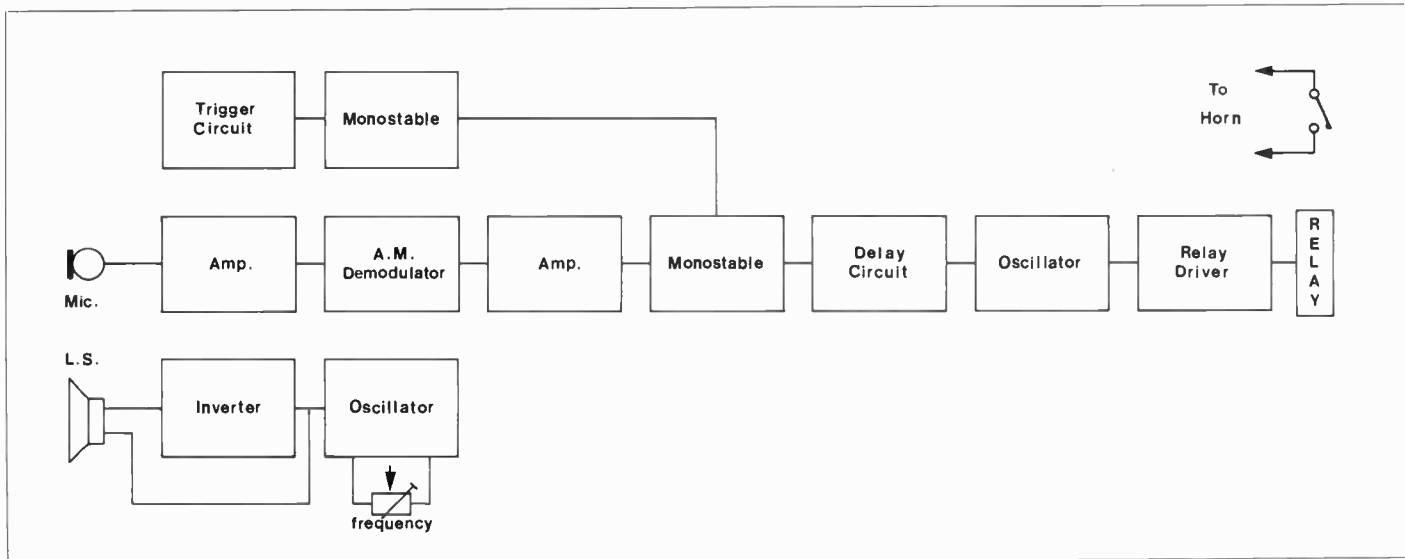


Figure 1. Block Diagram

sound waves, which will either be picked up direct from the transmitter, or via reflections from stationary objects. In either case, the received signals will all be the same as the transmitted frequency.

The same thing is not true if the sound waves are received by way of a moving object. If the object is moving away from the transmitting and receiving transducers, the Doppler Shift effect produces a downwards shift in frequency. If the object is moving towards the transducers, there is an upwards shift in frequency. It is by detecting this change in frequency that the alarm detects movement and is activated. In fact, it is not by directly detecting this shift in frequency that the unit functions but instead, it is a matter of detecting the interaction between the shifted and unshifted frequencies. This is a much easier and more reliable method.

The received signal is presented to what is really just an ordinary AM (amplitude modulation) detector of the type used in medium and long wave radios. The shifted and unshifted signals then produce a low frequency beat note which is equal to the difference in the two frequencies. For instance, if the unshifted signal is at 40kHz and the shifted signal is at 40.1kHz, the beat note will be 0.1kHz or 100Hz. This is the same effect that generates a tone when an AM radio is tuned to two stations that are on virtually the same frequency. In practice the beat note from an ultrasonic detector is normally between a few Hertz and around two hundred Hertz, depending on the speed and direction of the detected object. As a beat note is only generated when a shifted frequency is present, this signal can be amplified and used to activate the alarm.

Block Diagram

Figure 1 shows a block diagram of the car alarm. The transmitter is by far the simpler of the two sections, being little more than a 40kHz oscillator feeding into an ultrasonic transducer. A frequency of 40kHz is used only because the efficiency of both the receiving and

transmitting transducers peaks at around this frequency. In practice, the output frequency is trimmed to the one which gives optimum results. The output of the oscillator also feeds an inverter, such that the transducer is push-pull driven from the two antiphase (inverted and non-inverted) signals, receiving a high peak-to-peak drive voltage as a result.

The output from the receiving transducer is at a fairly low level, and is comparable to the output from an ordinary microphone. An amplifier is

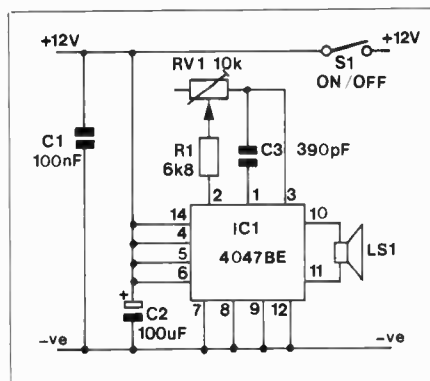


Figure 2. Ultrasonic Transmitter Circuit Diagram

therefore used to boost the signal to a usable level prior to demodulation. The demodulated signal is then used to trigger a Monostable Timer, but only if the amplifier supplies a suitably strong 'change' in output signal level. This first timer is controlled by a second Monostable Timer, which provides for the Exit Delay time period. This second timer is triggered at 'power-up' or switch-on, providing an output pulse of 10 to 12 seconds in length, which holds the first timer in an inactive state for the duration of this output pulse, during which time the ultrasonic receiver is allowed to settle down. Thereafter the circuit functions normally.

The main timer circuit controls a gated oscillator which is switched on when the unit is activated. A simple delay circuit between the monostable and the oscillator provides the Entry Delay. The oscillator operates the horn via a relay and relay driver circuit.

Circuit Operation

The transmitter and receiver circuit diagrams are shown separately in Figures 2 and 3 respectively.

Taking the transmitter first, this is based on a CMOS 4047BE monostable/astable device, which is obviously connected in the free running astable mode in this application. This device (when used in this mode) actually consists of an oscillator driving a divide by two flip/flop which has Q and \bar{Q} outputs. It is from these complementary outputs that the transmitting transducer is driven. Although this arrangement is somewhat more complex than the one outlined in Figure 1, it is essentially the same. RV1 is adjusted to set the optimum output frequency.

The receiving transducer connects direct to the input of a high gain common emitter amplifier based on TR1. Both the transducers are piezo-electric types and have an extremely high impedance. Consequently, no DC blocking capacitor is needed at the input of the receiver. TR1 provides a voltage gain of only about 40dB, which is substantially less than is normally utilized in an alarm of this type.

However, it must be borne in mind that in this case, the unit is to be used in the small confines of a car and a sensitive circuit with a large area of coverage is unnecessary. In fact it would probably be undesirable as it could easily lead to problems with spurious triggering of the unit.

D1 and D2 are a conventional diode demodulator circuit which feed the RF filter formed by R4 and C5. C5 has a larger value than normal for an AM demodulator, but this is due to the lower than usual carrier frequency and modulation frequency range.

TR2 is a transistor switch, which is 'normally off' due to R6 acting as a base leakage resistor tying the base connection to 0V. TR2 is forced into conduction momentarily by any abrupt change in the voltage charge across C5, which is communicated to TR2 via C6. TR2 provides the trigger signal for the horn timer IC2. This monostable is a 555 type but it is actually based on the CMOS

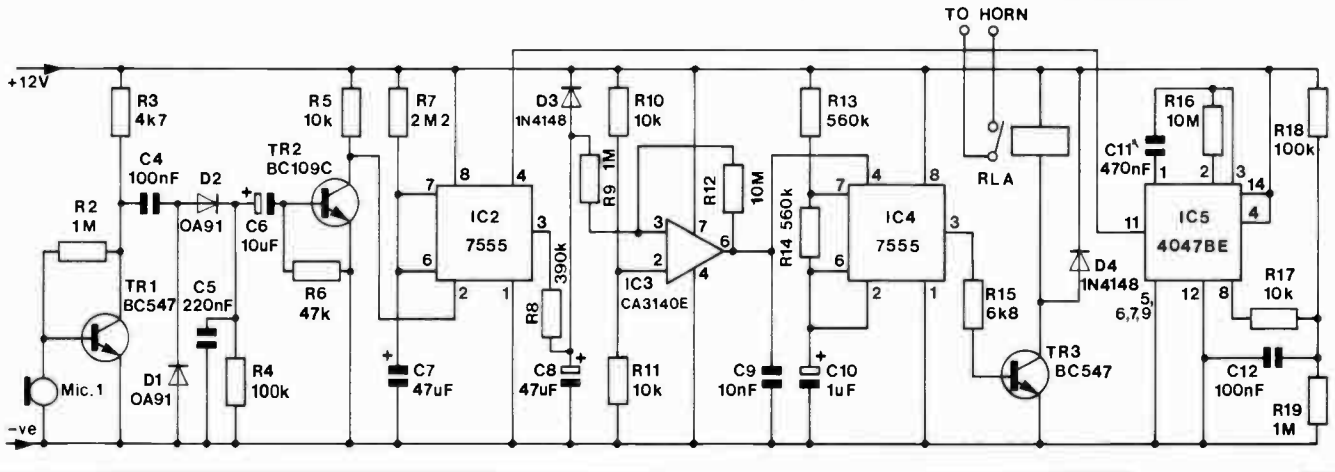


Figure 3. Receiver and Alarm Circuit Diagram

(ICM7555) version of the popular 555 timer. The 7555 has the advantage of a higher maximum operating voltage.

IC5 is a 4047BE CMOS device connected as a positive edge triggered (non-retriggerable) monostable, and it provides the Exit Delay time period. R17, 18 and 19 and C12 produce a trigger pulse at switch-on, whilst timing components C11 and R16 set the output pulse time at about 11.6 seconds. The \bar{Q} output at pin 11 goes low for this period, and it inhibits IC2 by controlling the reset input.

R7 and C7 are the timing components for IC2, and it is these that control the length of time that the alarm will sound. C7 must be a low leakage electrolytic or tantalum bead type capacitor if the timing cycle is to be

terminated properly. In theory the output pulse duration of IC2 is about 2 minutes but in practice, it is likely to be somewhat longer at around 2½ minutes.

Once triggered, IC2 Q output pin 3 goes high, and activates the Schmitt Trigger circuit built around operational amplifier IC3. However, R8 and C8 form a simple C - R timing circuit that gives a delay of about 18 seconds before the trigger threshold is reached, and these provide the entry delay. D3 ensures that C8 largely discharges when the unit is switched off so that the entry delay circuit is almost immediately ready to function again if necessary.

IC4 is a 7555 used as an astable oscillator, which operates the horn via RLA. The reset input of IC4 is normally

taken low by the output of IC3, and the oscillator is disabled, but when the output of the schmitt trigger circuit goes high, the oscillator functions normally. The relay is activated during the period when the output of IC4 goes high and the switching transistor TR3 is turned on. The output waveform of IC3 is not a square-wave with a 1 to 1 mark-space ratio, as the 'on' time of the horn is double the 'off' time. This is perfectly satisfactory for the present application though.

Construction

The Car Alarm printed circuit board layout is illustrated in Figure 4 and there are several points which should be noted. Firstly, IC1 and IC5 are CMOS devices and IC3 has a PMOS input stage. The standard antistatic handling pre-

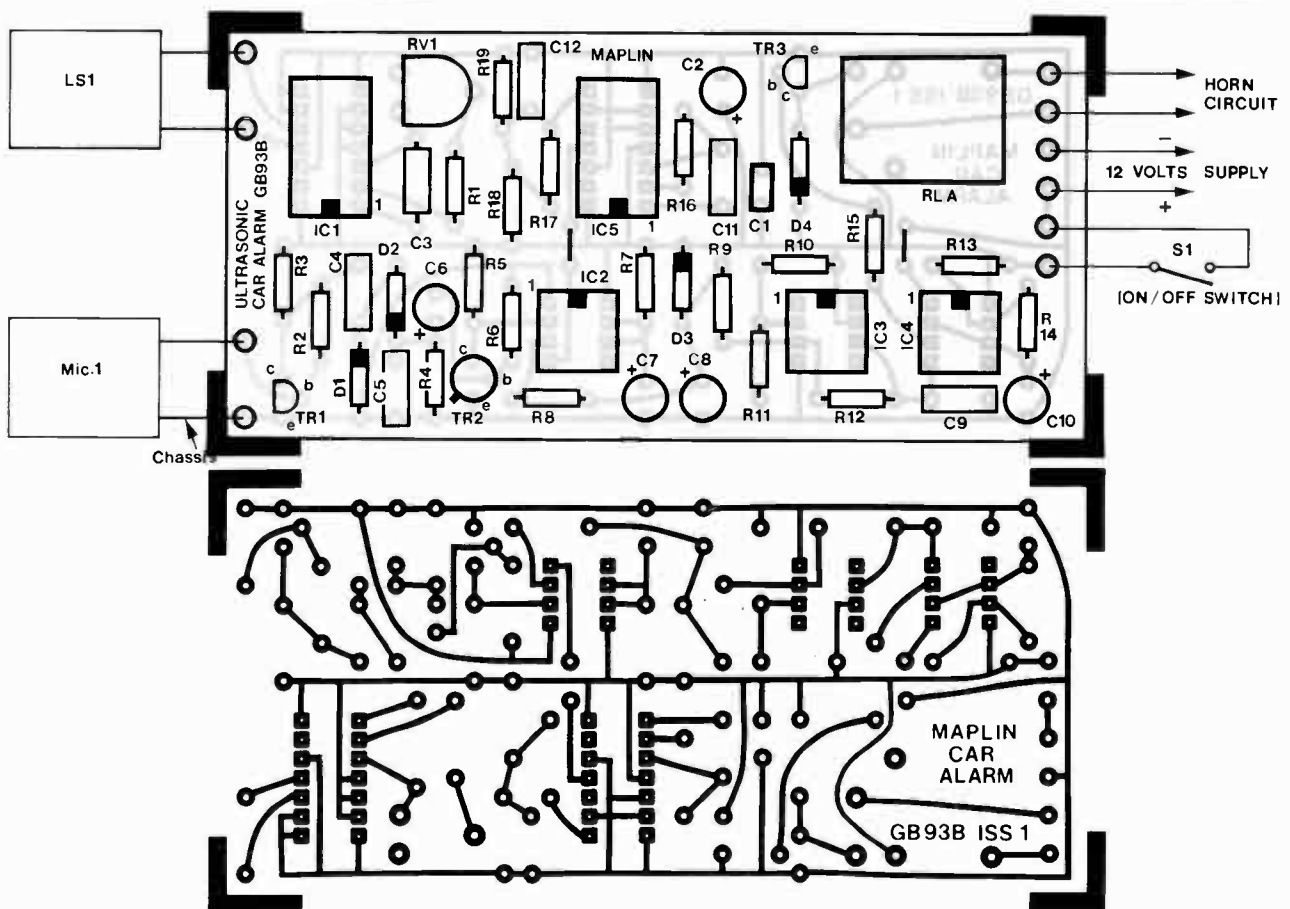


Figure 4. PCB Artwork and Legend

cautions, therefore, need to be taken when dealing with these three components. They should then be handled as little as possible and should be left in their antistatic packaging until they are ready to be pressed into their respective IC sockets, but not until these have been soldered to the PCB and the rest of the unit is, in other respects, finished. Note that although IC2 and IC4 are both CMOS devices, they have built-in protection circuitry that render any special handling precautions unnecessary. They are not amongst the cheapest of integrated circuits though, and it is advisable to fit them in IC sockets or holders anyway.

Diodes D1 and D2 are germanium types and these are more vulnerable to damage by heat than silicon types. It is not essential to use a heatsink on each leadout wire while it is soldered in place, but the soldering iron should not be applied to each joint for any longer than is absolutely necessary.

The usual procedure might be to insert and solder all the IC sockets first, then all resistors, using the PCB legend and with reference to Figure 4. When mounting the capacitors be sure to insert the electrolytic types C2, C6, C8 and C10 the correct way round. These have their *negative* electrodes marked by a dark band and/or a - sign. The tantalum bead capacitor C7 has the *positive* electrode marked with a + sign.

Now fit the transistors TR1 - 3, and diodes D1 - 4, making absolutely sure that they are inserted the correct way round, with reference to the legend and Figure 4. The diodes will have their cathodes marked with a dark or coloured band, identify these and align them with the bars on the legend.

The unit can use any relay which has a 12 volt coil with a resistance of about 200 ohms or more and at least one set of make contacts of adequate rating, although it is advisable to use the type specified as the printed circuit board has been designed to accept it and it can be

plugged into the board and soldered in place just like the other components. Alternative types would almost certainly have a different base configuration and would not fit the board properly if at all without some adaptation. It would therefore be necessary to either make a suitably modified board or to hard-wire the relay to the board and then mount it somehow, either on or off-board.

Veropins are fitted to the board at the points where connections to off-board components will be made. The two transducers can be mounted on the board if desired but it is advisable to fit veropins and then solder them to these, either vertically or horizontally, using a generous amount of solder. The piezo transducer pairs supplied by Maplin are not identical transmitting and receiving devices. That which is marked 'T40-16' is LS1, and that marked 'R40-16' is Mic1. LS1 can be connected either way round, but Mic1 should have the terminal which is electrically connected to its body connected to the earth (0V) rail.

Mechanical construction and installation in the vehicle must be varied to suit the prevailing circumstances. Positioning of the unit in the car is not too critical due to the small volume to be monitored, but it should be placed somewhere that has the two transducers facing outwards into the interior of the car, and not straight under a seat or something of this nature. With any alarm of this type, it is usual to disguise it to some extent so that its presence is not obvious to potential intruders. The on/off switch should be well hidden and a keyswitch could be used. However, the wiring to the switch is likely to be vulnerable and a policy of making the switch and wiring difficult to find in a short space of time is probably the better way of doing things. The take-off points for the supply to the unit should be chosen so that power is not disconnected when the ignition is switched off. For the ultimate in security, the alarm could be powered from its own supply

and the reasonably low current consumption of the circuit makes the use of (say) ten AA Ni-Cad batteries as the power source, a practical proposition. The relay contacts would normally be arranged so as to supply power to the horn when they close. Again, for the ultimate in security, the unit would operate its own alarm generator circuit and there have been plenty of designs for these published in the past. Although the circuit is a negative earth type, there should in fact be no difficulty in using the unit with a positive earth vehicle (the vast majority of cars have a negative earth).

