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June to August 1985

Volume 4 Number 15

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PROJECTS

FEATURES

First Base and Electronic Chronicles
We very much regret that Part 9 of First Base and Part 6 of Electronic Chronicles have been held over to the next issue of Electronics due to lack of space.

NEWS

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Editorial & Production
Editor Roy Smith
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Technical Editors Robert Kirsch, Dave Goodman
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Technical Artists John Dudley, Lesley Foster
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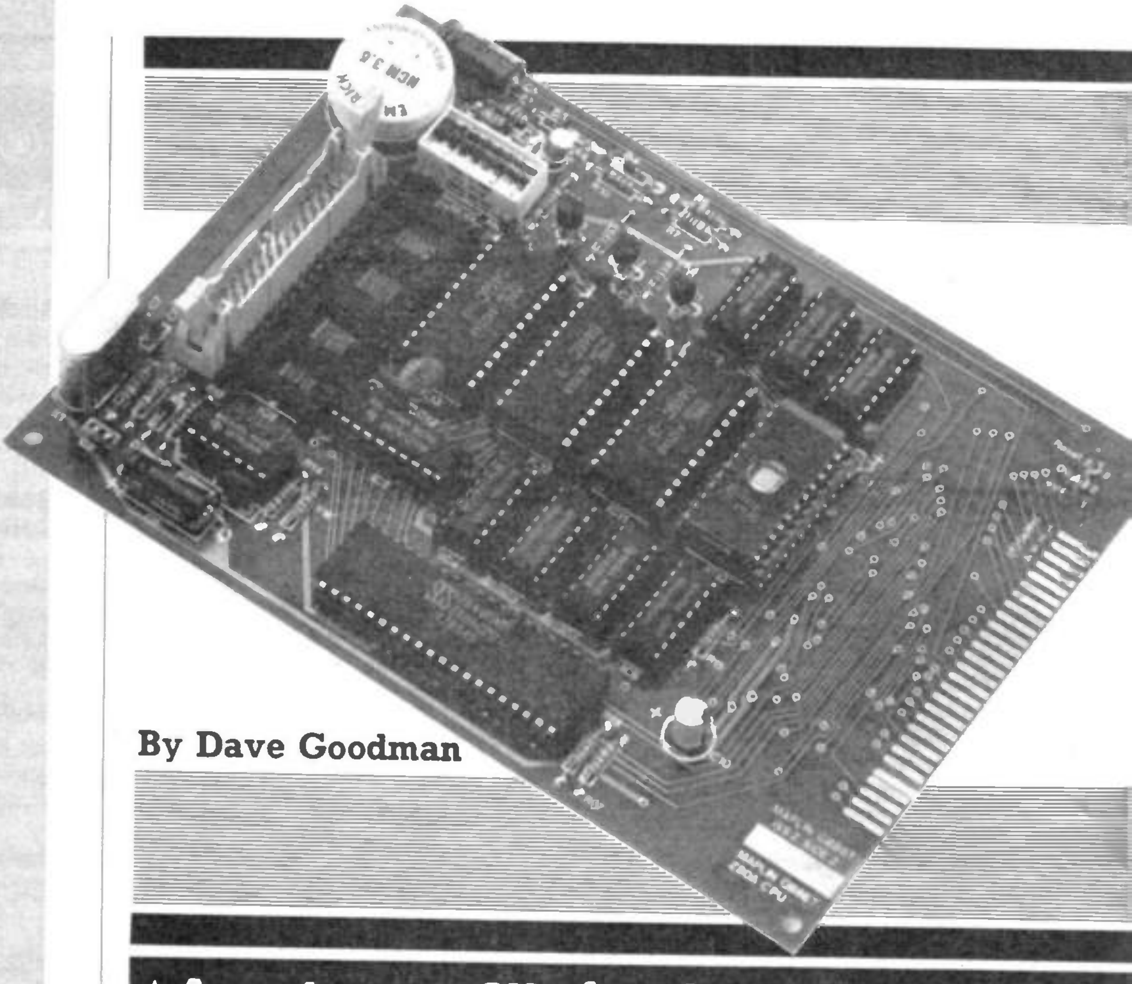
Z80 CPU MODULE



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

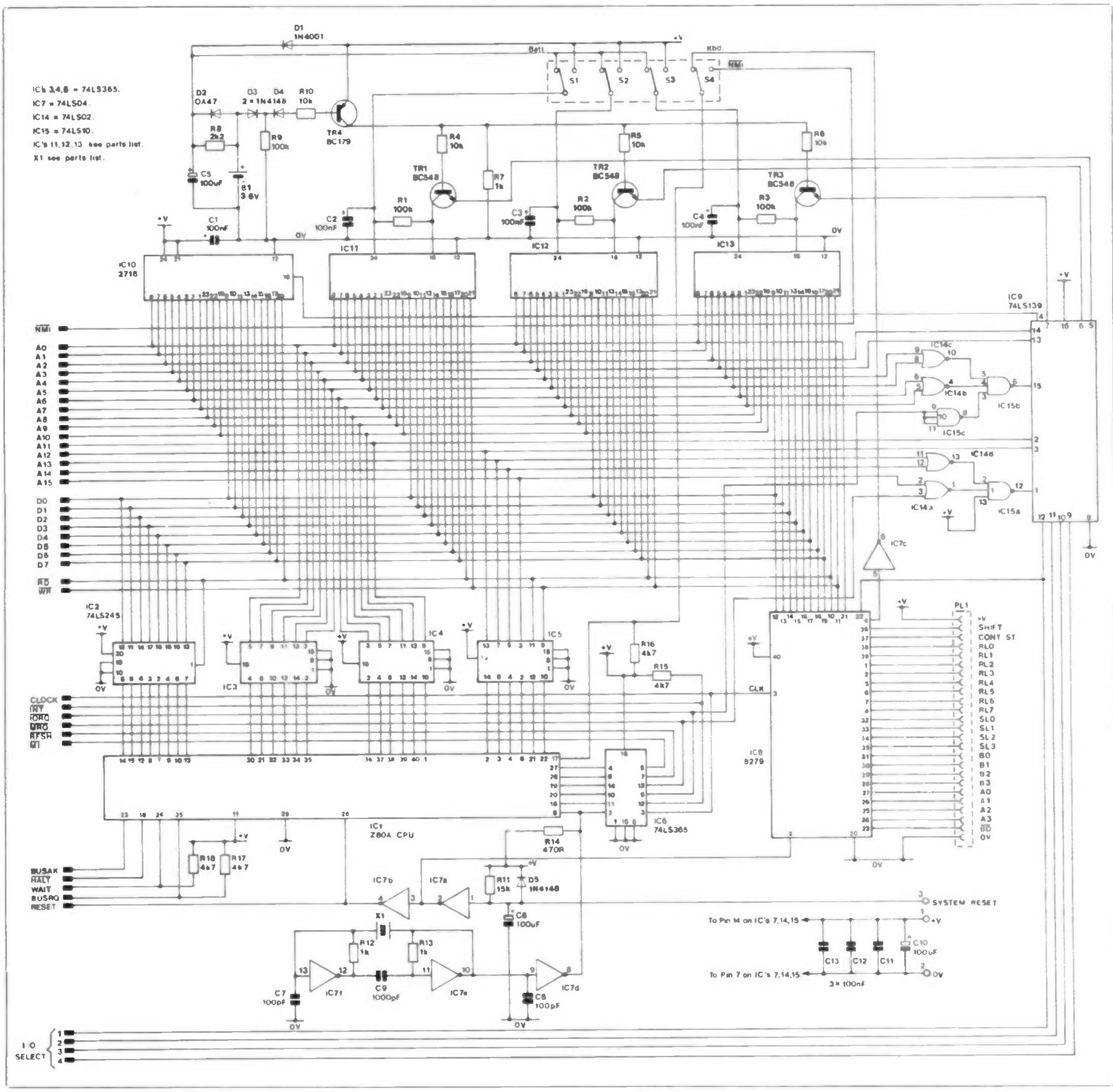


Figure 1. Circuit Diagram

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 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, 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 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

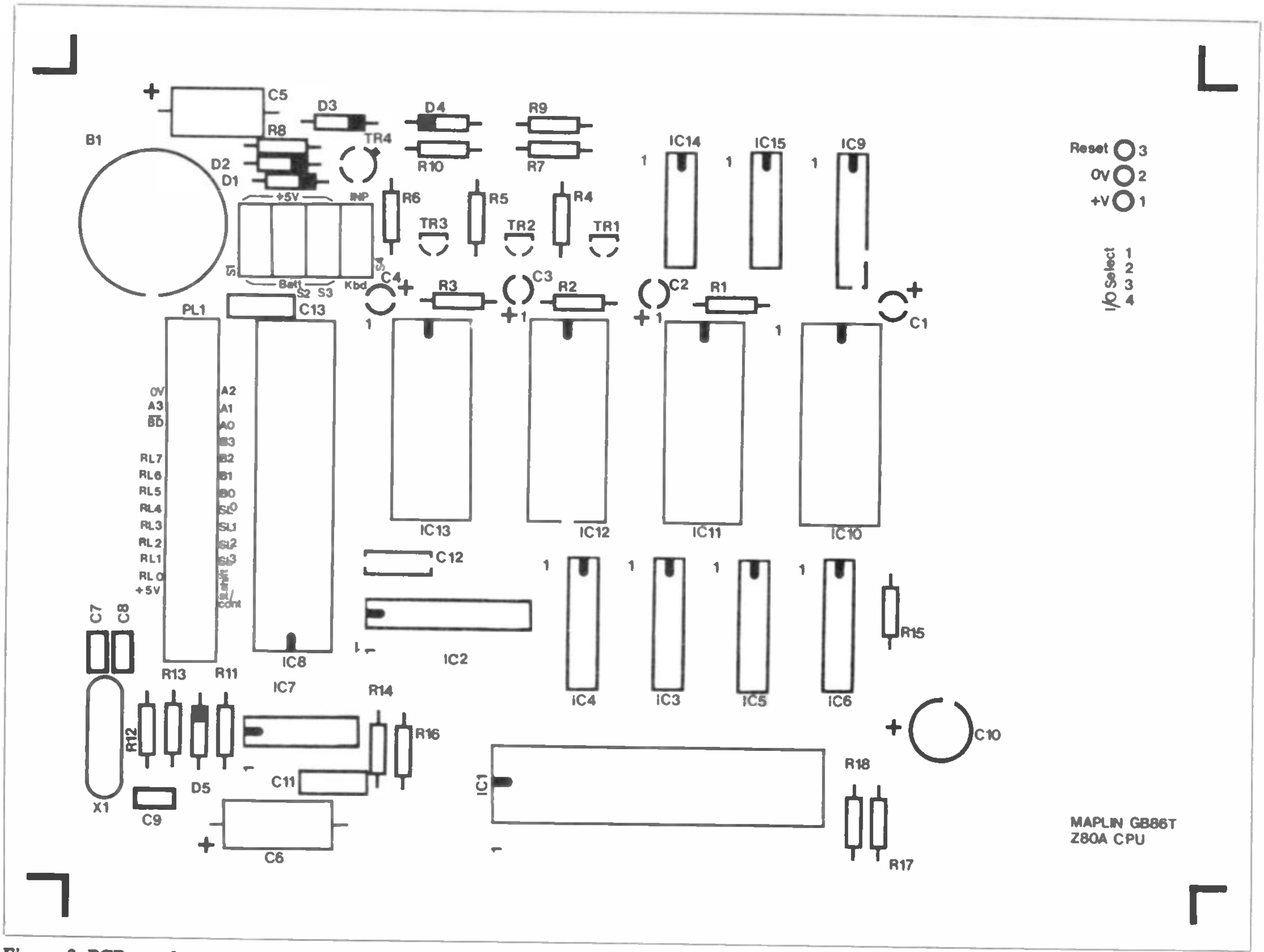


Figure 2. PCB overlay

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 ceramics 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

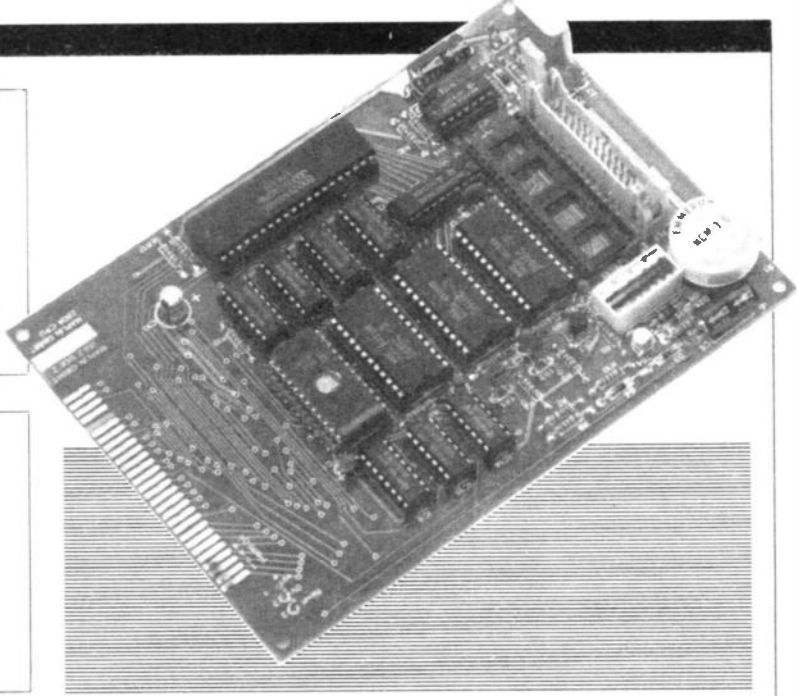
A multimeter set to read high ohms (x 10K or more) should be used to check for shorts *between* the address, data and control line connections along the edge connector. Then use the lowest resistance range to check for continuity along these connections. For example, with reference to Figure 1, it can 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 1MΩ impedance probe and a digital multimeter were used to take measurements for this procedure. Lower impedance equipment such as 20KΩ/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 (μPD446) 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 (I5) 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'.

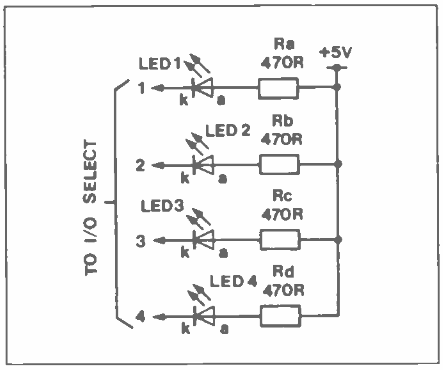


Figure 3. Test LED Display

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?
                            (2048 BYTES TESTED)
CP D          BA
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.

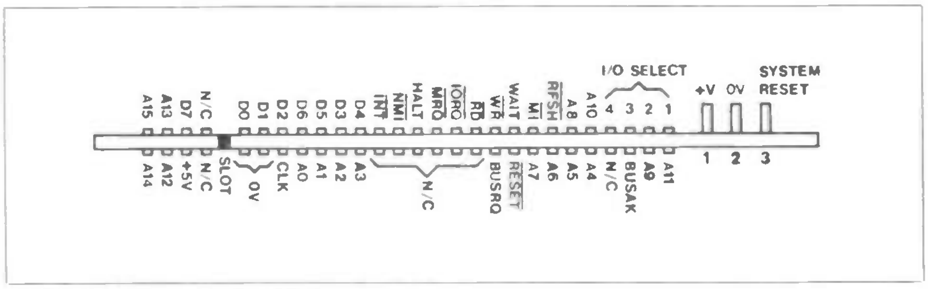


Figure 4. Expansion Connector

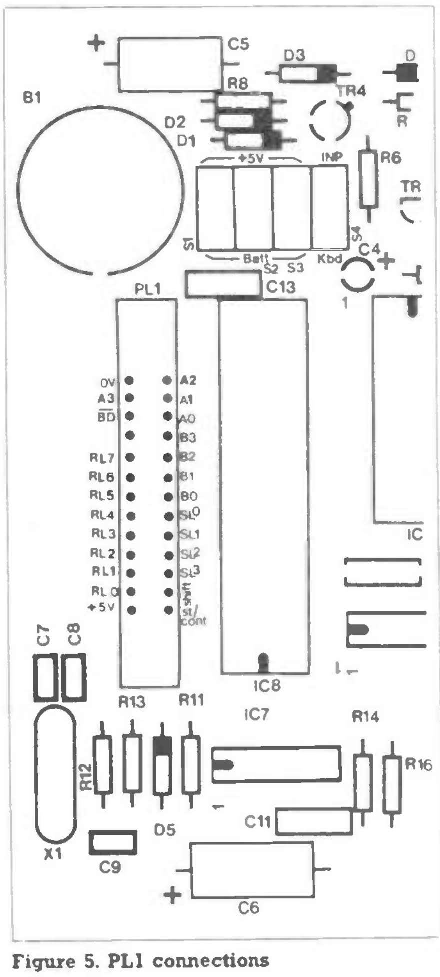


Figure 5. PL1 connections

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 ot 40p 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-PI0	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).
Z80 Assembly Language Programming (XW71N).
Programming the Z80 (XW72P).
Z80 Machine Code for Humans (WK81C).

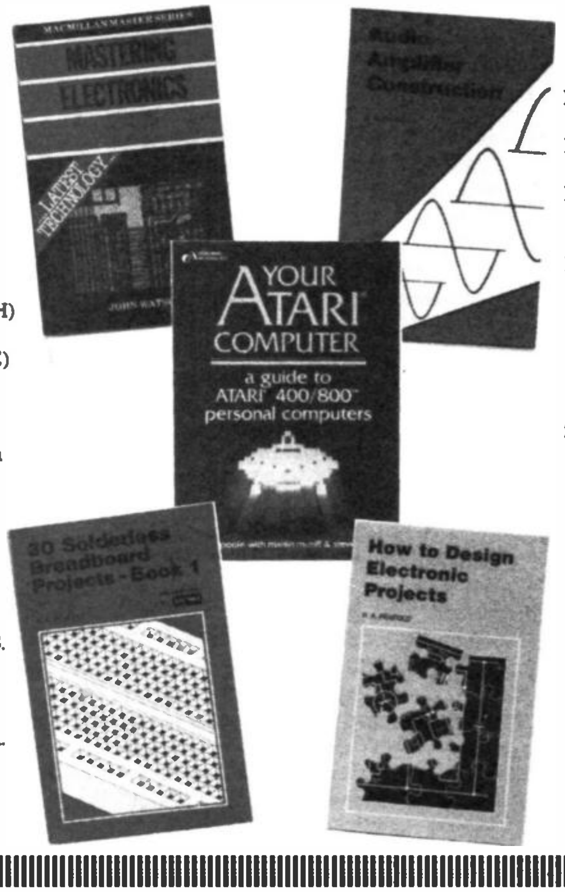
Z80 CPU MODULE PARTS LIST

RESISTORS: All 0.4W 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	100nF 35V Tantalum	4	(WW54J)
C5,6	100µF 10V Axial Electrolytic	2	(FB48C)
C7,8	100pF Ceramic	2	(WX56L)
C9	1000pF Ceramic	1	(WX68Y)
C10	100µF 6V3 P.C. Electrolytic	1	(RK50E)
C11-13	100nF Minidisc	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 C.P.U.	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	SPDT Quad DIL Switch	1	(XX29G)
B1	PCB Mounting 3V6 Battery	1	(RK46A)
	Z80 CPU Module PCB	1	(GB86T)
	14-Pin DIL Socket	3	(BL18U)
	16-Pin DIL Socket	5	(BL19V)
	20-Pin DIL Socket	1	(HQ77J)
	24-Pin DIL Socket	4	(BL20W)
	40-Pin DIL Socket	2	(HQ38R)
	Veropin 2141	1 Pkt	(FL21X)
OPTIONAL			
PL1	26-Way IDC Header Plug	1	(FJ15R)
	2 x 28-Way P.C. Edge Conn.	1	(FG23A)
X1	2·4576 MHz Crystal	1	(FY81C)
	or 1 MHz Crystal	1	(FY79L)
IC8	8279 Kbd/Display I/Face	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)

A kit of parts is available,
but does not include optional and test items:
Order As LK67X (Z80 CPU Module Kit) Price £29.95
The following item in the above kit
is also available separately,
but is not shown in the 1985 catalogue:
Z80 CPU Module PCB **Order As GB86T Price £10.95**

TOP TWENTY BOOKS

1. (1) Loudspeaker Enclosure Design and Construction. (WM82D) Cat. P47.
2. (2) Power Supply Projects, by R.A. Penfold. (XW52G) Cat. P43.
3. (3) Remote Control Projects, by Owen Bishop. (XW39N) Cat. P44.
4. (–) Mastering Electronics, by John Watson. (WM60Q) Cat. P42.
5. (7) International Transistor Equivalents Guide, by Adrian Michaels. (WG30H) Cat. P38.
6. (4) IC555 Projects, by E.A. Parr. (LY04E) Cat. P46.
7. (17) Electronic Synthesiser Projects, by M. K. Berry. (XW68Y) Cat. P48.
8. (6) How to Design and Make Your Own PCB's, by R.A. Penfold. (WK63T) Cat. P41.
9. (5) How to Build Your Own Solid State Oscilloscope, by F.G.Rayer. (XW07H) Cat. P45.
10. (8) A Z80 Workshop Manual, by E.A. Parr. (WA54J) Cat. P55.
11. (9) Radio Control for Beginners, by F.G. Rayer. (XW66W) Cat. P44.
12. (10) Electronic Music Projects, by R.A. Penfold. (XW40T) Cat. P48.
13. (13) Electronic Security Devices, by R.A. Penfold. (RL43W) Cat. P44.



14. (–) Spectrum Interfacing and Projects, by Graham Bishop. (WM52G) Cat. P65.
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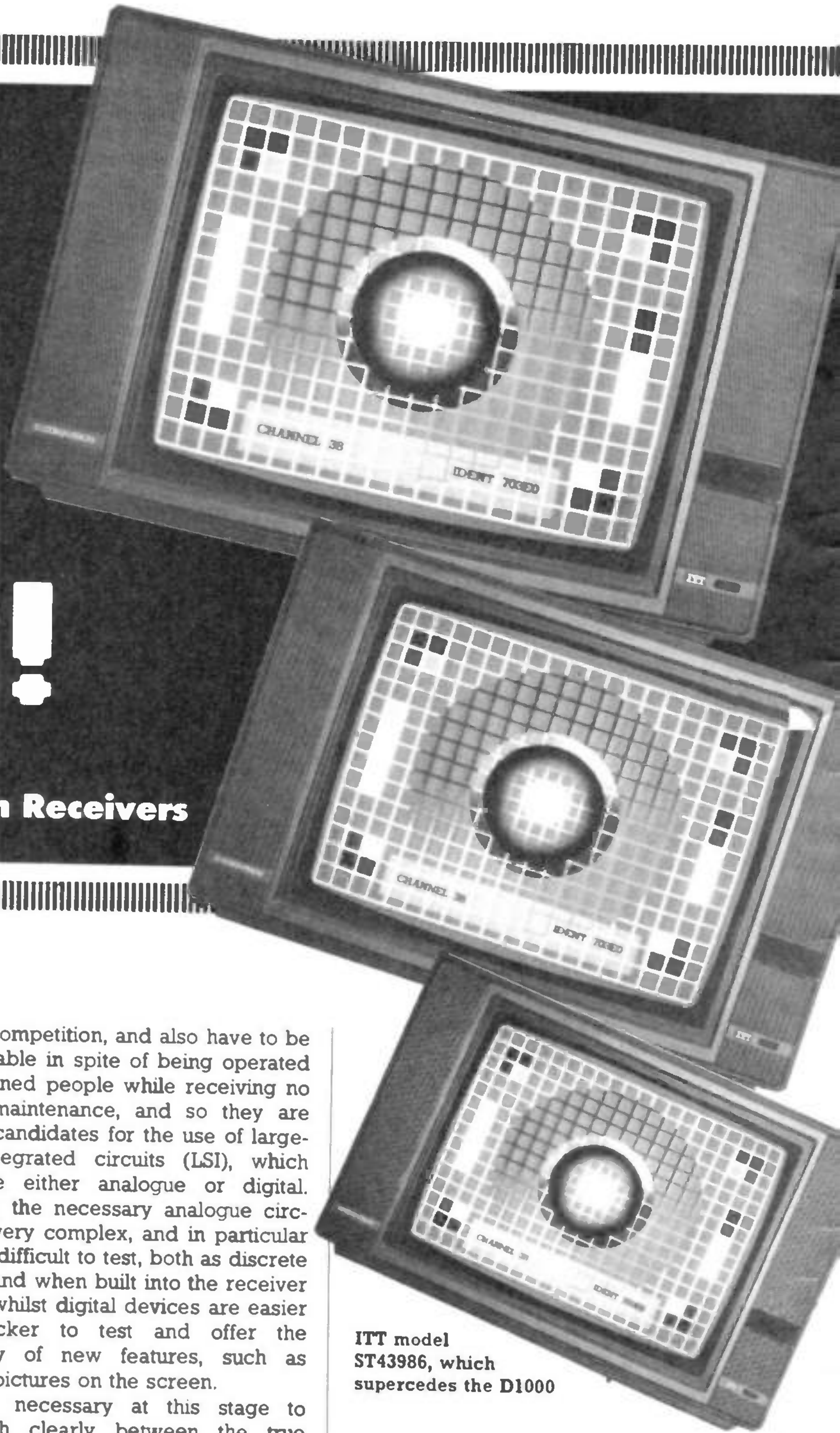
The DIGITS are coming!

Digital Techniques in Television Receivers



ITT model ST43986, which supercedes the D1000

Photographs supplied by ITT Digivision

By John Woodgate

In order to keep up the public's interest in buying new products, the household entertainment electronics (or 'brown goods', as it calls itself, from the days when radios were always brown and 'white goods', such as fridges, were always white) industry has to find a new product every five years or so. The last two steps have been colour TV and video recorders, and the next ought to have been satellite TV, but, at present, political and financial problems are delaying this project considerably. For cable TV, the problems are even bigger because the financial questions are so difficult and there is no indication that the general public will pay for such a service. So the industry may be forced to depend on the development of digital television sets, with new features that are attractive to the average viewer, to sustain the present market of about 3 million sets per year in Britain, most of which are replacements of older sets. British viewers tend to keep their sets for longer than the five to seven years for which they are basically intended, partly because modern sets do not really 'wear out', and partly as a result of the ingenuity of service engineers in keeping them going.

In this article, we shall look at the techniques used in the first production digital TV receivers, manufactured by ITT, and those proposed by other manufacturers of receivers and the necessary IC's for them. Because TV sets are made in very large numbers, they have to be very cheap to buy because of intense competition, and also have to be very reliable in spite of being operated by untrained people while receiving no routine maintenance, and so they are obvious candidates for the use of large-scale integrated circuits (LSI), which could be either analogue or digital. However, the necessary analogue circuits are very complex, and in particular are very difficult to test, both as discrete devices and when built into the receiver chassis, whilst digital devices are easier and quicker to test and offer the possibility of new features, such as multiple pictures on the screen.

It is necessary at this stage to distinguish clearly between the true *digital* receiver, which handles signals in digital form, and the *digitally-controlled* receiver, in which the signals remain in analogue form, but extensive and complex control features are included, which would be impracticable or impossibly expensive to realise with analogue technology.

Examples of the advanced control features which can be made available to the user by means of digital control systems, are the storage of user control settings for contrast, brightness, saturation and sound volume for each channel individually, and the adaptation of the receiver by the user or retailer to operate with different intermediate frequencies, as required in some countries, simply by re-writing firmware data through the remote control gun. Both of these features are currently offered by the Finnish manufacturer Salora.

Structure of the Colour Television Receiver

Figure 1 shows the structure of an analogue receiver. It would be possible to adopt some completely different structure for a ditigal receiver, such as direct digitising of the received UHF signal, which can be done now but at a prohibitive cost. Other techniques, such as synchrodyne reception, have been explored in the past, but no radically new structure seems to offer significant advantages at present.

Having then adopted this basic structure for the digital receiver, there is still a decision to be made as to the point where the signals will be converted from analogue to digital form. The standard intermediate frequency used for television receivers is in the region of 40MHz, and digitisation in this frequency

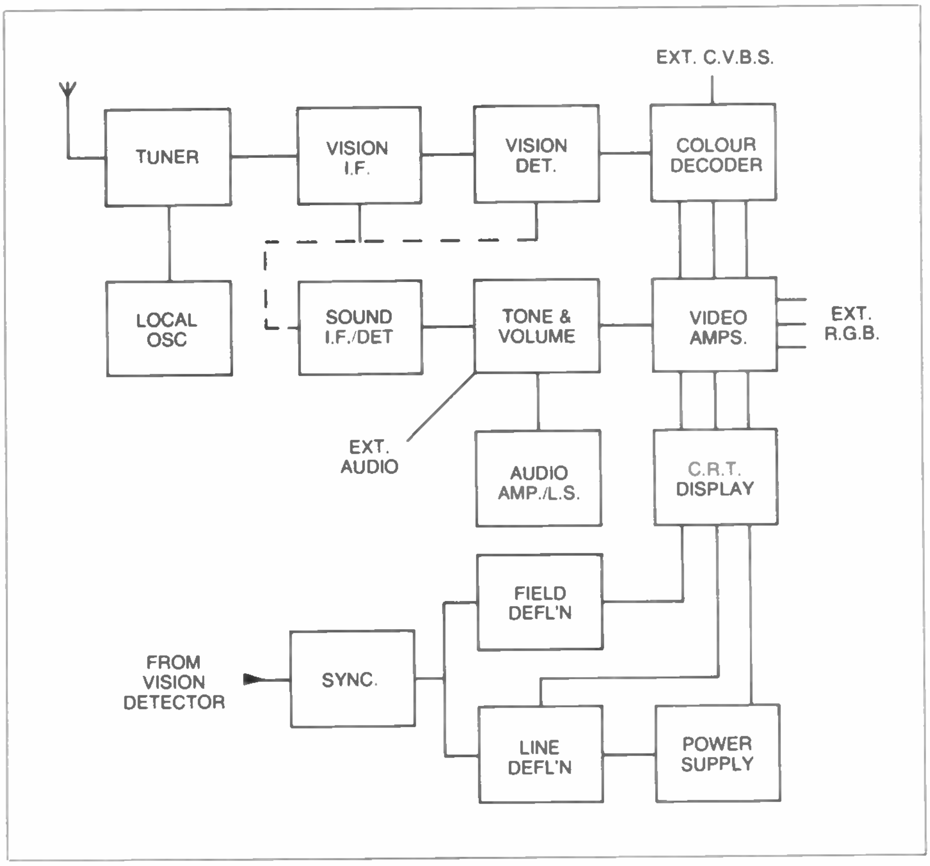


Figure 1. Block diagram of an analogue receiver

range is still too expensive. Consequently, the choice for digitising the video signal is between the encoded Combined Video, Blanking and Synchronising signal (CVBS), or the decoded colour-difference signals. This depends on whether the colour decoding is to be an analogue or a digital process. ITT have chosen to decode digitially, whereas Philips, for instance, propose to use hybrid technology, incorporating CCD analogue delay lines for decoding and to digitise the baseband colour-difference signals. Rather than decode the composite signal into luminance (Y), red-difference (R-Y) and blue-difference (B-Y) signals, there are advantages in using as colour-difference signals the components known as U and V. However, in this case the majority of the vision channel of the receiver remains in analogue form.

For the sound channel there is less debate. The obvious point of digitisation is the output of the sound detector. However, the audio signal at this point is not inherently band-limited, and direct digital conversion with a sampling rate near the Nyquist limit, or around 40kHz, would necessitate the inclusion of steep anti-aliasing filters. Fairly low-cost filters are available from the Compact Disc player development, but a much lower cost alternative is available, which will be explained when we come to the audio part of the receiver.

Figure 2 shows a block diagram of the first production digital receiver. There are nine integrated circuits, or eleven if the remote control transmitter and receiver are included. The use of these devices, in a receiver for the German market, including off-air stereo sound, saves up to 300 discrete components. For a British monophonic receiver, the saving is naturally somewhat reduced, but is still substantial.

Figure 3 shows the Central Control Unit (CCU), which contains an 8048 microprocessor core, 4 to 6 kilobytes of RAM and about 100 bytes of ROM. It accepts and stores in an associated EAROM, both factory alignment data and inputs from the user controls, as well as continuously monitoring several functions of the receiver and dealing with such housekeeping activities as the generation of appropriate reset signals under various initialisation and error conditions. Because of the complexity of some of the diagrams to be presented later, references to the interfaces of the various functional blocks with the CCU have been omitted, but it is necessary to bear in mind that there is a constant flow of data within the receiver, between the CCU and the other digital circuits. This takes place through a 3-wire bus, known as 'IM-bus', (for 'Intermetall-bus', Intermetall being the ITT semiconductor company). Unfortunately, this bus system is different from an earlier system implemented by Philips, know as I^2C, (for, unfortunately, Inter-Integrated Circuit bus), which is of wider application in spite of being a 2-wire system. While transcoding between these bus systems is not, of course, impossible, in practice receiver designers are faced with a considerable disincentive to mix devices from different manufacturers. It is, perhaps, just possible that recent expensive experience with incompatible systems in household video tape and disc recording, compared with the considerable success of the corresponding audio systems, Compact Casette and Compact Disc, which have become world-wide standards while allowing satisfactory commercial exploitation both by the originators of the systems and by their numerous competitive licensees, will convince manufacturers that such incompatibility is no longer an advantage to anyone. An encouraging development is seen in the Motorola Series 4 digital TV devices, which incorporate a bus system

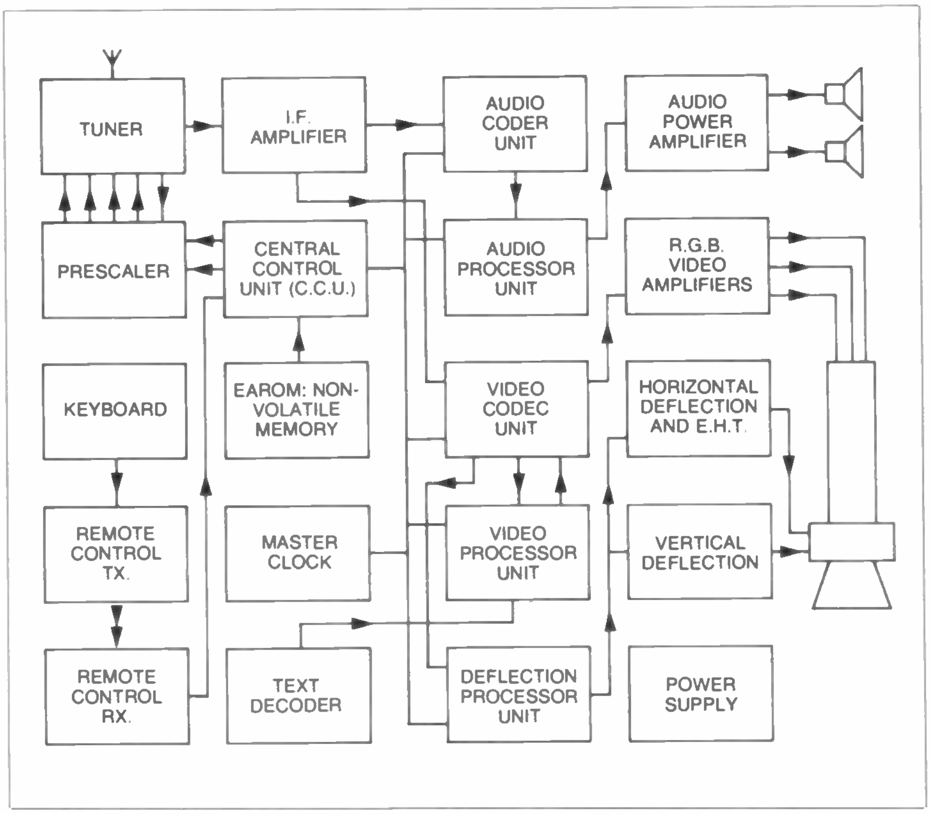


Figure 2. Block diagram of a digital receiver

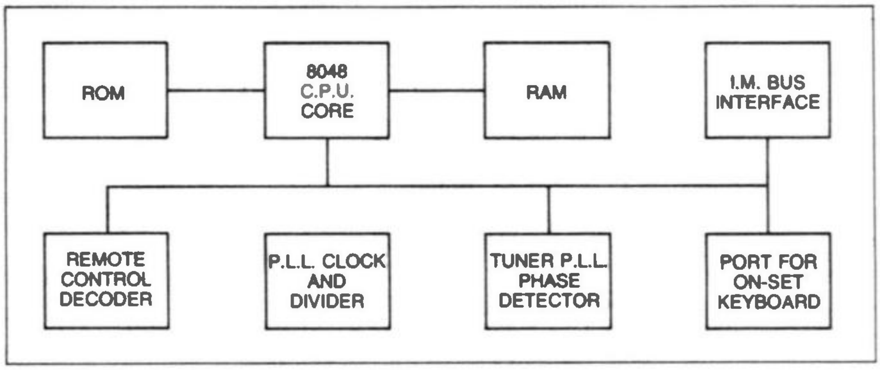


Figure 3. The Central Control Unit (CCU)

Salora 26J60

which is compatible with I²C.

We should now consider the impact of digital technology on the individual receiver functions.

Digital Control of the Tuner and Ancillaries

Figure 4 is a detailed block diagram of the hybrid analogue/digital frequency control loop which forms the basis of current tuner techniques as used in remotely-controlled receivers and in several proposed digital receivers.

For countries having on-going television broadcasting in VHF Bands I and III, as well as in UHF Bands IV and V, the local oscillator in the tuner must cover a frequency range from some 90MHz to 900MHz. The fast pre-scaler divides this frequency by 64 and the result is divided again by a programmable divider, whose output is compared with a reference signal of 976.5625Hz, produced by the division of a 4MHz crystal frequency by 2^{12}. The phase-comparator outputs are applied to an interface device, where they control the bias voltage applied to the variable-capacitance diodes used to tune the local oscillator. Both the division ratio of the programmable divider and the band-switching signals are derived by the CCU from the 'channel' number or transmitter channel data entered on the remote-control keypad. Considerable provisions have to be made to prevent the control system 'crashing', for example if an attempt is made to tune beyond a band-end. Automatic or manual search tuning facilities can also be provided.

In the Salora receivers mentioned previously, additional memory is provided for the CCU, which stores data on the division ratios required for four different values of intermediate frequency, and a further section of memory can be assigned either to increase the normal provision of 20 or 27 tuning presets to 59 (!), or to store the display and sound volume control settings chosen by the user for each preset station. This latter facility may not seem particularly necessary in this country, but elsewhere the signal characteristics of different transmitters vary considerably. A further facility provided by the CCU is the detection of the end of transmission,

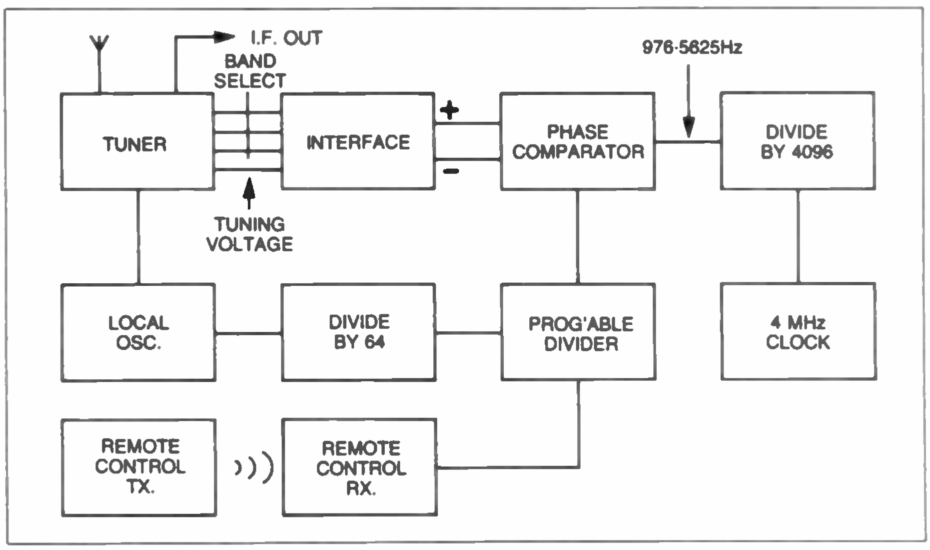


Figure 4. Digital tuning control

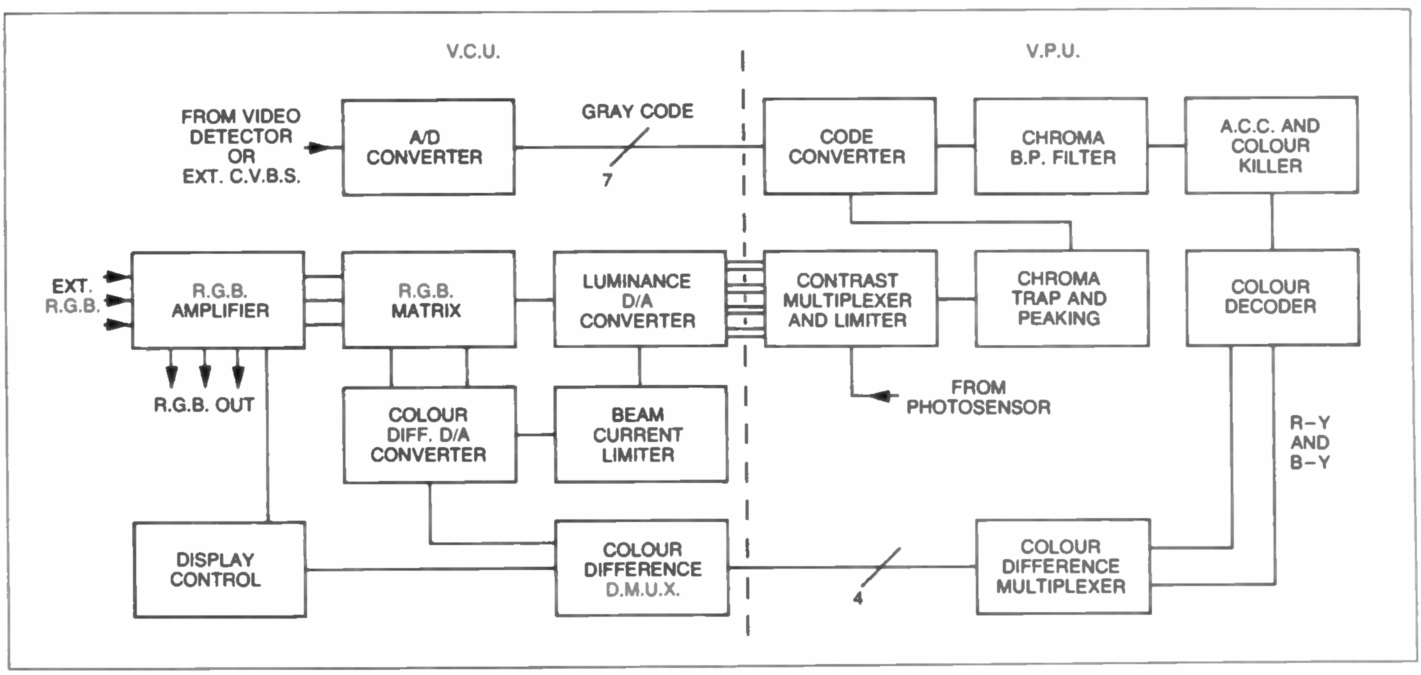


Figure 5. Digital video processing

and the receiver can be arranged to switch off automatically after a transmission break of some minutes. Had such a facility been available on early colour receivers, it would have been a valuable safety feature, but improvements in components and in safety requirements have made the modern receiver possibly the safest household electrical product.

Digital Video Signal Processing

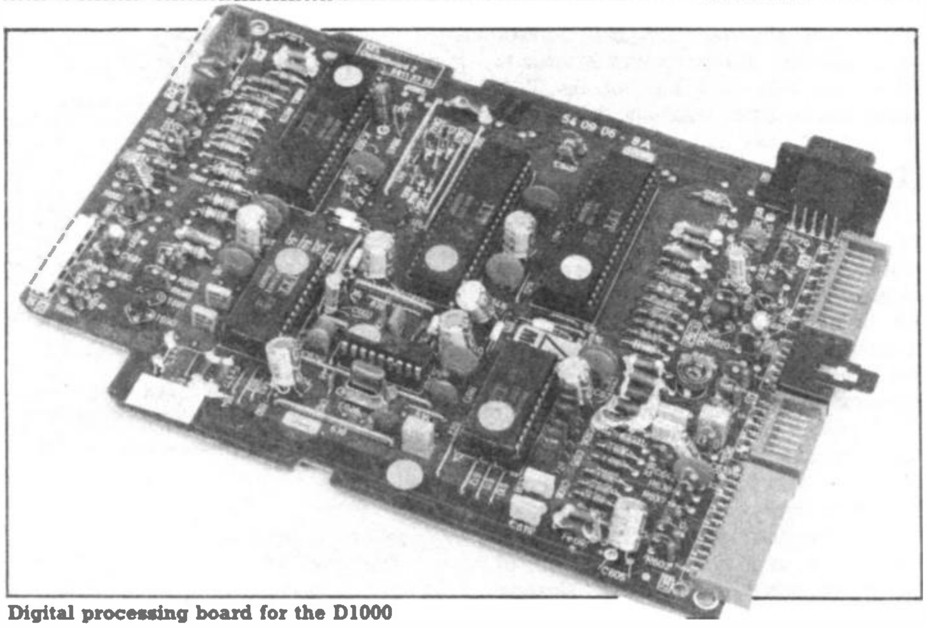
Figure 5 shows the ITT digital video processing, and complexity of the diagram is unavoidable because of the way in which the functions are split between the Video Codec Unit (VCU) and the Video Processing Unit (VPU). However, you may be reassured to learn that this is the most complex diagram that we shall be looking at in this article.

The composite video signal is digitised into a 7-bit Gray code, with a clock frequency of 4 times the colour subcarrier frequency of 4.433619MHz for CCIR 625-line PAL systems, or 17.734475MHz. The digital converter in Figure 5 is an n-bit flash converter using 2^n comparators. Unfortunately, 7-bit coding is not sufficient to give the visual effect of a continuous grey-scale on the display, while to adopt 8-bit coding would require 256 comparators instead of 128. The solution adopted is to add an offset equal to half a least-significant bit on alternate lines, which through visual integration gives the equivalent of 8-bit resolution. The Gray coding is a method of processing the digital signal so as to avoid errors due to spikes and glitches caused by differences in comparator speeds.

The signal is now passed in pseudo-8 bit form to the VPU. The partitioning of functions between the various chips is a very important and complex consideration, both from the engineering and the commercial viewpoints. Technically, the main constraints are total chip dissipation, number of pin-outs, and inter-function interference. Commercial considerations include chip-set cost, impact on total receiver cost (which is often only weakly correlated with chip-set cost) and, more subjectively, package count *per se*.

In the VPU, the Gray-coded signal is decoded, and the binary-coded 8-bit signal produced is split to the luminance (black-and-white) and chrominance (colour) channels.

