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No 42

# ELECTRONICS

## The Maplin Magazine

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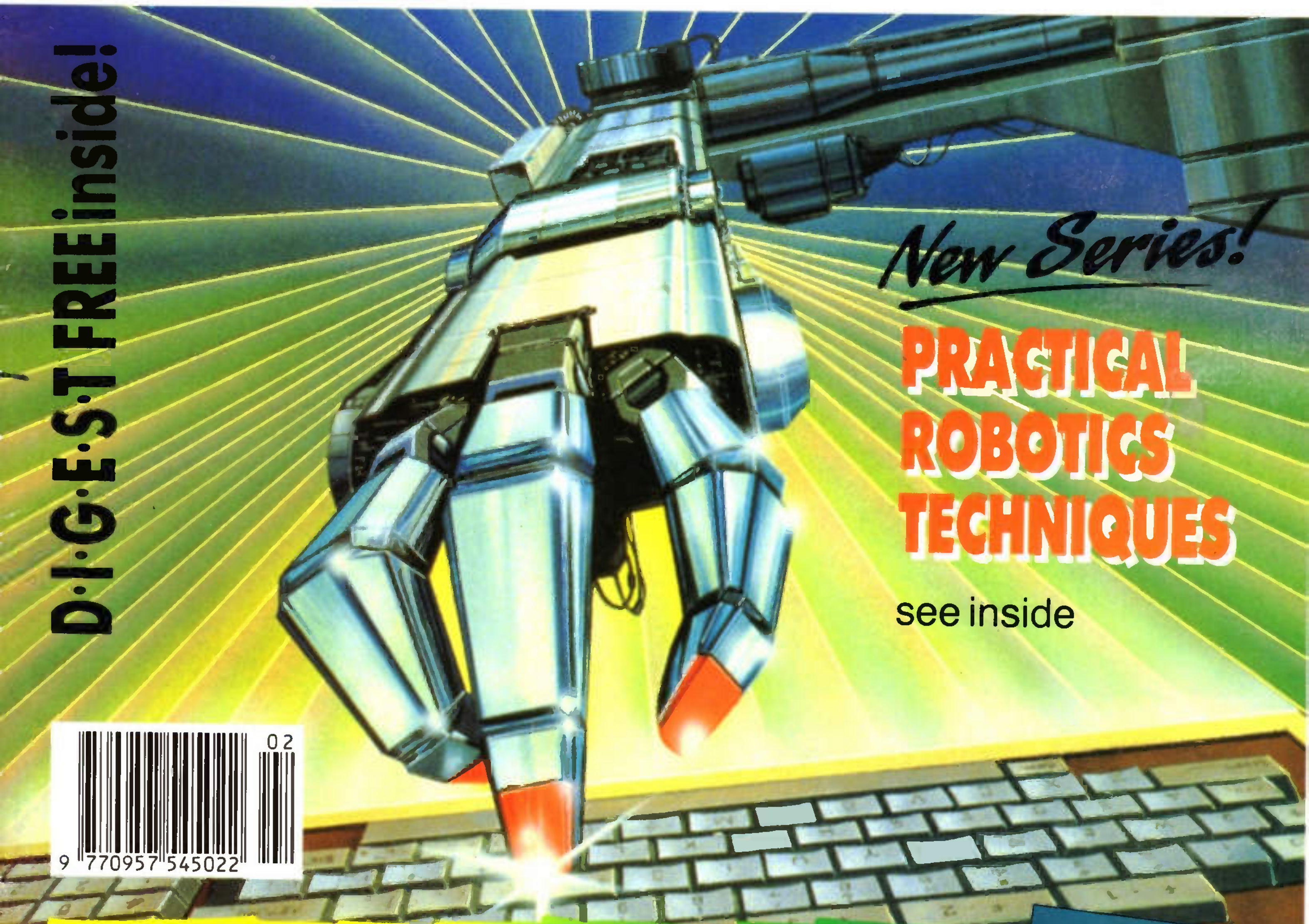

*New Series!*

**PRACTICAL ROBOTICS TECHNIQUES**

see inside

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• How to build a High Quality PSU • Data File: SSM 2044 Voltage Filter • 'TetraProbe' Test Unit • Beginners' AM Radio • TV Effects Unit • Win Imperial War Museum Tickets • Read all about BASIC Programming • Attenuators • How we Hear • Electronic Fundamentals and EPOS


FREE INSIDE! FREE INSIDE! FREE INSIDE!

# CONTENTS

**FEBRUARY TO MARCH 1991 VOL.10 No.42**

## EDITORIAL

Hello! And welcome to this edition of 'Electronics – The Maplin Magazine'! In the projects line-up there is a High Quality Power Supply which, when combined with the MOSFET Amplifier, published in the last issue provides the basis for a professional power amplification system. There have been many requests for beginners' projects, so we've designed an AM Radio project specifically for you. 'Data File' presents the SSM2044 VCF IC, ideal for use in synthesiser and audio effects applications. Test equipment is often needed on the work bench but is expensive to buy; the 'Tetraprobe' offers a viable alternative by combining four frequently used 'pieces of kit' into one compact unit. 'Attenuators' provides some useful ideas for measurements on the work bench. The 'TVFX Unit' presents the novel idea of using a colour TV or video monitor as the basis for a colourful pulsating screen display. Apart from our regular features, there are three new series: 'Practical Robotics' looks at how to build and control simple robots, 'Programming in BASIC' and also 'Hearing, Deafness and Electronic Technology' deals with the inner workings of the human ear. With such a lot inside you'd better read on and enjoy!

R. T. Smith

ABC 35,579


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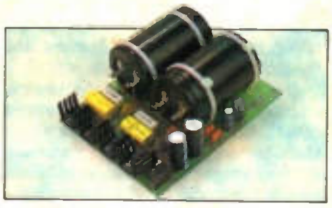
## PROJECTS







## FEATURES







## REGULARS



## CORRIGENDA

October to November 1990 VOL. 9 No. 40
Compuguard Vehicle Alarm Part One
The track layout of some early issue Compuguard main unit PCBs contained an error. Please refer to page 54 for details of the correction.

December 1990 to January 1991 VOL. 10 No. 41
Compuguard Vehicle Alarm Part Two
Figure 9 on page 11 has been updated and the old version was inadvertently printed with incorrect pin numbering. The numbering is as follows, where the first number is the old incorrect number and the second number is the new corrected number: 1 = 8; 2 = 7; 3 = 6; 4 = 5; 5 = 4; 6 = 3; 7 = 2; 8 = 1; 9 = 16; 10 = 15; 11 = 14; 12 = 13; 13 = 12; 14 = 11; 15 = 10; 16 = 9.
Table 1 on page 13 contains a printing error. (Please note that Table 1 in the Compuguard Leaflet (XK35Q) is correct). The twelfth line, last column, should read: TB2-6 and NOT TB2-8 as printed.

# NEWS Report

## When it's Not Smart to be Square

So it's goodbye to BSB and Hi to Sky. Indeed for BSB and its viewers, it is certainly 'a funny old world'. Exactly two days after launching their multi-million pound advertising campaign came the announcement of the Sky take-over – sorry, merger. Along with the demise of BSB comes the probable demise of the D-MAC (Multiplexed Analogue Component) broadcasting standard. Instead the PAL (Phase Alternation Line) system as used by Sky, and is likely to dominate the sky-waves. Sky say that their Astra satellites will continue to transmit PAL, although technically it would be possible to transmit the MAC system.

Meanwhile, the news is of no great concern to Maplin customers, who may have invested in the Maplin top of the range multi-satellite, receiving system. Although capable of picking up some 100 channels, the system was designed to receive PAL transmissions only. In fact Sky lost little time in launching their new series, 'The Golden Age of Movies'. Sky Television's 24-hour a day subscription film channel, 'Sky Movies', has lined up some vintage films which include 'The Seven Year Itch', and 'Ninotchka'. To celebrate the series, Sky has issued a brochure written by film critic Elkan Allan. Maplin have secured a dozen copies and the first 12 postcards which correctly identify the respective leading stars will enter the editor's draw. Entries by the 5th April please to Sky Movie Contest, Electronics – The Maplin Magazine, PO Box 3, Rayleigh, Essex SS6 8LR (or fax 0702 553935).

## A Dishy Future

Now it seems that the BBC are joining the satellite action. BBC TV Europe, the satellite relay of the best of BBC television to viewers in Europe, is to be re-launched from September 1991. The new service will offer a number of features not provided at present, including stereo sound and an extension of Teletext. The aim is to make BBC TV Europe the leading English language TV service in Europe, targeting everybody who speaks English. The service is already seen in well over half a million households in 22 countries throughout Europe via cablenets, SMATV and Direct-to-Home. BBC TV Europe, which is transmitted from East Spot Beam on Intelsat VI, is an 18 hours a day service made up of a simultaneous relay of BBC1 with BBC2 programmes substituted for purchased programmes, feature films and certain sporting events.

## BBC goes Selective

BBC Select is the name for the range of specialist television services to be launched later this year. A range of up to fifteen 'niche' subscription services for special interest groups will be offered initially. The programmes will be transmitted on both BBC1 and BBC2 transmitters during the night-hours shutdown. Programmes on BBC Select will be transmitted in scrambled or encrypted form which will be decoded and recorded onto the subscriber's video cassette recorder using a specially developed decoder.

The BBC will be concentrating on four broad categories: professional and training, community services, leisure and interest services such as motoring and music, and education services such as languages. Though whether viewers will be willing to pay the subscription and the cost of a special decoder remains to be seen.

## They said it. No Comment

An interesting couplet noticed in The Wall Street Gazette:

"Our office is all computerised. I happily exalt;
There are still as many mistakes,
But now they're no one's fault."

## Action-line DTI

Apart from releasing details of their proposals on the U.K. communications duopoly, the Department of Trade and Industry have been having a busy time. For Information Technology users, the DTI have launched 'Usability Now', a programme aimed at encouraging IT users to be more precise and demanding in their specifications for hardware and software with a view to improved efficiency and ease of use. The objective is to bridge the communications gap between the industry and the user, particularly for improving human-computer interaction. For details, contact the DTI: 071-222 3312.

The DTI have also put out a document which suggests that the U.K. has the broadest product base in Europe in electronic components. In particular, the U.K. has the largest semiconductor market in Europe and the second largest market for other electronic components. Growth areas include consumer electronics, automotive and mobile telecommunications.

## YEDA

The Young Electronic Designer Awards Scheme, which is now sponsored by Mercury Communications, is open to students at secondary schools, polytechnics and universities in the U.K. There are three age categories: junior (under 15), intermediate (15–17 years) and senior (18–25 years). The basic challenge of the scheme in this age of technology is for students to produce an electronic device of their own which is original, effective and has a useful application in everyday life. There are cash prices of £2,500 for the schools or colleges plus personal prizes. Additionally, the winning projects will be on show at the Science Museum. Details: 0403-211048.

## Skills Shortages

Employers, meanwhile, should make a note of the Science Museum event. Apparently nearly half of U.K. electronics companies are experiencing skills shortages and the situation is not getting any better. Factors include the falling number of school leavers and the lack of skilled training at school.

The combined power of the 'comms Industry' has got together to launch a new Certificate of Telecommunications Management, which aims to alleviate skills shortages in the industry. Those involved include the Telecom Users Association, the National Computer Society and the British Computer Society. Although whether, having managed to recruit the necessary skills, companies will still insist on a training exam is very much open to doubt. Especially as the comms world is such a fast moving and innovative subject.

## New Film Chip

Panasonic have introduced the world's first film chip capacitors able to withstand high temperature flow and re-flow soldering. The new UF-series is the product of a breakthrough in the technological development of passive components resulting in two model ranges: the ECH-U for critical applications requiring the maximum performance, and the ECW-U for more standard applications. Details: 0344 853550

## Strip Circuit

According to the influential daily news report 'Computergram', a Rome night-club is featuring a $150,000 American-built 'female' robot called 'Futura', which does a strip-tease amid dimmed lights and clouds of vapour. But just who gets turned on (or off) is not made clear.

## Happy Birthday Telecom Tower

One of London's best-known landmarks, The Telecom Tower recently celebrated its 25th birthday. Opened in 1965 by the then Prime Minister Harold Wilson, the 620 foot tower has become the focal point of the nation's telecommunications system. It acts as a switching point for radio, television and telephone signals world-wide. The tower can carry 110 television channels and 90,000 telephone and data links, sending signals by microwave radio which reduces the need for more expensive underground cables. For the statistical record, the tower cost £9 million to build and weighs 13,000 tonnes. To rise to 620ft, the tower's high-speed lifts travel at six metres per second.

## Challenging Disability

British Telecom is increasingly involved in social matters. Now the corporation has introduced a new video 'Everyday', which shows how four people have successfully dealt with their own challenges in communications. The four are, a teacher of lip-reading, a deaf teacher, a blind switchboard operator, and an artist who has multiple sclerosis. Copies of the 'Everyday' video are available on free loan to clubs, societies and community groups. Details: 071–356 5369.

## Don't Take Care

Honeywell has introduced a robust, sealed, 101-key, PC compatible, Hall-effect keyboard designed for industrial applications and environments. Suggested areas of operation include warehouses, shipping and maintenance centres where dust, grime, moisture and liquid contamination threaten keyboard operation.

The Honeywell Hall-effect solid-state series of keyboards have a proven long life of over 100 million operations. Now then, pass me that hot coffee . . . Details: 0344-424555.

## '999' – No Change

Suggestions that BT is to phase out the emergency number '999' are erroneous. BT has no plans in fact to move to suggested 911 or 112 numbers. "The 999 number is too firmly embedded in the nation's consciousness to make any change practicable or desirable", says BT.

## Mercury Calls

Following the 15% cut in the price of economy rate calls for residential customers calling North America, Mercury Communications has been pulling in new customers. By the end of the year, the total number of home users of Mercury's services was over 70,000. However, with BT still enjoying over 95% of all comms traffic, the government are keen to see Mercury extend their competitive service further. As a result, we can expect more tariff cuts before long.

## Father of Computing Goes on Show

From July this year for six months, the Science Museum will be putting on show Charles Babbage's full-size Difference Engine No. 2, constructed from original designs dating from 1847. The engine (which was never completed) consists of 4,000 parts, weighs 3 tonnes, and measures 10ft long, 6ft high and 1·5ft deep. It is widely believed, says the Curator of Computing, that Babbage failed because of the limitations of nineteenth-century machine tool technology. "By building a Babbage engine to original designs we have set out to prove that these machines could have worked in Babbage's day".

## Taking Note

It has been a very busy period in the micro market-place. Compaq Computer introduced what it describes as the highest-performance notebook personal computer, the LTE 386s/20, a PC small enough to carry in a briefcase yet as powerful as many desktop computers. The new system incorporates a 20MHz 386SX processor, cache memory, VGA graphics display, and high performance disk drive in a 7-pound package. Priced at around £4,000, the unit runs on a NiCad battery pack for a period of up to four hours, while a standard AC adapter plugs directly into the system to provide power when a mains supply is available. Details: 081-332 3354.

Somewhat smaller in both price and size is Amstrad's Z80-based notebook computer being prepared for release in the Spring. Also about to reach the U.K. is the new NEC notebook machine which is the size of a diary. However, the advent of the notebook computers is not deterring the industry from developing new laptop machines. Sharp Electronics have recently announced the new PC-4700 portable computer, combining lightweight and compact design with a high quality LCD screen display, for less than £1,000. Meanwhile Toshiba have launched the first colour laptop. The T5200C/200 is a 20MHz 386-based machine with a passive matrix, liquid crystal display screen. Weighing around 16lbs, the unit has a recommended retail price of £6,695.

## Taking the Census

Charles Babbage's machine would have been hard put to cope with the requirements of the 1991 census and surveys. Certainly the results would not have appeared within a year of the event. A contract worth some £1·2 million has been awarded to ICL to supply a Series 39 Level 65 mainframe computer to operate in the Population Census and Surveys office in Southampton. The Series 39, which will operate in conjunction with an existing Amdahl mainframe computer, will be used to process the main census data, with information being exchanged daily between the two systems.

## Who's Calling?

Apparently most people pick up their 'phone by the third ring, but allow videophones to ring *eleven times* on average before they are answered. According to a recent study, the first reaction of many people to the videophone ringing is to rearrange the papers on the desk and check their hairstyles.

Meanwhile videophone pioneer PictureTel is suggesting that picture 'phones are at long last becoming viable. By combining digital video compression algorithms and computer processor technologies, products that can deliver multimedia and video-conferencing are now feasible. But it is one thing telling your boss that you are not feeling too good and that you are staying home in bed, and his seeing you dressed ready for that golf match.

## Hot PhoneCards

According to a letter in "Electronics Weekly", you should be careful where you store your phonecard. Apparently body heat can cause the cards to loose their value. So keep the cards in a well insulated pocket, and definitely *do not* expose them to a hot radiator or excessively high temperatures! Meanwhile, the 100 millionth phonecard for BT has been produced. Currently over 30 million a year are being produced for the near 22,000 cardphones in the U.K. So popular are the various phonecard designs, that BT has set up its own 'Collector's Club'. Presumably they will not be producing a Hot NewsLetter.

It would seem Mercury have also been having problems with their card operated payphones, which made it possible for those in the know to use them for free! Now engineers have replaced the EPROMs containing the software in all of Mercury's 3,200 payphones. Somebody fetch me a 12 year old child.

It is a well know fact (or myth) that anyone *over* the age of 12 has trouble programming their video cassette recorders. Now leading Japanese producer Matsushita has developed the world's first recorder with both speech synthesis *and* speech recognition. This responds to spoken instructions and answers in a synthesised human voice. How is it done? Well the company makes use of 'Continuous Linear Alpha' technology, which makes it possible to recognise spoken commands from a speaker whose speech pattern has not been pre-registered. Groucho Marx would no doubt have approved.

## Getting Mobile

By the end of the decade, there could be up to 15 million mobile communications users in Europe, says Michael Naughton of IT consultancy Applied Network Research. "Of the 320 million people in Western Europe, there could be at least 32 million travelling business users". Though ANR is hesitant when it comes to forecasting the success of telepoint: "Unless the authorities licence CT2 operators to provide two-way services, allowing users to receive as well as send calls, well within present technological capabilities. Telepoint will continue to be shunned by users."

## Advantage Cellnet

British Telecom controlled Cellnet has agreed a £100,000 sponsorship of the Lawn Tennis Association. Tennis was chosen for its clean wholesome image. Lets hope that both the quality of British tennis and cellular radio improves as a result.

In fact Cellnet and sport are becoming even more interlinked with the news that the cellular radio operator is making use of a floodlight tower at Cheltenham Town Football Club's ground. At least fans will be able to 'phone home with the news that extra time is being played and to put lunch back into the oven.

The new 'Cellsite' is one of many which Cellnet are bringing into service as part of a £4 million programme. Those busy numbers on the M25 could soon become a relic of the past.


## Picture Caption Challenge

Yet again a caption challenge courtesy of British Telecom. The corporation, it seems, has its beady eyes on us. Why?

★ Somewhere there must still be an out of order 'phone box.

★ Now just where have those back-up engineers got to?

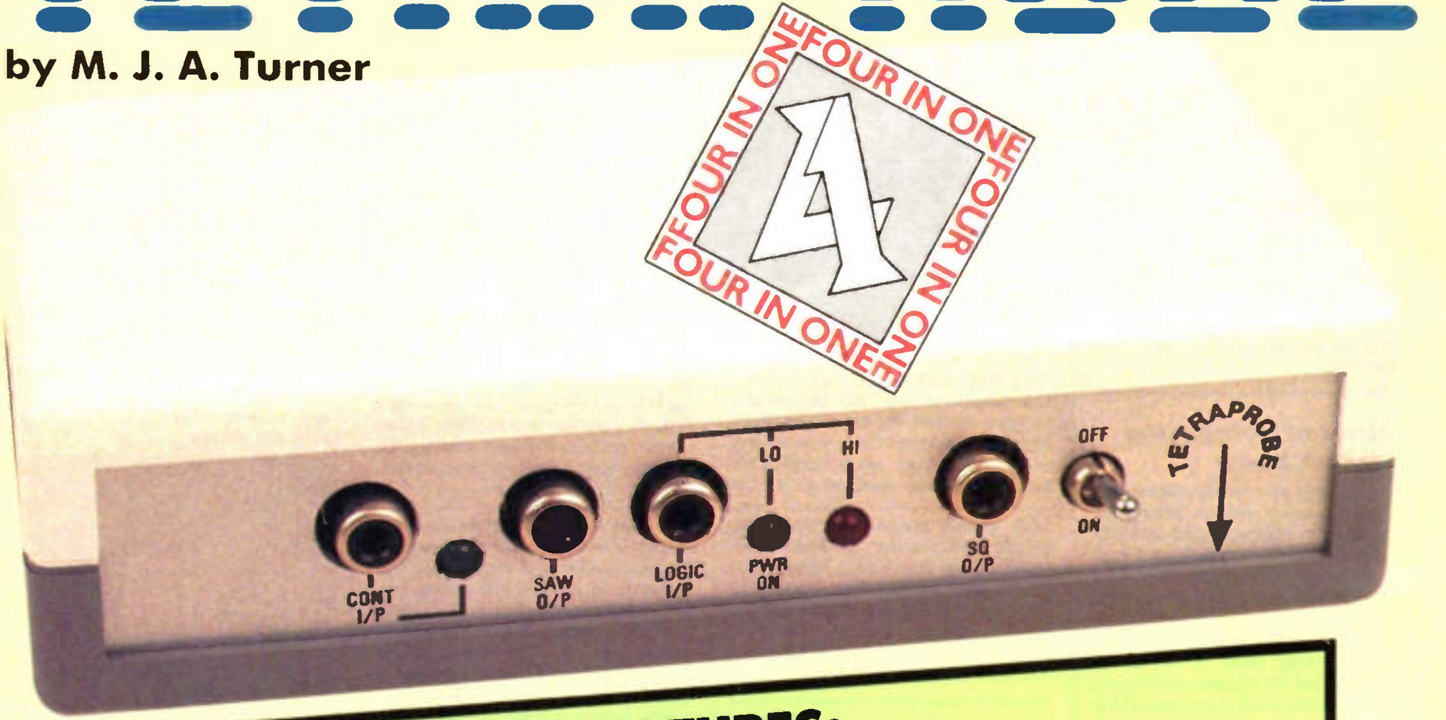
★ BT keeps an eye on potential competition following the publication of the Government's Duopoly review.

★ BT watching out for the subscriber protest march when they get their first Directory Enquiries charge bills.

Well not quite. In fact the picture shows Karen Bell of the BT Motor Transport Group in Birmingham, holding the valve seat insert that is the key element of the conversion of BT's vehicle fleet to unleaded petrol.

# TETRAPROBE

by M. J. A. Turner




## FEATURES:

- ★ Combines Four Widely Used Test Instruments
- ★ Compact Design
- ★ Low Power Consumption
- ★ Easy to Build and Use
- ★ Discriminating Continuity Tester
- ★ 1Hz Square Wave Output
- ★ 1kHz Sawtooth Wave Output

## Introduction

Probably four of the most widely used service instruments are the continuity tester, signal injector, logic probe and square wave generator. They rarely leave the workbench so frequently are they required, and consequently they take up a lot of space.

On the other hand the Tetraprobe contains all four instruments in one and it, in return for a few limitations, offers compact versatility.

## Power Supply

Figure 1 shows the circuit diagram. The power comes from a 9V PP3 battery and RG1 is a 5V regulator. C1 and C2 perform the usual tasks of decoupling and transient suppression.

## Continuity Tester

To test continuity of a conductor the design utilises both visual and audible indicators, comprising a green LED for forward biased germanium and silicon junctions, and a tone for metal conductors. IC1c acts as a comparator. The switch-over voltage is 50mV and is determined by the potential divider formed by R2 and R3. The conductor under test is connected to SK1. If its resistance is greater than 5Ω then the voltage at pin 10 will be higher than pin 9 and the output at pin 8 will be high. When current is flowing, LD1 will light. There will be a voltage of 0·1V or 0·6V across any forward biased semiconductor junctions. As these values are higher than the reference, the comparator will not switch over.

Any conductor of less than 5Ω, such as a length of PCB track or a good soldered joint, will switch the comparator output low and TR1, previously held saturated by the clamping action of D1, will be subject to the oscillations from the signal injector via C5, and a tone will be heard from the piezo transducer BZ1. The oscillations are prevented from disappearing into the output of the op-amp by D1 being reverse biased.

R4 protects the input from damaging overloads, as may be due to accidental connection to live circuits.

## Signal Injector

IC1b is used as a switched reference comparator. R9,10,11 determine the two reference voltages alternately applied to pin 5. When the output at pin 7 is high, C3 charges through R12 until its voltage is higher than that at pin 5 (2·3V). The output goes low and takes pin 5 down to 1·3V via R11. C3 then discharges through D4, until the voltage on C3 is lower than 1·3V. The output goes high again. This cycle repeats, and because D4 discharges C3 quickly, a sawtooth waveform is presented at TR2 base.

The sawtooth is buffered by TR2 in emitter follower mode, and the signal bifurcated, one part being sent via C5 to

### Specification

| | |
|---|---|
| Power Supply: | 9V PP3 battery |
| Standby Current: | 13mA approx. |
| Signal Injector: | 1Vpp into 1kΩ @ 1kHz ±5% |
| Square Wave Generator: | 1Hz @ 5Vpp ±5% |
| Square Wave Source: | 0·6mA @ 3·4V |
| Square Wave Sink: | 60mA @ 0·2V |

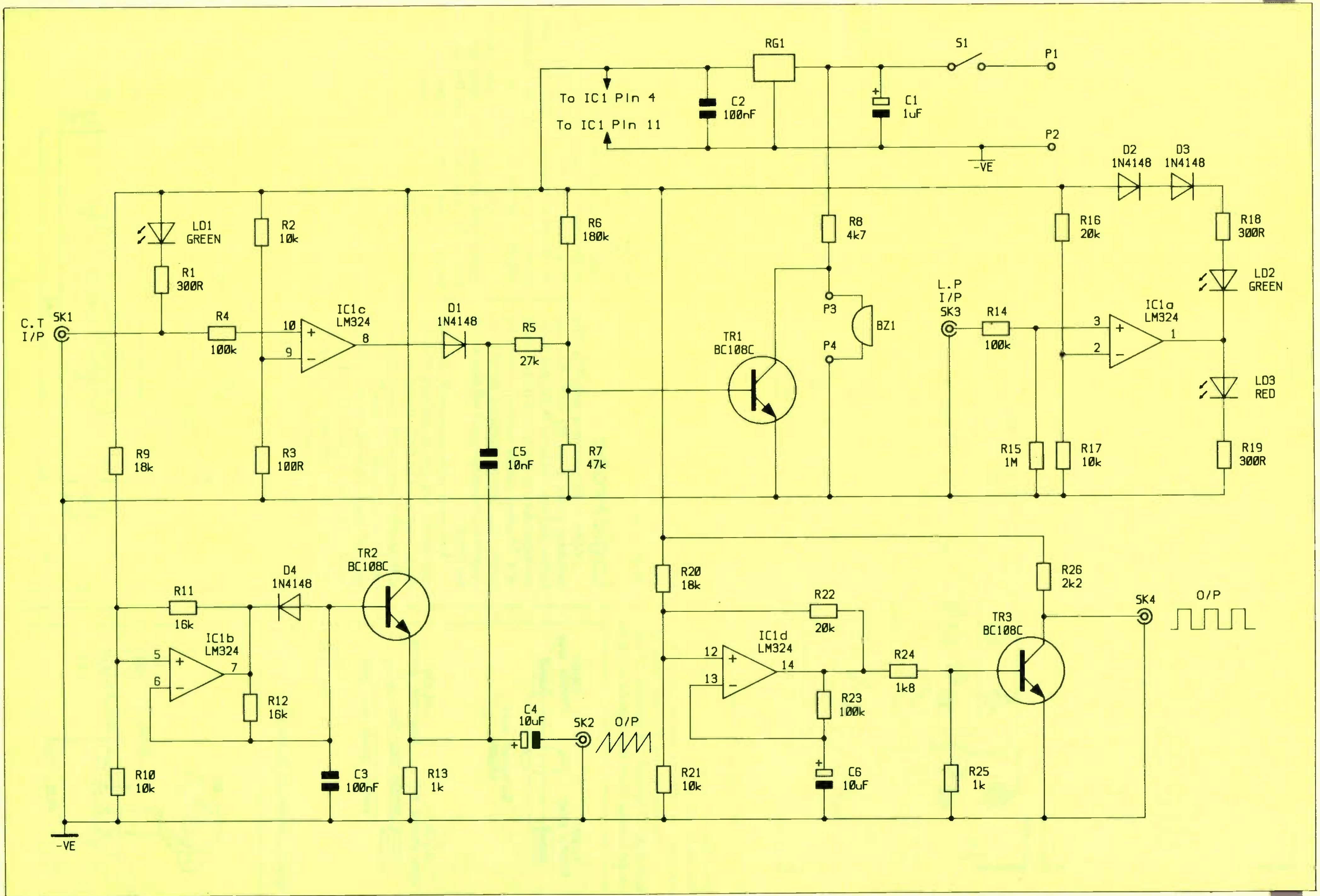



**Figure 1. Circuit diagram of Tetraprobe.**

gated bleeper stage of the continuity tester described above, and the other part delivered via C4 to the output socket SK2.

At low frequencies, the time taken to discharge C3 through D4 (approx. 20$\mu$s), can be omitted from the formula which is $f=1{\cdot}6/RC$. If D4 is removed from the circuit, the formula then becomes $f=0{\cdot}8/RC$ and the sawteeth become 'sharkteeth'. The values chosen produce a $+V_e$ going ramp of 1kHz @ 1V.

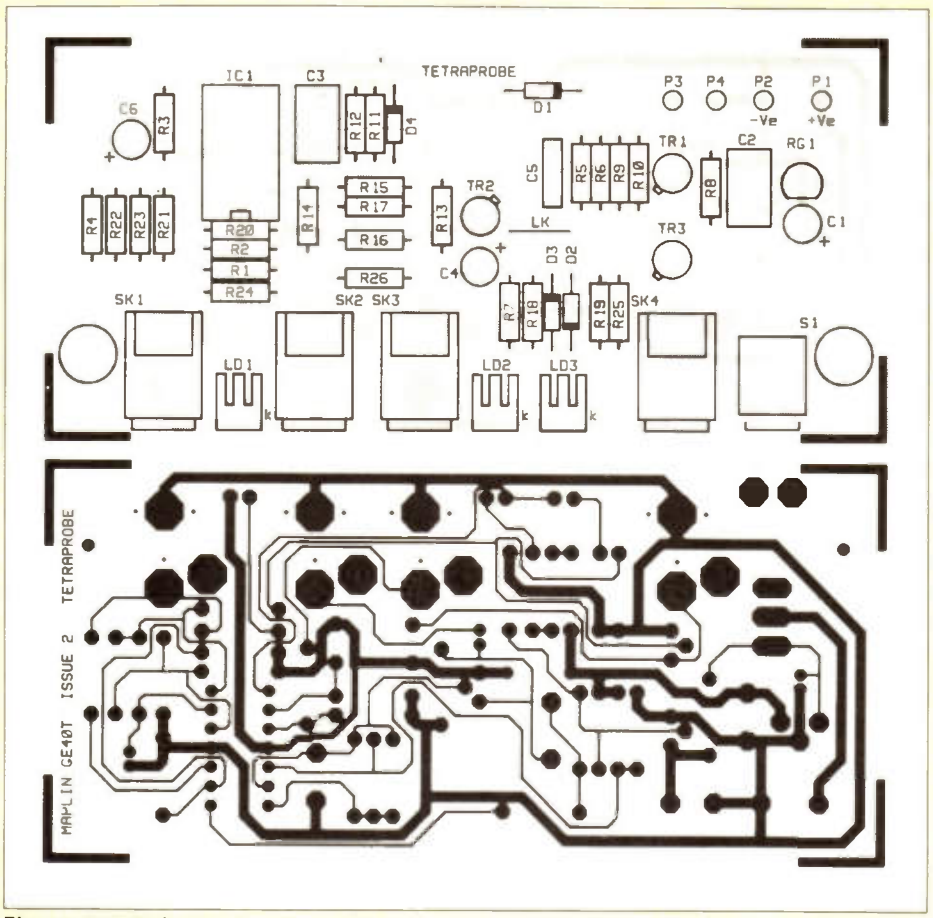



**Figure 2. PCB legend and track.**

## Logic Probe

Again a comparator is used, IC1a. The switching point is set by R16, R17 just below midway between 0·2V and 2·4V, corresponding to the typical output levels of a 74 series device working from a 5V supply. Any device connected via SK3 and operating around this point will also switch the circuit.

R14 protects the input and R15 makes sure that the output indicates logic '0' while there is no input to SK3. Therefore, LD2 also doubles as an on/off power indicator for S1! For signal inputs above 24Hz both red and green LED's will appear to be on continuously due to persistence of vision. Otherwise, the red LED will show logic '1' and the green will show logic '0'.

## Square Wave Generator

Logic gates are in general use for the production of square waves, but op-amps provide an alternative, which is in many ways preferable. The generator is used as a switched reference comparator. The action of the circuit is the same as the signal injector, except for the output.

R23 and C6 are the timing elements. The voltage at C6 moves between the two reference voltages, sequentially applied to pin 12. When these two voltages are 0·377 and 0·622 of the maximum charging voltage, 3·5V, then $f=1/RC$ gives the frequency as 1Hz and the mark/space ratio will be unity.

Transistor switch TR3 is compatible with most current logic devices and is able to deliver 0V to 5V into high resistance inputs such as CMOS, and can also drive up to fifteen 74 type inputs in parallel if required.

## Construction

The Tetraprobe is not a complex instrument and there should be no difficulties in its construction. The PCB components are mounted according to Figure 2 and the parts list. There is only 1 link (LK), on the board and this carries the 5V line from RG1 over impenetrable territory.

Incorrect diode polarity is a major cause of circuit failure, so when fitting the diodes do make sure that the broad band or cathode marker at one end of the diode body lies adjacent the white block printed on the legend. Using an ohmmeter to verify the polarity can be misleading, since while the range is switched to 'Ohms' on some meters, the red lead actually becomes *negative* and the black, *positive!*

Electrolytic capacitors are usually marked with at least one minus sign to denote the negative terminal. The positive terminal is usually unmarked, but generally has a longer lead and goes into the hole marked '+' on the legend.

If IC1 is viewed from above, with the indentation or notch at one end of the plastic package uppermost (at top), then the top left pin is pin number one. The legend on the PCB clearly reflects that of the IC. The IC socket is also provided with a

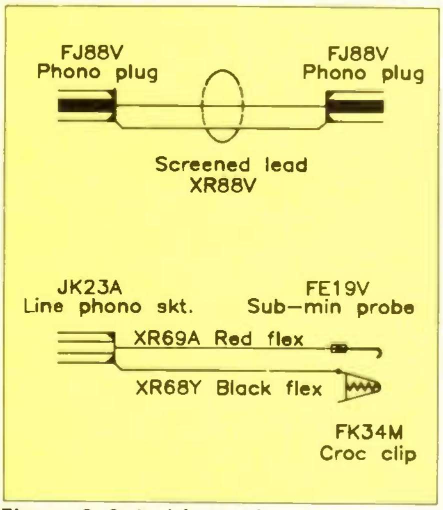



**Figure 3. Suitable test leads.**

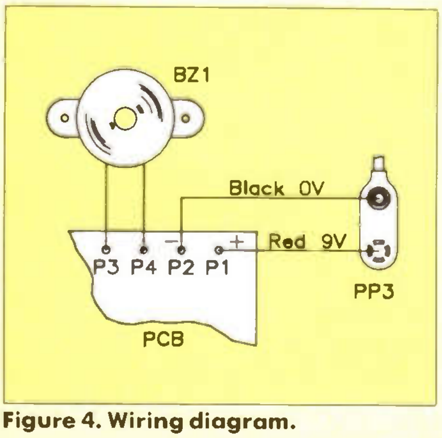



**Figure 4. Wiring diagram.**

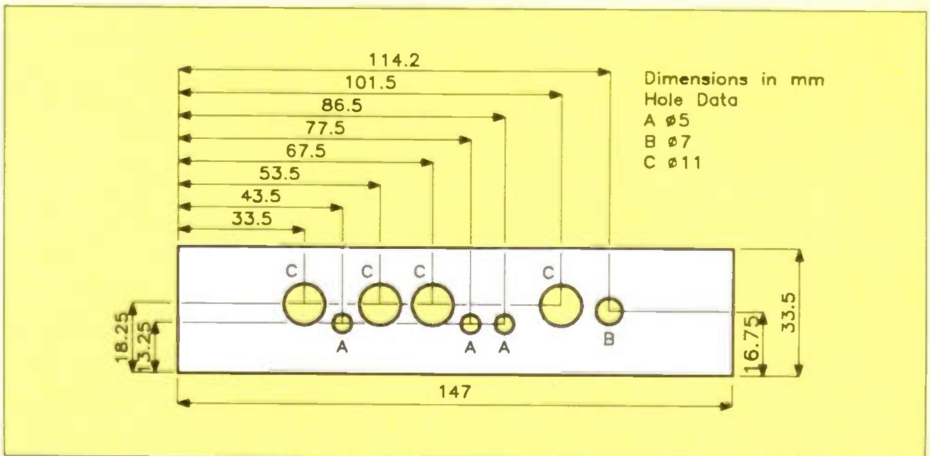



**Figure 5. Front panel drilling details.**

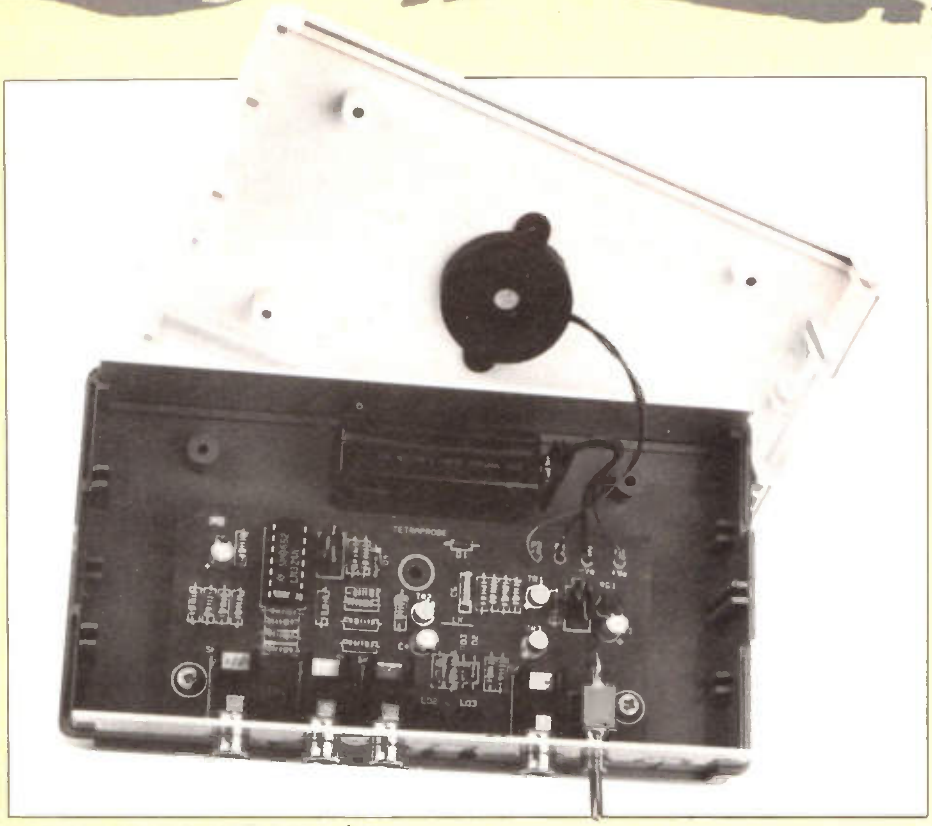



**Photo 1. Assembled Tetraprobe.**

similar notch and so should be inserted into the PCB wiith this corresponding to the white block on the legend. *Do not* insert IC1 into its socket yet!

Figure 3 shows suitable test leads for the Tetraprobe.

Battery and transducer wiring is shown in Figure 4. Single-ended 1mm veropins can be used to connect them to the board if preferred.

Photo 1 should help with the final assembly. Figure 5 shows front panel drilling details. Alternatively a pre-punched and printed plastic front panel is available. Please note that neither the case nor front panel are included in the kit.

## Testing

Before inserting IC1, connect a PP3 battery to the battery clip and switch on, and with a voltmeter set to 10V DC, test for +5V at IC1 socket pin 4 on the PCB. This will prove that RG1 is operating satisfactorily. You can now switch off and insert IC1 into its socket taking the usual precautions against damage to the pins, and *do* make sure that its notch is at the same end as the notch in the socket and the white block on the legend.

Plug the test lead into SK1 and short out the other end. LD1 should light and a tone should emanate from BZ1. If the tone is absent, then D1 may be the wrong way round or there may be a dry joint, perhaps in the test lead. Check that diodes or resistances greater than 5Ω only light the LD1.

The tone heard in the above test also proves that the signal injector is working. The wave shape can then be viewed on an oscilloscope via SK2.

The logic probe and square wave generator can be tested together, by connecting SK3 to SK4. LD2 and LD3 should alternately flash once every second.

## Using the Tetraprobe

All four sockets can be used independently and simultaneously, so two or more test leads may be needed. For example, the square wave generator and the logic probe can be used to check states in 'slow motion'.

R12 and R23 need not be fixed, if variable frequencies are required. Although intennded mainly for A.F. use, the signal injector contains R.F. harmonics, which will be demodulated when directly connected to the aerial input of a radio, operating on the LM/MW bands, resulting in a 1kHz tone from the loudspeaker.

If using the signal injector into loads of less than 1kΩ, then placing a resistor in series with the load, so as to bring the total up to 1kΩ or more, will maintain the shape of the waveform.

## TETRAPROBE PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS: All 0·6W 1% Metal Film. | | | |
| R1,18,19 | 300Ω | 3 | (M300R) |
| R2,10,17,21 | 10k | 4 | (M10K) |
| R3 | 100Ω | 1 | (M100R) |
| R4,14,23 | 100k | 3 | (M100K) |
| R5 | 27k | 1 | (M27K) |
| R6 | 180k | 1 | (M180K) |
| R7 | 47k | 1 | (M47K) |
| R8 | 4k7 | 1 | (M4K7) |
| R9,20 | 18k | 2 | (M18K) |
| R11,12 | 16k | 2 | (M16K) |
| R13,25 | 1k | 2 | (M1K) |
| R15 | 1M | 1 | (M1M) |
| R16,22 | 20k | 2 | (M20K) |
| R24 | 1k8 | 1 | (M1K8) |
| R26 | 2k2 | 1 | (M2K2) |
| CAPACITORS | | | |
| C1 | 1µF 100V PC Electrolytic | 1 | (FF01B) |
| C2,3 | 100nF Mylar | 2 | (WW21X) |
| C4,6 | 10µF 50V PC Electrolytic | 2 | (FF04E) |
| C5 | 10nF Polylayer | 1 | (WW29G) |
| SEMICONDUCTORS | | | |
| RG1 | µA78L05AWC | 1 | (QL26D) |
| IC1 | LM324 | 1 | (UF26D) |
| TR1-3 | BC108C | 3 | (QB32K) |
| D1-4 | 1N4148 | 4 | (QL80B) |
| LD1,2 | Mini LED Green | 2 | (QY87U) |
| LD3 | Mini LED Red | 1 | (QY86T) |

| | | | |
|---|---|---|---|
| MISCELLANEOUS | | | |
| S1 | R/A Toggle SPDT Up/Down | 1 | (FA70M) |
| SK1-4 | Phono Socket | 4 | (HF99H) |
| BZ1 | Mini Piezo Sounder | 1 | (FM59P) |
| | DIL Socket 14 Pin | 1 | (BL18U) |
| | PP3 Clip | 1 | (HF28F) |
| | Quickstick Pads | 1 Pkt | (HB22Y) |
| | PC Board | 1 | (GE40T) |
| | Instruction Leaflet | 1 | (XK25C) |
| | Constructors' Guide | 1 | (XH79L) |
| OPTIONAL (not in kit) | | | |
| | Verobox 211 | 1 | (LL08J) |
| | Tetraprobe Panel | 1 | (JR85G) |
| | Pins 2145 | 1 Pkt | (FL24B) |
| | Sub-Min Probe Red | 1 | (FE19V) |
| | Black Croc. Clip | 1 | (FK34M) |
| | Phono Plug Red | 2 | (FJ88V) |
| | Line Phono Socket Red | 1 | (JK23A) |
| | Min Extra Flex Black | 1 | (XR68Y) |
| | Min Extra Flex Red | 1 | (XR69A) |
| | Miniature Coax | 1 | (XR88V) |
| | Alkaline PP3 | 1 | (FK67X) |

The above items, excluding Optional, are available as a kit:
**Order As LP35Q (Tetraprobe Kit) Price £9.95**

The following are also available separately
but are not shown in our 1991 catalogue:
Tetraprobe PCB **Order As GE40T Price £3.25**
Tetraprobe Panel **Order As JR85G Price £4.45**

# TVFX
## Television Effects Unit

By David Lea

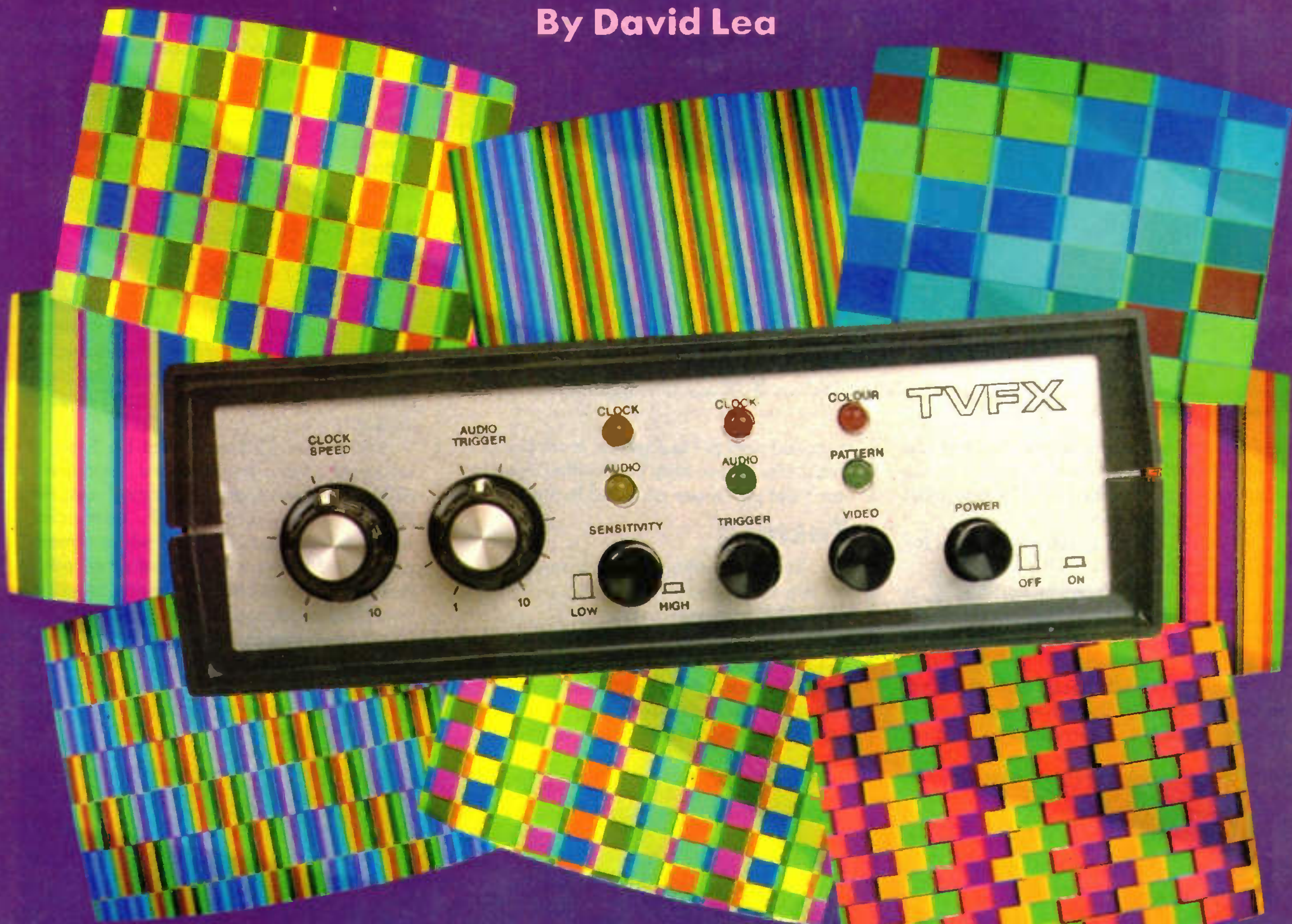



Photo 1. Montage of screen displays produced by TVFX unit.

**FEATURES:**
- ★ Displays Full Colour
- ★ Video and TV Outputs
- ★ Internal Clock or Audio Triggering
- ★ 12V DC Power Supply Input

| | | | |
|---|---|---|---|
| **Specifications of Prototype** | | | |
| Power supply input voltage: | 11V to 13V DC | Input impedance: | 140kΩ (high), 1·2MΩ (low) |
| Current at 12V: | 100mA | Filter response: | 15Hz to 90Hz −6dB |
| Power consumption: | 1·2W | Trigger sensitivity: | Max sensitivity 100mV (high)<br>Max sensitivity 1·5V (low) |
| **RF (UHF)** | | **Pattern Control** | |
| Carrier Output: | Channel 36<br>Frequency 591·5MHz | Clock speed: | Max 12 screens per second<br>Min 1 screen every 3 seconds |
| **Video (Composite)** | | Audio trigger: | Max 9 screens per second |
| Output level: | 1V peak to peak | **Patterns and Screens** | |
| Output impedance: | 75Ω | Patterns: | 64 patterns |
| **Audio** | | Colours in patterns: | 8 colours |
| Input attenuator: | −30dB (low sensitivity) | Full screen colours: | 8 colours |

## Introduction

For many years the comprehensive sound to light system has emerged as 'essential' equipment in the field of audio. The idea of sound to light is an old concept, but producing sound to light using TVs or monitors is fairly new. The project itself provides the means for generating a screen display from an audio signal under control of input signals to change the patterns. The project is centred around a TEA2000 colour encoder and SAA1043 universal sync generator. The TEA2000 provides the colour encoding for the video output, whilst the SAA1043 provides synchronisation for use with U.K. televisions and monitors. The configuration of these devices, with a complex logic array, produces the output to generate the patterns.

## Circuit Description

In addition to the circuit diagram shown in Figure 1, a block diagram is detailed in Figure 2. This should assist you when following the circuit description or fault finding in the unit. SK1 is the power socket and requires a regulated supply between +11V and +13V with the centre pin positive. Should the polarity be reversed then diode D1 across the supply rails is forward biased and blows a fuse to prevent further damage. Without this protection the semiconductors in the circuit could sustain permanent damage rendering them unusable. Capacitors C1 and C2 are used for decoupling the supply to regulator RG1 and audio stages. The regulator reduces the voltage to a +5V level suitable for TTL ICs.

The signal input from a sound source is brought in via two phono sockets, SK3 and SK5, to switch S2. High or low input levels can be catered for by using this switch and will allow for large signals from some amplifiers to be used as well as the small signals from pre-amps. Logarithmic potentiometer RV2 controls the signal level before it enters the audio stages. These consist of a summing amplifier IC2a and a filter IC2b. The filter is pre-set to limit input frequencies to the range of 15Hz to 90Hz. Low pass signals are pulse shaped by a series of NAND schmitt triggers IC3a to IC3c. These pulses are used to increment a binary counter IC7 in the complex logic array. When a sound source is not available, an internal clock can be selected using S3; this internal clock (IC1) sends out pulses to the counter at a uniform rate. The number of the pulses per second can be controlled with the linear potentiometer RV1. Only one trigger source can be selected at a time, and LEDs LD1 to LD4 indicate whether the internal clock or external audio is the source, as well as showing the pulses to the binary counter IC7.

The purpose of the binary counter is to provide the necessary inputs to the logic array IC8 to IC12. The logic is configured such that it produces the correct information for IC4, the TEA2000; this will enable the pictures on a screen to be displayed as a series of different sized and different coloured boxes. For more information on this IC, refer to the PAL colour encoder project published in the Maplin Projects Book 29 (XA29G). In addition a universal sync generator is needed to produce the necessary output to control changes of pattern on the screen. IC5, the SAA1043, fills this role and sends composite blanking and sync signals to the colour encoder. This is to ensure that the screen changes at the start of a picture build up. Figure 2 shows four outputs from the sync generator, each with a fixed frequency. The combination of frequencies produce the colour and size of boxes on screen. The outputs from the pattern generator contains the codes for the TEA2000 which then processes them

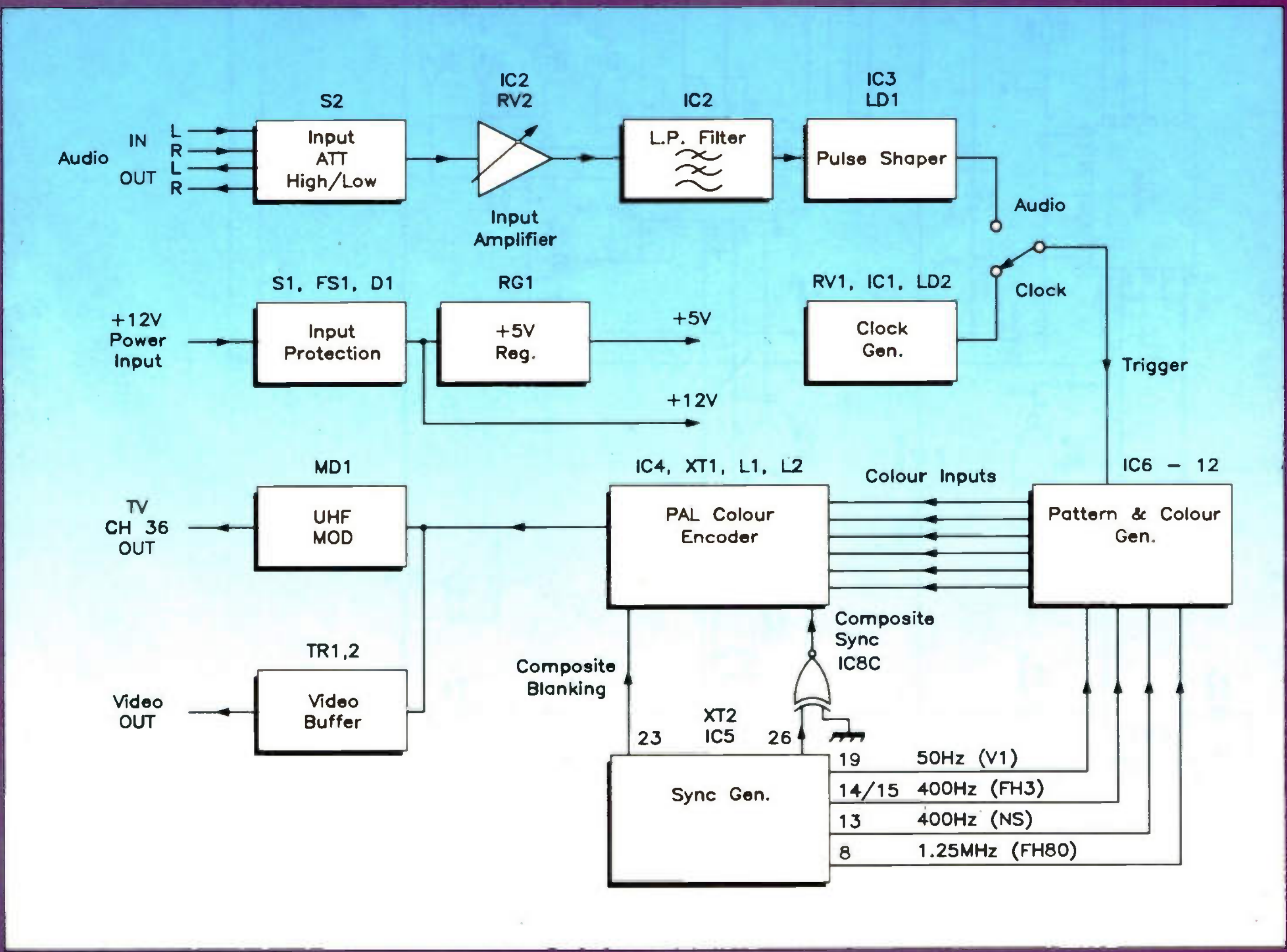



**Figure 2. Block diagram.**

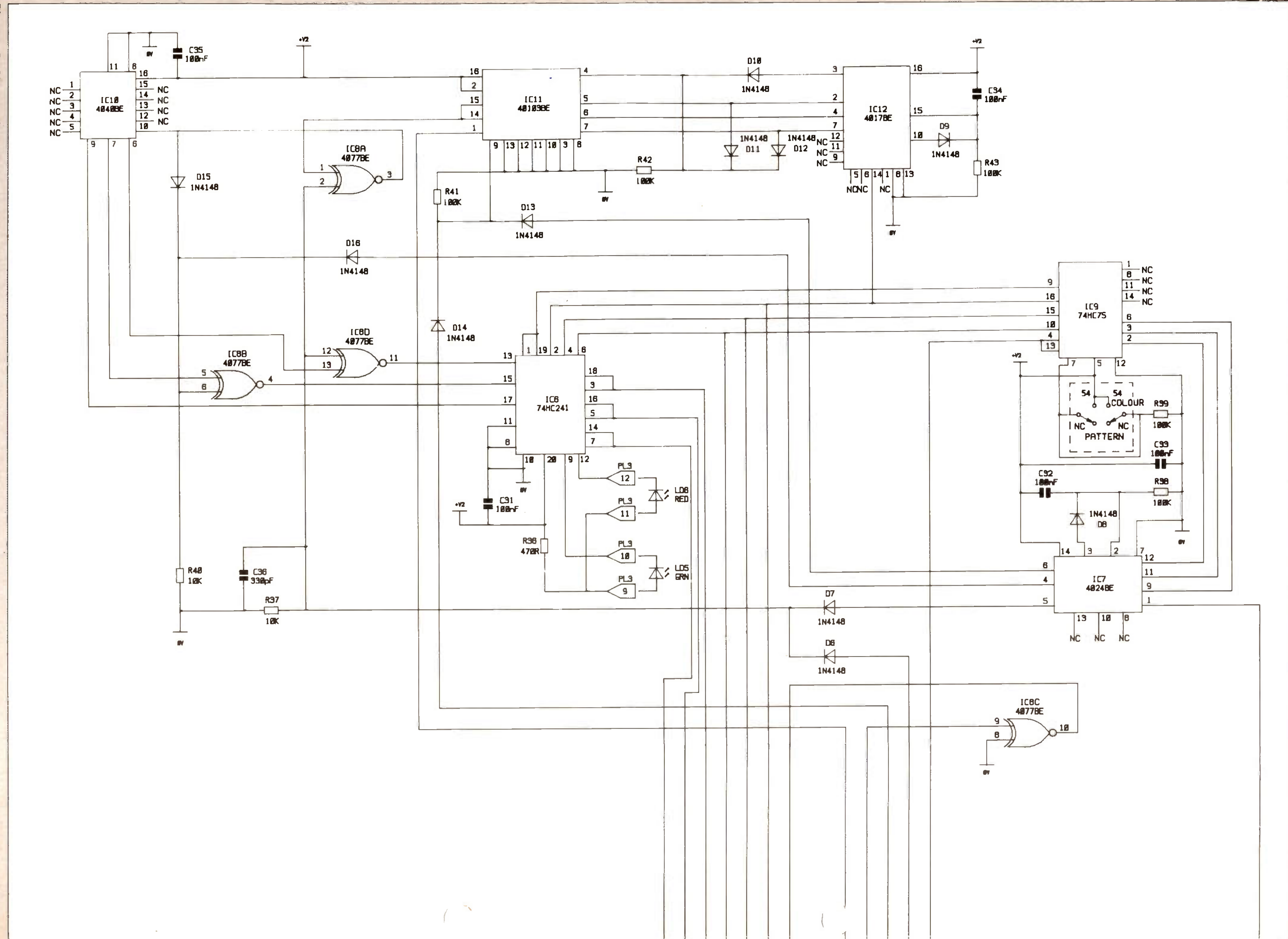
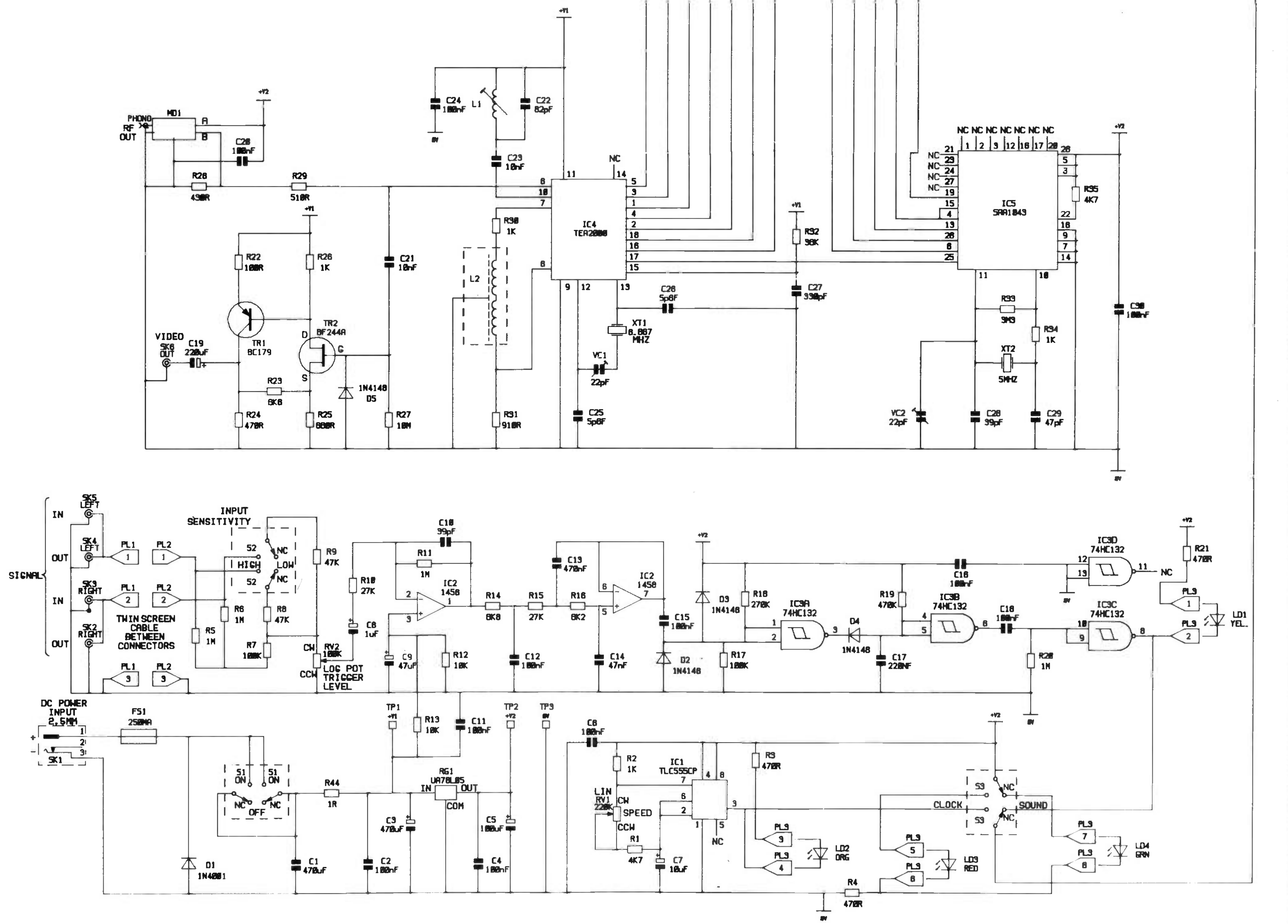



Figure 1. Circuit diagram.