RV1 must be given a suitable setting before the unit will function properly but this can be done fairly easily without resort to specialised test equipment. However, a digital frequency meter could be used to determine the operating frequency of LS1, by connecting the DFM input to either electrode of LS1. It may still be difficult to determine the exact mid-band operating range for the piezo transmitter, which can be anywhere from 35 to 45kHz. However, strong second order harmonics would be generated if the transducer were being forced to operate outside of its normal bandwidth, which should be picked up by a reasonably sensitive DFM. Therefore RV1 would be set to a position to obtain a two figure reading in kHz. A reading of 70kHz or higher is the result of harmonics, and it should be possible to find the transducer's operating range, the limits of which are marked by a tendency of the DFM to 'jump' from 35 - 45kHz to 70 - 90kHz or higher. Alternatively, the car alarm can be temporarily connected to a 12V supply, and set up with a sheet of smooth card or similar hard surface approximately 48 inches directly in front of the piezo transducers. A multimeter set to say 5V DC can be connected across C5 and OV. When the unit is switched on the meter should register an output from D2. Then all that is required is to adjust RV1 for the highest reading.

ULTRASONIC CAR ALARM KIT PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1,15	6k8	2	(M6K8)
R2,9,19	1M	3	(M1M)
R3	4k7	1	(M4K7)
R4,18	100k	2	(M100K)
R5,10,11,17	10k	4	(M10K)
R6	47k	1	(M47K)
R7	2M2	1	(M2M2)
R8	390k	1	(M390K)
R12,16	10M	2	(M10M)
R13,14	560k	2	(M560K)
RV1	Hor Encl Preset 10k	1	(UH03D)

CAPACITORS

C1	Minidisc 100nF 16V	1	(YR75S)
C2	PC Elect 100µF 25V	1	(FF11M)
C3	1% Polysty 590	1	(BX52G)
C4,12	Poly Layer 100nF	2	(WW41U)
C5	Poly Layer 220nF	1	Kit Only
C6	PC Elect 10µF 50V	1	(FF04E)
C7	Tant 47µF 16V	1	(WW76H)
C8	PC Elect 47µF 25V	1	(FF08J)
C9	Poly Layer 10nF	1	(WW29G)
C10	PC Elect 1µF 100V	1	(FF01B)
C11	Poly Layer 470nF	1	(WW49D)

SEMICONDUCTORS

IC1,5	4047BE	2	(QX20W)
IC2,4	TLC555CP	2	(RA76H)
IC3	CA3140E	1	(QH29G)
TR1,3	BC547	2	(QQ14C)
TR2	BC109C	1	(QB33L)
D1,2	OA91Y	2	(QH72P)
D3,4	1N4148	2	(QL80B)

MISCELLANEOUS

S1	SPST Ultra Min Tggle	1	(FH97F)
RLA	10A Mains Relay	1	(YX97F)
Mic1/LS1	Ultrasonic Transducers	1 Pr	(HY12N)
	PCB	1	(GB93B)
	DIL Socket 8-pin	3	(BL17T)
	DIL Socket 14-pin	2	(BL18U)
	Pin 2145	1 Pkt	(FL24B)
	Instruction Leaflet	1	(XK00A)
	Constructors' Guide	1	(XH79L)

The above items (excluding Optional) are available as a kit.

Order As LK75S (U/Sonic Car Alrm Kit)

The following item (which is included in the kit) is also available separately.

U/Sonic Car Alrm PCB Order As GB93B

ACTIVE CROSS-OVER

With three channel amplifier

by Dave Goodman

Very few loudspeakers are capable of handling the full audio range of frequencies, and continue to give maximum output efficiency at the same time. Indeed, it is not always desirable to rely on just a single loudspeaker system, especially if cabinet design and directional effects are taken into consideration. Many hi-fi speaker systems incorporate three loudspeakers; a large 'Woofer', for handling low frequency bass signals, a smaller 'Squawker' for mid-range frequencies, and an even smaller 'Tweeter' for the high frequency signals. Each speaker is then driven from an amplifier via a network of filters, called a cross-over, which divides the composite audio input signal into three distinct frequency bands as shown in Figure 4.

The Active Cross-Over Module does this electronically, providing more precise control over the frequency bands presented to each of the three loudspeakers. This active filter is not capable of driving loudspeakers directly, and so a power amplifier, one for each channel, must be provided between the filter outputs and each of the three speakers as in Figure 3.

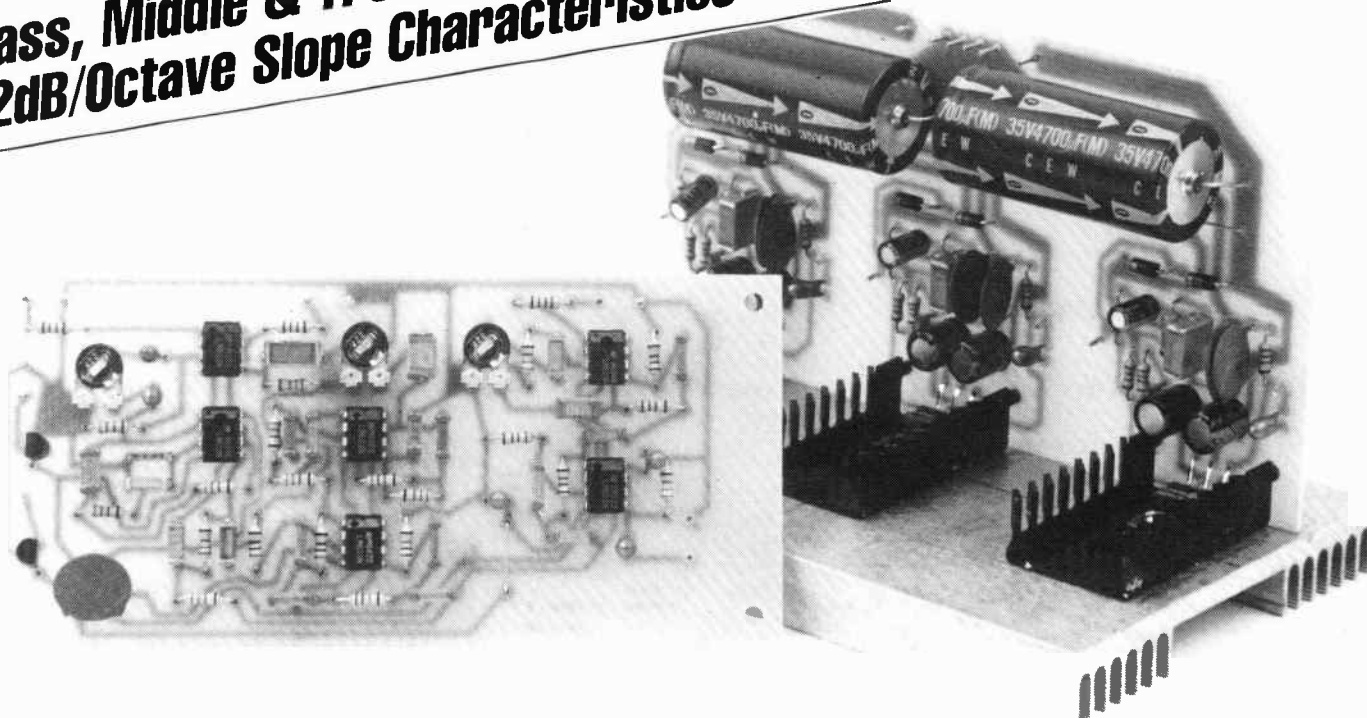
This means that three amplifiers with suitable power supplies will be required, and also a DC supply for the Cross-Over Module itself. For low power outputs, a three channel amplifier capable of delivering 10 watts per channel (total 30 watts) into 8 Ω load speakers is featured later on in this article, which has been developed for use with the cross-over module.

Circuit Description

Audio input signals are buffered by voltage follower IC5b, and applied to each filter section. The low pass filter, IC1 and associated circuit, exhibits a cut off at 500Hz with a second order response of 12dB per octave, ensuring higher frequency signals are well attenuated above 1kHz. RV1 presets the filter signal level, and IC2a provides a low impedance output from pin 3.

IC5a and IC6b provide the opposite effect in a high-pass filter configuration. Frequencies below 4kHz are attenuated by each 6dB section, again producing a 12dB per octave slope 2nd order response, which falls away below 2kHz. Within the pass band of both filters, the signal amplitude remains fairly constant with extremely low levels of distortion; down to below 12Hz in the bass channel

★ Cross-Over Frequencies at 650Hz & 4kHz
★ Bass, Middle & Treble Channel Outputs
★ 12dB/Octave Slope Characteristics



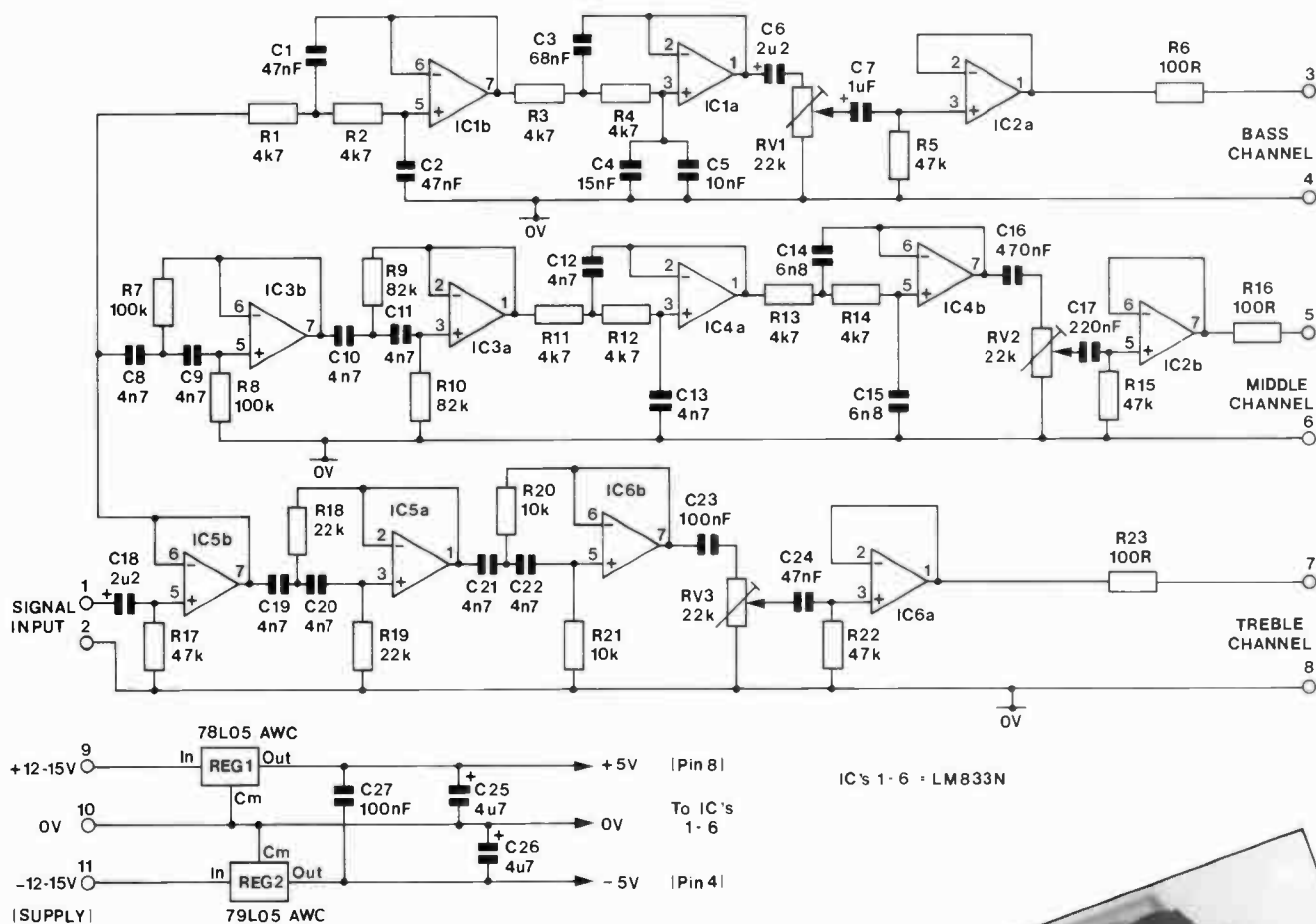


Figure 1. Cross-Over Circuit Diagram

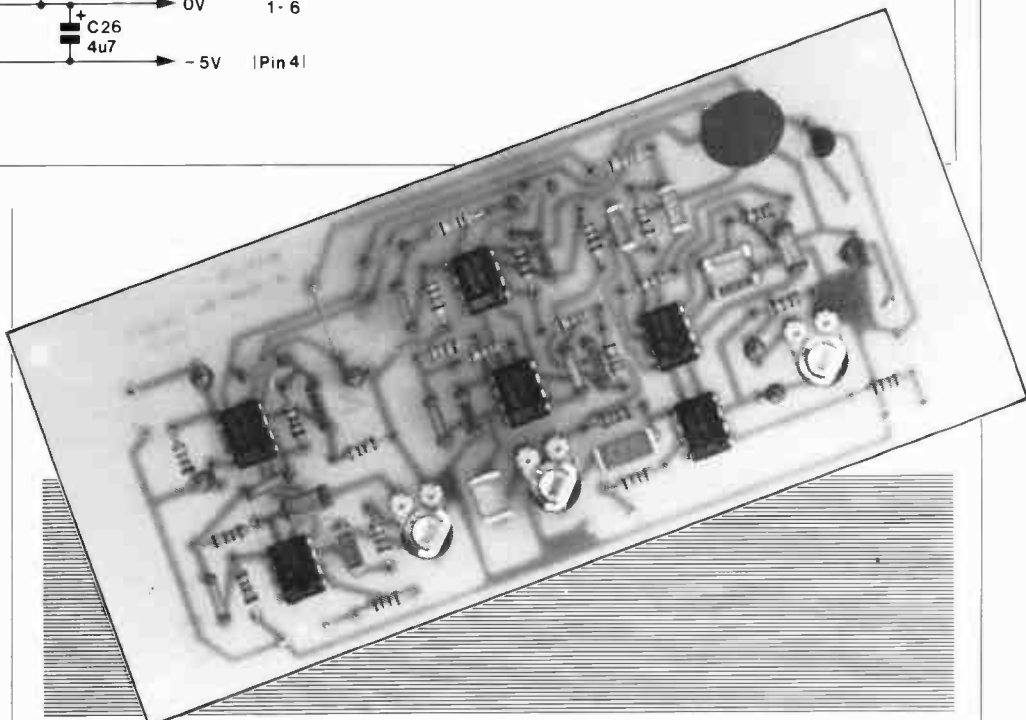
and well above 100kHz in the treble channel!

The trough between both 500Hz and 4kHz curves is catered for by using a band pass filter, comprising a high pass filter IC3, and a low pass filter IC4. The cut-off points are broadened slightly to allow for a flatter response in this area, and again for the lower and upper slope characteristic is 12dB per octave. Each filter output has a preset which allows signal amplitude levels to be varied from maximum output down to zero, like a volume control, and a low impedance output is derived from a final stage voltage follower.

The supply regulators REG1 and REG2 provide a stabilised $\pm 5V$ to the Active Cross-Over circuit, and require DC inputs of $\pm 8V$ to $\pm 15V$ @ 30mA.