In the luminance (black and white) chain, the chrominance (colour) signal is filtered out by means of a digital notch filter, whose low-frequency flank response, in the region of 3MHz, can be varied by a user control, 'picture sharpness', but to avoid increasing low-level signals. Both the filter flank shape and the level at which peaking begins are under software control. The line sync. pulses are stripped from the signal by offsetting it so that the pulses underflow the digital dynamic range. Following the peaking filter is the contrast control, which is a digital multiplier accepting a 6-bit multiplier input from the CCU, derived from the user's contrast setting, and a photo-sensor which detects the room lighting level. The luminance signal amplitude is limited at this stage by allowing overflow, but an offset is provided to accomodate negative-going overshoot caused by the peaking filter. The net result of all these processes is an expansion of the necessary dynamic range to 10 bits, which are transferred back to the VCU in the form of eight parallel bits, with two bits in 4-step pulse-width modulation on the LSB (Least Significant Bit) line.



Digital processing board for the D1000

In the VCU, the luminance signal is converted to analogue form, ready for matrixing with the colour-difference signals.

The chrominance signal chain in the VPU commences with a digital band-pass filter whose phase response is under software control, so that for off-air reception, the phase response of the I.F. amplifier can be compensated, while for local external video signals, a phase-linear characteristic can be provided. This filter is followed by the Automatic Colour Control (ACC), which is a gated A.G.C. stage, keeping the colour-burst amplitude constant at its output. Provision is also made for 'colour-killing' if the burst amplitude is too small to synchronise the local subcarrier oscillator in the decoder stage.

Decoding takes place with the signal in digital form, and the decoder stage uses a RAM as a line store for compensation of phase errors. This eliminates the expensive glass delay-line used in analogue receivers. The colour-difference output signals can be time-division mutiplexed because the signal bandwidth is only about 1MHz, whereas the sampling clock frequency is 17.7MHz. The next stage which adjusts colour saturation therefore requires only one multiplier under the control of the CCU which generates the required multiplying factors, not only for the appropriate colour saturation for the given user control settings of saturation and contrast, but also for hue control which can be provided by variable cross-talk between the colour-difference signals. By multiplexing the colour-difference signals, they can be transferred to the VCU for matrixing on only four instead of eight package pins while retaining 8-bit resolution.

In the VCU, the colour signals are first converted to analogue form and then matrixed with the analogue luminance signal. Both the luminance and chrominance A/D converters are R-2R ladder networks, and the colour-difference converter is clocked at one-quarter of the master clock frequency, the time-interleaved signals being gated into the appropriate ladder. The recovered analogue signals are sent to the RGB (Red/Green/Blue) matrix, where brightness data is introduced from the CCU. Brightness can be varied in 255 steps, which is functionally equivalent to continuous control. The matrixing coefficients are mask-programmable to allow for certain special requirements. The RGB amplifiers are buffers suitable for driving conventional video output stages. They can be gain-controlled for white-balance adjustment, and the addition of 255-step (8-bit) offset signals at this stage allows set-up, and continuous monitoring by the CCU, of the signal level giving spot cut-off (blanking) at the CRT (the picture tube).

Beam-current limiting for the three electron guns is arranged by sensing both the average CRT cathode current, and the 'white' transients in the video signals. The combined effect of these sensing signals is applied to the D/A converters to reduce contrast and brightness according to a predetermined algorithm.

Analogue RGB inputs are provided on the VCU which has facilities for clamping and gain control, and for fast switching between these inputs and the off-air or CVBS signal.

The display control stage operates in conjunction with the CCU and VPU in the field blanking interval when test signals are sent to the CRT. Over four blanking intervals, the dark current and the white level are measured for each gun, together with the CRT cathode leakage current and the photo-sensor current for automatic contrast control. Data collected in this routine is used to adjust the gain and bias of the RGB amplifiers so as to maintain the initially set-up conditions.

The Field Store

It is appropriate at this point to leave the description of the current receiver to examine the possibility of including in the receiver sufficient memory to contain one or more complete 'fields', and the advantages to be gained by doing so, (two fields of 312.5 lines interleaved make one frame or a picture).

Figure 6, in which the upper part is not a block diagram, shows that the usage of a field store can be divided into the two functions of data storage and data rate conversion, storage being more fundamental as it is an essential part of rate-conversion. Considering storage first, at the very basic level, text data (i.e. Teletext pages) can be stored, thus eliminating access time problems for, at least, the most-frequently used pages. The next feature is the provision of built-in games. Whether this possibility is commercially sensible is a matter of considerable doubt, comparing the ephemeral nature of the interest in any one game with the possible 20-year useful life which is predictable for a digital receiver. Only chess seems durable enough, but the level of interest in this game is quite low in most countries, except the USSR. There are, though, other possible candidates such as Monopoly, Backgammon or even Elite! It has been suggested that games software could be downloaded on a cable system, or even from Teletext, but market research suggests that people would not pay much for this.

The usefulness of a single field store for videotape editing might seem to be minimal, but at least it simplifies pictorial titling and some other techniques. Noise reduction is certainly one of the more important requirements for an advanced receiver, and can be realised with the use of the field store in a recursive filter configuration, so that noise is partly averaged out over a number of fields. The problem of blurring on movement can be solved by making the filter adaptive, and research is continuing in this area.

Used for data-rate conversion, the field store allows the realisation of a display standard. Naturally, if a high-resolution display is provided, some form of interpolation is required to expand the information actually transmitted, but human visual perception has proved surprisingly tolerant of some of these techniques (and surprisingly intolerant of some others!).

Beginning again at the lowest level, enhancement of videotex (e.g. Prestel) displays with high resolution pictures has been demonstrated some time ago, and the extension of these techniques to a practicable picture-phone appears simple, although the question of whether anyone will actually want it remains unanswered still!

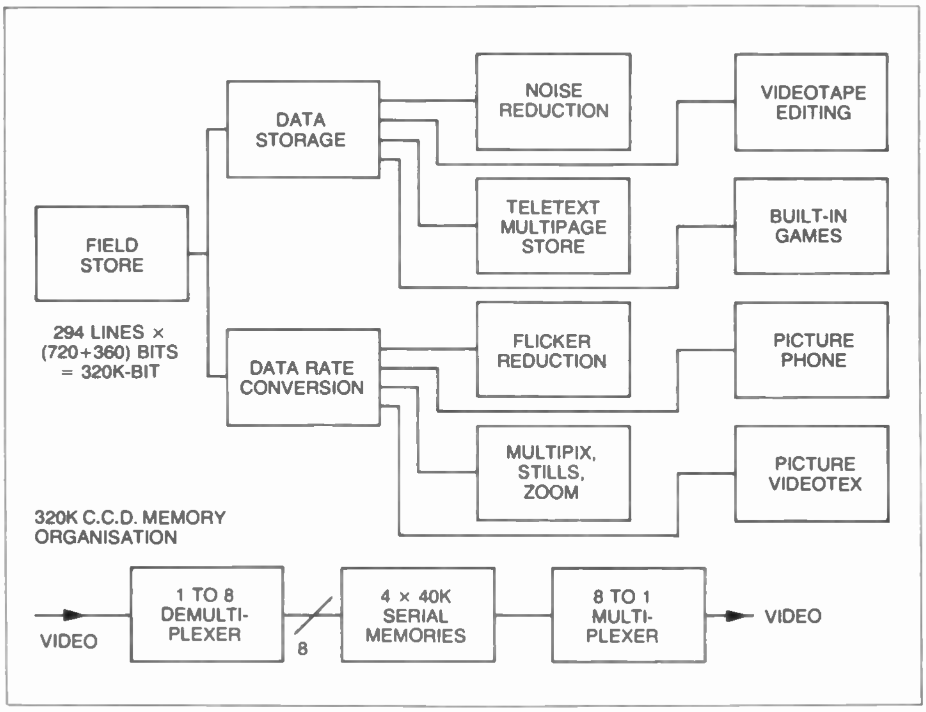


Figure 6. The Field Store. Seven of these make one complete field memory

User features, such as still and strobe pictures, picture-in-picture and multiple pictures are more certainly appealing to end-users. But perhaps the most significant possibility is the reduction in flicker that can come from an increase in field rate. The subjective effect of flicker, measured in terms of average picture brightness for the same subjective annoyance value of flicker, falls by some five times for the modest increase in field rate from 50 to 60Hz (25 to 30 frames per second), although this effect seems to fall rapidly above 80Hz for reasonable values of brightness. The possibility of providing effective standards-conversion in receivers breaches the well-established principle of concentrating complex signal processing at the sending end (originally totally justifiable on cost and reliability grounds) and makes conservation of spectrum space possibly the most important criterion for the choice of future transmission standards.

The lower part of Figure 6 shows one (Philips) proposal for the realisation of a low-cost memory device. Seven of these make up the 2M-bit store required and they are charge-coupled shift-registers which function as serial memories. The screen is mapped directly in the memory and no addressing is required, but of course, random access is not possible. The 1-to-8 multiplexing brings the speed requirements within the limits of current technology, and reduces the power requirement by a corresponding factor. The visible part of each line contains 720 luminance bits and 360 colour-difference bits, or the same memory space can store three text lines of 360 bits.

It is clear that the field store is a device which will produce radical and exciting changes in the capabilities of the television receiver, which cannot come too soon for the industry. But stringent cost restraints apply to this development as to all others and it is unlikely that receivers with field stores are less than 2 years away in the European market.

Digital Processing of Line Scan Synchronisation

Figure 7 shows the structure of the deflection processor in the ITT chip-set. Pseudo-8 bit digital video from the VCU is first clamped, and clamping pulses are derived which are fed back to the inputs of the VCU. The standard signal detector determines whether the horizontal (line) frequency of 15,625Hz (making 625 lines for each of 25 frames per second) is within 1 part in 10^7 of the nominal fixed ratio of 1:283.75 to the colour sub-carrier frequency, and if so, it switches the programmable divider to divide the master clock frequency by 1135, and to operate in this 'divider-locked' mode, independently of any line sync. pulses. Should the transmitted horizontal frequency deviate from its normal value, this mode can be cancelled in about 80ms, and a digital PLL circuit takes control. This uses the phase comparator block which actually contains two comparators. The first of these measures the phase error between the digitised sync. pulse and the output signal of the programmable divider, and adjusts the division ratio accordingly. Until synchronous operation is re-established, the digital low-pass filter is switched to a wide-band condition to ensure a fast response, and when the PLL is locked, the bandwidth is narrowed to reduce the effect of noise causing phase-jitter. The sync. pulse edges are subjected to an algorithm which increases the resolution of the phase measurement some 9 times. This first PLL however, does not include the Line Output Stage, and so a second PLL is used which achieves phase lock of the flyback pulse

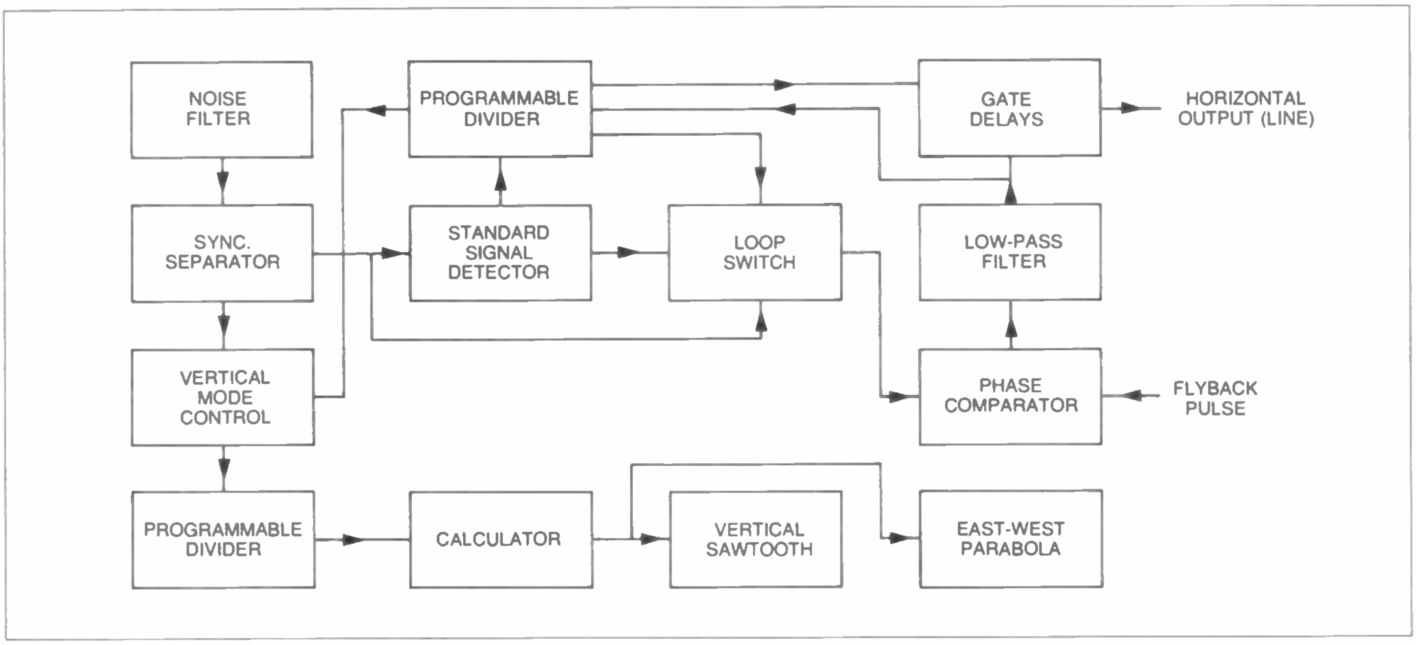


Figure 7. Deflection processor unit

(at the end of each line scan) to the divider output, by controlling the number of gate delays included between the divider output and the output stage drive. This allows fine control of the phase, corresponding to a maximum timing error of 3.5ns, or a picture shift of less than 0.1mm on the largest direct-view displays. This second PLL operates also when the circuit is in the divider-locked mode.

The horizontal drive (line output) circuit includes protection for the output stage in the event of failure of the normal drive pulse during standard switching in multi-standard receivers, or start-up conditions.

The vertical (field) sync. circuit operates in a similar manner. The programmable divider can operate in three modes according to the count ranges within which it can be reset by a sync. pulse. In the wide-range position, field rates of 45 to 55Hz can be accommodated and in the intermediate range division ratios of 618 to 632 are permitted to accommodate video tape recorders. In the 'standard signal' mode, the ratio is fixed at 625 so that the loss of one or more sync. pulses has no effect on the display.

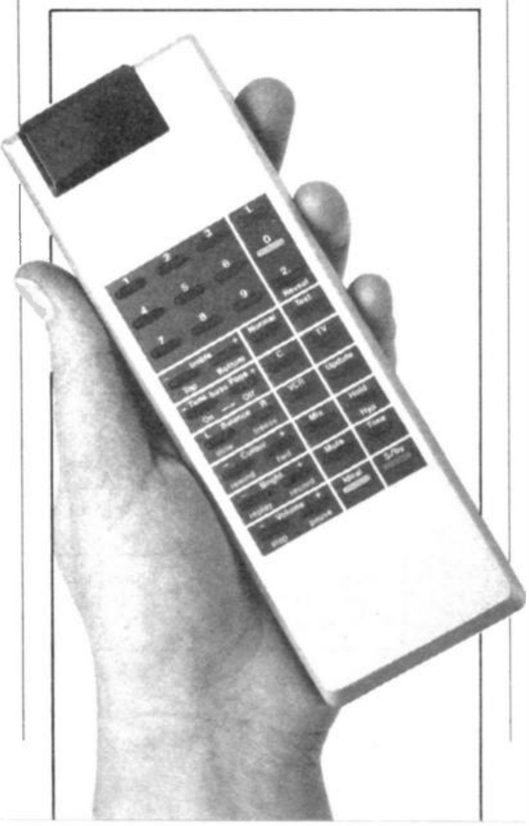
The vertical sync. circuits provide pulse-width modulated outputs for the vertical deflection amplifier and for east-west correction. The precise shapes of the integrated output pulses are derived from alignment data stored in the EAROM associated with the CCU and this data is processed in the calculator section of the DPU.

Master Clock Generator

Curiously, this apparently simple device is alleged to have been rather troublesome. It contains three voltage-controlled crystal oscillators for multi-standard PAL/SECAM/NTSC receivers, the rest of the digital clock PLL being included in the VPU. The early clock requirements were for 2-phase non-overlapping square pulses but the production series uses a single sinusoidal clock signal, thus preventing interference with signal reception, due to the clock's fast rising and falling edges, at harmonics of the clock frequency. This has resulted in the need for this device to wear a heat sink and it is still necessary for the digital processing module to be heavily screened (by consumer products standards, that is!).

Other Proposed Digital Devices

Naturally, information on developments in this field is difficult to obtain until devices are launched and in some cases not even then because some devices have proved less than satisfactory and have been redesigned after launch.



◀ **Remote Controller for the D1000**

Motorola have given details of a nine-piece chip-set known as 'System 4' and further devices in this system are under development. While the majority of these devices use analogue techniques, digital techniques are used for deflection waveform generation and for the luminance delay-time. There is also a CCU (based on the 6800 microprocessor), tuner local-oscillator, pre-scaler and EAROM combination, which is superficially similar to the ITT trio. Two analogue audio devices are available, one giving full stereo facilities and the other a (relatively) low-cost monophonic device. The infra-red transmitter and receiver chips form a powerful combination, offering eight 'pages' of 64 control keys and the receiver uses switch-capacitor techniques to eliminate discrete tuned circuits and screening.

SGS-ATES have announced a sync. separator and deflection processor which automatically switches between 625/50 and 525/60 (line/field) standards and even has a feature which allows a weak-signal picture to roll vertically instead of 'jumping'. Further devices include a CCU with on-chip non-volatile memory and remote-control receiver, a local-oscillator pre-scaler and numerous solutions for remote-control and tuner frequency control.

In Japan, considerable interest has been shown in the ITT chip-set, and Mitsubishi and Sony have shown receivers with more features than the ITT set but at a considerably elevated price-prediction for their home-market. Many Japanese manufacturers have received pilot production quantities of chip-sets, but Hitachi in particular have remained aloof, possibly because there is an entirely different solution soon to be announced.

It should be realised that many of the devices described in this article are mask-programmable to individual receiver manufacturers' requirements, and are therefore, not likely ever to become available in small quantities for private experimental purposes. However, some of the tuner control devices could be marketed generally, and could be used for VCO's covering several frequency ranges. Some of the remote-control devices also, could be useful in various applications other than television receivers.

Digital Audio Signal Processing

Figure 8 shows the ITT method of analogue-to-digital conversion used for the audio signal which avoids the necessity for complex anti-aliasing filters. The audio signals from the sound detector, or from an external source, are applied to a delta-modulator with a 4.4MHz clock frequency. This device also contains circuits which operate on external analogue signals only, for detecting identification signals, and for dematrixing stereo signals for the German stereophonic or bilingual television system.

Figure 9 shows the digital audio processor, in which the first process is to convert the delta-modulated data streams into parallel 16-bit signals at a data-rate of about 35kHz. This is carried out by a sequence of transversal and recursive low-pass filters. Dematrixing of stereo and bilingual signals follows, and then there are digital de-emphasis filters. Following these are the tone, volume, stereo base-width and simulated stereo circuits. These functions are carried out digitally, and the algorithms involve about 100 combined multiplication and adding processes in one 28 microsecond sampling period, i.e. a cycle time of 280ns which is really quite fast. Special provisions are included to mute the sound channels on switch-on until all 14 coefficient values have been loaded into the audio processor RAM from the CCU because many of them are under user control. This takes about 0.5s, rather less time than required to display a synchronised raster.

The outputs of the processor for the left and right audio channels are in the form of pulse-width modulated signals which can drive Class-D (digital) audio output stages directly, or can easily be filtered for connection to normal Class-AB amplifiers. The PWM carrier is at 554kHz, and an overall signal-to-noise ratio exceeding 70dB is achieved.

It will be noted that the techniques used in these devices are very complex, and the high speed of the processor is likely to involve a cost. The question thus arises whether it is justified to digitise the audio part of the receiver. But it must be borne in mind that there is a dramatic reduction in component count, consequent on the elimination of the analogue stereo decoder, which, for the German system, has not yet benefitted from the component economy brought to sound radio decoders by the first PLL devices such as the 1310. Unfortunately, this is of little consequence in the UK because we have no stereophonic television broadcasting, and it looks a long way off, like 36,000km, at present!

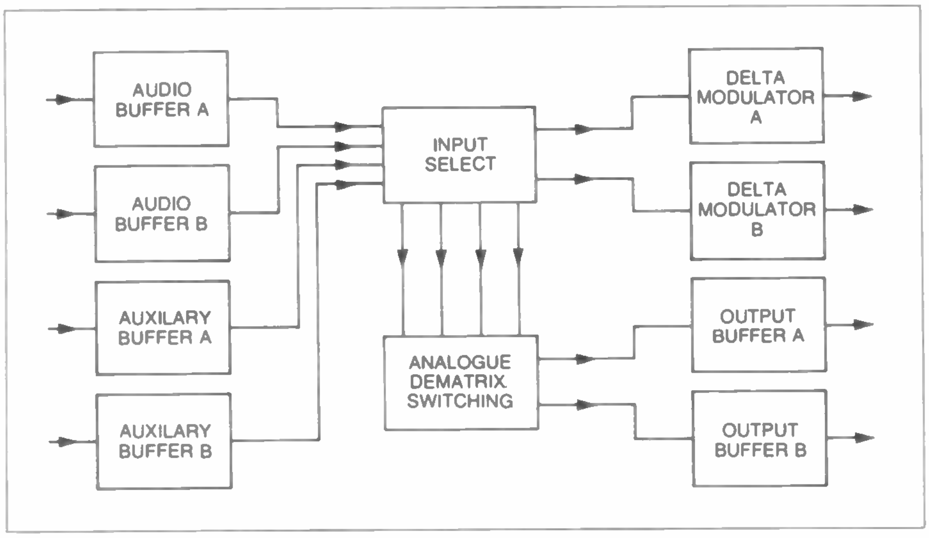


Figure 8. Digital coding of audio

The 'One-Chip' Teletext decoder

Figure 10 shows the basic elements of the new text decoder. This will cope with both European and US text standards, and has enough characters in the character generator ROM to display all the standard European Latin alphabets, selection of which may be by local (CCU) or transmitter control (alphabet selection code may be included in row 0 of each page). The device can support up to 64K-bits of external RAM for page storage.

The first stage of the decoder is data acquisition using the 7-bit Gray encoded video signal from the VCU. An adaptive recursive filter provides 'ghost' (image shadow effect, most often caused by a reflected UHF carrier arriving at the aerial slightly later than the signal proper) compensation, for delays up to 0.8 microseconds. Text transmissions are particularly sensitive to 'ghosts' in this delay range, and the path-difference

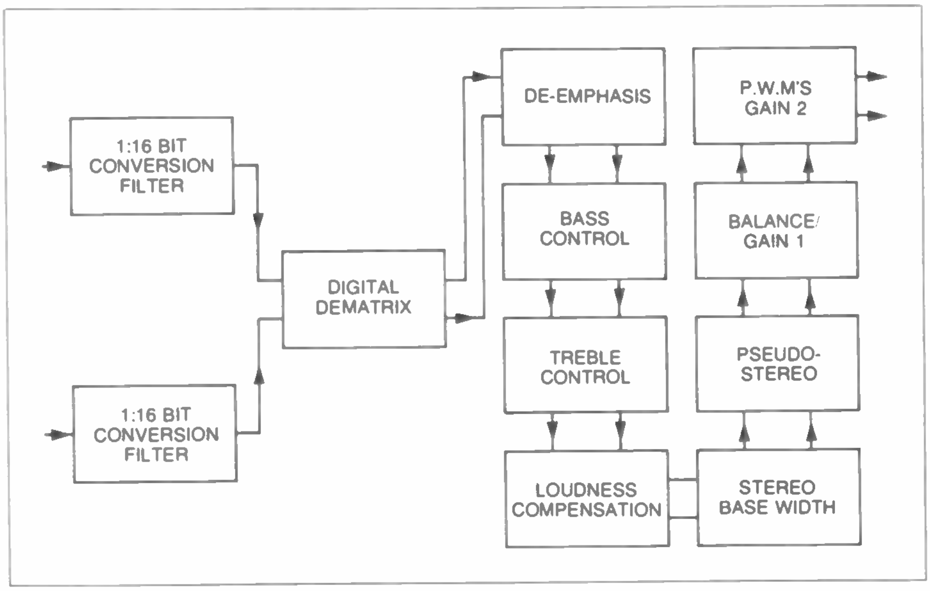


Figure 9. Digital audio processing

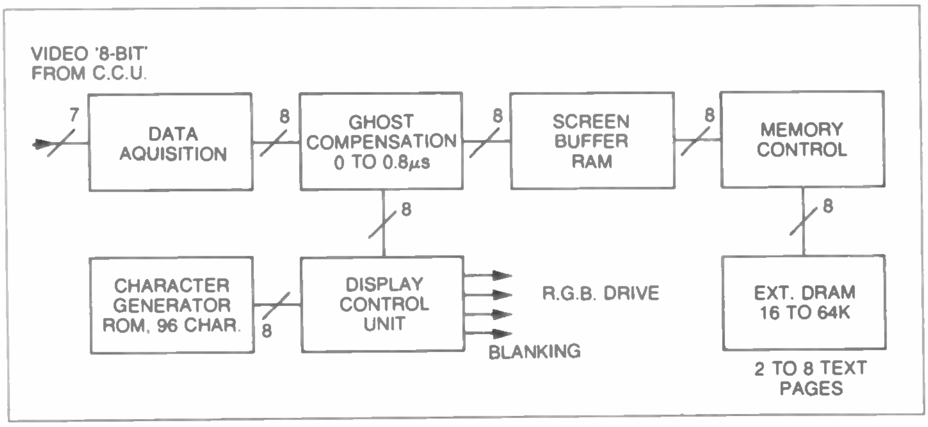


Figure 10. Digital Teletext decoder

(relationship of direct carrier to reflected carrier) of up to 800 feet is characteristic of fairly strong 'ghosts'. Pages selected by the user through the CCU are loaded into the buffer RAM which eliminates speed problems of the external RAM. The display control unit selects the required page for display, and translates the 8-bit data into 6 x 10 dot-matrix characters retrieved from the character generator ROM.

Coping with New Transmission Standards

Figure 11 is a list of some of the recent proposals for improved transmission standards for television, some of which are very expensive in spectrum space. The present ITT chip-set is designed to handle existing terrestrial standards, including SECAM, and is capable of producing enhanced displays but it is not designed to handle MAC or other time-compressed encoding. The development of these systems took place at the same time as the development of the present chips, and to attempt to include provision for undefined systems of novel architecture is usually an insurance against timely success.

C-MAC	625 lines, 50Hz field, 2:1 interlace, time multiplexed colour and luminance, up to 6 sound or data channels
NHK-HDTV	1125 lines, 60Hz field, 2:1 interlace, 5:3 aspect ratio, bandwidth compressed, 2 sound channels
Ext.MAC	625 lines, 50Hz field, non-interlaced display, 5:3 aspect ratio, compatible with 4:3 receivers, 11MHz bandwidth, 2 sound channels

Figure 11. Proposals for new television standards.

However, by avoiding, as a short-term measure, conversion of the signal to digital form, Philips and others have been able to propose MAC-compatible devices although these do not include MAC decoders which are not in mass production yet and of course, ITT's programme of research continues, hopefully with valuable feedback from set-makers and end-users. An example of this is the need to cope with the ultrasonic supervisory tones which the broadcasters in Britain add to the audio signals to control and monitor relay stations.

Benefits of Digital Receivers

Figure 12 lists the benefits to be expected from the digital receiver, without taking time-scale into account. The concept of a 'local' display standard has already been discussed, as have the new facilities. Greater reliability is a feature that must be put into proper context. The average service call-rate for receivers made in 1982, the latest year for which figures are available, is of the order of 0.4 per year and the digital receiver is expected to reduce this to 0.2 calls per year, or one call in five years. This is hardly to be considered a great advantage in practice, although a considerable technical achievement. However, there are other considerations. The worst-case receiver is likely to be much more reliable because more tests can be done in the available test-time, thus disclosing potential faults that may not otherwise be perceptible in normal operation, and the slow deviation from correct performance – short of failure as perceived by the users – but which is often all too evident to visitors, is virtually eliminated by the automatic correction facilities available with the present chip-set.

For Users:

- ★ Display standard independent of transmission
- ★ New facilities:-
  - Picture-in-picture
  - Multiple pictures
  - Strobe pictures
  - Noise and ghost suppression
- ★ Greater reliability, stability
- ★ Decreasing cost

For Manufacturers:

- ★ More predictable performance
- ★ Product diversity through software
- ★ Lower component count
- ★ Faster testing

Figure 12. Benefits of digital receivers.

Servicing the Digital Receiver

Detailed diagnosis and repair of the digital circuits in the field is not practicable, but can be carried out by manufacturers and large service organisations such as Mastercare and Telebank. Replacement of major components in the deflection and tube drive circuits, or of the display tube itself, however, are feasible in the field, and require new data to be entered into the EAROM servicing the CCU. For current receivers, this requires the use of a service computer or 'Electronic Screwdriver', but it is conceivable that the technique used in the Salora receivers, where the remote-control transmitter can be used to enter data that is normally regarded as factory-preset, may be extended in the future.

ITT 'Electronic Screwdriver'

Commercial, Management and Engineering Considerations

It is now time to examine the market which the digital receiver is entering. The evolution of the colour television receiver to date can be described by the tale of woe in Figure 13. The consequences of these facts are given in Figure 14.

1. Market price of colour receivers has hardly changed since introduction, despite considerable inflation
2. Production time has reduced from over 10 hours to less than 2 hours, already
3. There has been virtually no demand for product diversity

Figure 13. Commercial and management problems.

Because there is no demand for it, there is practically no product diversity (i.e, all television sets are much the same, irrespective of brand-name and advertising claims). This is particularly true in the UK, where the prominance of receiver rental has led to the major demand being for the television equivalent of the Ford Popular, that is cheap, reliable and with no special features because they might become out of date. Consequently, retailers have nothing on which to hang a sales-pitch, except price. This situation leads directly to the growth of large retail chains who can dominate the market, exclude smaller traders (witness the recent swallowing of 'big-fish' Currys by even-bigger-fish Dixons, and Comet's absorbtion by Woolworth) and squeeze manufacturing profit margins. The manufacturers are forced to concentrate on volume production to remain profitable, and thus cannot afford to lose market share which makes them even more vulnerable to price-squeeze. The indications are that end-users are now conditioned to low prices, which are no longer so much of an incentive, and are retaining their present receivers even if they could well afford to replace them, as many cannot, of course. The service life of these receivers is probably of the order of 10 years and practically all receiver sales are for replacement, with the exception of small-screen receivers on which manufacturing margins have been squeezed to vanishing point, because of the dire penalties of volume shortfall. Nevertheless, the market this year will dispose of some 3 million sets. Had there been no video recorders to sustain the market over the last few years, the situation would have been much worse. As it is, Philips and others have lost a great deal of money in the tape format battle and even Sony have not emerged unscathed partly because of the success in the low-price VCR market of their licensee, Sanyo. The format battle was quite unnecessary and the emergence of the new Philips VHS machines from Krefeld and Vienna will underline what could have been achieved several years earlier by enlightened co-operation on software compatibility with competition in the market-place between actual products.

The digital receiver thus enters a market which is not in a healthy state, particularly for the manufacturers and small retailers. It might be considered that the much-publicised cable and satellite television developments could provide some sort of life-line for the industry, but recent developments have shown that the capital investment requirements and long payback period for cable have discouraged some of the most experienced operators in the field, and the involvement of commercial television companies in satellite television inevitably gives rise to chicken-and-egg questions of truly astronomical dimensions, along the lines of 'few receivers in the field, so few viewers for the programmes, so small advertising fees, so few programmes, so little demand for receivers, so few low-cost receivers, so few receivers in the field, etc etc.'

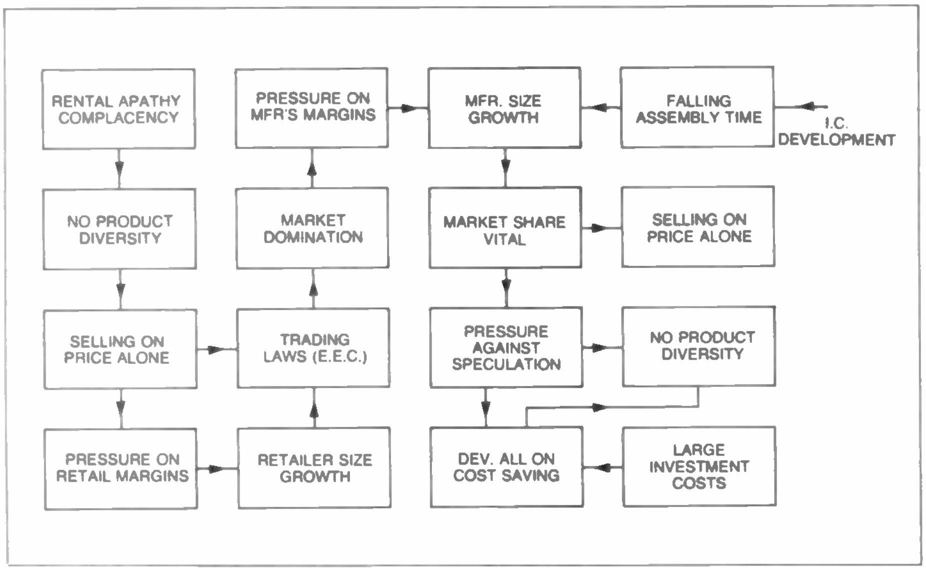


Figure 14. Impact of industry problems

That, luckily, is the negative side. The digital receiver itself, (not necessarily the ITT solution) may provide just the lifeline that the industry so urgently needs. For the first time, product diversity can be achieved, not in hardware but in software. Furthermore, the features offered by digital television are very likely indeed to be attractive to the general public, and to induce a new surge of receiver purchase in the next few years.

Summary and Conclusions

We have seen in some detail, the way in which the problems of digitising part of the television receiver have been solved in the first production devices, and how some other solutions are evolving.

The market into which the new receivers have to carve a niche for themselves is in a very poor state, but the solution may lie with the new designs. Only time will tell . . . as ever!

Basic Colour TV Principles

Figure A shows the three different signals produced by the (a) Green, (b) Red and (c) Blue guns of a colour TV camera if it were observing the colour bar test card as painted on a board. The three signals are mixed in proportions G = 0·59, R = 0·3, B = 0·11 (= 1), producing the monochrome or Black-and-White equivalent at (d), the Y signal, which is exactly what the single output from a Black-and-White TV camera would be, and which is known as the 'Grey Scale'. This is transmitted direct.

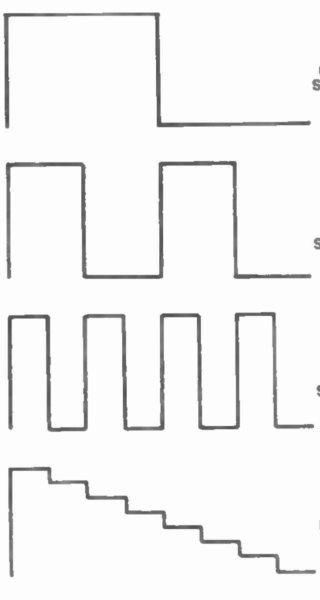


Figure A. The Three Colour Signals

Because Red = 0·3 + Blue = 0·11 = 0·59 = Green, only the R − Y and B − Y signals are quadrature modulated on a suppressed 4·433619 MHz subcarrier, with the B − Y lagging in phase by 90° with the R − Y, so that the two can be identified and isolated in the receiver. Positive values of R − Y = Red, positive values of B − Y = Blue, and negative values of both = Green. Okay so far?

Figure B shows the composite CVBS (Colour, Video, Blanking and Sync) signal as it leaves the transmitter. The numbers indicate the amplitude modulation level of the UHF carrier in %. Note that 'negative' amplitude modulation is used, and that the 'white level' corresponds to 20% and the 'black level' 76% of this. This ensures that in the event that a blank or 'black' picture is transmitted the carrier signal strength is 76% thus ensuring the exclusion of irritating background 'noise'. The basic Y Grey Scale can be seen carrying the phase encoded chrominance signals shown 'blocked in' as Y (yellow), Cy (cyan), G (green), M (magenta), R (red), B (blue). These require that the receiver must have a special decoder phase locked to the chrominance sub-carrier frequency. Because the chrominance subcarrier is suppressed, a 'pilot tone' has to be included for a phase locked loop, crystal controlled, subcarrier regenerator. Each line sync. pulse, A, of 4·7 ±0·1 μS duration, is followed by the 'Back Porch', a period between the end of the sync. pulse and the start of the 'proper' picture signal. This 'Back Porch' contains the 'Colour Burst', B, comprising 10 cycles of sine wave at 4·433619 MHz for a period of 2·5μS starting 5·6 ±0·1μS after the start of the line sync. pulse.

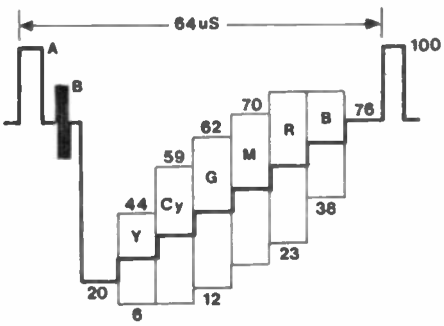


Figure B. Composite CVBS Signal for One Single Line of a Colour Bar Test Card

If you have managed to read this far, it must be mentioned that the above is the basis of the American NTSC system. The trouble with phase encoded signals is that a non-linear signal delay between transmitter and receiver can cause lag related phase errors in the chrominance signal, resulting in wrong colours being displayed. American TV's include a manual control to counter the effect, but in Europe error adjustment is automatic with the PAL (Phase Alternation, Line) system. The phase of the 'Colour Burst' swings ±45° on alternate lines, such that a phase error on odd lines, resulting in a colour change, is counteracted by an equal and opposite error on even lines, visual integration combines the two colour errors to the correct hue.

It can be seen from the signal waveforms in Figure A that the colour bar/grey scale test card can easily be electronically generated – which, of course, it is.

ZERO 2 INS AND OUTS

Interfacing to the Spectrum, Commodore C64 and BBC-B.

by Dave Goodman

Zero 2 needs two supply rails, +5V DC for TTL Logic and +9 to 15V DC for the three stepper motors. Figure 1 shows details of a regulator circuit and RS232 (or 423) connections. An unregulated DC power supply such as the ZX81 PSU can be used to drive both Zero 2 and regulator circuit or a suitable 9V @ 1.4A supply is available from Maplin (see Parts List).

Serial data protocol is established as an 8-bit word with 2 STOP bits and NO PARITY over an RS232 data link. The Spectrum INTERFACE 1 is capable of driving the robot to this requirement as is the BBC model B, although an RS423 (+/−5V) system is used here. Commodore users will need an additional RS232 interface module, as only serial TTL levels are available on this machine, and the Maplin unit functions well with this system. Whatever type of machine is used to control Zero 2, a data transfer rate of 4800 BAUD should be used at RS232 (423) levels.

For constructors who do not have INTERFACE 1 on their Spectrum, the Maplin RS232 module can be used with a few changes. The EPROM routines will not operate Zero 2 so do not use it. Insert link C for a clock frequency of 76.8kHz (Figure 3b) and type in the test program.

Test Program 1.
Commodore 64 and Maplin Kit (LK11M)

```
10      F$ = CHR$(128) + CHR$(0)
        + CHR$ (0) + CHR$ (0)
20      OPEN 200, 2, 0, F$
30      FOR I = 1 TO 4 : READ D
40      PRINT #200, CHR$(D);
50      NEXT I
60      RESTORE : GOTO 30
1000    DATA (See Data List)
```

Test Program 2.
BBC model B

```
10      * FX8,6
20      * FX3,7
30      FOR I = 1 TO 4 : READ D
40      VDUD
50      FOR T = 1 TO 10 : NEXT T
60      NEXT I
70      RESTORE : GOTO 30
1000    DATA (See Data List)
```

Test Program 3.
Spectrum and Interface 1

```
10      OPEN #5;"b"
20      FORMAT "b";4800
30      FOR I = 1 TO 4 : READ D
40      PRINT #5;CHR$(D);
50      NEXT I
60      RESTORE : GOTO 30
1000    DATA (See Data List)
```

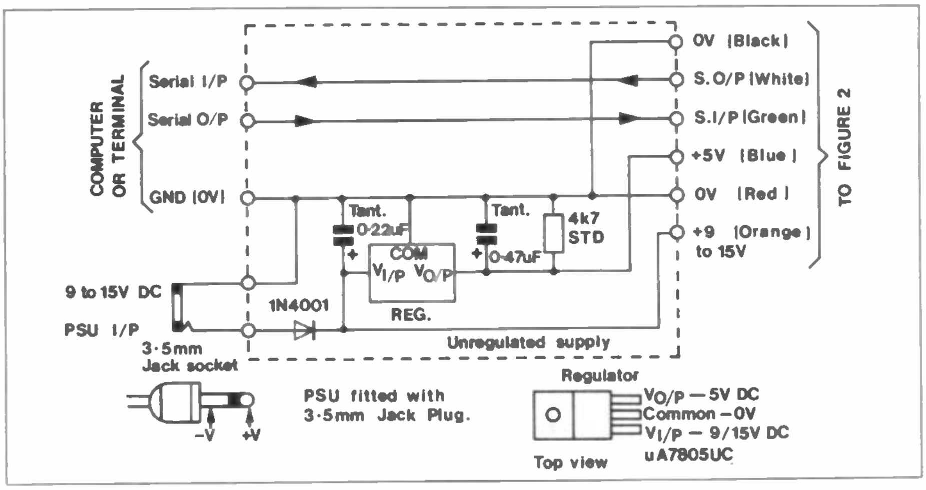


Figure 1. PSU – I/O Interface.

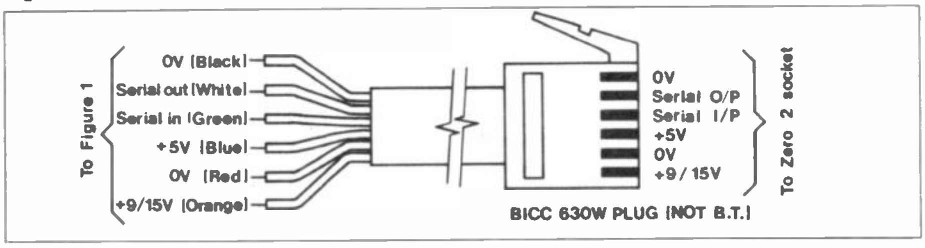


Figure 2. Umbilical Connector.

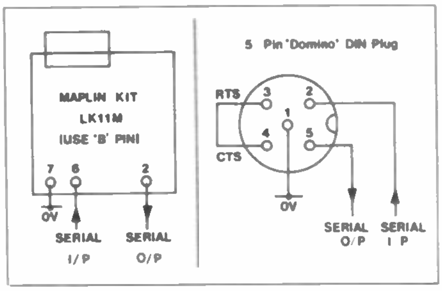


Figure 4. Commodore 64 connection via Maplin RS232 Kit.
Figure 5. BBC model B connections.

Test Program 4.
Spectrum and Maplin Kit (LK21X)

```
10      POKE 15612,3
20      POKE 15612,21
30      FOR I = 1 TO 4 : READ D
40      POKE 15614,D
50      NEXT I
60      RESTORE : GOTO 30
1000    DATA (See Data List)
```

Table 1.
Data List

Operation	Code(s)
Forward	5,0,10,15
Backward	15,10,0,5
Right Turn	7,2,8,13
Left Turn	13,8,2,7
Pen Up	17,16,18,19
Pen Down	19,18,16,17
Red LED	34
Green LED	33
Off	32
Horn Low	36
Horn High	40

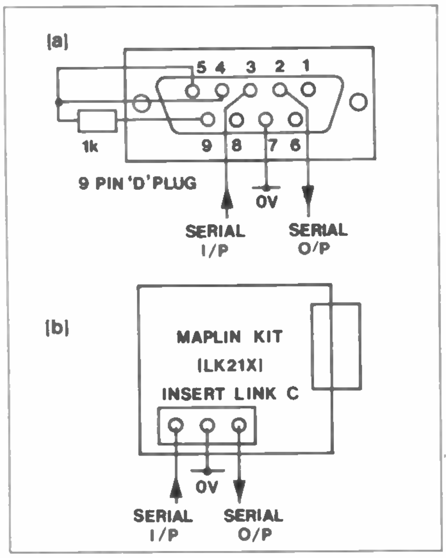


Figure 3. Spectrum Connections:
(a) Interface 1, (b) Maplin RS232 Kit.

ZERO 2 INTERFACE PARTS LIST

1k 1% Metal Film Resistor	(M1K)
4k7 Standard Carbon Resistor	(S4K7)
220nF Tantalum Capacitor	(WW56L)
470nF Tantalum Capacitor	(WW58N)
1N4001 Rectifier	(QL73Q)
µA7805UC Regulator	(QL31J)
Jack Socket 3·5mm	(HF82D)
9-pin 'D' Plug	(RK60Q)
5-pin 'Domino' DIN Plug	(RK64U)
Spectrum RS232 Kit	(LK21X)
Commodore RS232 Kit	(LK11M)
9V PSU	(YJ64U)
Zero 2 Kit	(LK66W)

SHARP MZ-80K SERIAL INTERFACE

By Dr. M.S. Girgis

The ZX81 Serial Interface finds a new lease of life for Sharp MZ-80K owners and with a few modifications, this project can be made to function with the MZ-80 I/O extension system. A kit of parts is available, containing a new translator ROM, but minus the original 5V regulator, heatsink and fixing screw and nut, and D1, which are no longer required.

Connection to the Sharp I/O expansion system is made via a 2 x 30 way connector, this being hard wired to the serial interface edge 'fingers'. Unfortunately, this connector is not available from Maplin, but details of how to make your own have been added at the end of this article.

Circuit Description

This is a modification of the ZX81 Interface article that was published in issue 7 of 'Electronics', and only the modifications needed and the software will be explained.

The original circuit used memory mapped I/O but it is a lot easier with the Sharp to use the Z-80 I/O ports (there are plenty of spare addresses) as all the necessary signals are available. A base address D0 Hex is chosen as it is not used for any of Sharps peripherals, so the next modification is to decode this by altering IC1 and IC2 bus connections. Figure 1 shows the modified section of the ZX81 serial interface circuit.

Construction

Follow the same construction guidelines given in the original article (See Electronics Magazine issue 7; or Project Book 7), to build the ZX81 board, but remember to to omit REG1 and D1, also note the value of R1 is now 390Ω. Figure 2 shows the edge connector on the ZX81 board, and designates which edge 'fingers' are needed for connection to the Sharp. Also note the additional links required across the edge 'fingers', across pins 1 and 2, and across the regulator holes.

Testing

To test any card inside the Sharp I/O box is not easy. Either you make yourself an extender card, buy one, or use the top slot of the box after removing the box cover. The latter is easy to do, and gives good access to the component side of the board under development. To do this, disconnect mains and any inter-connecting cables to or from the box. Invert the box and undo the five small screws holding the sides and top to the bottom of the box, and slide the one part cover backwards until free. Reconnect all cables and you are ready now to test. A word of warning; the power supply in the back of the box is connected to the mains on the primary side; it is well out of the way but be careful!

