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SEPTEMBER 1993
VOL. 12 No. 69

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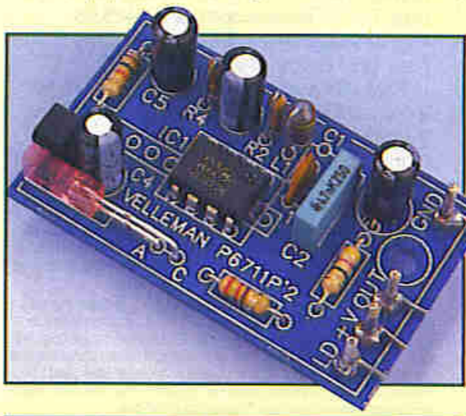

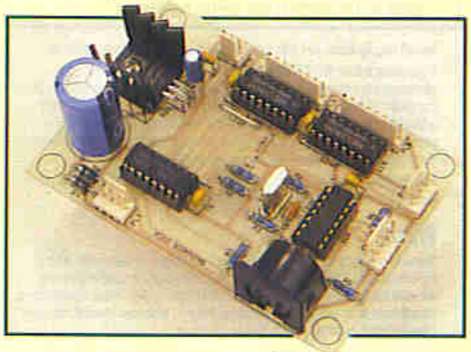

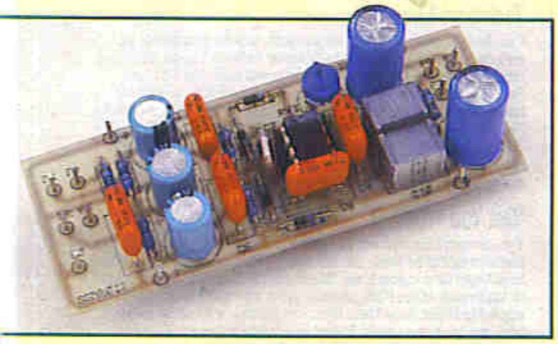

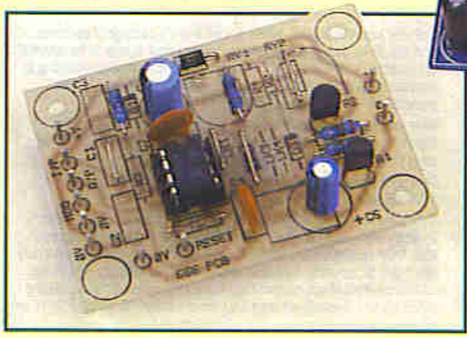

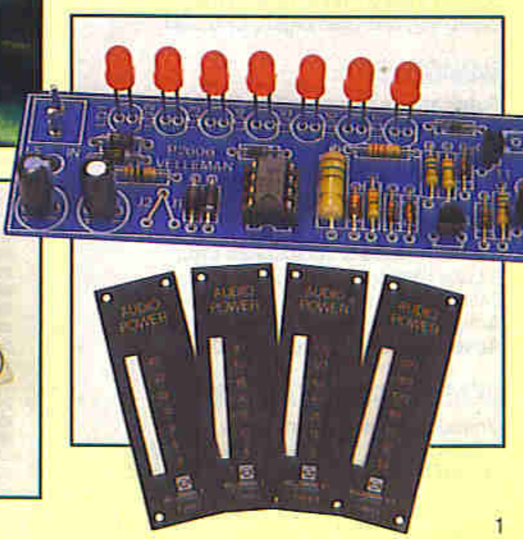

ABOUT THIS ISSUE...

Hello and welcome to this month's issue of 'Electronics'!

As you will have seen from the front cover, one of the features this month is about the causes and effects, of changes in global climatic conditions. The 'greenhouse effect', chlorinated fluorocarbons (CFCs) and other matters are discussed. Rather than trying to indoctrinate readers with a particular viewpoint, the evidence is presented so that you can draw your own conclusions.

At the risk of being accused of joining the 'green revolution', I feel that each and everyone of us has our part to play in looking after the environment in which we live. Electronics enthusiasts and engineers are, by and large, an intelligent bunch; we are therefore able to make sensible judgments and act accordingly. We can also educate and encourage those around us – family, friends and work colleagues. How many of us have poured ferric chloride or used car engine oil down the drain, without giving a second thought to the effects it may have? Aqueous PCB cleaning and rinsing solutions are now available, let's start using them! Similarly, other less environmentally harmful products are available for domestic and industrial use. But beware of products from companies that have jumped on the 'green bandwagon' for self-gain and consumer acceptance. Some products aren't as environmentally friendly as the packaging proudly proclaims! If you have any particular views, suggestions or innovations, then please write in. The editorial team can't reply to every letter (or we'll be too busy to produce next month's issue!) but you might see your letter in print on the 'Air Your Views' page!

This issue also features three great Data File type projects, ideal for experimentation and as building blocks in larger projects. One of the Data Files is based on the E510 MIDI keyboard scanning IC. This clever device, with the addition of a few additional ICs and a keyboard, will generate a serial data stream conforming to the MIDI protocol. Just plug into a MIDI sound source and go! It is usually necessary to employ a microprocessor, ROM, RAM and Serial I/O to achieve the same objective – the E510 does the same job in a 16-pin DIL IC package, not bad eh? If this project stirs up a fair bit of interest, then who knows what other MIDI projects the 'backroom boys' might come up with.

There are of course other projects, features, serials and all the usual regulars, but I leave you to discover them for yourself.

Next month's issue celebrates two years of 'Electronics' being published monthly (for the benefit of newer readers, prior to September 1991, 'Electronics' was published every other month). In next month's issue there will be a Readership Survey Questionnaire, it's your chance to let me know what you like and don't like about 'Electronics'. The results will be published soon afterwards and will *directly affect* what you see in the pages of 'Electronics' in future. So please take the time to complete the Questionnaire and send it back. There will also be some really super prizes to be won, winners will be drawn from the returned questionnaires. First prize is a superb 40MHz Dual Trace Oscilloscope worth £449.95. Runners-up prizes include copies of the New 1994 Colour Maplin Catalogue!

Free with next month's issue, there will be a copy of the new booklet 'A Guide to Making Your Own PCBs' by Keith Brindley. Next month's issue is likely to sell out early, so don't miss out – reserve a copy at your local newsagent or take out a subscription today!

So until next month, I hope you enjoy reading this issue as much as 'the team' and I have enjoyed producing it for you!

Front cover picture:
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Pictor International Ltd.
The future of the environment is in our hands; we all jointly share the responsibility for looking after the earth on which we live.

CORRIGENDA

July 1993 Vol. 12 No. 67 – IBM PC Prototyping Card.
Page 27 onwards: The text relating to SW1-1 to SW1-8 (the address-setting DIL switches) is transposed, i.e. SW1-1 should read SW1-8, SW1-2 should read SW1-7, SW1-3 should read SW1-6, and so on. This comment also applies to Table 5, but the circuit diagram and PCB are correct.
Page 27, text; and page 28, Table 4: Reference is made to pin numbers (P**). As there are no pin numbers on the PCB, read as follows: P31 = A2, P32 = A3, P33 = A4, P37 = Pin between A4 and +5V, P38 = Pin between A3 and +5V, P39 = Pin between A2 and +5V, P40 = +5V, P41 = +5V and P42 = +5V.

August 1993 Vol. 12 No. 68 – Infra-Red Door Lock.
Page 26, Parts List: The Compuguard Infra-Red Remote Control Unit (LP24B) was omitted – this item is included in the kit. C12 should be a 22nF Monolithic Ceramic Capacitor (RA45Y). There are two C15s listed and C14 was omitted; C14 is a 100nF 50V Disc Ceramic (BX03D) and C15 is a 1µF 100V PC Electrolytic (FF01B).

Multi-Purpose 741 Op Amp Card
Page 31: The final line of text in each column, just above Table 1, is missing. From left to right, the missing lines are: '(attempt)ing to be made different'; 'have a gain of 10 times'; 'signal will be inverted'; and 'will have a gain of 10 times'.

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Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

1. Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering iron, side cutters, pliers, wire strippers and screwdriver). Test gear not required and no setting-up needed.
2. Easy to build, but not suitable for absolute beginners. Some test gear (e.g., multimeter) may be required, and may also need setting-up or testing.
3. Average. Some skill in construction or more extensive setting-up required.
4. Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.
5. Complex.High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

Ordering Information

Kits, components and products stocked by Maplin can be easily obtained in a number of ways:

Visit your local Maplin store, where you will find a wide range of electronic products. If you do not know where you nearest store is, refer to the advert is this issue or Tel: (0702) 552911. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance.

Write your order on the form printed in this issue and send it to Maplin Electronics, P.O. Box 3, Rayleigh, Essex, SS6 8LR. Payment can be made using Cheque, Postal Order, or Credit Card.

Telephone your order, call the Maplin Electronics Credit Card Hotline on (0702) 554161.

If you have a personal computer equipped with a MODEM, dial up Maplin's 24-hour on-line database and ordering service, CashTel. CashTel supports 300-, 1200- and 2400-baud MODEMs using CCITT tones. The format is 8 data bits, 1 stop bit, no parity, full duplex with Xon/Xoff handshaking. All existing customers with a Maplin customer can access the system by simply dialling (0702) 552941. If you do not have a customer number Tel: (0702) 552911 and we will happily issue you with one. Payment can be made by credit card.

If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place orders directly onto the Maplin computer 24-hours a day by simply dialling (0702) 556751. You will need a Maplin customer number and a personal identification number (PIN) to access the system. If you do not have a customer number or a PIN number Tel: (0702) 552911 and we will happily issue you with one.

Full details of all of the methods of ordering from Maplin can be found in the current Maplin Catalogue.

Prices

Prices of products and services available from Maplin, shown in this issue, include VAT at 17·5% (except items marked NV which are rated at 0%) and are valid between 6th August 1993 and 31st August 1993. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue.

Technical Enquiries

If you have a technical enquiry relating to Maplin projects, components and products featured in 'Electronics', the Customer Technical Services Department may be able to help. You can obtain help in several ways; over the phone, Tel: (0702) 556001 between 2pm and 4pm Monday to Friday, except public holidays; by sending a facsimile, Fax: (0702) 553935; or by writing to: Customer Technical Services, Maplin Electronics PLC., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Customer Technical Services are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics PLC., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
up to £24.99	£17
£25 to £39.99	£24
£40 to £59.99	£30
£60 to £79.99	£40
£80 to £99.99	£50
£100 to £149.99	£60
Over £150	£60 minimum

Readers Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about 'Electronics' and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read — your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editors discretion. Any correspondence not intended for publication must be clearly marked as such.

TECHNOLOGY WATCH!

with Keith Brindley

I guess you've been asleep if you've missed the ballyhoo surrounding Kodak's launch of PhotoCD. I realise it was first announced three years ago, and was only actually available at the end of last year, but Kodak has been busy advertising, exhibiting, demonstrating and promoting the new technology with a marketing spend literally into the millions. Kodak wants PhotoCD to work and to be, quite simply, the format we all turn to in the future when we think of processing exposed films from our cameras.

And right enough, it's a tremendous technology. You take your film to your local process outlet (a chemist, or professional photographic laboratory, say) and in just a few days back comes your PhotoCD – complete with images. You can also have your developed film on slides, negatives, or prints (if you're still partly back in the stone age, that is), but why you should want to do this in the last remaining years of the twentieth century is way beyond me!

You can get around 100 to 150 images on a single PhotoCD disc (note the spelling of disc – PhotoCD is based on Philips' original optically-based compact disc format, of course – not on computer magnetically-based diskettes). The actual number of images you can store depends on the images themselves – greater the information in an image, greater its data and more of the disc is required for it to be stored. You can have colour and black and white images stored on a single disc. Images needn't all be from a single roll of film (that is, you can ask for several rolls of films, parts of rolls, and individual negatives or slides to be included). And images can be added to at later times up to the disc's maximum capacity. Initially, only 35mm format films could be processed onto PhotoCD, but as time goes on Kodak intends other formats to be included

Getting down to the nitty-gritty of technicalities, each image is actually stored in five different formats: wallet-sized (128 lines by 192 pixels); snapshot (256 lines by 384 pixels); standard (512 lines by 768 pixels); large (1024 lines by 1536 pixels); and poster (2048 lines 3072 pixels). The five images are stored within a single file which Kodak has given the name image pack. Each image pack on a PhotoCD is data compressed down to a size around 4·5 megabytes. If you've ever worked with photographic images on a computer, you'll realise that this is a simply tremendous reduction in file size. Compression is according to Kodak's own compression algorithm, which Kodak says is lossless. In fact, lossless isn't quite an accurate description as a small but nevertheless definite part of each image's visual information disappears in the process.

Back at the ranch, you stick your shiny new disc into your equally shiny new PhotoCD player and, hey presto, there are your images up on your television screen. As large as life (provided you haven't any pictures of Mount Everest in there!) and nearly every bit as clear.

In this light, PhotoCD is just one of the advancing waves of multimedia products which are about to knock us head over heels onto the great beach of life. Multimedia is an odd word, which means different things to different people but where the home – at least – is concerned, multimedia is based around the television. Multimedia in this respect is a complete home entertainment philosophy; of computers, games, television programmes themselves (who watches these, nowadays?), videos, CD-ROMs, and so on, of which PhotoCD is going to make a positive contribution, and take a large part. Getting back to my seaside metaphorical introduction to this paragraph, I guess you could say the sands of time (yuck!) are running out for television as a separate and individual medium. Over the next few years just about everything we do will be ruled by the old black box in the corner! As sure as the seas ebb and flow, there's not a King Canute among us who can stop the multimedia tide lapping at our feet.

I know in the past (indeed in this very column several months ago) I've been rather scathing about such wondrous progress. I mean, how can you take your disc, player and television into the office to bore your colleagues with the holiday snaps? Such cynicism towards new technologies might be justified on occasion, and creates a healthy argument about them too, but a few things recently have changed my view a little.

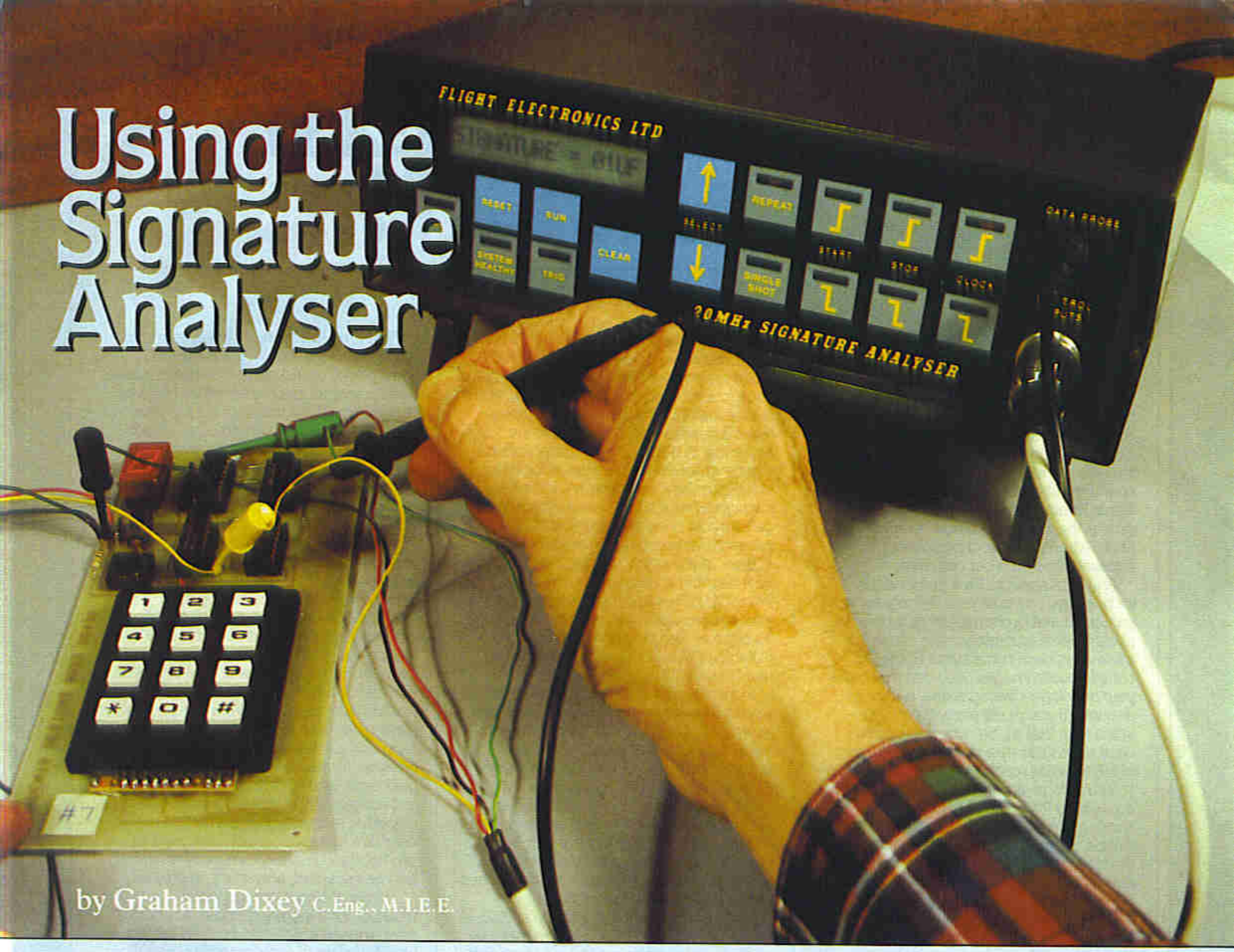
Firstly, as technology gets even more advanced, it's becoming feasible that small pocket-sized players will be available shortly. In a couple of years they could be cheap enough for most families to have one. If this happens, PhotoCD will reach the mass home market in the way it was intended. Of course, the more people who buy the new technology, the cheaper it will get, and so more people will buy it. This is a circle of prices and numbers which any new technology has to crack if it is to become popular. It's my bet now, that PhotoCD is about to do it.

Secondly, I've been playing with CD-ROM on my computer. CD-ROMs are based on the same compact disc technology that PhotoCD is, and there are several similarities and convergences between the two which make use of PhotoCD on the computer a real possibility. Having taken all your holiday snaps, you can now use them on your computer desktop; in your word processor files, paint packages, and so on. Of course, it's not just holiday snaps which could be used, but any other subjects. There's a huge market out there for producers of sales leaflets, promotional brochures, magazines, books and newspapers, and so on, and so on.

Thirdly, taking a philosophical breather for a moment, PhotoCD offers a permanence which could outlast even the usual storage of photographs by negatives and slides. Negatives and slides can be scratched, of course, if not carefully stored. On the other hand, the data stored on a PhotoCD is still there, regardless of whether the disc itself is badly treated; scratched or not. Such permanence, alongside actually being able to use the disc at the same time, might mean that, after widespread acceptance, PhotoCD will be the norm used by people to store long-term images. Maybe people will even throw away their negatives with the PhotoCD wrapping paper.

PhotoCD, if nothing else, is an ideal archiving method for the hundreds and thousands of photographs which people usually have, in an old cardboard box stuck on top of the wardrobe. Maybe now's the time to test the waters of the multimedia revolution. Go on – stick your toe in – take a look at PhotoCD!

Using the Signature Analyser



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

The Concept of Signature Analysis

In the troubleshooting of analogue equipment it is a standard procedure to measure the voltages and voltage waveforms at various nodes (junctions) in a circuit. The usual test instruments for this purpose are the CRO (Cathode Ray Oscilloscope) and some form of voltmeter such as a DVM (Digital VoltMeter). This technique is meaningful *only* if there is a written set of voltages for a fully functioning item of equipment of the same type, with which the measurements can be compared. Thus, it is standard practice for equipment manufacturers to annotate their circuit diagrams with the normal voltage values (including tolerances) and waveforms which should be expected at various test nodes. The serviceman is, therefore, using what is essentially a 'measure and compare' technique for which his abilities, at least at this stage of the troubleshooting procedure, need extend no further than the basic skills required for connecting and reading his test gear.

Similar techniques are difficult to employ in tracking down faults in digital systems. Within a reasonable range of tolerances, the signal is always either at logic 0 or logic 1, a fact that can be determined using the logic probe. Measurement of signal amplitude, as such, is not of great relevance. The very high-speed of modern digital circuits makes inspection of waveforms, using a CRO, a less than precise job in certain situations. However, every test point in a digital system that is working correctly will have its own specific characteristic, no matter how complex or simple the signal at that point. In other words, if it is possible to 'capture' the signal and in some way characterise it over a specified period of time, we ought to find that this characteristic is consistent between all such equipments that are functioning correctly. This characteristic of a signal at a given circuit node is termed its 'signature'.

The signature analyser, which, it is believed, was first developed by Hewlett-Packard, was intended for the rapid servicing of high-speed digital logic circuits. The signature, as presented by the analyser on its front panel display, consists of a four-digit code in what is a modified form of hexadecimal characters. Instead of the usual set of 0 to 9 plus A to F, we have the following:

0 to 9 plus A, C, F, H, P and U.

There may be several reasons for the use of this modified code. One writer claims that it avoids the ambiguity between the lower case letter 'b' and the numeral '6'. Another, that it will avoid the serviceman saying that the signature is 'near enough', if the result differs by only one character. For example, using conventional hexadecimal notation, one might get 3A4E as a signature when the specified signature is 3A4F. It is obviously tempting to round off the value and assume that all is well. This defeats the object of signature analysis, it is a precise method in that no approximations are allowed. The signature is either correct or it isn't. By the very nature of a digital system, a difference of one digit is profound. Personally, the latter reason for the choice of codes seems the more reasonable one.

The Principle of the Signature Analyser

Figure 1 shows the block diagram for a signature analyser, in this case it is for the Flight Electronics 20MHz analyser. At the heart of the instrument is a 16-bit shift register with four feedback taps. The input to the shift register is derived from a Modulo-2 summing circuit, the inputs to which are the four feedback paths mentioned, as well as the data input, taken from the test node itself. Other inputs to the analyser are the START and STOP signals as well the CLOCK, all three of these signals being derived from the system under test. The START and STOP signals are used to gate the input signal into the shift register, thus opening and closing what is, effectively, a 'time window'. Data is clocked through the

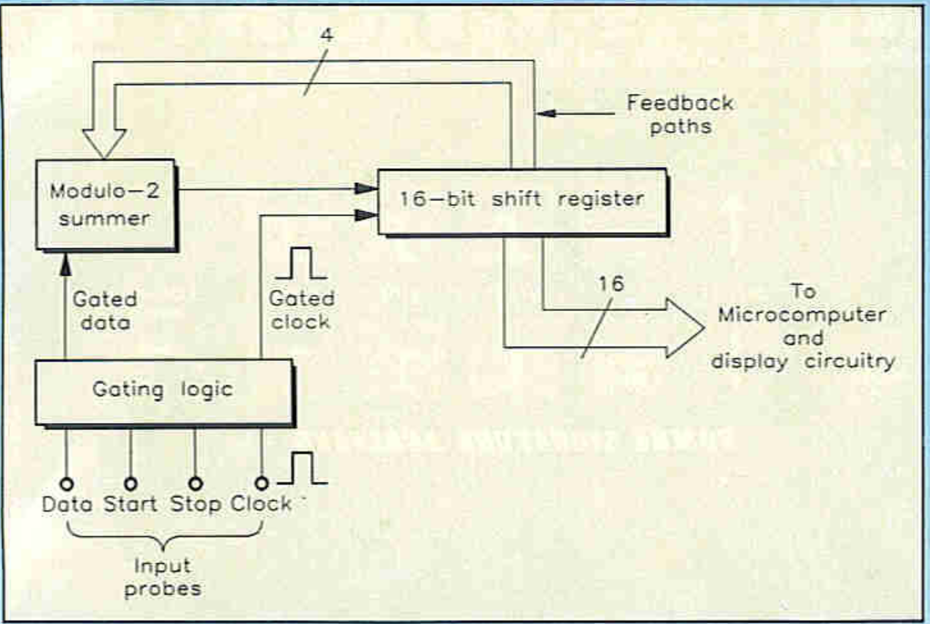


Figure 1. Simplified block diagram of the Flight Electronics signature analyser.

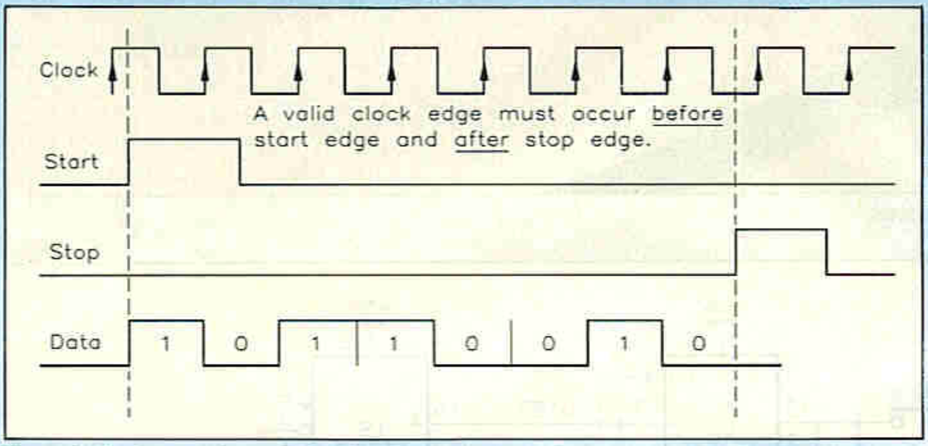


Figure 2. Timing waveforms for the signature analyser.

register by the CLOCK signal referred to. The combination of summer and shift register earns it the title of Linear Feedback Shift Register (LFSR).

The positions of the feedback taps in the register are chosen so as to generate the required types of signature, and also to allow the register to be able to cycle through the maximum possible number of states (216 = 65536) before repeating. It is possible, by mathematical analysis, to show that the analyser will ALWAYS detect single bit errors and that it has a probability of 99·998% of detecting multiple bit errors.

The timing waveforms are shown in Figure 2. The gate can be opened and closed by either a rising or a falling edge on the START and STOP pulses, and the valid CLOCK edge can similarly be either a rising or falling edge. These parameters are set up by the operator when the analyser is switched on, and should also be annotated on the system diagram, since the signatures obtained are dependent upon them. The selected edge of the START pulse must be preceded by a valid clock edge, and the selected edge of the STOP pulse must be followed by a valid clock edge. This relationship is shown in Figure 2. Once the gate is closed, on receipt of the STOP signal, the value held by the register is decoded and may then be displayed on a four-digit display of either the alpha-numeric or seven-segment type.

In the case of this particular instrument, the user may be offered the choice of single-shot or repetitive operation, that is the choice between taking one sample of the signal and displaying its signature, or having continuous sampling in which the display is continuously updated to show, if all is well, a consistent signature at the test point.

The Flight Electronics signature analyser is actually a very sophisticated instrument, incorporating as it does an 8085-based microcomputer that handles the inputs from the front panel membrane keys, sets up the operating parameters for the LFSR and the gating logic, and performs the required decoding functions for the displayed signature, as well as performing a self-test on the microcomputer circuit components.

Setting Up the Signature Analyser

The front panel control of the Flight Analyser is shown in Figure 3 and this may be taken as representative of the facilities that are needed for this type of test instrument. As far as the operator is concerned, once the machine has performed its self-test, after switch-on, the next step prior to using the instrument is to set up the operating parameters for the system under test. Figure 4 shows part of a circuit diagram in which the definitions

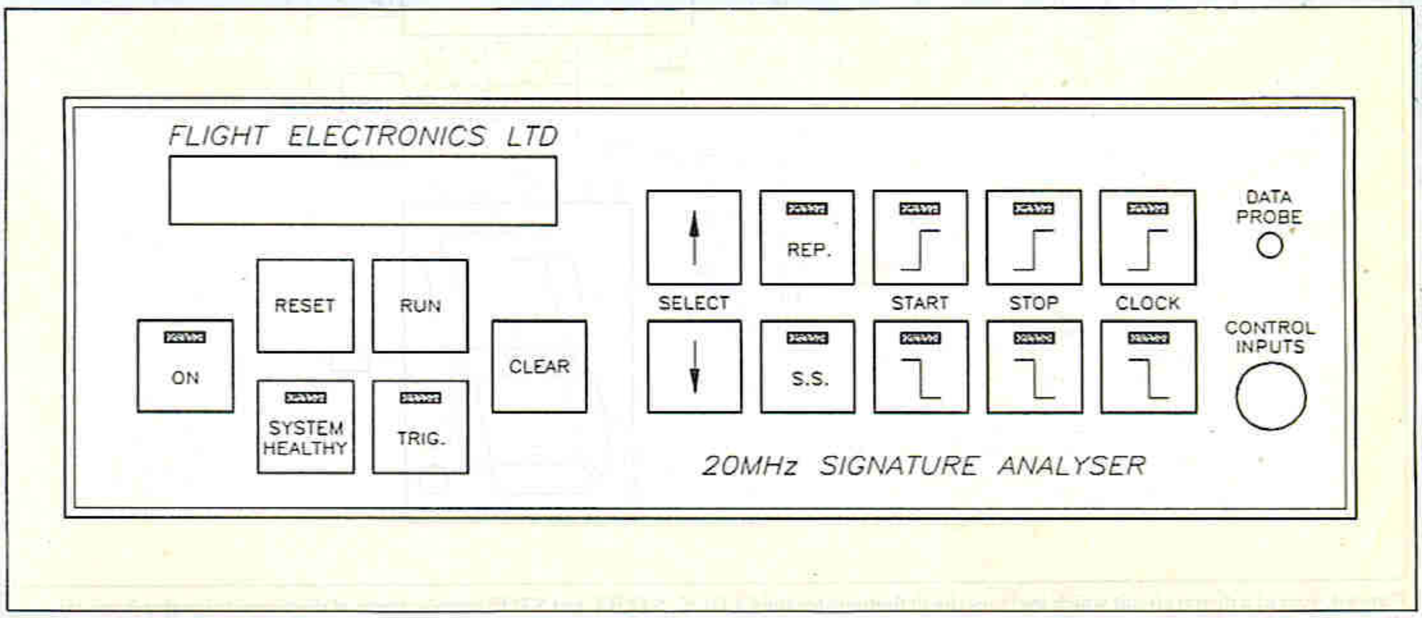


Figure 3. Front panel controls, indicators and connectors for the Flight Electronics signature analyser.

Front panel of the Flight Electronics Signature Analyser.

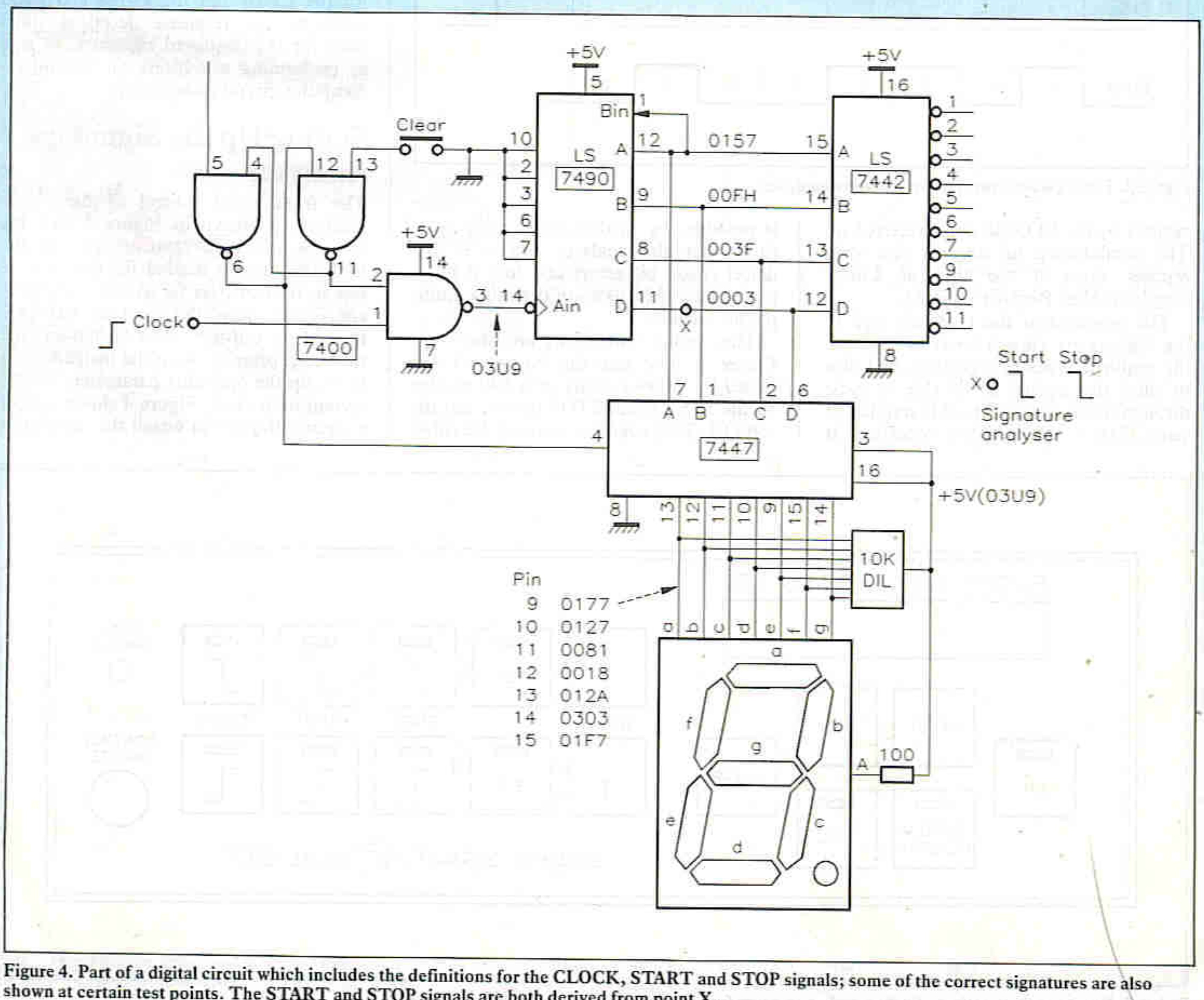


Figure 4. Part of a digital circuit which includes the definitions for the CLOCK, START and STOP signals; some of the correct signatures are also shown at certain test points. The START and STOP signals are both derived from point X.

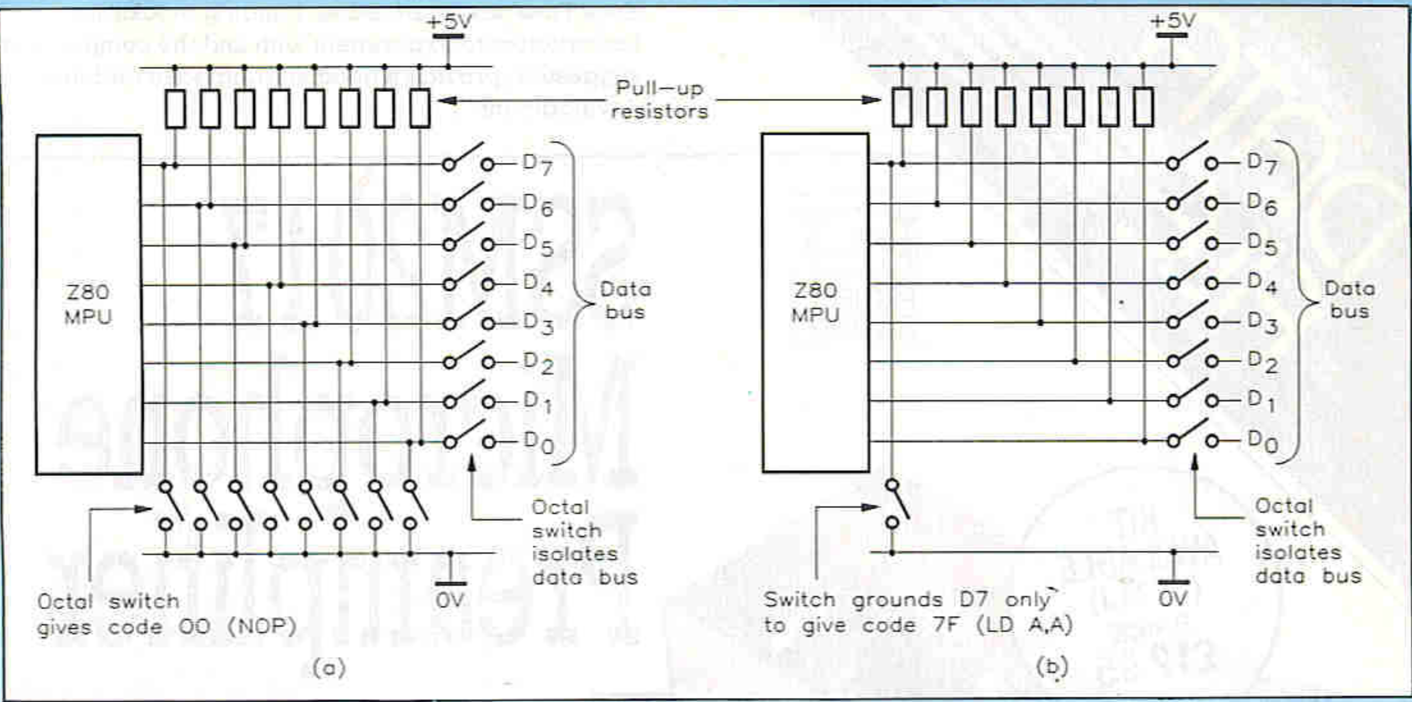


Figure 5(a). Hard-wired binary code 00H (NOP) for free-run test on a Z80 system; (b). A simpler hard-wired code for 7FH (LD A,A) on same system.

for the CLOCK, START and STOP signals are given; some sample signatures are also shown. Selected parameters are displayed on either the upper or lower row of LEDs; a pair of membrane keys, marked with UP and DOWN arrows, and referred to as SELECT keys, are used to select the required parameter, which will obviously be in either the upper row or the lower one.

Suppose that, as in the circuit of Figure 4, it is required to set up the following parameters:

REPETITIVE operation; rising CLOCK edge; falling START and STOP edges.

The user would press the SELECT membrane keys in the order UP, DOWN, DOWN, UP, illuminating the appropriate LEDs.

At each stage of this procedure the user is prompted (in the case of the Flight Analyser) by an on-screen message. At the end of the setting-up procedure a prompt 'RUN' appears and, provided that the analyser is connected to the system under test, and the latter has power, signatures can then be taken.

Connecting Up and Using the Analyser

The analyser is provided with a cable terminated in four colour-coded spring-loaded clips. These connect to the START, STOP, CLOCK and 0V points on the system under test. A further cable is terminated in the probe itself. The presence of the required signals is indicated by a flashing LED marked TRIG. The absence of this indication demands a check for the possibility that one of these signals is itself missing. With all indications correct, the signature can be taken by placing the tip of the probe on the test point. The signature at that point will then be displayed. Each of the test points can be checked in turn in this way until a faulty signature or signatures is discovered. This pin-points the local area of the fault. The precise nature of the fault, e.g., an IC pin 'stuck-at-0' or 'stuck-at-1', can then be determined using a logic pulser/logic probe combination.

Testing Computers

The signature analyser is eminently suitable for trouble-shooting on computers and other microprocessor-based systems. It is possible to run a special program which meets the needs of signature analysis. This could be one that accesses all memory locations. The address bus would be cycled through the full range of addresses on the memory map of the computer. The START and STOP probes must be connected to a suitable point in the circuit; the CLOCK probe could be connected to the R/W line. The data probe would then be applied to the designated test points in the system to allow signatures to be taken for comparison with a standard set.

Once incorrect signatures are identified, the 'path' of these should be traced back until correct signatures are found. This will localise the fault, although the use of a logic probe, pulser and current tracer may then be necessary to identify the precise problem. In a particular case, signatures entering an IC may be correct; those leaving may be in error. Thus, the IC itself, its socket (if fitted) or circuit connections should be investigated.

Testing the Kernel

The 'kernel' of a computer is the CPU itself and its immediate circuitry. This will include the clock oscillator, address bus and buffers, and the power supplies. The kernel can be tested rigorously with the aid of a signature analyser, by adopting a technique known as 'free running'. In this type of test, the CPU is forced to obey a dummy instruction repetitively while the address lines are monitored by the analyser. A convenient instruction is the NOP (No OPeration), which has to be 'clamped' permanently to the data bus so that it is executed for every address that appears on the data bus. Thus, in effect, the CPU does nothing except supply, in sequence, all of the possible addresses for the particular CPU type. For example, the range of possible addresses for an 8- bit processor is from 0000-FFFF.

The address bus is effectively being made to behave as a 16-bit binary counter, with A0 as the least significant bit and A15 as the most significant, hence all the address lines change state at different frequencies, each related to the one above or below it by a factor of two. Thus line A1 changes state at exactly half the speed of A0, but twice as fast as A2.

In order to force the NOP instruction onto the data bus, this bus must be capable of disconnection, in a physical sense, from the system. While this is rarely possible with existing systems, it is perfectly feasible with new designs to build in a facility that will greatly ease the burden of service personnel in the future. All that needs to be provided is an octal switch (in the case of an 8-bit data bus) plus some hard-wired binary code for the required instruction. One way to do this is shown in Figure 5(a).

In this example, switch S1 is an octal switch which disconnects the external data bus from the CPU. Hard-wired to the data bus immediately adjacent to the CPU is a bank of eight pull-up resistors. By wiring a switch or switches between ground and the lower end of any of these resistors, it becomes possible to pull any data line down to logic 0. In the example shown in this figure we have gone the whole hog and fitted an octal switch so that all data lines can be pulled down to give the code 00, which is the op code for NOP on a Z80-based system.

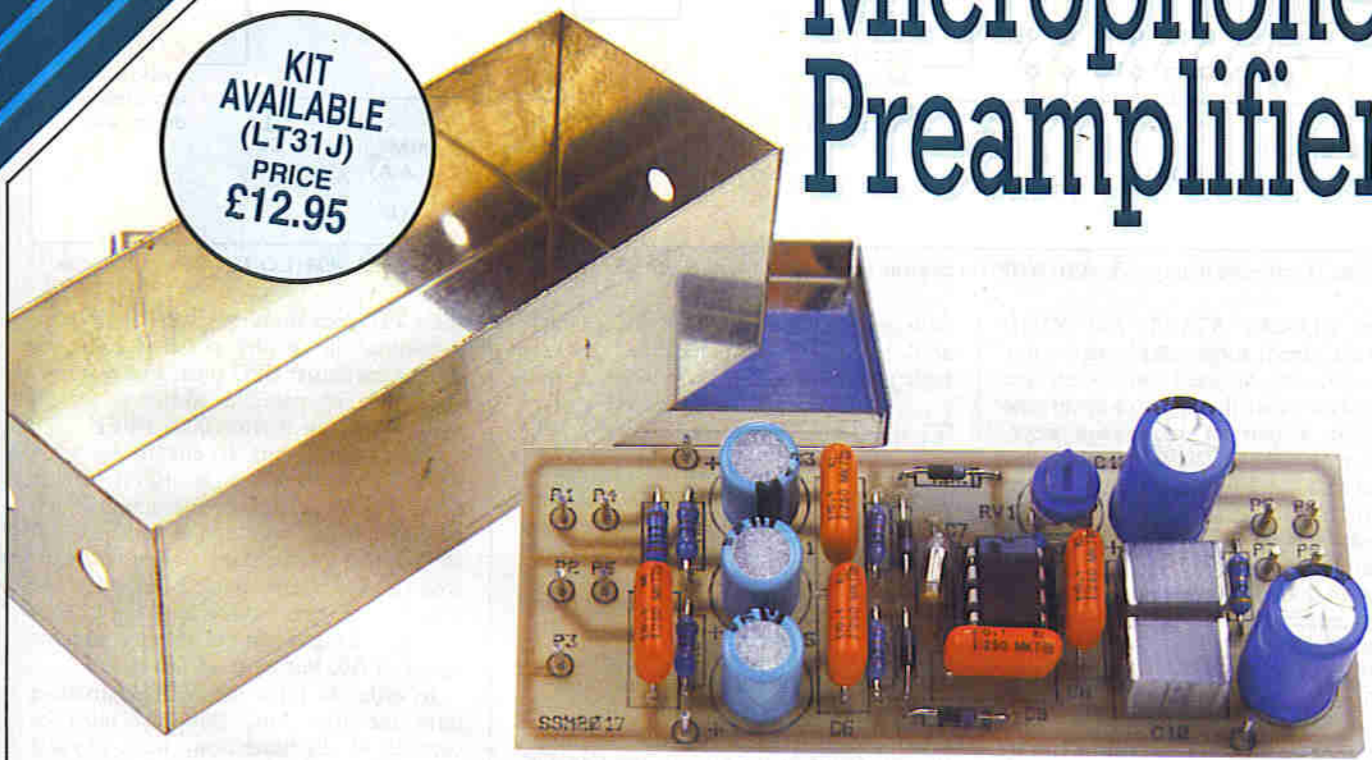
An alternative, that may be considered more convenient, is shown in Figure 5(b). In this case, only data bit D7 is pulled down by a single-pole switch S2. This gives the code 7F, which is the Z80 op code for the instruction 'LD A,A'. This is obviously easier to implement physically and is just as usable from the point of view of providing the required facility for the signal analyser.

DATA FILE

'Data Files' are intended as 'building blocks' for constructors to experiment with and the components suggested, provide a good starting point for further development.

2 PROJECT RATING

SSM2017 Microphone Preamplifier



Design by Max Horsey and Philip Clayton (Radley College) Text by Max Horsey and Martin Pipe

FEATURES

★ Low noise ★ Low distortion ★ Configurable for use with both balanced and unbalanced microphones ★ High slew rate ★ Wide bandwidth ★ Phantom powering for capacitor-type microphones ★ High gain (over 70dB) obtainable

APPLICATIONS

★ Mixers ★ Tape recorders ★ Uprating existing equipment

The SSM2017 IC, at the heart of this project, is a latest-generation audio preamplifier which is particularly suitable for use as a balanced microphone amplifier. It features an ultra-low noise level (around $2nV/\sqrt{Hz}$), wide bandwidth and high slew rate. It requires a dual rail supply of between ±6V and ±22V, and is available in an 8-pin DIL package. Whilst aimed at balanced applications, it can also be used with unbalanced microphones.

Pin Connections

Figure 1 shows the pin connections of the IC. The reference terminal (pin 5) is normally connected to ground, it can also be used for offset correction or level shifting.

Figures 2a and 2b show the various ways in which connections may be made to the IC. Figure 2a is for 'single-ended' devices (e.g., unbalanced microphones), where the screen or ground is connected to 0V in the circuit, and the signal is connected to the non-inverting input. Note that the unused input must also be connected to 0V. The capacitor removes any unwanted ultrasonic frequencies that may appear at the input.

Figure 2b shows the usual way of connecting a balanced microphone. The two resistors provide DC bias to keep the DC input voltages to within an

SPECIFICATION

THD:	<0·01dB (gain = 40dB)
Noise:	2nV/√Hz (typ.)
Bandwidth:	1MHz (gain = 40dB)
Slew Rate:	17V/μS (typ.)
Power Supply:	±6V to ±22V DC @ 14mA (max) per rail; 48V DC for phantom supply
Common-Mode Rejection Ratio (CMRR):	92dB (typ.)
Gain Adjustment (RV1 = 5kΩ, R6 = 10Ω):	10dB (x3·2) to 60dB (x1000)

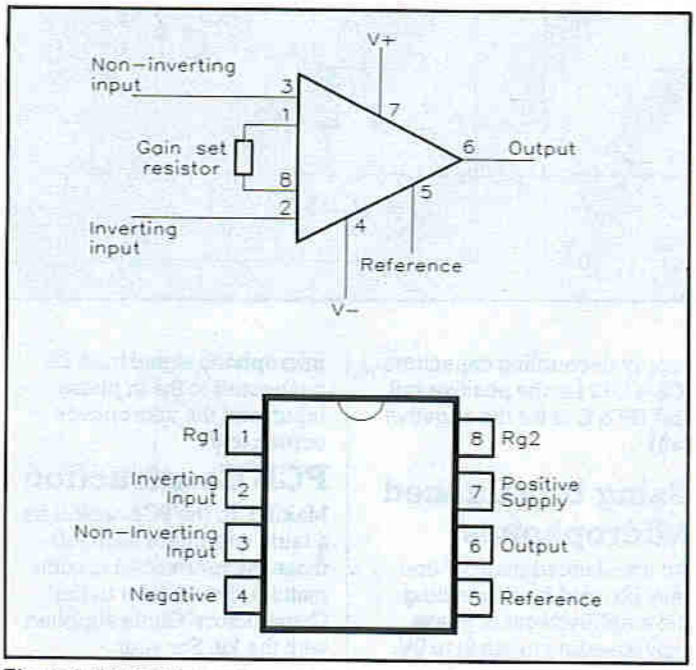


Figure 1. SSM2017 pinout.

acceptable range. The microphone screen is connected to 0V, the 'in-phase' signal is connected to the non-inverting input (pin 3), and the 'out-of-phase' signal is connected to the inverting input (pin 2).

Phantom Powered Microphone

When using an *electret* microphone *without* its own internal power supply, phantom powering may be supplied, using the circuit shown in Figure 3. ZD1 to ZD4 are present to provide transient over-voltage protection for the SSM2017, in those instances when microphones are connected to, or disconnected from, the circuit.

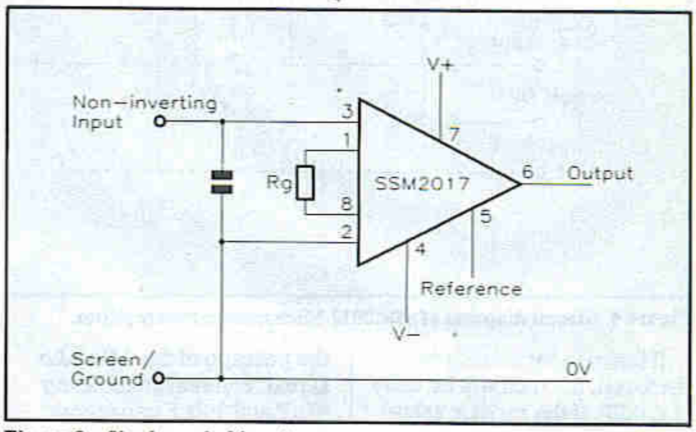


Figure 2a. Single-ended input.

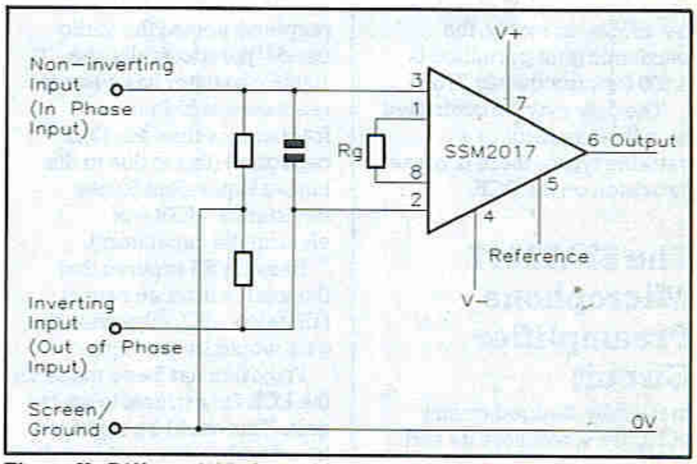


Figure 2b. Differential/balanced input.

Gain

Pins 1 and 8 are for the connection of a gain-setting resistor, R_g. The gain of the circuit is determined by the formula:

$$\text{Voltage Gain} = \frac{10k\Omega}{R_g} + 1$$

where R_g is the value of the gain set resistor.

The following table provides some typical values:

Voltage Gain	dB	$R_g(\Omega)$
1	0	open
3·2	10	4,700
10	20	1,100
31·3	30	330
100	40	100
314	50	32
1,000	60	10

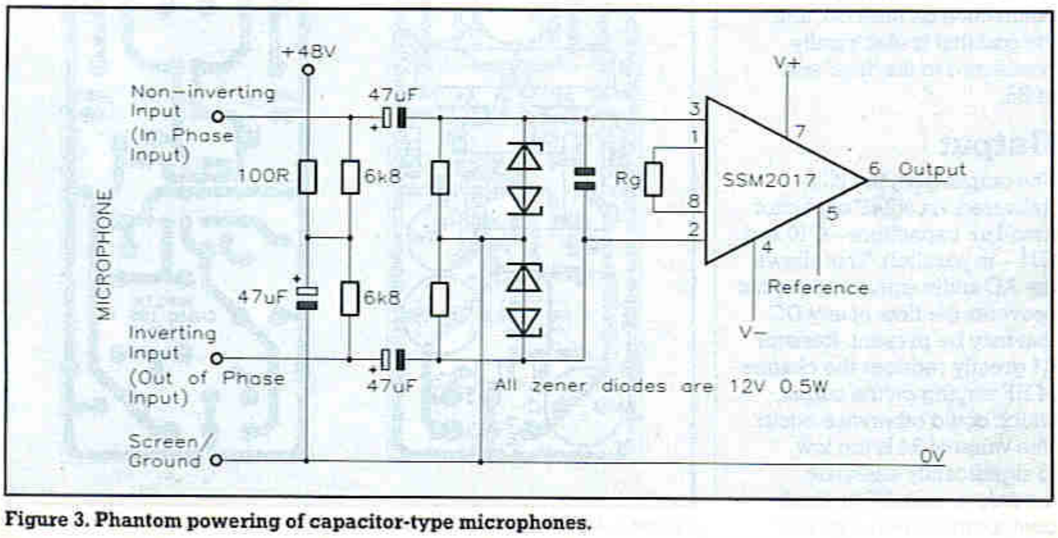


Figure 3. Phantom powering of capacitor-type microphones.

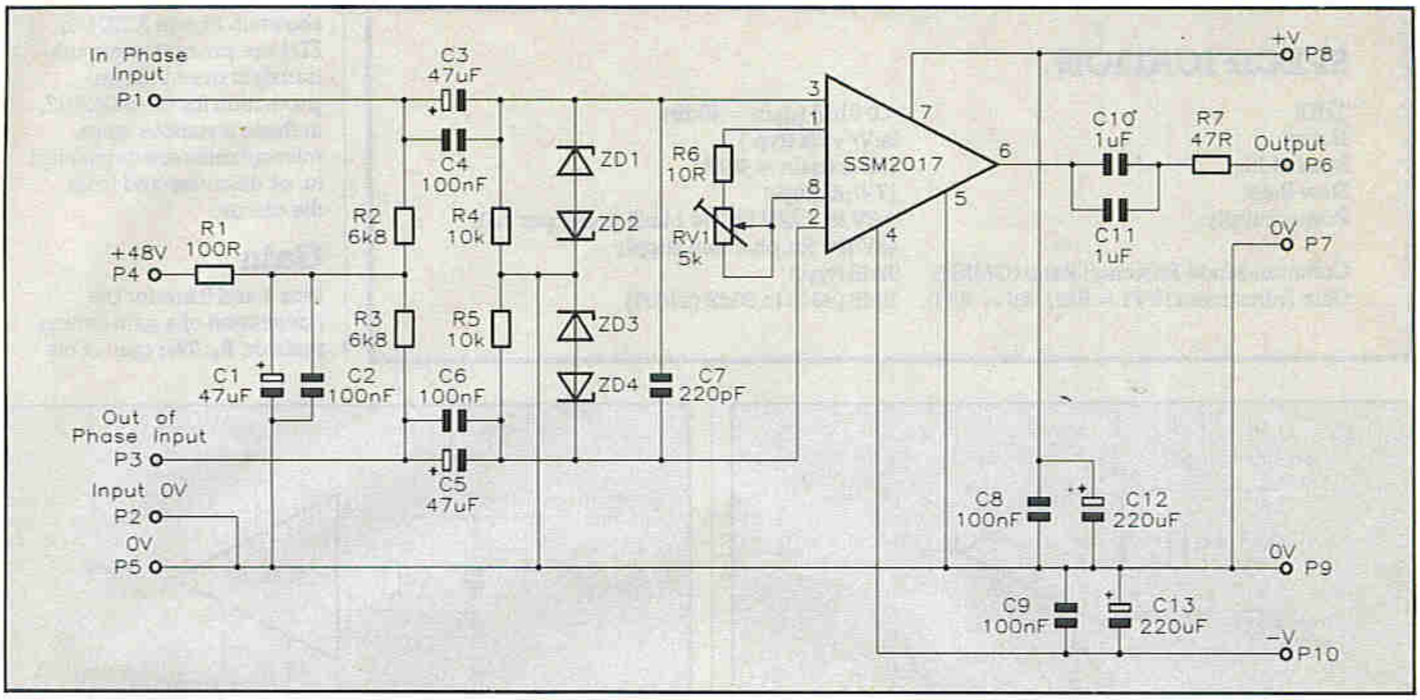


Figure 4. Circuit diagram of SSM2017 Microphone Preamplifier.

If the gain set resistor is removed, the gain will be unity (i.e. 0dB). If the resistor value is reduced to zero, the gain will – theoretically at least – be infinite. In reality, the maximum gain permitted is 3,500 (approximately 71dB).

The gain may be controlled by a fixed resistor or a variable type – there is preset provision on the PCB.

The SSM2017 Microphone Preamplifier Circuit

In the fully-fledged circuit of Figure 4, resistors R4 and R5 provide the DC bias as described earlier, and C7 removes unwanted high-frequencies. C1 and C2 decouple the phantom power supply, forming a simple RC filter with R1 that rejects any noise that would otherwise be introduced.

Gain Control

RV1, the gain set resistor, has a value of 2k2. This could be a fixed resistor if you know in advance the gain required and desire maximum reliability, or a preset (a space is available on the PCB). Coupling capacitors C3 & C4 and C5 & C6 prevent the flow of DC (i.e. the phantom power), but allow the passage of the AC audio signal. The reason for using 47μF and 100nF capacitors in parallel for each input is to maintain an even frequency response across the audio band – paradoxically, the 100nF capacitor has a lower reactance at higher frequencies than the 47μF capacitor! (this is due to the higher Equivalent Series Resistance – ESR – of electrolytic capacitors).

Resistor R6 ensures that the total resistance cannot fall below 10Ω, otherwise the gain would be too high.

Provision has been made on the PCB for a preset to set the gain. This could be replaced by a fixed resistor soldered between the original wiper connection on the PCB, and the pad that is electrically connected to the 'free' end of R6.

Output

The output from the IC is delivered via a 2μF capacitor (two 1μF capacitors – C10 and C11 – in parallel). This allows the AC audio signal to flow, but prevents the flow of any DC that may be present. Resistor R4 greatly reduces the chance of HF ringing on the output, which could otherwise occur. The value of R4 is too low to significantly attenuate the output signal. The final components are the power supply decoupling capacitors (C8 & C12 for the positive rail, and C9 & C13 for the negative rail).

Using Unbalanced Microphones

An unbalanced microphone may be used by connecting the amplifier's out of phase input (leading to pin 2) to 0V, as shown in Figure 2a. The microphone signal must be connected to the in phase input, and the microphone screen to 0V.

PCB Construction

Making up the PCB should be a fairly straightforward job – those inexperienced in such matters should refer to the Constructors' Guide supplied with the kit. For your assistance, the PCB legend

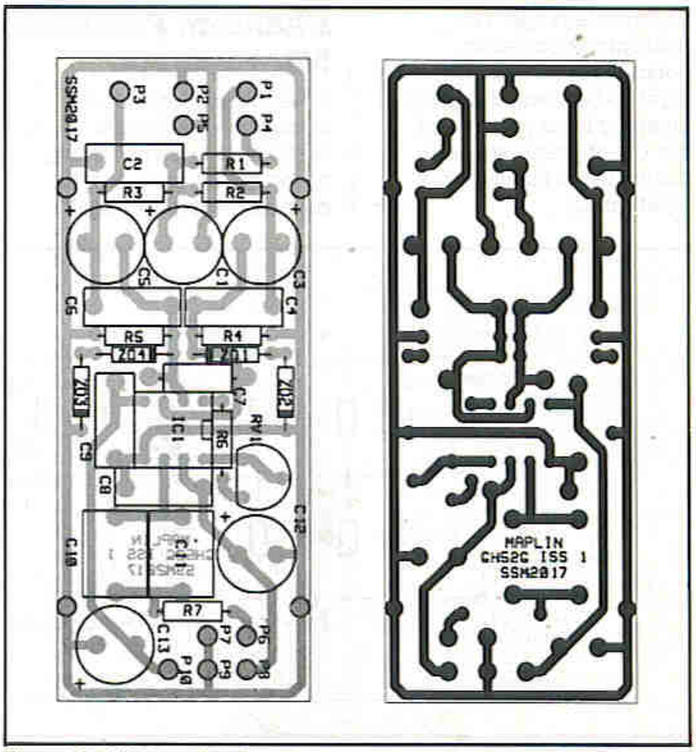


Figure 5. PCB legend and track.