Construction

Refer to the Parts List for component descriptions. Begin construction by making the three wire track links. Either bare copper wire (24 s.w.g) or thin hook up wire can be used for this purpose – insert the links and solder all six leads in place. At the risk of sounding obvious, a ready fluxed, multicore alloy solder should be used for soldering, and *not* plumbers or high melting point grades, as these are definitely not suitable for PCB work. Identify and insert R1 – R23. These components have their values coded with coloured bands around the



body, which have to be interpreted correctly with reference to a resistor value chart such as in the resistors section of the 1985 Maplin catalogue. Fit all six 8-pin DIL sockets, used for holding the IC packages, with the notched-end placed over each indent on the PCB legend. Solder all component leads in place and cut off excess wire ends. Next, insert the capacitors. There are five small 'tear drop' shaped tantalums with two different length leads. The longest lead is marked with a '+' sign insert this lead into the hole also marked with a '+' sign in positions C6, 7, 18, 25 and 26. Fit the brown circular disc ceramic C27, and solder all component leads in place. Cut

off excess wires. The remaining capacitors are silver-bodied polycarbonate types, some of which may have orange encapsulation on each end. Care must be taken when straightening leads on the non-encapsulated versions as they are easily broken! Their capacitance value may be identified in many ways; for example C1 has a value of $0.047\mu F$ which is 47nF or 473, the suffix 3 in the number being the number of noughts, or as 47000pF. Solder these components in place, then fit both regulator IC's and the three 22k presets. Insert all eleven vero pins – from the track side – and push each head down to the foil with a hot soldering iron. Solder all remaining

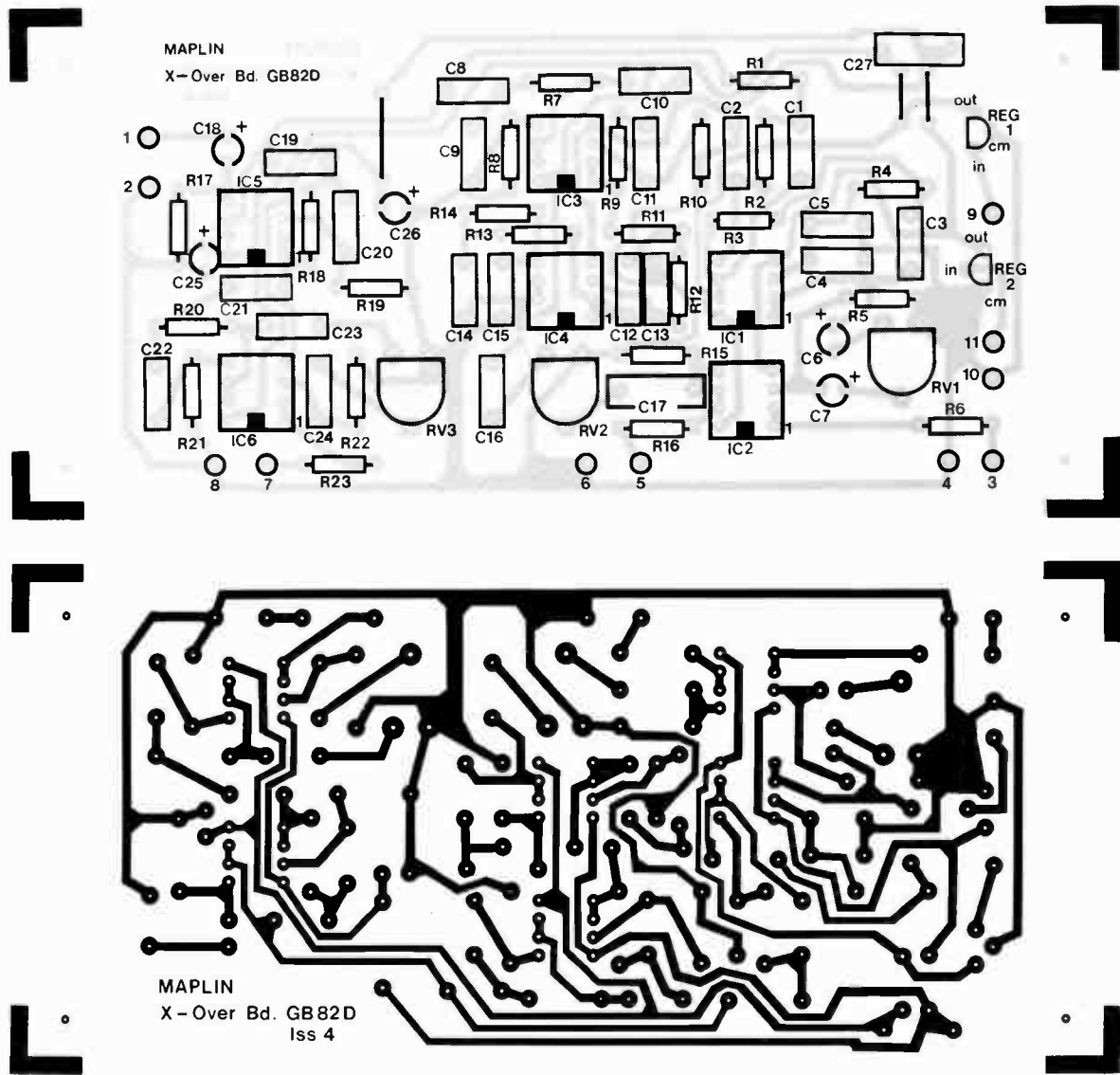


Figure 2. Cross-Over Track and Overlay

components and cut off excess wire ends. Inspect all components and solder joints, especially looking for solder bridges and short circuits; cleaning the tracks with a stiff brush and PCB flux solvent will facilitate this.

Testing

Do not insert any IC's at this stage. Connect a split rail power supply e.g. +15V/0V/-15V DC with +V to pin 9, -V to pin 11 and 0V to pin 10. Connect a DC voltmeter with negative lead to 0V pin 10, and positive lead to IC socket 6, pin 8. Turn on the supply and check a reading of +5V ($\pm 4\%$) is given. Replace the meter negative lead with meter positive lead on 0V and connect the negative lead to IC socket 6, pin 4. This time a -5V ($\pm 4\%$) measurement should be available. If either reading is incorrect, re-check the PSU connections and ensure the regulators are in their correct positions and orientated to the legend. Switch off the supply and insert IC's into each socket. Switch on the supply again and repeat the previous voltage checks. If a 5V supply rail is low (4.75V or less)

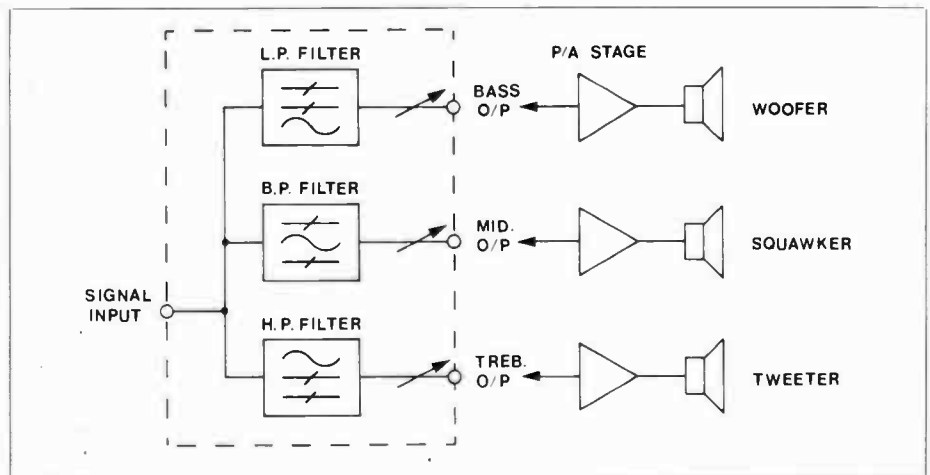


Figure 3. Cross-Over Block Schematic

then there may be an incorrectly fitted, or faulty IC.

To check the frequency response of each filter, you will need an audio signal generator, frequency counter and an AC milli-voltmeter calibrated in decibels.

Apply a low frequency sine-wave (15Hz) to the input by connecting the earth clip or screen of your coaxial test

lead to pin 2 (0V), and the 'live' clip to pin 1. The maximum input signal level that can be handled by the filters before distortion occurs, is 6.4V peak-to-peak or 2.25V RMS. Adjust the signal level to 0.775V RMS, which is normally zero (0) dB on most milli-voltmeter scales. Turn all three filter output presets clockwise for maximum output, and connect the AC

milli-voltmeter input to bass channel output pin 3 and screen (0V) to pin 4. Check the dB reading is about 1 to 2dB of the input level and increase the signal generator frequency. As the frequency approaches 1kHz, the output signal level drops rapidly and should be around 18dB down from the original 0dB reading. The remaining two filters can be similarly checked, and should produce results as shown in Figure 4. The Mid-range Channel (pins 5, 6) centre frequency is 2kHz, and since it is a band-pass filter, readings should be made both above and below the centre frequency.

The Treble Channel (pins 7, 8) is checked from 20kHz down to 2kHz and the slope readings noted. Slight differences at maximum response frequencies can be evened out by adjusting the appropriate channel preset. A difference of 1 to 3dB has very little effect upon the ear, and can be regarded as insignificant for most speaker systems.

Using the Cross-Over

The module could be fitted in a speaker cabinet, for instance, along with power supplies and output amplifiers and driven from a hi-fi system. Either preamp or speaker outputs could be connected to the module input, providing the peak signal does not exceed 6.4V (2.25V RMS). For connecting the input to an amplifier speaker outlet, a potential divider may be necessary where the total resistive load does not exceed the amplifier rating. Use high wattage resistors to allow for inadvertently overdriving the divider. Alternatively, the module could be mounted in a separate case with amps and PSU self-contained. Remember to keep the three output channel connections to the three power amplifier inputs as short as possible, only using screened audio cable, with the screening braid earthed, or connected to 0V, at the Cross-Over Module only; this is in order to help reduce earth-loop problems.

Amplification

All of the Maplin range of amplifier kits are suitable for use with the cross-over. The module itself is not a pre-amp and will not amplify signals connected to it, and is in essence, a frequency dependent attenuator, although pass band output levels will be similar to applied input levels. Details follow on constructing a three channel amplifier which will develop up to 10 watts RMS into 8Ω speakers for each channel.

3 Channel Amplifier

A design based on the TDA2030 IC uses dual supply rails, which enables loudspeakers to be wired directly to the amplifier outputs without the need for bulky DC decoupling capacitors.

IC amplifiers are critical at maximum supply voltages, and the TDA2030 supply must be kept below $\pm 19V$ DC (38V). Again, this problem is eased by using a dual supply derived from a 12V/0V/12V transformer. Without the

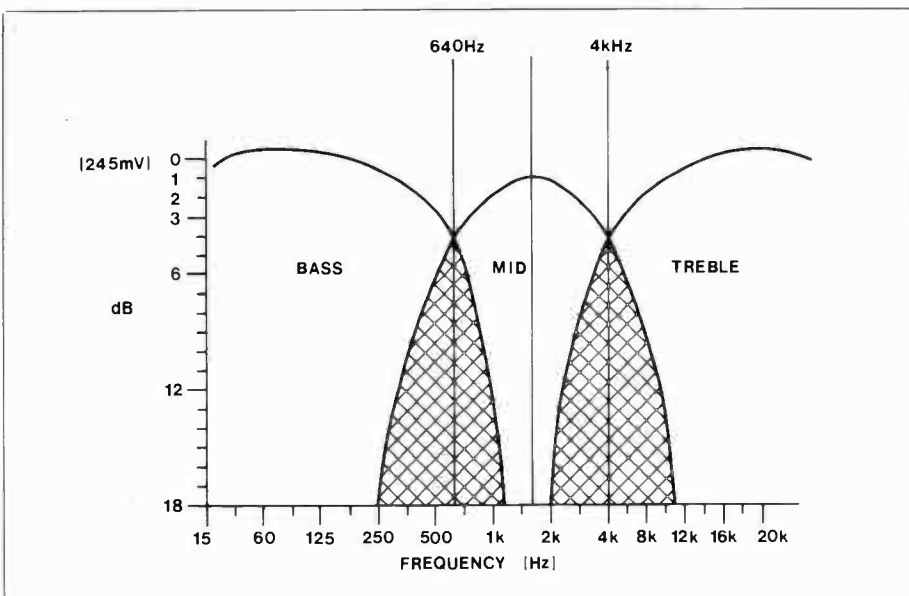
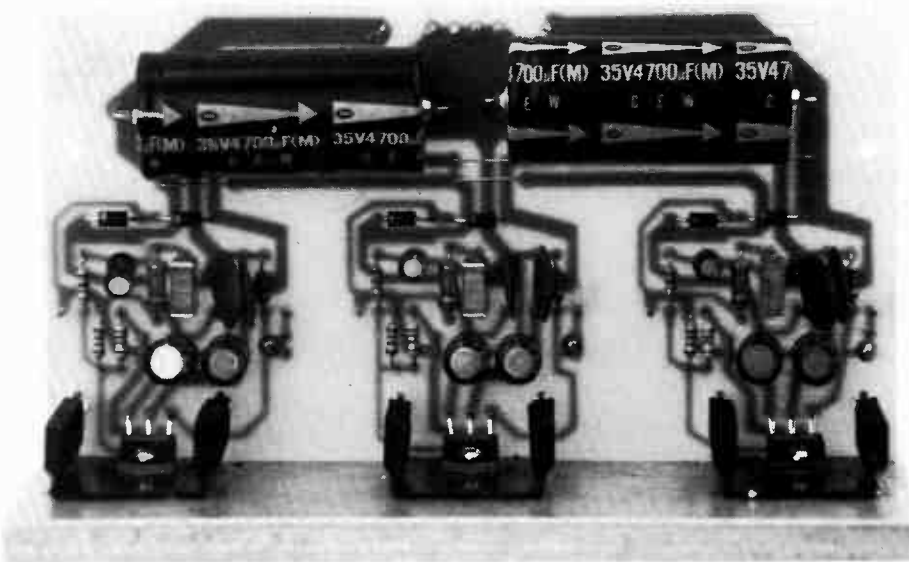


Figure 4. Typical Response Curves

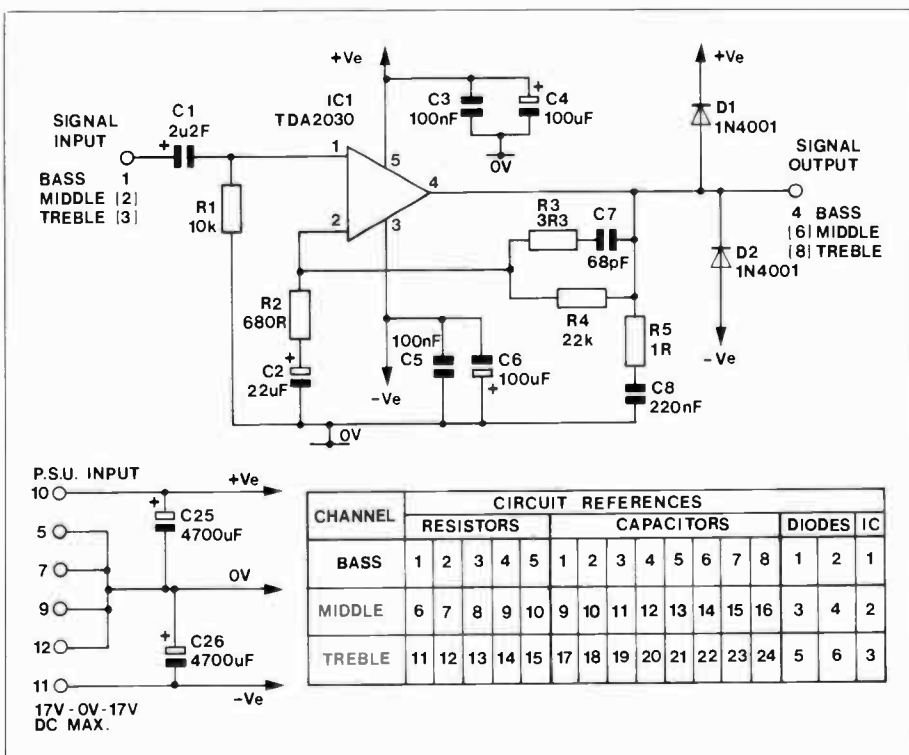


Figure 5. 3 Channel Amplifier Circuit Diagram

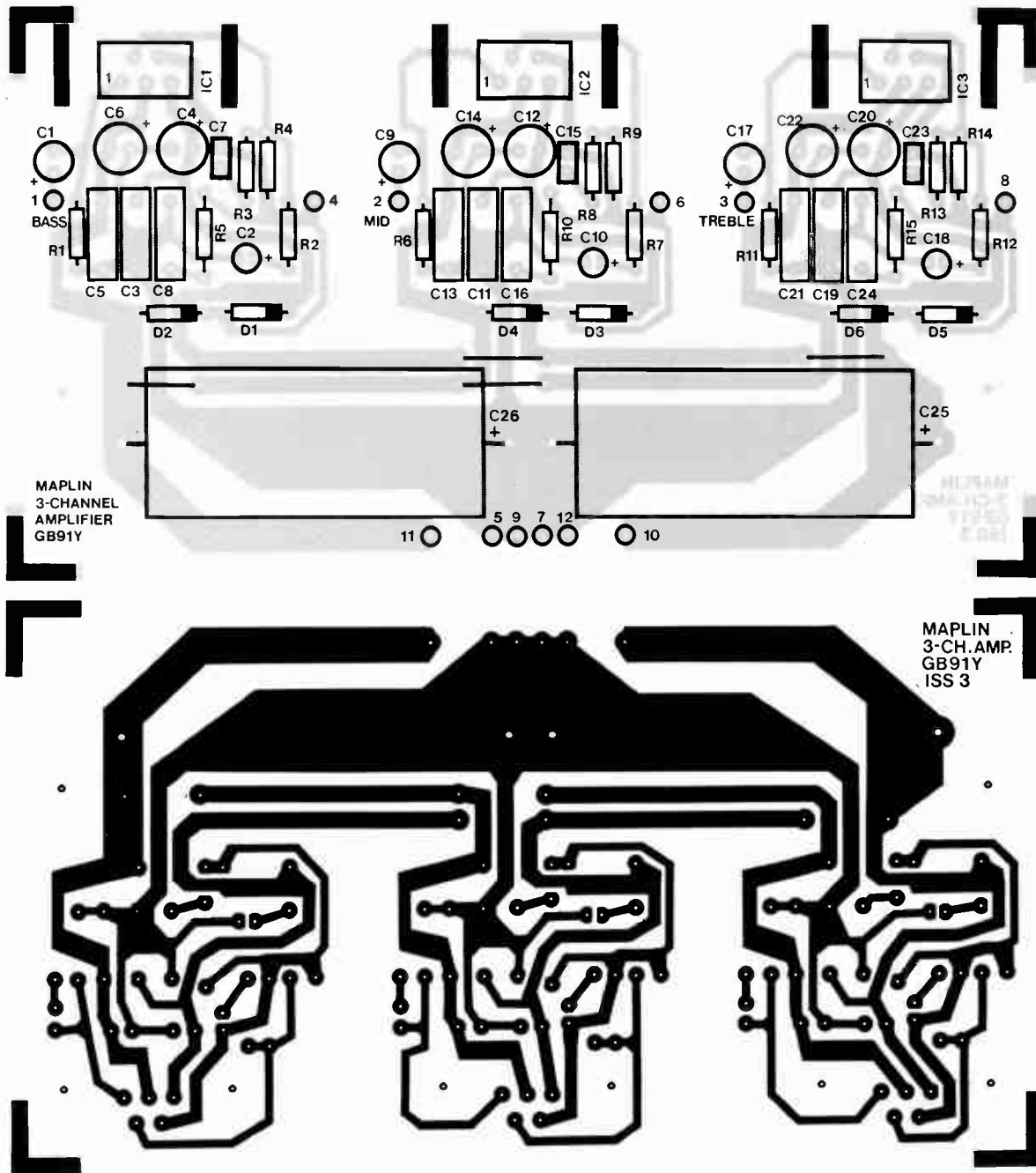


Figure 6. 3 Channel Amplifier Track and Overlay

addition of regulators or stabiliser circuitry, a full-wave bridge rectifier, and large reservoir capacitors will develop power supply rails of 17/0/17V DC which allows a theoretical power output into 8Ω of 15 watts. In practice though, this figure is limited to 10 watts RMS, due to amplifier design and PSU capability but should be found quite adequate for use in most domestic environments.