To test the board, do not insert any IC's, plug the card in the top slot, turn the I/O box on and test for 5 volts at pin 14 of IC's 1, 2, 5, pin 26 of IC3, and pins 21 and 24 of IC4, and finally pin 1 of IC6 and pin 8 of IC7. Turn I/O box off, remove board. Next, set switches 1, 2, 3, 5 to open and 4, 6 to closed (switch significance the same as for ZX81). This gives 7 bit word, 2 stop bits and no parity. Set switches 7 and 8 to NORM. Set RV1 wiper with its centre pointing to the arrow legend on the PCB. Now insert IC's noting correct orientation. Plug card into I/O box. Switch on. As normal, you should get MONITOR SP-1002. If this does not happen switch off immediately, take board out and check it again. If you have access to an oscilloscope or frequency counter, check for 4.8KHz on pins 17 and 40 of IC6 and adjust RV1 to suit.

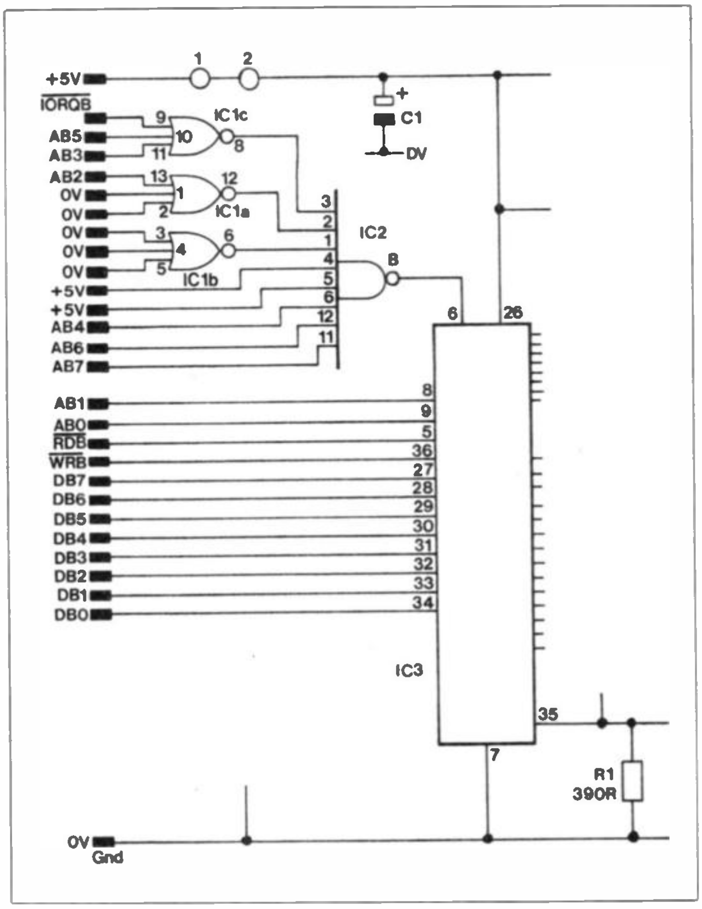


Figure 1. Modified part of ZX81 Circuit Diagram.

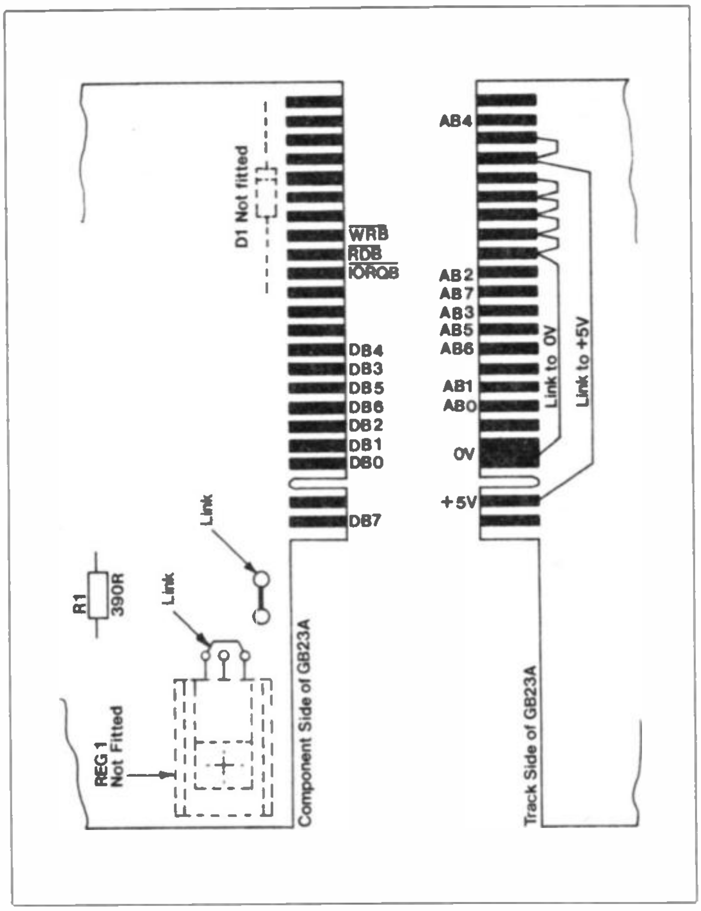


Figure 2. Connection details of ZX81 board.

Now load your BASIC as usual from tape or disk. Type and run Test Program 1. This will test all port locations along with EPROM addresses 0 to 511. The display data printed in Decimal and Hexadecimal shows ASCII and SHARP ASCII codes stored in IC4. If your test program stops or fails before printing address 511, make sure that you entered the test program correctly. If you still have problems, you will have to test the PIO (8255) by initialising as in lines 60 and 70 of Test Program 1, and outputting data to port A and reading port B to get an indication of the failure.

Next, make a temporary link between pins 3 and 6 (I/P and O/P). Type and run Test Program 2. When you make a keyboard entry, data will be transmitted and received then printed on the screen, proving the interface is working correctly. Because you will not be able to test for lower case characters from keyboard with BASIC by simply trying to toggle in the usual way, as this will return the ASCII values of keys pressed instead, Test Program 3 will print the whole ASCII set. Sharp graphics are still retained and can be used but only if you set the length of the word to 8 bits by opening switches 7 and 8. This is useful when interchanging data or programs with another Sharp MZ–80K. When using a 7 bit word as is usual, you will find that hitting a graphic key will either type an alphanumeric character in upper or lower case, or simulate the effect of a control character. This is because all graphics have their 8th bit set to 1. When this is removed by using 7 bits only, you are left with an ASCII code (0-127 Decimal).

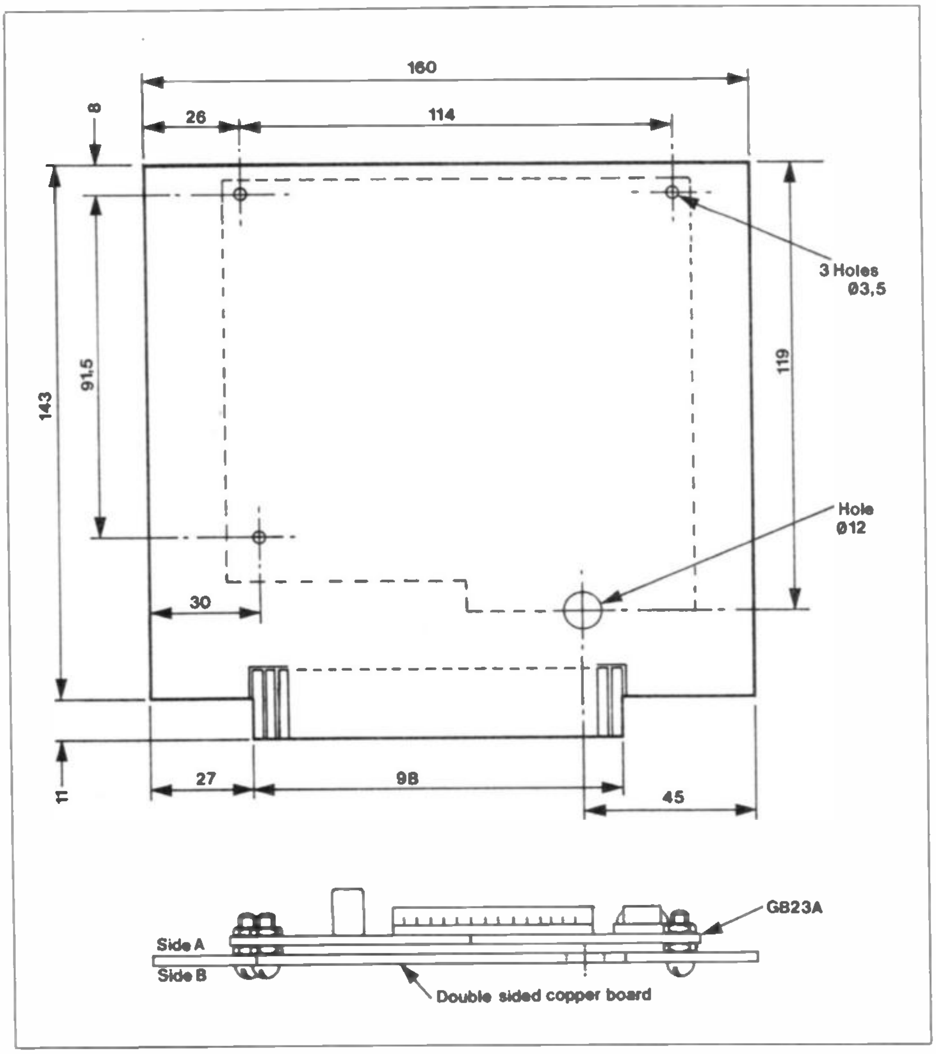


Figure 3. Suggested I/O connector.

Test Program 1

```
10 REM TEST PROGRAM 1
20 REM FOR MODEM INTERFACE
30 PRINT TAB(6);"RECEIVE CODES"
40 T=0
50 H$="0123456789ABCDEF"
60 OUT@211,130:REM CONTROL WORD'130'OUT T PIO CONTROL REGISTER '211' D3 HEX
70 OUT@210,13:REM CONTROL WORD TO UART'13'VIA PORT C LOWER'210' D2 HEX
80 PRINT "ADDRESS     DEC     HEX"
90 FOR I=0 TO 255
100 OUT@208,I:REM LOCATION ADDRESS OF IC4 'I' OUT  VIA PORT A'208'D0 HEX
110 INP@209,P:REM READ CONTENTS OF ADDRESS IN IC4'P' FROM PORT B'208'D1 HEX
120 PRINT ;I+T;"        ";P;"      ";
130 PRINT MID$(H$,1+INT(P/16),1);MID$(H$,1+P-(16*INT(P/16)),1)
140 NEXT I
150 IF T=256 THEN STOP
160 PRINT TAB(6);"TRANSMIT CODES"
170 T=256
180 OUT@210,9:REM CONTROL WORD TO UART
190 GOTO80
200 REM PLEASE NOTE THAT CONTROL CODE TO UART ALSO ENABLES OR DISABLES A8 IC4
```

Test Program 2

```
5 REM TEST PROGRAM 2 FOR SERIAL BOARD
10 CW=211:REM CONTROL REGISTER OF PIO
15 C=210 :REM PORT C
20 B=209 :REM PORT B
25 A=208 :REM PORT A
30 OUT@CW,130:REM 130 IS CONTROL WORD
40 GET N$:IF N$=""THEN40
41 N=ASC(N$)
42 PRINTN;"=";N$;
45 OUT@C,15
50 OUT@A,N
55 OUT@C,9
60 OUT@C,1
65 OUT@C,15
70 INP@C,F:IF F<128 THEN 70
75 OUT@C,14
77 INP@B,J
80 OUT@A,J
85 OUT@C,12
90 INP@B,G
95 PRINTG;"=";CHR$(G),
100 GOTO40
```

Test Program 3

```
10 REM TEST PROGRAM 3 FOR SERIAL BOARD
15 REM IMPORTANT FOR THIS TEST YOU MUST
USE 8 BIT WORD i.e switches 3&4 OPEN
20 CW=211
30 C=210
40 B=209
50 A=208
60 OUT@CW,130
70 FOR N=0 TO 255
80 N$=CHR$(N)
90 PRINT N;"=";N$;
100 OUT@C,15
110 OUT@A,N
120 OUT@C,9
130 OUT@C,1
140 OUT@C,15
150 INP@C,F:IF F<128 THEN150
160 OUT@C,14
170 INP@B,J
180 OUT@A,J
190 OUT@C,12
200 INP@B,G
210 PRINT G;"=";CHR$(G),
220 NEXT
```

Main Program

```
                             ORG   05000H
                             LOAD  05000H
                ;MODEM PROGRAM FOR
                ;SHARP MZ80-K BY
                ;DR.M.S.GIRGIS
                ;PORT ADDRESSES OF 8255
                PRTA:        EQU   0D0H          ;PORT A
                PRTB:        EQU   0D1H
                PRTC:        EQU   0D2H
                CNTR:        EQU   0D3H          ;CONTROL REGISTER
                ;CONTROL WORDS
                CNRWD:       EQU   8AH           ;TO SET MODE OF 8255
                RWD1:        EQU   0EH           ;RECEIVE WORD 1
                RWD2:        EQU   0DH           ;RECEIVE WORD2
                TWD1:        EQU   09H           ;TRANSMIT WORD 1
                TWD2:        EQU   01H           ;TRANSMIT WORD 2
                ;MONITOR EQUATES
                CR:          EQU   0DH           ;CARRIAGE RETURN
                MSG:         EQU   15H           ;MESSAGE
                PRNT:        EQU   0012H         ;PRINT ON SCREEN
                CASEFLAG:    EQU   1170H         ;UPPER LOWERCASE
                ?ADCN:       EQU   0BB9H         ;ASCII DISPLAY CONV
                GETKEY:      EQU   001BH         ;ONE KEY ENTRY
                LTNL:        EQU   06H           ;START NEW LINE
                BEEP:        EQU   02E5H
5000 C33450     ENTRY:       JP    RENTRY
                ;ANNOUNCE PROGRAM
5003 4D4F4445   M1:          DB    'MODEM PROGRAM',
5007 4D205052
500B 4F475241
500F 4D
5010 20464F52                DB    ' FOR SHARP',
5014 20534841
5018 5250
501A 204D5A38                DB    ' MZ80-K',
501E 302D4B
5021 20425920                DB    ' BY DR.M.S.',
5025 44522E4D
5029 2E532E
502C 47495247                DB    'GIRGIS ',CR
5030 4953200D
                ;
5034 3E16       RENTRY:      LD    A,16H         ;CLEAR SCREEN
5036 CD1200                  CALL  PRNT
5039 CD0600                  CALL  LTNL
503C 110350                  LD    DE,M1         ;PRINT MESSAGE
503F CD1500                  CALL  MSG
5042 CD0600                  CALL  LTNL
5045 CD0600                  CALL  LTNL
5048 CDE502                  CALL  BEEP
504B CDE502                  CALL  BEEP
504E 3E8A       MAIN:        LD    A,CNRWD
5050 D3D3                    OUT   (CNTR),A      ;SET 8255 MODE
5052 CD1B00     LOOP:        CALL  GETKEY        ;ANY KEY PRESSED?
5055 FE00                    CP    00H           ;NO
5057 CA5D50                  JP    Z,RECEIVE     ;THEN CALL RECEIVE
505A C29D50                  JP    NZ,TRANSMIT   ;YES THEN TRANSMIT
505D 3E0E       RECEIVE:     LD    A,RWD1        ;READ WORD 1
505F D3D2                    OUT   (PRTC),A      ;SET UART&EPROM
5061 DBD2                    IN    A,(PRTC)      ;READ PORTC UPPER

                ;TO READ STATUS
5063 CB7F                    BIT   7,A           ;TEST BIT 7
5065 CA5250                  JP    Z,LOOP        ;LOOP
5068 DBD1                    IN    A,(PRTB)      ;RECEIVE CHARACTER
506A 47                      LD    B,A           ;STORE IT IN B
                ;TO ENABLE EPROM
506B 3E0D                    LD    A,RWD2        ;READ WORD 2
506D D3D2                    OUT   (PRTC),A      ;OUT PORTC LOWER
506F 78                      LD    A,B           ;CHARACTER BACK IN A
5070 D3D0                    OUT   (PRTA),A      ;OUT TO EPROM
5072 DBD1                    IN    A,(PRTB)      ;TRANSLATED NOW
                ;IN AGAIN VIA PORT B
5074 FE11                    CP    11H           ;SEE IF CONTROL
5076 CCF650                  CALL  Z,CONTROL     ;CHARACTER
5079 FE12                    CP    12H
507B CCF650                  CALL  Z,CONTROL
507E FE13                    CP    13H
5080 CCF650                  CALL  Z,CONTROL
5083 FE14                    CP    14H
5085 CCF650                  CALL  Z,CONTROL
5088 FE15                    CP    15H
508A CCF650                  CALL  Z,CONTROL
508D FE16                    CP    16H
508F CCF650                  CALL  Z,CONTROL
5092 47                      LD    B,A           ;NOT CONTROL CHAR
5093 CD1200                  CALL  PRNT          ;STORE&PRINT
5096 78                      LD    A,B
5097 CD0E51                  CALL  PRINTIT
509A C35250                  JP    LOOP
509D 47         TRANSMIT:    LD    B,A           ;STORE IN B
509E CDDA50                  CALL  DELAY         ;KEY DEBOUNCE
50A1 FE70                    CP    70H
50A3 CAF950                  JP    Z,PTRON
50A6 FE66                    CP    66H
50A8 CCF050                  CALL  Z,CHANGE
50AB FE60                    CP    60H
50AD CCF350                  CALL  Z,CNG2
50B0 FE64                    CP    64H           ;IS IT SH&BREAK
50B2 CA0012                  JP    Z,1200H       ;JUMP TO 1200H
50B5 FE62                    CP    62H
50B7 282A                    JR    Z,UPPER
50B9 FE63                    CP    63H
50BB 282C                    JR    Z,LOWER
50BD FE16                    CP    16H
50BF CC1200                  CALL  Z,PRNT
                ;
50C2 DBD2       CHECK:       IN    A,(PRTC)      ;READ STATUS
50C4 CB77                    BIT   6,A           ;CHECK BIT 6
50C6 28FA                    JR    Z,CHECK
50C8 3E09                    LD    A,TWD1        ;TRANSMIT WORD1
50CA D3D2                    OUT   (PRTC),A
50CC 78                      LD    A,B
50CD D3D0                    OUT   (PRTA),A      ;TRANSLATE
50CF 3E01                    LD    A,TWD2
50D1 D3D2                    OUT   (PRTC),A
50D3 3E09                    LD    A,TWD1
                ;
50D5 D3D2                    OUT   (PRTC),A
50D7 C35250                  JP    LOOP
50DA F5         DELAY:       PUSH  AF            ;KEY DEBOUNCE

50DB CD1B00     DELAY1:      CALL  GETKEY
50DE B7                      OR    A
50DF 20FA                    JR    NZ,DELAY1
50E1 F1                      POP   AF
50E2 C9                      RET
                ;
                ;
50E3 AF         UPPER:       XOR   A             ;UPPER CASE
50E4 327011                  LD    (CASEFLAG),A
50E7 18D9                    JR    CHECK
50E9 3E01       LOWER:       LD    A,01H         ;LOWERCASE
50EB 327011                  LD    (CASEFLAG),A
50EE 18D2                    JR    CHECK
50F0 060D       CHANGE:      LD    B,0DH         ;CONTROL CODES
50F2 C9                      RET
50F3 0669       CNG2:        LD    B,69H
50F5 C9                      RET
50F6 3E0D       CONTROL:     LD    A,0DH
50F8 C9                      RET
50F9 3A4051     PTRON:       LD    A,(PTRFLAG)   ;PRINTER ONOFF
50FC B7                      OR    A
50FD 2807                    JR    Z,PTRON1
50FF AF                      XOR   A
5100 324051                  LD    (PTRFLAG),A
5103 C35250                  JP    LOOP
5106 3E01       PTRON1:      LD    A,01H
5108 324051                  LD    (PTRFLAG),A
510B C35250                  JP    LOOP
510E F5         PRINTIT:     PUSH  AF
510F 3A4051                  LD    A,(PTRFLAG)
5112 FE00                    CP    00H
5114 2002                    JR    NZ,PREOD
5116 F1                      POP   AF
5117 C9                      RET
                ;PRINTER DRIVER
5118 3E00       PREOD:       LD    A,00H
511A CD2D51                  CALL  PSTATUS
511D F1                      POP   AF
511E D3FF                    OUT   (0FFH),A
5120 3E80                    LD    A,80H
5122 D3FE                    OUT   (0FEH),A
5124 3E01                    LD    A,01H
5126 CD2D51                  CALL  PSTATUS
5129 AF                      XOR   A
512A D3FE                    OUT   (0FEH),A
512C C9                      RET
512D C5         PSTATUS:     PUSH  BC
512E D5                      PUSH  DE
512F 57                      LD    D,A
5130 1E06                    LD    E,06H
5132 010000                  LD    BC,0000H
5135 DBFE       PAGAIN:      IN    A,(0FEH)
5137 E60D                    AND   0DH
5139 BA                      CP    D
513A C23551                  JP    NZ,PAGAIN
513D D1                      POP   DE
513E C1                      POP   BC
513F C9                      RET
5140 00         PTRFLAG:     DB    00H
                             END
```

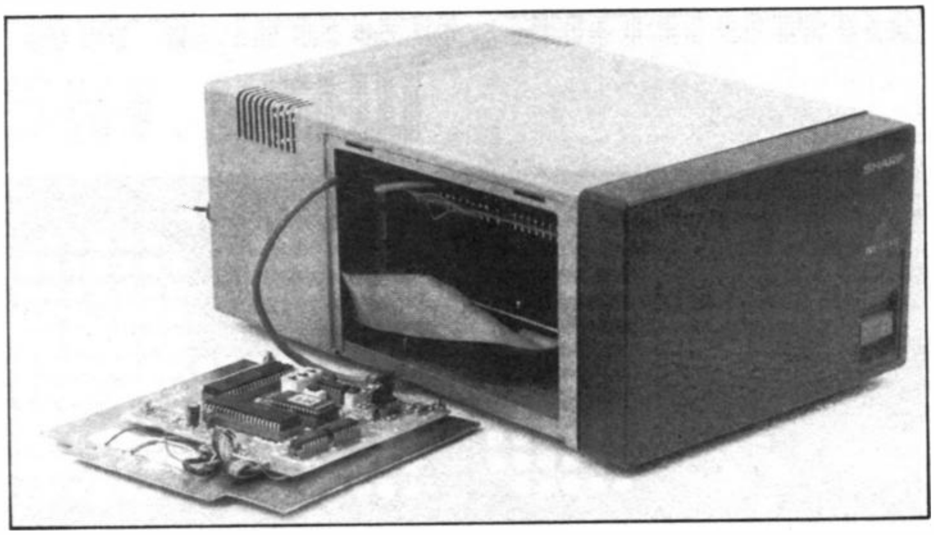
Control characters (the useful ones) are retained and can be used, i.e. clear screen, C/R, etc. The right and left arrows however will produce CR instead. This is done deliberately to avoid accidental use during communication. With all three of these test programs it is important to note that if you are using tape BASIC instead of disk BASIC, then you should change all INP@ and OUT@ statements to INP# and OUT#.

Now you have your interface working, you will need the software to be able to use it with a modem and your telephone to explore the world of communications, joining the ranks of the thousands of insomniacs! The Assembly program enclosed will enable you to do all this. It can be used with ZEN, or directly from Monitor. If you have ZEN, it is best you enter the source code so you can debug, expand, alter etc. If you do not have ZEN but you have Sharp assembler, you can adapt the code to Sharp format easily. Failing this, you can enter the object code directly in HEX shown on the left of the assembly listing under Sharp Machine code program, Xtalbug or similar. Failing all this, you can translate the Hex code into Decimal and poke it in using BASIC (code starts at address 5000 HEX) then use USR command to run.

Using Shift and Break will cause a jump to 1200 HEX i.e. ZEN, BASIC, or whichever system you are running the program under. If running from Monitor then do not use this command. Pressing Shift and the top Right blue graphics key will cause anything printed on the screen to be printed on the printer as well. Repeat the same to disable printer.

Making the I/O Connection

The sharp MZ80 I/O box is fitted with five 2 x 30 way sockets and guides for holding expansion boards. If a socket, suitable for use with these connectors, is not at hand, then Figure 3 can be followed as a guide to making your own. You will require a piece of double-sided copper-clad board, such as Maplin's WF42V – 'Medium double PCB'. Cut the board to the sizes given (160mm x 154mm) and drill three holes for mounting the ZX81 module. If the copper board is now inserted and removed several times into the I/O connector box, the copper surface will be scored in the correct positions. Using these marks as a guide you can use a pointed blade craft knife to cut out each 'finger' that corresponds to every contact in the connector. Cuts should be made *in between* and not 'on' the score marks. You will notice in Figure 4 that SIDE A positions 1 to 15 have not been cut as they all connect to 0V. *Do* ensure each 'finger' is cut around completely and does not short out to adjacent 'fingers' or to the rest of the board. A fourth hole can be cut to allow connecting wires to be fed through for connection to SIDE B 'fingers'.



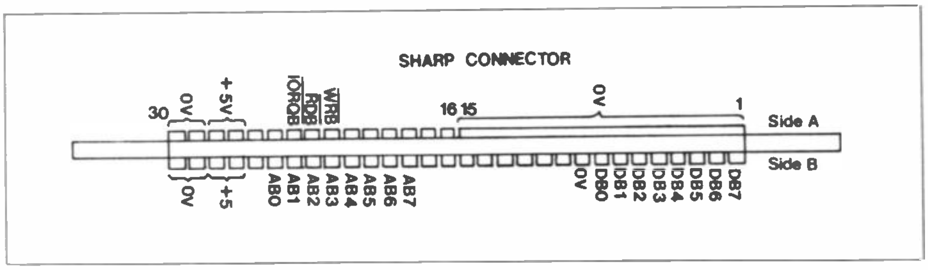


Figure 4. I/O connection details.

SHARP MZ-80K SERIAL INTERFACE PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1	390Ω	1	(M390R)
R2	100k	1	(M100K)
R3	1M	1	(M1M)
R4,5	150Ω	2	(M150R)
RV1	1M Hor. Sub-min Preset	1	(WR64U)
CAPACITORS			
C1	100μF 10V P.C. Electrolytic	1	(FF10L)
C2-5,8	100nF Minidisc	5	(YR75S)
C6	2μ2F 35V Tantalum	1	(WW62S)
C7	1nF Ceramic	1	(WX68Y)
C9	100pF Silver Mica	1	(WX13P)
SEMICONDUCTORS			
D2,3	1N4148	2	(QL80B)
D4	BZY88C4V7	1	(QH06G)
IC1	74LS27	1	(YF18U)
IC2	74LS30	1	(YF20W)
IC3	8255A	1	(YH50E)
IC4	2716/M9	1	(QY72P)
IC5	74LS14	1	(YF12N)
IC6	AY-3-1015D	1	(WQ18U)
IC7	ICM7555	1	(YH63T)
MISCELLANEOUS			
S1-6	DIL Switch SPST Dual	3	(XX26D)
S7,8	DIL Switch SPDT Single	2	(XX28F)
	8-pin DIL Socket	1	(BL17T)
	14-pin DIL Socket	3	(BL18U)
	24-pin DIL Socket	1	(BL20W)
	40-pin DIL Socket	2	(HQ38R)
	Veropin 2141	1 Pkt	(FL21X)
	Track Pin	2 Pkts	(FL82D)
	ZX81 Mod/Intface PCB	1	(GB23A)
OPTIONAL			
	10-Way Ribbon Cable	1 Mtr	(XR06G)
	10cm 24 s.w.g. Strapping Wire	1	(BL15R)
	Bolt 4BA ½in.	1 Pkt	(BF03D)
	Shake 4BA	1 Pkt	(BF21X)
	Nut 4BA	1 Pkt	(BF17T)
	PCB G.Fibre Med Dble	1	(WF42V)

A complete kit of parts is available, but does not include optional items:
Order As LK71N (Sharp Serial I/F Kit) Price £26.95
The following item in the above kit is also available separately, but is not shown in the 1985 catalogue:
Programmed EPROM 2716/M9 **Order As QY72P Price £4.95**

MACHINE CODE PROGRAMMING WITH THE

6502

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

With this part 'Machine-code programming with the 6502' comes to an end. I hope that I have shown that writing programs in machine code is not as daunting as you may have thought. I'm sure you now appreciate that Assembly Language programs are quite easy to write; the hard work comes in encoding them into machine code. So, if your machine has an 'assembler' then the creation of machine-code programs will be that much easier. Nonetheless, there is an element of achievement, initially at least, in doing the whole thing yourself.

There are in all 56 instructions in the 6502 set, 42 of which I have covered so far, either directly or by implication. So now, to round things off, I shall deal with these remaining 14 instructions with explanations and examples.

More branches - BCC, BCS, BVC, BVS (and CLV)

Let us define what these branches mean first, before going on to examples.

BCC - Branch on Carry Clear. That is, a branch is made to a new location if the carry flag C in the Processor Status Register is clear (C = 0). Since it will only be set if a preceding addition has produced a carry, then a branch will be made if such a result did not occur.

BCS - Branch on Carry Set. Obviously a complementary instruction to BCC, in which the branch is made if the addition does produce a carry (C = 1).

BVC - Branch on Overflow Clear and **BVS** - Branch on Overflow Set, are another pair of complementary instructions. The overflow flag V in the Processor Status Register is set if an arithmetic operation produces an overflow from bit 6 to bit 7 of the result which results in the sign of the result being changed. For example:–

```
 01000100
+01000011
 10000111
```

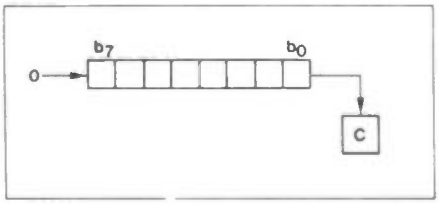


Figure 1. Effect of the LSR instruction

This addition of two positive numbers has resulted in a negative sum, since the convention is that bit-7 (the most significant bit) is 0 for positive numbers and 1 for negative numbers. The overflow branches allow this erroneous result to be detected and, hence, corrected. There is another use of the overflow flag V in connection with the BIT instruction but I shall come back to that shortly.

CLV - Clear the Overflow Flag – once an overflow has occurred and been detected, it is then necessary to clear this flag so that it can be used again in subsequent additions and subtractions. This instruction does just this.

Returning to BCC and BCS, an example of its use is to be found in connection with the LSR (Logical Shift Right) instruction. Figure 1 will remind you what happens when LSR is used. Bit-0 goes onto the carry flag C so that the latter becomes a 0 or a 1 depending on the current value of this bit. In this way, it is possible to test each bit, in sequence, of an 8-bit number by 'dropping' them in turn into the carry flag and using either BCC or BCS to find out which bits are 0's and which are 1's. This could be done as follows:–

```
        LDA  MEM     Load a number
                     from memory into
                     the accumulator
SHIFT   LSR          Shift right one bit;
                     bit 0 goes into C
        BCS  ITSA1   Go to ITSA1
                     if C=1
        JMP  ITSA0   Otherwise go to
                     ITSA0 since C=0
         ↓
         ↓
ITSA1   ———————      Start of ITSA1
                     program segment
         ↓
         ↓
        JMP  SHIFT   Go back to test
                     the next bit
         ↓
         ↓
ITSA0   ———————      Start of ITSA0
                     program segment
         ↓
         ↓
        JMP  SHIFT   Go back to test
                     the next bit
```

This program outline tests the bits in the data byte in sequence, branching differently for the 0's and 1's but doesn't know when to stop. To find out when all eight bits have been tested, it is necessary to set up a counter, say after the LDA instruction with the line:

LDX (or LDY) #08

then after each LSR, use DEX (or DEY) followed by BEQ OUT (or wherever you want to exit to) to keep track of the number of shifts carried out.

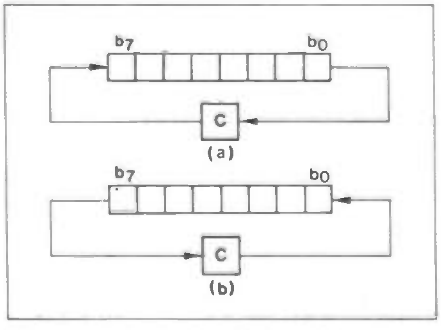


Figure 2. Effects of (a) ROR and (b) ROL instructions

Rotate and Shift - ROL, ROR, ASL

Both ROL (rotate left) and ROR (rotate right) perform what is called a '9-bit rotation', the 9th bit being the carry flag C. Figure 2 reminds you of the

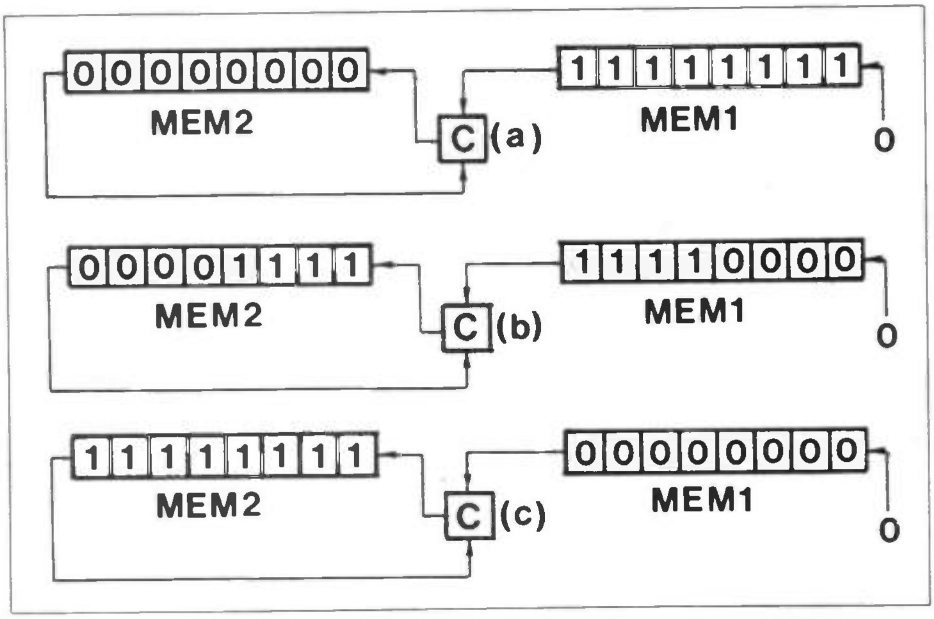


Figure 3. Sideways transfers with ASL and ROL instructions:
(a) initial state, (b) after four shifts and rotations, (c) after eight shifts and rotations

relation between the register in question and the carry flag for each of these operations. This register may be either the accumulator A or any memory location. By using the ASL (Arithmetic Shift Left) instruction followed by ROL, the contents of one memory location can be shifted 'sideways' bit by bit into another location. This is shown in Figure 3.

Assume that the location MEM2 holds all 0's initially and another location MEM1 holds all 1's and that we wish to transfer the contents of MEM1 into MEM2. A succession of ASL and ROL instructions alternately will achieve it, the carry flag acting as a 'link' between the two memory locations to 'transport' each bit across. Eight shifts and rotations will achieve the result. Naturally, we are not talking about a straightforward transfer of data from one memory location to another; that could be done quicker and easier by LDA and STA instructions. No, the use of this type of transfer occurs in mathematical operations such as multiplication. Because the multiplication of two 8-bit numbers can give a 16-bit result, then 16-bit working has to be adopted and both the multipicand and the final product have to reside in effective 16-bit registers made up of two memory locations considered to be side by side and linked by the carry flag and shift and rotate instructions as described. Thus, as each digit of the multiplier is used, the multiplicand is progressively shifted left from the right-most register into the left-most register to stay in step with the expanding result.

The instruction ROR is one that did not exist in early 6502's and its effect is the exact opposite of ROL. It could therefore, be used in conjunction with another ROR instruction to shift data between memory locations but in the opposite direction to that described above. Here is a multiplication program in Assembly Code in which this method is used.

MULTSUB	LDA	# 00 }	Initialise both
	STA	B }	bytes of result to zero
	LDX	# 08	Load X as counter
AGAIN	LSR	C	Shift multiplier right
	BCC	BIT 0	If b0 is a 0 then branch
	CLC		Clear carry
	ADC	D	Add multiplicand to accumulator
BIT 0	ROR	A	Shift this result right
	ROR	B	Catch b0 of A in B (b7)
	DEX		Decrement the counter
	BNE	AGAIN	Done for all 8 bits?

This program works as follows. The accumulator A and a memory location B hold the result; high byte is in A, low byte is in B. Another memory location C holds the multiplier and yet another memory location D holds the multiplicand. Now take it line by line.

The first two lines ensure that A and B contents are initially zero – after all they could hold anything from some previous processing. Then, to keep track of the number of steps in the process, the X register is set up as a counter with an initial value of 8 (since the multiplier has 8 bits). As explained earlier, the LSR instruction shifts the contents of C (the multiplier) right and pops its bit 0 into the carry flag; here it is tested by BCC to establish whether it is a 0 or a 1. The decision is based on a simple binary multiplication, see sum above.

In binary multiplication, there are only two values possible in the multiplier; either 0 or 1. Obviously any number multiplied by 0 is 0 and any number multiplied by 1 is just that number. Hence the need for testing each bit of the

```
   1011        (multiplicand)
  x1010        (multiplier)
   0000    }
  1011     }   Partial products
 0000      }
1011       }
1101110        Final result
               (product)
```

multiplier in turn for, when a bit is 0, nothing is added to the result whereas, when a bit is 1, we add the multiplicand, suitably shifted, to the result. The above example used 4-bit numbers to illustrate the point, the same principle applying of course, no matter how many bits in the numbers.

Suppose that the carry was a 1, then first time round, we add the multiplicand to the accumulator, having first cleared the carry flag. This forms the first partial product. At the moment, it resides in A. Now for the clever bit!

The above 4-bit example shows that the partial products formed are always ONE BIT TO THE RIGHT of the following partial product. However, in this particular program, no left shifting is carried out at all. Instead as each partial product is formed, it is SHIFTED RIGHT BY ONE BIT, from A into B, so that when the next partial product comes along to be added in, it is correctly aligned with the previous result. This is carried out by the consecutive ROR A and ROR B instructions. Naturally, when the bit of the multiplier is a 0, there is nothing to add in but we must still shift the existing result one bit right to obtain correct alignment. This is exactly what will happen if the BCC test is positive (i.e. C = 1) since the program branches directly to label BIT 0, missing out the addition step. A good way to prove to yourself how this works is take a couple of sample numbers and on some spare paper, do a dry run with pencil and rubber. Rule up some blocks to represent A, B, C and D, the carry flag and the X register and go through the program, line by line, until you exit from it. Then check your result. Of course, it is the last two lines, DEX and BNE AGAIN that allow you to exit since after having gone around the loop 8 times, the X register will contain zero, the BNE test will fail and out you come to the next program line.

Testing Bits With The BIT Instruction

The BIT instruction performs the logical 'AND' operation between the contents of the accumulator and any specified memory location M. However, unlike the instruction AND, it does not change the contents of the accumulator. Instead it sets the zero flag Z to 1 if the comparison succeeds i.e. if A.M. = 1. It also transfers the highest two bits, b_6 and b_7, of the memory data into the overflow (V) and sign (N) flags of the Processor Status Register. It has two addressing modes only, which are Zero Page and Absolute.

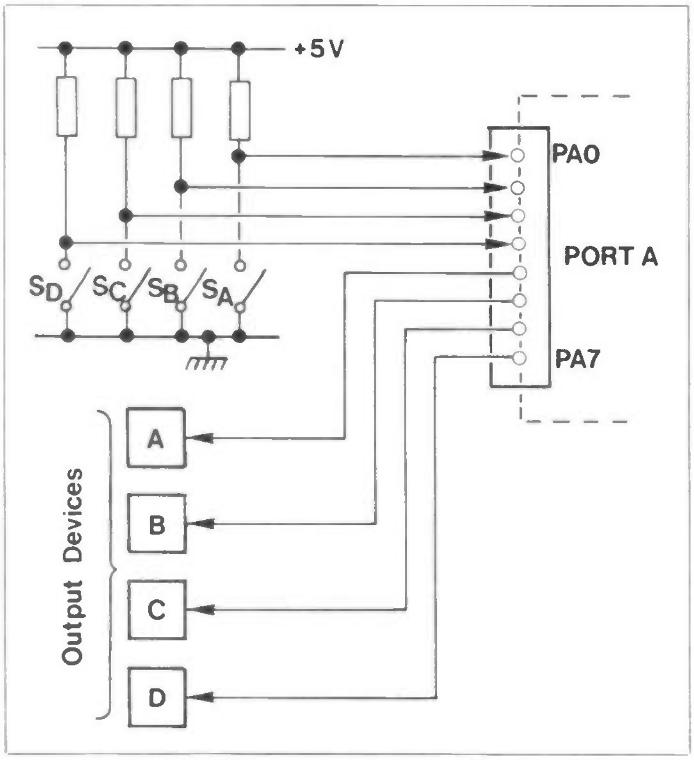


Figure 4. Diagram for BIT program

(a)

A	B	F
0	0	0
0	1	1
1	0	1
1	1	1

(b)

A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

Last line differs

Figure 5. Truth tables for (a) the inclusive-OR function and (b) the exclusive-OR function

Masking

What this all means in practice is that it is possible to test, one after another, as many memory locations as we like against a 'mask' set up in the accumulator, to see whether a '1' occurs at a particular bit in each memory word. Suppose, for example, we load 00010000 into the accumulator, i.e. a word in which the only bit that is 1 is b_4. Now we use the BIT instruction to compare it with the word 10010100 which is in some memory location M1. Put these one under the other to see the result.

```
           00010000    A
           10010100    M1
INTO 'N' ──┘  │
INTO 'V' ─────┘
b4 = MASK ────┘
```

Since b_4 is the only bit in A that is 1 then only a bit in this same position in M1 is capable of satisfying the test. As it happens, M1 does contain a 1 in this position so the test succeeds and the Z flag = 0. It may seem more logical to have made the Z flag equal to 1 for a successful test but it works nonetheless. We can detect this by using the BEQ instruction (or BNE, depending how you write the program); thus:

```
LDA   # 10
BIT   M1
BEQ   FRED
```

Suppose we follow this program segment with two more lines, as follows, what will these achieve?

```
BMI   JIM
BVS   GEORGE
```

I'm afraid that FRED, JIM and GEORGE are not real people; just labels to idenfity the destinations for the branches, handy if you can't think of anything else. However, if you've not lost the thread yet, you will realise that the BMI test succeeds while the BVS test fails, since the BIT operation put b_7 (which was a 1) of M1 into N and put b_6 (which was a 0) of M1 into V. Of course it's not really any good putting three branch instructions in series if you want to test all three since, if the first branch succeeds, the other two are bypassed, or if the second succeeds, the third is bypassed. But it does illustrate the role of the flags N and V in connection with the BIT instruction. There is never any need to set up a mask in the accumulator to test for 1's in b_6 and b_7 of a memory word; simply follow BIT with BMI or BVS (alternatively BPL or BVC – always two ways of achieving the same end!). Let us take an example of how BIT is used in connection with input/output.

Input/Output Masking

Figure 4 shows an input/output port with four switches connected as inputs on PA0 - PA3 inclusive. Four related output devices are connected to the other port lines PA4 - PA7. We want a program that continuously tests the switches and determines whether they are open (logic 0 input) or closed (logic 1 input). If a switch is found to be closed a 1 must be sent to the corresponding output device. Switch A controls Output Device A and so on.

In order to achieve this object, it is necessary to mask, in sequence, bits at PA0 - PA3 and, using the BIT instruction followed by a branch, test for the value of that bit. Then, if the branch succeeds, we go to a program segment, out of the main program, to set the appropriate output line to the logic 1 level.

The program is as follows:

```
        LDA  # F0  }  Initialise Port A
        STA  DDRA  }
START   LDA  #01      Mask PA0
        BIT  DRA   }  Test bit 0
        BNE  OUTA  }
LOOP1   LDA  #02      Mask PA1
        BIT  DRA   }  Test bit 1
        BNE  OUTB  }
LOOP2   LDA  #04      Mask PA2
        BIT  DRA   }  Test bit 2
        BNE  OUTC  }
LOOP3   LDA  #08      Mask PA3
        BIT  DRA   }  Test bit 3
        BNE  OUTD  }
```

The above section of program tests the inputs in sequence. The following is concerned with outputs.

```
OUTA    LDA  DRA   }
        ORA  #10   }  Set PA4 to
        STA  DRA   }  logic 1
        JMP  LOOP1    Return to test
                      next bit
OUTB    LDA  DRA   }
        ORA  #20   }  Set PA5 to
        STA  DRA   }  logic 1
        JMP  LOOP2    Return to test
                      next bit
OUTC    LDA  DRA   }
        ORA  #40   }  Set PA6 to
        STA  DRA   }  logic 1
        JMP  LOOP3    Return to test
                      next bit
OUTD    LDA  DRA   }
        ORA  #80   }  Set PA7
        STA  DRA   }  to logic 1
        JMP  START    Go back to
                      the beginning
```

Note that in the first part of the program, the BNE instruction was used since the result of a BIT operation is to set the zero flag (= 1) only if a 1 is NOT found in the tested position. Thus a successful BNE branch implies that Z = 0 and thus that a 1 *is* found.

In the second part of the program, another instruction, ORA, has crept in. This, I shall mention again but note now that it carries out the logical OR operation between the accumulator contents and the specified data. For example, in the lines:

```
LDA   DRA
ORA   # 10
```

Suppose that A contains 00001001 in binary, then since 10 (HEX) = 00010000, ORing these two numbers, bit for bit gives:

	00001001	A
OR	00010000	DATA
	00011001	RESULT OF ORA

In other words, a 1 has been 'forced' into bit 4 without affecting the values of the other bits, an important consideration when dealing with two-way traffic at the port.

More Logical Functions ORA and EOR

We saw in the previous program that the ORA instruction can be used to force any selected bit in a word to 1. Its most obvious application then is to send a 1 to any desired output line at a port without corrupting data (coming in or going out) or creating hazardous situations with conflicting levels. This is actually the INCLUSIVE–OR since the result of the OR operation is a 1 when the two bits OR'd are a 1 and a 0 or if they are two 1's. The truth table for ORA is shown in Figure 5(a) where A and B are the bits operated on and F is the result. Thus, there are three out of four lines for which the output is 1. Compare this with the truth table for the EXCLUSIVE-OR function in Figure 5(b) which shows that the last line when A = B = 1 no longer gives a 1 output – i.e. this case is 'excluded'. The EXCLUSIVE-OR operation in the 6502 is called EOR and is carried out between the contents of the accumulator and data specified, either a data word (immediate mode) or contents of a memory location (most other addressing modes). This gives an interesting result, as the following example shows.

Accumulator contents:	10101010
EOR this with:	11111111
Giving the result:	01010101

That is, every bit in the accumulator word has been inverted or 'complemented'. In fact, this is known as the 'one's complement' of the original word. It happens, of course, because whenever there are two ones in a column, the EOR gives zero (last row of the EXCLUSIVE-OR truth table) but if a column contains a one and a zero, the result is one (row two or three of the truth table). Thus, an EOR operation with all 1's (FF in hex.) always gives the one's complement of the number.

So What?

Well, it's based on complement arithmetic in which the operation of subtraction is turned into addition by taking the two's complement of the number you're taking away and 'adding' it to the number you're taking from. What then is the two's complement? It's the one's complement with a 1 added on. Here's an example.