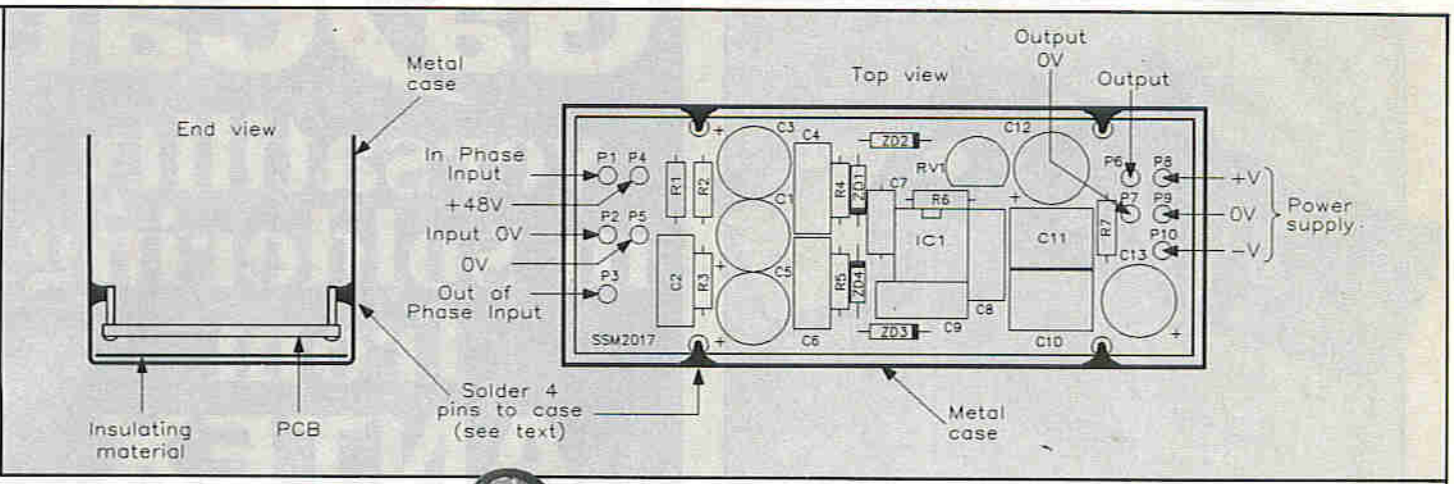
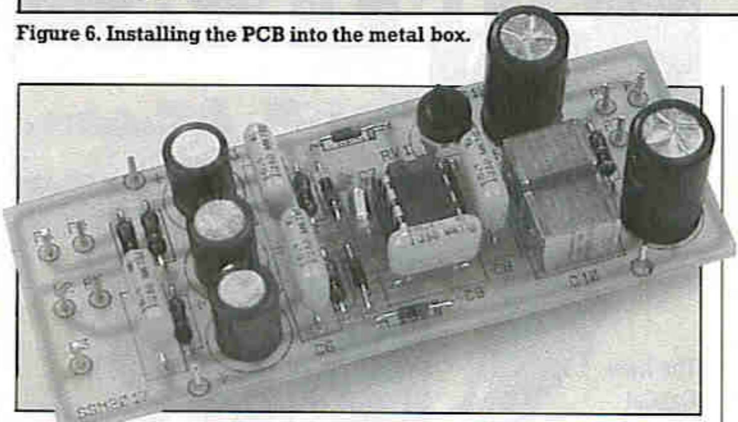


Figure 6. Installing the PCB into the metal box.



and track are reproduced in Figure 5. First fit the resistors, noting the arrangements for the gain-setting resistor (R6 & RV1), as discussed earlier. The capacitors should follow next; note that the electrolytic capacitors must be fitted the correct way round (the '−' symbol embossed on the side of the capacitor must face away from the '+' symbol of the PCB legend). The Zener diodes (ZD1 to ZD4) can now be fitted to the PCB; note that the band on the body of each diode should line up with the band on the PCB legend. Next, fit the PCB pins (these are fitted from the track side of the board), followed by the 8-pin DIL IC socket. This should be aligned, prior to soldering, so that the notch on its body should line up with the notch printed on the legend. The PCB is now complete, and should be checked for silly mistakes and solder bridges, etc., before final assembly and testing of the circuit.

Final Assembly

It is important that the SSM2017 Microphone Preamplifier is built into a metal case. Such screening is important, bearing in mind the high gains. If not included, hum problems may well arise, and crosstalk from other channels may be noticed. If several SSM2017 Microphone Preamplifiers are to be used, it is important, therefore, that each has its own screening; for this reason, a metal box of suitable dimensions (FD20W) is included in the kit.

For the purpose of this article, we will assume that you are installing this project inside a mixer. The SSM2017 Microphone Preamplifier is a versatile unit, though, and can be installed according to your particular requirements, provided that the same logic is applied.

Once you are satisfied with the constructional standard of your preamplifier, the PCB can be installed into the metal box as shown in Figure 6. It is advisable to place a piece of card at the bottom of the box, to prevent the possibility of the PCB shorting out against the metal. Note that the PCB is suspended in the box at four points (i.e. the four solder pins that are soldered to the walls) – these also provide a ground connection to the box.

Make up leads of sufficient length to go to the microphone socket (XLR and jack connections are shown in Figure 7), and to the unbalanced input terminals of your mixer. A cable suitable for all balanced-line connections within a piece of equipment is XS23A. For all external work, a more robust cable (e.g., XR08J) should be used. For the unbalanced audio connections, XR18U is a good low-noise screened cable, and would be ideal for use within a mixer or similar piece of equipment for this application. Again, for exterior use something more robust is required – a cable such as XS24B would be a good choice here. The final wiring consideration is that of the power supply; a split-rail DC supply (±6V to ±22V), capable of yielding 20mA or so on each rail, must be used. Standard 7/0·2 'hook-up' wire should be used here, red should be used for the +V lead, black for the −V, and green for 0V. **At this stage, prepare the leads (tin their ends, etc.), but do not solder them yet.**

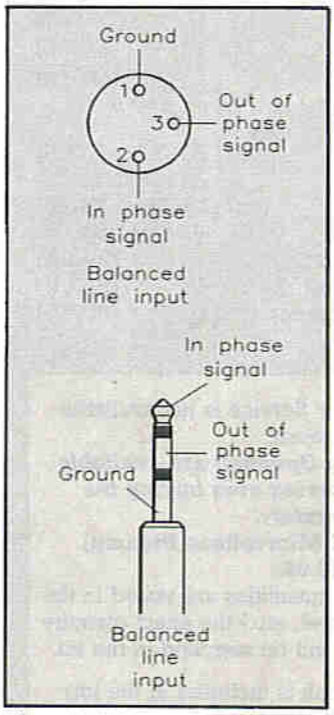
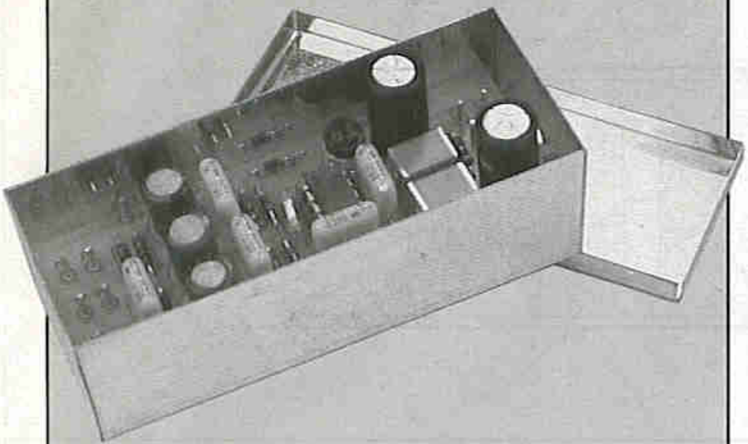


Figure 7. XLR and ¼in. jack plug connections.

To provide a neater finish, and to prevent the wires from chafing against the holes (note that the end-faces of the box have been pre-drilled), grommets should be used; note that these items are not supplied in the kit. If desired, a hole could be drilled in the top of the lid so that you have access to RV1, the gain control. Pass the wires through the holes, and then solder them to the appropriate pins on the PCB, as shown in Figure 6. Route the other end of each cable to its relevant destination, and solder it in place. IC1 may be fitted now.

Testing

The best way of testing the SSM2017 Microphone Preamplifier is to use it in its intended application – i.e., in the example given in this article one would plug in a microphone, power up the mixer and monitor the output through a pair of headphones. The mixer's internal VU meter will provide a rough guide when adjusting gain control RV1, assuming that this is fitted. Once tested, the upper case can be mated with the lower case; the two halves can then be held together with a blob of solder. Don't go too overboard, though – you might need to get back inside the unit again!



SSM2017 PARTS LIST

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

R1	100Ω	1	(M100K)
R2,3	6k8	2	(M6K8)
R4,5	10kΩ	2	(M10K)
R6	10Ω	1	(M10R)
R7	47Ω	1	(M47R)
RV1	5kΩ Cermet Preset	1	(WR41U)

CAPACITORS

C1,3,5	47μF 63V PC Electrolytic	3	(FF09K)
C2,4,6,8,9	100nF Polyester	5	(BX76H)
C7	220pF 1% Polystyrene	1	(BX49D)
C10,11	1μF Poly Layer	2	(WW53H)
C12,13	220μF 35V PC Electrolytic	2	(JL22Y)

SEMICONDUCTORS

ZD1,2,3,4	BZY88C 12V 500mW	4	(QH16S)
IC1	SSM2017	1	(CP89W)

MISCELLANEOUS

	Pin 2145	1 Pkt	(FL24B)
	8-pin DIL IC Socket	1	(BL17T)
	Metal Box	1	(FD20W)
	PCB	1	(GH52G)
	Instruction Leaflet	1	(XU33L)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

Twin-core Screened Cable		As required	(e.g. XS23A or XR08J)
Single-core Screened Cable		As required	(e.g., XR18U or XS14B)
	Wire 7/0·2 10m Black	1	(BL00A)
	Wire 7/0·2 10m Red	1	(BL07H)
	Wire 7/0·2 10m Green	1	(BL03D)

The Maplin 'Get-You-Working' Service is not available for this project.
The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.
Order as LT31J (SSM2017 Microphone Preamp) Price £12.95.
Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately.
SSM2017 Mic Preamp PCB **Order As GH52G Price £2.25.**

NEWS Report

Round the Clock Mini-Copiers

Canon has added two new models to its range of personal copiers with the introduction of the world's smallest and most portable A4 plain paper copiers – the FC310 and FC330. Designed for low volume users who may need to make copies outside normal copy shop opening times, these models seek to strengthen Canon's position in this important market.

The new replaceable cartridges in the Canon FC310 and FC330 use finer particles of toner to produce copy quality equal to large office machines. Almost everything that runs out or wears out is contained in a single cartridge so the copiers are virtually maintenance free.

Both models warm-up instantly, switch off automatically to save power and are kinder to the environment due to minimal ozone emissions. The new FC310 is priced at £675 + VAT, the FC330 at £795 + VAT.

Contact Canon 081 773 3173.

Great Great Grandson of the 8086 is Here

The Pentium microprocessor is with us, taking Intel beyond the 16-bit and 32-bit word into the realms of 64-bit design. It sounds nice, but will it really be the great leap in personal computing which Intel claims.

Intel are keen to provide reassurance that the processor is downward compatible and so the huge library of software written for earlier x86 machines will work harmoniously with the Pentium microcode. That said there will not be the large jump in speed apparent when transferring a 16-bit application from a 286 to a 386 or later from a 386 to a 486. Benefits will come when running 32-bit applications, but as yet 32-bit software is limited. At present prospective Pentium users are limited to Windows NT, the only real contending operating system that software houses are working on. The future of the Pentium therefore depends as much on the software writers providing suitable applications as it does on hardware manufacturers adopting the chip.

Architecturally the microprocessor is very different to its elder family members. Offered in 60 and 66MHz versions, the Pentium is a RISC device featuring two five-stage pipe-lines; a design which enables two instructions to be processed in every clock cycle. Additionally Two 8K on-chip caches, dramatically improved floating point performance and the 64-bit external bus provides a feel for what this chip is capable of achieving.

That apart will software and hardware designers be able to utilise the device to its full? With an initial production run of 10,000, several UK manufacturers have already promised Pentium boards by mid-summer. Whether these will make full use of the increased processing power is yet to be seen. The danger is that manufacturers will begin to produce the Pentium motherboards but in a rush to upgrade 486 blueprints, will switch off or bypass many of the Pentiums' new functions.

Fuzzy Video-Phone

The science-fiction fantasy announced in the sixties, has been launched by British Telecom. The Relate 2000 video phone is here, but don't get too excited because it's very expensive and the picture quality isn't that sharp. Available through BT shops and selected Dixons stores the new telephone – based on compression algorithms developed by Marconi – cost £399 each or £749 a pair.

"OF COURSE I'M ALONE, DARLING!"

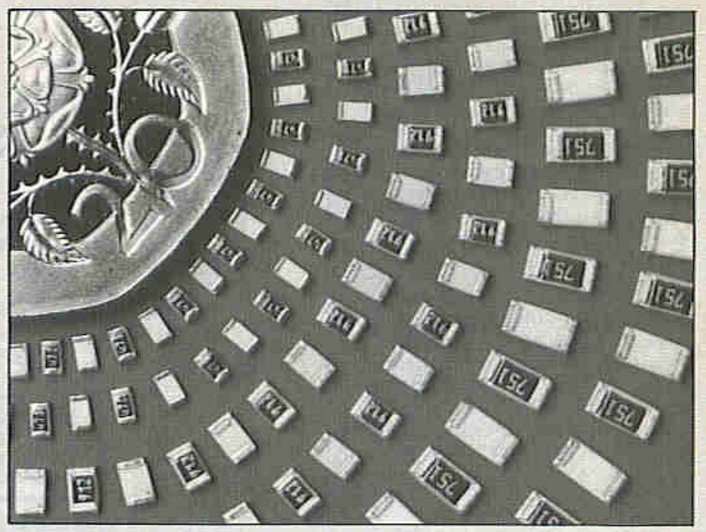
The problem is that the vast megabytes of data required to make up a picture cannot easily be transmitted over a standard twisted pair line. Opt for the television quality of fifty frames a second and problems get worst. Consequently, the three inch colour screen works at eight frames per second, producing pictures which even BT are willing to admit are fuzzy. A freeze-frame facility is available for sharper images.

Having waited several months to review a pair of the new telephones, we are not impressed. We suggest readers opt for the much cheaper and superior method of visual transmission; send photographs through the mail; the quality will be far superior and besides who wants to get dressed up to make a telephone call?

Cable Telephony Booms

The latest figures from the Independent Television Commission (ITC) reveal that the number of cable franchises offering telephony has doubled to thirty over the last year. Over 143,660 exchange lines have now been connected, increasing the number of installed lines by a third since the beginning of the year and by 360% over the last twelve months.

Surface Mount Resistors That Don't Drift



Surface Mount is not as unusual as is was a couple of years ago, but it is still a developing technology. Component Manufacturers have yet to resolve the problems of tolerance drift and component instability. In this respect,' Panasonic Industrial Europe Ltd claim to have produced the flawless resistor.

Using a new fabrication technique based on an alumina substrate with glazed metal elements coated with glass, resistors from the new ERJ range can be supplied in ranges from 1Ω to 10MΩ with tolerances of 1, 2, 5 and 10%. As Marketing Manager Dr John Turner explained "previous designs suffered from the migration of silver from the device contacts leading to inconsistent performance characteristics". This problem is totally alleviated by glazing leaving stable resistance ratings in the temperature range −50 to 70°C.

Contact Panasonic 0344 853827.

The Recession is Over – for Semiconductors at Least

The recession is over. You might not agree, but that is the official view of the UK Semiconductor Manufacturers Association, part of the trade organisation ECIF. Market figures gathered by the Association predict an industry wide growth rate of 19% for the year. It doesn't stop there either. The market demand for semiconductors is set to increase even further in future years. An expansion rate which is set to see the electronics industry becoming the largest industry sector in the UK by the turn of the decade.

Electronics Jobs for Wales...

In the same week as the publication of the recession-breaking figures from the UK Semiconductor Manufacturers Association came the news that a £42 million investment is planned to create at least a 1,000 new jobs in the semiconductor industry in Gwent.

ASAT(UK) Ltd are set to establish a plant to assemble and test integrated circuits at the Pen-y-fan industrial estate, Crumlin, near Newport. The project backed by Regional Selective Assistance from the Welsh Office, involves building a 110,000 square foot factory on a Welsh Development Agency greenfield site.

...and There's More

Electronics company Aiwa(UK), also based on the Pen-y-fan industrial site has just announced that it is creating an extra 480 jobs with a £27 million expansion. Six other local investments involving 240 new jobs have also been announced by The Welsh Development Agency. Which is all good news for an area depressed by the decline of the mining industry.

New High Capacity Cell From Ever Ready

Ever Ready Special Batteries has now introduced a new nickel cadmium (Ni-Cd) rechargeable AA size cell. Known as the AN65 it has a capacity of 650mAh, some 30% higher than the present AA cell. It joins a range of rechargeable cells and batteries that cater for the diverse needs of the electronics and electrical industries.

The Ever Ready range of Ni-Cd rechargeable cells includes over 3,000 different configurations. If the battery required by a customer is not in the standard range, the company claims it can manufacture customised products. In addition they also offer precision tested batteries whose performance under various conditions is guaranteed to fall within stringent parameters.

To achieve such a level of accuracy, the batteries are subjected to rigorous testing procedures such as capacity matching. This involves testing every individual cell prior to assembling the battery to guarantee identical discharge parameters from each cell.

Contact Every Ready Special Batteries 0702 207466.

999 Plans to be Dropped

Oftel Director General Don Cruickshank has decided that it might be unwise after all to take the 999 emergency calls service away from local telephone operators. The plans would have seen all of the county's emergency telephone calls routed through three centralised agencies, linking local fire, ambulance and police stations by computer.

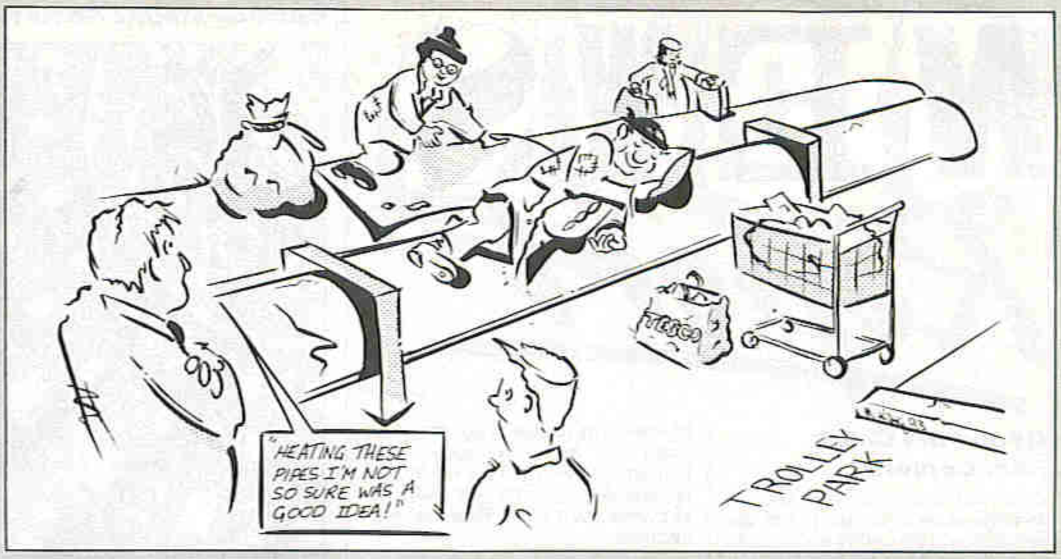
A special survey of the plan has concluded that there would be little benefit in making the change. Influenced perhaps by the problems the London Ambulance Service initially suffered when opting for a centralised telephone system, Oftel are now recommending that current arrangements are maintained. This means that operators at 57 BT local exchanges will continue to deal with the 999 calls.

Oftels' conclusion comes as no surprise. The centralisation plan has always faced strong opposition with opponents claiming that it would lead to hugh queues of callers and that the lack of local knowledge provided by an ordinary exchange could cost minutes and lead to deaths.

Tesco Protect Piped Assets

Tesco is determined not to be caught out this Winter; pipes outside the company's Aldershot Superstore have been fitted with Pyrotenax self-regulating cables. Constructed from a hybrid compound of radiation cross-linked fluoropolymers mixed with conducting carbons, the heating element within the cables varies its resistance in response to ambient temperature. The result is a heating element contained within a cable that automatically regulates its heat output according the ambient temperature. Manufactured by BICC Thermoheat of Hebburn, Tyne and Wear, the cables are to be used to protect external pipes throughout the loading area, main store room building and air-conditioning plant room at Tesco's Aldershot plant.

Contact BICC Thermoheat 091 483 2244.



BR Take Your Money Faster

Are you one of those people who queues up at a ticket office on a Monday morning to renew your travel card or present an involved request for an obscure journey? With the prices British Rail charge most people pay using some form of plastic with the inevitable result that delays are exacerbated. British Rail InterCity have got wise to this problem and have replaced conventional telephone lines with Packnet links for credit card authorisation at more than thirty ticket offices throughout the country.

With the new equipment a connection can now be made to the bank's host computer in under a second. Authorisation is usually transmitted back to the terminal before the credit card voucher has been printed. The reduction is considerable since telephone authorisation – that could have taken several minutes depending on the demand upon public lines – is usually required before a transaction can go ahead.

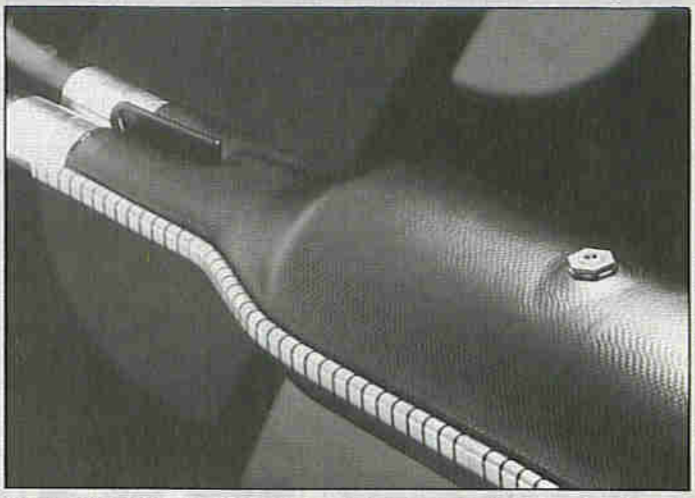
Engineering Council Wants Single Institution

The Engineering Council has strongly backed a report which calls for a new relationship between the council and the 42 engineering institutions, leading to formation of a single institution to represent the United Kingdom's engineers and technicians.

The Council has issued a statement after debating an interim report by the Steering Group of the Council of Presidents of the engineering institutions, which has investigated the unification of the profession. The report will now be used as a basis for direct discussions with the individual institutions, industry and with individual engineers.

The Council has urged that all those with the future of the profession at heart should now join with the Council and act purposively to press ahead with the actions of the report and the eventual aim of a single institution for engineers.

Woven Material Wins Queen's Award for Raychem



Raychem Ltd of Swindon has received a 1993 Queen's Award for Technological Achievement for the development of ground-breaking woven material currently used for telecommunication cable jointing all over the world.

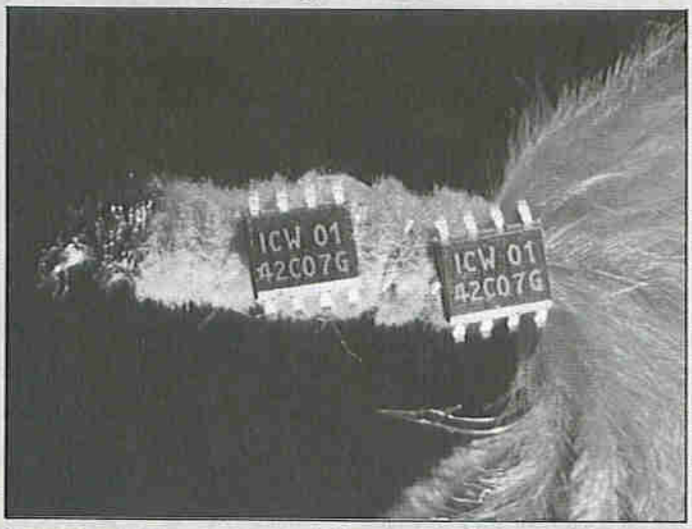
Rayfort material was developed at the company's European Corporate Technology laboratories in Swindon to meet the needs of network installers working on pressurised, high volume telecom lines. This is the company's second Queen's Award for Technology – in 1972 Raychem was honoured for the development of high voltage electrical terminations.

Work began in Swindon in 1980 to enhance the performance of Raychem's conventional heat-shrink closure system, which cut installation time for cable joints from four hours to around 30 minutes per joint. These innovation closures, which replaced the hand-moulded epoxy jointing system, were only suitable for unpressurised smaller joints within the network. They could not be used on the larger diameter pressurised lines – up to 4,800 pairs – due to performance limitations under continuous pressure.

Research concluded that the solution was to incorporate a specially woven fabric into the heat-shrink. The fabric reinforcement dramatically increased the creep performance of the unreinforced polymeric sheets, and in so doing opened the massive market of pressurised telecom cable to heat-shrink sleeves.

Contact Raychem 0793 528171.

Dual CMOS Frequency Generator



Designing a dual frequency economical oscillator circuit to fit into a small area of PCB? The ICW42C07 is a low-cost solution for generating two simultaneous buffered clocks from a single input frequency. The device from Microelectronics Technology Ltd (METL) is an ideal replacement for crystal oscillator designs, allowing greater flexibility and smaller board area at a reduced cost.

The 8-pin packaged device features a phase detector, loop filter and independent oscillator for reference. The phase-locked loop design incorporates a supply filter to eliminate noise and a voltage controlled oscillator which reduces phase jitter.

The two oscillator outputs allow for four programmable frequencies in the range 2MHz to 100MHz. Using a 14·318 reference input, the output options are 40, 50, 66·6 and 80MHz, suitable microprocessor clock control. Using a different reference input the same programmable ratios can be applied to generate customised frequencies as required.

Contact Microelectronics Technology Ltd 0844 278781.

Events Listings

25 July. 'All Formats Computer Fair'. National Motorcycle Museum, Birmingham. Tel: (0608) 66382.

7 and 8 August. Car Craft. Sandown Exhibition Centre, Sandown Park, Esher, Surrey, KT10 9AJ. Tel: (0428) 712180.

14 and 15 August. Vintage Model Rally. Old Warden, Bedfordshire. Tel: (0442) 66551.

8 and 9 September. Cabling World. Sandown Exhibition Centre, Sandown Park, Esher, Surrey, KT10 9AJ. Tel: (0932) 820100.

29 and 30 September. Highways Roadshow. Sandown Exhibition Centre, Sandown Park, Esher, Surrey, KT10 9AJ. Tel: (081) 684 4082.

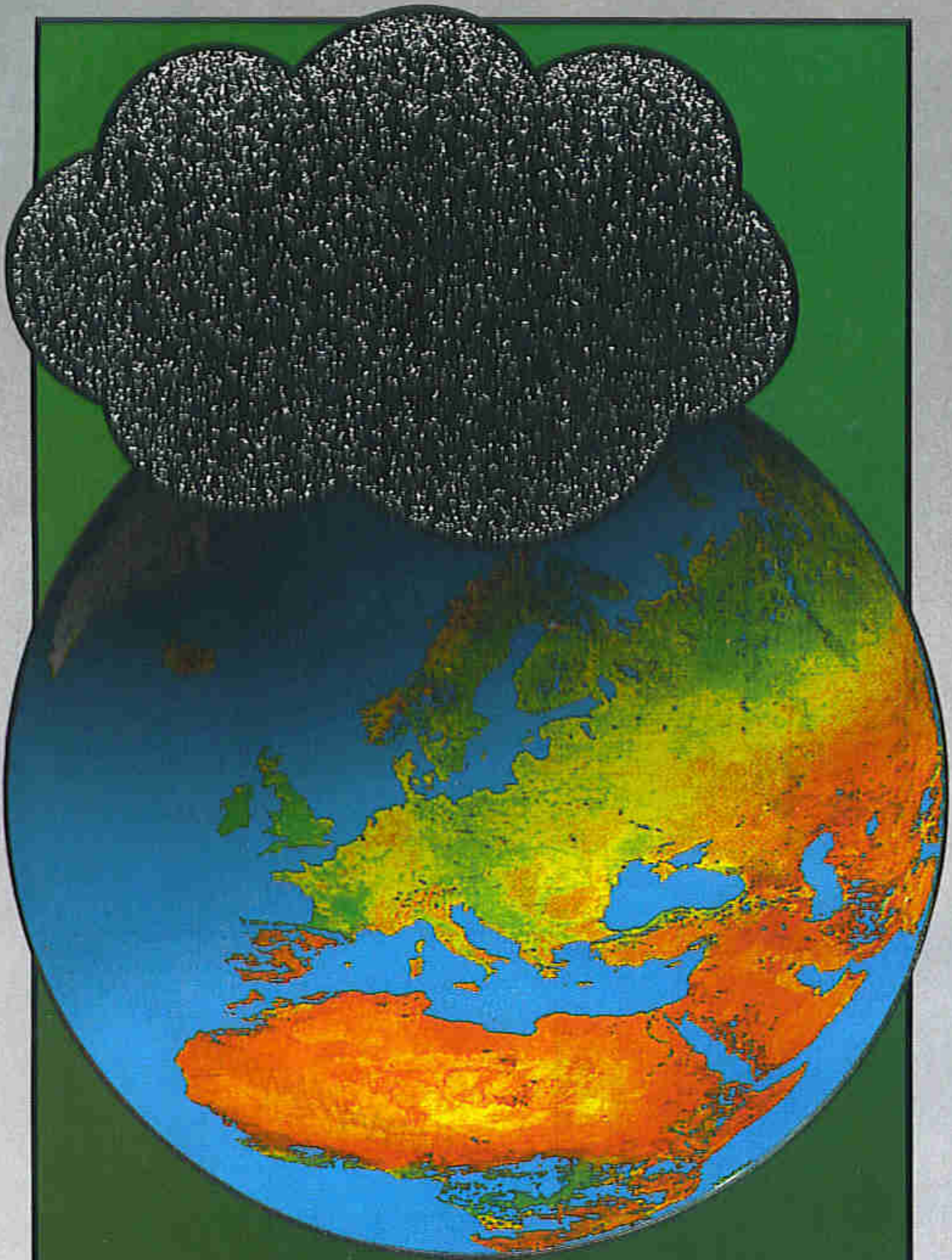
2 October. All Formats Computer Fair. Sandown Exhibition Centre, Sandown Park, Esher, Surrey, KT10 9AJ. Tel: (0608) 662212.

5 to 7 October. Electronics Manufacturing Technology Show and Electronic Design Show. Wembley Exhibition Centre. Tel: (081) 336 1282.

5 to 7 October. Euro-EMC. Sandown Exhibition Centre, Sandown Park, Esher, Surrey, KT10 9AJ. Tel: (0892) 544027.

6 and 7 November. The 7th North Wales Radio and Electronics Show, Aberconwy Conference and Exhibition Centre, Llandudno. Tel: (0745) 591704.

Please send details of events for inclusion in 'Diary Dates' to: The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR.



GLOBAL CLIMATIC CHANGES

by Douglas Clarkson

In spite of earnest initiatives to understand (or at least start to!) all of the factors that influence global weather patterns, it is widely recognised that, while it may be possible to predict the weather one week ahead, it is certainly not possible to accurately predict it over a month or more.

THUS, when climatologists predict scenarios ten years, and even one hundred years, ahead there is a certain level of uncertainty in their predictions. Those who develop models of climatic change, therefore, are faced with a challenge where the design of the model of climate change may not faithfully represent reality which is, after all, a highly complex interplay of events that differ widely in their significance.

It is universally recognised, however, that it is vitally important to understand the changes now taking place in the world's climate, the mechanisms that drive them, and the courses of action that will help to maintain balance in the world's weather patterns.

The discovery of our poor level of understanding of the world's past and present climate is, however, stimulating significant new climatic research. While various climatic models have been structured, observers expect final confirmation of global warming to be evident by the mid-1990s. The eventual deployment of the expected Earth Observing System, which consists of at least four satellites, will provide yet more data for analysis.

The world appears to be slowly responding to the increase in carbon dioxide (CO_2) present in the atmosphere. This is a good starting point to take when trying to understand the changes taking place. At the same time, however, there is so much linkage between ecosystems that a change in one element can subtly produce change in another element, which may be apparently totally unconnected.

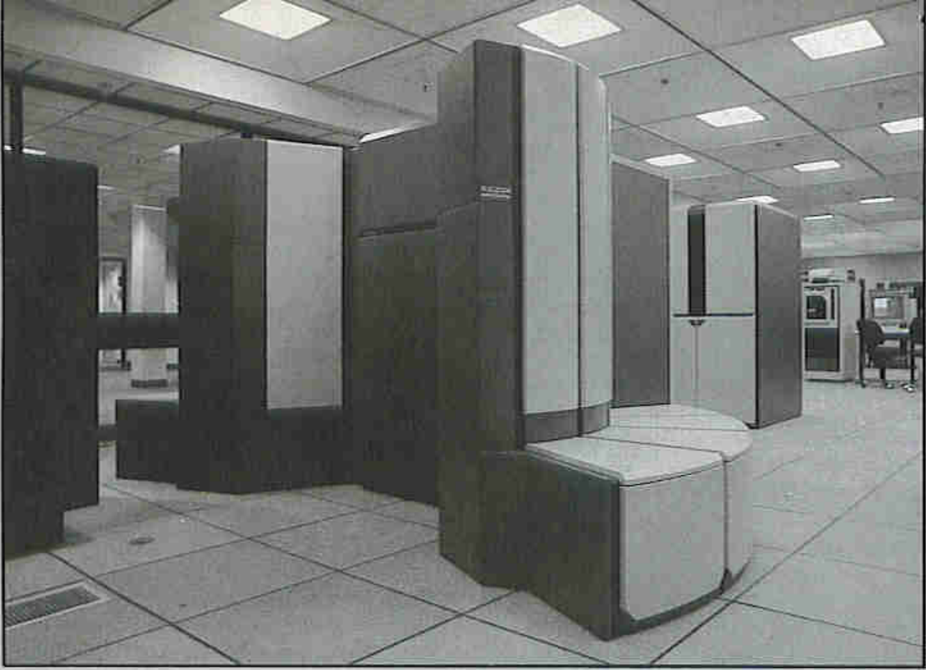
Carbon Dioxide – Friend and Foe

When the sun's radiation passes through the atmosphere to the Earth's surface, the shorter wavelengths of visible and short wave infra-red are absorbed to varying degrees. The warmed surfaces, in turn, radiate heat at longer wavelengths which is radiated away from the planet's surface, as shown in Figure 1.

If the Earth's atmosphere contained no CO_2 gas at all, then most of this heat would be radiated back out into space, and the Earth's climate would be significantly colder. The average temperature of the Earth would be −20°C, or some 35°C colder than at present.

The presence, of even the relatively low levels of CO_2 that are present in the atmosphere, acts to absorb some of this radiated energy before it leaves the atmosphere. This is the principle of the 'greenhouse' effect.

Before the Industrial Revolution, the level of CO_2 in the atmosphere was about 270ppm (parts per million). This has now risen to about 360ppm. This has largely been due to the burning of fossil fuels, such as coal, oil and gas. One very valuable set of data has been obtained at Mauna Loa in Hawaii over the last 30 years, as shown in Figure 2. There is a sharp reduction of the level in the spring and summer (as new plant growth absorbs the CO_2), and a sharp

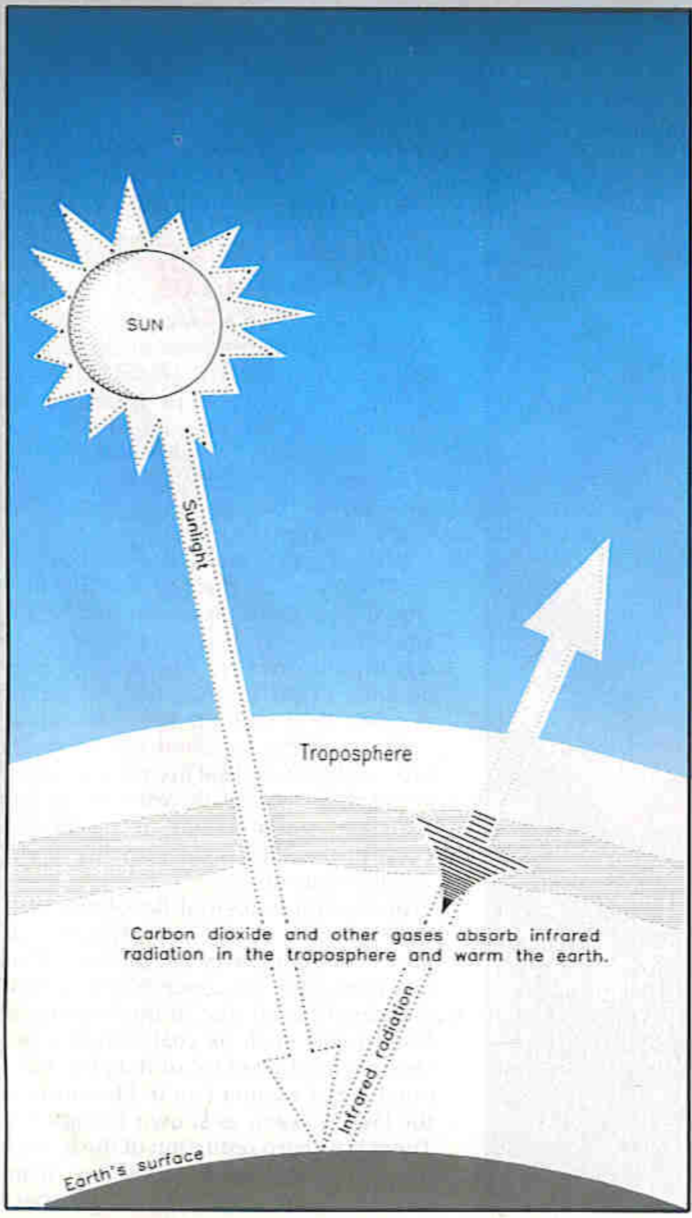


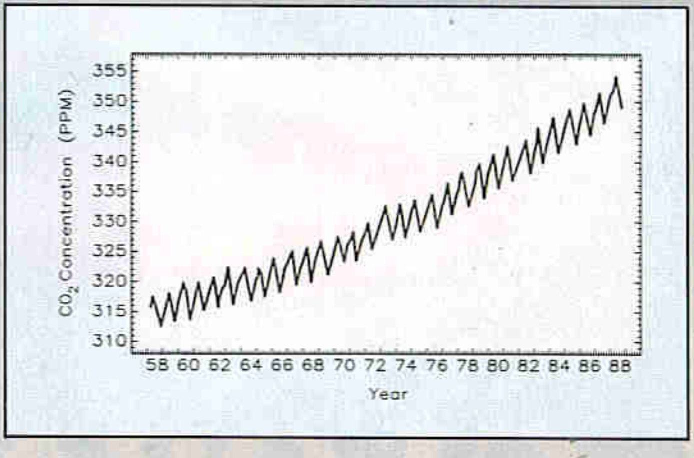
Left: Complex models require complex modelling tools. Shown is the Cray Y-MP8/864 supercomputer (one of the most powerful in the world) at NCAR. It has 64 million words of memory, eight processors (for parallel processing) and can execute an instruction every six nanoseconds.

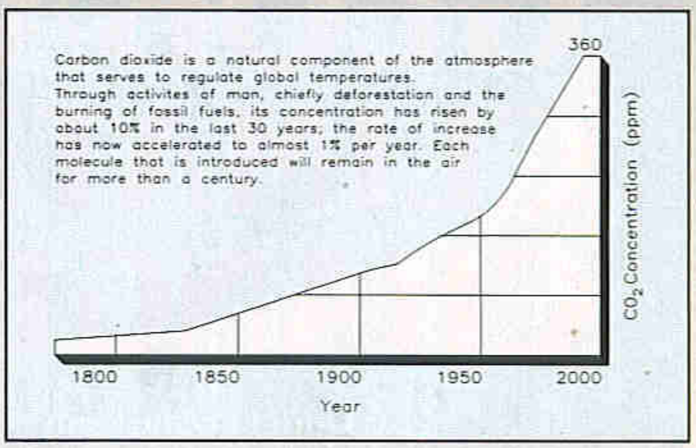
increase in the winter (as vegetable material decomposes). There is also an unmistakable steady rise in CO_2 concentrations – caused by the relentless burning of fossil fuels. It is this steady uncontrolled increase which is causing so much concern.

Figure 3 shows the relative rate of the rise of atmospheric CO_2. Data prior to 1958 has been taken from bubbles of air trapped in glacial ice from various sites around the world. This graph indicates a gradual increase of about 10ppm in around 50 years, during the early stages of the Industrial Revolution, to an increase now of 10ppm in less than ten years. The current initiatives to reduce global warming relate to preventing the rates of emission from going even higher. While it may be possible for developed countries to limit their output and switch to 'green' alternative sources, the developing world is fast becoming the future battleground against global warming. Mainland China, for example, has a growth level of around 10%, and has access to vast reserves of fossil fuels, such as coal.

Figure 2 gives a clue which suggests that the CO_2 level in the atmosphere is a balance between many factors within nature. Abundant growth of trees and plants will reduce levels. The decay of plant material will add to the burden of CO_2. One of the great surprises, however, is that the world's oceans play a major part in helping to balance the CO_2 equation. The burning of the world's fossil fuels acts only to tip the balance ever so slightly, in an annual net positive increase of 3 billion tons, within a total production figure of over 200 billion tons.







Left: Figure 1. Mechanism of global warming – the sun's radiation, which penetrates to the surface level, is radiated back as longer wavelength heat radiation, which is then absorbed increasingly by higher levels of 'greenhouse' gases such as CO_2 *(EPA General, 1989).*
Top: Figure 2. Variation in levels of CO_2 observed at the Mauna Loa observatory in Hawaii. There is a seasonal variation, and also a steady upwards trend due to the burning of fossil fuels *(Chemical Engineering Progress, August 1989).*
Above: Figure 3. Measured rise of CO_2 in the atmosphere since the beginning of the Industrial Revolution. Data prior to 1958 has been obtained from various glacial ice samples *(NCAR).*

Figure 4 shows the competing effects of the main absorbing and emission processes. If there was no burning of fossil fuels and no deforestation, then present estimates indicate that there would be an annual net reduction of 3 billion tons in the amount of CO_2 in the atmosphere. The world's oceans are acting like a 'sponge', trying to remove excess CO_2 from the atmosphere – though they need time to absorb significant amounts.

In understanding the carbon cycle, it is important to estimate the known amounts of CO_2 within various 'reservoirs'. Table 1 shows the relative quantities considered to be locked in various areas. Note that the total locked up in the atmosphere and world vegetation is similar to that held within the world's soils. The oceans, however, store more than twice that of all land and atmospheric reservoirs combined.

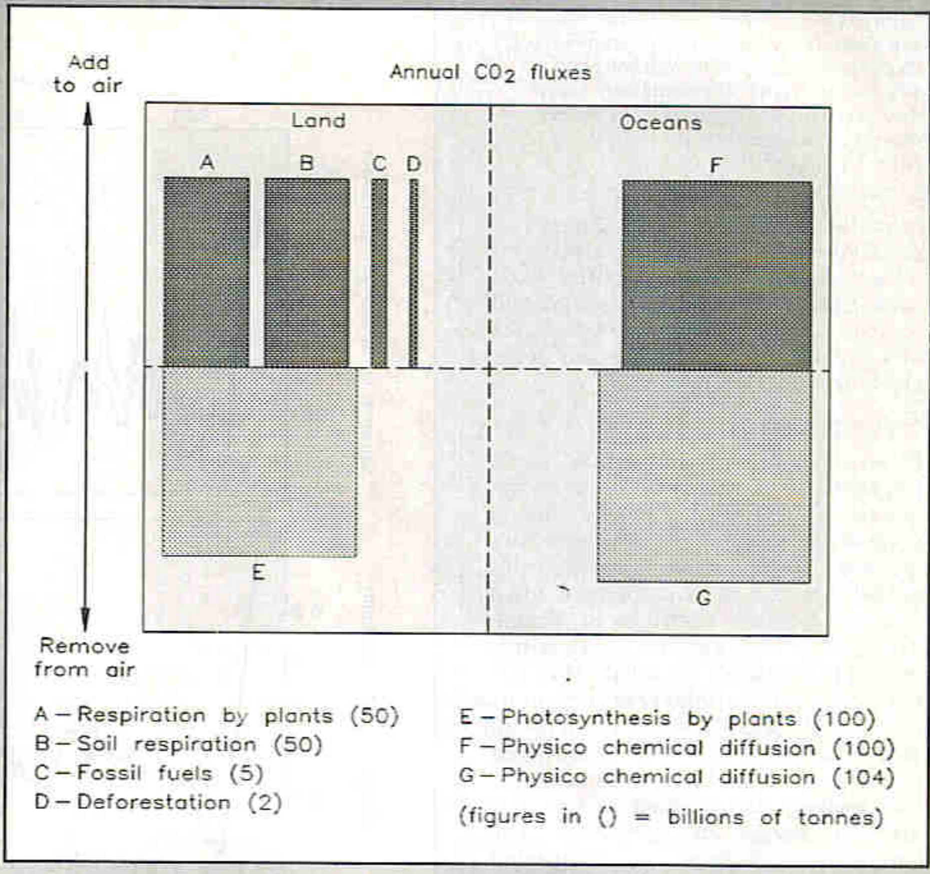
The anticipated level of fossil fuel reserves indicates that there remains a formidable amount of CO_2 to be released by future generations of fossil fuel burners. If it was released overnight, then the level of CO_2 in the atmosphere would increase by a factor of ten. 'Friendly' mechanisms of the oceans, which pump excess CO_2 into the depths, would not be able to cope with such a massive injection of the 'greenhouse gas'.

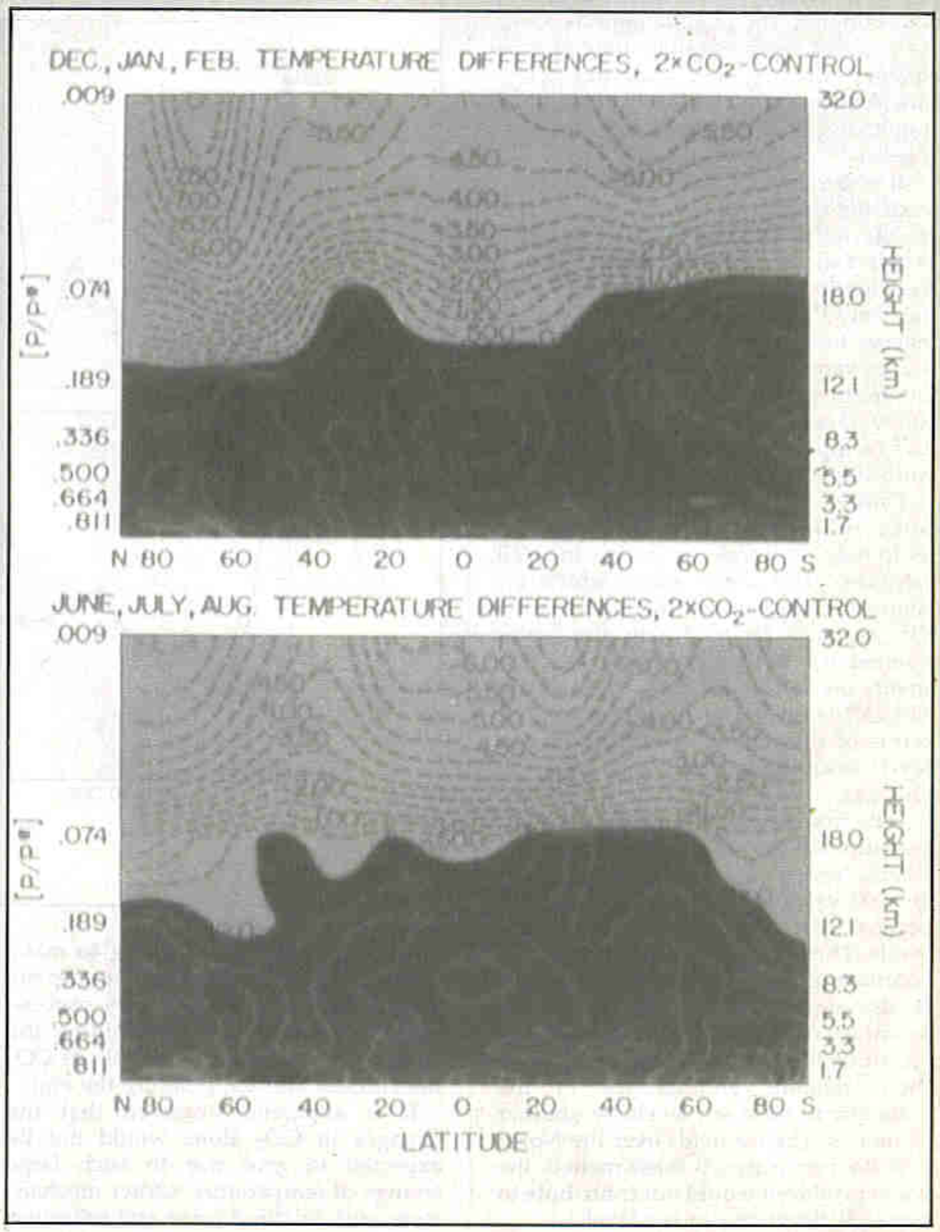
Reservoir	Size of reservoir (billions of tonnes)
World Vegetation	560
World Soils	1,500
Atmosphere	735
Oceans	36,000
Fossil Fuel Reserves	5,000 to 10,000

Table 1. Indication of relative size of CO_2 planetary reservoirs.

CO_2 – The Balancing Act

The ocean absorbs carbon through the process of plankton growth. The end-product of this growth is the deposition, of the carbon rich skeletons of such organisms, on the ocean floor. Over periods of geological time (i.e. many millions of years), these sediments form carbonate rocks which, in time, are pushed deeper into the Earth's crust where volcanic processes are probably active in releasing CO_2 from them during volcanic eruptions. This is a long-term carbon cycle, which is only tentatively understood. So there may be long quiet periods of the Earth's climate, where CO_2 is slowly removed

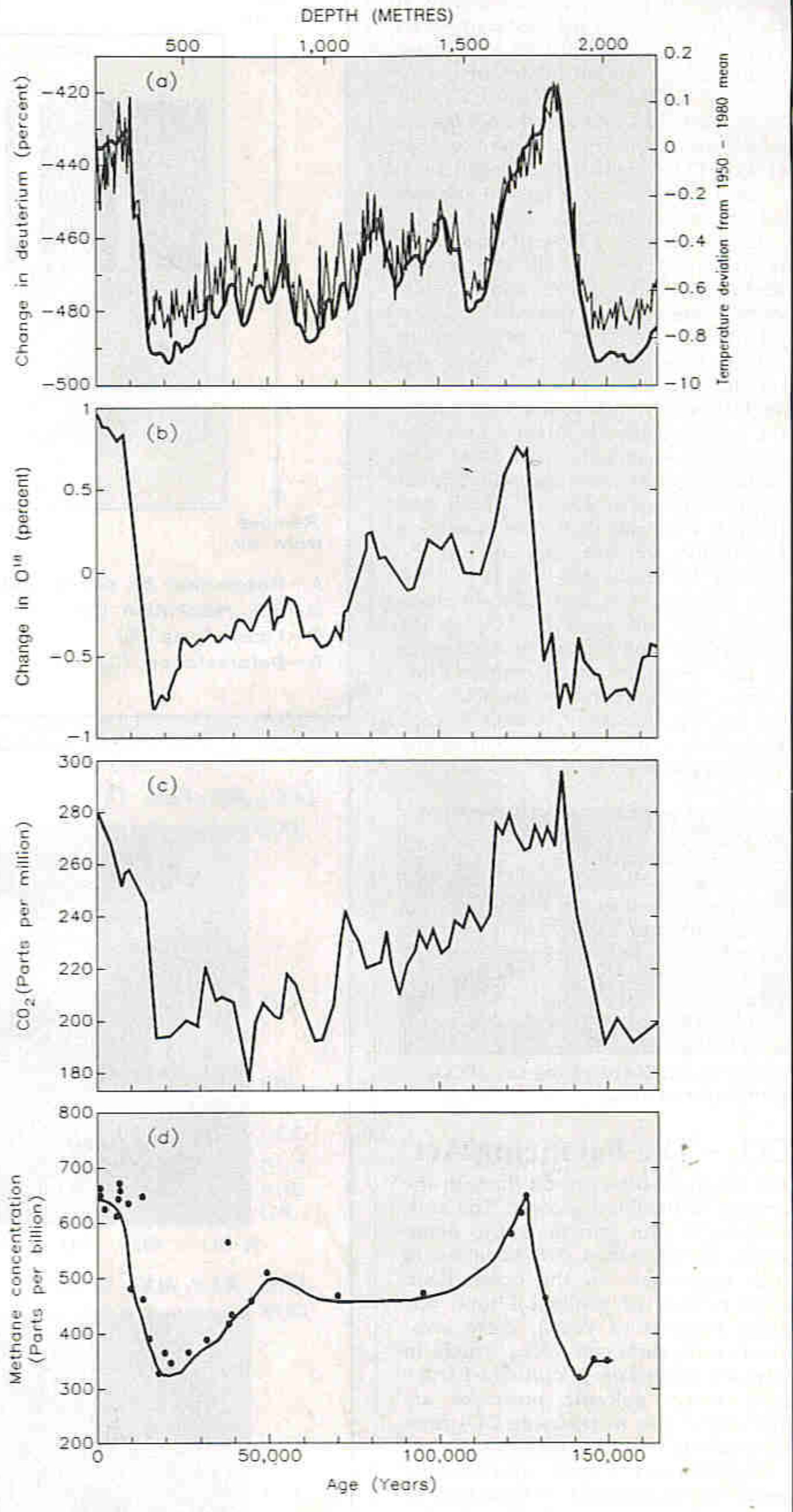




Top Right: Figure 4. Drawing showing the relative mechanisms of CO_2 emission and absorption of both land and ocean. The net positive increase of 3 billion tons per year is a small percentage of total emission and absorption.

Right: This graphic shows a zonally-averaged latitude height distribution of temperature changes due to CO_2 concentrations doubling in a climate model, based on a three-year period and averaged from a 20-year run of the model. This is not a climate forecast.

Right: Figure 5. Sequence of data from the Vostok ice core showing change in deuterium and O^{18} with concentration of CO_2 and methane. The deuterium and O^{18} data is considered to indicate accurately changes in temperature *(Scientific American, April 1989).*



from the atmosphere, and periods of rapid increase which are associated with volcanic eruptions. Over vast geological timescales, there is a general balance, although there may be phases of transition between stable and non-stable intervals.

Secrets in the Ice

In trying to predict the future, many scientists have tried to unravel the secrets of the past. Indeed, many researchers see this as the 'best way forward'. The Antarctic ice is well-placed to record climatic changes, and a team of Russian scientists at Vostok extracted an ice core some 2,200 metres long in order to establish the gas composition of bubbles of air within its structure. Figure 5 shows a sequence of data dating back 160,000 years – in which deuterium ('heavy' water), O^{18} (an isotope of oxygen), CO_2 and methane levels are indicated. The temperature changes are interpreted from the relative levels of deuterium in the samples. The relative abundance of O^{18} provides a similar temperature history. Cooling and warming cycles are also shadowed by levels of methane (another greenhouse gas) in the atmosphere.

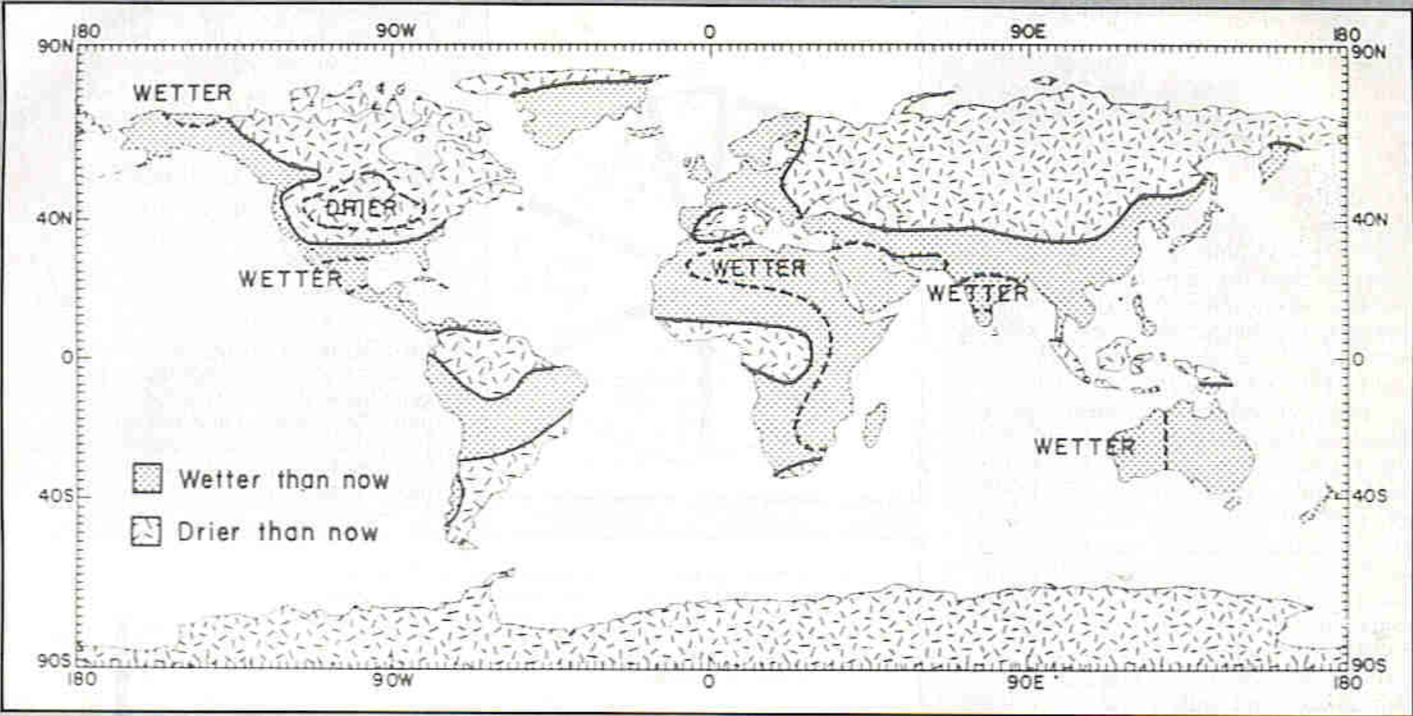
It is perhaps relevant at this stage to consider the usefulness of the analysis of the ratios of O^{18}/O^{16} in samples of water and ice. Water evaporating will be slightly deficient in O^{18}, because the heavier O^{18} atom requires slightly more energy to enter the vapour state. When water vapour falls as snow, there is a tendency to add to this effect so that snow deposits are more deficient in the O^{18} isotope – an effect which increases with decreasing temperature.

During periods of major glaciation, large volumes of the world's oceans evaporate and fall as snow in cold latitudes. The ocean water which remains becomes increasingly rich in the O^{18} isotope. By analysing the water content (or derived content) in sediments on the ocean floors, the ratio of O^{18}/O^{16} content can be interpreted in terms of the relative variations in sea level associated with such physical changes.

Data from various ice series, and also examination of sediments from ocean floors, reveal that, within the past 160,000 years, the level of the world's oceans was some 50m below present levels. The great mass of ice formed on continental surfaces caused the oceans to rise significantly at the end of the recent Ice Age. Even with this relatively recent melting (some 12,000 years ago), there remains enough ice in the Antarctic to raise sea levels by another 20 metres. The ice fields over the North Pole float on water; if these melted, the water produced would not contribute to any significant rise in sea level.

The big question in trying to make sense of the data relates to whether the temperature is following CO_2 concentrations, or if CO_2 is determining the changes in temperature directly. Is CO_2 the chicken and temperature the egg?

It is apparent, however, that the changes in CO_2 alone would not be expected to give rise to such large swings of temperature. Other mechanisms, such as cloud cover and reflection from ice surfaces, must be involved in magnifying the effect of any CO_2 changes. This is precisely the problem which today's climatologists face – what are these other mechanisms and how do they operate? It is estimated that such other factors have multiplied the effect of greenhouse gases by a factor of between 5 and 14 over the period of time corresponding to the Vostok data.