Circuit Description

Three identical amplifier stages are available on the PCB, any of which can be used for bass, middle or treble frequencies. As dual supply rails are used, the input signal is referenced to 0V by coupling capacitor C1 and resistor R1. The amplifier IC1 is used in a similar fashion as for operational amplifiers in the non-inverting mode. Amplifier gain is determined by the feedback components R4, R3, C7 and R2 as $\times 30$ and the

Specification

Min PSU:	±4.5V DC @ 5VA
Max PSU:	±18.5V DC @ 50VA
Max Power into 8Ω	10 Watts/Channel
Full Power Bandwidth	25Hz - 40kHz ±1dB
T.H.D.	0.1% @ 1kHz
Max Input Signal before Clipping	300mV RMS (0.85V peak-to-peak)
Input Impedance	10kΩ
O/P Load	>4Ω, (Typically 8Ω)

Zobel network R5, C8 helps prevent oscillations being generated under various output load conditions. Diodes D1 and D2 protect IC1 under reversed supply conditions but are only effective if both supply rails are fitted with fuses.

Supply decoupling components C3 to C6 remove high frequency spikes from the IC supply rails and presents the track connections to pins 3 and 5 at a low impedance. For the amplifier shown in Figure 5 only, pin 4 is the speaker output connection and the speaker return to 0V is at pins 5, 7, 9 or 12.

Construction

Four 13mm wire links should first be shaped and inserted into the PCB. Use either tinned copper wire (24 SWG) or hook-up wire for the links. Prepare two diodes D1 and D2 by carefully bending each lead to a 'U', then line up the silver band (cathode) to the bar on the legend. Insert one large standard 1Ω resistor R5 and minimum resistors R1 to R4. Locate the small 68pF ceramic capacitor C7 and insert this component into the PCB. Next, mount tantalum capacitor C1. This component is polarised and the longest lead is

marked with a '+' sign on the body. Insert this lead into the PCB hole marked '+'. The three radially mounted capacitors are fitted next C4, C6 and C2. Like C1, these components are polarised but this time, the shortest lead is marked with a '-' sign on the body. Do not insert this lead into the hole marked with a '+' sign! Finally, insert both brown ceramic discs C3 and C5, followed by the rectangular polycarbonate C8. Solder all components onto the track foil, cut off excess wire leads and insert components into the remaining two amplifiers. The procedure is the same as for the first amplifier which can be used as a guide. Solder these components as before and insert twelve vero pins in positions 1 to 12. They are inserted from the track side; push the pin heads down to the foil pads with a hot soldering iron and solder in place. Fit the two large capacitors, C25 and C26, noting the +V lead alignment. Solder all remaining leads and remove excess wires. Now the three IC's can be mounted. Insert their five leads into the PCB with the metal tabs facing towards the PCB outside edge. Push the body down until just 5mm of terminal lead is left between board and IC. Solder the leads and cut off spare ends.

Heatsink

Next refer to Figure 7, heatsink details. If you are using the recommended heatsink, drill three 3.2mm holes in the positions shown and remove any burrs from the hole edges. Whatever type of heatsinking is used, do not run the amplifiers into a load without ensuring adequate heat removing facilities are present. Up to 30 watts of heat will be dissipated in the metal heatsink under full drive conditions, and this must be radiated into the surrounding air, away from the IC's and components. Figure 8 shows the amplifier mounting details.

Each IC is mounted over a vaned heatsink bracket, which slots into the PCB and the assembly is bolted onto the aluminium heatsink panel. To begin, spread a film of silicone grease or heatsink compound over a vaned bracket base, lay it on the heatsink panel with the bolt hole lined up, and repeat this with the other two brackets. Apply silicone grease to both faces of the mica insulating washer and lay it over the bracket with the long end extending towards the slot opening. Again, repeat this on the other two brackets and insulators. Spread a thin film of grease onto each IC mounting tab (metal side) and position all three IC's over their respective insulators, brackets and heatsink panel as shown. Insert into each IC the small screw insulator (shoulder washer) and push a 6BA bolt through the assembly. Fit a washer and 6BA nut to each bolt, and tighten all three with a screwdriver. The vaned bracket has two lugs at one end which should have entered through each hole drilled in the PCB; bend the lug ends slightly outwards to hold the PCB firmly at right angles to the heatsink panel. Inspect the com-

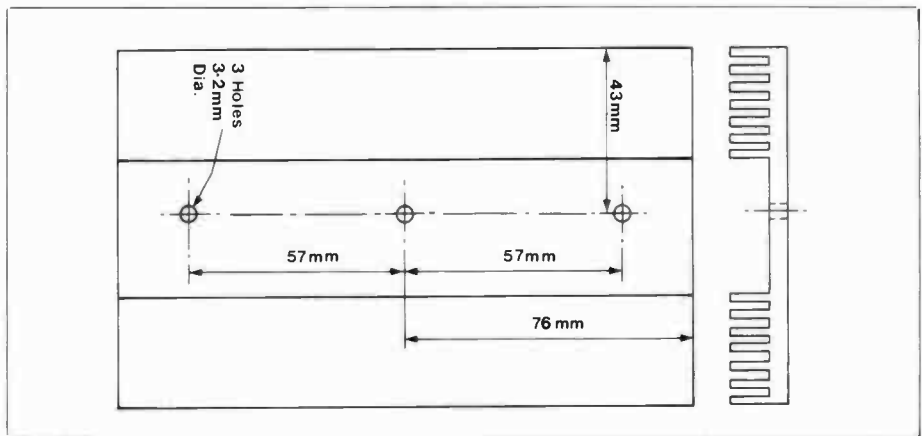


Figure 7. Heatsink Drilling Details

pleted assembly checking components and soldering before applying power.

Testing

A dual power supply is required, such as the circuit shown in Figure 11, capable of supplying +17V/0V/17V DC maximum at up to 3 amps. You will also require the services of a good multimeter. First check the IC mountings are not shorting by connecting the meter, set to measure ohms, between the heatsink panel and each of the metal IC tabs in turn. There should be no connection here. If there is, then strip down the faulty assembly and check the construction again. Most likely causes are metal flakes on the mica insulator or the screw head shorting to the metal IC tab.

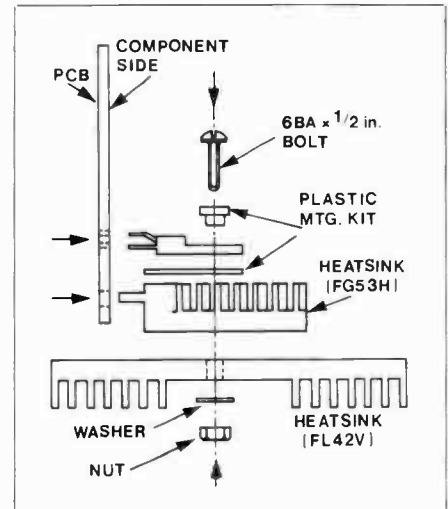


Figure 8. Amplifier Assembly

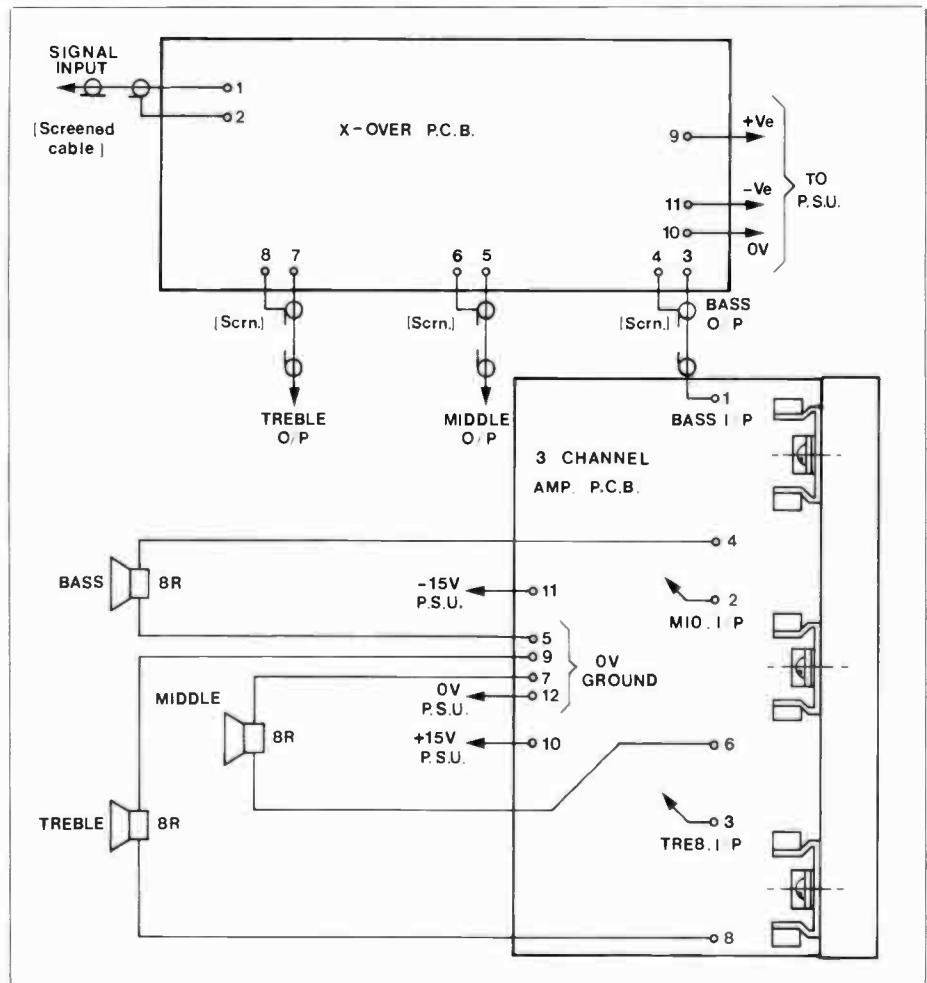


Figure 9. Interwiring

Connect your power supply with +V lead to pin 10, negative lead to pin 11 and 0V to any one of the four 0V pins. With the multimeter set to read volts DC, connect meter negative lead to amplifier output pin 4. Switch on the PSU and check the voltage reading is at zero volts, $\pm 15\text{mV}$. Repeat this check on output pins 6 and 8 in turn. Turn off the supply. Remove the PSU +V lead from pin 10, set the multimeter to DC amps range and connect the meter negative lead to pin 10 and the meter positive lead to PSU +V lead. Switch on the supply and check that a quiescent current of 90 to 100mA is measured. Switch off the supply, disconnect the meter and replace the PSU positive lead to pin 10. The amplifier module should now be working.

Using the Amplifier

Figure 9 shows the wiring connections to the three amplifiers. If you are using the Cross-Over module in conjunction with the amp, then two brackets can be made, shown in Figure 10. The module is mounted between C25, 26 and stands vertically, held in place by two brackets and four 6BA bolts, nuts. Use short lengths of screened audio cable for

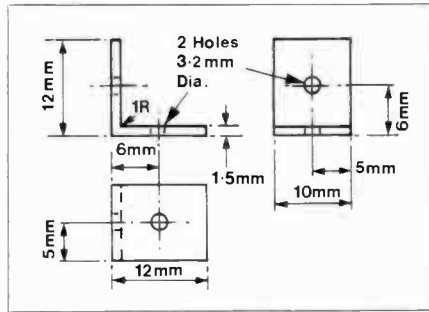


Figure 10. Support Bracket Details

connecting cross-over outputs to amplifier inputs, as shown, and connect the screen wires at the Cross-Over Module end only. Loudspeakers used should be capable of handling up to 20 watts or more to allow for short transient pulses, especially on the bass channel 'Woofer'. Two final important points to note are: Power supply voltages must not exceed 18.5V DC off load, or the IC will be damaged and ensure adequate air flow ventilation around the heatsink panel and finning.

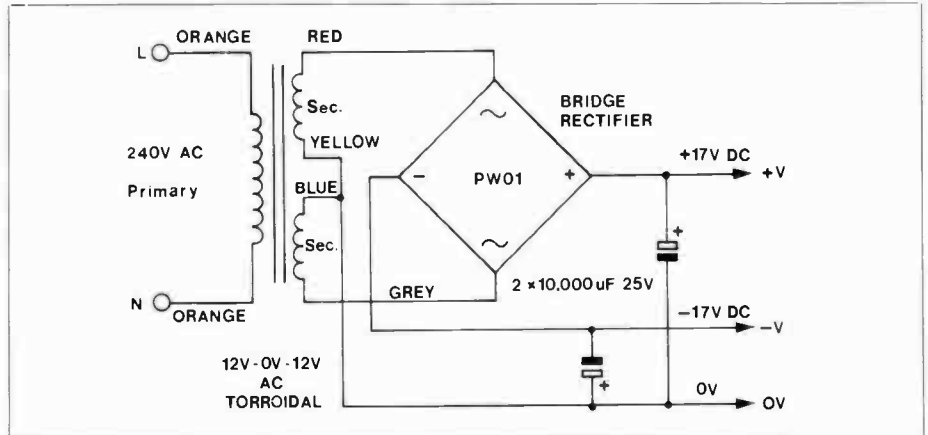


Figure 11. PSU Circuit

3-WAY ACTIVE CROSSOVER KIT PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)			
R1-4,11-14	4k7	8	(M4K7)
R5,15,17,22	47k	4	(M47K)
R6,16,23	100 Ω	3	(M100R)
R7,8	100k	2	(M100K)
R9,10	82k	2	(M82K)
R18,19	22k	2	(M22K)
R20,21	10k	2	(M10K)
RV1-3	Hor Encl Preset 22k	3	(UH04E)

CAPACITORS			
C1,2,24	Poly Layer 47nF	3	(WW37S)
C3	Poly Layer 68nF	1	(WW39N)
C4	Poly Layer 15nF	1	(WW31J)
C5	Poly Layer 10nF	1	(WW29G)
C6,18	Tant 2 μ F 35V	2	(WW62S)
C7	Tant 1 μ F 35V	1	(WW60Q)
C8,13,19-22	Poly Layer 4n7F	10	(WW26D)
C14,15	Poly Layer 6n8F	2	(WW27E)
C16	Disc 100nF 50V	1	(BX03D)
C17	Poly Layer 470nF	1	(WW49D)
C23	Poly Layer 220nF	1	(WW45Y)
C25,26	Poly Layer 100nF	1	(WW41U)
C27	Tant 4 μ F 16V	2	(WW64U)

SEMICONDUCTORS			
IC1-6	LM833N	6	(UF49D)
RG1	μ A78L05AWC	1	(QL26D)
RG2	μ A79L05AWC	1	(WQ85G)

MISCELLANEOUS			
PCB		1	(GB82D)
Pin 2145		1 Pkt	(FL24B)
DIL Socket 8-pin		6	(BL17T)
Instruction Leaflet		1	(XT52G)
Constructors' Guide		1	(XH79L)

The above items (excluding Optional) are available as a kit.

Order As LK69A (Active Crossover Kit)

The following item (which is included in the kit) is also available separately.

Active Crossover PCB Order As GB82D

3 CHANNEL AMPLIFIER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,6,11	10k	3	(M10K)
R2,7,12	680 Ω	3	(M680R)
R3,8,13	3 Ω	3	(M3R3)
R4,9,14	22k	3	(M22K)
R5,10,15	1 Ω	3	(M1R)

CAPACITORS			
C1,9,17	Tant 2 μ F 35V	3	(WW62S)
C2,10,18	PC Elect 22 μ F 25V	3	(FF06G)
C3,5,11,13,19,21	Disc 100nF 50V	6	(BX03D)
C4,6,12,14,20,22	PC Elect 100 μ F 25V	6	(FF11M)
C7,15,23	Ceramic 68pF	3	(WX54J)
C8,16,24	Poly Layer 220nF	3	(WW45Y)
C25,26	Axial 4700 μ F 35V	2	(FB96E)

SEMICONDUCTORS			
D1-6	1N4001	6	(QL73Q)
IC1-3	TDA2030	3	(WQ67X)

MISCELLANEOUS			
PCB		1	(GB91Y)
Bolt 6BA 1/2in.		1 Pkt	(BF06G)
Nut 6BA		1 Pkt	(BF18U)
Shake Washer 6BA		1 Pkt	(BF26D)
Pin 2145		1 Pkt	(FL24B)
Vaned Heatsink TO202		3	(FG53H)
Flat Heatsink		1	(FL42V)
Kit (P) Plas		3	(WR23A)
Instruction Leaflet		1	(XT52G)
Constructors' Guide		1	(XH79L)

OPTIONAL			
Silicone Grease Tube		1	(HQ00A)

The above items (excluding Optional) are available as a kit.

Order As LK70M (3 Channel Amp Kit)

The following item (which is included in the kit) is also available separately.

3 Channel Amp PCB Order As GB91Y

MAINS Tx/Rx DRIVER MODULE

- ★ Transmits or Receives Serial Data over 240V AC Mains Wiring
- ★ Transmission Rates up to 4.8k Baud
- ★ Suitable for Computer Data Links and Security Systems

by Dave Goodman

Mains wiring is a convenient medium for connecting intercommunications devices over short distances on the same phase. The mains voltage must be isolated from the driver electronics and a modulated carrier signal applied to both LIVE and NEUTRAL cables. In a domestic situation, several ring mains systems would be terminated at the consumer fuse panel and the carrier would be transmitted through to all socket outlets in the house. The maximum data frequency able to be carried on any ring main is determined by the impedance and noise of the line. For instance, triacs used for power and light control, transmit a high level of switching noise down the mains wiring, as do motors and pumps when first switched on. These factors are variable in every case and should be considered when determining data speed. Tests in a factory environment have produced good results over hundreds of feet with RS232 and TTL computer communications up to 4800 baud, although this cannot be guaranteed in every case!