Subtract 10100110 from 11000000:

```
One's complement
              of 10100110 = 01011001
add 1 for two's complement        +1
                    gives   01011010
add this result
    to the other number     11000000
                          + 01011010
                           100011010
                           ↑
            disregard carry
```

and the rest of the result is the answer, i.e. 00011010.

If you don't believe me, check it by taking the decimal equivalents. Here goes:

```
        11000000 = 192
        10100110 = 166
subtracting gives   26
        00011010 = 26,
       therefore O.K.
```

So subtraction could be performed by:

LDA	#FF	Load all 1's into A
EOR	M2	Form 1's complement of M2
CLC		Clear carry flag prior to addition
ADC	#01	Form 2's complement of M2
ADC	M1	Produce difference M2 – M1

Another use of EOR is to perform comparisons. The truth table shows that the result of the operation is zero for two 1's or two 0's. Thus, if two identical numbers are exclusive-OR'd, the result will be zero, a state that can be detected by testing the zero (Z) flag in the Processor Status Register. Thus:

LDA MEM1	Load A with number in MEM1
EOR MEM2	Compare with number in MEM2
BEQ EQUAL	Branch to somewhere else if the same
NEXTLINE	Otherwise carry on with the program

Transfer Instructions TSX and TXS

The role of the stack as a temporary data store was explained in Part Seven. The Stack Pointer Register keeps track of how far into the stack the storage has gone. Last In First Out structures have the main disadvantage that they impose a given order to the sequence of removal of data. Obviously it is an advantage to be able to over-ride this order. By loading the X register with a certain number and using TXS, the Address held by the Stack Pointer Register can be changed and this register then points elsewhere in the Stack. The status quo can be restored by using TSX. However, this instruction would in fact, be used first to deposit the current value of the stack pointer in memory, where it could be retrieved later by a further TXS instruction. Like this, where S is the Stack Pointer Register.

TSX		Transfer current S value into X
STX	MEM1	Store this value in MEM1
LDX	# NEW POINTER	Load X with new SP value
TXS		Transfer it to S
↓ ↓ ↓		} Execute program
LDX	MEM 1	Load X with original S value
TXS		Transfer it back to S

The No Operation or NOP Instruction

This, the final instruction discussed, does absolutely nothing. Nonetheless, it has two uses.

First, it occupies just two cycles of machine time which, with a 1MHz clock, is 2 microseconds. Thus, short, known delays can be built into a program by including NOP's in the program.

Secondly, it is sometimes useful to include some NOP's in a program that is being developed. This creates 'holes' in the program that can be filled by useful instructions without the necessity to shift all the addresses about.

That, I'm afraid, is it. I'm only too aware that there is an awful lot more that could be said but one has to stop somewhere. I hope that it has helped to introduce assembly language and machine-code programming to some who thought it might be too difficult. They will now realise that it's not as hard to get to grips with as they previously thought. Those who have developed an interest in low level languages in a general way, may be interested to learn that this series will now be followed by a similar series on that other popular processor, the Z80.

FABULOUS FIVE

From Robert Penfold

CBM64/VIC-20 Sequencer Interface

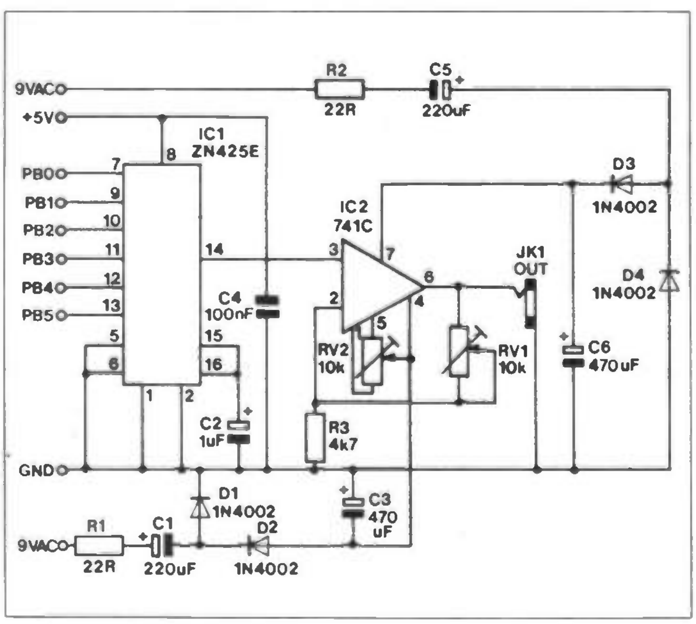
Computers have numerous applications in the field of electronic music and one of the most popular uses is as a sequencer for a synthesiser. This simple interface enables either a Commodore 64 or VIC-20 computer to control a monophonic synthesiser which has the standard 1 volt per octave control voltage characteristic. A range of 63 notes gives coverage of more than five octaves including semitones. Although most synthesisers have a compass of only two or two and a half octaves available from the keyboard, most will in fact cover five octaves or more via the CV input.

The control voltage from the keyboard is usually provided by a potential divider comprised of equal value resistors. This provides a series of voltages with an equal increment of just over 80 millivolts from one level to the next. This is very convenient as far as computer control is concerned, since a digital to analogue converter provides the same type of output. It is therefore basically just a matter of scaling the output of the converter to give the correct increment voltage. Driving a DAC from the CBM64 or VIC-20 is not difficult as both have a user port that has eight input/output lines. In this case they act as outputs, and six of them are used to drive IC1, which is a ZN425E ADC/DAC which is obviously operated as a DAC in this case. Although this is an 8-bit type, as only 6-bit resolution is needed in this application the two least significant bits are simply tied to earth. The six most significant bits are driven from the six least significant lines of the user port (PBO to PB5). This leaves PB6 and PB7 free, but one of these must be used to provide the gate/trigger signal.

The output of IC1 increments at nominally 40 millivolts per bit which is slightly under half the required level. IC2 is an operational amplifier connected in the non-inverting mode, and it provides buffering as well as the voltage amplification. RV1 is adjusted to give precisely the correct voltage gain while RV2 is an offset null control that ensures good accuracy at low output voltages. IC2 requires dual balanced supplies of about plus and minus 8 to 15 volts. Neither of the computers have suitable supplies available at their user ports, but they do have two 9 volt AC outputs which can provide suitable voltages after smoothing and rectification. This is the purpose of D1, D2, C3, etc.

Connection to the user port is via a 2 by 12 way 0.156 inch edge connector and details of the user port are given in the CBM64 and VIC-20 manuals. To set the output lines as outputs a value of 255 must be written to the data direction register (POKE 37138,255 for the VIC-20 and POKE 56579,255 for the CBM64). Data is then written to address 37136 or 56577 respectively for the VIC-20 and CBM64. Assuming PB6 provides the gate/trigger signal, 64 must be added to the note value in order to give an active gate/trigger signal, and just the note value is used to enable the envelope shaper to fade the note away. In order to set up RV2 correctly, write a value of 65 to the interface (1 + 64) to give the lowest note from the synthesiser (there is no note 0). Adjust RV2 by trial and error so that the interface gives exactly the same note as the lowest note of the keyboard. Then write a value of 89 (25 + 64) to the interface so that a note two octaves higher is obtained. RV1 is then adjusted so that the correct note is produced. If this procedure is repeated two or three times the unit should then track accurately over the full five and a bit octave range.

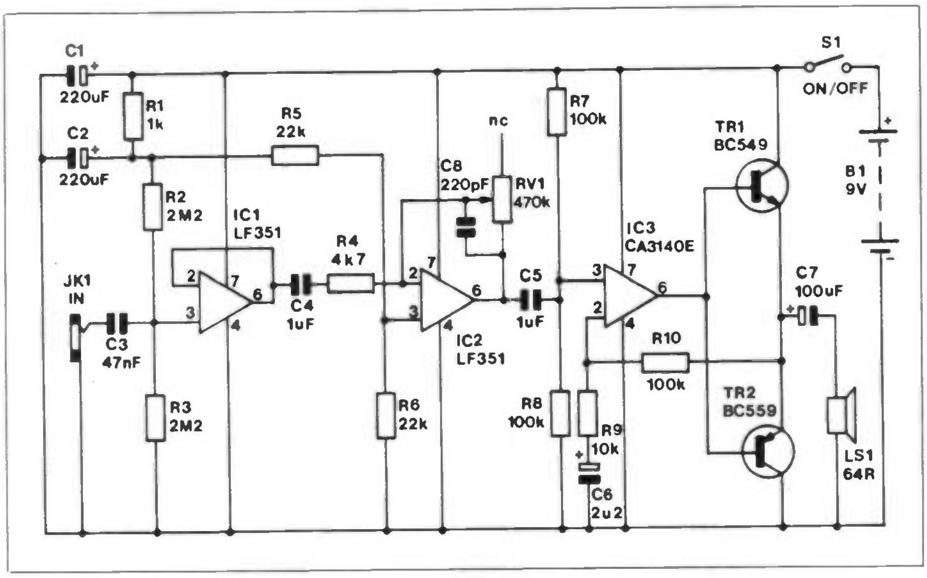
Obviously there is insufficient space available in an article such as this to permit software to be provided, but it should not be too difficult to devise a suitable routine. Each note is produced by first writing the note value plus 64 to the interface and then writing just the note value (which is analogous to releasing a key). Then the next note value (plus 64) is written to the interface. The program should enable note value, gate time, and total duration to be programmed for each note.



SEQUENCER INTERFACE PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1,2	22Ω	2	(M22R)
R3	4k7	1	(M4K7)
RV1,2	10k Hor. Sub-min Preset	2	(WR58N)
CAPACITORS			
C1,5	220μF 35V Axial Electrolytic	2	(FB62S)
C2	1μF 100V Axial Electrolytic	1	(FB12N)
C3,6	470μF 16V Axial Electrolytic	2	(FB72P)
C4	100nF Ceramic	1	(YR75S)
SEMICONDUCTORS			
IC1	ZN425E	1	(UF38R)
IC2	μA741C	1	(QL22Y)
D1-D4	1N4002	4	(QL74R)
MISCELLANEOUS			
JK1	Jack Skt Brk	1	(HF90X)
	2x12 Way PC Edgecon	1	(BK74R)
	16-Pin DIL Socket	1	(BL19V)
	8-Pin DIL Socket	1	(BL17T)

Signal Tracer



The way in which a Signal Tracer is used when fault-finding on audio and radio equipment goes beyond the scope of this article, but those who are not familiar with this type of test gear can find further details in the Project Fault Finding article. This particular Signal Tracer has an input impedance of over 1 megohm, and needs only about 1 millivolt RMS in order to produce full output. Of course, signals well below 1 millivolt will give an audible output from the unit, and it is adequate for most signal tracing. The maximum output power is only about 100 milliwatts RMS into the built-in loudspeaker, but this is perfectly adequate for the present application.

The circuit really breaks down into three sections; an input buffer stage, a high gain amplifier, and a class B power amplifier. Starting with the input stage, this has operational amplifier IC1 in a non-inverting unity gain circuit with biasing provided by R2 and R3. The bias circuit is fed from the supply lines by way of lowpass filter R1-C2. This is needed to prevent feedback through the supply lines from producing low frequency instability. The high value of R2 and R3 gives the unit its high input impedance.

IC2 is another operational amplifier, but in this case the inverting mode is used. R5 and R6 bias the non-inverting input, with the lowpass filter again being brought into action in order to avoid low frequency instability. R4 and RV1 are the negative feedback circuit which control the voltage gain of IC1, and by means of RV1 the gain can be varied from zero at minimum resistance to 40dB (100 times) at maximum resistance. C8 provides a certain amount of treble cut which helps to give an improved signal to noise ratio at high gain settings (where maximum treble cut is achieved). Although a logarithmic potentiometer is normally used for a volume control, in this case a linear type has been specified as it makes it easier to gauge the strength of the input signal.

IC3 is a non-inverting amplifier having discrete class B output stage TR1-TR2 and overall negative feedback via R10. R10 and R9 set the voltage gain of the output stage at a little over 20dB (11 times). An unusual feature of the circuit is the lack of any quiescent bias current through the output transistors to combat crossover distortion. Instead a large amount of negative feedback and the high slew rate of IC3 are used to reduce this distortion to an acceptable level. Although the output stage does not achieve hi-fi standards, it is perfectly adequate for this application. An advantage of this system is that it helps to give the circuit a low quiescent current consumption of only about 7 milliamps.

A point that must be borne in mind when constructing a unit such as this is that the high gain and input impedance make the circuit vulnerable to stray feedback and pick-up of mains hum etc. The component layout should have the input and output circuits well separated, and screened lead should be used between JK1 and the component board. It is advisable to house the unit in a case of all metal construction and earthed to the negative supply rail to provide screening against sources of electrical interference.

SIGNAL TRACER PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1	1k	1	(M1K)
R2,3	2M2	2	(M2M2)
R4	4k7	1	(M4K7)
R5,6	22k	2	(M22K)
R7,8,10	100k	3	(M100K)
R9	10k	1	(M10K)
RV1	Pot Lin 470k	1	(FW07H)
CAPACITORS			
C1,2	220μF 10V Axial Electrolytic	2	(FB60Q)
C3	47nF Carbonate	1	(WW37S)
C4,5	1μF Carbonate	2	(WW53H)
C6	2μ2F 100V Axial Electrolytic	1	(FB15R)
C7	100μF 10V Axial Electrolytic	1	(FB48C)
C8	220pF Ceramic	1	(WX60Q)
SEMICONDUCTORS			
IC1,2	LF351	2	(WQ30H)
IC3	CA3140E	1	(QH29G)
TR1	BC549	1	(QQ15R)
TR2	BC559	1	(QQ18U)
MISCELLANEOUS			
S1	SPST Ultra-min Toggle	1	(FH97F)
JK1	3.5mm Jack Socket	1	(HF82D)
LS1	Hi-Z L/S 64R	1	(WF57M)
B1	9 Volt PP3	1	(FK58N)
	Battery Clip	1	(HF28F)
	8-Pin DIL socket	3	(BL17T)

Tape Preamplifier

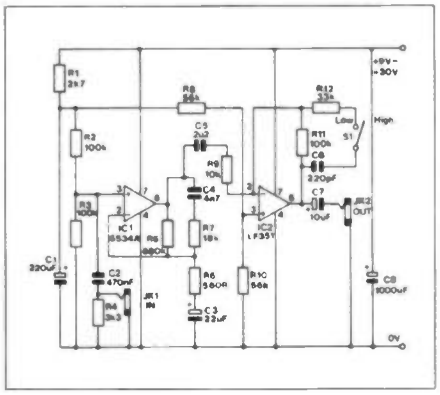
When used in conjunction with a cassette mechanism fitted with a standard (low impedance) record/replay head, this preamplifier provides a useful cassette player for use with a budget audio system. In fact, two preamplifiers will normally be needed since this circuit is a mono type, and for stereo operation, a separate preamplifier for each channel will be required. The circuit has a very low noise level and in use the background noise will always be predominantly that of the tape itself, even when using high quality types.

The output from a cassette head is quite low, being typically just a few hundred microvolts. The output is actually frequency dependent and rises at a rate of 6dB per octave; in addition equalisation (in the form of treble boost) is used during the recording process. The preamplifier must therefore provide a high voltage gain plus suitable equalisation. The circuit must obviously provide treble cut, but the degree of high frequency attenuation required is less than one might expect. This is due to the relative low efficiency of the tape head and the tape itself at high frequencies. This is the reason for boosting the H.F. signal content during recording, but notwithstanding the effect is in fact so severe that the preamplifier only has to provide equalisation at low and middle frequencies, and must have a flat response over the high-middle to treble frequency range.

In this circuit, IC1 provides the

equalisation and most of the voltage gain. This is an NE5534A operational amplifier, which is an ultra low noise type specifically designed for use in demanding audio preamplifier applications. It operates in the non-inverting mode, with biasing for the non-inverting input provided by R2 and R3.

There is likely to be a substantial amount of noise on the supply lines if the preamplifier is powered from the same source as the cassette motor, and R1 plus C1 are therefore used to filter this noise and prevent it from being coupled to the non-inverting input of IC1 via the bias circuit. R5 and R6 set the voltage gain of IC1 at just over 60dB at low frequencies but the shunting effect of C4 and R7 reduces the gain over the bass to middle frequency range to give the required equalisation. The voltage gain is a more modest 30dB or so over most of the audio range.



The signal at the output of IC1 is inadequate to drive most amplifiers and IC2 is used to boost the signal to a more useful level of a few hundred millivolts RMS (at full tape modulation). IC2 is a simple inverting mode circuit which has a voltage gain of 20dB. When S1 is closed, R11 is shunted by R12 and C6 in series. These introduce a small amount of additional negative feedback at high frequencies which produces treble cut. This gives a reduction in the background 'hiss', although at the expense of reduced high frequency performance. When playing a Dolby B encoded cassette on equipment which does not include a suitable decoder it is normal to provide a certain amount of treble cut to compensate for extra treble boost provided by the encoding process. Switching in the top cut filter is a convenient way of doing this, but it must be emphasised that this is just a top cut filter and not a proper Dolby B decoder. Note that in a stereo unit S1 should, of course, be a single DPST switch with one pole used in each channel rather than two SPST switches.

Due to the high gain of the circuit, especially at low frequencies, it is important to use screened leads at the input in order to avoid significant pick up of mains hum and noise from the motor.

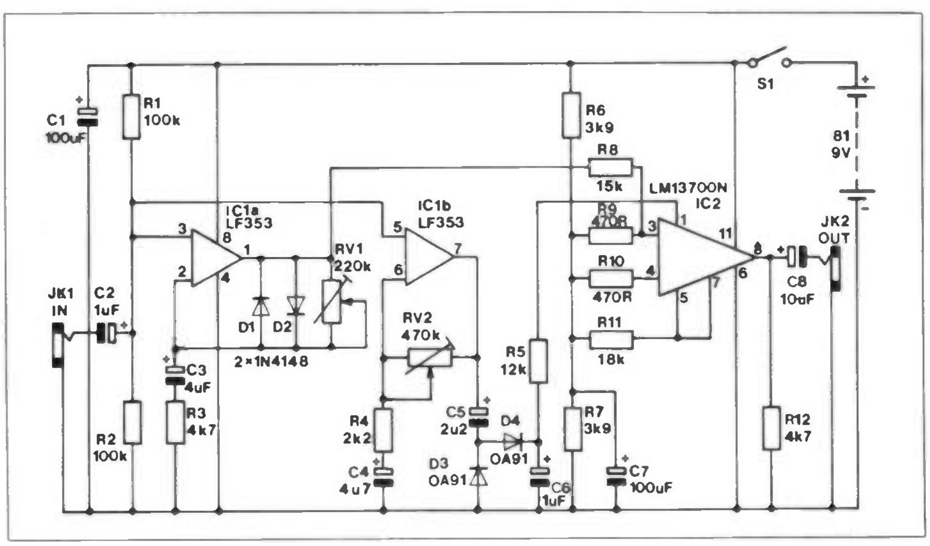
TAPE PREAMPLIFIER PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1	2k7	1	(M2K7)
R2,3,11	100k	3	(M100K)
R4	3k3	1	(M3K3)
R5	680k	1	(M680K)
R6	560Ω	1	(M560R)
R7	18k	1	(M18K)
R8,10	56k	1	(M56K)
R9	10k	1	(M10K)
R12	33k	1	(M33K)
CAPACITORS			
C1	220µF 35V Axial Electrolytic	1	(FB62S)
C2	470nF Carbonate	1	(WW49D)
C3	22µF 25V Axial Electrolytic	1	(FB30H)
C4	4n7F Carbonate	1	(WW26D)
C5	2µ2F Polyester	1	(BX84F)
C6	220pF Ceramic	1	(WX60Q)
C7	10µF 25V Axial Electrolytic	1	(FB22Y)
C8	1000µF 35V Axial Electrolytic	1	(FB83E)
SEMICONDUCTORS			
IC1	NE5534A	1	(YY68Y)
IC2	LF351	1	(WQ30H)
MISCELLANEOUS			
S1	SPST Ultra-min Toggle	1	(FH97F)
JK1,2	3.5mm Jack Socket	2	(HF82D)
	8-Pin DIL Socket	2	(BL17T)

Fuzz Unit

There are numerous types of fuzz unit, giving a range of subtle variations on the basic effect. The most common form of fuzz effect is a straightforward clipping of the signal to introduce severe harmonic distortion. A point which should be borne in mind is that it also generates strong intermodulation distortion which restricts its use to just one note at a time. This fuzz unit is slightly different to the conventional type, but it is basically a clipping circuit. It is different in that it incorporates an envelope shaper that retains the original attack and decay characteristics of the guitar, or at least something approximating to these. Normally a simple clipping amplifier is used and this gives a virtually constant output level until the signal decays below the point where clipping and the fuzz effect are produced. Of course, in practice the next note is normally produced before the output has a chance to decay that far, and the output lacks any real shape at all.

In this circuit IC1 is an operational amplifier connected in the non-inverting mode. The inclusion of D1 and D2 in the negative feedback loop introduces the clipping. At output levels of less than about 1 volt peak to peak D1 and D2 are not brought into conduction as their forward threshold voltage of about 0.6 volts is not reached. The voltage gain of the amplifier is consequently controlled by RV1 and R3. At output levels of much more than about 1 volt peak to peak D1 and D2 will be brought into conduction (D1 on negative peaks and D2 on positive peaks). They shunt RV1 to give more feedback, lower voltage gain, and the required distortion. RV1 is adjusted so that the basic voltage gain of the amplifier is sufficient for the guitar to produce strong clipping.



The output of IC1a is fed to a voltage controlled amplifier (VCA) built around operational transconductance amplifier IC2. This is a conventional circuit which uses one section of the LM13700N (the other section is left unused). The voltage gain of the circuit is controlled by the bias current fed to the amplifier bias input at pin 1, but the addition of series resistor R5 gives a current flow that is roughly proportional to the applied voltage, and voltage rather than current control is consequently obtained. The control voltage is obtained by amplifying, rectifying, and smoothing the input signal. IC1b provides the amplification while D3, D4 and C6 provide the rectification and smoothing. The control voltage is roughly proportional to the amplitude of the input signal, as is the gain of IC2. The almost constant output level from IC1a is therefore shaped to give an output which retains a reasonable approximation to the original envelope shape of the input signal. A useful by-product of the envelope shaping is that a noise gate action is obtained. This avoids the problems of high noise, hum pick-up and feedback that accompany the use of many fuzz units.

RV1 is adjusted to give the required degree of fuzz. A low setting will give little or no distortion while with most guitars a high resistance will produce a strong fuzz effect even when the signal has decayed to a low level. RV2 is simply adjusted by trial and error to find the setting which gives the best envelope shape. With too low a resistance the signal will decay too early, but with an excessive resistance the envelope shaping will be virtually non-existant.

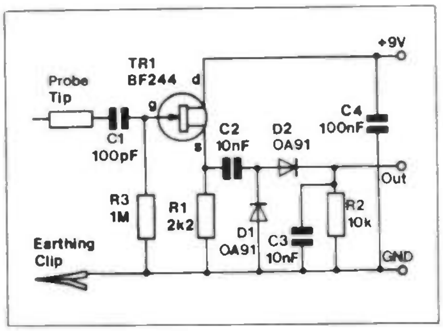
FUZZ UNIT PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1,2	100k	2	(M100K)
R3,12	4k7	2	(M4K7)
R4	2k2	1	(M2K2)
R5	12k	1	(M12K)
R6,7	3k9	2	(M3K9)
R8	15k	1	(M15K)
R9,10	470Ω	2	(M470R)
R11	18k	1	(M18K)
RV1	220k Hor Sub-min Preset	1	(WR62S)
RV2	470k Hor Sub-min Preset	1	(WR63T)
CAPACITORS			
C1,7	100μF 10V Axial Electrolytic	2	(FB48C)
C2,6	1μF 100V Axial Electrolytic	2	(FB12N)
C3,4	4μ7F 100V Axial Electrolytic	2	(FB18U)
C5	2μ2F 100V Axial Electrolytic	1	(FB15R)
C8	10μF Axial Electrolytic	1	(FB22Y)
SEMICONDUCTORS			
IC1	LF353	1	(WQ31J)
IC2	LM13700N	1	(YH64U)
D1,2	1N4148	2	(QL80B)
D3,4	OA91	2	(QH72P)
MISCELLANEOUS			
S1	SPST Ultra-min Toggle	1	(FH97F)
JK1,2	Jack Skt Brk	2	(HF90X)
B1	9 Volt PP3	1	(FK58N)
	8-Pin DIL Socket	1	(BL17T)
	16-Pin DIL Socket	1	(BL19V)
	Battery Clip	1	(HF28F)

RF Probe

Although this probe is designed for use with the signal tracer described above, it could in fact be used with any sensitive amplifier to facilitate tracing of radio frequency signals. To be more precise, it can be used to trace amplitude modulated signals at any frequency from around 100kHz to 50MHz, provided they are strong enough to give an audible output from the signal tracer. In practice there is usually no problem if tests are made in the intermediate frequency stages of a receiver, but there could be an inadequate signal level to operate the equipment if tests are made on radio frequency and mixer stages, unless steps are taken to ensure that there is a fairly strong input signal to the circuit under investigation. A point that has to be emphasised is that the probe is totally unable to demodulate frequency modulated signals, and is primarily intended for checking AM radios. However, it would presumably be feasible to carry out signal tracing on an FM receiver using an AM test signal.

The circuit is just a buffer amplifier followed by a conventional AM demodulator. The buffer amplifier uses a JuGFET device, TR1, as a source follower (the FET equivalent of a bipolar emitter follower stage). This gives the probe an input impedance of about 1 megohm shunted by a capacitance of about 10pF or so. The output of TR1 feeds into a simple two diode demodulator and RF filter C3-R2. The circuit requires a 6 to 12



volt supply and has a current consumption of under 1 milliamp. There should be no difficulty in powering the probe from the signal tracer.

Devices of this type are normally constructed as small hand held probes with the input connected to a metal prod at the front of the unit. This can consist of a long 6BA or M3 bolt which can have the screw thread filed away at the end to give a neater finish. The case can be any small type, and something like a 35mm film container is ideal. The earth lead is terminated in a crocodile clip which connects to the earth rail of the equipment under test. The output is taken to the signal tracer via a screened lead. In fact, twin screened lead is ideal as the extra inner conductor can be used to carry the positive supply to the probe. It is not advisable to build the unit into the signal tracer and have a screened lead to carry the input signal to the probe as the capacitance in the cable could produce severe detuning and loading of the equipment under test.

RF PROBE PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1	2k2	1	(M2K2)
R2	10k	1	(M10K)
R3	1M	1	(M1M)
CAPACITORS			
C1	100pF Ceramic	1	(WX56L)
C2,3	10nF Carbonate	2	(WW29G)
C4	100nF Ceramic	1	(BX03D)
SEMICONDUCTORS			
TR1	BF244	1	(QF16S)
D1,2	OA91	2	(QH72P)

New Books

High Performance Loudspeakers
by Martin Colloms
Considerable changes have taken place in the area of high performance loudspeaker design, in particular, recent developments in digitally encoded sound sources, producing a new digital programme standard. New work on the laser analysis of diaphrams, investigation into the stored energy in enclosures, driver developments, and even new discoveries into distortion introduced by defective or over driven crossover components, are included in this third edition.
Also included are such recent topics as low mass honeycomb speaker enclosures, electrostatic speaker theory, new diaphram materials, low distortion magnet systems, computer controlled testing procedures, listening room design, enclosure design.
225 x 145mm hard cover, 318 pages, illustrated.
Order As WP21X (Hi Perfmnce L/Spkrs) Price £15.95

BBC Micro Wargaming
by Owen and Audrey Bishop
For BBC micro users looking for new and interesting games to play, and who are new to wargaming, or for experienced wargamers who would like to introduce the computer to the wargaming table. This book describes the principles of wargaming, providing modular routines that you can use directly, or adapt to suit yourself. There are also several complete programs which will also run on the Acorn Electron. The scenarios provided include battles from the popular Medieval, Napoleonic and World War II periods, including a futuristic Space War.
235 x 153mm, 230 pages, illustrated.
Order As WP27E (BBC Micro Wargaming) Price £9.95

The BBC Micro ROM Book
by Bruce Smith
The use of ROM-based software is a feature almost unique to the BBC micro, and this book shows how the paged ROM system, and ROM filing system work, providing programming examples to help readers produce their own sideways ROMs using EPROMs, and sideways RAMs. A large amount of available page ROM associated hardware, such as ROM boards, sideways ROM and EPROM programmers, and ROM based software – including 'toolkits', monitors and utilities – are examined in detail.
235 x 152mm, 280 pages, illustrated.
Order As WP23A (BBC Micro ROM Book) Price £10.95

Adventure Games for the Amstrad CPC464
by A. J. Bradbury
Create your very own adventure games using the powerful Locomotive BASIC. Whether you are an experienced programmer or a complete novice, you will find all the information needed to prepare, map and program complete adventures, using the modular routines and listings supplied. References to professional techniques are made throughout, and it is possible with practice that the user will eventually be able to write his own truly remarkable adventures.
234 x 152mm, 232 pages, illustrated.
Order As WP17T (Advntr Games Amstrad) Price £8.95

How to Write Amstrad CPC464 Games Programs
by W. Simister
A step-by-step guide to help you write your own graphics games programs on the Amstrad CPC464. By working through each program in the order given in this book it is hoped that within a fairly short time you will aquire a better understanding of Locomotive BASIC, and how to logically plan your own programs. It is recommended that this book be studied while actually sitting at the computer, so that you can readily SAVE all that you enter immediately onto tape.
178 x 110mm, 136 pages.
Order As WP20W (Write Amstrad Games) Price £2.85

Ins and Outs of the Amstrad
by Don Thomasson
Although there is a rapidly expanding variety of books relating to software for the Amstrad CPC464 now available, hardware considerations have been somewhat overlooked. This book explores some of the important features of the CPC464, one of which is the ease with which all major software functions can be accessed by simple calls to the operating system, meaning that the maximum use can be made of the computer, whether you are a first time user or an experienced programmer. In particular a comprehensive description of how to add external devices through the use of the expansion and printer ports is given, and anyone wanting to get more involved in hardware for the Amstrad will find this book indispensable.
210 x 140mm, 126 pages, illustrated.
Order As WP25C (Ins/Outs Amstrad) Price £7.95

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WY17T	Euroboard 6-way	£7.25 (B)●
Page 131		
HL49D	Mains Socket SA2111	£2.75 (D)●
Page 132		
HL50E	Sleeve 8037	18p (G)
Page 133		
FJ32K	L/Plg-US/Skt USA/BT	£5.45 (C)●
Page 134		
RK87U	Video Lead 5	£2.49 (C)
Page 135		
YW35Q	Adaptor T	95p (D)●
Page 136		
RW24B	Dinpek L	£1.25 (E)●
RW18U	Dinpek E	£1.25 (E)●
RW19V	Dinpek F	£1.25 (E)●

ELECTRICAL

Page 137		
HL57M	5 Amp Plug Nylon	95p (E)●
RW67X	13 Amp Plug Nylon	95p (E)●
HL80Q	Kettle Connector	£1.45 (D)●
Page 138		
HL86W	Junction Box Lge	£1.25 (D)●
Page 140		
★YB20W	Room Thermostat	£7.95 (B)●
Page 141		
XY08J	Extn Lead 5A	£14.95 (A)●
XY09K	Extn Lead 13A	£15.95 (A)●

HARDWARE

Page 142		
LR52G	Bolt 4BA 1.1/2in	75p (F)●
BF06G	Bolt 6BA 1/2in	28p (G)
LR53H	Bolt 6BA 1.1/2in	£1.35 (E)●
BF38R	Pozi Screw M3 25mm	95p (F)●
LR58N	Pozi Screw M3 40mm	95p (E)●
Page 143		
BF51F	Isobolt M3 6mm	35p (G)●
LR62S	Isotag M5	DIS (G)●
LR63T	Isotag M4	38p (F)●
LR64U	Isotag M3	25p (G)●
LR65V	Isotag M2.5	25p (G)●
LR66W	Isotag M2	DIS (H)●
LR67Y	SH-Tpr No.2 x 3/8in	19p (G)●
Page 144		
BH44X	Plas Fixing	DIS (G)
FW10L	Spade 2BA	35p (F)●
FW15R	Studding 6BA	40p (F)●
FW35Q	6BA Spacer 1/2in	66p (F)●
LR69A	8BA Spacer 1/8in	DIS (F)●
FG32K	M3 Spacer 1/8in	95p (E)●
Page 145		
LR50E	SR Grommet 7K-2	32p (F)
LH12N	Aly Sheet 18 swg	£1.95 (D)●
WH48C	Mains Warning Label	20p (G)●

HEATHKIT

Page 147		
HK00A	Heathkit Catalogue	95p N/V●
Page 152		
HK78K	HD-8999 Pro CW Keybd	£199.95
Page 154		
HK33L	EI-3133 Soldering Crs	£29.95●
Page 156		
HK09K	EE-3105A Tst Eqp Crs	£99.95●
Page 157		
HK42V	EE-3106 Elct Com Crs	£99.95●
Page 158		
HK82D	EE-1002 Transtr Crs	£99.95●
Page 162		
HK91Y	EWA-3400 Assembled	£395.95●
Page 164		
KA13P	Hero Mem Bd ET-18-6	£99.95
HS08W	ETA-18-6 RAM Fr Hero	£45.00
Page 167		
★KA00A	Hero Jr Kit RTR-1-1	£549.95●
Page 169		
HD67X	Heathkit EEA-3105A	£34.95●
Page 172		
HS85V	Heathkit EC-1121	£74.95 N/V
Page 173		
HK50E	IM-5258 Distrtn Anly	DIS
Page 174		
HK87X	PS2405 Hand-Freq PSU	£29.95
HK94C	SMA-2400-1 Antenna	£19.95●
Page 177		
HK72P	ID-1990 Digi Baromtr	DIS

KNOBS

Page 178		
RX30H	Knob RN82	42p (F)●
Page 179		
†HB30H	Knob RS3	98p (E)●
Page 180		
RX18S	Collet Knob Black	55p (F)●
RX19V	15mm Collet Indctr	25p (G)●
RX20W	15mm Collet Skirt	30p (F)●
WL43W	3/8in Nut	20p (G)●
Page 181		
RX38R	Nylon Rod	28p (F)●
RX39N	Vernier Dial Small	£3.45 (C)●
RX40T	Vernier Dial Medium	£3.95 (C)●

MICROPHONES

Page 183		
YB31J	Cassette Mic Jacks	£2.25 (D)●
YB33L	Electret Casette Mic	£3.25 (C)●
WF35Q	Dynamic Ball Mic	£12.45 (A)●
Page 184		
WF05F	Communications Mic	£7.95 (B)●
YW70M	Diff Comm Mic	DIS (B)●
YW77J	Mic Hldr Screw-Fix	35p (F)●
YW79L	Mic Hldr Magnetic	DIS (E)●
XY72P	Base Station Mic	£44.95 (A)●
Page 185		
XG12N	Base Stn Mic BSA810A	£44.95 (A)●
LB08A	Tie-Clip Mic	£8.95 (B)●
FK42V	FM Clip Mic WM53	DIS (A)●
Page 186		
BK01B	FM Mic	DIS (A)●
Page 187		
BK02C	FM Mic Adaptor	DIS (A)●
YW78S	Cast Base Mic Stand	£4.95 (C)●
XB45Y	5-Foot Mic Stand	£14.95 (A)●

MUSICAL & EFFECTS

Page 188		
YK56K	Stereo Mixer MM2	£15.95 (A)●
Page 191		
YB88V	Mini Compressor	£29.95 (A)
YB42V	Steel Mag Pick-up	£12.95 (B)●

OPTO-ELECTRICAL

Page 192		
RX85T	MES Batten Hldr	30p (G)●
BK56K	Chrome Neon Red	79p (E)●
Page 193		
WL75S	LES Bulb 12V	22p (G)●
Page 194		
WL29G	LED Orange	20p (F)●
YH53H	Cliplite Amber	20p (G)
YH54J	Cliplite Clear	20p (G)
YH56K	Cliplite Green	20p (G)
YH58L	Cliplite Red	20p (G)
YH57M	Cliplite Yellow	20p (G)
Page 196		
FR38N	1/2" Display Type 1	£1.78 (E)●
BY68Y	DD Display Type C	£3.45 (C)●
Page 197		
YJ49D	Message Disply Systm	£69.95 (A)
Page 198		
★YY86W	Infra-Red Sensor	£1.35 (F)

ORGAN COMPONENTS

Page 203		
XB13P	KB Mounting Strip	68p (E)●
Page 205		
XB00A	Gold Wire	£2.25 (D)●
Page 206		
BY51F	Mr Ky Tb Rtr To Main	DIS
FL76H	Key Tab	£3.45 (E)●
Page 207		
XB95D	Organ Stool	DIS (A)●

PANEL METERS

Page 208		
LB80B	Sig Strength Meter	£2.48 (D)
RK21X	Quick Fit Mtr 50-0-50	DIS (C)
RK08J	Quick Fit Mtr 500uA	DIS (C)
Page 209		
★RW96G	2inPn Mt 100-0-100uA	£8.25 (B)
★RW98H	2inPn Mt 500-0-500uA	£8.25 (B)
★RW91Y	2in. Pan Meter 50uA	£8.25 (B)
★RW92A	2in. Pan Meter 100uA	£8.25 (B)
★RW93B	2in. Pan Meter 500uA	£8.25 (B)
★RW94C	2in. Pan Meter 1mA	£8.25 (B)
★RW95D	2in. Pan Meter 5mA	£8.25 (B)
★RW96E	2in. Pan Meter 10mA	£8.25 (B)
★RX33L	2in. Pan Meter 100mA	£8.25 (B)
★RX34M	2in. Pan Meter 500mA	£8.25 (B)
★RX36Q	2in. Pan Meter 1A	£8.25 (B)
★RX37S	2in. Pan Meter 300V	£8.25 (B)
★RX53H	2in. Pan Meter 'VU'	£8.25 (B)
RX54J	Large Panel Meter	£11.95 (B)●
RX92A	Meter MI 15V	£9.95 (B)●
RX88V	Meter MI 300V	DIS (B)
RX90X	Meter MI 5A	£9.95 (B)●
RX91Y	Meter MI 15A	£9.95 (B)●
RX93B	Meter MI 25A	£9.95 (B)●

PCB EQUIPMENT

Page 210		
FL02C	SRBP 0.1in Type 3	£1.45 (D)●
FL19V	DIP Board	£5.95 (C)●
HQ48C	Vero V-Q Board	£2.95 (C)●
Page 213		
RK41U	Etching Kit CM100E	£4.95 (B)●
YJ42V	Film Clear Solution	95p (C)●
Page 214		
WF41U	PCB F.Glass Lrg Sngl	£3.45 (C)●
BW24B	Track Tape 62	£1.95 (D)●
BW25C	Track Tape 75	£1.95 (D)●
BW28D	Track Tape 100	£1.95 (D)●
BW29G	Track Tape 200	£2.75 (D)●
BW31J	Pad 100	£2.25 (D)●
BW32K	Pad 125	£2.25 (D)●
BW33L	Pad 150	£2.25 (D)●
BW34M	Pad 200	£2.25 (D)●
FJ57M	Pad 250	£2.95 (C)●
BW35Q	Pad 300	£2.65 (D)●

PROJECTS & MODULES

Page 220		
GB24B	Enlarger Timer PCB	£5.95 (C)
Page 228		
FJ53H	TU 1000 Front Panel	£2.65 (D)
FJ54J	TU 1000 Rear Panel	£2.10 (D)
Page 232		
★XH48C	MES33	DIS
FL88G	HiFi Amp Pk Det PCB	DIS (C)●
XX32K	H/Phones Skt Brckt	DIS (E)
XY22Y	HiFi Amp Screen	DIS (C)
XY23A	HiFi Amp Frt Panel	DIS (A)
Page 234		
YQ10L	12/30V PSU Module	DIS (B)●
Page 241		
YQ38R	30/2 PSU PCB	£1.98 (D)
Page 249		
†XY88T	Matinee Main PCB	£58.00 (A)
†XY91Y	Matinee Organ Kit	£314.95 (A)
XX43W	Matinee Dem Cassette	DIS (D)●
Page 252		
BY83E	Synth VC Pn & AncPCB	£10.45 (B)
†XQ01B	5600 Front Panel	£24.98 (A)●
†BY84F	5600 Rear Panel	£4.55 (C)●
†XQ02C	5600 Cabinet	£64.23 (A)●
†LW53H	5600S Synth Kit	£619.95 (A)●
Page 253		
†XQ03D	3800 Front Panel	£13.98 (A)●
BF88G	3800 VCA Bkt	DIS (E)●
†BY85G	3800 Rear Panel	£4.56 (C)●
†XQ04E	3800 Cabinet	£58.80 (A)●
†LW54J	3800 Synth Kit	£358.75 (A)●
Page 254		
YQ58L	Sequencer Main PCB	£7.45 (B)●
†LW88W	Sequencer Kit	£98.95 (A)●
Page 255		
GA58P	Spectrum Shaper PCB	£8.45 (C)●
Page 258		
XX44X	Synclock Front Panel	£2.10 (D)
Page 261		
QY54J	Low Current Disp	£3.98 (C)●
Page 262		
RK38N	Freq Cnt Front Panel	£2.75 (D)●
Page 267		
GB41U	VIC Extendiboard PCB	£8.95 (B)●
Page 271		
XF80Q	E&MM June '82	DIS●

PROTECTION

Page 273		
RX50E	Chassis F/H 1.1/4 in	30p (F)●
WR18U	Fuse A/S 500mA	8p (G)●
WR19V	Fuse A/S 1A	8p (G)●
WR20W	Fuse A/S 2A	8p (G)●
WR16S	Fuse 1 1/4 10A	9p (H)●
WR17T	Fuse 1 1/4 15A	9p (G)●
Page 274		
†BK21X	Thermal Breaker 1A	£3.90 (C)●
†BK22Y	Thermal Breaker 3A	£2.25 (C)●
BK23A	Thermal Breaker 5A	DIS (C)●
†BK24B	Thermal Breaker 12A	£2.25 (D)●
†BK26W	Thermal Breaker 15A	£2.25 (D)●
HW05F	RF Supp Choke 2A	38p (F)●
Page 275		
FK46A	Panic Button	£1.45 (E)●
XG58N	Infra Red Detector	DIS (A)●
FK75S	Panic Horn	£12.95●

RECORD, TAPE & VIDEO

Page 276		
XB25C	Belt Drive Turntable	DIS (A)●
FJ18U	Dr/Belt N/Pan AS8187	£3.25 (C)
FJ23A	Dr/Belt Htchi AS8210	£3.25 (C)
Page 277		
HR01B	Ctrdg BSR X5M	£4.25 (C)●
HR10L	Ctrdg BSR SC12H	£4.75 (C)
Page 278		
HR15R	Ctrdg Goldring G850	£8.45 (B)
Page 280		
BK10L	Stylus Toshiba N501	£7.46 (B)●
BK12N	Stylus JVC DT31	£3.75 (C)●
†BK15R	Stylus P/snc EPS205	£5.98 (B)●
†BK16S	Stylus PN12	£5.90 (B)●
FG97F	JVC DT37 Stylus	DIS (B)●
HR48C	Stylus D110SR	£3.45 (C)●
HR49D	Stylus D120SR	£3.45 (C)●
†YX31J	Stylus Toshiba N55	£4.95 (C)●
Page 281		
FG71N	Rollecleana	DIS (B)●
YB55K	Cleaning Kit C51	£3.95 (C)
LX10L	Anti-Stat Mat C119	£3.95 (C)
★LX04E	Anti Stat Gun RC2000	£5.45 (B)
Page 282		
YK73Q	Head Cleaner Aerosol	DIS (D)
RB03D	Cassette Case	34p (F)
FR80Q	Index Cards	£2.45 (D)●

RESISTORS

Page 284		
M	M1R to M8R2 (1%)	2p (H)●
Page 287		
WR78K	Hor Skeleton 100R	12p (G)●
WR79L	Hor Skeleton 220R	12p (G)●
WR80B	Hor Skeleton 470R	12p (F)●
WR81C	Hor Skeleton 1k	12p (F)●
WR82D	Hor Skeleton 2k2	12p (F)●
WR83E	Hor Skeleton 4k7	12p (F)●
WR84F	Hor Skelton 10k	12p (F)●
WR85G	Hor Skeleton 22k	12p (F)●
WR86T	Hor Skeleton 47k	12p (F)●
WR87U	Hor Skeleton 100k	12p (F)●
WR88V	Hor Skeleton 220k	12p (F)●
WR89W	Hor Skeleton 470k	12p (F)●
WR90X	Hor Skeleton 1M	12p (F)●
WR91Y	Hor Skeleton 2M2	12p (F)●
WR92A	Hor Skeleton 4M7	12p (F)●
WW00A	Vrt Skeleton 100R	12p (F)●
WW01B	Vrt Skeleton 220R	12p (F)●
WW02C	Vert Skeleton 470R	12p (F)●
WW03D	Vrt Skeleton 1k	12p (F)●
WW04E	Vrt Skeleton 2k2	12p (F)●
WW05F	Vrt Skeleton 4k7	12p (F)●
WW06G	Vrt Skeleton 10k	12p (F)●
WW07H	Vrt Skeleton 22k	DIS (F)●
WW08J	Vrt Skeleton 47k	12p (F)●
WW09K	Vrt Skeleton 100k	12p (F)●
WW10L	Vrt Skeleton 220k	12p (F)●
WW11M	Vrt Skeleton 470k	12p (F)●
WW12N	Vrt Skeleton 1M	12p (F)●
WW13P	Vrt Skeleton 2M2	12p (F)●
Page 288		
FW93B	W/W Pot 1k	£2.95 (C)●
FW94C	W/W Pot 5k	£2.95 (C)●
FW95D	W/W Pot 10k	£2.95 (C)●
FX18U	W/W Pot 50k	£3.75 (C)●