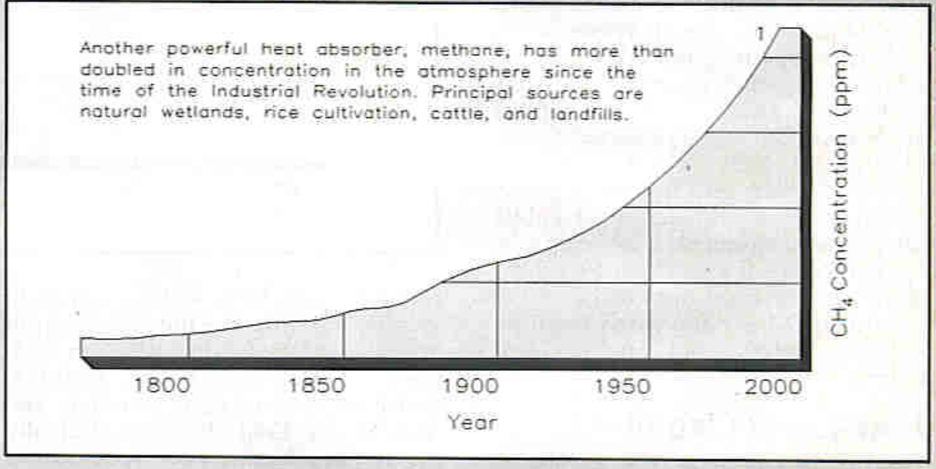
Searching for Cycles

The evidence of previous periodic cycles, of slight warming and then cooling of the Earth, indicated that there was some natural cycle of global climate taking place before man began to burn fossil fuels. A comprehensive theory to account for these changes was developed by Milutin Milankovitch in 1920. He identified that there were three separate components of change in the Earth's orbit around the sun – each one, in turn, influencing the amount of heat absorbed at various latitudes on the Earth. Where these diverse effects reinforced each other, then significant changes to heat uptake on the Earth would be expected to take place. Three effects, that of the tilt of the Earth's axis (period 41,000 years), precession of the equinoxes (period 22,000 years) and eccentricity of the Earth's orbit (period 100,000 years) add together to add perturbations to the Earth's climatic model. Many of the climate changes previously observed in ice core studies have been confirmed using Milakovitch's model. It is the sudden release of CO_2, however, which is introducing an unknown element into future climate change predictions.

Methane – Roles and Responsibilities

CO_2 has, up until now, been identified as the main greenhouse gas in the Earth's atmosphere. The Vostok ice core data revealed, however, that methane present in the atmosphere during the last glacial retreat around 10,000 years ago contributed around 25% to the process of global warming.

Today, levels of methane were rising at 1% per year during the 1980s. Figure 6 shows the concentration of methane in the atmosphere in recent decades. Today's level of 1·7ppm is about five times the level present during the last Ice Age. The methane is considered to originate from a range of sources. One source of methane is that of domestic cattle. Microbes in the gut of these animals produces, on average, 200g of methane each day. The numbers of such cattle has increased from around 700 million in 1940, to 1,300 million in the 1980s. Rice fields in Asia also encourage the proliferation of methane-producing microbes. Apart from these, methane hydrates locked in the sediments of cold ocean floors are potentially a major source of methane. Disturbance of such sediments, or changes in temperature, can release methane from their structures. Another 'natural' source of methane, strangely enough, is the world population of termites, which have a consuming passion for vegetable material. Methane is also released from gas and oil wells, and landfill sites – where domestic rubbish decomposes – located all over the world are a source of increasing levels of methane. Even the asphalt on our roads (it's not just the cars themselves that cause global warming!) has been shown to react with sunlight and produce methane. Table 2 indicates the relative amounts considered to be released into the atmosphere by these various mechanisms.



Above: NCAR (National Center for Atmospheric Research) soil moisture pattern projection, based on paleoclimatic reconstructions of the Altithermal Period (4,500 to 8,000 years ago), comparisons of recent warm and cold years, and a climate model experiment.

Right: Figure 6. Variation in levels of methane in the atmosphere during the Industrial Revolution. Earlier data is taken from glacial ice samples *(NCAR)*.

Source	Amount methane released per year (millions of tonnes)
Domestic Animals	90
Paddy Fields	50
Rubbish Tips	70
Methane Hydrates	150
Termites	150
Asphalt	30

Table 2. Principal sources of methane released into the atmosphere.

Methane, however, does not survive in the atmosphere forever. Processes which break it down result in 'only' a net annual increase of 50 million tons. The main mechanism which removes methane 'naturally' from the atmosphere is the hydroxyl free radical (–OH). Although present in small amounts, it plays a vital role in removing methane from the atmosphere.

Research shows, surprise surprise (!), that the levels of these useful hydroxyl ions have fallen by about a quarter in northern latitudes over the last 40 years. The principal culprit is considered to be carbon monoxide from car exhaust pollution. It is also relevant to point out that hydroxyl ions also have a role to play in breaking down CFCs, which deplete ozone. The less hydroxyl ions present, the longer the present CFCs can persist in the atmosphere and damage the ozone layer even further.

Thus, car exhaust pollution has a two-fold effect on global warming. The carbon monoxide which is released is responsible for allowing higher levels of methane to become established in the atmosphere, which increases global warming. This is another good reason for fitting catalytic converters to car exhausts.

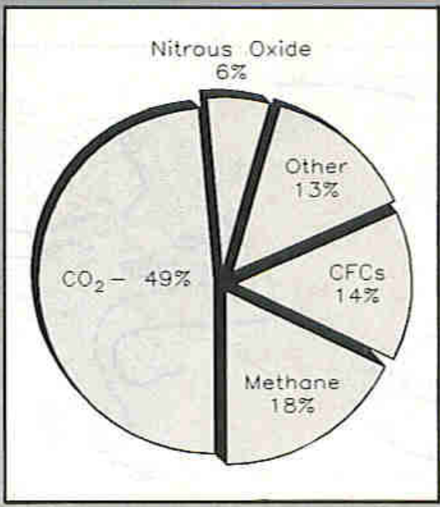
The influence of methane on the delicate balance of the atmosphere does not, in fact, end with its influence as a global warming gas. High in the stratosphere, methane is broken down to produce water vapour. When clouds of such vapour form, they act as catalysts in the process of ozone destruction. Holes in the ozone are associated with the formation of such clouds.

Thus the facts and figures of global warming present a picture of subtle interactions. Scientists, for example, have still no clear picture of how higher levels of ultra-violet light will alter the balance of CO_2 produced and taken up by the world's land surfaces and oceans.

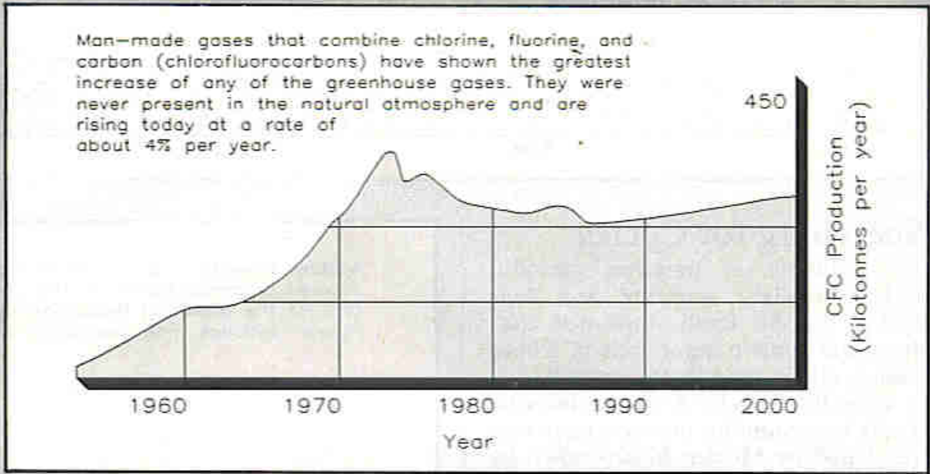
Low-Level Ozone

Children in city areas of Los Angeles have a reduced lung capacity compared with those living in rural communities. It is considered that high levels of ozone have damaged their lungs. There is evidence that, during hot summer spells, ozone begins to accumulate over large areas of the industrialised world. Over Europe, for example, ozone fog even extends over the open areas of western Ireland. Europe's air quality is potentially a health risk. It is almost certainly a health risk to many species of trees; indeed, it has been suggested as a major factor in the strange death of large numbers of trees in Europe and North America. The death of these trees is a boost to global warming, as additional amounts of CO_2 are released into the atmosphere. Low-level ozone is itself a greenhouse gas. There is every indication, however, that increased levels of low-level ozone will be produced if levels of nitrogen oxides – another by-product of human activity – continue to rise.

So the picture of global warming is by no means simple, since there are a number of processes which continue in parallel and influence the end result; in addition, processes interact with each other. The scenario is one, however, which requires pressing attention. The fears of the Cold War and 'mutually assured destruction' have passed. It is interesting that the break-up of the Cold War took place at a time when concern about climatic change finally boiled over into newspaper headlines. There is little doubt that meeting the responsibilities is going to be a great challenge.



Left: Figure 7. The diagram shows the relative man-made contributions to the greenhouse effect – CFCs play a significant part *(EPA General, Jan/Feb 1989).*



Below: Figure 8. Rate of production of CFCs since the 1960s. Levels are still rising by 4% per year *(NCAR).*

The Role of CFCs

Figure 7 shows how CFCs contribute significantly to global warming. This puts into perspective the contributions from the other 'greenhouse' gases. Figure 8 shows how the level of production of these compounds has tended to level off during the 1980s. The present rate of rise (4% per year) means that not enough substitutes are being used quickly enough on a global scale.

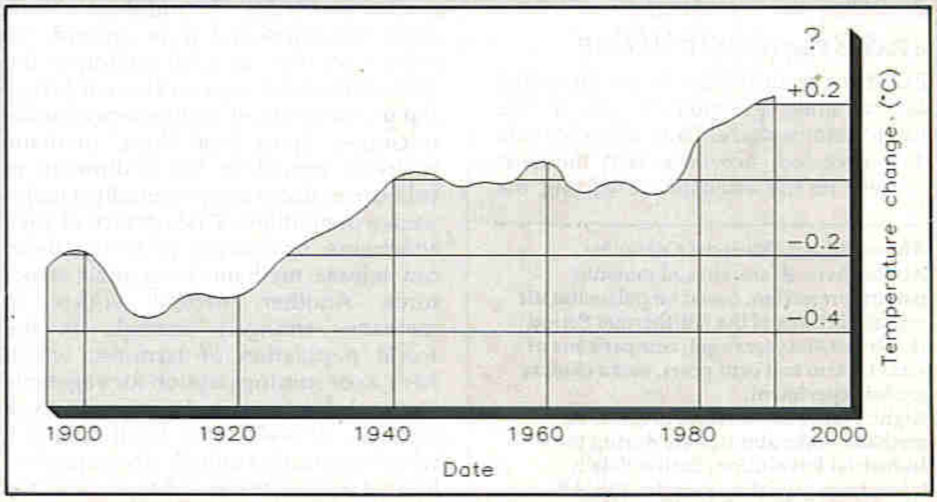
Sifting the Evidence

There is, at present, unanimity amongst the world scientific community in the belief that global warming has already arrived and is here to stay. Figure 9 shows the annual and 5 year averaged values of combined land and ocean temperatures of the Earth for the period 1880–1989, expressed as a deviation from the average temperature for 1951–1980. It is the apparent 'blip' from 1980 onwards which numerous observers identify as being some kind of turning-point of global warming.

Model Predictions

Based on the understanding as of 1989, predictions of median changes in surface air temperatures was made by four main groups of climate change simulations assuming a doubling of CO_2 levels. The data is presented in Table 3.

These changes are very much greater than all the fluctuations detected in the 160,000 year series of the Vostok ice

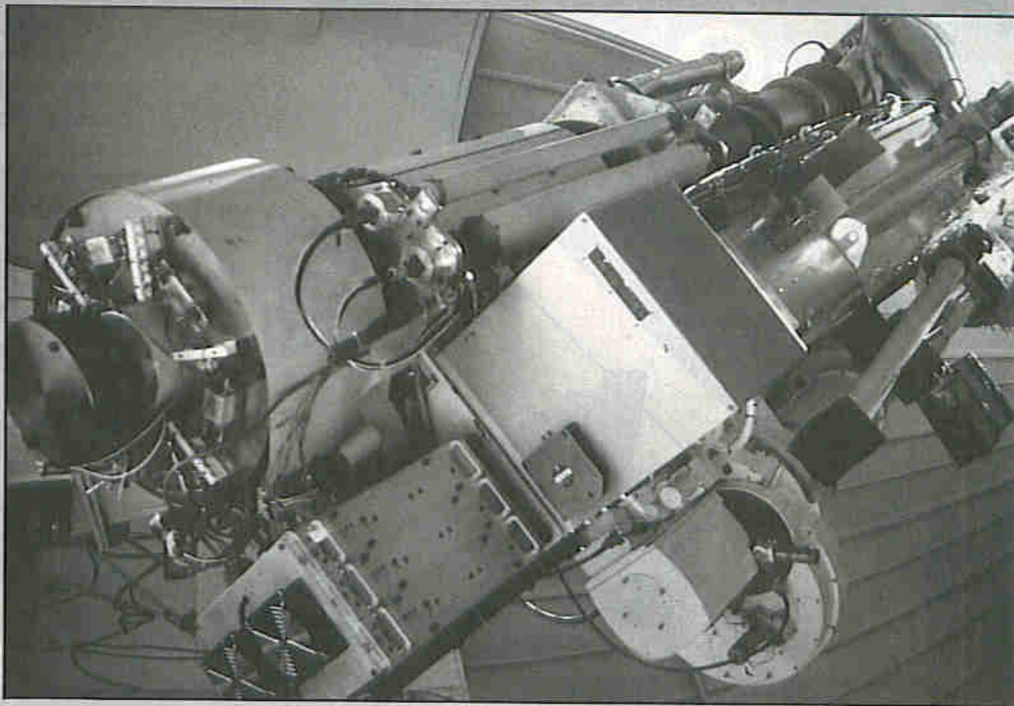


Right: Figure 9. Showing the annual and 5 year averaged values of combined land and ocean temperatures of the Earth for the period 1880–1989, expressed as a deviation from the average temperature for 1951–80 *(NCAR).*

Temperature Change (°C)			
Model	Season	Global	Northern Hemisphere
CMM	Winter	3·72	3·74
CMM	Summer	3·30	2·85
GFDL	Winter	4·50	5·65
GFDL	Summer	4·06	5·65
GISS	Winter	4·64	5·58
GISS	Summer	4·33	3·35
OSU	Winter	3·19	3·12
OSU	Summer	3·03	3·33

CMM – Community Climate Model, developed by NCAR, Boulder, Colorado, USA.
GFDL – Geophysical Fluid Dynamics Laboratory model, National Oceanic and Atmospheric Administration, Princeton, USA.
GISS – Goddard Institute for Space Sciences model, New York, USA.
OSU – Oregon State University model, Oregon, USA.

Table 3. Changes in surface air temperature, as predicted by four climate models, for a doubling of atmospheric CO_2.



cores. During this period of switching of climatic behaviour between ice ages and interglacial periods the Earth cooled on average at most by one degree on average and warmed by 0·2°. These predicted changes in temperature rise are clearly something to anticipate with trepidation. With the level of CO_2 rising at around 4·5% per decade, simplified arithmetic determines that the CO_2 levels will have doubled by the middle of the next century if such rates of increase were continued.

The world would be quite a different place today if warmed to this extent. A very significant amount of the Antarctic ice mass will have melted, causing the sea levels to rise. Climate patterns could also be radically altered.

It is clearly quite desirable never to have got into this position in the first place. It is important to stabilise, and then reduce, greenhouse gas emissions; their 1987 levels are taken as a reference value for future good intentions. The USA, for example, plans to limit its emissions of greenhouse gases to the 1987 level, by the year 2000. Various countries in the EEC (such as Germany) are, however, looking to reduce emissions below this level. Perhaps the more shrewd developed countries can see that the process of reducing CO_2 emissions is, in reality, energy efficiency reflected in reduced energy costs. There is after all, a very direct economic benefit in reducing such emissions through better utilisation of energy.

The 'Greenhouse Conspiracy' Theory

Scientific opinion, however, tends to polarise to different viewpoints. There is at present a counter-group of scientists who indicate that the 'hype' surrounding global warming is no more than a 'greenhouse conspiracy', in which it is fashionable to believe in global warming even though, it is claimed, present data shows no indication of such an effect.

One of the chief arguments for this viewpoint is that the bulk of ground-based temperature monitoring is undertaken in built-up areas where artificial warming takes place – 'urban bias'. As towns and cities have grown, this effect will correspondingly increase, and so evidence of apparently increased temperatures is misleading. The data of satellite observation is also claimed to show no real indication of global warming, being based, for example, on the temperatures of large tracts of ocean. At the end of the day, it will be scientific observation that will decide the issue. Instead of various groups of scientific opinion trying to outflank each other, attention should instead be directed to undertaking a more precise and structured investigation.

Researchers also indicate that where trees have been exposed to circulating air with double the present levels of CO_2, the volume of the trees are approximately twice as great as similar trees exposed to 'normal' circulating air. Higher levels of CO_2 should, in many cases, stimulate plant growth and increase the rate at which plants remove it from the atmosphere.

Above: The coronometer of the NCAR High Altitude Observatory at Mauna Loa, Hawaii. Scientists believe that the sun is not a constant energy source and that changes in radiant energy influence the Earth's space environment, its natural atmosphere, and possibly its climate. The instrument, as can be guessed by its name, makes daily observations of the sun's corona.
Below: According to experts, floods are set to become more common in lower regions as the sea level rises, due to global warming.

Conclusion

There is clearly too much at stake to take the viewpoint that, as long as some scientists remain unconvinced, then the prospect of imminent global climatic change should be pushed to the sidelines. Climatic research constantly shows that Nature is full of surprises, and that our ignorance of many of the basic mechanisms of the regulation of the climate is only too apparent.

It is clearly the time to moderate our influence on the Earth's atmosphere, and allow Nature the chance to restore a position of delicate balance.

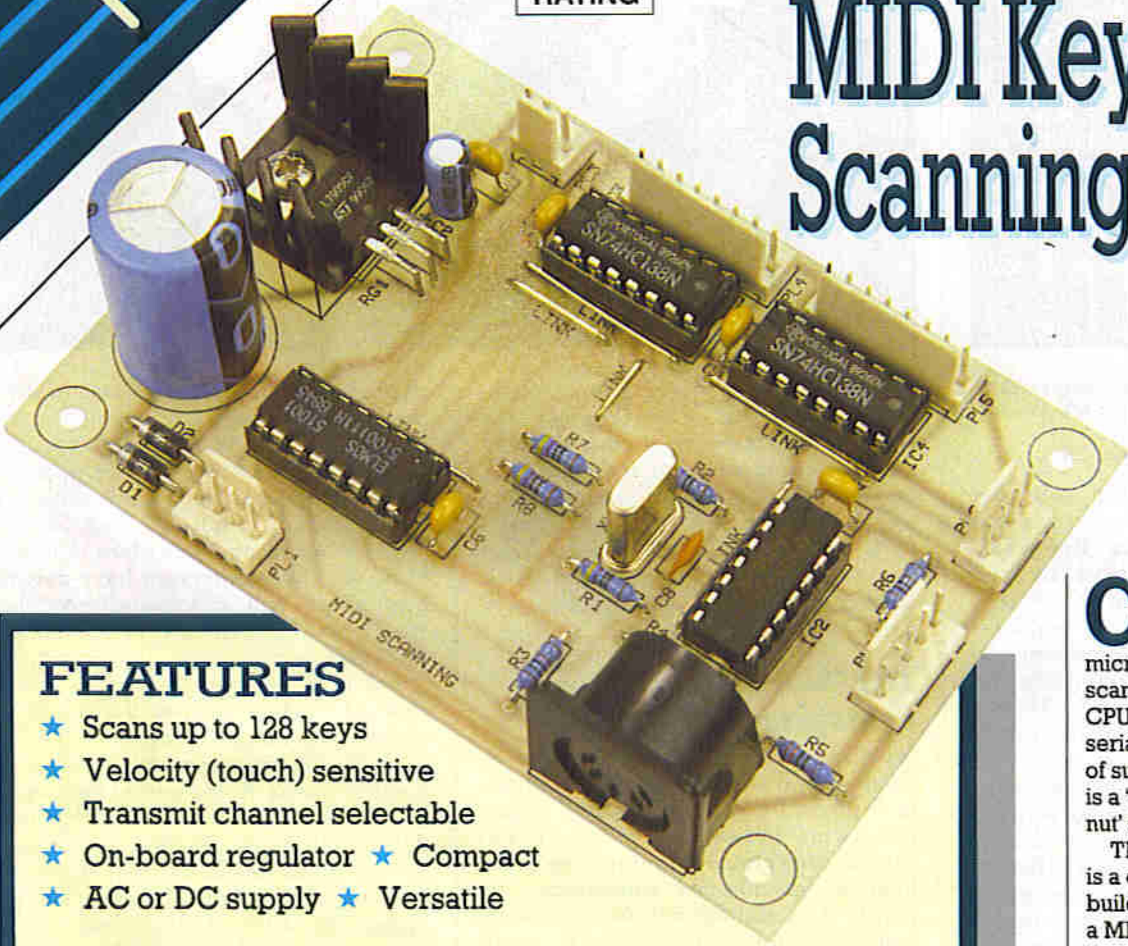
All photographs: National Center for Atmospheric Research (NCAR).

DATA FILE

'Data Files' are intended as 'building blocks' for constructors to experiment with and the components suggested, provide a good starting point for further development.

2 PROJECT RATING

E510 MIDI Keyboard Scanning Module



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APPLICATIONS

★ MIDI keyboard ★ MIDI pedal-board ★ Basis of a MIDI master keyboard ★ MIDI retrofit for non-MIDI keyboards

by Joe Fuller

The Musical Instrument Digital Interface (MIDI) has been adopted as a worldwide serial interface standard by manufacturers of electronic musical instruments and ancillary equipment; providing unparalleled possibilities for control and communication. MIDI allows a diverse range of devices to be interconnected; almost regardless of manufacturer or type. MIDI devices include; synthesizers, MIDI guitars, MIDI 'wind' instruments, drum machines, effects processors, mixers, computers and lighting equipment. Commonly, MIDI is used by keyboard players to interconnect synthesizers, allowing a range of 'instruments' to be played and controlled from one master keyboard.

Conventionally, the generation of serial MIDI data requires a microprocessor-based scanning system, comprising CPU, ROM, RAM, and both serial and parallel I/O. The use of such a system is costly and is a 'sledgehammer to crack a nut' solution.

The module presented here is a compact and versatile building block, around which a MIDI keyboard, pedal-board or master keyboard can be constructed. The module utilises a dedicated IC to perform scanning. For maximum versatility, an on-board supply regulator is provided, along with various inputs and outputs routed to strategically grouped connectors. The module only requires the addition of an AC or DC supply, some address decoding and a keyboard with changeover contacts to operate. Figure 1 shows the module in block diagram form.

It must be realised that the module does not produce any sound of its own, just MIDI data. A MIDI sound module or synthesizer is required to interpret the MIDI codes and generate the required sounds.

E510 MIDI Scanning IC

Figure 2 shows the pinout of the E510 IC and, in block diagram form, the internal workings of the IC.

The E510 can scan up to 128 changeover keyboard contacts (over ten octaves). Each time a key is pressed or released, the velocity of the key travel is measured by measuring the time taken for the moving keyboard contact to travel between the stationary normally closed and normally open contacts. Key travel is only recognised if a complete transition between both contacts is made, thus alleviating contact bounce problems.

On power-up, the E510 initiates a reset comprising 1,024 clock cycles, during reset all keys are scanned but the serial output is inhibited.

Timing is performed by a reverse counting seven bit counter; to prevent underflow and hence erroneous velocity information, the counter is inhibited when it reaches a value of 1 (minimum velocity).

An internal first-in first-out (FIFO) register allows fully polyphonic operation, i.e. several notes can be played simultaneously.

The serial output produces serial data according to the MIDI specification. The data rate is 31,250 baud. Data bytes are transmitted in a three byte sequence as follows:

Note On: 1. Channel Number/ Note On; 2. Note Number and 3. Velocity.

Note Off: 1. Channel Number/ Note Off; 2. Note Number and 3. Velocity.

Address Bus

The address bus consists of seven lies A0 to A6, and using these outputs in conjunction with external address decoding, the IC scans each of the contacts on the keyboard. Up to 128 contacts can be scanned by the IC. The MIDI code generated directly corresponds to the note address, i.e. MIDI note 00 hex is address 0, and MIDI note 7F hex is address 127.

Normally Closed and Normally Open Inputs

Both the Normally Closed (NC) and Normally Open (NO) inputs are pulled high by

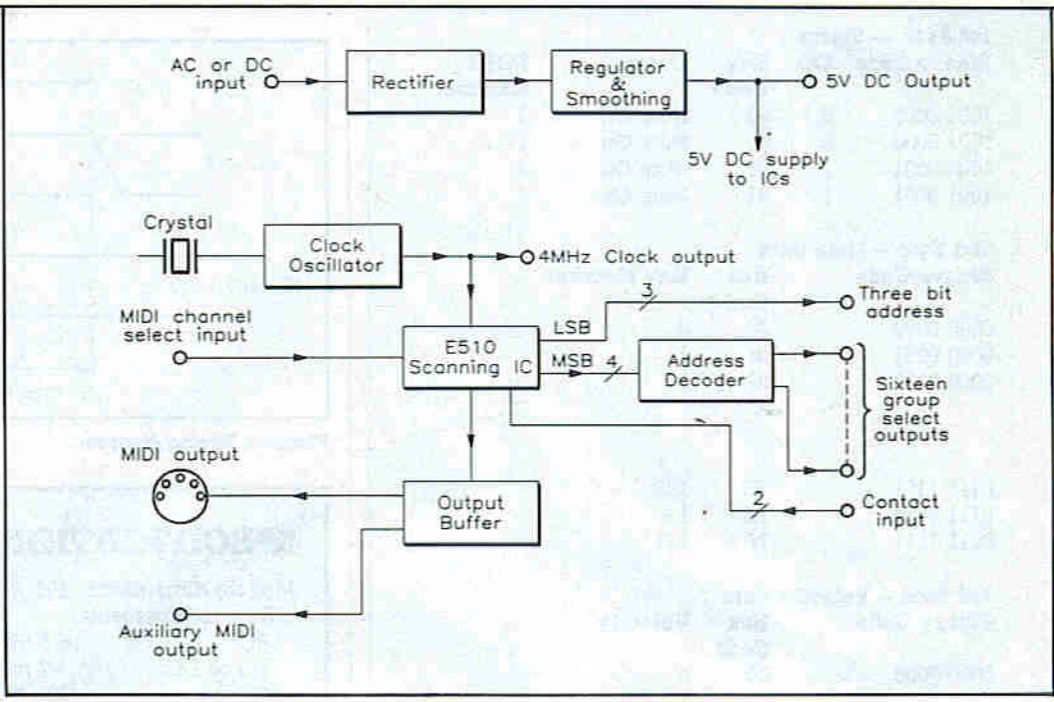
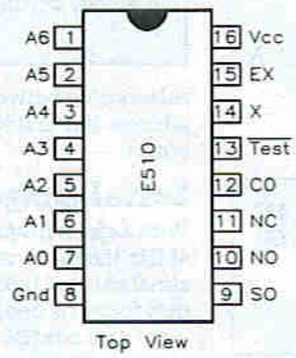


Figure 1. Block diagram of E510 Keyboard Scanning Module.



Pin No.	Function	
1	A0	key addresses
2	A1	
3	A2	
4	A3	
5	A4	
6	A5	
7	A6	
8	Gnd	
9	SO : serial output	
10	NO : NO input	
11	NC : NC input	
12	CO : MIDI channel no	
13	Test	
14	EX : external clock	Quartz crystal
15	X :	
16	Vcc : 5V ± 5%	

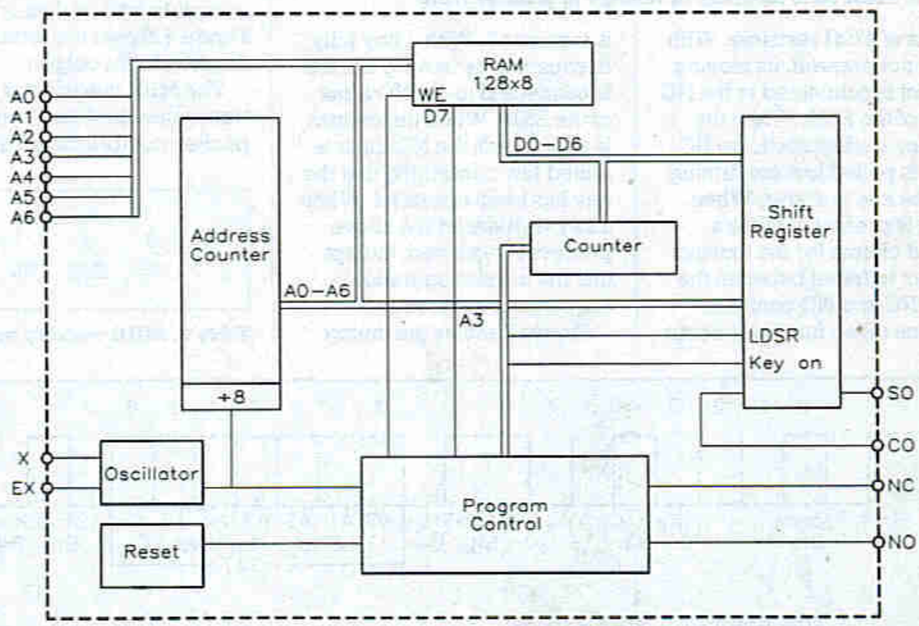


Figure 2. Block diagram and pinout of E510 IC.

1st Byte — Status Binary Code	CO	Hex Code	Event	MIDI Channel
1000 0000	0	80	Note Off	1
1001 0000	0	90	Note On	1
1000 0001	1	81	Note Off	2
1001 0001	1	91	Note On	2

2nd Byte – Note data Binary Code	Hex Code	Key Number
0000 0000	00	0
0000 0001	01	1
0000 0010	02	2
.	.	.
.	.	.
.	.	.
0111 1101	7D	125
0111 1110	7E	126
0111 1111	7F	127

3rd Byte – Velocity data Binary Code	Hex Code	Velocity
0000 0000	00	0
0000 0001	01	1
0000 0010	02	2
.	.	.
.	.	.
.	.	.
0111 1101	7D	125
0111 1110	7E	126
0111 1111	7F	127

Table 1. MIDI status and data bytes.

0	12	24	36	48	60	72	84	96	108	120	127
c	c	C0	C1	C2	C3	C4	C5	C6	C7	C8	G9

7 octave span of piano keyboard (C0 to C7)

Note: MIDI note 60 is Middle C

Table 2. MIDI Note numbers in relation to musical scale

means of 470Ω resistors. With a key not pressed, its moving contact is connected to the NC input of the E510. When the contact is addressed, the NC input is pulled low confirming that the key is at rest. When a key is pressed it takes a period of time for the moving contact to travel between the fixed NC and NO contacts, the time taken for this to occur is measured. With a key fully depressed, its moving contact is connected to the NO input of the E510. When the contact is addressed, the NO input is pulled low confirming that the key has been operated. When a key is released the above process is repeated, except that the contact operation sequence is reversed.

Figure 3 shows the timing relationship between the address bus and NC/NO inputs.

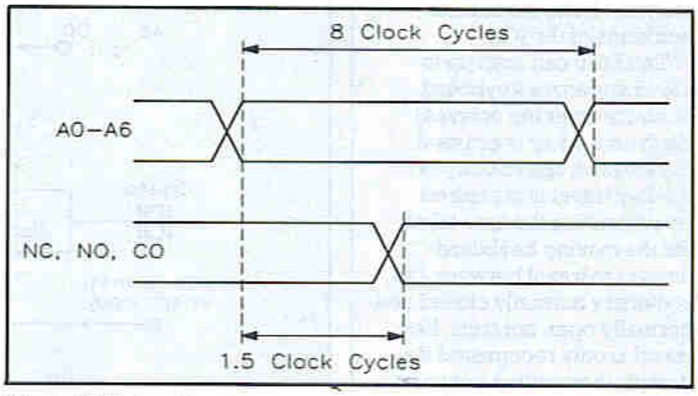


Figure 3. Timing diagram.

SPECIFICATION

Module dimensions:	101 × 35 × 69mm (WHD)
Power requirements	
AC:	6-0-6V to 15-0-15V
AC or DC:	+7 to +25V DC
Current:	20mA quiescent
Logic connections:	TTL/HC compatible
Serial data output:	MIDI standard 5mA current loop
Auxiliary output:	MIDI format TTL compatible
Scanning range:	128 notes
Velocity resolution:	128 steps/256μs

Serial Output

With a clock frequency of 4MHz, the baud rate of the serial data is 31250 baud. The data format is one start bit, eight data bits (D0 to D7) and one stop bit. The period of one complete byte of data is 320μs. Figure 4 shows the format of the serial data output.

The MIDI note data is transmitted as three-byte packet, comprising a status byte and two data bytes. The status byte specifies the note event (note on or note off) and the MIDI channel number (channel 0 or channel 1). The first data byte specifies the note number and the second data byte the velocity.

Examples of MIDI status and data bytes are given in Table 1. Table 2 shows the relationship between MIDI note numbers and the musical scale. Table 3 shows the relationship between MIDI velocity data and the musical loudness scale.

0	1				64				127
off	*ppp*	*pp*	*p*	*mp*	*mf*	*f*	*ff*		*fff*

Table 3. MIDI velocity value in relation to musical loudness.

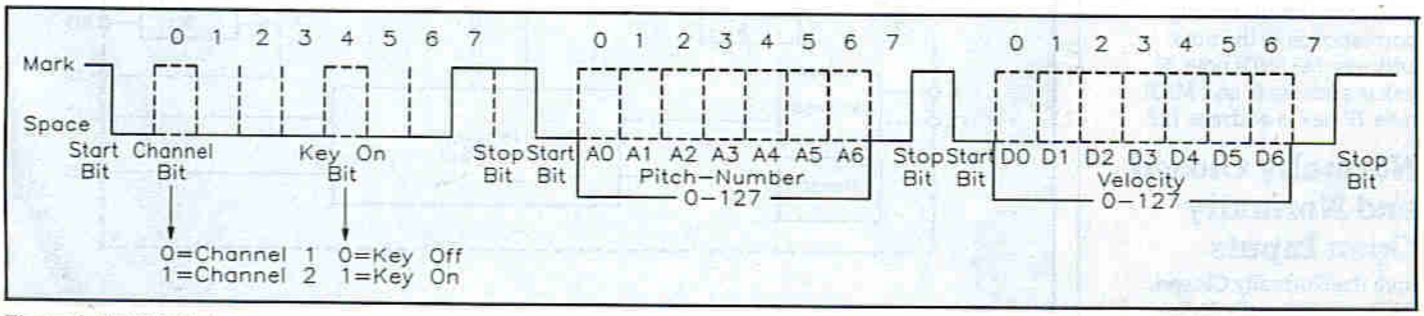


Figure 4. MIDI data stream.

Channel Select

The E510 can transmit data on either MIDI channel 1 or 2, this is determined by the logic level of the CO pin. With CO pulled low, data is output on channel 1; with CO pulled high, data is output on channel 2. Since the CO pin is checked every contact scanning cycle, it is possible to dynamically change the MIDI channel at any point during the scan of the keyboard, thus providing a split point.

Clock Inputs

The EX and X inputs are used to connect the on-chip clock oscillator to an external parallel-resonant crystal. The EX input can also be used as a TTL-level input for an external clock. If an external clock is used the X input should be left unconnected.

Test Input

The test input is used for factory testing and in normal use should be pulled high.

Circuit Description

The circuit diagram of the module is shown in Figure 5, and Figure 6 shows the PCB legend and track. D1 and D2 provide rectification when the module is powered by an AC supply from a centre- tapped transformer and polarity protection when the module is powered from an unregulated DC supply. C1 a large value electrolytic capacitor provides smoothing, prior to regulation by RG1. C2 & C3 ensure that the regulator's output is free from high frequency noise. C4 to C7 are located adjacent to each IC and prevent spurious operation caused by supply borne digital noise. IC1, forms the heart of the module; scanning the keyboard and generating MIDI data. IC1's clock is provided by IC2a, b & c. IC2a & b, together with X1, C8, R1 & R2 form a standard crystal oscillator circuit with

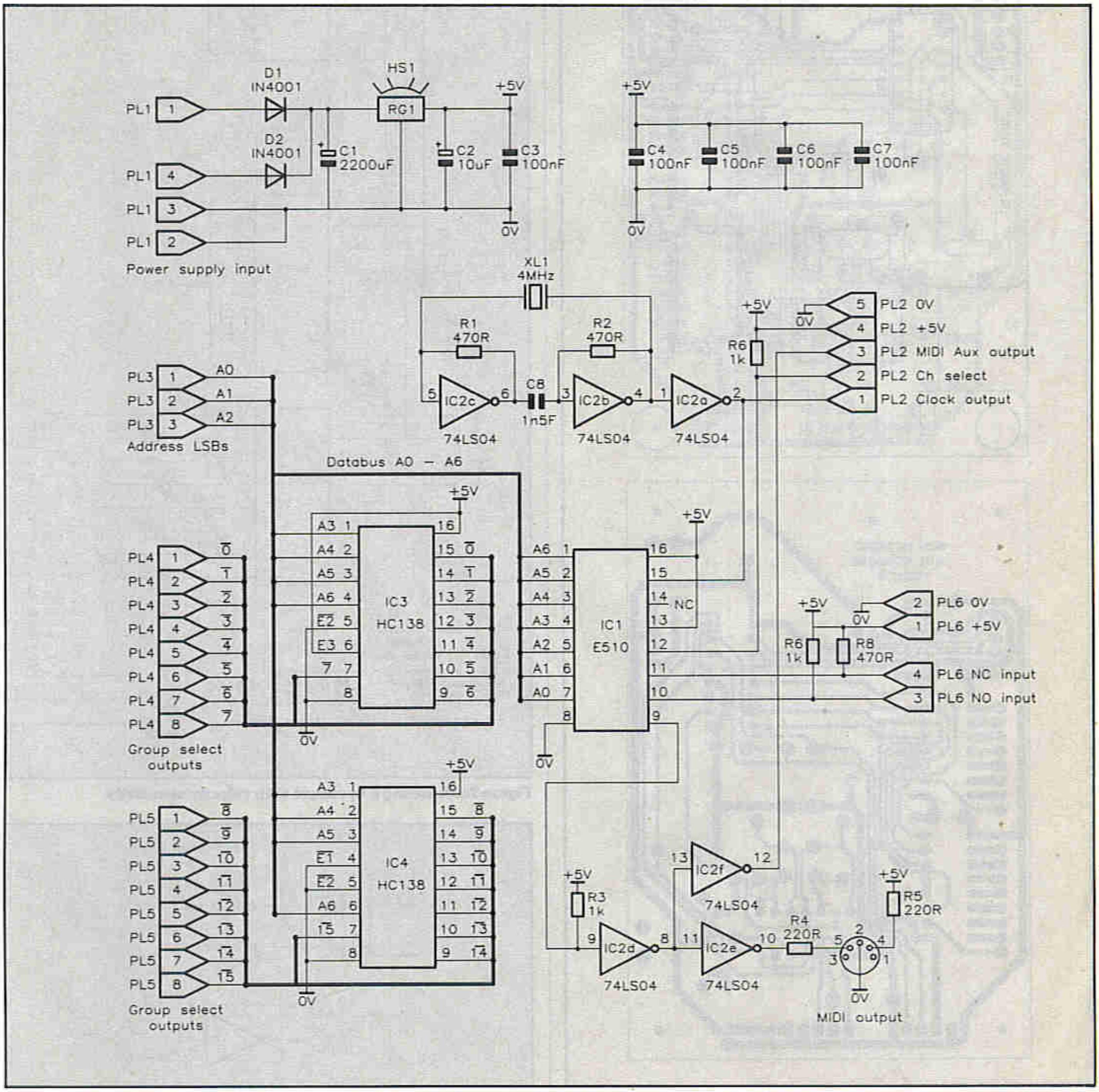


Figure 5. Circuit diagram of E510 Keyboard Scanning Module.

an output frequency of 4MHz. IC2c serves to buffer the clock output. The serial data output pin of IC1 is open collector and requires an external pullup resistor R3. The serial data is buffered by IC2e, f & g. IC2f, R4 & R5 supply the MIDI output socket SK1 and are configured in the usual 5mA current loop configuration. IC2g provides a buffered TTL level auxiliary MIDI output for connection to other circuitry. R6, 7 & 8 are the pullup resistors for the channel select

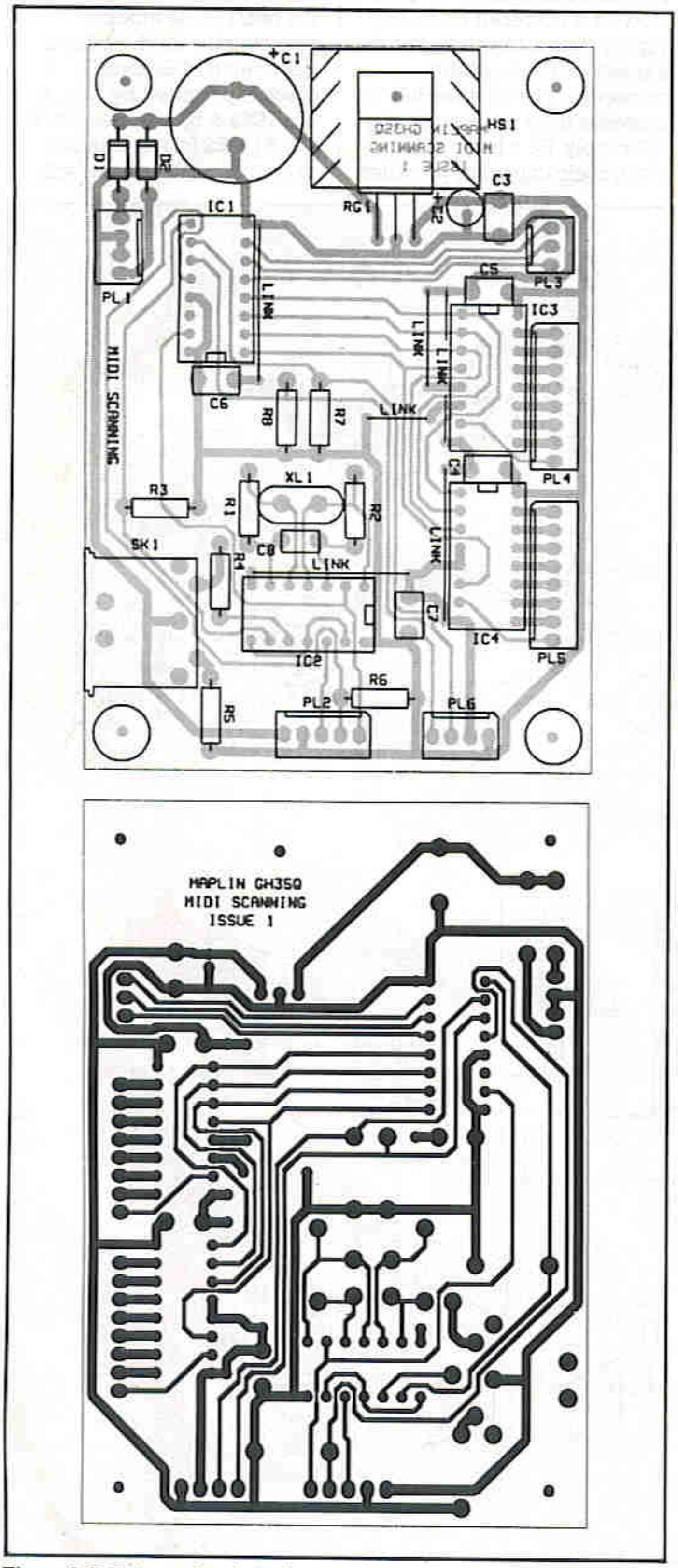


Figure 6. PCB legend and track.

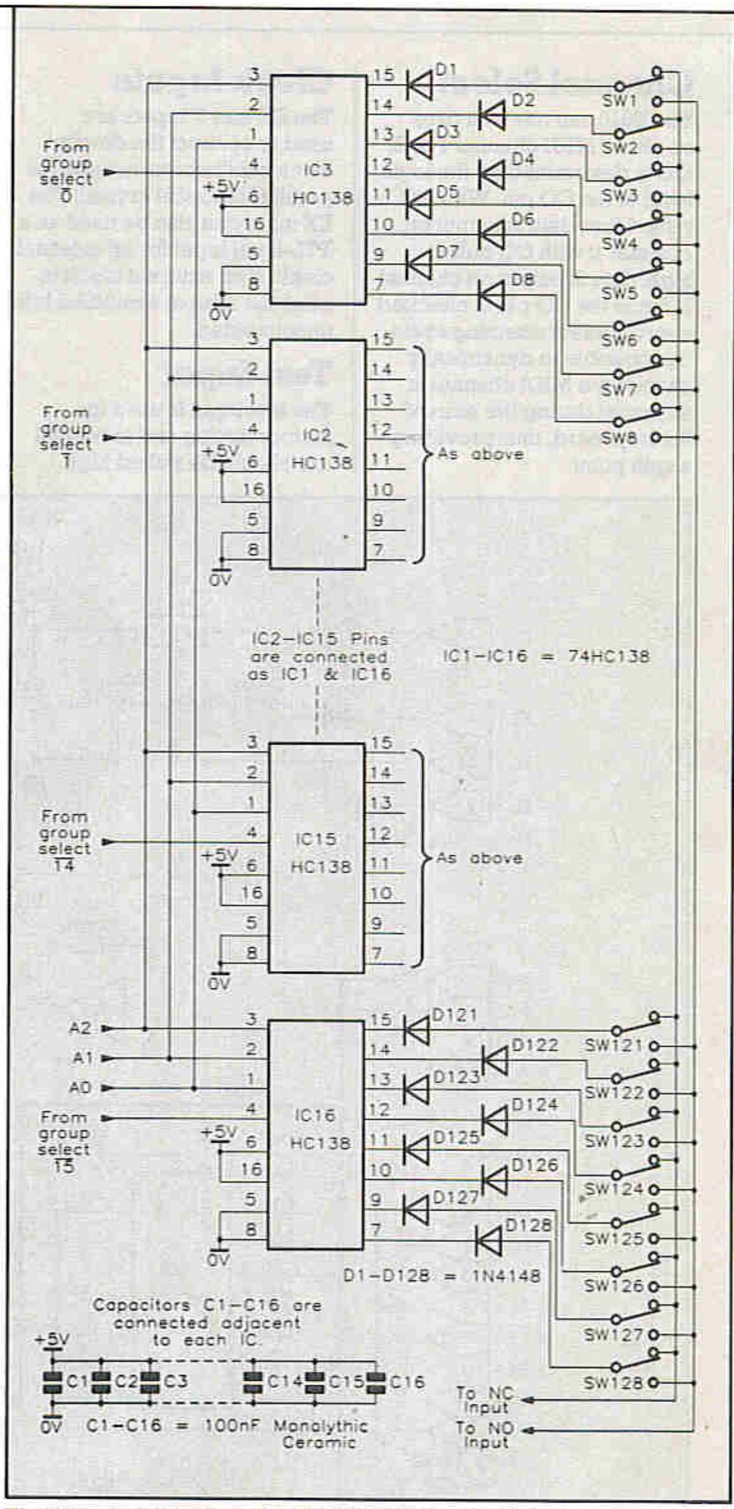


Figure 7a. Scanning a keyboard with velocity sensitivity.

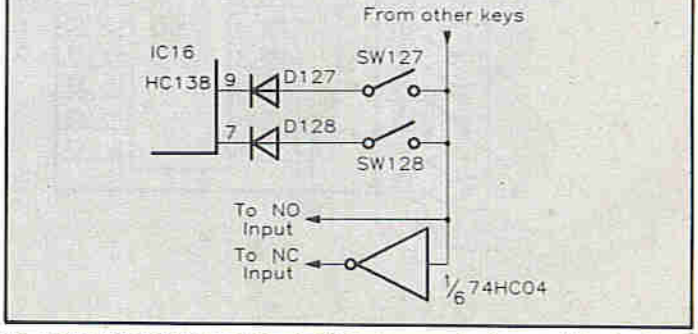


Figure 7b. Modifications required for a non-velocity sensitive keyboard.

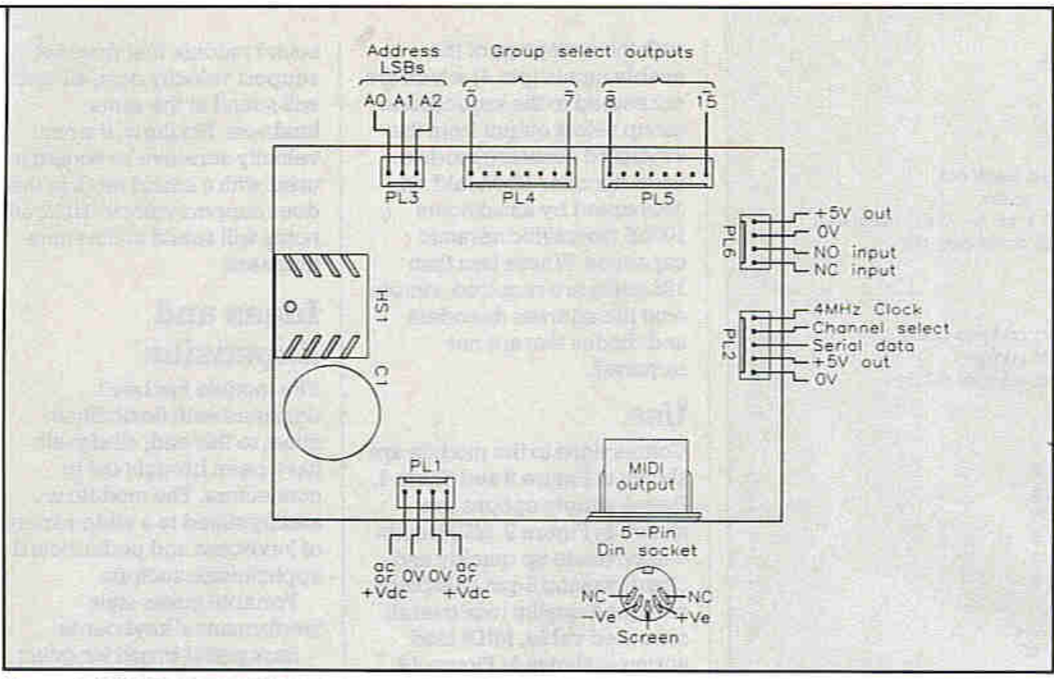


Figure 8. Module connections.

(CO), normally closed (NC) and normally open (NO) inputs respectively. IC3 & 4 form group select decoding (eight keys to a group), each group is decoded from the four most significant address bits from IC1. The sixteen outputs are used, in conjunction with the three least significant address bits from IC1, to drive external address decoders.

External Address Decoding

Figure 7a shows the additional circuitry required to scan a keyboard with changeover contacts (up to 128 notes), this configuration will resolve velocity data. Figure 7b shows the modification required to scan a keyboard with single normally open contacts. Note that in this case it is

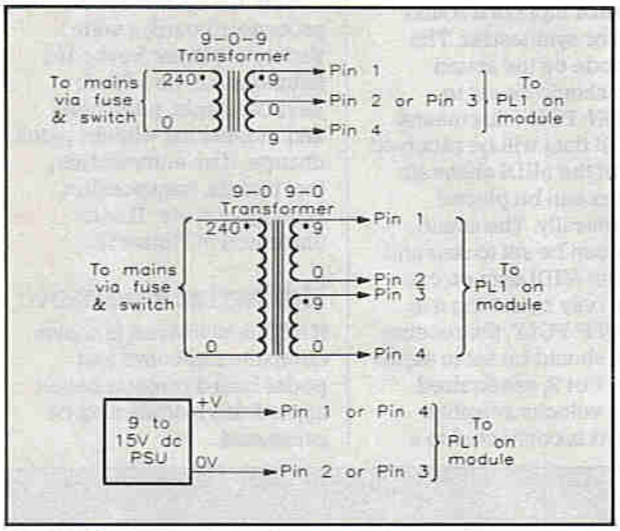


Figure 9. Power supply options.

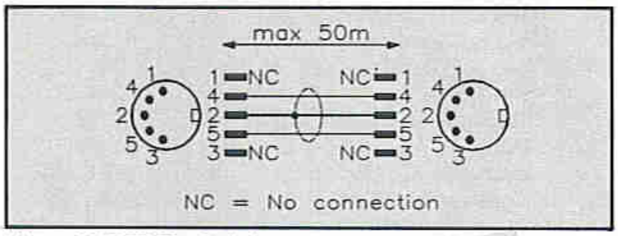
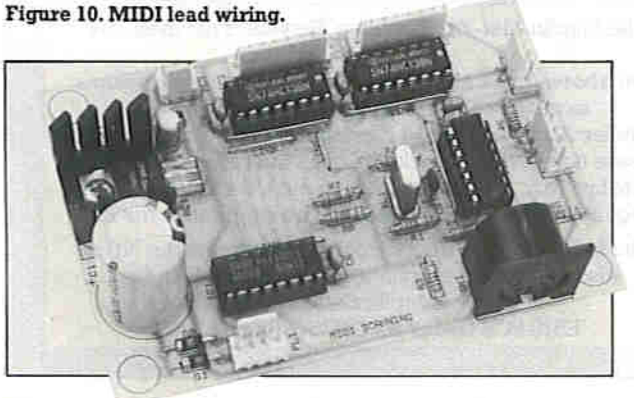


Figure 10. MIDI lead wiring.



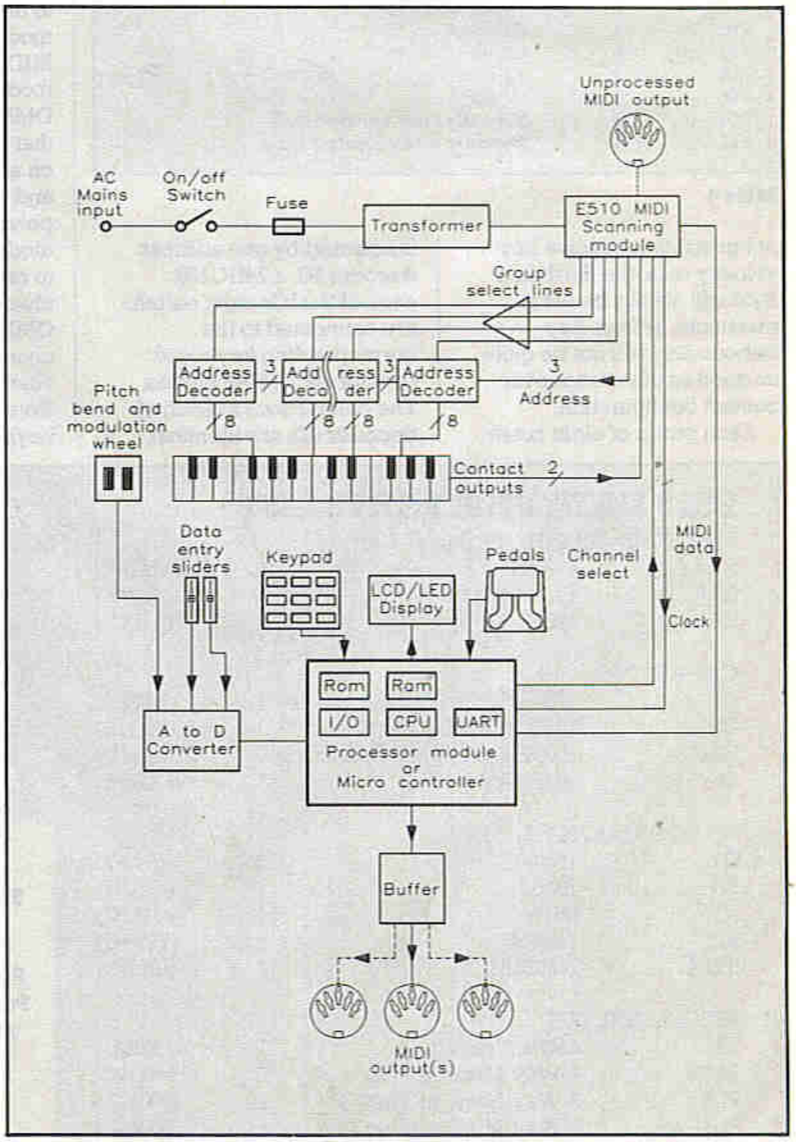


Figure 11. Block diagram of a MIDI master keyboard based on the E510 Keyboard Scanning Module.

Connector	Pin No.	Description
PL1	1	AC/+V DC in
PL1	2	0V
PL1	3	0V
PL1	4	AC/+V DC in
PL2	1	4MHz buffered clock out
PL2	2	MIDI channel select (0V=channel 1, nc or +5V=channel 2)
PL2	3	Buffered MIDI serial data out
PL2	4	+5V out
PL2	5	0V out
PL3	1	A0 note select address (LSB)
PL3	2	A1 note select address
PL3	3	A2 note select address (MSB)
PL4	1	Group select 1
PL4	2	Group select 2
PL4	3	Group select 3
PL4	4	Group select 4
PL4	5	Group select 5
PL4	6	Group select 6
PL4	7	Group select 7
PL4	8	Group select 8
PL5	1	Group select 9
PL5	2	Group select 10
PL5	3	Group select 11
PL5	4	Group select 12
PL5	5	Group select 13
PL5	6	Group select 14
PL5	7	Group select 15
PL5	8	Group select 16
PL6	1	+5V out
PL6	2	0V out
PL6	3	Normally open contact input
PL6	4	Normally closed contact input

Table 4.

not possible to resolve key velocity data; the third data byte will always be set at maximum, 7F hex. Key debouncing will not be quite as good as the changeover contact configuration.

Each group of eight notes is scanned by one address decoder IC, a 74HC138, each of the ICs eight outputs are connected to the corresponding keyboard contact via 1N4148 diodes. The connections to each of decoder ICs are identical, with the exception of the enable inputs (pin 4) which are connected to the appropriate group select output from the keyboard scanning module. Each decoder IC should be decoupled by an adjacent 100nF monolithic ceramic capacitor. Where less than 128 notes are required, simply omit the address decoders and diodes that are not required.

Use

Connections to the module are shown in Figure 8 and Table 4. Power supply options are shown in Figure 9. MIDI leads can be made up quickly and cheaply using 5-pin DIN plugs and good quality twin overall screened cable, MIDI lead wiring is shown in Figure 10.

The MIDI output from the module should be connected to the MIDI input of a sound module or synthesizer. The MIDI mode on the sound module should be set to OMNI ON: POLY, this means that MIDI data will be received on any of the MIDI channels and notes can be played polyphonically. The sound module can be set to respond to receive MIDI data on one channel only by setting it to OMNI OFF: POLY, the receive channel should be set to either channel 1 or 2, as required. Note if a velocity sensitive keyboard is connected to a sound module that does not support velocity data, all notes will sound at the same loudness. Similarly, if a non-velocity sensitive keyboard is used with a sound module that does support velocity data, all notes will sound at the same loudness.

Ideas and Expansion

The module has been designed with flexibility in mind, to this end, all signals have been brought out to connectors. The module is ideally suited to a wide variety of keyboard and pedal-board applications, such as:

Portable guitar-style 'performance' keyboards.

Bass pedal-board for guitar and keyboard soloists.

Master keyboard.

With the addition of a processor board, a wide variety of master keyboard functions can be added; keyboard split, pitch bend and modulation wheels, patch change, data entry sliders, foot pedals, transposition, arpeggiator, etc. This is illustrated in Figure 11.

Editorial Footnote

If sufficient interest is shown, complete keyboard and pedal-board projects based around this module may be presented.

E510 DATA FILE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,2,7,8	470Ω	4	(M470R)
R3,6	1k	2	(M1K)
R4,5	220Ω	2	(M220R)
CAPACITORS			
C1	2200μF 35V PC Electrolytic	1	(JL28F)
C2	10μF 50V PC Electrolytic	1	(FF04E)
C3-7	100nF Monolithic Ceramic	5	(RA49D)
C8	1n5F Ceramic	1	(WX70M)
SEMICONDUCTORS			
D1,2	1N4001	2	(QL73Q)
RG1	7805	1	(QL31J)
IC1	E510	1	(KU41U)
IC2	74LS04	1	(YF04E)
IC3,4	74HC138	2	(UB33L)
MISCELLANEOUS			
X1	4MHz Crystal	1	(FY82D)
PL1,6	4-Way Minicon Plug	2	(YW11M)
PL2	5-Way Minicon Plug	1	(FY93B)
PL3	3-Way Minicon Plug	1	(BX96E)
PL4,5	8-Way Minicon Plug	2	(YW13P)
SK1	5-Pin PCB DIN Socket	1	(YX91Y)
	14-Pin DIL Socket	1	(BL18U)
	16-Pin DIL Socket	3	(BL19V)
	Vaned Heatsink	1	(FL58N)
	Bolt M3 × 10mm	1 Pkt	(JY22Y)
	Nut M3	1 Pkt	(JD61R)
	Shakeproof Washer M3	1 Pkt	(BF44X)
	PCB	1	(GH35Q)
	Instruction Leaflet	1	(XU25C)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are available as a kit, which offers a saving over buying the parts separately.

Order As LT35Q (E510 Keyb Scanner) Price £34.95.

Please note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately, but is not shown in the 1993 Maplin Catalogue.