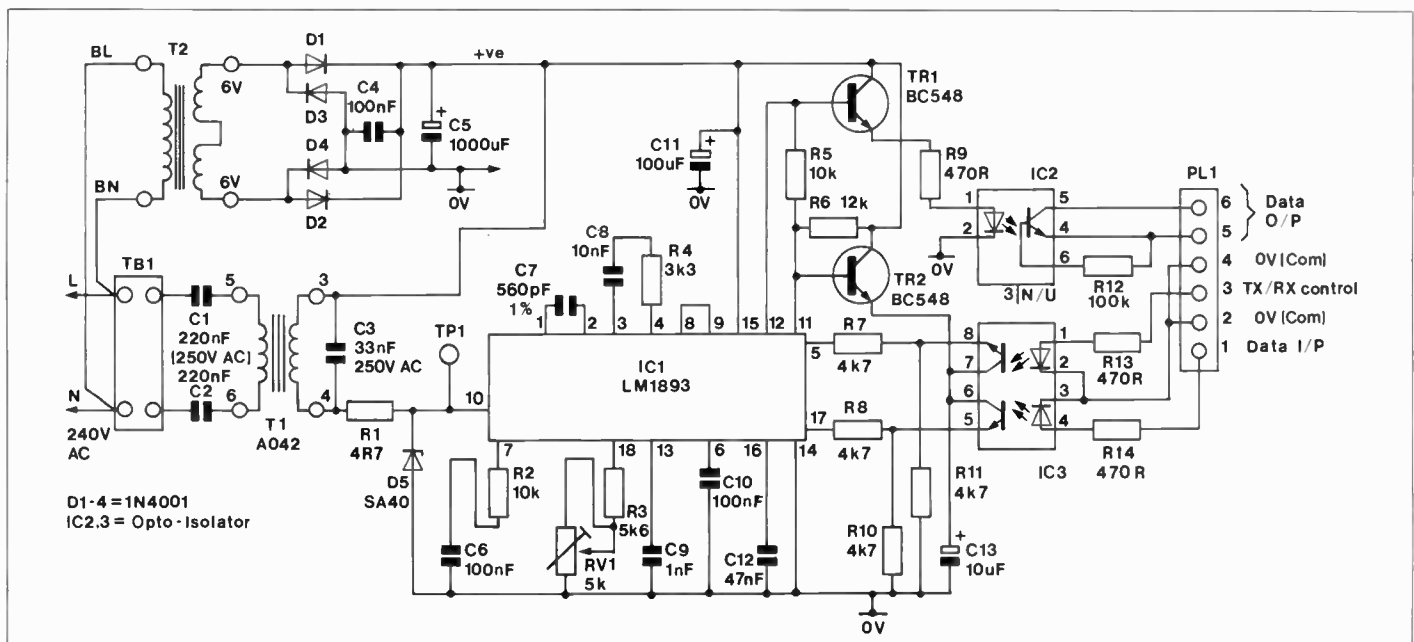
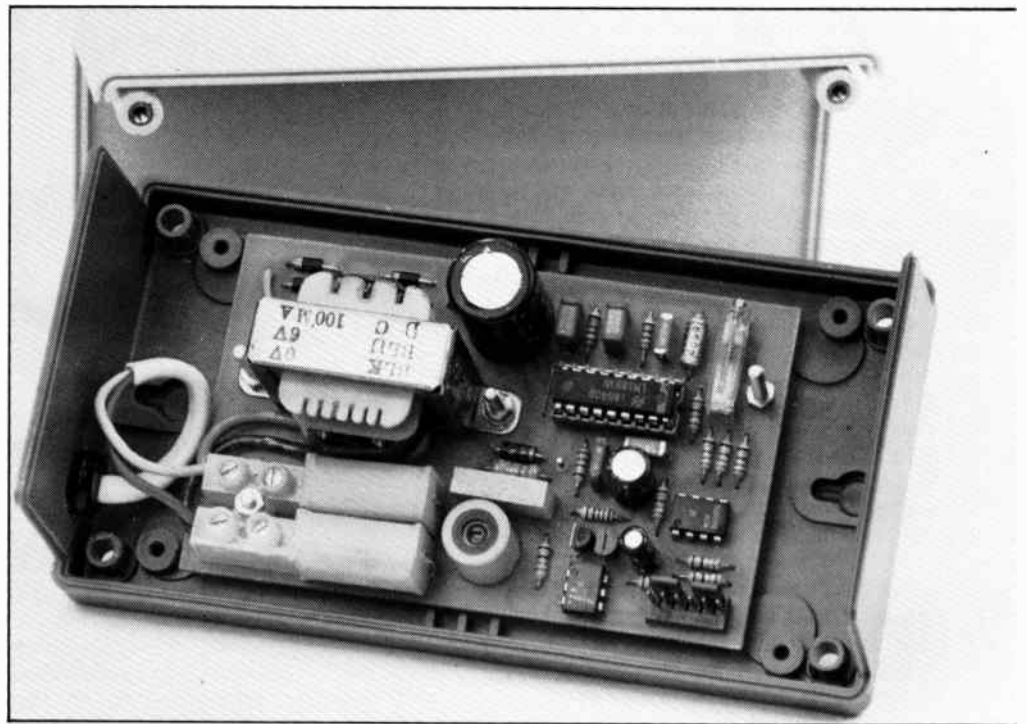


Figure 1. Circuit Diagram

Caution

It must be pointed out that the Mains Driver Module, by nature, is connected directly to 240V AC and therefore an element of danger exists to the constructor. Physical contact with the mains can be lethal and every precaution MUST be taken to prevent this from happening, either by accident or from poor constructional ability.

Circuit Description

IC1 is an LM1893 Bi-line Carrier Current Transceiver which performs half-duplex serial data transmission with the Tx/Rx control line high, or receives with the Tx/Rx control line low. Opto-couplers are incorporated to ensure the complete isolation of connecting devices from the mains system. Data input is via IC3, which switches an internally generated 5V from IC1 pin 11 via emitter follower TR2 to IC1 pin 17. This input is normally at 0V with data low at PL1 pin 1. The Tx/Rx control input at PL1 pin 3 should be low (0V or no connection) to receive data or taken high to transmit data, which restricts operation to half duplex or one way operation at anytime. IC1 pin 5 is the control input and is normally at 0V or in receive mode. Data output signals are available from IC1 pin 12 and are buffered by emitter follower TR1 to IC2. Both collector and emitter junctions are taken out to PL1 pins 6 and 5 so that either inverting or direct outputs (see Figure 7) can be made available. T2, D1 to D4 and C5 supply the power to IC1, which is approximately +14.8V DC off load. This IC requires a minimum of 14V DC for correct operation and associated components on IC1 have been optimised for this voltage. T1 is the interface between IC1 and the mains power line, connected via high voltage isolating capacitors C1 and C2. With C3 and R1, this tank circuit resonates at 125kHz which is the centre frequency of the FSK generator in IC1. Two frequencies are generated and they are 127.750kHz for data low which is 1.022×70 , and 122.500kHz for data high. During data transmission, both frequencies are applied from IC1 power driver output pin 10 to the tank circuit. The signal amplitude at TP1 is approximately 20V peak and is coupled at a low impedance to the power line. RV1 allows a small amount of control of the PLL oscillator and is used during initial adjustment and C7 determines the oscillator centre frequency.

In the receive mode, C1 and C2 block the mains voltage but allow a small degree of HF carrier into the tank circuit. As the tank is tuneable, optimum band-pass characteristics can be set and most line noise rejected. D5 acts in parallel with an internal zener on IC1. This device is an extremely fast switch and grounds short period transient spikes that often appear on the mains. Without this protection, the input stages of IC1 would be easily damaged. An internal limiter/gain stage or ALC is effective during both Tx and Rx modes and the R2/C6

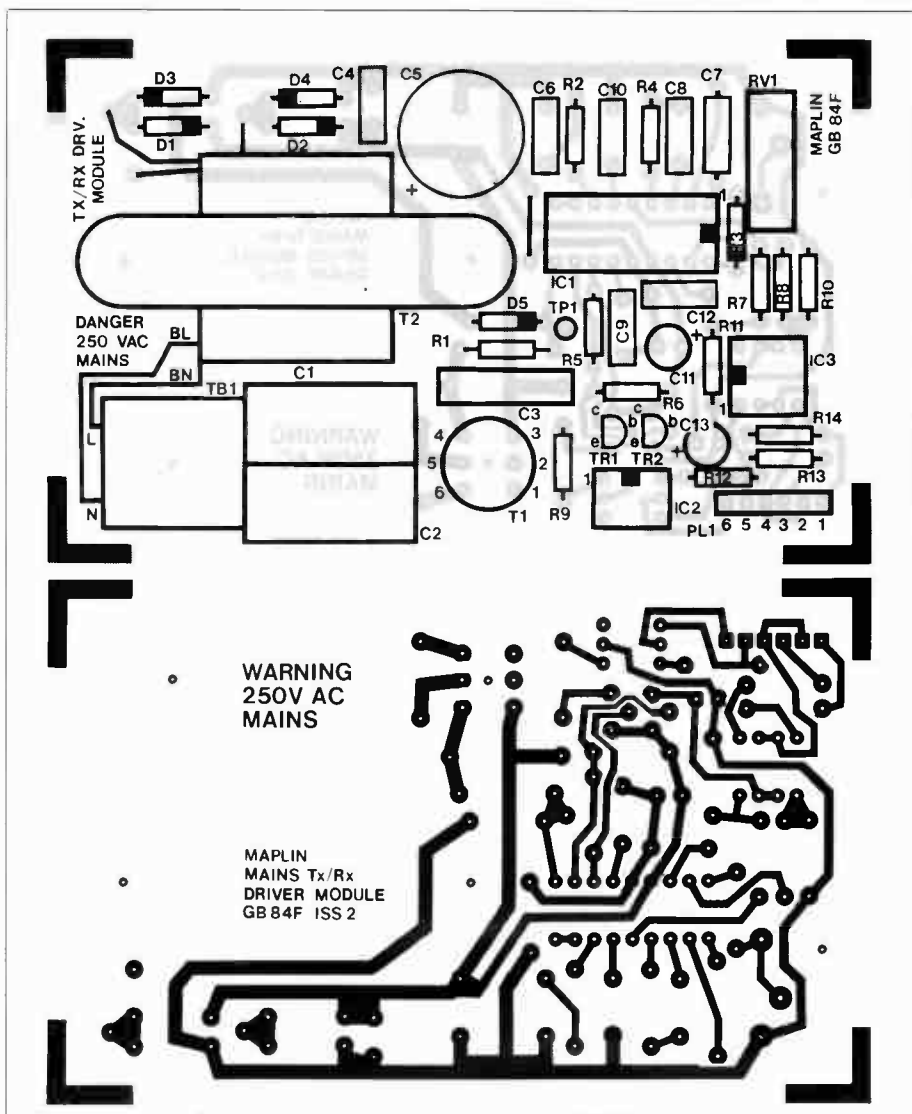


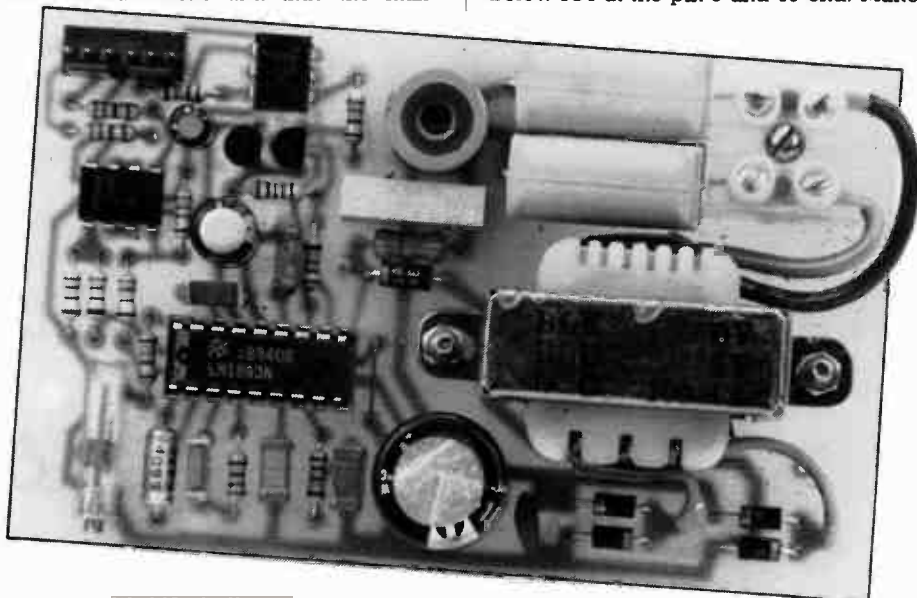
Figure 2. Artwork and Legend

time constant sets the ALC response time. One important feature of the output driver stage is its ability to balance carrier amplitude with line impedance. Very low impedance lines would otherwise severely load the tank circuit, thus damping it and increasing both supply current and out of band harmonics, neither of which are desirable! C9 (pin 13) rejects short, line impulse noise pulses. The capacitor determines the filter characteristic and thus the max-

imum usable data frequency. Noisy mains will require a higher capacitance, perhaps 47nF, with a reduced 'BAUD' rate at this pin 13.

Construction

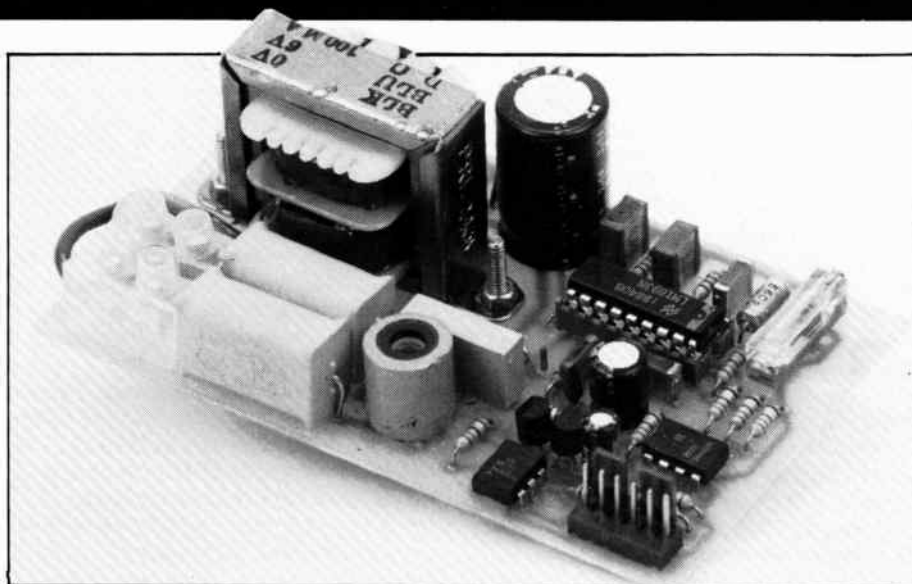
Great care must be exercised during soldering on this project to prevent connections being made between mains input stages and low voltage areas. There is one link required, to be fitted just below IC1 at the pin 9 and 10 end. Make



and insert the link and fit the larger standard resistor R1. Identify and insert the remaining resistors, R2 to R14 and carefully solder, then trim, these components. Ensure when fitting R12 that enough clearance is allowed for the 6 way housing to sit onto PL1 properly.

Next insert the five diodes. D5 may look similar to the 1N4001 rectifying diodes and the body markings should be carefully examined. Mount each of the diodes with the silver banded end in line with the white bar on the PCB legend; do not reverse them.

Fit the 18 pin IC socket and the polycarbonate capacitors C6, C8 to C10 and C12. Solder in and trim these components. Insert IC2 and IC3 directly into the PCB, IC2 is the 6 pin device. Fit TR1 and TR2 directly above IC2 with the body flat section aligned with the legend. The ICs may have either a notch cut in one end which should line up with the notch on the legend, or pin 1 may be marked with a circular indent on top of the package. Insert a polystyrene 560pF capacitor at C7 and a multi-turn cermet, RV1, with adjusting screw head facing the PCB edge. Mount C5, C11 and C13, with the longest lead to the +V sign on the board, the short lead should be



mounting lug between C5 and D5 but do not fit a bolt through the outside lug at this stage. Also, do not fit C1 and C2 or the 2-way terminal block on the PCB at this stage. Solder any remaining terminals to the board, trim and inspect all components and tracks. Clean the solder joints with a PCB solvent and brush, especially around the area of T1.

Testing

Insert IC1 into its socket and fit T2 mains wires (thicker) into the 2-way terminal block TB1. Connect a length of two core mains wire into the terminal block and a suitable mains plug onto the other end, ready for plugging into the mains and switching on. Certain items of test equipment are necessary for accurate alignment of the unit. You will require a good voltmeter, a 9V battery, e.g. PP3, and some clip leads. An Oscilloscope or Frequency Counter is also required for setting the PLL oscillator and tuning T1.

Connect a voltmeter with negative lead to either D3 or D4 anode (opposite to band end), which is supply 0V. Switch on the mains power and measure +14.5 to +15V DC on IC1 pin 15. If this reading is not correct, then *switch off immediately* as there may be a fault. Check IC1 pin 11 for +5V to +5.5V DC and TP1 for approximately +14V DC. Do ensure that adequate insulation is

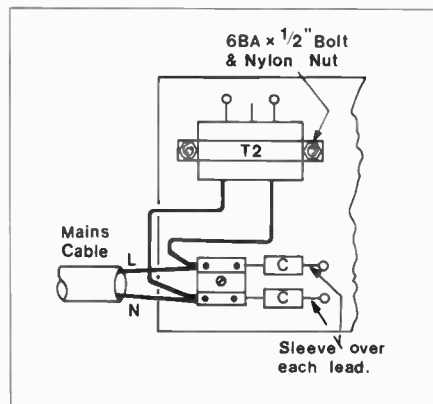


Figure 4. Connections to PCB

provided between the PCB and work top and keep your hands well clear of the terminal block. Switch off the mains supply and remove the mains lead from the 2-way terminal block.

Take HV mains capacitors C1 and C2, cut off two 10mm lengths of sleeving and slide over one lead of each capacitor (see Figure 4). Cut each remaining lead to 10mm long and insert each one into the terminal block so that the capacitor body fits up against the terminal block with no gaps. Tighten both terminal screws. Insert both sleeved ends into the PCB at C1 and C2 and place each capacitor firmly into the board with the terminal block mounting hole directly above a hole in the PCB.