PHONO RF OUT
MD1
C20 100nF
R28 430R
R29 510R
+V1
+V2
0V
R22 100R
R26 1K
TR1 BC179
TR2 BF244A
VIDEO SK6 OUT
C19 220uF
R23 6K8
1N4148 D5
R24 470R
R25 680R
R27 10M
C21 10nF
C24 100nF
L1
C22 82pF
C23 10nF
R30 1K
L2
R31 910R
IC4 TEA2000
NC
C25 5p6F
VC1 22pF
XT1 8.867 MHZ
C26 5p6F
R32 39K
C27 330pF
IC5 SAA1043
R35 4K7
R33 3M3
R34 1K
XT2 5MHZ
VC2 22pF
C28 39pF
C29 47pF
C30 100nF
SIGNAL
IN
OUT
SK5 LEFT
SK4 LEFT
SK3 RIGHT
SK2 RIGHT
PL1
PL2
TWIN SCREEN CABLE BETWEEN CONNECTORS
INPUT SENSITIVITY
S2
HIGH
LOW
R5 1M
R6 1M
R7 100K
R8 47K
R9 47K
R10 27K
C8 1uF
RV2 100K
CW
CCW
LOG POT TRIGGER LEVEL
C10 39pF
R11 1M
IC2 1458
C9 47uF
R12 10K
R14 6K8
R15 27K
R16 6K2
C12 100nF
C13 470nF
C14 47nF
C15 100nF
D2 1N4148
D3 1N4148
R18 270K
R17 100K
IC3A 74HC132
D4 1N4148
C17 220NF
R19 470K
IC3B 74HC132
C16 100nF
C18 100nF
IC3D 74HC132
IC3C 74HC132
R20 1M
R21 470R
PL3
LD1 YEL.
DC POWER INPUT 2.5MM
SK1
FS1 250MA
S1 ON
OFF
D1 1N4001
R44 1R
TP1
TP2
TP3
R13 10K
C11 100nF
RG1 UA78L05
IN
OUT
COM
C1 470uF
C2 100nF
C3 470uF
C4 100nF
C5 100uF
C6 100nF
R2 1K
IC1 TLC555CP
LIN RV1 220K
SPEED
R1 4K7
C7 10uF
R3 470R
LD2 ORG
S3
CLOCK
SOUND
LD3 RED
LD4 GRN
R4 470R

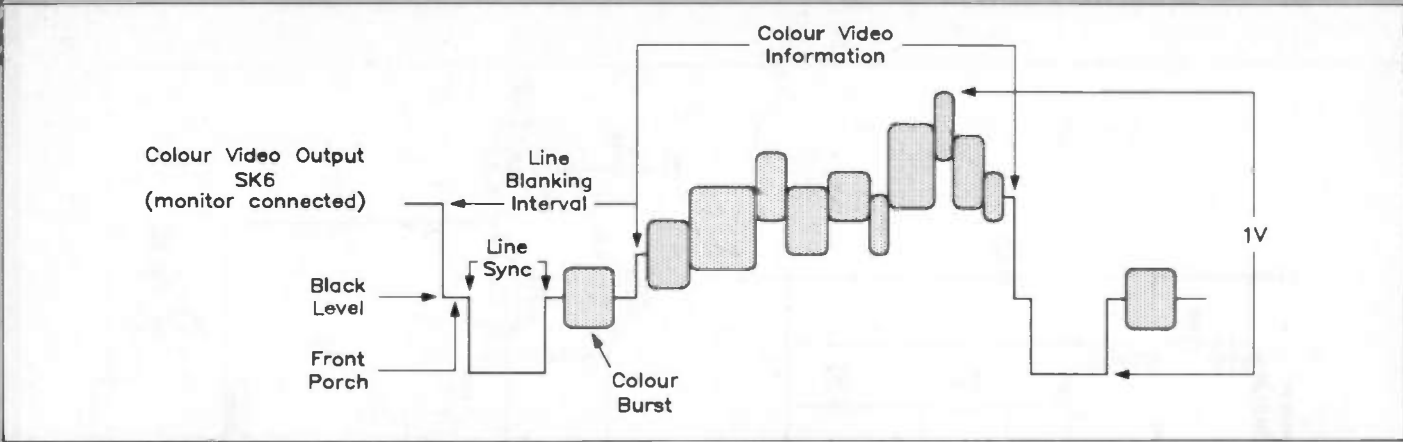



**Figure 3. Video signal.**

into PAL colour video signals; essential for U.K. TVs and monitors, see Figure 3. The output from the colour encoder is relayed to both a video buffer and a UHF modulator. The video buffer, TR1 and TR2, provides a signal level suitable for the 75Ω output on SK6. The UHF modulator MD1 converts the video signal into a modulated RF carrier at a frequency of approximately 591·5 MHz (TV channel 36).

## PCB Assembly

The PCB is a double sided plated through glass fibre type, chosen for maximum reliability and stability. However removing a misplaced component can be difficult so please double check the type, value and polarity before soldering! The PCB has a printed legend that will assist you when positioning each item, see Figure 4 and Figure 5.

The sequence in which the components are placed is not critical. However the following instruction will be of use in making the task as straightforward as possible. It is easier to start with the smaller components such as resistors followed by

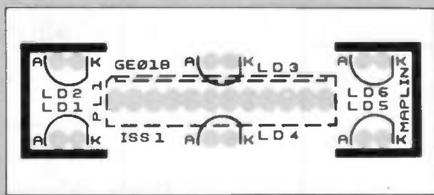



**Figure 5. Led PCB legend.**

the ceramic, polylayer and electrolytic capacitors. The polarity for the electrolytic capacitor is shown by a plus sign (+) on the PCB legend. However, the majority of electrolytic capacitors have the polarity designated by a negative symbol (−), in which case the lead *nearest* this symbol goes away from the positive sign on the legend. When soldering in the crystals XT1 and XT2, be extremely careful not to overheat them as this can cause damage.

All diodes have a band at one end to identify the cathode (K) lead. The legend shows the diode position with a symbol like a resistor, but with the prefix 'D' followed by the component's number as identified in the parts list. The symbol also has a bar across one end, and this is where the

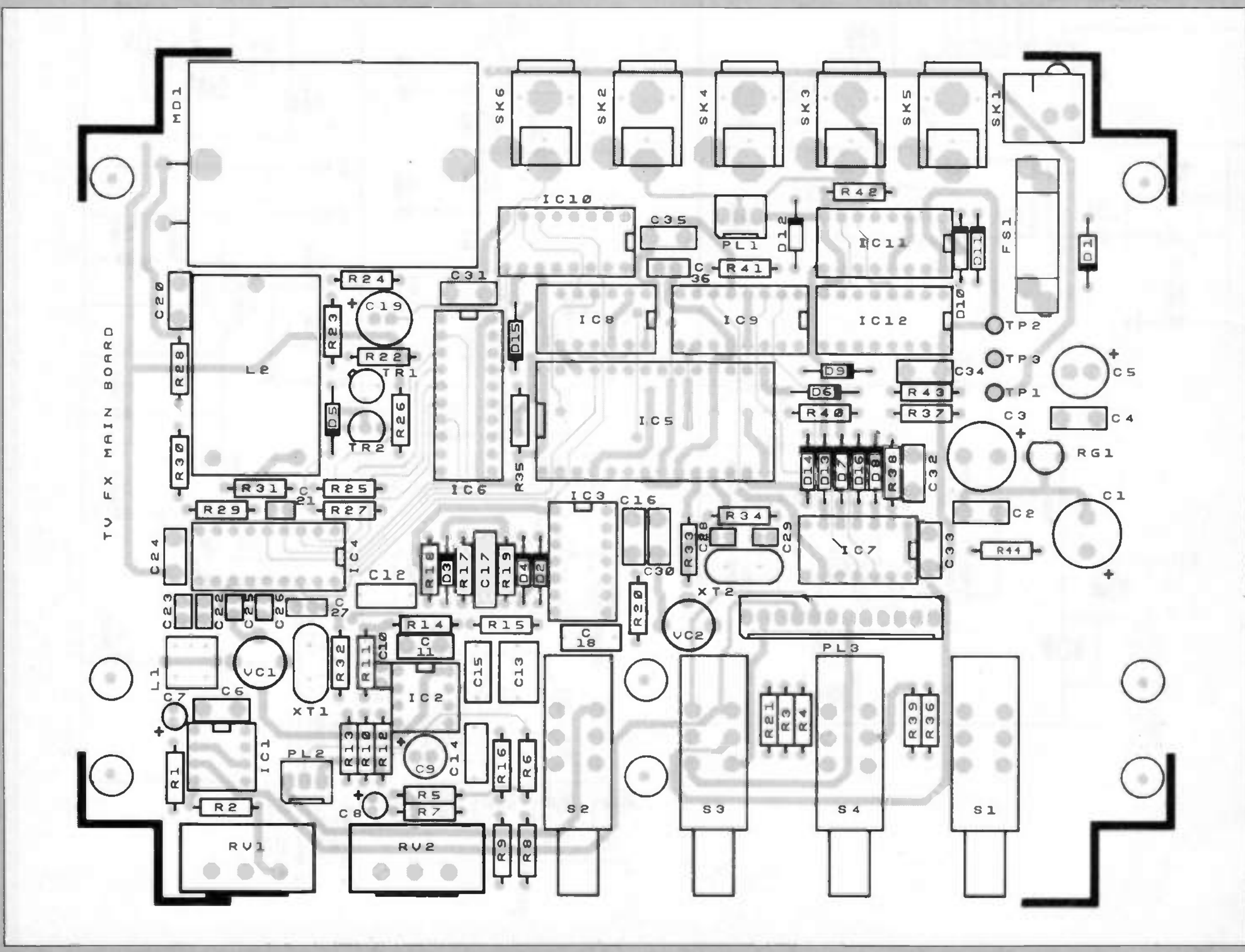



**Figure 4. Main PCB legend.**

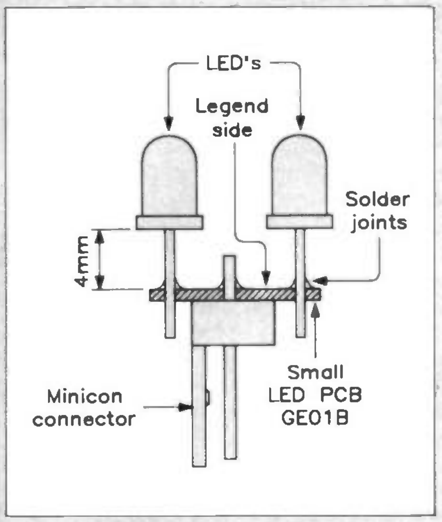



**Figure 6. Mounting the LEDs.**

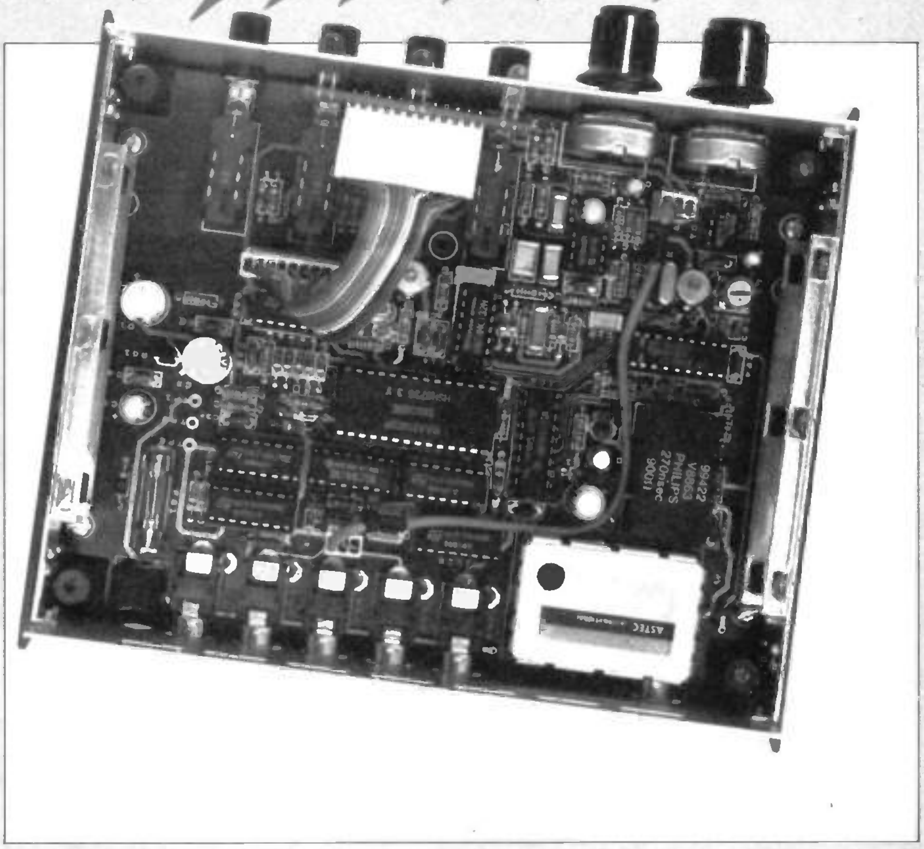


**Photo 2. Plain view of the assembled PCB fitted into the suggested case.**

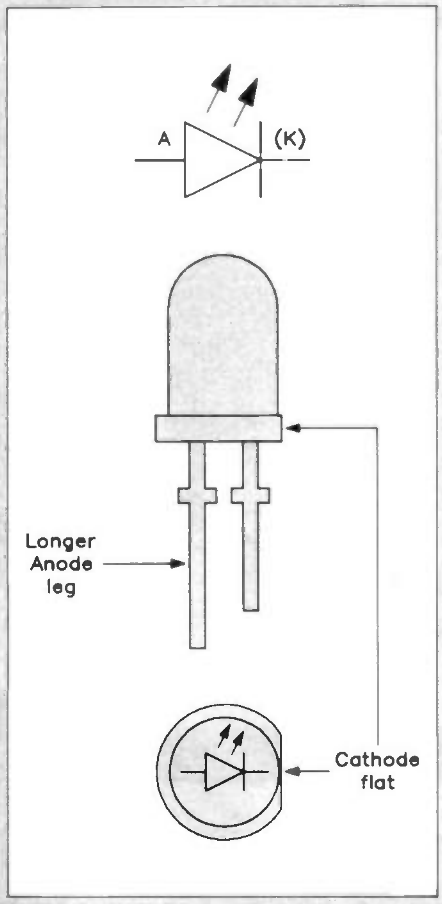



**Figure 7. LED information.**

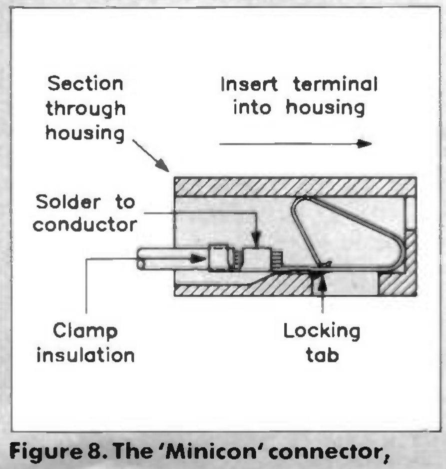



**Figure 8. The 'Minicon' connector,**

cathode is placed. Be sure to position them according to the legend, where the markings are shown. Installing the LEDs on the small boards will be tricky. These LEDs need to be mounted on the track side of the board (see Figure 6). The short lead of the LED is cathode (K); this is also denoted by a flat along one side of the package as shown in Figure 7.

Next, install transistors TR1 and TR2, and voltage regulator RG1, making sure that they are not put in the wrong positions, as they are similar in package style! Where the leads of the transistors are placed in the PCB is critical; the legend shows flat surfaces and tabs which conform to the package design of the transistor or regulator. When fitting the IC sockets ensure that you match the notch with the block on the legend, *do not* install the ICs until the testing stage! When fitting the 'Minicon' connectors, ensure that the locking tabs are all facing the correct way. Output sockets SK2 to SK6 are phono sockets; these are easy to fit into the board, see Figure 4. Potentiometers RV1 and RV2 are mounted on the board; ensure they are of the correct values before soldering.

Finally install switches S1 to S4. This completes the assembly of the circuit board and you should now check your work very carefully making sure that all solder joints are sound. It is also *very important* that the solder side of the PCB does not have any trimmed component leads standing proud by more than 2mm, as they may cause short circuits. The completed PCB assembly is shown in Photo 2. Further information on soldering and assembly techniques can be found in the Constructors' Guide supplied with the kit.

## Wiring

The kit contains two types of wire, a twenty-way ribbon cable and a two-core screened cable. No specific colour has been allocated for each of the wire connections. The use of coloured wires is to simplify matters, thus making it easier to trace separate connections. Actual connections between the PCB are made using 'Minicon' connectors and the method of installing them is shown in Figure 8. The three way 'Minicons' are signal interconnections on the PCB itself; the twelve-way 'Minicon' is connected to the additional smaller LED board (see Figure 9). Many of the components that would usually be mounted on box panels have been positioned on the PCB to simplify construction. The small LED board can be glued into the front of the box with the LEDs poking through the front panel.

## Testing and Alignment

The initial testing procedure can be undertaken using the minimum amount of equipment. You will need a multimeter and a regulated +12V DC power supply capable of providing at least 150mA. All the following readings are taken from the prototype using a digital multimeter, and some of the readings you obtain may vary slightly depending upon the type of meter used!

Double check that none of the ICs have been fitted into the sockets on the board and all internal leads are connected. The first test is to ensure that there are no short circuits before connecting to a

DC supply. Set your multimeter to read OHMS on the resistance range and connect the two test probes to TP1 and TP3. With the probes either way round, a reading greater than 400Ω should be obtained. If a lower reading is registered then check solder joints and component leads; that they are not shorting between tracks. Next monitor the supply current; set your meter to DC mA and place in series with the positive line of the power supply. With S1 switched to the 'ON' position, apply 12V DC and a current reading of approximately 25mA should be obtained; the trigger select LED LD3 or LD4 on the small board should be illuminated. Disconnect the supply, remove meter.

Reconnect the power supply to the unit (SK1), and set your multimeter to read DC volts. All of the voltages are positive with respect to ground, so connect your negative test lead to the ground test point TP3. When the unit is powered up all voltages present on the PCB assembly should approximately match the following readings.

| | |
|---|---|
| TP1 = +12V | TP2 = +5V |
| IC1 PIN 4 = + 5V | IC2 PIN 3 = +6V |
| IC2 PIN 8 = +12V | IC3 PIN 14 = +5V |
| IC4 PIN 11 = +12V | IC5 PIN 5 = +5V |
| IC6 PIN 20 = + 5V | IC7 PIN 14 = +5V |
| IC8 PIN 14 = + 5V | IC9 PIN 5 = +5V |
| IC10 PIN 16 = + 5V | IC11 PIN 2 = +5V |
| IC12 PIN 16 = + 5V | |

Turn off the supply and install the ICs making certain that all pins go into their sockets and the pin 'one' marker is at the notched end. Reconnect the meter into the +V supply again and set to DC mA. Power up the unit and observe the current reading which should be approximately 110mA. Set switches S2 to S4 in the 'out' position. Note the illumination of the LEDs LD1, LD2, LD4 and (LD2 should flash) on the small PCB. This completes the DC testing for the TVFX board. Now disconnect the multimeter and power supply from the unit and proceed with alignment.

Before commencing the video testing and alignment check the following:

| | |
|---|---|
| Clock Speed (RV1) | = fully counter clockwise (position 1) |
| Audio Trigger (RV2) | = fully counter clockwise (position 1) |
| Sensitivity (S2) | = button out (low sensitivity) |
| Trigger (S3) | = button out (audio) |
| Video (S4) | = button out (pattern) |
| Power (S1) | = button out (on) |

Next connect the video output SK6 to a colour monitor, or the RF from modulator MD1 to a colour television tuned to UHF Channel 36, and the monitor/TV should display a patterned screen. If no pattern is displayed then try adjusting the channel tuning control on the television. If no colours are seen then try adjusting VC1 until the colour locks in, this will be when the crystal is oscillating at 8·867MHz, see Figure 10. The crominance filter L1 will seem to have little effect on the overall picture; however its setting will determine the final picture quality of the digitally generated graphics as the filter increases the amplitude of the colour video information.

The frequency output of the video modulator MD1 is factory set to channel 36 (591·5MHz), which should be suitable for most applications. If necessary it can be retuned by adjusting the ferrite core of its oscillator stage, as shown in Figure 10.

Variable capacitor VC2 sets the oscillator for the sync generator; although adjusting this has no dire effect on the overall picture. VC2 should be set halfway. If a more accurate measurement is needed then the frequency on IC5 pin 24 should be 1·25MHz. All adjustments should be made using a trimming tool, the one found most suitable is the pot core type (stock code BR51F).

## Using the TVFX

All external connections are of the phono type, with the exception of the power socket, SK1. It requires an external power source with positive on the centre pin from a regulated supply. Sockets SK5 and SK3 are audio inputs, left and right channels respectively, and sockets SK4 and SK2 are the respective outputs.

Audio in and out can be connected two different ways as shown in Figure 11 and Figure 12; audio between the pre-amp and power amplifier; audio out from a power amplifier to the speakers. Socket SK6 provides a 75Ω video output to a colour composite monitor, in addition to the video socket an output from modulator MD1 allows the unit to be used on domestic television sets.

The front panel of the TVFX has the

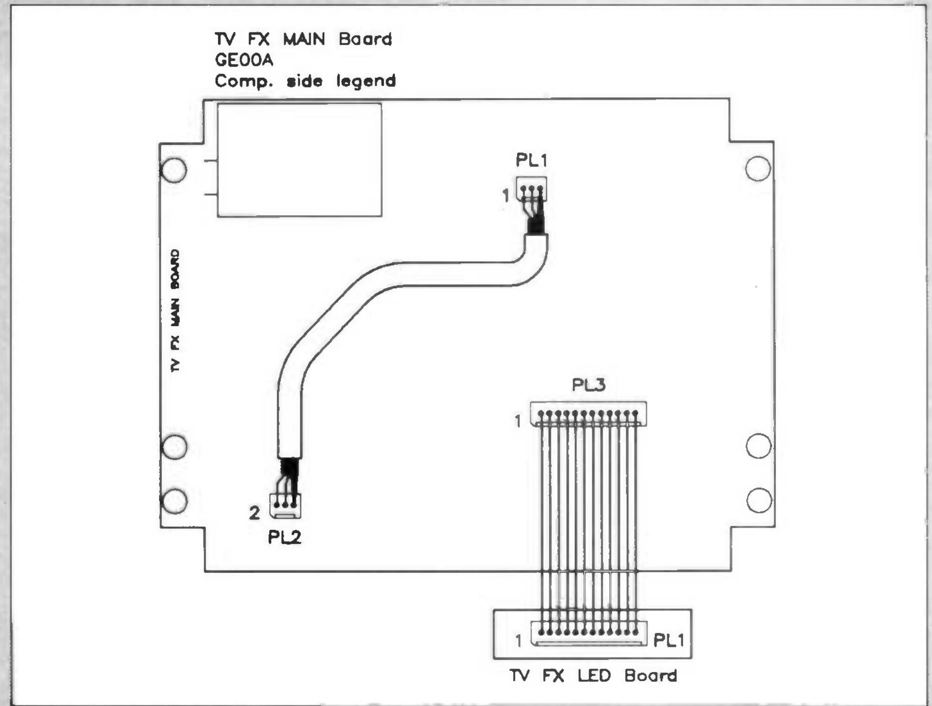



Figure 9. The wiring diagram.

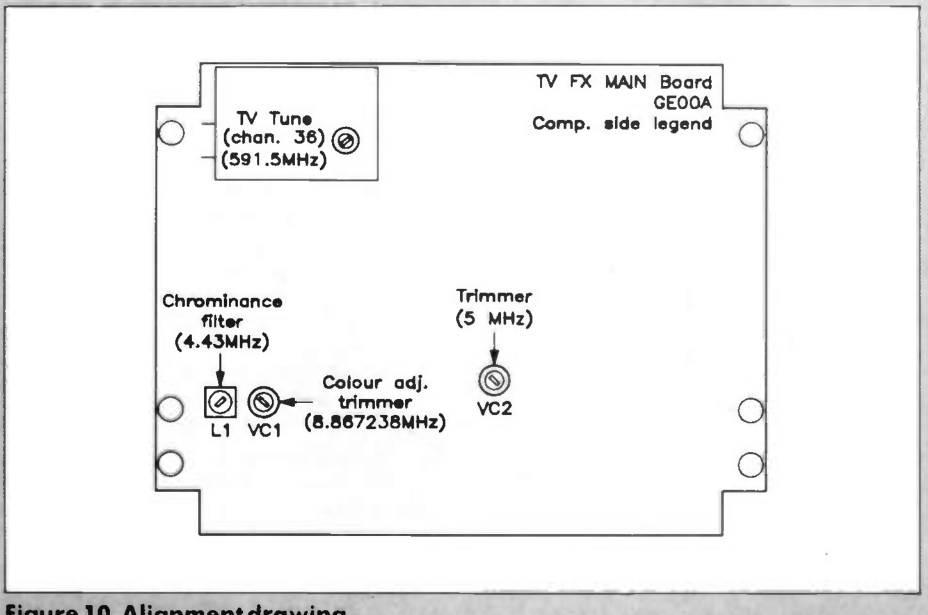



Figure 10. Alignment drawing.

necessary controls to change screens, triggering sources and sensitivity. Variable controls RV1 and RV2 alter the internal clock speed and the incoming audio signal level. A series of LEDs provide an indication of internal clock speed, audio triggering, and the state of the switches (whether they are in or out). Switch S2 is essential for correct operation of the unit and the state of the switch depends on the configuration of the audio inputs; a high sensitivity is generally needed for small signals. Switch S3 is the trigger select, this connects either the audio trigger or internal clock to the pattern generator. Switch S4 determines which type of screen display; either patterned or coloured, is to be displayed. Switch S1 is the power switch. Variable resistor RV1 controls the speed of the internal clock and RV2 determines the level of audio signal required to trigger the unit which should be set to the minimum usable position, to avoid overloading.


**Photo 3. The assembled TVFX unit.**

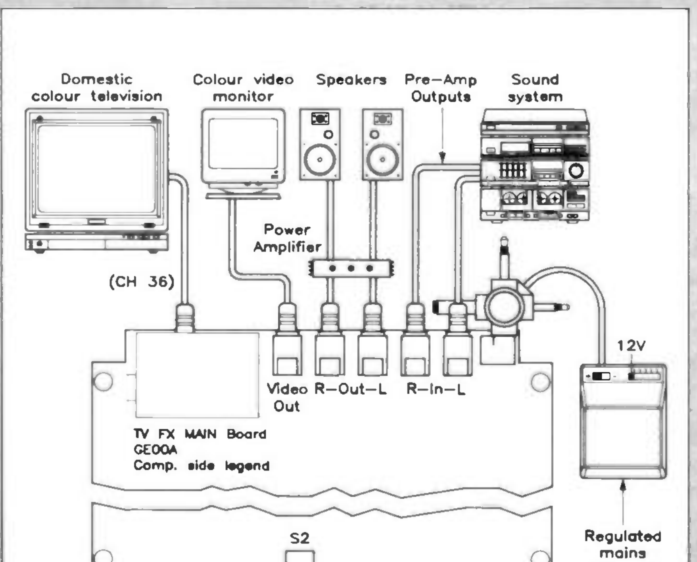



**Figure 11. Pre-amp connections.**

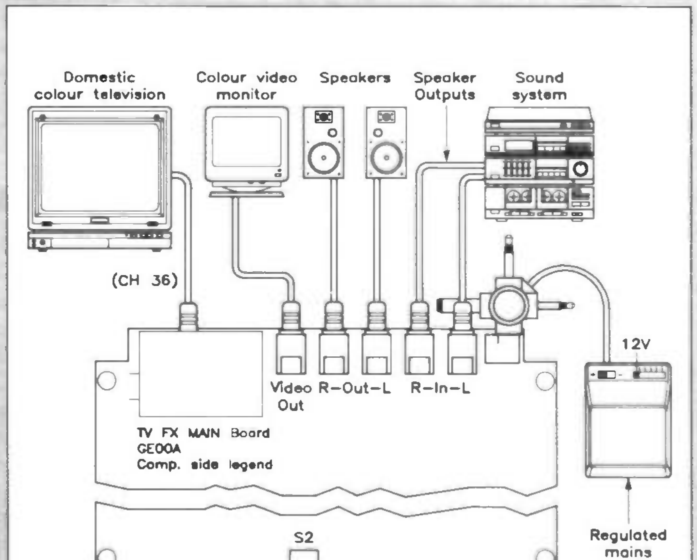


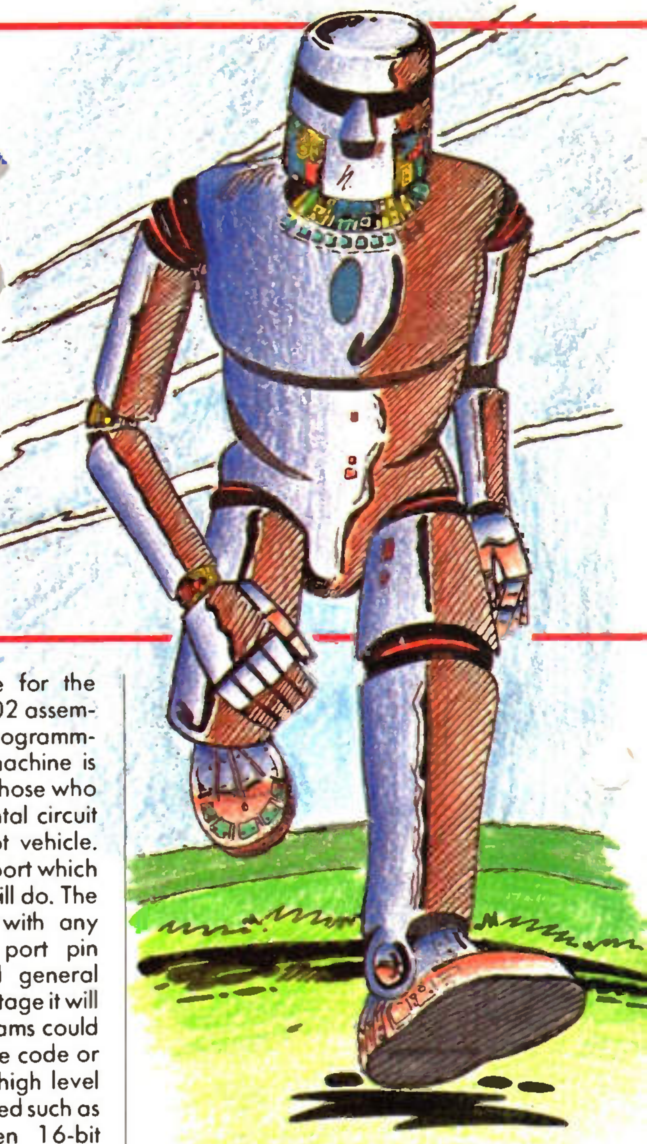

**Figure 12. Power amp connections.**


Continued on page 39

# PRACTICAL ROBOTICS TECHNIQUES

## Part 1 – An Introduction to Control by Experiment

by Alan Pickard



A robot vehicle always seems to provide fascination to the observer, whether he/she is merely curious or is an aspiring constructor who would like to know how to be able to acquire one to play with, program or maybe build one from basic principles.

Over the last decade or so, there have been many attempts to provide the electronics/micro hobbyist with the means to produce a buggy or turtle-like vehicle to be controlled by a home computer. Whilst there have been many good designs providing reasonably inexpensive and useful end results, I have the impression that these devices merely provide stimulus for genuinely interested readers, the vast majority of whom never actually take the plunge in attempting to build one of their own for a variety of reasons.

In this first part of this three part series, I hope to be able to persuade readers that it *is* possible to carry out some very simple experiments in robotic vehicle control which may encourage them to progress to a complete design.

Although the series will conclude with a complete design, albeit with some options in its specification, the emphasis will be very much on individual functions, with the minimum of theoretical material required to enable working control circuits to be constructed and tested.

For the purpose of this series our robot is described as a 2-wheeled vehicle which is under the control of a computer user port having 8-bits or control lines. It is defined as being a control system which is programmable and re-programmable. In other words, the robot operates via computer instructions (a program) and also in response to environmental conditions encountered (from sensors). Figure 1 shows the basic requirements of a robot vehicle system.

## The Control Computer

As already mentioned, an essential requirement of a robot system is its control computer, whether this is an integral part of the robot or an external general purpose microcomputer. The main computer I have used is the BBC Micro. This machine is one of the most versatile available for the hobbyist, offering BBC Basic, 6502 assembly language and an 8-bit fully programmable user port. However, this machine is not an essential requirement for those who wish to carry out the experimental circuit work or build a complete robot vehicle. Any computer which has a user port which can be programmed via Basic will do. The user will need to be familiar with any special details such as user port pin connections, Basic syntax and general layout of the machine. At a later stage it will be seen that all robot test programs could be converted into 6502 machine code or for example Z80 code. Other high level languages could also be employed such as FORTH or PASCAL and even 16-bit processors are not excluded.

The series will be based on the use of the BBC Micro, but its special features will not be fully exploited so that the reader can relate its use to his or her own machine. An experienced BBC Micro user will be able to see the possibilities that the basic ideas offer with that machine. Towards the end of the series alternative machines, e.g. PC's, and other processors such as the 16-bit 68000 and 8086 series will be discussed in the context of controlling a robot vehicle.

## A Preliminary Practical Experiment

Before delving into any circuit details or programming requirements, we will look at a very simple experiment in robotics which requires only familiarisation with simple BASIC and the ability to connect a few wires.

A cheap source of D.C. motors already linked to a wheel assembly can be found in a radio-controlled car chassis. These can be bought very cheaply in toy shops or model shops, sales or recovered from a child's toy box, particularly if already broken or discarded. All that is required from the radio controlled car is the bare chassis, drive wheel(s) and motor assembly and its battery compartment intact. (Any radio control circuits should be disconnected and/or removed.) These vehicle motors typically run on multiples of 1·5 volt cells (HP7/AA, HP11/C or HP2/D size) depending on the size of the motor and its current consumption. They are often high speed vehicles and because this is incompatible with an experimental control vehicle, it is usually essential to 're-program' the battery compartment wiring so that anything down to one cell is used to achieve the desired speed. The benefits become obvious if initially the vehicle shoots along the floor at many times the expected speed!

The first experiment makes use of the cassette port of a home computer, that is to say those pins which enable a cassette player/recorder to be switched on and off from the computer. The BBC Micro (and Electron) use pins 6 and 7 of a 7-pin DIN socket to complete a circuit comprising a D.C. motor and its power supply. Although

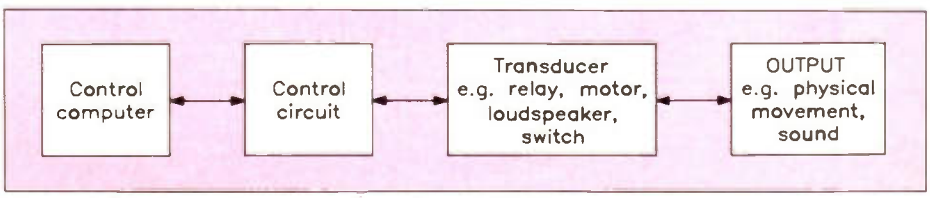



**Figure 1. Basic requirements of a robot vehicle system.**

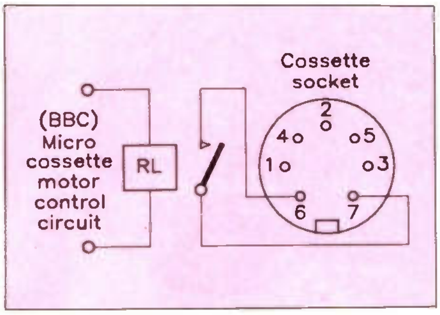



**Figure 2a. Connection details for BBC/Electron.**

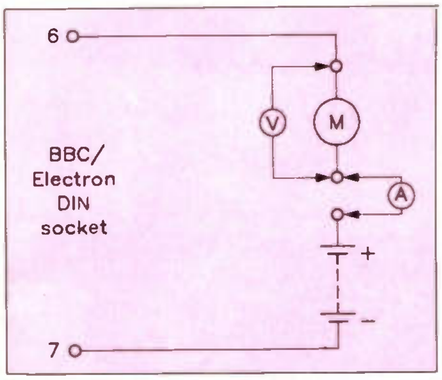



**Figure 2b. Connecting your first robot.**

never included with robot control in mind, it is simply a means of switching a motor on and off. On the BBC Micro this can be carried out directly from the keyboard or via a simple BASIC program. Figure 2a shows connection details for your motor/wheel unit.

It can be seen from the diagram that whichever instruction causes the cassette motor to turn on or off simply activates a relay. The relay contacts are 'voltage free' and can therefore be connected safely to an external circuit with its power supply. It must be understood however, that your load circuit must not exceed the voltage and current ratings of the relay switch contacts themselves. The BBC Micro cassette relay contact limits are around 9 volts and 100 mA. This relay could not be expected to switch on a milk float! Figure 2b shows how to connect your first robot.

Connections 6 and 7 are short-circuited by the relay contacts to complete the circuit, and the diagram also shows how to measure voltage and current with the motor under load.

For anyone who does not have a motor available to test (suitable inexpensive D.C. motors are available from Maplin, see components list), an alternative test circuit can be produced consisting of merely an LED and resistor as shown in Figure 3. This provides a means of turning on and off a device which effectively simulates a motor. This technique may be employed later to test simple programs prior to connecting up motors.

To avoid confusion, the circuit shown inset illustrates how the test circuit operates. This circuit requires a source of +5V and this can be considered as a separate supply, as for the motor. The supply could be obtained from four cells in series (4 x 1·2V = 4·8V), or in the case of the BBC Micro from pins 1 (+5V) and 5(0V) of the user port. Figure 3 shows the same connection method as the motor load circuit. Note that the 1·2V value refers to a rechargeable cell – dry batteries are 1·5V at the beginning of their life. Completing the circuit by the operation of the relay contacts forward biases the LED and current limited by the resistor value flows around the circuit.

The next step is to 'program' the unit to provide movement. The keyboard instruction used by the BBC Micro or Electron is *MOTOR 1 for ON and *MOTOR 0 for OFF. Very simple testing of the load circuit can be achieved by typing these commands in individually or by utilising the BBC Micro user programmable keys, i.e. f1 for ON and f0 for OFF. This is achieved as follows:

```
*KEY 0 *MOTOR 0 ||M
*KEY 1 *MOTOR 1 ||M
```

where '|' is the vertical rule character entered via [SHIFT] and [BACKSLASH]. Thus the motor can be switched on and off by use of these two keys. This simple test can be verified easily and simply with no 'load' connected to the cassette port by listening to the relay clicking inside the machine and also observing the LED at the front of the keyboard. Another method of testing could be to use a cassette machine itself as a load and observe the cassette motion or the spindle rotating. Although not exactly mindbending or impressive, these exercises can inspire confidence and give the reader a feel for indulging in further control experiments. When this has been proven a simple BASIC program can be tried as follows:

```
10 *MOTOR 1
20 FOR T = 1 TO 1000
30 NEXT T
40 *MOTOR 0
```

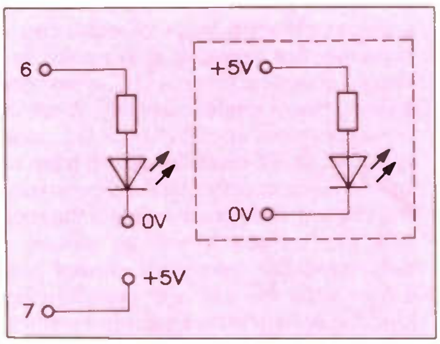



**Figure 3. An alternative test circuit, using an LED.**

Running this program will cause the motor/wheel unit to switch on for a period of about 1 second and then stop.

Even this simple testing is a useful exercise in the principle of carrying out all future testing one step at a time. A robot vehicle is not necessarily a complex device but there are various considerations which depend on each other for correct operation. So far, for this simplest experiment in control, we have selected a suitable motor/wheel/battery unit, a suitable control circuit (cassette port) and a means of software control (keyboard operations and BASIC program). Our 'system' looks like the diagram in Figure 4.

Each aspect of the system must function correctly before the robot can perform its programmed activity. Hardware operation (mechanical, electrical and electronic) and software should all be thought out carefully and tested separately before connection to the system. In this ultra-simple example I hope that the potential constructor will see the benefit of adopting such an approach in later experiments and ultimately the construction and design of a complete vehicle.

To finish off the first experiment a slightly more useful demonstration program can be achieved by adding 3 more lines to the test program:

```
50 FOR T = 1 to 1000
60 NEXT T
70 GOTO 10
```

This provides an ON/OFF sequence such that the vehicle moves forward (depending on battery connection polarity) for a period, stops for the same period, and then repeats the cycle until [ESCAPE] is pressed.

Varying the range of values for T will obviously affect the ON and OFF times. A number of points are worth noting which will be useful when trying out later experiments with robot movement. Firstly, be prepared for your vehicle to move off at a higher speed than expected (requiring a reduction in the number of batteries used in series), or even in the wrong direction! Secondly, remember to clear a way for the vehicle's progress, preferably on the floor. Finally, when running a program such as the first test program, try to arrange for the [ESCAPE] key to be pressed when the vehicle is 'OFF' as otherwise it will stay 'ON' which may be very inconvenient! Using the [BREAK] key as a panic button is not really a good habit to get into, as it resets things and may result in the

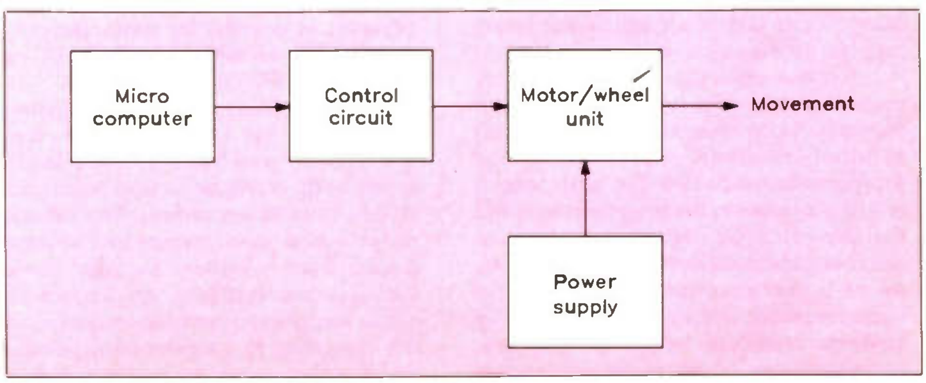



**Figure 4. Our first practical robot system.**

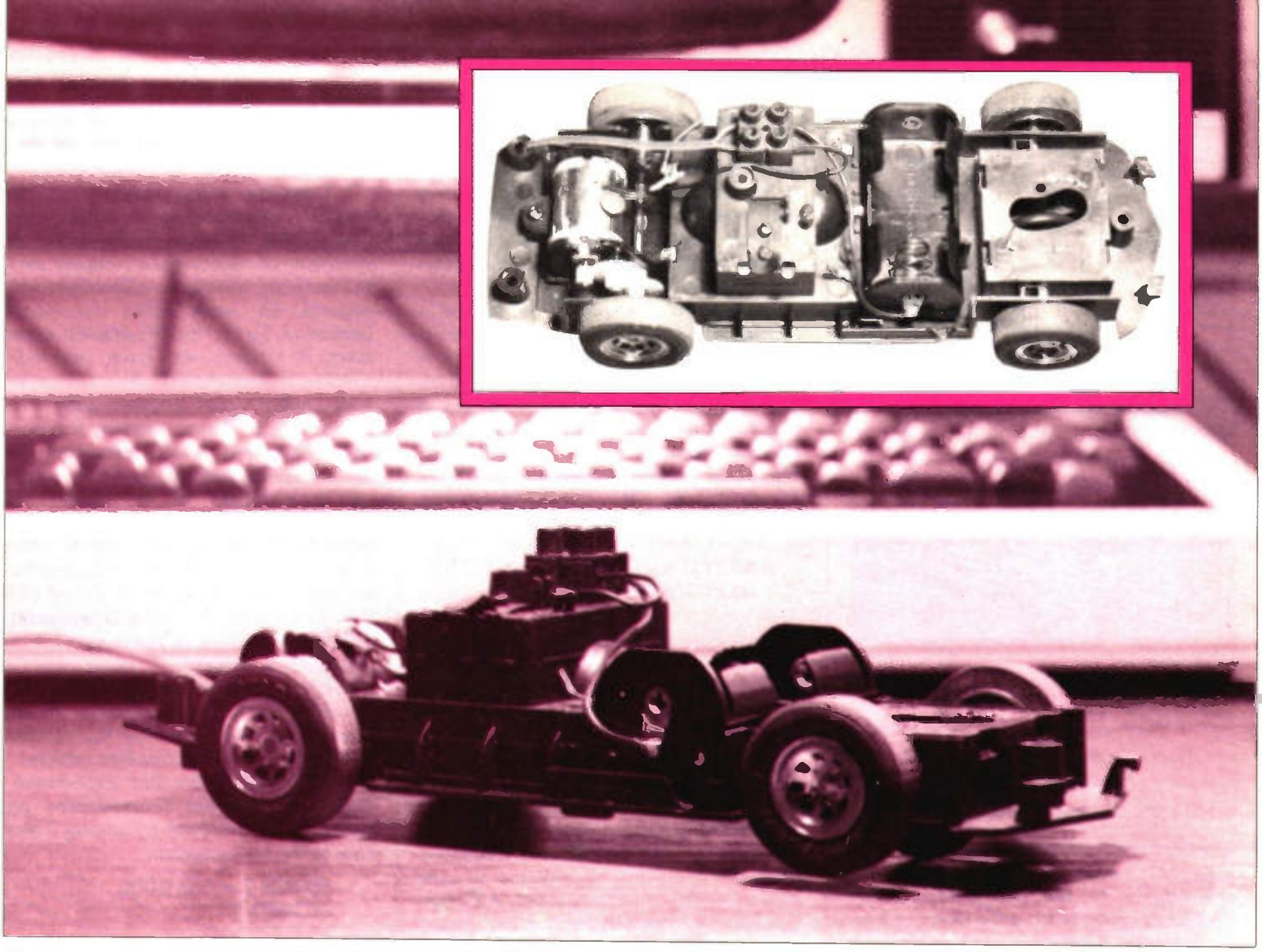


Photo 1. Computer controlled vehicle. Inset: Top view of vehicle.

accidental loss of longer (unsaved) programs at a later stage. A useful if not essential facility for a robot test vehicle is a motor power supply switch. This is very convenient but not a practical 'panic' switch if the vehicle is on the move! It does mean that you can run test programs with the vehicle disabled, but without having to physically disconnect it or unplug it from the control computer. Another idea would be to fit an infra-red receiver circuit to the vehicle providing a remote panic button, but this is hardly practical for such a simple vehicle as this first one, and will involve further power supplies.

## Motor Power Sources

Batteries are a very convenient means of providing power to motors and although a constructor may consider using for example the +12V supply provided on an external socket in the case of the BBC Micro for a disk drive, this is not really feasible for the following two reasons.

If a disk drive uses this power supply rather than a separate mains derived one it would be inconvenient switching from disk to robot 'peripheral' when loading test programs stored on disk. The other reason is that it is better in the long term to avoid the use of cable connections wherever possible as ultimately the robot may have an on board computer in the form of a microcontroller, which is itself powered by batteries. Although much of the experimental work in the series will revolve around a home computer, it is desirable for a robot vehicle to be independent and not connected by cable (or at least additional wires) to its control computer.

The title of this series suggests practical exercises or experiments in robotics rather than simply presenting a ready made and complete design. At each stage it is expected that the experimenter will consider different ways of achieving an objective. For example, at this point he or she will choose a suitable D.C. motor or an existing motor wheel assembly. A suitable power source is then chosen. A D.C. motor specified as 3V could be driven from two cells in series or only one if a slower speed is preferred. The power rating of the motor and the surface it will be driven on determines the amount of current being drawn from the cell and therefore how long the battery lasts. If your test surface is a standard pile carpet then more motor torque is required than if you were working on a smooth table top or carpet tiles. A carpet surface may mean connecting batteries in parallel for more current or upgrading from HP7(AA) to HP11(C) cells or HP11 to HP2(D) and so on.

It is perhaps useful to arrange an operating motor circuit such that current can be monitored (see Figure 2b). In other words using a simple 'jack' to suspend the wheels from its test surface. This will show not only how much current and voltage is drawn from a battery but also current surges when switching on (repeatedly). When designing a more substantial vehicle it is important to consider such details as motor voltage and current requirements and it will become obvious that rechargeable batteries are a good investment with of course a suitable charger. A multi-purpose charger is very useful when trying out various battery combinations and will be useful again when considering control circuit supplies later which must be kept separate from motor supplies.

## Materials

To carry out the simple experiments in this first introductory article, all that is required apart from the charger and suitable batteries are things like battery holders, e.g. HP11 (single box), connector blocks, double sided tape, blue-tack, wire, miscellaneous nuts and bolts or self-tapping screws, SPDT switch, 7-pin DIN socket (for BBC Micro).

Specific items from the Maplin catalogue are as follows:

| | | |
|---|---|---|
| Small motor | 1 | YG13P |
| Min motor | 1 | YG12N |

## The Next Stage

In this introductory article we have looked at simple control of a mechanical device, its power supply and required software. We have also set the scene for a disciplined, systematic approach to experimenting with robotics and designing a robot vehicle. In Part 2 we will look at basic microcomputer interfacing principles to enable us to control a robot vehicle having two independently controlled motor/wheel units from a computer user port. We will also look at other input and output devices to be included in the system.

# Square One

## A First Course in the Theory and Practice of Electronics

Part 6 by Graham Dixey C.Eng., M.I.E.E.

## Chips in Logic Systems

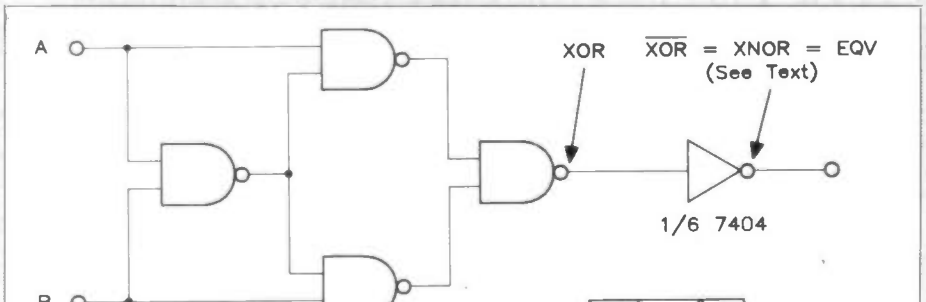
In the preceding part of this series, we looked at some of the basic logic blocks, the gates that in combination can produce a variety of useful functions. Gates are not known as the 'building bricks' of logic for nothing. Many of the more exotic functions are actually nothing more than vast arrays of gates. Integrated circuit technology has allowed the production of such arrays on single chips of silicon, and at an affordable price. The nature of the chip means that it is a non-repairable item and this, coupled with its low cost, means that it can be discarded when it fails, to be replaced by another. The complexity of many chips makes it unrealistic to bother unduly about their 'contents'. Instead we focus our attention on what the chip can do rather than how it does it. It becomes an element in a system, an element whose function is defined and which can be tested and identified by measuring the logic levels or events occurring at the chip pins. The chip pin-out diagram becomes the important reference, together with the system diagram that shows the interconnection of the chips in the system. A full-adder (to name just one IC that we shall investigate) becomes just a 'block' in the system diagram, its purpose defined either by its name or type number placed in or near the block.

It is only at a relatively low level of complexity that we can investigate the interconnection of actual gates to perform specified functions. Above that we are into systems, as explained above. Therefore, in order to give the reader more practice in studying the behaviour of individual gates, we shall in this article construct some more circuits, building on our knowledge gained in the previous part of the series.

## The Comparator

The most complex circuit that we built last time was the 'four gate' exclusive-OR (XOR) circuit. It was seen that the only time the output of this circuit was a logic 1 was when *one only* of the two inputs was logic 1. The other two possible combinations, inputs both logic 1 or both logic 0, produced a logic 0 output. Suppose we follow this circuit with an inverter (Figure 1): what is the result likely to be? If we think about it, remembering that an inverter 'swaps the logic levels over', we shall come to the conclusion that the output column of the truth table for the new circuit will be the exact opposite (known as the 'inverse') of the same column for the XOR function. This is seen to be true in Figure 1. If there is any doubt it can be dispelled by wiring the circuit up and testing it as described before. The inverter could have been made from a NAND gate with its inputs strapped together, which was also discussed last time, but instead a new chip has been introduced, the 7404 'hex inverter'. As its name suggests this has six inverters on the one chip. Since it has taken one complete 7400 IC to make the XOR function, we need a second chip anyway, and it might as well be the 7404 as any other. This will provide us with a source of inverters for other purposes should we need them. In this instance we don't, of course, but in other circumstances we might.

The new function that is produced in this way has various names, depending upon the specific point of view. It may be called a 'comparator' since it effectively




| A | B | F |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

TRUTH TABLE

**Figure 1. The comparator function.**

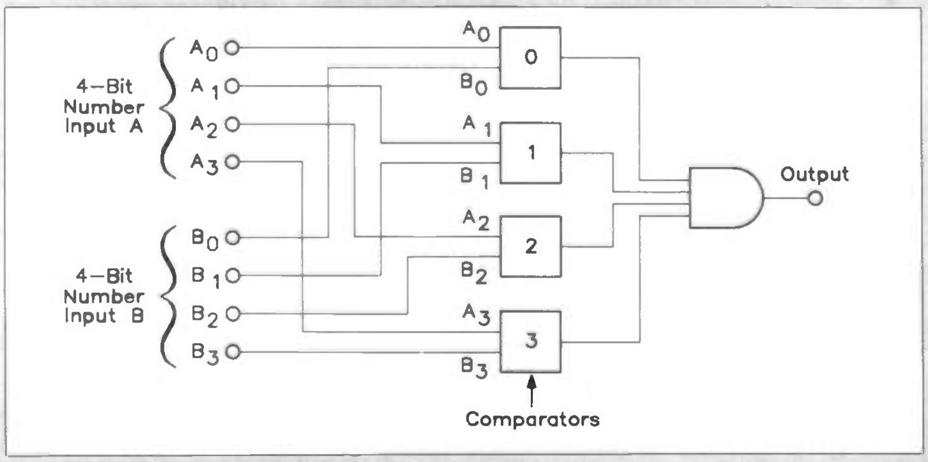



**Figure 2. A 4-bit comparator circuit.**

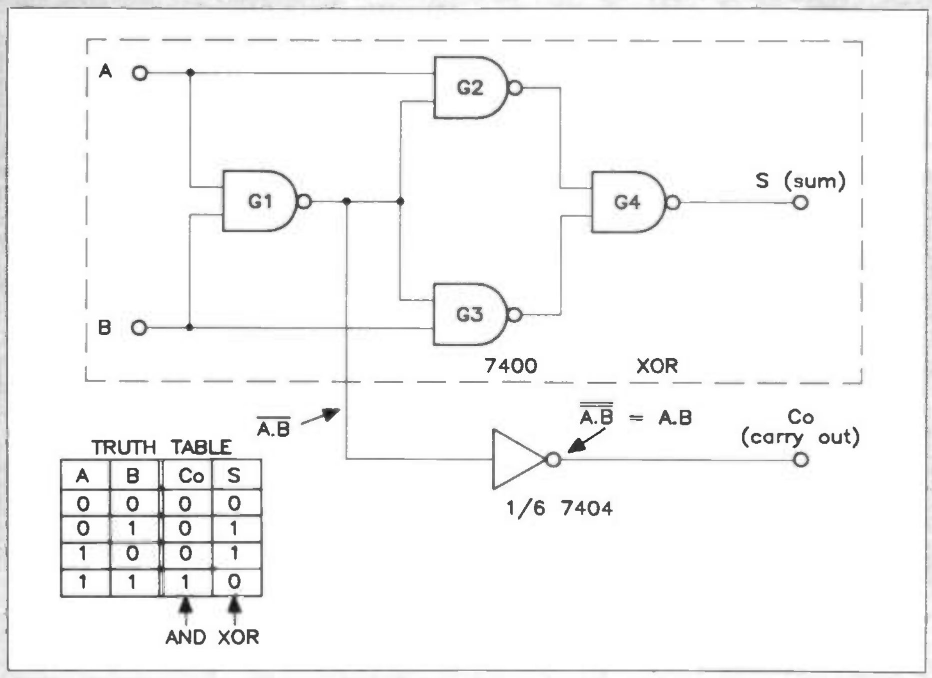



**Figure 3. The half-adder circuit.**

compares the logic levels at the two inputs; it then sets the output to logic 1 only if they are equal, whether both logic 0 or both logic 1. Figure 2 shows an extension of this idea, more useful than just comparing two bits, in which four comparators are used to compare two 4-bit binary numbers. The output from the AND gate will only be logic 1 when the 4-bit numbers are equal. Notice how we have automatically slipped into the 'system' concept with only one gate actually being drawn (the AND gate), the others being represented by the four comparator blocks each of which we know contains the gate arrangement of Figure 1.

Another name for the comparator is 'equivalence' (EQV), which is more of an algebraic description, telling us that the output is a logic 1 when the inputs are equivalent. A further method of labelling this function is to call it 'exclusive-NOR' (XNOR) since it is the inverse of the XOR function.

## Comparator ICs

There are several ICs available that will compare either two 4-bit or two 8-bit numbers. Not only will they give an indication when the two numbers are equal but will also signal the other two states, namely 'A greater than B' or 'A less than B'.

Examples of 4-bit comparators of this type are the 7485 and 74LS85 TTL ICs. These have separate outputs to indicate which of the three possible conditions is true. It is possible to cascade such ICs to increase the bit size of numbers compared. However, there is also an 8-bit comparator IC available, the 74LS684. Again this can detect the three possible conditions but signals the results in a slightly different manner. On the two output pins, each goes low separately to indicate either A>B or A=B, but both pins high at the same time means that A<B.

## Adder circuits

### 1. The Half-Adder

The XOR function was converted into the comparator circuit by adding just one more gate. An equally simple modification produces another quite different function. In this case it is the 'half adder' of Figure 3. This time it is an inverter, which is connected to the output of gate G1 and consequently produces the function A and B. Why? Because this gate, being a NAND gate, produces A NAND B; if this is inverted by the said inverter, the result will be NOT A NAND B. Whichever way you look at this the answer surely has to be A AND B. Just take the well known fact that 'two negatives make a positive'. Both NOT and NAND are negative functions; when they cancel out all that is left is AND!

There are now two outputs in the new circuit. One is the XOR output of A and B; the other is the AND of A and B. The truth table for these two outputs appears in Figure 3. Note how they have been named. The XOR output is called S and the AND output is called $C_0$. The latter stands for the 'carry out' that can occur when two bits are added together. For example, consider the following.

If A = 0 and B = 0 then A + B = 0 (sum) and (carry) = 0.
If A = 0 and B = 1 then A + B = 1 (sum) and (carry) = 0.
If A = 1 and B = 0 then A + B = 1 (sum) and (carry) = 0.
If A = 1 and B = 1 then A + B = 0 (sum) and (carry) = 1.

Put another way:

| | | | |
|---|---|---|---|
| 0 | 0 | 1 | 1 |
| +0 | +1 | +0 | +1 |
| 0 | 1 | 1 | 10 |
| | | | ↑ |
| | | | ($C_0$) |

To relate this to the truth table of Figure 3, add the values of A and B in each of the four rows and the values of S (sum) and $C_0$ (carry out) will be seen to obey the above rules. All we are doing is adding two binary digits together to produce a sum and carry. This circuit, able to add two bits and produce sum and carry outputs, is known as a 'half-adder'. The reason that it is known as a half-adder is because it can only add together *two* bits, and thus is unable to handle a carry-in from a previous column of addition. Remember that in most practical cases it is multi-digit numbers that get added, not merely pairs of bits. For example, consider the following addition of two 4-bit binary numbers:

```
 PQRS
 1011
+0011
 ----
 1110
```

Taking the addition column by column:

The addition of column S is 1 + 1 giving a SUM of 0 and a CARRY of 1; this carry goes into column R, so that:

The addition of column R is 1 + 1 + a CARRY of 1, giving a SUM of 1 and a CARRY of 1;

The addition of column Q is 0 + 0 + a CARRY of 1, giving a SUM of 1 and NO CARRY;

Finally the addition of column P is 1 + 0 + NO CARRY, giving a sum of 1 and NO CARRY.

It should be noted that the additions of columns R and S both produced carries in this example. Thus, the following column additions involved adding *three* bits and not two. The column that will only ever involve adding two bits is column S, since there is no previous addition to generate a carry. A half-adder will suffice for this column but subsequent columns will require a 'full-adder'.

### 2. The Full-Adder

The full-adder, whose block diagram is shown in Figure 4, consists of two half-adders plus an OR gate, thus showing that two halves don't always

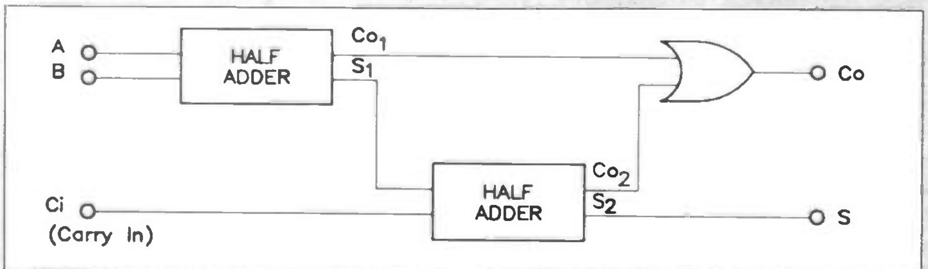



**Figure 4. The full-adder block diagram.**

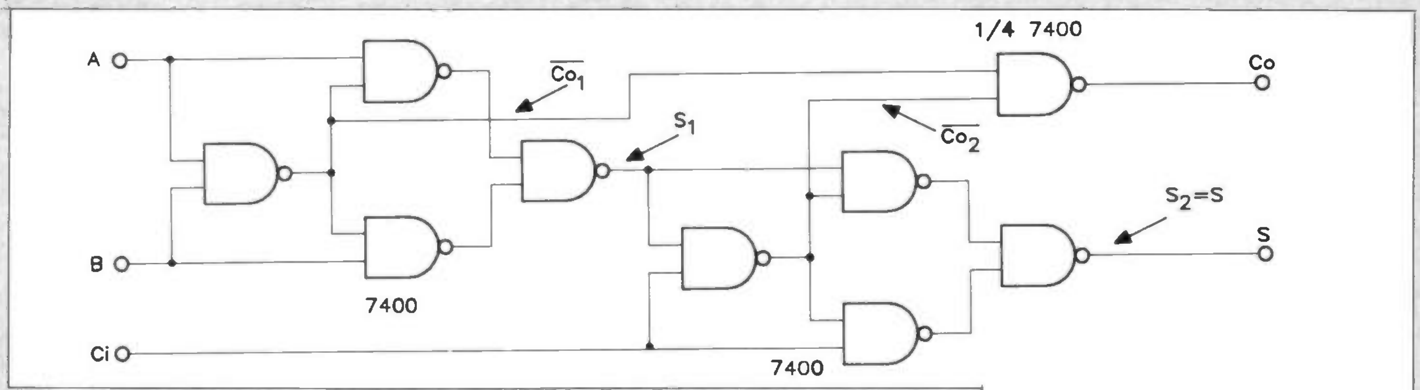



**Figure 5. Gate circuit for the full-adder.**

TRUTH TABLE

| A | B | Ci | Co | S |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 |

make a whole! One half-adder has as its inputs the column bits which we shall call A and B; the inputs to the second half-adder are the SUM output of the first half-adder plus the CARRY IN bit C. The end result is the SUM output S from the second half-adder. All very logical it is hoped. The CARRY output $C_0$ is obtained by ORing the individual carries from the two half-adders.

Producing the required OR gate using NAND logic highlights a point of interest and reveals a circuit simplification. It may be remembered from the previous article that the OR function of two inputs is obtained by inverting these two inputs and then NANDing them; this was possible because of de Morgan's theorem. Now the carry out from a half-adder is actually obtained from another inverter, as required to obtain the OR function, and we end up with *two* inverters in series – an obvious case of redundancy! One inverter will cancel out the other, meaning that we can dispense with them both. On this basis the full-adder gate circuit will look like Figure 5. The final carry out is produced by NANDing the inverted individual half-adder carries directly.

This Figure includes the truth table which can be used to prove the validity of the circuit after it is wired up. Three switched inputs for A, B and $C_i$ and two LEDs for the outputs S and $C_0$ are all that are needed apart from a +5V power supply in order to test the circuit. Pin-outs for 7400 and 7404 chips are given in Figure 6, as required for the circuits so far.

**3. The Parallel Adder**

When it comes to adding together two multi-bit numbers, there are two ways of doing it. Either we can add the bits together all at once and produce a simultaneous result, or we can add the bits together one at a time and get the result bit by bit. The former method involves a parallel adder and the latter, a serial adder. The parallel adder will be explained first and is shown in Figure 7. A 4-bit adder is actually shown, but the principle can be extended to as many bits as you wish.

The first feature that one may note is that the circuit consists of one half-adder and three full-adders. Following on from the recent discussion on carries, this should come as no surprise; the first stage does not need to include any carry. The half-adder adds together the least significant bits (LSBs) of the two numbers; the full-adders add together the higher order bits. The two 4-bit numbers have been called A and B, the individual bits in each number being given a distinguishing suffix. Thus the LSB column comprises the bits $A_0$ and $B_0$, the next column the bits $A_1$ and $B_1$, and so on. In a similar way the SUM output is a 4-bit number comprising the bits $S_0 - S_3$ inclusive.