SEMICONDUCTORS

Page 291		
BL32K	AD161	88p (E)●
YH93B	AM7910	£34.95 (A)●
WQ18U	AY-3-1015D	£4.75 (B)●
QF37S	BU208	£2.98 (D)
YH58N	CA3080E	£1.25 (E)
QH30H	C106D	42p (E)●
YY75S	ICL7660CPA	£2.95 (C)●
Page 292		
QH35Q	LH0042C	£8.45 (B)
WQ32K	LM334	£1.85 (D)
YY73Q	LM336Z	£2.25 (D)
QH41U	LM381	£2.75 (D)
WQ34M	LM384	£2.95 (D)●
YY88H	LM1830	£3.95 (C)
WQ38N	LM3808	£1.56 (E)
YY96E	LM3915	£3.85 (C)
YY97F	LM3916	£3.85 (C)
YY90X	M108	£8.95 (A)●
YH89W	MC1488N	75p (D)●
YH90X	MC1489N	75p (D)●
QH49D	MC3340P	£2.45 (C)●
WQ42V	MCM4027 250ns	£1.95 (C)●
WQ43W	MC6800P	£4.45 (B)●
WQ44X	MC6802P	£4.95 (B)●
WQ45Y	MC6810AP 450ns	£2.95 (C)●
WQ46A	MC6821P	£2.95 (C)●
QQ03D	MC6845	£10.95 (A)●
WQ48C	MC6850P	£2.45 (C)●
QY36Q	MF10CN	£4.45 (C)●
QH54J	MJE340	78p (F)
QH57M	MJ2801	£2.28 (C)●
YH88Y	ML928	£5.75 (C)●
YH89A	ML929	£5.45 (C)●
QH61R	MPSA65	25p (F)●
WQ54J	NE531	£2.80 (C)
★QH66W	NE 555	28p (F)●
QH67X	NE 556	38p (E)
QH68A	NE 567	£1.98 (D)
YY87U	NE571	£2.95 (C)●
YY88Y	NE5534A	£1.75 (C)●
QH82D	OC45	72p (F)
†QH89W	OC83	80p (F)●
WQ58P	RO-3-2513	£8.95 (B)●
QL08G	SG1495D	£8.75 (C)
QL07H	SG3402	DIS (C)
QY18U	SP8680B	£12.95 (B)●
QL13P	TBA810P	£1.45 (E)●
WH20W	TDA1022	£3.45 (B)●
QY32K	TDA 1102SP	DIS (C)
YY70M	TDA2005M	£4.25 (B)
WQ66W	TDA2006	£1.75 (D)
YH87U	TDA7000	£2.45 (C)
WQ76H	TL172C	70p (D)●
YY86V	TMS1121	£5.96 (B)●
BL22Y	uA723C TO99	56p (E)●
QL22Y	uA741C 8-pin DIL	32p (F)
QL23A	uA741C 14-pin DIL	56p (E)●
QL24B	uA747C	70p (E)●
QQ28F	VK1010	£1.95 (D)●
WQ96E	VN46AF	£2.10 (D)
WQ97F	VN66AF	£2.45 (D)●
QY43W	XR2211CP	£2.98 (C)
QY61R	ZN415E	£1.40 (D)●
QL48C	ZTX302	28p (G)●
QL70M	Z8J	£4.95 (C)●
QW01B	Z80-CTC	£3.75 (C)●
QW03D	Z80-PIO	£3.75 (B)●
QR17T	2N2905	38p (F)●
QR24B	2N3054	80p (E)
BL45Y	2N3055H	95p (E)●
QR50E	2N5458	75p (F)●
Page 293		
QR59P	2SC1162	58p (F)●
QQ35Q	2SJ48	£4.98 (C)
QW09K	2SJ50	£5.95 (B)●
UF31J	2SJ115	DIS (C)●
UF30H	2SK405	DIS (C)●
QW11M	2102 450ns	£1.45 (C)●
QW12N	2114 450ns	£1.95 (D)●
QW13P	2708 450ns	£7.98 (B)
★QQ07H	(2716 350ns)	£3.95 (B)●
★QQ08J	(2732 350ns)	£4.95 (B)●
QQ09K	(2764 250ns)	£4.45 (A)●
YH88V	27128	£8.95 (A)●
QX00A	4000UBE	28p (F)●
QX01B	4001BE	28p (F)●
QL03D	4001UBE	28p (F)●
QX02C	4002BE	28p (F)●
QX04E	4007UBE	28p (F)●
QW14Q	4008BE	68p (E)●
QX05F	4011BE	28p (F)●
QL04E	4011UBE	28p (F)●
QX06G	4012BE	28p (F)●
QX07H	4013BE	38p (F)●
QW15R	4014BE	68p (E)●
QW16S	4015BE	68p (E)●
QX09K	4017BE	68p (E)●
QX10L	4016BE	68p (E)●
QW18U	4021BE	65p (E)●
QX13P	4024BE	56p (E)●
QX14Q	4025BE	25p (F)●
QX16S	4027BE	45p (F)●
QX17T	4028BE	57p (E)●
QW22Y	4032BE	80p (E)●
QW25C	4035BE	80p (E)●
QW26D	4038BE	85p (E)●
QW27E	4040BE	68p (E)●
QW28F	4041UBE	65p (E)●
QX19V	4042BE	57p (E)●
QW29G	4043BE	58p (E)●
QW30H	4044BE	57p (E)●
QW32K	4046BE	68p (E)●
QX20W	4047BE	68p (E)●
QW33L	4048BE	62p (F)●
QX22Y	4050BE	40p (F)●
QW36Q	4052BE	68p (E)●
QW38P	4053BE	68p (E)●
QW41U	4063BE	86p (E)●
QX23A	4066BE = FD1079DS	38p (F)●
QW42V	4067BE	£2.75 (C)●
QX24B	4068BE	28p (F)●
QX25C	4069UBE	28p (F)●
QX28D	4070BE	28p (F)●
QW43W	4071BE	28p (G)●
QX27E	4072BE	28p (D)●
QW44X	4073BE	28p (F)●
QW45Y	4075BE	28p (F)●
QW47B	4077BE	28p (F)●
QX28F	4078BE	28p (F)●
QW48C	4081BE	28p (F)●
QW49D	4082BE	28p (F)●
QW50E	4085BE	68p (F)●
QW52G	4089BE	£1.40 (D)●
QW53H	4093BE	45p (F)●
QW54J	4094BE	80p (D)●
QX29G	4096BE	90p (E)●
QW57M	4099BE	£1.25 (E)●
QW61R	40103BE	£2.25 (D)●
QW62S	40104BE	£1.36 (E)●
QW63T	40105BE	£2.45 (D)●
QW64U	40106BE	80p (F)●
QW65V	40107BE	72p (E)●
QW67X	40109BE	£1.25 (E)●
QW68Y	40110BE	£2.45 (D)●
QW74R	40181BE	£2.45 (C)●
QW78K	40194BE	80p (E)●
QW79L	40257BE	£1.85 (E)●
QW93B	4116 250ns	£1.45 (C)●
XX01B	4136	98p (E)
QQ06G	4164 200ns	£4.45 (B)●
QX30H	4416BE	£1.92 (D)
QX32K	4518BE	49p (D)●
UF23A	4536BE	£2.95 (C)●
QQ47B	4541BE	70p (D)●
UF21X	4598BE	£2.80 (C)●
UF33L	6116 (446) 150ns	£4.25 (B)●
UF34M	(6264-150ns)	£14.95 (A)●
QQ04E	6402	£5.45 (B)●
QQ02C	6502	£7.95 (B)●
UF25C	6522 VIA	£5.95 (B)●
QX37S	7400	28p (F)●
YF00A	74LS00	28p (G)●
QX38R	7401	28p (F)●
YF01B	74LS01	28p (G)●
QX39N	7402	28p (F)●
YF02C	74LS02	28p (G)●
QX74R	7403	28p (F)●
YF03D	74LS03	28p (G)●
QY24B	74S03	45p (E)●
QX40T	7404	34p (F)●
YF04E	74LS04	28p (G)●
QX41U	7405	34p (F)●
YF05F	74LS05	28p (G)●
QX75S	7406	46p (E)●
QX76H	7407	46p (E)●
QX42V	7408	28p (F)●
YF06G	74LS08	28p (G)●
YF07H	74LS09	28p (G)●
QX43W	7410	28p (F)●
YF08J	74LS10	28p (F)●
QX44X	7411	28p (F)●
YF09K	74LS11	28p (G)●
YF10L	74LS12	28p (G)●
QX45Y	7413	38p (E)●
YF11M	74LS13	38p (F)●
QX46A	7414	80p (D)●
YF12N	74LS14	57p (F)●
YF13P	74LS15	28p (G)●
QX78K	7416	40p (E)●
QX79L	7417	40p (E)●
QX47B	7420	28p (F)●
YF14Q	74LS20	28p (G)●
QX48C	7421	57p (E)●
YF15R	74LS21	28p (G)●
YF16S	74LS22	28p (F)●
QX80B	7425	40p (E)●
QX81C	7426	45p (F)●
YF17T	74LS26	28p (F)●
QX49D	7427	40p (F)●
YF18U	74LS27	28p (F)●
YF19V	74LS28	28p (F)●
QX50E	7430	28p (E)●
YF20W	74LS30	28p (G)●
QX51F	7432	34p (E)●
YF21X	74LS32	28p (G)●
YF22Y	74LS33	28p (F)●
YF23A	74LS37	28p (G)●
QX82D	7438	45p (F)●
YF24B	74LS38	28p (G)●
YF25C	74LS40	28p (F)●
QX54J	7442	74p (E)●
YF26D	74LS42	57p (F)●
QQ52G	74LS47	80p (D)●
QQ53H	74LS48	80p (D)●
YF27E	74LS51	28p (G)●
YF28F	74LS54	28p (F)●
QX56L	7470	57p (F)●
QX57M	7472	57p (E)●
QX58N	7473	57p (E)●
YF30H	74LS73	34p (F)●
QX59P	7474	60p (E)●
YY83E	74ALS74	45p (E)●
YF31J	74LS74	40p (F)●
QX60Q	7475	62p (F)●
YF32K	74LS75	50p (F)●
QX61R	7476	70p (E)●
YF33L	74LS76	45p (F)●
QX85G	7483	£1.10 (D)●
QX63T	7485	£1.10 (C)●
YF36Q	74LS85	80p (E)●
QX84U	7486	40p (F)●
YF36P	74LS86	40p (F)●
QX66W	7490	62p (D)●
YF38R	74LS90	50p (F)●
QX68T	7491	80p (D)●
YF39N	74LS92	62p (F)●
QX69Y	7493	57p (D)●
YF40T	74LS93	62p (F)●
QX70M	7495	68p (D)●
YF41U	74LS95	80p (D)●
QX87U	7496	£1.25 (D)●
QX71N	74107	50p (E)●
YF43W	74LS107	45p (F)●
QX86V	74109	80p (D)●
YF44X	74LS109	50p (F)●
YF45Y	74LS112	50p (F)●
YF46A	74LS113	50p (F)●
QX72P	74118	£1.25 (E)●
QX73Q	74121	50p (E)●
WH00A	74122	74p (E)●
QQ54J	74LS122	80p (D)●
WH01B	74123	80p (E)●
YF48C	74LS123	£1.10 (E)●
★YF49D	74LS125	£1.10 (E)●
YF50E	74LS126	57p (F)●
WH03D	74132	80p (D)●
YF51F	74LS132	80p (E)●
YF52G	74LS136	50p (F)●
YF53H	74LS138	80p (F)●
YF54J	74LS139	80p (F)●
WH05E	74141	80p (D)●
WH06G	74145	£1.10 (D)●
YF56K	74LS145	£1.00 (D)●
QX89W	74150	£1.95 (C)●
WH07H	74151	88p (D)●
YF58L	74LS151	£1.45 (E)●
YF57M	74LS153	80p (E)●
WH08J	74154	£1.45 (C)●
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YF59N	74LS154	£1.75 (E)●
YF59P	74LS155	80p (F)●
YF61R	74LS157	80p (F)●
YF62S	74LS158	72p (F)●
WH09K	74160	£1.10 (D)●
YF63T	74LS160	80p (F)●
YF64U	74LS161	80p (F)●
YF66W	74LS163	80p (F)●
WH10L	74164	£1.10 (C)●
YF67X	74LS164	80p (E)●
YF68Y	74LS165	£1.25 (D)●
YF69A	74LS166	£1.70 (D)●
YF71N	74LS169	£1.10 (E)●

1985 Catalogue Page No.		VAT Inclusive Price
YF72P	74LS170	£1.80 (D)•
YF73Q	74LS173	£1.10 (E)•
WH11M	74174	£1.10 (D)•
YF74R	74LS174	85p (F)•
YF75S	74LS175	80p (F)•
YF76H	74LS181	£1.95 (C)•
YF78K	74LS190	95p (E)•
YF79L	74LS191	95p (E)•
WH12N	74192	£1.25 (E)•
YF80B	74LS192	£1.10 (E)•
YF81C	74LS193	£1.10 (E)•
WH13P	74194	£1.10 (D)•
YF82D	74LS194	85p (E)•
YF83E	74LS195	85p (F)•
YF84F	74LS196	85p (E)•
YF85G	74LS197	85p (E)•
YF86T	74LS221	85p (E)•
YF87U	74LS240	80p (E)•
YF88V	74LS241	80p (E)•
YF90X	74LS243	85p (E)•
★QQ56L	74LS244	80p (C)•
UB67X	74HC245	£2.48 (D)
YF91Y	74LS245	£1.25 (D)•
YF92A	74LS251	85p (E)•
YF93B	74LS253	85p (E)•
YF95D	74LS257	85p (E)•
YF96E	74LS258	85p (E)•
YF97F	74LS259	£1.25 (E)•
QY50P	74LS280	80p (E)•
YF98H	74LS288	80p (F)•
YH00A	74LS273	£1.25 (D)•
YH01B	74LS279	80p (F)•
YH02C	74LS283	80p (E)•
YH06G	74LS298	£1.10 (D)•
UB76H	74HC364	£4.95
UB77J	74HC366	£4.95
★YH11M	74LS365	57p (F)•
YH12N	74LS366	57p (F)•
YH13P	74LS367	57p (F)•
YH14Q	74LS368	57p (F)•
YH15R	74LS373	£1.10 (E)•
YH16S	74LS374	£1.10 (E)•
YH18U	74LS377	£1.45 (D)•
YH19V	74LS378	95p (D)•
YH21X	74LS380	88p (D)•
YH22Y	74LS383	£1.10 (D)•
YH23A	74LS385	£1.25 (D)•
WH02C	74LS629=74LS124	£1.45 (D)•
YH29G	74LS670	£1.95 (C)•
QY08J	74C925	£7.25 (B)
UF53H	75491	75p (E)•
YH40T	8080A	£8.45 (C)•
YH41U	8085A	£4.95 (B)
YH44X	8212	£2.46 (D)•
YH46A	8224	£3.25 (C)•
YH49D	8251	£3.95 (C)•
YH50E	8255A	£4.15 (C)

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QX37S	7400	28p (F)•
YF00A	74LS00	28p (G)•
QX38R	7401	28p (F)•
YF01B	74LS01	28p (G)•
QX74R	7403	28p (F)•
YF03D	74LS03	28p (G)•
QY24B	74S03	45p (F)•
QX81C	7426	45p (F)•
YF17T	74LS26	28p (F)•
YF23A	74LS37	28p (G)•
QX82D	7438	45p (F)•
YF24B	74LS38	28p (G)•
QX05F	4011BE	28p (F)•
QL04E	4011UBE	28p (F)•
QX43W	7410	28p (F)•
YF08J	74LS10	28p (F)•
YF10L	74LS12	28p (G)•
YF14Q	74LS20	28p (G)•
YF16S	74LS22	28p (F)•
YF25C	74LS40	28p (F)•
QX08G	4012BE	28p (F)•
QX50E	7430	28p (F)•
YF20W	74LS30	28p (G)•
QX24B	4068BE	28p (F)•
QX42V	7408	28p (F)•
YF06G	74LS08	28p (G)•
YF07H	74LS09	28p (G)•
QW48C	4081BE	28p (F)•
QX44X	7411	28p (F)•
YF09K	74LS11	28p (G)•
YF13P	74LS15	28p (G)•
QW44X	4073BE	28p (F)•
QX48C	7421	57p (E)•
YF15R	74LS21	28p (G)•
QW46D	4082BE	28p (F)•

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QX39N	7402	28p (F)•
YF02C	74LS02	28p (G)•
YF19V	74LS28	28p (F)•
YF22Y	74LS33	28p (F)•
QX01B	4001BE	28p (F)•
QL03D	4001UBE	28p (F)•
QX80B	7425	40p (E)•
QX02C	4002BE	28p (F)•
QY59P (?)	74LS260	80p (E)•
QX49D	7427	40p (F)
YF18U	74LS27	28p (F)•
QX00A	4000UBE	28p (F)•
QX14Q	4025BE	25p (F)•
QX28F	4078BE	28p (F)•
QX51F	7432	34p (E)•
YF21X	74LS32	28p (G)•
QW43W	4071BE	28p (G)•

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QW45Y	4075BE	28p (F)•
QX27E	4072BE	28p (F)•
QX84U	7486	48p (F)•
YF36P	74LS86	40p (F)•
YF52G	74LS136	50p (F)•
QX26D	4070BE	28p (F)•
YF99H	74LS266	68p (F)•
QW47B	4077BE	28p (F)•
YF27E	74LS51	50p (G)•
QW50E	4085BE	88p (F)•
YF28F	74LS54	28p (F)•

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QW33L	4048BE	62p (F)•
WH03D	74132	80p (D)•
YF51F	74LS132	85p (E)•
QW53H	4093BE	45p (F)•
QX45Y	7413	38p (E)•
YF11M	74LS13	38p (F)•
QX46A	7414	80p (D)•
YF12N	74LS14	57p (F)•
QW84U	40106BE	68p (F)•
QX40T	7404	34p (F)•
YF04E	74LS04	28p (G)•

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QX41U	7405	34p (F)•
YF05F	74LS05	28p (G)•
QX75S	7406	48p (E)•
QX76H	7416	40p (E)•
YH12N	74LS366	57p (F)•
YH14Q	74LS368	57p (F)•
QX25C	4069UBE	28p (F)•
QX78H	7407	48p (E)•
QX79L	7417	40p (E)•
★YH11M	74LS365	57p (F)•
YH13P	74LS367	57p (E)•
QX22Y	4050BE	40p (F)•

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★YF49D	74LS125	£1.10 (F)•
YF50E	74LS126	57p (F)•
QW67X	40109BE	£1.25 (E)•
QW28F	4041UBE	85p (E)•
YF90X	74LS243	85p (E)•
YF87U	74LS240	80p (E)•
YF88V	74LS241	80p (E)•
★QQ56L	74LS244	80p (C)•

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YF91Y	74LS245	£1.25 (D)•
UB67X	74HC245	£2.48 (D)
QX04E	4007UBE	28p (F)•
QW85V	40107BE	72p (E)•
QX50P	7474	80p (E)•
YF31J	74LS74	40p (F)•
YY83E	74ALS74	45p (E)•
QX07H	4013BE	38p (F)•
YF75S	74LS175	80p (F)•
WH11M	74174	£1.10 (D)•
YF74R	74LS174	85p (F)•
YH19V	74LS378	95p (D)•

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YH00A	74LS273	£1.25 (D)•
YH16S	74LS374	£1.10 (E)•
YH18U	74LS377	£1.45 (D)•
QX56L	7470	57p (F)•
QX57M	7472	57p (E)•
QX58N	7473	57p (E)•
YF30H	74LS73	34p (F)•
QX61R	7476	70p (E)•

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YF33L	74LS76	45p (F)•
QX71N	74107	50p (E)•
YF43W	74LS107	45p (F)•
QX66W	74109	60p (D)•
YF44X	74LS109	50p (F)•
YF45Y	74LS112	50p (F)•
YF46A	74LS113	50p (F)•
QX16S	4027BE	45p (F)•
YH01B	74LS279	80p (F)•
QW29G	4043BE	58p (E)•
QW30H	4044BE	57p (E)•
QX72P	74118	£1.25 (C)•
QX19V	4042BE	57p (E)•
YF73Q	74LS173	£1.10 (E)•
QX60Q	7475	62p (F)•
YF32K	74LS75	50p (F)•
YH15R	74LS373	£1.10 (E)•

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YF97F	74LS259	£1.25 (E)•
QW57M	4099BE	£1.25 (E)•
UF21X	4508BE	£2.80 (C)•
YF72P	74LS170	£1.80 (D)•
YH29G	74LS670	£1.95 (C)•
QX70M	7495	88p (D)•
YF41U	74LS95	88p (D)•
WH13P	74194	£1.10 (D)•
YF82D	74LS194	85p (E)•
YF83E	74LS195	85p (F)•
YH23A	74LS385	£1.25 (D)•
QW25C	4035BE	80p (E)•
QW82S	40104BE	£1.35 (E)•
QW78K	40194BE	80p (E)•

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QX87U	7496	£1.25 (D)•
QX86T	7491	80p (D)•
WH10L	74164	£1.10 (D)•
YF67X	74LS164	85p (E)•
YF68Y	74LS165	£1.25 (D)•
YF69A	74LS166	£1.70 (D)•
QW15R	4014BE	68p (E)•
QW16S	4015BE	68p (E)•
QW18U	4021BE	85p (E)•
QW64J	4094BE	80p (D)•
QW63T	40105BE	£2.45 (D)•

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QX85W (?)	7490	62p (D)•
YF39R	74LS90	55p (F)•
YF38N (?)	74LS92	62p (F)•
WH09K	74160	£1.10 (D)•
YF63T	74LS160	80p (F)•
YF78K	74LS190	95p (E)•
WH12N	74192	£1.25 (E)•
YF80B	74LS192	£1.10 (E)•
YF84F	74LS196	85p (E)•
YH21X	74LS380	88p (D)•
QX09K	4017BE	68p (E)•
QX10L	4018BE	68p (E)•
QX32K	4518BE	49p (D)•

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QX88Y	7493	57p (D)•
YF40T	74LS93	62p (F)•
YF64U	74LS161	80p (F)•
YF66W	74LS163	80p (F)•
YF71N	74LS169	£1.10 (E)•
YF79L	74LS191	95p (E)•
YF81C	74LS193	£1.10 (E)•
YF85G	74LS197	85p (E)•
YH22Y	74LS383	£1.10 (D)•
QX13P	4024BE	55p (F)•
QW27E	4040BE	68p (E)•

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QW81R	40103BE	£2.25 (D)•
UF23A	4536BE	£2.95 (C)•
QW68Y	40110BE	£2.45 (D)•

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YF54J	74LS136	68p (F)•
YF56P (?)	74LS155	80p (F)•
YF53H	74LS138	68p (F)•
QX54J	7442	74p (E)•
YF26D	74LS42	57p (F)•
WH05E	74141	95p (D)•
WH06G	74145	£1.10 (D)•
YF56K	74LS145	£1.00 (D)•
QX17T	4028BE	57p (E)•
WH08J	74154	£1.45 (C)•
YF58N	74LS154	£1.75 (E)•

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QQ52G	74LS47	80p (D)•
QQ53H	74LS48	98p (D)•
YF61R	74LS157	88p (F)•
YF62S	74LS158	72p (F)•
YF86D	74LS257	85p (E)•
QW79L	40257BE	£1.95 (E)•
YF98E	74LS256	85p (E)•
YH06G	74LS298	£1.10 (D)•
YF59P	74LS153	80p (E)•
YF93B	74LS253	85p (E)•

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WH07H	74151	88p (D)•
YF58L	74LS151	£1.45 (F)•
YF92A	74LS251	85p (E)•
UB76H	74HC364	£4.95
UB77J	74HC366	£4.95
QX89W	74150	£1.95 (C)•

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QW42V	4067BE	£2.75 (C)•
QW35Q	4052BE	68p (E)•
QW38P	4053BE	68p (E)•

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QX23A	4066BE = FD1079DS	30p (F)•
QX30H	4416BE	£1.82 (D)
QX63T	7485	£1.10 (C)•
YF35Q	74LS85	80p (E)•
QW41U	4063BE	85p (E)•

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QX85G	7483	£1.10 (D)•
YH02C	74LS283	80p (E)•
QW14Q	4008BE	80p (E)•
QW22Y	4032BE	80p (E)•
QW26D	4038BE	85p (E)•
YF76H	74LS181	£1.95 (C)•
QW74R	40181BE	£2.45 (C)•

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QW52G	4089BE	£1.40 (D)•

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QX73Q	74121	50p (E)•
WH00A	74122	74p (E)•
QQ54J	74LS122	80p (D)•
WH01B	74123	85p (D)•
YF48C	74LS123	£1.10 (E)•
YF86T	74LS221	85p (E)•
QX20W	4047BE	68p (E)•
QX29G	4098BE	90p (E)•
WH02C	74LS629=74LS124	£1.45 (D)•
QQ47B	4541BE	70p (D)•

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QW32K	4046BE	68p (E)•
WQ54J	NE531	£2.80 (C)
YY68Y	NE5534A	£1.75 (C)•

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QL22Y	uA741C 8-pin DIL	32p (F)
QL23A	uA741C 14-pin DIL	55p (E)•
QL24B	uA747C	70p (E)•
XX01B	4136	98p (E)

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QH35Q	LH0042C	£5.45 (B)
YH58N	CA3080E	£1.25 (E)

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WQ34M	LM384	£2.95 (D)•

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QL13P	TBA810P	£1.45 (E)•
WQ66W	TDA2006	£1.75 (D)

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YY70M	TDA2006M	£4.25 (B)
QY32K	TDA 1102SP	DIS (C)

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QH41U	LM381	£2.75 (D)

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YY87U	NE571	£2.95 (C)•

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QH49Q	MC3340P	£2.46 (C)•

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QY36Q	MF10CN	£4.45 (C)•

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YY60X	M108	£9.95 (A)•
WH20W	TDA1022	£3.45 (B)•

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QY61R	ZN415E	£1.40 (D)•

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YH67U	TDA7000	£2.45 (C)
QL08G	SG1495D	£8.75 (C)

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QL07H	SG3402	DIS (C)

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YH68Y	ML928	£5.75 (C)•
YH69A	ML929	£5.45 (C)•

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WQ76H	TL172C	70p (D)•
YY86H	LM1830	£3.95 (C)

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YY73Q	LM3362	£2.25 (D)
YY96E	LM3915	£3.85 (C)
YY97F	LM3916	£3.85 (C)

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UF53H	75491	75p (E)•
QY08J	74C925	£7.25 (B)

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YY98V	TMS1121	£5.95 (B)•

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QY18U	SP8680B	£12.95 (B)•

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★QH66W	NE 555	28p (F)•
QH67X	NE 556	38p (E)

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QH68A	NE 567	£1.98 (D)
WQ36N	LM3909	£1.55 (E)

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WQ32K	LM334	£1.85 (D)

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YY75S	ICL7660CPA	£2.95 (C)•

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BL22Y	uA723C TO99	95p (E)•

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QQ02C	6502	£7.95 (B)•
WQ43W	MC6800P	£4.45 (B)•
WQ44X	MC6802P	£4.95 (B)•

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WQ46A	MC6821P	£2.95 (C)•
UF25C	6522 VIA	£5.95 (B)•
WQ48C	MC6850P	£2.46 (C)•
QW03D	Z80-PIO	£3.75 (B)•

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QW01B	Z80-CTC	£3.75 (C)•
YH40T	8080A	£8.45 (C)•
YH41U	8085A	£4.95 (B)
YH46A	8224	£3.25 (C)•
YH50E	8255A	£4.15 (C)

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YH49D	8251	£3.95 (C)•
YH44X	8212	£2.46 (D)•

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YH89W	MC1488N	75p (D)•
YH90X	MC1489N	75p (D)•
WQ18U	AY-3-1015D	£4.75 (B)•
QQ04E	6402	£5.46 (B)•
QQ03D	MC6845	£10.95 (A)•

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QW11M	2102 450ns	£1.45 (C)•
WQ46Y	MC6810AP 450ns	£2.95 (C)•
QW12N	2114 450ns	£1.95 (D)•
UF33L	6116 (446) 150ns	£4.25 (B)•
UF34M	(6264-150ns)	£14.95 (A)•
WQ42V	MCM4027 250ns	£1.95 (C)•
QW83B	4116 250ns	£1.46 (C)•
QQ08G	4164 200ns	£4.45 (B)•

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QW13P	2708 450ns	£7.98 (B)
★QQ07H	(2716 350ns)	£3.95 (B)•
★QQ08J	(2732 350ns)	£4.95 (B)•
QQ08K	(2764 250ns)	£4.45 (A)•
YH88V	27128	£9.95 (A)•

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XY84F	Softy 2 System	£224.25 (A)•
FJ86L	Spare UV Bulb Epr Er	£14.95 (A)•
WQ58P	RO-3-2513	£8.95 (G)•

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YH93B	AM7910	£34.95 (A)•

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QY43W	XR2211CP	£2.98 (C)

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XX14Q	Soldercons	£1.95 (E)•
BL17T	DIL Socket 8-pin	5p (H)
BL18U	DIL Socket 14-Pin	8p (G)
BL19V	DIL Socket 16-pin	9p (G)
HQ76H	DIL Socket 18-pin	10p (G)
HQ77J	DIL Socket 20-pin	11p (G)
HQ78K	DIL Socket 22-pin	14p (G)
BL20W	DIL Socket 24-pin	14p (G)
BL21X	DIL Socket 28-pin	15p (F)
HQ38R	DIL Socket 40-pin	22p (F)

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★WY08J	Standard Fan	£13.95 (A)•

SPEAKERS & SOUNDERS

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FL39N	Buzzer 6V	£1.25 (E)•
FL40T	Buzzer 12V	£1.25 (E)•
FK81C	6V Buzzer	£1.65•
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FK80B	Musical Buzzer LBM 7	£3.95 (D)•
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WF54J	Direct Radiant Piezo	£4.95 (C)•
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LB23A	Mag Earpiece 2.5mm	30p (G)•

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LH82D	Boom Mic Headphone	£17.95 (A)•
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YJ01B	Tweeter J40 8R	£17.95•
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XG46A	Spkr 10in 100W GP 8R	£32.95 (A)•
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XG51F	Spkr 12in 100W TC16R	£34.95 (A)•
XG52G	Spkr 15in 100W 8R	£38.95 (A)•

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XG54J	Spkr 18in 300W 8R	£84.95 (A)•

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XY73Q	10W Shelf Spkrs	£21.95 (A)•
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FG09J	Soldering Aid Set	£4.46 (C)
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HX12N	Large Pot Core	£1.46 (E)•
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MEASUREMENTS IN ELECTRONICS

By Graham Dixey C.Eng., M.I.E.R.E. Part Six

One of the most exciting aspects of electronics as a hobby is the enormous variety of circuits that can be built and ideas that can be tried out. But at the end of the assembly, after one's careful wiring up comes the crucial phase of testing. Does it work at all? If it appears to work, does it work properly i.e. does it meet its performance specification in every detail? It may be argued that it isn't always necessary to test a circuit or system objectively if a subjective assessment appears to show that all is well. There is some truth in this. Having built a hi-fi amplifier, for example, and then having taken the bull by the horns and switched it on, it seems to work alright, why worry further? Well for one thing, it's a brave man (or a foolish one!) who will be so trusting as to apply power to an expensive circuit without some preliminary checks. And anyway, isn't it worth while getting some correlation between electrical performance and sound quality? Presumably, we built the amplifier, not just because we're music buffs but also because of our interest in electronics. It's up to us to increase our understanding of the subject by measuring the circuit performance not only with our ears but by the dispassionate attachment of electronic instruments to the circuit. This, the final article in this series, will explain some of the ways in which a typical circuit might be evaluated.

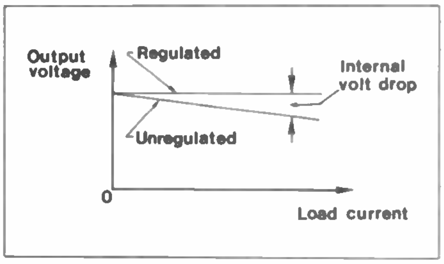


Figure 1. Characteristics of regulated and unregulated power supplies.

Some Preliminary Checks

Assume that a circuit has been built and is ready for testing. There are certain safety checks that should be made before applying power. Some 'chips' can be quite expensive and the last thing that is wanted is an avoidable assembly error resulting in another cheque being written out at square one. Be especially careful where connection to the mains has to be made since such voltages can be injurious to your health as well as that of your components. It is a good idea to test the power supply quite separately from the main circuit. So, disconnect the supply lines from the circuit board first. Next check that any electrolytic capacitors in the power supply are connected in the right polarity. Check that any regulator chips of the plug-in type are the right way round in their sockets. There is always the possibility, though a small one, that the mains transformer or a rectifier or regulator is defective. Check for shorts in the latter two items with your multimeter on the ohms range.

Now if you're reasonably happy with the circuit apply the power. Wait a few moments before reaching for a meter. If a strange cooking smell becomes apparent, switch off and investigate your mains transformer. Chances are all will be well; so carry on with the voltage measurements. Keep personal safety in mind with this sort of testing. Avoid direct contact with the mains, use insulated test probes. If you clip the earthy side of your voltmeter to the 0V line at the start, then you'll only need one hand for the measurements; put the other one in your pocket. If your work area has a concrete floor, put a mat down to stand on (preferably rubber). It'll keep your feet warm and reduce risk of shock. Fortunately these days, most circuits are battery powered so the personal safety aspect is less likely to appear.

Naturally the voltages measured with the circuit board disconnected are the 'off-load' voltages. If the supplies are regulated they will read the same values with the main circuit connected; if they don't something is wrong. In an unregulated supply the voltage drops as the load current increases because of the internal volt drop in the transformer and rectifier.

Regulation curves for these two types of supply are shown in Figure 1. You can simulate your circuit's current demand with a dummy load across the power supply lines. Calculate the value of this resistance by dividing rated voltage by known current demand.

For example, if the power supply is to deliver 12V at 400mA then

dummy load value =

$$12/(400 \times 10^{-3}) = 30 \text{ ohms.}$$

Don't forget the power rating of this load though. Using, say, $P = V^2/R$ we get $P = 12^2/30, = 4.8W$ i.e. the required resistor is a small wirewound type of at least this rating and not a small carbon resistor which would normally only be able to handle about ¼W.

If all seems well with the power supplies, turn your attention to the main circuit board. Don't rush into connecting up the supply lines. Curb your impatience and connect your multimeter, on ohms, across the supply rails on the board. Don't necessarily expect to read the same value of resistance as was calculated for the dummy load; life just isn't that simple! But if a much lower value is measured e.g. zero ohms, then something is wrong.

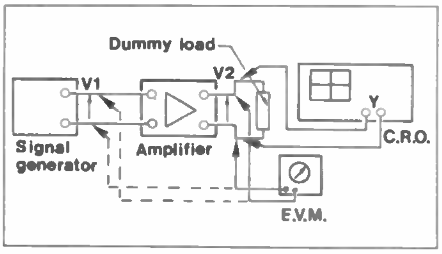


Figure 2. Set-up for measuring amplifier sensitivity.

Carry out a visual check of all soldered joints using a small magnifying glass on IC bases and wherever the tracks are fine. You may find a solder 'bridge' somewhere i.e. an overflow of solder from one track to the next. Check the correct siting, values and polarities of all components. If no obvious error is found, leave the multimeter on the ohms range, showing the 'low' on the supply rails and systematically, as far as possible, disconnect power feeds to various parts of the circuit until the low resistance reading disappears. Such elimination may involve lifting one end of a resistor. Faulty chips can be eliminated by lifting them out in turn until the 'low' disappears. If the fault is cleared, or there was no fault, it is time to go on to the next stage.

At least nothing very dramatic is likely to occur with power on so the supply lines can be connected up to the circuit board and the power switched on. Certain controls such as volume controls are better set to their minimum settings first. What actually happens next de-

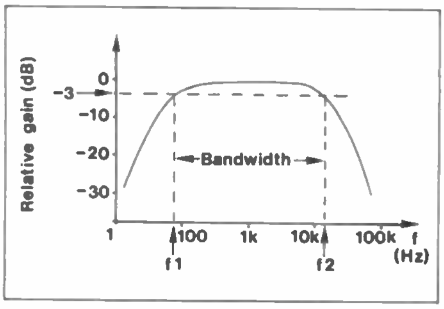


Figure 3. Bandwidth of an amplifier.

pends upon the nature of the circuit, whether it is an audio amplifier or a musical doorbell or whatever. It may not work correctly. If it doesn't it will be necessary to apply a fault-finding procedure as described in Part Five of this series to find the faulty component. But when all is well, the circuit can be evaluated.

Measuring Audio Amplifiers

This example is chosen because of the variety of testing techniques that can be demonstrated. The full specification for a quality amplifier can be quite daunting when it comes to testing it. Some measurements, such as that of Total Harmonic Distortion and Signal/Noise ratio are very difficult for the amateur to measure as they require specialised equipment. However, there is a lot that can be learnt about the performance of an audio amplifier with just a signal generator, electronic voltmeter (EVM) and a cathode ray oscilloscope (CRO). With such items of test equipment it is possible to measure sensitivity, bandwidth, input and output impedances, effect of tone controls, etc.

Sensitivity of Amplifiers

Sensitivity is defined as 'the input voltage required to produce full output'. The nature of the amplifier will decide what is meant by full output. If, for example, the amplifier is just a two-stage voltage amplifier, then the required output will be some specified voltage level (without distortion). But the subject of the test may be a fully-fledged audio amplifier with multiple input facilities, tone controls, etc. In which case each separate input e.g. MIC, PHONO, TAPE, RADIO will have its own sensitivity figure; the output will be the rated power output of the amplifier. Whatever the type of amplifier the set-up is shown in Figure 2.

Assume that the amplifier is of the more complex type; set all tone controls 'flat', volume control to maximum, balance control (if stereo) midway and replace speakers with dummy loads. These loads should have a value nominally equal to the speaker impedance (a very indeterminate quantity anyway), say 8 ohms and of suitable power rating. It is unlikely that a power output meter will be available, so power will have to be measured indirectly. This is done by measuring the RMS voltage across the load R with an EVM and dividing this voltage squared by the load resistance, i.e. $P = V_{RMS}^2/R$. Putting it the other way round, for any given power output,

$$\text{voltmeter reading} = \sqrt{\text{power output x load R}} \quad V_{(RMS)}$$

For example, if the amplifier has a power rating of 30W and the load is 8 ohms, then

$$\text{voltmeter reading} = \sqrt{30 \times 8} = \sqrt{240} = 15.5\text{V}$$

Note that the above is based on the RMS value of output voltage and is thus average continuous wave power (often erroneously referred to as RMS power). Beware of the term 'music power', which is merely the capacity of the amplifier to supply such power for a specified short time at a given distortion figure. If your amplifier specification includes music power, don't expect to get this output from your amplifier; anticipate about half this value on these tests.

Thus, to measure sensitivity the signal generator is turned up until the load reads this value of voltage. The test frequency would normally be a mid-band frequency e.g. 1kHz. The CRO is used purely to check that the amplifier does not go into distortion; if it does it is not delivering rated output. All being well, the EVM is transferred to the input to read the voltage there, on a much lower range of course. This gives the sensitivity figure of the amplifier which, as an example, might be specified as:

100mV for 30W into 8 ohms

For a stereo amplifier, this test should be repeated for the other channel. In the case of multiple inputs already mentioned, the test would be carried out for each separate input. There will be radical differences between the sensitivities for different types of input. For example, on RADIO, the sensitivity might be 50-100V but on PHONO only 1-2mV would drive the amplifier to full output, assuming a moving coil-type pick up.

Amplifier Bandwidth

The generally accepted way of specifying the bandwidth of an amplifier is that 'it is the frequency difference between the two frequencies at which the output is 3dB below the mid-band i.e. 0.707 of the output voltage at mid-band, usually 1kHz.' This is illustrated in Figure 3. In practice one might as well say that it 'equals' the value of the upper

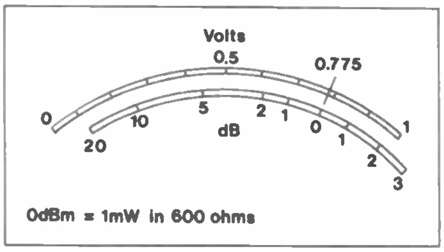


Figure 4. Correspondence between voltage and dB scales of electronic voltmeter (EVM).

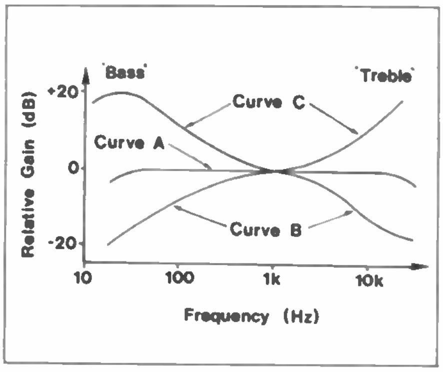


Figure 5. Response curves of amplifier tone controls.

-3dB frequency f_2 since $f_2 - f_1 = f_2$, f_1 being so small compared with f_2. However, for audio work, it is not just the bandwidth $f_2 - f_1$ that matters but the individual frequencies themselves. For example, if two amplifiers have the same upper -3dB frequency of 18kHz but different low frequency points, say 40Hz and 100Hz respectively, then even though the bandwidth is virtually the same in both cases, the former is much richer in bass response than the latter and will sound quite different.

The bandwidth may be measured using either the dB or voltage scales of the EVM. Figure 4 shows the corresponding scales on a typical instrument. The same set-up is used as in Figure 3, but there is no need to transfer the EVM to the input. The reference point of 0dB, by the way in which it is defined, usually corresponds to 0.775V (see Apendix A); therefore it is unlikely that the amplifier will be overloaded at this level. However, the CRO will confirm this. Thus, if the input to the amplifier is adjusted so that the EVM reads 0dB at 1kHz, then the frequency is first reduced, then increased, until the reading falls to -3dB in each instance, giving the 'cut-off frequencies' f_1 and f_2. The voltage level out of the signal generator should not be re-adjusted once set initially at 1kHz.

Alternatively, the input at 1kHz may be adjusted to give, say, 1V output. An output of 3dB below 1V = 0.707 x 1V = 0.707V, so the procedure is the same as before except that now we are looking for two readings of 0.707V rather than -3dB; the frequencies f_1 and f_2 are of course the same.

Overall Response and Effect of Tone Controls

The previous ideas may be extended to obtain a complete frequency response graph including the degree of bass and treble cut and lift. Because of the wide frequency range encompassed a logarithmic frequency scale has to be used. The vertical scale may be voltage output or the ratio voltage out/voltage in = voltage gain. But it is usually plotted as 'relative gain in dB', by which is meant 20 log . (voltage gain at test frequency/voltage gain at reference frequency). The reference frequency is usually 1kHz.

So if, as before, the amplifier input is adjusted to give an output reading of 0dB at 1kHz, the frequency can be varied in convenient steps to cover the required range, the input level not being touched again during this procedure. With the tone controls set 'flat' this gives the basic response, which should be quite uniform over a very wide band. This is curve A in Figure 5. Then both controls can be set to 'cut', followed by both set to 'lift' to obtain curves B and C respectively. These show the maximum degrees of cut of lift at any point within the amplifier's response.

Terminal Impedances of Amplifier

These are the values of impedance that appear between either the amplifier's signal input terminals or output terminals. The importance lies in the principle of matching these impedances to the signal source (e.g. pick-up) or load (e.g. loudspeaker). In audio work, for example, the values of terminal impedances influence the characteristics of the devices mentioned. Outside the audio field, one may be interested in measuring the input of a circuit where a very high impedance is required, as in the first stage of an electronic voltmeter. Because these impedances are dynamic quantities, they cannot be measured by anything as simple as an ohmmeter. They have to be measured under working conditions using signals. There are two very similar methods, shown in Figure 6, for measuring input impedance.

Taking circuit (a) first, the calibrated resistor R is set to zero and the output level of the signal generator, at 1kHz, is adjusted for any convenient reading of the EVM (below maximum output to avoid distortion). Resistor R is then increased until the EVM reading falls by 6dB i.e. to half its original reading. The value of R then equals the input impedance of the amplifier. It would be nice if R was a proper decade resistance box but if it isn't, don't worry. Use a convenient potentiometer and then use an ohmmeter to measure its resistance. This won't be as accurate, of course, but the chances are that a high degree of accuracy is less important than just a close approximation. This technique tends to run out of steam at high input impedances, of the order of Megohms. Any attempt to adjust R results in the injection of mains hum into the amplifier whenever one's hand gets anywhere near the variable resistor. This is overcome by circuit (b).

A 1nF capacitor is selected, which has a value as close as possible to this stated value. The closer its value to 1nF (1000pF) the more accurate the result. The signal generator is set to a frequency at which the reactance of C is negligible, say 3kHz. A convenient reading of the EVM is obtained as before. Then the frequency is reduced until the EVM reading reduces by 3dB i.e. to 0.707 of its original value. The reactance of C now equals the input impedance.

For example, if the frequency is reduced to 48Hz to produce the 3dB drop,

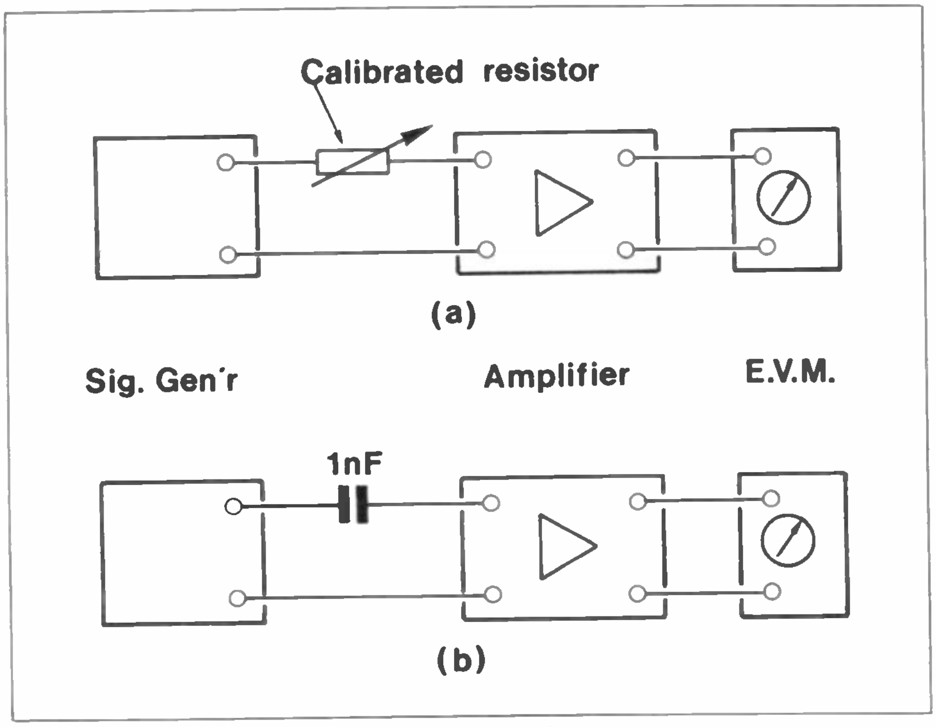


Figure 6. Measuring the input impedance of an amplifier (a) for low to moderate impedances, (b) for high impedances.

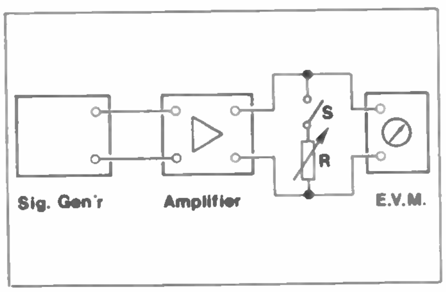


Figure 7. Measuring the output impedance of an amplifier.

then

$$R_{IN} = 1/(2\pi \times f \times C),$$
$$= 1/(2\pi \times 48 \times 10^{-9}) \text{ (1nF} = 10^{-9}\text{F)}$$
$$= 10^9/96\pi$$
$$= 3.3 \text{ Megohms}$$

Two things should be noted. The input impedance is assumed to be essentially resistive, which it usually is. In this second method the reduction in the EVM reading is only 3dB because the phasors of the voltage across the capacitor and the voltage across the amplifier input are at right angles and, together with the signal generator voltage, have a $1:1:\sqrt{2}$ relationship.

The output impedance of an amplifier is usually quite easy to measure unless very low in value. The set-up is shown in Figure 7. With switch S open the signal generator is adjusted to make the EVM read some convenient value. Switch S is then closed and R adjusted until the reading of the EVM is halved (−6dB). The value of R then equals the output impedance.