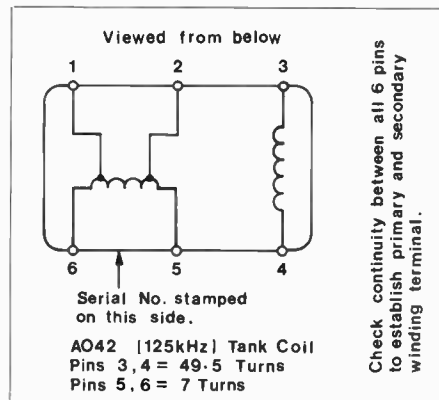


Figure 3. Tank Coil

marked with -V signs along the capacitor body. Insert the rectangular HV capacitor C3 and disc capacitor C4, veropin TP1 and PL1. Solder all components and remove excess lead ends. Ensure all components are pressed down onto the PCB and not 'floating in the air'. Refer to Figure 3 for details on tank coil T1. The former has six pins, arranged with three per side. Pins 5 and 6 are the 'LIVE' connections to the mains and are on the same side as the AO42 stamping on the body. If in doubt where these pins are, check for continuity with a resistance meter. Insert T1 into the PCB with pins 4, 5 and 6 closest to C1 and C2 position. This component **MUST** be fitted correctly.

Mount mains transformer T2. One side has two thick leads, for 240V connection, and the other side has the three thinner secondary wires. The centre, 0V, wire on the secondary is not required and can be cut off or soldered into the spare pad nearby (see PCB legend) while the remaining two thinner wires are fitted, any way around, at D1/3 and D2/4 (see Figure 4). Use a single 1/2in 6BA bolt and nylon nut through the inside

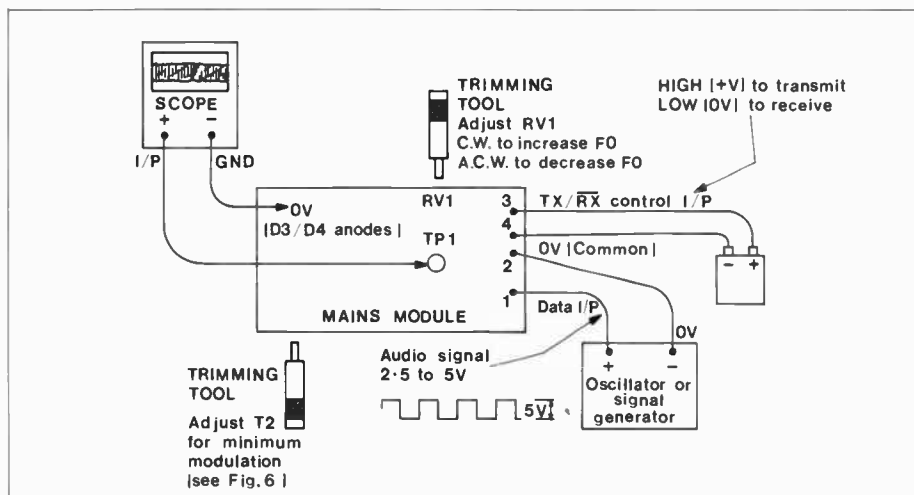


Figure 5. Test Set-up

Final Assembly

Split the box into two sections and retain the lower grey half. Refer to Figure 9 and lay the PCB inside the box section approximately centrally. Mark all three 'A' holes through the PCB with a pencil. One next to RV1, one through T2 outside lug and one beneath the terminal block. Drill the holes using a 3mm drill bit and also a 12mm hole in one end panel, closest to T2 as shown. Countersink the three small holes from the outside and fit three countersunk lin. 6BA bolts as Figure 10. On the inside, fit a shake washer and two 6BA nuts over each lin. bolt and tighten up. Drop the PCB over the bolts and press down onto the lock nuts, then fit a 6BA nylon nut over each bolt. Ensure one mounting bolt inserts through the terminal block.

Fit the SR grommet three inches along from the unterminated end of the flat mains cable and insert the locking peg. Squeeze the peg into the grommet with pliers or in a vice and insert into the large hole previously drilled in the end panel. Terminate both mains cable and T2 secondary wires as shown.

Final Testing

Connect a 9V battery with negative lead to pin 2 and positive lead to pin 3 on PL1. Note that the common 0V on this plug does not join to the power supply 0V (see Figure 5). Clip on a Frequency Counter or an Oscilloscope with earth to D3/D4 anode and TP1. Plug in the mains leads and switch on. With a trimming tool, adjust RV1 for a reading of $127.750\text{kHz} \pm 100\text{Hz}$. When this is done, also connect the battery positive lead to data I/P pin 1 on PL1. The frequency should drop to approximately 122.5kHz . Remove the battery positive from data I/P pin 1 only but keep the connection to pin 3 (Tx/Rx) on PL1. If a low frequency signal generator is available, connect this between 0V pin 2 and data I/P pin 1. A signal amplitude of at least 2.5V peak is required at a frequency of 100Hz. Monitor the modulating waveform from TP1 on the Oscilloscope with reference to Figure 6. Turn the slug in T1 anti-clockwise until level with the can top, then screw down carefully with a trimming tool (plastic) for $2\frac{1}{2}$ turns to begin with. The carrier oscillogram should increase in amplitude to around 20V peak and the modulation gradually disappear. Adjust for maximum amplitude with minimum modulation of the carrier. If a signal generator is not available, alternatively connect, then disconnect, battery positive to data I/P pin 1 by hand while following the previous instructions.

Aligning the tank circuit while connected directly to the mains will optimise the module for maximum efficiency with the wiring medium. If doubtful about doing this test while connected to the mains, simulate the wiring with a $\frac{1}{2}$ Watt 3R3 resistor instead. Remove both C1 and C2 leads (power off, of course!) from each terminal block and solder the test resistor to C1 and C2

leads. Proceed with the alignment as before. This method of simulating the line does not fully optimise the tank circuit, but is recommended for those with a 'nervous disposition!'

Using the Module

Figure 8 shows the general method of using the driver module. It must be remembered that this unit is only an interface between communicating equipment and the mains and is not a complete encoding/decoding system with protocol and handshake. Communicating devices can be of any form, e.g. alarm systems, RS232 keyboards or TTL outputs from microcomputers.

Both input and output connections are opto-isolated and require external

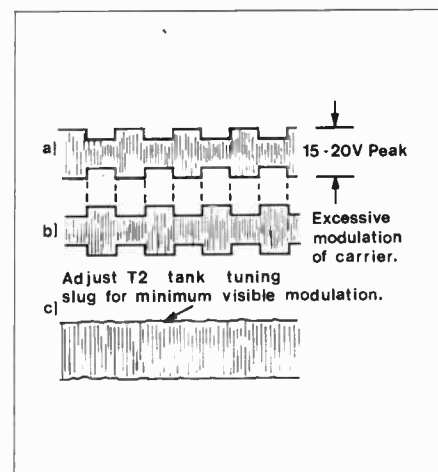


Figure 6. Tx Envelope

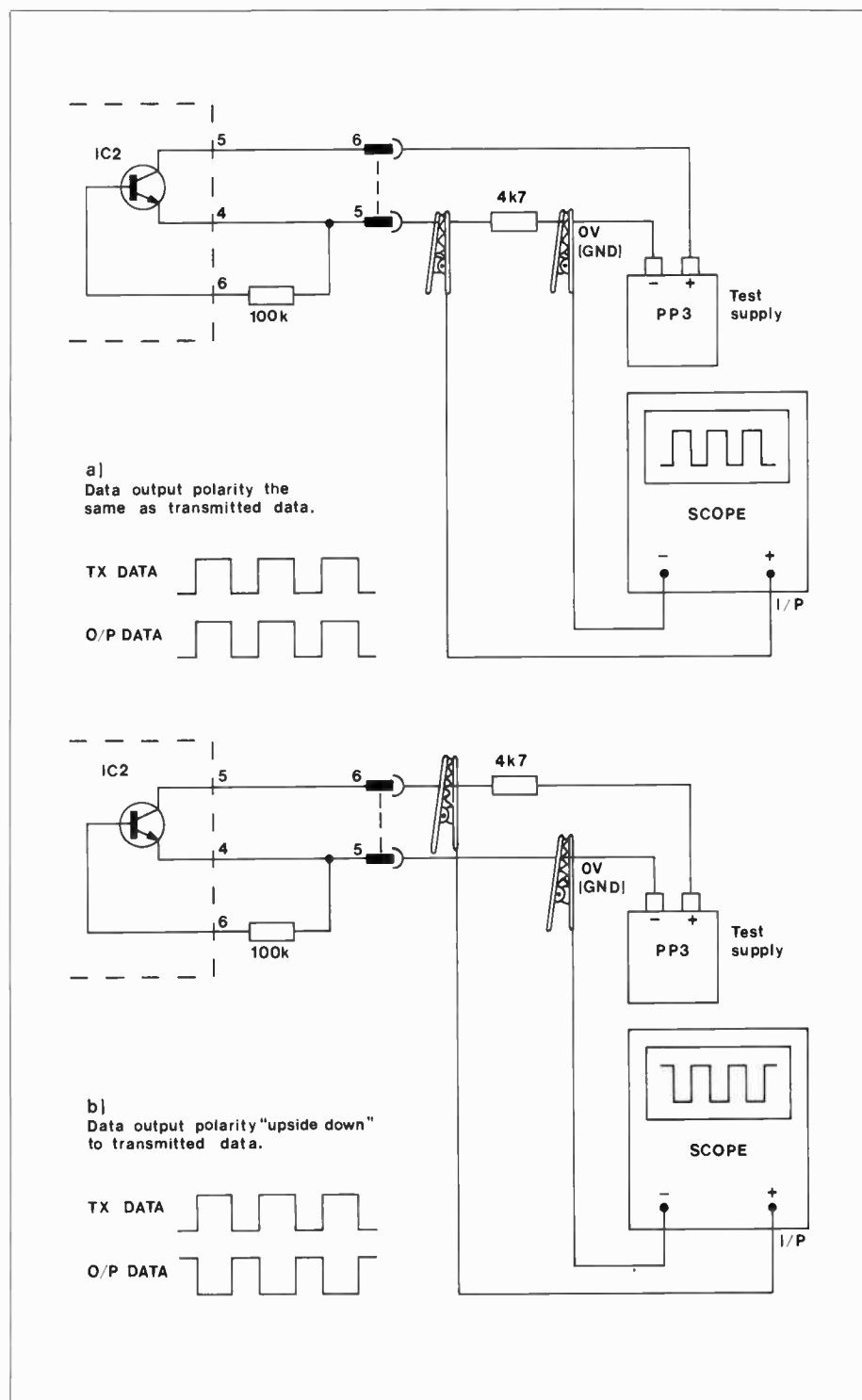


Figure 7. Data Output

sourcing to operate LEDs or collector/emitter junctions. Figure 7 shows both inverting or direct connections from the data output pins on PL1 but this can only be checked if at least two driver modules are 'on line', one transmitting and one receiving. One method of using these modules could involve connecting the Tx/Rx control line via a battery and 'Make' contact from a burglar alarm sensor. A second driver module could be connected to a burglar alarm placed anywhere without restrictions from contact wiring. When the sensor is activated, the carrier is transmitted and the receiver data O/P will go high (or low) to suit requirements. This is then used to trip the alarm unit. Any number of sensors or modules could be used, but independent channel recognition is not possible without tone or data encoding. If an intelligent computer communications

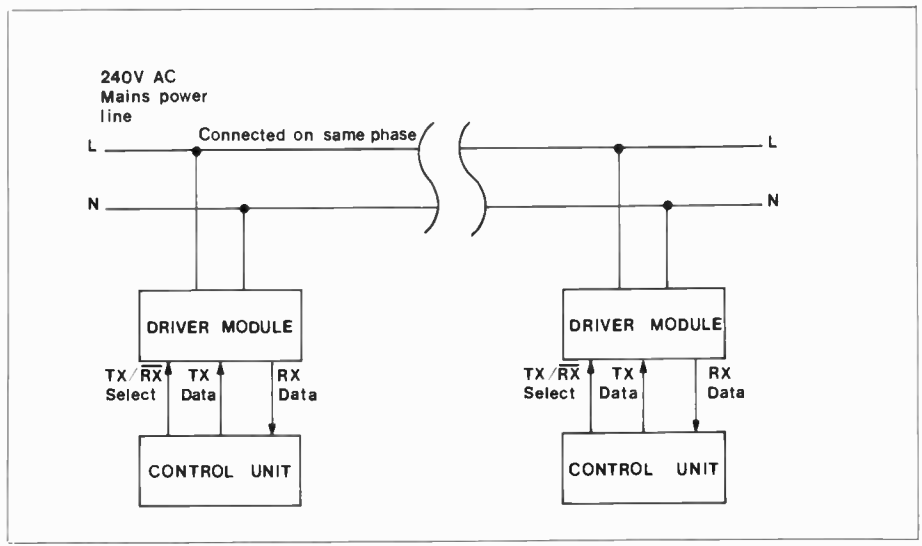
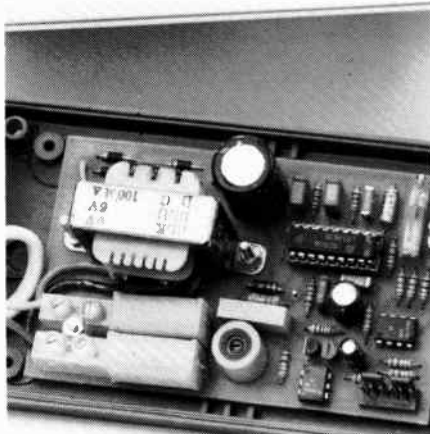


Figure 8. Connecting to Mains



link is to be used, then polling several terminal units could be implemented. A master unit transmits a recognition WORD and the appropriate receiver responds. The communications channel is then established between these two devices only until further control words are recognised.

This type of system has been successful on an experimental basis using RS232 links to the driver modules. Baud rates of up to 4.8kbps have been used, although standard 8-bit words at 300bps are less prone to noise and interference and better suited in this environment. As a general guide, limit the maximum data frequency to below 2.5kHz.

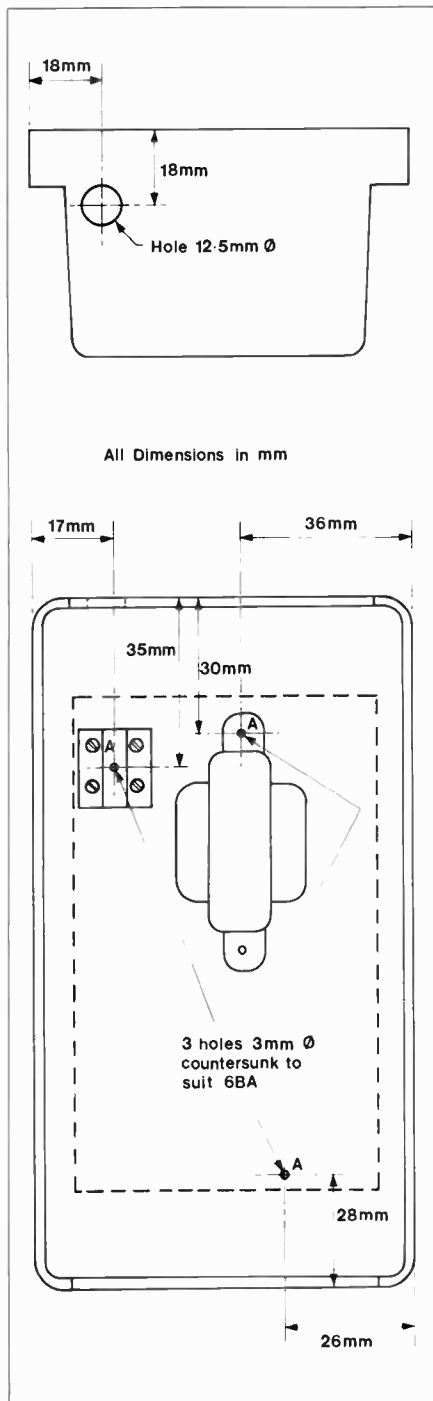


Figure 9. Box Details

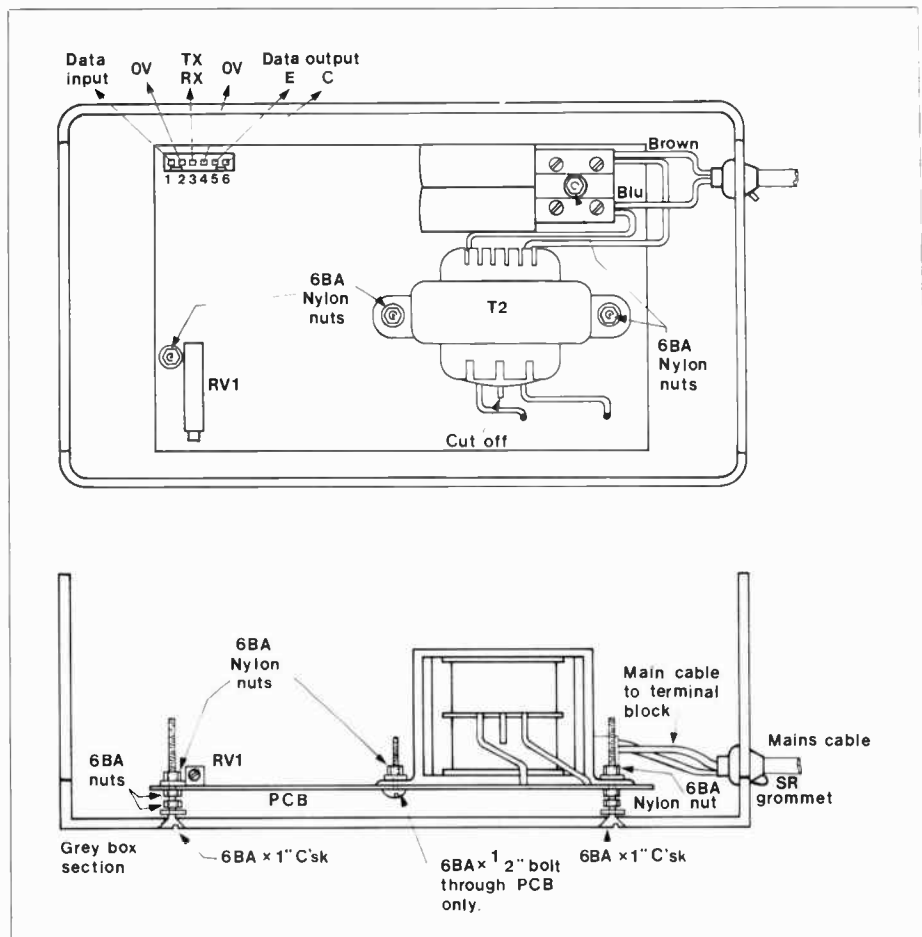


Figure 10. Assembly

Continued on page 54.