The only linking between one adder and the next is by way of the line connecting the 'carry out' from one stage to the 'carry in' of the next. There is a final carry out $C_{03}$ from the highest order stage. If the addition of two 4-bit numbers results in a 4-bit result (e.g. 1000 + 0011 = 1011), this final carry out will be 0. If the addition produces a 5-bit result (e.g. 1000 + 1011 = 10011) then this final carry will be a 1.

Parallel addition is used in microprocessors. This is illustrated in Figure 8, where the contents of two 8-bit registers. A and B, are added together. The carry out 'drops into' a bit of the Status register known as the CARRY FLAG. Here it is preserved as the 'ninth bit' of the result. It can be used as such especially in 16-bit arithmetic. The 8-bit result of the addition is usually written back into the A register. Thus the full 9-bit result appears in the Carry Flag 'alongside' the A register.

**4. Serial Adder**

The parallel adder requires an adder block for each column of addition. For example, a 16-bit parallel adder needs one half-adder and 15 full-adders. Such circuits are somewhat hardware intensive. On the other hand, the simultaneous addition of bits makes them extremely fast. However, where speed is of less than paramount importance, the hardware requirements can be greatly reduced by the use of serial addition. As one might expect, the bit pairs are taken, starting at the LSB end of the addition, one at a time and the addition performed column by column. Naturally it is necessary to 'memorise' the carry between one column addition and the next. How this can be done is shown in the block diagram of Figure 9.

Essentially this diagram shows the same serial adder five times, but for successive states of the addition process.

In Figure 9 (a) the component parts of the serial adder and the data to be

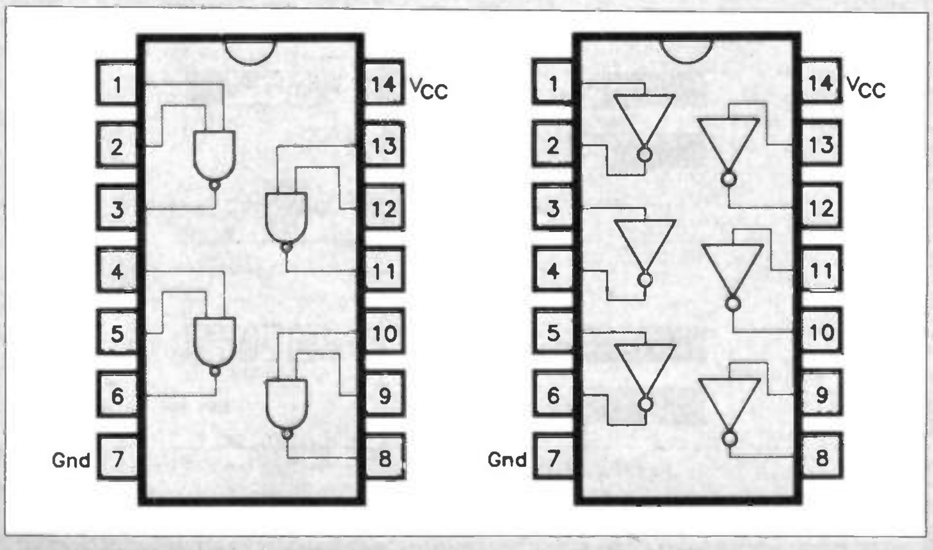



**Figure 6. Pin-outs for 7400 and 7404 ICs.**

operated upon are identified. The former comprises the following:

A full-adder whose inputs are the data bits A and B and a carry in $C_i$, two 4-bit shift registers which hold the two numbers to be added, and the 4-bit result is similarly held, as it is accumulated, in another 4-bit shift register. A D-type flip-flop is used to temporarily store the carry out $C_0$ resulting from each addition process.

This circuit contains two logic devices not discussed so far. Taking the D-type flip-flop first, this need only be regarded as a 'single-bit data store' whose output, Q, is forced to be a copy of its input D. Only when a clock pulse is applied to the clock input will the logic level at D, whatever it is, be transferred to an internal store and appear at Q; the latter effectively retains (stores) this binary value until the next clock pulse is applied, until which time D is ignored. The other device, the shift register, is an extension of this same idea, except that it is a string of D-type flip-flops that can store a multi-bit binary number, in this case a 4-bit number. It is called a 'shift register' because the application of a clock pulse causes the data held in any of the individual flip-flops to move one place to the right. Thus, after four clock pulses, the data bit in the leftmost flip-flop will have simply 'moved through' the whole register completely. With these ideas in mind it is not too difficult to understand how the serial adder works.

By an operation which is not of specific importance at the moment, the two shift-registers A and B are loaded with the two 4-bit numbers to be added. At this time the 'result shift-register' is assumed to be reset (contents = zero) as is the D-type flip-flop; the latter state means that the only inputs to be added are the LSB digits $A_0$ and $B_0$, $C_i$ being zero at this time. The addition of $A_0$ and $B_0$ will cause appropriate outputs to appear at the S and $C_0$ terminals of the full-adder. What happens next when the clock pulse is applied is of great importance. Essentially three things happen.

(i) The S output of the half-adder is 'clocked into' the 'results shift-register' and becomes $S_0$ in that register.
(ii) The $C_0$ output of the full-adder is clocked into the D-type flip-flop and is stored at its Q output. This becomes $C_1$ ready for the next column addition.
(iii) Both the A and B shift-registers have their contents shifted one place right. Thus $A_0$ and $B_0$ 'drop-off' the end and their places are taken by $A_1$ and $B_1$. The other order bits also follow them one place to the right.

This is the situation depicted by Figure 9 (b) and shows that the data, plus carry, are set up for the next two columns to be added. Subsequent operations are essentially the same, with the final state being shown in Figure 9 (e). The 4-bit sum appears as $S_3S_2S_1S_0$ with the fifth bit of the result (assuming that there is one) retained in the D-type flip-flop.

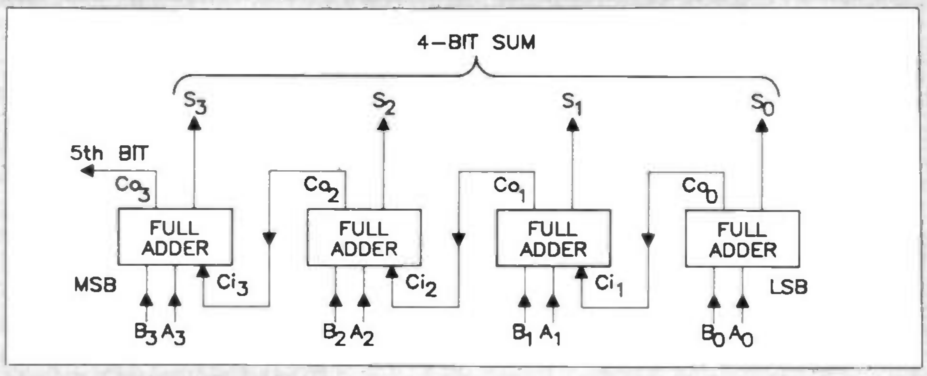



**Figure 7. A 4-bit parallel adder.**

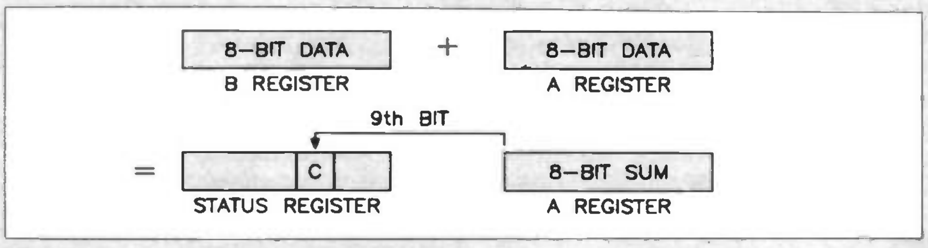



**Figure 8. Parallel addition in a microprocessor.**

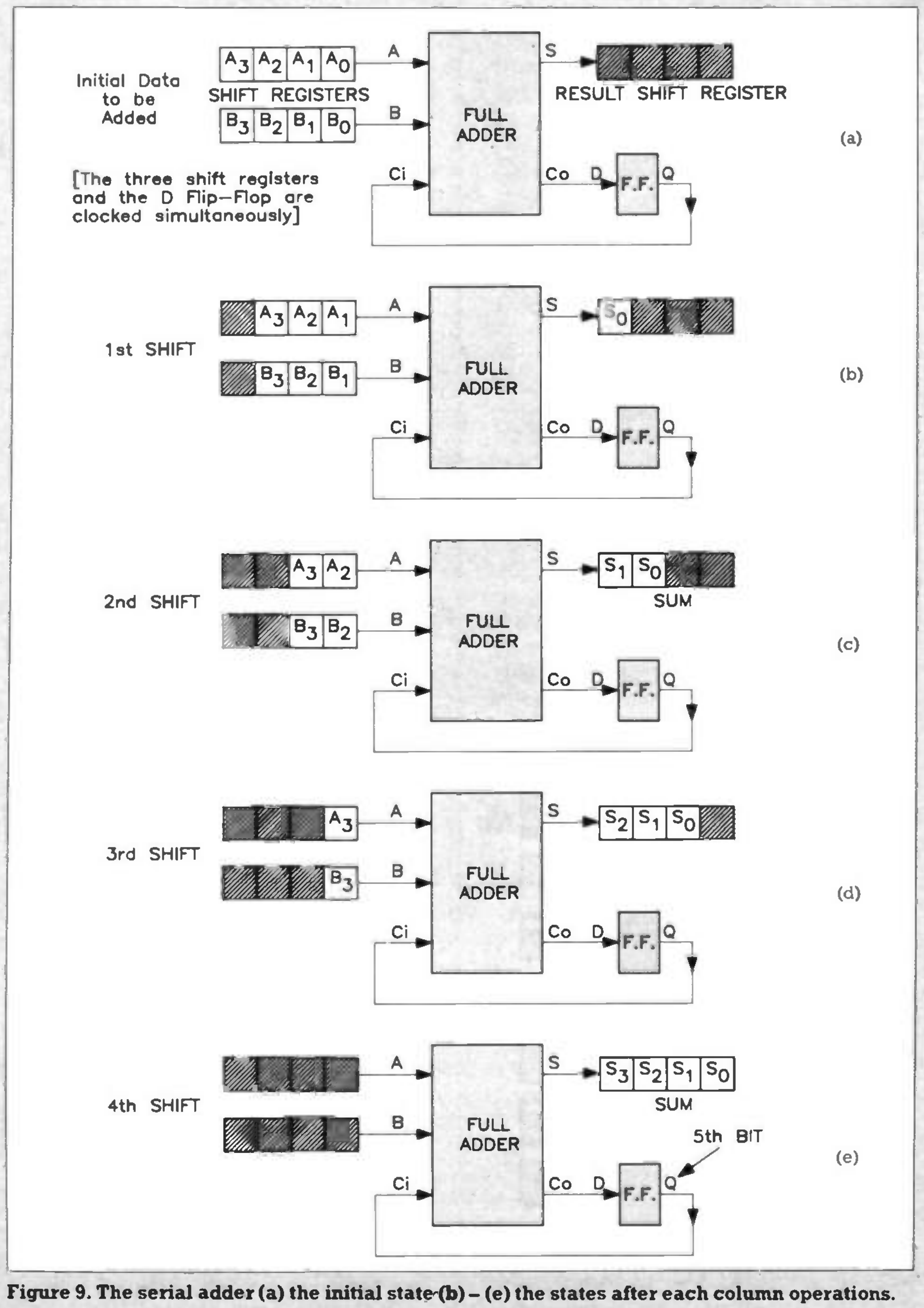



**Figure 9. The serial adder (a) the initial state (b) – (e) the states after each column operations.**

## 5. Available Adder ICs

While there is much to be learned by breadboarding the above types of adder circuit, in practice it is more likely that fully integrated versions would be used rather than that they would be constructed from individual gates. Some cheap and readily available ICs are as follows:

The 7483, 74LS283 and 74HC283 are examples of TTL 4-bit full-adders that can be cascaded to perform parallel addition on any two binary numbers A and B. The lowest order adder must have its $C_1$ taken to zero volts, while its carry out is simply linked to the carry in of the next adder up the chain. A carry out is available from the last adder in the chain. How easy it is to connect up these devices can be judged by looking at Figure 10 which shows a 12-bit parallel adder.

Where absolute speed is less important than power consumption, the CMOS 4008BE 4-bit full-adder offers an alternative. Otherwise it is similar in application to the TTL versions.

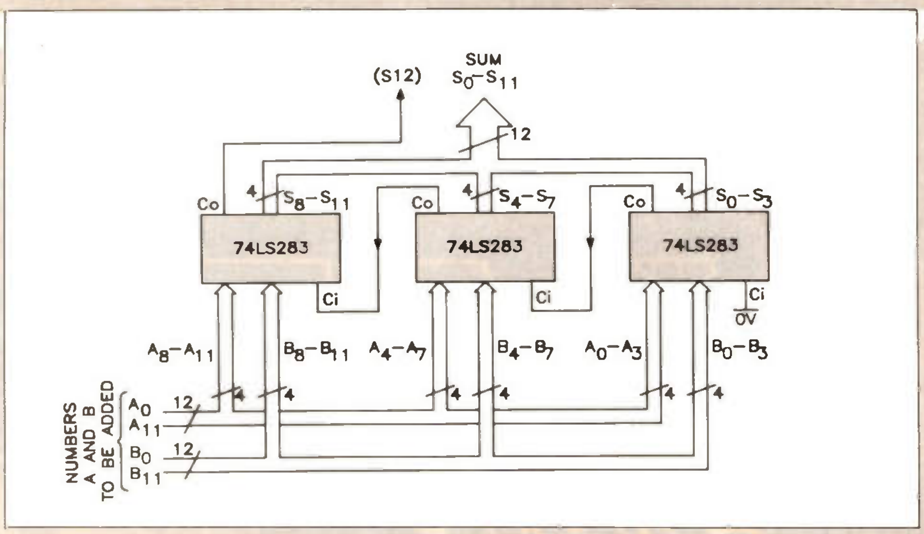



**Figure 10. A 12-bit parallel adder formed by cascading three 74LS283 4-bit full-adders.**

In the next issue we continue the concept of 'chip systems' by taking a look at the principles of some of the chips that go to make up a microcomputer.

# Stray Signals

by Point Contact

As readers of detective novels will know, acute powers of observation are a must for the successful sleuth, whether of the regular force or one of the "little grey cells" brigade. Even the most (apparently) insignificant detail can provide grounds for a solid deduction. For instance, unlikely as it may seem, even as mundane an institution as a public convenience can furnish one with information as to the local set-up. No need even to set foot inside – a cursory glance suffices; if the building is labelled "LADIES" and "GENTLEMEN" one is almost certainly in true blue country, whereas "MEN" and "WOMEN" indicates a local authority from the other side of the political divide. I mention this merely to underline the fact that engineers of all sorts, and particularly electronic engineers of course, are all very observant people – aren't we? (Have you ever spent ages trying to get an amplifier to amplify, only to discover that the DC conditions were all wrong and the active devices all bottomed or cut off?)

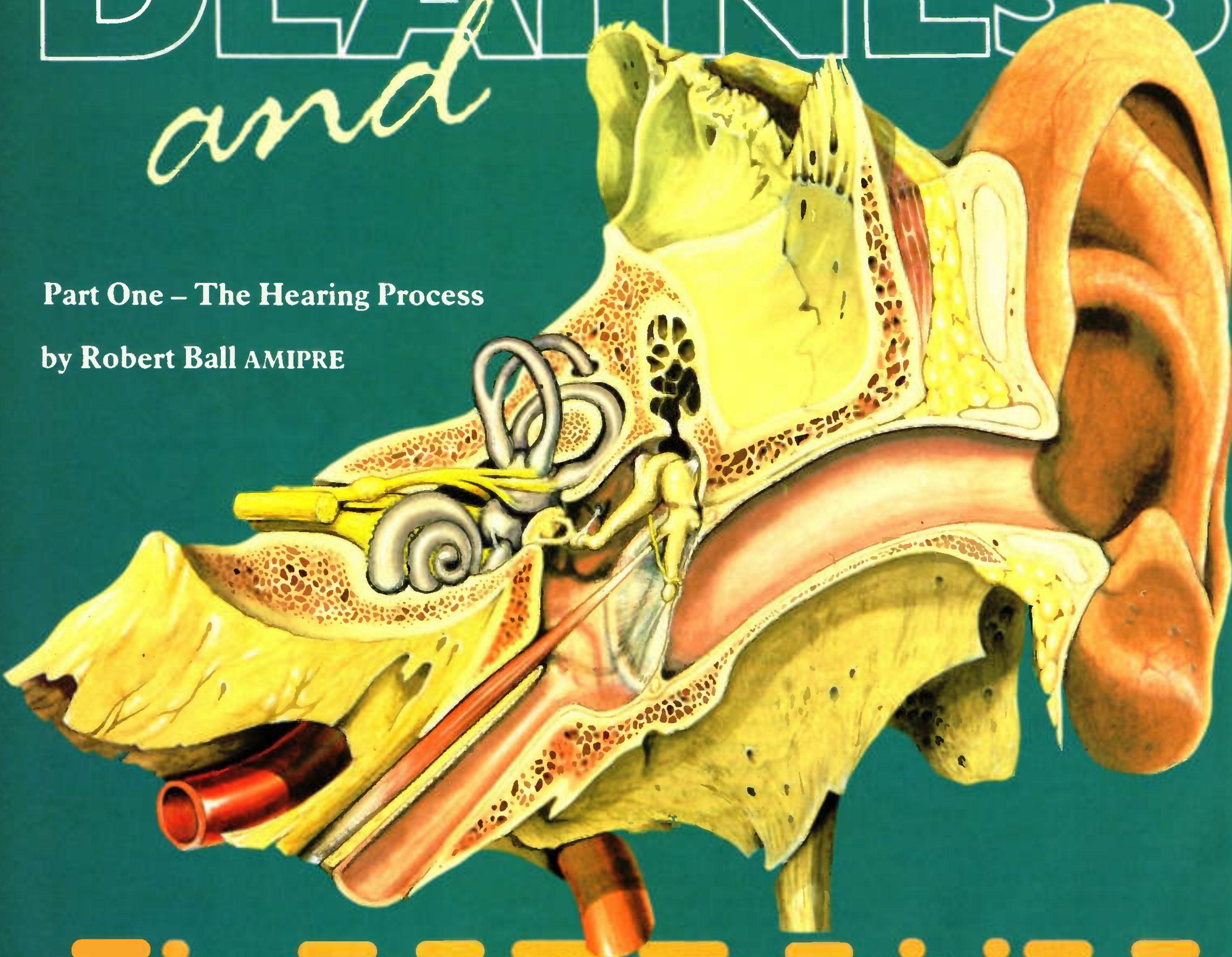
Point Contact was fortunate enough earlier this year to attend the 5th International Conference on Radio Receivers and Associated Systems, held at Churchill College, Cambridge. (The venue was one of the least attractive colleges in the city, being built of a very unpleasant type of brick in a severely functional style; the only thing to be said in its favour is that at least it is not built of dingy grey pre-stressed concrete.) This prestigious gathering was attended by all sorts, from the grand old men of radio-communications such as "Sosh", to shiny young new Ph.D's presenting their first papers. In between, the majority of attendees were, like Point Contact, practising electronic engineers in (comparatively?) early middle age. The distinguished Chairman opened the proceedings with a gaff – "Gentlemen, I am pleased to welcome you all to this Fifth . . ." – which he then made worse by breaking off to look around and concluding that just "Gentlemen" was correct, in the absence of any Ladies. P.C. looked around too, but though I couldn't spot any ladies from where I sat, there were certainly several present a little later at the coffee break following the first three papers! I doubt if they all arrived late, and they must have felt distinctly discriminated against by the distinguished Chairman's distinguished Introduction.


The papers presented during the three days of the Conference ran true to form, with most being of some interest, some of very little but just one or two being really novel and worthwhile. At lunch time each day, P.C. repaired to a nearby local hostelry where the pub-grub was appetising and cost but a fraction of that at the College – perhaps that's why so many of my colleagues also found their way there. Returning to the College after lunch on the first day, I suddenly realised that P.C. (and all the other male attendees) was as much a victim of sex discrimination as the hapless ladies mentioned earlier. For, would you believe, their powder room was labelled "LADIES" whilst our facilities were clearly labelled "MEN". Whether the architect of Churchill College was a feminist with a thing about male chauvinist pigs, or whether the college authorities know something about the relative degree of civilisation of male and female undergraduates, I leave you the reader to decide.

Yours sincerely,

*Point Contact*

# HEARING, DEAFNESS and ELECTRONIC TECHNOLOGY



Part One – The Hearing Process

by Robert Ball AMIPRE

## Foreword to the Series by David Holroyd

Deafness has often been called the *Lonely Disability*. This title arises from the difficulties many deaf people face when communicating in a hearing world. Advances in electronics are starting to clear away some of these problems.

There have been many attempts to improve communication with deaf people over the centuries. The first of these was shouting and later on, the ear trumpet. Electronic hearing aids in various guises date from the early twentieth century. The basic principle was and still remains that of a microphone, amplifier and speaker which relays the sound, in an amplified form, directly into the external auditory canal. Hearing aid technology has advanced such that the large chest amplifier units are a thing of the past. As with all branches of electronics, the advent of miniaturisation means that hearing aids can now be minute, see Photos 1 and 2. Most will fit behind the ear, some will fit into the ear and others are combined with spectacles to create as little personal embarrassment or disruption as possible.

## Introduction

The following, which is the first in a series of articles on Hearing, Deafness and Electronic Technology, has been written in association with the University College Hospital and the Royal National Institute for the Deaf. It explains the hearing process and what can go wrong with our ears. It is hoped that it will encourage both deaf and hearing people to accept deafness as part of life, and encourage positive thinking and action to help deaf people to integrate with society as a whole. Every person, whether deaf or hearing, has a vital role in today's world, each with their own, totally unique, contribution.

## The Ear and How it Works

Figure 1 shows a cross section of the human ear. The ear is divided into three main sections; the outer, inner and middle ear. Each section will be dealt with separately.

### The Outer Ear

The outer ear consists of the auricle, which is the visible part of the ear, and the external auditory canal. The canal is a narrow passage, approximately 8mm in diameter and 25mm long. Its surface is lined with skin and ends at the tympanic membrane (ear drum). The outer part of the canal has wax secreting glands and fine hairs, which give protection from dust and debris.

The ear drum separates the outer ear from the middle ear; it is roughly circular in shape and is anchored to the ear canal wall. Sound pressure waves in the air enter the ear and cause the ear drum to vibrate in sympathy with the sound.

### The Middle Ear

The middle ear consists of a small cavity, approximately 13mm long by 13mm high, which is filled with air. Air pressure in the middle ear cavity is equalised with that of the outside world by means of the eustachian tube, which connects the cavity with the nose and throat. The tube normally remains closed except when yawning, swallowing or nose blowing; often 'clicks' or 'pops' will be heard in the ears, which is perfectly normal. This mechanism ensures that the pressure differential imposed on the ear drum is minimal. Often, when driving up or down a steep hill in a car, a sensation of pressure will be felt in the ears. This will be accompanied at some stage with 'ears popping' as the eustachian tube equalises the pressure, the sensation of pressure is then relieved. The middle ear is separated from the inner ear by a wall of bone, in which there are two small openings known as the oval and round windows.

The middle ear cavity is straddled by three tiny bones, the ossicles, these bones are the smallest to be found in the human body. Their function is to pass sound vibrations from the ear drum to the fenestra ovalis (oval window). The bones are named after items from the blacksmith's forge. The malleus (hammer) is firmly attached to the ear drum on its inner side and is connected to the second bone, the incus (anvil). The incus joins with the head of the stapes (stirrup), the base of which fits precisely into the oval window. Any vibrations of the ear drum, caused by sound waves entering the ear, are passed along the chain of ossicles and so into the inner ear via the oval window. Here the perilymph fluid, which fills the inner ear, moves in sympathy with the vibrations caused by the sound waves. The fenestra rotunda (round window) is closed by a thin membrane that allows this fluid to move freely. Tiny muscles support the ossicles and, if tightened, can restrict movement, thus reducing sensitivity; which is in fact necessary to help prevent loud sounds from damaging the ear. This sensitivity adjusting mechanism is under control of the auditory nervous system. In other words, the ear has an inbuilt AGC (Automatic Gain Control) system, which accounts for the ears logarithmic response to increasing sound level.

### The Inner Ear

The inner ear, also known as the labyrinth (a structure of winding passages), is embedded in a mass of bone. This extremely delicate and intricate structure consists of two main parts; the cochlea, which transfers sound waves to the auditory nerve; and the semi-circular canals, which provide motional information to the vestibular nerve (nerve of balance). The

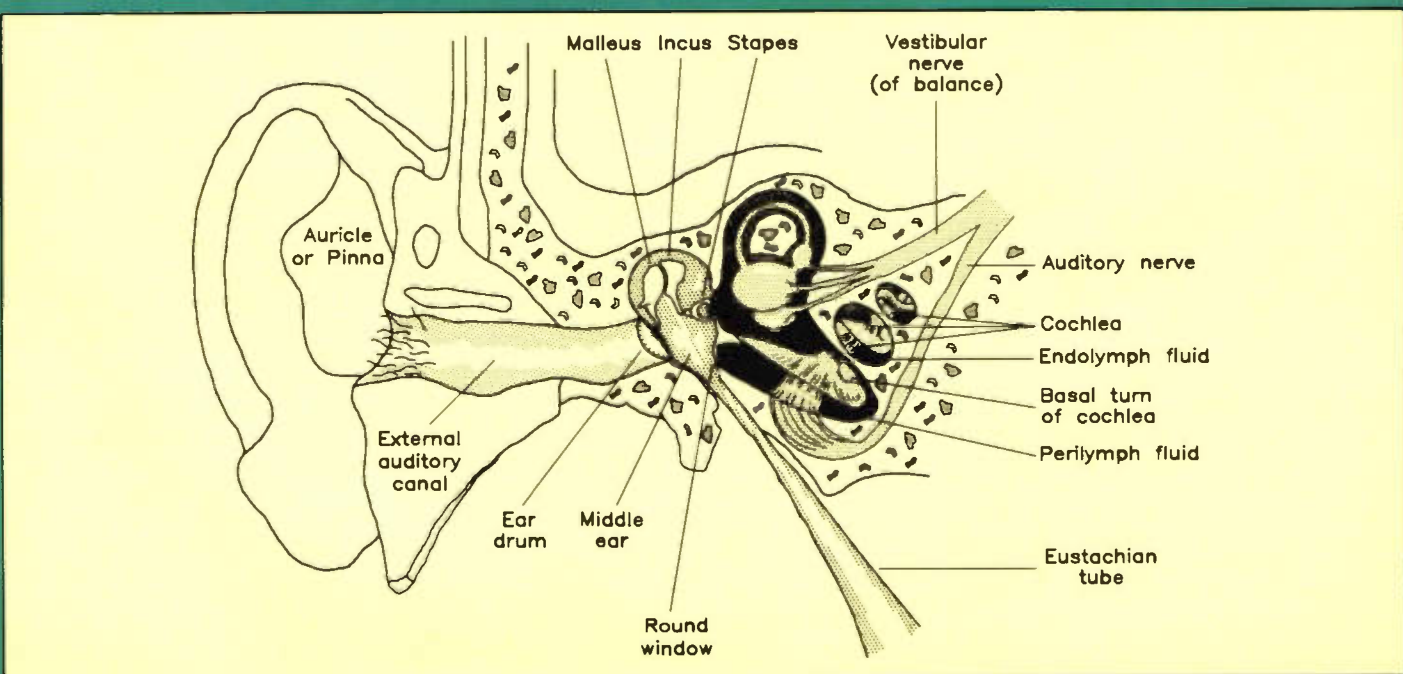



**Figure 1. The human ear.**

close relation of the hearing and balance mechanisms explains why hearing problems are often accompanied by giddiness. An example of this is Ménière's Disease, which is a combination of nerve deafness, tinnitus (noises in the ears) and vertigo (giddiness and vomiting).

The cochlea, see Figure 2, is like a snail's shell, consisting of a 35mm-long tube, which is coiled 2¾ times. It is divided longitudinally into upper and lower chambers by a spiral partition. Both chambers are filled with endolymph fluid. Sound waves pass from the oval window, along the upper chamber to the top of the cochlea, and then back along the lower chamber to reach the round window.

Located between the upper and lower chamber is the organ of corti, itself housed in an inner tube and filled with fluid. The organ of corti contains some 17,000 small cells covered with minute hairs, each cell is connected to a fibre, or fibres, of the auditory nerve. Sound waves travelling through the fluid in the cochlea move the hair cells. The resulting nerve impulses pass along the auditory nerve to the brain where they are interpreted as recognisable sounds, such as music or speech. The nerve impulses are coded in a complex way, and at least six stages along the pathway to the brain the impulses are re-coded. Not surprisingly, it is extremely difficult to correct this complex 'transmission system' if it goes wrong.

One feature of human hearing is that it is more sensitive to frequencies around 1kHz, corresponding to the pitch range of human speech. This effect becomes apparent at low sound levels, which is why many Hi-Fi amplifiers have a 'loudness' button to boost low and high frequencies, thus redressing the balance.

## Deafness and its Diagnosis

At first it may seem that diagnosis of deafness is a simple matter, however deafness is not a 'black and white' case of can or cannot hear. In the same way that a piece of electronic audio equipment can have its frequency response measured, so can human hearing, this is known as audiometry. This may show up an overall hearing loss across the audio frequency range or a number of dips and troughs at specific frequencies. The deafness, as previously mentioned, may be conductive or nerve deafness, each requiring a range of different treatments. To enable the best treatment to be applied, to reduce hearing loss or restore normal hearing, correct diagnosis of the problem is necessary.

An otologist is a doctor who specialises in diseases of the ear, nose and throat (commonly abbreviated to E.N.T.). By asking suitable questions, examining the ears and performing tests, the doctor may discover the cause of deafness. Examination of the nose and throat may also be required as these are closely related. All cases of deafness should be examined by an otologist, as there may be a simple remedy which can put the matter right.

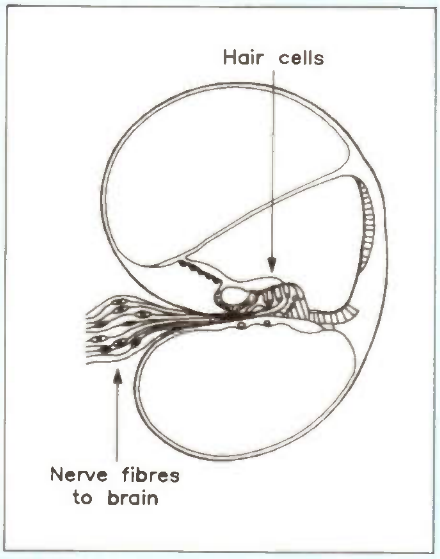



**Figure 2. Cross section of the cochlea.**

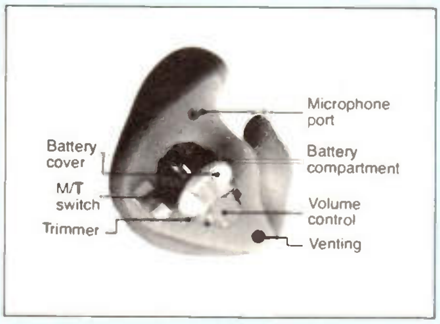



**Photo 1. A modern miniature 'in the ear' type hearing aid.**

**Photo 2. A patient wearing an 'in the ear' type hearing aid.**

## Tuning Fork Tests

Tuning fork tests can distinguish, on the whole, between conductive deafness and nerve deafness. Although sounds are normally carried to the inner ear by the conducting mechanism of the middle ear (air conduction), they can also bypass the middle and be transmitted directly to the inner ear through the bone structure of the skull (bone conduction). The test is performed by striking a tuning fork and holding it alternately against the skull behind the ear and in front of the ear. If bone conduction is louder than air conduction, there must be an obstruction to the passage of sound waves through the outer or middle ear (conductive deafness). Different pitch tuning forks are used to test hearing sensitivity at different frequencies.

## Pure Tone Audiometry

A much more precise measurement of hearing can be determined by using an audiometer. Pure tones (sinusoids) of different frequencies and amplitudes (loudness) are reproduced through a pair of headphones worn by the patient. A audiogram (graph) is plotted, showing hearing loss at each test frequency, measured in decibels. An audiogram showing 0dB loss implies normal hearing sensitivity; a 30dB loss means that conversation is heard faintly, and a 60dB loss that only a shout is heard. Pure Tone audiometry does not measure the ability to understand speech, but reveals a great deal of useful information.

## Speech Audiometry

An estimate of how well speech is heard can be made by testing hearing with spoken and whispered words and sentences at various distances. A more accurate assessment can be made by speech audiometry. This involves replaying a tape through headphones, with recordings of various words at known amplitudes. The words are specially chosen to show up different hearing problems. A 'score' of correctly identified words is marked on a graph. These tests are valuable tools in the diagnoses of different types of deafness.

## Conductive Deafness

Conductive deafness may be caused by anything that obstructs the conductive mechanism and prevents sound waves reaching the ear. Common causes of conductive deafness will be dealt with briefly.

### Obstruction of the External Canal

Obstruction of the external canal must be more or less complete before deafness is noticed. The commonest obstruction is wax. Under normal circumstances, wax is produced in small amounts by the glands situated near the opening of the canal. It forms small beads mixed with dust and dead skin flakes, which then fall out of the ear. This self clearing mechanism works well for most people and contrary to popular belief, does not need any help from cotton tipped sticks, corners of towels, fingers, etc. Pushing things blindly down the ear only serves to increase wax production and push wax firmly down onto the drum, where it causes pain and deafness. As a result of this widespread practice, and also because some people do make abnormal amounts of wax, periodic removal, by a doctor or nurse, may be required.

It is not uncommon for children to place small objects in their ears (such as peas, erasers from the top of pencils), which become lodged and cause deafness. It is important that removal of such an object is only carried out by qualified medical personnel, otherwise the object may be pushed further along the external canal, possibly causing damage. It is important to strongly discourage children from placing any object in their ears.

## Otitis Externa

A common condition is skin inflammation of the external auditory canal. Itchiness is the main symptom. As a result of scratching, and less commonly due to an underlying skin condition, such as eczema, the canal wall becomes swollen and infected. At some stage pain and discharge may occur. However deafness is usually slight or absent. Treatment usually includes cleaning of the canal by a doctor or nurse, avoiding of further scratching and use of eardrops.

## Secretory Otitis Media

A common childhood condition, although it may affect adults too, that is often referred to as 'Glue Ear'. This is caused by the eustachian tube becoming obstructed, often by adenoids at the back of the nose, so that air cannot enter the middle ear. The middle ear cavity fills up with fluid, causing the ear-drum to become immobile. After some time the fluid becomes thicker and of similar consistency to that of glue, hence the name.

In mild cases recovery may occur spontaneously. If this does not occur the treatment involves making a small hole in the ear drum (myringotomy), usually under a general anaesthetic. A grommet (ventilation tube) may be inserted and the adenoids may also be removed. Adenoids usually disappear at puberty and most children with 'glue ear' do not need treatment after this time. Hearing is usually fully restored to normal.

## Otosclerosis

This is the most commonly occurring form of conductive deafness in adults, but it affects women more than men, often starting at around 30 years of age and may run in families. Otosclerosis is caused by an overgrowth of bone in the middle ear which involves the stapes. The normally free-moving ossicles become rigid and thus cannot vibrate, thus sound is not passed into the inner ear, resulting in progressive conductive deafness.

The stapedectomy operation has revolutionised the outlook on this condition. Most cases are considered for surgery and the success rate is very high. Under a general anaesthetic the ear drum is turned forward and the middle ear exposed. Using a special operating microscope, which is an invaluable development in modern ear surgery, the fixed stapes is removed from the ear. In its place a small piston made of a bodily inert material, such as stainless steel or Teflon, is placed in the oval window and attached to the incus by a miniature clip. This minute structure, which is only 5mm long and 0·5mm in diameter, restores the pathway for sound to pass into the inner ear.

## Chronic Middle Ear Infection

Chronic middle ear infection is a problem that is far less common than it used to be, mainly due to antibiotics. Acute infections, if properly treated, are rarely followed by chronic discharge, which can destroy the ossicles and perforate the ear drum. Minor perforations of the ear drum can be repaired by skin grafts. Operations for acute mastoid (bone behind the ear) infection, once a common surgical emergency, are now rare.

Sometimes, due to an abnormal ear drum, quantities of dead skin can accumulate in the middle ear and mastoid bone. Although hearing may not be severely affected, a mastoid operation may be recommended by a specialist. This is because the dead material may become infected and spread infection to the inner ear or brain.

## Sensory Neural Deafness

Sensory neural deafness, which is commonly known as 'nerve deafness' or 'perceptive deafness', is caused by damage to the cochlea. This particularly sensitive part of the ear can be damaged before birth as the result of infections, such as rubella (German Measles) during pregnancy; because of difficult labour or prematurity. In some cases the cochlea fails to develop fully. Later infections such as mumps or meningitis can also cause sensory neural deafness, as can accidents involving head injury.

The cochlea may also be damaged by certain drugs, especially antibiotic streptomycin or *excessive* use of aspirin. Exposure to loud noises over long periods also causes damage to the ear. In years past riveters of ship's boilers developed severe sensory neural deafness from working on the inside of the boiler. Current legislation requires that people being exposed to loud or explosive noise, especially for long periods, wear ear plugs or muffs to reduce the noise level.

Listening to loud music can cause damage to the ear, sound pressure levels exceeding 90dBA *will cause damage*. This level is easily achievable with personal stereos and often massively exceeded at concerts and discotheques. If you value your hearing, then the obvious answer is to turn down the volume (or wear ear plugs at concerts and discotheques!). Kylie Minogue and Jason Donovan fans please take note!

## Presbyacusis

More commonly known as 'old age deafness', presbyacusis is an age related hearing loss. In much the same way as all our other senses tend to diminish with advancing age, hearing may also diminish. The actual degree will vary from person to person, but about one-fifth of the population can expect to have some degree of hearing loss through this form of sensory neural deafness. For old people it is extremely important that family and friends maintain good contact and provide support, so that presbyacusis does not become another contribution to the loneliness that so many old people experience. Conventional hearing aids will usually achieve a good deal of improvement in all but the most profoundly deaf cases.

## Concluding

In the first part of this series we have looked at how the ear works and what can go wrong with our ears. In the next issue, we shall deal with electronic implants which can restore a degree of hearing to people who have become profoundly or totally deaf.

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## Acknowledgements


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Royal National Throat, Nose and Ear Hospital.

Addenbrooks Hospital, Cambridge.

London School of Hygiene and Tropical Medicine.

Photographs supplied by Broadway Hearing Aids, 119 Broadway West, Leigh-on-Sea, Essex. SS9 2BU.

Intro picture by Peter Cull/Science Photo Library.


## Additional Information

Additional information may be obtained from the E.N.T. Department of your local Hospital (see telephone directory for address) or the Royal National Institute for the Deaf, whose address is given below:

The Royal National Institute for the Deaf,
105 Gower Street,
London. WC1E 6AH.

# FUNDAMENTALS

**by David Clark**

For the newcomer to the electronics hobby, who cannot clearly remember the physics he or she learned at school, it would not be out of place to go over again some of the basic principles of electricity, a form of energy which our modern electrical and electronic devices and machines have enslaved for the not inconsiderable benefit of us all. Indeed, the 20th century is unique in being one period in time where technological, industrial and social revolutions have followed hard on the heels of one another at a speed and with a frequency hitherto unheard of in any other century in human history. Before, approximately one or two drastic changes per hundred years were normally quite often enough, thank you! It makes you think, doesn't it?

All due in large part to this magic stuff called electricity. It would not hurt the experienced enthusiast either, to periodically refresh himself with a 'grass roots' understanding of electricity and how it behaves. With such understanding the operation of an electronic circuit becomes clearer; the need for the consideration of insulating materials, heat dissipation of individual components or complete systems, and good wiring practices, to use a few examples, become obvious. For instance:

## Resistance and Resistors

The movement of electrons through materials and the effects produced by that movement is the basis behind all electrical and electronic circuits, and yet little is written in hobby magazines about this process, attention being concentrated on the operation of the final circuit. In an attempt to alter this balance, here is a look at arguably the most basic electrical property of materials, that of resistance.

An electric current is a flow of electrons, and resistance is a measure of the ability of a material to oppose the flow of electrons within it. All materials have some resistance. Let us expand this a bit further. Nearly all materials are conductors of electric current to some degree, some better than others. It could be said of rubber, for example, that it makes a good insulator for the simple reason that it is such a dreadful conductor. Resistance may be a desirable or an undesirable property, depending on what is required. A material with a low resistance would be chosen for a conductor, e.g., a copper wire. In this case, any resistance is *undesirable*. A material with a very high resistance (like the aforementioned rubber) would be chosen for an insulator, or, to use another example of a material, a ceramic encapsulation of some sort, and here a high resistance is essential. A controlled amount of resistance which is deliberately desired by the designer is a manufactured component called a resistor, undoubtedly *the* commonest component used in electronics. In the case of a metal oxide resistor, a material such as tin oxide is deposited onto a ceramic rod, and this has a resistance somewhere between that of a piece of wire and a good insulator, with a final value determined during its manufacture.

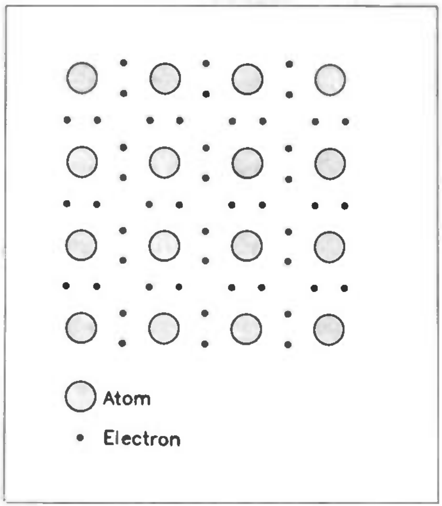


**Figure 1. Covalent bonding.**

The explanation for the phenomena of resistance is to be found in the atomic structure of the material. The atoms of a solid are arranged in a lattice with the positions of the atoms fixed relative to each other by inter-atomic forces. In some materials, the bonds between the atoms are made by the 'sharing' of the outer electrons which orbit the nuclei of the atoms concerned. These are called 'covalent' bonds, and within these the electrons are tightly held and so are not free to move through the material, see Figure 1. It is, therefore, difficult to cause an electric current to pass through such a material, i.e., it is an insulator.

The outer electrons of the atoms of some materials however, particularly metals, are not so tightly held and can become 'free' electrons and move through the material, other free electrons taking their places. Under the influence of an electric field, an applied voltage perhaps, these electrons will drift in one direction and so a current flows. These materials are conductors.

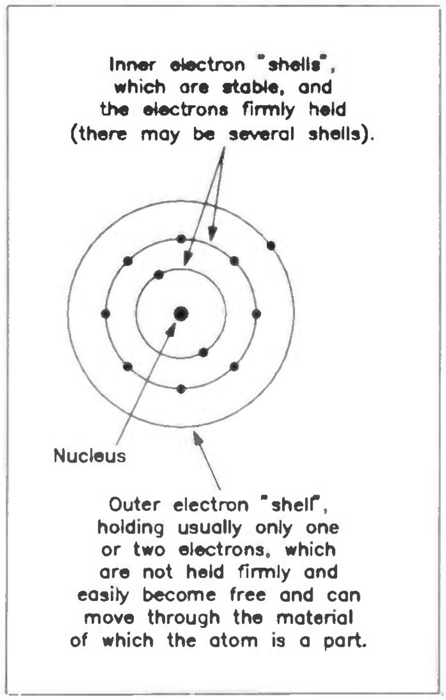


**Figure 2. A metal atom.**

A similar process occurs in metal oxides, which are 'ionic' compounds. The atomic lattice in this case is composed of two elements, the metal itself and oxygen, but in this instance they are present as 'ions'. As in the pure form, the outer electrons of the metal atoms are able to leave their orbit around the nucleus, see Figure 2. Electrons possess a negative charge, and in a normally balanced atom there are an equal number of positively charged 'protons' within the nucleus, and so the atom has no overall charge. If however an electron were to leave its outer orbit, the atom will be left with an overall positive charge, and is then known as a 'positive ion'. The oxygen atom however, is capable of accepting extra electrons into its outer orbit, thus making it a 'negative ion', as in Figure 3.

The tin oxide compound used in our resistor is, therefore, a lattice of positive and negative ions, with electrons capable of moving from one position to another through the material. As in the pure metal, under the influence of an electric field, the electrons will tend to drift in the same direction, and so a current flows (Figure 4).

Since the free electrons are likely to be captured by the oxygen atoms, there will be less free electrons per unit volume (i.e. electron density) at any instant in the tin oxide than in the pure metal, and since a substance's resistance is related to its free electron density, the tin oxide has a greater resistance to current flow than a pure metal.

The free electron density of the material determines its resistance in the following way. An electron in an electric field experiences a force proportional to that field, which is in itself proportional to the voltage causing it, and so this causes the electron to move. Only the free electrons can move, and so the size of the current flowing is proportional to the number of free electrons, i.e. the resistance is inversely proportional to the free electron density. To put an actual number to the resistance of a material, its resistance in ohms is defined as the ratio of the voltage applied across it in volts over the current flowing through it in amps. This is Ohm's Law, and can be written:

$$R = V/I$$

and it means that the current through it will be proportional to the voltage across it, i.e:

$$I = V/R$$

This is simply due to the fact that, by increasing the applied voltage and hence the electrical field, the force on each electron is increased and so the rate of flow of electrons past a fixed point is increased, which is exactly the same as saying the current flow is increased.

Ohm's Law can also be written in the form:

$$V = I \times R$$

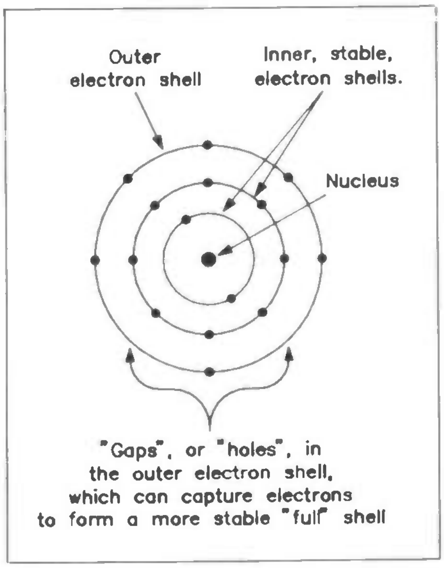


**Figure 3. An oxygen atom.**

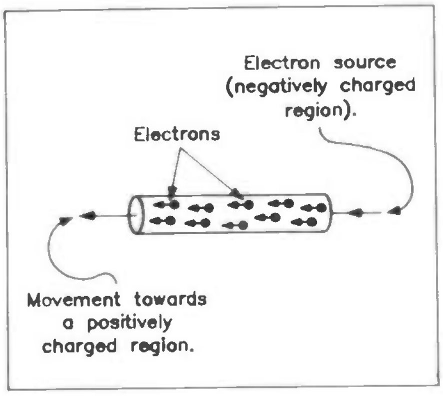


**Figure 4. Movement of free electrons through a material in an electric field.**

This indicates that when a current is flowing through a resistance, a voltage or 'potential difference' is created across it as a result (as opposed to the previous situation where a voltage applied across a resistance causes a current to flow). This is explained as a consequence of electrons flowing through a lattice of atoms or ions.

Although the atoms in the lattice are fixed in position relative to each other, in fact they vibrate about that position since they possess a certain amount of energy due to being at a temperature above absolute zero, which is around −273 degrees centigrade. So as the electrons pass through the lattice they tend to collide with atoms which get in their way, and transfer some of the energy they possess to the atom, making it vibrate further, as illustrated in Figure 5.

Since temperature is a manifestation of the atomic vibrations, this extra energy is eventually dissipated from the material as heat. The voltage, or potential of a point is a measure of the energy possessed by the electrons at that point, so, since electrons are *losing* energy as they pass through the resistor, the voltage at the 'far' end of the resistor will be lower than at the 'near' end, i.e. there is a potential difference across the resistor. This then explains the process of current flow and resistance, one of the fundamental processes which makes the whole electronics industry possible, and also illustrates how you will *always* have heat dissipation and power loss to some degree where resistance is involved.

## Capacitance and Capacitors

The second characteristic of materials of fundamental importance to the electronics industry is that of capacitance, which is the ability to store an electric charge and hence energy. (This is not to be confused with a battery, which is a kind of chemical electric generator.) Just as all materials have resistance, all materials also have capacitance. This is usually quite small, as between a pair of wires say, and is sometimes undesirable but cannot be helped. A lot of the time it does not matter. Everywhere where there is a potential or voltage difference there is an electric field, on which the behaviour of capacitance depends. It can be deliberately increased by using specific materials and optimising the physical configuration of the materials relative to each other, where it is desired that this property be exploited for some reason, and the commonest component used for this purpose is the capacitor. As with resistance, the explanation for the phenomena of capacitance is to be found at the atomic level, and is again to do with the

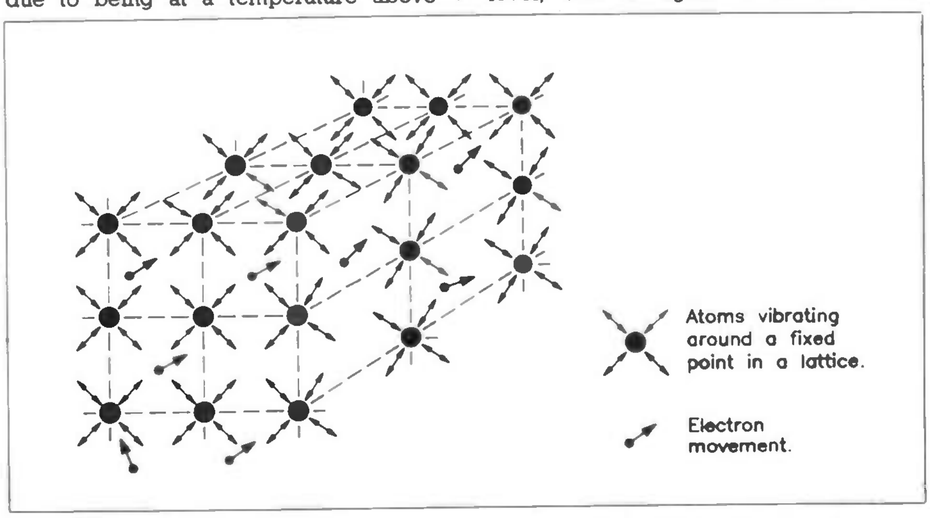


**Figure 5. Electrons moving through a crystal lattice tend to collide with the vibrating atoms.**

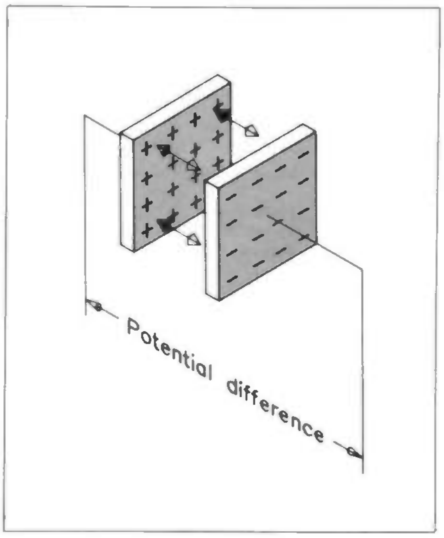


**Figure 6. Opposite charges on the plates of a capacitor attract each other and form a stable state.**

movement of electrons. (Because of this, all capacitors also have some resistance – a pure capacitance cannot be achieved.)

All electrons have by definition some charge associated with them, and this is measured in Coulombs (each electron has a charge of $1{\cdot}6 \times 10^{-19}$). Therefore, any region of a material which holds an excess of electrons will be harbouring a negative charge; likewise, a material maintaining a region of positive ions can be considered to be storing a positive charge. The purpose of a capacitor in a circuit, and the means whereby it has its effects, is the storage, and release, of energy with a chosen time constant (equal to C x R), and it does this by storing electric charge. Energy is associated with charge by virtue of the fact that the charge will have a certain potential, or voltage, which is a measure of its energy level. Since electrons must move around a circuit through the conductors to be of practical use, the electrical parts of the capacitor, i.e. the 'plates', must be conductive to electrons, and so the energy stored in a capacitor is the energy which keeps the charge on the plates, and *not* flowing to the rest of the circuit.

Positive and negative charges attract each other, and try to recombine to become a more stable neutral charge. A positive charge is effectively a place where an electron should be but isn't, a negative charge is a place where there is a surplus electron. But such electrons need a conductive path between these places to redress the imbalance. If two conductive plates are in close proximity but electrically insulated from one another, and an EMF or voltage drives electrons onto one plate, then positive charges will move onto the other one (i.e. electrons flow out, causing a momentary flow of current – note that current is not actually flowing through the capacitor though). Figure 6 shows how the positive charges on one plate, and negative charges on the other, are attracted toward each other, but cannot cross the gap and neutralise each other. So when the energy source is removed, a stable state of oppositely charged plates is achieved and the energy is stored.

This can be released by providing a path for electrons to flow onto the positive plate and/or out of the negative plate, thus neutralising the charge on the plates. The amount of energy a capacitor can store is determined by the total amount of charge, 'Q', in coulombs which can be held on the plates at a given voltage 'V', and is defined by the equation:

$$C = Q/V$$

where 'A' is the area of each plate, 'd' is the distance between them, and '$\epsilon$' is a constant which depends on the nature of the material between the plates (the dielectric) and is called its permittivity. The explanation for this equation is that the larger the area of the plates the more charge can be stored on them given a fixed charge density (charge per unit area) for each plate, and the closer together the plates the greater the effect of the charges on each other across the gap. Similarly, the greater the permittivity of the dielectric, the more charge can be stored for a given plate area and separation.

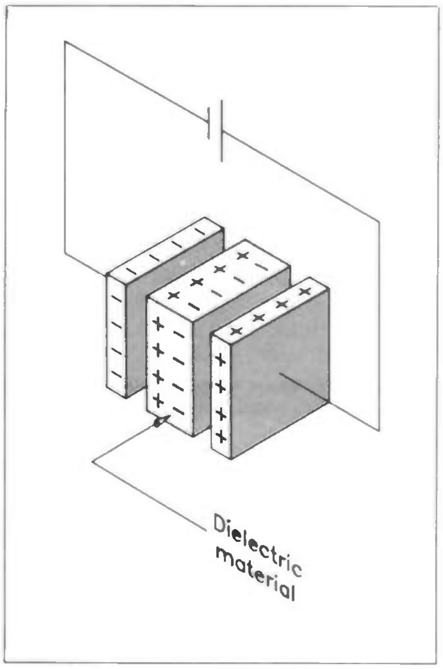


**Figure 7. Addition of a dielectric material between the plates increases the capacitance of the capacitor.**

The action of the dielectric is as follows. The dielectric is a material which is insulating, but which is capable of becoming polarised, that is to say the electrons of its molecules are not free to move through the material, but *can* move within each molecule so that in the presence of an electric field, for example between the plates of a charged capacitor, the electrons will move to one end of the molecule, thus giving it a positively charged end and a negatively charged end. Thus, the surface of the dielectric next to the positively charged plate becomes negatively charged, and the surface next to the negatively charged plate becomes positively charged. This has the effect of bringing the plates electrically closer together, and the action of the oppositely charged plates on each other is increased, so for a given voltage between the plates more charge can be held, and by the definition:

$$C = Q/V$$

the capacitance is increased, yet the whole dielectric is still an insulator, see Figure 7. Electrolytic capacitors employ this technique, and without it large value capacitors would be physically enormous.

This then is how capacitors work at a basic level, enabling a whole range of sophisticated possibilities at circuit level.

## Inductance and Inductors

The third fundamental process in electronics is inductance, and in some ways this is a similar process to capacitance. The effect of an inductor in a circuit is to store and release energy, according to the time constant L/R, but in an inductor this is achieved by means of a magnetic field, whereas in a capacitor it is achieved by an electric field. The explanation for the effect is again found in the movement of electrons. When a current (i.e. a flow of electrons) is moving through *any conductor* a magnetic field is produced around it. As with capacitance, this field may be a nuisance to other circuits and requires protective or controlling measures, or it may not. This is illustrated in Figure 8.

Just as the small capacitances of conductors can be increased by increasing the size of the conductors and the selection of materials and their configuration, likewise the small magnetic field around a conductor can be increased by looping the wire many times into the form of a coil, and by placing materials which might influence a magnetic field into the middle of the coil, as Figure 9.

The explanation for the energy storage capability of a coil is as follows. A wire coil having a steady current through it will have around it a stable magnetic field, just as a capacitor having a steady

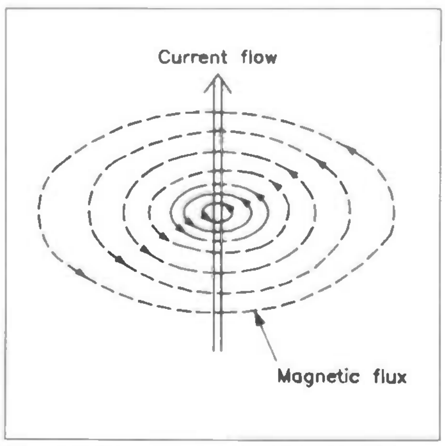


**Figure 8. A steady current through a wire produces a stable magnetic field around it, the flux density being greatest near the wire.**

voltage across it has a stable electric field between its plates. The electric field of a capacitor is stored by virtue of the effect of opposite charges across the plate; the magnetic field is stored around a coil by the following process.

It is a fundamental electromagnetic principle that an electric current will be induced in a conductor placed in a changing magnetic field, and that if there is a path for the electrons, that current will flow, and because a current is flowing, an EMF or voltage appears across the conductor. This is the principle of current generating machines like alternators and dynamos. And it also works in reverse.

If an externally supplied current through a coil is constant and unchanging, then the magnetic field around it will also be unchanging. But if the current changes, say for example it decreases, then the magnetic field also changes. The change in the magnetic field, in this case, causes a force to act on the electrons flowing through the coil, and the direction of this force is such as to try to force the electrons to continue in the *same direction* in which they were travelling to produce the magnetic field in the first place, in other words to try to *maintain* the stable magnetic field. So, if there is a path for the electron flow, the effect is to oppose the reduction of current flow; if the path has been broken for example by opening a switch in the circuit, then a large voltage will be induced across the coil as the coil tries in vain to force a current to flow to maintain the magnetic field, and this may in fact be large enough to cause an arc across the switch contacts. The equations associated with this process are:

$$B = (\mu \times I)/(2 \times \pi \times a)$$

where 'B' is the magnetic flux density around a wire, 'I' is the current through the

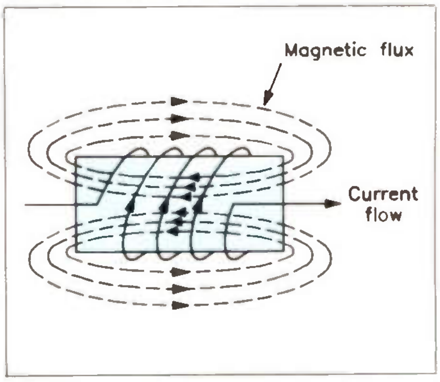


**Figure 9. The magnetic flux density around a wire can be increased by having the wire configured as a coil and using a magnetic core material.**

wire, and 'a' is the distance of the flux from the wire. '$\mu$' is a constant called the permeability of the material in which the field exists, and is analogous to the permittivity of the dielectric of a capacitor, in that by the use of iron materials as a core in a coil of wire the magnetic flux density can be increased for a given current flow and coil configuration. If these cores are non-ferrous, it can be reduced.

The inductance of a coil is given by:

$$L = (N \times \Phi)/I$$

where 'L' is the inductance of the coil, 'N' is the number of turns of the coil, and '$\Phi$' is the magnetic flux through the coil produced by that current.

So, this indicates that for a given current the inductance of a coil can be increased by either increasing the number of turns on the coil, or by increasing the magnetic flux through the coil which can be done by altering the physical configuration of the coils so that more of the magnetic flux is contained within the wires of the coil, or by using a core of higher permeability thus producing more magnetic flux.

This then, has been a look at the basics behind resistance, capacitance and inductance, three of the fundamental properties of materials which have been examined and exploited from the early experiments of Faraday and his contemporaries of the eighteenth century, to the complexities and sophistications of todays electronic systems, ranging from labour saving devices and home entertainments, to devices for the exploration of the universe.

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## MISS SAIGON COMPETITION WINNERS

In the June-July 1990 issue of 'Electronics – The Maplin Magazine' we set the 'Miss Saigon Competition'. Entrants had to correctly answer five questions about popular stage productions and artistes. All entries received before the closing date, 30th September 1990, were entered into the draw. Ten 'Miss Saigon Original Cast Albums' were available for the prize-winners. However only seven entrants correctly answered the questions (multiple entries were disqualified). All prize-winners have been advised by post. Maplin Electronics would like to thank the Cameron Mackintosh Productions for providing the prize-winners albums.

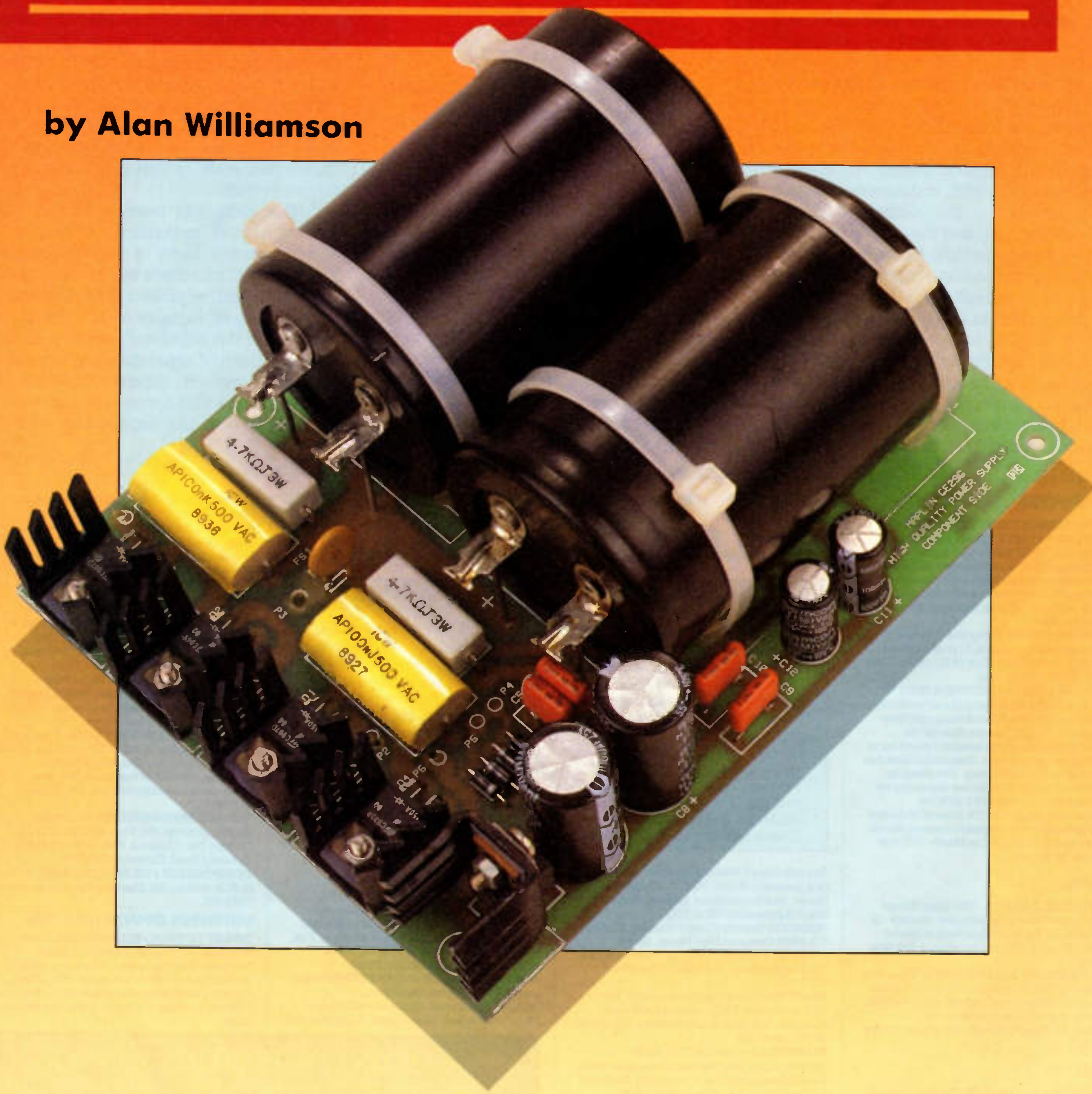
The correct answers are as follows: 1) Les Miserables; 2) All three; 3) Les Miserables; 4) The Man in Grey; 5) Sarah Brightman (at time of competition).