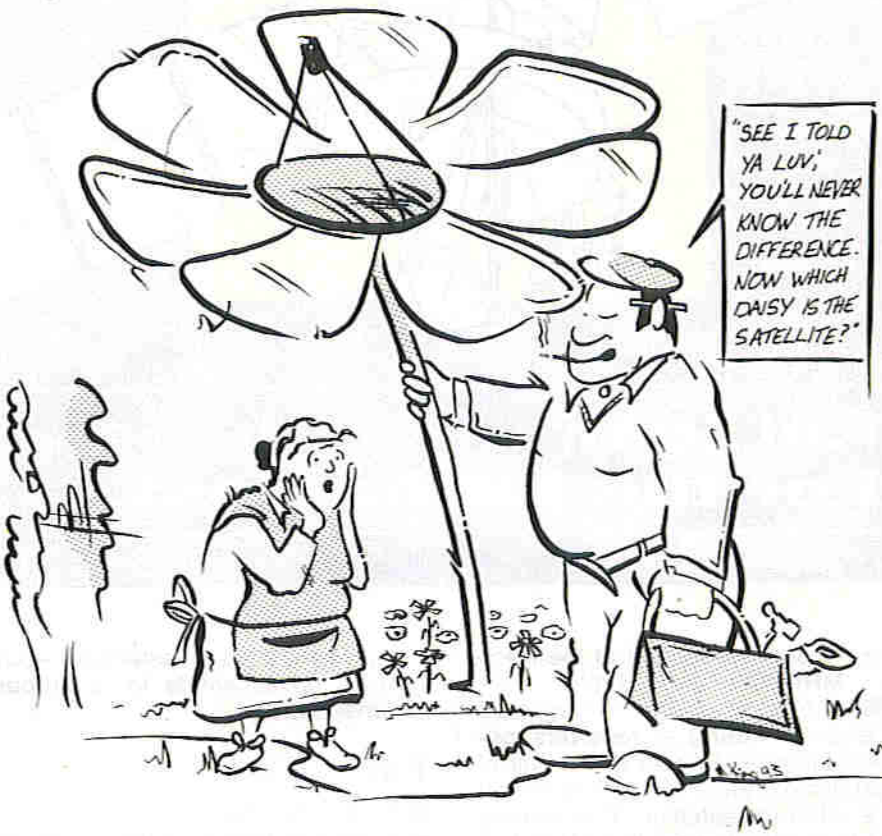
E510 PCB **Order As GH35Q Price £3.45.**

Stray Signals

by Point Contact

Memory chips represent an area of device development that is in a constant state of turmoil. With 4M-bit devices becoming commonplace and 16M-bit devices close behind, the semiconductor industry is busy developing 64M-bit and 256M-bit chips, with a speculative eye even further ahead on gigabit devices. There has to be a limit somewhere, and this is set by a memory chip so densely-populated, and hence with such fine dimensions, that the charge held at each storage location is either zero, or just one single electron. Researchers at Cambridge are looking at just such devices, offering (in principle) 1,000G-bit capacities, though this is still far-off into the future at the moment. Furthermore, their current efforts operate at low temperature – around 0·1K, or pretty close to absolute zero – but again the prediction is, eventually, for devices operating at room temperature. Meanwhile, on a completely different tack, researchers from the Center for Molecular Electronics at the US-based Syracuse University are working on a memory system which uses a bacterium as the basic memory cell (no, this is not the April issue!). A particular strain of light-sensitive bacteria creates a specific protein in their cells when exposed to light, the absorption of the light energy causing a near-instantaneous movement of negative charge along the protein chain. The whole cell responds in about a picosecond, and can be flipped 'on' or 'off', so providing the basic binary storage function. Again, capacities of many gigabytes are being bandied about as feasible, particularly for use in the associative memories which, it is claimed, will form an essential part of AI (Articial Intelligence) systems.

You may recall my mentioning 'impulse radio' in a recent Stray Signals. Well, a few more details have surfaced in one of the American controlled-circulation magazines, although the information is still somewhat sketchy. The impulses are typically around 1ns wide and are pulse position modulated, though the pulse repetition frequency was not stated. With peak shifts in the order of microseconds, video data rates can be supported. The signal is spread over a bandwidth of around 1GHz, this being achieved directly by the narrow pulse width, rather than by a separate 'chipping' signal as in conventional direct sequence spread spectrum. When a much larger peak position deviation is used in conjunction with pseudo-random noise code modulation, thousands of separate channels become available, each causing no interference to the others within a typical service area of 5 miles radius. In this type of application, though, the receiver complexity is substantially increased. The company developing the scheme has applied to the FCC for permission to use it for PCS – Personal Communications Services. Watch this space.



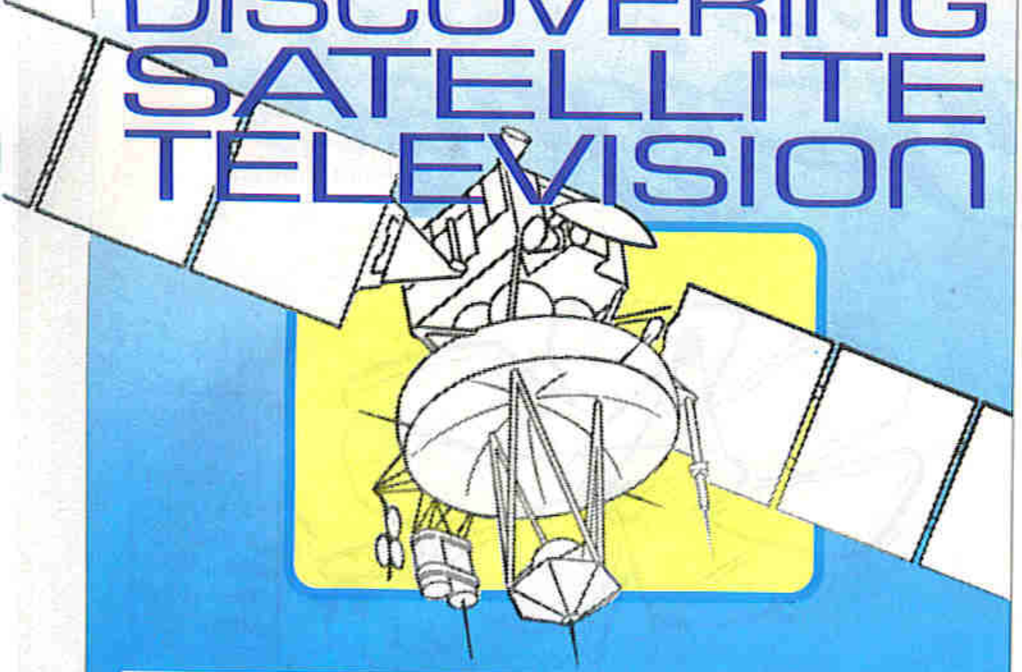
The design of the dish of a radar transmitter/receiver usually presents a difficult problem – there is an awkward trade-off to be made. If the whole of the dish is illuminated equally by the transmit antenna (usually a horn), then there will be off-axis sidelobes of quite large amplitude relative to the main beam, not to mention wastage of power spilt over the edge of the dish, towards the rear. These problems can be reduced by tapering off the intensity of the illumination towards the edge of the dish, but then the main beam is mostly formed by a much smaller area of dish, the accuracy of which is thus more critical. One could of course have ones cake and eat it, performance-wise, simply by making the dish larger – but that is very costly. The sidelobes are detrimental also on receive, resulting in unwanted returns from targets which should be invisible to the radar. The shape of the sidelobes is dependent upon just how exactly the power tapers off towards the rim of the dish – or looking at it another way, for a given illumination pattern, on the particular diameter of the dish. In one of those acts of lateral thinking which are so obvious when someone points it out ("now, why didn't I think of that?"), the Electrical Engineering Department at the Georgia Institute of Technology has come up with a solution. Why not incorporate many different diameters into the dish so that, instead of a few large sidelobes with deep nulls in between them, there is a continuum of low-level sidelobes? Lots of different diameters can be arranged by serrating the edge of the dish, like the petals of a giant daisy. Just paint the centre yellow, the rest of the dish white, add perfume to taste and you have a *really* environmentally-friendly radar installation!

Talking of electronics and smells reminds me of a remarkable demonstration of a 5W 130MHz RF power amplifier. Nothing too remarkable about that, one might think – except that the year was 1957, and the transistor a small-signal germanium type; the only power transistors in those days were strictly limited to working at audio frequencies. At that power level, it should have melted, but – oh no, I've run out of space again; I'll try and remember to tell you next time!

Yours sincerely,

Point Contact

DISCOVERING SATELLITE TELEVISION



Part Seven by Martin Pipe
For the Enthusiast...

Last month we looked at the Pace MRD-920 and Mimtec Premiere 2 IRDs (integrated receiver-decoders) – receivers primarily intended for use with a pair of fixed dishes, each of which is aimed at a different satellite. This month, and next month we will look at two receivers which are primarily intended for the multi-satellite or 'enthusiast' market. The enthusiasts, equipped with their motorised dishes (generally 90cm or greater in diameter) scan the sky from horizon to horizon (at least until buildings start getting in the way!), searching out obscure satellites and hoping to catch a snippet of an obscure newsfeed. It may sound ridiculous, but try it – and you're hooked! In addition, you may come across a live sporting or concert feed for one of the pay-TV channels – apart from the financial savings, you end up with far superior picture (i.e. non-Videocrypt) and sound quality. And you don't get the cock-ups – those who watched (or more to the point, *listened to*) a certain Genesis concert last year will know what I mean!

Aside from eavesdropping on the 'behind the scenes' activities of professional broadcasters, there is the finished product to look at as well – television and radio channels from all over Europe. France, Germany, Italy, Poland, Greece, Turkey, even what used to be Yugoslavia . . . you name it, it's there. Just what the language student ordered!

You can experiment with multi-satellite reception with your existing Astra dish – something that will be discussed in a future instalment – but there is no substitute for a proper motorised dish.

TechniSat ST-6002S

The receiver looked at this month is the TechniSat ST-6002S, from highly-respected German manufacturer TechniSat, manages to cram it all in. Microprocessors galore (even an RS232 interface – more of which later) on-screen menus, an eight-event 'video' timer, a 2GHz tuner, a dish positioner with a 50-satellite memory and 'autofocus'. Partnered with the appropriate LNB, dish and decoder there's little that this receiver cannot do.

This dedicated multi-satellite receiver also incorporates the dish positioner. Designed for the satellite enthusiast who wants everything, but in a single smart box, the ST-6002S is also billed as being flexible and easy to use. It offers many features that put it at the top of its class – and at a low price when compared to the combined cost of a separate receiver and positioner. A couple of years back, Maplin sold the predecessor to this receiver (the ST-6000S), which was (and still is) a very highly regarded receiver. It will be interesting to see how the two units differ.

The features packed into the ST-6002S include a 2GHz tuner (for full Ku-band coverage with a triple-band LNB), Wegener-compatible stereo sound (using the appropriate circuitry to expand the dynamic range as required) with independently tunable subcarriers, an 'auto focus' system for the dish positioner (read on!), a flexible decoder loop and a RS232 interface for external control. Other features will be described as the review progresses.

The unit is the same size (and weight!) as a large VCR, and is ruggedly built. There are five push-buttons on the front-panel; these allow the user to have basic control over the receiver – power (the secondary side of the mains transformer is switched), channel (but only those of the current satellite) and volume. Pressing two of the keys simultaneously causes the unit to enter into its 'set up' mode – more of which later. Also on the front panel is a four-digit LED channel display, and a 'standby' LED that is always on when power is applied to the unit – regardless of whether the unit is in standby mode or not.

The manual supplied with the receiver (one of the first in the UK) was an appallingly bad series of photocopied sheets, which contained factual errors in addition to being poorly presented. A proper manual will be forthcoming though, and this will (hopefully) be of the same standard of presentation (and accuracy?) as the German one supplied with the receiver (I can't read German, though, and TechniSat

The TechniSat ST-6002S receiver – a formidable piece of kit.

(UK) should not presuppose this of their customers!).

Like the Pace MRD920 and the Trac/Ferguson BSB receiver, all the operational parameters are controlled via a series of on-screen menus. These are accessed via a compact, basic and easy-to-use remote control unit; pressing 'menu' gives you a choice of options, which can then be selected using the arrow keys.

The Ins and Outs

The rear panel is well-equipped with connectors. There are two SCART sockets – one provides video and audio outputs only, and presents a switching voltage on Pin 8 whenever the receiver is switched on. This socket is thus designated as the 'TV' port; switching on the receiver forces a TV set, connected to the receiver via a SCART-to-SCART lead, to go into its 'monitor' mode (which, thankfully, on most such sets only happens when the TV set is set to the channel designated as the 'VCR channel'. The other SCART socket is designed primarily for use with a decoder; it has a video output which can, normal processed video aside, be set via one of the on-screen menus to provide one of four types of baseband (various combinations of clamping, filtering and de-emphasis), for flexibility. The socket also allows video input – i.e. return from the decoder. Unfortunately, TechniSat assume that your decoder, rather than the receiver, provides audio, and so in 'decoder mode' the receiver expects audio channels as well. This is fine for MAC transcoders, but not so good for most other types. Thankfully, though, the outputs from the receiver's audio circuitry are present on this socket. Therefore, to avoid an eerie silence from your Videocrypt decoder (isn't it good that the Videocrypt designers left the audio alone!), the audio input pins should be linked to the output pins. TechniSat are not the only manufacturers to use this audio loop-through system (this was also a feature of the Pace receiver reviewed last month), but it would be nice to bypass this facility (via an on-screen graphic) if it wasn't required! If no decoder is required, then this socket can be used to supply the normal video output to a VCR.

The video, decoder and audio outputs are also available via a quartet of phono sockets on the rear panel. The spare decoder socket can be used to source another decoder; although the receiver only has the capacity to accept the return video from one decoder, an external switch box can be used.

As the TechniSat is a receiver/positioner, there are an array of push-to-release terminals for connection to the actuator on the dish. Two of these are for the motor, another two accept the feedback signal, and the remaining connector sources 5V, which is required if the feedback sensor is one of the more reliable opto-coupler types.

The ST-6002S rear panel. Alas, it loses the 70MHz loop and mechanical polariser connections of its predecessor, the ST-6000S.

Only 1 LNB input is incorporated, which is rather inflexible if more than one dish is to be used. The same criticism was levelled at the ST-6000S, though. One way in which this receiver does score over its predecessor, though, is that a 2GHz (2050MHz to be precise) tuner is fitted, and so the unit will give full coverage when used with a triple-band LNB. As we found out last month with the Pace MRD920, a standard receiver, which only goes as far as 1750MHz, will cause a 'hole' in coverage to be experienced. 2GHz tuners are thankfully becoming more common in modern receivers, but out of the four tested the inexpensive Mimtec Premiere (not touted as a multi-satellite receiver as such) was the only one to incorporate this feature. The LNB voltage can be switched between 13V and 18V, which can be used for band switching. Alternatively, the voltage change could be used to select between LNBs if a suitable switch-box is used.

Another pair of spring-loaded terminals are provided to connect to connect the polariser. Note that only magnetic polarisers are catered for; this is a shame, as the lower-loss mechanical types cannot be used. The ST6000S did have this facility, and it will be sorely missed amongst the enthusiast fraternity. Where the ST-6002S *does* show its heritage is that only two skew (polarisation control) settings can be programmed for each *satellite* – the skew cannot be programmed on a *'per channel'* basis a la Pace MRD920. So what is the problem, I hear you ask? After all, each satellite will only require two polarisation settings – vertical and horizontal (or left-hand circular and right-hand circular). Now if a mechanical polariser was used – as you could with the ST-6000S – then this would not matter too much. But the ST-6002S can only be used with a current-driven magnetic polariser – which effectively 'twists' the incoming wave from the satellite transponder so that it lines up with the resonant probe in the LNB. Unfortunately for the ST-6002S, though, the amount of current required to twist an incoming signal, of given polarity, by the same amount will depend on its frequency. As a result, the two skew settings for each satellite position will inevitably have to be a compromise, set to a frequency central to the band in use – at frequencies at the extreme ends of the band, some cross-polarisation (adjacent opposite-polarity pictures breaking through) or a slightly weaker signal may be noticed. During normal use, this was (thankfully) not experienced. However, the problem was particularly bad for those satellites (e.g., Eutelsat II-F1) that operate in both the FSS band (10·95 to 11·7GHz) and the Telecom band (12·5 to 12·75GHz). The only practical solution is to assign the 11GHz and 12GHz channels of the relevant satellites to separate satellite positions (with 50, the ST- 6002S has plenty!). Nevertheless, the most elegant solution would be for each of the 200 channels to have its own skew setting (however, this will require twice as much memory – 50 satellite positions, each with two separate skew settings, would require 100 memory locations). TechniSat, please note for upgrades and successive models!

Apart from the RF input and output connections (note that the modulator can only be tuned between channel 35 and 44, which is rather limiting and should be borne in mind if you are planning to distribute satellite programmes round the house using RF), there is one more socket, which makes the TechniSat ST-6002S unique. This connection is a RS-232 socket, and it enables the receiver to be hooked up to a computer, or to another ST-6002S, for remote programming. This feature will be looked at in greater detail later.

We have lamented on the sad demise of the 70MHz loop; the ST-6002S does not buck this trend.

Setting Up

Once the ST6002S has been connected up to a suitable dish and TV set, various important parameters need to be programmed into the receiver. The receiver must first be switched into its 'set up mode'; to do this, the up and down keys on the front-panel are held down simultaneously. Once this has been done, the 'system menu' appears on the TV screen. From this, the east and west dish limits can be set, beyond which the dish cannot be used. The purpose of these limits is twofold. Firstly, it prevents the actuator from moving the dish to the point where damage could be caused (this could be strain placed on the polar mount's components, or the potential hazards of a nearby wall!). The limits are also an arbitrary reference point from which the feedback pulses, supplied by the actuator, can be counted as the dish moves; as a result the positioner part of the unit will always know where the dish is. This is particularly relevant if the position be stored, and recalled later.

A 'change system options' sub-menu allows the LNB voltage switching to be recognised correctly within the normal operating menus. Such switching can be defined as band switching or polarity depending on the LNB in use. The LNB voltage can also be fixed at 18V, if a normal single-band LNB is used. The 'change system options' menu can also be used to set the language of the on-screen graphics (English, French or German) and the LNB offset. The latter option allows you to compensate for any local oscillator errors so that the correct frequency is displayed when tuning in new channels. The LNB offset can be adjusted independently for both the 11GHz, and the 12GHz, ranges. A similar feature is provided on the Pace MRD-920.

The next sub-menu allows you to program in a new satellite. Around twenty have already been catered for, ranging from Intelsat 202 (63°E) to Panamsat (45°W). It is basically a case of choosing one of the channels on the desired satellite, and moving the dish until it comes in 'loud and clear' (of course, this assumes that the skew settings are OK, and that the LNB's local oscillator is on frequency!). However, the way in which you program a satellite, that is not already on the database, is very inflexible. You must have already programmed in a 'favourite' channel for that satellite first. Now, if you know of a channel that is already broadcasting via the new satellite, then that's fine. The clumsy method that TechniSat recommend to get round this piece of flawed operating logic involves 'choosing a channel with a frequency which is nearest to the one of the new satellite' and 'moving the dish until you receive it'. But for occasionally-used satellites with their unpredictably-chosen transponders (newsfeeds, etc.), this system is totally impractical, and downright frustrating! By far the best system would be to include a 'fast scan' function, which tunes across the IF band rapidly and cyclically. Using this method, there is a good chance of picking up a channel from the wanted satellite as the dish is moved; once the satellite has been found and stored, it is a simple matter of tuning in the wanted channels. In fact, this system was used on the ST-6000S – far better, and easier to use. Once upon a time, just about all satellite receiving equipment incorporated a 'scan' function.

But the misery for satellite hunters does not stop here. A horrible blue mute screen is provided whenever the signal strength drops below a certain level. Now, if TechniSat have seen fit to include such a useless feature, the least they could do would be to make it switchable, via one of the comprehensive on-screen menus. It is particularly galling when you are setting up the dish mount for the first time (dish installation, by the way, will be covered in a subsequent part of the series).

Ironically, the next function of the system menu is 'auto location', which is an attempt to make system set up easier if 'a TechniSat actuator is used'. It is not completely automatic though, as the position of Astra needs to be stored first. Every ST-6002S is supplied with an internal up-to-date database of channels and their satellites; the automatic location system works by moving the dish until one of the channels on the next satellite is found; it then stores the position and moves onto the next one. However, it is important to adjust the LNB offset (on one of the Astra channels) so that the channels stored in the database are accurately tuned into the actual channels themselves. Otherwise the receiver will get somewhat confused.

The final option in the system menu enables the RS232 interface; the submenu allows data to be read from or sent to another ST6002S, or the receiver to communicate with a computer.

Dish of the Day

Well that's the system set up menu, which after initial set up is only used for programming new satellites or external communication via the serial interface. In general use, there is another set of on-screen menus, which are accessed by pressing the 'menu' key on the remote control.

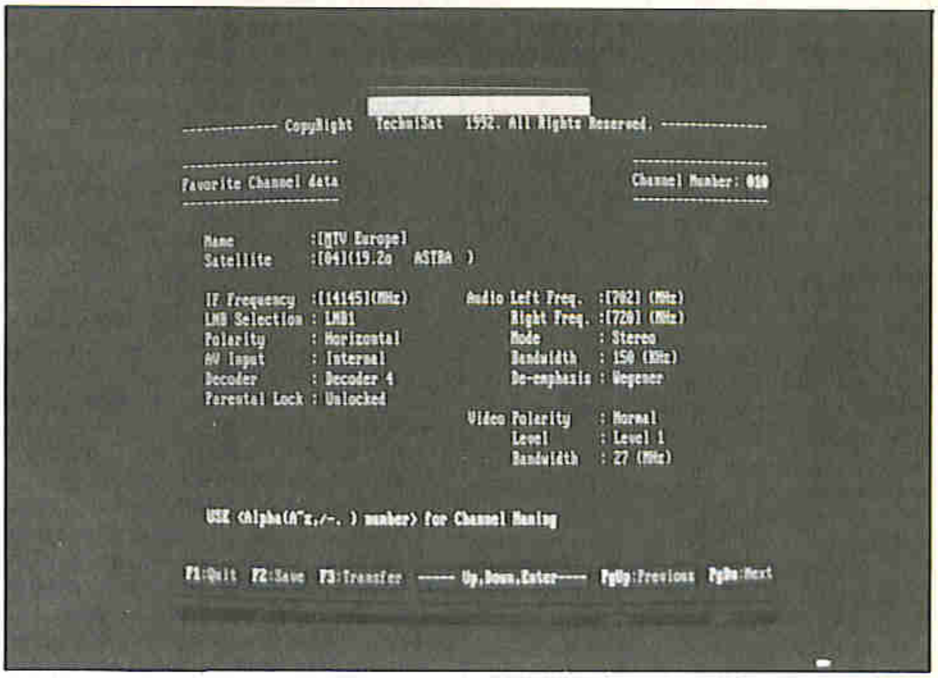
The first allows a channel to be

One of the ST-6002's barrage of on-screen menus. This one controls audio parameters (note that one of the audio subcarriers has been deliberately mistuned very slightly – see text). Screen image © UK Gold 1993.

selected. There are 200 of these 'favourite' channels, and so being able to choose it from a list, or by entering its number is clearly a great help. The other way of selecting channels is to use the 'up' and 'down' keys on the receiver's front-panel; this method can only access the channels on the currently selected satellite, however. Each channel can be assigned a name by the user; this briefly appears, together with the channel number and satellite name (unfortunately, the satellite names are preset), whenever a channel is chosen. Using the PC software (read on!), you can program satellite names, though – but you do need a spare PC, and the cash to lay out for the software.

The satellite can be accessed via the left and right keys on the unit. Alternatively, the second sub-menu allows the satellite to be chosen via the remote control. In addition, trying to access channels beyond the last one stored for that satellite position causes the receiver to ask you if you want to move to the next stored satellite. Unlike channels, the satellites cannot be named by the user, which is a pity as you are stuck with those in operation at the time the operating software was written. However, the PC software does remedy this – but you require a PC to be available, and you have to purchase the software as well. It would be nice to have satellite naming on the receiver as standard. There are 50 satellite positions available on the ST-6002S – the 30 or so that are not already programmed are referred to by the menu system as 'spare'.

The ST-6002S features eight event timers (the 'program timer events' sub-menu), which work in conjunction with a video recorder so that those 'all-important' programmes are not missed. With their large choice of channels, multi-satellite systems are an ideal candidate for such a feature; each event timer will position the dish and change channel. Single, daily and weekly recordings are catered for – and the timer allows you to plan ahead by years if you wish; somewhat impractical, I know, but the receiver allows it! Of course, for the timer to work the correct time and date (the ST-6002S has a comprehensive calendar) need to be entered via another sub-menu ('internal clock adjust'). Thankfully, the ST-6002S features a battery back-up system – the receiver was unplugged for a week, and when power was re-applied it was still there. Unfortunately, Mimtec did not, for some reason, equip their Premiere 2 model with such a feature; a power cut (no matter how short) loses all clock and timer information.



A screen shot of the TechniSat channel/satellite editor software, which runs under MS-DOS on an IBM PC/XT/AT or clone.

Dish alignment of sorts is possible using the 'alignment dish position' sub-menu, but this is really intended for situations where bad weather has influenced the dish position, a satellite has drifted off position slightly, or the dish has not moved, for some reason, to its optimal position. You can move the dish within a limited range, until the currently-set channel on the desired satellite appears once more. The revised setting can apply to all satellites ('shift all satellites'), or to just the one ('shift' current satellite). Dish autofocus is also accessible from this sub-menu; invoking this option causes the receiver to find the optimal satellite position by automatically 'peaking' the dish for maximum signal strength. However, I could not get this to work reliably – particularly where the wanted satellite is close to another, strong, satellite (e.g., Astra and Eutelsat IIF3). Whenever the dish moves from one preset satellite to another, autofocus is automatically engaged as the dish approaches its destination (logical if it worked!); I found myself using the 'manual' option to peak the dish on many occasions.

Parental Lock

With more 'adult' type channels appearing, it is just as well that most receiver designers incorporate a parental lock into their receivers. A submenu allows you to 'lock' out a channel so that it cannot be accessed via the front-panel controls (the locked channel is 'skipped over'– you have to key in its number into the handset. Obviously, the handset must be kept under lock and key, otherwise the object of the parental lock is defeated!

Name those Channels

The TechniSat ST-6002S gives you the opportunity to give each of its 200 channels a name, via the 'channel data' sub-menu. This is a development of the system used by the Pace MRD920, which allows you to name only the first 20 channels.

Using the ST-6002S's channel-naming function is easy to use; it can only be described as being similar to the system by which you enter a 'high score' into an arcade video game. You use the up and down arrow keys to change the character (upper or lower case, or numbers, can be chosen), and the left and right arrow keys to move on to the next character in the word. Names can be up to 10 characters in length.

The 'channel data' menu also harbours another function – 'copy channel data'. This function allows you, using a spare unassigned channel, to put your most used channels into the order you prefer. Alternatively, you can simply copy data from an existing channel to a spare one; this allows you to program in a new channel that is of basically the same parameters as the original one, but only varies in, say, transponder frequency – such a feature will, no doubt, be very useful when Astra 1C comes fully on stream. It's a lot quicker to simply retune the IF frequency, than programming in a new channel from scratch!

In Control

Audio, video, and skew control functions can be accessed via dedicated buttons on the remote control unit. Unlike the main menus, which operate against a blue background, with these functions you can still see the picture.

A press of the 'audio' button takes you into the audio control submenu, which gives you control over audio bandwidth, de-emphasis, mono/stereo operation and tuning. Three bandwidths are available; 150kHz (for the Wegener subcarriers), 280kHz (for medium-bandwidth primary subcarriers – e.g., those on Astra) and 350kHz (for wide-bandwidth primary subcarriers). Three de-emphasis modes are also available – 50μs (most primary subcarriers), J17 (mainly French Telecom-borne channels, but also the Italian RAI channels) and Wegener Panda-1, for use with narrow-band subcarriers – for example, stereo soundtracks and the multitude of radio stations on Astra.

We have discussed the limitations of fixed subcarriers spaced 180kHz apart – both the Pace and Mimtec receivers reviewed last month used this system. The TechniSat has independently-tuned audio subcarriers. Each demodulator is tunable over a range of 5MHz to 8·8MHz, so allowing all present subcarriers to be accessed. Coupled with the de-emphasis and bandwidth options mentioned earlier, this makes the ST-6002's audio capabilities very flexible – better specified, in fact, than some receiver/positioners at twice the price. One of the limitations of the ST-6000S receiver was that the audio bandwidth of the second audio channel (only brought into effect when stereo operation was selected) was fixed at 180kHz. This meant that best results from wideband stereo feeds (concerts and the like) could never be achieved. The successor to the ST-6000S does not suffer from this limitation, gives a wider subcarrier tuning range and offers Wegener as standard. Well done TechniSat! Another useful feature is 'pair', which allows the most often-used subcarrier pairs (e.g., 7·02MHz/7·20MHz and 7·38MHz/7·56MHz) to be accessed with greater ease – in a similar way to cheaper Astra receivers with their fixed-subcarrier access.

Even audio muting (which has its own button on the handset) and volume control (operated by the up and down keys during normal operation) is provided. This latter feature is particularly handy for matching the audio level of the receiver to that of your audio equipment. It is a pity, though, that the volume setting is not storable on a 'per channel' basis, since the audio levels of channels available from various channels varies tremendously. The levels of Super Channel's narrow-bandwidth subcarriers, for example, are notoriously low; changing to another channel without altering the volume control may well 'blast yer ears off!' However, this criticism can be levelled at just about all receiver manufacturers.

The sound quality of the ST-6002S was well up to standard – on all modes, but particularly the Wegener subcarriers, which were the most often used during the review period. The only problem noticed in operation was a very slight 'warbling' noise, that was only noticeable when listening via headphones. Since this receiver offers two independently tunable subcarriers, each audio stage has its own local oscillator stage (refer to Part One of this series). These appear to be beating with one another, proving that the two audio stages are inadequately separated on the PCB. Out of interest, this problem has plagued all stereo receivers (with independently tunable subcarriers) encountered by the author. You could go to the lengths of screening each section, but the easiest way round the problem is to 'detune' (one of) the subcarrier(s) slightly; in practical terms slight detuning makes no discernable difference to the audio quality, apart from removing the warbling (Who says the broadcasters' subcarriers are 'dead on frequency' in the first place? – Ed).

Video Matters

The 'video' key on the handset accesses (surprise, surprise!) the video-related functions. The first controls the IF frequency (950 to 2050MHz) in 250kHz steps. Pressing the relevant arrow key down causes this tuning function to work much faster, but it is still a laborious function. Oh for the ST-6000S method, which splits up the band into 50 segments (arbitrarily numbered 1 to 50) which are accessed sequentially via 'up' and 'down' keys. Fine tuning on the ST-6000S was accomplished via a dedicated function (accessed, in this case, by a pair of dedicated buttons). As mentioned before, the ST-6000S also features a 'fast scan' function which is also sadly lacking in its younger sibling.

A choice of two IF bandwidths (27MHz or 18MHz) are offered. The 27MHz IF bandwidth is ideal for use with Astra, but causes a certain amount of streaking on peak whites with wideband (36MHz) channels, such as the excellent Superchannel, which is delivered via a relatively high-power widebeam transponder on board Eutelsat II-F1, and as such can be picked up satisfactorily, using a 90cm dish, over most of Europe. However, this streaking was not too obtrusive. The 18MHz bandwidth option, meanwhile, helps with weak signals – e.g., the CMTV country music channel carried for cable networks via Intelsat VI-F4 (27·5°W), or those occasional newsfeeds that make multi-satellite reception that much more enjoyable. The ST-6002 performed well with these weakly-received channels, indicating a low threshold.

For everyday use, the two IF bandwidth options given are a good choice, but it would have been nice to see that 70MHz loop – far more flexible! It must be said, though, that IF bandwidth selection is extremely rare in a multi-satellite receiver of the ST-6002S's price range.

Video polarity selection is also provided with the required dish and LNB, this allows 'C' band reception without external video inversion circuitry. Decoder options are well catered for – this is particularly important in modern receivers, since more and more broadcasters are turning to subscription for raising revenue. In addition to normal 'de-coderless' operation, there are four decoder 'loopthrough' modes, referred to as d1 to d4, which were looked at earlier (refer to 'The Ins and Outs'). The second one, d2 (unclamped, unfiltered, de-emphasised baseband decoder output) gave good results with a bog-standard Thomson Videocrypt decoder – and exceedingly good results they were. In fact, I can say that the ST-6002S gave the best Videocrypt pictures that I have ever seen – thus proving that you don't need a special 'patented' interface – just a well-designed one operating to the Videocrypt specification. Good results were also obtained using the Ferguson/Trac MAC transcoder – even the weaker (in the UK at least!) Eurocrypted DMAC channels at 1°W would lock. I found that mode 'd1' (unclamped, unfiltered, non de-emphasised baseband decoder output) gave the best results with the MAC transcoder.

Operationally, this system is very similar to one used on the elderly (but well ahead of its time) Salora XLE multi-satellite system that the author once used. To give satisfactory results with a Videocrypt decoder, though, the latter needed modifications to its video circuitry – thankfully the ST-6002S does not!

Two other functions are accessible via the 'video' key. Each channel can be assigned one of four preset video levels – with very little to choose between them! Finally, there is a form of signal strength 'meter', which takes the form of a negative number. The lower the negative number, the higher the signal strength. This system, in my view, did not provide consistent and meaningful results – a decent analogue meter like that provided on the Echostar would be a much more useful tool, although a little out of place on the ST-6002S's modern fascia.

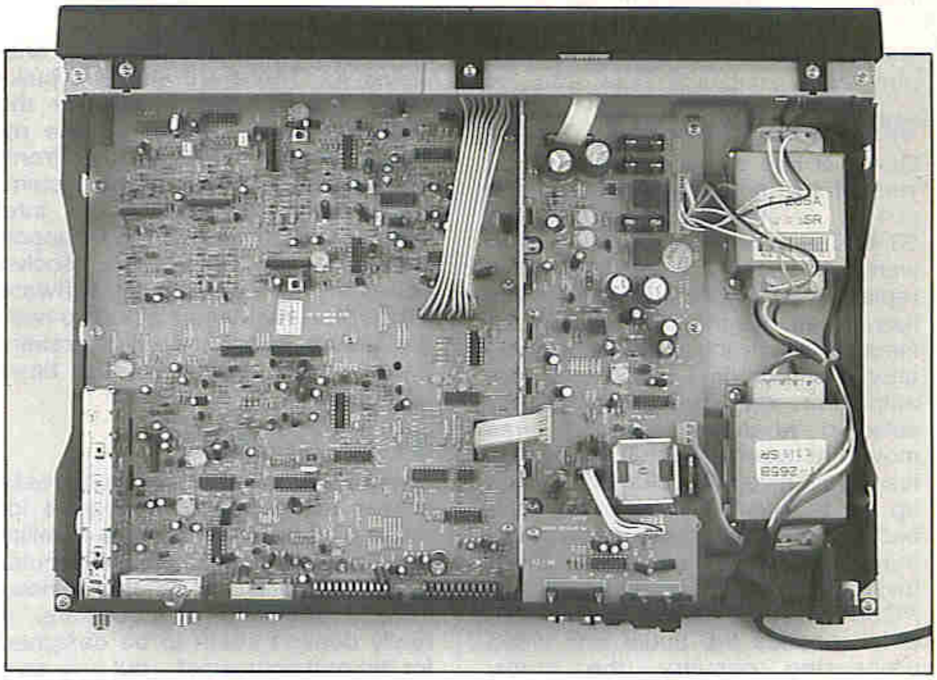
Overall, the ST-6002S provided superb quality pictures – with appropriate source material, it was capable of resolving sharp pictures with very little trace of noise. Subjectively at least, it gave the best quality video of the group – and better results than several receivers that are twice its price. The only problem was with the on-screen graphics, the stability of which tended to vary with the video content of the transmitted picture. And one more thing, TechniSat, please do something about that blue mute screen!

Skew Menu

The ST-6002 can only, as we saw earlier, control magnetic polarisers. The skew level can be varied via the final sub-menu, which is entered into by pressing the 'skew' button on the handset (Without this, you're lost!) The current supplied to the polariser is variable between −45mA and +45mA, and so will be suitable for most, if not all, magnetic polarisers. As we saw earlier, there are two skew settings per channel – vertical and horizontal – and these can be toggled between, in the 'polarity' option. The final option provided alters the LNB voltage (this option can only be accessed if switchable LNB voltage has been selected in the 'change systems option' sub-menu); 'LNB1' sends 13V DC up the LNB cable and selects the 11GHz frequency range of a triple-band LNB system, while 'LNB2' supplies 18V DC to the LNB output, enabling the 12GHz range of a triple-band LNB to be selected.

Computer Interface

A feature unique to the ST-6002S (why hasn't this been thought of before?) is the RS232 interface, which takes the form of a 9-pin 'D' socket. This is not a fully-implemented RS232 interface; only the TXD (transmit data), RXD (receive data) and ground pins are used – there is no handshaking. However, this implementation is all that is required. Accessed via the system menu, this can be used to transfer data between two such receivers so that the channel and satellite data can be passed from one receiver to another. Installation technicians will certainly find this feature of use! This feature has been used before on other microprocessor-controlled receivers, but machine-specific protocols have been used (generally variants of the I^{2}C bus).



Inside the ST-6002S.

The use of a RS232 interface has wider implications. For example, it can be hooked up to other computing devices. And to this end TechniSat have made available PC (or compatible) software that runs under MS-DOS. This allows you to load up the current database from your receiver, amend it and then write the modified data back to the receiver. Every parameter for each of the 200 favourite channels and 50 satellites can be changed. New satellites can now be defined, and given names. If you know the orbital position of your new satellite, you can approximate where the ST-6002S thinks it is. The receiver memorises each position by a 4-digit number, which is the number of actuator feedback pulses from an origin (in this case, the east dish limit) It is a simple matter of working out the number of pulses that correspond to one degree of arc of dish travel (this can be worked from the known difference in orbital position between two satellites and the difference in the pulse count) and then extrapolating. When making your calculation, though, it is advisable to use as your reference the satellites nearest in orbital position to your intended one.

In all, programming the ST-6002S becomes a lot easier (and quicker) when using the software. It also means that TechniSat can sell up-to-date databases which will require minimal set up (initial orbital position and skew settings); this could be a real convenience to the user. It does require a PC, though – but these computers are becoming increasingly common as their prices continue to fall. The software is very fussy in the way it is operated, however – the receiver must be activated before the software tries to read the machine's current database, otherwise a misleading 'jack error connection' message is produced. The version of the software available at the time of review was an early pre-release version without manual, and so much hair-pulling and lead-checking resulted! The other problem is that only the COM 1 serial port is recognised by the program – which is a pain if you have a printer or other such device connected. Hopefully subsequent versions of the software will rectify this, and provide other useful features. The batch file that starts the program initialises the serial port, defining which one is used and the data transfer rate. It should be a fairly easy matter to alter this to suit your requirements. The data transfer rate, which is 9600 bits/s, should be left alone, though!

Out of interest, the PC control kit represents unbelievably good value for money. For £15, you get the program disc (on a 3½in. high-density disc), the operating instructions, an interface lead and a 9-way gender changer (surely a 9-way to 25-way adaptor would have been more useful?). If you are interested in the ST-6002S, and have (or are thinking of buying) a PC or compatible (despite the choice of disc format, the program works on any PC with at least 256k memory and a serial port), this kit is an *essential* purchase!

What's Inside?

During a late stage of the review, I was sent a more up-to-date version (v.1·73, as opposed to v.1·1) of the ST-6002S's internal operating software; this took the form of a replacement 27C512 EPROM. This has sorted out the autofocus problems, although the only major operational difference I noted was that autofocus was not automatically selected whenever the dish was moved between satellites. Nevertheless, it did give me a chance to open up the receiver – and that can't be bad, can it? (You mean you needed *that* much of an excuse – Ed?). Inside the case are no less than four PCBs. The first is the main PCB, which houses the audio and video processing circuitry, the tuner/demodulator, RF modulator and socketry. Another PCB contains the (linear) power supply circuitry, the polariser driver, and the dish positioner (clanky old relays, rather than quiet and reliable MOSFETS, are used!). A small sub-PCB contains the RS232 sub-board, the heart of which is a MAX232 RS232 transceiver IC. There are also two bulky mains transformers – one for the positioner, and another for the receiver circuitry. Behind the front-panel lives the 'brains' of the system, which is based around an Intel 80C32 microcontroller and support circuitry – a 28-pin DIL socket accepts the operating software EPROM. A real-time clock chip (with 3V lithium battery) is also present here – this operates the timer functions.

The Verdict

It appears that the ST-6002S really seems to have been designed for those who only want a multi-satellite system to gain access to the popular cable channels, or to the various foreign language broadcasters. It really doesn't seem to be designed for the real enthusiast – but only as a result of its operating software. This is a real pity, since this TechniSat is a really superb receiver, based around excellent hardware. In fact, I can safely say that the ST-6002 performed better in some respects than a certain over-rated (and overpriced!) American receiver that becomes obsolete with every new software update! Die-hard enthusiasts aside, this receiver is great for normal day-to-day use by the family, and will open up the wide choice of programming that multi-satellite systems bring. Its £350 price tag, in my opinion, represents exceptional value for money when one considers what is on offer. It must be said that, quirks aside, this was my favourite receiver out of the four. It must be noted that the review sample was one of the first in the UK, and the hardware bugs (e.g., distorted on-screen graphics) may well have been fixed. What's more, a proper English manual will be forthcoming.

Recommended Retail Prices (inclusive of VAT @ 17·5%)

TechniSat ST-6002S: £350

TechniSat ST-6002S PC Control Software: £15 (including lead and adaptor)

(Prices are correct at time of press)

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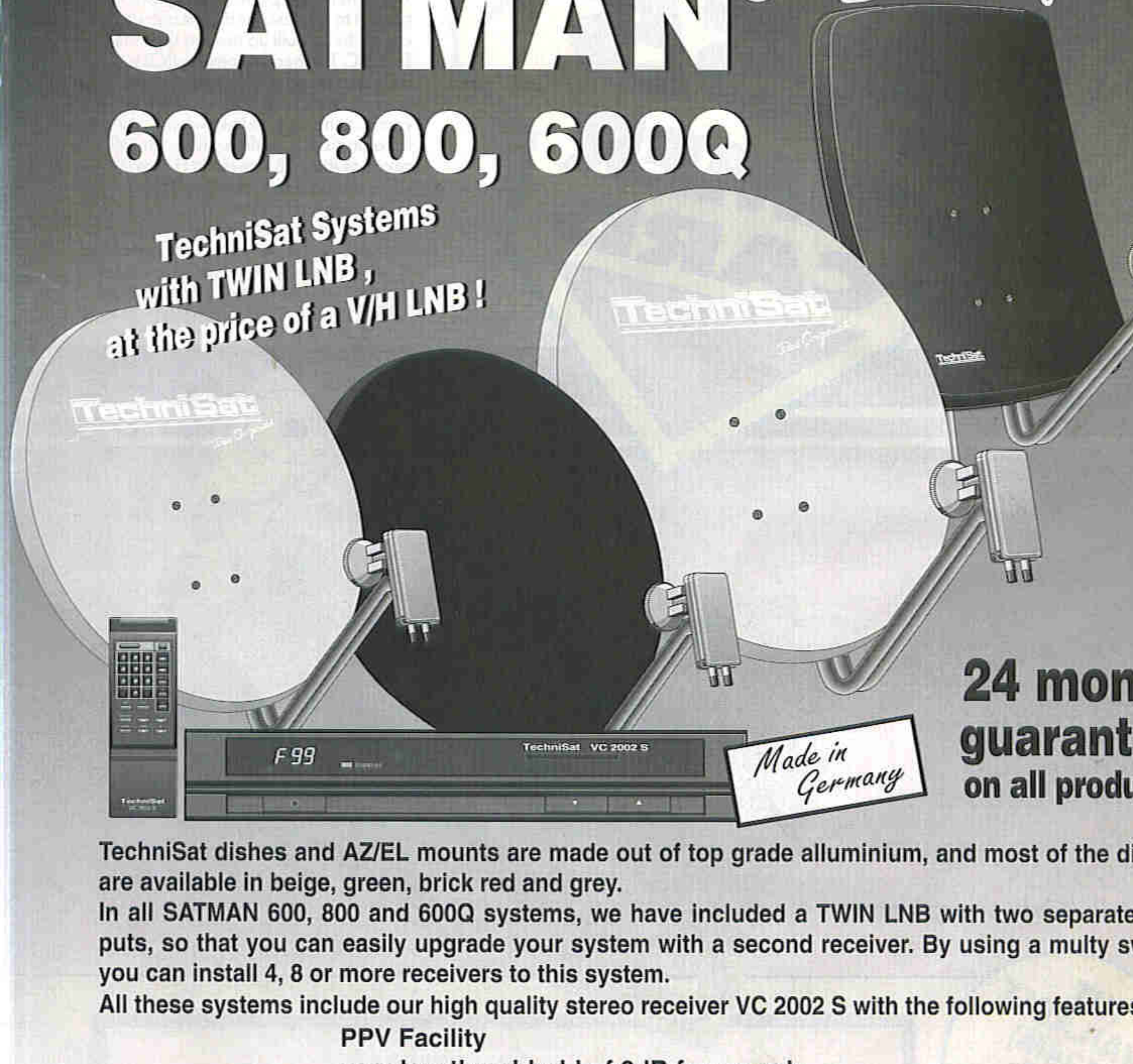

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2
PROJECT RATING

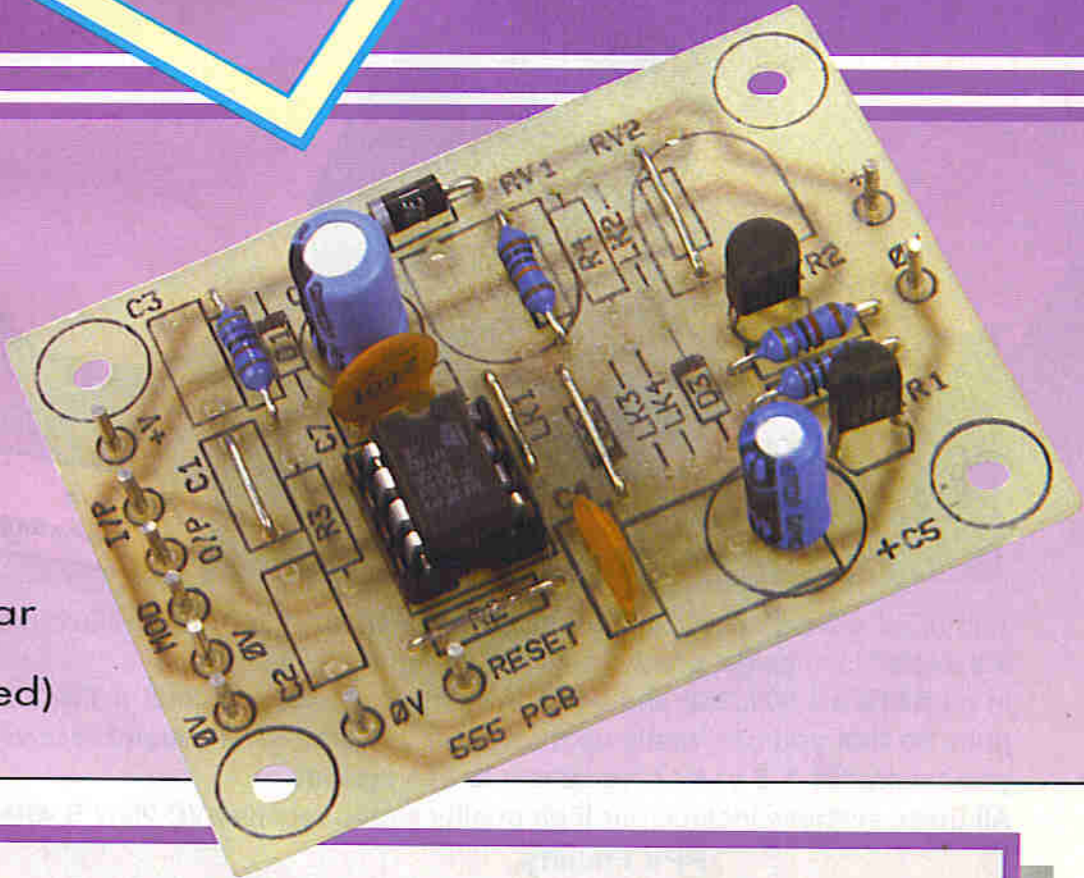
MULTI-PURPOSE 555 TIMER CARD

by Alan Williamson

The 555 timer IC, shown in Figure 1, has been around since the early 1970s, and can be found in many circuits. Configurable as a monostable or an astable multivibrator, it can be used in many applications – for example, precision timing, pulse generation, sequential timing, time delay generation, pulse width modulation, pulse position modulation, missing pulse detection and oscillators. 'Real world' uses for the 555 therefore include logic pulsers, DC-DC converters, alarm systems, servo controllers and remote control systems. The general-purpose 'building block' project to be described here allows such circuits to be built up around this versatile 8-pin IC. The accompanying PCB is designed to incorporate all of these possible variations, by simply fitting components or wire links where required for a particular configuration. The full circuit of the PCB is given in Figure 2, while the PCB track and legend are reproduced in Figure 3. You should compare the circuit diagram of your intended configuration with that of Figure 2, since links may be required to complete the circuit – refer to the build schedule of Table 1 during construction.

FEATURES

* Up to 11 configurations
* Monostable or astable operation
* Single PCB construction
* Uses the popular 555 IC (NE555 supplied)



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APPLICATIONS

* Timer circuits * Pulse width modulation * Square-wave generation * Reset pulse generation and watchdog circuits for microprocessors * Experimentation and circuit development * Education

Power Supply Circuit

A simple power supply circuit, shown in Figure 4, is provided on-board. Diode D4 (1N4001) is used to protect the 555 and the polarised electrolytic capacitors from damage, in the event of accidental reverse- polarity connection of the power supply. The reservoir capacitor, C6 (100μF), is mounted close to the '+' supply pin, to counteract the 'crowbar' effect, in which the supply is effectively shorted to ground during the extremely brief output transition from low to (active) high (this applies to the NE555 variant only, which has a totem-pole output stage – CMOS versions do not suffer from this problem). C6 thus prevents collapse of the supply voltage. C7 (100nF disc ceramic), meanwhile, decouples any high-frequency noise on the supply. C6 and C7 are thus essential if this module is to be run from the same power supply as other circuitry.

Circuit Configuration Options

For each circuit configuration, information is given which allows you to calculate circuit values where necessary. The components required are referenced in each circuit diagram, but links may also be needed, and so you should refer to the build schedule in Table 1 (on following page) before starting construction. There are two basic modes of operation – monostable and astable – but each can be configured slightly differently to suit a range of particular applications; these will also be described.

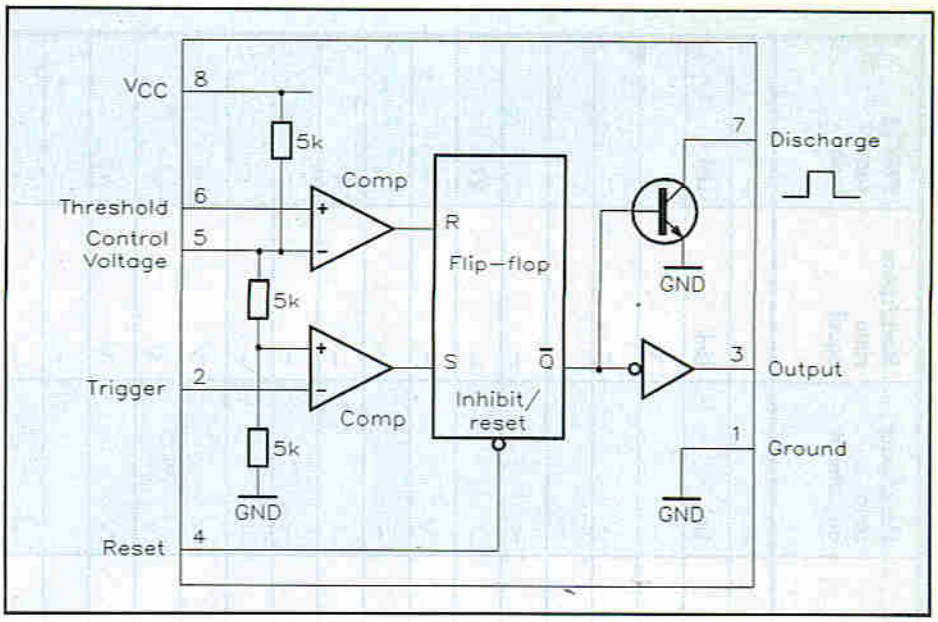
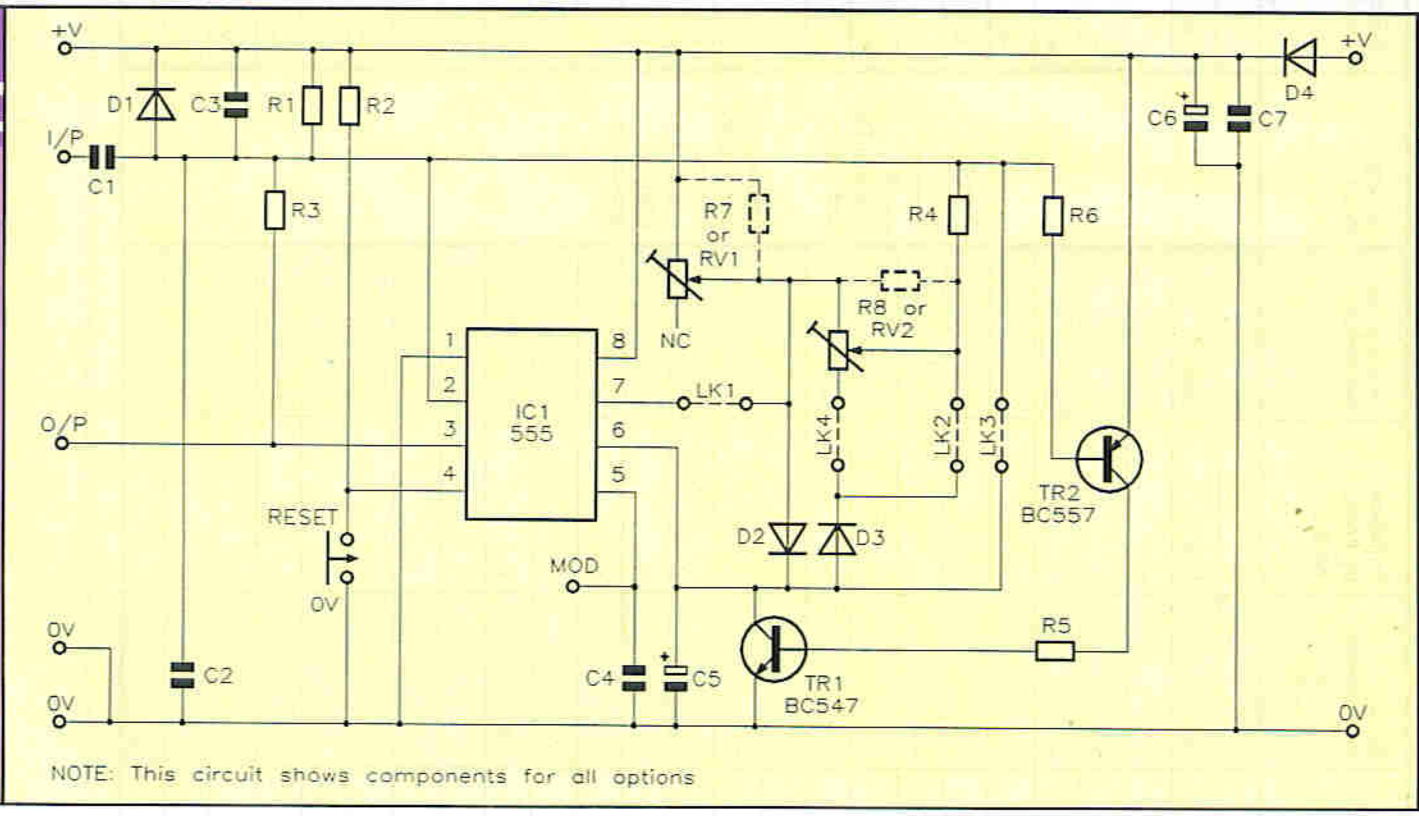
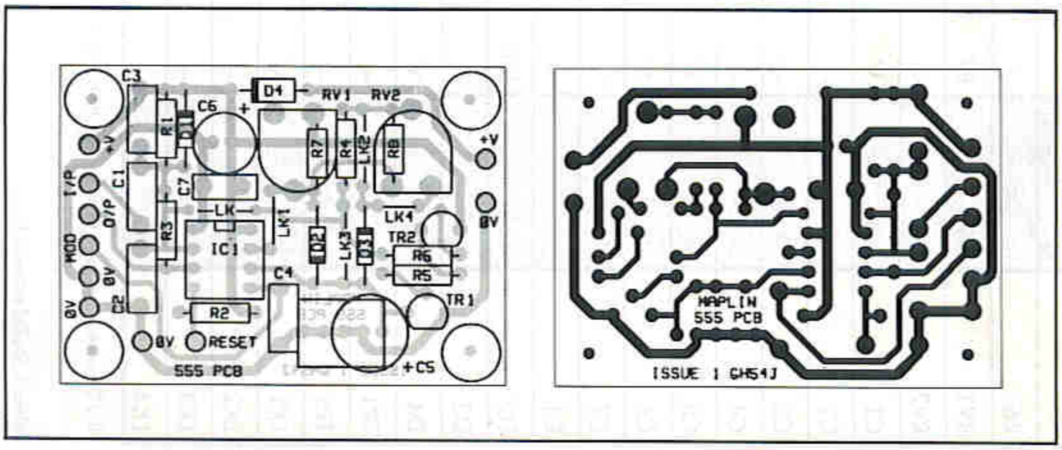


Figure 1. Block diagram of 555 timer.





Above: Figure 2. Full circuit diagram of the Multi-Purpose 555 Timer Card.

Left: Figure 3. PCB legend and component overlay.

Configuration → Component ↓	Basic Monostable	Basic Monostable with Edge Triggering	Basic Monostable with Noise Immunity	Initiation by Power Supply	Retriggered Monostable	Adding Reset	Basic Astable	Duty Cycle ≤50%	Mark/space ratio adjustment	Mark/space ratio equal	PWM of control input*
R1	√	√	√	√	√		–	–	–	–	–
R2	Link	Link	Link	Link	Link		Link	Link	Link	Link	Link
R3	–	–	–	–	–		–	–	–	√	–
R4	–	–	–	–	–		–	–	√	–	–
R5	–	–	–	–	√		–	–	–	–	–
R6	–	–	–	–	√		–	–	–	–	–
RV1	R7	R7	R7	R7	R7	Fit R4. Wire a push-to-make switch between P9 and P10.	R7	R7	–	–	R7
RV2	–	–	–	–	–		R8	R8	√	–	√
C1	Link	√	√	–	–		–	–	–	–	–
C2	–	–	–	√	–		–	–	–	–	–
C3	–	–	√	–	–		–	–	–	–	–
C4	–	–	√	–	–		–	–	–	–	√
C5	√	√	√	√	√	All other components fitted as normal, for intended application	√	√	√	√	–
C6	√	√	√	√	√		√	√	√	√	√
C7	√	√	√	√	√		√	√	√	√	√
D1	–	√	√	√	–		–	–	–	–	–
D2	Link	Link	Link	Link	Link		–	√	√	–	–
D3	–	–	–	–	–		Link	√	√	–	–
D4	√	√	√	√	√		√	√	√	√	√
TR1	–	–	–	–	√		–	–	–	–	–
TR2	–	–	–	–	√		–	–	–	–	–
LK1	√	√	√	√	√		√	√	–	–	–
LK2	–	–	–	–	–		√	√	–	–	–
LK3	–	–	–	–	–		√	√	√	√	–
LK4	–	–	–	–	–		–	–	√	–	–

* If a DC control voltage is to be derived from RV2, its wiper should be connected to the 'MOD' pin, using some insulated wire. The RV2 side of LK5 should then be connected to ground.

Table 1. Build schedule.

1. Basic Monostable Multivibrator

A basic monostable is shown in Figure 5. When the input pin of the 555 is taken below a third of the supply voltage (representing a 'low' logic state; the 555's input is active low), the output (pin 3) will become (active) high. The period of time for which the output will remain high is determined by the time constant of R7 and C5 multiplied by 1·1 (1·1 × R × C); if the input pin is held low for a longer period than the predetermined time, the output will remain 'high' until the input itself is taken high. Resistor R1 is used as a 'pull up', the value should be 1kΩ or greater (2MΩ max); very high values may cause problems with noise.

The minimum value for R7 is 2kΩ in monostable mode (and 1kΩ in the astable configuration). Its maximum value is 3·9MΩ (5V supply), or 10MΩ (15V supply); note, however, that accuracy will suffer with values over 1M; and environmental noise may prove to be a problem with false triggering – particularly when low supply voltages are used. There are no limits on value for C5; but if electrolytic capacitors are used, leakage current may be a problem when used with high values of R7. The voltage rating of the electrolytic capacitor should be *just* above the supply rail voltage – this is because an electrolytic will only become a capacitor with at least 10% of the rated voltage across it. A 100V electrolytic working on a 5V supply, for example, will possibly pose a problem.

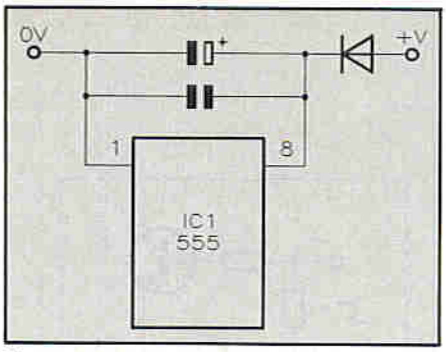


Figure 4. PSU circuitry.