Other Measurements

The techniques just described are useful for evaluating many forms of amplifier. Such circuits could be said to 'process' the signal, to distinguish them from circuits that actually generate signals e.g. sinewave oscillators, wavetorm generators, etc. Essentially the techniques for evaluating circuits of the latter type have already been discussed when the CRO was dealt with. The methods involve the measurement of amplitude and frequency (or time period). Similarly, the evaluation of digital circuits can be carried out using the CRO and logic probe, which has also been dealt with.

While the subject of electronic measurements is virtually endless, it is hoped that this short series has been of use to the serious constructor and experimenter.

Appendix A - the dB Scale and the dBm

The dB scale of an EVM can be looked at in two ways. In terms of voltage the number of decibels (dB) equals 20 log (V_2/V_1) and thus is not a 'level' but just a logarithmic ratio of two voltages.
For example, if

$$V_2 = 2\text{V and } V_1 = 10\text{mV},$$
$$\text{the ratio in dB} = 20 \log (2/10^{-2})$$
$$= 46\text{dB}$$

However, the dB was actually created to compare two 'powers' (in which case No. of dB = 10 log (P_2/P_1) and a related unit is the 'dBm'. The dBm is actually a power level and is the number of dB that a given power level is above or below the reference level of 1mW. Thus, if the output of an amplifier is 1W, its output could also be expressed as 10 log (1W/1mW) which equals 10 log $(1/10^{-3})$ = 30dBm. Because these ideas spring from telecommunications practice, in which a standard impedance (resistance) of 600 ohms is used, the reference level of 1mW i.e. 0dBm actually equals $(0.775\text{V})^2/600\Omega$. Thus, the 0dB mark on the EVM scale coincides with 0.775V on the appropriate range.

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

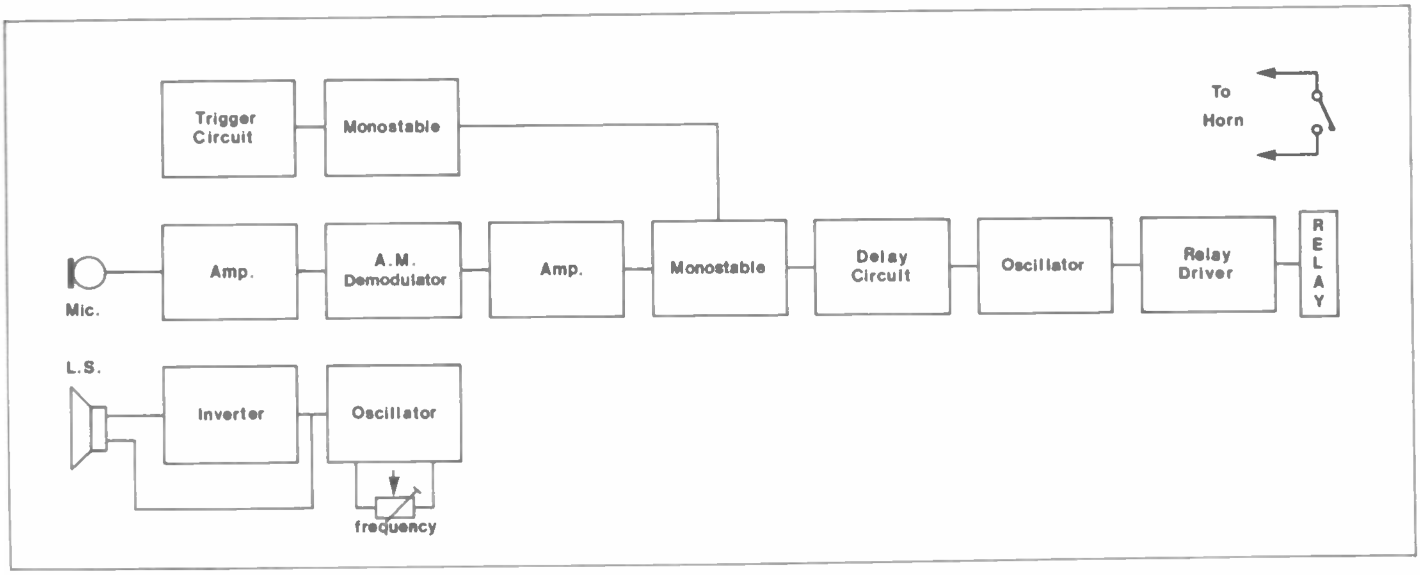


Figure 1. Block Diagram

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

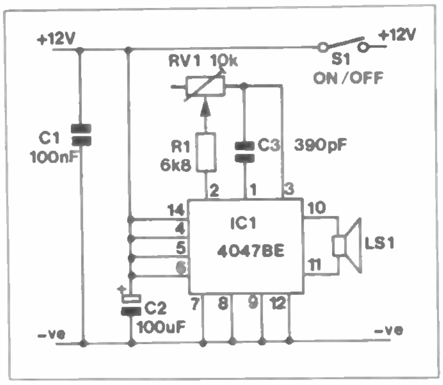


Figure 2. Ultrasonic Transmitter Circuit Diagram

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 $\overline{Q}$ 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

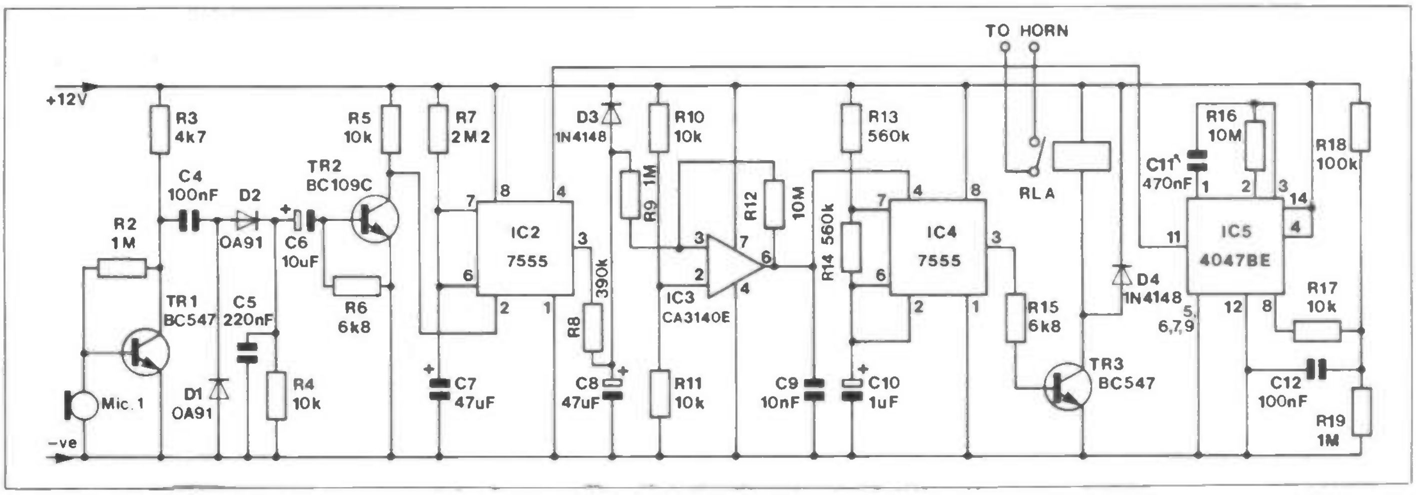


Figure 3. Receiver and Alarm Circuit Diagram

(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 $\overline{Q}$ 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-

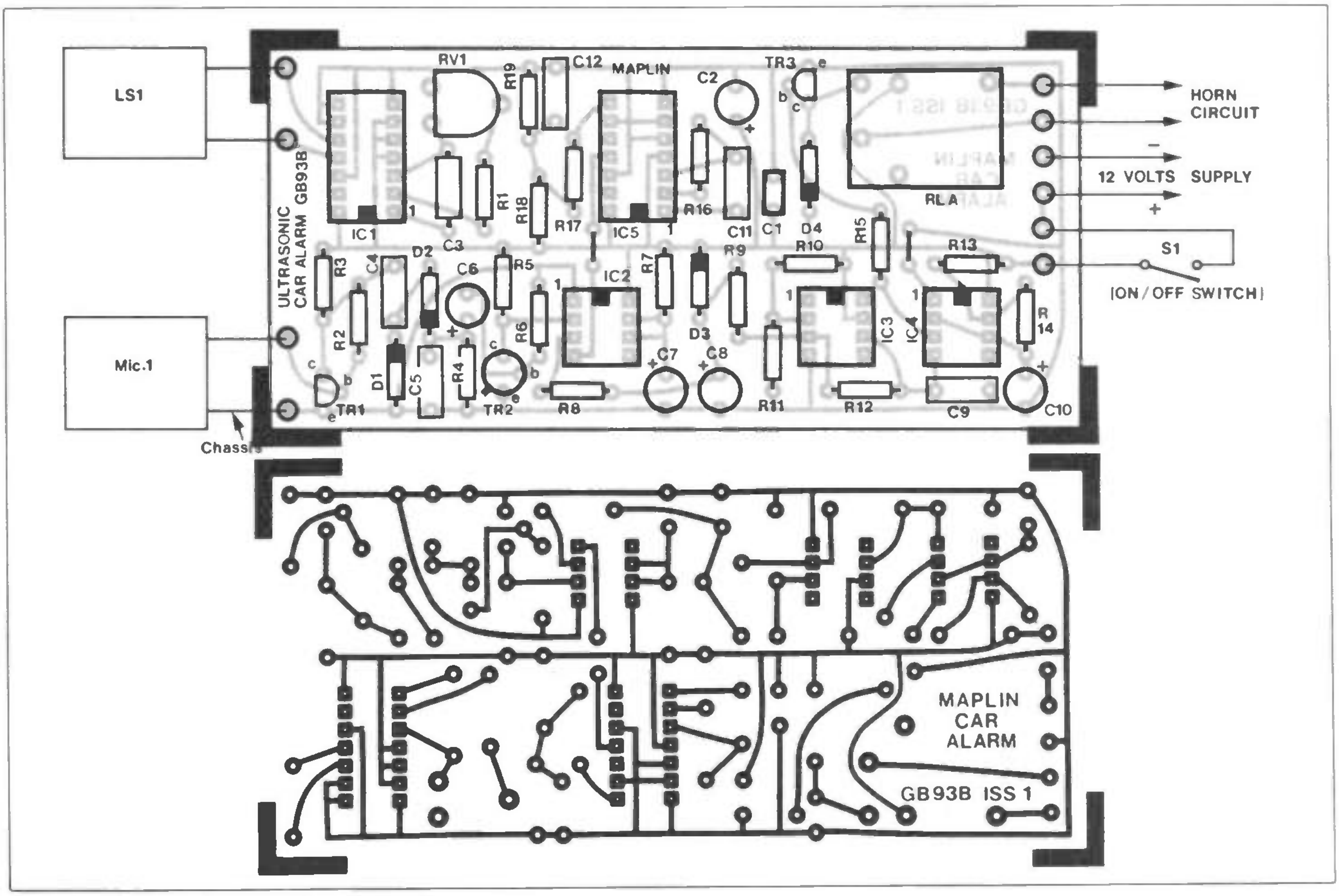


Figure 4. PCB Artwork and Legend

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 heatshunt 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 tendancy 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 24 inches directly in front of the piezo transducers. A multimeter set to say 5V DC can be connected across C5 and 0V. 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 PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1,6,15	6k8	3	(M6K8)
R2,9,19	1M	3	(M1M)
R3	4k7	1	(M4K7)
R4,5,10,11,17	10k	5	(M10K)
R7	2M2	1	(M2M2)
R8	390k	1	(M390K)
R12,16	10M	2	(M10M)
R13,14	560k	2	(M560K)
R18	100k	1	M100K)
RV1	10k Hor. Sub-min. Preset	1	(WR58N)
CAPACITORS			
C1	100nF Ceramic	1	(YR75S)
C2	100µF 25V P.C. Electrolytic	1	(FF11M)
C3	390pF Polystyrene	1	(BX52G)
C4,12	100nF Carbonate	2	(WW41U)
C5	220nF Carbonate	1	(WW45Y)
C6	10µF 50V P.C. Electrolytic	1	(FF04E)
C7	47µF 16V Tantalum	1	(WW76H)
C8	47µF 25V P.C. Electrolytic	1	(FF08J)
C9	10nF Carbonate	1	(WW29G)
C10	1µF 100V P.C. Electrolytic	1	(FF01B)
C11	470nF Carbonate	1	(WW49D)
SEMICONDUCTORS			
IC1,5	4047BE	2	(QX20W)
IC2,4	ICM7555	2	(YH63T)
IC3	CA3140E	1	(QH29G)
TR1,3	BC547	2	(QQ14Q)
TR2	BC109C	1	(QB33L)
D1,2	OA91	2	(QH72P)
D3,4	1N4148	2	(QL80B)
MISCELLANEOUS			
S1	SPST Ultra-min. Toggle	1	(FH97F)
RLA	10A Mains Relay	1	(YX97F)
Mic1/LS1	Ultrasonic Transducers	1 pr	(HY12N)
	Printed Circuit Board	1	(GB93B)
	8-pin DIL Socket	3	(BL17T)
	14-pin DIL Socket	2	(BL18U)

A kit of parts is available for this project:
Order As LK75S (U/Sonic Car Alarm Kit) Price £19.95
The following item in the above kit is also available separately, but does not appear in the 1985 catalogue:
U/Sonic Car Alarm PCB **Order As GB93B Price £4.95**

PROJECT FAULT FINDING

By Robert Penfold Part 3

SIGNAL INJECTION AND SIGNAL TRACING EXPLAINED

So far in this series, we have considered very basic and non-technical methods of fault finding, plus current and voltage tests. The old saying about there being 'more than one way to skin a cat' certainly applies to electronic fault finding, and there are often several possible and perfectly valid ways of tackling the problem. The one that offers the best way forward depends on the equipment you have available, your technical knowledge and experience, and to a certain extent, on personal preference. Voltage testing is probably the most common form of checking, but as we discovered in Part 2 of this series, results can often be difficult to interpret correctly, with there often being numerous possible causes for an incorrect reading. Also, it can be difficult to determine just what is an acceptable voltage reading and what is indicative of a fault.

In this third article we will look at two other methods of fault diagnosis. I am not really putting these forward as alternatives for use in place of voltage and current checks, but more as means of augmenting these. The greater the variety of methods of testing you have at your disposal, the greater the chance of locating the fault in a reasonable space of time. When looking for a fault, the normal course of events would be to first look for any obvious physical causes such as accidental short circuits and broken wires, and then to proceed to voltage checks and tests with items of equipment such as signal injectors and trackers. The best approach to adopt after the initial testing for physical damage really depends on the project concerned, and while (say) a signal injector can give speedy results in some cases, it is quite useless in others.

Signal Injection

Signal tracing and signal injection are probably the most popular forms of testing, apart from voltage checks. This form of testing only applies to circuits that take a signal and then process it using a series of circuits. Although by no means all projects fall into this category, a surprisingly large number do, including such things as radios, amplifiers and musical effects units. Even many digital circuits can be tested using a form of signal injection or tracing.

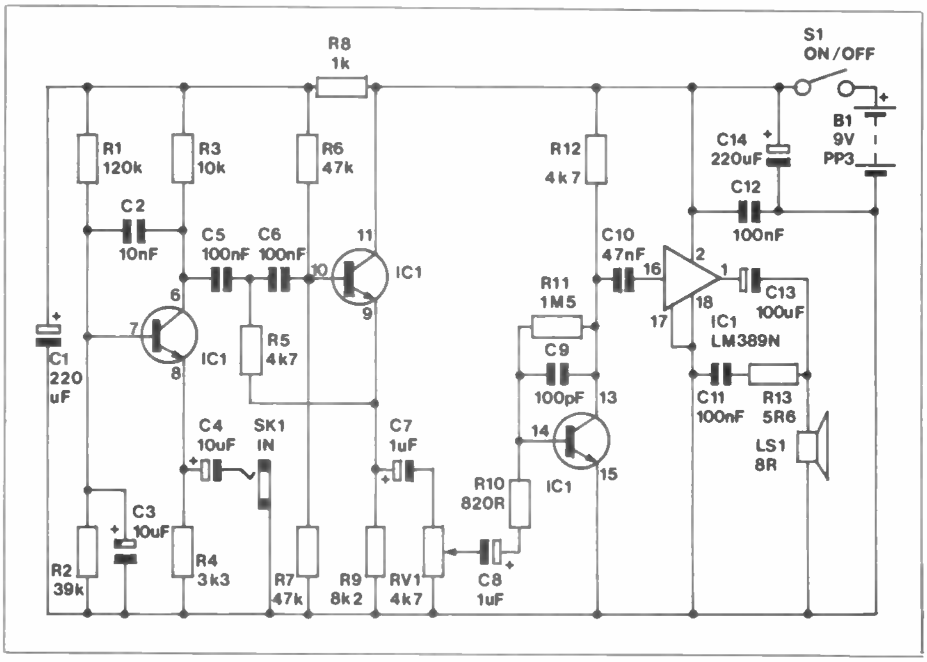


Figure 1. Telephone Amplifier Circuit

A signal injector merely produces an audio squarewave signal, usually at a frequency of about 1kHz. A squarewave signal contains strong harmonics (multiples of the fundamental frequency), and it therefore provides a broad spectrum of radio frequency signals as well as an audio signal. It can therefore be used for testing radio and intermediate frequency stages of radio receivers in addition to audio equipment tests. A point worth noting is that any signal source which provides a signal within the appropriate frequency range can be used for signal injector type testing. Audio and RF signal generators are perfectly suitable for this type of testing when used on the appropriate stages of a receiver (or whatever). For audio testing, it is even possible to use something like the audio output from a radio set or cassette recorder.

The basic method of testing using the signal injection technique is very simple indeed. The signal is injected at various points in the circuit, starting at the output and working towards the input. At some stage the signal will fail to reach the output and the break in the signal path (and presumably the fault as well) then lies between the last test point and the penultimate one. It is not essential to work through the system in this way and an alternative is to make the first check about half way through the signal path. If the signal reaches the output then the fault is in the input half of the circuit; if it does not, the fault is in the output half of the circuit. In this way, half the circuit is quickly eliminated from the search. This process can then be repeated on the half of the circuit containing the fault, then on the quarter which contains the fault, and so on until the precise area of the fault is found. You may prefer to simply work from one end of the circuit to the other which is probably easier for someone of limited experience, and this is a perfectly valid approach for someone who is not involved in professional servicing (where the fastest possible diagnosis is important on economic grounds). Whichever system you adopt, the basic principle is the same, as are the pitfalls that must be avoided.

The telephone amplifier circuit of Figure 1 is a good example of a circuit that lends itself well to the signal injection technique. A description of this circuit was given in the 'Five Easy Pieces' article in issue 12 of this magazine and a detailed description will not be provided here. There are four stages which are, working from the input to the output, a common base amplifier, an active high-pass filter, a common emitter amplifier and a class B audio power amplifier.

The first test could consist of injecting a signal across the loudspeaker. In practice, this would not be advisable since the very low output impedance of the power amplifier (which can be a matter of a few milliohms) is shunted across the loudspeaker and would practically short circuit the output of the signal injector. It is unlikely that this would damage the signal injector but the result of the test would be inconclusive, making it rather pointless. A better way of doing things would be to disconnect the positive terminal of C13 from the output of IC1 and then inject the signal into the free end of C13. Of course, the earth output of the injector is connected to the negative supply rail of the telephone amplifier for all tests.

One problem with many signal injectors is that they give no control over the output level. This can result in little output when driving a loudspeaker, and an excessive signal level for low level stages. This is something that is not too important provided you are aware of it, and in this case even a quiet tone from the loudspeaker would probably indicate that all is well. A proper signal generator gives good control over the output level, and is really preferable for this type of testing, but even a good quality instrument is unlikely to give much output when directly driving a loudspeaker.

If no output is obtained from this test, the next test would be to inject the signal at the other terminal of C13. If this gives an output, then C13 is obviously faulty. If it does not, it would not be correct to assume that the loudspeaker is faulty. First it would be necessary to try connecting the output of the injector direct across the loudspeaker terminals, as the problem could merely be a broken lead in the cable to the loudspeaker.

The next test point would be at the collector of the driver transistor (IC1 pin 13). Although this circuit is a little unusual in that the three transistors are part of IC1 rather than discrete components, this makes no difference as far as voltage checks and signal injection tests are concerned. The output impedance of this stage is relatively high at about 4k7 and it should be perfectly satisfactory to inject the signal here. Failure to produce a strong output signal would mean that the output amplifier, or its immediate circuitry is at fault. C10 might be failing to provide a path for the signal, and injecting the signal direct at the input of the amplifier (pin 16 of IC1) would be one way of checking this. If injecting the signal direct at the input terminal produces an output from the unit, this would indicate that C10 is faulty.

As is the case with voltage tests, care has to be taken when interpreting results of signal injection tests. In this instance, failure to obtain an output with the signal injected to pin 13 or pin 16 of IC1 does not necessarily mean that the output amplifier is faulty. For example, a fault in the driver stage, such as the transistor or R12 going closed circuit, would effectively short circuit the input of the output stage to earth. One way of testing for this would be to disconnect C10 from R11, R12, etc., and to then inject the signal into the free end of C10. With the driver stage no longer able to influence results, the absence of a strong output would indicate a fault in the output stage. On the other hand, if an output is obtained, the driver stage is obviously at fault. This is an example of where a voltage test might prove to be a quicker and easier way of doing things. There should be about half the supply voltage at the collector of the driver stage (pin 13 of IC1). If the transistor or R12 were to go closed circuit the voltage would be 0 volts or 9 volts respectively.

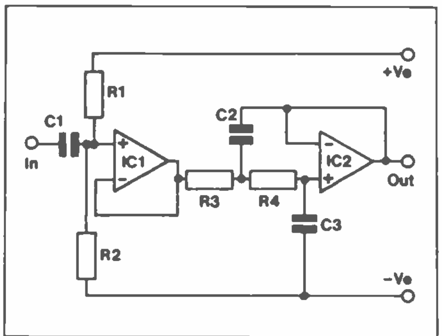


Figure 2. Breaking the Signal Path at R3 would prevent IC2 from functioning properly

If the test at pin 13 of IC1 generated a suitable output signal, then further tests would be at points such as C8+, IC1 pin 9, and IC1 pin 6.

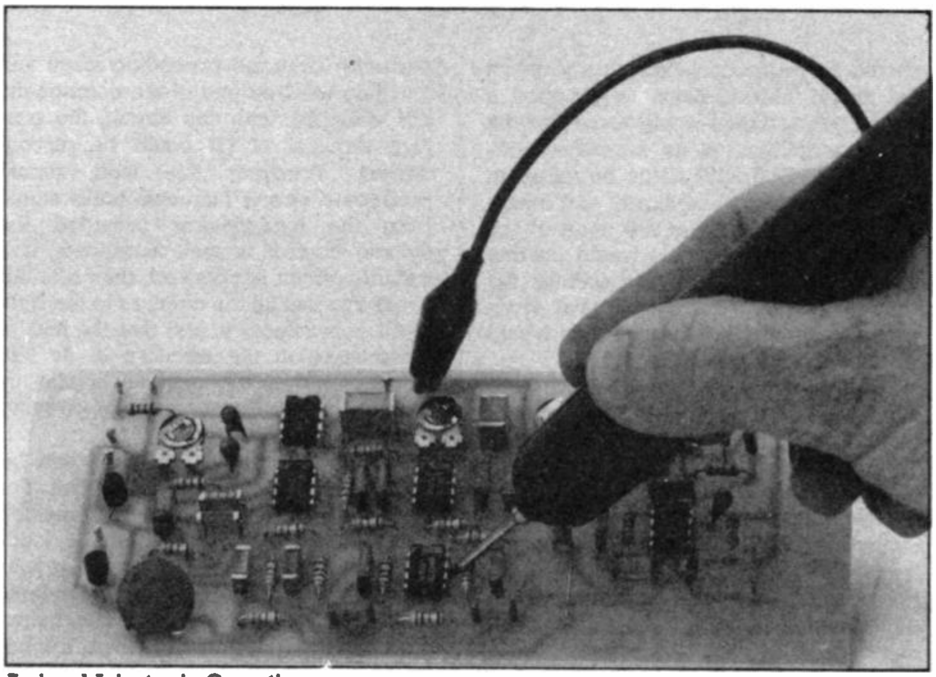
With audio equipment, it is often possible to make signal injection tests without the aid of any equipment whatever. Touching any fairly sensitive point along the signal path should result in a certain amount of hum and noise (picked up in your body) being coupled into the signal path and reproduced from the loudspeaker. One problem with this approach is that the output impedance of the preceding stage can damp the signal being injected (which is usually at a reasonably high amplitude but from a high source impedance). This can be avoided by disconnecting the coupling capacitor from the preceding stage and touching the free end of the component. For example, with this circuit, the positive terminal of C7 could be disconnected. Touching this lead should produce a strong hum and noise signal from the loudspeaker provided the volume control is well advanced. If a suitable output is obtained, then it is fair to assume that all the circuitry to the right of C7 is satisfactory, and that the fault is somewhere in the circuitry to its left. Conversely, if no output signal is obtained, the fault must be in the circuitry to the right of C7.

The same basic approach can be tried at other points of the circuit. For instance, at C5 and C10. This method does not apply to testing of the loudspeaker since the signal pick-up in your body is likely to be well short of the level needed to produce an audible output from the loudspeaker. However, a loudspeaker can easily be tested by connecting it to the earphone output of a radio or cassette recorder or a rough and ready test can be made by simply connecting the speaker across a 9 volt battery via a resistor of a few hundred ohms in value. This test should produce a click from the loudspeaker as it is connected and disconnected.

Of course, this simple touch method of testing should not be used on mains powered equipment that does not incorporate an isolation transformer. In fact, it is not a good idea for someone of limited experience to undertake servicing of any equipment of this type as it would be all too easy to sustain a severe electric shock.

It is often possible to glean useful information without making any proper tests, and experienced radio and television service engineers can sometimes pin-point a fault just by switching on a piece of equipment and making a few observations. With a circuit such as the telephone amplifier, there is relatively little that can be ascertained merely by switching on, but some useful pointers might be obtained. If listening carefully to the output from the loudspeaker reveals at least a small amount of background 'hiss', then it is likely that at least the output stage and probably the driver stage as well are functioning properly. If there is a fair amount of 'hiss', and it varies in sympathy with changes in the setting of the volume control, then it is a fair bet that the fault is somewhere quite near the input of the unit. If there is a total lack of background noise, it is probable that the fault is in the output stage.

When applying any form of signal injection technique that involves breaking the signal path, you must always be careful to only break the path at an AC coupling if erroneous results are to be avoided. The circuit diagram of Figure 2 is a good example of where the signal path should not be broken. This consists of an operational amplifier buffer (IC1) feeding into an active lowpass filter



A signal Injector in Operation

based on a second operational amplifier (IC2). The output of IC1 is a dubious point at which to inject a signal due to the low output impedance of an operational amplifier. Disconnecting R3 from the output of IC1 and injecting the signal into its free end would fail to work because IC2 is biased from the output of IC1 by way of filter resistors R3 and R4. With this path broken, there would be no bias for IC2 and the injected signal would, in all probability, fail to reach the output of IC2 even if no fault was present in the circuit. In this instance, there is an easy solution to the problem and the signal can be injected at the junction of R3 and R4.

Signal Tracing

Signal tracing is a method of fault finding I prefer to the injection method and the tracing system is generally somewhat easier to implement. Before testing can commence, a suitable input signal must be supplied to the equipment under test. This can be provided by a signal generator or injector but in most cases, it would be supplied by the normal signal source for the equipment. In the case of the telephone amplifier, it is obviously not enough to merely plug in the pick-up coil, and a signal must be supplied to the coil. It would not be very convenient to use a telephone to provide this signal, but the coil will pick up any audio frequency magnetic field. For instance, placing the coil near the mains transformer of a mains powered project should provide a 50Hz signal (but obviously the equipment must be switched on). A loudspeaker driven at moderate volume will also produce a suitable field.

Having secured a suitable input signal, the signal tracer is used to determine how far into the circuit the signal gets before it disappears. The fault lies at, or just before, the point at which the signal can no longer be traced.

A signal tracer is really just a highly sensitive amplifier which is capable of detecting very small audio signals. Most types either have an RF probe to permit any reasonable strong and suitably modulated radio frequency signals to be detected, or have a built-in demodulator action so that RF signals can be detected without having to use a special probe.

The telephone amplifier amply demonstrates the need for high sensitivity. The first check would be at the negative terminal of C4 to determine whether or not any signal was actually reaching the input of the amplifier. The output from the pick-up coil is not very great and is typically under 1 millivolt. Other signal sources such as microphones also produce a very low level output signal, and without the ability to produce at least a barely audible output from very low amplitude signals, a signal tracer is of relatively limited value.

A signal tracer normally has a gain control and from the loudness of the output and the setting of the gain control, it is possible to roughly gauge the strength of the detected signal. This is important because the fault will not always produce a complete break in the signal path and might just cause a loss of gain. Faults of this type can be difficult to locate using a signal injector as these normally provide a strong output signal which can sometimes force a significant signal through a faulty stage. With a signal tracer, a stage which has a low level of gain will normally show up quite plainly. If (say) the signal level at the collector of the driver transistor (IC1 pin 13) proved to be little different to the signal at the base of this transistor (IC1 pin 14), this would clearly indicate a fault in the driver stage which would be expected to have a voltage gain of fifty times or more. However, bear in mind that not all stages of a circuit provide any voltage gain. In this circuit, there is a high-pass filter between the input stage and the volume control. This provides only unity gain at band-pass frequencies, and at low frequencies below the cut-off frequency, it can provide quite a lot of attenuation. This is something that would have to be taken into consideration if 50Hz mains hum was used as the input signal.

A useful point to keep in mind is that a signal tracer can be used to detect signals where they should not be, as well as an absence of signals from where they should be. For example, there should be no significant signal present across a decoupling capacitor such as C3. If a significant signal is detected across a decoupling capacitor, it almost certainly means that the component is faulty.

So far we have assumed that the fault causes a complete break in the signal path or severe losses. In practice, faults do not always manifest themselves in this way and the problem might be severe distortion with little or no loss of gain. This is another occasion when a signal tracer is likely to be of much more use than a signal injector. With a sinewave signal or an audio signal such as speech or music fed to the input of the circuit, even moderate levels of distortion are likely to be easily detected using a signal tracer. Rather than working from the input to the output of the unit checking for a loss of signal, it is then a matter of checking for the increase in distortion.

Checking for distortion with a signal injector is likely to prove fruitless. The square-wave output signal when distorted is likely to remain little changed (a clipped square-wave is a square-wave), and more importantly, the audio output is unlikely to sound significantly different.

These are alternatives to using a signal tracer for the type of testing described above, and an oscilloscope is often used as a form of signal tracer. This enables precise measurements of such things as voltage gain and signal amplitudes to be made, as well as permitting signal waveforms to be viewed. To describe methods of testing using an oscilloscope really requires a complete article and this is not something that will be considered here.

At the other end of the scale, a crystal earphone will suffice for much signal tracing work and I use one of these extensively in this application. The jack plug is removed and replaced by a couple of crocodile clips or clip type test prods. Although a signal level of about 1 volt peak to peak is needed in order to generate an output at high volume, signals of only a few millivolts will give an audible output. This type of earphone has a fairly high input impedance and a DC resistance that is extremely high so that the biasing of the circuit under test is not affected significantly. It is only fair to point out a couple of limitations which are the inability to detect really small signals of under a millivolt, and the inability to directly detect RF signals even if they are modulated. Despite these limitations, this very simple piece of test gear can be invaluable when testing audio equipment and even when testing digital circuits. The usefulness is certainly totally out of proportion to its very low cost.

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.

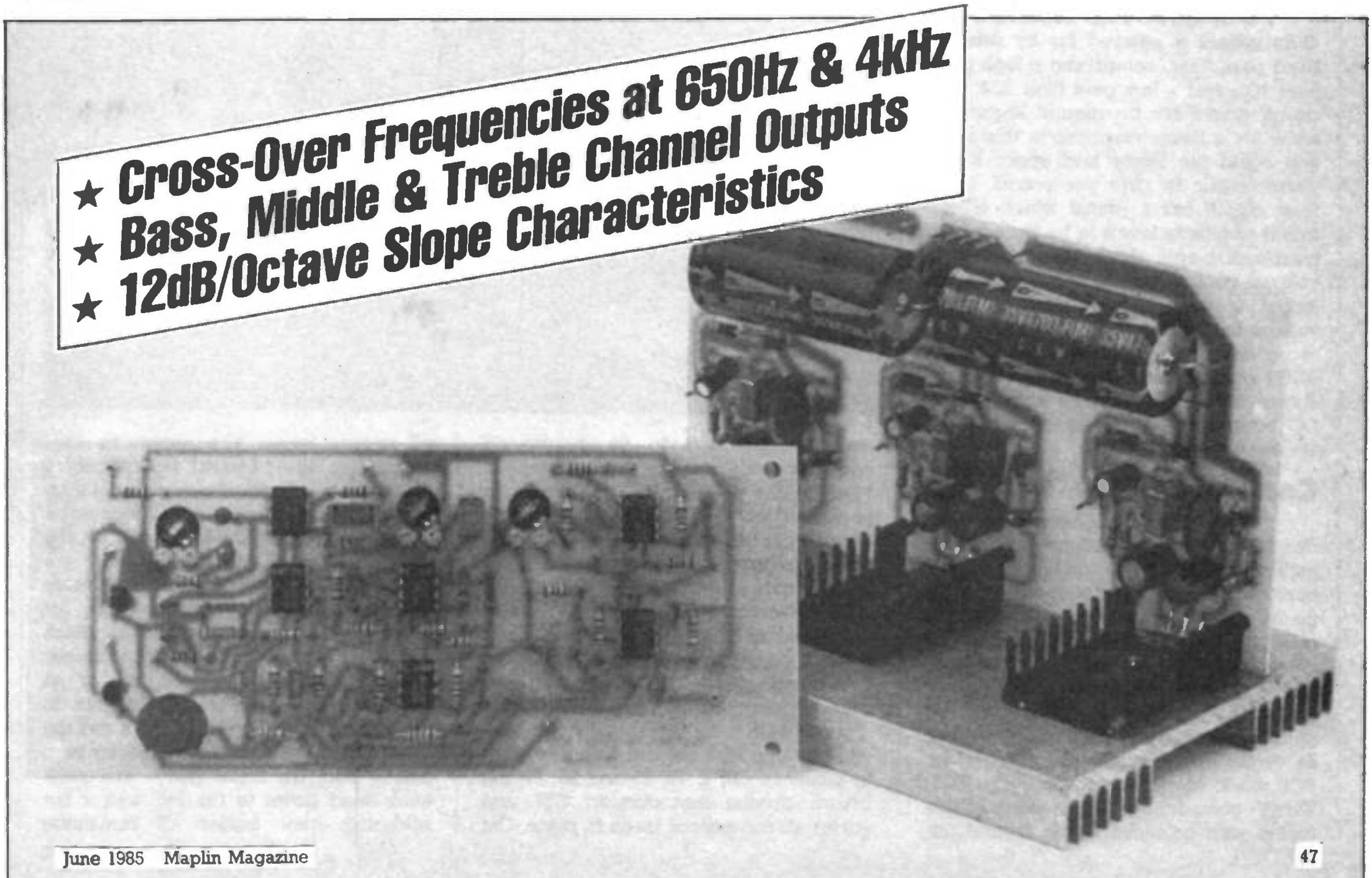
The Active Cross-Over Module does this electronically, providing more precise control over the frequency bands presented to each of the three loudspeakers. This active filter is not capable of driving loudspeakers directly, and so a power amplifier, one for each channel, must be provided between the 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 8Ω 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



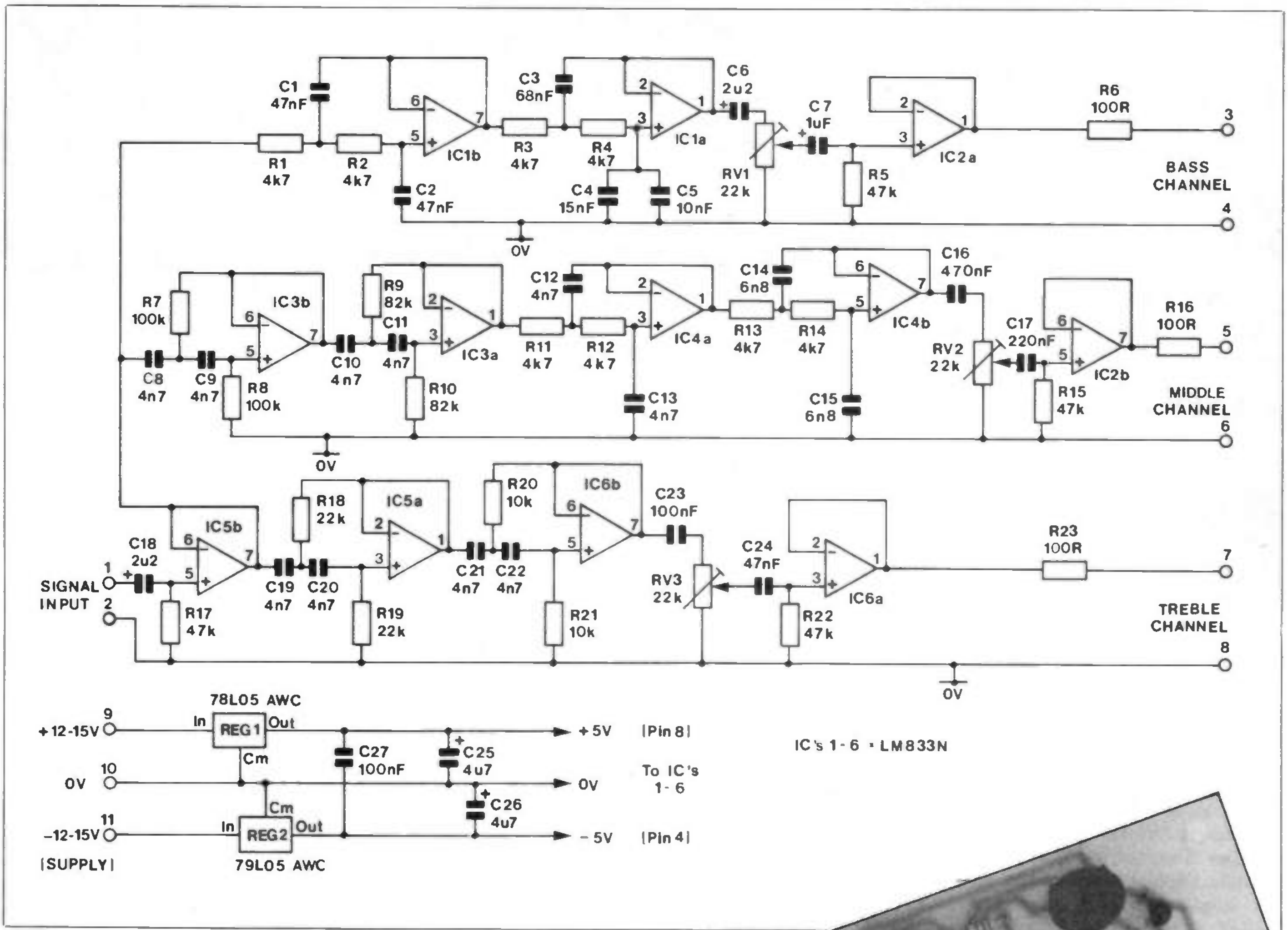
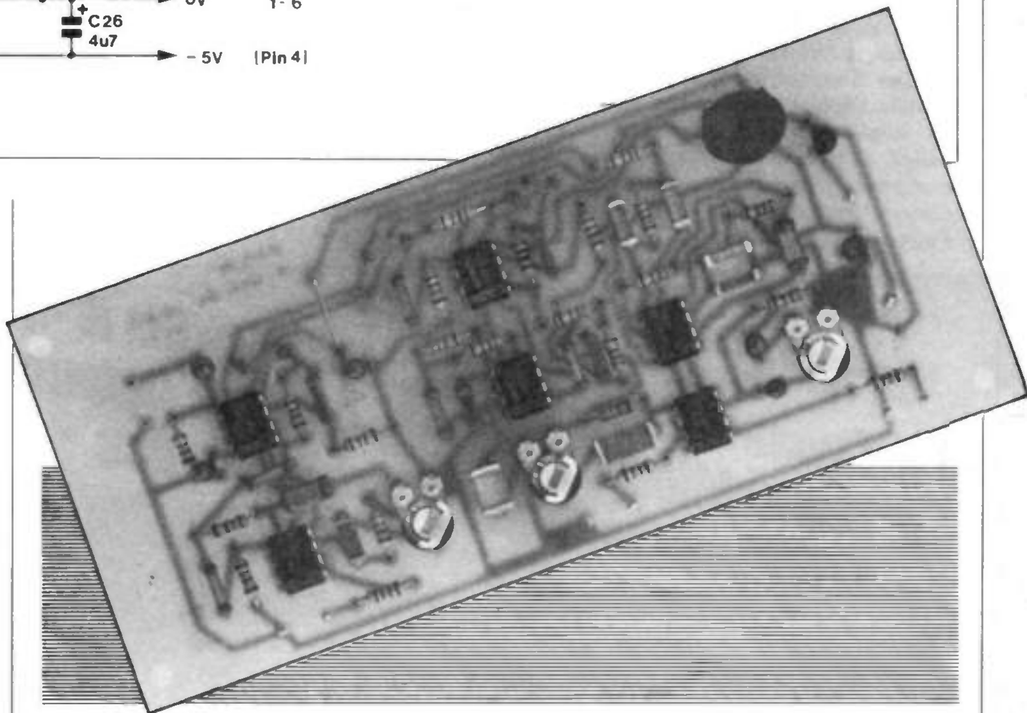


Figure 1. Cross-Over Circuit Diagram

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 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 +/− 5V to the Active Cross-Over circuit, and require DC inputs of +/− 8V to +/− 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 0.047μF 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

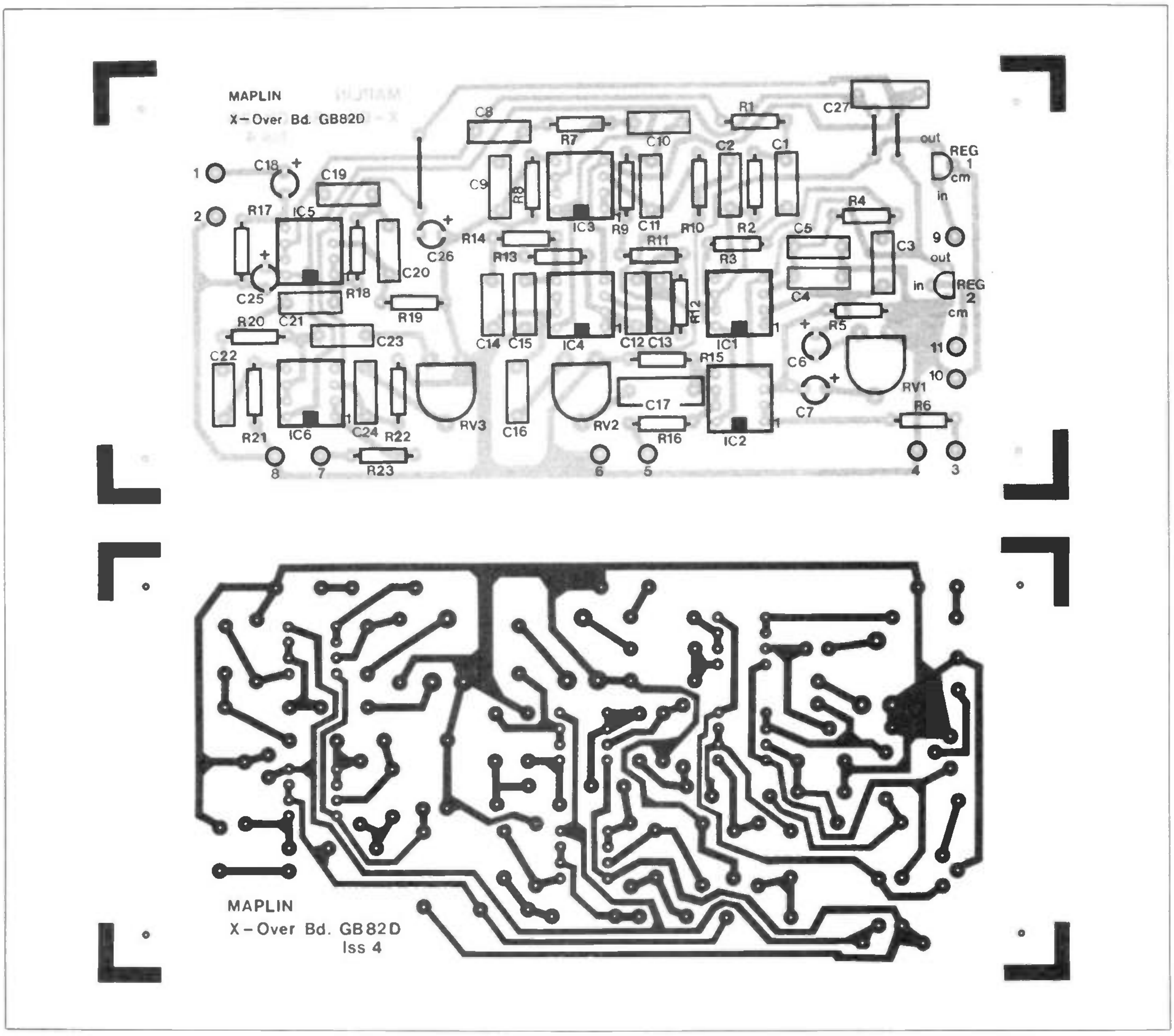


Figure 2. Cross-Over Track and Overlay

omponents 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 (±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 (±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) then there may be an incorrectly fitted, or faulty IC.

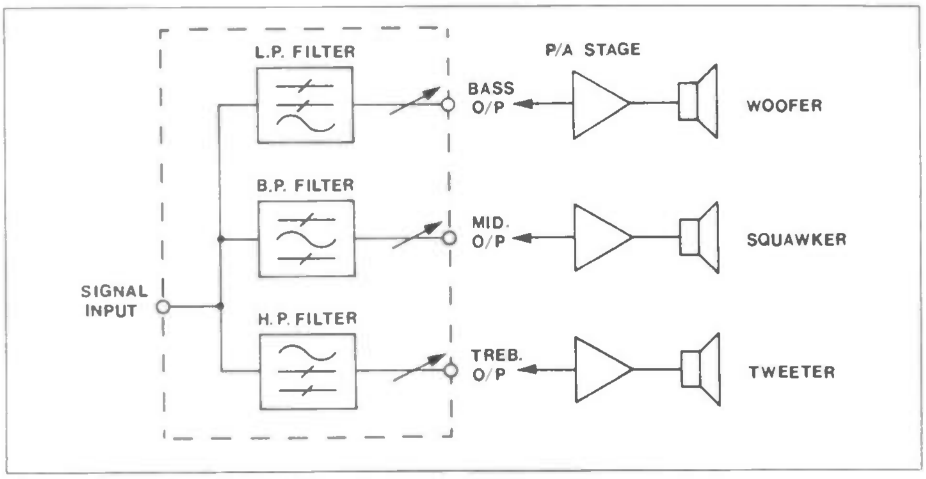


Figure 3. Cross-Over Block Schematic

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.