The seven lucky prize winners are:

**S Newman, Sussex; T Hearne, Sussex; I. Aitken, Herts; R Davies, Cambs; J Attle, Sussex; G Butler, Co Dublin; D Davey, Sussex.**

# HIGH QUALITY POWER SUPPLY

by Alan Williamson



## SPECIAL FEATURES

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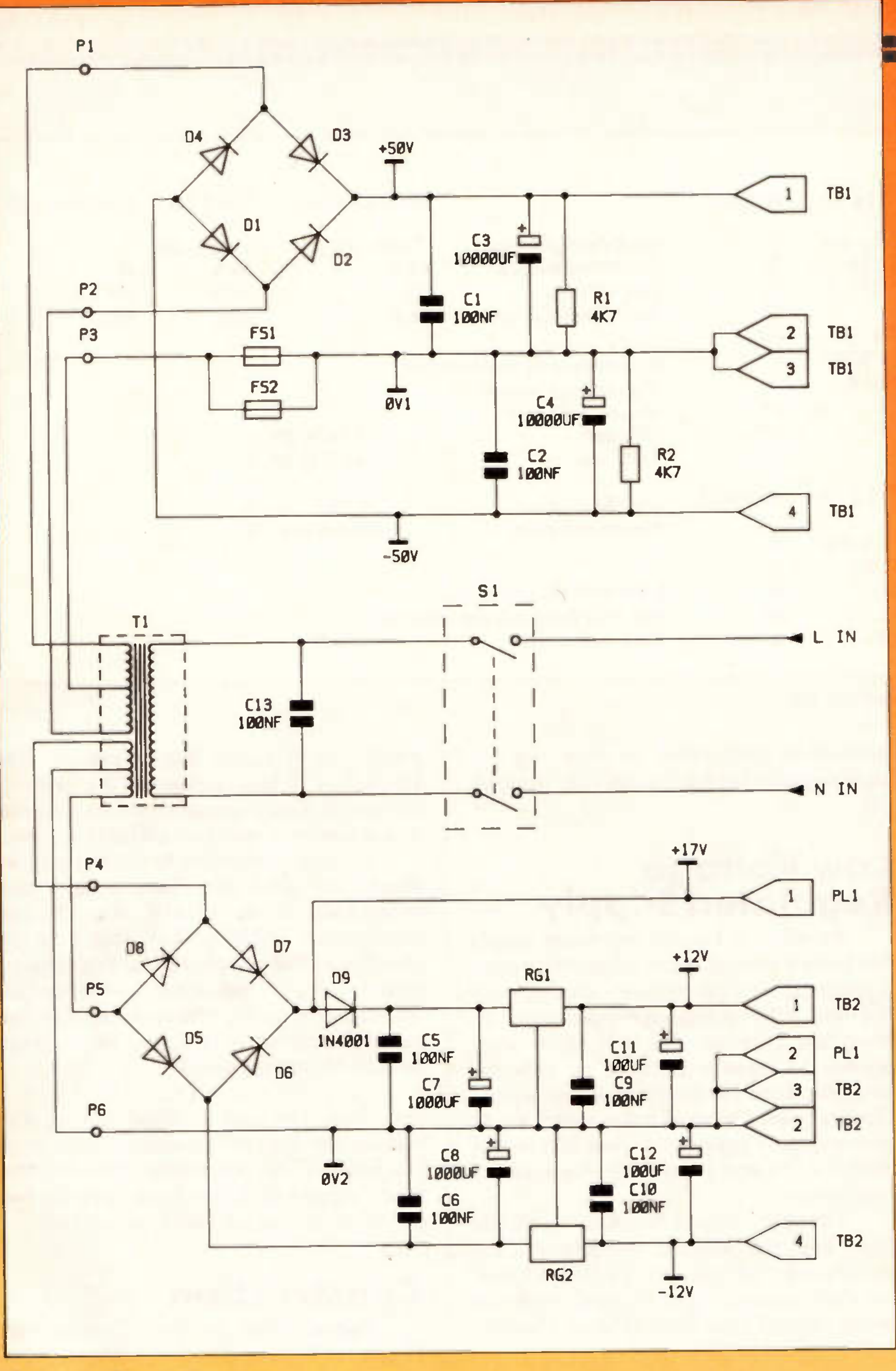



**Figure 1. Circuit diagram.**

| 10,000$\mu$F 63V Can | 100Hz | 400Hz | 1kHz | Symbol |
|---|---|---|---|---|
| Value | 10·47 | 10·48 1 | 4·59 | mF ($10^{-3}$ F) |
| Ripple Current | 9·8 | N/A 1 | 0·8 | A |
| Leakage Current | 18·9 | N/A | N/A | mA |
| Power Factor | 2·26 | 8·25 2 | 9·67 | D |
| Quality Factor | 0·44 | 0·12 | 0·03 | Q |
| Equivalent Series Resistance | 0·346 | 0·313 | 0·33 | Ω |
| Equivalent Parallel Resistance | 0·385 | 0·317 | 0·33 | Ω |

| 10,000$\mu$F 63V Audio Can | 100Hz | 400Hz | 1kHz | Symbol |
|---|---|---|---|---|
| Value | 9·7 | 10·65 1 | 5·18 | mF ($10^{-3}$ F) |
| Ripple Current | 13·2 | N/A 1 | 4·5 | A |
| Leakage Current | 6·3 | N/A | N/A | mA |
| Power Factor | 0·1 | 0·28 | 0·32 | D |
| Quality Factor | 9·7 | 3·48 | 0·75 | Q |
| Equivalent Series Resistance | 0·016 | 0·011 | 0·014 | Ω |
| Equivalent Parallel Resistance | 1·6 | 0·138 | 0·022 | Ω |

**Table 1. Capacitor specifications: audio versus can.**

## Foreword

This high quality power supply was especially designed in response to many requests from our customers for a PSU to partner the 150 watt MOSFET amplifier (YM27E).

## High Voltage Supply

The power supply can be used with any amplifier requiring a symmetrical ±50 volt supply.

So what makes this high quality supply different from any other power supply? Well, basically it's the choice of 'audio grade components'. For example an audio grade transformer, as used here, employs a better quality core, one with a higher iron content to achieve a lower external flux density, which means that the transformer is more efficient at converting the magnetic energy back into electrical power. In the case of the audio grade capacitor; let's list the differences between two capacitors of equal voltage and value, see Table 1. As you can see, 'audio grade' capacitors are a superior breed of animal with the lowering of ESR (equivalent series resistance) and use of high quality materials in construction will ensure a stable tonal balance over the audio bandwidth, second and third harmonic distortion will be at a minimum.

The rectifier diodes used are high efficiency fast recovery type. Fast recovery diodes turn off very quickly, preventing a reverse current flowing through the diode, this is caused by the capacitance across the diode's PN junction. The diodes also have a low forward voltage drop, 0·85V as opposed to 1·1V for a conventional rectifier diode, respectively dissipating a power of 0·85 watts per ampere for fast recovery diodes and 1·1 watts per amp for a conventional diode. So the name of the game here is efficiency; the more power we can get from the transformer with minimum loss, the more power we can deliver to the speaker.

As you can see from the circuit diagram shown in Figure 1, the power supply is in the usual configuration – in the order of transformer, bridge rectifier D1-D4, and smoothing capacitors C3 and C4. The extra capacitors C1 and C2 provide high frequency decoupling. Resistors R1 and R2 discharge the reservoir capacitors (C3 and C4) when the output supply lines are unterminated, or when the amplifier is turned off and is unable to discharge the last 10 volts or so, as large electrolytic capacitors like these can stay charged for months. An interesting point to note here is, in case you didn't know, that after discharging an unconnected electrolytic capacitor of this sort, if it is then left sitting for a few minutes, a voltage will appear across it. This is due to dielectric absorption in the electrolyte, sometimes called dielectric hysteresis.

You may have noticed in the circuit diagram of Figure 1 the two parallel devices between the transformer centre tap and the common earth point. These are

| | 7812 100mA | 7812 1A | Symbol |
|---|---|---|---|
| Output Voltage | 12 ± 4% | 12 ± 4% | V |
| Line Regulation | 0·25 | 0·085 | % |
| Load Regulation | 0·25 | 0·07 | % |
| Ripple Rejection | 51 | 71 | dB |
| Quiescent Current | 3 | 4·3 | mA |
| Input Voltage Range | 14·5/35 | 14·5/30 | V |
| Output Impedance | 0·2 | 0·018 | Ω |
| Output Noise | 80 | 75 | μV |
| Short Circuit Current | N/A | 350 | mA |

| | 7912 100mA | 7912 1A | Symbol |
|---|---|---|---|
| Output Voltage | −12±5% | − 12 ± 4% | V |
| Line Regulation | 1 | 0·085 | % |
| Load Regulation | 0·2 | 0·07 | % |
| Ripple Rejection | 55 | 60 | dB |
| Quiescent Current | 3 | 1·5 | mA |
| Input Voltage Range | −14·5/−35 | − 14·5/−30 | V |
| Output Impedance | N/A | N/A | Ω |
| Output Noise | 80 | 300 | μV |
| Short Circuit Current | N/A | 350 | mA |

**Prototype Specification**

High voltage Section

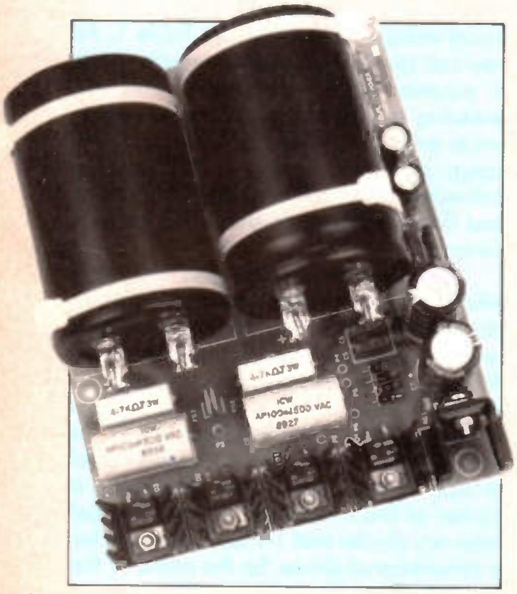
| | | |
|---|---|---|
| Maximum Output | | |
| Off Load: | ±53V/± 2V | V |
| Full Load: | ±46·7 @ 2A | V |
| Load Regulation | 11·887 | % |
| Maximum Ripple | 350mV rms | V |

**Low voltage Section**

See 78/79 regulator specification

Maximum current 160mA

**Table 2. Regulator specifications: 100mA versus 1A.**



**The completed PCB.**

not ordinary fuses but 'MultiFuses™', which act like a fuse but don't 'blow' like an ordinary fuse! The devices have a low resistance in the 'untripped' state of approximately 0·34Ω with a holding current of up to 0·9A. The 'trip' current is 1·35A, and in the tripped state they have a high resistance of >500Ω which still allows a small amount of current to flow keeping the device heated and therefore latched in this state. The idea of placing these devices in this position is to protect the amplifier *and* speaker from being over driven, and also against a large DC offset due to a failed component in the power supply or amplifier, which would cause a large current to flow along the 0 volt rail. Over-driving the amplifier into distortion will also cause large currents to flow along the 0 volt rail, and both these conditions will trip both the MultiFuses™ into the high impedance state, thereby limiting the total current flow from the speaker and amplifier 0 volt earth returns to less than 100mA! Being a thermal sensitive device the MultiFuse™ can be reset by being allowed to cool, either by removing the input signal or turning the amplifier (supply) off.

## Low Voltage Regulated Supply

An extra ±12 volt regulated supply has been included in this project to power a preamplifier. Fast recovery diodes were not used in the rectifier as efficiency isn't an important criterion. But, the same story applies to these capacitors as with the large capacitors in the main power supply. Quality counts, so small value switch mode power supply capacitors were chosen for their low ESR and excellent high frequency response.

Although only 160mA is available from the low voltage winding on the transformer, 1A regulators where chosen for their superior specification in almost every respect than their 100mA counterparts, see Table 2.

A +17 volt supply has been made available to power a speaker protection circuit, which will be published at a later date. Diode D9 is fitted in series with the positive (+V) supply line to prevent the 1000μF (C7) from powering this protection circuit during power down, to achieve a near instantaneous turn off for the circuit.

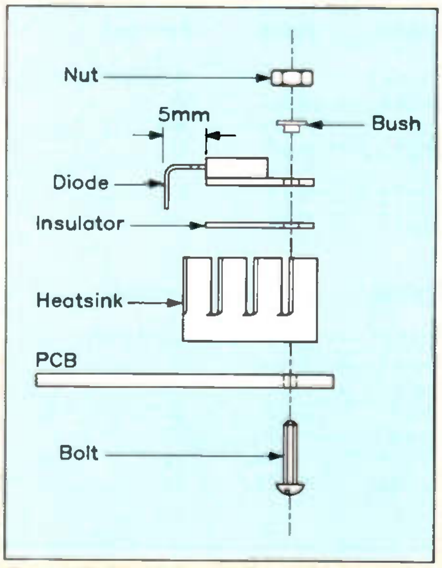



**Figure 2. Diode leg assembly.**

If you are intending to use this power supply for other amplifiers driving low impedance loads (2-4Ω) then larger transformers (625VA, 43V rms max. *) could be usefully employed for their higher output current and even lower output impedance than the one specified, but the penalty incurred is that you need deep pockets to pay for them!

* 43V rms = 60V DC.

Capacitor C13 is fitted across the transformer side of the mains switch, and this helps to suppress any noise on the mains supply, or spikes generated by the action of turning the switch on and off.

## Construction

Please refer to the Constructors' Guide for hints and tips on soldering and constructional techniques.

Start construction by cleaning the tarnish off all component leads with a piece of emery cloth. Even if the component looks clean, they will benefit from this when it comes to soldering.

Insert diodes D7-D9 being careful of the orientation as always, solder and then crop the excess leads, repeating this process for each component. Next fit the remaining components including the terminal connectors (alternatively you may prefer to solder the output leads direct to the PCB), except the electrolytic capacitors, regulators and diodes D1-D4.

The diodes require that their legs be bent through 90° approximately 5mm from the body, see Figure 2. After forming the leads, fit the diodes onto the PCB with an insulating pad, bush and heatsink using the M3 nuts and bolts provided. Align the heatsink and diode squarely against the edge of the PCB before tightening, once this has been done the diodes can then be soldered.

Bolt the two regulators together on

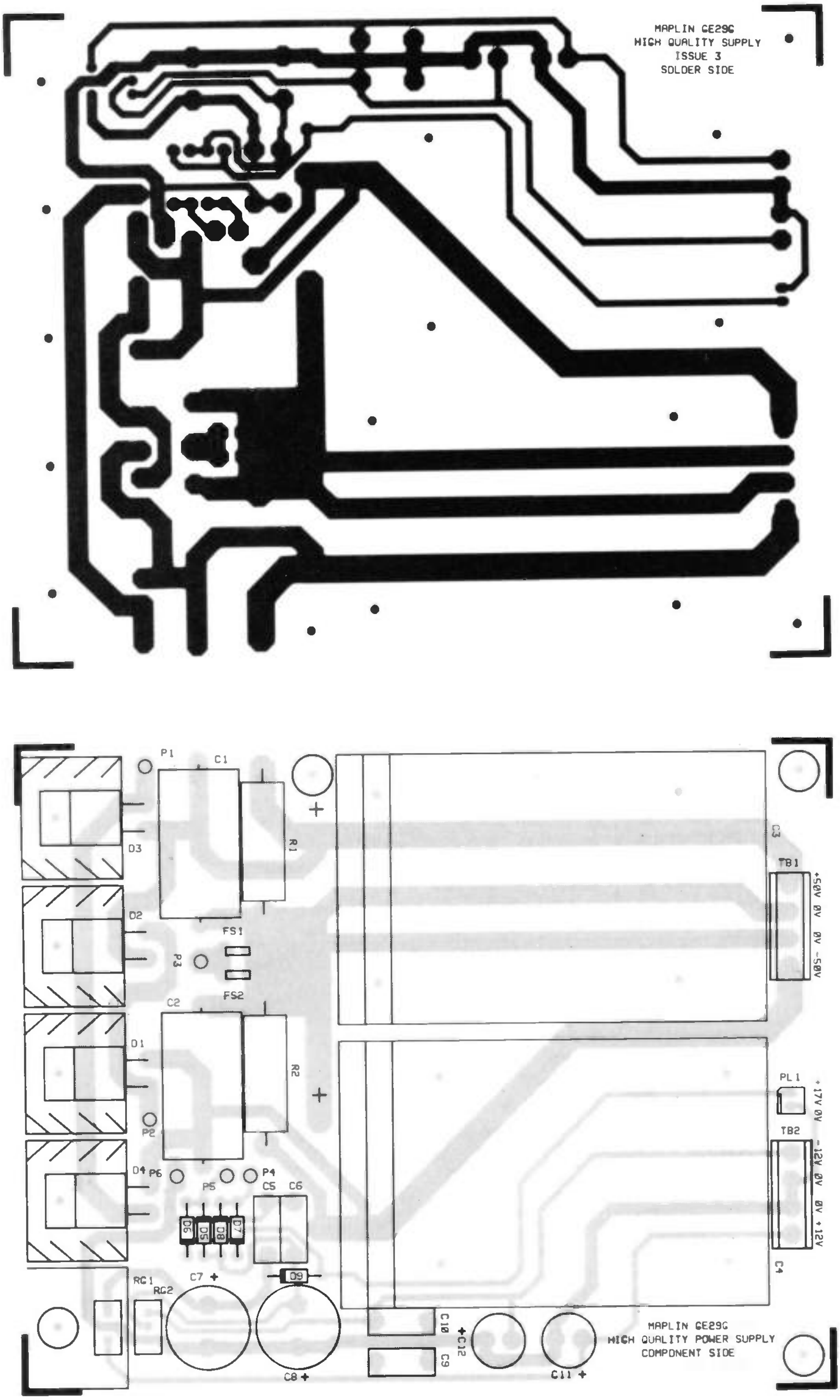



**Figure 4. Component legend.**

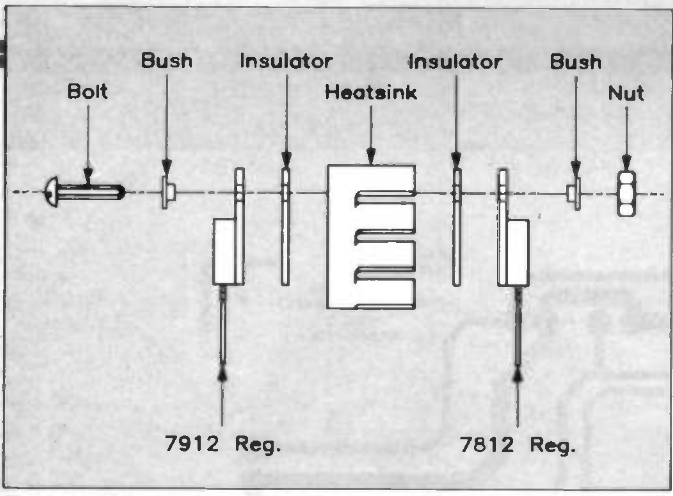
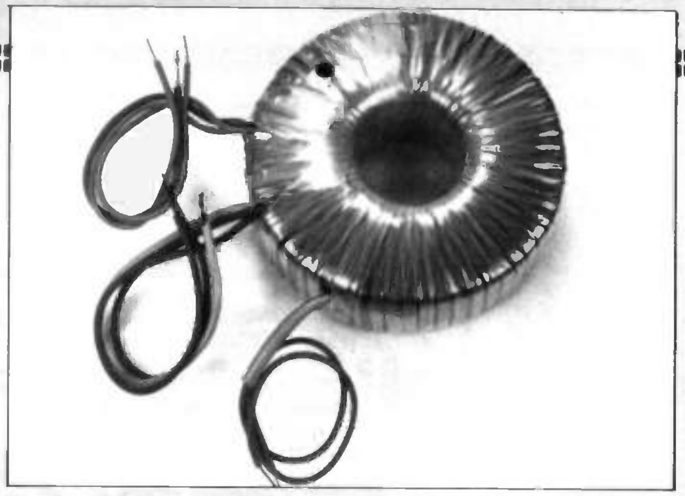



**Figure 3. Regulator assembly.**



**The transformer.**

the remaining heatsink with the insulators and bushes; note that the 7812 regulator is fitted to the inside of the heatsink like D1-D4, see Figure 3. Insert and solder as a complete assembly. Do not tighten the M3 screw and nut until installed and solder, to provide movement for adjustment.

Next are the small electrolytic capacitors, and a little care is needed with these. As they are polarised devices, there is a negative (−) stripe on the can; keep this stripe furthest away from the plus (+) symbol on the PCB – obvious I know, but double-check the capacitors to see that you have got the polarisation correct before soldering.

Last but not least is the large electrolytics. First insert the cable ties through the holes near the centre of the PCB from the component side, and back through the holes on the edge of the board, feed the tapered end of each cable tie into the ratchet mechanism at the other end to make a loop large enough for the capacitor. Insert the capacitors into the loops and align with the legend, and make sure that the solder tags are *over* their allocated holes in the board and that the *unpainted* tag is adjacent to the *positive* (+) symbol on the PCB. Double check to ensure correct polarity. Then you can secure the capacitors by pulling the cable ties tight and trim off the excess.

Cut the tinned copper wire into four equal lengths, then with a pair of pliers bend each wire 5mm from the end to a right-angle. Insert the wires through the capacitor tags and into the PCB. Solder the wires to the tags of the capacitors, and then the PCB. Finish by trimming off any excess wire, and give the PCB a thorough cleaning with thinners or PCB cleaner (YJ45Y). The power supply is now complete and ready for testing and should look as shown in Figure 4.

## Testing

Before attempting to power up the supply, *do* check the polarisation of each diode and capacitor, especially the large electrolytics, as an incorrectly inserted capacitor could explode, and we don't want dismembered readers everywhere! Don't forget to check the regulators, the 7912 (−12V) regulator is next to C7. If you have a multimeter, set it to the resistance/continuity range, and use to check the insulation between each diode and regulator tab to heatsink. No reading should be obtained, if you are getting a reading, replace the insulator and bush.

Attach only the low voltage windings of the transformer to the power supply board, and *use a safeblock* type of quick connector to connect the transformer to the mains. Power up the supply, and be very careful where you put your hands, *the mains can kill!* Check the output of each regulator using a multimeter with the range set to 20V, the outputs should read 12V ± 4% on the meter. If anything is amiss, re-check the diodes, capacitors and regulators.

Assuming everything is working so far, re-check the polarity of the large electrolytics once more before attaching the high voltage windings to the power supply, again the *unpainted* tag of the capacitor should be next to the plus (+) symbol on the board. Only after you are completely satisfied that the capacitors are correctly wired, can the transformer high voltage leads be attached, and power be applied to the circuit. Check the output of the high voltage rails using a multimeter set to the 200V range, you should get a reading of 53V (±2V). All that remains now is to fit the power supply into the amplifier case.

It is recommended that short lengths of 1·5mm$^2$ solid core cable are used to connect the power supply to the amplifier. Happy listening!

## HIGH QUALITY POWER SUPPLY PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS** | | | |
| R1,2 | 4k7 3W Wirewound | 2 | (W4K7) |
| **CAPACITORS** | | | |
| C1,2,13 | 100nF Polypropylene | 3 | (FA21X) |
| C3,4 | 10,000µF 63V Audio | 2 | (FA18U) |
| C5,6,9,10 | 100nF Polyester | 4 | (BX76H) |
| C7,8 | 1000µF 25V SMPS | 2 | (JL56L) |
| C11,12 | 100µF 50V SMPS | 2 | (JL49D) |
| **SEMICONDUCTORS** | | | |
| D1-4 | BYW80-150 | 4 | (UK63T) |
| D5-9 | 1N4001 | 5 | (QL73Q) |
| RG1 | µA7812UC 1A | 1 | (QL32K) |
| RG2 | µA7912UC 1A | 1 | (WQ93B) |
| **MISCELLANEOUS** | | | |
| FS1,2 | MFRO90 | 2 | (UL68Y) |
| TB1,2 | PC Terminal Block 4-Way | 2 | (RK73Q) |
| PL1 | Minicon Plug 2-Way | 1 | (RK65V) |
| T1 | Transformer | 1 | (YZ23A) |
| | Vaned Heatsink | 5 | (FL58N) |
| | Insulator TO220 | 6 | (QY45Y) |
| | Plastic Bush | 1 Pkt | (JR78K) |
| | Minicon Hsng 2-Way | 1 | (HB59P) |
| | Minicon Terminals | 1 Pkt | (YW25C) |
| | PC Board | 1 | (GE29G) |
| | Constructors' Guide | 1 | (XH79L) |
| | Tie Wrap 385 | 4 | (FE00A) |
| | TC Wire 1·25mm 18 swg | 1 Roll | (BL12N) |
| | Isobolt M3 x 12mm | 1 Pkt | (BF52G) |
| | Steel Nut M3 | 1 Pkt | (JD61R) |
| **OPTIONAL (not in kit)** | | | |
| S1 | 4A Rotary Mains Switch DPST | 1 | (FH57M) |
| | Fuse 20mm 2A A/S | 1 | (WR20W) |
| | Fuse Holder 20mm | 1 | (RX96E) |
| | Fuse Holder Insulating Boot | 1 | (FT35Q) |
| | M3 Insulated Spacer 10mm | 1 | (FS36P) |
| | Cable Min. Mains Black | 1 Mtr | (XR01B) |
| | Cable Three Core and Earth | 1 Mtr | (XR53H) |
| | SR Grommet 5R2 | 1 | (LR48C) |
| | Zip Cable | 1 Mtr | (XR39N) |

The above items, excluding Optional, are available as a kit:
**Order As LP15R (HQ PSU Kit) Price £74.95**

The following item is also available separately:
HQ PSU PCB **Order As GE29G Price £7.45**

Earlier this year saw Maplin's Manchester store introducing an Electronic Point of Sale (EPOS) system followed by Maplin shops at Birmingham, Brighton, Edgware and Nottingham. Within the next few months, EPOS systems will have been installed in the remaining Maplin shops, at which time, Maplin will have joined the ranks of the major supermarkets and DIY stores in joining the electronic revolution.

In fact this particular revolution got under way some 100 years ago when the first cash register arrived on the retail scene. At that time, the equipment was seen more as a method of controlling staff from dipping their fingers into the till rather than providing essential management information facts and figures. Now of course, the cash tills are seen as being more a method of keeping the supermarket lines moving, controlling stock and assisting staff.

EPOS equipment as we know it – the industry is already onto its second generation and close to the third generation – was introduced just ten years ago. According to consultancy PA, over 350,000 retailers are potential users accounting for up to 800,000 EPOS units.

Already PA says that there are 100,000+ terminals installed in the U.K. by 1993, the estimate is that nearly half a million units will be in operation. All parties agree that the installation of EPOS is doubling every year.

In fact it is the department stores which are already onto their second generation equipment, while supermarkets who were a little slow to get their EPOS act together are doing their best to catch up fast. At the same time they are introducing fully comprehensive bar coding linked systems as are the ever-expanding number of DIY stores.

Even the Post Office, seldom regarded as an instigator of high-tech, are midway through a trial involving a £100m nation-wide computerisation of its counter operations. A highly sophisticated £17m EPOS pilot based in the Thames Valley is linking over 120 post offices to such departments as the Girobank, Driver and Vehicle Licensing Centre and National Savings. Ever cautious where the Queen's Mail and related business is concerned, the Post Office are linking their system to IBM, ICL and Tandem centres.

Maplin will certainly find itself in good EPOS company. Sir Terence Conran who controls the Storehouse Group which includes Heals, Habitat and BHS, sees EPOS as being a golden triangle. This will link goods in shops with buyers in head offices who will know what is selling, and will therefore be able to pass the information direct to the manufacturers. In turn, the supplier will be able to provide more of what is selling or less of what is not moving so fast. Tesco meanwhile, expects to have all its major supermarkets on an EPOS network by mid summer, each linked to bar code scanners and local look-up price facilities. Nixdorf controllers will act as links between the terminals and Tesco's IBM mainframes.

## The Maplin Connection

When Maplin's Mark Dove started his investigation of EPOS systems, he soon discovered that there was a very wide variety of equipment and supplies in the market-place. In fact there are over 50 suppliers whose ranks include such well known names as ICL, IBM, Hugin/Sweda, NCR, Nixdorf and Thorn EMI as well as several specialist companies.

Having braved the world of exhibitions and seminars, Mark decided to concentrate on a system suitable for a trade counter application which would be based in each branch and would be capable of handling retail, professional and cash and carry sales. This capability would give maximum flexibility for the store operators and managers and of course head office. In the event, the Maplin contract was awarded to P.O.S., a Halifax-based specialist EPOS supplier. With the agreed objective of getting the system up and running by June this year, all parties had their work cut out to achieve the deadline.

**by Alan Simpson**

# ELECTRONIC POINT OF SALE – HIGH-TECH IN THE HIGH STREET

## Why P.O.S?

There are many computer companies capable of providing retail systems from small specialists to large multinational companies. Maplin wanted a supplier with a track record and the ability to identify closely with the software requirement. P.O.S. who have branches in Scotland and the North and South of England were ideally situated to meet the Maplin shop expansion plans. As P.O.S. director Glyn Stirzaker said; "We had to develop a special software base to cope with the special requirements of Maplin. These included the requirement for a retail point-of-sale system to run alongside a trade counter together with quantity price breaks and the need for a sophisticated enquiry and stock control."

For Maplin, the benefits are clear. The EPOS system will improve stock control in shops; improve all areas of shop administration; provide detailed sales information for head office and provide a secure management reporting function. With many of Maplin packaging products already incorporating a bar code symbol, the introduction of a scanner to the system could be a logical development in the future.

## The Bar Facts

Regular readers of 'Electronics – The Maplin Magazine' will be no strangers to bar coding technologies. In fact an article in a previous issue took a technical look at bar coding, pointing out the fact that even our magazine has a bar code on its cover. But in any case, avoiding a close encounter with EPOS and bar coding systems has become a difficult matter. Not only are they standard fittings at your local supermarket, but bar coding even has a role in blood banks, and ski resorts – though one is assured that there is no deliberate connection.

Bar coding is increasingly seen as being the central ingredient of an electronic point of sales system. Typically the supermarkets, department stores and hotels are linking together cash terminals into a central computer, either based on site or at a remote head office. The EPOS terminal which acts as a database or memory bank, holds details of price and product identification as well as details of transactions and stock levels whether goods, products or services.

As Michael Bernstein of management consultancy Sterlings of North London explains: a bar code is a series of proportional bars and spaces arranged in such a way as to encode data in a machine readable form. A wide range of material can accommodate bar coding formats, including paper, plastic and metal foil. There are two main types of bar code readers: hand-held such as pen-shaped contact wands, and hands-free, fixed beam scanners where items are passed across the beam.

## Focus on Fund Transfer

According to industry authority Nick French of consultancy PA, Electronic Fund Transfer Point Of Sale (EFTPOS) systems can best be described as being an electronic method of transferring funds. The overall objective is to eliminate the paper chase where millions of bit of paper – including those issued by the U.K.'s 90m credit cards holders – move from the retail store to the local bank and onward to the card settlement centres.

EFTPOS says PA's Nick,is a method of adding value to any EPOS transaction. If information on a card is received and the transaction captured electronically, then the system in use is EFTPOS irrespective of whether the system transmission is operating in real-time or off-line mode.

Not that all EFTPOS progress has been smooth. Plans to have a nation-wide EFTPOS U.K. service, the pilot of which was set up some three years ago by an associate company of the high street banks, has now had its electronic plug pulled. The £50m cashless shopping scheme was taking too long in its development stage to satisfy many of its members who one by one withdrew their support – and more importantly – their money.

## Switching Track

According to PA, EFTPOS was overtaken by events such as the major retailers preferring the direct debit card such as Switch. Unlike the standard credit card transactions which are either collected by the retailer and submitted to a local bank or as is increasingly the practice, especially in the garage trade, transmitting details direct to the credit card company. Very probably, before you have had time to sign the credit card voucher, the item will have reached your bank account. Such is the speed off electronic accounting.

For many end users, the benefit of EFTPOS seems distinctly one-sided. But the banks appear to recognise that the instant debiting of customers' accounts is a major change from normal practice. As a result, many banks operate a delayed debiting system, equivalent to the normal cheque clearing period. But as PA warns, do take care. Even if the financial institution does not debit your account immediately, the item is noted or marked on your account.

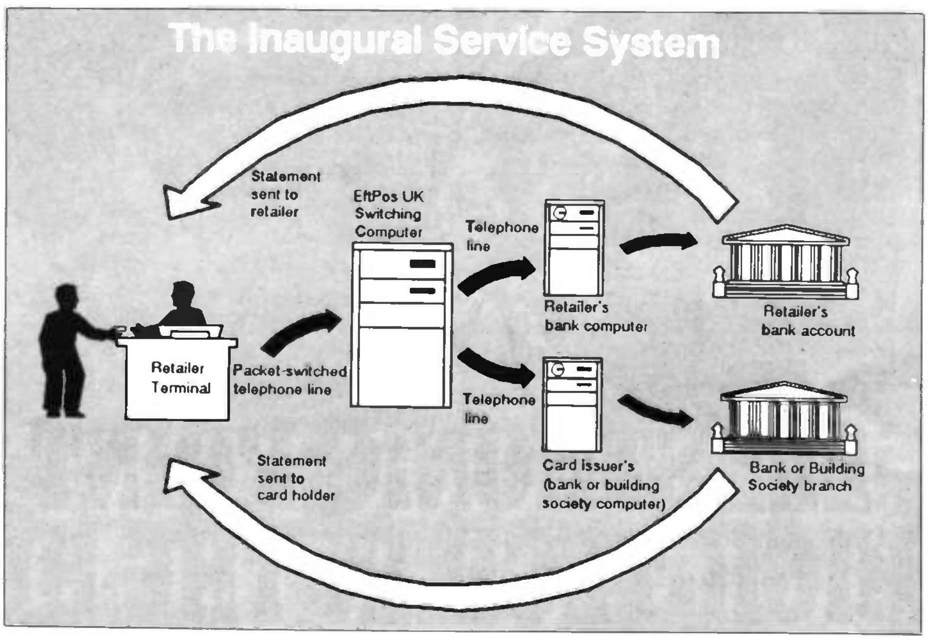
As Michael Bernstein of Sterlings states, EPOS systems were first introduced some twenty years ago as a stand-alone unit at the time when the first electronic card register entered the market. Since that time, the unit itself together with the cost of the related terminal and supporting processor have come tumbling down, making EPOS a highly cost-effective system for retail outlets of all sizes and activities.

EPOS, as users soon discover, provide an enormous range of facts and figures. Such as which products are selling best; at what time of day; at what store and what is the related profit factor. But the central feature must be that of providing a stock control application. This allows close monitoring of stock levels and the elimination of over or under stocking.

EPOS systems are now mostly fully integrated with up to 30 terminals being linked by standard twisted pair cable into a PC controller. This in turn connects by means of an Ethernet network into a local computer. Normally the EPOS systems make use of a dial-up public switched phone network to exchange data between the stores and HO at least once a day. The link can go two-way with the store sending sales data and receiving in return, details of special price offers or changes.

But as is the case with many areas of information technology, the bar coding and EPOS industry is not short of developments. For those light sensitive areas, scanners which make use of infra-red light or even a radio frequency identification transmission signal to speed authentication of credit card transactions are becoming available. At the same time, the technologies can be expected to have a major role in Electronic Data Interchange (EDI) procedures. Come 1992, the European Community will be imposing the use of EDI – a method of transacting paperless trading and recording – for customs and excise operations. Meanwhile, bar coding is expected to have an even more important role in recording and transmitting data.

Maplin's EPOS system it seems will be here to stay.



**TVFX** *Continued from page 15*

## TVFX PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless specified)

| | | | |
|---|---|---|---|
| R1,35 | 4k7 | 2 | (M4K7) |
| R2,26,30,34 | 1k | 4 | (M1K) |
| R3,4,21,24,36 | 470Ω | 5 | (M470R) |
| R5,6,11,20 | 1M | 4 | (M1M) |
| R7,17,38,39,41-43 | 100k | 7 | (M100K) |
| R8,9 | 47k | 2 | (M47K) |
| R10,15 | 27k | 2 | (M27K) |
| R12,13,37,40 | 10k | 4 | (M10K) |
| R14,23 | 6k8 | 2 | (M6K8) |
| R16 | 8k2 | 1 | (M8K2) |
| R18 | 270k | 1 | (M270K) |
| R19 | 470k | 1 | (M470K) |
| R22 | 100Ω | 1 | (M100R) |
| R25 | 680Ω | 1 | (M680R) |
| R27 | 10M | 1 | (M10M) |
| R28 | 430Ω | 1 | (M430R) |
| R29 | 510Ω | 1 | (M510R) |
| R31 | 910Ω | 1 | (M910R) |
| R32 | 36k | 1 | (M36K) |
| R33 | 3M3 | 1 | (M3M3) |
| R44 | 1Ω | 1 | (M1R) |
| RV1 | 220k Pot Lin | 1 | (FW06G) |
| RV2 | 100k Pot Lin | 1 | (FW05F) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1,3 | 470μF 16V PC Elect | 2 | (FF15R) |
| C2,4,6,11,16,20, 24,30-35 | 100nF Minidisc | 13 | (YR75S) |
| C19 | 220μF 16V PC Elect | 1 | (FF13P) |
| C5 | 100μF 16V Minelect | 1 | (RA55K) |
| C7 | 10μF 16V Minelect | 1 | (YY34M) |
| C8 | 1μF 63V Minelect | 1 | (YY31J) |
| C9 | 47μF 16V Minelect | 1 | (YY37S) |
| C10,28 | 39pF Ceramic | 2 | (WX51F) |
| C12,15,18 | 100nF Polylayer | 3 | (WW41U) |
| C13 | 470nF Polylayer | 1 | (WW49D) |
| C14 | 47nF Polylayer | 1 | (WW37S) |
| C17 | 220nF Polylayer | 1 | (WW45Y) |
| C21,23 | 10nF Ceramic | 2 | (WX77J) |
| C22 | 82pF Ceramic | 1 | (WX55K) |
| C25,26 | 5p6F Ceramic | 2 | (WX41U) |
| C27,36 | 330pF Ceramic | 2 | (WX62S) |
| C29 | 47pF Ceramic | 1 | (WX52G) |
| VC1,2 | 22pF Trimmer | 2 | (WL70M) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| D1 | 1N4001 | 1 | (QL73Q) |
| D2-16 | 1N4148 | 15 | (QL80B) |
| LD1 | LED Yellow | 1 | (WL30H) |
| LD2 | LED Orange | 1 | (WL29G) |
| LD3,6 | LED Red | 2 | (WL27E) |
| LD4,5 | LED Green | 2 | (WL28F) |
| RG1 | μA78L05 | 1 | (QL26D) |
| TR1 | BC179 | 1 | (QB54J) |
| TR2 | BF244A | 1 | (QF16S) |
| IC1 | TLC555CP | 1 | (RA76H) |
| IC2 | 1458 | 1 | (QH46A) |
| IC3 | 74HC132 | 1 | (UB29G) |
| IC4 | TEA2000 | 1 | (UH66W) |
| IC5 | SAA1043 | 1 | (UK85G) |
| IC6 | 74HC241 | 1 | (UB59P) |
| IC7 | 4024BE | 1 | (QX13P) |
| IC8 | 4077BE | 1 | (QW47B) |
| IC9 | 74HC75 | 1 | (UB20W) |
| IC10 | 4040BE | 1 | (QW27E) |
| IC11 | 40103BE | 1 | (QW61R) |
| IC12 | 4017BE | 1 | (QX09K) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| SK1 | PCB 2·5mm DC Pwr Skt | 1 | (FK06G) |
| SK2-6 | PCB Phono Skt | 5 | (HF99H) |
| PL1,2 | Minicon Latch Plug 3Way | 2 | (BX96E) |
| PL3 | Minicon Latch Plug 12Way | 2 | (YW14Q) |
| S1-4 | Latchswitch 2-Pole | 4 | (FH67X) |
| L1 | 15μH Adjustable coil | 1 | (UH86T) |
| L2 | DL270 Delay line | 1 | (UH84F) |
| MD1 | UHF Modulator UM1233 | 1 | (FT30H) |
| FS1 | 250mA Fuse | 1 | (WR01B) |
| XT1 | 8·867238MHz Crystal | 1 | (UH85G) |
| XT2 | 5MHz Crystal | 1 | (UL51F) |
| | Fuse clip | 2 | (WH49D) |
| | TVFX Main PCB | 1 | (GE00A) |
| | TVFX LED PCB | 1 | (GE01B) |
| | Knob KB4 | 2 | (RW87U) |
| | Small Lch But Knob Black | 4 | (BW13P) |
| | DIL Socket 8 Pin | 2 | (BL17T) |
| | DIL Socket 14 Pin | 3 | (BL18U) |
| | DIL Socket 16 Pin | 4 | (BL19V) |
| | DIL Socket 18 Pin | 1 | (HQ76H) |
| | DIL Socket 20 Pin | 1 | (HQ77H) |
| | DIL Socket 28 Pin | 1 | (BL21X) |
| | Minicon Terminal | 3 Pkts | (YW25C) |
| | Minicon Lch Housing 3 way | 2 | (BX97F) |
| | Minicon Lch Housing 12 way | 2 | (YW24B) |
| | Lapped Pair | 1 Mtr | (XR20W) |
| | Ribbon Cable 20 Way | 1 Mtr | (XR07H) |
| | Constructors' Guide | 1 | (XH79L) |

OPTIONAL

| | | |
|---|---|---|
| Case 3502 | 1 | (YN33L) |
| Self-Tapping screw no. 4x¼" | 1 Pkt | (FE68Y) |
| TVFX Front Panel | 1 | (JR68Y) |
| TVFX Back Panel | 1 | (JR69A) |
| AC Adaptor Regulated | 1 | (YB23A) |
| Phono/Coaxplg Vid Lead | 1 | (FV90X) |

The above items, excluding Optional, are available as a kit:
**Order As LP00A (TVFX Kit) Price £54.95**

The following items are also available separately but are not shown in our 1991 catalogue:
TVFX PCB **Order As GE00A Price £13.45**
TVFX LED PCB **Order As GE01B Price £2.45**
TVFX Front Panel **Order As JR68Y Price £2.95**
TVFX Back Panel **Order As JR69A Price £2.45**

# OH–NOT SUCH A LOVELY WAR

For our intrepid Out and About reporter, the earth literally moved when he stepped back in time to the 'Blitz Experience' at London's Imperial War Museum.

The Imperial War Museum is an unusual place in many ways – a museum devoted to modern war housed in an ancient asylum, it appears full of contradictions with collections ranging from tanks and guns to works of art and films. The museum, which won the coveted Museum of the Year Award in 1990, also houses a wide collection of high technology.

According to Allan Morrow, the museum's Audio/Visual officer, it has one of the most complex technical installations in any British museum. While it may appear somewhat simplistic on the surface, a sophisticated range of electronics supports the exhibits. Allan, who happens to be a keen 'Electronics' reader, says it was fortunate that we were able to lay all the underfloor and riser cabling whilst the Museum was being rebuilt. The 100 or so cable runs, connecting various points in the museum to the control room, connect up to individually screened pairs of computer cable. A serial RS 422 based system, the fully patched design is not only highly resilient but is interference screened for data transmission. Also inserted are some 16 fibre optic lines, ready to meet the emerging requirements of the museum. Each of the 100 cable groups also has a double-screened video cable, a twin individually screened twisted pair of two channel audio and a 15 way multicore for switching/status indication.

Central to most operations is Tapeless Audio (ESTA) supplied by Electrosonic. This is a 8-track digital device with audio stored on EPROMs. The Blitz Experience uses 8 minutes of 8-track audio (the largest current such ESTA installation) and separate systems are used elsewhere for hand-sets and loudspeaker sound replay. The big advantage, says Allan, is that no moving parts are involved. The high sound quality remains unaltered after any number of playings. An added bonus is that the unit instantly returns to the start position when the handset is replaced.

In addition to the more standard A/V items, there are a few interactive units, located at various points around the museum available to visitors. Users can dictate the path they want to follow by means of the touch screens. At all points, a large screen displays the picture in order that other spectators can see what is going on.

Each unit consists of a computer and laser vision player which generate the signal in the control room. Here a fault detection system ensures that the AV programs are kept up and running. Operations apart, Allan is also involved in in-house graphics, based on Commodore Amiga computers, the main one having a 28MHz processor accelerator and 8-megabytes of 32-bit RAM.

## A Moving Experience

Without doubt, the highlights of the exhibition are the simulated London Blitz and Trench Warfare experiences. With help from electronics and much innovative thought, the museum staff have recreated the intensity and drama of these experiences which, in the case of the Blitz, Londoners went through half a century ago.

Air raid sirens heralded the onslaught of the blitz, and here the experience can be relived in South London. The set was created by the specialist theatrical company, Kimpton Walker – the company responsible for the Museum of the Moving

# OUT AND ABOUT

by Alan Simpson

▲ 'Going over the top.'
◀ Just some of the extensive displays.
▼ Recapturing the 'Blitz' experience.

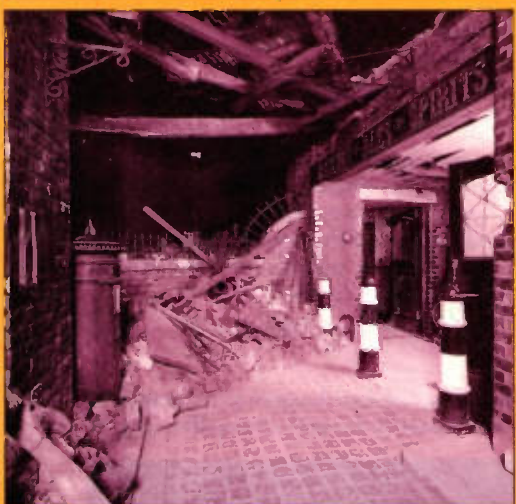


Image on the South Bank and the Channel Tunnel exhibition in Dover.

The temperature is that of a cold autumn morning; water gushes from shattered pipes and gutters, dogs bark; the dome of St Pauls burns and even the earth moves from yet another near miss (the york stone floor sits on a steel frame carried on motorised rollers). The Blitz Experience, which lasts about eight minutes, processes small groups of visitors starting in the air raid shelter. On the sound track, the terrifying atmosphere of a bombed city is built up, threaded through with sighing, broken sentences, shouted orders, cries of fear and reassurances for the victims.

At every turn Kimpton Walker harnessed technology to provide the shock realism. The movement of torches among the wreckage, the flare of incendiary bombs, the acrid smells of burning wood mixed with the damp and corrosion, and graphic simulation of the smoke of explosives are all featured.

As the set designers point out, the space available was not lavish. In fact the entire three dimensional set, which includes a public air raid shelter, a street with pub, grocer's shop, Victorian semi and Georgian town house as well as perspectives of a city aflame plus much more, is concentrated into an area of as little as 15·5 × 7 metres.

Meanwhile, for the Trench Experience, the contractors made use of fibre optics fed from tungsten halogen sources to provide the candle and oil lamp effect, and similarly from metal halide sources to provide the cool natural lighting. These were supplemented by low voltage tungsten halogen lighting, with glass colour filtering, for general lighting, with all the lighting being programmed into the central system for the experience.

## A Sound Matter

Meanwhile, the Imperial War Museum's department of Sound Records have amassed over 14,000 hours of historical records, mainly personal interviews. These cover the minutiae of life – details which may not otherwise be preserved, but which are of great importance to the museum in presenting an understanding of the impact of war. Contemporary sound effects have also been compiled in order to recreate the atmosphere of a period.

All of this material is being catalogued and indexed in a computerised system so that information from different sources can be identified. "This last year," says department researcher Rory O'Connell, "we have been inundated with requests for sound effects for events connected with the 50th anniversary of the Second World War."

Currently the department is concentrating on gathering personal interviews on First World War recollections as witnesses are fast disappearing, and even radio programmes are being stored. All the taped information is being fed into a database held on Apricot computers, with master copies of all tapes and disks being stored off site for security.

To emphasise the fact that more than one hundred million people have died this century as a result of war, an electronic clock was set in motion last June marking up 5 units on every rotation. On the 31st December 1999, the clock will have reached that 100m mark.

The Imperial War Museum is in Lambeth Road, London SE1 and is open daily from 10am to 6pm; adults £3, concessions £1.50. Admission to the Blitz Experience is an additional £1, concessions 50p. For further information, phone 071-416 5000.

The museum have kindly made complimentary tickets available to 'Electronics' readers. To win the tickets, all you have to do is to send in the answers to the four questions listed below. First all-correct answers pulled out of the editor's woolly hat – well it is getting colder – will win. Post entries to:

The Imperial War Museum Contest, The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex, SS6 8LR. Or fax your entries to (0702) 553935, but don't forget to mark your fax 'THE IMPERIAL WAR MUSEUM CONTEST', include your name and address. Entries by January 15th 1991 please.

## COMPETITION

Name the odd one out:
- (a) Messerschmitt
- (b) Hurricane
- (c) Spitfire

Is 'MATILDA' the name of:
- (a) An anti-aircraft gun
- (b) A Second World War tank
- (c) The name of the German Afrika Korps' pin-up

Is the Sopworth Camel:
- (a) A First World War aircraft
- (b) A secret desert warfare plot
- (c) A brand of U.S. cigarettes

'ENIGMA' played a major role in the Second World War. Was it:
- (a) The name given to members of the Dutch underground
- (b) A POW escape boot, fitted with compass and map
- (c) An encyphering machine

# ATTENUATORS THEORY & DESIGN

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

## Introduction

A circuit that consists entirely of resistors may not sound very exciting, but there are nonetheless such circuits that have very real uses. One circuit that falls into this category is the 'attenuator'. As the name implies, its function is to attenuate or reduce the magnitude of a signal. This allows control to be exercised over the magnitude in a way that may be determined either subjectively or objectively, the latter usually in a very precise manner.

Consider the subjective aspect first. Everyone is used to adjusting the sound level, or volume as we usually call it, of a radio, hi-fi amplifier or television set. We know the control that does this as the volume control and it is, in fact, a rudimentary form of attenuator. As can be seen in Figure 1, it often takes the form of a potentiometer, which may be a rotary or slide type. The full signal is applied across the ends of the track, and a proportion of it appears between the wiper and the 'bottom' end of the track. The proportion of signal obtained depends upon the wiper position. Thus the signal output from the wiper can take any value between zero (wiper at 'bottom' or earthed end of track) and maximum (wiper at top of track).

What the potentiometer volume control represents is a continuously variable attenuator. It is set to the required position by ear (the subjective element referred to), though it could be calibrated in values of sound level if required. However, that is not as simple as it may sound, since there are a number of complicating factors. As we shall see shortly, there is a particular method of calibration that we can use. But before we discuss that we need to consider another important aspect of attenuators in general, namely the terminal impedance.

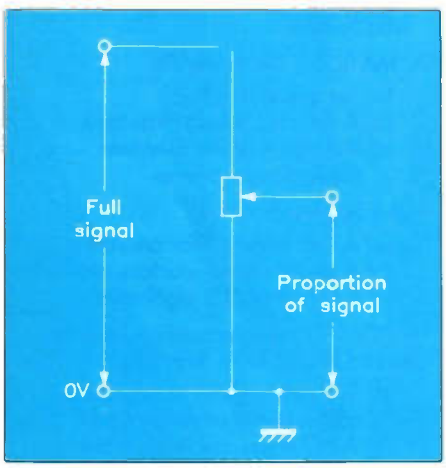



**Figure 1. A simple, continuously variable attenuator – the volume control.**

Figure 2 repeats the previous figure but now includes a reference to that value of impedance (in practice just a resistance) that appears between the wiper and the zero volt (ground) line. It should be evident that this depends upon the wiper's position on the track. When the wiper is at the bottom of the track, the impedance between the wiper and ground is clearly zero, while if it is at the top of the track, this impedance will be equal to the total track resistance of the potentiometer. In the specified case of a 10kΩ (10 kilohm) potentiometer, the output impedance will vary between the limits of zero ohms and 10k.

## Why Does This Matter?

In the case of a simple volume control, it probably won't matter at all. There are, however, other examples where the change of impedance with change of wiper position is quite unacceptable. For example, in the case of laboratory measurements on amplifiers, receivers, etc., the validity of the results would be affected most significantly by such behaviour. What is needed in such cases is a means of controlling attenuation while maintaining constant impedance across the terminals of the attenuator. In practice this will involve ensuring that this impedance is constant not only across the output terminals of the device, but across the input terminals too.

Before going on to the design of such circuits, it is worth having a brief look at another simple form of attenuator, one which offers a fixed degree of attenuation. This is shown in Figure 3 and is seen to consist of two resistors only, R1 and R2, in the form of an 'inverted L'. Probably most readers will identify this circuit immediately as the well known 'potential divider'. The output voltage, $V_2$, is related to the input voltage, $V_1$, and the resistor values by the relation:

$$V_2 = V_1.[R2/(R1 + R2)]$$

As we would expect, the degree of attenuation is determined by the relative values of the two resistors, R1 and R2. We could rearrange this equation so that the left-hand side is actually the ratio of the two voltages, as follows:

$$V_2/V_1 = [R2/(R1 + R2)]$$

Remembering that the gain of an amplifier is expressed by the ratio of amplifier output

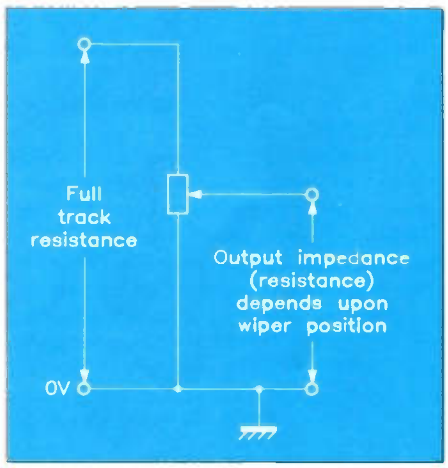



**Figure 2. The output impedance of a volume control varies with wiper position.**

over amplifier input, the above expression obviously does the same for the loss of the attenuator. That is, the loss of an attenuator also equals output/input. The difference is that, in the case of an amplifier, this ratio is usually greater than unity while, in the case of the attenuator, it is always less than unity.

To take two specific examples to illustrate this:

Example 1. An amplifier produces an output voltage of 1·0V rms when the input voltage is 0·1V (100mV) rms. The gain of the amplifier, expressed as a numerical ratio is:

Output voltage/input voltage = 1·0/0·1,
= 10

Example 2. Two resistors are arranged as in Figure 3 and have their values proportioned in such a way that an input voltage of 1·0V rms results in an output voltage of 0·1V rms. The loss of the attenuator, also expressed as a numerical ratio, is:

Output voltage/input voltage = 0·1/1·0,
= 0·1

Comparing the two figures obtained, it is evident that the reciprocal of the gain is the loss: 1/10 = 0·1.

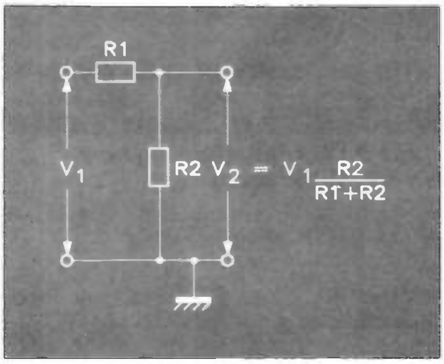



**Figure 3. A simple fixed value attenuator.**

## Gains and Losses in Decibels (dB)

As the two examples above have shown, it is possible to express either gain or loss as a numerical ratio. But this method has its limitations and so in practice it is quite usual to use a logarithmic ratio known as the 'decibel (dB)' instead. This is especially useful where the numerical ratios (of amplifiers) would be extremely large (high gain), or when the numerical ratios (of attenuators) is extremely small (high loss). This leads to the other advantage of the decibel, which is that its logarithmic nature also allows the total loss or gain of a series of connected units to be obtained, by a simple addition of the decibel values for each unit in the system. Figure 4 illustrates this idea.

The decibel often confuses newcomers, a situation that we shall try to avoid on this occasion! The unit is essentially defined in terms of the ratio of two 'powers'; call them P1 and P2. The formula for their ratio in dB is:

Ratio in dB = 10.log(P2/P1) [or the ratio P1/P2 can be used]

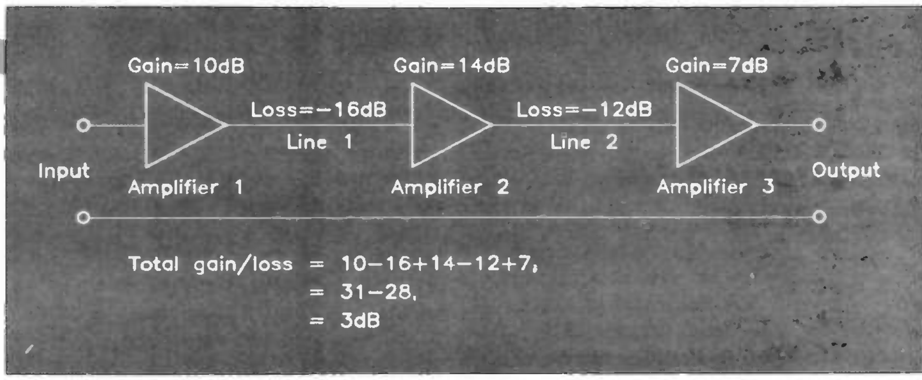



**Figure 4. Gains and losses in a series system. Use of the decibel simplifies the overall calculation.**

Since it is usually much more convenient to deal with the ratio of two voltages (a lot easier to measure for a start) than that of two powers, the above formula is extended to embrace voltages by what appears to be a simple modification of this formula, as follows:

Ratio in dB = 20.log(V2/V1) [or V1/V2]

All that appears to have changed is that 10 has become 20! What this simple substitution of one expression for another (without any intermediate explanation) masks is that the latter expression is only strictly true if the two voltages, $V^1$ and $V^2$, are measured across impedances of *equal value.* Putting in the missing steps shows why this is so. Repeating the expression for dB as the ratio of two powers:

Ratio in dB = 10.log (P2/P1)

Power may be expressed in terms of voltage and resistance, as in:

Power P = $(\text{Voltage V})^2$/Resistance R
i.e. P = $V^2/R$

If we associate a voltage V1 and a resistance R1 with the power P1, and a voltage V2 and a resistance R2 with the power P2, it becomes possible to write the formula for the ratio of two powers as:

$$\text{Ratio in dB} = 10.\log\,(V2^2/R2)/(V1^2/R1), \quad = 10.\log\,(V2^2/V1^2)/(R1/R2)$$

The slight rearrangement between the first and second lines produces the ratio of R1/R2. Suppose these are equal, what would be the result? They would cancel out! This leaves the expression as:

$$\text{Ratio in dB} = 10.\log(V2^2/V1^2), \quad = 10.\log(V2/V1)^2, \quad = 20.\log(V2/V1)$$

This neatly returns us back to the expression given previously without proof, showing along the way that the final expression only occurs if you let R1 = R2. This is what was said earlier, namely the voltages V1 and V2 must be measured across equal impedances (by which we actually mean equal resistances).

While we acknowledge that, for the sake of convenience, this fact is often blatantly ignored – the decibel being used to express the ratio of two voltages, whatever the impedances – for the rest of this discussion on attenuators, the assumption will be made that the resistance values are in fact equal. This will form the basis for the design of an attenuator to a given specification.

Table 1 gives the voltage (or current) and power ratios corresponding to a range of decibel values. Lines 2 to 5 of the table give both positive and negative decibel values and it should be noted that the ratio corresponding to a negative decibel value is merely the reciprocal of the ratio (1/ratio) for equivalent positive value. Thus, any other values may easily be deduced by the reader.

Values of decibels not included in the table may be calculated if they are an algebraic sum of the integers 3, 6 and 10, etc.

Example 1. The voltage ratio corresponding to 26dB is given by:

'Voltage ratio for 20dB' *times* 'the voltage ratio for 6dB'

From Table 1, this ratio = 10 x 2 = 20.

Example 2. The voltage ratio corresponding to 17dB is given by:

'Voltage ratio for 20dB' *times* 'voltage ratio for (−3dB)'

From Table 1, this ratio = 10 x 0·707
= 7·07.

We shall make more use of this table later in designing attenuators for specific losses.

**Table 1**

| Gain/loss (dB) | Corresponding Voltage Ratio (output/input) | Corresponding Power Ratio (output/input) |
|---|---|---|
| 0 | 1·000 | 1·00 |
| +3 | 1·414 | 2·00 |
| −3 | 0·707 | 0·50 |
| +6 | 2·000 | 4·00 |
| −6 | 0·500 | 0·25 |
| +10 | 3·160 | 10·00 |
| +20 | 10·000 | 100·00 |
| +30 | 31·600 | 1000·00 |
| +40 | 100·000 | 100000·00 |

## Iterative Impedances for Networks

Figure 5 shows a block which contains some unspecified arrangement of resistors. It has two input terminals, marked 1 and 2, and two output terminals, marked 3 and 4. It is thus described by the general title of a 'four terminal network'. Sometimes (quite often in fact) two of the terminals are common, especially 2 and 4 which might well be the ground or zero volt line. Nonetheless, the term 'four terminal' remains. In this figure each pair of terminals is closed by a resistive impedance, $Z_A$ at the input and $Z_B$ at the output. These produce 'iterative' impedances as follows.

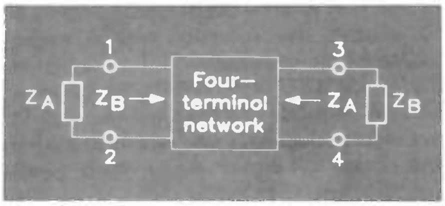



**Figure 5. Iterative impedances.**

The iterative impedance of a network is the value of impedance measured at one pair of terminals of the network, while the other pair is terminated with an impedance of the same value. In Figure 5, closing terminals 3 and 4 with an impedance $Z_B$ causes the same value of impedance, $Z_B$, to be 'seen' when looking into terminals 1 and 2. In the same way, closing terminals 1 and 2 with an impedance $Z_A$ causes this same value to appear between terminals 3 and 4. If the network is symmetrical, the iterative impedances $Z_A$ and $Z_B$ are equal and their common value is known as the 'characteristic impedance' of the network.

The nature of the resistor network of Figure 5 was not described, but it could have been similar to either of the circuits of Figure 6. These are known, for fairly obvious reasons, as (a) T-type and (b) Pi-type networks. Because they are pure resistors they will attenuate all signals, whatever their frequencies, to the same degree. Of course, there will be a limit to the truth of this statement somewhere, but careful design should ensure that it is true for the full range of frequencies of interest for any given application. Notice that in the T-type, the two series resistors are known as R1, while in the pi-type both shunt resistors are known as R4. Thus, both networks are symmetrical.

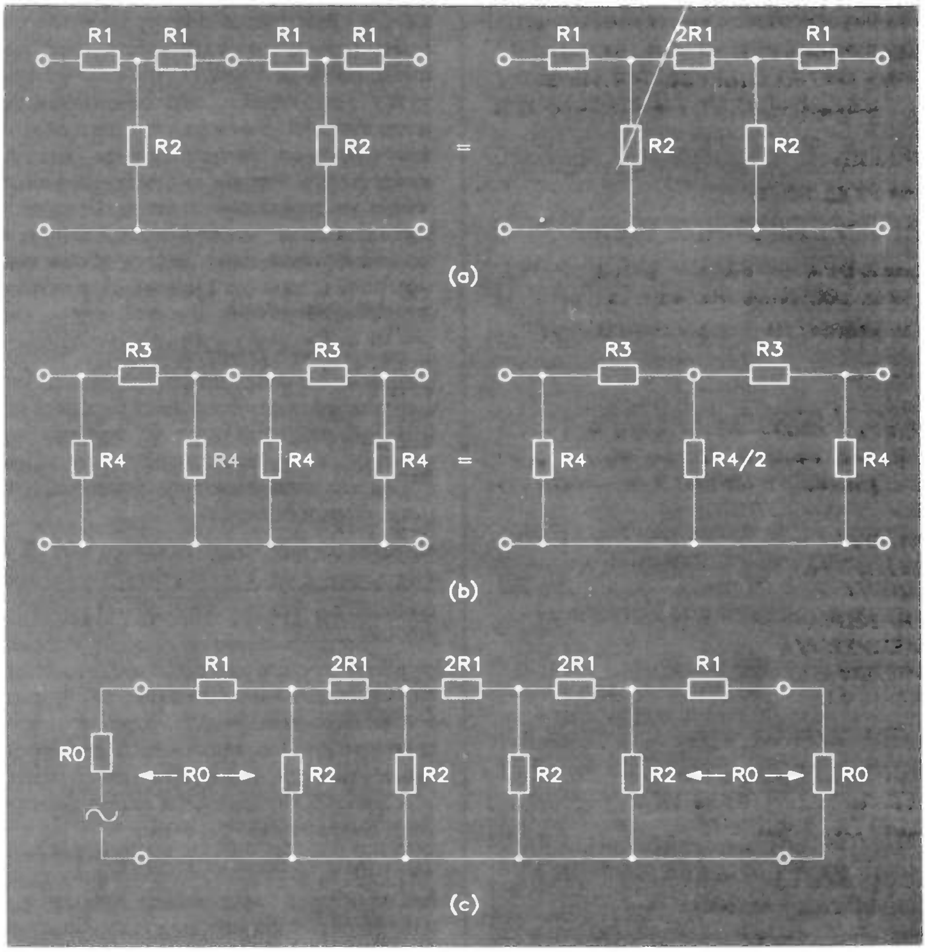



**Figure 7. Cascaded attenuator pads: (a) T-type (b) Pi-type, showing how resistors may be combined, (c) system is matched throughout.**

## Characteristic Impedance

Figure 6 also shows each of the networks being terminated in a resistor of value $R_0$. This is the characteristic impedance mentioned earlier. A moment's thought shows that it is nothing more than the total resistance value between terminals 1 and 2 of a network of four resistors in a series-parallel arrangement.