Edge Triggering

The 555 timer, in its normal state, is DC coupled. As a result, the output will remain high if the input remains low beyond the timed period, and will continue to do so

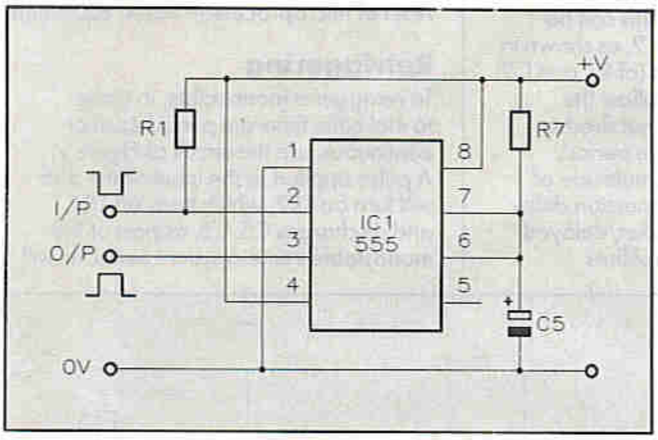


Figure 5. Basic monostable circuit.

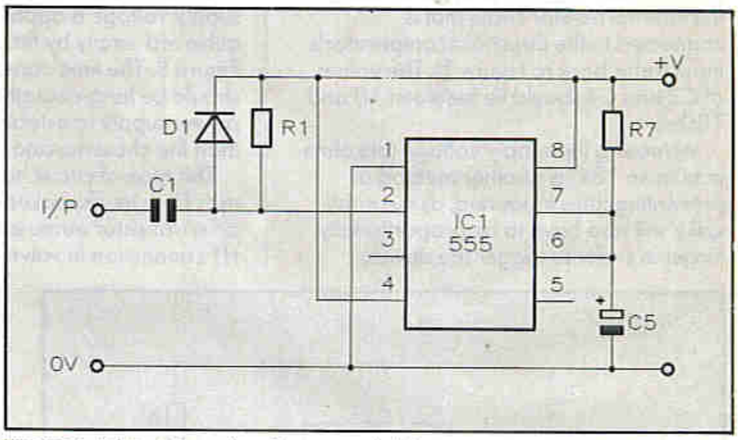


Figure 6. Edge-triggering the monostable.

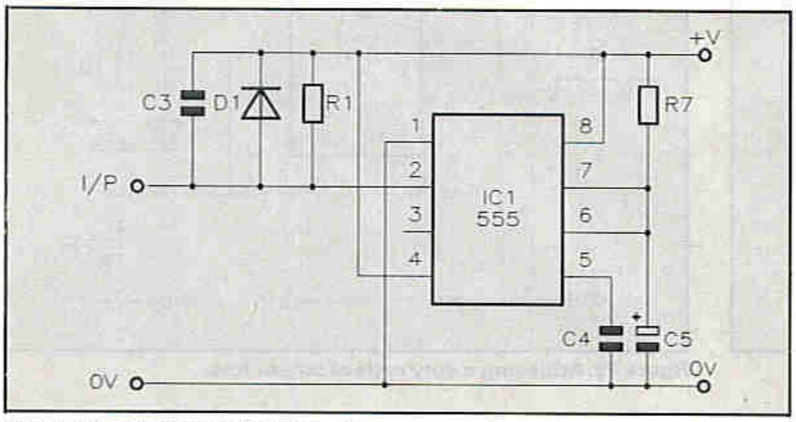


Figure 7. Improving noise immunity.

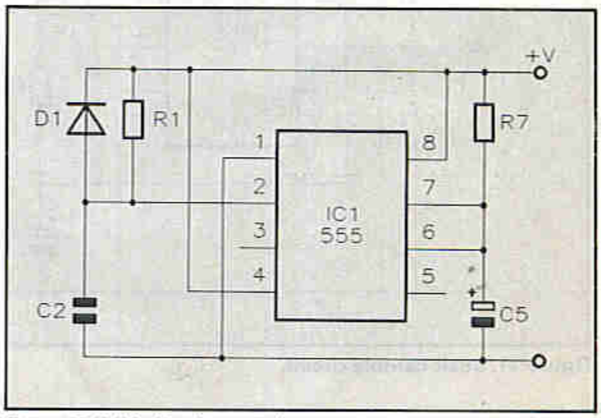
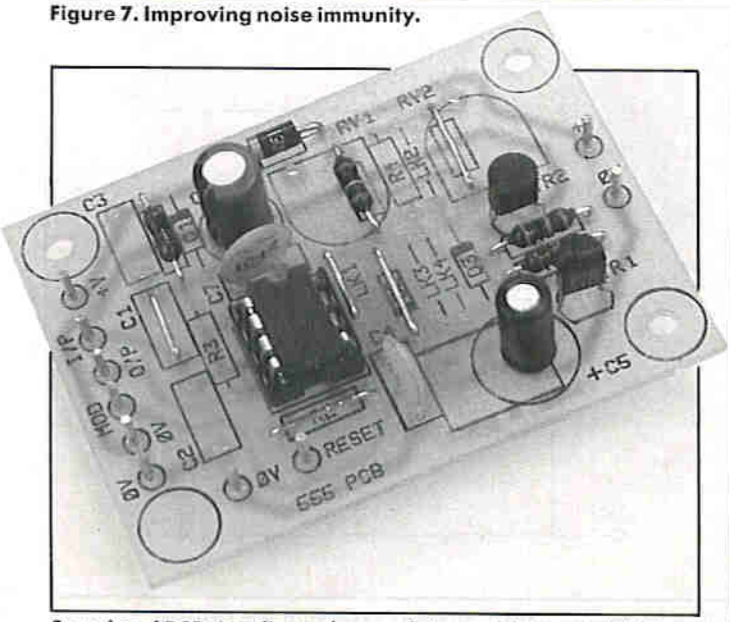


Figure 8. Initiation by supply.



Completed PCB, (configured as a retriggerable monostable).

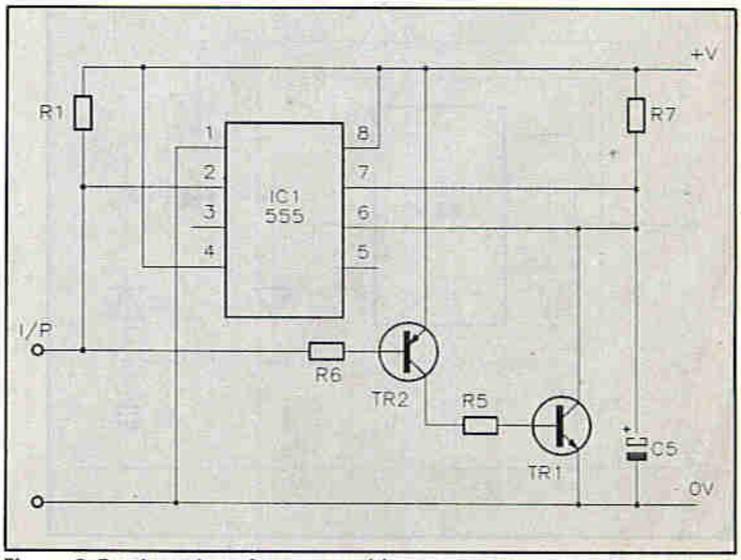


Figure 9. Retriggering of a monostable.

until the input reverts to a high condition. This can be a real pain if the output pulse *must* be of shorter duration than that of the input pulse. This phenomenon can, however, be prevented if the 555 can be triggered by the falling *edge* of the input pulse (remember that it's active low!). The modification is shown in Figure 6; a capacitor (C1) is added to the input – the smaller the capacitor, the sharper the pulse the better (a value of between 1 and 10nF would be ideal). Diode D1 is required to clip the input capacitor pulse above the positive supply rail voltage, thus protecting the input.

Adding Noise Immunity

C3 will help to prevent false triggering by decoupling the input to the positive supply rail (refer to Figure 7). C4 will also help to prevent false triggering, by decoupling the internal resistor chain that is connected to the threshold comparator's input (refer back to Figure 1). The values of C3 and C4 should lie between 10 and 100nF.

Increasing the supply voltage (absolute maximum 18V) is another method of preventing false triggering, as the noise spike will also have to be proportionally larger in order to trigger the device.

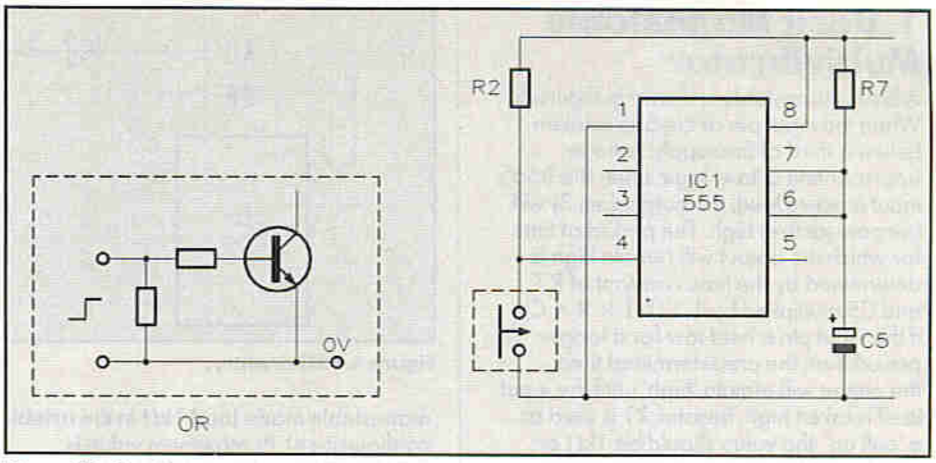


Figure 10. Reset.

Initiation by Supply

The monostable can be triggered as the supply voltage is applied. This can be achieved simply by fitting C2, as shown in Figure 8. The time constant (of R1 and C2) should be long enough to allow the power supply to establish, but shorter than the chosen monostable period.

This type of circuit has a multitude of uses from loudspeaker connection delay on a transistor audio amplifier, delayed HT connection in valve amplifiers (allowing heater and bias to be established), and automatic power-up reset of microprocessor-based equipment.

Retriggering

To retrigger a monostable, in order to make the time-out period appear continuous, use the circuit of Figure 9. A pulse applied to the input of the 555 will turn on TR2, which turns on TR1 and discharges C5. C5, as part of the monostable's time constant network, will

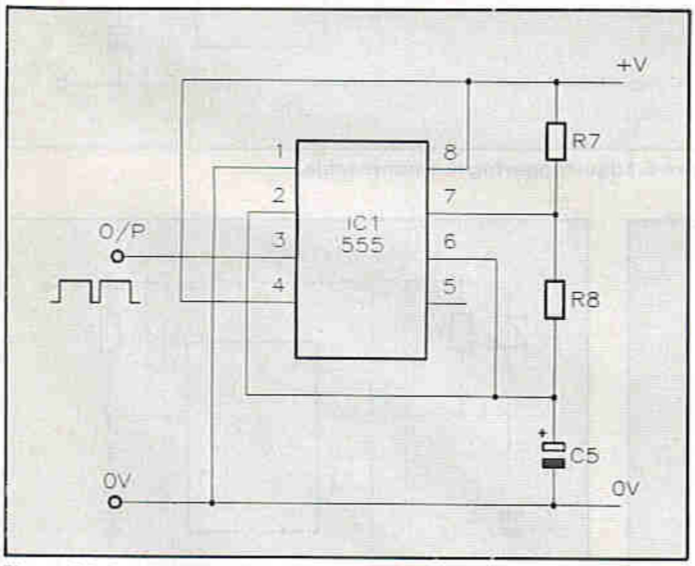


Figure 11. Basic astable circuit.

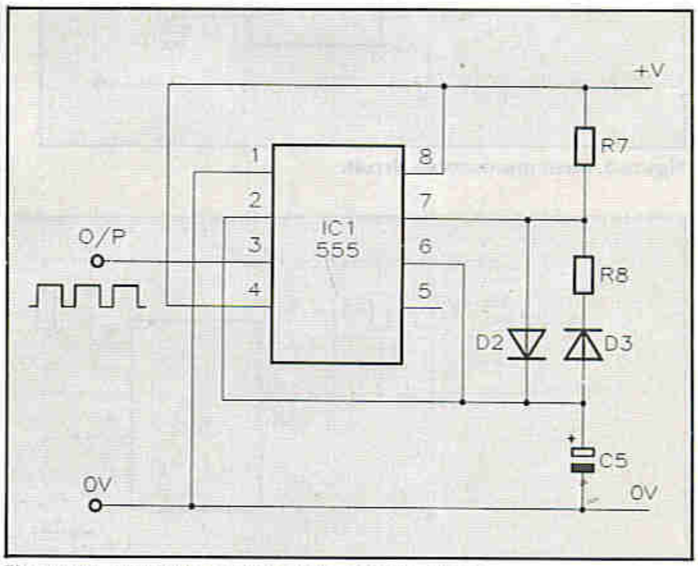


Figure 12. Achieving a duty cycle of 50% or less.

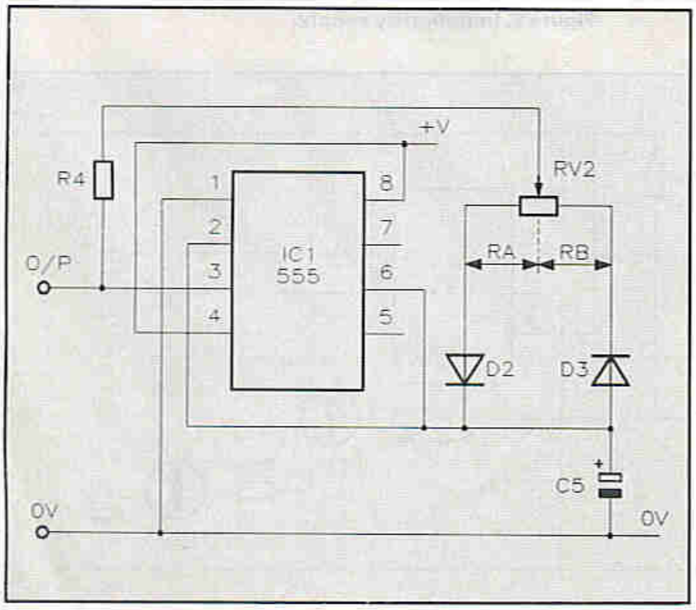


Figure 13. Mark/space adjustment with constant frequency.

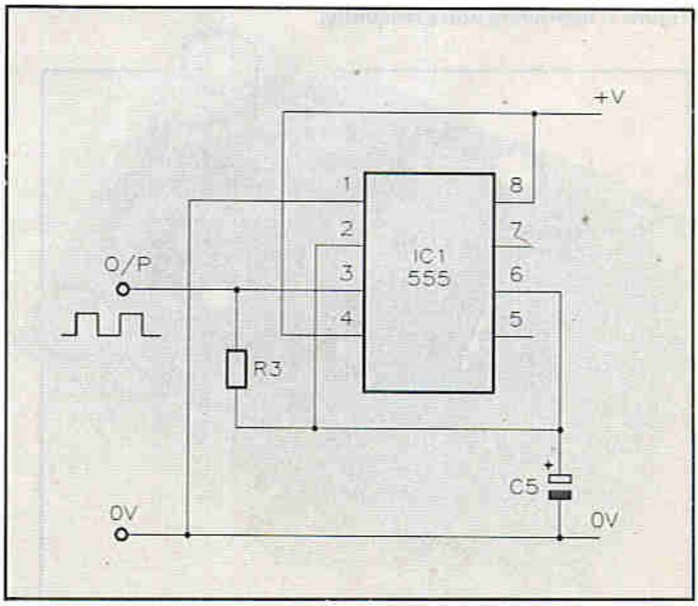


Figure 14. Maintaining a 50% duty cycle with one resistor.

then have to charge up again to time out. Care must be taken that the instantaneous current pulse from C5 does not exceed the maximum collector current of TR1.

This type of circuit can be used as a 'watchdog'. The sole purpose of this type of circuit is to detect failure of a microprocessor system (caused by, for example, a power supply glitch or peripheral problem). The circuit would, of course, have to be edge-triggered, since you cannot predict the state in which the microprocessor will lock up.

If a continuous train of pulses (e.g., system timer derived interupt) from the computer is fed into the input of the 555, the output will remain high until the processor fails. The 555 would then time out; the output would then revert to a low condition, and operate a DIL or reed relay. The coil of the relay is connected to the positive supply rail and the output pin (3) of the 555; a diode is wired in parallel with the relay coil to protect the 555 (cathode to the positive supply rail). The relay switch contacts are then wired in parallel with the computer's reset switch.

Forced Reset

Resetting a monostable, before it has timed out, can be achieved by fitting a resistor (R2) and push-to-make switch, as shown in Figure 10. A value of 10kΩ would be suitable for most applications. An alternative to the switch could be a transistor, operated by a logic circuit or microprocessor.
The reset function could also be used to gate an astable multivibrator.

2. Basic Astable Circuit

A basic astable multivibrator is shown in Figure 11. Its output frequency can be calculated from the following equation

$$f = \frac{1{\cdot}44}{(R7 + (2 \times R8)) \times C5}$$

The time period for the 'high' output (or charge time) can be found from the following equation:

$$T_H = 0{\cdot}69 \times (R7 + R8) \times C5$$

The time period for the 'low' output (or discharge time), meanwhile, is:

$$T_L = 0{\cdot}69 \times R7 \times C5$$

These equations show that the high output period is longer than the low output period; this effect can be minimised by making the value of R7 at least 100 times greater than the value of R8. The maximum value for the sum of R7 and R8 is 3M9 (with a 5V supply voltage), or 10M (with a 15V supply voltage).

Duty Cycle

To achieve a duty cycle of 50% or less, the timing capacitor should be charged by R7 only, and discharged through R8 as normal. This can be accomplished by fitting a diode (D2) in parallel with R8, as shown in Figure 12. However, D2 has a voltage drop across it, and this will affect the mark/space ratio; diode D3 should therefore be included for compensation in the discharge path. Fitting RV1 and RV2 in place of R7 and R8 will allow independent adjustment of the individual mark and space timing; however, the frequency will also be altered.

Figure 13 shows how the mark/space ratio can be altered without changing the output frequency; which can be calculated from the following equation:

$$f = \frac{1}{1{\cdot}44 \times RV2 \times 2 \times R4 \times C5}$$

This circuit could form the basis of a PWM (pulse width modulation) driver for use with racing car servos, or the electromechanical polarity controllers used with satellite TV receiving systems.

Figure 14 shows an alternative method of achieving an equal mark/space ratio, this time using only one resistor. In this example, the frequency of the oscillator is determined by the following equation:

$$f = \frac{1}{1{\cdot}44 \times R3 \times C5}$$

This latter circuit is ideal for square wave oscillators, sounders and flashers.

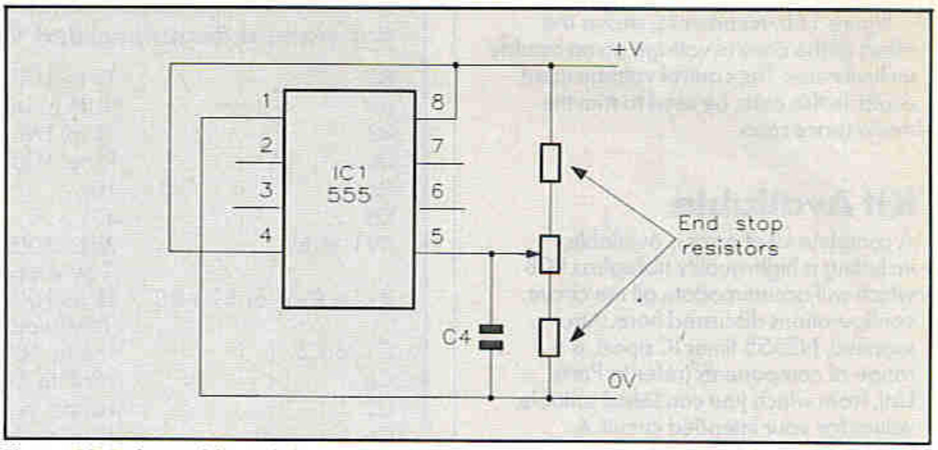


Figure 15. Pulse width modulation.

More on Pulse Width Modulation

Applying a DC voltage to the control input (pin 5), as shown in Figure 15, will alter the threshold and trigger comparator input levels. If the 555 is configured as a monostable, the pulse width will therefore be altered; the pulses will be wider if the input modulation voltage to pin 5 is above two-thirds of the supply voltage, and narrower if below; refer to Figure 16a. The control voltage input could be used to trim the pulse width. If choosing this option, by mounting PCB pins instead of RV2, wires could be brought out to an external potentiometer. Alternatively, the control voltage could be a suitably-processed *AC-coupled* audio signal.
A connection on the PCB, 'MOD', can be used for this purpose – it is connected *directly* to the control input of the IC. Note that AC coupling, therefore, will have to take place off-board.

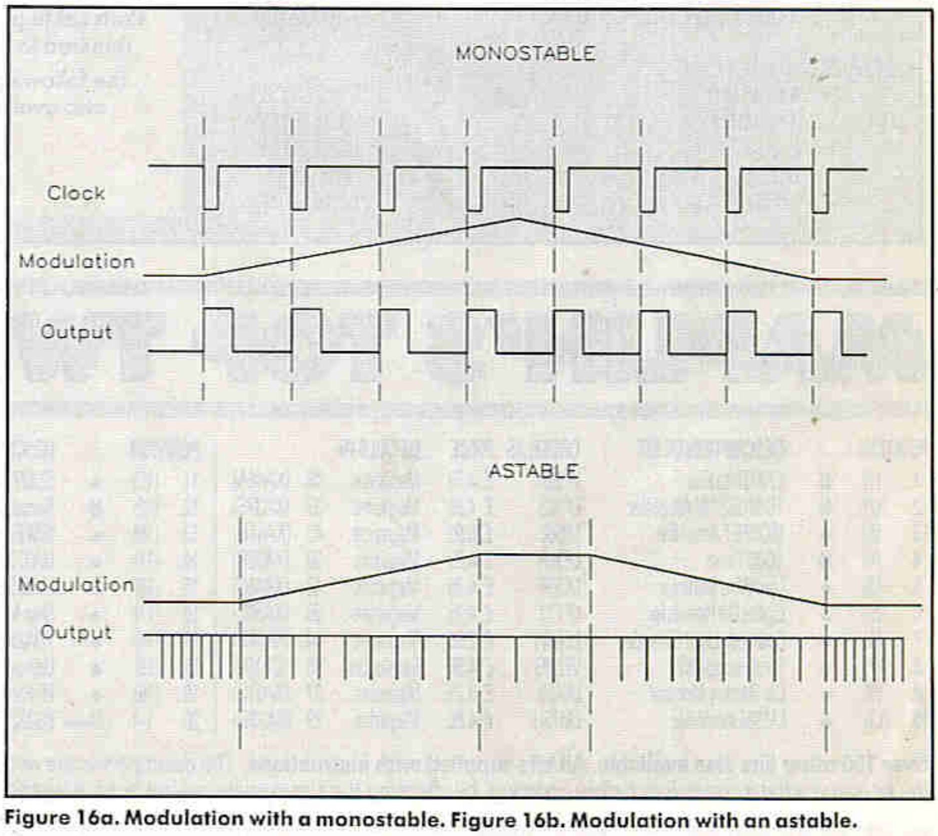


Figure 16a. Modulation with a monostable. Figure 16b. Modulation with an astable.

Figure 16b, meanwhile, shows the effect of the control voltage on an astable multivibrator. The control voltage input could, in this case, be used to trim the mark/space ratio.

Kit Available

A complete kit of parts is available, including a high-quality fibreglass PCB which will accommodate all the circuit configurations discussed here. Also supplied, NE555 timer IC apart, is a range of components (refer to Parts List), from which you can select suitable values for your intended circuit. A list of recommended values for each component is given in Table 2. Once again, we refer you to Table 1, which tells you which items to fit to the PCB, for your chosen application. All links, by the way, can be derived from component lead offcuts.

A DC supply of between 6V and 18V DC can be used to power the circuit. The device itself consumes 10mA, but its output can source or sink up to 200mA and this should be taken into consideration.

All connections are brought out to PCB pins on the side of the board; these are the monostable trigger input, modulation input, output, DC supply and ground. For flexibility, the DC supply and ground connections are also brought out to PCB pins on the opposite side of the board.

Component	Recommended Value
R1	1k to 100k
R2	0Ω (i.e. wire link) to 100k
R3	1k to 1M
R4	1k to 100k
R5	10k
R6	47k
RV1 or R7	2k to 100k (Maximum 3M9 (5V supply) or 10M (15V supply) for monostable operation)
RV1 + RV2, or R7 + R8	1k to 100k (Maximum 3M9 (5V supply) or 10M (15V supply) for astable operation)
C1 to C3	1nF to 100nF Polyester Layer
C4	10nF to 100nF Polyester Layer
C5	100pF to 100µF Polyester Layer
C6	47µF to 100µF Electrolytic
C7	100nF ceramic

Table 2. Suggested practical component values.

MULTI-PURPOSE 555 TIMER CARD PARTS LIST (Refer to Table 1)

RESISTORS: All 1% Metal Film (Unless specified)			
	1k	3	(M1K)
	4k7	2	(M4K7)
	10k	3	(M10K)
	47k	2	(M47K)
	100k	3	(M100K)
	1M	1	(M1M)
	Hor Encl Preset 10k	1	(UH03D)
	Hor Encl Preset 100k	1	(UH06G)
CAPACITORS			
	1nF Polyester Layer	1	(WW22Y)
	10nF Polyester Layer	1	(WW29G)
	100nF Polyester Layer	3	(WW41U)
	1µF 100V PC Electrolytic	1	(FF01B)
	10µF 50V PC Electrolytic	1	(FF04E)
C6	100µF 25V PC Electrolytic	2	(FF11M)
C7	100nF 50V Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
	1N4148	3	(QL80B)
D4	1N4001	1	(QL73Q)
	BC547	1	(QQ14Q)
	BC557	1	(QQ16S)
	NE555	1	(QH66W)

MISCELLANEOUS		
8-Pin DIL Socket	1	(BL17T)
Pin 2145	1 Pkt	(FL24B)
PCB	1	(GH54J)
Instruction Leaflet	1	(XU23A)
Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are available as a kit, which offers a saving over buying the parts separately.

Order As LT34M (Multi-Purpose 555 Timer Card) Price £4.95

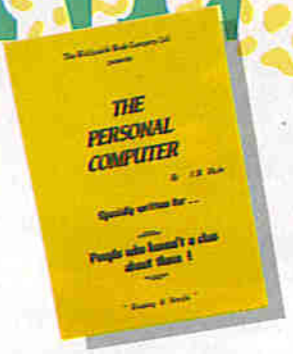
Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately, but is not shown in the 1993 Maplin Catalogue.

Multi-Purpose 555 Timer PCB

Order As GH54J Price £2.25.

NEW BOOKS



The Personal Computer

by J. R. Doyle

There have been many books and articles, in the leading PC magazines, explaining how to use the modern 'Personal Computer', how it works and describing the system operation. To many readers, the information given has been a case of 'too much, too soon', with many authors showing off their in-depth knowledge and expertise of the subject matter. This book breaks the mould and starts from the very beginning, and explains all in plain language. When some technical knowledge is given, this is presented as simply, and as concise as possible.

The book covers basic fundamentals such as types of hardware, keyboard layout, VDUs, mouse, floppies and printers. Several chapters are devoted to using a PC. Interesting, and informative little snippets of information are given throughout the book, that all help the reader in understanding and hopefully, to alleviate the readers fears about their use. Chapters are dedicated to the 'graphical user interface' (GUI), disk operating system (DOS), modems and networking. A glossary of terms used in computing is given at the end of the book.

To check whether you have taken in the information, a little 'exam' is given at the very end of the book (with the answers), the questions are of the 'true or false' type.

A handy little book that should remove many of the problems that many first-time users of PCs experience.

1992. 55 pages. 210 x 148mm, illustrated.

Order As WZ95D (Personal Computer) £3.75 NV

Instrumentation Electronics

by P. P. L. Regtien

We are all aware that electronics has penetrated deeply into our daily life, for electronic systems can be observed almost everywhere. There are hardly any appliances, tools or instruments that do not contain electronic parts, and designers of technical systems must be fully-aware of the possibilities and limitations of modern electronics. It is equally important that users of electronic systems have at least some basic knowledge of electronic principles to exploit fully the possibilities of an instrument, to be aware of any limitations and to correctly interpret measurement results.

This book is designed to offer the basic knowledge to obtain these skills, and covers the basic properties of both analogue and digital components and circuits, as used in electronic measurement systems.

The book adopts a modular approach with each chapter discussing a particular subject. The chapters are divided into two parts; the first part provides the basic, and the second part providing more specific information.

The end of each chapter has a summary and some useful exercises with worked examples given at the back of the book, making it an ideal self-teaching aid.

The book is based on electronic and electronic instrumentation courses, and requires a basic knowledge of mathematics and physics to first year degree level, or equivalent. No knowledge of electronics is required.

A well written and constructed book with its end-of-chapter problems and summaries will be invaluable to those on an undergraduate course or interested in instrumentation and measurement.

1992. 490 pages. 233 x 173mm, illustrated.

Order As WZ87U (Instrument Electron) £18.95 NV

A Concise User's Guide to Windows 3.1

by N. Kantaris

This book was written to help the newcomer to Windows 3.1, consequently the material is presented on the 'what you need to know first, appears first' basis. However, it is not necessary to start at the beginning and go right through to the end. Each section has been designed to be self-contained, so the more experienced user can start at any section.

Windows not only acts as a graphical front-end to your PCs disk operating system (DOS), but also contains its own word processor, database, communications, and electronic calendar modules, to name but a few, all of which are examined. An understanding of Windows cuts down the learning curve on other available packages specifically designed to run under the Windows environment. For example, once you have learned to install printers, and switch between them, you will never again have any difficulty performing this operation from within other applications which run under Windows. Furthermore, learning to manipulate text in the Windows' Write module will lay very strong foundations on which to build expertise when you need to master a full-blown word processor with strong elements of desktop publishing.

With the help of this Concise Guide, you should be able to get the most out of your computer, when using Windows, in terms of efficiency and productivity – in the shortest, most effective and informative way.

1992. 150 pages. 198 x 130mm, illustrated.

Order As WZ71N (Guide to Windows 3.1) £4.95 NV

Power Electronics Handbook – Components, Circuits and Applications

by F. F. Mazda

The aim of this book is to provide the power electronics engineer with all the information to design power circuits for a variety of applications. It describes the characteristics of power semiconductor devices, and how they are used in power circuits.

The book sets out to give the maximum amount of information in a concise form, with the emphasis being on the practical rather than the theoretical and is conveniently divided into three parts. Part One, components, covers power semiconductor devices, thermal design, power semiconductor components, EMC, and power semiconductor protection. Part Two, circuits, discusses static switches, AC line control, phase-controlled rectification and inversion, direct AC frequency converters, forced commutation techniques, DC to DC converters and DC link frequency converters. Part Three describes some of the applications of power semiconductor circuits, such as power supplies, electrical machine control, heating and lighting and electromechanical applications. A list of symbols used, a glossary of terms and a bibliography are provided.

The book is profusely illustrated and will be of great interest to the power electronics engineer and student.

1993. 418 pages. 231 x 154mm, illustrated.

Order As AA07H (Power Electron Book) £19.95 NV

Principle of Electricity – Fourth Edition

A. Morley and E. Hughes, revised by W. Bolton

This standard text, now in its fourth edition, has been expanded and revised to give complete and current coverage of the electrical principles required by technicians. The text is ideal for students studying for BTEC National Certificates, or Diplomas, in Electrical Engineering, Electronics, Telecommunications and related subjects.

Additional chapters cover transformers, circuit theorems, DC, transients and three-phase supply and the material on electronics has been completely rewritten to cover semiconductors.

The contents include 83 worked examples and 435 problems, most of which have been taken from past examination papers, with the answers at the back of the book. Conveniently located at the front is a very useful section on symbols, abbreviations and definitions, that are used throughout the book.

This well illustrated and concise book is highly recommended for students studing electrical engineering and related topics.

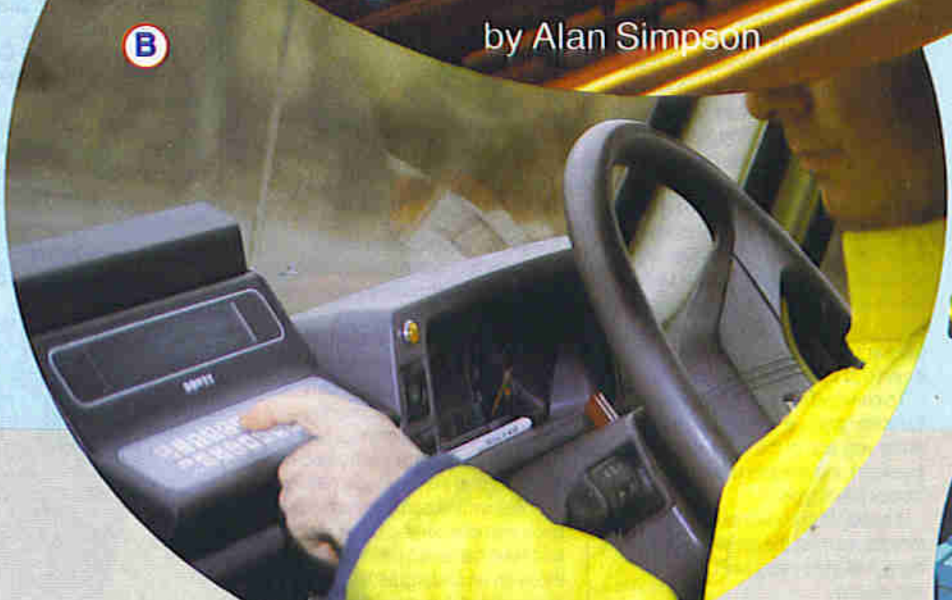
1992. 480 pages. 214 x 137mm, illustrated.

Order As WZ86T (Principles of Elect) £11.99 NV

Few drivers on the Brent Cross flyover of the North Circular Road will not have experienced a close encounter of the RAC kind. It is here that the high profile, futuristic RAC office is sited. In fact, there are similar RAC offices in Walsall, Glasgow, Stockport and Bristol, each having been deliberately designed to attract the attention of passing drivers. Along with sales centre locations at many of the UK motorway service areas, the RAC likes to be seen by its 5·4 million members – and prospective members.

THE NEW HIGH-TECH *Knights of the Road*

by Alan Simpson



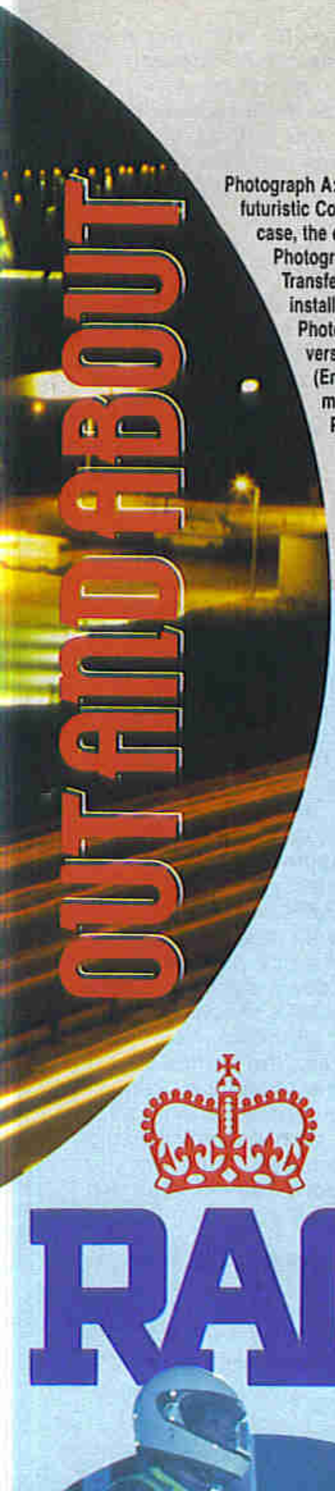
When it comes to pioneering the interests of motorists, the RAC is second to none. The company, which has doubled its membership size since 1987, was established back in 1897 by a group of motoring enthusiasts who declared themselves to be 'a society for the protection, encouragement and development of automobilism'. The title of Royal Automobile Club came in 1907 when King Edward VII extended his patronage. Today, apart from actually manufacturing or selling motor cars, the RAC covers just about every motoring service and eventuality.

However, those high profile offices are doing far more than just acting as a fixed promotional hoarding. Each building is a command and control super-centre, housing a highly complex network of computers and communication networks which cover the whole country. So if you are desperately seeking assistance, an 0800 charge-free call will automatically get you in touch with the nearest centre. Nearest in RAC terms, is the office which can take the call. If the local office is busy, then the call will automatically cascade to the next available office. A central database ensures that no matter where you phone from, you will get a 'local' service.

For the majority of motorists, joining the RAC is effectively an insurance in case of breakdown. Sooner or later, say the RAC, the majority of us will experience that awful moment when the car or motorbike breaks down. And sooner, rather than later, we hope that assistance will arrive! In the RAC's case, that help could arrive well within the hour – 85% of calls are responded to within the hour and, if it is of any comfort, 99% of calls are answered within two hours. The RAC also claims to answer 90% of telephone calls for help within 10 seconds – well within their own quality target. Apparently the average time spent on a repair job by a patrol is only 20 minutes, so with luck you may not even miss the kick-off or curtain-up, and be on time for that special date. As their advert says, the RAC are the new 'knights of the road'.

Breakdown Call

As soon as a call is received from a stranded motorist, the system is triggered. The national charge-free number called is automatically routed to the nearest centre by BT Linkline. Should the control centre itself breakdown (last year Brent Cross was temporarily immobilised when a workman accidentally cut the BT cable!), the call will automatically route to the next centre. Here a 'user friendly' operator will take details – concentrating in the first instance on whether there is any major panic involved – entering details on the menu-driven screen. These details appear on a dispatch screen, giving details of the problem and location. Before long an RAC patrol, or contract garage (if the vehicle has been accident-damaged or all RAC patrols are busy) is on its way to the scene – the vehicle's registration number is the key identification factor which helps the patrol to locate it. Meanwhile, the operator's screen will provide details of the anticipated response time. One unexpected benefit of the new computer system is that it allows the collation of informa-

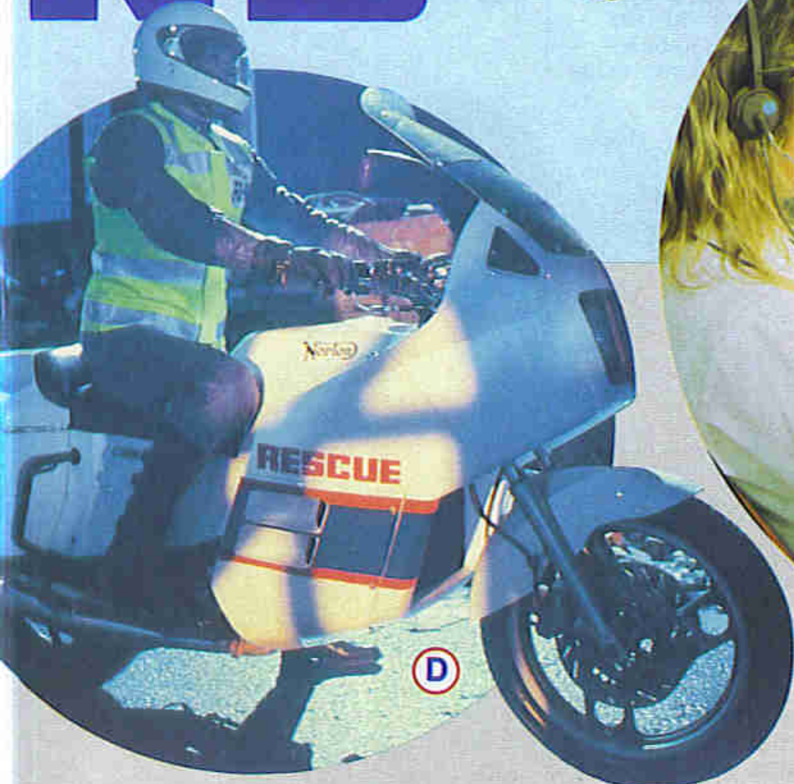


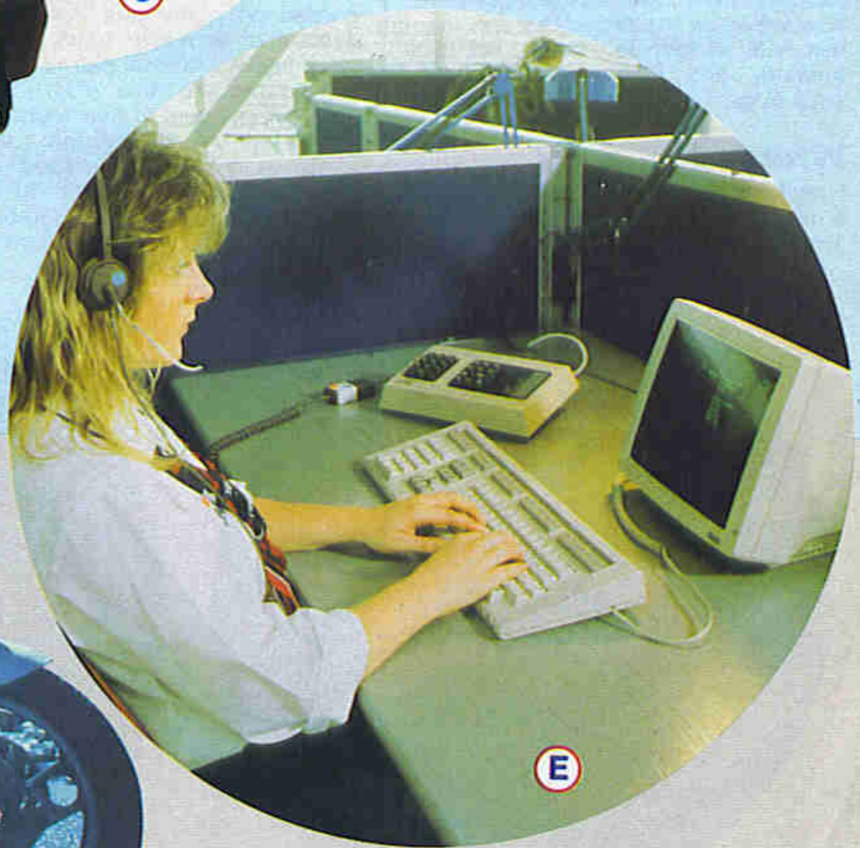
Photograph A: One of the RAC's futuristic Control Centres – in this case, the one by the M6.
Photograph B: A Mobile Data Transfer (MDT) terminal, as installed in each patrol vehicle.
Photograph C: The carryphone version of the RAC ET (Emergency Telephone), manufactured by Motorola.
Photograph D: One of the new Knights of the Road.
Photograph E: CARS – £30 million of technology to aid the RAC member.

tion about breakdowns in a way which was impossible with the paper system. As a result, faults which have commonly recurred in particular vehicles can now be fed back to their manufacturers. In return, several leading car manufacturers now provide free membership of the RAC to purchasers for a year or more, a facility which applies to some 70% of new cars sold in the UK.

The RAC subdivides each region into command areas, each with a full quota of resource vehicles, crews and supervisory staff. The controller consults his screen for data on the incident and the availability of patrols, and sends the data by radio to the selected patrol, via a Mobile Data Transfer (MDT) terminal in the breakdown van. The patrol acknowledges the call, and heads off to help the stranded motorist.

RAC





Each of the mobile data terminals, fitted to all patrol vehicles, has a 160-character LCD display and specially-defined status keys, and is connected to the vehicle's radio system. Plans are already in hand for the next generation of terminal, which will have a QWERTY keyboard to allow text messages to be passed back to control. In any case, each patrol is equipped with a cellular mobile phone which is there primarily to assist members pass on messages, but also can provide emergency communication. But, as the RAC's David Armstrong comments, the majority of our radio traffic is data and is likely to remain so.

Peak Flow

Having arrived at the scene of the breakdown, the patrol will send a data message back to control (another message is sent when the job is completed). As might be expected, peak hour periods coincide with national rush hours – between 7.00 and 10.00 a.m., and 4.00 and 7.00 p.m. However, special factors – such as torrential storms or dense fog – can similarly create havoc with available resources. The worst time? "Well (reflects Andy Edge, the RAC database manager, with something of a shudder), heavy rain after a cold spell on a Monday morning". The weather, it seems, has much to answer for in terms of breakdowns, which can reach 22,000 calls for help in a single day. At such times, even Andy confesses how surprised he is over the resilience of the system. "It never goes down – just occasionally slows up". However, the system did come to a near halt at Brent Cross, when an explosion hit the Edgware Road flyover, which is close to the RAC centre. All lines of communication were cut, and so calls had to be diverted by link line to other centres. Power, however, is not so much of a problem; each centre has its own emergency power supply which swings into action a fraction of a second after national supplies fail.

Such rush and problem hours can be easily accommodated by the DEC VAX computer network, which links the regions. The star and delta layout provides maximum resilience, but even if the network was to fail completely, individual regions can carry on autonomously. Including routers, the RAC has some 83 nodes on its wide area DECNET circuits, which are carried over dedicated BT KiloStream lines.

Getting to Their Man

At least it should provide some degree of comfort to the hapless motorist, stranded somewhere between Stow on the Wold and Chipping Norton on a dark and rainy night, to know that the RAC has recently implemented some of the most modern communication systems. Having groped your way to a telephone – or, if you are a member of the Cellnet/Vodafone club, groped your way to your cellphone – your call will be speedily handled. At each control centre, a bank of operators handle the calls, automatically distributed to them by an ACD-linked telephone system. Manned 24 hours a day, seven days a week, the system incorporates a call-logging device, together with a dot matrix screen displaying details of all calls handled, waiting time, and (the dreaded word for the RAC!) the number of calls abandoned. "Until we installed the new system, we never knew just how many people tried to contact us and got lost – now we know the facts. Our aim is to eliminate all lost calls as far as it is humanly and technically possible", says Edge.

Where Are You?

Hopefully, you have broken down near a roadside restaurant or petrol station. Typically, these are landmarks giving the RAC location-finding team vital clues. But it is not just Happy Eaters and BP garages which are featured on the RAC's geographic database. Also included are some 45,000 Ordnance Survey place names, 1·5 million address files based on postcodes, prominent landmarks including public houses (not quite all, but RAC researchers are working on it!) and garages. The RAC confidently believes that they can pinpoint your position within 100 metres, and that it can find their member within one hour. Obviously a boon for chaps like Mark Thatcher whose navigational skills are more than suspect!

All this geographical information, however, is not limited to 'search' and 'find' operations. The RAC is actively expanding its maps and graphics activities, marketing up-to-date maps and, via its numerous patrols, providing road information up-dates to members and media.

CARS

Hardly surprisingly, the RAC have christened their rescue service 'CARS' – an acronym for Computer Aided Rescue Service. CARS links the telephone system to a network of computers, and a national trunked radio system into a seamless web. The system, developed at a cost of £15 million over the last few years, is already handling some 2·8 million breakdown calls a year, and is well set to handle the anticipated 4 million by 1995.

For an organisation which, until seven years ago, did not own a single computer in the breakdown operation, there is no stopping current technological advances. In those BC (Before Computer) days, everything was recorded on paper and handled via a system of conveyor belts. Messages were flashed to local patrols by an AM private mobile radio (PMR) system. This commitment to new technology is confirmed by Andy Edge; "We are installing a new IBM-based system called RESPOND (wait for it) – RESPonsive ON-line Database – which, by providing a common database, will achieve for our insurance business and parts of RAC Enterprises what CARS is doing for roadside assistance". Other facilities being considered include the setting up of a database of stolen vehicles. Then, if there is a call for assistance, all parties will be alerted.

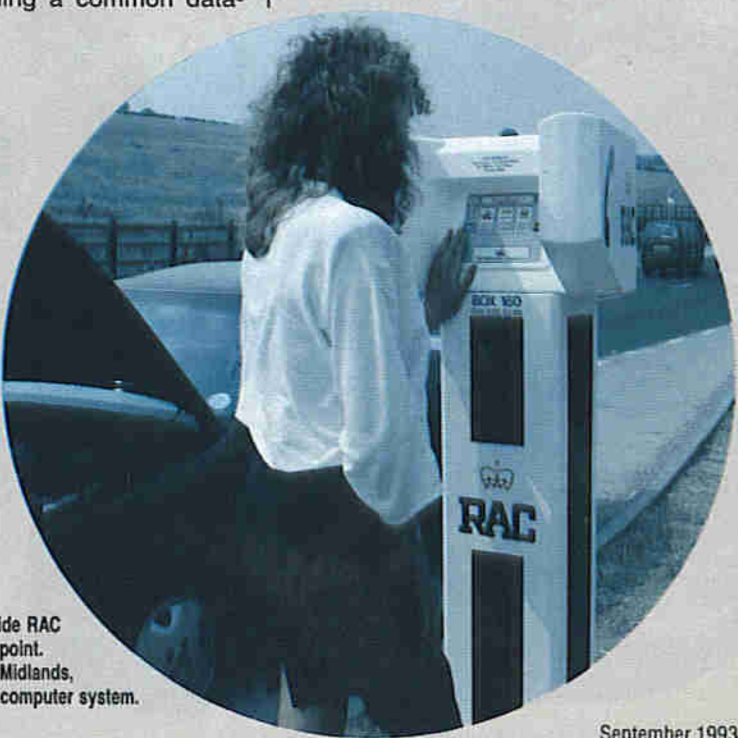
Down Under

When it came to selecting a suitable computer system, the RAC travelled to Australia to examine a promising DEC-based Computer-Aided Dispatch operation. The system was brought over for a trial, while an in-house user group was formed to design a package which would not only meet all present requirements but would accommodate the future. Overall, the package had to be competitive and flexible and, if possible, sourced from single suppliers. In the procurement process, Dowty (now Dopra System Integration) were chosen as the sole supplier, with Storno and YRL as subcontractors. DEC supplied the hardware through YRL, who also provided the tailor-made software. To give some idea of the undertaking, the bulk of the software (some 900,000 lines) was written in Fortran, and 300,000 in C.

All five RAC centres have a pair of MicroVAX computers, each capable of handling all the traffic of one centre, or taking over the work of another should a failure occur, thereby providing total resiliency. Breakdown details are logged onto a local VAX machine which can 'speak' to all other networked VAXs – in particular, the central site at Stockport. Current rescue details apart, the computers also look after important areas such as membership data and automated payment to garage contractors for breakdown services rendered.

Safe and Secure for a Lifetime

With women motorists in mind, the RAC has linked forces with Cellnet to



Above Right: A roadside RAC emergency telephone point.
Above Left: The West Midlands, as seen by the RAC's computer system.

provide a lower-cost cellular phone service. The RAC ET (Emergency Telephone) combines an automatic free link to the emergency and breakdown services within a carryphone, for use in or out of the car. The unit also takes calls, messages and 'phones home' at any time. Calls are routed from the local radio relay station, along a MegaStream line, to Cellnet where calls will be redirected to a local RAC centre. Here, the emergency calls will be priority identified.

When used as an emergency telephone only to counter breakdown frustration, ET running costs average less than 50p a day and the Motorola (an apt supplier!) unit costs about £200 to buy. Otherwise watch out. While the rental costs are about half of those of the standard cellular phone service, the costs of calls are in a higher bracket. Even so, Cellnet believe they are on to a very good thing and are forecasting some ten million domestic customers by 1999.

More for the Motorist

But it is not just rescuing damsels (and others) in distress in which the RAC excels. The organisation, as David Armstrong makes clear, provides a whole raft of services. These include acting as the British Motor Sport authority – in particular, organising the British Grand Prix and the RAC Rally. The RAC is also on hand to provide legal advice to over 200,000 members annually. With over £7 million in claims being recovered under the Accident Recovery Scheme, the service is much appreciated. Perhaps even more comforting in these days of automatic camera speed traps, an RAC member receiving a summons for a motoring offence can receive free legal representation by a solicitor (and sometimes by counsel) appointed by the RAC in any court of summary jurisdiction in the UK. Free technical advice from RAC engineers is also available to members on all aspects of motoring. This includes advice on the purchase, repair and general maintenance of cars. The engineers will also check invoices for repairs on behalf of members and negotiate with manufacturers to assist in problems arising out of new vehicle warranty claims. The RAC will also happily quote you a full range of insurance services – covering both car ownership and mechanical breakdown.

Perhaps a more easily recognised benefit is the Signs division, and here new mobile workshops have recently hit the roads. But when unusual subjects are signed, the retrieval team have an easy time. As the National Signs Manager, John Barrand, says, "unusual subject matters often attract sign collectors, whether signposting the way to a pop concert or 'a great haggis shoot' in Scotland."

Also clearly visible are the large range of publications designed to assist the motorist in every possible way. These include street maps and driving manuals, holiday and hotel guides, route planners, camping and caravanning guides, European atlases, road maps and videos. There is also a 'Free Members' update, which is issued regularly, while the publication 'RAC Motoring' is produced every alternative year and issued free to members.

On a somewhat wider front, the RAC runs a fully comprehensive travel service advising on routes, potential trouble spots and the provision of essential touring accessories (compulsory in certain countries). If you intend cashing in on the now almost limitless duty allowances from Calais, then the RAC will make the necessary ferry reservations – and hopefully advise on the dangers of overloading your Mini with cut-price beer.

But not all RAC personnel spend their lives inspecting the innards of your car. An influential team regularly inspects and recommends hotels, grading them on a scale from one to five. Just what rating they would award to the popular French-operated 'Formula One' chain of motels, where booking formalities are limited to the insertion of a credit card into the front door, and staff are noticeable by their total absence, is an interesting thought. Minus 5 star perhaps? The RAC also maintain and operate two club houses; one in London's Pall Mall, and the other in Woodcote Park, Surrey.

On the Campaign Trail

The company, says David Armstrong, is still campaigning hard on the motorist's behalf, just as it did at the beginning. But for many motorists, a higher RAC profile in this area of activity would be appreciated. Many commentators, perhaps, would like to see the RAC hammering away at the Government to relax the speed limits on motorways, withdraw its planned road pricing scheme, or introduce the French system of flashing amber traffic lights at crossways after midnight. (For the record, the RAC states that 74% of accidents occur in built-up areas, 23·5% on non-built up roads, and just 2·5% on motorways) But, for a body whose patrons include HM The Queen, and whose President is HRH Prince Michael of Kent, such jousts against the establishment must perhaps be limited! Although to be fair, the RAC believe that they hold no punches.

Not that there is any lack of punching funds available. Income for 1991 alone totalled nearly £200 million. Today, quality of service is at the heart of the modern RAC objectives. As is the RAC Motorman Scheme, which provides breakdown cover for new vehicle purchasers. Cars which are already participating in the scheme (which generates almost one million new members a year) include those manufactured by such industry giants as Ford, Vauxhall, Renault, Volkswagen, Toyota and Lotus.

But not all is hard graft for the numerous RAC patrols teams. One patrol, responding to an 'out-of-petrol' call from the M4, found the car's female occupants sunbathing 'Fergie style' on its roof – whether the patrol had to send for reinforcements is not known. 1997 sees the RAC celebrating its first centenary. Certainly the motoring world has changed dramatically from those 'red flag preceding the automobile' days. The next 100 years are likely to see an even more dramatic change, with battery power possibly replacing petrol, and cars running on a navigational radar-aided course. Even so, there is no question that the RAC will not be on hand to top up the battery or advise on how to get out of the electronic directional traffic jams.

Impressed by the RAC services? Then you could experience the delights of RAC membership yourself – and for free. No more wondering if you are going to make it to the local Maplin shop and back. No more worrying if you are planning to visit a special friend in the next county. The RAC has kindly donated three one-year subscriptions, together with six RAC atlases as runners-up prizes. There's also the opportunity for all the winners to visit their local RAC Control and Command Centre. All you have to do to enter this super competition is to correctly answer the four questions listed below, write your answers on the cover-mounted entry card, fill in your name, address and daytime telephone number, and post your entry, to reach us by 30th September 1993. If the entry card is missing, you can still enter by sending your answers on a postcard (or sealed envelope) to: 'RAC Contest', The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR.

As ever, employees of Maplin Electronics and their family members are not eligible to enter.

RAC Competition

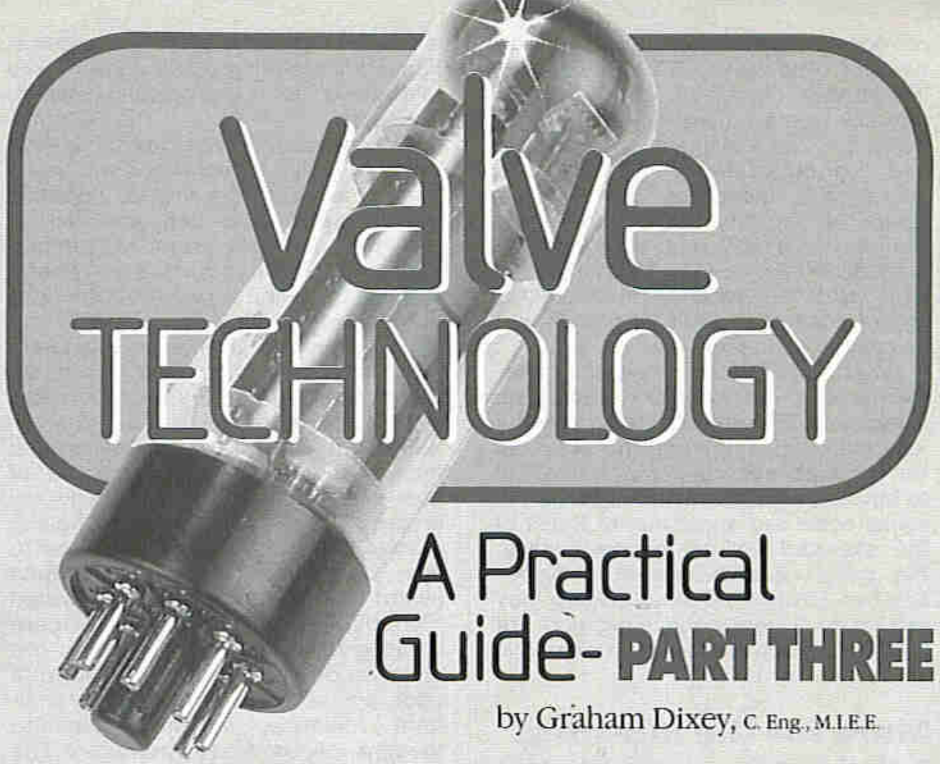
So rev up now!

1. Until recently Princess Di was to be seen in her:
a) Mercedes Sports
b) Sinclair C5
c) Trabant
d) Patriotic *British* sports car

2. Who is a typical driver of the Renault Espace?
a) Dr Who
b) Local fish-and-chip shop owner
c) Harrison Ford
d) A family man

3. The world's first automobile trial held in France in 1887, was won at an average speed of:
a) 71mph
b) 16·22mph
c) 136mph
d) 215km/h

4. Spot the odd one out:
a) 911
b) 924
c) 944
d) 999



Valve Technology

A Practical Guide - PART THREE

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

In Part Two of this series we looked at the basic principles of the triode amplifier and considered how to calculate its gain, how it could be biased and so on. Now we shall design an amplifier from square one and see how it stands up to a practical test. The valve that we shall use is the ECC81, which we now know is the same thing as a 12AT7, or even a CV455. Since this comprises two triodes in a single envelope, we shall only need to use one of them, at least initially.

Design of a Triode Amplifier

It would be nice if the design of an electronic circuit could be carried out merely by using a set of formulae into which we inserted the required parameters for performance, and out came all the component values! Unfortunately, life just isn't like that and there is usually an element of 'guestimation' somewhere in the design, often at the beginning. For example, supposing that we know that we need to amplify a certain signal by 20 times, how do we proceed to design an amplifier using this single fact? What DC supply voltage should be applied to the stage? What should be the value of the anode current? Where do we place the grid bias point on the mutual characteristic? In short, where do we start?

Where we start is dictated largely by common sense, though a little previous experience helps as well. Take the question of the supply voltage; this may well be dictated by the availability of an existing power supply. However, we should also consider how large the output signal can be, since this may influence the choice of an alternative DC supply. Let us take an example.

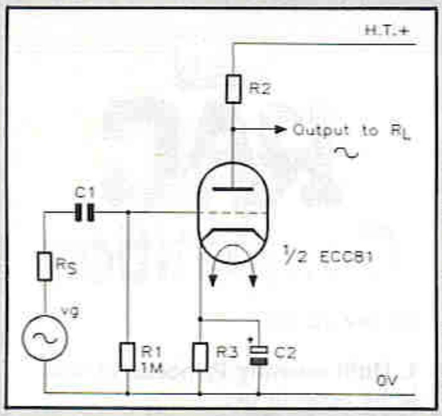


Figure 1. Basis for the design: circuit diagram for a single-stage triode voltage amplifier.

The circuit for the amplifier that we are going to design is shown in Figure 1. It is a simple, single-stage voltage amplifier, which is assumed to be fed from a source of some impedance R_S, and whose output is to drive a load R_L. In this design we shall have to determine the values of the anode load and cathode bias resistors, R2 and R3 respectively, as well as the value of the input coupling capacitor C1 and the cathode bypass capacitor C2. The grid leak resistor R1 has the usual value of 1MΩ.