Sixteen Channel Logic Tester



by Robert Penfold

- ★ Simultaneous Testing of up to 16 IC Pin-Outs
- ★ All 16 Channels Displayed on Your Oscilloscope Screen
- ★ Easy to Construct

While logic circuits are in many ways very simple, having just two stable signal states, they can nevertheless be quite difficult to test. The point in the circuit where the fault lies may show clear signs of incorrect operation with perhaps, a static logic level where there should be a pulse stream or an indeterminate DC level, rather than a proper logic 0 or logic 1 potential. However, there are often a vast number of points in the circuit that must be checked one by one in order to trace the point where the fault exists.

This oscilloscope add-on was designed to speed up fault finding on digital equipment by enabling a number of points in the circuit (up to 16) to be monitored simultaneously. There is more than one way of doing this, and several approaches were tried. A self-contained tester with a couple of LED indicators to show the signal condition at each test point would be feasible, but a reasonably sophisticated logic probe type circuit would be needed for each pin in order to give really good results. This would result in a relatively high component count and cost. Another approach is to have a sort of sixteen channel trace splitter, although it would only need to deal with logic levels and a normal linear type of splitter would not be needed. This would be ideal in that it would display the waveform at each test point but in practice, it would require a fairly sophisticated circuit to work properly. Even then the height for each trace would be rather restricted and the overall display brightness would probably be rather low.

The basic idea adopted in the final circuit is to have an integrated circuit test clip which fits onto 14 and 16-pin DIL integrated circuits, and couples the signals on the pins through to the oscilloscope interface unit. The interface combines the signals so that they produce a simple histogram display on the screen of the oscilloscope, and the signal level for each pin can be seen at a glance. If a pin has a pulse signal and is not static, this shows up as an unstable area of display. The accompanying oscillographs show the types of display that are obtained. The unit provides market signals which ease the task of

relating each part of the display to its relevant integrated circuit pin. Again, these can be seen by referring to the oscillographs.

System Operation

The unit is built around a 16-line to 1-line decoder, as can be seen from the block diagram of Figure 1. The decoder has 16 inputs and a single output with one of the input signals being coupled through to the output terminal. Just which of the inputs this is, depends on the four bit binary code fed to the control inputs of the device. In this case, these are fed from the four least significant bits of a 5-

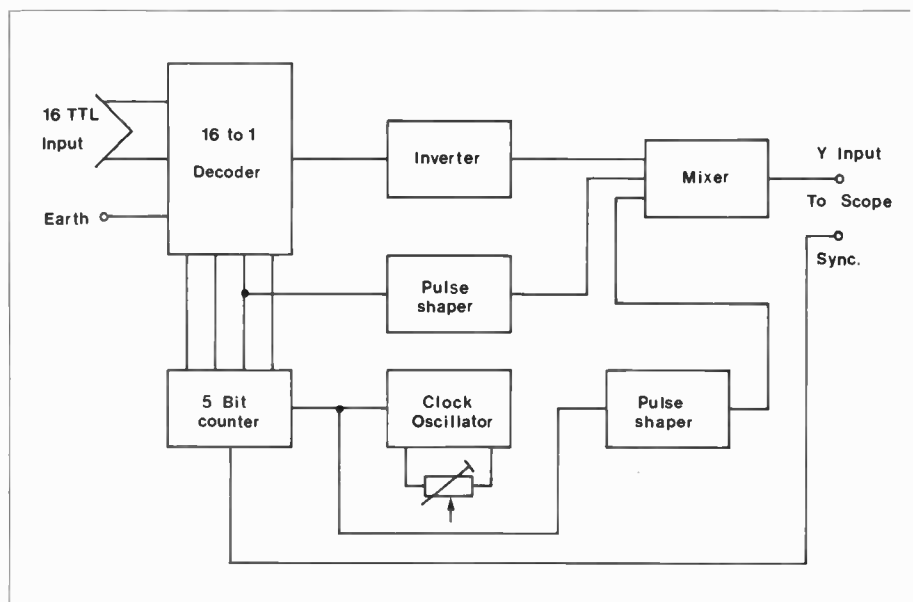


Figure 1. Block Schematic

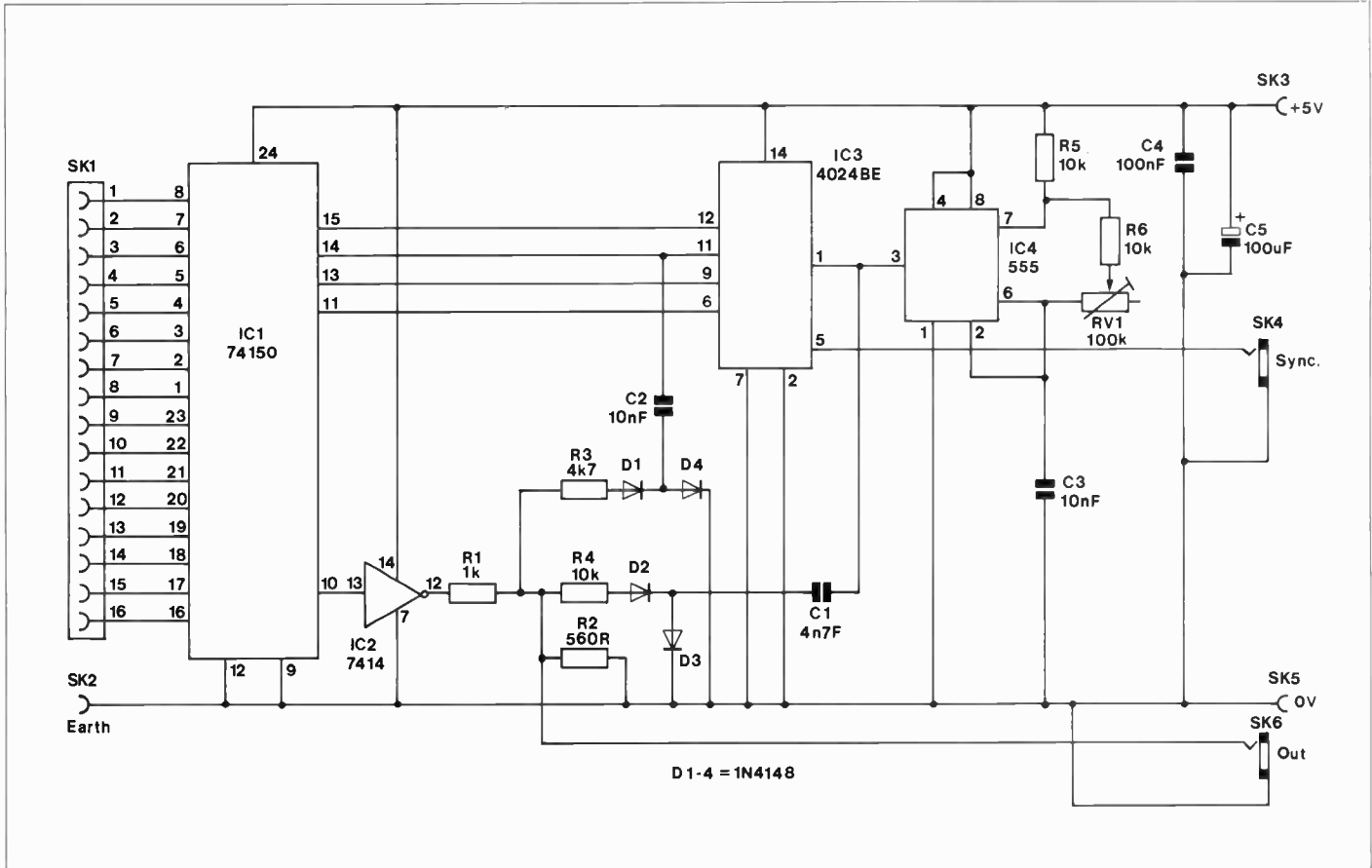


Figure 2. Circuit Diagram

bit binary counter and this circuit is in turn, driven from a clock oscillator. Initially, input 1 is coupled to the output but after one clock pulse, input 2 is coupled through to the output, then input 3 after a further clock pulse, and so on until input 16 is coupled through to the output. The circuit then cycles back to the original state with input 1 being fed through to the output, and it cycles indefinitely in this manner.

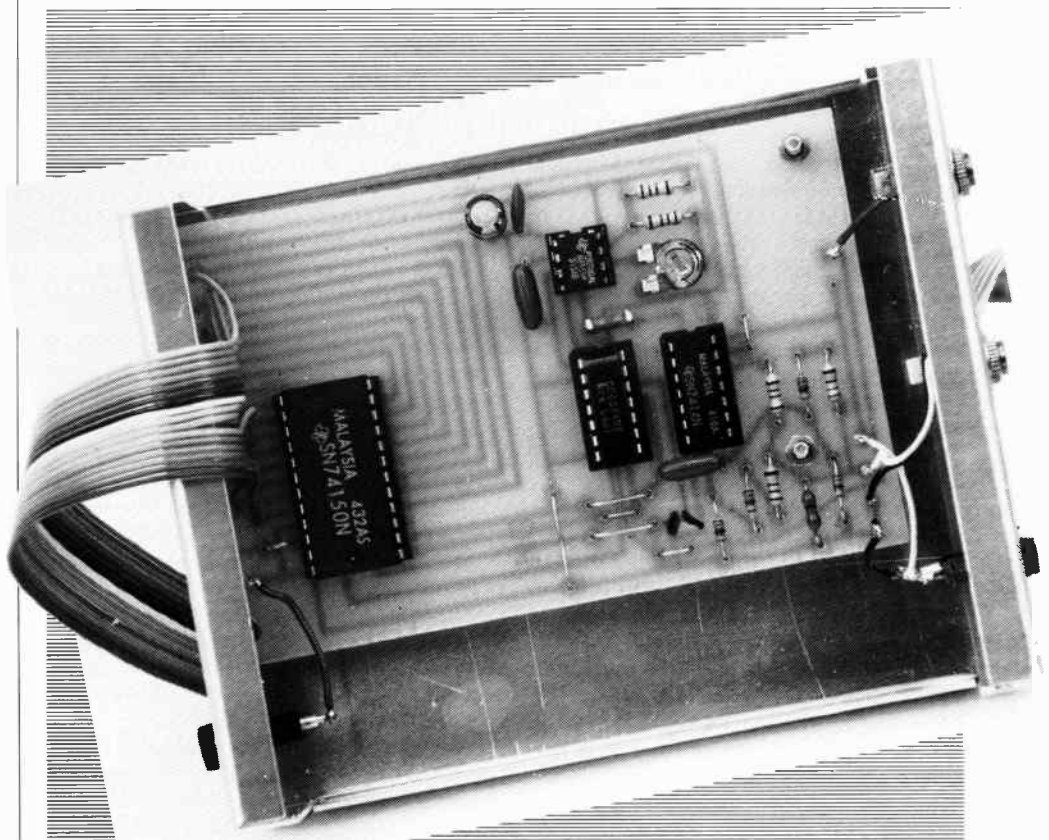
The 16 to 1 decoder inverts the signal and an inverter is therefore connected at the output of the decoder to re-invert the signal back to its original polarity. The output from the inverter is connected to the Y input of the oscilloscope via a simple passive mixer circuit. The waveform fed to the oscilloscope contains information that can be used to show the logic of each input but on its own, this is insufficient. The problem is simply that there is no way of telling which part of the display relates to a given pin of the test device.

To overcome this, the oscilloscope is set to the external synchronisation mode. The synchronisation signal is taken from the most significant bit of the binary counter. This ensures that a meaningful display is obtained, starting with pin 1 on the left and running through to pin 16 on the right. This assumes that the clock oscillator is adjusted to give, reasonably precisely, sixteen clock cycles per sweep of the screen. For this reason the clock frequency is made adjustable so that it can be trimmed to a suitable frequency. Most oscilloscopes have switchable positive and negative synchronisation modes but some instruments

only have one mode or the other. In this case, either mode will do since each full cycle of the 16 to 1 decoder corresponds to just one half cycle at the synchronisation output. Thus, triggering on the leading or falling edge of the signal gives the desired result. The display is less bright than for a free running sweep since, in

effect, only every other sweep is performed, but this does not dim the display to a significant degree.

A problem with this basic arrangement is that it can be difficult to rapidly relate each part of the display to its corresponding pin number as the graticule is unlikely to have a convenient



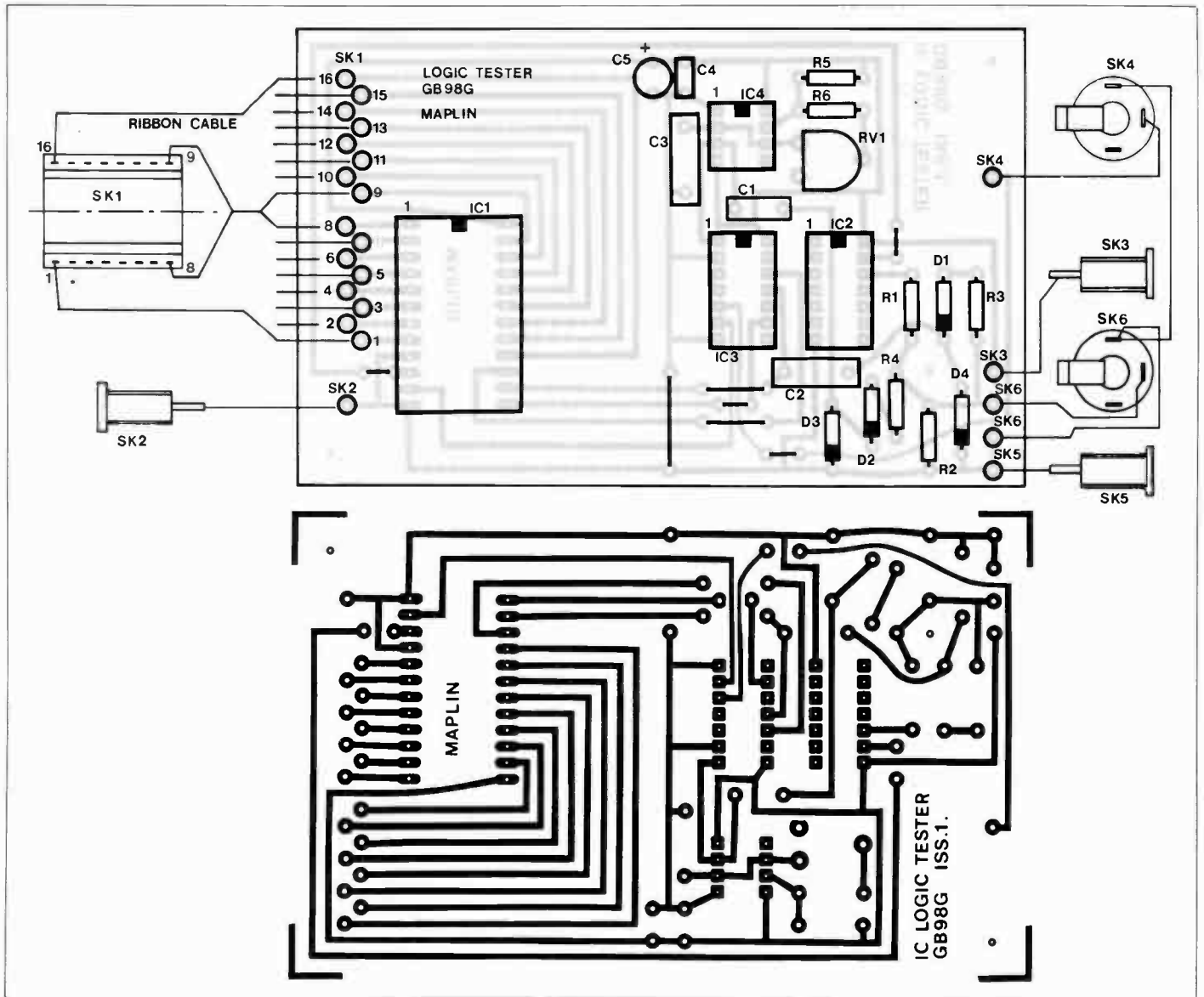


Figure 3. PCB layout and wiring

number of horizontal divisions, such as 8 or 16. Obviously a graticule or some other form of marker, could be made and fitted onto the screen, but it is more convenient to use some form of electronic marker. In this case, negative pulses are modulated onto the display to indicate the divisions between parts of the display. Apart from pulses to divide the display into its sixteen basic parts, there are stronger markers which divide the display into quarters. This enables the section of the display which relates to any given pin number to be rapidly and easily located, or working the other way, any given part of the display to be easily translated to the appropriate pin number of the device under test.

The sixteen marker signals are generated by feeding the clock signal to a pulse shaper circuit which converts the roughly squarewave signal into a train of negative pulses. These are then combined with the main output signal at the mixer stage. The four larger marker signals are produced in essentially the same manner but the signal for the pulse shaper is taken from the second bit of the binary counter. This gives a divide-by-four action and the required one marker pulse for every four clock pulses.

Circuit Operation

A very simple circuit is used, and the full circuit diagram of the unit appears in Figure 2. IC1 is the 16 to 1 decoder, and this is a TTL 74150 device. As explained previously, the signal is inverted through this device and the output signal must be re-inverted in order to retain the original signal polarity. One of the inverting Schmitt Triggers of IC2 provides the necessary re-inversion. The other five inverters of IC2 are left unused. There is a negative enable input at pin 9 of IC1 and taking this high, holds the output terminal high. This function is not needed in this application and pin 9 is simply tied to the earth rail. Note that an earth input is included and it is essential that this is connected to the earth rail of the equipment under test to ensure that the input levels are referenced to the earth rail potential of the equipment under investigation. Without this connection, the two earth rails might not be at the same potential, and even if they were, problems with noise could occur.

The 5-bit binary counter is a CMOS 4024BE device, IC3. This is actually a seven stage type, but here the last two stages are just ignored. Although IC3 is a

CMOS device and IC1 is a TTL type, IC3 is able to drive the inputs of IC1 satisfactorily. The reset input of IC3 (pin 2) is not required here and is just connected to earth. The synchronisation signal is taken direct from the stage 5 output of IC3, and any oscilloscope which has an external synchronisation input should trigger reliably from a 5 volt logic signal.