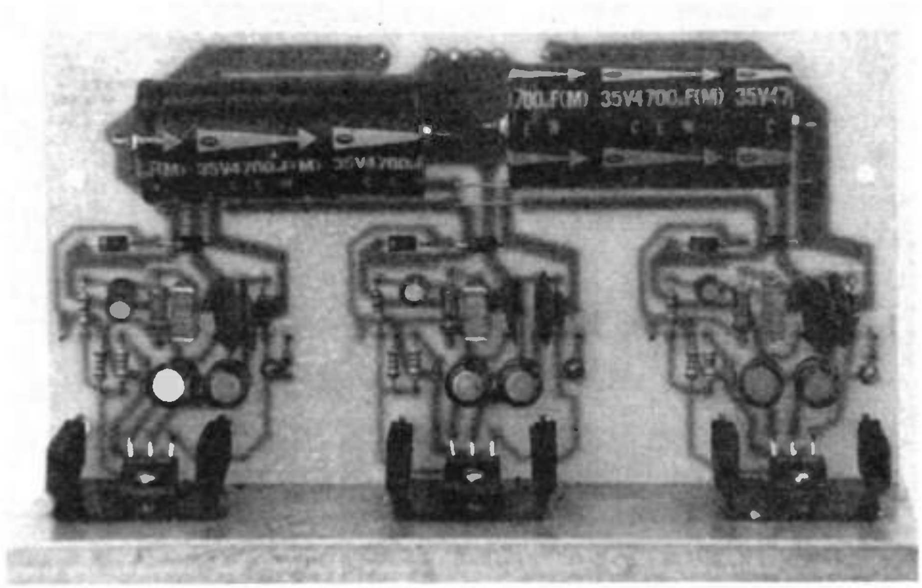
Amplification

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* +/− 19V DC (38V). Again, this problem is eased by using a dual supply derived from a 12V/0V/12V transformer. Without the



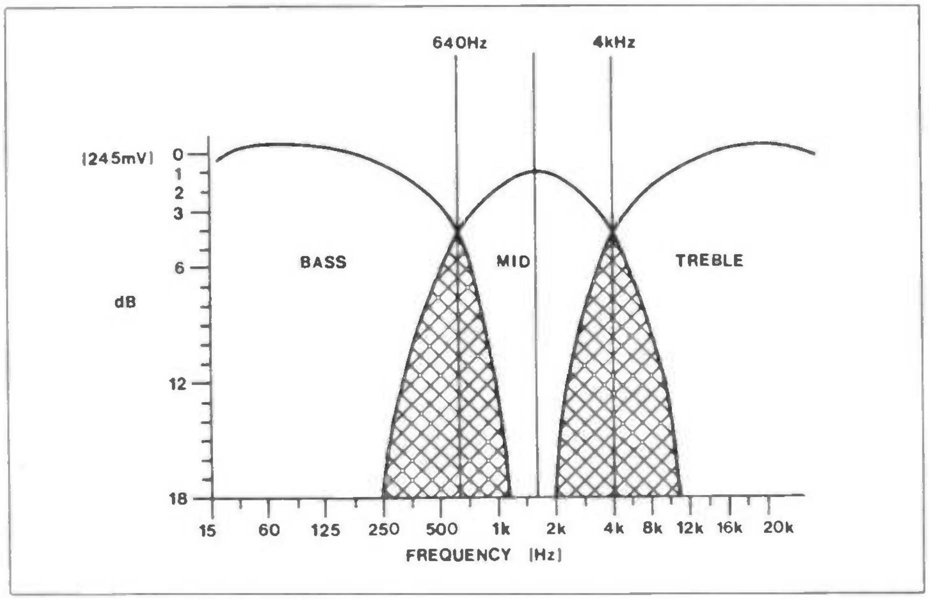
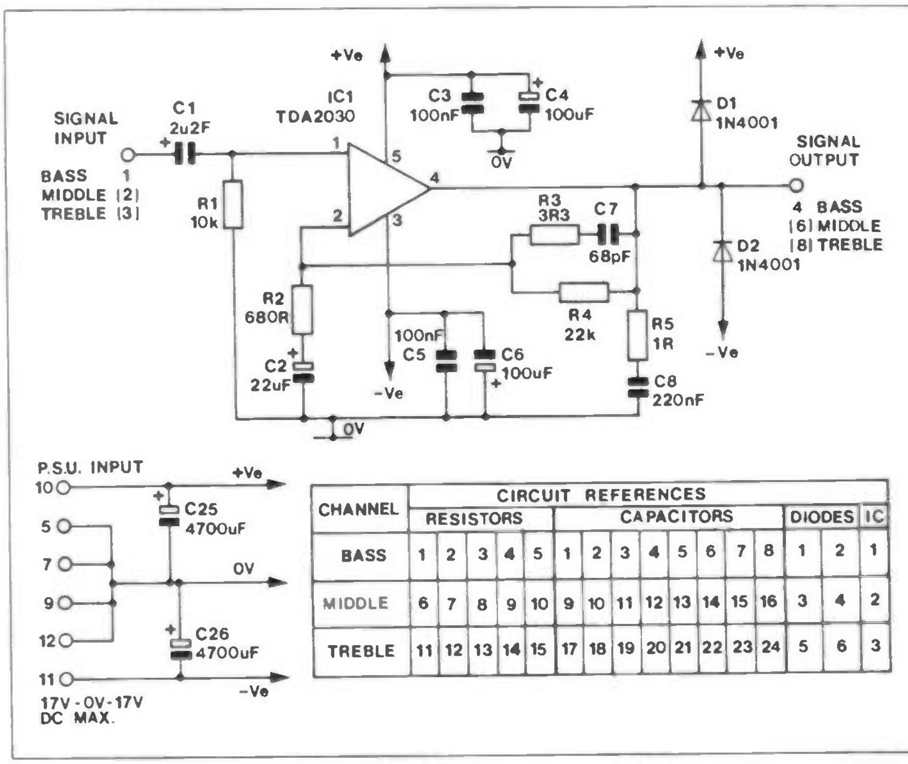


Figure 4. Typical Response Curves



CHANNEL	CIRCUIT REFERENCES															
	RESISTORS					CAPACITORS								DIODES		IC
BASS	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	1
MIDDLE	6	7	8	9	10	9	10	11	12	13	14	15	16	3	4	2
TREBLE	11	12	13	14	15	17	18	19	20	21	22	23	24	5	6	3

Figure 5. 3 Channel Amplifier Circuit Diagram

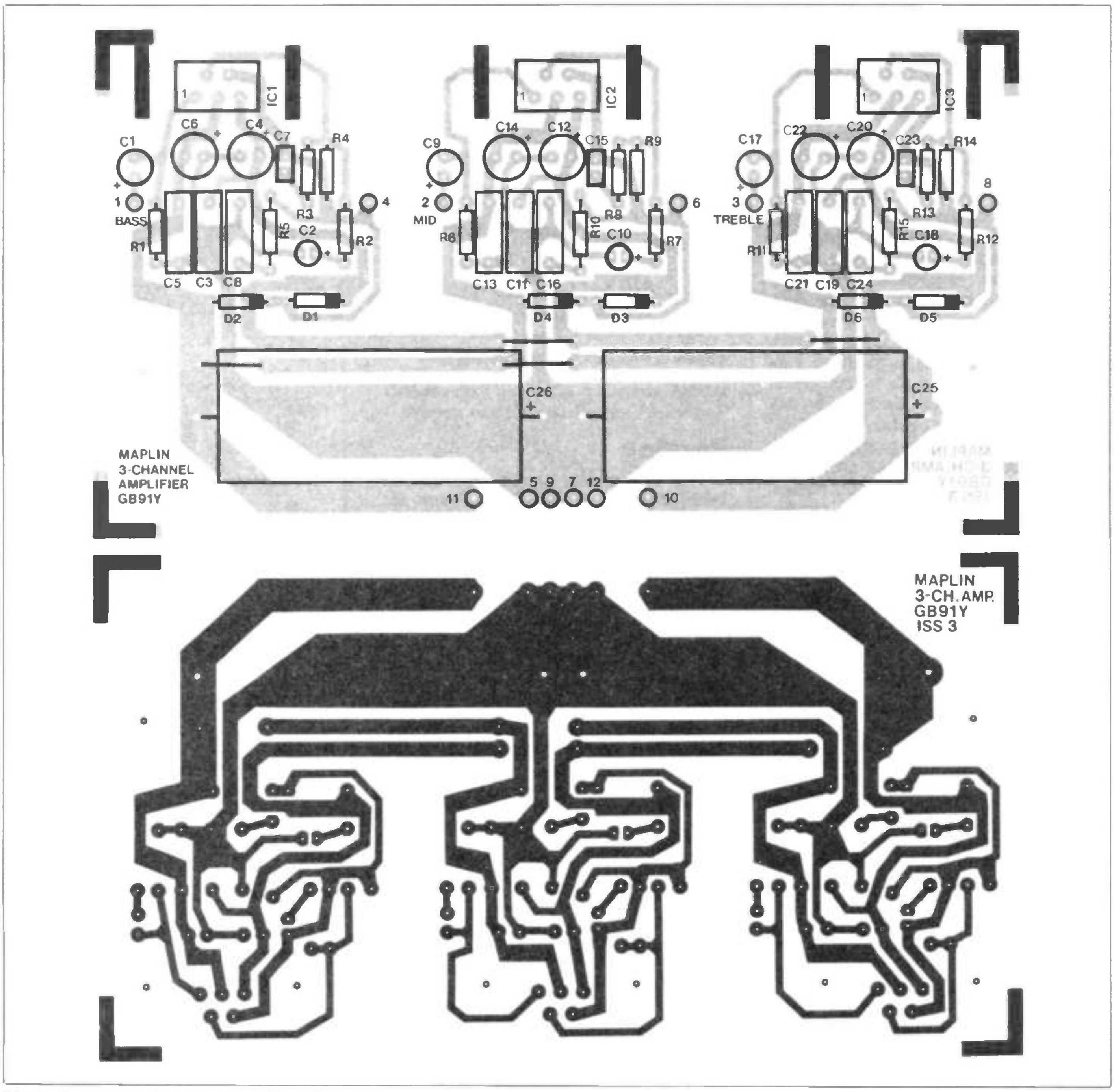


Figure 6. 3 Channel Amplifier Track and Overlay

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 x 30 and the Zobell 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.

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)

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 retangular 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 completed assembly checking components and soldering before applying power.

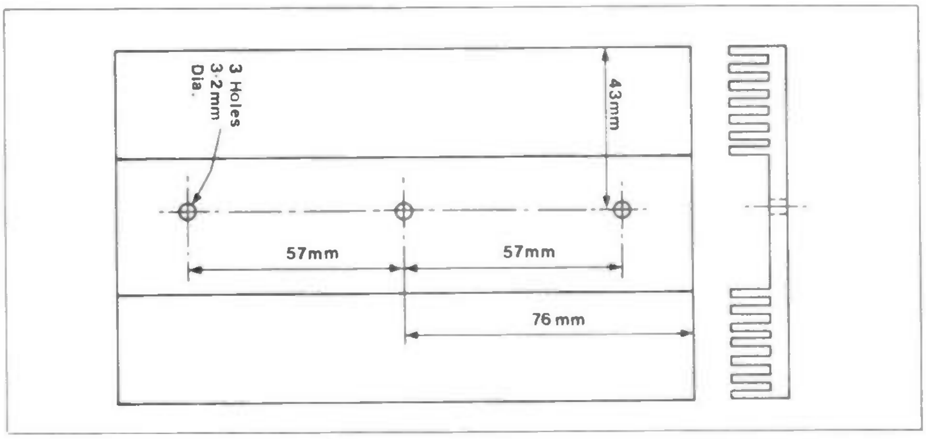


Figure 7. Heatsink Drilling Details

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.

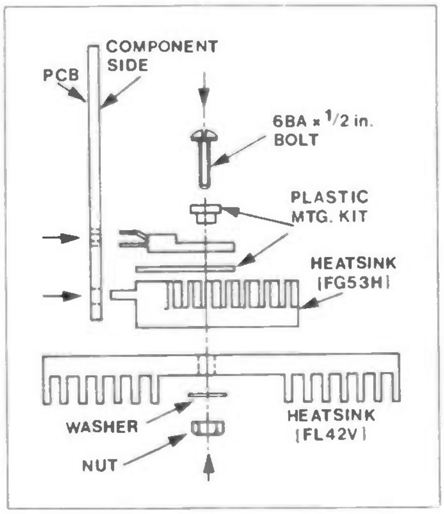


Figure 8. Amplifier Assembly

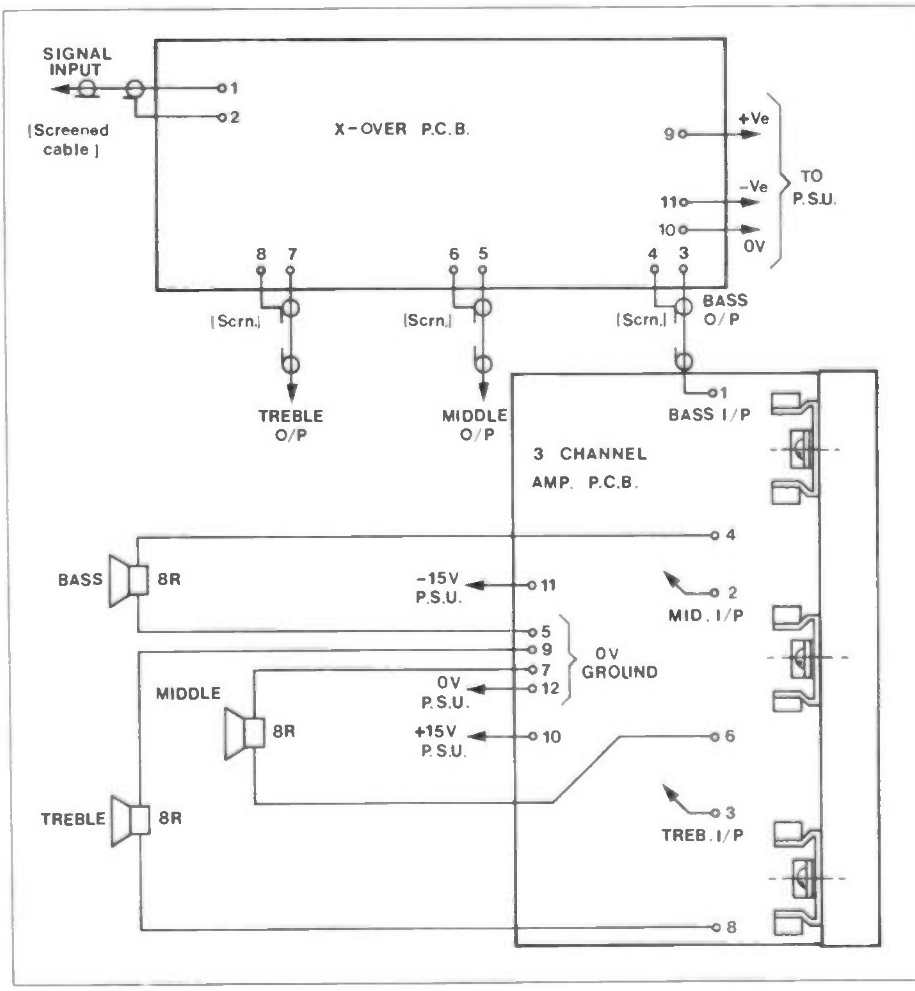


Figure 9. Interwiring

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, ±15mV. 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 diodes D1 to 6 on the amplifier PCB and stands vertically, held in place by two brackets and four 6BA bolts, nuts. Use short lengths of screened audio cable for 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.

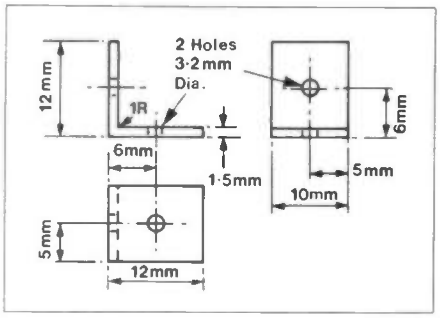


Figure 10. Support Bracket Details

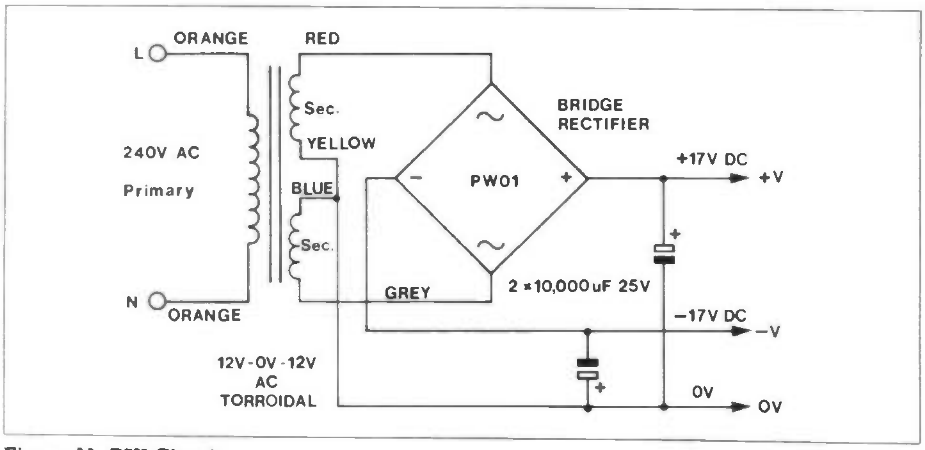


Figure 11. PSU Circuit

ACTIVE CROSSOVER PARTS LIST

RESISTORS: All 0.4W 1% Metal Film.

R1-4,11-14	4k7	8	(M4K7)
R5,15,17,22	47k	4	(M47K)
R6,16,23	100Ω	3	(M100R)
R7,8	100k	2	(M100K)
R9,10	82k	2	(M82K)
R18,19	22k	2	(M22K)
R20,21	10k	2	(M10K)
RV1-3	22k Hor. Sub-min. Preset	3	(WR59P)

CAPACITORS

C1,2,24	47nF Polycarbonate	3	(WW37S)
C3	68nF Polycarbonate	1	(WW39N)
C4	15nF Polycarbonate	1	(WW31J)
C5	10nF Polycarbonate	1	(WW29G)
C6,18	2µ2F 35V Tantalum	2	(WW62S)
C7	1µF 35V Tantalum	1	(WW60Q)
C8-13,19-22	4n7 Polycarbonate	10	(WW26D)
C14,15	6n8 Polycarbonate	2	(WW27E)
C16	470nF Polycarbonate	1	(WW49D)
C17	220nF Polycarbonate	1	(WW45Y)
C23	100nF Polycarbonate	1	(WW41U)
C25,26	4µ7F 16V Tantalum	2	(WW64U)
C27	100nF Disc	1	(BX03D)

SEMICONDUCTORS

IC1-6	LM833N	6	(UF49D)
REG 1	µA78L05AWC	1	(QL26D)
REG 2	µA79L05AWC	1	(WQ85G)

MISCELLANEOUS

	Active Crossover PCB	1	(GB82D)
	Veropin 2145	1 Pkt	(FL24B)
	8-Pin DIL Socket	6	(BL17T)

A complete kit of parts is available.
Order As LK69A (Active Crossover Kit) Price £16.95
The following item in the above kit is also available separately, but is not shown in the 1985 catalogue:
Active Crossover PCB **Order As GB82D Price £4.75**

3 CHANNEL AMPLIFIER PARTS LIST

RESISTORS: All 0.4W 1% Metal Film unless specified.

R1,6,11	10k	3	(M10K)
R2,7,12	680Ω	3	(M680R)
R3,8,13	3Ω3	3	(M3R3)
R4,9,14	22k	3	(M22K)
R5,10,15	1Ω ½W 5% Carbon	3	(S1R)

CAPACITORS

C1,9,17	2µ2F 35V Tantalum	3	(WW62S)
C2,10,18	22µF 25V P.C. Electrolytic	3	(FF06G)
C3,5,11,13,19,21	100nF Disc Ceramic	6	(BX03D)
C4,6,12,14,20,22	100µF 25V P.C. Electrolytic	6	(FF11M)
C7,15,23	68pF Ceramic	3	(WX54J)
C8,16,24	220nF Carbonate	3	(WW45Y)
C25,26	4700µF 35V Axial Electrolytic	2	(FB96E)

SEMICONDUCTORS

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

MISCELLANEOUS

	3 Channel Amp PCB	1	(GB91Y)
	Veropin 2145	1 Pkt	(FL24B)
	Vaned Heatsink TO202	3	(FG53H)
	Bolt 6BA x ½in.	1 Pkt	(BF06G)
	Nut 6BA	1 Pkt	(BF18U)
	Shake 6BA	1 Pkt	(BF26D)
	Flat Heatsink	1	(FL42V)
	Kit (P) Plas.	3	(WR23A)

OPTIONAL

	Silicone Grease Tube	1	(HQ00A)

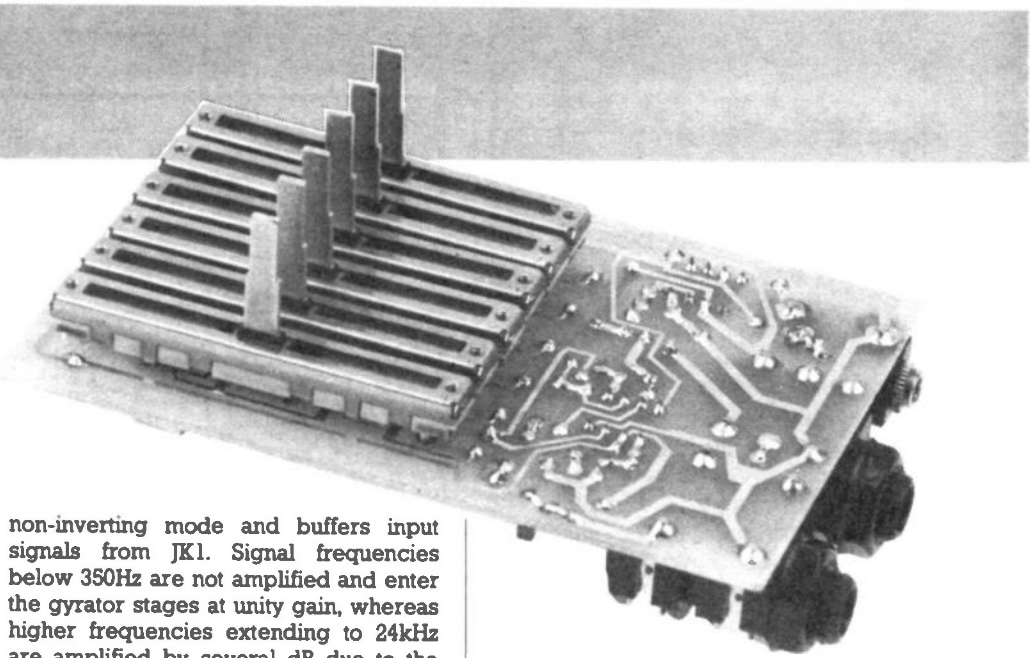
A kit of the above parts, excluding the optional item, is available:
Order As LK70M (3 Channel Amp Kit) Price £18.45
The following item in the above kit is also available separately, but is not shown in the 1985 catalogue:
3 Channel Amp PCB **Order As GB91Y Price £4.95**

Guitar Equaliser

- ★ Powered from Battery or External PSU
- ★ Extremely Low Current Consumption
- ★ Up to 10dB of Boost or Cut for Each String Frequency

by Dave Goodman

Front Panel



Presented here is a 6-channel Graphic Equaliser for use with electric guitars, tuned to the standard E, A, D, G, B, E frequency range of 82.4 to 329.6Hz. Every channel provides up to 10dB of signal boost or cut associated with each string, and up to 6dB gain increase on upper harmonics, extending to 25kHz.

The module uses micro-power IC stages to keep current consumption extremely low, allowing long life from PP3 type batteries, or power can be supplied externally via an integral 3.5mm socket.

Circuit Description

The signal input jack is a stereo version with three contacts, with the first contact connected directly to battery negative. When the guitar jack plug is inserted into JK1, this negative contact makes, via the jack plug earth sleeve, to the second (centre) jack contact. The battery negative is then extended through to pin 8 of the filter and pre-amp IC's and to the zero volts generator, IC1. The battery positive connection is extended through external PSU socket SK1 to D1, which protects the module electronics from possible damage, due to reverse battery or external supply connections. R7 and R8 potentially divide the supply and voltage follower IC1 provides a low impedance, '0V' potential, thus providing dual +V and −V supply rails to the op-amps. IC2 is configured in the non-inverting mode and buffers input signals from JK1. Signal frequencies below 350Hz are not amplified and enter the gyrator stages at unity gain, whereas higher frequencies extending to 24kHz are amplified by several dB due to the impedance of R3 and C2 reducing as frequency increases.

The six gyrators, IC3 - 5, have band pass characteristics determined by the two capacitive series elements and are chosen to closely approximate each guitar string frequency. Varying the slider resistance determines the gyrator resonance which increases or decreases the feedback path of IC2. Therefore, each filter frequency band can be independently amplified and attenuated by up to 10dB, or kept at unity gain by positioning the slider to its mid-point.

Construction

Components are mounted on both sides of the circuit board so construction *must* be made as follows.

Locate and insert the 20k resistors R9, 11, 13, 15, 17 and 19. Now insert the 470Ω resistors R10,12,14,16,18 and 20. Fit the remaining 11 resistors. Ensure each resistor is pushed down onto the PCB, turn the board over and carefully solder all 46 leads onto the copper track. Cut off excess wire ends close to the solder joint, then insert the 17 track 'through' pins. These pins should be in one long (or two) strips; insert a pin into the circled hole on the component side of the board; bend the strip sideways until it breaks off and repeat for the remaining 16 positions. With a hot soldering iron, push each pin head flat down to the board and solder it. Also solder these pins in place on the other side of the board. At this stage, clean off excess flux from both sides of the board with a PCB cleaner and a stiff brush, and inspect for shorts and dry joints. Fit diode D1 in place by bending each lead 3mm away from the body and inserting into the board with the banded end lined up to the legend.

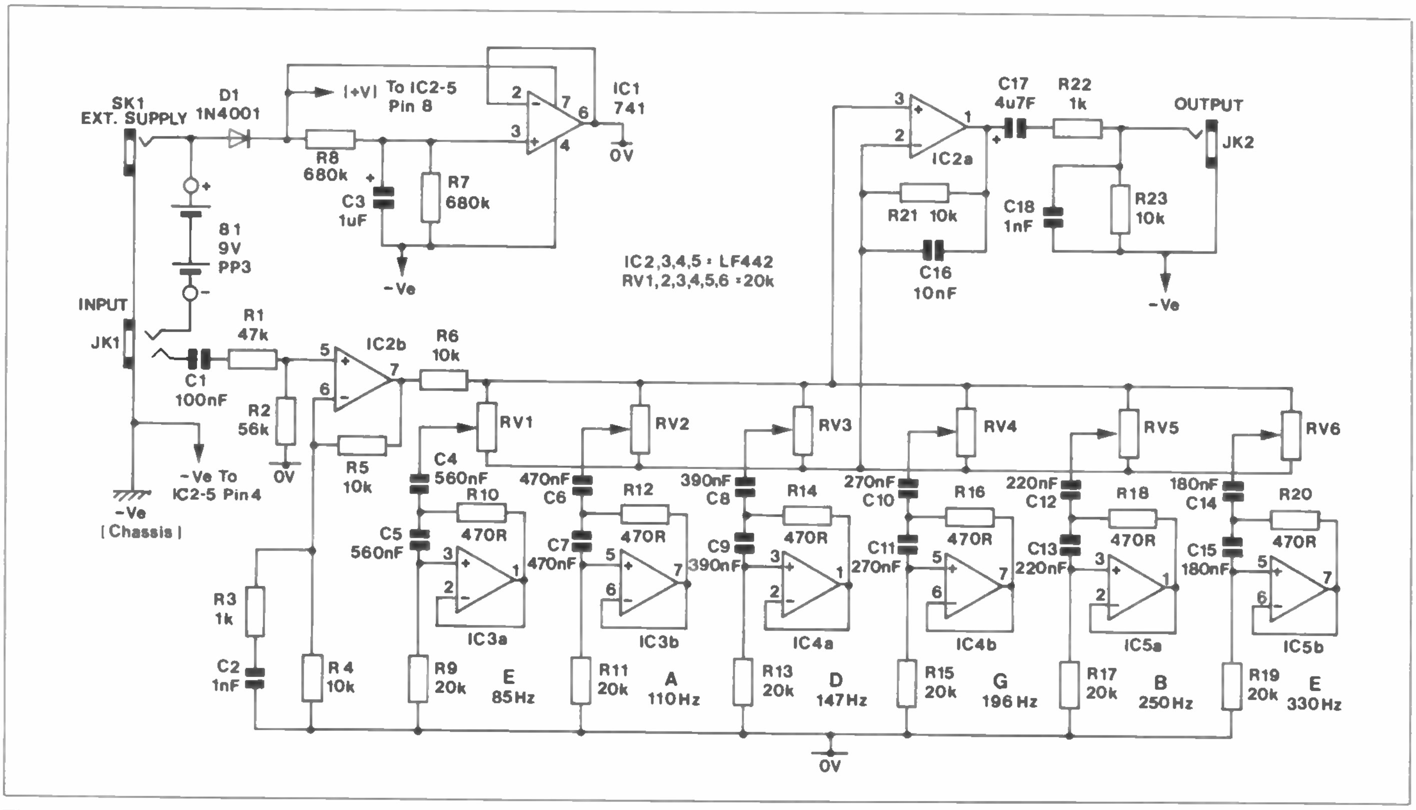


Figure 1. Circuit Diagram

Specifications

Power Requirements
a) 9V DC Battery at 1.5mA.
b) External PSU, 9 to 24V DC.

Frequency Response
a) 6 Band Equaliser ±10dB Boost and Cut per Channel, (30Hz - 450Hz).
b) 6dB Upper Harmonics Emphasis to 25kHz.

Maximum Input Levels

All sliders at 0dB:	1.414V RMS (4V peak).
All sliders at Max Boost:	77.5mV (220mV peak).
Input Impedance:	100kΩ.
Output Impedance:	1kΩ (Load = >10kΩ).

External PSU socket accepts a 3.5mm jack plug, with tip = +V supply.
¼in. Jack input and output sockets.

Insert the five 8-pin DIL sockets, with the notched end lined up to the legend and solder in place. Fit the small ceramic capacitor, C16 and both tantalum capacitors C3 and C17. Note that these last two components have their longest lead marked with a '+' symbol on the body and this lead should be inserted into the PCB hole also marked '+'. The 15 silver polycarbonate capacitors can now be fitted. Be careful when adjusting leads tacked onto the body ends, as they are easily broken. Some of these capacitors may have sealed ends and are more tolerant. Now solder all component leads in place and cut off wire ends close to the solder joint.

Refer to Figure 3 for slider mounting details. Place the PCB with the components facing downwards and insert a 20k slider from the track foil side as shown. Before soldering the slider on the opposite component face, check for 1.5mm clearance between PCB and slider housing and ensure it is held perpendicular to the board. If any solder joints or leads are touching the metal slider, clip off the top of the joint until clear. Repeat the procedure for the remaining 5 sliders.

Finally, mount the two jack sockets and the small 3.5mm socket finishing with the battery clip. The red lead (+V) inserts between SK1 and JK1, and the black lead (−V) between JK1 and JK2. Solder these components and re-inspect the construction. Insert the 741 (IC1) only, for now and continue with testing.

Testing

A multimeter is required to be connected with negative lead on pin 4 and positive lead on pin 7 of IC1. Connect the battery clip to a PP3 or PP6 battery and check there is no reading. Insert a spare ¼in. jack plug or a guitar lead into the stereo socket, JK1. There should now be a positive voltage reading, approx-

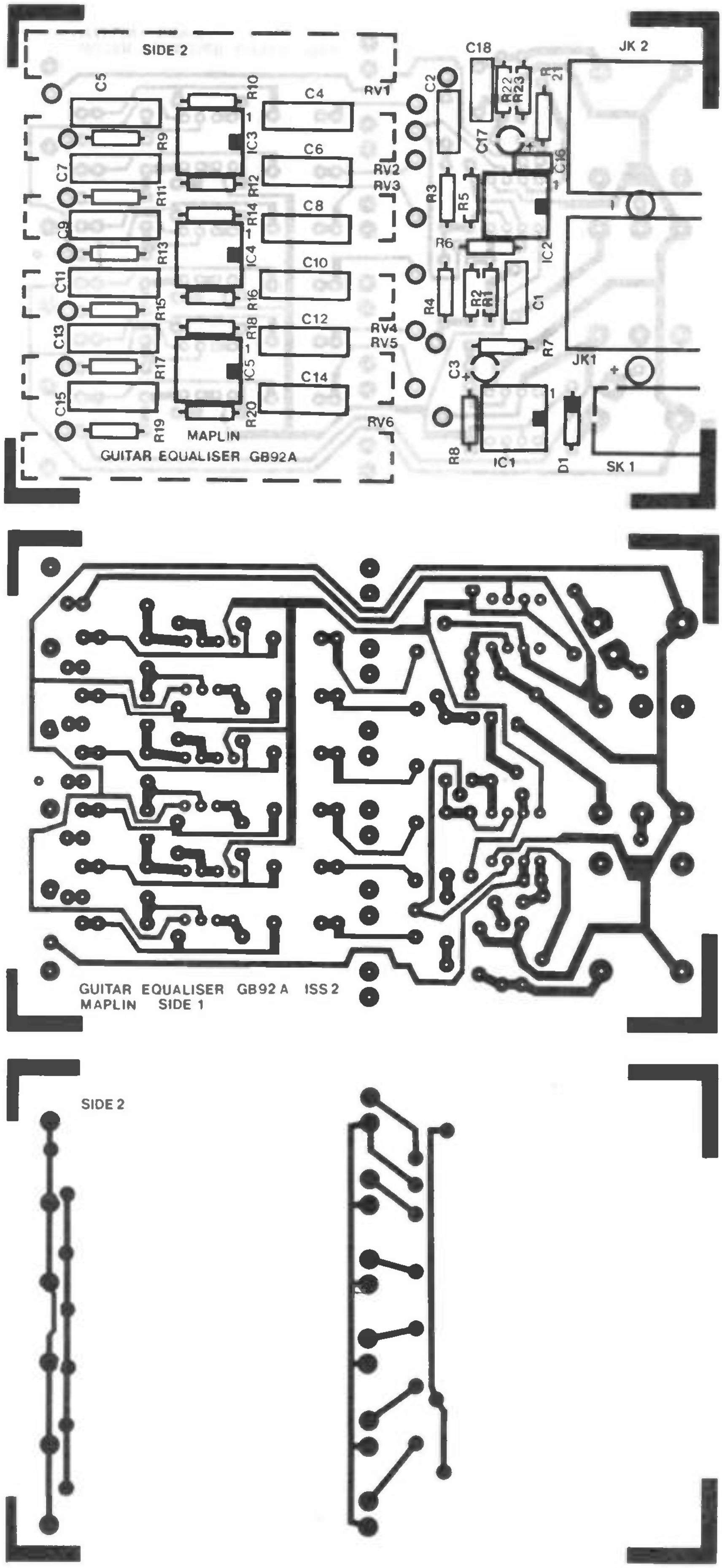


Figure 2. PCB Track Artworks and Overlay

imately 0.6V less than the battery voltage, e.g. battery = 9V, reading = 8.4V. Now place the meter negative lead on IC1 pin 6 (0V) and the positive lead on IC3 pin 8. A positive reading of half the previous measurement, e.g. +4.2V should be noted; remove the positive lead only, and attach to IC3 pin 4. This time a negative reading, e.g. −4.2V should be given. If using a mechanical meter, you will have to reverse the meter leads to do this!

Remove the battery and insert all four LF442's, IC2 to IC5. Reconnect the battery, plug in an electric guitar and connect JK2 to a suitable amplifier. Ensure all sliders are working and all filters are operational.

The six frequencies chosen are representative of the common tuning range used on most guitars, except for electric bass, and signal thresholds should be suitable for most guitar pick-ups. Some high-output pick-ups may overdrive the equaliser and cause excessive distortion. Of course, this effect may be desirable to some users but if not, use must be made of the guitar's volume control.

Final Construction

Figure 4 shows box cutting details, and a stick-on front panel is available for this project; this panel is not punched for the slots for the six slider controls. Cutting the slots for each slider tang may prove difficult, and unfortunately this is left to the constructors capabilities. The PCB is held in place by both Jack Socket locking nuts, and suitable knobs for the sliders can be fitted.

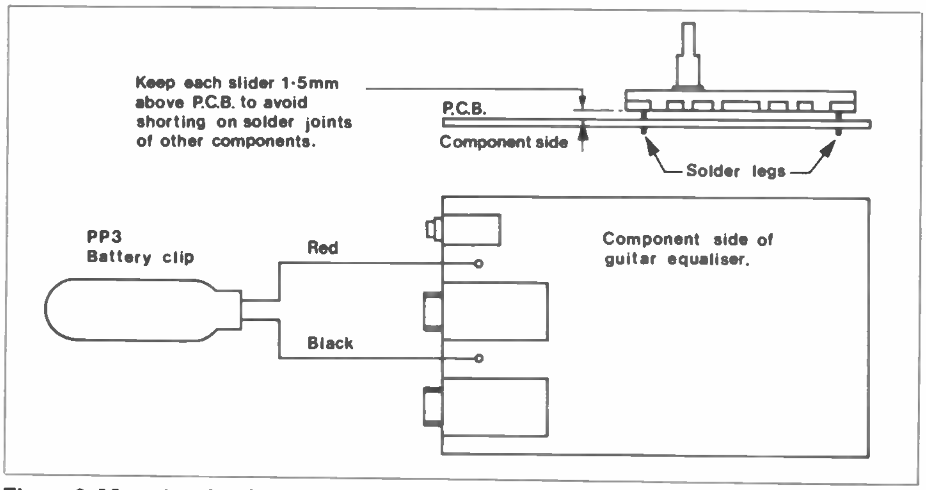


Figure 3. Mounting the slider controls

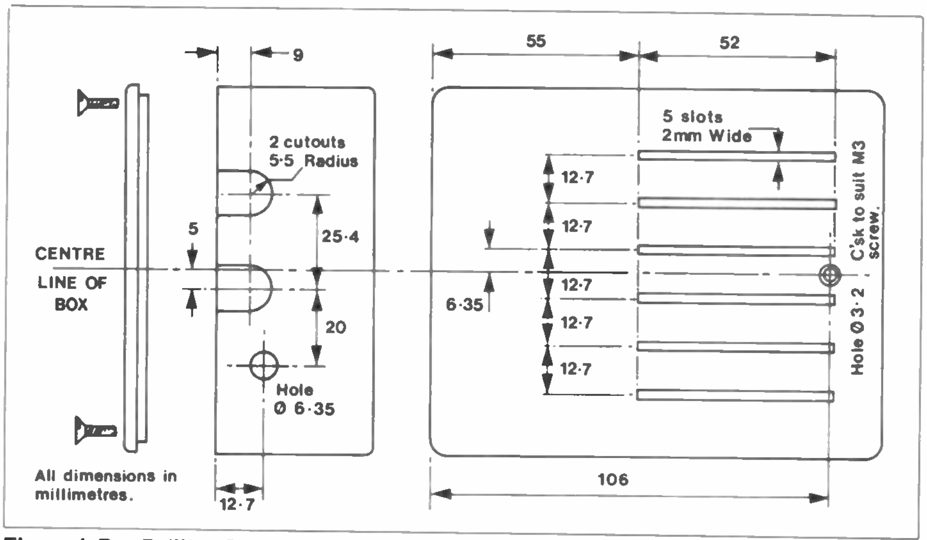
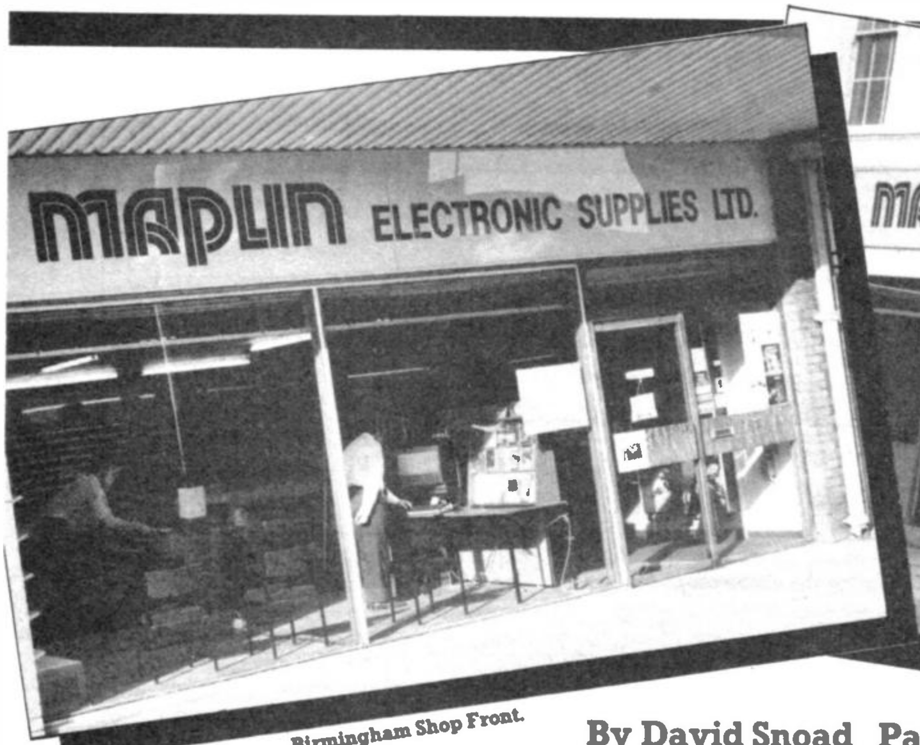


Figure 4. Box Drilling Details

GUITAR EQUALISER PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1	47k	1	(M47K)
R2	56k	1	(M56K)
R3,22	1k	2	(M1K)
R4,5,6,21,23	10k	5	(M10K)
R7,8	680k	2	(M680K)
R9,11,13,15,17,19	20k	6	(M20K)
R10,12,14,16,18,20	470Ω	6	(M470R)
RV1-6	Min. Slide 20k LIN	6	(FT68Y)
CAPACITORS			
C1	100nF Carbonate	1	(WW41U)
C2,18	1nF Carbonate	2	(WW22Y)
C3	1µF 35V Tantalum	1	(WW60Q)
C4,5	560nF Carbonate	2	(WW50E)
C6,7	470nF Carbonate	2	(WW49D)
C8,9	390nF Carbonate	2	(WW48C)
C10,11	270nF Carbonate	2	(WW46A)
C12,13	220nF Carbonate	2	(WW45Y)
C14,15	180nF Carbonate	2	(WW44X)
C16	10nF Ceramic	1	(WX77J)
C17	4µ7F 16V Tantalum	1	(WW64U)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
IC1	µA741C	1	(QL22Y)
IC2-5	LF442	4	(QY30H)
MISCELLANEOUS			
JK1	Stereo PCB ¼in. Jack Skt	1	(FJ05F)
JK2	Mono PCB ¼in. Jack Skt	1	(FJ00A)
SK1	Mono PCB 3·5mm Jack Skt	1	(FK02C)
	8-pin DIL Socket	5	(BL17T)
	Guitar Equaliser PCB	1	(GB92A)
	PP3 Battery Clip	1	(HF28F)
	Track Pin	1 Pkt	(FL82D)
	ABS Box 2005	1	(LH61R)
	Knob B Slide	6	(YG09K)
	Guitar Equaliser Front Panel	1	(FT69A)
	Pozi Screw M3 x 40mm.	1 Pkt	(LR58N)
	Isonut M3	1 Pkt	(BF58N)
	Nylon Washer 6BA	1 Pkt	(BF84F)
	Spacer M3 x ¼in.	1 Pkt	(FG33L)
	Spacer M3 x ½in.	1 Pkt	(FG34M)
OPTIONAL			
	Battery (Ni-Cad) PP3	1	(HW31J)

A kit of parts (excluding optional items) is available:
Order As LK74R (Guitar Equaliser Kit) Price £26.95
The following items in the above kit are also available separately, but are not shown in the 1985 catalogue:
Guitar Equaliser PCB **Order As GB92A Price £5.45**
Guitar Equaliser Front Panel **Order As FT69A Price £1.75**
Miniature Slide Pot 20k LIN **Order As FT68Y Price £1.45**



Birmingham Shop Front.

Hammersmith Shop Front.

By David Snoad Part Two

MAKE IT WITH MAPLIN

In part one of this article, I endeavoured to provide a background to those early Maplin years, from onset of the business operation in a suburban semi to the first counter service retail outlet in Westcliff-on-Sea. Part two will pick up from this point and take us through the opening of two more shops, providing the opportunity to meet the staff at both the London and Birmingham branches.

It was early in 1975 that the first shop opened; it took only a few months before the Maplin directors recognised that this diversification from mail order was going to be successful. In fact, the two types of business complemented each other perfectly with the mail order, even in the early days, providing a service which had to be admired. As a result of properly planned advertising, the company became well-known fast and the shop provided that personal touch which some customers preferred.

Discount Vouchers

Maplin it seemed, had a licence to print money, in fact they did, in the form of discount vouchers. Many readers will no doubt remember that era, when you could not buy anything without the sales assistant stuffing your pockets full of green stamps, pink stamps or some other form of voucher for you to collect. It became a craze! We started to wonder if green stamps were going to take over from the pound! Of course Maplin joined in the fun by issuing its own 'Monopoly-type' money. I am sure that during Maplin's infancy, it helped give the company identification, but as soon as the craze started to die and it was realised customers preferred competitive prices, the scheme was phased out.

Exciting Times

Although every stage of a growing company is important, I do think that the period when the mail order was handled from above the Westcliff Shop, was one of the most exciting. Many new projects were being developed both in-house and in conjunction with magazines. It was during this time that many of the journals chose to offer back-page advertising to this reliable company, a move which certainly helped Maplin convince its customers that the company was here to stay. By the beginning of 1976, the number of staff had risen to 16, still a small company and because the complete generation was in one small building, the employees tended to be a very friendly group. Maplin had by now produced three catalogues. It has become obvious that with each new publication, there was a large rise in the level of business transactions. It was decided during the summer of 1976 that if trade was to increase at the same rate the following winter (as it had done the previous one), then there just would not be enough room to handle the work. Preparations were therefore put in hand to move the mail order side of the business into larger premises.

On The Move

Towards the end of 1976, a 5000 sq ft warehouse was found in Leigh-on-Sea which seemed ideal. It was only three miles from the Westcliff Shop and appeared at the time to have plenty of room for expansion. By the middle of 1978, the headcount had risen to 47 and already every conceivable corner of the warehouse was in use. The previous winter season had again been much busier than anticipated and another move was on the cards. This change of premises every couple of years was definitely becoming too regular and the disruption to work flow was not acceptable. This time a 15,000 sq. ft. warehouse was found in Hadleigh, Essex. Again, only two miles away from the previous premises which was convenient for all concerned. The beginning of 1979 saw Maplin move up in status; there were now 99 employees and the small company image seemed to be disappearing fast.