If we are using the simple valve power supply presented in the last article, then the available DC output voltage will be approximately 150V, and the amplifier design will have to take that into account as a limiting factor. Suppose that we know that the signal source will never provide a signal greater than 0·6V RMS in magnitude. If the gain of the amplifier is 20 times, then the output voltage from the amplifier can never be greater than $0{\cdot}6 \times 20 = 12$V RMS. This we must convert to a Pk-to-Pk value in order to see how the signal swings fit in with the limit of 150V total dictated by the power supply.

The relation between RMS value and the corresponding Pk-to-Pk value is given by:

Pk-to-Pk value = RMS value $\times\ 2\sqrt{2}$

Which in this case means that the Pk-to-Pk output voltage

= 12 × 2·828,
= 34V (approx.)
= 17V peak.

This is apparently well within the range of the 150V supply to be used. All we need do is ensure that the steady (no signal) value of the anode voltage allows the total swing of 34V to take place without either signal peak approaching too closely to either 0V or +150V. The easy solution is to set the steady anode supply voltage halfway between 0V and the HT value, namely 150V. This would give a steady anode voltage of 150/2 = 75V. On positive half-cycles of the signal, the output level would rise to 75 + 17V, which equals 92V; on the negative half-cycles of the signal, the output level would fall to 75 −17V, which equals 58V. Quite clearly there is a healthy margin in hand in terms of the voltage gap between each peak and the appropriate supply rail, as shown in Figure 2. This should always be integral to any amplifier design. It might be tempting to assume that, in the case of this particular design, where the anode voltage is set midway between 0V and HT+, that we could actually drive the amplifier so as to produce an output swing of 75V peak, the anode voltage then rising to +150V on one half-cycle and falling to 0V on the other. This is only theoretically possible however, the

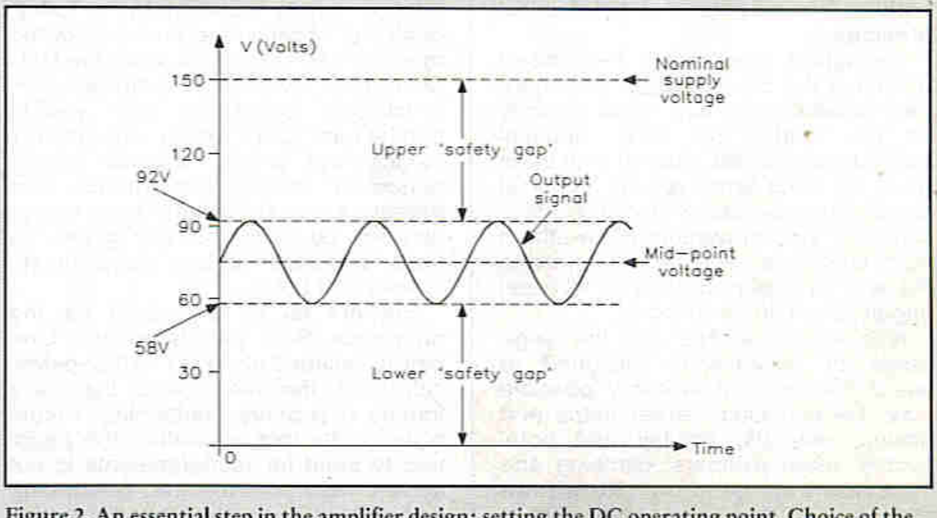


Figure 2. An essential step in the amplifier design: setting the DC operating point. Choice of the mid-point ensures maximum symmetry of output but other settings are possible.

difference between theory and reality being that non-linearity of the valve characteristics would cause gross distortion to be produced well before these limits were reached.

It is not always either necessary or desirable to set the steady value of the anode voltage to half the supply voltage, just to ensure that the signal can be accommodated. As long as the signal swing does not closely approach either HT+ or 0V, a wide range of values for the choice of steady anode voltage is possible. In this particular design we shall set the value at about 100V.

Calculations for the Anode Current and Anode Load

The steady value of the anode voltage is equal to the supply voltage minus the potential drop across the anode load resistor. Mathematically:

$$V_{a(DC)} = V_{HT} - (I_a \times R2) \quad \text{(Equation 1)}$$

If we substitute the known quantities into the above equation, we get:

$$100 = 150 - (I_a \times R2)$$

The second term on the right-hand side, i.e. the product of anode current and anode load resistor, is unknown, or at least one of the terms within it, either I_a or R2, is effectively unknown, since knowing either of these would allow the other to be found by transposition! The question is, which one can be turned into a 'known' term?

One parameter that has been defined for this amplifier design is the voltage gain, which is required to be 20. The formula for voltage gain, or Voltage Amplification Factor (VAF) as it is alternatively known, for a triode is as follows.

$$\text{VAF} = \frac{\mu \times R_L}{r_a + R_L} \quad \text{(Equation 2)}$$

The values for the above parameters for the ECC81 are typically r_a = 13·5kΩ; μ = 54 at an anode voltage of about 170V, rather higher than that used in this design. We can, at least initially, substitute these values into the equation for VAF, as well as the required value of VAF, namely 20, to give:

$$20 = \frac{54 \times R_L}{13{\cdot}5 + R_L}$$

(R_L and r_a both in kΩ)

Transposing and simplifying,

$$R_L = 270/34,$$
$$= 7{\cdot}94\text{k}\Omega.$$

You may be saying at this stage that what we are interested in finding is not R_{eq} but R2, the anode load resistor. Yes, that is true, but in this design they are assumed to be the same thing. Since the load which the amplifier is driving is high, it has negligible shunting effect on the anode load and, hence, on the voltage gain. We can consider other cases later.

We should probably choose to use the nearest preferred value to the above calculated one, namely 8·2kΩ, even though, in theory, this would give a gain slightly higher than that required. However, this is not of any real importance, since there is no guarantee as to the *actual* value of g_m that the valve in use will have anyway, because the figure of 4·0mA/V quoted in the data book is no more than a guide to the *typical* value, and production tolerance spreads will ensure that some samples will lie above this value and some below. In fact, I decided to use a 10kΩ resistor for the anode load thus, hopefully, giving me a little gain in hand.

You may get some flavour of how design goes in practice from this: you just cannot be too academic about it, because so often there are few parameters that can be tied down exactly, and flexibility and compromise often have to be used.

We can now return to Equation 1 above and substitute into it the value of R2. This gives:

$$100 = 150 - (I_a \times 10)$$

(I_a is assumed to be in mA)

This must be transposed for I_a to give:

$$I_a = (150 - 100)/10, = 5\text{mA}.$$

This value of anode current is well within the capabilities of the ECC81, as can be seen from the mutual characteristics for this valve given in Figure 3.

Calculation of Cathode Bias Resistor

This is R3 in Figure 1, and its value is given by the following Ohm's Law equation.

$$R3 = \frac{\text{Bias voltage required}}{\text{Anode current.}}$$

The value of bias voltage required is obtained from Figure 3, where the anode current value calculated previously, namely 5mA, is projected across to the V_a = 100V characteristic and then projected down onto the $-V_g$ axis. The value of V_g required is then found from this construction to be −0·5V. The value of R3 is easily obtained now by dividing the bias voltage (0·5V) by the anode current (5mA) – convenient figures! – to give a value for R3 of exactly 100Ω.

Decoupling the Cathode Bias Resistor

As is the case with common emitter transistor amplifiers, the resistor in the cathode lead (emitter lead) must be

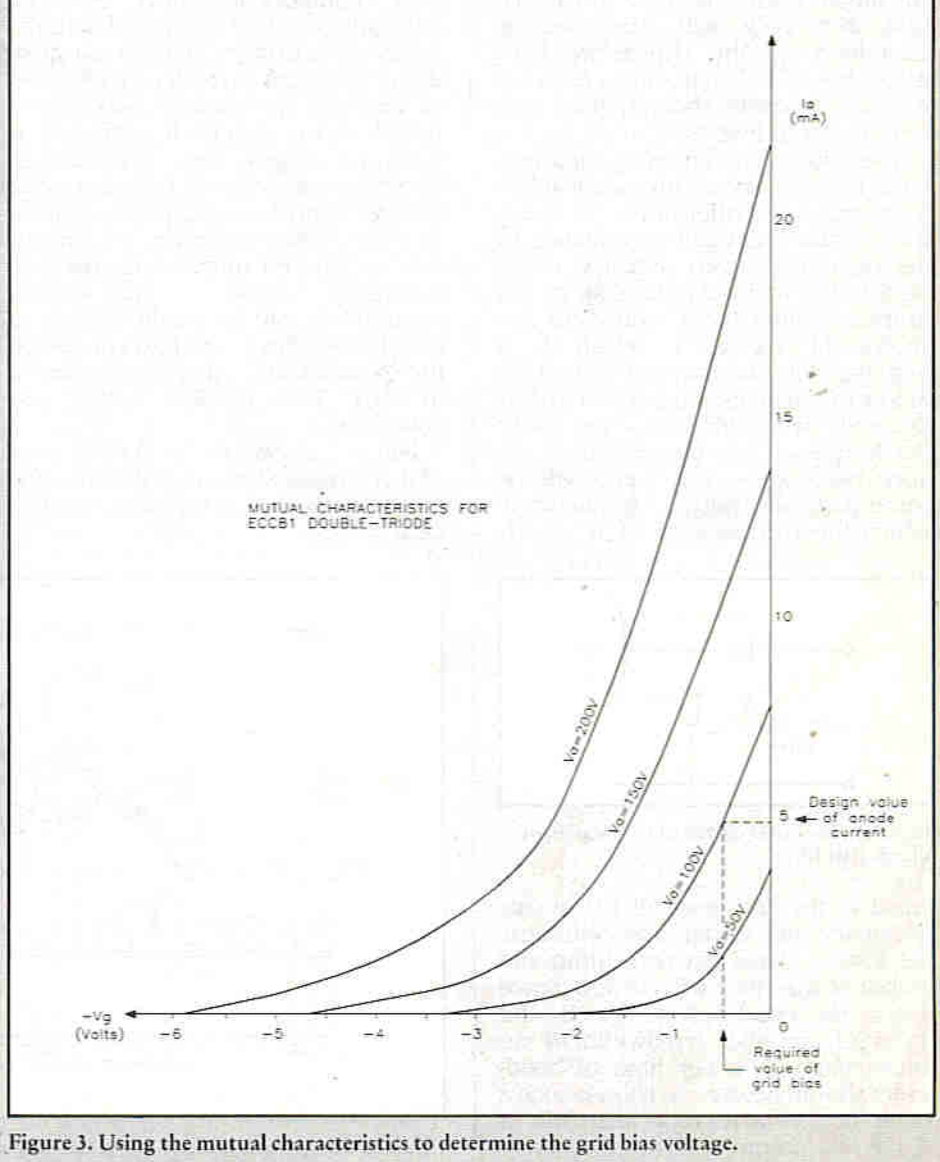


Figure 3. Using the mutual characteristics to determine the grid bias voltage.

decoupled satisfactorily at all frequencies of interest. The rule-of-thumb method that allows the correct choice of decoupling capacitor to be made is as follows.

'At the lowest frequency of interest, the decoupling capacitor should have a reactance no greater than one tenth of the value of the resistor that it is to decouple'.

Using this rule, and with a bias resistor value of 100Ω, the decoupling capacitor should have a reactance of not more than 10Ω at the lowest signal frequency. Let us assume the latter is to be, say, 20Hz. Using the formula for capacitive reactance, that:

$$X_c = \frac{1}{2\pi \times f \times C}$$

the value of C works out to be 796μF.

Rounding this up to 1000μF should ensure satisfactory decoupling.

The Input Coupling Capacitor

It is fairly common practice at audio frequencies to use a value of about 10 to 100nF, usually the latter; on an old circuit diagram this would be marked as a value of 0·1μF, which is just another way of expressing the same value. However, rather than just make this bald statement, which could even be regarded as something of a get-out, we should justify the value by calculation. Not only will this give us confidence in the choice we have made, but will also provide a basis for making alternative choices, given new criteria, should we want to do so.

The value of this coupling capacitor, C1 in Figure 1, is only important at low frequencies. Furthermore, at these frequencies the input capacitance of the valve, being very small, is of no significance and the equivalent circuit of the amplifier input reduces to that shown in Figure 4, which is a high-pass filter comprising C1 and R1. At low frequencies, the reactance of C1 becomes of significance – the lower the frequency, the greater this reactance becomes – and there will be some particular value of frequency at which the reactance of C1 is exactly

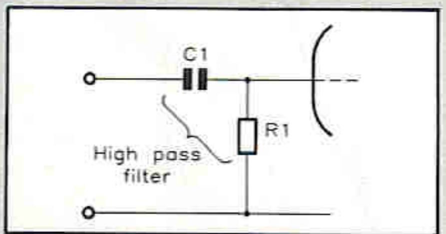


Figure 4. The input circuit of the amplifier as a high-pass filter.

equal to the resistance of R1. At this frequency and under this condition, the loss of signal between input and output of this filter will be 3dB. Since this is the usual way to specify the limits of amplifier bandwidth, if we know what the lower limit of bandwidth should be, we can choose such a value for C1 that no more than 3dB of signal loss occurs at this frequency.

To take an example, suppose that the lower −3dB frequency is to be no higher than 20Hz then, at this frequency, the reactance of C1 should not exceed the value of R1, namely 1MΩ. Using the formula for capacitive reactance in exactly the same way that we did when determining the value of the cathode bypass capacitor C2, we obtain a relationship as follows.

$$1M\Omega = 10^6\Omega, = \frac{1}{2\pi \times 20 \times C}$$

from which:

$$C = \frac{1}{40\pi \times 10^6} F$$
$$= 0{\cdot}008\mu F \text{ (approx.)},$$
$$= 8nF.$$

From this result, it is obvious that a value of 100nF more than meets the bandwidth requirement.

This completes the basic design of the amplifier, and it now remains only to hook it up and test it.

Construction

There is a slight difference in the hook-up methods used with valve circuits compared with those using solid-state devices. The latter, because of their small size, lend themselves readily to stripboard construction. In contrast, the valve has to be plugged into a base, which is itself a relatively large component which must be physically attached to a panel with the necessary hardware. This is no great disadvantage, as in fact it provides a set of nine (in the case of B9A bases) useful wiring points. If a tagstrip is mounted nearby, then it is easy to hook up components between valve base pins and the tagstrip connections. To make life even easier, solder tags can be secured underneath the base mounting screws, so that ground connections can be made straight to the chassis. This is the basis on which the experimental valve chassis shown in Part Two of this series was constructed.

Figure 5 shows the underside view of this chassis where the layout for the components used in this design can be clearly seen.

It is usual when wiring up valve equipment to connect up the heater wiring first. This is always done in twisted pairs to reduce electromagnetic fields from the AC heater current. The terminal block at the end of the chassis can have a pair of terminals allocated for the heater connections, with a further twisted pair running from here back to the power supply. In the same way, a pair of terminals will also be allocated for the HT+ and 0V connections, these running back to the power supply on suitably colour-coded wires. Although I used full wiring posts on my prototype power supply, the proper connectors to fit should be recessed 4mm sockets, so make up 'proper' wire connections terminated in 4mm plugs to connect at the power supply end, rather than simply using wires with bared ends!

The heater connections on the valve base are pins 4 and 5, with pin 9 as the centre-tap, but this orientation is for a *12·6V heater supply.* As explained in Part Two, since we are using a 6·3V supply, the *two halves* of the valve heater are connected in *parallel.* This is done by strapping pins 4 and 5 on the valve base together and running the heater twisted pair from the terminal block to the pins 4/5 and 9 respectively.

The HT connections were run so that one tag on the tagstrip was used for the +150V supply, while the 0V wire was taken directly to chassis by way of one of the solder tags, as shown.

The grid leak resistor R1 is hooked directly between pin 2 of the valve base and a solder tag. Similarly, the parallel cathode bias and decoupling components are taken straight from pin 3 to a solder tag. The input capacitor C1 is connected between the tagstrip and pin 2 of the valve. The anode load resistor R2 is similarly connected between pin 1 of the valve and the tagstrip. It actually takes only a few minutes to hook up a circuit of this sort. Not only that but it is easy to make changes, substitute other components, and so on, because the disconnections and reconnections are

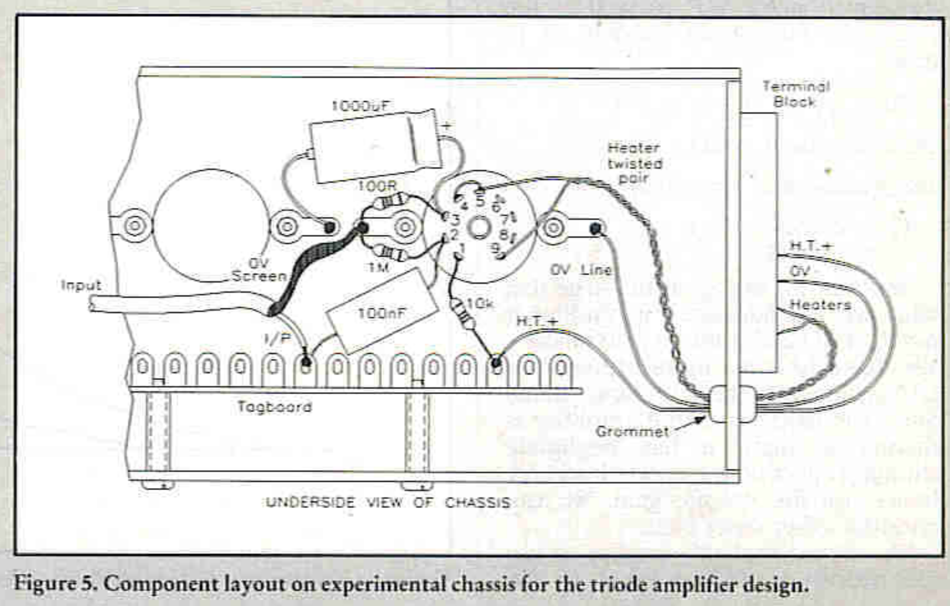


Figure 5. Component layout on experimental chassis for the triode amplifier design.

made at nice solid metal tags and not through small holes in a PCB or piece of stripboard.

Testing the Circuit

Measurements of the DC conditions were made first of all. The following figures were obtained; the figures in parenthesis were the design values.

Anode DC voltage = 116V (100V)
Anode current = 0·46mA (0·5mA)
Cathode bias voltage = 0·46V (0·5V)

The supply voltage was measured at 165V, so was in fact 15V up on the nominal value taken. This fact, together with the fact that the anode current was slightly lower than the design value, accounted for the somewhat raised value of anode voltage. This was not considered critical, however, since Figure 2 shows quite clearly that the maximum expected signal swing can still be accommodated, which was borne out in practice. These DC conditions were accepted as satisfactory and AC testing was then carried out.

Measurement of signal gain was carried out with an input of 1·7V Pk-to-Pk (0·6V RMS) at the test frequency of 1kHz. The output voltage was measured as 30V Pk-to-Pk (13V RMS).

Thus, the mid-band voltage gain (VAF) = 13/0·6, = 21·67.

This compares extremely well with the design value for the VAF of 20.

The output waveform was extremely clean with no discernible distortion.

This was true over the full bandwidth of the amplifier.

In order to measure the bandwidth, an analogue electronic voltmeter was used to set up an output reference of 0dB at 1kHz. Without any further adjustment of input signal level, the frequency was first reduced until the output fell by 3dB. the frequency at which this was noted was 6Hz. The frequency was then increased until, at some high frequency, the output again fell by 3dB. The frequency on this occasion was 130kHz.

The bandwidth of 6Hz to 130kHz thus more than covers the audio-frequency range and in practice it would be necessary to make the high-frequency gain roll off at a rather lower frequency. However, that was not the object of the exercise on this occasion.

Effects of External Loads

As shown in Figure 1, the amplifier is operating into an open circuit. While this may not be strictly realistic, it is not too far from what may be an actual operating condition. If the following stage was also a voltage amplifier of similar type, then its input impedance would be the resistance of its grid leak, at least up to the point where the input capacitance of the following stage started to be significant. Thus the 10k anode load would be looking into a 1MΩ following impedance. This would have little shunting effect on the anode load and, hence, little effect on the voltage gain.

In any cases where the input impedance of the second stage was comparable to the value of the anode load of the first stage, then the effective load of the first stage becomes equal to these two impedances in parallel. In the equation for the VAF, these can be combined into a single equivalent term, R_L'. Then:

$$VAF = \frac{\mu \times R_L'}{r_a + R_L'} \qquad \text{(Equation 2a)}$$

Alternative Expression for Voltage Gain

In Part Two the VAF was stated as being given by the following expression:

$$VAF = g_m \times R_{eq} \qquad \text{(Equation 3)}$$

This requires further explanation, especially in view of the fact that I have actually used a different expression for VAF (Equation 2 above) in the calculations for the gain of the amplifier – or have I? The truth is that the two equations are absolutely identical, merely two alternative ways of stating the same thing. This can be shown quite easily when we understand what R_{eq} means. It is, in fact, the parallel sum of r_a and the anode load R_L. That is:

$$R_{eq} = \frac{r_a \times R_L}{r_a + R_L}$$

Figure 6 shows two middle-frequency equivalent circuits for a valve amplifier. Figure 6a is known as the 'constant voltage' circuit, while Figure 6b is known as the 'constant current' circuit. The constant voltage circuit includes a voltage generator, whose value is $\mu.V_g$, feeding into r_a and R_L in series. The voltage (V_o) across the load R_L is the output of the amplifier and, by proportion, will be as follows:

$$V_o = \mu.V_g \times \frac{R_L}{r_a + R_L}$$

If we divide both sides by V_g (the signal input), the left-hand side will be V_o/V_g, which is obviously the voltage gain, or VAF. What is left on the right-hand side once V_g has been removed will be recognised as the right-hand side of the original equation (Equation 2). That should justify that equation; now for the constant current circuit.

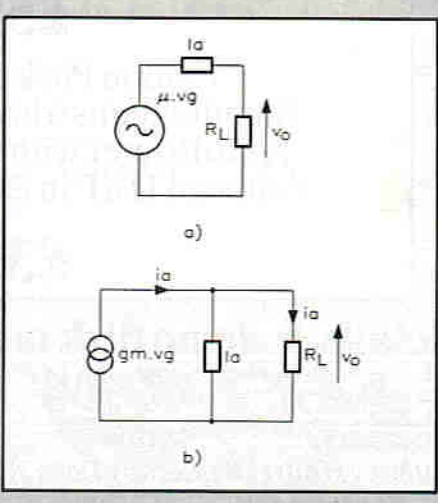


Figure 6. (a), constant voltage and (b), constant current equivalent circuits for a valve amplifier.

The circuit of Figure 6b may not look the same as that of Figure 6a but it is directly equivalent to it. The voltage generator $\mu.V_g$ feeding into a 'series' resistor combination has been replaced by a current generator $g_m.V_g$ feeding into a 'parallel' combination of the same two resistors. This time, instead of the output voltage dividing between two series resistors, the output current divides between two parallel resistors. The proportion of the total current that flows in R_L produces the output voltage V_o by Ohm's Law. This current in R_L is given by: $g_m.V_g[r_a/(r_a + R_L)]$, so that the output voltage will be as follows:

$$V_o = g_m.V_g \times \frac{r_a}{r_a + R_L} \times R_L$$

Again if we divide both sides by the input voltage V_g, the left-hand side will be equal to the VAF and the right-hand side will be equal to $(r_a.R_L)/(r_a + R_L)$, which is the parallel sum of these two resistance values, namely R_{eq}, as defined earlier.

What I have done here is to show that there are two different expressions for VAF, each taken from a different type of equivalent circuit. If you want to show that Equations 2 and 3 are equal, you can easily do so by using the relation that:

$$\mu = r_a \times g_m$$

But I'll leave that up to you!

The Cathode Follower

This circuit, shown in Figure 7, is the valve equivalent of the emitter follower and has the same advantages. The load R_L is in the cathode lead. The grid leak resistor and the input coupling capacitor are required as before. The grid bias voltage is derived in exactly the same way as for other valve amplifiers, by the DC voltage drop across a resistor in series with the cathode. However, since the value required for R_L might not be compatible with the resistor value calculated for the bias voltage, one or other of the two arrangements shown in Figure 8 may sometimes be used.

In Figure 8a, the load resistor comprises two resistors in series, (R_L = R2 + R3), because the value calculated for the cathode bias is less than that required for the load. In this case the DC bias voltage is developed across R2 and the grid leak is returned to the junction of R2 and R3 instead of to 0V.

In Figure 8b, the load resistor has to have a smaller value than that required for developing the bias. In this case, the total resistance of R2 and R3 in series is used to obtain the bias voltage (grid leak returned to 0V) and R2 is

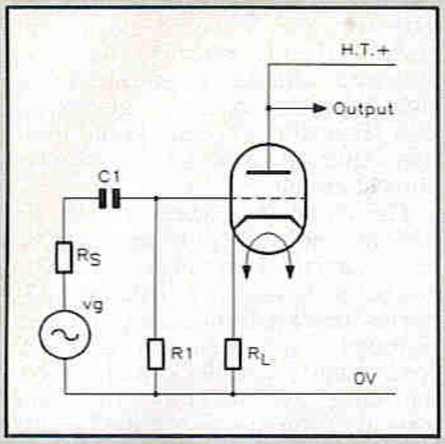


Figure 7. The cathode follower.

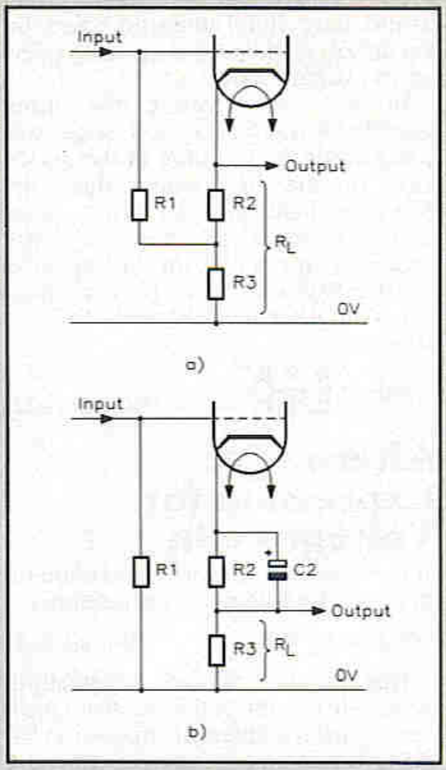


Figure 8. Biasing the cathode follower: (a), load value greater than bias value; (b), bias value greater than load value.

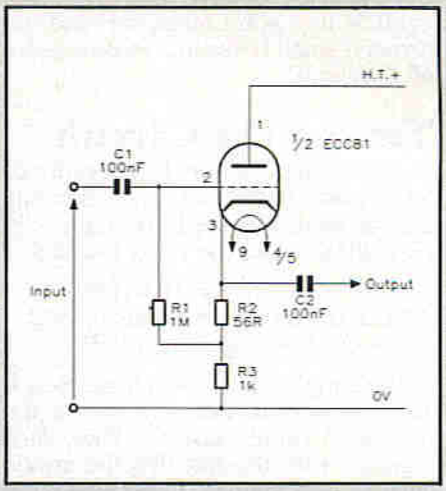


Figure 9. Design for a cathode follower.

short-circuited to AC by capacitor C2 so that only R3 acts as the load for the amplifier. These latter arrangements are to be preferred to ensure that the output is not *less* than the input level, which is likely in Figure 7.

The input impedance of a cathode follower is very high (though in practice it may be limited by the presence of the grid leak across the input), while the output impedance is very low. It is essentially an amplifier with 100% negative feedback, so the gain drops to less than unity while the bandwidth increases in inverse ratio.

A circuit was designed using the criteria that I_a = 10mA; V_a = 150V, giving a grid bias voltage of −0·6V (taken from the mutual characteristic of Figure 3). The value of cathode bias resistor calculated from this data is 60Ω (0·6V/10mA) and a standard value of 56Ω was actually used. This is R2 in Figure 9. To allow a reasonable signal swing, it was decided to set the cathode potential at +10V; thus R3 would need to be about 1kΩ in value.

The circuit of Figure 9 was hooked up and tested. In practice, the anode current turned out to be 7·7mA, setting the cathode potential at +8·6V. The gain was measured as 0·83 at the mid-band (1kHz). The bandwidth was too wide to be measured with the available signal generator but, as an indication of how far the bandwidth is extended, the gain (relative to 1kHz) fell by 0·6dB at 5Hz and by 0·4dB at 500kHz.

Next month we unravel the mysteries of tetrodes and pentodes.

PROJECT RATING 1

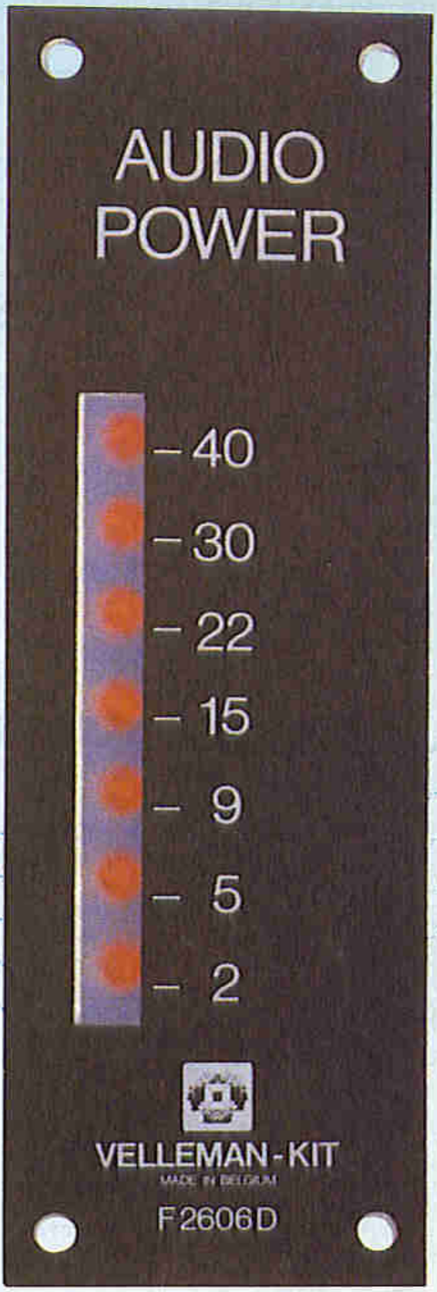
7-LED AUDIO POWER METER

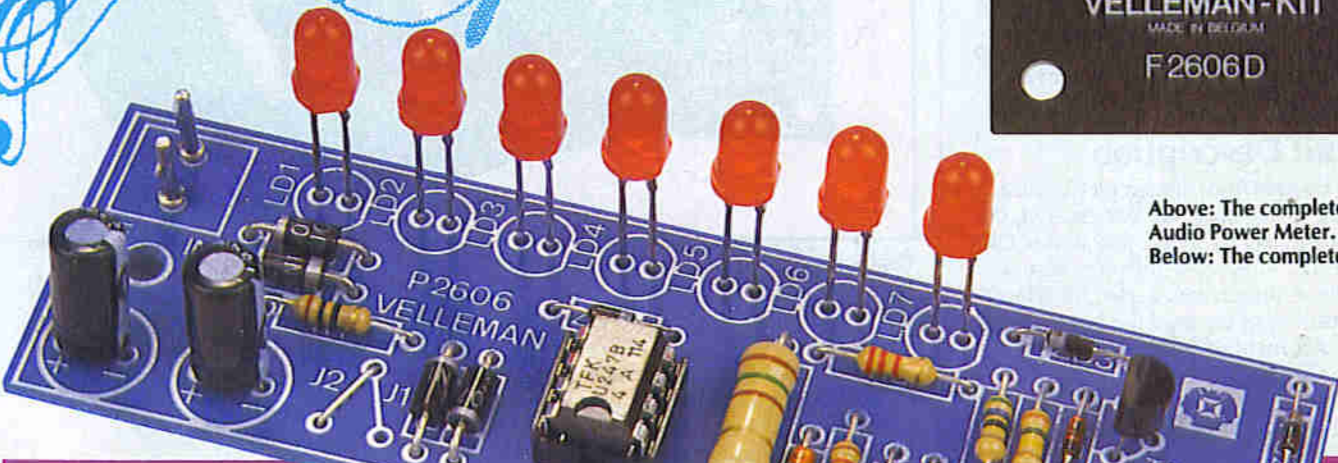
KIT AVAILABLE (VE27E) PRICE £18.95

Text by Martin Pipe and Nigel Skeels

If you've ever wondered how much power your amplifier is kicking out, the 7-LED Audio Power Meter will help you find out.

This project has seven LEDs that illuminate, in bargraph fashion, indicating the peak power output levels.





Above: The completed 7-LED Audio Power Meter. Below: The completed PCB.

FEATURES

- ★ 7-LED scale
- ★ Measures peak audio power levels up to 200W
- ★ Directly driven from the loudspeaker output – no other power required
- ★ Metal front plate and four plastic scales included for easy panel mounting
- ★ Can be built into amplifier or speaker enclosure
- ★ Suitable for use with 4Ω and 8Ω speakers

APPLICATIONS

- ★ In-car audio
- ★ Disco systems
- ★ Speaker and amplifier designs

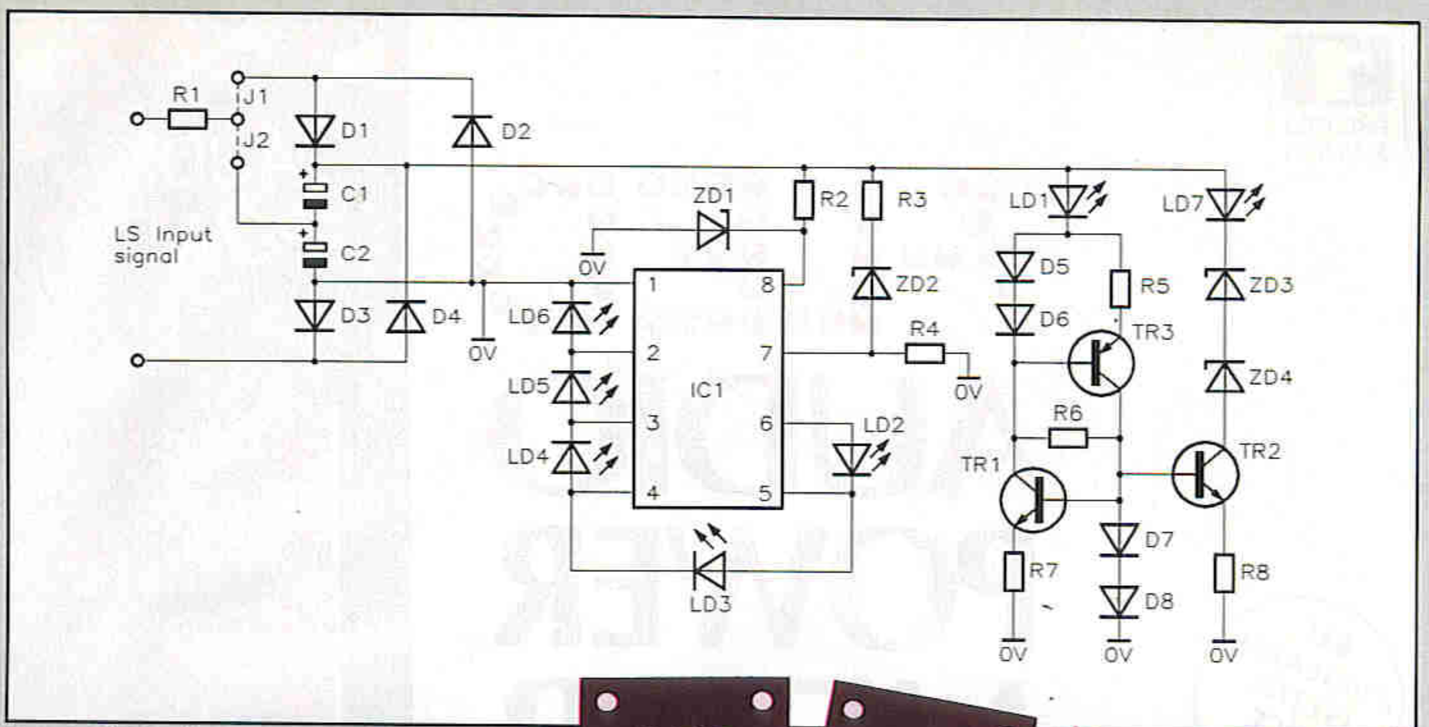


Figure 1. 7-LED Audio Power Meter circuit diagram.

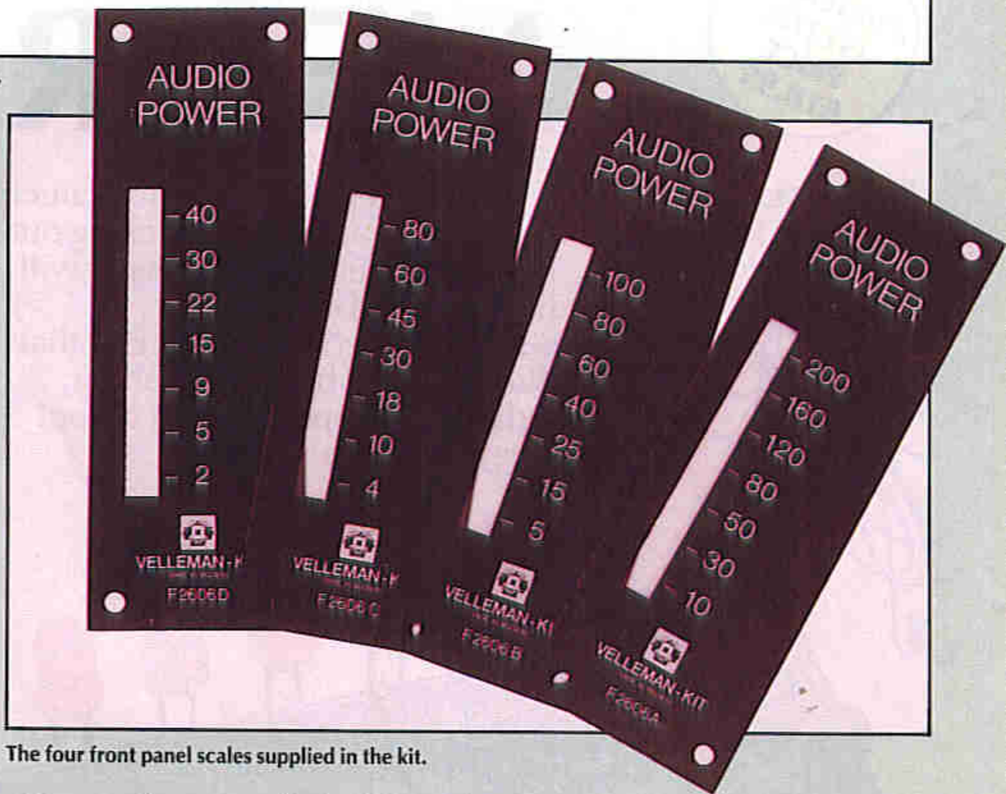
Two power ranges are selected via a link on the PCB; since the power level will depend on the impedance of the speaker used, two front-panel scales are provided for each sensitivity – one for use with 4Ω speakers (100W and 250W, 'low' and 'high' sensitivity settings respectively), and another for use with 8Ω speakers (50W and 125W respectively). The device is directly connected to the loudspeakers or amplifier output, and does not require its own power supply, since it derives its power from the amplifier's audio output.

Disco and PA riggers may find the meter quite useful; using a visual indicator for power being fed into a speaker could help to prevent damage caused to the drive units by overloading.

Circuit Description

As can be seen from the circuit diagram in Figure 1, the input signal is applied, via R1, to either D1 (J1) or the junction of C1 and C2 (J2). These two links are present, as we have already mentioned, to select the sensitivity of the module. If J1 is fitted, the input is rectified by diodes D1 to D4. C1 and C2 are used for smoothing.

If J2 is fitted ('low' sensitivity) C1, C2, D3 and D4 act as a voltage doubler. During the positive cycle of the signal, C2 will be rectified by D3, and during the negative cycle C1 is rectified by D4. For measuring the output of high-power amplifiers (the J1 option is used here), voltage doubling is not required, and so the signal is simply rectified. T1 and T3 act as two current sinks delivering approximately 12mA each, which is passed through D5 & D6 and D7 & D8, giving LD1 (the 'least significant' LED) a set current of 24mA. The dissipated power is split over both transistors. T2 also acts as a current sink, but LD7 (the 'most significant' LED) will only illuminate when there is 24V present on the circuit. The circuitry associated with LD1 and LD7 has been incorporated simply because IC1 can only drive 5 independent LEDs.



The four front panel scales supplied in the kit.

By convention, most audio signal meters have a logarithmically-calibrated volume unit (VU) scale (audio recordings have a wide dynamic range, over which a VU-weighted meter will provide a clearer indication) and so each of the four front panel scales is calibrated logarithmically. In the driver configuration used, the current flowing through the LEDs is set at 20mA – they are connected in series to reduce current consumption. The five LEDs under the control of IC1 illuminate when the voltage at pin 7 reaches 0·1, 0·3, 0·5, 0·7, and 0·9V respectively.

Due to the presence of Zener diode ZD2, the supply voltage of IC1 must be approximately 6V before the first LED (LD2) will illuminate.

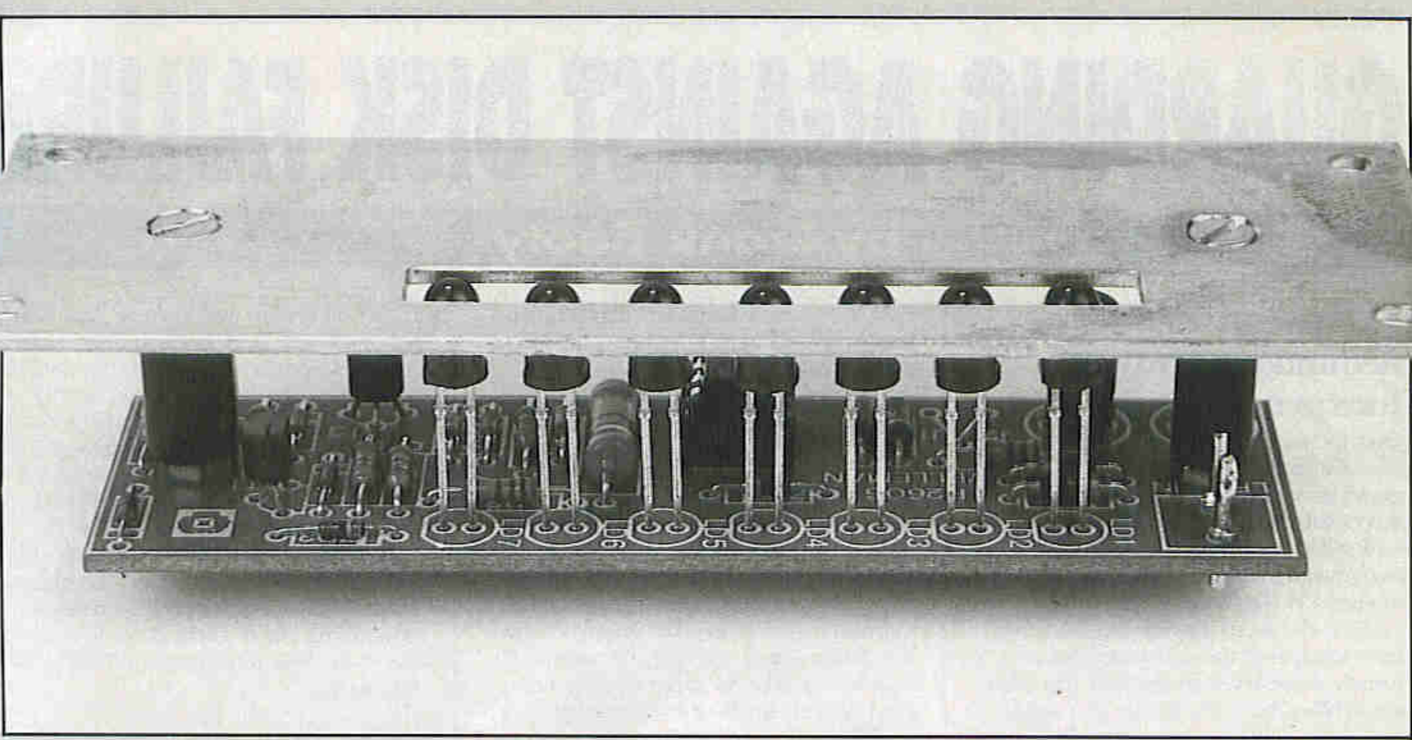
Construction

Construction of this project is very simple, and is dealt with in greater detail in the leaflet supplied with the kit. Novices should consult the Constructors' Guide (XH79L) for practical guidance.

The first component to be mounted on the PCB is the wire link, which sets the power range to suit your equipment and

Speaker Impedance	Amplifier's max. power	J1	J2	Scale for front panel
4	250	IN	OUT	10W to 200W
8	125	IN	OUT	5W to 100W
4	100	OUT	IN	4W to 80W
8	50	OUT	IN	2W to 40W

Table 1. Which link and front panel scale do I need?



Side view of the module, showing how the LEDs are mounted.

should be fitted in either position J1 or J2. The link required may be determined from Table 1.

Install the other components, beginning with the smallest first. The diodes, electrolytic capacitors and transistors are all polarised devices and care should be exercised when fitting them to the PCB. Information on the corresponding symbols of PCB legend – be it a physical outline or a polarity symbol – will help you get the component correctly orientated prior to soldering. The IC socket must also be correctly orientated in this way – do not, by the way, fit the IC until soldering is complete. When fitting the PCB pins, note that they are pushed in from the component side of the board – the tip of your hot soldering iron may help to force the pin into position. The final point to note is that the distance, from the tip of each of the seven LEDs, to the PCB should be 23mm. As for other semiconductors, care should be taken. The IC can now be inserted into its socket – the correct way round. This would now be a good stage to check your work for misplaced components or solder problems – your amplifier may not take too well to a direct short applied across its terminals, which has been caused by an accidental solder bridge!

Finally, the metal front plate is screwed to the board, as shown in Figure 2. Note that the PCB is separated from the front plate using two 20mm plastic spacers. If you are mounting the power meter onto a metal front panel (e.g., that of an amplifier), you could, as an alternative, use the supplied front plate as a template. This would allow you to prepare (i.e. drill the four holes and cut the LED slot) the front panel and mount the meter directly; this may lend a better final appearance to your equipment.

Depending on the range selected by the links, and the impedance of the speaker system, the relevant scale can now be glued to the front panel/plate. Be sure to avoid getting any adhesive on the clear section of the scale, otherwise the light path of the LEDs may be partially blocked, lending an untidy appearance to the finished installation. Note that adhesive is not supplied – epoxy glue (e.g., FL45Y) is perfectly adequate. *Do not use solvent-based glue, which may attack the plastic and render the scale markings illegible.*

Installation

The exact method of installation will depend on your individual requirements. We have looked at how the 7-LED Audio Power Meter may be fitted directly to the front panel of an amplifier instead of the supplied one, which is used as a template. If desired, the meter can also be fitted directly onto a speaker cabinet. An oblong cut-out should be made, with slightly larger dimensions than those of the PCB – but only just, so that there are no ugly gaps visible around the front plate, and so that the mounting screws will penetrate into wood! Figure 2 gives the dimensions of both PCB and front plate. Don't, at this stage, forget that provision should be made for the lead-in wires from the speaker input (these can be obtained from the crossover's input leads).

For best results, and minimum disruption to the sound quality of your speaker, a gasket should be used to provide an airtight seal where the meter's front plate meets the wood of the cabinet. Although one is not supplied, one can be made cheaply and easily (a cork tile, etc.). Alternatively, flexible rubber sealant (YJ91Y) could be used.

You could build the meter into its own enclosure, so that it can be used as a stand-alone test-meter. The clear plastic box, in which the kit is supplied, could be used for this purpose – others can be found in the current Maplin Catalogue.

Wiring up the 7-LED Audio Power Meter is easy. There are only two connections ('LF IN'), which are connected across the amplifier output, or loudspeaker input (whichever cabinet is

Continued on page 62

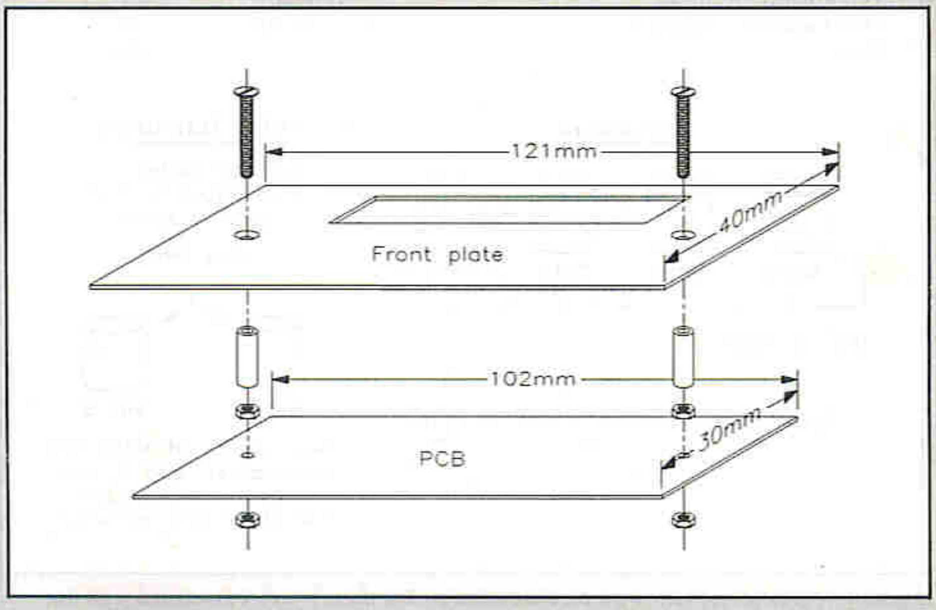


Figure 2. Fitting the PCB to the metal front plate.

GUARDING AGAINST DISK FAILURE

by Frank Booty

The Theory of a Redundant Array of Inexpensive Disks

Over the past decade, the power and size of midrange computer systems has grown enormously. The small, but highly successful IBM System/38 processors look somewhat dwarfed set against a 9406-E90 system with 512 Megabytes of main storage, 125 Gigabytes of disk storage and 2,400 workstations. During this time, the main strength of the midrange systems, namely single level storage, has also been the Achilles' heel. The failure of a single disk drive will bring down the whole system, and will require a lengthy restore process of all the disks from the most recent tape back-up.

As history has shown, the reliability of the various components used in computers has improved considerably to the point where a user would be very unlucky to experience a failure of the CPU or associated cards. Disk drives have improved too, and reliability is now commonly in excess of 150,000 hours mean time between failures (MTBF).

However, disk drives are still mechanical devices, and as such will fail periodically. The large number of disk drives now being attached to systems also increases the probability that a single unit will fail. Add to this, the number, size and importance of the application systems being run on midrange processors, then the failure of disk drives is a bigger problem than ever before.

The vulnerability to disk failure on midrange systems has been recognised, and two techniques have been introduced to protect against them – 'checksum' and 'mirroring'. Both techniques are intended to overcome the need for a lengthy 'restore from tape' of the complete system should a disk fail, thus reducing downtime. However, both techniques have their advantages, and disadvantages, which are described as follows.

Checksum

This was introduced on the IBM System/38, and is basically a parity check across a set of disks. If one disk in the set fails, once it has been replaced, the data can be reconstructed from the remaining disks in the set. The advantages of checksum are that it replaces the long restore process with the shorter checksum rebuild (typically three hours against 24 hours once the repair has been carried out); it restores the disks as they were before the failure; and has from one disk in eight to one disk in three overhead (typically one disk in four), see Figure 1. However, the disadvantages are that the system will still stop; the users will still experience down time; some additional hardware still has to be purchased; and there is a significant performance overhead on the system, from 5% to 20%.

Disk Mirroring

Disk mirroring became available on IBM's AS/400 with Version 1 Release 3 of the OS/400 operating system. All disk writes are duplicated to two sets of disks and two identical copies of the data are maintained. If a disk fails and one copy becomes unavailable, then the other copy can be used. Various levels of mirroring are available and duplication can be increased to include not only the head drive assembly (HDA) but the disk controller, the I/O processor (IOP) and the system bus.

Disk mirroring can thus ensure 100% system availability due to a failure in the disk subsystem. If a disk subsystem component has failed then, depending on the system design, either the component can be repaired and the disk sets re-synchronised whilst the system is still running, or planned maintenance can be arranged for a convenient time.

The benefits of Disk mirroring are that it eliminates the long restore process; restores the disks as they were before the failure; there is no stopping of the system; down time is eliminated; and there is minimal impact on system performance. But, with disk mirroring, there is a one disk in two overhead, and the process is very expensive.

Summarising disk protection options (see Figure 1), it can be seen that whilst mirroring appears to be the ideal solution to the problem of protection against disk failure, there is a very high cost associated with this technique. For many sites, this cost cannot be justified by the needs of the business. What is required is a technique which offers a level of protection similar to mirroring but at a cost closer to that of checksum. This requirement is fulfilled by disk arrays.

Redundant Array of Inexpensive Disks (RAID)

This was a set of standards produced by the University of California at Berkeley in 1988. The problem being addressed was that of disk performance for scientific applications and a possible solution was to replace one large disk with several smaller disks with the data spread across them. Rather than the 3MB/sec transfer rate associated with a single disk, an array of four disks could achieve 12MB/sec.

However, the effect of increasing the number of disks fourfold was to increase the probability of a disk failure, and thus

Summary of Disk Protection Options

	None	Checksum	Mirroring
Restore required	Yes	Yes	No*
Typical restore time	24hr	3hr	–
Disks restored as were	No	Yes	Yes
System stops	Yes	Yes	No
Downtime experienced	Yes	Yes	No
Performance overhead	–	5% to 20%	0%
Disk hardware overhead	–	13% to 33%	50%
Cost	–	Low	High

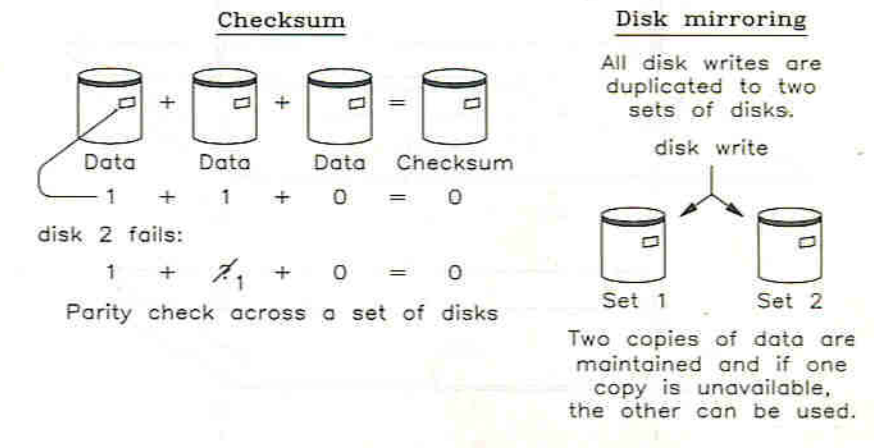


Figure 1. Mirroring appears to be the ideal solution, but there is a cost associated with the technique.

the concept of built-in redundancy was introduced. This work resulted in a set of standards which defined five levels of RAID. Further RAID levels have been added subsequently. Not all RAID levels are commercially viable, but those which are will be examined and the advantages and disadvantages of each highlighted.

RAID level 1 – This offers disk mirroring at the controller level, and should not be confused with disk mirroring as discussed previously which is a function of the OS/400 operating system. 'RAID level 1' (along with the other levels of RAID) is transparent to the operating system. However, the principal is exactly the same.

All disk writes are duplicated by the disk controller (not OS/400) to two disks and two identical copies of the data are maintained, as shown in Figure 2. If one disk fails, then the second disk of the set can be used. Each pair of disks is viewed by the system as a single logical volume and the mirrored set does not count toward the total 'disk access storage device' (DASD) capacity of the machine, as with disk mirroring by the operating system.

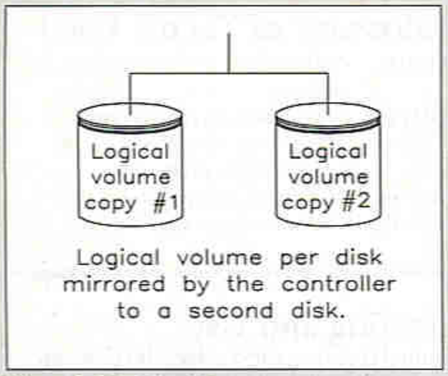


Figure 2. RAID level 1.

Since one in two disks are redundant, 'RAID 1' is an expensive option. However, performance with 'RAID 1' is virtually the same as the unprotected system, even if a disk fails.

RAID level 3 – Whereas 'RAID 1' can be viewed as mirroring at the disk controller level, 'RAID 3' is checksum at the controller level. A single large disk is replaced by, for example, four disks which are ⅓ size. The data is spread across three of these disks by the disk controller (not OS/400) and the fourth is used as a parity drive, as shown in Figure 3. If one disk fails then the data can be reconstructed dynamically from the remaining two disks and the parity disk, until such time as the failed disk can be replaced and rebuilt. Each set of disks is viewed by the system as a single logical drive.

Although 'RAID 3' replaces one disk by a number of others, which are smaller and thus cheaper, 'RAID 3' is still quite an expensive option. For large block transfers, such as those found in the scientific environment, 'RAID 3' will offer very high performance since seek and latency are virtually eliminated. Indeed, this is where the 'RAID' story started. However, for the sort of interactive environment found on the AS/400 the performance of 'RAID 3' is poor, since every system I/O will generate multiple disk I/Os.

Should a disk fail, the resulting performance as the data is regenerated dynamically is also very poor, and unsuited to the commercial environment. A further problem is that because there are now several disks instead of one, the MTBF will be proportionally lower, although the MTBF for a single small disk will probably be better than that for a single large disk.

RAID level 4 – Although not commercially viable, 'RAID level 4' is a useful illustration of how 'RAID 3' develops into 'RAID 5'. The problem with 'RAID 3' in the interactive environment is that since the contents of one logical volume are spread across several physical disks plus a parity disk, one system I/O results in multiple disk I/Os. What 'RAID 4' does is revert to using full size disks and having one logical volume per physical disk while still maintaining a parity disk. See Figure 4.

Since typically only one disk in four is redundant, 'RAID 4' is quite cost-effective. Interactive performance should now be enhanced over 'RAID 3', except that there will be contention accessing the parity drive which is now shared between several logical volumes. A write operation cannot complete until both the data and the parity have been written.

RAID level 5 – To overcome the parity bottleneck with 'RAID 4', the parity is shared across all the drives in 'RAID 5', as shown in Figure 5. Each disk is now larger than the logical volume (about 25 to 40% larger), with the spare capacity being used to store the parity for another disk in the set. If a disk fails, the data can be dynamically reconstructed until such time as the failed drive can be replaced and rebuilt.

Since there are no redundant disks with 'RAID 5', but only a redundant area on each disk, this level of 'RAID' is very cost-effective. There is still a contention issue writing the parity if the logical volume on the disk is in use, but 'RAID 5' is best suited to the interactive environment found on AS/400, and will outperform 'RAID 3' and 'RAID 4'. Performance will be reduced if a disk fails since contention will occur on the disk which contains the parity for the failed disk.

Future Development of RAID

A summary of existing 'RAID' levels is shown in Figure 6. The Berkeley standards defined only five levels of 'RAID', although the technology will develop further in the future. 'RAID 5', for example, could be developed to overcome any contention problems by writing the parity to a buffer instead of direct to disk. The write operation can thus complete quicker and performance will improve. The parity information is transferred from the buffer when the disk is available. The natural extension of this is to not only write the parity to a buffer but also the data itself. The data and the parity can then both be transferred to the disks when they are available and this will lead to very high performance. The problem is that in case of a power failure, the disks must continue to run until such time as the buffered information can be permanently written to disk.

Unlike full system mirroring, all levels of 'RAID' have single points of failure at the disk controller, the IOP and the system bus level. However, a failure in any of these components of a disk subsystem will not normally result in loss of data and will thus not require a lengthy restore from tape. As the technology develops, redundant

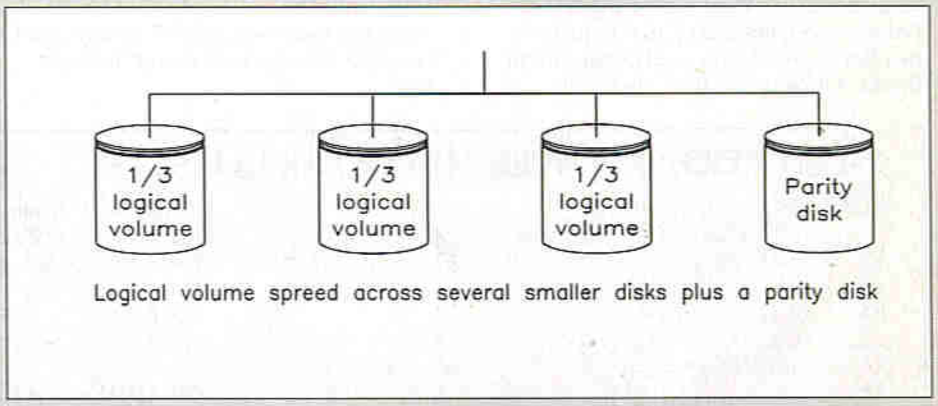


Figure 3. RAID level 3.