For example, for the T-type of Figure 6(a) for the total resistance between terminals 1 and 2 is given by:

$$R_0 = R1 + [R2 \times (R1 + R_0)/(R2 + R1 + R_0)]$$

On the usual basis that the value of $R_0$ is known (since it would normally be specified for a given case), the unknowns are then R1 and R2. What we appear to have is a single equation with two unknowns and, as we all know, to solve for *two* unknowns we must have a *pair* of simultaneous equations. This apparent dilemma is solved by the fact that the resistors R1 and R2 determine two characteristics of the network, as follows:

(i) the characteristic impedance,
(ii) the attenuation of the network.

At this point it should be quickly pointed out that we are not going to get involved in setting up and solving any simultaneous equations. Networks of the type discussed have been around for a long time and ready-made equations exist for determining the resistor values for either type, based on a knowledge of the characteristic impedance and the required degree of attenuation. These are as follows.

### T-type attenuator:

$R1 = R_0.(n - 1)/(n + 1)$ (i)
$R2 = R_0.2n/(n^2 - 1)$ (ii)

### Pi-type attenuator:

$R3 = R_0.(n^2 - 1)/2n$ (iii)
$R4 = R_0.(n + 1)/(n - 1)$ (iv)

In the above expressions, the quantity 'n' is defined by:

n = input voltage/output voltage.

While the above is quite straightforward, it is based upon the use of numerical ratios of input and output voltages rather than the preferred decibels discussed earlier. However, provided that we can

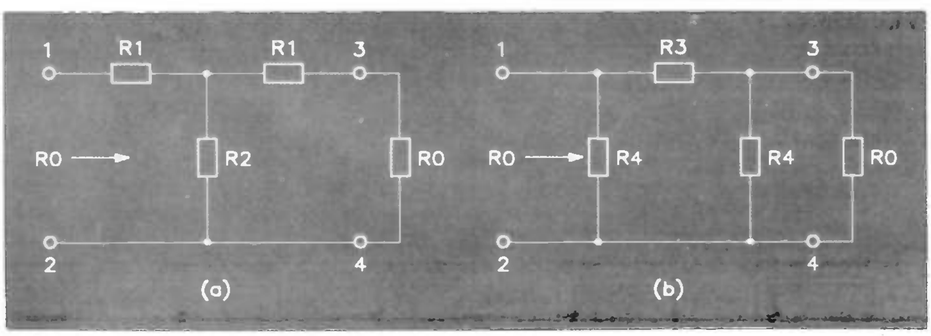



**Figure 6. The T-type and Pi-type attenuators.**

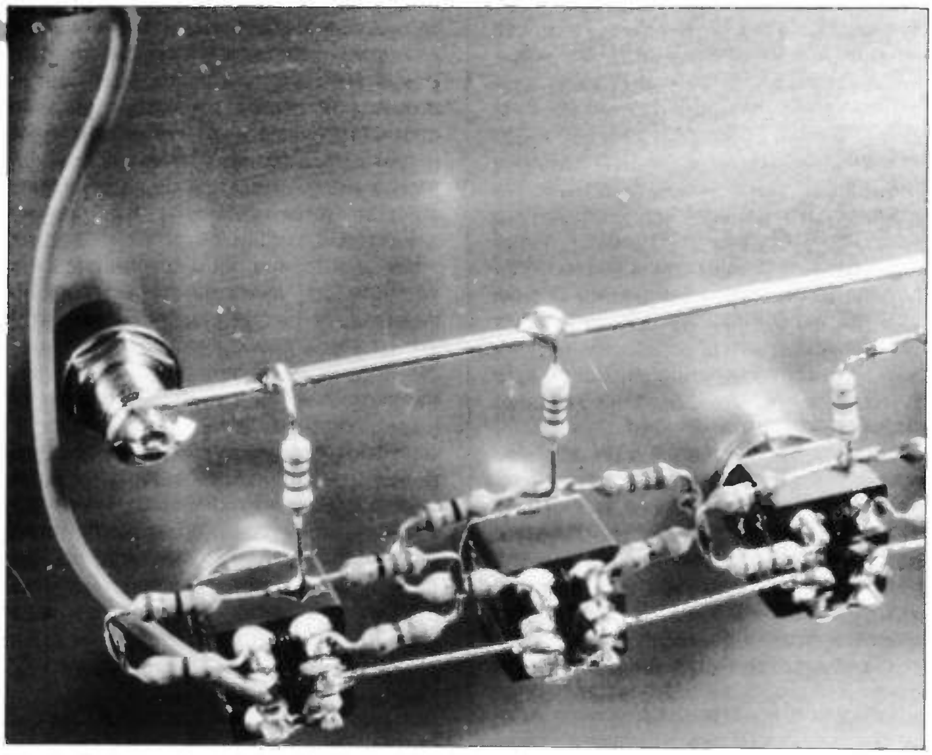


**Photo 1. Close-up of the 10dB and 20dB sections.**

turn an attenuation value expressed as 'so many dB' into the corresponding numerical ratio, the use of the equations (i) – (iv) above is easy enough. Earlier we saw how to use Table 1 for this conversion. Now is the time to put it to more practical use.

## Design of a T-type Attenuator

In order to design an attenuator to a given specification, it is necessary to know the required characteristic impedance and loss of the proposed attenuator. Once these are known, simple arithmetic will determine the resistor values, which will then have to be made up from the available ranges. The alternative is to have them custom made, a process which is only feasible for extremely large production runs. What we are talking about here is the design of practical attenuators for use on the amateur work bench – attenuators that can be built easily and cheaply and give a creditable performance.

Suppose that the characteristic impedance will be 600Ω and the loss is to be 10dB.

The first thing to do is to convert the loss in dB into its equivalent numerical ratio. from Table 1, this is seen to be 3·16:1. We are talking about 'voltage ratio' here.

Thus, in the formulæ for R1 and R2, $R_0 = 600\Omega$ and n = 3·16.

Using equation (i)

$$
\begin{aligned}
R1 &= R_0.(n - 1)/(n + 1),\\
&= 600.(3{\cdot}16 - 1)/(3{\cdot}16 + 1),\\
&= 600.(2{\cdot}16)/(4{\cdot}16),\\
&= 311{\cdot}54\Omega
\end{aligned}
$$

Using equation (ii)

$$
\begin{aligned}
R2 &= R_0{\cdot}2n/(n^2 - 1),\\
&= 600.[(2 \times 3{\cdot}16)/(3{\cdot}16^2 - 1]),\\
&= 600 \times [6{\cdot}32/(9{\cdot}99 - 1)],\\
&= 600 \times [6{\cdot}32/8{\cdot}99],\\
&= 421{\cdot}80\Omega
\end{aligned}
$$

Neither of these is a preferred value from the E24 resistor range, but a good approximation can often be obtained by combinations. One could work out complex series/parallel arrangements that would yield a very close total to that required, but often a pair of resistors in series will do, as well as being the easiest combination to calculate. For example:

The value of R1 could be made up by 270 + 39 = 309Ω, while the value of R2 could be produced quite closely from 390 + 33 = 423Ω.

It should be borne in mind that resistor tolerances will play their part in determining the actual value obtained; the closer the tolerance of the resistors, the more accurate the result.

## Design of a Pi-type Attenuator

The same performance could have been achieved using a Pi-type attenuator instead. We should expect the resistor values to be different. If we now perform the calculations required, for the identical specification, using equations (iii) and (iv), we can see how different the values are.

Using equation (iii)

$$
\begin{aligned}
R3 &= R_0.(n^2 - 1)/2n,\\
&= 600.(3{\cdot}16^2 - 1)/(2 \times 3{\cdot}16),\\
&= 600.(9{\cdot}99 - 1)/6{\cdot}32,\\
&= 853{\cdot}48\Omega.
\end{aligned}
$$

Using equation (iv)

$$
\begin{aligned}
R4 &= R_0.(n + 1)/(n - 1),\\
&= 600.(3{\cdot}16 + 1)/(3{\cdot}16 - 1),\\
&= 600.(4{\cdot}16/2{\cdot}16),\\
&= 1155{\cdot}56\Omega.
\end{aligned}
$$

In this case, we notice that the resistor values obtained are rather higher than those required for the T-type attenuator. However, they are still practical values and either type of network would be suitable for the stated specification.

The value of R3 can be obtained from the sum: 820 + 33 = 853Ω, thus working out most conveniently.

A close approximation to R4 is:

1000 + 150 + 5·6 = 1155·6Ω.

From the above, one could say that the Pi-type has the edge on the T-type in terms of its greater ease in obtaining the required resistor values. Other designs may show that the T-type is to be preferred.

## Cascaded Attenuator Networks

A single network of either T or Pi-type is often referred to as a 'pad'. Pads of the same characteristic impedance may be series connected (cascaded) in order to obtain higher values of attenuation, especially if a 'stepped' attenuator is required. In the latter type, a switch is used

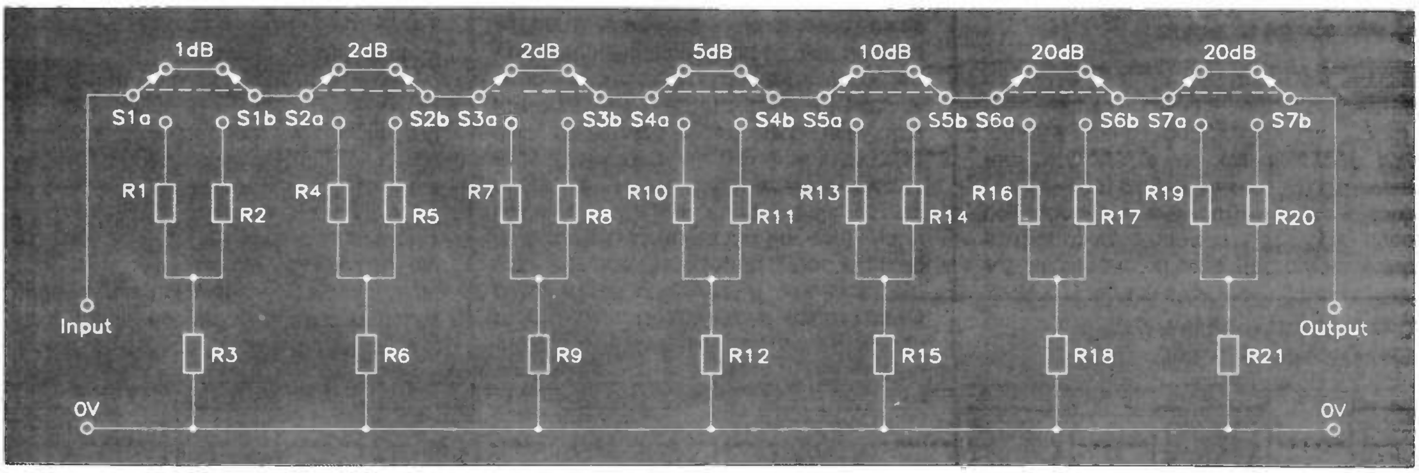



**Figure 8. Design for a variable attenuator, 0-60dB in 1dB steps.**

to select the number of sections that, added together, give the required overall attenuation. Figure 7 shows the cascading of both types of attenuator pad and it should be noted that, when this is done, the series-connected pairs of R1's can be replaced by a single resistor of value 2R1; while the shunt connected pairs of R4's can be combined into a single resistor of value R4/2. The iterative impedance is, of course, constant along the network and is equal to the characteristic impedance as stated earlier. Each pad matches the next, while the source is matched to the input and the load is matched to the output (Figure 7(c)).

This is fine where it is only required to produce a fixed amount of attenuation of high value. A laboratory attenuator would need to be variable to be of any real use and this implies keeping the individual pads separate in order to be able to switch them into circuit as required. This will now be put into practice with a design for an attenuator, of characteristic impedance 600Ω, that allows a wide range of attenuation values, in 1dB steps, to be obtained.

The circuit diagram for this design appears in Figure 8 and full construction details are given, illustrated by photographs of the author's prototype. There is little to the actual construction but one criterion to bear in mind is that lead lengths should be kept as short as possible. For this reason, the resistors are wired directly to the switch contacts, either between them or down to a heavy gauge tinned copper wire bus-bar, which acts as the common ground line. As shown in Photo 1.

Miniature double-pole change-over toggle switches are used, the total attenuation being selected by the appropriate combination of switches set. Otherwise, unselected pads are bypassed. The wiring of one of these switches is shown in Figure 9.

The choice of 600Ω for the characteristic impedance coincides with the terminal impedance of signal generators designed for use in audio testing; in fact it is a telecommunications standard. Thus, this attenuator design will be found useful over and beyond the full audio-frequency range. Attenuators used at radio-frequencies usually require a much lower value of characteristic impedance, typically 50Ω.

## Choice of Resistor Values

One problem that often arises when calculating resistor values from formulæ, is that the values obtained are invariably not those found in the preferred ranges. Approximations affect accuracy, with the obvious statement that 'the more approximate, the less accurate'. Another factor that also affects accuracy is the tolerance of the resistor type used. For most work in electronics a tolerance of ±5% is acceptable but for an attenuator, intended as a piece of precision test gear, a tighter tolerance is needed. Fortunately, Maplin's range of metal film resistors having a

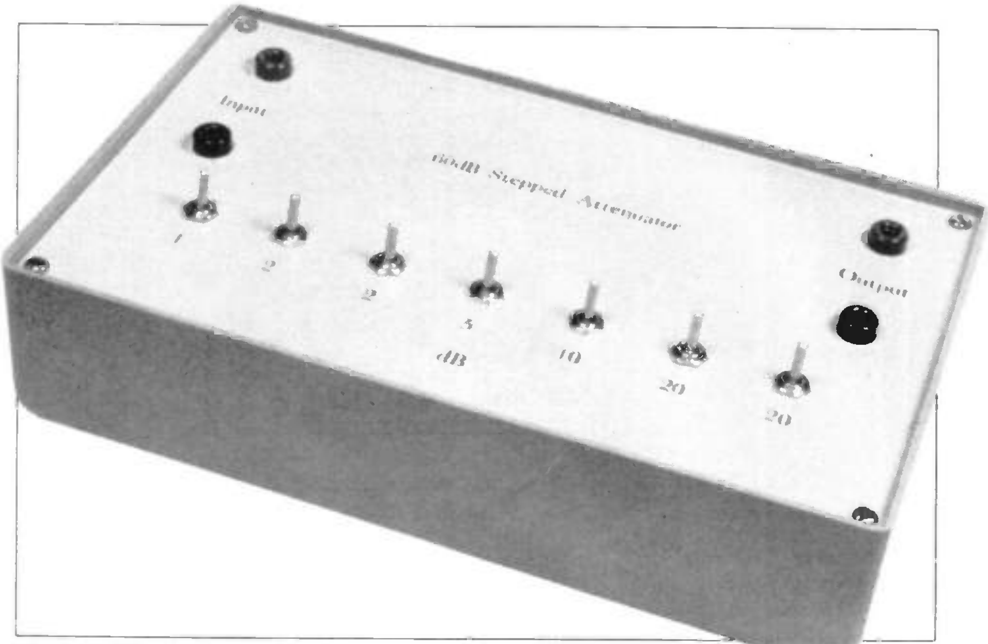


**Photo 2. The 60dB Stepped Attenuator.**

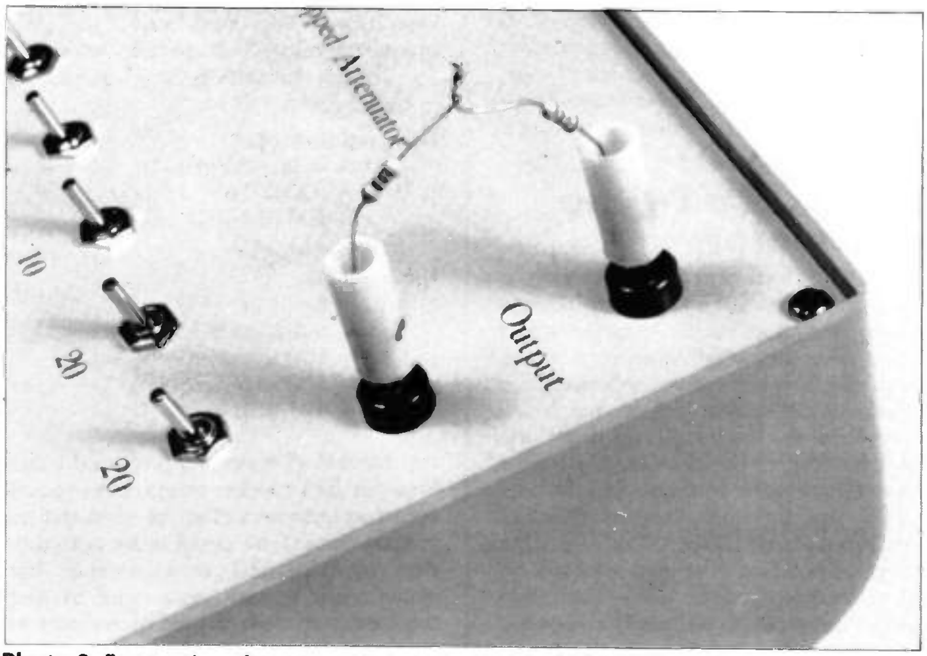



**Photo 3. For testing the output is terminated in 600Ω (270 + 330).**

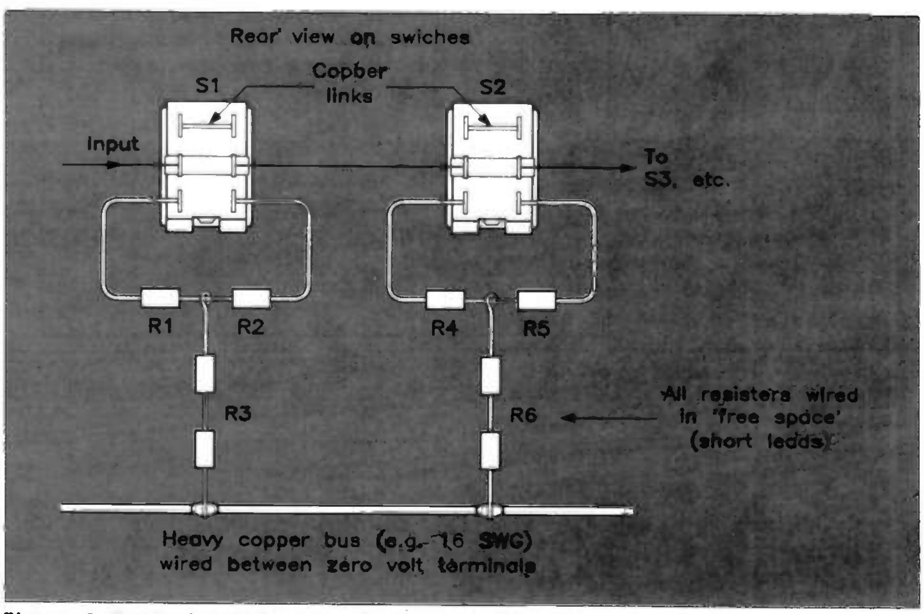



**Figure 9. Typical switch wiring in the variable attenuator design.**

tolerance of ±1% and a power rating of 0·6W are readily available. Using this range, even with approximations, the overall accuracy of each pad is likely to be little worse than ±1%. The data shown in Table 2 lists the design values and approximated values of resistance, as well as the combinations of resistors required to achieve them. Refer to the circuit of Figure 8 on page 45.

## Measurement of Amplifier Gain Using a Variable Attenuator

The gain of an amplifier is the ratio of output voltage to input voltage. It will, to a greater or less extent, vary with frequency, and a complete statement of amplifier gain should take this into account, often shown as a graph of gain versus frequency. It would seem that all one has to do is to set up an input voltage at some test frequency and measure the output voltage at that frequency. A simple division then yields the gain. However, as gain/frequency plots are usually given in dB rather than as a numerical ratio, it would then be necessary to calculate the equivalent number of dB for each gain measurement, a tedious procedure if there are many points to plot.

Another disadvantage of the above method is that the accuracy relies upon the accuracy of the instruments used to measure the voltage. If the gain of the amplifier is high, one set of measurements (those at the input) will be made at very low levels, a few mV perhaps, while the output voltage measurements will be at a much higher level, of the order of volts. By using a variable attenuator, it is possible to place the responsibility for accuracy on the attenuator, shifting it totally from the voltmeter, which need not be particularly accurate at all. The method is shown in Figure 10.

The completed attenuator (Photo 2) is interposed between signal generator and amplifier input; initially it is set to maximum attenuation. A voltmeter, whose only performance criteria are that it should not load the circuit nor vary widely over the frequency range used, is connected across the output of the signal generator. The output of the latter is adjusted so that the voltmeter reads some convenient voltage, e.g. 1 volt, at the chosen test frequency. The voltmeter is now transferred to the amplifier output. It will probably read very little. The setting of the attenuator is gradually reduced until the voltmeter reads the same value as previously, in this case 1 volt.

Since the input into the attenuator and the output of the amplifier have the same values, it follows that the attenuation exactly cancels the gain of the amplifier. Thus, reading the setting of the attenuator yields the gain value of the amplifier!

For example, if the controls of the attenuator indicate 20dB, 10dB, 5dB and 1dB attenuation, then the amplifier gain is equal to:

$$20 + 10 + 5 + 1 = 36\text{dB}$$

By repeating this procedure over a range of frequencies, it is possible to plot the gain/frequency characteristic of an amplifier. If the amplifier being tested has gain and/or tone controls, then graphs with these controls set to their 'cut' and 'boost' positions can also be plotted. However to ensure accuracy, if the amplifier's input impedance is not 600Ω then this should be added across the attenuator output with a resistor chain as shown in Photo 3. This can also be used to test the attenuator itself using an oscilloscope or VVM.

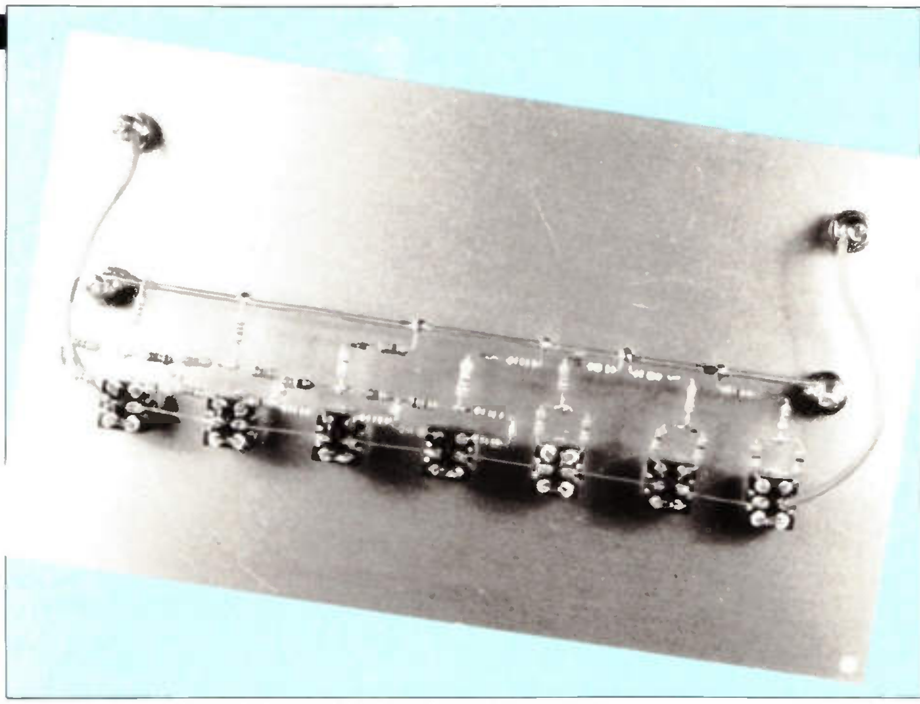


**Photo 4. Rear view of assembled attenuator panel.**

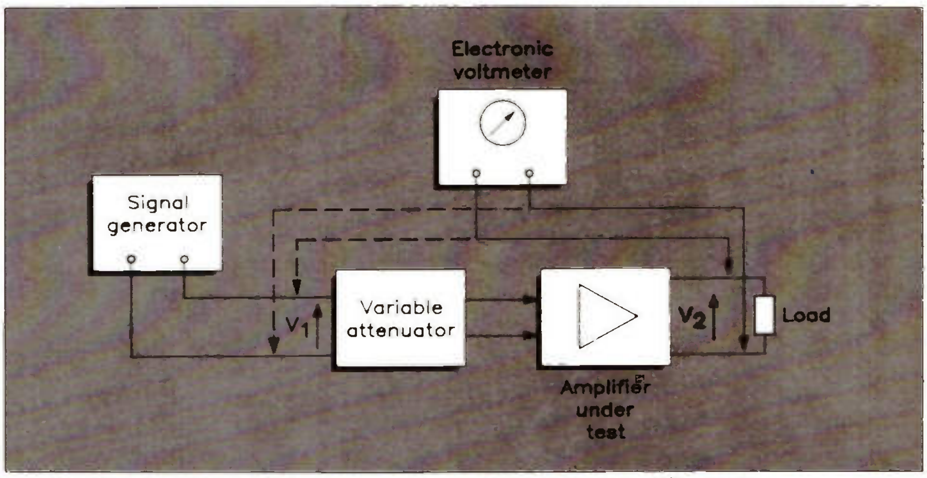



**Figure 10. Using a variable attenuator to measure amplifier gain.**

**Table 2**

| Attenuation Value (T-pad) | Design Resistance Value | Approximated Resistance Value | Series Resistor Combination Required |
|---|---|---|---|
| 1dB | R1,R2 = 33Ω | 33Ω | 33Ω |
| | R3 = 5200Ω | 5210Ω | 4k7 = 510Ω |
| 2dB | R4,R5,R7,R8 = 68Ω | 68Ω | 68Ω |
| | R6,R9 = 2573Ω | 2580Ω | 2k4 + 180Ω |
| 5dB | R10,R11 = 168Ω | 168Ω | 150Ω + 18Ω |
| | R12 = 987Ω | 992Ω | 910Ω + 82Ω |
| 10dB | R13,R14 = 311·5Ω | 311Ω | 300Ω + 11Ω |
| | R15 = 422Ω | 423Ω | 390Ω + 33Ω |
| 20dB | R16,R17,R19,R20 = 491Ω | 492Ω | 470Ω + 22Ω |
| | R18,R21 = 121Ω | 120Ω | 120Ω |

## Introduction

The increased use of the Medium Wave broadcast band by local radio stations has brought about a renewed interest in simple AM (Amplitude Modulation) receivers for the home constructor. Much of the interest comes from beginners, many of whom have very little experience (if any) in the construction of electronic circuits. With this in mind, the Beginners' AM Radio is a simple design requiring a minimum of alignment but which is however, capable of providing reasonable reception of the stronger stations. A key feature of the design is its small size and portability and to achieve this, the circuit uses a minimum of components and operates from a comparatively small 'N' size battery. Generally, the volume of the stations received is comparatively low due to the relatively simple design of the circuit and for this reason a rotary volume control is not used. A switchable attenuator is provided to prevent overloading and to reduce the volume of the demodulated signal should an exceptionally strong station be encountered. In the majority of cases it will not be necessary to use the attenuator; however, it was considered that the inclusion of this facility would be beneficial to some users. In order to capitalise on the available space, the on/off switch forms an integral part of the headphone socket; the receiver being powered up when the headphones are connected and powered down when they are removed.

## Circuit Description

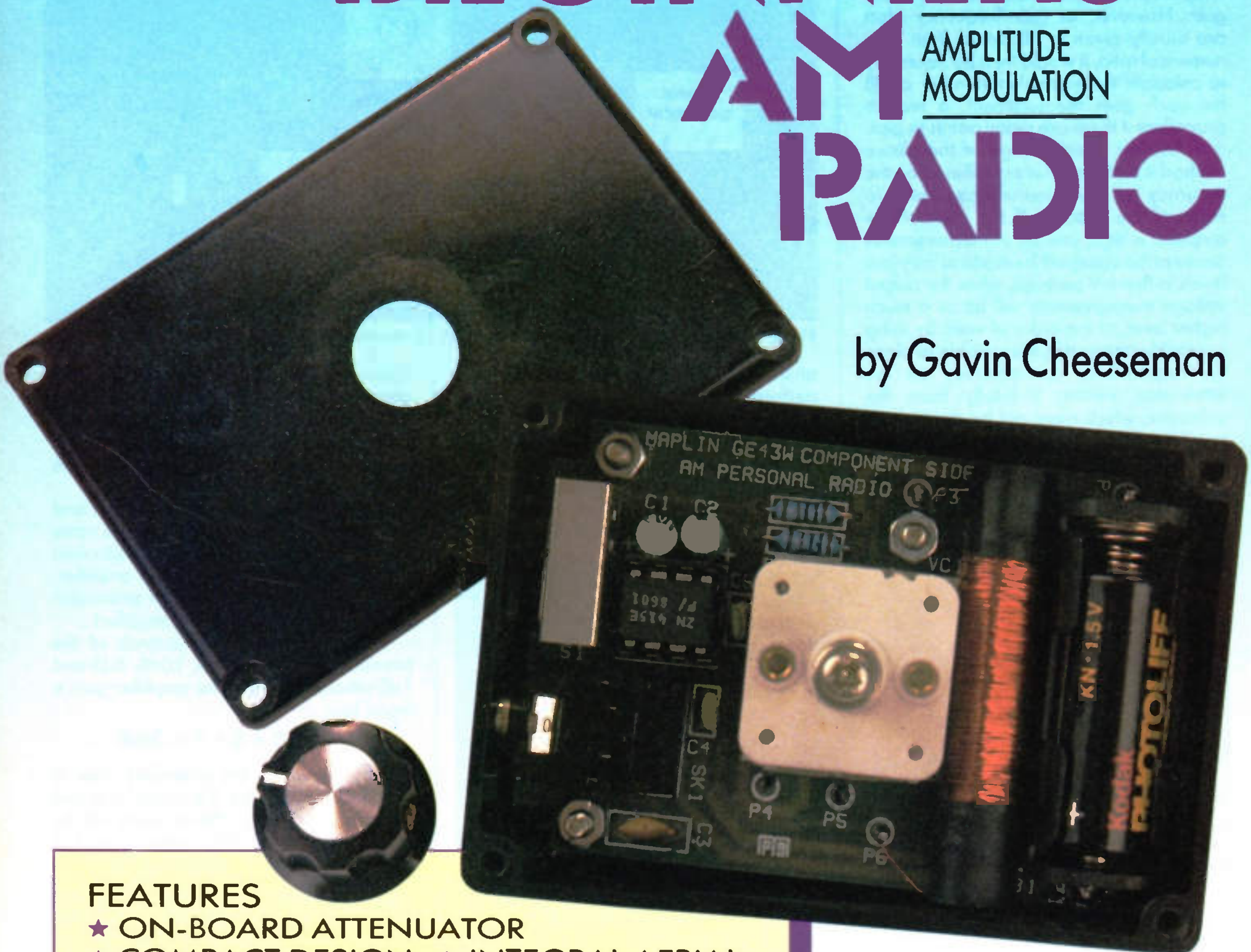
The Beginners' AM Radio employs the Tuned Radio Frequency (TRF) principle of radio reception in which the tuning is carried out in the RF amplifier stage only and the receiver is based around the ZN415E AM radio IC. Supplied in an 8-pin DIL package, the ZN415E comprises an RF amplifier, demodulator, audio amplifier and AGC (Automatic Gain Control) circuit. Referring to Figure 1, it can be seen that IC1 requires very few external components to function.

Aerial coil L1 effectively serves two purposes, acting as the receiving aerial and also forming a tuned input circuit in combination with variable capacitor VC1. Capacitor C3 acts as a very simple low pass filter, removing the remaining radio frequency (RF) signal from the recovered audio. Conversely, C1 and C2 act as interstage coupling capacitors allowing audio frequencies to pass but removing the very low frequency components of the signal and blocking DC. Slide-switch S1 operates the attenuator: when S1 is open,

# BEGINNERS' AM RADIO

AMPLITUDE MODULATION

by Gavin Cheeseman




FEATURES
★ ON-BOARD ATTENUATOR
★ COMPACT DESIGN ★ INTEGRAL AERIAL
★ HEADPHONE OPERATED POWER ON/OFF

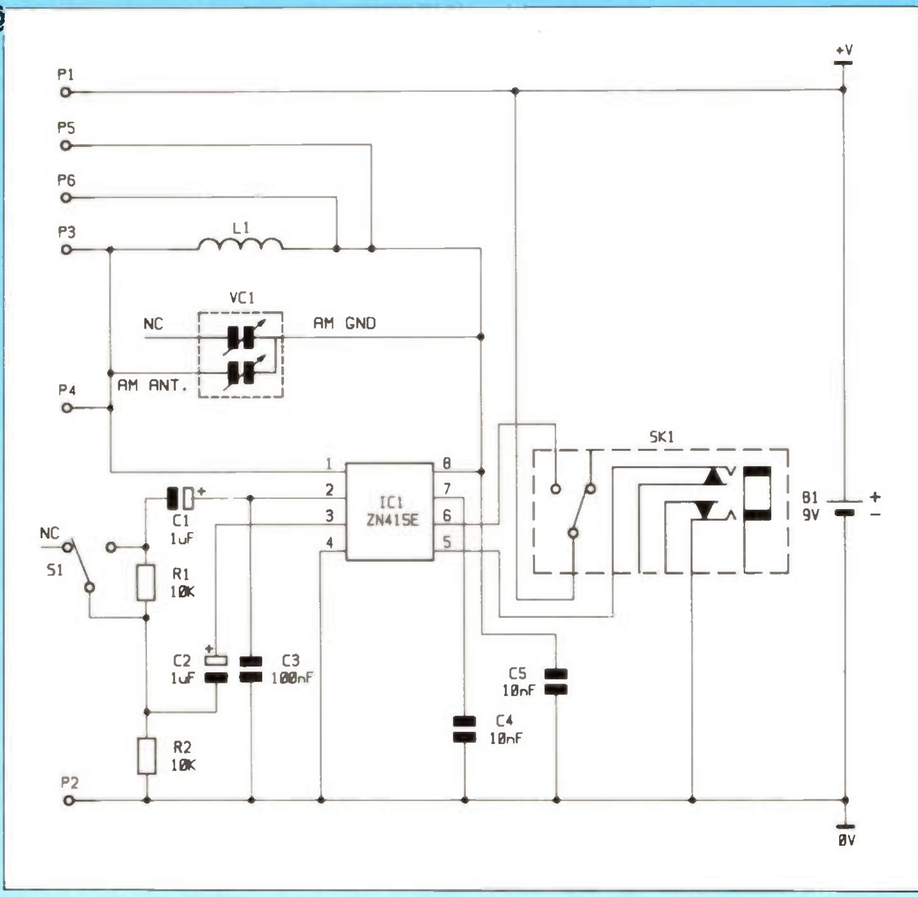



Figure 1. Circuit diagram.

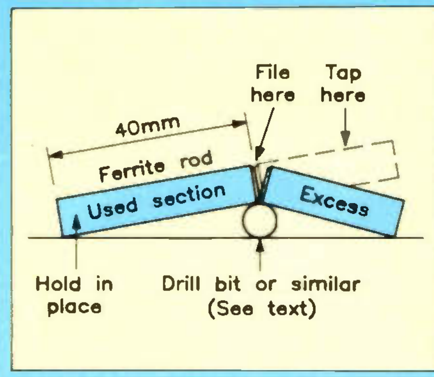



Figure 3. Cutting the ferrite rod.

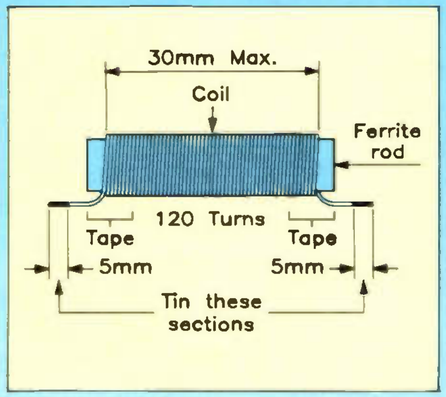



Figure 4. Constructing L1.

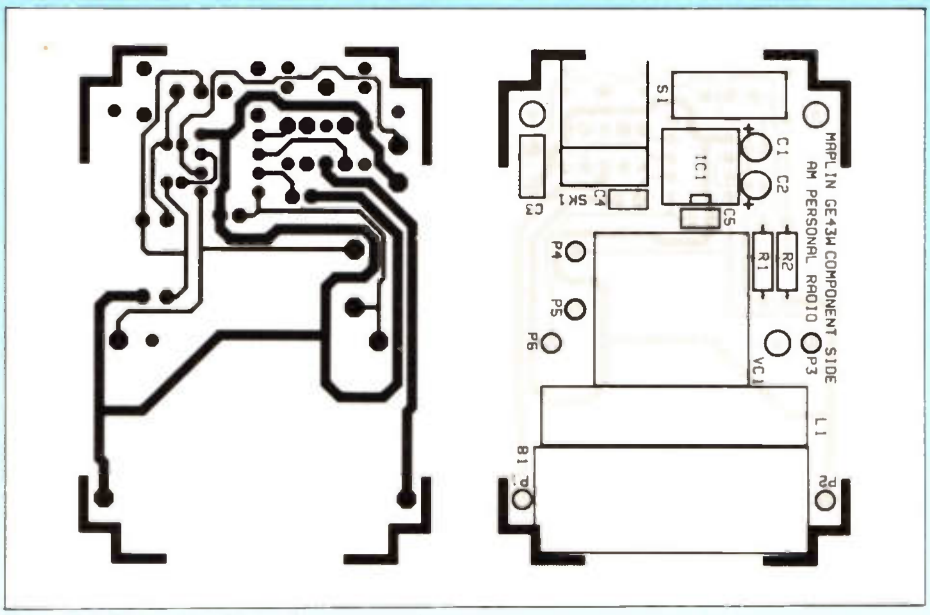



Figure 2. PCB track and legend.

resistors R1 and R2 act as a potential divider, reducing the signal level; however, if S1 is closed R1 is bypassed and the signal is allowed to pass unhindered. Capacitors C4 and C5 are decoupling components. The final audio output (after amplification) is fed to jack socket SK1 which also provides power supply switching via an internal SPDT switch. It should be noted that for optimum performance the outer (screen) connection of the socket remains open circuit; this presents the output with a higher impedance load as the headphones are then effectively connected in series.

## Construction

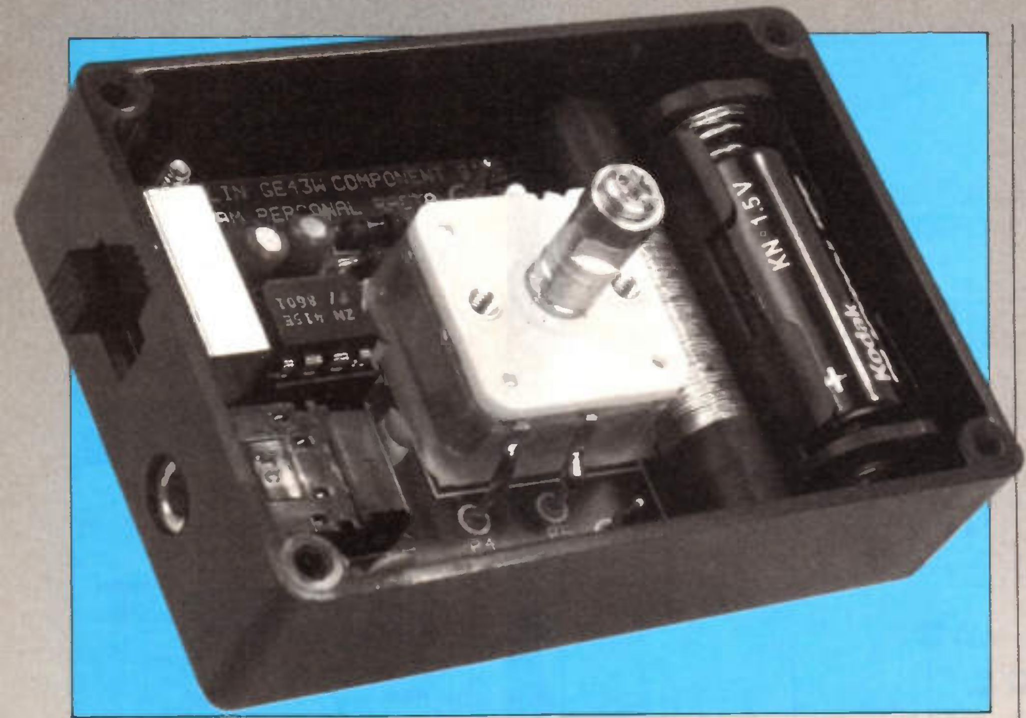
The Beginners' AM Radio uses a high quality, fibreglass PCB with a printed legend for high reliability and ease of construction. Begin by fitting the resistors. The IC socket should be fitted such that the notch at one end of the socket corresponds with that on the PCB legend (shown in Figure 2). Do not insert the IC at this stage. Jack socket SK1 should then be installed keeping the base of the component flush with the PCB as much as possible. Similar considerations apply when installing the slide switch (S1). When fitting electrolytic capacitors C1 and C2, make sure that the correct polarity is observed; the negative lead, indicated by a minus (−) sign on the side of the capacitor, must be inserted away from the positive (+) symbol on the PCB legend.

Next fit the PCB pins. After insertion, use a hot soldering iron to press the pins into place. If sufficient heat is used, it should not be necessary to use any great amount of force. Once in place, the pins may then be soldered. The battery holder tags are soldered directly onto the appropriate PCB pins; the negative end of the holder can be identified by the internal spring clip terminal. Solder the holder's positive tag to P1 and the negative tag to P2.

By far the most involved part of constructing the module is winding the aerial coil L1. Although this is not actually difficult some care is required to make sure that the correct length of ferrite is cut and that the coil is wound neatly. Enough excess wire is included in the kit to allow several attempts at winding the coil should this be necessary but if the instructions are followed precisely you should encounter few problems.

To construct L1, it is first necessary to cut the ferrite rod supplied to a suitable size to fit onto the PCB. The easiest method of cutting ferrite is to file a ring around the rod at the point where it is required to break and then while holding it firmly the unwanted part of the rod should be tapped lightly until it fractures. A small metal rod such as a screwdriver or drill bit can be used to aid the breaking of the ferrite rod and this technique is illustrated in Figure 3. During the process, it is recommended that for safety, the rod is covered with a piece of cloth as sharp splinters of ferrite can be produced at the breaking point.

The coil is wound from 120 turns of 34swg enamelled copper wire as shown in Figure 4. There are several methods of fixing the wire in place, but the quickest and easiest is by adhesive tape. Electrical insulating tape is best but ordinary, clear household adhesive tape will suffice. The wire should be secured with the tape at




The completed PCB fitted into the box.

corresponds with that of the socket. After completing construction of the receiver, it is a good idea to double check your work to make sure that there are no obvious errors. In particular, double check the soldering for any dry joints or solder short circuits. For further information on soldering and constructional techniques, refer to the Constructors' Guide included in the kit.

## Testing

The Beginners' AM Radio is designed to operate with medium impedance headphones such as the type commonly used for personal stereos (32Ω approx.). A suitable set of headphones is Maplin stock code XM42V. The overall performance obtained from the circuit is very much dependent on your location and strong local stations will usually provide the best quality reception. It should, however, be possible to receive some medium strength signals at reduced volume levels. The receiver is designed to operate from an alkaline N type battery such as Maplin stock code FM13P. Clip the battery into the holder, making sure that the correct polarity is observed; the positive end of the battery faces toward P1. Plug a suitable set of headphones into the headphone socket (SK1). With S1 in the open position, listen to the output from the headphones and adjust VC1 until a signal is received. If you have no test equipment, then the frequency range of the receiver can only be determined by listening to different stations of known frequency and noting the relevant settings of VC1.

Figure 6 shows the frequency range obtained from the prototype and the corresponding settings of VC1. Obtaining the correct frequency range is very much down to accurate coil winding. For those who possess an RF signal generator and wish set up the frequency range accurately, VC1 can be trimmed using the adjustment screws on the back of the capacitor; however, it should be noted that only fine tuning is possible using this method and accurate coil winding is still important. Any

one end of the ferrite rod and close wound in a neat fashion. When the coil is finished, the last few turns should be held in place using a second piece of adhesive tape. Alternatively the ends of the coil may be glued to the ferrite rod; this method probably provides a more permanent solution but it will be necessary to hold the coil in place whilst the glue is drying.

Variable capacitor VC1 is held in position on the PCB using the self adhesive pads provided. Remove the protective backing from one side of each of the pads and position them such that they cover the area marked out for VC1 on the PCB and also part of the area marked for L1 as shown in Figure 5. Do not remove the remaining half of the backing until you are ready to fix VC1 into place. Position VC1 such that the terminals marked A and G line up with P4 and P5 respectively. The variable capacitor terminals can then be soldered to the PCB pins. The third terminal of VC1 (marked O) remains unconnected and should be trimmed to prevent it shorting against P6.

Press L1 into position so that the overlapping section of adhesive pad holds the coil in place. Solder the ends of L1 to P3 and P6. It is a good idea to tin the tip of the wire before soldering to ensure that the enamel is removed. The tinned section of wire should extend no more than 5mm from each end. The length of wire between the coil and the PCB pins should be kept as short as possible, no longer than 2cm. When all of the other components are in place, the IC can then be fitted, ensuring that the notch at one end of the IC

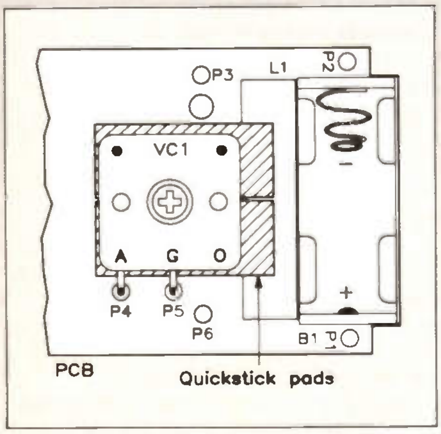



Figure 5. Positioning the adhesive pads.

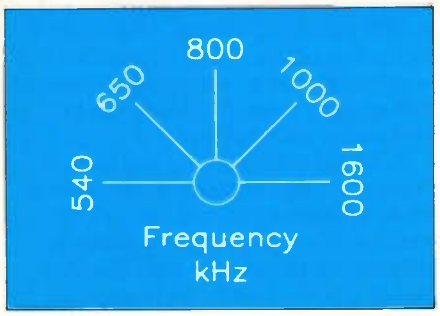



Figure 6. Tuning range.

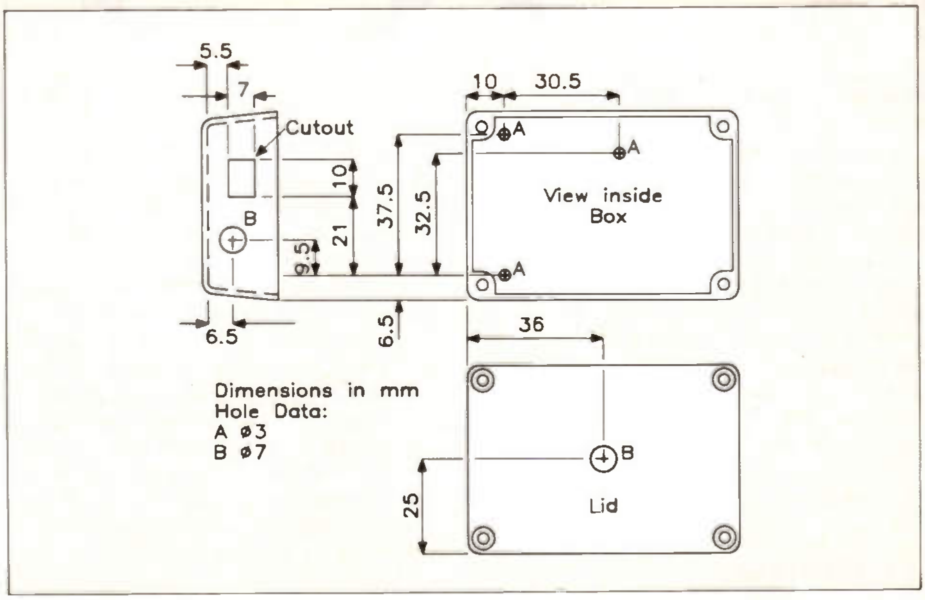



Figure 7. Drilling details.

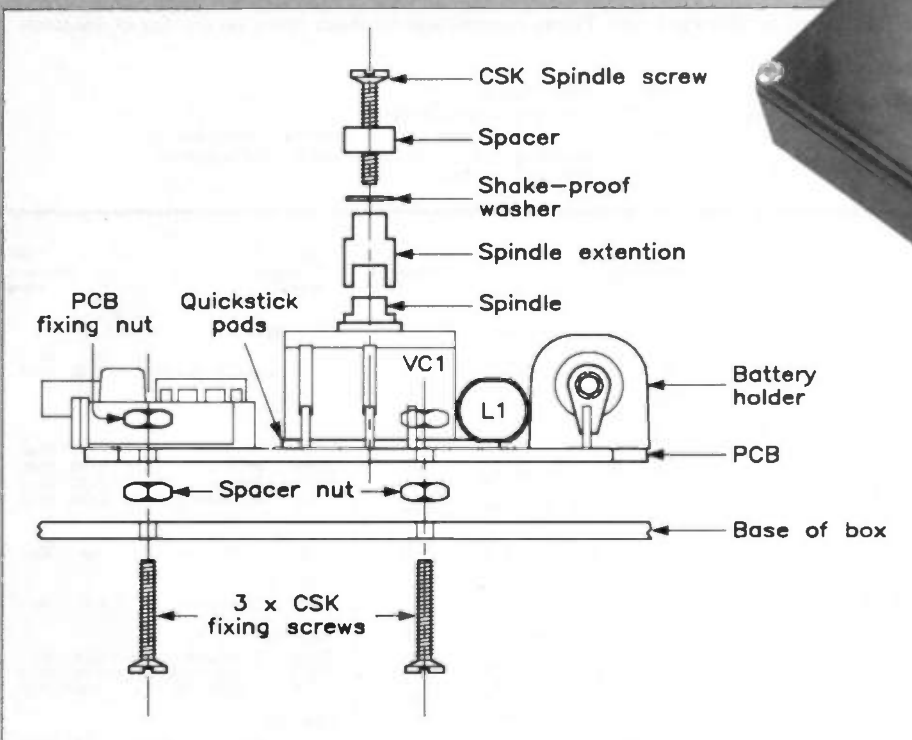
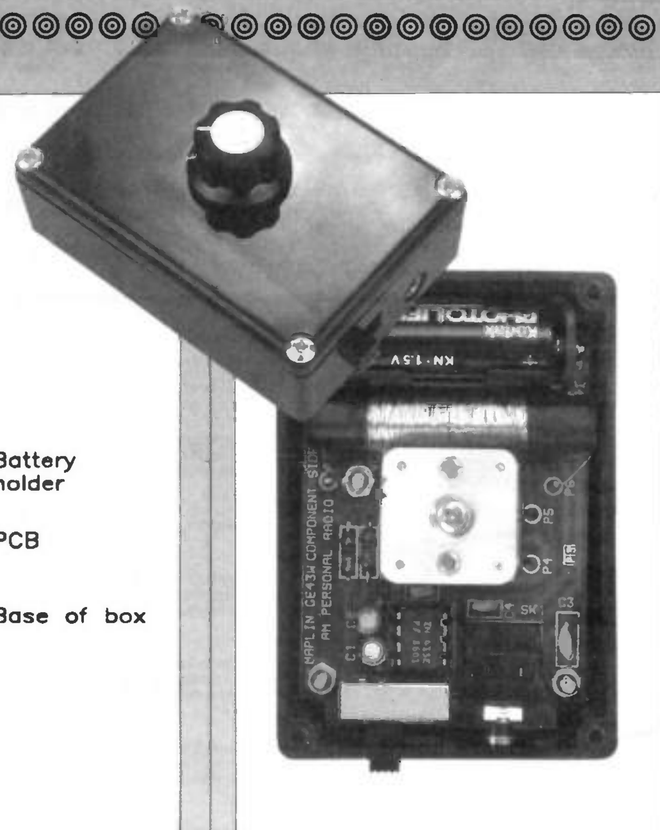



Figure 8. Final assembly.



View from above of assembled PCB and box.

alignment should be carried out before VC1 is fixed in position as the adhesive pads are not re-usable.

## Housing the Receiver

A suitable box in which to house the finished module is Maplin stock code LL12N (not supplied in the kit). It is necessary to drill the box in order to mount the PCB and to allow access to the attenuator switch, headphone socket and tuning capacitor. Figure 7 shows the necessary drilling information. Attenuator switch, S1 requires a rectangular hole; the easiest way to cut this is probably to drill the box out as accurately as possible and use a file or a sharp knife to cut the hole to the correct shape.

Figure 8 shows the PCB mounting details together with the spindle and knob assembly for VC1. The PCB has 3 fixing holes and is mounted using M2·5 nuts and screws. Nuts are also used as spacers to separate the PCB from the base of the box. After the box is drilled, insert the three fixing screws through the appropriate holes and fit the spacer nuts. The nuts should not be fully tightened at this stage and no more than 5mm of each screw should protrude into the inside of the case. The PCB may then be placed in position and the three fixing nuts can be screwed into place using a pair of long nose or snipe nose pliers. The screws should then be tightened so that the heads are flush with the outside of the box and the nuts hold the PCB tightly in place. Before the tuning knob is fitted in position fix the box lid into place using the 4 self-tapping screws supplied.

The knob used is a type K7A (Stock code YX01B). Tuning capacitor VC1 should be set to the fully anti-clockwise position and the knob placed over the spindle. For alignment purposes, position the knob so that the pointer corresponds with the position of P5 on the PCB and tighten the knob fixing screw. Check that the knob does not foul the lid of the box by rotating it from fully anti-clockwise to fully clockwise. If the action is not smooth release the fixing screw and raise the knob. Tighten the fixing screw and repeat the above procedure until a smooth action is obtained.

Finally, the Table below shows the specification of the prototype receiver.

| | |
|---|---|
| **Power Supply** | **Alkaline N type** |
| **Operating Frequency** | **540kHz – 1600kHz** |
| **Suitable Headphone impedance** | **32 Ohm nominal** |
| **PCB Dimensions** | **66mm x 45mm** |

## BEGINNERS' AM RADIO PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

| | | | |
|---|---|---|---|
| R1,2 | 10k | 2 | (M10K) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1,2 | 1$\mu$F 63V Minelect | 2 | (YY31J) |
| C3 | 100nF Minidisc | 1 | (YR75S) |
| C4,5 | 10nF Ceramic | 2 | (WX77J) |
| VC1 | Min. AM Tuner Capacitor | 1 | (FT78K) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| IC1 | ZN415E | 1 | (QY61R) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| S1 | R/A SPST Slide Switch | 1 | (FV01B) |
| P1-6 | Pins 2145 | 1 Pkt | (FL24B) |
| SK1 | PCB 3·5 Stereo SPCO Skt. | 1 | (JM22Y) |
| | N Battery Box | 1 | (JB84F) |
| | Ferrite Rod 810 | 1 | (YG20W) |
| | EC Wire 34 swg | 1 Roll | (BL42V) |
| | DIL Socket 8-Pin | 1 | (BL17T) |
| | PC Board | 1 | (GE43W) |
| | Constructors' Guide | 1 | (XH79L) |
| | Quickstick Pads | 1 Stp | (HB22Y) |

OPTIONAL (not in kit)

| | | |
|---|---|---|
| Verobox 301 | 1 | (LL12N) |
| Alkaline KN Battery | 1 | (FM13P) |
| Knob K7A | 1 | (YX01B) |
| Spacer 4BA x ¼ Inch | 1 Pkt | (FW31J) |
| Poziscrew M2·5 x 12mm | 1 Pkt | (BF40T) |
| Isoshake M2·5 | 1 Pkt | (BF45Y) |
| Isonut M2·5 | 1 Pkt | (BF59P) |

The above items, excluding Optional, are available as a kit:
**Order As LP28F (Beginners' AM Radio) Price £6.95**
The following item is also available separately:
**Beginners' AM Radio PCB (GE43W) Price £1.98**

# 1991 CATALOGUE PRICE CHANGES

**The price changes shown in this list are valid from 1st January to 30th April 1991. Prices charged will be those ruling on the day of despatch.**

For further details please see 'Prices' on catalogue page 577.

**Price Changes**

All items whose prices have changed since the publication of the 1991 catalogue are shown in the list below.