The clock signal is generated by IC4 which is a 555 timer device connected in the standard astable configuration. RV1 is adjusted to give a suitable clock frequency. Spare inverters of IC2 could be used to generate the clock signal but in practice, it is better to use a 555 clock circuit as this gives much better stability and avoids the need for frequent retrimming of the clock frequency.

A passive mixer circuit is used at the output of the unit and this consists of just four resistors (R1 to R4). These have been given fairly low values so that, in conjunction with the input capacitance of the scope, they introduce little lowpass filtering and do not seriously degrade the bandwidth of the system. The values of R1, R3 and R4 set the relative strengths of the main signal, the four large marker signals and the sixteen marker signals respectively. Each pulse shaper merely

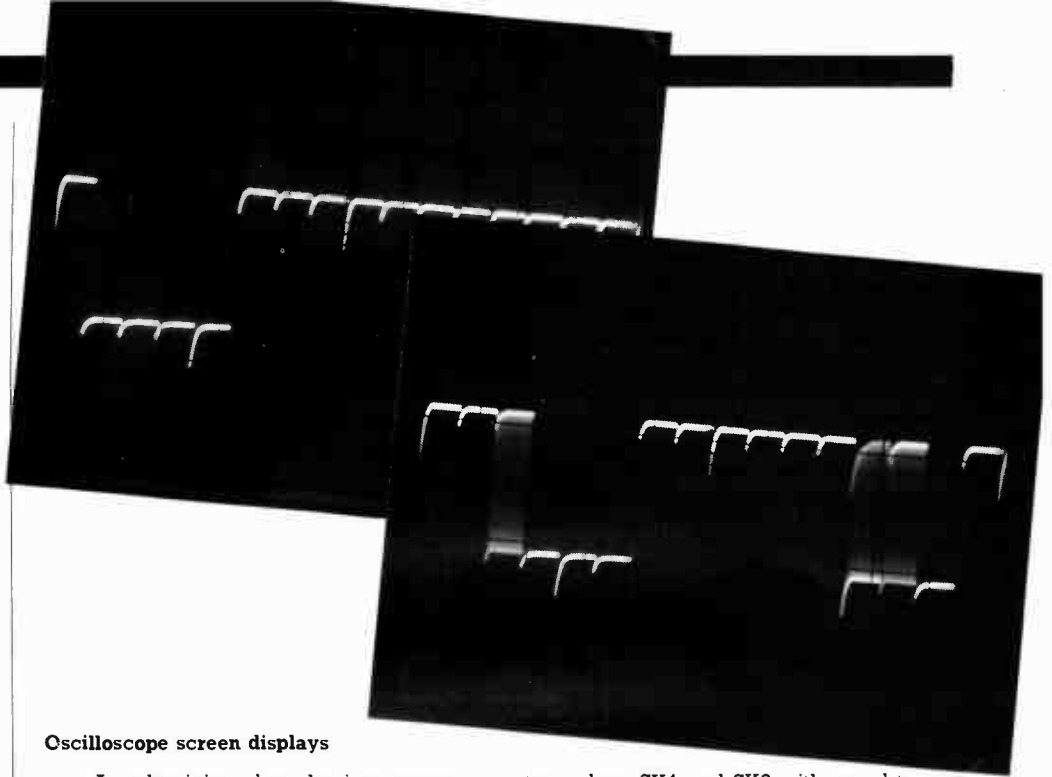
consists of two diodes and a capacitor which provide brief negative pulses. The value of the capacitors set the pulse widths and in order to make them stand out better, the four marker signals have roughly double the width of the sixteen markers. The width and amplitude of the marker signals has to be a compromise between clearly marking the borders between different sectors of the trace and encroaching on the main part of the trace to such an extent that ambiguities are produced. The specified values give a good compromise but the values of R3, R4 C1 and C2 can be altered to suit individual preferences if desired.

The circuit requires a 5 volt supply and it has a current consumption of about 70 milliamps. No built-in power supply has been included as there should be no difficulty in finding a suitable external supply in most cases. The prototype is used in conjunction with a Crotech 3132 oscilloscope which conveniently provides a 5 volt supply output for use with add-on circuits. If your oscilloscope does not have a suitable supply output, the circuit under investigation may well be able to supply the modest current requirement of 70 milliamps, or a bench power supply set for an output of 5 volts can be used.

Construction

The printed circuit track pattern and component layout are shown in Figure 3. Start by fitting the link wires, veropins, resistors, capacitors, and then fit the diodes and integrated circuits. IC3 is a CMOS device and it should consequently be fitted in a (14-pin DIL) integrated circuit holder. The other normal anti-static handling precautions should be taken, with IC3 being fitted in place only when all the other components have been added and all the wiring has been completed. Leave IC3 in the anti-static packaging until then and use a minimum of handling when plugging it into the holder. Although IC1 is not a MOS device, it is a fairly expensive type and a socket for this device should be considered essential.

The printed circuit board is connected to the integrated circuit test clip via a piece of 16-way ribbon cable, about half a metre or so long. As this cable is carrying high speed signals in parallel, it is advisable not to use a long cable. Although 16-way cable is not available, it is easily produced by tearing off 4 ways from a 20-way cable. The integrated circuit test clip is not polarised and it will fit onto test devices either way round. This could lead to confusing results in this application and it is advisable to put a mark on it next to pin 1 to reduce the risk of clipping it onto a test device with the wrong orientation. Of course, fitting it the wrong way round will not cause any damage but the various sections of the display will not correspond to the pins of the test device in the way you think they do, giving misleading results unless the mistake is spotted.



Oscilloscope screen displays

An aluminium box having approximate outside dimensions of 133 by 102 by 38 millimetres will accommodate all the components but this represents about the smallest size that will do so. The printed circuit board is mounted on the base panel of the case using M3 or 6BA fixings and as the case is a metal type, it is obviously essential to fit spacers to keep the connections on the underside of the board well clear of the case.

The ribbon cable can be taken out between the top and base sections of the case at one end of the unit, and SK2 is fitted at this end of the unit. The other four sockets are mounted at the opposite end of the case. SK2 to SK6 are then wired to the board using ordinary insulated multistrand hook-up wire, and this wiring is all included in Figure 3.

In Use

Two test leads are required in order to connect the unit to the oscilloscope. Assuming the oscilloscope has BNC type connectors, both leads should consist of about half a metre of 50Ω (UR76 type) cable fitted with a BNC connector at the oscilloscope end, and a 3.5 millimetre jack plug at the tester end. These connect the output of the tester to the Y input of the oscilloscope, and the sync. output of the tester to the sync. input of the oscilloscope. An alternative and cheaper way of making the connections would be



to replace SK4 and SK6 with panel terminals that would enable the normal test leads of the oscilloscope to carry the two sets of interconnections.

With the test clip left unconnected, everything else connected up (including a suitable power source) and the oscilloscope set at a sweep rate of about 1ms per centimetre, a stable trace should be obtained, provided external synchronisation is selected and the sync. level control is adjusted to a suitable setting. A fairly low sensitivity of about 0.5 volts per centimetre should suffice. This level of sensitivity may actually appear to be rather on the high side for logic signals but bear in mind that there are losses through the mixer stage at the output of the unit, and the output is consequently not at normal logic levels. It is best to use DC coupling, if this option is available, as this enables static levels to be accurately measured, but AC coupling gives usable results.

RV1 is simply adjusted to give precisely sixteen sectors from one side of the screen to the other but make sure that the horizontal shift control is set properly before adjusting RV1. If the oscilloscope has a "fine" sweep speed control, it is quite acceptable to give RV1 a roughly mid-setting and then adjust the sweep speed to give the correct trace. Note that when the inputs are left floating, being TTL types they float to the high state.

The unit is then ready for use. With any piece of equipment of this general type, it is a good idea to try it out on some pieces of digital equipment that are functioning correctly to familiarise yourself with the types of display that should be obtained. An important point to keep in mind is that the unit has standard TTL inputs and it therefore increases the loading on the test points by one TTL load. This additional loading will be unimportant in most cases but it could produce problems when testing some types of logic circuit (particularly those which use old type CMOS devices).

16 CHANNEL IC LOGIC TESTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1	1k	1	(M1K)
R2	560Ω	1	(M560R)
R3	4k7	1	(M4K7)
R4-6	10k	3	(M10K)
RV1	Hor Encl Preset 100k	1	(UH06G)

CAPACITORS

C1	Poly Layer 4n7F	1	(WW26D)
C2,3	Polyester 10nF	2	(BX70M)
C4	Disc 100nF 50V	1	(BX03D)
C5	PC Elect 100μF 10V	1	(FF10L)

SEMICONDUCTORS

IC1	74150	1	(QX89W)
IC2	7414	1	(QX46A)
IC3	4024BE	1	(QX13P)
IC4	NE555	1	(QH66W)
D1-4	1N4148	4	(QL80B)

MISCELLANEOUS

SK1	IC Test Clip 16	1	(FY74R)
SK2,5	2mm Socket Black	2	(HF44X)
SK3	2mm Socket Red	1	(HF47B)

SK4,6	Jack Socket 3.5mm	2	(HF82D)
	Box AB10L	1	(LF11M)
	PCB	1	(GB98G)
	DIL Socket 24-pin	1	(BL20W)
	DIL Socket 14-pin	2	(BL18U)
	DIL Socket 8-pin	1	(BL17T)
	Ribbon Cable 20-way	1m	(XR07H)
	7/0-2 Wire 10M Blk	1	(BL00A)
	Bolt 6BA lin.	1 Pkt	(BF07H)
	Nut 6BA	1 Pkt	(BF18U)
	6BA Spacer 1/2in.	1 Pkt	(FW35Q)
	Instruction Leaflet	1	(XT49D)
	Constructors' Guide	1	(XH79L)

OPTIONAL

PL2,5	BNC Plug	2	(HH17T)
PL4,6	2mm Plug Black	2	(HF38R)
PL3	Plug Plus 3.5mm	2	(HF80B)
	2mm Plug Red	1	(HF41U)
	Low C Cable	1m	(XR19V)

The above items (excluding Optional) are available as a kit.

Order As LK77J (Scope Logic Tstr Kit)

The following item (which is included in the kit) is also available separately.
IC Logic Tester PCB Order As GB98G

MAINS Tx/Rx DRIVER continued from page 49.

MAINS TX/RX DRIVER KIT PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1	4Ω7	1	(M4R7)
R2,5	10k	2	(M10K)
R3	5k6	1	(M5K6)
R4	3k3	1	(M3K3)
R6	12k	1	(M12K)
R12	4k7	4	(M4K7)
R7,8,10,11	470R	3	(M470R)
R9,13,14	100k	1	(M100K)
RV1	18-Turn Cermet 5k	1	(WR48C)

CAPACITORS

C1,2	IS Cap 220μF	2	(FF57M)
C3	IS Cap 33nF	1	(FT34M)
C4	Minidisc 100nF 16V	1	(YR75S)
C5	PC Elect 1000μF 35V	1	(FF18U)
C6,10	Poly Layer 100nF	2	(WW41U)
C7	1% Polysty 560pF	1	(BX54J)
C8	Poly Layer 10nF	1	(WW29G)
C9	Poly Layer 1nF	1	(WW22Y)
C11	Poly Layer 47nF	1	(WW37S)
C12	PC Elect 100μF 25V	1	(FF11M)
C13	PC Elect 10μF 50V	1	(FF04E)

SEMICONDUCTORS

D1-4	1N4001	4	(QL73Q)
D5	Zener SA40A	1	(QY71N)
TR1,2	BC548	2	(QB73Q)
IC1	LM1893N	1	(UF50E)
IC2	Opto-Isolator	1	(WL35Q)
IC3	Dual Opto-Isolator	1	(YY62S)

MISCELLANEOUS

T1	Tank Coil AO42YUK	1	(FT55K)
T2	Sub-Min Tr 6V	1	(WB00A)
	Terminal Block 5A	1	(HF01B)
	Bolt 6BA 1/2in.	1 Pkt	(BF06G)
	C/S Screw 6BA lin.	1 Pkt	(BF13P)
	Shakeproof 6BA	1 Pkt	(BF26D)
	Nut 6BA	1 Pkt	(BF18U)
	Nylon Nut 6BA	1 Pkt	(BF80B)
	PCB	1	(GB84F)
	Heat Shrink CP 16	1m	(BF86T)
	PCB Latch Pl 6W	1	(YW12N)
	DIL Socket 18-pin	1	(HQ76H)
	Box 102	1	(LH01B)
	SR Grommet F31	1	(LR47B)
	Pin 2145	1 Pkt	(FL24B)
	Instruction Leaflet	1	(XT53H)
	Constructors' Guide	1	(XH79L)

OPTIONAL

	Twin Mains DS White	As Req.	(XR00A)
	PCB Latch Hsng 6-way	1	(BH65V)
	Terminal Pins	6	(YH25C)
	Test Resistor 3Ω3	1	(M3R3)
	13A Plug	1	(RW67X)

The above items (excluding Optional) are available as a kit.

Order As LK68Y (Mains Tx/Rx Kit)

The following items (which are included in the kit) are also available separately.

33nF 250V Capacitor Order As FT34M
Zener SA40A Order As QY71N
Tank Coil AO42 Order As FT55K
Mains Tx/Rx PCB Order As GB84F

Please note that the text and accompanying parts list for the Wave Meter have been missed off Page 11 of this issue. See Table.1.

later on. The coils perform the following functions:

- T1 Local oscillator coil
- T2 Aerial tank coil
- T3 Mixer coil
- T4 IF coil

As with the transmitter, expensive test equipment is needed for accurate alignment of the receiver stages, though not really necessary. A small crystal earpiece can be used to monitor one of the PWM channels, where a low-pitched 50Hz buzz can be heard. Remove the 3.5mm jack plug from the earpiece lead and solder one lead to 0V (pin 4) and the other to pin 5. Connect a multimeter set to read milliamps between pin 7 and the battery positive lead and apply power.

Current reading should be about 13mA. Place the transmitter 2 to 3 feet away from the receiver and with no transmitting aerial fitted, switch that on as well. Ensure that RF energy is being developed with your wavemeter and listen to the earpiece. If no buzz is heard, adjust T4 so

that the slug screw slot faces along a line with pin 6 and pin 7 on the PCB. Turn T3 slug to the same position. Slight adjustment of both may be necessary to find the correct operating areas. When this is done, remove the meter and reconnect battery positive to pin 7.

Table.1.

PARTS LIST FOR WAVE METER							
CAPACITORS			MISCELLANEOUS				
C1	27pF Ceramic	1	(WX49D)	M1	Hi-Z 50µA Meter	1	(FM98G)
C2	100nF Minidisc	1	(YR76S)		Former 351	1	(LB17T)
SEMICONDUCTORS					E.C. Wire 24swg	1 roll	(BL28F)
D1	OA90	1	(OH71N)		E.C. Wire 18swg	1 roll	(BL25G)

Also the parts list for LK68Y (mains TX/RX driver kit) on page 54 has a few discrepancies. The parts list below (Table.2.) is a corrected version and should be used when ordering any components.

MAINS TX/RX DRIVER KIT PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1	4117	1	(M4R7)
R2,5	10k	2	(M10K)
R3	5k6	1	(M5K6)
R4	3k3	1	(M3K3)
R6	12k	1	(M12K)
R7,8,10,11	4k7	4	(M4K7)
R9,13,14	470R	3	(M470R)
R12	100k	1	(M100K)
RV1	18-Turn Cermet 5k	1	(WR48C)

CAPACITORS

C1,2	IS Cap 220µF	2	(FF57M)
C3	IS Cap 33nF	1	(FT34M)
C4	Minidisc 100nF 16V	1	(YR76S)
C5	PC Elect 1000µF 35V	1	(FF18U)
C6,10	Poly Layer 100nF	2	(WW41U)
C7	1% Polysty 560pF	1	(BX54J)
C8	Poly Layer 10nF	1	(WW29G)
C9	Poly Layer 1nF	1	(WW22Y)
C12	Poly Layer 47nF	1	(WW37S)
C11	PC Elect 100µF 25V	1	(FF11M)
C13	PC Elect 10µF 50V	1	(FF04E)

SEMICONDUCTORS

D1-4	1N4001	4	(OL73Q)
DS	Zener SA40A	1	(OY71N)
TR1,2	BCS48	2	(OB73Q)
IC1	LM1893N	1	(UF50E)
IC2	Opto-Isolator	1	(WL35Q)
IC3	Dual Opto-Isolator	1	(YY62S)

MISCELLANEOUS

T1	Tank Coil AO42YUK	1	(FT55K)
T2	Sub-Min Ty 6V	1	(WB00A)
	Terminal Block 5A	1	(HF01B)
	Bolt 6BA 1/4in.	1 Bolt	(BF06G)
	C/S Screw 6BA 1in.	3 Screws	(BF13P)
	Shakeproof 6BA	3 Washers	(BF26D)
	Nut 6BA	6 Nuts	(BF18U)
	Nylon Nut 6BA	4 Nuts	(BF80B)
	PCB	1	(GB84F)
	Heat Shrink CP 16	5cm	(BF86T)
	PCB Latch P1 6W	1	(YW12N)
	DIL Socket 18-pin	1	(HQ76H)
	Project Box D-009	1	(ZB02C)
	SR Grommet F31	1	(LR47B)
	Pin 2145	1 Pin	(FL24B)
	Instruction Leaflet	1	(XTS3H)
	Constructors' Guide	1	(XH79L)

OPTIONAL

	Twin Mains DS White	As Req.	(XR00A)
	PCB Latch Hsng 6-way	1	(BH65V)
	Terminal Pins	6	(YH29C)
	Test Resistor 3Ω	1	(M3R3)
	13A Plug	1	(RW67X)

The above items (excluding Optional) are available as a kit.

Order As LK68Y (Mains Tx/Rx Kit)

The following items (which are included in the kit) are also available separately.

33nF 250V Capacitor Order As FT34M
Zener SA40A Order As QY71N
Tank Coil AO42 Order As FT55K
Mains Tx/Rx PCB Order As GB84F

Table.2.
Correct parts list for LK68 kit

Please accept our apologies for these errors and hope that they have not caused any inconvenience.

Quality Control Department May 1993.

/// Maplin /// Maplin ///

/// Maplin /// Maplin ///