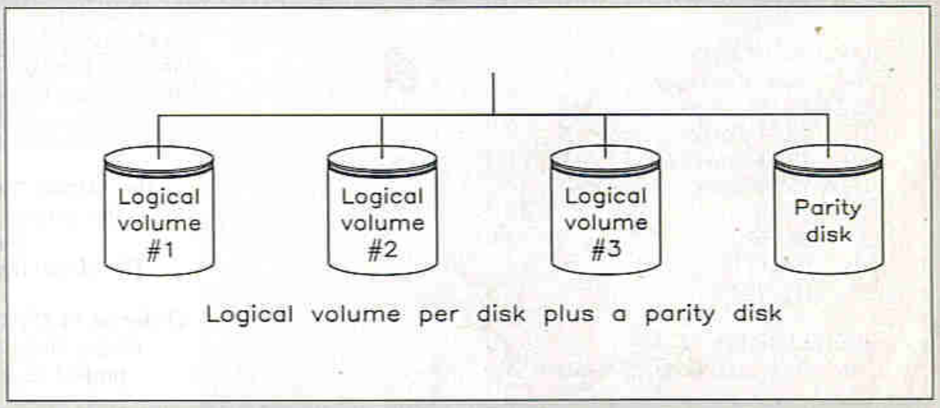


Figure 4. RAID level 4.

controllers and dual channel attachment will start to be introduced which will eliminate these single points of failure.

If a disk HDA does fail, then the 'RAID' subsystem is vulnerable to a second disk failure until such time as the faulty drive can be replaced. Techniques exist which can reduce this window of vulnerability. 'Hot sparing' enables a spare disk to be powered on and running within the subsystem in order to take over from a disk which fails. The disk controller will switch the spare in as a replacement as soon as it detects a disk is faulty. 'Hot plugging' enables the customer to remove a faulty disk and replace it with a new unit while the subsystem is powered up and operating. The disk controller will then rebuild the information on the new disk.

The various levels of 'RAID' discussed could be implemented without the

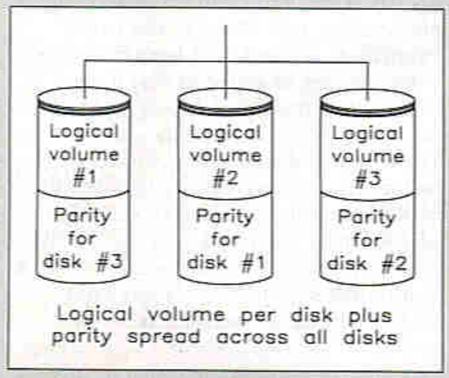


Figure 5. RAID level 5.

Level	Method
RAID 1:	Logical volume per disk, mirrored to a second disk.
RAID 3:	Logical volume spread across several smaller disks, plus a parity disk.
RAID 4:	Logical volume per disk, plus a parity disk.
RAID 5:	Logical volume per disk, plus parity spread across all disks.

	Performance on an IBM AS/400	Cost
RAID 1:	Very good	Very high
RAID 3:	Poor	High
RAID 4:	Poor	Moderate
RAID 5:	Good	Low

Figure 6. Summary of RAID levels.

operating system knowing. For example, the disk controller could make each logical volume appear to the AS/400 as a normal 9336 (IBM type) drive. However, should a disk fail, there is no mechanism for the disk controller to report this fact to the operator. The very nature of the 'RAID' device means it will continue to work as normal, albeit slower in some cases. For full error reporting and logging to be implemented, there will need to be changes to OS/400 to accommodate this. Current implementations of 'RAID' overcome this problem by generating the highest level of disk error which is non-fatal.

Conclusions

'RAID' is a technique which, at fairly low-cost, protects against the failure of a disk HDA – this being the component of a disk subsystem which is most likely to fail. All levels of 'RAID' have single points of failure and 'RAID' is not therefore the ultimate in disk protection. At present, this can only be provided by full system mirroring. 'RAID' can also suffer from poor performance in the interactive environment found on the AS/400, especially if a disk fails and data has to be dynamically reconstructed. What 'RAID' does offer is a cost-effective method of protecting against the majority of disk subsystem failures in those cases where the cost of full mirroring cannot be justified.

Glossary of Terms Used

RAID:	Redundant array of inexpensive disks.
MTBF:	Mean time between failures.
HDA:	Head drive assembly.
IOP:	Input/output processor.
MB/sec:	Megabytes per second.
DASD:	Disk access storage device.

7-LED Audio Power Meter continued from page 59

used!). The meter thus sits in parallel with the speaker. Since the meter has a very high input impedance, it will hardly load the amplifier, and so 7/0·2 wire will be ideal for the two interconnecting wires. Polarity is not important, thanks to the rectifier configuration used by the circuit. Before wiring up the unit, check the resistance across the LF IN terminals – this should be very high. If it appears to be low, check your work before connecting it up to your equipment. If desired, the meter could be switched out of circuit when not required – a SPST switch could be wired in series with one of the input leads.

Testing and Use

Initial resistance test aside, the best way to test the module is to connect it to your audio system and then power up. Use is pretty straightforward; unless switched out of circuit, the meter will provide a reliable indication of the power that your amplifier is delivering to its loudspeaker load.

7-LED AUDIO POWER METER PARTS LIST

RESISTORS			
R1	10Ω	1	
R2	150Ω 1W	1	
R3	2k2	1	
R4	120Ω	1	
R5,7	56Ω	2	
R6	150k	1	
R8	33Ω	1	
CAPACITORS			
C1,2	47µF Electrolytic	2	
SEMICONDUCTORS			
D1-4	1N4007 or equiv.	4	
D5-8	1N4148 or equiv.	4	
ZD1	20V 1·3W Zener Diode	1	
ZD2	4V7 400mW Zener Diode	1	
ZD3,4	11V 400mW Zener Diode	2	
T1,2	BC546	2	
T3	BC556	1	
IC1	U247B	1	
LD1-7	LED Red	7	
MISCELLANEOUS			
	Countersunk Steel Screw M3 × 30mm	2	
	Nut M3	4	
	Plastic Spacer 20mm	2	
	Aluminium Front Plate	1	
	Plastic Panel Scales	4	
	PCB	1	
	PCB Pins	2	
	Wire Link	1	
OPTIONAL (Not in Kit)			
	Constructors' Guide	1	(XH79L)
	Double Bubble Sachet	1	(FL45Y)
	Toggle Switch 10A SPST	1	(JK25C)
	Flexible Rubber Sealant	1 Syringe	(YJ91Y)
	Wire 7/0·2 10m Red	1 Pkt	(BL07H)
	Case as per user requirements		

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available in kit form only.
Order as VE27E (7-LED Audio Power Meter) Price £18.95.
Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

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.

AIR YOUR VIEWS

S·T·A·R L·E·T·T·E·R

This issue, C. Hobson from Exeter, Devon, receives the Star Letter Award of a £5 Maplin Gift Token for his letter, on Valve Technology and their superb quality and longevity.

That Train Just Keeps On A-Rolling...

Dear Editor,
I write in response to the letter in issue 67 (July 1993) concerning 'Model Railway Projects', Yes please! More *are* required, although I have given up waiting since building the *original* Digital Controller. I now have track section detection plus points control all interfaced to your Z80 boxed Hex project.
Ian King, Eastleigh, Hampshire.

Yes, it certainly has been a long wait, but we're sure you'll find that it's been worth it. We like your novel use for the Z80 Development System – perhaps you may consider submitting it as a 'Circuit Maker' project?

Dear Sir,
I am writing to you concerning the subject raised by Mr W. H. Hiscock on your 'Air Your Views' page in issue 67 (July 1993). This subject being Model Railways (I too am a keen railway and, of course, electronics enthusiast) and his opinion that you do not give enough space to the subject. Thus, I, Mr Hiscock and hundreds of other modellers, I am sure, would be delighted to see more projects concerning model railways contained in your wonderful publication.
I have worked on several projects for digitally controlled signalling and have even attempted interfacing my home computer with my moderately sized layout. But the project you mentioned in your reply sounds fantastic. An enthusiast's dream. As I am sure Mr Hiscock will know, on an electrtic system, any two Locos on the same section of track move together and share the power – thus running at half the normal speed. Independent (or cab) control would be wonderful.
I hope that this letter has served as the 'feedback' you asked for. I thought that the use of the word 'feedback' was particularly amusing considering the amplifier projects and articles on microphones contained in the magazine. An intentional or unintentional pun?
Gareth Jinkerson, Lowestoft, Suffolk.
P.S. Does your Digital Multi-Train Controller work on a similar principle as the 'Zero 1' system?

No, you're on the wrong track. No puns in this magazine – intentional or otherwise! The Hornby Zero 1, by the way, works along similar lines but, to the trained eye, can be seen to be completely incompatible with the Maplin system.

Dear Sir,
I also have had your Magazine for some years now, just like Mr Hiscock, I know you have put in train controllers in the past but I would like to see a simple one put in using the 2N3055 transistor as I have a few of these. I would like to see a simple device to stop a train that is out of sight, my layout is in the loft and the train goes behind the boards in the loft, and I would like to stop the train behind these and bring another one out, as there is a siding set up at the back. I would also like to see a simple train chuffer small in size, also a two-tone horn.
Mr K. Hall, Coventry.

Thanks for your suggestions – not everybody requires a complex multi-train controller. The sound effect generators would certainly go down well!
Many thanks for those who sent in comments regarding the Digital Train Controller project. Unfortunately, due to lack of space we could only find room for three such letters. Never mind, though – the design is scheduled for publication in the November issue, which is out on October 1st!

Valves and Pint Glasses

Dear Sir,
I found Graham Dixey's Valve Technology write-up in your July 1993 magazine quite refreshing, especially after a steady diet of ICs, transistors and the like. It revived many pleasant memories of my 1940s introduction to that technology by some wonderful teachers, and of the long hours of enthusiastic discussions on the subject over numerous 'jars of suds' with my old classmates. Even today there are many old-timers like myself who still carry on in electronics keeping up with the latest happenings just as your magazine does. For example, three years ago I met one gentleman doing an Open University electronics course who was servicing video game machines, in Cornwall, for a living. He was 65 and doing quite well for himself.
So much for identifying some clientele Maplin may not be aware of, and on to several moot points: (a) the 'valve age' is still here in the form of TV picture tubes, VDU cathode ray tubes, radar magnetrons, high powered travelling wave tubes, klystrons, etc. (b) my 20 valve amateur radio HF transceiver (Drake TR–3) has been in constant use since the early 1960s with only four valves being replaced to date. Perhaps that's a statistical fluke since average valve life is 2000 to 3000 hours.
(c) functionally equivalent 'Far East' equipment is much more complex than my TR–3, but so is the upkeep cost. While owners of the sophisticated solid-state versions send their equipment out to well-equipped shops for (pint depriving) repairs. I treat my own with educated kicks, proper tweaks, and 5p resistors or slightly more expensive electrolytics for misbehaviours. That way I have the best of both worlds: mind blowing time travel to the 60s with a soldering iron, and my self-satisfaction of the results in the company of a pint. However, don't get me wrong. I enjoy chips also for they give me great pleasure in home brewing test equipment and other projects. While I am doing just that, I shall be waiting anxiously for your next issue containing Valve Technology Part 2 and other fine articles.

Glad you're enjoying the series and I quite agree with you, in that I don't believe either that something should become obsolete and never be touched again with so much as a ten foot pole just because 'progress' pronounces it to be 'Stone Age'. As I said last month, until better and more impressive inventions are invented, the current level of technology is perfected as far as possible and, as a result, does the job. It will still do the job after 'better/smaller/faster/lighter' (delete as appropriate) gadgets come along to supposedly replace it. One result of this of course is that the older methods become more attractive somehow (nostalgia sets in).

The Spectrum Lives On...

Dear Sir,
Could I through the letters page bring to the attention of Spectrum computer users a software-based magazine that I have been a satisfied subscriber to for a number of years. The magazine is almost 100% reader's contributions of programmes, reviews, tutorial etc. and covers all interests from serious aspects of computing through to the lighter games side. One of its many strengths is the technical help and advice to reader's problems in the letters pages. Various systems are covered and the magazine is available on tape or as +3, Disciple & +D disc.
Mr M. R. Perry, Kidderminster, Worcs.

Glad to be of service to all our Spectrum-equipped readers!

Hey Mr Postman

Dear Sir,
I was pleased to receive this month's 'Electronics', delivered to me (at No. 30) not by the hand of the Royal Mail but by a kindly neighbour from No. 38. A glance at the address label explained this curious situation. Whilst we of the computing fraternity appreciate the pressing need to differentiate between zero and character O, the average postman on a dull wet morning, the subtle distinction must seem wholly unnecessary and confusing. I attach the offending label to illustrate the point. Try to imagine viewing this in poor light through a rain splashed plastic wrapper and you may appreciate the difficulty. Even in good light with reading glasses the barred zero looks remarkably like an '8'.
Spare a thought for the postmen, several of whom are no doubt included in your subscription list – their comments may be illuminating.
G. Nicholls, Kingswinford, West Midlands.

We're glad that all you can complain about is the address label! A valid point nevertheless – who knows, we may find ourselves producing our address labels with a different printer. You may find it of interest that the labels do, in fact, satisfy the Post Office requirements!

DIY Satellite

Dear Sir,
I was interested to learn that your Satellite series is to re-appear shortly. I built myself an Astra satellite receiver using a Philips tuner, and would be interested in a remote control system. Could your VE72B be adapted? At present I am using a 'mechanical' system with a 12 way rotary switch (selecting preset tuning resistors) to select 12 'even' (V) channels. An additional switch changes over to 'add' (H) channels, but most of these are encrypted. Sound was obtained by reducing the toning capacitors on a commercial unit to increase the frequency from 6·0 to 6·5MHz. A variable sound IF would make the unit more versatile. The receiver does not contain an Energy Dispersal Circuit, and experiments to incorporate that used in the 'Elekor' design (1986/7) were not successful.
V. T. Rolfe, Reading, Berkshire.

Congratulations for taking the DIY approach. Your tuner wouldn't be from an old BSB receiver, would it?
If you're interested in remote control, why not use the M419B voltage synthesis tuning IC, as used in the Maplin NICAM tuner? This IC stores up to 16 channels (each of which can have a different tuning voltage), drives a 7-segment LED display directly, and offers an additional D-A output (e.g., skew, audio tuning) and switching (polarity, decoder, power, etc.). More importantly, it can be hooked up to an infra-red receiver, and used with the NICAM infra-red control unit. Take a look back to the June/July 1990 (No. 38), August/September 1990 (No. 39) and December 1990/January 1991 (No. 41) issues of 'Electronics', which describe the NICAM tuner and remote control system – you may well be pleasantly surprised! We bet that your picture is flickering a bit! The energy dispersal signal is a 25Hz sawtooth wave, and without removing it with a DC clamp or other such circuit, the picture may well be objectionable to watch on occasions! Out of interest, the energy dispersal waveform is added to the video signal at the up-link end, to remove any chance that the re-transmitted signal has of interfering with any ground-based microwave links using the same (Ku) band of frequencies.

A GUIDE TO PROFESSIONAL AUDIO PART SIX

by T. A. Wilkinson

In Part Six we take a general look at mixers, and follow a typical mixing desk stage by stage from input to output. Mixing desks are considered to be the heart of many audio installations, as this is where all of the signal sources converge and are processed before distribution to their final destinations. The range of mixers available today is massive, from simple 3-input, single output portable units to full-blown 52-input, 24-output automated consoles; there is something to suit all needs and budgets.

Concepts and Theory of Operation

Whatever the application the concept is the same, that is, multiple individual inputs brought together and reduced to a lesser number of outputs. Each output containing some or all of the input elements in varying controlled quantities.

Control is the key element, the ability to increase or reduce the level or amount of a particular source of signal is a basic requirement. Add to this equalisation, special processing, monitoring, relative position and routing of signals and the picture begins to build.

We are all familiar with mixers of some kind or other, our domestic Hi-Fi and video equipment at home may have microphone and line inputs which can be used simultaneously. The quantity of each, and addition of, these signals needs to be controlled and a simple mixer will be used. In some cases it may be rather crude, but it is still considered as a mixer.

Theory of Operation

The most basic of all mixing devices is the passive mixer. Earlier in this series we briefly discussed microphone combiners using transformers. As discussed, these operate as simple passive mixing devices to combine the various inputs into a single output, and Figure 1 shows how this may be done.

The transformer has multiple primary windings, one for each balanced input, and these inputs have absolute isolation from each other. Assuming that each primary winding has the same number of turns, the output of the single secondary winding will be the sum of the inputs. Although this type of arrangement works well and is used, inevitably there are some drawbacks.

Most obvious is the fact that there is no control over the signal level of each of the inputs. To be really effective all inputs must have equal amplitude. Also the inherent properties of transformers dictate that there will be some undesirable elements such as distortion. One great advantage however, is that, as this is a purely passive system, there is no need for any sort of power supply, and therefore it can be used anywhere at anytime.

Passive mixers which use resistors are another possibility, in fact Photo 1 shows just such a unit. This is a BBC MX 18 portable mixing unit dating from about 1945

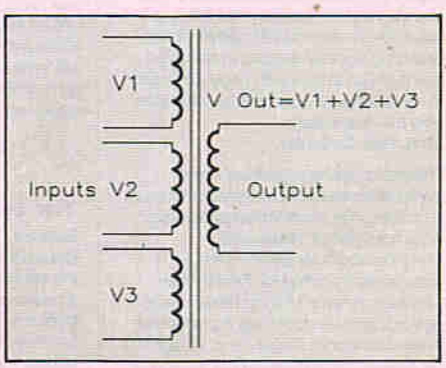


Figure 1. Passive 3 into 1 transformer mixer, as used in microphone combiners.

(top right of picture). It is a purely passive unit and allows four inputs to be controlled and mixed together to provide a single output. Inputs and output are all balanced, in fact this mixer is balanced all the way from input to output with no part of the signal path operating in unbalanced mode.

The unit would have been used in outside broadcast situations, perhaps with its accompanying amplifier, the BBC OBA8, also shown in Photo 1 (bottom right), to drive GPO telephone lines. Omitted from the picture is the power supply unit, a massive thing capable of providing the necessary HT for the amplifier valves!

As a point of interest, I recently hooked up this mixer and proved it still worked, and the sound quality was surprisingly quite good. Maybe there are some lessons to be learned here!

Modern mixers are of course far from passive or simple, but the resistive mixing techniqe is still very much in existence. A typical example is the concept of mixing together the left and right signals of a stereo source to produce a single mono signal, as in Figure 2 (right).

Of course resistors R1 to R4 need to be sufficiently large in value so as not to effectively overload anything further back down the chain, and, with the correct component values, this system offers a very simple way to mix together the two sources.

Virtual Earth Mixers

Virtual earth mixers are very commonplace in all audio equipment, and are based around op amps employed in inverting mode. Figure 3 shows just such an arrangement, where V1 to V4 are the four audio sources which are fed via mix resistors R1 to R4 to the mix bus, the virtual earth point, hence the name. The value of resistors R1 to R4 needs to be fairly large in order to isolate the inputs from each other. Op amp IC1 is used as a summing amplifier, whose output is equal to the sum of the input voltages.

The gain of the circuit is determined by the relationship of R_F/R_x, where R_x = any one of resistors R1 to R4. If R_x and R_F have the same value then the gain will be unity (0dB), increasing the value of R_F gives a corresponding increase in gain. Thus if R_x is 100kΩ and R_F is 200kΩ, then the circuit has a voltage gain of 2, or 6dB.

Figure 4 develops the circuit of Figure 3 further into a basic working circuit by adding a DC blocking capacitor and level control pot to each input. Control of the amplitude of each input is now possible, and adjusting any of the level control pots will have no effect on the other inputs.

Photo 1. A BBC MX18 portable mixer (top right) with modern equivalent at top left, and OBA8 amplifier (bottom right).

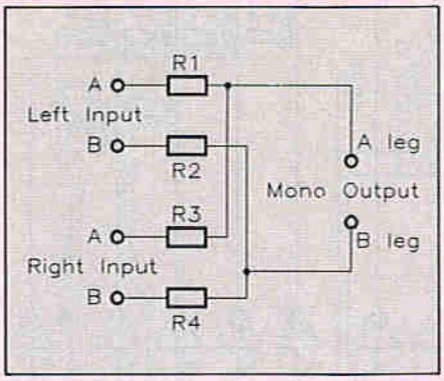


Figure 2. Resistively mixing together the left and right elements of a stereo source to produce a mono result.

The total number of inputs which can be added to such a mixing arrangement is governed by how much noise is acceptable, but in practical terms it should be possible to add several dozen without generating too much noise.

In reality, however, professional mixing desks are necessarily rather more complex than that of Figure 4, and have many active stages. The mix amplifier forms only a small but significant part of the overall system.

Figure 5 (on page 66) shows a typical schematic arrangement of a complete, real mixing desk based on a four year old Chilton QM3 (as can be seen in Photo 2), (on page 67) configured for 24-input channels with eight group and one main stereo output. For simplicity, only *one* input channel is shown (to the left of the bus lines), but the group and main outputs are shown in full (to the right of the bus lines). The various stages can be explained from input to output, as follows.

Channel Input Stages

A good mixing desk will offer both line level and mic level inputs on separate sockets to each channel. Our QM3 does just this, the selection is made by a switching arrangement following the mic and line input amps. The mic input has a switchable 20dB pad (attenuator) to allow the use of high output microphones, and a balancing transformer follows prior to the mic amp differential inputs.

Some mixers can accommodate both line and mic inputs on a single input socket, and fed directly to a single input amp with a wide gain range, the necessary gain for a particular input source being selected by a single or dual gain pot. Other mixers may (again) offer a single input socket to each channel followed by an adjustable attenuator, prior to the input amp. With

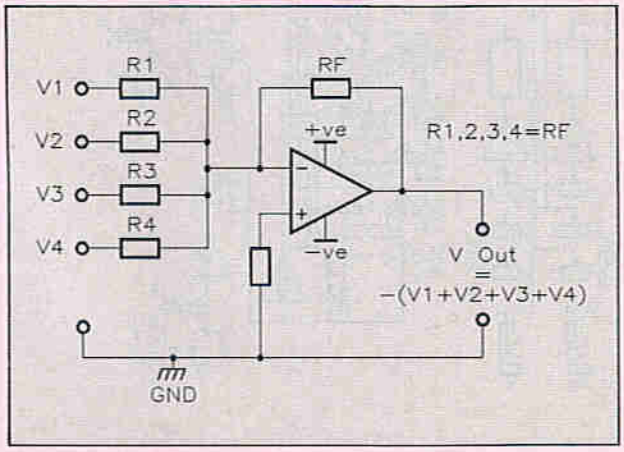


Figure 3. Inverting op amp used in summing mode as mix amplifier. V out is the sum of V's in, and overall gain is unity with equal resistor values.

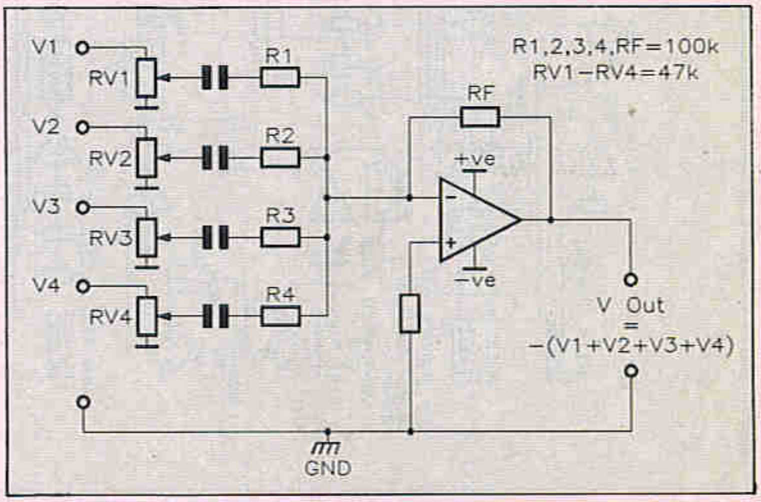


Figure 4. Working AC mixer amplifier, with input level control pots.

this system also a wide range of input levels is catered for.

Equalisation (EQ) and Filters

The input amp is normally followed by a range of filters and equalisation controls, used to shape the frequency response and offer an increase or reduction of gain at specific frequency bands.

Filters are a combination of variable high-pass and low-pass types which can be adjusted to specific cut-off points in order to restrict or contain the bandwidth of a particular channel of the mixer. For example, the filter controls (sometimes referred to as 'rolloff' or 'shelf' controls) could be set up to avoid low-frequency rumble on a microphone. In this instance, the high-pass filter, or 'rolloff' control, may be adjusted to a rolloff point of say 100Hz, and the frequency response would be rolled off below this figure at perhaps 6 or 12dB per octave, and thus reduce the low-frequency rumble to a more acceptable level. Similarly, the low-pass filter can be used to reduce any unwanted high frequency noise to rolloff at say 12kHz.

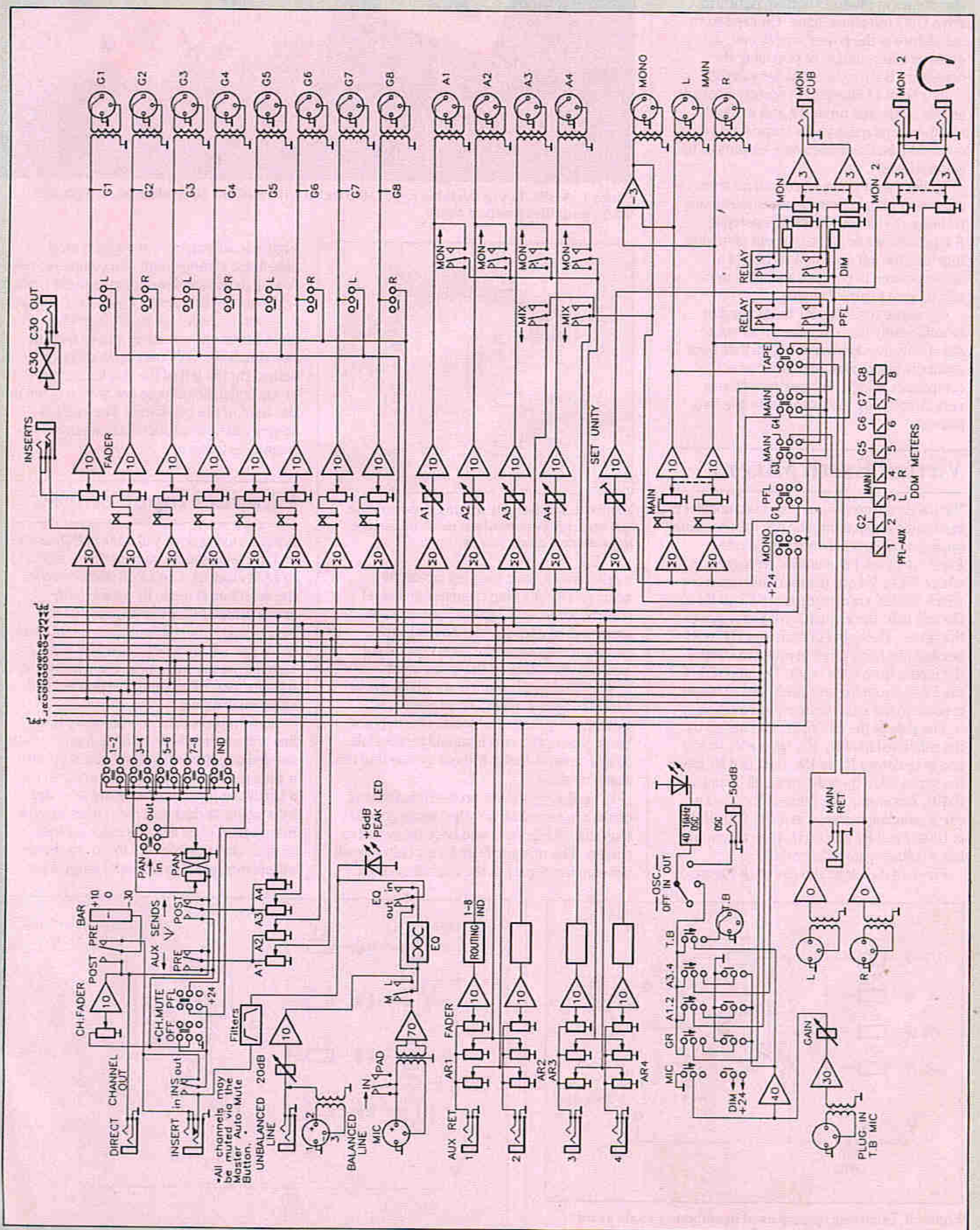


Figure 5. Chilton QM3 mixing desk schematic diagram. Only one input channel is shown.

Photo 2. Chilton QM3 Mixer.

Equalisation comes in many forms, from the very basic but adequate, to very complex and mind (and budget) blowing arrangements! Simpler types offer upper, mid and lower frequency cut and boost centred around respective fixed operating points. These will often be sufficient for many situations, but invariably there will be occasions when the fixed operating point will not be the frequency at which you need to make corrections.

Parametric equalisers and EQ with sweeping arrangements and adjustable 'Q' overcome this by allowing the operator to select and adjust the frequency point around which the equalisation controls will operate. These systems can be quite complex to use and can alter the sound quite severely, but with carefully considered operation they have the ability to be very useful tools.

The thing to bear in mind with any form of EQ is that it should really only be used to overcome a problem, and perhaps *should* not be used as a matter of course, although some would argue that it is a creative tool, and I suppose in some ways it may have a little creative appeal for some people.

But what is the point of using expensive condenser microphones, and the latest digital recording equipment offering a flat frequency response and a faithful reproduction of its source, if we are going to destroy all of that by adding unnatural amounts of frequency boost or cut where it is not necessary?

Peak LED

Normally located between input amp and channel fader, the channel peak LED gives an indication of available headroom. Headroom can be described as how much signal level capacity is available (in hand) before the onset of serious distortion. The peak LED is designed to light when a predetermined level of available headroom is reached, in the mixer described here, the LED lights when there is 6dB of headroom available.

The Insert Point

The next stage in the mixer is normally the 'insert point', which is a breakout jack socket that allows the signal on a channel to be diverted away from the mixer to the input of a signal processor, such as an echo or delay unit, and returned through the same connector *back* into the mixer. Often an insert in/out switch is fitted, which enables signal processing equipment to be permanently wired to insert jacks, thus allowing the processor to be easily selected by the mere operation of the switch.

Many mixers offer only a single two pole jack connector on each channel as an insert point. The connector will have switched contacts and, with no jack plug inserted, the tip and ring of the socket are shorted together. However, inserting a plug breaks the short and sends the channel signal away to the processor via the ring contact, to be returned via the tip contact. This arrangement only allows for unbalanced operation at the insert point.

Some mixers provide an insert point in the form of two jack sockets called 'send' and 'return'; these enable balanced line operation to interface with ancillaries equipped in such a way.

Insert points can also be found on group, auxiliary and main mixer outputs, giving total flexibility and offering simplicity as far as patching in temporary outboard equipment is concerned.

Pre-fade Chain

The pre-fade chain performs several functions and feeds many areas of a mixing desk. The term 'pre-fade' simply means that, before the fader control, any signals available on the pre-fade chain are not affected by the operation of the channel faders.

The most obvious use of pre-fader signals is direct access to the various input channel sources for monitoring purposes (both visual and audible), without adding that particular source to the overall mix. For example, during a typical radio show, it is necessary to 'set up' the next piece of music or speaking guest while another piece of music is being played. This setting up must be done without affecting the *current* setup of the mixer, thus the PFL (Pre-Fade Listen) switches will be used. This routes the selected source to the PFL bus and hence on to the monitoring circuits and the monitor loudspeakers/meters in order to adjust the gain control, thus the correct levels can be set without the need to open that source's fader.

In Figure 5, it can be seen that operating any PFL switch does a number of things. Firstly, the audio signal itself is sent to the PFL audio bus, and at the same time +24V DC is fed to the +PFL DC bus. This is used to activate various relays associated with the PFL monitoring chain, and also powers a 'PFL active' LED (normally one per input channel), used to indicate that the PFL chain is in use, and what is assigned to it.

Pre-fade systems can get a bit complicated, with some mixers having additive pre-fade chains which allow many, or all, of the input sources to be monitored pre-fade. Other mixers have override pre-fade chains which allow only one input source to be monitored at one time. Typically, operating any PFL switch overrides any other already made PFL switch.

Another override system operates on a high/low number basis, such that any higher numbered channel PFL switch overrides any lower numbered switch that may already be operated.

Channel Fader

At last comes the channel faders, and many people imagine these to immediately follow the input connectors, but in professional mixing equipment this is rarely the case. Thus the channel gain, equalisation/filtering, signal processing send and returns, and the PFL chain are *all* before the fader, and any input will have undergone many stages before it gets anywhere near the fader control!

Channel faders are really only potentiometers of one kind or another, generally slider type pots are used but rotary pots are used in portable equipment where space is at a premium.

Slider faders as used in professional equipment are more often than not constructed from conductive plastic materials, the most notable types are made by Penny and Giles, and Alps. Conductive plastic faders are many times the price of carbon track types but have a noise free lifespan of many years.

When a user has spilt a can of fizzy drink or sugary coffee into the conveniently placed fader slot, the fader module can be easily removed, dismantled, washed with warm water and dried out, and subsequently refitted with no degradation of sound quality.

Typically, a Penny and Giles fader module has strips of conductive plastic which form the resistive tracks. Suspended above the tracks are stainless steel rails along which a metal actuator slides on three Teflon type bushes. Attached to the actuator are pre-formed 'feeler' brushes which determine the potential division point. Mechanically, the actuator assembly glides smoothly on the rails with just the right amount of friction and feel. If the movement becomes sloppy to the touch, it is quite simple to rectify this by replacing the worn Teflon bushes. I frequently come into contact with faders of this type that have seen more than ten years use, and still offer sterling service, although bushes and the like have been replaced several times.

Ironically, after many manufacturers have spent much cash and years developing and perfecting conductive plastic faders, carbon types are now making a comeback. This is due to the fact that VCAs (Voltage Controlled Amplifiers) are being used much more by some manufacturers in order to adjust and control signal levels.

The use of VCAs means that the fader itself is not directly in the audio signal path, and acts only as a potential divider supplying a DC level to the reference input of the VCA which actually controls the audio signal level, thus a dirty, noisy fader track is no longer such a problem. However, a dirty fader track used with a VCA will produce erratic behaviour and inaccurate control of the audio signal.

Immediately following the fader amp there will normally be found a line level, direct channel output socket. This simple facility has many uses and could be fed direct to tape recorder inputs or similar, again giving the desk increased flexibility.

Channel Routing

Following the channel fader are the 'pan pot' (panoramic potentiometer) and channel routing switches. The functions of these two items are really interrelated.

The channel routing switches determine the final destination of a mixer input channel. If, for example, a mixing desk had 24 inputs with eight group outputs and a dedicated L/R stereo output, then any input channel is able to connect to any of the available output routes including the aux (auxiliary) facilities.

On a mixer with eight group outputs, the groups would normally be arranged as odd and even pairs to allow for eventual stereo mixing, thus groups 1 & 2, 3 & 4, 5 & 6, 7 & 8 would be arranged as four stereo groups with 1, 3, 5, 7 being primarily intended as left outputs, and 2, 4, 6, 8 as right outputs.

In addition to the group switches, a channel input can be routed independently of the groups directly to the dedicated stereo output. This operation requires a routing switch known as a 'DIRect', 'INDependent' (as used by Chilton), or 'Remix' switch, which when operated routes the output of that channel (via the Left and Right buses) to the main stereo output *in addition* to any group output, should one be selected.

A further set of routing switches follow the group output amps. These are L/R switches which when operated send the selected group outputs to the stereo bus.

The 'pan pot' on each input channel shifts the relative position of the signal. With a channel routed directly to the stereo output the signal can be moved to any position from fully left (pan pot set fully anti-clockwise) to fully right (pan pot fully clockwise), or anywhere in between. Set centrally at 12 o'clock, the signal would sit in the middle of the stereo image. For example, a single vocalist would normally be positioned centrally in the stereo sound stage, and so the pan pot would be set to its mid position. If the vocalist underwent some signal processing such as echo, the output of the echo unit may be stereo with differing left and right delay times, and the result of this when added to the mix gives a widened stereo effect to the vocal.

Not so long ago, I recorded a whole weekend of a live Asian arts/music festival for re-broadcasting. One of the bands captured on tape that hectic weekend insisted on having a 1·5 second, left to right echo delay on the vocals to give that authentic Bangrha feel to their songs. The resulting sound was very strange to my western ears and quite difficult to control, but it was what they wanted and I willingly obliged. Having no executive producer on this session meant I couldn't really refuse, and the band seemed to like it, so what the hell!

Pan pots normally follow or approximate constant Power Law, that is to say, with the pot set centrally the signal is 3dB down. On any mixer equipped in such a way it is easy to observe this by setting up a steady oscillator tone on an input channel routed to a pair of group outputs or the main stereo output. Setting the pan pot centrally with equal signal levels to left and right outputs, turn the pot to either fully left or fully right and observe the appropriate meters. The meter of the output that the pot is being turned *toward* should show an increase in level of 3dB, returning the pot to its mid position shows a corresponding decrease of 3dB on the same meter.

In Figure 5 such an oscillator is shown near bottom left of the diagram, and is able to provide a range of tones covering the audio spectrum. A constant tone source of this sort is essential to set up the 'master' output levels; it is impractical to try to do this accurately using a speech or music source. Once the basic levels are set and balanced, then mixing can be done by ear.

Many mixers include a switch which allows the user to switch the pan pot out of circuit, effectively overriding any panning, thus positioning the signal centrally between left and right.

Aux Facilities

Any mixer will normally offer a number of auxiliary send and return paths, these are included in order to allow signals to be routed away from the mixer for feeds to additional items of gear such as PA systems and foldback/headphone monitors.

For example, during a recording session, different musicians will require different feeds and mixes of input sources or tape replay sources available from the desk. So one musician could be fed with say a mix of keyboards and guitars only via aux send 1 to his headphones, and another fed a mix of drums and bass only via aux send 2. In this way each will be totally separate of the other, furthermore, with aux 1 and 2 selected pre-fader, the sources they are using need not be faded up on the desk and thus not added to the mix.

Aux sends and returns will be available on all input channels, and most of the group, main and other outputs. Additionally they are totally independent from the rest of the mixer and will be available pre-fader, post-fader or switchable to either depending on the design.

Buses

Eventually our signal finds its way via the routing selection switches to the various buses. In our schematic diagram the signal is routed to the direct L/R outputs, but could also be routed to one or more pairs of group outputs. In this way both a direct stereo mix and group mix are available; this allows for a direct stereo recording and a multitrack recording to be made simultaneously.

The buses themselves can be thought of as long pieces of wire with many interconnecting junctions, with input channel output signals meeting on the bus with their selected mix, monitoring or output stages.

On the face of it, the buses appear quite straightforward, but in reality this is rarely the case. For a start, any decent mix bus will not be any old bit of wire but, more likely, a solid length of high quality heavy gauge copper conductor. Furthermore, because the buses are normally the noisiest part in a mixer, the bus system will have had much thought put into its design and will have a specifically designed (low-ish) impedance figure in order to minimise bus generated noise.

Whenever another circuit is added to a bus a little more noise is also added, and it is vitally important that any unused inputs or sources should be routed away from the buses by switching out the appropriate routing switches. Thus only those channels and sources actually in use will contribute to the overall bus noise.

The signals now present on the bus bars are passed to the appropriate mix amplifiers. These summing amplifiers may be unity gain or may have a preset amount of gain in order to make up for the losses of previous stages, or mix bus losses.

Each group, stereo, auxiliary and monitor bus will have its own dedicated mix amp, and this is followed by an appropriate output fader control prior to a final output buffer or amplifier. If the desk's final outputs are balanced then a further stage of electronic or transformer balancing follows, the final desk outputs appearing on XLR or jack type connectors.

Of course the total number of final outputs depends on mixer facilities, but will include one output for each of the groups, aux sends, stereo outputs, mono output (sum of L+R) and loudspeaker/headphone outputs. Additionally, there may also be outputs for special units fitted to the mixer such as line up oscillators, compressors/limiters, and talk-back communication systems, etc.

Monitoring

Monitoring is the general term used to describe both visual monitoring, by meter, and audible monitoring by loudspeaker and headphones. Both visual and audible monitoring systems are needed to establish and control operating and recording levels.

In order to be fully aware of what's happening at various stages of the mixing process, and therefore remain fully in control, it is necessary to have a visual indicator of the levels of each input channel, group output and main stereo output. Comprehensive mixing desks will have a full range of meter type monitoring.

As usual the facilities offered vary with the manufacturer, and largely depend on how much you are prepared to pay. One cost-effective solution is to provide LED bargraph displays with either VU (Volume

Unit) or PPM (Peak Program Meter) type characteristics on each of the input channels, with mechanical VU or PPM types for the group and main outputs. If more cash is available then mechanical VUs for *all* inputs and outputs is better, and if funds are not a problem then it could be PPMs all the way!

A VU meter is essentially an rms reading voltmeter with a scale graduated in decibels in logarithmic steps, covering for example −6dB to +20dB. 0dB is not of course zero, but the unity gain signal level reference. On the other hand a Peak Program Meter employs rather more electronics to respond to peak voltages and hold this level on the display for a short time, thus giving an indication of the average peak signal level going through the system. Much like a peak level meter for a tape recorder, a PPM can be used to ensure output levels, including transients, are within the correct limits for whatever follows the mixing desk. It is the sort of device used to monitor the signal sent to a radio transmitter, for example.

In theory a good compromise could be made with mechanical VUs for the inputs and PPMs for the outputs, but, as VU and PPM meters have very different characteristics, this can be impractical and lead to operator confusion. It is therefore much more desirable to stick to one standard or the other with either all VU or all PPM types.

Whatever the metering system, it must be ergonomically and logically laid out with easy-to-find switching arrangements for pre- and post-fader assessment. At the end of the day, no matter how good you think your ears are there is no substitute for a flexible, comprehensive, accurate method of visual monitoring.

Each input channel of our QM3 mixer is equipped with bargraph meters using PPM type characteristics (24 in total), any of these meters can be selected to monitor either pre- or post-fader, by the operation of a switch located adjacent to the bargraph display.

The group outputs 1 to 8 each have a moving coil PPM meter assigned to them, however, meter 1 also doubles as the pre-fade listen meter, operational only when a PFL switch is on. Also used in a dual function role are meters 3 and 4, these, when selected by the monitor selection switches, monitor the main Left and Right stereo outputs or Left and Right tape return inputs.

Audible monitoring operates along similar lines to monitoring by meter, but the fact that there will normally be only one pair of loudspeakers to listen to all of the mixer functions means that further switching and routing arrangements must be used in order to get at all areas of the mixer audio path.

The usual set up is to always monitor the main output with all other monitor switches off, and then select specific monitoring requirements as needed. Operating any PFL switch routes the PFL bus via the relay to the monitor outputs, but many other monitor combinations are possible by using the monitor selection switches located on the monitor section of the mixer. Depending on mixer design, the headphone monitor outputs may follow exactly the functions of the loudspeakers, or may be independently controlled by means of their own dedicated monitor selection system.

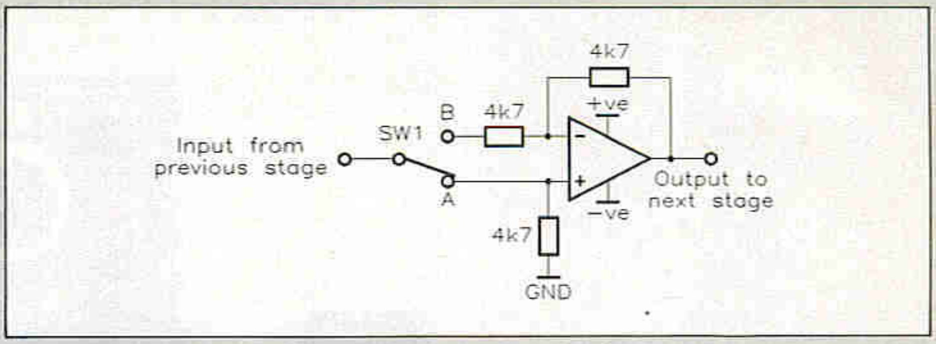


Figure 6. Switchable phase inversion system.

Phase Inverter

A phase inversion system is something that all serious mixers should, but do not always, include as standard. Quite simply this very useful tool shifts the relative phase of an incoming signal by 180° at the push of a button or the flick of a switch.

This allows direct use to be made of stereo MS microphone techniques with no extra hardware required. In addition, the phase reverse system can prove to be an invaluable tool for correcting phase inversion problems such as those caused by interfacing with a piece of equipment which is wired incorrectly, or where a different standard has been used for hot and cold signal wires of a balanced pair.

In a permanent, fixed installation such as a radio studio where equipment connected to the mixer does not really change from day to day, a phase reverser is not absolutely necessary, but in a recording studio situation or out in the field, with constantly changing outboard gear being brought in, it's worth its weight in gold.

A possible arrangement of a simple electronic switchable phase reverse system appears in Figure 6. With the switch in position A the signal remains unaffected, whilst in position B the signal undergoes a shift of 180°. Either way the gain of the circuit remains at unity (0dB).

Mixer Construction

As the name implies, modular mixers offer part or total sectional modular construction, with each section such as input channels, EQ sections, group/main/aux outputs arranged as independent plug-in modules.

This offers many benefits over non-modular types, firstly, when deciding the configuration of a new mixing desk, it is possible to mix and match the modules to suit individual requirements, and it is always possible to change your mind later by replacing modules with different specification or new improved types. Many manufacturers have different types of the various stage modules with more or less facilities, depending on budgets and requirements.

Secondly, modular construction allows quick and easy maintenance. A complete, faulty EQ section, for example, can be removed and replaced with a spare in a matter of minutes, keeping downtime to a minimum whilst giving the maintenance engineer a chance to correctly diagnose and repair the fault, under less pressure than would be the case in a live studio!

But – and there's always a but – modular mixers are, by the very nature of their construction, invariably more expensive than other types. Yet again proving that what you get is what you pay for, and you can't have your cake and eat it!

The budget and semi-professional end of the market is dominated by mixers of non-modular construction of varying quality. These mixers are usually of the flat rectangular box variety with the top plate being formed from a single punched and drilled piece of metal. On many types all of the switches, knobs and electronic devices will be mounted on one large printed circuit board. This is a viable proposition in terms of economy, but a simple operation such as replacing a noisy pot or broken switch may necessitate a full strip down of the top panel in order to get at the offending part, resulting in expensive, labour intensive repairs and lengthy downtime. Typically this type of mixer offers reduced but moderate facilities with maybe some balanced (often electronic) and some unbalanced inputs and outputs.

In fact, there are some very good non-modular units on the market, whilst not perhaps designed for 24-hour, heavy-duty operation, for lighter duty tasks and occasional use they are a real alternative to some expensive dinosaurs.

Portable Mixers

With the increase in recent years of high quality, truly portable recording equipment such as DAT, comes a corresponding increase in well equipped portable professional mixers. Of course there has always been portable equipment of sorts, portable it may have been (by the virtue of battery operation), but lightweight and compact it certainly wasn't! See Photo 3 for examples of both old and new.

The new breed of battery operated, throw-over-the-shoulder mixer has facilities only dreamed about a few years ago, with provision for phantom power, balanced line operation and decent monitoring and communication options now commonplace. A nice example of a modern unit appears in Photos 4 and 5. This mixer, the ASC MINX, is a particular favourite with TV news crews, sound recordists and radio OB (Outside Broadcast) engineers throughout Europe. Facilities are comprehensive with three transformer balanced inputs switchable for mic or line operation, each with independent gain and fader controls, high-pass filter and Pre-fade Listen.

Other facilities include a built-in electret talk-back mic for communication/talk-back routes to mixer output and commentator/

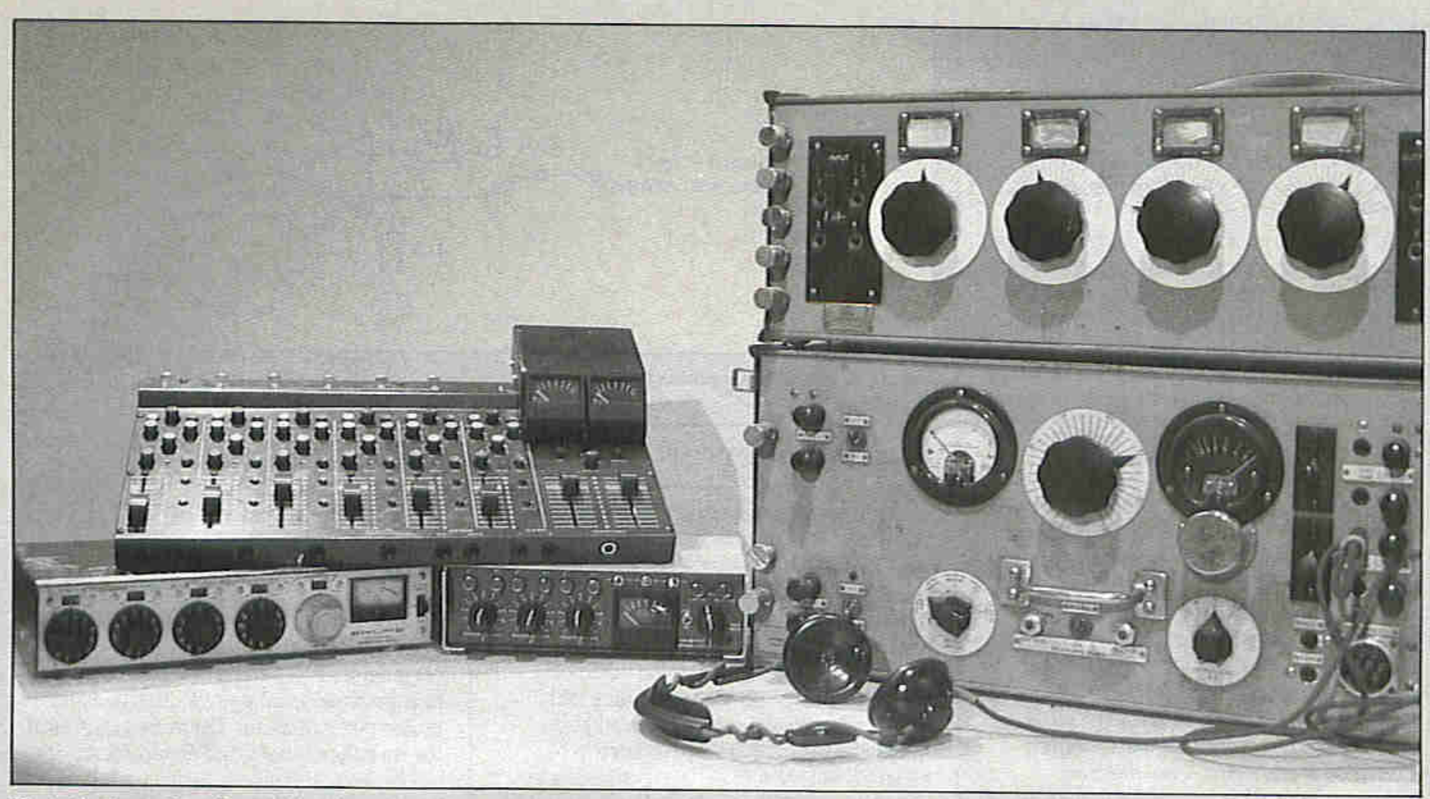


Photo 3. Examples of portable mixers.

presenter headphones, a good quality line-up oscillator and a nice little PPM meter.

A balanced line level output is available with a switchable 50dB attenuator, allowing the unit to be used with either mic or line inputs on subsequent equipment; output is via standard XLR type connector or terminal posts for direct connection to OB music lines.

The MINX can be powered by two internal PP3 type batteries giving up to 10 hours operating life, or direct from the mains, which will also charge Ni-Cd batteries if fitted. At something less than £500, this unit offers excellent value with the reliability and facilities to match.

Mixers for Broadcasting

Radio stations and other broadcasting environments require mixing desks with rather specialised facilities; mixers are often referred to as sound desks or radio sound desks rather than simple mixing desks, and form an integrated part of the studio suite.

Desk output level limiters, voice over (ducking) systems and simple echo systems together with telephone 'hybrid' units allowing on-air phone conversations for phone-in programmes, will also form an integrated part of the sound desk making this more of a control centre than a mixing desk, although similar in appearance.

Perhaps the most important criteria of such a sound desk is its communication abilities. An 'on-air' facility will require many communication paths to other areas and locations within a complex, and to the outside world.

Typically a radio station may have dozens of audio sources available to it other than the run of the mill mics, CD/gram players and tapes installed in the studio itself. Normally these additional sources such as sport venues, outside unmanned studios, and other incoming lines will be routed to an 'outside source' selection matrix which forms part of the studio desk.

Because not all of the Outside Sources (OSs) will be used everyday, it is unnecessary to dedicate an input channel of the desk to each source, and thus only a small number of desk inputs (perhaps 3 or 4) will be used exclusively to accommodate dozens of OSs.

Each OS will be connected to a selector switching system and routed by the channel input as in Figure 7, allowing simple routing to the desk input channel.

In addition to routing the OS to the desk input, the OS matrix also sends either the studio desk output or 'clean feed' (desk output minus the contributing source) back to the origin of the outside source in order that both parties in a two-way interview situation can talk and listen to each other.

Monitoring and metering on a radio desk is often very different to general-purpose mixing desks. The metering (usually PPM types) is normally limited to two or three meters only, with one meter for PFL purposes, one meter showing the desk output in either MS or AB modes (often operator selected) and possibly a third meter indicating the station output levels. Although in numerical terms metering seems to be limited, the function of each meter will be comprehensive and may be arranged in such a way as to perform several tasks.

Audio monitor systems will be unique to a specific installation, headphone feeds for example may be of the split feed variety with a presenter hearing desk output in one

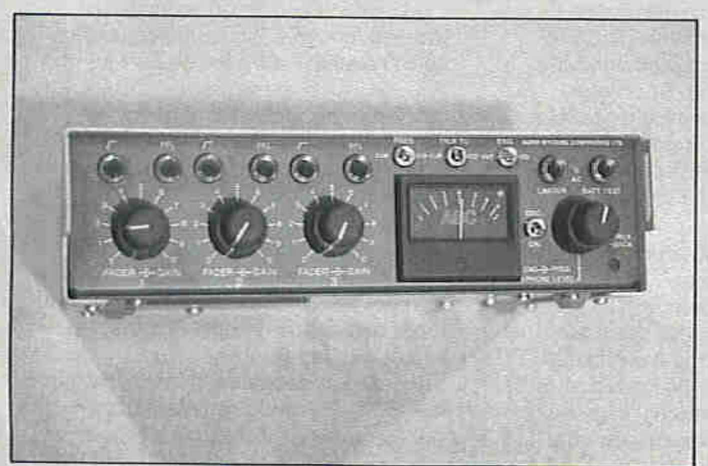


Photo 4. The ASC MINX portable three into one mixer.

Photo 5. The rear panel of the ASC MINX.

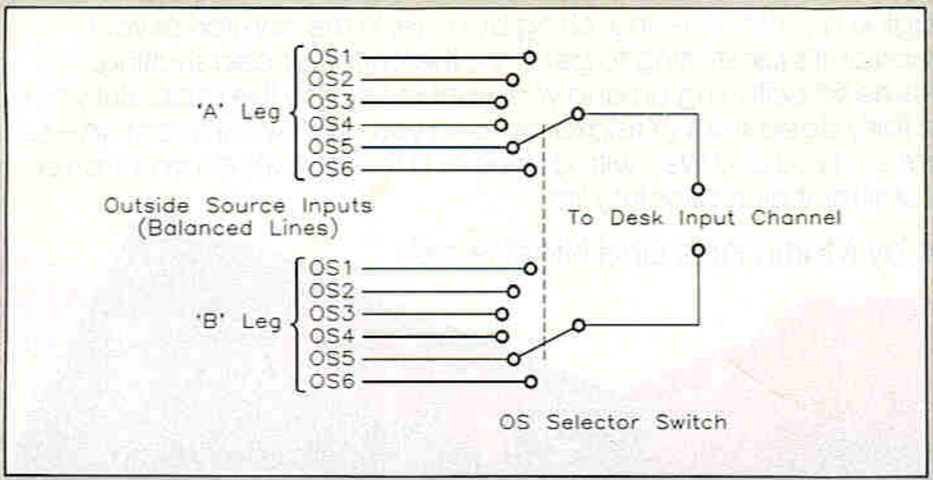


Figure 7. One method of selecting any one of six 'outside sources' to a single channel input of a mixing desk.

ear with studio talkback/PFL/desk output in the other. It constantly amazes me how a radio presenter can conduct a serious interview whilst simultaneously listening and responding to producer talk-back messages shouted into his headphones!

Recording Mixers

Dedicated recording studio mixers are based on general-purpose types with additional facilities to handle a variety of modern recording techniques. For multitrack recording, a number of tape returns inputs will be added to some input channels allowing rapid tape monitoring and mixing to be carried out without having to plug-up large numbers of connectors each time off-tape monitoring is required. Tape returns are selected by simple switch or push-button operation.

Other facilities may include MIDI inputs/muting for interface to samplers or keyboards and the like, allowing interactive instruments/mixer control and various monitoring options for feeding to performing artists headphones.

Lots of insert points are essential for feeding signals to and from the ever growing mass of outboard processing gear commonplace in modern studios. For absolute flexibility every input and output should have its own insert point facilities.

The Future in Control

Automation of mixing desks and consoles looks to be the way forward into the future and is already becoming big business. Add-on systems are available to adapt existing analogue mixers to give digital (often MIDI) control of certain functions of the mixers inputs and outputs.

Fully automated mixing desks have been around for some time with top of the range systems from Solid State Logic being very prominent in leading recording studios. These 'grown up' consoles offer total control of signals from input to output with the ability to reproduce from disc, exact control setting of the mixer, from a recording session sometime in the past. Unfortunately it is outside the scope of this feature to offer more detail of such systems, but perhaps something along these lines could be considered as a future article.

Digital automated consoles convert incoming analogue signals to digital to allow the control and manipulation of signals to be carried out in the digital domain, with their return to analogue (where required) at the desk outputs.

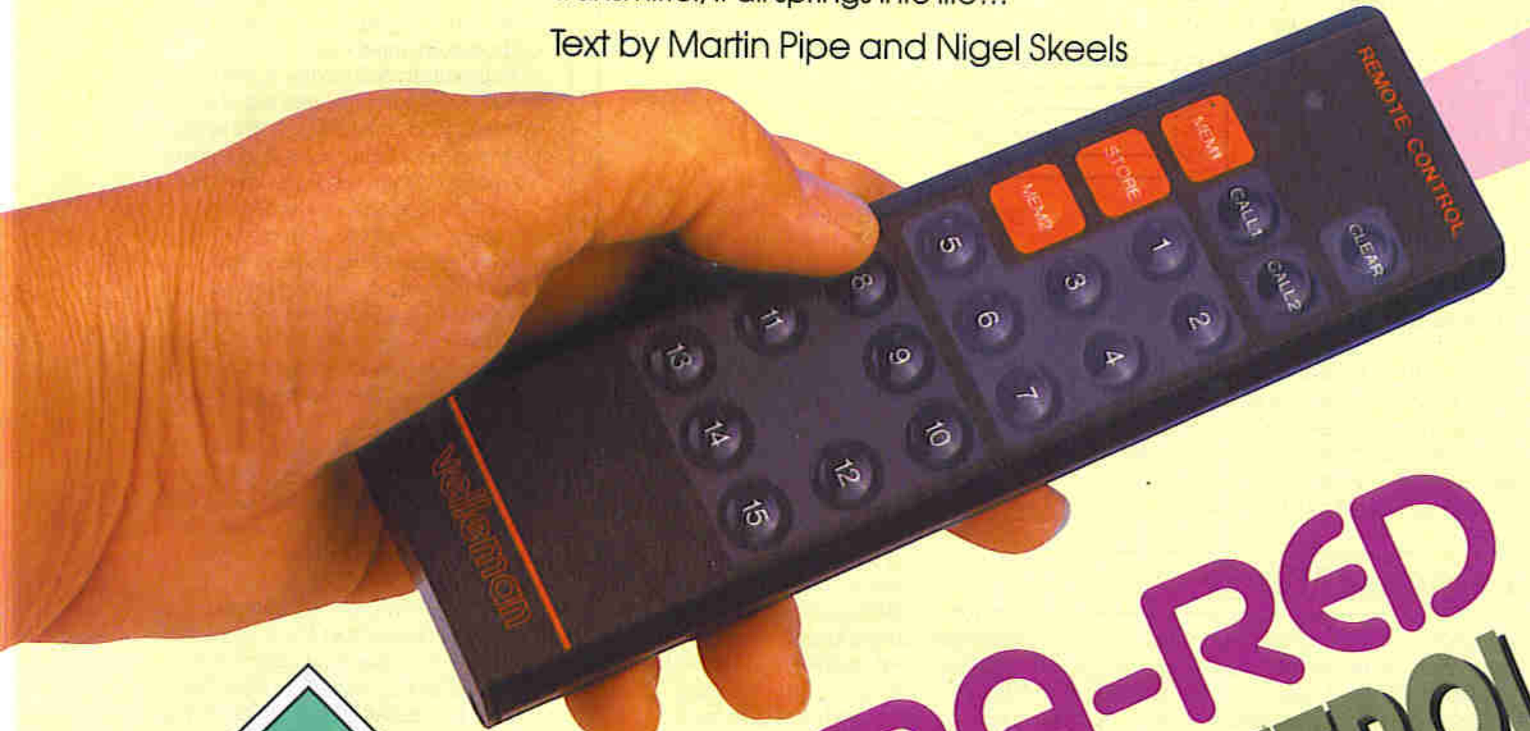
Of course, in some installations it may never be necessary to leave the digital domain from mixer input all the way to tape recorder output, the whole thing being mixed, processed and recorded digitally – big money!