**Key**

| | |
|---|---|
| DIS | Discontinued |
| TEMP | Temporarily unobtainable. |
| FEB | Out of stock; new stock expected in month shown. |
| *NV* | Indicates that item is zero rated for VAT purposes. |
| † | Whilst stocks last. |

| 1991 Catalogue Page No. | | VAT Inclusive Price | |
|---|---|---|---|

## Audio, Video & Computers

**Page 31**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| FV36P | Record Clean Cloth | £1.48 | £1.30 |

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| | | | |
|---|---|---|---|
| FD42V | Drive Belt 15.5mm | *DIS* | |
| FD43W | Drive Belt 18mm | *DIS* | |
| | | 1+ | 10+ |
| FQ63T | Send Cassette Head | £19.95 | £17.25 |
| | | 1+ | 25+ |
| FQ65V | Stereo Cassette Head | £4.95 | £4.25 |

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|---|---|---|
| | | 1+ |
| CT39N | TDK MA-XG90 | £8.95 |
| CT37S | Maxell MX-C90 | £3.75 |

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|---|---|---|
| YU13P | [A] Enhancer Stabiliser | *DIS* |
| YP47B | [A] Video-Cine Adaptor | *DIS* |

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|---|---|---|
| MF26D | SK-204 Traffic Cop | *DIS* |

## Batteries & Power Supplies

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| | | |
|---|---|---|
| FK55K | Zinc Carbon KAAZN | *DIS* |
| FK56L | Zinc Carbon KCZN | *DIS* |
| FK57M | Zinc Carbon KDZN | *DIS* |

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|---|---|---|
| JG92A | 12V Lighter Batt 27A | *DIS* |

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|---|---|---|
| JG89W | Merc Batt HG11 | *DIS* |

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|---|---|---|---|
| | | 1+ | 25+ |
| FV70M | Ni-cad D 1600mAh | £2.95 | £2.34 |
| YG03D | Ni-cad D 4000mAh | £5.45 | £4.46 |

## Books

**Page 63**

| | | |
|---|---|---|
| | | 1+ |
| WS82D | Elect Wiring Domestc | £10.95*NV* |

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| | | |
|---|---|---|
| WP76H | Mastr Electrical Eng | £5.99*NV* |
| WS54J | Basic Skills Elect | £4.95*NV* |

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|---|---|---|
| HK45Y | Elect Dictionary | *DIS* |

**Page 67**

| | | |
|---|---|---|
| WP07H | Engineers Sourcebook | £12.95*NV* |

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|---|---|---|
| WS22Y | Audio Circuit Manual | £11.95*NV* |

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|---|---|---|
| WG01B | Book NB447 | £10.95*NV* |
| WM60Q | Mastering Electronic | £5.99*NV* |

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|---|---|---|
| WP98G | Elec in Practice | £5.95*NV* |
| XW63T | Book JM671 | £5.25*NV* |

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|---|---|---|
| XW30H | Cost Effectv Constrc | £8.99*NV* |
| XW31J | Proj for Car/Garage | £9.99*NV* |

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|---|---|---|
| RB10L | Book NB269 | £12.95*NV* |

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|---|---|---|
| WS74R | Opto Elec Line Trans | £13.95*NV* |

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|---|---|---|
| WP51F | Audio Projects | £10.99*NV* |

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|---|---|---|
| WG82D | Book FT1364 | £14.95*NV* |
| WS00A | Comp Disc Tech | £25.00*NV* |
| WS96E | The ICE Manual | £11.95*NV* |

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|---|---|---|
| WP96E | Pract MIDI Handbook | £6.95*NV* |

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|---|---|---|
| XW54J | Book NB439 | *DIS* |
| WP87U | Radio Ams Exam Manul | £6.45*NV* |
| WS13P | A/R Operating Manual | £6.95*NV* |
| WS14Q | VHF/UHF Manual | £9.95*NV* |

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|---|---|---|
| WS16S | HF Antennas All Locs | £5.75*NV* |
| RB22Y | Book BP222 | *DIS* |
| WS61R | Short Wave Listening | £14.95*NV* |

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|---|---|---|
| WP47B | Scanners | £8.95*NV* |

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|---|---|---|
| WS34M | Guide TV-Vid Tech | £12.95*NV* |
| WG89W | Book NB132 | *DIS* |
| WS92A | Mobile Radio Svcing | £30.00*NV* |

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| | | |
|---|---|---|
| WP56L | Service Vid Recordrs | £25.00*NV* |
| WS98G | Wash Machine Manual | £11.95*NV* |
| WS97F | Dishwasher Manual | £11.95*NV* |

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|---|---|---|
| XW98G | Book FT1070 | *DIS* |
| WM79L | Micro I/Face Ccts | £2.75*NV* |
| WA02C | Book MM495 | £12.99*NV* |

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|---|---|---|
| WA05F | 6502 Assembly Subs | *DIS* |
| WK30H | Programming 6809 | £20.95*NV* |
| WA04E | 68000 Assembly Prog | £21.95*NV* |

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|---|---|---|
| WP58N | Understanding C | £20.95*NV* |

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|---|---|---|
| WM77J | Working dBase II | £10.95*NV* |

## Boxes

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|---|---|---|---|
| | | 1+ | 25+ |
| FG41U | PSU Box and Plug | £2.20 | £2.02 |
| | | 1+ | |
| JM16S | PSU Grommet | 8p | |

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|---|---|---|---|
| | | 1+ | 10+ |
| LL08J | Verobox 211 | £5.25 | £4.95 |
| LL09K | Verobox 212 | £5.75 | £5.58 |
| LQ07H | Verobox 214 | £7.25 | £6.85 |
| LQ08J | Verobox 215 | £7.45 | £7.11 |
| LQ09K | Verobox 216 | £7.75 | £7.56 |

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|---|---|---|---|
| | | 1+ | 5+ |
| YU96E | [A] Instrument Case IB-1 | £8.45 | £7.65 |
| YU97F | [A] Instrument Case IB-2 | £8.95 | £8.28 |
| YU98G | [A] Instrument Case IB-3 | £9.45 | £8.80 |
| YU99H | [A] Instrument Case IB-4 | £10.45 | £9.49 |

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|---|---|---|---|
| | | 1+ | 10+ |
| YN53H | Box CAN40 | £3.25 | £2.85 |
| YN49D | Box CAN80 | £4.25 | £3.75 |
| YN50E | Box CCN80 | £5.95 | £5.35 |
| YN51F | Box CCN160 | £8.95 | £7.95 |
| YN52G | Box CCN220 | £11.95 | £9.95 |
| | | 1+ | 50+ |
| FE36P | Lug 40 | 45p | 38p |
| FE37S | Lug 80 | 52p | 43p |
| | | 1+ | 25+ |
| FE38R | Sink 20 | £1.60 | £1.41 |
| FE39N | Sink 40 | £1.95 | £1.66 |
| FE41U | Gasket CCN | £1.20 | £1.09 |

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|---|---|---|---|
| | | 1+ | 10+ |
| YJ11M | [B] Wallbox Plain | £10.95 | £9.95 |
| | | 1+ | 5+ |
| XM12N | [D] 19" Case 4817 | £47.95 | £42.55 |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| JU45Y | Grommet Foot 6.9mm | 24p | 20p |

## Cables

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| | | |
|---|---|---|
| | | 1+ |
| BL46A | L C Wire Black | £1.10 |
| BL47B | L C Wire Blue | £1.10 |
| BL49D | L C Wire Green | £1.10 |
| BL53H | L C Wire Red | £1.10 |
| BL55K | L C Wire White | £1.10 |
| BL56L | L C Wire Yellow | £1.10 |

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| | | |
|---|---|---|
| XR22Y | EHT Wire | 50p |
| BL16S | EC Wire 2.0mm 14swg | 72p |
| YN79L | 250 ECW 2.0mm 14swg | £2.56 |
| BL24B | EC Wire 1.6mm 16swg | 72p |
| YN80B | 250 ECW 1.6mm 16swg | £2.56 |
| BL25C | EC Wire 1.25mm 18swg | 75p |
| YN81C | 250 ECW 1.25mm 18swg | £2.56 |
| BL26D | EC Wire 0.9mm 20swg | 75p |
| YN82D | 250 ECW 0.9mm 20swg | £2.65 |
| BL27E | EC Wire 0.71mm 22swg | 78p |
| BL28F | EC Wire 0.56mm 24swg | 78p |
| YN84F | 250 ECW 0.56mm 24swg | £2.86 |
| BL29G | EC Wire 0.45mm 26swg | 86p |
| BL39N | EC Wire 0.375mm28swg | 86p |
| BL40T | EC Wire 0.315mm30swg | 92p |
| BL41U | EC Wire 0.28mm 32swg | 92p |
| YN88V | 250 ECW 0.28mm 32swg | £3.36 |
| BL42V | EC Wire 0.236mm34swg | 96p |
| YN89W | 250 ECW 0.236mm34swg | £3.45 |
| BL44X | EC Wire 0.15mm 38swg | £1.06 |
| YN91Y | 250 ECW 0.15mm 38swg | £3.95 |
| BL60Q | EC Wire 0.125mm40swg | £1.06 |
| YN92A | 250 ECW 0.125mm40swg | £4.25 |
| BL61R | EC Wire 0.1mm 42swg | £1.45 |
| BL62S | EC Wire 0.08mm 44swg | £1.98 |
| BL11M | TC Wire 1.6mm 16swg | 62p |
| BL12N | TC Wire 1.25mm 18swg | 65p |
| BL13P | TC Wire 0.9mm 20swg | 68p |
| BL14Q | TC Wire 0.71mm 22swg | 75p |
| BL15R | TC Wire 0.56mm 24swg | 80p |

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|---|---|---|
| XR01B | Min Mains Black | 26p |

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| | | |
|---|---|---|
| XS13P | Earthing Wire | 80p |

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| | | |
|---|---|---|
| XR26D | Multi-Core 6-Way | 56p |
| XR27E | Multi-Core 9-Way | 68p |
| XR28F | Multi-Core 15-Way | 98p |
| XR46A | Multi-Core 25-Way | £1.36 |
| XR54J | Multi-Core 36-Way | £1.75 |

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| | | |
|---|---|---|
| PB28F | 25m Systflex 1mm Blk | £1.20 |
| PB29G | 25m Systflex 1mm Grn | £1.20 |
| PB30H | 25m Systflex 1mm Red | £1.20 |

## Capacitors

**Page 121**

| | | | |
|---|---|---|---|
| | | 1+ | 100+ |
| WX53H | Ceramic 56 | 10p | 9p |
| WX54J | Ceramic 68 | 10p | 9p |
| WX55K | Ceramic 82 | 10p | 9p |
| WX56L | Ceramic 100 | 10p | 9p |
| WX57M | Ceramic 120 | 12p | 10p |
| WX58N | Ceramic 150 | 12p | 10p |
| WX59P | Ceramic 180 | 12p | 10p |
| WX60Q | Ceramic 220 | 12p | 10p |
| WX61R | Ceramic 270 | 14p | 12p |
| WX62S | Ceramic 330 | 14p | 12p |
| WX73Q | Ceramic 2700 | 10p | 9p |
| WX74R | Ceramic 3300 | 10p | 9p |
| WX75S | Ceramic 3900 | 10p | 9p |
| WX76H | Ceramic 4700 | 10p | 9p |
| WX77J | Ceramic 10,000 | 12p | 10p |
| WX78K | Ceramic 22,000 | 12p | 10p |

**Page 122**

| | | |
|---|---|---|
| WX31J | Mica 4700pF | *DIS* |

**Page 123**

| | | | |
|---|---|---|---|
| BX25C | Polystyrene 33 | *DIS* | |
| | | 1+ | 25+ |
| BX94C | Polystyrene 47,000 | 45p | 42p |

**Page 124**

| | | | |
|---|---|---|---|
| | | 1+ | 100+ |
| BX84F | Polyester 2.2uF | 68p | 59p |

**Page 126**

| | | | |
|---|---|---|---|
| FB91Y | Axial 2200uF 50V | £1.48 | £1.13 |
| FB92A | Axial 2200uF 63V | £1.56 | £1.27 |

**Page 128**

| | | | |
|---|---|---|---|
| | | 1+ | 50+ |
| WL69A | Trimmer 10pF | 30p | 27p |
| WL70M | Trimmer 22pF | 38p | 34p |
| WL72P | Trimmer 65pF | 40p | 35p |

**Page 130**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| HX99H | Ceramic Fltr 10.7MHz | £1.36 | £1.27 |
| UF71N | Fltr 10.7MHz/50kHz | £1.36 | £1.27 |

## Communications

**Page 140**

| | | |
|---|---|---|
| | | 1+ |
| HK25C | HD-1234 Antenna Sw | £39.95 |
| HK24B | HN-31A Cantenna Load | £34.95 |

**Page 143**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| FT47B | Twin Second Jk 5/6A | £3.95 | £3.25 |

## Connectors

**Page 147**

| | | | |
|---|---|---|---|
| HH17T | BNC Plug 50 | £1.45 | £1.20 |
| FE99H | BNC Plug 75 | £1.86 | £1.61 |
| HH18U | BNC Round Skt 50 | £1.25 | £1.13 |
| FE31J | BNC Round Skt 75 | £1.40 | £1.21 |

**Page 148**

| | | | |
|---|---|---|---|
| FJ76H | Car AE Line Skt | 56p | 50p |

**Page 151**

| | | | |
|---|---|---|---|
| JL99H | Grounding Post | 48p | 39p |

**Page 153**

| | | | |
|---|---|---|---|
| RK62S | D-Range 9-Way Cover | £1.20 | 97p |
| BK60Q | D-Range 15-Way Cover | £1.28 | £1.14 |
| YQ50E | D-Range 25-Way Cover | £1.36 | £1.20 |

**Page 162**

| | | | |
|---|---|---|---|
| FT87U | 20W IDC Edge Connctr | £2.25 | £2.07 |

**Page 163**

| | | |
|---|---|---|
| FV83E | Stg Transheader 16w | *DIS* |
| FV86T | Stg Transheader 34w | *DIS* |
| FA53H | Stg Transheader 40w | *DIS* |
| FA54J | Stg Transheader 50w | *DIS* |

**Page 165**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| JB21X | 2x1/4skt x3.5plg Mon | 98p | 83p |

**Page 172**

| | | | |
|---|---|---|---|
| HL43W | Euro Facility Plug | £2.85 | £2.65 |

**Page 173**

| | | | |
|---|---|---|---|
| FE79L | R/A Euroconn Lead | £2.65 | £2.42 |
| | | 1+ | 10+ |
| YZ10L | 4 Way Mains Conn | £9.75 | £8.69 |
| YZ11M | [A] 6 Way Mains Conn | £13.95 | £12.52 |

**Page 174**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| HL23A | Mains Socket P430SE | £1.65 | £1.51 |
| HL37S | Mains Socket P636 | £1.75 | £1.61 |

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| | | | |
|---|---|---|---|
| | | 1+ | 100+ |
| HL51F | Boot 9455 | 52p | 48p |
| FK96E | Batt Pl Skt Pair | 80p | 72p |
| FK97F | GP Pl Skt Pair | 75p | 57p |
| | | 1+ | 25+ |
| HL01B | Octal Ch Plug | £1.75 | £1.61 |
| HL00A | Octal Ch Skt | £1.45 | £1.15 |
| HL02C | 8-way Plug | £2.25 | £2.07 |
| HL03D | 8-way Socket | £2.45 | £2.28 |

**Page 177**

| | | |
|---|---|---|
| FL84F | Edge Conn 116 | *DIS* |

**Page 178**

| | | |
|---|---|---|
| JB79L | 0.156in 2x28way Egcn | *DIS* |

**Page 181**

| | | | |
|---|---|---|---|
| FK07H | PCB Mini DC Pwr Skt | 36p | 33p |

**Page 187**

| | | |
|---|---|---|
| RK85G | Video Lead 2 | *DIS* |

## Electrical Accessories

**Page 189**

| | | | |
|---|---|---|---|
| | | 1+ | 50+ |
| FE78K | Terminal Block 2A | 48p | 42p |
| HF01B | Terminal Block 5A | 60p | 44p |
| HL54J | Terminal Block 15A | 75p | 60p |
| HL55K | Terminal Block 30A | £1.36 | £1.04 |
| | | 1+ | 25+ |
| HL56L | Terminal Block Conn | £2.45 | £1.98 |
| HL58N | Rubber 13A Plug | £1.56 | £1.43 |
| HL61R | Flex Connector | £1.98 | £1.81 |

**Page 190**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| HL62S | Mains Adaptor 2-way | £1.28 | 98p |
| HL63T | Mains Adaptor 3-way | £2.25 | £1.90 |
| HL64U | Shaver Adaptor | £1.20 | 92p |
| HL65V | Junction Box Small | 75p | 64p |
| | | 1+ | |
| HL68Y | Single Skt Unswtched | £2.45 | |
| XJ81C | [A] Single Skt Unsw 10pk | £19.95 | |
| HL69A | Dble Skt Unswitched | £4.45 | |
| XJ82D | [A] Double Skt Unsw 5pk | £18.95 | |
| JG35Q | Triple Skt Unswtched | £8.95 | |

*£1.00 handling charge must be added to each mail-order. [A], [B] etc. against price indicates additional charge for carriage (see Order Coupon).*

| 1991 Catalogue Page No. | | VAT Inclusive Price | |
|---|---|---|---|
| XJ94C | [C] Triple Skt Unsw 5pk | £39.95 | |
| HL71N | Single Sw Socket | £2.75 | |
| XJ83E | [B] Single Sw Skt 10pk | £23.95 | |
| JG40T | Metal Single Sw Skt | £5.45 | |
| XJ98G | [B] Mtl Sngl Sw Skt 5pk | £24.95 | |
| XJ84F | [A] Double Sw Skt 5pk | £20.95 | |
| JG41U | Metal Double Sw Skt | £9.45 | |
| XJ99H | [D] Mtl Dbl Sw Skt 5pk | £44.95 | |

**Page 191**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| YN46A | [A] Extn Lead 13A | £9.95 | £8.00 |
| | | 1+ | 10+ |
| HL76H | Cooker Switch | £9.45 | £8.80 |
| HL78K | Shaver Skt Isolated | £22.95 | £20.93 |
| | | 1+ | 25+ |
| HL83E | Switched Flex Outlet | £4.75 | £4.13 |
| HL86T | Blanking Plate | £1.20 | 97p |
| | | 1+ | |
| HL87U | 20A Plateswitch | £3.95 | |
| JG30H | 20A Neon Plateswitch | £5.75 | |
| HL89W | Light Swch ST Single | £1.65 | |
| XJ85G | [A] Light Sw ST 1W 10pk | £11.95 | |
| HL90X | Light Swch DT Single | £1.98 | |
| HL91Y | Light Swch Dual | £3.45 | |

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| | | | |
|---|---|---|---|
| HL92A | Light Switch Triple | £4.45 | |
| | | 1+ | 10+ |
| FQ16S | Auto Security Switch | £21.95 | £19.95 |
| | | 1+ | |
| JG31J | Metal Box 16mm | 98p | |
| XJ88V | [B] Metal Box 16mm 20pk | £11.95 | |
| JG32K | Metal Box 25mm | £1.06 | |
| XJ89W | [A] Metal Box 25mm 10pk | £7.95 | |
| JG33L | Metal Box 2-way 25mm | £1.25 | |
| XJ90X | [A] Metal Bx 2w 25mm 5pk | £5.45 | |
| JG34M | Metal Box 2-way 47mm | £1.98 | |
| YB14Q | Sur Patt 20mm Sngl | £1.06 | |
| YP99H | [A] Patt 20mm Sngl 10pk | £7.75 | |
| YB15R | Sur Patt 29mm Sngl | £1.16 | |
| XJ91Y | [A] Patt 29mm Sngl 10pk | £8.45 | |
| YB16S | Sur Patt 29mm Dble | £1.98 | |
| XJ92A | [A] Patt 29mm Dble 5pk | £8.45 | |

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| | | | |
|---|---|---|---|
| YB17T | Sur Patt 47mm Dble | £2.95 | |
| YB18U | Conversion Pattress | £3.45 | |
| XJ93B | [A] Conv Pattress 5pk | £14.95 | |
| JG36P | 3-way Conv Pattress | £4.45 | |
| XJ95D | [B] 3w Conv Pattress 5pk | £17.95 | |
| FQ02C | BC Lampholder | £1.45 | |
| YP98G | Lampholder 10pk | £10.95 | |
| JG37S | Rose and Pendant 6in | £3.45 | |
| YT00A | [A] Rose Pendant 6in 5pk | £14.95 | |
| LB63T | Bayonet L/Hldr | £1.16 | |
| XJ87U | Battenholder 10pk | £8.95 | |
| FQ05F | Ceiling Rose | £1.48 | |
| XJ86T | Ceiling Rose 10pk | £10.95 | |
| JG38R | Rose Lampholder | £3.45 | |
| XJ96E | Rose Lampholder 10pk | £27.95 | |
| | | 1+ | 100+ |
| FQ07H | Starter 80W | 28p | 22p |
| JK70M | ES Panel Lampholder | £1.20 | 91p |
| | | 1+ | 25+ |
| BK69A | ES to BC Adaptor | £2.75 | £2.47 |

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| | | | |
|---|---|---|---|
| BK70M | BC to ES Adaptor | £1.98 | £1.73 |
| | | 1+ | 10+ |
| XJ78K | [A] Consmr Unit 12W 100A | £22.95 | £19.15 |
| | | 1+ | |
| XJ79L | [C] Consmr Unit wth ELCB | £59.95 | |
| XJ80B | Door for Consmr Unit | £3.45 | |
| | | 1+ | 10+ |
| JG42V | 6A MCB | £5.45 | £4.75 |
| JG43W | 16A MCB | £5.45 | £4.75 |
| JG46A | 20A MCB | £5.45 | £4.75 |
| JG44X | 32A MCB | £5.45 | £4.75 |
| JG45Y | 50A MCB | £6.45 | £5.45 |

## Entertainment

**Page 197**

| | | | |
|---|---|---|---|
| YU80B | Stereo Headphones | DIS | |

## Hardware

**Page 207**

| | | | |
|---|---|---|---|
| JC80B | Pozi Screw M5 20mm | 24p | 20p |
| BF33L | Pozi Screw M4 6mm | 20p | 18p |
| JC73Q | Pozi Screw M4 10mm | 20p | 18p |
| JC74R | Pozi Screw M4 16mm | 20p | 18p |
| JC75S | Pozi Screw M4 20mm | 20p | 18p |
| JC76H | Pozi Screw M4 30mm | 24p | 20p |
| BF38R | Pozi Screw M3 25mm | 30p | 26p |
| JC72P | Pozi Screw M3 30mm | 36p | 33p |
| LR58N | Pozi Screw M3 40mm | 44p | 40p |
| JC68Y | Pozi Screw M2.5 10mm | 16p | 12p |
| JC69A | Pozi Screw M2.5 20mm | 26p | 23p |
| JC66W | Pozi Screw M2 10mm | 24p | 21p |
| JC67X | Pozi Screw M2 12mm | 30p | 27p |
| JD25C | Isobolt M5 10mm | 52p | 46p |
| BF46A | Isobolt M5 12mm | 56p | 49p |
| JD26D | Isobolt M5 16mm | 62p | 56p |
| JD27E | Isobolt M5 20mm | 68p | 63p |
| JD28F | Isobolt M5 25mm | £1.36 | £1.18 |
| JD29G | Isobolt M5 40mm | £2.05 | £1.73 |
| BF48C | Isobolt M4 6mm | 36p | 32p |
| JD20W | Isobolt M4 10mm | 38p | 34p |
| BF49D | Isobolt M4 12mm | 40p | 35p |
| JD21X | Isobolt M4 16mm | 42p | 37p |
| JD22Y | Isobolt M4 20mm | 46p | 42p |
| BF50E | Isobolt M4 25mm | 56p | 51p |
| JD23A | Isobolt M4 30mm | £1.65 | £1.56 |
| JD24B | Isobolt M4 40mm | £1.65 | £1.56 |
| BF51F | Isobolt M3 6mm | 28p | 23p |
| HY30H | Isobolt M3 10mm | 28p | 23p |
| BF52G | Isobolt M3 12mm | 28p | 23p |
| JD16S | Isobolt M3 16mm | 28p | 23p |
| JD17T | Isobolt M3 20mm | 98p | 92p |
| BF53H | Isobolt M3 25mm | 98p | 90p |
| JD18U | Isobolt M3 30mm | 98p | 92p |
| BF54J | Isobolt M2.5 6mm | 86p | 79p |
| JD14Q | Isobolt M2.5 10mm | 86p | 76p |
| BF55K | Isobolt M2.5 12mm | 86p | 76p |
| JD15R | Isobolt M2.5 20mm | 98p | 88p |
| JD11M | Isobolt M2 6mm | 98p | 88p |
| JD12N | Isobolt M2 10mm | 98p | 88p |
| JD13P | Isobolt M2 12mm | 98p | 88p |
| JD61R | Steel Nut M3 | 12p | 10p |
| JD62S | Steel Nut M2.5 | 18p | 15p |
| JD63T | Steel Nut M2 | 18p | 15p |
| BF56L | Isonut M5 | 36p | 32p |
| BF57M | Isonut M4 | 28p | 23p |
| BF58N | Isonut M3 | 28p | 23p |
| BF59P | Isonut M2.5 | 20p | 17p |
| LR59P | Isonut M2 | 20p | 17p |
| JD75S | Steel Washer M4 | 10p | 9p |
| JD76H | Steel Washer M3 | 8p | 7p |
| JD77J | Steel Washer M2.5 | 8p | 7p |
| JD78K | Steel Washer M2 | 8p | 7p |
| BF60Q | Isowasher M5 | 20p | 18p |
| BF61R | Isowasher M4 | 14p | 12p |
| BF62S | Isowasher M3 | 14p | 12p |
| BF63T | Isowasher M2.5 | 14p | 12p |

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| | | | |
|---|---|---|---|
| JD94C | Springwash M5 | 10p | 9p |
| JD95D | Springwash M4 | 10p | 9p |
| JD96E | Springwash M3 | 10p | 9p |
| JD97F | Springwash M2.5 | 10p | 9p |
| JD98G | Springwash M2 | 10p | 9p |
| BF42V | Isoshake M5 | 10p | 9p |
| BF43W | Isoshake M4 | 10p | 9p |
| BF44X | Isoshake M3 | 10p | 9p |
| BF45Y | Isoshake M2.5 | 10p | 9p |
| LR61R | Isoshake M2 | 10p | 9p |
| LR63T | Isotag M4 | 56p | 49p |
| LR64U | Isotag M3 | 48p | 37p |
| BF02C | Bolt 4BA 1 4in | 32p | 28p |
| BF03D | Bolt 4BA 1 2in | 36p | 33p |
| BF04E | Bolt 4BA 1in | 48p | 42p |
| BF05F | Bolt 6BA 1 4in | 24p | 20p |
| BF07H | Bolt 6BA 1in | 80p | 75p |
| BF08J | Bolt 8BA 1 4in | 86p | 79p |
| BF09K | Bolt 8BA 1 2in | 86p | 79p |
| FP69A | Bolt 8BA 3 4in | 86p | 75p |
| BF10L | C/S Screw 4BA 1 2in | 18p | 15p |
| LR56L | C S Screw 6BA 1/4in | 20p | 18p |
| BF12N | C S Screw 6BA 1 2in | 20p | 17p |
| LR00A | C S Screw 8BA 1 2in | 20p | 17p |
| | | 1+ | |
| BF14Q | Panel Screw | 8p | |
| LR75S | C/S Panel Screw | 10p | |
| | | 1+ | 10+ |
| BF16S | Nut 2BA | 48p | 42p |
| BF18U | Nut 6BA | 18p | 14p |
| BF19V | Nut 8BA | 18p | 14p |
| BF20W | Washer 2BA | 18p | 14p |
| BF21X | Washer 4BA | 18p | 14p |
| BF22Y | Washer 6BA | 18p | 14p |
| BF23A | Washer 8BA | 18p | 14p |
| BF24B | Shake 2BA | 10p | 9p |
| BF25C | Shake 4BA | 10p | 9p |
| BF26D | Shake 6BA | 10p | 9p |
| LR01B | Shake 8BA | 10p | 9p |
| BF28F | Tag 4BA | 24p | 20p |
| BF29G | Tag 6BA | 24p | 20p |
| LR02C | Tag 8BA | 24p | 20p |
| LR67X | Slf-Tpr No.6 x 3 8in | 24p | 20p |
| BF67X | Slf-Tpr No.6 x 1 2in | 24p | 21p |
| FE68Y | Slf-Tpr No.4 x 1 4in | 24p | 20p |
| BF65V | Slf-Tpr No.4 x 3 8in | 24p | 20p |
| BF66W | Slf-Tpr No.4 x 1 2in | 24p | 20p |
| BF64U | Slf-Tpr No.2 x 3 16" | 24p | 20p |
| LR68Y | Slf-Tpr No.2 x 3 8in | 24p | 20p |

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| | | | |
|---|---|---|---|
| | | 1+ | |
| BF84F | Nyl Washer 6BA | 16p | |
| FP98G | 4 x 1/4 PoziCsk Scrw | 26p | |
| LB99H | Blk Wdscrw No 4 1/2" | 15p | |
| | | 1+ | 25+ |
| YL23A | Hand Wheel Bolt | 36p | 30p |
| | | 1+ | |
| FE69A | Hex Clear Spacer | 80p | |
| LR71N | Threaded Spacer 4BA | £1.36 | |
| FG39N | Threaded Spacer M4 | £1.28 | |

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| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| FB98G | Rubber Coupling | £1.20 | £1.10 |
| | | 1+ | 25+ |
| BK87U | Snap Rivet | 52p | 46p |
| JU39N | Std Grommet 4.0mm | 4p | |
| FW59P | Thk Grommet 6.4mm | 5p | |
| FW60Q | Std Grommet 9.5mm | 6p | 53p |
| JU41U | Std Grommet 15.5mm | 9p | |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| JU42V | Blnk Grommet 15.5 | 8p | |
| JU43W | Blnk Grommet 20.0 | 10p | 9p |
| JU44X | Blnk Grommet 25.4mm | 14p | 13p |
| | | 1+ | |
| JP12N | L Corner | 32p | |

## Heathkit

**Page 213**

| | | | |
|---|---|---|---|
| HK71N | GD-1701 Flood Alarm | DIS | |

**Page 214**

| | | | |
|---|---|---|---|
| MF35Q | SCD-1 Suprcndctr Kit | DIS | |
| HK04E | EE-3140 Hooby Elect | £65.95 | |
| HK32K | EE-3100 Basic Eltrty | £53.95NV | |

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| | | | |
|---|---|---|---|
| HK08J | EE-3104A Elect Crs | £79.95 | |
| HK09K | EE-3105A Tst Eqp Crs | £129.95 | |
| HK42V | EE-3106 Elct Com Crs | £85.95 | |

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| | | | |
|---|---|---|---|
| HK10L | ET-3600 Analog Trner | £174.95 | |
| MF28F | Heathkit ET-3567 | £199.95 | |

**Page 217**

| | | | |
|---|---|---|---|
| HK13P | ET-3700 Digital Trnr | £189.95 | |
| MF38R | ETI-7510 Repair Dig | £94.95 | |

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| | | | |
|---|---|---|---|
| HK18U | ET-3400A Micro Trnr | £319.95 | |
| HK19V | ETW-3400A Assembled | £459.95 | |

## Knobs

**Page 223**

| | | | |
|---|---|---|---|
| | | 1+ | 100+ |
| WL45Y | 15mm Collet Cap Blk | 8p | 7p |
| WL46A | 15mm Collet Cap Blue | 8p | 7p |
| WL47B | 15mm Collet Cap Grn | 8p | 7p |
| WL48C | 15mm Collet Cap Grey | 8p | 7p |
| WL49D | 15mm Collet Cap Red | 8p | 7p |
| WL50E | 15mm Collet Cap Yllw | 8p | 7p |
| | | 1+ | 50+ |
| WL43W | 3 8in Nut | 28p | 26p |
| WL44X | 10mm Nut | 28p | 26p |

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| | | | |
|---|---|---|---|
| RX29G | Spindle Coupler | £1.48 | £1.41 |
| RX30H | Ext Spindle | £1.65 | £1.59 |
| RX44X | Flywheel | DIS | |

## Microphones

**Page 227**

| | | | |
|---|---|---|---|
| YN10L | Spctrm 600 Mic Yellw | DIS | |

## Musical & Effects

**Page 233**

| | | | |
|---|---|---|---|
| YP48C | Mini Guitar Amp | DIS | |

**Page 236**

| | | | |
|---|---|---|---|
| YM88V | Mic Mixer | DIS | |

## Opto–electrical

**Page 244**

| | | | |
|---|---|---|---|
| | | 1+ | 250+ |
| RX60Q | Holder MES Green | £1.56 | £1.33 |
| RX61R | Holder MES Red | £1.56 | £1.33 |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| HQ64U | Lensholder | £1.56 | £1.38 |

## Panel Meters

**Page 260**

| | | | |
|---|---|---|---|
| LB80B | Sig Strength Meter | £2.65 | £2.36 |
| LB79L | Tuning Meter | £2.65 | £2.36 |

## PCB Equipment

**Page 262**

| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| FL19V | DIP Board | £7.95 | £7.31 |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| FL20W | Pin 2140 | £1.65 | £1.56 |
| FL23A | Pin 2144 | £1.20 | £1.13 |
| FL24B | Pin 2145 | £1.20 | £1.13 |

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| | | | |
|---|---|---|---|
| FL80B | Pin 0266 Pk of 100 | £4.25 | £3.97 |
| | | 1+ | 5+ |
| FP39N | Wiring Combs Pk 100 | £12.45 | £11.85 |
| | | 1+ | 25+ |
| FL29G | 13-Way Tagstrip | 32p | 29p |
| | | 1+ | 10+ |
| YL11M | Vero Plugblock | £9.95 | £9.32 |

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| | | | |
|---|---|---|---|
| XB43W | [A] Seno Etch System | £9.95 | £8.57 |

**Page 271**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| BW21X | Track Tape 31 | £1.48 | £1.38 |
| BW22Y | Track Tape 40 | £1.48 | £1.38 |
| BW23A | Track Tape 50 | £1.48 | £1.38 |
| BW25C | Track Tape 80 | £1.98 | £1.84 |
| BW26D | Track Tape 100 | £1.98 | £1.84 |
| BW27E | Track Tape 125 | £2.10 | £1.94 |
| BW28F | Track Tape 150 | £2.75 | £2.59 |
| BW29G | Track Tape 200 | £2.75 | £2.59 |
| BW30H | Pad 075 | £2.25 | £2.10 |
| BW31J | Pad 100 | £2.25 | £2.10 |
| BW32K | Pad 125 | £2.25 | £2.10 |
| BW33L | Pad 150 | £2.25 | £2.10 |
| BW34M | Pad 200 | £2.25 | £2.10 |
| FJ57M | Pad 250 | DIS | |
| BW35Q | Pad 300 | DIS | |
| | | 1+ | 10+ |
| BW39N | IC Pads 100 | £5.95 | £5.66 |

## Projects & Modules

**Page 273**

| | | | |
|---|---|---|---|
| | | 1+ | |
| FS01B | Geiger Front Label | £1.75 | |
| FS02C | Geiger Rear Sml Labl | £1.75 | |
| FS03D | Geiger Rear Lrg Labl | £1.75 | |

**Page 275**

| | | | |
|---|---|---|---|
| LW74R | Radar Ch PSU Module | £19.95 | |
| LW75S | Radar Extr Ch Module | £6.95 | |

**Page 278**

| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| LM79L | Aud/Vid Mod Hard Kit | £9.95 | £8.95 |

**Page 279**

| | | | |
|---|---|---|---|
| | | 1+ | |
| GD69A | Temp Mod Ser/Par Bd | £6.95 | |

**Page 282**

| | | | |
|---|---|---|---|
| GE30H | Ioniser Pick-Up Bd | 98p | |
| | | 1+ | 10+ |
| LM97F | Ioniser Kit | £32.95 | £30.95 |

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|---|---|---|---|
| | | 1+ | 25+ |
| LP30H | 1/300 Timer | £4.95 | £4.45 |

**Page 290**

| | | | |
|---|---|---|---|
| | | 1+ | |
| GB67X | RTTY Terminal PCB | £10.95 | |

**Page 293**

| | | | |
|---|---|---|---|
| YT05F | [B] Box Drilled + Chssis | DIS | |

**Page 296**

| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| YM16S | Gen Purp I P Str Ass | £9.95 | £8.95 |
| | | 1+ | |
| LR34M | HQ Mixer PCB No.24 | £3.65 | |

**Page 297**

| | | | |
|---|---|---|---|
| GD34M | Lo-z Mic Preamp PCB | £2.36 | |
| | | 1+ | 10+ |
| LK87U | Line Amp Kit | £5.95 | £5.25 |
| YM21X | Line Amp Assembled | £8.95 | £7.95 |
| | | 1+ | |
| LR23A | HQ Mixer PCB No.8 | £2.95 | |
| | | 1+ | 10+ |
| LK85G | Peak Overload Kit | £3.25 | £2.95 |
| YM19V | Peak Overload Assbld | £5.75 | £5.25 |
| | | 1+ | |
| LR21X | HQ Mixer PCB No.6 | £1.86 | |
| | | 1+ | 10+ |
| LK83E | Tone Cntrl mono Kit | £4.75 | £4.25 |
| YM17T | Tone Cntrl mono Ass | £7.45 | £6.75 |

**Page 299**

| | | | |
|---|---|---|---|
| GA31J | Compander PSU PCB | DIS | |
| XG37S | [A] Mk N R Unit Case | DIS | |

**Page 302**

| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| LP03D | TDA2822 Stro Pwr Amp | £6.95 | £6.45 |
| | | 1+ | 25+ |
| LP16S | TDA7052 Kit | £3.95 | £3.57 |
| | | 1+ | 10+ |
| LW36P | 8W Amp Kit | £6.95 | £6.27 |

**Page 303**

| | | | |
|---|---|---|---|
| YQ43W | 15W Amp Kit | £6.95 | £6.25 |
| YQ37S | 15W Amp Module | £9.75 | £8.75 |

**Page 306**

| | | | |
|---|---|---|---|
| | | 1+ | |
| GA28F | 150W MOSFET PCB | £2.95 | |

**Page 307**

| | | | |
|---|---|---|---|
| GD80B | HP Mosfet Driver PCB | £4.45 | |
| | | 1+ | 2+ |
| LM50E | HP Mosfet Driver Kit | £11.95 | £11.35 |
| | | 1+ | |
| GD91Y | Watt Watcher PCB | £3.20 | |
| | | 1+ | 25+ |
| LM57M | Watt Watcher Kit | £5.25 | £4.75 |

**Page 308**

| | | | |
|---|---|---|---|
| | | 1+ | |
| GD72P | D Party Contrllr PCB | £4.95 | |
| GD20W | ADA Digital Echo PCB | £6.45 | |

**Page 311**

| | | | |
|---|---|---|---|
| GD83E | Tunes Generator PCB | £3.95 | |
| | | 1+ | 10+ |
| LM47B | Multi-tune Gen Kit | £10.95 | £9.95 |

**Page 313**

| | | | |
|---|---|---|---|
| | | 1+ | |
| GD63T | Mini Metal Detctr Bd | £1.48 | |

**Page 316**

| | | | |
|---|---|---|---|
| GD44X | 4 1 2 Dig Countr PCB | £7.95 | |
| | | 1+ | 10+ |
| LM19V | 4.5 Digit Countr Kit | £25.95 | £22.95 |
| | | 1+ | |
| RK39N | Freq Cnt Front Panel | £3.75 | |

**Page 317**

| | | | |
|---|---|---|---|
| GD29G | Fib Optic Tx PCB | £2.45 | |
| GD28F | Fib Optic Rx PCB | £3.65 | |
| | | 1+ | 10+ |
| LM12N | Fib Optic Tx Kit | £8.95 | £7.65 |
| LM11M | Fib Optic Rx Kit | £9.95 | £8.95 |

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| | | | |
|---|---|---|---|
| | | 1+ | 5+ |
| LK95D | Digitiser Kit | £38.95 | £34.95 |
| | | 1+ | 10+ |
| LK51F | Light Pen Kit | £9.95 | £8.95 |

**Page 325**

| | | | |
|---|---|---|---|
| | | 1+ | |
| GD05F | Amstrad Controller | DIS | |
| GD37S | Reversiboard | DIS | |
| FA86T | 50 way Amstrad Cable | DIS | |
| FA88V | Amstrad Front Panel | DIS | |
| FA89W | Amstrad Rear Panel | DIS | |
| LK97F | [B] Amstrad ROM Card Kit | DIS | |
| YM57M | [B] Amstrad Contrllr Asm | DIS | |
| GD04E | Amstrad Motherboard | £9.95 | |
| | | 1+ | 10+ |
| LK98G | Amstrad Motherbd Kit | £18.95 | £15.95 |

*£1.00 handling charge must be added to each mail-order. [A], [B] etc. against price indicates additional charge for carriage (see Order Coupon).*

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|---|---|---|---|

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|---|---|---|---|
| | | 1+ | |
| GD06G | Amstrad 6x8 bit PCB | £12.95 | |
| | | 1+ | 10+ |
| LM02C | Amstrad 6x8 Bit Kit | £24.95 | £21.95 |
| | | 1+ | |
| GD07H | Amstrad PSU PCB | DIS | |
| XH65V | Amstrad Booklet | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| LP10L | SP0256 Kit | £15.95 | £14.45 |
| | | 1+ | 5+ |
| LM80B | Rec Playbk Kit | £38.95 | £34.95 |
| | | 1+ | |
| GD88V | Rec Playback PCB | £8.75 | |

## Protection

**Page 333**

| | | | |
|---|---|---|---|
| WH49D | Fuse Clip | 4p | |

**Page 334**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| HW04E | RF Supp Choke 1A | 36p | 35p |
| HW05F | RF Supp Choke 2A | 40p | 37p |
| HW06G | RF Supp Choke 3A | 45p | 42p |

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| | | | |
|---|---|---|---|
| | | 1+ | 50+ |
| YR90X | R-C Network | £1.65 | £1.57 |
| | | 1+ | 25+ |
| HW07H | Delta Cap | £1.06 | 94p |

## Radio Control

**Page 344**

| | | | |
|---|---|---|---|
| | | 1+ | |
| JP93B | Blaster Tie Clips | DIS | |

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| | | | |
|---|---|---|---|
| JL66W | BJ Front Whl Assmbly | DIS | |
| JR41U | Big John Aerial | 48p | |
| JL71N | BJ Front Shocks | DIS | |

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| | | | |
|---|---|---|---|
| JF61R | Killer 2130 | DIS | |
| JF74R | Killer 2250 | DIS | |
| JF91Y | Killer 4015 | DIS | |

**Page 349**

| | | | |
|---|---|---|---|
| JF09K | Beagle BG-50 | DIS | |

## Resistors

**Page 355**

| | | | |
|---|---|---|---|
| WR79L | Hor0.25W Preset 220R | DIS | |
| WR83E | Hor0.25W Preset 4k7 | DIS | |
| WR92A | Hor0.25W Preset 4M7 | DIS | |
| WW02C | Vrt0.25W Preset 470R | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | |
| YP02C | High Power Pot 47R | £2.68 | |
| YP03D | High Power Pot 100R | £2.68 | |
| YP04E | High Power Pot 470R | £2.68 | |
| YP05F | High Power Pot 1k | £2.68 | |
| YP06G | High Power Pot 4k7 | £2.68 | |
| YP07H | High Power Pot 10k | £2.68 | |
| YP08J | High Power Pot 47k | £2.68 | |
| YP09K | High Power Pot 100k | £2.68 | |
| YP10L | High Power Pot 1M | £2.68 | |

**Page 358**

| | | | |
|---|---|---|---|
| FX07H | Slide Bezel | 65p | |

## Semiconductors

**Page 365**

| | | | |
|---|---|---|---|
| UJ22Y | BUV48A | DIS | |

**Page 366**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| YH98G | 2N3055 | 75p | 65p |
| QH59P | MPF102 | 75p | 69p |

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| | | | |
|---|---|---|---|
| WQ96E | VN46AF | £1.06 | 92p |
| WQ97F | VN66AF | £1.48 | £1.36 |
| QH74R | QA200 | DIS | |

**Page 369**

| | | | |
|---|---|---|---|
| QL05F | SC146D | DIS | |

**Page 380**

| | | | |
|---|---|---|---|
| UH72P | 74AC373 | DIS | |

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|---|---|---|---|
| UF18U | 74HC4514 | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| UL33L | LM837 | £2.45 | £1.93 |
| UL05F | OP-77GP | £1.68 | £1.43 |

**Page 394**

| | | | |
|---|---|---|---|
| UJ35Q | L465A | £4.95 | £4.14 |

**Page 396**

| | | | |
|---|---|---|---|
| RA75S | TLC251CP | £2.45 | £1.96 |

**Page 401**

| | | | |
|---|---|---|---|
| QH39N | LM2879 | DIS | |
| QL13P | TBA810P | £1.56 | £1.29 |
| | | 1+ | |
| BR02C | 5W Amp PCB | £2.75 | |

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| | | | |
|---|---|---|---|
| RA79L | LMC835N | DIS | |

**Page 413**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| RA81C | SAA1099 | £9.95 | £8.63 |

**Page 416**

| | | | |
|---|---|---|---|
| UK83E | ZNA234E | £14.95 | £12.71 |

**Page 418**

| | | | |
|---|---|---|---|
| WQ37S | LM3820 | DIS | |
| QH45Y | MC1310P | DIS | |
| BR03D | Decoder PCB | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| YH67X | ML922 | £7.25 | £6.10 |
| QR57M | ML926 | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| UK71N | L297 | £4.95 | £4.26 |

**Page 431**

| | | | |
|---|---|---|---|
| FP62S | ICM7224IPL | £12.95 | £9.78 |

**Page 435**

| | | | |
|---|---|---|---|
| YY76H | TDA1024 | DIS | |

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| | | | |
|---|---|---|---|
| QL34M | uA7805KC | DIS | |
| WQ91Y | uA79MGU1C | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | |
| YQ39N | 0.1A Reg PSU PCB | £2.65 | |

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| | | | |
|---|---|---|---|
| UF48C | ADC0844CCN | DIS | |
| UF47B | DAC0832LCN | DIS | |

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|---|---|---|---|
| | | 1+ | 25+ |
| QW94C | 7106 | £7.45 | £6.04 |

**Page 457**

| | | | |
|---|---|---|---|
| WR31J | Transkt 3-Lead TO5 | 28p | 26p |
| WR26D | Kit TO126 | 12p | |
| WR23A | Kit (P) Plas | 12p | |
| XX14Q | Soldercons | £2.95 | £2.76 |

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| | | | |
|---|---|---|---|
| FA06G | Header 40-pin | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| HQ81C | 8W Hi-Fi Heatsink | £1.75 | £1.61 |
| HQ69A | 50W Hi-Fi Heatsink | £1.98 | £1.84 |

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| | | | |
|---|---|---|---|
| FL54J | Heatsink 10DN | £2.95 | £2.82 |

## Speakers & Sounders

**Page 465**

| | | | |
|---|---|---|---|
| QY16S | Rubber Disc 27mm | 10p | 9p |

## Switches & Relays

**Page 480**

| | | | |
|---|---|---|---|
| | | 1+ | |
| JR79L | Small Toggle Cover | £1.28 | |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| BK68Y | SPCO Nonlock Switch | £2.75 | £2.60 |

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| | | | |
|---|---|---|---|
| FP51F | Mod Sw Momentary | £1.48 | £1.33 |
| FP52G | Mod Sw Latching | £1.80 | £1.61 |
| | | 1+ | 50+ |
| UH76H | Mod Sw LED Red | 80p | 72p |
| UH77J | Mod Sw LED Green | 80p | 72p |
| | | 1+ | 25+ |
| FT16S | Small Click Switch | 32p | 30p |
| FK85G | L P Cap Red | 28p | 27p |
| FK87U | L P Cap Green | 28p | 27p |
| FK89W | L P Cap White | 28p | 27p |
| FK91Y | L P Cap Blue | 28p | 27p |
| FK93B | L P Cap Black | 28p | 27p |

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| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| YR88V | Solenoid 12V | £7.75 | £7.42 |
| YR89W | Solenoid 240V AC | £8.95 | £8.57 |
| BK48C | Ult-Mn Rlay 6V DPDT | DIS | |
| YX95D | Ult-Mn Rlay 12V DPDT | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| FX89W | Dil Reed Relay 1p12V | £2.75 | £2.59 |
| | | 1+ | 50+ |
| FX68Y | Reed SW Standard | 86p | 81p |

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| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| FA74R | 13A Mercury Tilt Sw | £8.95 | £7.65 |
| | | 1+ | 25+ |
| FS99H | Encap Merc Switch | £3.95 | £3.34 |
| FA76H | 45deg Tipover Switch | £3.50 | £3.05 |
| FA77J | 79deg Tipover Switch | £2.65 | £2.30 |
| FE11M | Min Tilt Switch | £1.20 | £1.02 |
| UK57M | Vibration Switch | £2.20 | £1.90 |

## Test Gear

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| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| FS95D | Safety Lead 4mm | £5.95 | £5.20 |

**Page 502**

| | | | |
|---|---|---|---|
| UL72P | M3500TC Fuse | £2.65 | £2.36 |

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| | | | |
|---|---|---|---|
| | | 1+ | |
| HG12N | IG-5282 Audio Gen | £114.95 | |
| HK34M | IB-5281 RCL Bridge | £129.95 | |
| HE95D | IT-3120 Trans Tester | DIS | |
| HT51F | IM-5215 40kV Probe | £69.95 | |

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| | | | |
|---|---|---|---|
| HE98G | IT-5230 CRT Tester | DIS | |

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| | | | |
|---|---|---|---|
| YM67X | [C] M9020 | DIS | |

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| | | | |
|---|---|---|---|
| XG93B | [F] Hobby Audio Osc | DIS | |

## Tools

**Page 521**

| | | | |
|---|---|---|---|
| | | 1+ | 250+ |
| FR22Y | Storage Drawer | £1.06 | 84p |
| | | 1+ | 100+ |
| FG00A | Dbl Storage Drawer | £1.68 | £1.44 |

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|---|---|---|---|
| | | 1+ | 25+ |
| FP56L | Dividers A Pk of 12 | 98p | 92p |

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| | | | |
|---|---|---|---|
| | | 1+ | |
| FV47B | Robust Screwdriver | DIS | |
| FV49D | Crosspoint Driver 0 | DIS | |
| FV50E | Crosspoint Driver 1 | DIS | |
| FG03D | 5mm x no1 Angle Drvr | £1.06 | |
| FG04E | 6mm x no2 Angle Drvr | £1.20 | |

**Page 526**

| | | | |
|---|---|---|---|
| BR72P | Heavy Duty Cutter | DIS | |

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| | | | |
|---|---|---|---|
| FV54J | Min Long Nose Pliers | DIS | |

**Page 529**

| | | | |
|---|---|---|---|
| FY32K | Hand Wrap Tool | DIS | |
| FA00A | Telscpic Insp Mirror | DIS | |

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| | | | |
|---|---|---|---|
| FY36P | Min Spanner 24 | £2.56 | |
| FY37S | Min Spanner 68 | £2.56 | |
| JK79L | Spanner 2.5x3.2 | £2.56 | |
| JK80B | Spanner 3x3.5 | £2.56 | |
| JL61R | Spanner 4x5 | £2.56 | |

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| | | | |
|---|---|---|---|
| FY38R | Ring Spanner 02 | £4.45 | |
| FY39N | Ring Spanner 46 | £4.45 | |

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| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| FS96E | HQ Centre Punch | £5.25 | £4.72 |
| | | 1+ | |
| FY57M | Wet & Dry Coarse | 28p | |

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| | | | |
|---|---|---|---|
| FY53H | Mini Vice | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| YP70M | [A] Pistolgrip Hnd Drill | £10.95 | £9.89 |
| YN56L | [A] Hand Drill | £16.95 | £14.95 |

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| | | | |
|---|---|---|---|
| | | 1+ | |
| QY65V | Metric Drill 1mm | 52p | |
| QY90X | Metric Drill 1.2mm | 52p | |
| QY94C | Metric Drill 2mm | 48p | |
| QY95D | Metric Drill 2.5mm | 52p | |
| FV60Q | Metric Drill 3mm | 52p | |
| FV61R | Metric Drill 3.5mm | 52p | |
| FV62S | Metric Drill 4mm | 52p | |
| FV63T | Metric Drill 5mm | 68p | |
| FV64U | Metric Drill 6mm | 86p | |
| HQ02C | HS Drill 1 16in | 52p | |
| HQ03D | HS Drill 5 64in | 52p | |
| HQ04E | HS Drill 3 32in | 52p | |
| HQ05F | HS Drill 7 64in | 52p | |
| HQ06G | HS Drill 1 8in | 52p | |
| HQ07H | HS Drill 9 64in | 52p | |
| HQ08J | HS Drill 5 32in | 52p | |
| HQ10L | HS Drill 3 16in | 68p | |
| HQ12N | HS Drill 7 32in | 75p | |
| HQ14Q | HS Drill 1 4in | 98p | |
| HQ16S | HS Drill 9 32in | £1.28 | |
| HQ18U | HS Drill 5 16in | £1.36 | |
| HQ22Y | HS Drill 3 8in | £1.80 | |
| HQ26D | HS Drill 7 16in | £2.75 | |
| HQ29G | HS Drill 1 2in | £3.45 | |
| FV65V | Masonry Drill 3 16 | 75p | |
| FV66W | Masonry Drill 1 4 | 80p | |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| JK81C | Die Holder 13 16 | £3.95 | £3.40 |
| | | 1+ | 12+ |
| JU38R | Cutting Compound | £1.98 | £1.73 |

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| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| FY71N | Aluminium Solder | 98p | 91p |

## Wound Components

**Page 555**

| | | | |
|---|---|---|---|
| | | 1+ | |
| LB17T | Former 351 | 98p | |
| LB18U | Former 450 | £1.48 | |
| LB19V | Former 722 1 | 98p | |
| LB22Y | Former 722 4 | DIS | |
| LB44X | Former Base | 56p | |

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|---|---|---|---|
| | | 1+ | 100+ |
| HX11M | Type 3 Clips | 15p | 14p |

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| | | | |
|---|---|---|---|
| WH30H | Choke 1.5uH | DIS | |

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| | | | |
|---|---|---|---|
| | | 1+ | 10+ |
| BK57M | 600 Ohm Isotran | £5.95 | £5.50 |

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| | | | |
|---|---|---|---|
| YM50E | [A] 100VA US Mains Trans | £20.95 | £18.08 |

**Page 561**

| | | | |
|---|---|---|---|
| | | 1+ | 25+ |
| FT32K | 50W Ferrite Tran Kit | £3.65 | £3.45 |

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| | | | |
|---|---|---|---|
| FT33L | 100W Ferrit Tran Kit | £3.95 | £3.68 |

## Miscellaneous

**Page 564**

| | | | |
|---|---|---|---|
| | | 1+ | |
| FS12N | Temp Clock Black | DIS | |

*£1.00 handling charge must be added to each mail-order. [A], [B] etc. against price indicates additional charge for carriage (see Order Coupon).*

## CORRIGENDA

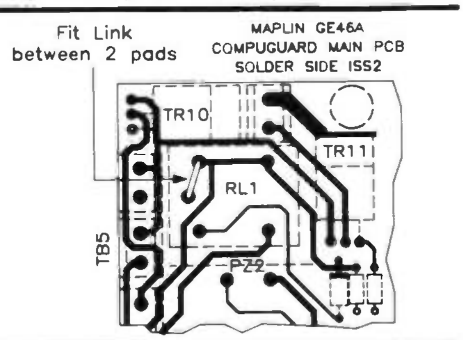
### Compuguard Part 1, Kit LP22Y
### 'Electronics' No. 40 (October-November '90)

Oops! Those gremlins have been up to their old tricks again, this time with the Compuguard Main Unit PCB (GE46A).

The ignition disablement relay, RL1, is incorrectly connected, with the result that its moving contact is not joined to anything! This causes TB4-11 (ignition input) and TB4-10 (ignition output) to be permanently open circuit.

If you have purchased one of these kits (or the PCB) and the board is marked 'issue 2', then you must join two pads together with a wire link as shown in the accompanying diagram. The link is best fitted after RL1 is installed and can be hooked around the relays two pins and anchored with strong solder joints.

If however your board is marked 'issue 3' then this error will have been corrected and the modification is not necessary.



# ORDER COUPON

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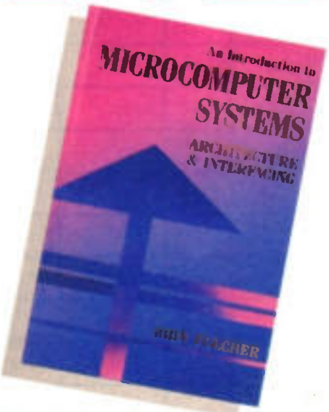


## An Introduction to Microcomputer Systems

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**by John Fulcher**

Provides a thoroughly modern and up-to-date introduction to microcomputer interfacing, as well as a general introduction to the fundamentals of microcomputer architecture. Discussion of the hardware and software aspects of interfacing are woven together and exemplified by reference to two industry standard 16-bit microprocessors, the Intel i8086 and the Motorola 68000. The approach taken throughout is that, in order to interface a peripheral device successfully, it is first necessary to have a basic understanding of how it works. It is also imperative to understand the workings of the peripheral support chip, as well as the microcomputer to which the device is being interfaced, and its instruction set. A working knowledge of the relevant standards must also be acquired. All these topics receive full coverage in this informative book.

Contains over 350 diagrams and written in a clear and friendly style, and packed with up-to-date specifications and data. Numerous programming examples are shown based on the above mentioned two standard 16-bit microprocessors, with self test objectives and summaries provided with each chapter, with self-assessment review questions. There is an extensive list of references for further reading, and detailed appendices on the Motorola 68000 and Intel iAPX86 families.

Suitable for students of computer science and electrical and computer systems engineers, and anyone who needs to interface real-world devices and peripherals to their microcomputers. For those with a hardware background, the necessary I/O programming techniques are introduced; for those with a programming background, the relevant hardware concepts are presented. Whilst no previous knowledge of computer architecture or electronic hardware is required some previous 'exposure' to assembly language is assumed.

1989. 240 x 160mm. 440 pages, illustrated, hard cover.

***Order As WT11M (Intro MCP Systems) Price £18.95 NV***


## TTL Pocket Guide

**Volume 1: 7400 to 74200**

Provides a comprehensive listing of all commonly used TTL ICs from 7400 to 74200 as available from all the major manufacturers. All the current families, Standard, Low Power, Schottky, Low Power Schottky, Advanced Schottky, Advanced Low Power Schottky, High Speed and Fast Schottky are covered. The format and content make this guide easy to use; each page describes one device only and is divided into 8 sections. The first section shows the internal schematic diagram of the device, using a clear and simple logic diagram within the familiar package leadout icon identifying pin functions. This is followed by a brief description of the device with reference to its internal structure.

The next section provides details about operating the device, describing input signals or levels at particular pins, and in some cases showing up subtle differences between various families, providing invaluable information for the designer. A fourth section lists major applications followed by a summary of essential data. Below this a table indicates the TTL families in which the device is available and finally, device description and type number references. At the back is a manufacturers' index showing which companies manufacture each package. The Pocket Guide extracts all the essential data from the manufacturers' own data books and presents it in a clear and concise format, and is invaluable as an aid to choosing a device or identifying an unfamiliar component.

English translation of the German original. 1990. 185 x 105mm. 288 pages, illustrated.

***Order As WT21Y (TTL Pocket Guide 1) Price £11.95 NV***


## Assembly Language Subroutines for the 6809

**by Lance Levanthal & Sally Cordes**

As with 'Assembly Language Subroutines for the 6502' by the same author, this book provides the reader with actual software routines that can be used immediately, rather than just teach programming. It serves as both a source and a reference for 6809 assembly language programs, containing a collection of useful subroutines described in a standard format, the essentials of which are identical to those for the 6502, accompanied by an extensive documentation package covering parameters, results, execution time and memory usage.

The collection emphasises common tasks that will be required in many applications including code conversion, array and bit manipulation, data structure management, I/O routines, sorting and searching, and routines handling common family chips such as parallel and serial interfaces and timers. This book will save you much time and effort by not having to write and de-bug your own standard routine library, instead just choose the specific routines required and get on with the main task of completing your programs. Each routine is provided with test data to verify correct assembly. Recommended.

1989. 235 x 171mm. 365 pages, illustrated.

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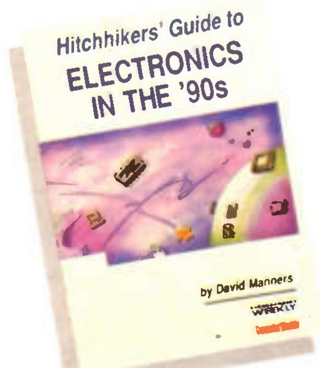


## Hitchhikers' Guide to Electronics in the '90s

**by David Manners**

The strides made by electronics technology in the last 40 years would have been scarcely conceivable by electronics engineers of the 1940s. Imagine them trying to come to terms with the idea of the thermionic valve giving way to the incredibly smaller and more efficient transistor – never mind the concept of a million such transistors sharing the same tiny crystal and wired together to make a complete circuit. Imagine a computer that sits on your lap and is powered by batteries, instead of taking up half the space of the Albert Hall; a machine which can transfer documents around the world in seconds – these are *giant steps*. This highly readable book puts these advances in a historical context, looking at the microchip technology which is at the heart of all technological advances, and surveying the major industrial electronics power houses, and finally peeking into the future of both the technology and the emerging markets.

Chapters include a discussion on the impact of electronics, how it is shaping politics and the world; the 'chip wars' technology race and how Japan won; brief history of electrical discoveries and electronics; jargon; electronics industry and consumers; the chip business and the main worldwide companies, who and where they are; trends for the '90s, the pressing need for both the U.S. and Western Europe to rebuild technological and industrial strength, and whether Eastern Europe will become a serious market or producer. A really interesting book.

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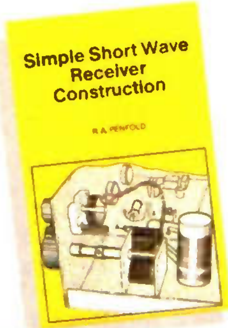
## Protection of Electronic Equipment

**Edited by W.S.E. Mitchell**

This technical monograph, published by The Institute of Electrical and Electronics Incorporated Engineers, is intended as a guide for the protection of electronic equipment against the potentially harmful effects of wide-ranging environmental and electrically-induced conditions. Individual chapters are written by specialists in their particular fields, covering such areas as protection against climatic and mechanical environments, hazardous areas (chemical etc.), electromagnetic and RF interference, electrostatic discharge, surges and transients on power or signal lines, thermal protection and management and special requirements relating to micro-electronic devices. Although much of this relates to industrial installations and military cases – one chapter deals with Nuclear Electro-Magnetic Pulse (NEMP) protection for instance – you can learn an awful lot about protecting your projects and other electronic equipment from the weather and/or mechanical shock and vibration, and be able to incorporate proper precautions against interference and mains noise, avoid hum loops and learn how to earth chassis' and circuits properly. There is good advice on correct wiring procedures, so you should be able to design and make up well thought-out cable looms taking all these precautions into account and not simply string things together with haphazard wiring!
1989. 210 x 148mm. 96 pages, illustrated.

***Order As WT23A (Protect Elec Equip) Price £5.00 NV***




## Simple Short Wave Receiver Construction

**by Robert Penfold**

Short Wave Radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of DIY, and the receivers described in this book can all be built at low cost. All the sets are easy to construct, full wiring diagrams, etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.
Topics covered include: the broadcast bands and their characteristics; the amateur bands and their characteristics; the propagation of radio signals; simple aerials; making an earth connection; short wave crystal set; simple t.r.f. receivers; single sideband reception; and a direct conversion receiver. Contains everything you need to know in order to get started in this absorbing hobby.
1990. 178 x 111mm. 88 pages, illustrated.

***Order As WT16S (Simple SW Rcvr Cons) Price £3.95 NV***



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| 3. | (2) | | Digital Watch | FS18U | £ 1.98 | Catalogue | '91 | (CA08J) |
| 4. | (4) | | Car Battery Monitor | LK42V | £ 8.95 | Magazine | 37 | (XA37S) |
| 5. | (10) | | PWM Motor Driver | LK54J | £ 9.95 | Projects | 12 | (XA12N) |
| 6. | (14) | | Mini Metal Detector | LM35Q | £ 5.25 | Magazine | 25 | (XA25C) |
| 7. | (5) | | LM386 Amplifier | LM76H | £ 3.75 | Magazine | 29 | (XA29G) |
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Over 150 other kits also available. All kits supplied with instructions.
*The descriptions are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate project book, magazine or catalogue mentioned in the list above.*

## Introduction

This is the age, in case you hadn't noticed, of the information technology revolution. Like a fast spreading, insidious disease, computers are increasingly found everywhere and getting into everything. The 1980's is a decade notable for the micro-chip boom, allowing for the first time the mass manufacture of affordable machines that can be used in the home by the general populace at large, and in consequence computing ceases to be a technology hitherto only accessible by big businesses, scientific research establishments and universities. The effect can be (and has been) compared with that other, much earlier 'information technology' revolution – when latter Dark Age kings decided that it was high time that they themselves should learn to read and write so as to be able to keep important records.

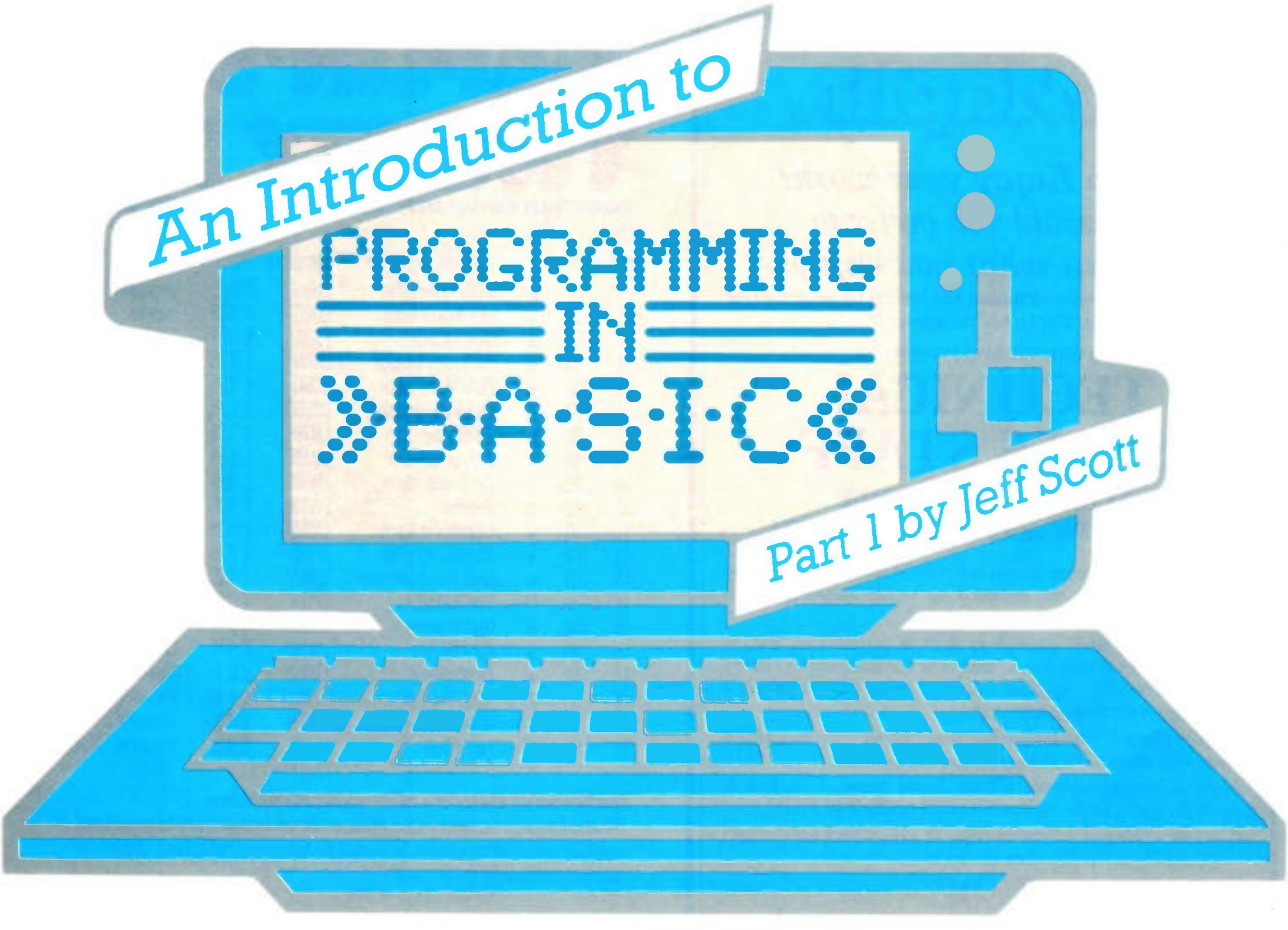
Computers have turned the lives of countless people who have come into contact with them practically upside down, and usually for the better (although recipients of erroneous gas bills might argue otherwise). No longer the exclusive territory of the trained programmer, millions of amateurs can now get their hands on their very own keyboard. Some take to it like a duck to water, others have problems coming to terms with it, and are not helped by all the myths and legends that surround computers, and progress little beyond playing computer games. Which is a shame because even a modest 8-bit home micro is still a very powerful tool, especially if you can program it yourself.

## DIY Programming

A computer processes information, often called 'data', but in order to do this it has to have instructions so as to know what to do with this data. A series of instructions is called a 'program' (not, you will note, 'programme'). A computer can be programmed in one of three fundamental ways.

i. In binary code, because a computer treats everything as a number, and a number as a pattern of '0's and '1's, represented as 'low' or 'high' voltage levels on a bundle of eight wires known as a 'data bus'. Each wire can only represent two numbers, 0 and 1 (a 'bit'), but the next 'highest' wire is a multiple of 2 of the previous. This is what is meant by 'binary', because this is a numbering system using the base of 2 (unlike decimal for instance which uses the base of 10). The eight wires on their own can represent numbers 0 to 255 (a 'byte'). Primitive computers (as in the very early days) can be programmed by setting up the required 8-bit pattern with switches, and then pushing a button will put this value into program memory and the location of the memory will be incremented to the next following 'address', and the process repeated for the next 8-bit pattern, or byte, and so on. A sequence of such bytes is called 'machine code'. Obviously this method of writing a program is so mindbendingly tedious to do and error prone that no modern computers are programmed this way by a human being.

ii. Using an 'Assembler'. An assembler is a program resident in the computer which preferably allows the programmer to refer to all his numerical data, and the machine's instructions, by name. Such a utility is called a 'symbolic assembler', since these are 'symbols'. The human mind can recognise names or words much better than strings of apparently meaningless numbers, especially if written in binary, for example '11010111' is not very obviously different to '11010011' to look at but the actual difference is (usually) vitally important. An assembler actually puts such binary patterns directly into memory, but after translating alphabetic words and written numeric values understandable to a human into binary patterns and in



| Label | Mnemonic | Operand | |
|---|---|---|---|
| BASE | EQU | 1024 | Define word 'base' to mean the number 1024, in this case it will be used as an 'address' or memory location. |
| START | LDX | #0 | 'Start' is name of memory location where this program starts. Load register X with value 0. |
| | LDA | #32 | Load accumulator with value 32 (decimal). |
| LOOP | STA | BASE,X | Store accumulator contents at address 'base' with offset X. |
| | INX | | Increment X register by one. |
| | BNE | LOOP | Branch not equal to 'loop'. When X reaches count 255 it will zero again on next increment. Here BNE is used to test for a non-zero. |
| | RTS | | Return from subroutine if X = 0, i.e. exit when finished. |

the right sequence. An example of such 'assembler code' might be as shown in table above:

The 'mnemonics' are the fixed set of numeric codes which the actual microprocessor recognises as instructions. Naturally then the use of an assembly language presupposes that the programmer is familiar with the MPU's (Micro-Processor Unit) particular 'instruction set' (varies between different makes) and memory layout of the machine, and is still a very long winded way of writing programs of any complexity – because it is only 'one step up' from raw machine code, assembly is a 'low level' language.

iii. Using a High Level Language (HLL). This will use statements, instructions and maybe complete sentences which are much closer to normal English, although it still looks a bit strange at first. There are many high level languages around now; FORTH, FORTRAN, PASCAL, COBOL, ALGOL, PL/I, C, are examples of some high level languages currently in use. Each language was developed with particular applications in mind; FORTRAN was developed by a scientific committee for scientific applications (complex mathematics in engineering, etc.), COBOL by a business committee for tasks involving sums of money, stock records and progress reports. However, recognising perhaps that the first timer is not at all familiar with computers, the one which most personal or home microcomputers come already equipped with is BASIC, which is an acronym for 'Beginner's All-purpose Symbolic Instruction Code', and it may be no surprise to learn that BASIC was designed by an educational committee as a language to help teach computing.