Hammersmith Shop

Up until now, the company had been concentrating its effort into perfecting the mail order service, but by the beginning of 1980 it was decided to look for another shop. The first logical step was to choose premises in London. Hammersmith was chosen for several reasons; it is ideal for customers within the Capital and coming from the South West, being not far from the end of the M3, M4 and M40. For those people travelling in London, Hammersmith has many advantages; being served by no less than three underground lines, the District, Piccadilly and Metropolitan, and is also easily reached from all the London British Rail main line stations. Premises were chosen in King Street where bus passengers are also catered for. Many buses including the 27, 91, 260, 266 and 291 pass the shop door. Driving in

London can be difficult and parking is usually impossible but Hammersmith is one of the few areas where parking is relatively easy. Although mostly metered, there are usually plenty of spaces available in the adjoining streets.

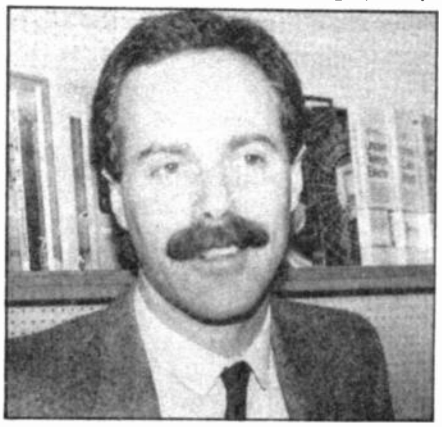
We will now come up-to-date and meet the present Hammersmith Shop staff. Starting with the longest serving salesman at this shop, Peter Keelin, who joined Maplin shortly after the Hammersmith branch opened. Before joining the company, Peter worked as a service engineer for a burglar alarm company, bringing with him some useful technical expertise which has enabled him to help many customers over the past years. Peter is not frightened of sport, he boxed regularly before working for Maplin but fortunately, has never used these skills on any of the customers. Peter now enjoys a little snooker and tennis and other pastimes include driving Scalectrix cars and some do-it-yourself in a recently purchased house. There is also time for computing on his Atari and a small amount of home electronic construction. Peter, who is now the assistant manager, has seen many changes during the past few years. He has kept up with company developments and is particularly enthusiastic about the forthcoming 'Trade Price List' saying, "with so many trade customers these days, it is a logical step forward."

The second longest serving and, for some reason, the most popular member of staff at the London store is Karan Frake, joining shortly after Peter about four years ago. Karan is employed to look after the stock control, as can be seen from the photograph. She also spends a lot of her day answering the telephone which rings remorselessly. Karan would like it known that contrary to widespread belief, Hammersmith is not the Head Office. Although anyone could be forgiven for making this mistake, it is impossible for Karan to help customers with mail order enquiries as much as she likes to help. Considering that Karan's previous job was hairdressing, she has done well to acquire a basic understanding of such a technical subject as electronics. Karan does not serve in the shop but she is well known to many regular customers through the assistance she offers on the telephone. Among her hobbies, Karan lists cooking and fashion plus keeping her hand in with hairdressing.

Karan hard at work on Stock Control.

Next, is Melvyn Crawford who joined Maplin in Southampton just before the shop opened there in October 1983. He helped to lay out the shop ready for the opening which was an ideal way of becoming familiar with the vast range of products which Maplin now stock. This opportunity to learn about the product range together with Melvyn's excellent electronics knowledge meant he was well prepared the day the doors opened. Since then, Melvyn has worked as a relief assistant covering holidays, etc., in other shops and moved to London permanently about a year ago. He is the contemporary of the staff, well suited to a fast moving occupation. Previous to joining the company, Melvyn played in a band, he still plays clarinet, saxaphone and guitar but only for his own amusement. Melvyn's main ambition, which has occupied most of his spare time over the past months, is to be an author. He is quite convinced that his recently completed novel is going to be a great success. Although spending most of his leisure hours writing, Melvyn still has time to show his workmates what a speed freak he is when it comes to the scalectrix circuit.

Hammersmith Shop Staff (left to right) Paul, Peter and Melvyn.



Mr. Martin Jay, Hammersmith Shop Manager.

Paul Irvine is the shortest serving member of staff at Hammersmith, joining the company eighteen months ago. He previously worked in a school which was quite a contrast to his present occupation. Paul knew Maplin before he started working for the company, his understanding of electronics was rather limited but he soon found his feet, proving to be a very competent member of the team. Married and living in London, Paul is a keen computer owner, he also plays snooker regularly. In the last magazine, I mentioned the interest shown in roller skating by the Westcliff Shop staff. It seems that the lads at Hammersmith are not to be beaten when it comes to this thrill of speed on wheels. Paul is also a practised driver of scalectrix model cars. Returning to the sanity of the shop, Paul has mentioned how interesting it has been working for Maplin. He has been surprised at the cross-section of customers he meets each day, from hobbyists to people developing new ideas, from regular local customers to visitors from all across the country and abroad.

The final member of the Hammersmith team is Martin Jay who joined Maplin three years ago as the store manager. Martin has always been in a Hi-tech environment but believes his forte is sales rather than as a technician. He says that between them, his staff have the technical expertise and he hopes to provide the sales back-up. Originally from the country, Devon in fact, Martin enjoys living and working in London even with the difficulties such as commuting and higher prices. He says that working for a private company is in many ways, better than some of the corporations he has been with in the past.

Looking Ahead

Martin is pleased to announce the changes to his shop which were planned for completion before publication of this magazine. He says the improvements which include re-positioning the counter, moving the stock room and improving the display and demonstration area should help him to provide an even more professional service.

For those customers from out of town, Martin is quick to remind them that a trip to his shop can be a pleasurable day out. Of course, we would not dare to try and list here what you can do in London but we are able to tell of the excellent facilities which are close at hand. Only 200 yards away is the Kings Mall Shopping Centre with a large car park. The centre contains many of the national multiples including branches of Habitat, CRS, Dixons, Safeway, Mothercare, W.H. Smith, etc. If fast food appeals, there are many to choose from with Macdonalds, Pizza Hut, Spud-U-Like and many others. An evening out is also catered for with the popular Lyric Theatre, Hammersmith Palais, cinemas and restaurants only a short walk away. For those who have not called at the Hammersmith Shop recently, we recommend another visit and as Martin says, he will do his utmost to ensure that you are totally satisfied with the service you receive.

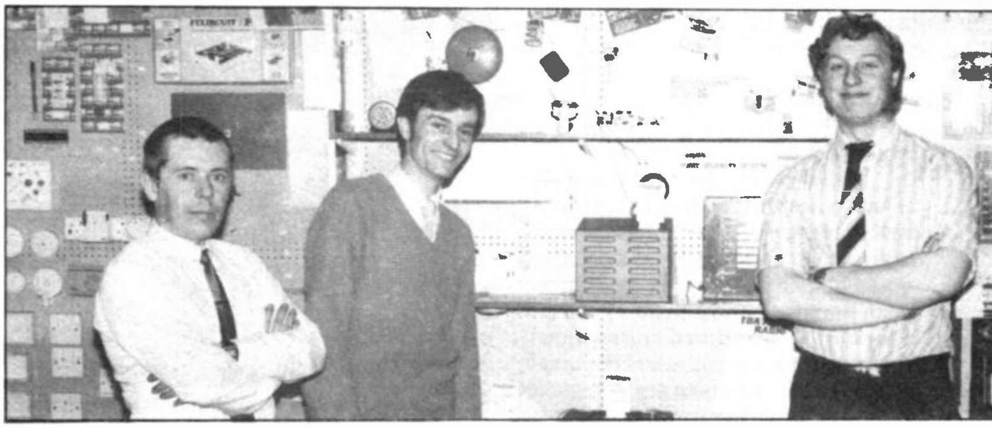
Birmingham Shop

Two years after the Hammersmith Shop was opened, it was decided to open the next Maplin outlet. The most sensible move seemed to be northwards. Choosing Birmingham was easy, the difficult task was finding suitable premises in an unknown city! After much searching and deliberation, a shop was chosen in Perry Barr. It seemed to offer just what was needed, easy access to both the city centre and motorways, being on a major road junction on the A34 but most important, excellent free parking on the doorstep. The shop which is contained in the Lynton Square Shopping Precinct, opened in August 1982 and within days it became obvious that the choice of premises was meeting with the approval of customers.

The first member of the Birmingham team to be employed was David Kirk who is now the assistant manager. He started five months prior to the opening, helping to prepare stock records and lay out the products within the shop. David had been a Maplin customer for many years before joining the company and was therefore more familiar than most with the Maplin range. Although still young, David has moved around, born in Leicester, brought up in Cornwall and moved to Birmingham to attend Aston University. David now enjoys working for Maplin and is looking forward to the day when he will be able to manage his own Maplin branch. Among his hobbies, David enjoys cycling and also participates in tennis, table tennis, badminton and squash. David is also an ardent electronic hobbyist having built many different projects, mainly audio. He now intends to extend this hobby to amateur radio by studying for his licence.

No roller skates or scalectrix cars at Birmingham but one thing the staff do have in common is a growing interest in radio. This all started when Robert Pritchard joined Maplin approximately 11 months ago. Robert or rather Bob (G4VAR) as he is known to his pals has been a radio ham for about 5 years. This was a natural progression as with many enthusiasts after the limitations of C.B. Bob, married with two children (a 4 year old boy and a girl of 2 years) still finds time to re-build a motor bike, make wine and beer, operate his computer, build electronic projects and carry out do-it-yourself. Before joining Maplin, Bob worked as a coach painter, an entirely different skill to his present occupation but his spare time was obviously sufficient to provide a good working knowledge of electronics.

John Ryan is the shortest serving employee at Birmingham, becoming a member of the team about nine months ago. He is also the youngest, having been on a radio and TV repair course and spent time servicing office equipment since leaving school. His hobbies include snooker and table tennis, also electronics which proves useful as he has been able to build projects for his recently acquired car. John is also studying for his radio licence to allow him to join his



Birmingham Shop Staff (left to right) Bob, John and Dave.

Mr. Roy Martin, Birmingham Shop Manager.

workmates on the air.

The manager at Birmingham is Roy Martin, coming to Maplin approximately a year ago from a company specialising in Land Rover parts. Prior to this, Roy spent several years working for a musical instrument manufacturer and through this job, he had the opportunity to meet several interesting personalities including members of the Beatles and Rolling Stones. Since leaving school, Roy has had a varied career including a position as assistant to a professional golfer, but he now believes he has found his niche with Maplin. Roy's hobbies include electronics, computing and now radio along with everyone else in his shop. Roy recognised that many customers were radio hams and on several occasions, they would specifically ask to be served by Bob. Not wanting to be left out, Roy sat the necessary exam and is now a licenced amateur as well, you may know him as (G1MOR). In addition, Roy does a little computing; he does not enjoy games but prefers to use his computer for something useful. Among its applications, Roy's wife finds the computer handy for recording her cookery recipes. A very friendly person, Roy likes to make his customers feel at home and will be only too pleased to provide a warm welcome if you have not visited him before.

Since the Birmingham Shop opened, it has fast become known as a reliable source of components within the Midlands area, both to hobbyists and professionals alike. Again, we see the Maplin name being linked with many major corporations, serving such customers as Lucas, British Telecoms, G.E.C. and many more. But most of all, the Birmingham Shop staff are heavily involved in promoting the company to local educational authorities. They are finding that there is much interest in the Heathkit educational courses which is useful with the Birmingham Polytechnic sited so conveniently on the other side of the road.

The next couple of years are likely to see change to both the Perry Barr shopping complex, which contains Maplin, and the City itself. Firstly, a major redevelopment scheme is underway to refurbish the precinct, expanding it and adding a massive new Hypermarket. Secondly, as you may already know, the City Council have plans to close the roads in the centre of town on August Bank Holidays and create a Monte Carlo type motor racing circuit. I have no doubt that, assuming Parliament give their final seal of approval, this will be a spectacular event and do much to attract visitors to the city.

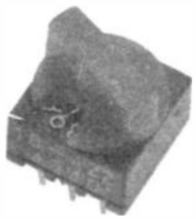
Free Offer

So, here we have two more inviting shops to visit and to make the trip even more worthwhile, the special offer shown in the last magazine is being extended. The offer is only open to readers of this magazine visiting either the Hammersmith or Birmingham shops before the end of August. Take this magazine with you, spend more than £25 and you will receive the Pocket Multimeter illustrated absolutely *free of charge*. This offer is only open to customers of Hammersmith and Birmingham shops and is not available by mail order or at any other shop.

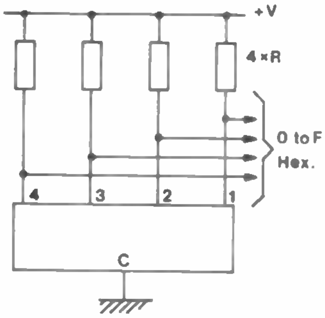
In the next magazine, we will introduce the Manchester and Southampton shops along with another reminiscence of Maplin.

New Products

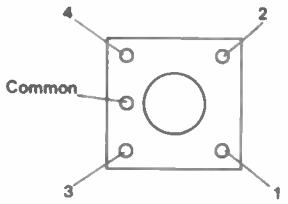
Sub-Miniature PCB Mounting 'Hex' Encoded Rotary Switches



Extremely compact, PCB mounting, sub-miniature switch arrays which can produce any 4-bit hexadecimal number from 0 to F by simply turning the integral knob to one of 16 click-stop positions. The switches are 10mm square and 11mm high overall excluding pins. The five pins are spaced for a 0.1in. matrix, comprising one common pin and four 'output' pins for hex 0 to 3.



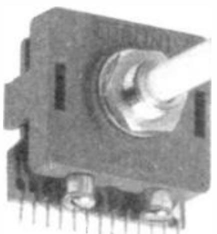
Switch QY68Y is arranged so that any pin output 'bit 0' in hex is connected to the common pin. Switch QY69A has the complementary arrangement in that any pin output 'bit 0' in hex is open circuit, or *not* connected to the common pin.



Bottom View

Order As
QY68Y (PCB Hex Sw On = 0) **Price £2.75**
QY69A (PCB Hex Sw On = 1) **Price £2.75**

Right Angle PCB Mounting Rotary Switches

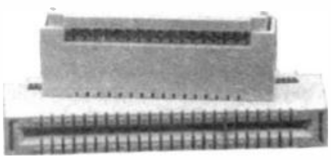


To compliment our range of rotary switches shown on page 395 of the 1985 catalogue, we present these right-angle PCB mounting versions, which feature single line PCB insertion pins on a 0.1in. spacing. Two mounting pillars and fixing screws are provided under the switch body to ensure rigid support to the PCB, in addition to the usual ⅜in. spindle bush and nut fitting for front panel mounting, and adjustable end stop. The switch contacts are an integral part of a PCB at rear of the switch and are brought out to the insertion pins at the bottom. Available as make before break in 1 x 12 way, 2 x 6 way, 3 x 4 way and 4 x 3 way versions.

Order As
FT56L (PCB R/A Rotary 1x12W) **Price £2.95**
FT57M (PCB R/A Rotary 2x6W) **Price £2.95**
FT58N (PCB R/A Rotary 3x4W) **Price £2.95**
FT59P (PCB R/A Rotary 4x3W) **Price £2.95**

NEW IDC PRODUCTS

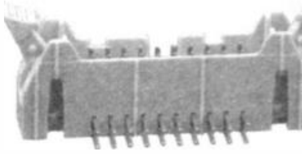
New IDC Edge Connectors



To augment our existing range of IDC connectors, these grey moulded edge connectors feature closed ends for precise mating with a tongue shaped card edge, thus completely obviating any mismatch due to sideways slip. The 2 x 25-way and 2 x 17-way are particularly suitable for use with the Amstrad CPC464. Another specialised feature of these connectors is the use of a polarising key which, if required, can be fitted *between* any pair of contacts thereby preserving full use of the maximum number of ways. These connectors can be supplied in 16-way, 20-way, 26-way, 34-way, 40-way and 50-way. Polarising keys are available separately.

Order As
FT86T (16W IDC Edge Connctr) **Price £1.95**
FT87U (20W IDC Edge Connctr) **Price £2.45**
FT88V (26W IDC Edge Connctr) **Price £2.95**
FT89W (34W IDC Edge Connctr) **Price £3.45**
FT90X (40W IDC Edge Connctr) **Price £3.95**
FT60Q (50W IDC Edge Connctr) **Price £4.95**
QY73Q (Polarising Key IDC) **Price 5p**

Right Angle 20 Way IDC PCB Header Plug



A right angle PCB mounting IDC header plug for use with 2 x 10-way IDC cable connectors.

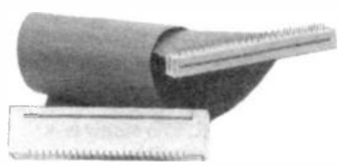
Order As FT72P (R/A 20Way PCB Header) **Price £1.75**

50 Way IDC Cable

A useful addition to our range of IDC cables as shown on page 80 of the 1985 Maplin catalogue, is this 50 way cable. Sheathed in grey PVC, conductor number 1 is marked by a red stripe on one edge. Sold in 30cm (12in.) lengths.

Order As XR79L (Flat IDC Cable 50Way) **Price 80p**

Amstrad IDC Printer Cable

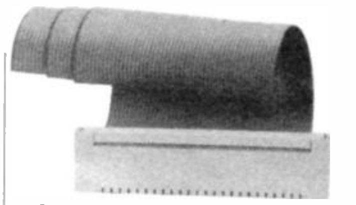


A metre of 50 way IDC cable having a 50 way IDC edge connector at one end, and a 50-way transition header at the other end. Particularly suitable for use with the Amstrad CPC 464.

Order As FT66W (2x25W Amstrad Printr Cable) **Price £9.95**

IDC Edge Connector and Cable Assemblies

Two IDC edge connectors with cable attached, in 2 x 17 way and 2

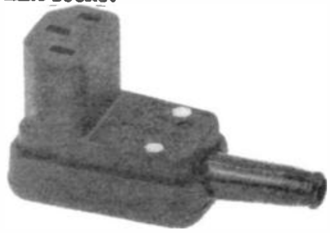


x 25 way, each fitted with a one metre length of cable.

Order As FT71N (2x17W IDC Edge + Cable) **Price £5.95**
Order As FT70M (2x25W IDC Edge + Cable) **Price £7.95**

NEW STYLE EUROPEAN MAINS CONNECTORS

Right Angle Euro Mains Inlet Line Socket



For use with HL15R on page 130 of the 1985 catalogue, this well finished right angled or side entry line socket is rated at 6A at 250V AC. It features clearly labelled screw terminals for connecting wires to Live, Neutral and Earth. In addition there is a metal cable clamp, and a strain relief sleeve.

Order As FT62S (R/A Euro Mns In P588) **Price £1.95**

Mains Outlet Chassis Socket

A mains outlet chassis socket complementary to the mains inlet chassis plug HL15R. Physically identical it requires a 32 x 25mm mounting hole, and has an overall depth of 35mm. Fixing centres are 40mm x 6BA or M3, countersunk. Contacts are rated at 6A at 250V AC, with solder tag terminations at rear 2·5mm wide x 10mm long.

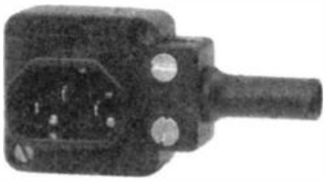
Order As FT63T (Euro Outlt Skt P675) **Price 65p**

Mains Outlet Line Plug

A line plug for use with the chassis mounting Euro outlet socket. The line plug has shielded pins to prevent accidental touching of the pins whilst inserting or removing the plug. Wires are terminated to the connectors using screw terminals. Includes cable clamp and strain relief sleeve.
Rated at 6A at 250V AC.

Order As FT64U (Euro Outlt Plg P686) Price £1.75

Right Angle Euro Mains Outlet Plug



A right angled or side entry Euro style mains outlet plug, having a special feature in that the centre portion carrying the shielded pins can be inserted into the body during assembly in any one of four positions, or it may be removed and rotated through 90° to a new position, so that the cable may exit vertically up or down, or to the left or to the right. Includes cable clamp and strain relief sleeve.
Rated at 6A at 250V AC.

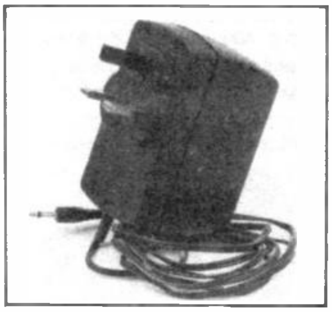
Order As FT65V (Euro R/A Out Plg P685) Price £1.95

Right-Angle Polarised Locking Plug 17-Way

By popular demand we have added the 17-way R/A locking or 'minicon' plug to the range of these connectors as shown on page 126 of the catalogue.

Order As FT67X (RA Lch Minicn Pl 17W) Price £1.10

Power Supply Unit for Zero 2

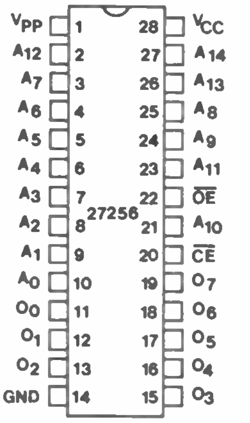


An unregulated 9V DC power supply that directly plugs into a 3-pin 13A mains socket. Specifically intended to power the Zero 2 Turtle robot, it can however be used to power anything requiring a 9V supply at up to >1A. The unregulated output is 9V DC @ 1.4A full load, and can be up to a maximum of 15V DC off load. The PSU has brass Live and Neutral mains pins, and a plastic Earth pin (Earth not used). Fitted with 1.6 metres of light cable terminated in a 3.5mm jack plug, where the tip is +9V, and the sleeve is 0V. Dimensions, 90mm long x 57mm wide x 62mm deep, excluding pins. Weight 550gm.

Order As YJ64U (Zero 2 Mains Adaptor) Price £7.95

27256 256K EPROM

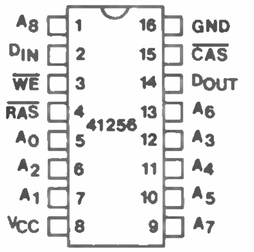
A 32, 768 x 8 bit ultra-violet erasable PROM, featuring 250ns access time and high-performance programming at only 12.5V. Inputs and outputs are TTL compatible in READ and program modes. For READ operation, V_{CC} and V_{PP} must be +5V ±5%. Supply current is 105mA max.



(45mA typical), standby current is 40mA max. For programming mode, V_{CC} must be taken to 6V ±0.25V and V_{PP} to 12.5V ±0.3V ***N.B: NOT 21V.*** With address and data stable (2μs), a 1ms ±5% active low pulse is applied to pin 20. An average program time is 1½ minutes per chip. The erasure procedure and timings are the same as for the 128K EPROM on page 370 of our 1985 catalogue.

Order As QY75S (27256 – 250ns) Price £18.95

41256 256K Dynamic Random Access Memory

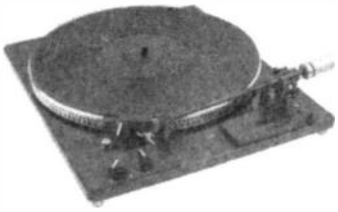


A 262,144 x 1 bit D-RAM having an access time of 150ns. Operation is from a single +5V supply at less than 70mA with standby current at less than 5mA. The output is 3-state TTL compatible.

Order As QY74R (41256-150ns) Price £9.95

12V Disco Record Deck

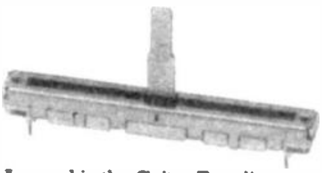
A good quality record deck for general purpose usage and suitable for use in mobile discos etc. Finished in matt black, it features a counterbalanced tone arm supported in gimbal bearings, having anti-skate adjustment, and an arm lift or cue lever which also operates a friction brake acting on the tone arms's vertical pivots. An unusual feature of this



deck is that it uses an electronically controlled drive motor which operates from 12V DC. Two controls are provided to select either 33 or 45 RPM, and provide for a degree of fine speed adjustment. The turntable motor is started and stopped by simply lifting the tone arm away from, and returning it to the arm rest. The integral headshell is wired for stereo, but no cartridge or carrier is supplied. Connections are brought out to a five way tag strip, which includes chassis earth. The motor and control circuit require a DC power supply of 9 to 15V DC at 40mA (12V DC typical) – motor stall current (turntable stopped) is 225mA. The complete unit measures 330mm x 285mm at base, and requires a clearance of 50mm below this (depth of plinth). Weight, 1.7kg. Note that this record deck will replace XB25C shown on page 276 in the 1985 catalogue.

Order As XG68Y (P295 12V Disco Deck) Price £42.95

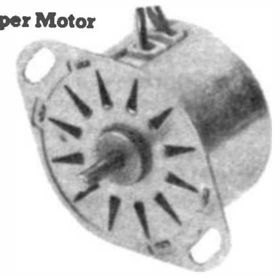
Miniature Slider Potentiometer



As used in the Guitar Equaliser Project featured in this issue, a 20kΩ, linear track slider potentiometer measuring only 60mm long x 7.5mm wide. It has PCB insertion pins for directly mounting flat to a printed circuit board, to a height of 7.5mm excluding lever. The pin spacing is not compatible with 0.1in. Veroboard. Alternatively it can be attached to a front panel etc., having two M2 size threaded holes at front with fixing centres of 56mm. The 20mm long lever can accept our slider knob YG09K. The lever has a centre click-stop action.

Order As FT68Y (Min Slide 20K LIN) Price £1.45

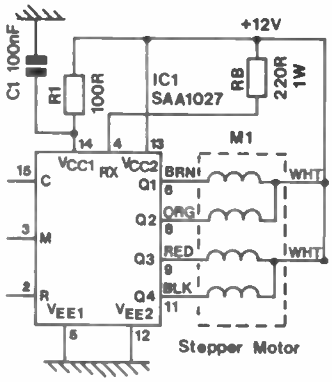
Stepper Motor



A 12V 4-phase, unipolar stepping motor suitable for small robots and all kinds of applications requiring medium torque at low current drains. A suitable driver is the SAA1027 (described below) and a kit is also available which contains the motor, the IC and the passive components required.

Specifications:

Step angle:	7·5°
Current per phase:	130mA
Resistance per phase:	94Ω
Inductance per phase:	43mH
Dynamic torque, at 10pps:	80gm/cm (8mNm)
Response frequency:	300pps
Rotor inertia:	4gm/cm²
Weight:	57gm
Dimensions:	35mmØ x 25mm deep
Max. width across mounting tabs:	50mm
Fixing centres:	42mm x 6BA/M3
Drive Shaft:	3mm dia x 11mm long

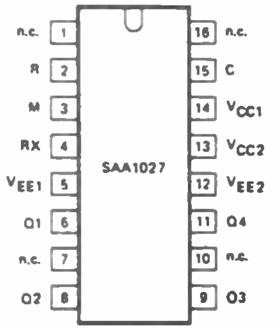


The motor is provided with six wires 230mm long, colour coded White, Brown, Orange, Black, Red, White.

Order As
FT73Q (Stepper Motor Size 1) Price £9.95
LK76H (Stepper Motor Driver Kit) Price £13.35
(These two items will not be available until early July.)

Stepper Motor Driver IC

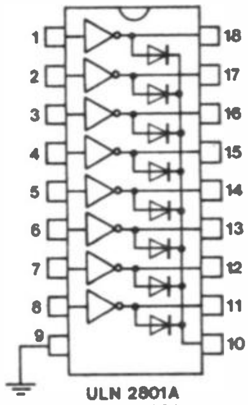
A 16-pin IC designed to drive 4-phase unipolar stepping motors. The IC has a bi-directional 4-state counter, and a code converter so that the four outputs switch in the right order. Supply voltage 9.5V to 18V (typically 4.5mA at 12V). Output current possible is 350mA per output (500mA absolute max. at 25°C).



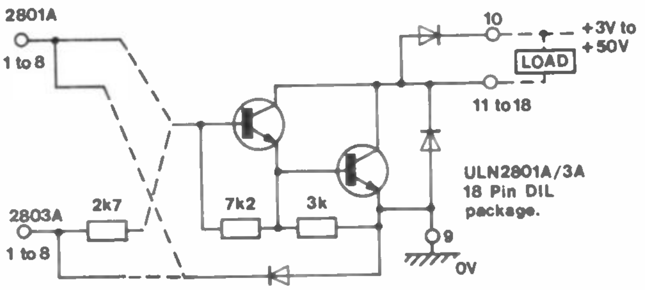
The motor will run clockwise when pin 3 is low (<4.5V), and counter-clockwise when pin 3 is high (>7.5V). The motor will step once for each low to high transition on pin 15. Pin 2 should be connected to pin 13 unless a reset function is required. Taking pin 2 low sets output pins 6 and 9 low, and pins 8 and 11 high.

Order As QY76H (SAA1027) Price £3.75

Octal Darlington Driver Arrays
Eight separate darlington amplifiers in one 18-pin package, each capable of supplying 500mA at up to 50V. Outputs may be paralleled to give up to 4A at 50V (at 23% duty cycle and 25°C). Internal diodes are provided for inductive loads. Type 2801 may be used with standard bipolar digital logic or CMOS, while type 2803 has a 2k7 base resistor to enable direct connection to TTL and 5V CMOS.
Order As
QY78K (ULN2801A) Price £1.72
QY79L (ULN2803A) Price £1.82

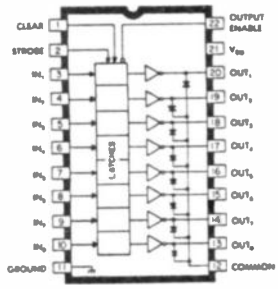


ULN 2801A
ULN 2803A



Latching Octal Driver
A high current, high voltage driver IC comprising eight CMOS data latches, a bipolar darlington transistor driver for each latch, and CMOS control circuitry. Inputs are CMOS, PMOS and NMOS compatible, and a pull-up resistor is required for TTL. Input speeds up to 5MHz are possible with 5V supply, and much higher rates with 12V supply. Outputs are open collector with integral diodes for inductive loads, and are capable of sinking 500mA at 50V at 25°C. If more than two maximum loads are connected at once, then the duty cycle must be reduced (to 23% for all eight loads at 25°C). Outputs can be paralleled for higher currents.

Specifications:
Supply voltage (V_{DD}): 5V to 12V
Input voltage high (min):
V_{DD} − 1·5V (V_{DD} max.)
Input voltage low (max):
1V (−0·3V min.)
Supply current:
5·6mA @ V_{DD} = 5V;
8mA @ V_{DD} = 12V



UCN-5801A

Data present at an input is transferred to its latch when pin 2 is high. A high on pin 1 sets all latches to output off regardless. A high on pin 22 sets all outputs off regardless. When pin 22 is low, the output depends on the state of its latch.
Order As QY77J (UCN5801A)
Price £7.95

AMENDMENTS TO 1985 CATALOGUE

UNIVERSAL BATTERY CHARGER YK31J (Page 34). This universal nickel cadmium battery charger has changed in style but is essentially the same as the style shown in the catalogue. The new type is not supplied with a carry case, nor does it have monitor meter. The charger will take up to four AA, C or D type cells including PP3, but not button cells. Size 210mm long x 104mm deep x 55mm high, colour black with transparent lid. Fitted with 1.6 metres of mains lead.

C ANALOGUE PORT CABLE (Page 134). This cable assembly has a 15-pin D range plug, and not 16-pin.

HERO JUNIOR KIT KA00A (Page 167). This kit version of Hero Jr now includes the RS232 interface RTA-1-3, and the cartridge adaptor RTA-1-5. The Hero Jr Kit has also been reduced in price to £549.95.

LOW-COST PHOTOTRANSISTOR YY66W (Page 198). This device now has a TIL78 package and not TO106, and has only two leads for collector and emitter. The collector is denoted by a flat on the package and the shorter of the two leads. Electrical characteristics are Light Current at 940nm Vce = 5V, H = 20mW/cm^2), 7mA; Dark Current at Vce = 30V, < 0.1nA; Peak Spectral Response, 940nm.

40W STEREO AMPLIFIER XH48C (MES33). (Page 232). We regret that it has become necessary for us to discontinue kit XH48C. Some of the special parts are no longer available. Please check before commencing construction that all the parts you are going to need are available and order any that appear on page 232 of the 1985 catalogue at once, as all these items will be discontinued when all present stocks are exhausted (i.e. are currently 'while stocks last'). If you are now unable to complete this project as a result of our inability to supply all the parts, we will consider requests for refunds, and you should write at once giving full details of your claim to:
The Sales Manager, Maplin Electronic Supplies Ltd, P.O. Box 3, Rayleigh, Essex SS6 8LR.

RESISTANCE WIRE BL64U (Page 286). This constantan resistance wire is supplied as 1 oz reels, not 2 oz reels.

200W 15 INCH BIG CAT XG53H (Page 391). The specifications table should read 200W continuous rms, and not 100W rms.

15W LINE TRANSFORMER YX66W (Page 435). This item has been erroneously omitted from the catalogue, and is still available. Current price £3.95.

THYRISTOR MCR102 QH43W
This device has been while stocks last for some time; it has not appeared in either the 1984 or 1985 editions of the catalogue. However a number still remains in stock. The MCR102 has the following specifications: Case style, TO92f; PIV, 30V; IT (r.m.s), 0.8A; VGT (max.), 0.8V; IGT (max.), 0.2mA; IH (max.), 5mA; Price 59p.

CORRIGENDA

Project Book 6
Tuneable Scratch Filter. In Figure 7, the wiring diagram, the connections from S1 and SK1, to C2 and C2 ground, are shown reversed at the PCB. S1 connects to C2 via the veropin to the left of C2, and SK1 earth connects to PCB 0V via the veropin to the right of C2.

Vol. 3 No. 10
80 Metre Amateur Receiver. In the Parts List RV2 should be the 4k7 Log Pot and RV3 is a 4k7 Lin Pot.

Vol.3 No. 12
PWM Motor Driver. In Figure 8, the +V lead should be Red and the 0V lead should be Black.

Vol. 4 No. 13
New products, transformer kits. The turns ratio quoted for the 20, 50, and 100 watt transformer kits are in the wrong order. Final corroborated turns/volts ratios are as follows:-
20VA − 6.04 turns per volt, +1% for each multiple of 10VA loading.
50VA − 4.8 turns per volt, +1% for each multiple of 10VA loading.
100VA − 4.16 turns per volt, +1% for each multiple of 10VA loading.
N.B. 240 volt isolation transformers can easily be made (provided the factory wound primary windings are not used as the secondary), as follows:-
For 20VA 1,450 turns of 34 s.w.g. enamelled copper wire (80mA out).
For 50VA 1,150 turns of 31 s.w.g. enamelled copper wire (200mA out).
For 100VA 1,000 turns of 28 s.w.g. enamelled copper wire (400mA out).

Vol. 4 No. 14
4 Channel PWM Controller. In the circuit diagram Figure 1, and in the parts list, the horizontal subminiature preset RV1 (WR59P) is shown as being 22kΩ, whereas in fact it should be 100kΩ (Stock Code WR61R). In addition in Figure 1 the four outputs CH1 O/P to CH4 O/P are shown with each output and adjacent earth PCB pin numbers the wrong way round. The correct pin numbering is as follows:-
CH1 output, pin 13; ground, pin 12.
CH2 output, pin 15; ground, pin 14.
CH3 output, pin 17; ground, pin 16.
CH4 output, pin 19; ground, pin 18.
Pin 20 is +5V from supply, i.e. is electrically connected to pin 1, and can be used as a +5V out.

Zero 2. The Zero 2 'turtle' robot article was written by David Buckley, whose name unfortunately somehow went missing from the article. We hope Mr. Buckley will accept our sincere apologies.

New Products, IPC Insertion Tool.
This IPC insertion tool has been described as being required to connect cables to the 4-way or 6-way IPC line plugs, this is incorrect. The tool is used for connecting wires to Master or Secondary Jack Units having a BT type number with the suffix /3A.

CLASSIFIED

If you would like to place an advertisement in this section, here's your chance to tell Maplin's 200,000 customers what you want to buy or sell, or tell them about your club's activities – absolutely free of charge. We will publish as many advertisements as we have space for. To give a fair share of the limited space, we will print 30 words free of charge. Thereafter the charge is 10p per word. Please note that only private individuals will be permitted to advertise. Commercial or trade advertising is strictly prohibited in the Maplin Magazine.

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For the next issue your advertisement must be in our hands by 8th July 1985.

VARIOUS FOR SALE

EDUCATIONAL ELECTRONIC KIT Denshi Block SR4A deluxe, 150 circuits available, powered from 9V battery. Unwanted Christmas present, £35 plus part postage. Tel: Rochdale 32075.

HEATHKIT 10-18U oscilloscope £70 or swap for Thandar 'scope or Electron computer. 100kΩ/volt multimeter, £25. Wanted, Black and Decker Powercentre and Stanley compressor drill attachment. 01 690 9697.

SERVICE MANUALS for Heathkit GD-1U, £6.00: HD-10, £7.20: IM-13U, £11.00: SB-301, £16.40: SB-600, £2.00: SB-610, £10.00: AW-1U, £1.50: GC-1U, £1.50: postage inclusive. Mr. Small, 8 Cherrytree Road, Chinnor, Oxfordshire.

EXCHANGE AMPEX 1163 4-track recorder, Ferrograph IV tape-deck with stereo valve amplifier, power pack, single-beam oscilloscope (old), manuals and other electronic material for good double-beam oscilloscope. Tel: (0524) 761875, Carnforth, Lancs.

COMPUTERS

MAPLIN SPECTRUM EASYLOAD UNIT (kit LK39N), fully built and tested, with instructions, case, rechargeable ni-cad. Modified to include Spectrum reset switch. £20.00 including P & P. Mr. G.A. Smith, Tel: 0323 897376 after 6 p.m.

SHARP MZ-80A 48K personal computer, integral monitor, tape deck, keyboard. Much software plus books, £210. Tel: Southend (0702) 341856.

COMPUTER SYSTEM. Expanded TRS80 I, level II 32K, LP VII dot-matrix printer, (BBC, Dragon etc. compatible) plus interface and paper, computer monitor, CTR80 cassette recorder, nearly £200 assorted software/books, 19 tapes. Cash needed urgently - cost £1150 - offers over £325. St. Helens (0744) 811816.

JUPITER ACE MICRO for sale – includes all leads, power supply, introductory cassette – also *17* games, 16K memory expansion, edge connector. £45 post paid. R. Hanley, Clonmoylan, Portumna, County Galway, Ireland.

ZX SPECTRUM BOOK LIBRARY. Send SAE for details to P. Lavender, dept. M.C, 27 Min-Y-Coed, Radyr, Cardiff CF4 8AQ.

SHARP MZ711 COMPUTER 64K RAM, comprehensive 200 page manual includes BASIC, circuit diagrams, monitor details, maps etc. Unused, unwanted Xmas present in original packing. £110 o.n.o. Tel: (0580) 712019.

MAPLIN 300 BAUD MODEM. RS232 interface. Professionally built in silver and black case. BBC lead supplied. £35. Hornchurch (04024) 51423.

MUSICAL FOR SALE

MAPLIN 5600S SYNTHESISER complete component schedule, requires only time to complete. Must sell, any reasonable offer considered. Mr. Gregory, Tel: Staverton 434.

PAIR AUDAX LOUDSPEAKERS bass/midrange driver units (without cabinets), new unused, 30cm (12in) dia. 50W 8Ω, resonance 60Hz, £35.00 the pair. 0268 415173 (answerphone).

PENSIONER 69, would like to buy a Maplin organ circuit board, unused or not completed. No damage accepted. E.E. Matthews, 63 The Oval, Otley, West Yorkshire, LS21 2EE.

3600 SYNTHESISER (digital keyboard and other modifications), £195. Electronic piano, Elektor design £120. Clef String Ensemble (many extras), £160. Microtan 65/Tanex (needs attention), £80. Carter ASCII keyboard, £25. Offers for any item considered. Telephone Knowle 78488 evenings/weekends please.

MATINÉE ORGAN, working but cabinet unfinished, £200. Thame 4921 (STD 084421).

MAPLIN MATINÉE ORGAN regularly used, no known faults, most modifications, excellent condition, £300. Tel: 01 551 3348

WERSI HELIOS W2T ORGAN, computer 64 presets, Wersiharp, digital reverb, all options, sapele mahogany cabinet, add-on transporter ends, microphone. Tapes available. £3,100 o.n.o (list £11,500). Plymouth (0752) 42786.

ROLAND POLY JUNO 6, excellent condition, also stand and jack lead, £450. Roland SH101 mains adaptor (mono), plus lead and case, £250. Tel: Paul (0702) 715543 evenings after 6.00pm.

MANY PARTS FOR MES53 ORGAN including 61 note keyboard with contacts, 2 DMOT2 MkII, power supply and most boards with components fitted, £80. Also Maplin 3800 synthesiser, tuned and in home built cabinet. £125 o.n.o. 01 764 5360.

WANTED

WANTED, CIRCUIT DIAGRAM and tape and keyboard I/O methods for the ZX Spectrum. Please send to: A. Gonnet, Sun Cottage, Bellingdon, Chesham, Bucks HP5 2XW.

WANTED, CIRCUIT DIAGRAM for W.K.S 1001, or W.K.S 1001 transmitter, any condition, will pay reasonable price including postage. Write to: Martin Fuller, 37 Greenfield Close, Eccles, Nr Maidstone, Kent ME20 7HU.

WANTED, SONIC TAPE MEASURE either complete, or as kit with instructions and circuits. Contact C.K. Cole, 18 Beech Grove, Harrogate, HG2 0EX.

MAPLIN'S TOP TWENTY KITS

THIS	LAST MONTH		DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(-)	◆	Live Wire Detector	LK63T	£2.95	14 (XA14Q)
2.	(1)	◆	75W Mosfet Amplifier	LW51F	£15.95	Best of E&MM
3.	(2)	◆	Partylite	LW93B	£10.95	Best of E&MM
4.	(4)	◆◆	Car Burglar Alarm	LW78K	£7.49	4 (XA04E)
5.	(8)	◆	Light Pen	LK51F	£10.95	12 (XA12N)
6.	(10)	◆	Computadrum	LK52G	£9.95	12 (XA12N)
7.	(6)	◆	ZX81 I/O Port	LW76H	£10.49	4 (XA04E)
8.	(9)	◆	Ultrasonic Intruder Detector	LW83E	£10.95	4 (XA04E)
9.	(11)	◆	Syntom Drum Synthesiser	LW86T	£12.95	Best of E&MM
10.	(15)	◆	Musical Announcer	LK57M	£13.50	13 (XA13P)
11.	(7)	◆	8W Amplifier	LW36P	£4.95	Catalogue
12.	(12)	◆◆	Logic Probe	LK13P	£10.95	8 (XA08J)
			Case also available: FJ37S Price £1.48			
13.	(13)	◆◆	Harmony Generator	LW91Y	£17.95	Best of E&MM
14.	(-)	◆	Spectrum Easyload	LK39N	£9.95	10 (XA10L)
15.	(-)	◆	Burglar Alarm	LW57M	£49.95	2 (XA02C)
16.	(-)	◆	15W Amplifier	YQ43W	£5.75	Catalogue
17.	(-)	◆	PWM Motor Driver	LK54J	£9.50	12 (XA12N)
18.	(-)	◆	Cautious Ni-cad Charger	LK50E	£19.95	11 (XA11M)
19.	(-)	◆	Car Battery Monitor	LK42V	£7.95	Best of E&MM
20.	(-)	◆	Noise Gate	LK43W	£9.95	Best of E&MM

Over 100 other kits also available. All kits supplied with instructions.

The descriptions above are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate Project Book mentioned in the list above – see inside back cover for details.

1985 CATALOGUE

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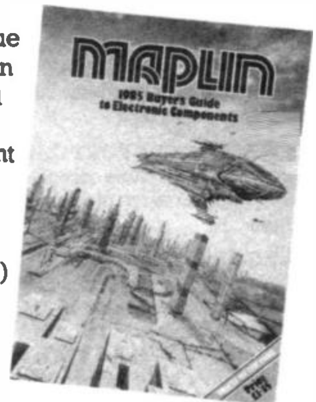

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Project Book 1 Universal Timer. Programmable mains controller. **Combo-Amplifier.** 120W MOSFET power amp. **Temperature Gauge.** 10°C - 100°C, LED readout. **Pass The Bomb!** Pass-The-Parcel with a difference. **Six easy-to-build Projects on Vero-board.** Car batt. monitor; Colour snap game; CMOS Logic Probe; Peak Level meter; Games timer; Multi-colour pendant.
Order As XA01B (Maplin Project Book No. 1) Price 70p *NV*.

Project Book 2 Digital Multi-Train Controller. Controls up to 14 model trains. **Home Security System.** Six independent channels. **Digital MPG Meter.** With large LED display, a must for more economical motoring.
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Project Book 6 VIC20 & ZX81 Talkbacks. Speech synthesis projects. **Scratch Filter.** Tunable active circuit 'reclaims' scratched records. **Bridging Module.** Converts two 75W MOSFET amps to one 400W full bridge amplifier. **Moisture Meter.** Finds damp in walls and floors. **ZX81 TV Sound and Normal/Inverse Video.** TV sound and inverse video direct. **Four Simple Veroboard Projects.** Portable Stereo Amp; Sine Generator; Headphone Enhancer and Stylus Organ.
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Electronics Issue 10 Spectrum Easyload. Helps cassette loading with the Spectrum. **80m Receiver.** Simple SSB direct conversion receiver. **Fluorescent Tube Driver.** 8W 12V for camping and caravanning. **Auto-Waa.** Automatic waa-waa effects unit. **Digi-Tel Expansion.** Expands Maplin Telephone Exchange to 32 extensions. **Oric 1 Modem Interface.** Adapts the Oric 1 to the Maplin Modem. **Dragon 32 Extendiport.** Makes the Dragon's cartridge socket more accessible.
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Electronics Issue 11 Mapmix. Six channel audio mixer. **Xenon Tube Driver.** Xenon flash tube module with strobe. **Enlarger Exposure Meter.** Simple inexpensive tool for the darkroom. **8 Channel Fluid Detector.** Check control fluid level in up to 8 containers. **Servo & Driver Module.** Servo mechanism with driver module kit. **Mk II Noise Reduction Unit.** Improves signal noise ratio of tape recordings. **Cautious Ni-Cad Charger.** Controlled charging of ni-cad cells. **Motherboard for The BBC Micro.** Gives easy access to ports.
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Order As XA13P (Maplin Magazine Volume 4 Issue 13) Price 75p *NV*.

Electronics Issue 14 Live Wire Detector. Invaluable aid for the handyman. **Trundle.** The line follower robot as featured on Channel 4. **Zero 2.** High quality 'turtle' robot. **4-Channel PWM Controller.** Digital control of motors and servos. **Display Driver Module.** How to use our LED bargraph display ICs. **Control-A-Train.** Full inertia control of model trains.
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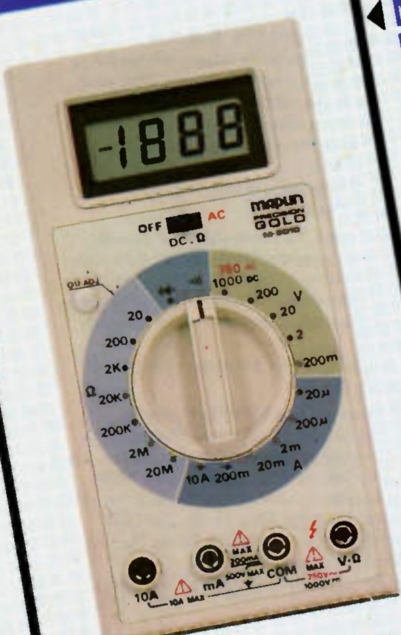

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