BASIC has one important feature – it is an 'interpreted' language. Most of the other high level languages convert the typed-in listing, called the 'source code', directly into machine code which the MPU can 'read' immediately, and this is called the 'object code' and is actually the final program which the computer will execute, or run. It cannot execute the source code. A program called a 'compiler' is used to read the written source code and from it produce the object, or binary machine code that the MPU can use. The result, being operated on directly by the MPU, is usually very fast and can be said to 'run at machine code speed'.

BASIC is different. Here the program is at one and the same time the source code. It is more or less read by the computer in the same way as you would read it, word by word, line by line. Again (like the compiler), between the source code and the MPU is another intermediary; resident software called the 'interpreter'. The interpreter reads the source code and then, according to what has been found, initiates many machine code routines that the MPU can follow to carry out the required tasks. Because the interpreter has to painstakingly find and translate everything it needs, an interpreted language; very slow in operation, but the advantages are two-fold.

Firstly, any instruction, with or without accompanying 'parameters' (data), can be typed in 'direct mode' or at 'command level', and the interpreter will respond immediately and execute the instruction in real time (without the performance of waiting for compiling processes, for example). This is very useful for testing the validity of instructions that you may want to use and to see if you are getting the answers you want. When these trials are successful you can repeat the writing of the instructions but this time as part of a BASIC listing, or program, in memory (more of this in a minute). Secondly, once running, such a BASIC program can be stopped at any time during execution and changed or corrected, or in order to examine its progress before re-continuing, and it is even possible to jump into it anywhere from the 'command level'. The listing remains available in memory all the time, and in this way it is very easy to develop the program through a process of 'moulding and shaping' with repeated test runs.

BASIC was developed by John Kemeny and Thomas Fritz in the 1960's at Dartmouth College. Since then this interpretive language has been enhanced by many new commands as computers have become smaller, cheaper and more available. The (sometimes unfortunate) side effect of this is that now there are many different variations on the theme, as various manufacturers push their own particular preferred version of the language with their machines. BASIC's for IBM, Commodore, BBC and Atari computers, as examples, are not all exactly the same. One or two are a fair equivalent to the original international 'Microsoft' standard; some, like the BBC machine's BASIC, have very advanced features which make their BASIC programs nothing like Microsoft.

The upshot of this is that there will inevitably be a number of commands which are not shared by all BASIC's. For example 'WHILE . . . WEND' loop commands are not found in all, and commands with similar purposes may have different names from one machine to another. It is always best to become familiar with the instruction manual which comes with the computer, which will outline the function of each command. Most of the commonly found and fundamental BASIC commands and programming techniques will be dealt with in this series, and quoted examples will follow the Microsoft standard as much as possible.

## Programming

So what is a program? A program is a series of logical steps for solving a problem. A computer is well able to carry out a repetitious task where humans would tire and make mistakes. A typical example is the widespread use of computers to calculate company payrolls where, operating on given data like gross salary, taxation rates and hours worked, the computer will calculate the net salary for each employee.

A program can be one of two types: either the repetitious type, or the iterative type. In the case of the repetitious type, as with the example of payroll calculations, the programmer knows the results he wants and it is only a matter of carrying out the calculations a given number of times.

For the iterative type, the programmer knows the limits within which the answer lies, and by a succession of steps – a process of elimination, then – the program 'zeros in' on the final answer. Either process can be laboriously tedious for a human being.

## Logical Steps to Problem Solving

It always pays to put down one's ideas on paper before actually writing the program. What you mustn't do is sit down at the keyboard immediately. The only exception to this rule would be if you have the imagination and the capacity for logical thought – which, incidentally, the computer will teach you – to have it all worked out in your head first. Otherwise, the normal course of events is to establish exactly what the program is required to do and then in what way it is going to do it. Trying to do this as you go along while writing the actual program usually gets you into all sorts of difficulties as you invariably come across problems you didn't anticipate.

Ideas for completing stages of the problem are put down in a series of logical steps, exactly as one would solve a problem manually. For example, a sequence of steps required for the calculation of a payroll might be:

Read gross salary of first employee

Deduct 6% superannuation

Deduct 5% national insurance

Deduct allowances

Calculate 25% tax on remainder

Deduct season ticket loan instalment from net salary

Print final net salary

Read gross salary of next employee

In other words, 'loop' back to the beginning and repeat operations with a new set of data, and so on until all employees are done. This is a repetition type of program.

## The REM statement

Every program needs to be properly 'documented', so that anyone (or, more usually, yourself at a later date) can understand what's going on. Aside from having running instructions and any other essential bits of information on paper, the program should also have some explanational text in it somewhere. In addition, sections of the program will need little reminders, so that you can find places again and know why certain parts of the program do some things in a particular way. These reminders are called 'REM' statements. 'REM' is a BASIC command allowing such comments to exist in the listing, and is from 'REMark'. Some examples may be:

REM This program calculates the cost of a building

REM Subroutine for cost of materials

REM Subroutine for cost of labour

REM VAT constant

The 'REM' statement has the effect of causing the interpreter to ignore the remainder of the line after 'REM', allowing any non-executable text to be included. Otherwise the interpreter will try to execute it! It is always a good idea to include plenty of 'REM' statements so anyone else taking over the program can understand it. In fact, there are many instances where the programmer who created the original version cannot recall what he did, making improvements and updates very laborious and difficult some while later, because he did not document the work sufficiently. There is nothing like having to work out all over again what the program is doing.

## Variables

Variables are what BASIC uses to store data in the computer in a form accessible to the program. They are given names by the programmer. Very often these are single character names, 'A', 'B', 'X' etc., but they can also be words; 'STATUS', 'PI', 'MAX', 'DEVICE'. You should know that some versions of BASIC can recognise only the first two characters of any variable name – the remainder of the word is ignored – while others recognise the whole name up to say eight letters as being different from any other variable name. So beware of using variable names which are too similar if the number of recognisable characters are limited to the first two. Also beware of trying to inadvertently use a valid BASIC command as part of a variable name! This is a common beginner's mistake.

Unlike many other languages, BASIC's variables are very easy to create. They don't exist until the program runs, or you begin using them in 'direct mode'. You create them simply by including them in the first series of instructions that will use them. This is very different from the compiled languages, which usually like all their variables 'declared' first before the program can use them (this includes assembly).

In BASIC, variables come in three different types – these are floating point numeric, integer numeric, and strings. As an illustration, using the name 'A', there could be three and entirely separate versions of a variable called 'A', which can exist simultaneously, as table shows below:

| | | |
|---|---|---|
| A | floating point i.e. <whole number> . <fraction> |
| A% | integer, whole numbers only, no fractions |
| A$ | string of alphanumeric characters up to a maximum of 255 letters, e.g. "This is a string." |

## The LET Statement

A value can be assigned to a variable using the 'LET' statement. This originally was the way a BASIC variable was created – taking one of the above examples, we can, either in direct mode or as part of a program, have 'LET A$ = "This is a string."', and then A$ will hold the message "This is a string" until changed or erased. The other two variable types can be created in the same way.

LET I = 0·1
LET P% = 100

Note 'I' can be 0·1 because it accepts floating point values, 'P' could not because it is of the integer type. However the need to create variables is so common that now the LET statement is often dropped, and many BASIC's recognise a variable assignment on simply encountering:

I = 0·1
P% = 100

Although still provided, 'LET' is now probably the most redundant BASIC command word. It is possible because the interpreter, not being able to match 'I' or 'P' to a valid BASIC keyword – it keeps a reference library of valid keywords – then begins to search for a match among its store of variables. If 'I' or 'P' exist they are re-assigned, if they do not exist they are first created, then assigned. However, once in existence, if either variable is assigned the value of zero, it doesn't disappear. Once a variable is brought into being it stays.

It is important to recognise that the above examples are *assignment* statements, *not* equations. For instance, suppose a program may need to go through a loop ten times, incrementing the value of 'A' by 10% each time.

LET A = A * 1.1

This does not mean that 'A' equals 'A' incremented by 10%. It is saying 'increase the old value of A by 10% and call the result A'.

## Arithmetic Operators

The usual arithmetic operations are permitted in BASIC but some of the symbols may look a little strange, as shown thus:

| Symbol | Order of priority |
|---|---|
| () brackets | innermost first |
| ↑ exponent | left to right |
| / division | left to right |
| * multiplication | left to right |
| + addition | left to right |
| − subtraction | left to right |

The order of priority for combinations of the above operates from top to bottom, where several of the symbols appear in a complete formula in a BASIC program line. Parts within innermost brackets are calculated first, and addition and subtraction have the lowest priority, the exponent having the highest priority. To illustrate a complex example:

C = 1/((1/(C1 + C2)) + (1/(C3/4)))

Which would normally be written on paper as:

$$C = \frac{1}{\dfrac{1}{C1 + C2} + \dfrac{1}{C3 \div 4}}$$

There are two innermost sets of brackets, on a 'fourth level' resulting in C1

+ C2 being calculated first, then C3 ÷ 4. Then a 1 is divided by the C1 + C2 result, then the other by the C3 ÷ 4 result. These 'third level' results are added on a 'second level', and finally 1 is divided by this on the 'first level', and the final result assigned to C. C1, C2 and C3 are other variables. The brackets are used to separate the formula into stages and force it to be read by the interpreter in the required logical sequence.

If the formula is so large that the programmer is not sure in which order the computer will carry out the operation, it is best to split the formula into separate stages on different lines, with a 'diagnostic' 'PRINT' statement so that the results of each stage can be checked.

The mathematical symbols are not as you might expect. $4^2$ is written as 4 ↑ 2; 4 ÷ 2 is written 4 / 2; and 4 x 2 is 4 * 2, a convention you will have to get used to.

## The PRINT Statement

'PRINT' usually prints to the VDU (Visual Display Unit – your TV or monitor) screen, while 'LPRINT', meaning Line PRINT, outputs to a printer. However some machines don't have 'LPRINT', and require that you 'OPEN' a channel to the printer as an external device (more of this at a later date). Most of the time you will be 'PRINT'ing to the screen, especially during the development stage of a program. The 'PRINT' function prints the values of variables and also any constant messages when required, which do not exist as variables. To print the answer to a calculation like:

T = D / S

Where 'T' is time in hours, 'D' is distance travelled in miles, and 'S' is speed in miles per hour, one could merely type 'PRINT T' to get the answer to the speed distance calculation. However in a program of which this may a part, it is much more professional to see what 'T' actually means instead of the program assuming that the user knows already. Lots of explanatory instructions and qualifying statements make for what is called a 'user friendly' program. In this event, the value 'T' would be presented as:

PRINT "Journey time is"; T; "hours."

The function literally prints the words between quotes, and note that a complete sentence can be made with 'T' in the middle by using semicolon separators. The above will appear as: 'Journey time is 2 hours.' if 'T' is 2.

Some BASIC's allow formatted output of numeric data. This can be useful for rounding off decimal places. To round off floating point variables 'A' and 'B' to two decimal places one would say:

PRINT USING "##.##"; A, B

and if 'A' and 'B' were 19·276 and 21·328 respectively, they will be printed as:

19·28 21·33

'A' and 'B' could be prices, and here the function has rounded these up to the nearest new penny. However not all BASIC's have the 'USING' keyword, so some other method must be found.

## RUN and END

A BASIC program, once in memory, is started with the command level or 'direct mode' command 'RUN'. In some BASIC's this command can also load the program from storage prior to 'RUN'ning, for example 'RUN "PROG.BAS"'. As mentioned earlier the program is the same file that you have written and edited because an interpreter is used on it at execution time. When the 'RUN' command is keyed, two things happen. Firstly, all variables are erased, or 'cleared', if any exist. Then secondly the program is executed starting with the very first BASIC line in memory. It may not be readily appreciated that 'RUN' can also appear in the program. In this event, if executed, the statement causes the program to re-run itself again from the start afresh. Moreover, it needn't have to 'RUN' from the beginning if we don't want it to – a command 'RUN 200' would cause it to commence at line 200 instead.

Really you should use the 'END' statement at the position where the program is going to finish. If this is the very last line in memory then it doesn't matter if 'END' is not present; the interpreter will simply run out of lines to read and 'END' the program, returning to the command level. However, if subroutines are included after the end of the main program, then the interpreter will attempt to execute these as well, which is not right. Subroutines cannot be 'RUN' like the main program; more about this subject later. This problem is known as 'crashing through', where the interpreter goes onto subroutines after the end of the main program because there is no 'END' statement to prevent it. 'END', then, should precede the first subroutine.

## Line Numbers

We have seen that, thanks to the interpreter, BASIC commands can be typed in and executed in 'real time'. These commands are transient, that is, the computer executes them, and then forgets them, and if you want it to repeat the exercise, the command has to be re-entered. For instance:

PRINT "Hello there"

in 'direct mode' will cause the machine to echo on screen the message 'Hello there'. If you want it to do it again you have to type it all again. Writing a BASIC *program* is different in the only respect that the command lines are preceded by line numbers. Applied to what we have discussed so far, the above can be turned into a program by typing:

```
10 REM DO JOVIAL MESSAGE
20 PRINT "Hello there"
30 END
```

As you type, the machine does not appear to respond, as it would to 'direct' commands or statements. Because instead the interpreter, now in 'edit mode', is building a program into memory. This can be seen by using the 'LIST' command. 'LIST' will cause the program to be 'LIST'ed out on screen for examination or changes.

Line numbers are very important in BASIC. They make it possible for every important location in a program to have reference made to it by a unique number. This is essential for loops using 'GOTO's, and calling subroutines with 'GOSUB'. It is also a general convention that as you write, you skip a few numbers to the next line; a typical and well used value to increment by is 10. This leaves 'room' for up to a further nine extra lines to be inserted between any two original lines, should changes and additions need to be made (and they will!).

Some BASIC's include commands which exist specifically to make life easier while writing a BASIC listing or program. These vary from machine to machine, but typical examples are:

AUTO: automatic line numbering. Obviates the need to type each new line number while writing, because this is done automatically. The direct mode command 'AUTO 100, 10' will cause the first line number to commence at 100, and further lines to be incremented by 10. This helps prevent repetitions by mistake, where the original line will be replaced by the new version with the same number.

RENUM: a facility for 'tidying up' the line numbers in a listing. If, during subsequent development, the program needs some changes and insertions, the line numbers will include some with odd values, which might make it difficult to find one's way around the program (line numbers represent locations, remember). The command 'RENUM 100, 10' will cause all line numbers to be altered and re-commence at 100 and be incremented by 10. All references in the program to any lines will also be altered to reflect the changed values. It then becomes easier to keep track of a reference to a line numbered '2230' after renumbering than '2791', before renumbering.

LIST: lists the program, or part thereof, on screen for examination. One can specify a portion of it only, with for example 'LIST 800 – 1000'. Only lines numbered 800 to 1000 will be printed on screen. Usually 'LIST'ing can be slowed or paused, or stopped while it is happening, because 'LIST'ing on screen happens quite fast! Also possible are 'LIST – 900', list everything up to 900 only; 'LIST 3000 –', list everything from 3000 onwards. For printing on paper, the command may typically be 'LLIST'. Your manual will explain the procedure for your machine in more detail.

DELETE: it may be that you will be provided with the 'DELETE' command. This is extremely useful for extensive editing. Single lines can be deleted (removed from the program) by simply typing their number *only* followed by RETURN. But 'DELETE' allows groups of several lines to be removed more easily, and works exactly like LIST ('DELETE 800 – 1000', etc.).

To insert a line, all you need do is choose a number between the values of the two lines between which you wish to insert the new line, and write the new line. It doesn't matter where on the screen you type this new line to be inserted (usually). The method for changing or editing lines however depends on how good the BASIC editor is (IBM GW BASIC and Commodore's BASIC's are brilliant, whereas for example the BBC's BASIC editor is horrible to use). The ideal is one which merely allows you to list the line to change (or more), and type, insert or rub-out text over the top. Keying RETURN will cause the interpreter to re-read this line and re-enter the modified version into the listing in memory which, having the same line number, *will replace the original.*

## LOAD, SAVE, STOP and CONT

A BASIC program is loaded into memory from storage with the direct command 'LOAD "<filename>"'. On PC machines (IBM or similar) the program file will have the name '<filename>.BAS', '.BAS' being what's called an extension which qualifies the type of data stored, in this case, a BASIC program. While working in the BASIC environment, this extension is not included when 'LOAD'ing BASIC programs, as the system adds it automatically. With other makes of computer there are as many variations. Some machines require that the storage type is specified, e.g. tape or disk. 'SAVE' performs the exact opposite and 'SAVE's the BASIC program listing in memory to storage. Some disk operating systems allow a file to replace an existing file with an identical name, others won't without special 'over-write' or replacement syntax.

A program can be 'STOP'ped while running. This is usually done by pressing both 'CTRL' and 'C' keys, but some machines may have a special 'STOP' key. It interrupts the program and returns the interpreter to the command level. Here variables can be examined by printing them out by hand, or altered, as a diagnostic exercise while testing the program. Provided no lines are changed, the program can be re-continued where it left off with 'CONT' (CONTinue). Some versions include the facility to slow the program down to a crawl or 'freeze' it midstride so that you can follow what it's doing (usually the same technique used to slow or pause a 'LIST'ing on screen). An extremely useful extension of this idea is a command called 'TRACE', a keyword which displays on screen the number of every line that the interpreter has currently started to read, so that a problem can be pinpointed to the exact BASIC line.

## CLEAR and NEW

All variables are erased with the command 'CLEAR', or 'CLR'. If it gets to a stage where there are too many variables cluttering up memory, they can be wiped out of existance to make room for more with this statement. 'NEW' does the same to the whole program in memory – before beginning to write a fresh new program, 'NEW' will ensure that no other BASIC lines are left. For this reason, as it erases everything, 'NEW' is not a command to be used lightly.

At this stage, get used to entering and editing BASIC programs using simple 'REM' and 'PRINT' statements, and get familiar with all the BASIC keywords that your machine has. Only then will you know which similar looking variables to avoid!

## FOR . . . NEXT

This is one of the commonest and most powerful BASIC statements, because it enables the computer to repeat a calculation or a process over and over using increasing or decreasing values. The ability to re-direct program flow according to certain conditions is what distinguishes a computer from a calculator, say. Whereas with a calculator one has to manually punch in values for all of a number of repetitions, the computer retains these, or versions modified by a previous iteration, for further repeats of the same process. Such a process becomes a loop, which was mentioned previously, and in programming such conditional modifications of program flow are called 'constructs'. We have, then, a number of programming 'constructs' at our disposal, the 'repeat/until', 'do/while' and 'if/then' constructs being good examples. The short assembly language example shown before is a 'repeat/until' construct, because it is saying "keep doing this process over and over until the X register contains zero".

'FOR/NEXT' is a 'do/while' construct, and the condition sought, in order that the loop should not be exited, is usually that a count should remain within a limit of some description. The 'counter' is a numeric variable, and the starting and finishing values are determined, together with the amount to increment or decrement by, with the qualification as to whether to count up or down. A simple example will help clarify this. Suppose we wanted a program to print the five times table, starting with 5 x 1 and ending with 5 x 12:

```
10 REM FIVE TIMES TABLE
20 LET A = 5
30 FOR J = 1 TO 12
40 S = A * J
50 PRINT A; "x"; J; "="; S
60 NEXT J
70 END
```

Several points are reinforced here. Note the 'REM' and 'END' statements for reasons discussed previously. The 'LET' statement in line 20 sets the variable 'A' to 5, but we could have simply written '20 A = 5'. Line 30 initialises 'J' with the starting value of 1 using 'FOR', and 'TO' sets the terminating value at 12. After the process has been carried out in lines 40 to 50, which is to produce one line of the times table using 'J' as the multiplier, line 60 contains the 'NEXT' statement which increments 'J', then tests it to see if it is still 12 or less. If so, then execution is not allowed to proceed further but is diverted back to line 40 again. In other words, 'do process while J is less than or equal to 12'. When the program gets beyond line 60 and 'END's, 'J' will have the value 13.

For the required number of processes to take place, the 'NEXT J' statement must be on a line following all of the required processes. Putting the 'PRINT' statement after 'NEXT J' will only print one line, '5 x 13 = 65', because 'J' will be one greater than the terminal count value.

'A' needn't have been necessary, since its value is constant, we could have used just 'S = 5 * J' in line 40, and dispensed with line 20 altogether. However, having 'A' instead can be very useful, as will be seen in a minute.

There is more to the 'FOR / NEXT' loop than appears here. It was not actually necessary to use 'NEXT J', just 'NEXT' would have done, but only because, in this case, there is only one for/next loop. If two or more loops are 'nested', each will have to have a 'NEXT' statement qualified by the variable name applicable to it alone to prevent confusion.

Furthermore, in the above example, the interpreter takes it for granted that the 'J' counter is incremented by one each time. If we wanted to write the table 'backwards', i.e. 12 x 5 first and downwards, line 20 would have to be '20 FOR J = 12 TO 1 STEP –1', and 'STEP –1' will cause the counter to be *decremented* (take 1 away each time). The loop can be made to show the table in increments of two: '20 FOR J = 1 TO 12 STEP 2'. 'STEP' allows counter increments to suit any application if the counter variable is required in a particular range of values for some formula: 'FOR J = 20000 TO 100000 STEP 10000'. Fractions are allowed too, provided the counter variable is not an integer.

## Nested Loops

There can be any number of 'FOR / NEXT' loops in a program, but they must be entirely separate as in Figure 1, or 'nested' as in Figure 2, but never 'crossed' or overlapping, Figure 3 – you cannot have 'NEXT J' if the immediately previous 'FOR' was for 'I'. Nested for/next loops can be shown in operation by extending the times table idea to include a print-out of all the times tables from 1 to 10.

10 REM ONE TO TEN MULTIPLICATION TABLES

20 FOR A = 1 TO 10

30 FOR J = 1 TO 12

40 S = A * J

50 PRINT A; "x"; J; "="; S

60 NEXT J

70 PRINT

80 NEXT A

90 END

The loop 30 to 60 is nested inside the loop 20 to 80, and now you can see that variable 'A' in the first example has become the counter variable for the 'first level' loop above in the second example. Only after the one times table has been completed does line 80 increment 'A' to 2, and 'J' again goes through the 'second level' loop twelve times before 'A' is incremented to 3, and so on. The 'PRINT' statement on line 70 puts a blank line space between each of the tables, and when eventually the interpreter is allowed to reach line 90 the program 'ENDS'.

```
30 FOR J = 1 TO 10
40 :
50 NEXT J
60 :
70 :
80 FOR I = 1 TO 5
90 :
100 NEXT I
```

**Figure 1. Separate 'FOR / NEXT' loops.**

```
30 FOR I = 1 TO 10
40      FOR J = 1 TO 10
50           FOR K = 1 TO 5
60 :
70           NEXT K
80      NEXT J
90 NEXT I
```

**Figure 2. Nested 'FOR / NEXT' loops.**

```
30 FOR J = 1 TO 10
40 :
50 FOR I = 1 TO 5
60 :
70 NEXT J
80 :
90 NEXT I
```

**Figure 3. Incorrect crossed 'FOR / NEXT' loops.**

## DATA, READ and RESTORE

While variables are very useful for storing constants as well as variable data, if there is a large amount of unchanging, constant data required in the program, these shouldn't really be assigned to variables as a large number of these will then be tied up for 'mundane' purposes, using up variable storage space, limiting the variety of free variable names available and increasing running time, since the interpreter has to repeatedly search through a mass of information in the variable storage area to find a few particular items. Fixed information is better made available within the actual program in 'DATA statements', and which are extracted using the 'READ' statement.

The list of constants occupying one line are separated by commas; there is no comma after the last item in any data line. The line begins with the word 'DATA'. Like 'REM', it causes the interpreter to ignore the remainder of the line and go to the next. Actually 'DATA' lines can be anywhere in the listing, but it is usual to have them, if required, either at the beginning or the end of the program to keep things tidy and so you can find them all easily again.

The items are extracted and assigned to a variable by the 'READ' command. When a 'READ' statement is first met in a program, the value of the first data item is assigned to the variable following 'READ', e.g. 'READ A'. A second 'READ' operation reads the second item, either to the same or another variable, and so on – a simple example might be:

10 REM READ DATA DEMO

20 DATA 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

30 READ A, B, C, D, E, F, G, H, I, J

40 X = A+B+C+D+E+F+G+H+I+J

50 PRINT "THE SUM OF"; A; "TO"; J; "IS"; X

60 END

RUN

THE SUM OF 0 TO 9 IS 45

However, the use of variables 'A' to 'J' is wasteful; it is far better to have a single 'general purpose' variable, and we could use 'A'. Using a 'FOR / NEXT' loop to read the data, a 'tidier' version, which is much more economical with variables, would be:

10 REM READ DATA DEMO 2

20 DATA 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

30 FOR J = 1 TO 10

40 READ A

50 X = X + A

60 NEXT J

The result is exactly the same. If there are too many items of data compared to the number of 'READ' operations, the extra data will be ignored. On the other hand, if there are not enough data items, then the program will run out of items to read, and the interpreter will end the program prematurely with an 'OUT OF DATA' error message.

Provided the program only reads data once after it is 'RUN', it should not be 'out of data' if there are the correct number of items. If it needs to read them again from the beginning, we have a small problem. The interpreter remembers where it got up to in the list of data items after the last 'READ', and if there are no more it will not go back to the beginning again automatically. But this can be forced by the statement 'RESTORE', which resets the interpreter's data position counter to the first item again. Some BASIC's allow a 'restore' to a particular line number, so that a particular set of data items (out of two or more sets) can be selected.

The above example is given for numeric data items, but sentences can be stored in this way too. The only difference is that the variable that the 'READ' operation will assign is a string variable. With this revelation in mind, see if you can work out how the following works. Computer programs often use a 'menu' so that the user can select a particular requirement from a range of options. This menu has its options in the form of a data list, which is easy to edit or add to, and which makes it shorter than it would otherwise be if all the displayed options were in the form of text between quotes (") and following a mass of 'PRINT' statements:

10 REM EXPANDABLE DATA READING OPTIONS MENU

20 :

30 DATA 1st Option

40 DATA 2nd Option

50 DATA 3rd Option

60 DATA 4th Option

70 DATA 5th Option

80 DATA 6th Option

90 DATA 7th Option

100 DATA 8th Option

*(more can be inserted here up to 10 in total)*

110 DATA 0

120 :

130 RESTORE

140 FOR J = 1 TO 10

150 READ ITEM$

160 IF ITEM$ = "0" THEN GOTO 190

170 PRINT J; ". "; ITEM$

180 NEXT J

190 PRINT

200 PRINT "Please choose 1"; "–"; J –1;

210 INPUT OPT

220 IF OPT < 1 OR OPT >= J THEN GOTO 130

230 ON OPT GOSUB 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000

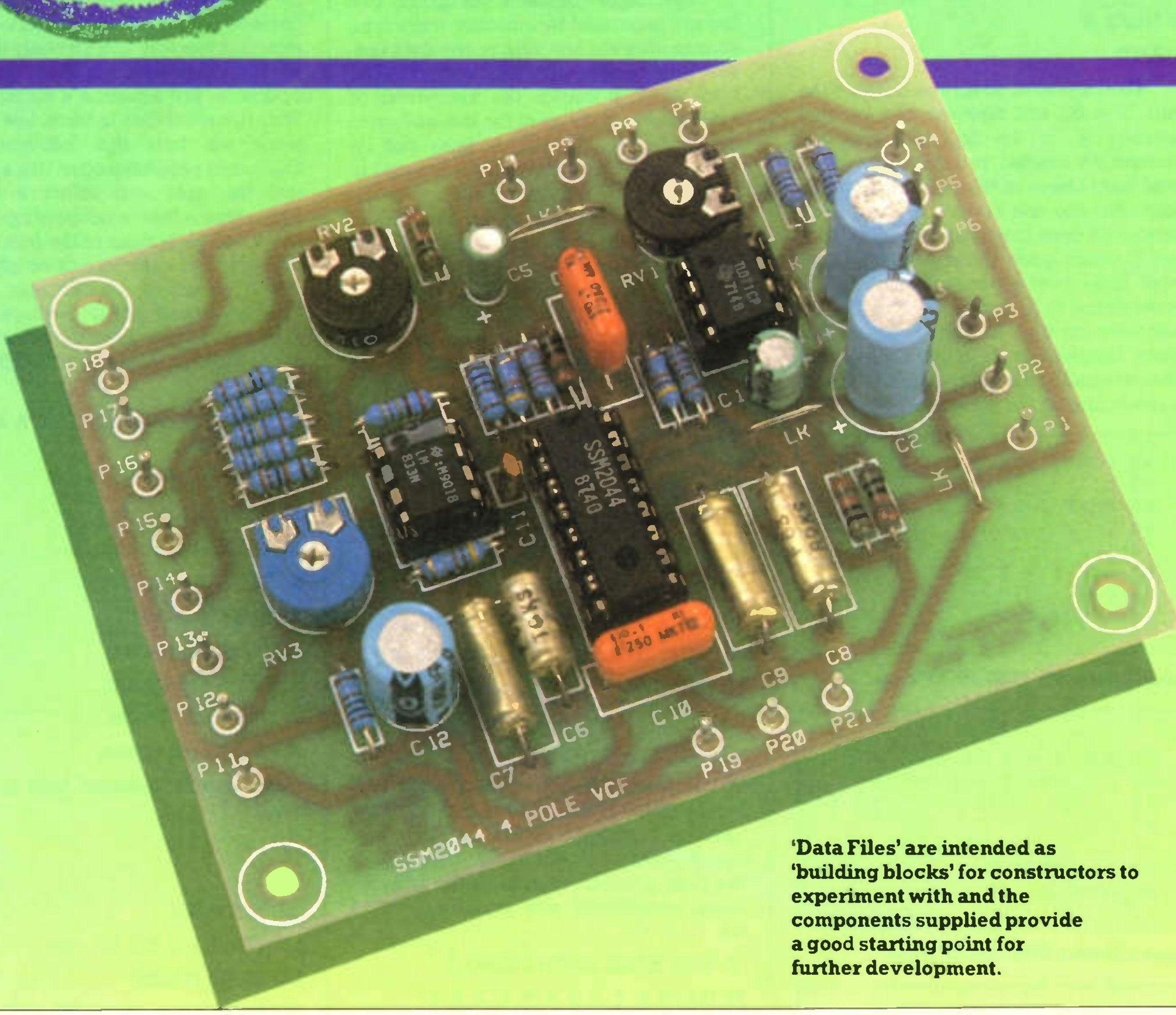
240 GOTO 130

Note that it's perfectly alright to jump out of the loop if necessary, as with 'IF ITEM$ = "0" THEN GOTO 190'. You cannot however jump into a 'FOR / NEXT' loop from somewhere else, as the interpreter will present a 'next without for' error, if it

***Continued on page 68***

# DATA FILE

# SSM2044 4-POLE VOLTAGE CONTROLLED FILTER




**'Data Files' are intended as 'building blocks' for constructors to experiment with and the components supplied provide a good starting point for further development.**

## FEATURES

- ★ Low External Parts Count
- ★ Wide Supply Voltage Range
- ★ Kit Available

## APPLICATIONS

- ★ Electronic Music Systems
- ★ Voltage Controlled Oscillators
- ★ Sweep Oscillators

| Parameter | Conditions | Min | Typ | Max |
|---|---|---|---|---|
| Positive supply voltage | | +5V | +15V | +18V |
| Negative supply range | | −5V | −15V | −18V |
| Positive supply current | Pin 13 at 0V | 1·0mA | 1·4mA | 2·0mA |
| Negative supply current | Pin 13 at 0V | 4·5mA | 6·2mA | 8·0mA |
| Q Control threshold voltage | | 400mV | 500mV | |
| Frequency control range | | 10000/1 | 50000/1 | |
| Frequency control input range | | 120mV | +1 | 80mV |

**Table 1. IC Electrical Characteristics.**

## Introduction

The SSM2044 is a low cost, 4-pole voltage controlled filter IC which is ideal for use as an electronic low pass filter. It is also possible to use the device as a voltage controlled sine wave oscillator. Figure 1 shows the IC pinout and Table 1 shows the typical electrical characteristics of the IC.

## IC Description

The IC uses a unique filtering technique to provide low noise operation and a high rejection of control signals with an extended control range. Figure 2 shows typical filter responses obtainable using the SSM2044. The differential signal inputs will accept signals up to ±18V peak to peak.

The effective Q of the filter is determined by the current flow into pin 2 of the IC. When the Q control current reaches a critical value (approximately 425$\mu$A) oscillation will occur at the cut-off frequency. When used as an oscillator the IC is capable of producing a comparatively pure sine wave. For all Q settings below the oscillation threshold the final roll-off at high frequencies approximates −24dB/octave. Figure 3 shows the resonance of a 4-pole low pass filter as a function of feedback or Q control current. It can be seen that the rate of change is very slow when the Q current is low, but increases rapidly as the oscillation threshold is approached. The type of response shown can be a problem when designing a Q panel control with the right 'feel'. Ideally the control potentiometer should have a characteristic which is a reciprocal of this response. One way to approximate this response is to connect a logarithmic potentiometer in reverse of the standard configuration. To obtain better resolution a resistor equal to one third of the value of the pot can be connected in series with the 0V end to ground, thus discarding the lower 25% of the Q response curve, where little change is evident. The sense of the Q control is such that minimum resonance is achieved at 0V and the resonance increases with positive Q control current.

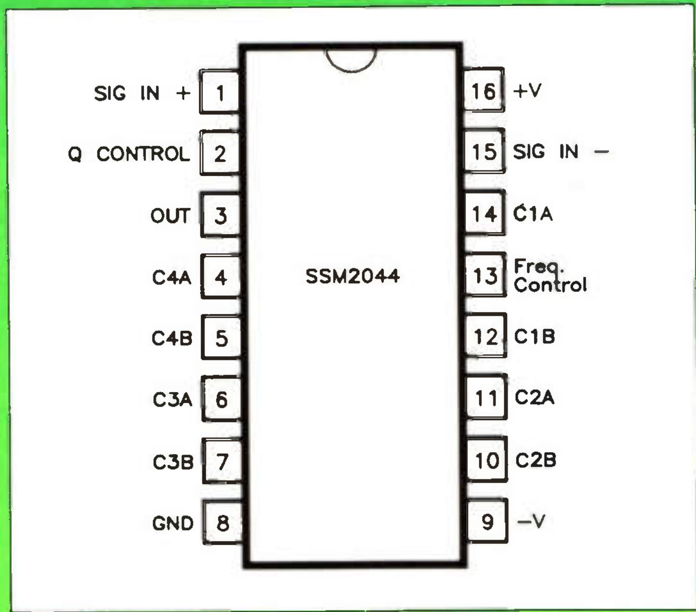



**Figure 1. IC pinout diagram.**

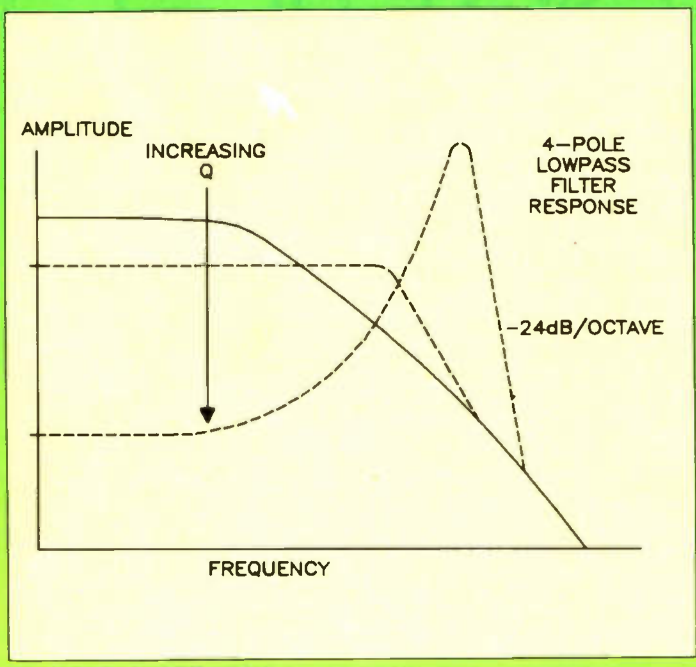



**Figure 2. Typical SSM2044 filter responses.**

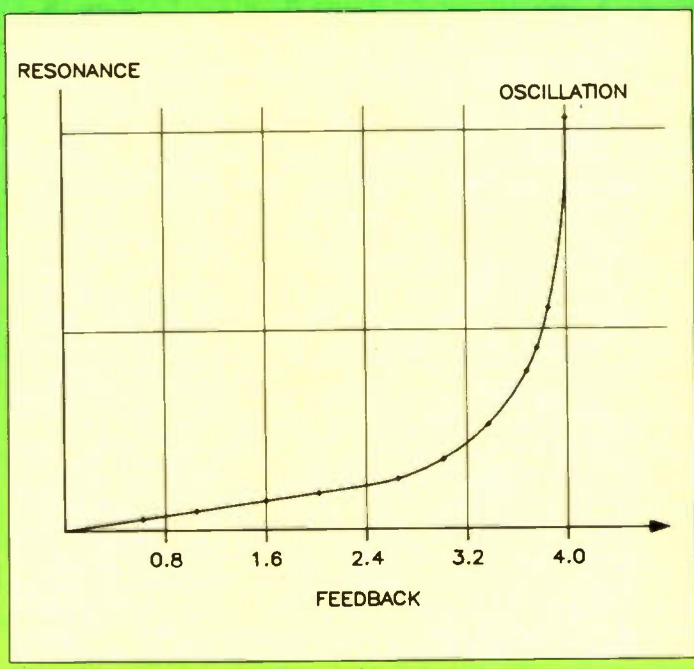



**Figure 3. Resonance verses Q control current.**

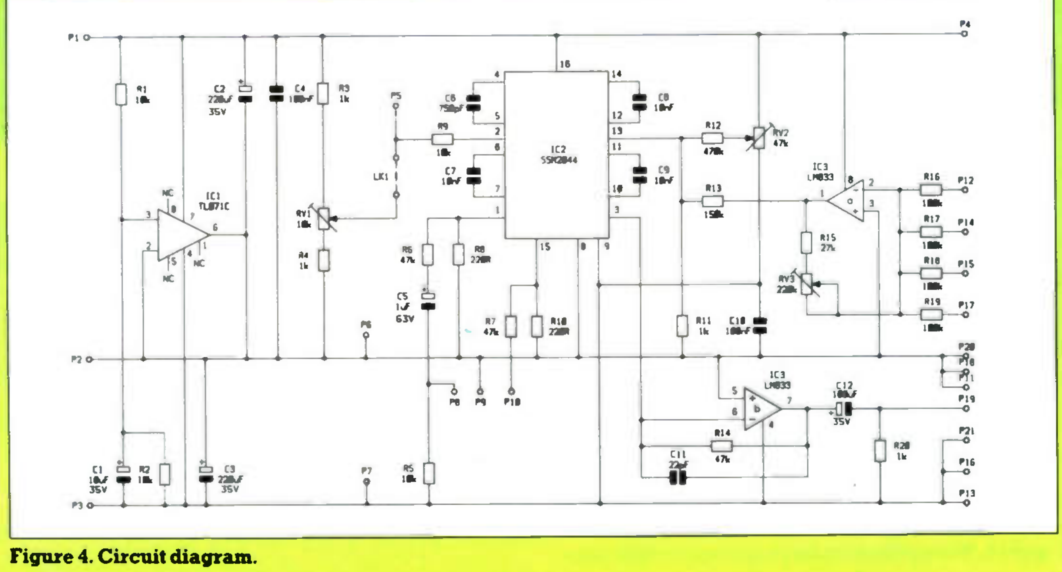


**Figure 4. Circuit diagram.**

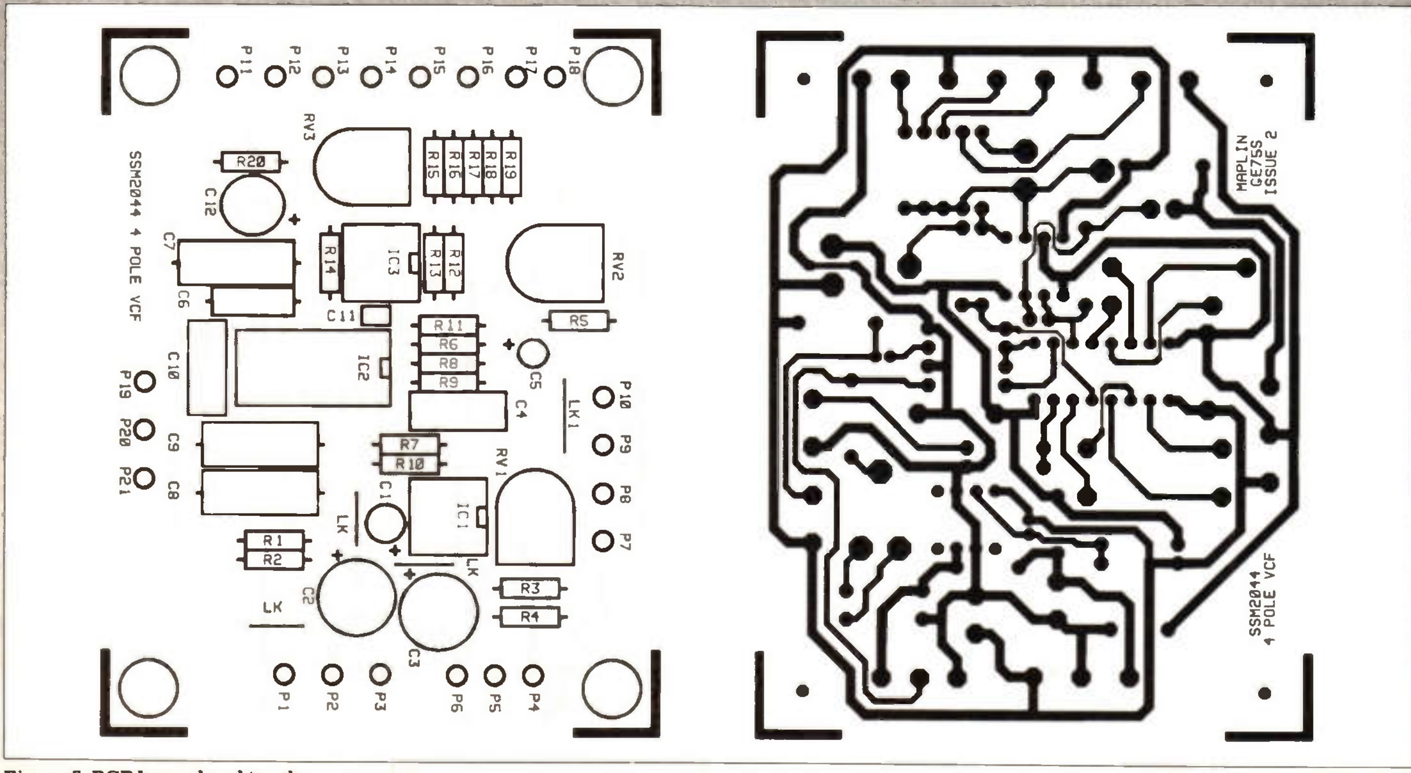



**Figure 5. PCB legend and track.**

## Kit Available

A kit of parts, which includes a high quality fibreglass PCB, is available for a general purpose application circuit using the SSM2044. Figure 4 shows the circuit diagram of the module and Figure 5 shows the legend.

Additional components have been included in the design to allow the circuit to operate from a single rail supply. The module requires a single power supply of between 12V and 30V which is capable of supplying up to 50mA. As always, it is important that the power supply is adequately smoothed to prevent the introduction of mains hum onto the power supply rails. When using a single supply, power supply connections are made to P1(+V) and P3(0V). Figure 6 shows the wiring information for single supply operation.

It is equally possible to power the circuit from a split rail power supply of between ±6V and ±15V, and when the module is used in this way, R1, R2, R5, R20, C1 and IC1 should be omitted, and wire links fitted in place of C5 and C12. When using a split supply, power supply connections are made to P1(+V), P2(0V) and P3(−V). Wiring information for this type of configuration is shown in Figure 7.

The circuit can use either single ended or balanced inputs and provides a single ended output. The non-inverting input and the output have facilities for capacitive coupling. If a single ended input is required, then input connections should be made to P8 with the 0V return to P7 or P9 as appropriate. For a balanced input, connections should be made to P8(+i/p), P9(0V) and P10(−i/p). Note: the balanced input configuration is practical only when using a split supply.

A total of 4 voltage control input pins are provided for frequency control (P12, P14, P15 and P17), all of which are connected via 100k resistors to the inverting input of IC3a, which effectively acts as a summing amplifier. Preset resistor RV2 is used to set the centre point of the frequency range, while RV3 adjusts the sensitivity of the voltage control inputs.

Wire link LK1 allows the choice of either an onboard Q

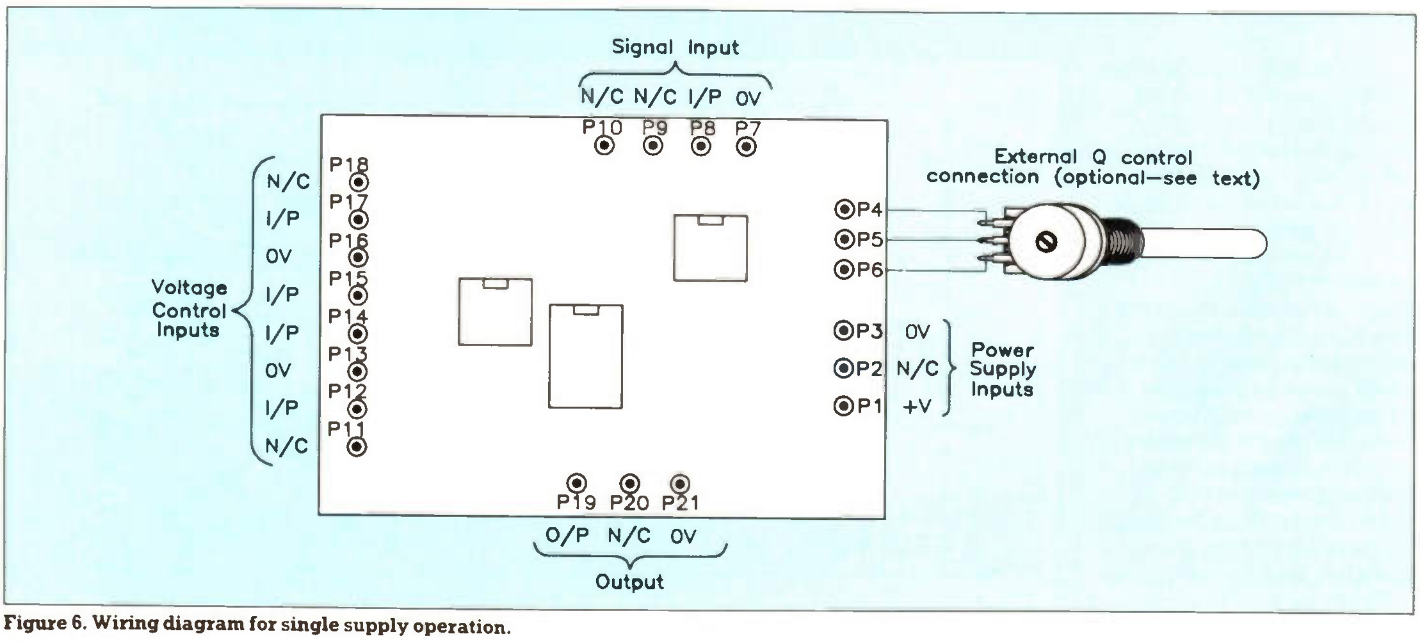



**Figure 6. Wiring diagram for single supply operation.**

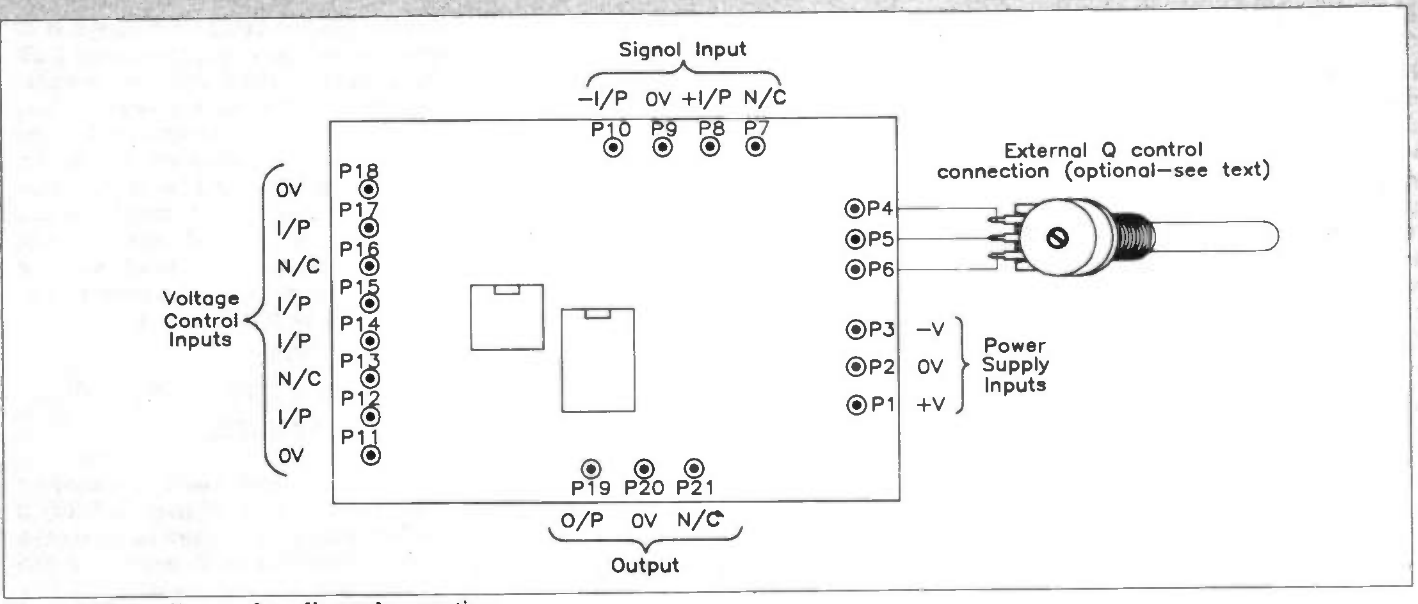



**Figure 7. Wiring diagram for split supply operation.**

control preset (RV1) or an external potentiometer. If LK1 is fitted, Q control is via the on-board preset; however, an external Q control potentiometer may be connected to P4, P5 and P6 and in this case LK1, RV1, R3 and R4 must be omitted. A suitable value for the potentiometer is 10kΩ.

As mentioned, some of the components are only required in certain configurations and to illustrate this, Table 2 shows the appropriate components together with the different circuit options available. The table also shows which of the options are available for use with split (balanced) or single supplies only. In addition to LK1 there are three other wire links on the PCB (marked LK); these are all fitted independent of the options chosen. Please note: if all of the components shown in the parts list are fitted, the module is then configured to operate from a single rail power supply, with Q control via RV1 and with a single ended input.

## Applications

The module may be used in many different applications requiring a voltage controlled low pass filter or oscillator. Operating frequency ranges can be changed by fitting different values in place of C6. Optimum performance will usually be achieved using the highest specified supply voltage as this allows improved dynamic range.

By applying the output of a low frequency ramp or triangular wave oscillator to the control voltage input, the module

| | SINGLE SUPPLY | SPLIT SUPPLY | ON BOARD Q CONTROL | EXTERNAL Q CONTROL | SINGLE ENDED INPUT | BALANCED INPUT |
|---|---|---|---|---|---|---|
| LK1 | – | – | YES | NO | – | – |
| R1 | YES | NO | – | – | – | – |
| R2 | YES | NO | – | – | – | – |
| R3 | – | – | YES | NO | – | – |
| R4 | – | – | YES | NO | – | – |
| R5 | YES | NO | – | – | – | – |
| R7 | – | – | – | – | NO | YES |
| R20 | YES | NO | – | – | – | – |
| RV1 | – | – | YES | NO | – | – |
| C1 | YES | NO | – | – | – | – |
| C5 | YES | LINKED | – | – | – | – |
| C12 | YES | LINKED | – | – | – | – |
| IC1 | YES | NO | – | – | – | – |
| SINGLE ENDED INPUT | YES | YES | – | – | – | – |
| BALANCED INPUT | NO | YES | – | – | – | – |

**Table 2. Construction information for different options.**

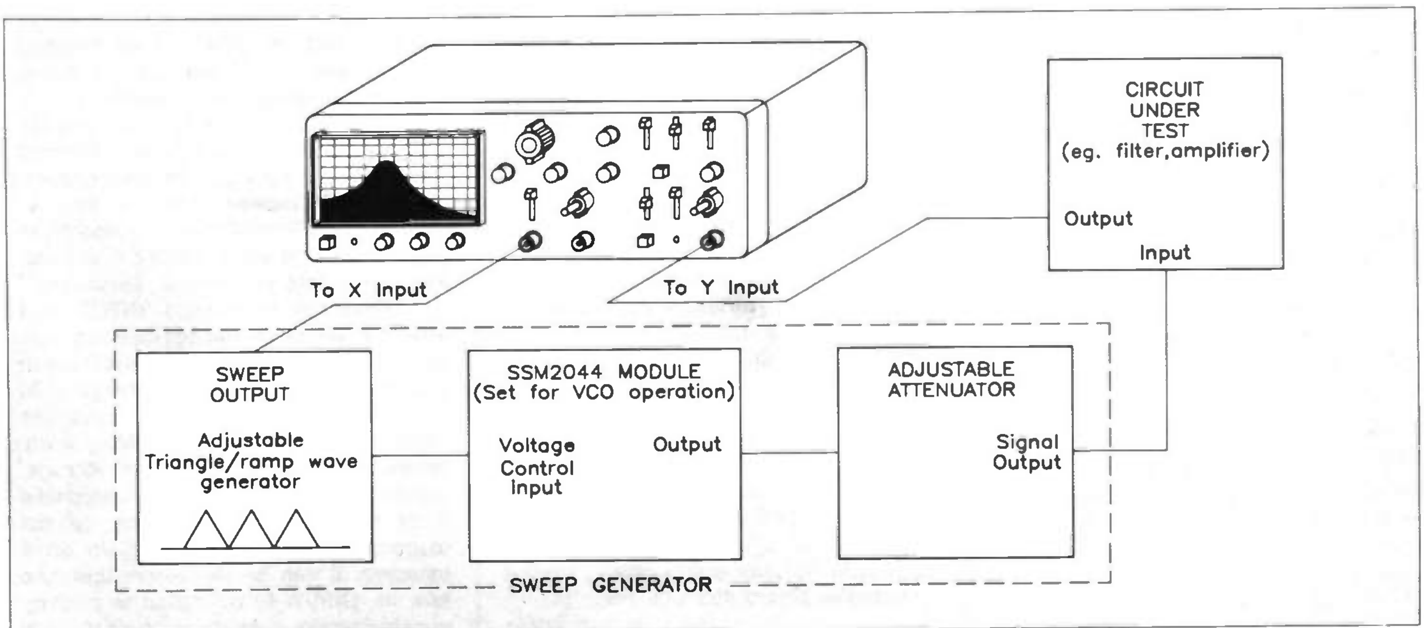



**Figure 8. Basic block diagram of a sweep generator incorporating the SSM2044 module.**

*Continued on page 76.*

***Programming in BASIC***
***Continued from page 63***

hasn't read the line saying 'FOR . . .'. Also, there should only ever be one 'NEXT' for each 'FOR'. If it is necessary to skip a section of the instructions in the loop, you must 'GOTO' the line having the 'NEXT' – you cannot simply use a statement like 'IF . . . THEN NEXT <n>', this is a no-no, as it will sooner or later again cause a 'next without for' error.

## The INPUT Statement

We saw earlier that the 'LET' statement can be used to assign a value to a variable, and that the 'DATA' and 'READ' statements can be used to 'initialise' several variables if required. But BASIC provides for a variable to be given a value by the user from the keyboard. This is the 'INPUT' statement, which is necessary where the program requires data of some kind from the person using the program. By using 'INPUT' on a line, the program is forced to wait for something to be keyed in and presents a 'prompt' ('?') on screen while waiting for the answer. To illustrate:

```
10 REM GUESSING GAME
20 PRINT "TYPE A NUMBER BETWEEN 1 AND 9"
30 INPUT A
40 PRINT "YOUR NUMBER IS"; A
50 END
```

When 'RUN' the program produces:

```
TYPE A NUMBER BETWEEN 1 AND 9
? 5
YOUR NUMBER IS 5
```

You always get a flashing cursor while 'INPUT' is active. Typing '5 (RETURN)' allows the program to continue and supply the answer. It would be nicer however if the question mark immediately followed the request, making a proper question. Lines 20 and 30 can be combined to form:

```
20 PRINT "TYPE A NUMBER BETWEEN 1 AND 9"; : INPUT A
```

And when run this will be displayed as:

```
TYPE A NUMBER BETWEEN 1 AND 9? 5
YOUR NUMBER IS 5
```

The semicolon defeats the carriage return at the end of the 'PRINT'ed message, and the colon allows two statements to share a BASIC line, in this case both 'PRINT' and 'INPUT'. But often you can take advantage of the fact that 'INPUT' can also display one message line on its own, like 'PRINT':

```
20 INPUT "TYPE A NUMBER BETWEEN 1 AND 9"; A
```

'INPUT' also allows more than one number to be entered at the same time. For instance:

```
INPUT A, B, C
```

requires data in the format <first number>, <second number>, <third number> with commas between, before being terminated with a carriage return or the 'enter' key. If fewer than the required quantity of numbers is entered, the interpreter will put up another prompt '?' for the missing entry, and continue to do so until all the required data is input to the relevant variables. If there are more individual data items than there are specified variables to take them, you will get a 'extra ignored' message, or something similar, so this form of multiple entry using one 'INPUT' statement requires precise co-operation by the program user.

## Strings

Up to now we have mostly dealt with numeric variables, like 'A = 5'. But whole alpha-numeric sentences can also be handled as variables. Suppose we wish to assign the days of the week to a variable, by 'LET A = "MONDAY" etc. This will cause a 'type mismatch error', because either the variable or the information we are trying to assign to it is of the wrong type. Integers (e.g. 'A%') can only represent whole numbers, a floating point variable (e.g. 'A') can only represent whole and/or fractional numbers, but for one or more 'words' the string variable is needed, as in 'A$' (and, if used, numbers will also become words). Assigned to A$, "MONDAY" becomes a 'string', because it is stored in BASIC memory as 'a string of characters'. To assign some text as a string to a string variable, the entire sentence must be enclosed in quotes ("). Notice that this follows the same convention that operates for the 'messages' that can follow 'PRINT' and 'INPUT' statements. Following on from this, while a numeric variable can be cleared by assigning it the value of 0, it may come as no surprise to learn that a string variable is cleared by e.g. 'A$ = ""', literally nothing between quotes.

## Inputting Strings

Whole words or sentences can be input by specifying a string variable after 'INPUT', obviously where the information from the user is needed in alphabetic form, in the case for example of a security password required before the program can be used. There is another, though less obvious, advantage. Where numeric data is required, it is usual to input numeric variables with 'INPUT A' etc. However, if by mistake a letter or string of characters was entered the program will stop with a 'type mismatch' error.

One of the things that should concern the programmer is to anticipate in how many different ways the final program can be 'abused' by a user. The program, if able to anticipate erroneous data input and the pressing of wrong keys, etc., through using built-in techniques commonly called 'traps', will be much more 'user friendly' and able to safe-guard itself against information errors and 'crashes'.

An example of this is shown in the above menu. In this case the menu checks that the inputted data from the keyboard, which would be an options choice from the menu list from 1 to whatever, is within the range of options available, i.e., numbers less than 1 or greater than the highest numbered option are ignored. An extension of this would be to recognise that the input was non-numerical *before* the interpreter stopped with an error message, because the input was the wrong type required for the variable. The menu could be modified with:

```
210 INPUT OPT$
215 IF OPT$ = "" THEN OPT$ = "0"
216 OPT = VAL(OPT$)
```

Now the input could be anything including 'nothing at all' (just RETURN). If OPT$ is 'empty' or '""' (nothing entered) it is given the character '0', because on line 216 the real selection variable 'OPT' is assigned the *value* of OPT$, which the 'VAL' statement cannot do if the string is 'empty'. If 'OPT$' is a string of numbers then the conversion goes ahead okay; if on the other hand the first or all of the characters are non-numeric then the 'VAL(' function assumes zero. Whichever, 'OPT' gets a legal number. This process can be expanded to also exclude fractions, by changing line 216 to 'OPT = INT(VAL(OPT$))', which will cause 'OPT' to have only the whole number portion of the digit string assigned to it through the function 'INT(', which has the effect of changing floating point numbers into integers by ignoring fractions.

## Manipulation of Strings

There is a complementary of the function 'VAL(', having the opposite action. 'STR$(' has the effect of converting a value of a numeric variable into a string of digits for a string variable. Hence 'A$ = STR$(A)' will result in 'A$' having an ASCII word which is the written number of the value of 'A'.

When the statements 'PRINT', 'LPRINT' and 'PRINT#' (to an external device) are used, number to string conversions are automatic, and it is always the *string* that appears in print, not the actual bytes of the number that is stored (which will produce meaningless characters). When numeric data is sent to storage (disk drive or tape) it is also in the form of digit strings if 'PRINT#' is used. Real strings are unchanged, obviously.

When the statements 'INPUT' and 'INPUT#' are used, the opposite conversion takes place if a value needs to be read and assigned to a *numeric* variable. In other words, the functions expect the value to be written in digit string form, whether from keyboard or storage, there's no difference. The conversion fails if the characters are not digits, i.e. not characters '0' to '9', producing an error message. It can be seen from this then how an 'INPUT(#)' operation to a *string* variable works regardless of which type of characters are involved, alphabetic or numeric, because no conversion is necessary.

Furthermore, the ASCII (American Standard Code for Information Interchange) values of individual characters can be handled. The standard ASCII code for 'carriage return' is 13. You can create two blank lines with 'PRINT : PRINT', but 'PRINT CHR$(13)' will have the same effect since the ASCII character 13 is printed, producing one line space, and then of course if there is no semicolon at the end of the 'PRINT' statement to suppress the automatic carriage return at the end of 'PRINT' we will get another one. 'PRINT CHR$(13); CHR$(13);' is yet another variation for the same result. All characters can be 'PRINT'ed individually in this way if their values are known, using 'CHR$(<value>)'.

The ASCII value of a character can be discovered by the 'ASC(' function. This returns the value to a numeric variable or 'PRINT' statement, as in:

```
PRINT ASC("@"); ASC("A"); ASC("B")

 64 65 66
```

Strings can be added together using '+', which has the effect of 'concatenating' strings. At the same time, string constants between quotes and/or single character derivatives from numbers can be included. For example:

```
WEEK$ = "MONDAY" + CHR$(13) +
"TUESDAY" + CHR$(13) +
"WEDNESDAY" + CHR$(13) +
"THURSDAY" + CHR$(13) +
"FRIDAY" + CHR$(13) +
"SATURDAY" + CHR$(13) +
"SUNDAY" + CHR$(13)

PRINT WEEK$

MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
```

Because there is a character 13 between each word, the whole string 'WEEK$' comes out as a list and not a single line. Now look at this:

```
100 DAY = 0
110 FOR SCAN = 1 TO LEN(WEEK$)
120 IF ASC(MID$(WEEK$,SCAN,1)) = 13
THEN DAY = DAY + 1 : PRINT " "; DAY;
130 PRINT MID$(WEEK$,SCAN,1);
140 NEXT SCAN
150 END
```

'LEN(' returns the number of characters in the string 'WEEK$', and 'MID$(' is a string editing function which can extract a number of characters from any position in a string, in this case, from position 'SCAN' and for number of letters '1'. The 'for / next' loop prints all the days in the week exactly as 'PRINT WEEK$' would, but one character at a time while it is searching the string for carriage returns (13's) so as to subsequently display extra information in the relevant places:

```
MONDAY 1
TUESDAY 2
WEDNESDAY 3
THURSDAY 4
FRIDAY 5
SATURDAY 6
SUNDAY 7
```

Some versions of BASIC allow individual letters to be changed using 'MID$('. If we say 'MID$(WEEK$,1,1) = "S" : MID$(WEEK$,2,1) = "U", then 'MONDAY' is changed to 'SUNDAY'. Alternatively, the ASCII 'CHR$('codes can be used in place of "S" and "U", but not all BASIC's allow individual characters of a string to be changed like this.

Similary, 'LEFT$(WEEK$ 7)' extracts the first seven letters of 'WEEK$' producing 'MONDAY', and 'Right$(WEEK$, 7)', 'SUNDAY'. Sunday can be moved to become the first day of 'WEEK$' by:

```
WEEK$ = RIGHT$(WEEK$,7) +
LEFT$(WEEK$,LEN(WEEK$)−7)
```

producing:

```
SUNDAY 1
MONDAY 2
TUESDAY 3
WEDNESDAY 4
THURSDAY 5
FRIDAY 6
SATURDAY 7
```

from the above program.

Much can, and has, been written about extensive string manipulation in this way. The foregoing is just an indication of the possibilities, more can be gleaned from your computer manual and a number of books about BASIC.

## IF . . . THEN . . . ELSE

Along with 'FOR / NEXT' loops, the other important attribute which makes a computer different from any other kind of machine is its ability to make decisions, and alter the direction of its actions according to the kind of information found. For instance, one might want to know for how many years one should invest £100 at 9% compound interest for the principal sum to reach £1,000.

Assuming one did not know the compound interest formula, one would start by calculating the interest and adding it to the principal. One variable would act as an 'accumulator', keeping a count of the number of years. Another statement of the program would test to see if the principal sum had become equal to or exceeded the target of $1,000. If so, then the number of years is printed and the program terminated. This is an 'iterative' type of program which arrives at one answer after computing and adding compound interest several times until the final goal is reached.

'IF' and 'THEN' are instrumental in re-directing program flow. The construct of 'if / then' is 'IF <condition true> THEN <action> ELSE <no action or alternative action>.

## Flow-Charting

Take a look at Figure 4. It is a 'flow-chart' of the aforementioned compound interest calculator program. As mentioned in Part 1, this is the sort of thing you must do first, to work out beforehand how your program is going to perform its actions *before* you actually start writing any of it! Following flow-charting conventions, Figure 4 begins and ends with 'START' and 'END' contained in lozenges, to make it clear where these are. Actions are described briefly in boxes and linked by lines showing the direction of program flow from one to the next.

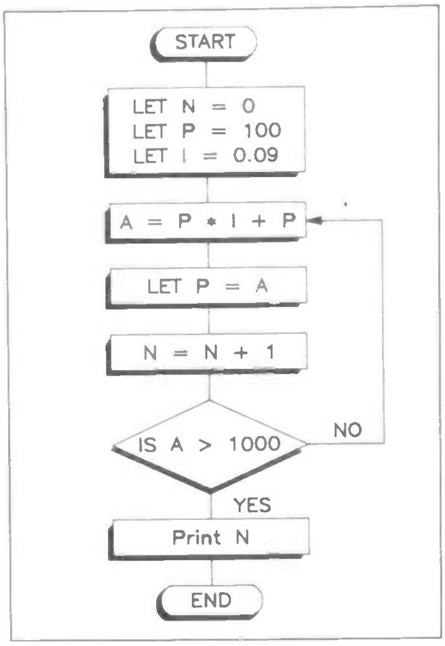



**Figure 4. Flow chart for a compound interest problem.**

The diamond shaped box is the interesting one because this is where a decision is being made, in this case, whether the target of £1,000 has been reached or not.

Program flow is modified according to the result of a logical comparison. The comparison symbols used in BASIC are:

| | |
|---|---|
| = | equal to |
| > | greater than |
| >= | greater than or equal to |
| < | less than |
| <= | less than or equal to |
| <> | not equal to |

In the case of 'IF / THEN' the sign '=' really does mean 'equal to' and is not an assignment, as in the 'LET' statement. The simplest form for 'if / then' is 'IF <condition true> THEN <action>'; if not true then program execution continues on the line *after* the statement unchanged. Many versions of BASIC allow an extension of this idea if the result of the test is not true, using 'IF <condition true> THEN <action> ELSE <alternative action>'.

The Boolean logical operators 'OR', 'AND' and 'NOT' can also be used in comparisons. The following are then possible:

```
IF Z = Y OR Z = X THEN PRINT Z
IF A = 10 AND B = 10 THEN END
IF NOT A THEN GOTO 100
```

This last actually looks at a negation of 'A', as the operator 'NOT' inverts the value as read. If 'A' were −1, then in the above test it is read as 0 and the line would *not* 'GOTO 100'. Similarly:

```
IF A THEN GOTO 100
```

which simply tests 'A' which again must be *zero for no action*. If it is not zero then 'GOTO 100' is executed. Just to add further confusion, most BASIC interpreters allow the 'GOTO' to be dropped if this action is required following 'THEN', so:

```
IF A THEN 100
```

is possible.

```
IF ( C>=64 AND C<=90 ) OR ( C>=97
AND C<=122 ) THEN 2200 ELSE C=46
```

shows how 'IF / THEN' can be expanded to test for values within one or more ranges. Note that, as with arithmetic operators, comparisons within brackets are tested first.

Having worked out how to solve the compound interest problem by means of the flowchart in Figure 4, we can now go on to write the program in Figure 5, where:

N = number of years
P = initial amount
I = interest in decimal

The point to bear in mind is to set the value of the principal to the new value (principal plus interest) each time. This is done at line 60 by the 'LET' statement. It is also good practice to set the accumulator 'N' to zero at the start just to ensure that it is 'cleared'. You can double-check the program's answer using the formulae:

$A = P\,(1+I) \uparrow N$
$1000 = 100\,(1+0.09) \uparrow N$
$10 = (1.09) \uparrow N$

Taking logarithms to the base 10 each side:
$1 = N\ 0.0374$
$N = 26.719$ or 27 years.

```
10 REM PROG FOR SOLVING COMPOUND INTEREST PROBLEM
20 N = 0
30 P = 100
40 I = 0.09
50 A = P * I + P
60 LET P = A
70 LET N = N + 1
80 IF A > 1000 THEN 90 ELSE 50
90 PRINT "Number of years is"; N
100 END
```

**Figure 5. Program for the compound interest problem.**

## WHILE . . . WEND

This is an enhancement which is available on some versions of BASIC. We have seen that the 'FOR / NEXT' statements can be used to execute a loop a number of times determined by a 'counter' variable, and the loop ends when the value of that variable exceeds a given limit. It is, in theoretical terms, a 'do / while (within range)' construct. What makes the 'WHILE / WEND' statements different is that a tested condition is used to decide whether to perpetuate the loop or not and which is not a count, but can be a test of any parameter. The following revised menu example will illustrate the principle by *not* employing 'WHILE / WEND':

```
10 REM DATA READING MENU
20 :
< 30 - 100 data statements >
105 :
110 DATA 0
120 :
130 RESTORE
140 J = 0 : ITEM$=""
150 IF ITEM$ = "0" THEN 190
160 READ ITEM$ : J = J +1
170 IF ITEM$<>"0" THEN PRINT J; ". ";
ITEM$
180 GOTO 150
190 PRINT
200 PRINT "Please choose"; 1; "–"; J –1;
210 INPUT OPT$ : IF OPT$="" THEN
OPT=0 ELSE OPT=INT(VAL(OPT$))
220 IF OPT < 1 OR OPT >= J THEN 130
230 ON OPT GOSUB 1000, 2000, 3000, 4000,
5000, 6000, 7000, 8000
240 GOTO 130
```

In line 150, execution is allowed to continue to line 160 *while* 'ITEM$' is not equal to '0'. After printing the menu option line (and only if it isn't '0'), execution is redirected back to line 150 again. Upon 'ITEM$' no longer being 'not equal to' '0', execution jumps to line 190, which is immediately after the 'loop back' instruction at 180. So, line 150 could just as easily be '150 WHILE ITEM$ <> "0", and line 180 '180 WEND'. 'WEND' is, of course, 'While END' (end of 'while' loop). 'WHILE / WEND' loops may be nested, as in Figure 6, just as 'FOR / NEXT' loops can.

Notice that with 'WHILE / WEND' the condition is always *tested first*. If the condition is false first time round, then even one iteration of the loop will not be executed. Try removing the 'ITEM$ = ""' statement in line 140 of the above, and see what happens when an out-of-range or wrong entry forces the menu to re-run a second time. Now 'ITEM$' retains the string "0", and no more options can be read from data, producing no list. What's more, the choices available will be in the range 1 to −1! No choice at all.

```
10 WHILE < condition 1 >
20 statements
50      WHILE < condition 2 >
60          statements
100     WEND
110 WEND
```

**Figure 6. Nested WHILE – WEND loops.**

Some machines may even support the 'DO / WHILE' variation. This will be different in that the condition is tested last, as in:

```
100 DO
110 statement
120 statement
130 statement
140 WHILE <condition true>
150 next statement
```

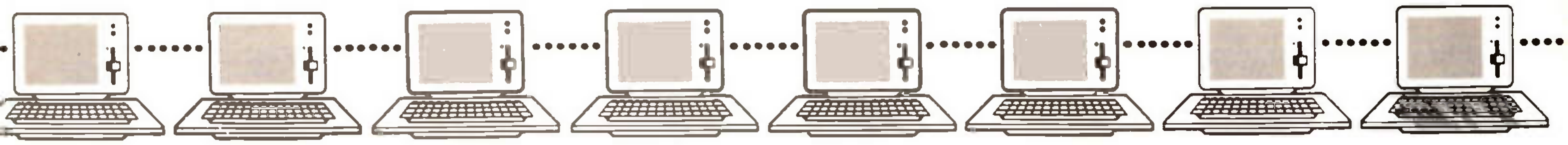
Execution will keep returning from lines 140 to 110 while the condition is true, and only allowed to progress onto line 150 if false. At least one run through the loop 110 – 130 must occur before line 140 is reached, regardless.

The following shows an example of 'WHILE / WEND' for receiving data from a keyboard which must match a constant, as in the case for a request for a security password before the program can be used:

```
90 IN$ = "" : PRINT "ENTER PASS-
WORD : ";
100 WHILE IN$ <> PASSWORD$
110 INPUT IN$
120 WEND
130 :
140 start of actual program
```

A more sophisticated version could make it more difficult by not showing the characters as they are typed (in case anyone is watching), and requiring precise key strokes:

```
90 IN$ = "" : PRINT "ENTER PASS-
WORD : ";
100 WHILE IN$ <> PASSWORD$
```



```
110 K$ = INKEY$ : IN$ = IN$ + K$
120 IF K$ = CHR$(13) THEN 90
130 WEND
140 :
150 start of actual program
```

As soon as IN$ matches PASSWORD$ execution goes straight to line 140 without having to key RETURN. But if there is an error, RETURN will allow a second attempt via line 120. This is necessary or else it will be impossible to try again without re-running the program from start. The 'INKEY$' function is often different between the various versions of BASIC, some will have alternatives; 'GET K$' for instance. If you don't have 'WHILE / WEND' with your version of BASIC, don't worry. 'WHILE / WEND' and even 'DO / WHILE' BASIC constructs can be easily simulated using 'IF / THEN' in loops created using 'GOTO's, as the previous menu example shows.

Try some experiments of your own to produce some of the fundamental loops of various sorts. 'FOR / NEXT' is fairly straightforward in that it provides for a process to be repeated X number of times, or until 'forced' to end by jumping out with 'IF / THEN'. If you don't have 'WHILE / WEND', practice simulating it using 'IF / THEN' with 'GOTO's to form a loop. In like manner you can also try 'do / while'. To reiterate:

For / next construct (counted iterations):

FOR <variable*> = <initial value>
TO <terminal count>
[ STEP (−) <increment> ]
<statements>
NEXT <variable*>

*Asterisk same variable name*

If / then construct (conditional branching):

IF <condition true> THEN <action>
[ ELSE <alternative action> ]
<next statement>

'ELSE' can also mean 'no action', or 'no deviation from program flow', or in other words the next following statement will be executed on the next line.

The following can be simulated if actual BASIC keywords representing them are not available:

Do / while construct (condition tested first):

if <condition false> goto next line after loop else do <statements> then go back to beginning again

which can be written as:

IF <condition false> THEN GOTO <end of loop> : <statements> : GOTO <start of loop>

This includes:

WHILE <condition true> <statements>
WEND

because the condition is tested first. The statements are repeated only if the condition is true, and even when these are executed for the first time, the construct does so only if 'true'. In other words, if the condition is false first time round, the statements will never be executed at all.

Repeat / until construct (condition tested last):

do <statements> then test if <condition true> and loop back to beginning if 'false', else continue

which can be written:

<statements*> : IF <condition false> THEN GOTO <beginning of statements*> again (else continue to) <next statement>

*Asterisk same variable name*

The statements are executed at least once, whether the condition is true or not. Figures 7 and 8 illustrate in flow chart form the 'repeat / until' and 'do / while' constructs which might be easier to follow. It all seems a bit complicated at first but it is important to grasp these concepts early, as they are the foundations of the way in which computers operate. Next time we shall be looking at subroutines and sequential data storage amongst other things.

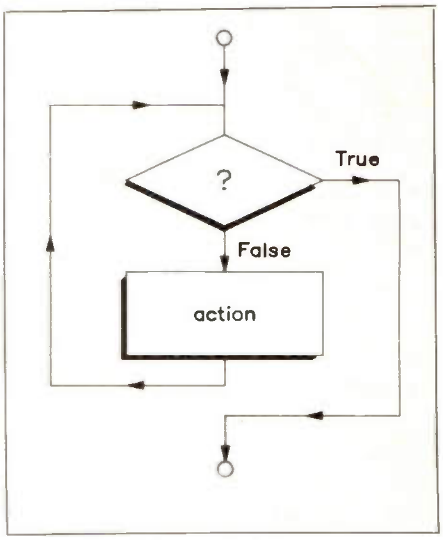



**Figure 7. The 'Repeat / Until' construct.**

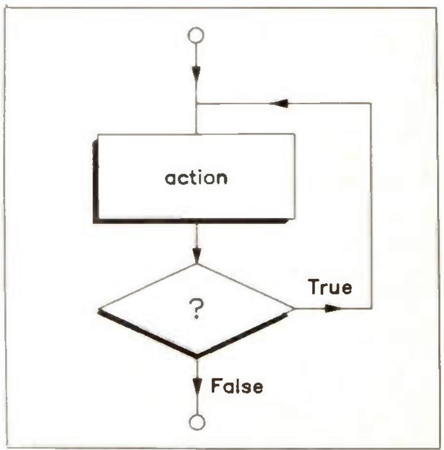



**Figure 8. The 'Do / While' construct.**

# Audio Frequency Induction Loop Systems

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## Part 4 – A practical system – and other stories

### New Readers Start Here

Audio frequency induction loop systems (AFILS) are used mainly for communicating with hearing aid users (hereinafter called 'Grandmas', with absolutely no intention of patronizing them), but are increasingly being used for confidential communication with staff in public buildings and spaces. Speech (and/or music) signals are amplified and used to drive a current through a loop of wire (or a system of loops) encircling the area where the system is to be used. The resulting magnetic field is picked up by suitable receivers (hearing aids equipped with magnetic antennas or 'telecoils') carried by the Grandmas or staff.

This is Part 4 of the series, and it won't make much sense without the previous Parts, which are in Issues 39, 40 and 41 of the Magazine, so if you are seriously interested in audio frequency induction loop systems, you will need to order the back numbers (why not do it now?). There is far too much information in the previous three parts for any sort of 'instant update', on the theory and practice already covered, to be given in this article.

### A Practical System

The most likely instance of an amateur being asked about installing an AFILS is where one is required in a church. For those people who don't have 'churches', please replace by the appropriate word, and do the same for any architectural features that may be mentioned. A typical professional installation might cost £2,000, and such a cost is perfectly justified. An amateur, however, would not charge for time spent, and could make some savings on equipment by choosing from the Maplin range. For example, a professional would choose an amplifier costing in the region of £400, but with Maplin we can do better.

### Begin at the Beginning

It is essential to make some sort of plan – it needn't be too formal – about how and when the work is to be done, and where, for example, the amplifier is to be located. It obviously needs mains power nearby, and it must be accessible to authorized people, without being exposed to possible 'adjustment' by well-meaning but misguided people, such as choirboys or vicars. It would be a *mistake* to hide it away in some very inaccessible place. It should be possible to hear what is going on in the body of the church from the amplifier position: in this way it is possible to set up the system quite easily, whereas if you cannot hear what is going on, setting up becomes very difficult.

The next step is to decide where the loop cable is to run. In many churches, floor level is the only choice, and the cable can run along the outer edges of the pews or other seating, or at the junction of walls and floor. The former position is often convenient, but coverage in wide side-aisles can be too weak. The aim should be to encircle all the seating, because if some is left out, that is exactly where the Grandmas will want to sit! Having determined the cable position, the dimensions of the loop should be measured, and preferably marked on a plan of the floor layout for future reference. A decision has to be made whether to extend the loop into the chancel or not. For the present, it will be assumed that this is not required, and that the loop is approximately rectangular and measures 16m × 20m.

### Microphones

Obviously, we have to provide microphones to pick up the sounds to feed into the loop amplifier. There will clearly be one microphone in the pulpit, one or even two on the choir, one on the congregation for responses, singing and general atmosphere, and it will probably be necessary to allow at least one for the organ. This latter may seem surprising, but remember that most hearing aids can only receive *either* from the microphone (M position of the selector switch) *or* from the telecoil (T position). Only a few aids have an MT switch position, so most Grandmas will not hear the organ unless it has a microphone. If the organ is electronic, of course, it may be possible to extract a 'DI' feed for the loop system amplifier.

Now we have to choose microphones, and here comes snag number one. Good dynamic (moving coil) microphones are expensive, and many are sensitive to external magnetic fields, including that created by the loop, and thus may suffer from magnetic (not acoustic) feedback problems. Electret microphones offer good quality at lower prices and are not (normally) subject to magnetic feedback problems. However, those in the Maplin range all require a battery, and this is not good news, because inevitably one or more batteries will be found to be flat just when they are needed. The best technical solution is to rewire for phantom power, but since this involves modifying a new piece of equipment, you will forgive me for not explaining how to do it: only if you know precisely what you are doing should you compromise the guarantee on the equipment. A slightly less elegant solution is to provide a central mains-derived 1·5V supply (you only need about 20mA at most for four microphones), regulated and heavily smoothed, which can be fed to each microphone. You could connect the supply to a dummy AA size battery (YX92A) by cutting the shorting strap.

Assuming that you are going to use electrets, and that you are not going to buy capsules (QY63T and FS43W) and make your own cases (thus solving the battery problem at source), you should consider a cardioid (YK64U) for the pulpit. A directional microphone will capture the voice without much reverberation, which is essential for clear hearing. An omnidirectional microphone (YK63T) on the congregation will allow the reinsertion of a controlled amount of reverberation. This microphone should not be more than 10m from the pulpit microphone, otherwise nasty echo effects may occur. If the choir is to have a single microphone, then it may be omnidirectional if the chancel roof is not too 'live', otherwise a cardioid is indicated. This microphone may often conveniently be suspended vertically over the centre of the chancel (you can see why an internal battery is not a good idea!). If two choir microphones are used, they should be of the cardioid type, each facing the appropriate choir stalls. A further microphone, on a long lead, may be desirable for ceremonies such as christenings, and this should be a cardioid type: alternatively, one might be suspended permanently over the font.

## Mixer

Clearly, with several microphones to cope with, some form of mixer is essential. A decision has to be made whether someone is going to attend the mixer during services, or whether it is to be pre-set and unattended. In the latter case, some form of automatic gain control (AGC), separate for each microphone, should be provided. It might be possible to use the musical effects compressor (YB88V) in some way, but I have not yet tried it. It would also be possible to use the preamplifier board from the small amplifier described in Part 2. For the present, it will be assumed that someone will at least fade in and out the microphones as they come into and out of use. 'Open' (i.e. faded in) microphones that are not in use pick up noise and reverberation (and the choirboys' chatter), which interfere with the wanted signals. Now we strike Snag No. 2. The electret microphones have low impedance (600Ω) outputs, but most of the less costly Maplin mixers are designed for high impedance (50kΩ) microphones. If you can afford the 6 channel professional mixer (XM02C), go for it, but please *don't* use the graphic equaliser to 'improve' the sound: it won't! Leave the channel treble controls 'flat', as well, and use the bass control only on the pulpit microphone to compensate, if necessary, for bass lift due to 'proximity effect'. If the professional mixer is beyond your budget, and you only have two microphones (pulpit and choir/organ), the stereo mixer (XJ17T) would be suitable. Another possibility is the 6 channel kit mixer (LK49D), which has enough gain for some electret microphones even though its input impedance is rather high. Yet another solution is provided by the mixer modules, (LK80B, LK86T, LK85G and LK88V). I would not recommend using the latter as a VU meter, because I believe that the peak programme meter is a much better form of indicator (see Part 5, I hope), but it would be ideal as a headphone monitor. You *must* listen to the signal you are feeding to the loop: how else can you be sure it is free from distortion and hum, or that it is even there at all? For this job, you could also use the 'indicator board' from the amplifier described in Part 2, with some changes to component values.

## Budget

Now is the time when you can tell whoever controls the money bags roughly what the cost of the parts for the system will be. (Yes, I know we haven't looked at the final amplifier, yet: allow £100 or so until you have a better estimate.) Don't forget that the pulpit microphone will need a gooseneck (probably LH88V plus JH58N) or some other form of stand: don't use floor stands *anywhere* for an AFILS. Why? Well, just think: there you are, wearing your hearing aid and contemplating the infinite, when somebody kicks the stand! The other microphones will also need fixings, and cables. If you are running 1·5V from a central power supply, you could use (PB49D or PA17T) cable to wall-boxes carrying 4-contact DIN connectors (HH33L) or multiway connectors (FK24B), with the corresponding connectors on the microphones. If the building is at all damp, it is best to use gold-plated connectors, not for show but for real reliability. You would be ill-advised to hard-wire the microphones to the cables: they should be recovered and stored out of harm's way when cleaning and building operations are going on. It is also *essential* that any switches on the microphones themselves, if they are accessible, should be locked in the ON position, otherwise one will undoubtedly be OFF just when it is most essential that it should be ON, or vice versa. This is another reason why internal batteries are not practicable.

## Loop Design

Since the Maplin range does not (yet?) include a current-drive amplifier, we are looking at voltage drive. A 16 × 20m loop could be voltage driven directly, using 7/0·2 or 1/0·6 wire, or thicker wire with a series resistor, but is too large for direct voltage drive to be the most efficient technique. This can easily be demonstrated, once we begin the design procedure.

Perimeter of loop $= 2 \times (16 + 20) = 72$m

Therefore, inductance $L = 2 \times 72 = 144\mu H$

Inductive reactance at 5kHz $= 2 \times \pi \times 5000 \times 144 \times 10^{-6} = 4{\cdot}52\Omega$

Current required for a field strength of $0{\cdot}1 Am^{-1}$ at the centre of the loop

$= \pi \times 16 \times 20 \times 0{\cdot}1 \div 2\sqrt{(16^2 + 20^2)} = 1{\cdot}96A$

Normalized listening height $= 2 \times 1{\cdot}2 \div \sqrt{(16^2 + 20^2)} = 0{\cdot}09$

This is rather too low to meet the British Standard (BS6083–4) requirement for uniformity of field strength (±3 dB), which requires a value of 0·15 minimum for the normalized listening height. However, it is unlikely that the loop can be installed below floor level, so as to increase the listening height, so the lack of uniformity has to be accepted. Since it appears as a rather strong field in the aisles, near the loop conductor, it may well not be very significant.

Current increase required due to listening height = 1·013

This is determined by interpolation from Table 1 (Part 1 – Issue 39). It is 0·1dB and thus quite negligible.

We could drive this loop from an amplifier with a low-level equaliser, but, as I explained before, this is not a very good technique as it requires very careful design and the amplifier needs extra heat-sinking arrangements. The high-level equaliser described in Part 2, mainly in the context of 100V line amplifers, can be used in this case with advantage. Referring to Figure 23 (the same as Figure 13 in Part 2), and using the equations in the Appendix to Part 2,

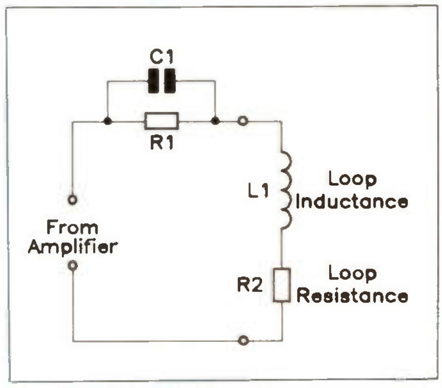



**Figure 23. A high level equaliser, for use with a voltage drive amplifier and a large loop (16 × 20m).**

$R1 = 10^4 \times \pi \times 144 \times 10^{-6} \div 2{\cdot}652 = 1{\cdot}71\Omega$

$R2 = 10^4 \times \pi \times 144 \times 10^{-6} \div 3{\cdot}751 = 1{\cdot}21\Omega$

$C = 4{\cdot}121 \div (10^9 \times 144 \times 10^{-6}) = 28{\cdot}6\mu F$

Figure 24 shows the current produced by a constant voltage input, as a function of frequency, both as calculated by a CAD program and actually measured on a dummy loop.

We can calculate what conductor size gives a loop resistance of 1·21Ω as described in Part 1.

$A = \rho k/R$
$= 18 \times 10^{-9} \times 72 \div 1{\cdot}21 = 1{\cdot}07\,10^{-6} m^2 = 1mm^2$

I really didn't 'fiddle' that result! It means that the loop can use the inexpensive and unobtrusive 32/0·2 'power connection wire', (PA00A for 100m of black). The capacitor should preferably be built up from thirteen 2·2µF polyester (BX84F) in parallel, but 'reversoradial' 100V reversible electrolytics could be used: the 50V range however is rather too lossy for comfort at the high currents possible in this application.

We know from the analysis of this circuit in Part 2 that the impedance stays constant at the low-frequency value up to about 2·5kHz and then increases steadily, reaching $\sqrt{2}$ times the low-frequency value at 5kHz, thus giving us the 5kHz bandwidth limitation necessary in order to be sure of not causing radio interference (provided, of course, that the amplifier is stable and not overloaded!). Figure 25 shows the impedance/frequency characteristic, calculated with a CAD program. The impedance is thus 2·92Ω, and we ideally need a maximum r.m.s. current of 5·6 times the value of 1·96A calculated above, to be sure of coping with signal peaks while maintaining the average field strength of $0{\cdot}1Am^{-1}$ specified by BS6083–4. This gives an amplifier output requirement of 11A and 32V, i.e. 352W. If we had not equalised the loop, we would have needed a loop resistance equal to the inductive reactance at 5kHz, i.e. 4·52Ω, and the same current, which gives 49·7V and 547W! Clearly, the equaliser is worthwhile. A current-drive amplifier would have to give

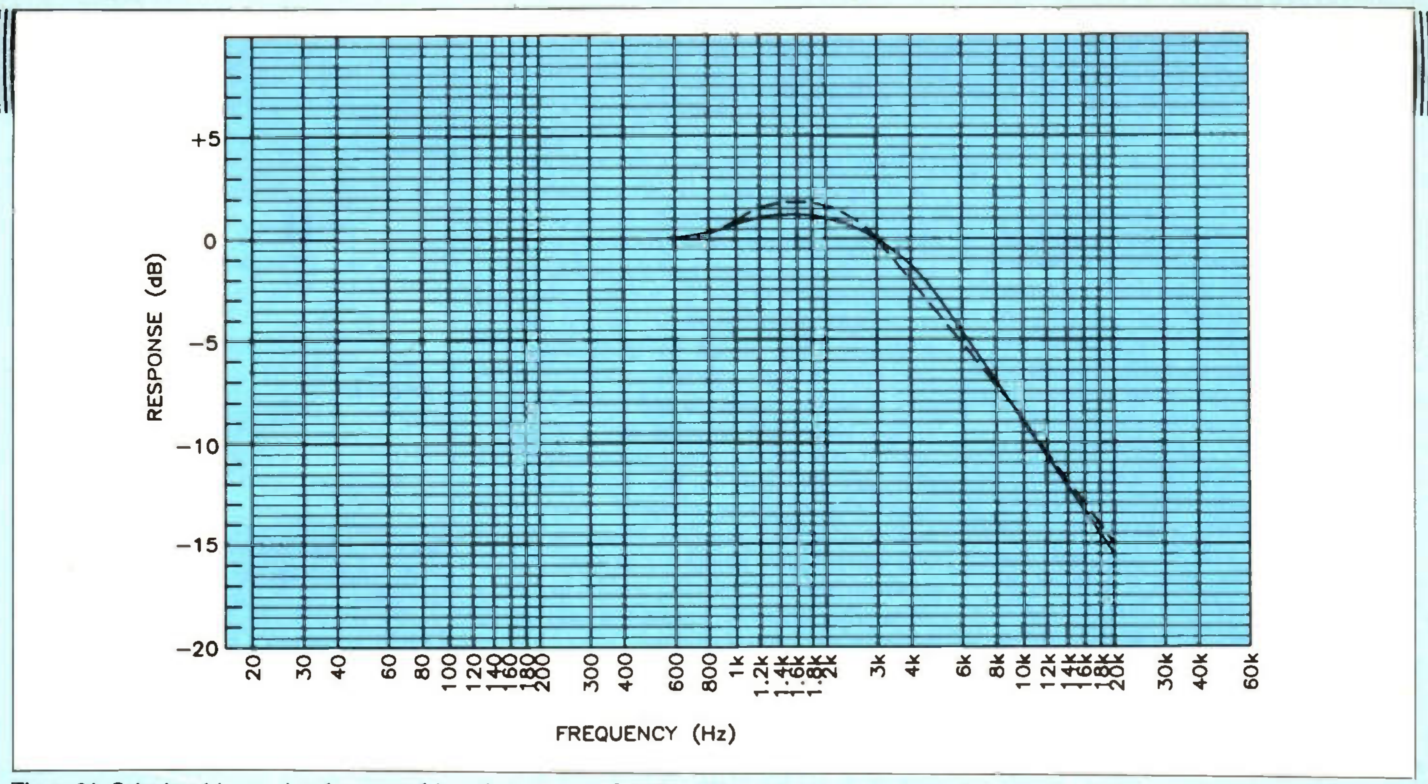



**Figure 24. Calculated (———) and measured (– – –) current as a function of frequency, for constant voltage input.**

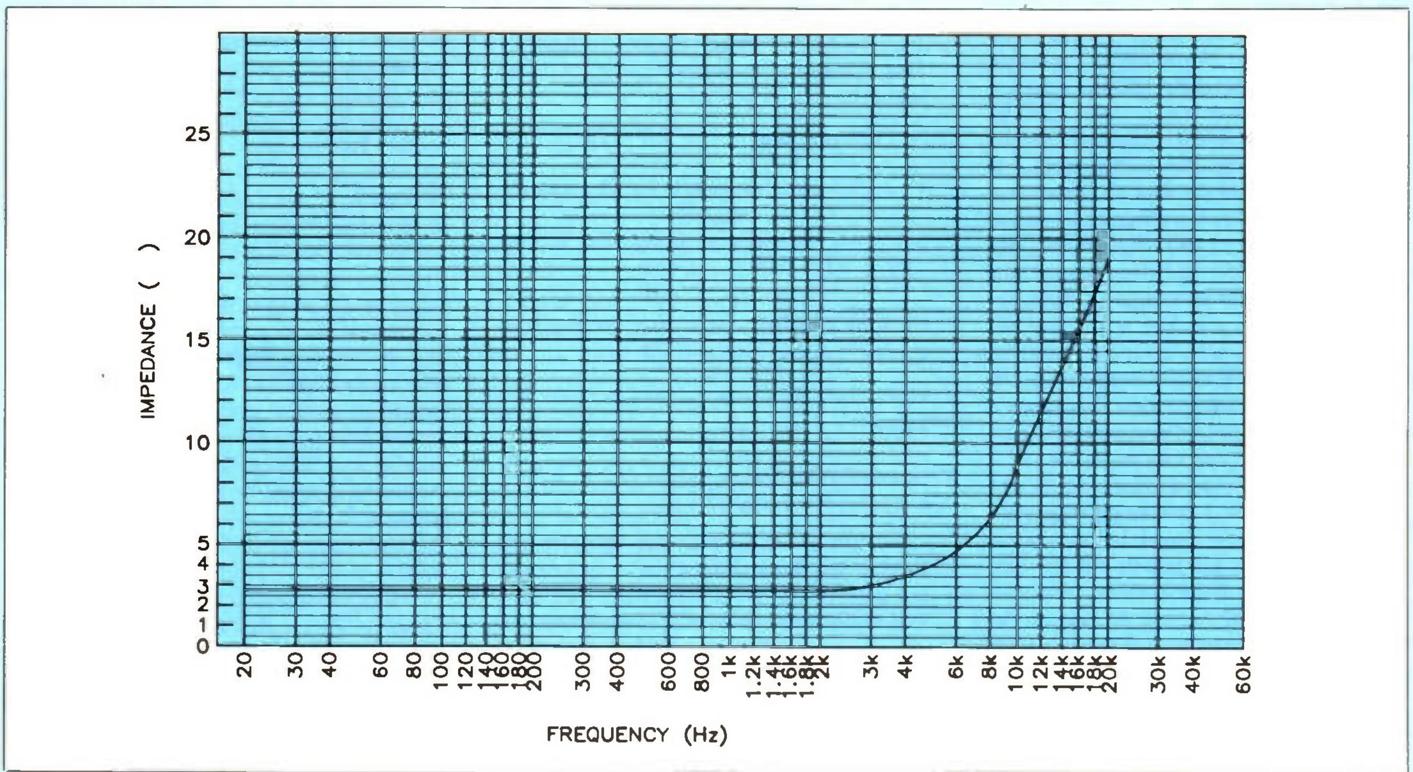



**Figure 25. Calculated input impedance of the equalised 16 × 20m loop.**

11A and $(11 \div \sqrt{2}) \times \sqrt{(4{\cdot}52^2 + 1{\cdot}21^2)}$ V, i.e. 37·1V and 407·7W. However, even the requirement for 352W is fairly expensive to fulfil (although the Maplin 1kW MOSFET amplifier would obviously walk it!). Luckily, most churches have very low levels of magnetic noise interference, and we can reduce the magnetic field strength requirement by at least 6dB without being likely to run into trouble. *You must check,* however, with a volunteer Grandma (or, preferably, a young hearing-aid user who is into electronics, if you can find one) that the interference level is actually low enough to do this. Assuming that it is, the amplifier of choice is the 150W power amplifier LW32K. It is probable that the new 150W MOSFET amplifier described in Issue 41 of 'Electronics' would also be suitable, but of course I have not been able to try one yet. The bipolar amplifier will drive a 2·9Ω load without protest, although you clearly cannot sine-wave test the system at maximum level without blowing the 3A fuse in the output circuit. On speech and music there will be no problem, so *don't* put in a higher current fuse.

*If* the magnetic noise level is really low, as it often is, you may even be able to use the 50W amplifier kit (LW35Q), with the stereo power supply so as to ensure that the maximum current can be obtained. This amplifier will deliver 72W into 4Ω, and current limits at about 5A, so the maximum field strength is rather low, but may well be enough. This amplifier has the capability of producing much higher currents, and I hope to be able to say more about this in future. I cannot recommend the newer 50W module based on the TDA1514 for this application, as its protection circuits were not designed with AFILS in mind.

## Box Cleverly

If you have chosen a kit amplifier, and perhaps a kit mixer as well, it is of course absolutely essential to build the equipment into a proper metal box or boxes, *properly earthed*, and with the requisite mains switch, fuse and power indicator to make a safe and reliable piece of equipment. The opposite of 'amateur' is not 'professional' but 'cowboy': there is absolutely no reason why a piece of equipment designed by an amateur should not be every bit as well-built as a good commercial product. This extends to the labelling of all controls *and* the supply of an Instruction Book. Now is the time to *prove* that you can do a better job than the oriental person who wrote the IB for your VCR or printer!

## Installation

The first step is to install the loop temporarily on the floor, and then connect up the amplifier and one microphone so as to check, with one or more Grandmas, that the system basically works, with sufficient level to banish magnetic interference, good intelligibility and without obvious distortion. If you listen through a hearing aid, the signal will sound very 'toppy': *don't* try to alter that because most people using an aid suffer from loss of high-frequency hearing, so a toppy signal is just what they want. If you are offered a 'lorgnette' receiver, use it with caution, because a normally-hearing person has no idea where to set the gain control and the performance of these devices varies widely in any case. You should rely on what Grandma tells you, or preferably on what the average of four Grandmas tells you.

When your 'trial loop' system works properly, you can then install the loop and microphone wiring, which *must* be kept well apart (1 metre, for preference) and cross, if it cannot be avoided, only at right-angles. An electrician will show you how to find ways through walls etc., and how best to conceal the wiring. Finally, you can install the amplifier and mixer, and connect up the system. Then comes the task of setting up all the mixer controls for best results. Don't use any tone controls, except possibly a little bass cut on the pulpit microphone. Mark the positions of the controls, and ensure that a plan of the wiring and a copy of the Instruction Book are put in the archives, as well as a copy of each to be stored beside the amplifier.

## Hide not your AFILS under 36·368 litres!

How will people know that you have installed an AFILS? Well, you can put it in the Parish magazine, but not everyone reads all of it, and new residents will not know unless you put up some of the discreet signs marketed by, for example, the Royal National Institute for the Deaf. Preferably, too, any side areas not covered by the AFILS should be indicated by the same sign with a black diagonal bar across it. There should also be an AFILS sign outside the door, in the porch if there is one.

## Sufficient unto...?

It is important that budgeting should take the future into account. It is no good installing an AFILS or anything else, without making provision for its upkeep and its eventual replacement (in say, ten to fifteen years time). Some expenditure will probably be required each year: for example, microphones are easily damaged or might even be stolen. The whole system should be checked over at least once a year, and *any defects at any time* should be reported to whoever is responsible for maintaining the system. A neglected fault can turn into a costly failure if not repaired at once. This all means that you should set up 'perpetual funding' for the system. One way would be to hold some sort of modest event every year, with the proceeds going to the 'AFILS fund'.

## Other stories

I am just going to touch on receiver design here, to introduce some of the ideas we shall need in earnest in Part 5.

The output voltage produced by a 'telecoil' (magnetic antenna, like a ferrite rod antenna but optimised for audio frequencies and, of course, not tuned) is proportional to frequency, so that if we simply amplify it in the receiver, we get a very 'toppy' sound. In a hearing aid, resistive loading on the telecoil causes the response to flatten out from 1·5 to 2·5kHz, but the earphone usually also has a treble peak. For people with normal hearing, a flatter response is more acceptable, but, contrary to popular belief, there is no pressing reason to extend the frequency response beyond 5kHz or so: the top one or two octaves are necessary for high fidelity, but not for quite acceptable reproduction quality. If this were not so, virtually all VCRs without FM sound, and most audio cassette recorders, would be useless. Actually, it is not difficult to extend the overall system response, without raising the −3dB frequency at the loop amplifier

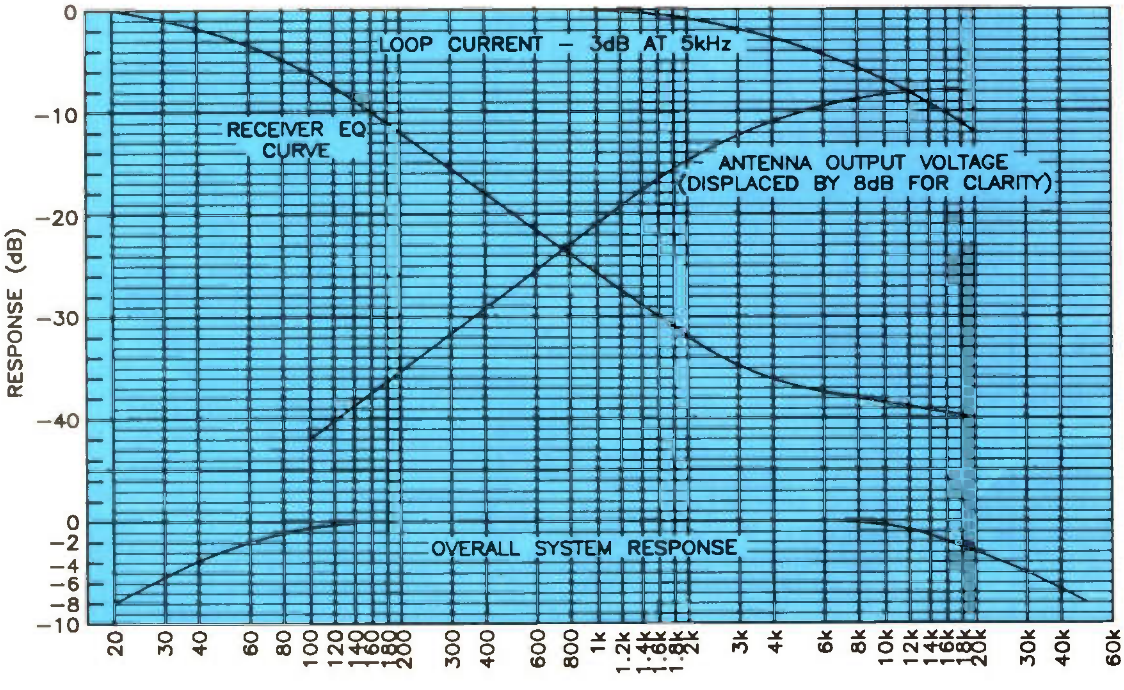



**Figure 26. Loop current, magnetic antenna voltage, receiver EQ and overall system frequency responses.**

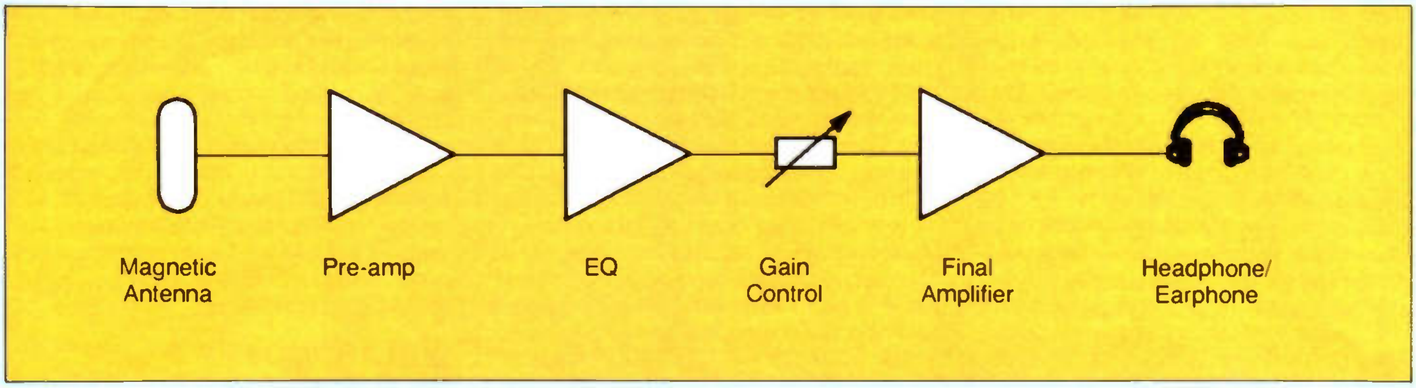



**Figure 27. Block diagram of an AFILS receiver for a person with normal hearing.**

beyond 5kHz (and thereby requiring a bigger amplifier to supply the necessary higher driving voltage).

## *Receiver EQ*

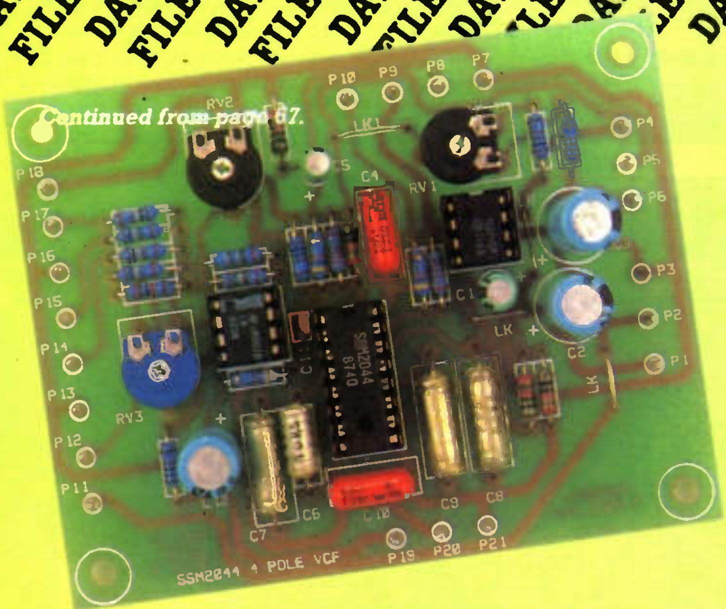
In order to compensate for the rising output voltage of the telecoil with frequency, we can provide EQ, in the form of high- frequency cut, in the receiver. This has to work, not from 1kHz as in a normal 'tone control', but from low frequencies (Figure 26). Now, it is easy to see that if we stop the EQ at 5kHz, we can get an overall system response that is flat to 10kHz or even 20kHz. The penalty for this is that we get more noise, but the magnetic noise at high audio frequencies is usually negligible (not necessarily near TV sets, monitors or high-frequency fluorescent lamps, though).

## *Magnetic antenna*

The telecoils used in hearing aids are naturally very small, and consist of thousands of turns of very fine wire indeed on a rod of high-permeability nickel-iron. Consequently, they are quite expensive, and are not readily available. At present, there is no suitable component in the Maplin range. However, such components do exist (inductors of a few tens of millihenrys on an open ferrite core) and perhaps in the next part I can give more details. Meanwhile, we can see that a receiver needs some amplification, an EQ stage, and some more amplification to feed headphones or an earphone. For the final amplifier, the LM386 (UJ37S) is very suitable, and the single-supply op-amp LM358 is good for the preamplifier and EQ. A block diagram of the receiver is shown in Figure 27. All the details of this design are not yet finalised, but will be revealed in Part 5, along with a field-strength meter having peak programme meter (PPM) characteristics, which allows more accurate measurements of the field strength actually achieved with speech and music signals than any other form of meter.

DATA FILE

*Continued from page 67.*




could be used to form part of a sweep oscillator circuit; this can be used in conjunction with an oscilloscope to display filter frequency responses. The oscilloscope may then be triggered using the same ramp/ triangle waveform used to drive the VCO. A typical set-up for this type of system is shown in Figure 8. Table 3 shows the specification of the prototype SSM2044 module.

| | | |
|---|---|---|
| Power supply voltage | Single supply | 12V – 30V |
| | Split supply | ±6V – ±15V |
| Power supply current | (Quiescent) | 15 mA at 30V |
| Operating frequency range | (Cut-off frequency) | 10Hz – 50kHz |
| Voltage control input range | | 0V – 30V |

**Table 3. Specification of prototype. (Power supply = 30V unless otherwise specified.)**

## SSM2044 4-POLE VCF PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS: All 0·6W 1% Metal Film (unless specified)** | | | |
| R1,2,5,9 | 10k | 4 | (M10K) |
| R3,4,11,20 | 1k | 4 | (M1K) |
| R6,7,14 | 47k | 3 | (M47K) |
| R8,10 | 220Ω | 2 | (M220R) |
| R12 | 470k | 1 | (M470K) |
| R13 | 150k | 1 | (M150K) |
| R15 | 27k | 1 | (M27K) |
| R16,17,18,19 | 100k | 4 | (M100K) |
| RV1 | 10k Hor. Encl. Preset | 1 | (UH03D) |
| RV2 | 47k Hor. Encl. Preset | 1 | (UH05F) |
| RV3 | 220k Hor. Encl. Preset | 1 | (UH07H) |
| **CAPACITORS** | | | |
| C1 | 10μF Minelect 35V | 1 | (JL05F) |
| C2,3 | 220μF PC Elect 35V | 2 | (JL22Y) |
| C4,10 | 100nF Polyester | 2 | (BX76H) |
| C5 | 1μF Minelect 63V | 1 | (YY31J) |
| C6 | 750pF Polystyrene 1% | 1 | (BX55K) |
| C7,8,9 | 10,000pF Polystyrene 1% | 3 | (BX86T) |
| C11 | 22pF Ceramic | 1 | (WX48C) |
| C12 | 100μF PC Elect 35V | 1 | (JL19V) |
| **SEMICONDUCTORS** | | | |
| IC1 | TL071C | 1 | (RA67X) |
| IC2 | SSM2044 | 1 | (UL19V) |
| IC3 | LM833N | 1 | (UF49D) |
| **MISCELLANEOUS** | | | |
| P1-21 | Pin 2145 | 1 Pkt | (FL24B) |
| | DIL Socket 8-pin | 2 | (BL17T) |
| | DIL Socket 16-pin | 1 | (BL19V) |
| | SSM2044 PCB | 1 | (GE75S) |
| | Constructors' Guide | 1 | (XH79L) |
| | SSM2044 D/File Ins | 1 | (XK26D) |

A complete kit of parts is available for this project:
**Order As LP45Y (SSM2044 4-Pole VCF Kit) Price £10.95**

The following item is also available separately, but is not shown in our 1991 catalogue: SSM2044 PCB **Order As GE75S Price £2.45**

**A readers forum for your views and comments. If you want to contribute, write to:**

**The Editor, 'Electronics – The Maplin Magazine' P.O. Box 3, Rayleigh, Essex, SS6 8LR.**

# Dear Editor — AIR YOUR VIEWS

### Nonagenarian Hobbyist

Dear Sir,
I thank you for your quick response to my recent small order. I have traded with you over many years, not among the mighty big spenders, but my dealings have always been of a happy and satisfactory order. I hasten to apologise, therefore, for the omission of 75p for carriage from my order. I am now 91 years old; therefore your generous offer to await my next order for the payment cannot be sustained. There may never be a next order. My eyesight is failing, and nonagenarians cannot expect to go on for ever, or for periods counted in years, and I would hate to die in debt. I could not pass through the Pearly Gates, or even the more probable Gates of Hell with a clear conscience owing 75p. I therefore enclose my cheque for this amount herewith, and I take the opportunity of offering my sincere gratitude for the way that with your very efficient help I have been able to enjoy thirty-one years of a most engrossing and fascinating hobby. I can read a book with one eye, but I cannot handle a hot soldering iron with safety, but I have had my day and enjoyed most of it, so without spilling a lot of sentimental mush I will wish you and all your company all the happiness and success you deserve in many years to come. Who knows? I may yet pop up again!
**L. Nash, Truro, Cornwall.**

### Beginners' Appeal

Dear Sir,
I was delighted to read 13 year old M. Bridgstock's letter 'Beginners' Projects Wanted' (Electronics October/November). I and several of my friends, around the 50 mark also find most of the projects too complicated and/or too expensive. It's soul destroying to spend pounds on components, only to find your effort doesn't work. Come on Maplin, give us beginners a fair crack of the whip.
**D Woolven, Newport, Gwent.**

### Saxy Mike

Dear Sir,
At the outset of commencing a design for a pick-up (radio or using a lead) microphone for a Saxophone, I was immediately stumped as to which microphone I could use. Could you please offer any suggestions or sources of information concerning this matter.
**E. Freeman, Newcastle.**

*If any readers have experience in miking-up saxophones, please write in and we can pass your letters on.*

### Finished!

Dear Sir,
Looking through past issues of Electronics from 1984 onwards, I notice that you have never run a specific article on finishing off electronic projects. I am sure that beginners and the more experienced alike might benefit from an article of this type, as so often a well built project is let down by how it is housed, clear lettering etc. This is probably more important than ever with your increasing range of ready built modules, giving people with basic knowledge like myself, building blocks to experiment with.

I must agree with R. Potter Chesterfield on the comments about a Maplin shop in Sheffield. Perhaps you could have one in the new prestigious Meadowhall Complex in Sheffield, which opened on the 4th September. With an estimated 30 million visitors a year it would be good news for both yourselves and customers in the North. Finally well done on the excellent format of this magazine, both the projects and features are very enlightening and I am sure you must find the feedback from readers very useful.
**P. Goodrich, Sheffield.**

*A feature on finishing projects has been suggested several times and it really is a good idea. We hope to come up with something along these lines in the near future.*

### 1·2kW Power Controller

Dear Sir,
Just a point about the 1·2kW power controller featured in the October/November issue (No.40). Why is the circuit inserted in the neutral pole of the mains and not, as one would have expected, the live? As it stands any appliance plugged into the socket is completely live while the controller is switched on – thus delivering the full power of the mains to anyone unlucky enough to come into contact with a live terminal, even if the control was turned down. As the mains is an alternating current anyway, surely there would be no difference if the unit were connected in the live pole?
**A. Stiles, Derby.**

*Alan Williamson from the lab replies: You are quite right, there would be no difference to the performance of the controller if it were positioned in the live pole of the mains instead of the neutral. However the main reason why the controller is in the neutral line is to ensure that it is as safe as possible to use – because the earth and neutral lines are at the same potential at the substation, there is a lower probability of insulation breakdown between the controller circuit and its earthed case. As for the appliance remaining completely live even if the controller is turned right down, it must be said that any equipment plugged into the mains supply has to comply with minimum insulation standards; if the equipment is unsafe when plugged into the controller, it will be equally unsafe when plugged into the mains supply direct! We hope you are not suggesting that the mains connections of such equipment can be treated with any less respect just because it's supplied via a 'dimmer device'. Any equipment plugged into the controller must be treated as if it were plugged into the mains proper; you shouldn't become complacent with, for example, a table lamp plugged into a wall socket just because the switch on the lamp holder is off! Such switches are mostly single pole type and not always on the live side. You would seem to be suggesting that the controller should render the applicance completely safe while fully 'off'; it would not. The only way to make any mains appliance truly safe is to completely remove its plug from the mains socket.*

## S·T·A·R L·E·T·T·E·R

*This issue, P. Baxter from Gosport receives the Star Letter Award of a £5 Maplin Gift Token for his letter on... Well you'd better read it!*

£5 Gift Token

### Whinge! Whinge!

Dear Editor,
I am fed up with readers of 'Electronics' bitching and whingeing about the lack of information provided in Graham Dixey's excellent Square One series. I am tempted to get out the feeding-bottle, as some readers appear to be unable to accept solid food when it comes to electronics. Electronics is a subject which requires the use of the old grey matter, yes in other words you have got to think! Hobbyists nowadays seem only to be interested in projects that are fully developed, have a double-sided plated-hole circuit board, and a list of instructions that can be copied parrot fashion. In art, this is called painting by numbers! May I suggest that any reader that is throwing a tantrum because he or she cannot put a project together in two seconds flat, and get it to work first time, buy some books on the subject. What, spend money on books, shock horror! Well go down to your local library (yes you might have to use those things that stick out of your bottom called legs) and borrow some books. If you pay Poll Tax then use the library services that you pay for! It is not surprising that this nation is in such an abysmal state, if the average electronics hobbyist is representative of the average British subject, incapable of thinking, reasoning and asking, why? Perhaps it is the fault of the educational system, I don't know, or perhaps today's society makes life too easy by spoon-feeding (sorry bottle-feeding) everyone. Kick yourself up the back side otherwise the Germans will do it for you. Oh by the way, thanks for a great magazine, however a couple of points. Please stop colouring in components on circuit diagrams, I know the artists like to make things look nice, but it makes circuits very ambiguous. That said, the selective highlighting in illustrative diagrams works really well.

*Well! Some people certainly do seem to get upset and feel extremely strongly about the subject of where to draw the line when it comes to providing information. If any other readers would like to continue the debate, please write in.*

# AIR YOUR VIEWS

## MIDI

Dear Sir,

For several years now I have purchased the Maplin Catalogue and this year I was prompted to buy your magazine for the first time. I was very impressed by the amount of interesting material included. I should like to suggest two areas, however, where there do not seem to be many projects or Maplin products. The first is MIDI, the Musical Instrument Digital Interface whereby electronic instruments can be connected and played together. Many keyboards now have MIDI facilities and the place of the "Practical MIDI Handbook" in your Top Twenty would indicate that this is an area popular with your readers and customers. For a specific project I would like to suggest a MIDI to RS232 Converter so that any computer with such an interface could be used to send or receive from a MIDI device. I only know of one commercially available product which does this and it is only available from the U.S.A. Such a project would be a good introduction to the whole subject which has great scope for home construction (it could perhaps use the micro-controller featured in the October/November magazine). The second area is add-in boards for IBM compatible PCs. These computers are now becoming much cheaper and will continue to do so. It is possible to pick up a working model for a couple of hundred pounds at auctions for example. As far as I can see, most of your computer projects are for "home" computers. Example PC projects could include interfaces for many of your current products including the weather satellite receiver, train controller, etc. (or even a MIDI board). I look forward to reading future issues of your magazine.

**J. Gall, Godalming, Surrey.**

*Thanks for some really good ideas. Watch this space, as you might have a nice surprise in the near future!*

## Young Hams

Dear Sir,

We have an Electronics and Radio Youth Club here in Thanet which has been going for a number of years with Dr. Ken Smith who works in the University, as our Leader. So here is a report about the new session and what the boys want to get done. The average age of members is 13 years, and a lot of people say that youngsters are not interested in radio and electronics, but that is certainly not so with our band of young people. Some of us went with Ken on a week's youth hostel cycle tour around the New Forest, Isle of Wight (yes, we do that too). We visited the "Wireless Museum" at Arreton Manor, and were most impressed with the interesting things there. Our leader is so keen on collecting and giving talks on old wirelesses, we can see why now! The main project this term will be everyone building RDF receivers, for club outings to "find the hidden transmitter" Also, as quite a lot of old members passed the RAE (and GCE/GCSE) from the clubwork over the years, some of us will study that Course this year. Others are interested in the new RSGB "novice licence". (We also like writing on the word processor, like I'm doing now. We write a magazine/newsletter called the "TECnician".) We don't think many 13 year olds will be reading your magazine, but what is important, is older people (teachers, uncles, etc.) who might do, could well mention our club to any young person who could be interested, but they must be keen, and help run the club, as it is very 'democratic' (we have a members committee who run things).

**R. Collins, Ramsgate, Kent.**

*Anyone wishing to contact the club can drop us a line with a SAE and we will pass the letter on.*

## I Can't Get The @&%%£$ Thing To Work!

Dear Sir,

With reference to the letter from H.C. Thomas, Doncaster and Simon Ferrari, Macclesfield in issue 39. Beginners by definition need encouragement and information, not you have it wrong try again. After three attempts to make the initial Square One project work I have become so frustrated that only an extreme effort of self control prevents me from writing in an abusive style in reply to the patronising tone of your letters page editor and H.C. Thomas. I totally agree with Simon Ferrari and would be pleased if you could pass a copy of this letter to him. I would also be pleased to see one letter from a genuine beginner (by the same count anyone experienced) who managed to get this project working with the components named without having to resort to other sources of information, e.g. prior knowledge. I can only say your present editorial style is hardly conducive to an expanding readership. I do so wish to progress my understanding of electronics but your lame use of catch 22 is an extreme form of "I'm alright Jack". Stop beating around the bush and supply the information required, your credibility is waning. Your reply to Simon Ferrari was not a satisfactory answer.

**J. Clark, Newcastle Upon Tyne.**

*Firstly writing abusively does not help anyone and is also something that the post office will have something to say about. However, we always welcome constructive criticism, which enables us to improve the content of 'Electronics'. Perhaps Simon Ferrari would like to write in again and say whether the practical advice given was of help. Obviously we can't go into too much detail in the letters page, simply because of the space available. If you have a particular problem and require assistance then why not write a letter to the Technical Department. After all, we pay them to help YOU! As human beings, by nature, all the things that we do require some degree of prior knowledge. A beginner's series is difficult to write because of knowing 'where to draw the line' at explanations (how to put the plug on the soldering iron for instance). Perhaps if you had written in explaining exactly what problems you are having, then we might have been able to help. Our Constructor's Guide, which is supplied free with every kit, is full of useful information and advice. Another excellent source of information is your local library, it's free (as long as you return the books before they're overdue!) and if they don't have the book you require, they can probably obtain it for you. Finally, don't forget patience is a virtue, perseverance helps a lot too!*

## Square One Printing Error

Dear Sir,

May I first start by congratulating you on a really superb series, 'Square One' in 'Electronics' magazine. May I point out though that there is an error in the calculation on page 8 though I assume that this is a misprint. You see, according to my calculations, 40Hz gave me a capacitive reactance of 39788·736Ω, which rounded up gives 39·79kΩ (not 39·79Ω as printed).

As you may be aware by my callsign, I am a radio ham as may be many of your readers. Would it be possible to see a bit more from Bob Penfold who I know has written a lot for the amateur radio fraternity, with more radio targeted projects in the 'Bob's mini-circuits' pages or how about a section aimed at radio hams. By the way the RTTY system is good as well but how about a means of adapting it to/for the Sinclair Spectrum computer owner/user and the Commodore user. I am a Spectrum 48K+ owner, the Spectrum being a popular computer with many radio hams.

I have been a regular subscriber of the Maplin mail order system and 'Electronics' mag for over a full year now and have found the magazine to be a very informative journal, having it delivered direct from Maplin each time it comes out. May I take the opportunity to say that I fully agree with Mr H.C. Thomas of Doncaster (August 'Electronics' page 62) on the subject of making the brain work though I have to scratch my own head at times myself, then ask the guys at the club for help.

**R. Davidson, G7FHD, Cleveland.**

*You are of course quite correct, a typographical error was responsible for the missing 'k', which makes the result incorrect by a thousand times. If any readers have interfaced the RTTY system to Commodore or Sinclair computers, then drop us a line.*

## DC-AC Mains Inverter

Dear Sir,

So you want project ideas? How about a 240V 50Hz standby supply of small size, lightweight, high performance and low cost. How? By replacing the 50Hz transformer by two VCO's driving pulse generators, each handling one half of the output. A fast, tight feedback loop would be facilitated by high frequencies. This could offer high efficiency plus excellent regulation and purity of output, with capacitive, inductive and resistive loads. At least in theory! (I suspect it's not exactly easy.)

**C. Collins, Letchworth, Herts.**

*You're right the design of such a beast is not easy, however it is not necessary to use two VCO's, pulse generators, etc. A technique known as synchronous rectification can be used, in a modified form, where each half cycle is produced by alternating between two rectifiers in a complimentary pair. Essentially the circuit is a SMPS with some additional circuitry. Who knows what will emerge from the pit next (my Lab is not a Pit, it's a cave – Dave Goodman).*

## It's in the Bag! (Somewhere)

Dear Sirs,

I am a subscriber to your 'Electronics' magazine, and have been receiving it on a regular basis for a number of years, or so I thought. When my postman was delivering the most recent issue, he pointed out to me how difficult it was for him to see the address label. The multi-coloured magazine comes in a clear plastic envelope with only a tiny slip of poorly printed paper as the address label. The postman said he was amazed that it ever gets delivered, and asked if I had ever missed an issue?

**M. Phelan, Co. Waterford.**

*The postal delivery of 'Electronics' does occasionally suffer from this problem, mainly attributed to the bag labels. We are seriously looking at producing a carrier sheet, which is easy to read and can't turn over, as sometimes happens with the bag labels. Even so the vast majority (≃99·75%) of subscribers receive their copies without problems. Please bear with us, we are 'addressing' the problem.*

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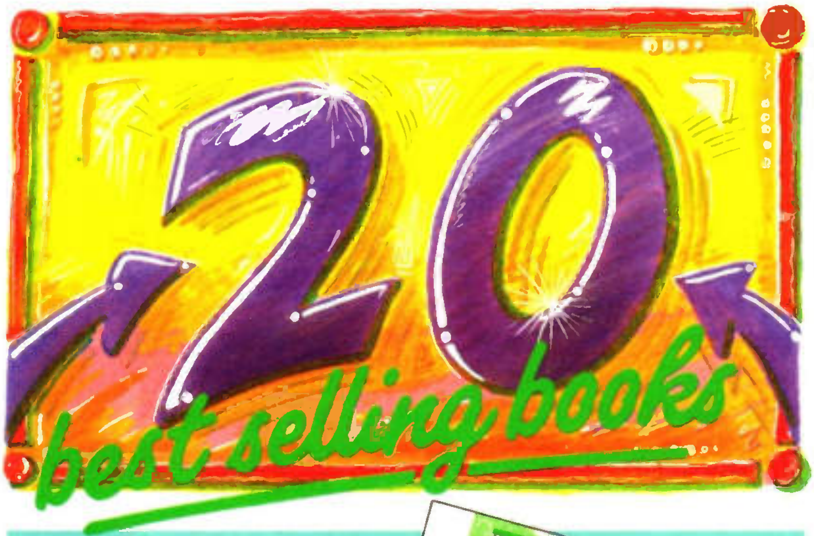


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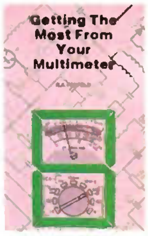


Getting the Most from your Multimeter, by R.A. Penfold. *(WP94C) Cat. P74.* Previous Position: 2. **Price £2.95.**

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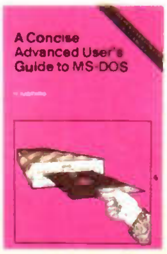


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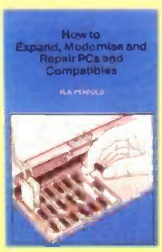


How to Expand, Modify and Repair PC's and Compatibles, by R.A. Penfold. *(WS95D) Cat. P93.* Previous Position: 17. **Price £4.95.**

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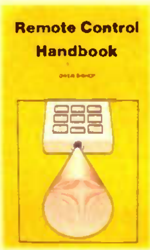


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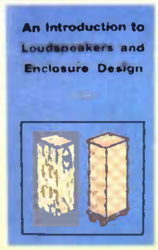


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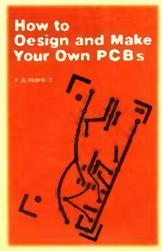


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