In the next part, we take a look at all popular types of recording media.

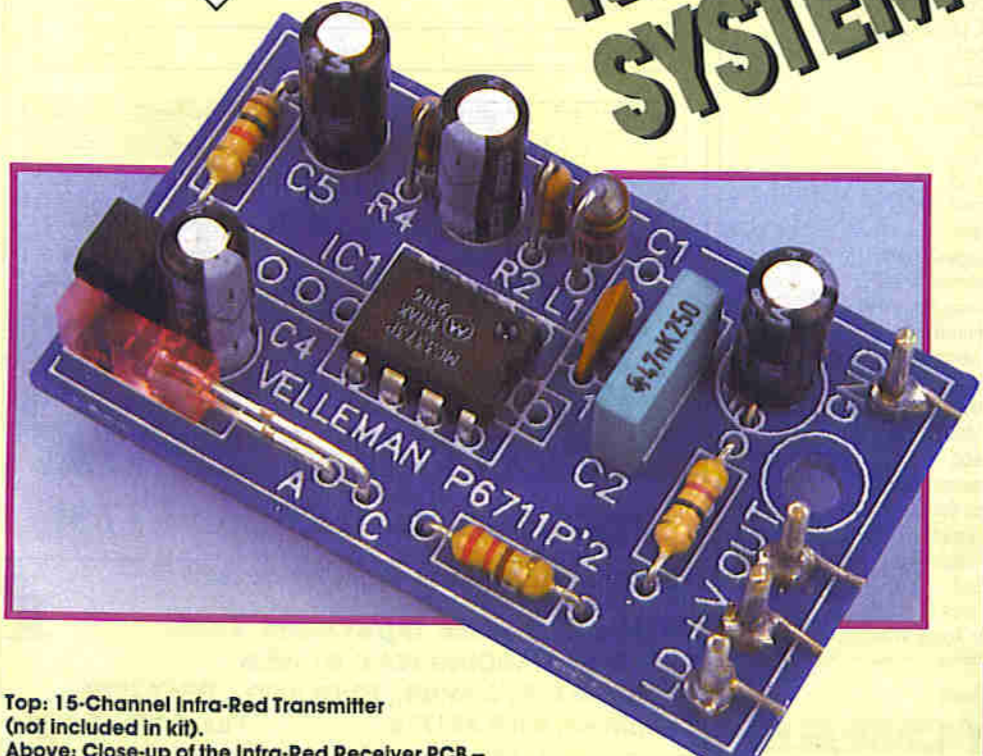
2
PROJECT RATING

Imagine a winter evening, sitting by a fire, in the comfort of your armchair. It's just starting to get dark, the curtains need shutting, the lights need switching on and you want to listen to the radio. But you're in a fairly deep state of relaxation, and you don't want to get up – so what *can* you do? Well, with a press of a few buttons on an infra-red transmitter, it all springs into life…

Text by Martin Pipe and Nigel Skeels



15 CHANNEL INFRA-RED REMOTE CONTROL SYSTEM



FEATURES

- Controls up to 15 separate open collector outputs
- Each output can have 'pulse' or 'toggle' operation modes
- 'Rotary' switching or independent channels
- Two memories for storing commonly-used output combinations

KIT AVAILABLE
Price: £38.95

Top: 15-Channel Infra-Red Transmitter (not included in kit).
Above: Close-up of the Infra-Red Receiver PCB – note the way in which the LED has been fitted.
Right: The completed 15-Channel Infra-Red Receiver.

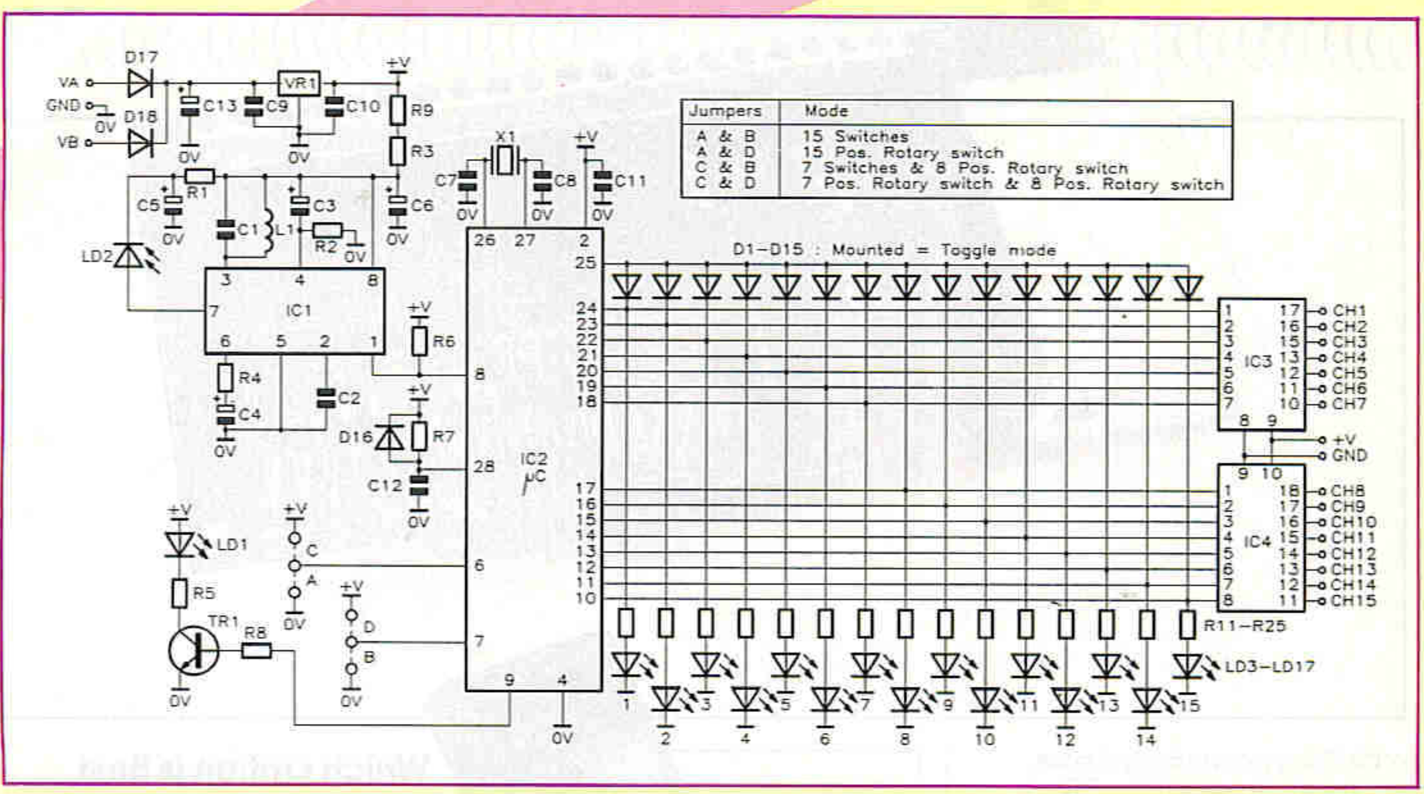


Figure 1. 15-Channel Infra-Red Receiver circuit diagram.

Using the 15-Channel Receiver Module, together with the 15-Channel Infra-Red Transmitter (described in 'Electronics' Issue 59, November 1992), such levels of home automation become a possibility. The transmitter sends a burst of coded infra-red light (the precise code depends on which key has been pressed), which is then intercepted by the receiver module, which picks up and decodes the signals from the transmitters. The fifteen outputs from the receiver could be used to energise relays (not included), for example. These could control your curtain moving mechanism, lights, radio – and anything else that you fancy – leaving you still sitting comfortably in your armchair!

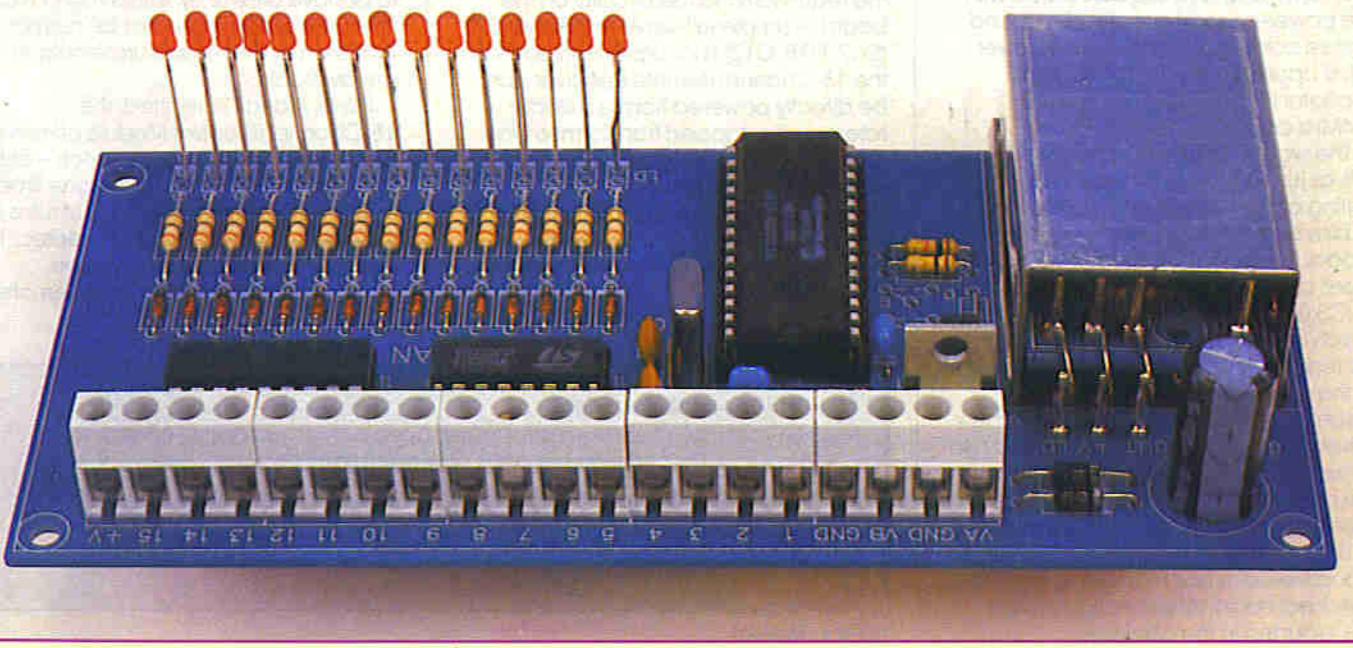
Receiver Circuit Description

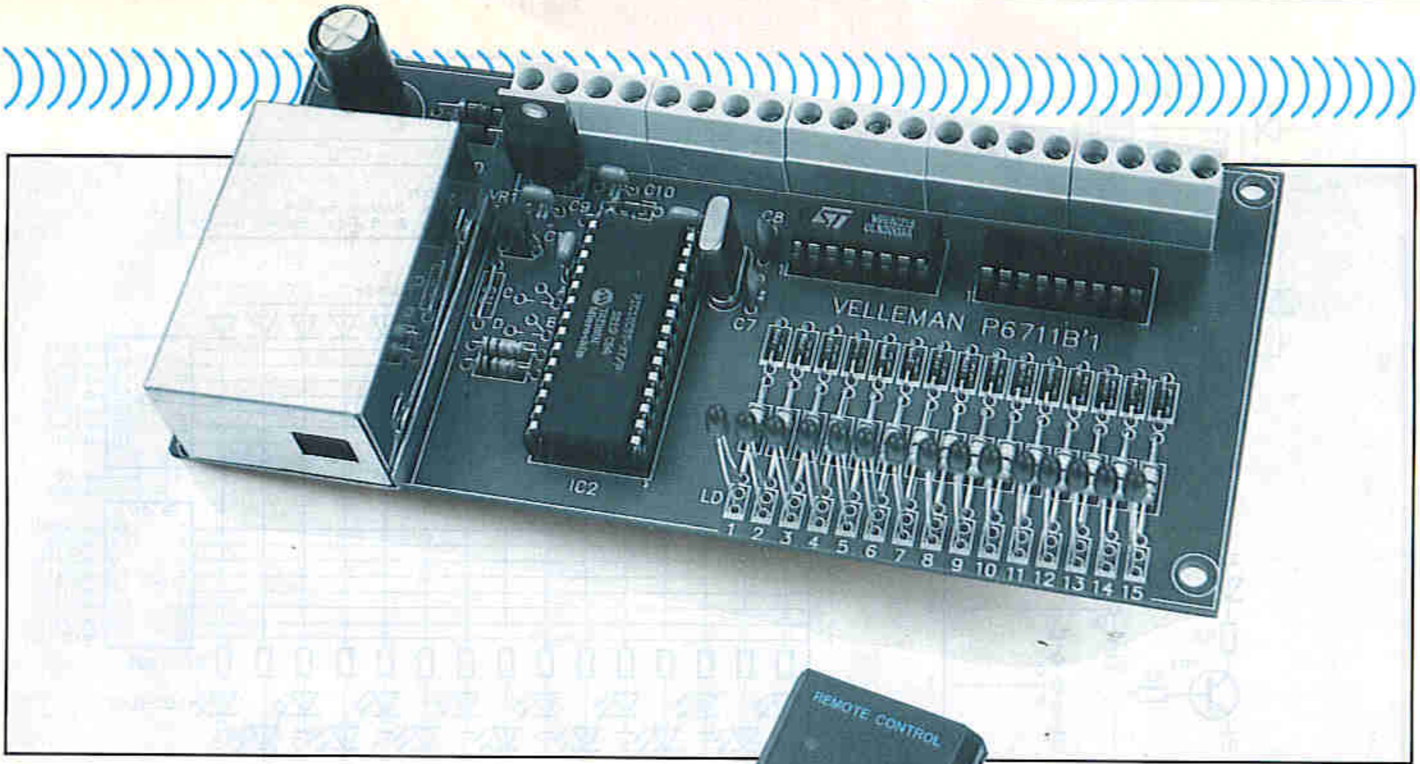
Operation of the transmitter is given, as mentioned earlier, in a previous issue of 'Electronics'. Basically, though, it sends a series of codes (corresponding to the keys pressed) which have been pulse-width modulated on a 38kHz carrier. We will therefore concentrate on the receiver, the circuit diagram of which is shown in Figure 1.

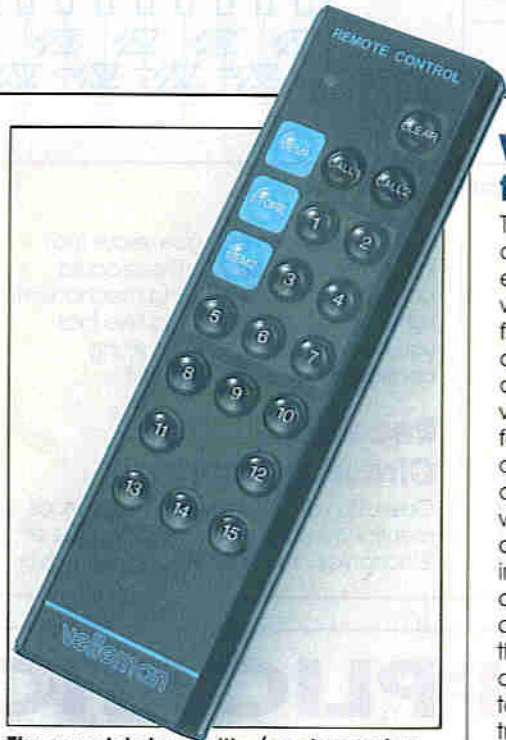
The information from the transmitter is picked up by the receiver via LD2, which is a photodiode sensitive to infra-red light. The output from this component is processed by IC1 (2182 or 3373), which contains an AGC amplifier, pulse shaper and pulse-width demodulator. The duty

APPLICATIONS

* Lighting * Stage effects * Home automation * Security systems
* Adding infra-red remote control to logic-controlled VCRs and cassette decks







of this IC is to recover bursts of code, which are then passed to the PIC (Peripheral Interface Controller) microcontroller chip, IC2. This is a single-chip 8-bit microcomputer, which has the ROM (carrying the special operating software) and RAM on-chip. IC2 will only respond if the information contains the correct carrier frequency and a valid address. LD1, which is operated by one of IC2's I/O ports via TR1, will momentarily illuminate if a correct code is received.

The fifteen outputs are also derived from IC2's I/O ports. The PIC chip used has two 8-bit ports, and one 4-bit port. The 4-bit port (pins 6 to 9) is used in three different ways. One bit accepts the data from IC1 via a pull-up resistor (pin 8), while another drives LD1 (pin 9). The other two bits of this port (pins 6 and 7) are brought out as links; connecting them to ground (pins A or B) or +5V (pins C or D) allows various options to be chosen – more on these later. The fifteen outputs are derived from the two 8-bit ports (pins 10 to 17, and 18 to 25).

D16, R7 and C12 are associated with the power-on reset circuitry of IC2, and ensure correct operation when power is first applied to the unit. The clock oscillator for IC2 is derived from X1, a 4MHz crystal.

The way in which the system works will, as just mentioned, depend upon the setting of the two wire links connected to pins 6 and 7 of IC2, and whether the diodes D1 to D15 are fitted or left out – more on this later.

IC3 (ULN2003) and IC4 (ULN2803), which contain open-collector Darlington buffers (7 in IC3, 8 in IC4), are connected to the outputs from IC2. Buffers are essential, so that useful devices can be driven. Each output can drive an LED (via a current-limiting resistor) in addition to the buffer; this enables its status to be monitored. The buffers used are capable of sinking currents of 500mA, at up to 50V. Inductive loads (such as relays) can be switched; note that protection diodes are included in the package.

The complete transmitter/receiver system.

The final components in the design are those relating to the power supply. VR1 is a 7805 voltage regulator, which supplies the required 5V to the circuitry on the board. A simple full-wave rectifier circuit (D17, D18, C13) is incorporated, so that the 15-Channel Remote Receiver can be directly powered from a suitably-rated centre-tapped transformer. One of around 9V per winding, would be sufficient (YN15R, rated at 250mA per winding, would be ideal for the job). Alternatively, DC (8 to 14V) can be applied between 'VA' (or 'VB') and 'GND' (0V).

Which Option is Best for My Application?

Table 1 gives a summary of set up options. Diodes D1 to D15, when fitted, enable the 'latch' facility. This means that when the receiver decodes a pulse train from the remote control, the output in question will stay on until it receives another pulse train to switch it off, and vice versa. This latching capability is ideal for lighting control applications – a press of the key will turn a light on; pressing it again will turn it off. The 'pulse' facility would be ideal for a relay-operated curtain rail with a DC motor – in this instance, the button on the remote control would be held down until the curtains reached the desired point on the rail. Another button would operate another relay, providing reverse-polarity to the motor and causing the curtain to travel in the other direction.

The other options are invoked by arranging links. There are four of these – A, B, C and D. Various combinations of these are possible, and cause the system to behave differently. If links A and B are fitted, the system operates as 'normal'; that is to say that 15 separate outputs are available.

If links A and D are fitted, the 15-Channel Receiver Module effectively becomes a 15-way rotary switch – only one output can be on at any one time; in other words, selecting an output turns off the one that was previously selected. This option is useful if a relatively large number of sources need to be remotely

Component Link	Effect
D1 to D15	Leave out for 'pulse' operation, fit for 'toggle' operation. Each channel is configurable in this way.
A and B	15 independent switches.
A and D	15-way rotary switch.
B and C	7 independent switches, one 8-way rotary switch.
C and D	2 independent rotary switches; one 7-way, one 8-way.

Table 1. Options

selected – for example, cable TV technicians could monitor any one of 15 sets of composite video/audio signals (i.e. television channels) from the comfort of a chair.

If links C and B are fitted, the first seven outputs operate as if links A and B were fitted (i.e. seven independent switches), while the remaining eight operate as if links A and D were fitted (i.e. the rotary switch option). This option may be useful when automating a digitally-controlled amplifier, for example; source selection could be accomplished using the rotary switch, while power, volume and tone control could be implemented using the seven switches (wired for 'pulse' operation).

The remaining option is when links C and D are fitted. Here, two independent rotary switches (one 8-way, the other 7-way) are provided. This would be useful, to quote another audio example, in Hi-Fi shops. Prospective audiophiles often want to try different combinations of equipment – the so-called 'A/B comparison'. Armchair control would, of course, be extremely useful in this application.

Construction

If you are new to project building, you are advised to refer to the Constructors' Guide (order separately as XH79L) for helpful practical advice on how to solder, and identify components. The 15-Channel Receiver Module s built up on two PCBs; a small board containing the preamplifier and photodiode, and a larger 'main' board that contains the logic components and output terminals. The preamplifier PCB is mounted within a screened box since it is sensitive to interference, which may cause erroneous operation.

Generally, it is advisable to fit the smaller components first, since gaining access to their PCB positions may prove difficult once the larger ones have been fitted.

Preamplifier PCB

Fit the resistors first, followed by L1 and the capacitors (watch out for C3 to C6, which are electrolytic types). L1, R2 and R4 should be mounted vertically. Fit LD1; before this component is fitted, its leads should be formed as shown in Figure 2. Note that the anode lead should be the one nearest the PCB. The photodiode, D, can follow; this should be orientated with its outline on the legend. Fit the four PCB pins (these are inserted from the component side of the board), followed by IC1. The IC is soldered directly to the PCB; desoldering it because you inserted it incorrectly may damage the component, and it certainly wastes time, so get it right first time!

Check the finished PCB for any obvious mistakes or solder-related gremlins – once you are satisfied, the board can be slid into its housing as shown in Figure 3. As can be seen from the drawing, the board is slid between two sets of runners. Once the PCB is in position, solder can be applied to the runners that are visible; it will flow onto the tinned copper tracks on the sides of the PCB, providing a connection between the screen and the board, as well as mechanical integrity. Before soldering, though, ensure that both LD1 and D project from the rectangular aperture at the front of the housing.

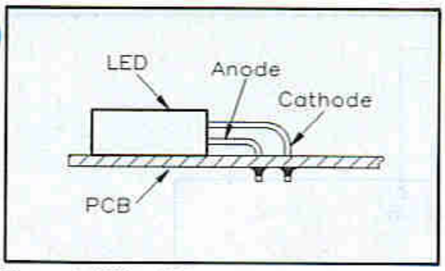


Figure 2. Fitting LD1.

Main PCB

Begin by fitting the resistors, followed by the capacitors and diodes D17 and D18. Note that a wire link should be fitted in the R9 position. The option links (A,B,C,D) should also be fitted; refer to Table 1. C13 is an electrolytic device, and so care should be taken to ensure that it is fitted the correct way round. The diodes are also polarised components; the band on each diode, which indicates the diode's cathode, should line up with the 'filled-in' end of the corresponding symbol printed on the PCB legend. The same comments on installation apply to D1 to D15, which should be fitted next. Please note that not all of these diodes may need to be fitted;

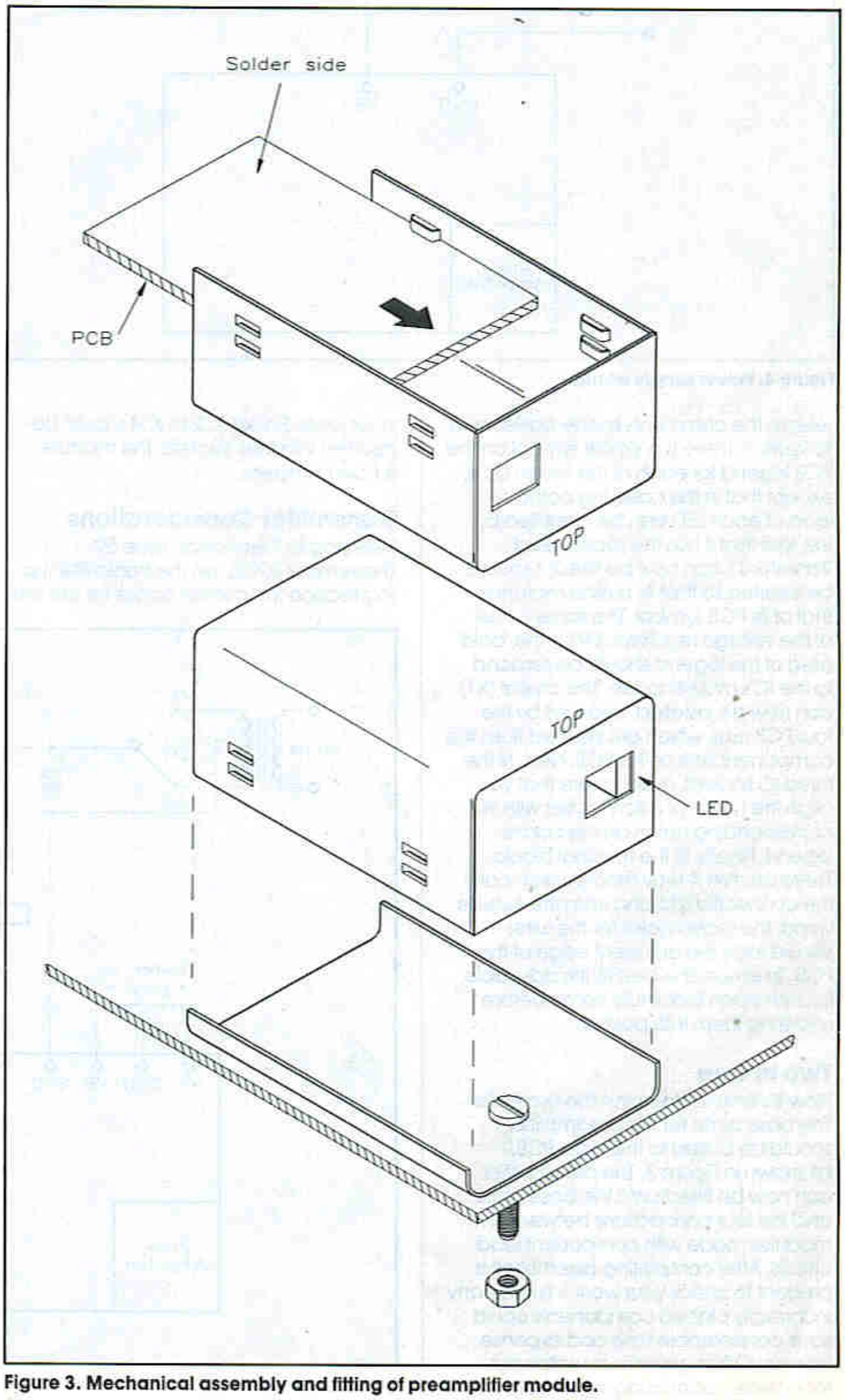


Figure 3. Mechanical assembly and fitting of preamplifier module.

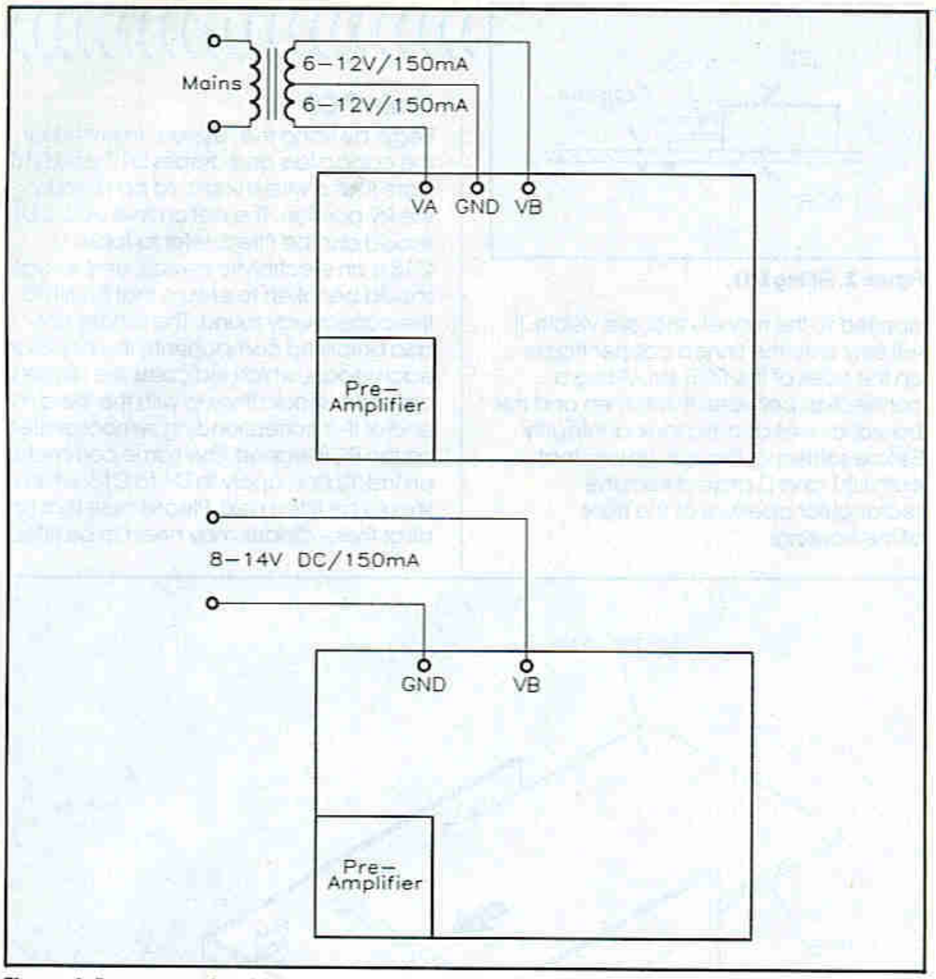


Figure 4. Power supply wiring.

refer to the comments made earlier, and to Table 1. There is a similar symbol on the PCB legend for each of the fifteen LEDs, except that in this case, the cathode lead of each LED can be identified by the fact that it has the shorter lead. Transistor T1 can now be fitted; it should be inserted so that its outline matches that of its PCB symbol. The same is true of the voltage regulator, VR1 – the 'bold' area of the legend should correspond to the IC's mounting tab. The crystal (X1) can now be installed, followed by the four PCB pins, which are inserted from the component side of the PCB. Next, fit the three IC sockets, making sure that you align the notch of each socket with its corresponding notch on the board legend. Finally, fit the terminal blocks. There are five 4-way blocks which carry the connections to and from the outside world; the receptacles for the wires should face the adjacent edge of the PCB. To ensure the best fit, it is advisable to push each block fully home before soldering them into position.

Two in One

Now it's time to combine the two PCBs. The base plate for the preamplifier should be bolted to the main PCB, as shown in Figure 3. The preamplifier can now be fitted onto the base plate, and the four connections between the modules made with component lead offcuts. After completing assembly, it is prudent to check your work – finding any incorrectly placed components could save considerable time and expense later on. Other gremlins to watch out for include solder bridges/whiskers and poor joints. Finally, IC2 to IC4 should be inserted into their sockets; the module is now complete.

Transmitter Considerations

Referring to 'Electronics' Issue 59 (November 1992), set the transmitter up to produce the correct codes for use with the 15-Channel Infra-Red Receiver. This involves fitting only D4 of the option diodes, as is made clear in Table 1 of that article. If you already have such a transmitter, for the Digitally Controlled Preamplifier ('Electronics' Issue 52) or the Synthesised Digital Tuner ('Electronics' Issue 67), please note that it will not work, as it has been set up to produce different codes; however, it can be modified.

Wiring and Testing

The exact way in which the 15-Channel Receiver is used will depend on its exact application. A centre-tapped transformer (9V-0-9V) is connected to terminals 'VA', 'GND' and 'VB', as shown in Figure 4. Alternatively, an existing DC supply can be connected to pins VA or VB (+8V to +14V), and GND (0V). In Figure 5, the relays are powered by a separate transformer. The output of this is rectified and fed, to the collectors of the switching transistors in IC3/IC4, via the '+V' pin. The rectified output from this second transformer is also applied directly to each relay coil, the other end of which is connected to the relevant output. Note that if a relay to be used as an output load, an optional (i.e. it's not in the kit!) 1N4001 protection diode should be wired across its coil, as shown in Figure 5. Alternatively, if a DC supply is to be used and the relay voltages are suitable, then the supply can be used to power both the module and the relay switching circuitry – provided, of course, that it can source enough current!

The Mains Opto-Switch (LP55K, which was featured in 'Electronics' Issue 41 – Dec 1990/Jan 1991) could be used as an alternative to a relay if mains loads, of

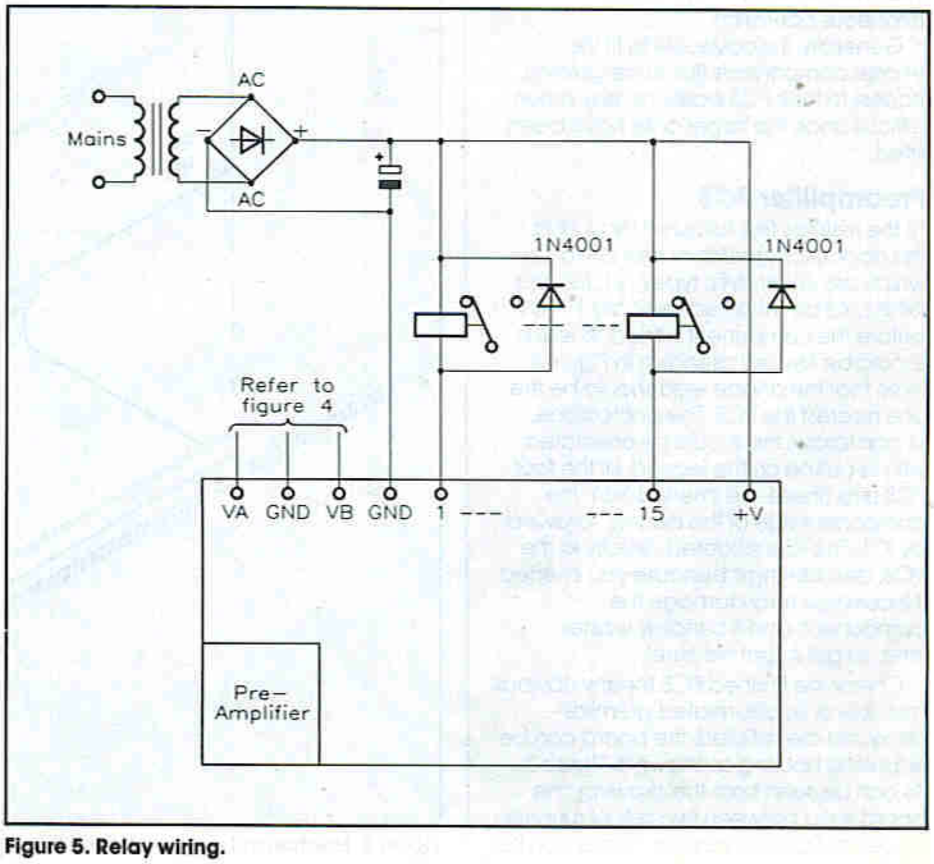
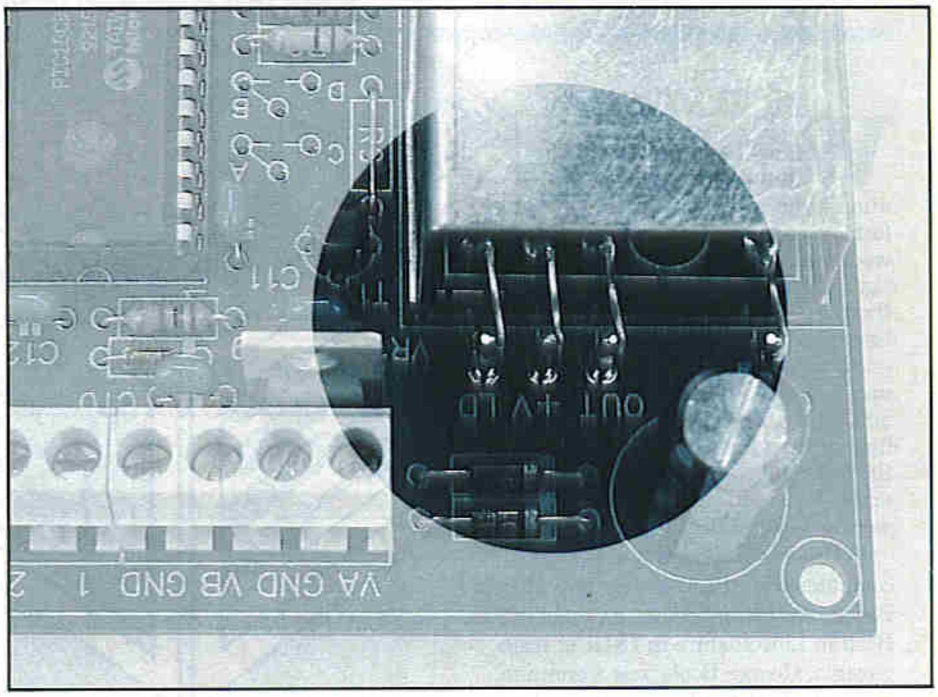


Figure 5. Relay wiring.

up to 250W (resistive), are to be switched. This method of switching is a lot quieter than a relay – both electrically and mechanically – and is more reliable in the long term. Since the Mains Opto-Switch requires a CMOS-level switching voltage, +12V DC should be applied to the '+V' pin of the receiver board.

The best way of testing the system is to apply power, and try it out. Go through all of the 15 channels, pointing the remote control transmitter at the receiver and pressing the appropriate buttons – the corresponding LEDs should light up. Please note that if the receiver is not responding to the transmitter, the transmitter may be to close, causing the receiver's preamplifier to overload; try moving the two units further apart.



Close-up of the wiring between receiver sub-PCB and the main PCB.

Using the System

The buttons on the remote control are self-explanatory. The buttons numbered 1 to 15 correspond to the channels. There are also 2 memories, which can be useful for recalling the settings used most often.

To use the memory facility, press the buttons (1 to 15) depending on what you wish to store, whilst simultaneously holding down the 'STORE' button. Press either the 'MEM1' or the 'MEM2' keys, depending on which memory you want to store the information in. Release all buttons, and the LED on the receiver will flash twice to show that the memory has been programmed. The memory is recalled by pressing either the 'CALL1' or the 'CALL2' key, depending on which memory you wish to access.

The 'CLEAR' button has the function of resetting the receiver, so that all outputs are switched off.

15-CHANNEL INFRA-RED RECEIVER PARTS LIST

RESISTORS: All 5% 0·6W Metal Film		
R1	1k	1
R2	39k	1
R3	47Ω	1
R4	22Ω	1
R5	220Ω	1
R6	100k	1
R7,8	10k	2
R11-25	390Ω	15
CAPACITORS		
C1	3n9F Ceramic	1
C2	47nF Ceramic	1
C3	2μ2F Electrolytic	1
C4	4μ7F Electrolytic	1
C5	10μF Electrolytic	1
C6	47μF Electrolytic	1
C7,8	18pF Ceramic	2
C9-C12	100nF Ceramic	4
C13	1000μF Electrolytic	1
SEMICONDUCTORS		
LD1	(Preamp) LED Red Square	1
LD1-15	(Main Bd.) LED 3mm Red	15
LD2	BPW41 IR Photodiode	1
IC1	2183 or 3373	1
D1-16	1N4148	16
D17,18	1N4005	2
T1	BC547	1
VR1	7805CT	1
IC2	VK6711	1
IC3	ULN2003	1
IC4	ULN2803	1

MISCELLANEOUS			
L1	4700μH Inductor	1	
X1	4MHz Crystal	1	
	16-pin DIL Socket	1	
	18-pin DIL Socket	1	
	28-pin DIL Socket	1	
	4-Way PCB-Mounted Screw Terminals	5	
	Screening Can	1	
	Preamplifier PCB	1	
	Main PCB	1	
	PCB pins	8	
	Wire links	20	
	Screw M3 × 10mm	1	
	Nut M3	1	
OPTIONAL (Not in Kit)			
	Constructors' Guide	1	(XH79L)
	Magazine No. 59 (November 1992)	1	(XA59P)
	15-Channel Infra-Red Transmitter Kit	1	(VE72P)
	250mA Transformer 9V-0-9V	1	(YN15R)
	Relays	Application specific	
	1N4001	As required	

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

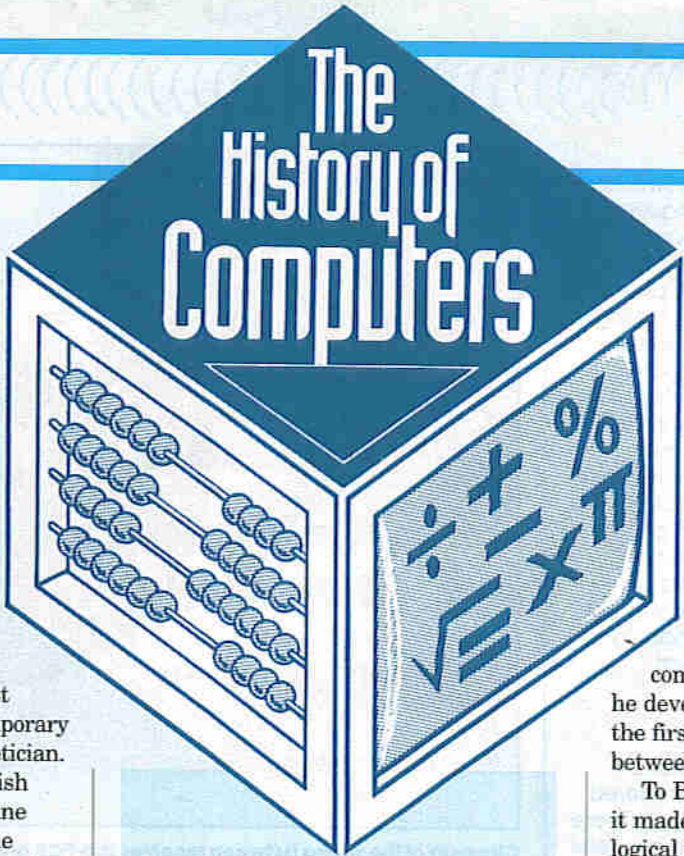
The above items (excluding Optional) are available in kit form only.

Order As VE73Q (15-Channel I/R Receiver)

Price £38.95.

Please Note: Some parts, which are specific to this project (e.g., PCBs, IC1, IC2) are not available separately.

6. The Early Theoreticians BOOLE and JEVONS



by Greg Grant

We have previously seen how Leibniz interested himself in binary notation, even trying to create some form of numerical system that would underpin scientific investigation and mathematical thought. In this he failed, but he was not the only one to do so. Although his work would be carried on by Plouguet, Lambert and others, they too would get no further than he had done. In fact, the division between mathematics and logic would remain until the work of George Boole.

If Charles Babbage was the first computer scientist, then his contemporary Boole was the first computer theoretician. Born in Lincolnshire in 1815, of Irish parents, George Boole was a genuine original. Whilst still in his teens, he became a teacher in a school in Lincoln, later moving to another in the outlying village of Waddington. It was in the course of his work that this largely self-taught mathematician wondered if mathematics, particularly algebra, could be used to express logical relations. His interest in this area grew and came to a head after a dispute between two of the leading mathematicians of the day, Augustus De Morgan and William Hamilton. Boole got in touch with De Morgan who, like himself, was working on a paper on logic.

They agreed that they should publish their work simultaneously and so De Morgan's 'Formal Logic' and Boole's 'Mathematical Analysis of Logic' hit the bookstands, together, in 1848.

Babbage immediately recognised that Boole's book was a masterpiece and noted, in the margin of his copy, that it was the work of a real thinker.

In the following year, Boole was appointed Professor of Mathematics at Queen's College Cork, despite lacking a degree. Six years later, he published another masterpiece 'An Investigation Of The Laws of Thought'. Tragically, his life was cut short at the age of 49 through lung congestion.

What did Boole do that was so important to modern computing? Simply that he advocated the use of symbols alongside accurate laws of combination, and the form of algebra he developed – Boolean Algebra – was the first attempt to bridge the gap between mathematics and logic.

To Boole this was a true calculus, and it made the manipulation of abstract logical functions possible or, put simply, allows you to express logical reasoning in an algebraic form.

He put forward a calculus that gave two interpretations, one of which was relevant to relationships among objects, the other to relationships among facts, as expressed by propositions.

The basis of this system is the concept of Sets or Groups, which can be designated by the familiar symbols of 'a', 'b' or 'c'. For instance 'a' might represent a set of engineers, 'b' a set of scientists and 'c' a group of professional people with electronics training. You can then express the connection between the sets by something familiar to all of us – equations.

Boole introduced two important quantities to which an operation can be applied namely '.' and '+'.

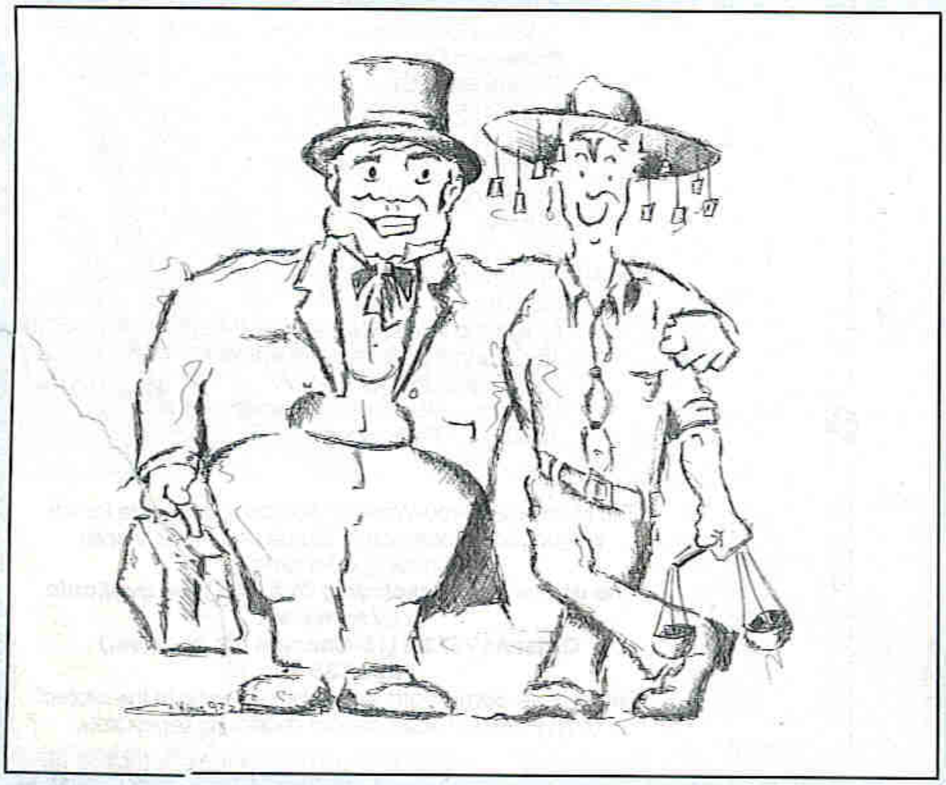
So 'c.b' indicates the group or set of objects designated by 'c' and 'b' or, in our example 'scientists with electronics training.'

Equally, 'a + b' indicates the set of objects that fall into either the 'a' class, or the 'b' class. In the example above, 'a + b' means 'engineers and scientists'. From all of the above we can say then that c(a + b) indicates 'scientists and engineers with electronics training.'

So far, revolutionary, but what happens when we have two sets with identical contents?

The concept of 'a . a' or 'a^2' can only mean one thing – a. After all, engineers are engineers, and scientists are scientists whether they have had electronics training or not, and so in Boole's system $a^2 = a . a = a$. In conventional mathematics this is only true when a = 1 or O.

Now we can see where Boole succeeded and Leibniz failed. His lasting achievement was to show the very close relationship between logic and binary



arithmetic. In fact, the discipline of symbolic logic was virtually founded by Boole.

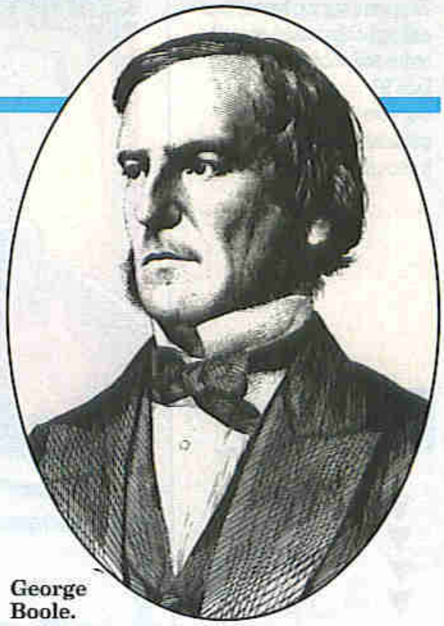
Another brilliant logician of this period was William Stanley Jevons, the originator of the Truth Table. Born in Liverpool in 1835, the ninth of eleven children, Jevons was educated at the Mechanics Institute High School before being sent to the University College School in London when he was fifteen.

In 1853, he was chosen as the Assayer of a new Australian Mint, and in the course of the next six years, he read widely and developed a considerable interest in meteorology, becoming the discoverer of the 'Jevons Effect'. This showed that the very presence of a rain gauge causes air-flow turbulence, which causes some of the rain to be swept past the gauge and so go unrecorded.

Part of his extensive reading was J. S. Mill's 'Logic' and, on his return to England, he enrolled as a student once more at his old university. During the course of his studies, he much admired the lectures of De Morgan. Soon, he began to spread the idea of 'logic tabulation.'

However, Jevons was not content simply to explore these ideas. He applied them to machinery, and in 1869 he published his paper 'The Mechanical Performance of Logical Inference' in which he discussed what he called a 'Logical Abacus'. This was a machine he had designed and built to carry out logical manipulations.

This most useful device was capable of solving problems involving overlapping sets with as many as four different components requiring interrelation. It was operated via a set of keys rather like those on a cash register. In the following year, Jevons refined his ideas in his book 'Elementary Lessons In Logic.'



George Boole.

Jevons, like Babbage, was one of the few men of the day to realise the significance of Boole's work, which his own complimented. His ideas enabled statements concerning an event and their respective truth values to be tabulated in binary form. Nine years after Jevon's 'Elementary Lessons in Logic' appeared, the German mathematician and logician, Frege, coined the expression 'Truth Table' for Jevons's tabulations.

Thus by the final decades of the 19th century, much of the basic mathematical foundations of computing had been laid. What is more, a number of scientists and engineers began to build calculators, the result of continued mathematical frustration. We will take a look at three of them next month.

NOT

A	$\overline{A}$
0	1
1	0

AND

A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

OR

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

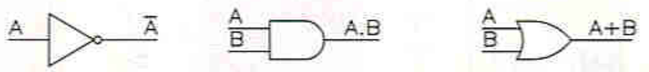


Figure 1: Tables showing the end result of every possible operation of NOT, AND and OR, with the corresponding present day electronic symbols.

NEXT issue

In next month's super issue of 'Electronics – The Maplin Magazine', there are some really great projects and features for you to get your teeth into! To whet your appetite, here's a taste of some of the goodies on offer:

PC WEATHER STATION

Yet another example of how your IBM PC/XT/AT/386/486 (or compatible) can be put to practical use, the Weather Station takes the form of an 8-bit expansion card that works in conjunction with outdoor-mounted wind speed and direction sensors. With suitably-written programs, patterns in wind behaviour can be monitored, output can be graphically displayed, and flexible control systems can be implemented; sample BASIC routines are included. The card has also been designed for expansion – the later addition of an analogue-to-digital converter will allow a wide variety of transducers to be connected.

EXPLORING VENUS

Venus, the second planet in order from the sun, is often visible to observers unaided by a telescope. Before the sun is visible, its light is reflected back to Earth by Venus, giving rise to its name of 'morning star'. Assisted by their crude telescopes, the first astronomers gazed upon the 'green planet', believing vegetation to be responsible for its colour, and that Venus was indeed the Earth's twin. Alas, modern scientific exploration suggests that nothing could be further from the truth, as you will discover when you read Douglas Clarkson's article.

AUDIO SPECTRUM ANALYSER

If you've got a graphic equaliser, a spectrum analyser will help to ensure that you set your system up to give the flattest frequency response possible. Those who don't have a graphic equaliser will be pleased to know that the Spectrum Analyser forms part of a modular system, which will incorporate a graphic equaliser in the course of time.

LOOP ALARM

You've probably seen these in high-street shops, where they are used to stop thieves sneaking off with expensive goods. A wire (the 'loop') is passed through a convenient aperture (carrying handle, bike frame, between the rungs of a ladder, etc.) in each item to be protected. For the benefit of those who haven't found out the hard way, the alarm sounds if the loop is broken. The bad news for smaller retailers and homeowners is that commercially-available units of this type do tend to be quite expensive – the good news is that you will shortly be presented with a DIY alternative!

DISCOVERING SATELLITE TELEVISION

This month, Martin Pipe
his reviews by casting
over the Echostar SR-
manual 'knobs and
the enthusiast. F
Assistance Devic
resolve a watch-
more than r
in detail.

Plus
usua
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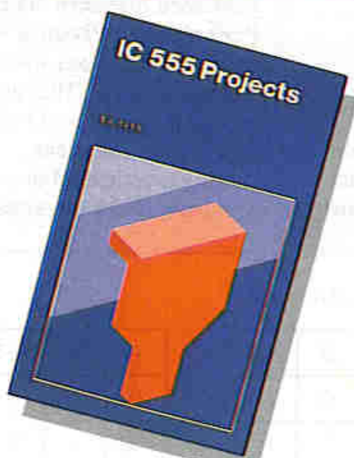
MA
BRITA
ELECTR

These are our top twenty best selling books based on mail order and shop sales during June '93.
Our own magazines and publications are not included in the chart below.

The Maplin order code of each book is shown together with page numbers for our 1993 catalogue. We stock over 250 different titles, covering a wide range of electronics and computing topics.

Number ONE



IC555 Projects
by E.A. Parr
Lots of super ideas for this very useful IC.
(LY04E) Cat. P76.
Previous Position: 2.
Price £2.95.

2 ▼▼▼▼

Getting The Most From Your Multimeter, by R.A. Penfold. *(WP94C) Cat. P70.* Previous Position: 1. **Price £2.95.**

3 NO CHANGE

Home VCR Repair Illustrated, by Richard Wilkins & Cheryl Hubbard. *(WZ32K) Cat. P89.* Previous Position: 3. **Price £13.95.**

4 ▲▲▲▲

The Complete VHF/UHF Frequency Guide, by B. Laver. *(WT70M) Cat. P86.* Previous Position: 10. **Price £9.95.**

5 ▼▼▼

... Enclosure Design and ... 82D) *Cat. P79.* ... **Price £9.95.**

6

... 95.

7 ▼▼▼▼

Power Supply Projects, by R.A. Penfold. *(XW52G) Cat. P73.* Previous Position: 5. **Price £2.50.**

8 ▼▼▼▼

An Introduction to Loudspeakers and Enclosure Design, by V. Capel. *(WS31J) Cat. P79.* Previous Position: 6. **Price £2.95.**

9 ▼▼▼▼

International Transistor Equivalents Guide, by Adrian Michaels. *(WG30H) Cat. P66.* Previous Position: 8. **Price £3.95.**

10 ▲▲▲▲

How to Use Oscilloscopes and Other Test Equipment, by R.A. Penfold. *(WS65V) Cat. P70.* Previous Position: 11. **Price £3.50.**

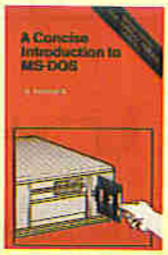
11 ▲▲▲▲

The Washing Machine Manual, by Graham Dixon. *(WS98G) Cat. P89.* Previous Position: 13. **Price £11.95.**

12 ▲▲▲▲

The Robot Builder's Bonanza, by G. McComb. *(WT77J) Cat. P103.* Previous Position: 20. **Price £14.95.**

13 ▼▼▼▼



A Concise Introduction to MS-DOS, by N. Kantaris. *(WS94C) Cat. P98.* Previous Position: 7. **Price £2.95.**

14 ▲▲▲▲

Electronic Music Projects, by R.A. Penfold. *(XW40T) Cat. P81.* Previous Position: 18. **Price £2.95.**

15 ▼▼▼▼

How to Use Op Amps, by E.A. Parr. *(WA29G) Cat. P69.* Previous Position: 12. **Price £2.95.**

16 ▼ RE-ENTRY ▲

Towers' International Transistor Selector by T.D. Towers. *(RR39N) Cat. P66.* Previous Position: Re-Entry. **Price £19.95.**

17 ▼▼▼▼

50 Projects Using Relays, SCR's and Triacs, by F.G. Rayer. *(RH30H) Cat. P73.* Previous Position: 15. **Price £2.95.**

18 ▼ RE-ENTRY ▲

Remote Control Handbook, by Owen Bishop. *(WS33A) Cat. P73.* Previous Position: Re-Entry. **Price £3.95.**

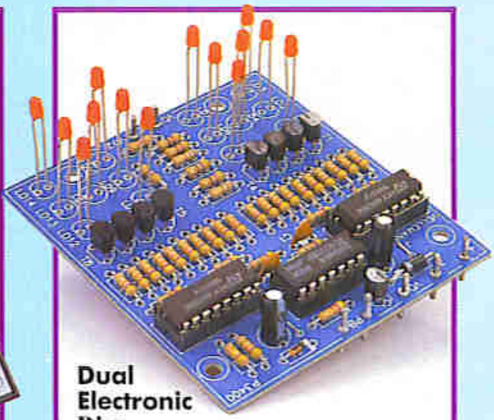
19 ▼ RE-ENTRY ▲

Radio Amateurs Examination Manual, by G.L. Benbow. *(WP87U) Cat. P83.* Previous Position: Re-Entry. **Price £6.75.**

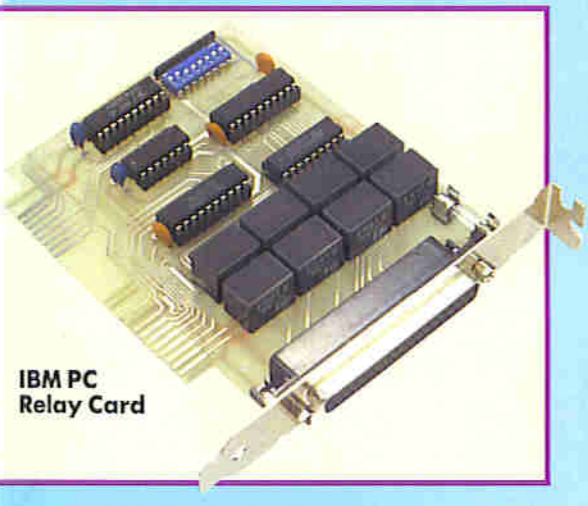
20 ▼▼▼▼

More Advanced Power Supply Projects, by R.A. Penfold. *(WP92A) Cat. P73.* Previous Position: 17. **Price £2.95.**

Z80 Development System



Dual Electronic Dice



IBM PC Relay Card

DID YOU MISS THESE PROJECT KITS?

3-TONE CHIME

Attract attention with this easy-to-build chime unit. Uses include doorbell and P.A. announcements.
Order as VE88V, Price £11.95.
Details in 'Electronics' No. 58 (XA58N).

METROBEAT

Keep right on tempo with this innovative musicians' project. Facilities include foot-switch control.
Order as LP95D, Price £34.95.
Details in 'Electronics' No. 58 (XA58N).

Z80 DEVELOPMENT SYSTEM

Develop your own Z80 control system that can accept up to 8K of on-board memory and has four decoded I/O select lines.
Order as LK67X (Z80 CPU), Price £33.45 and LT15R (Z80 Keypad) Price £24.95.
Details in 'Electronics' No. 58 (XA58N).

PROGRAMMABLE PULSE GENERATOR

This BCD switch controlled unit allows precision pulses to be generated over the range 1 μs to 999ms.
Order as LT20W, Price £22.95.
Details in 'Electronics' No. 61 (XA61R).

DUAL ELECTRONIC DICE

At last, no more hunting under the table for dropped dice; this low-cost project is a must for dice-based board games.
Order as VE07H, Price £11.95.
Details in 'Electronics' No. 61 (XA61R).

IBM PC RELAY CARD

For use with IBM PC, PC-XT, PC-AT and compatible clones, this unit provides your PC with eight programmable sets of change-over contacts.
Order as LT16S, Price £24.95.
Details in 'Electronics' No. 65 (XA65V).

3-Tone Chime

Programmable Pulse Generator

Metrobeat

Maplin's 'Get-You-Working' Service is available on ALL of these Project Kits.

These descriptions are necessarily short. Please ensure that you know exactly what the kit is and what it comprises before ordering, by checking the appropriate issue of 'Electronics' referred to in the list. The referenced back-numbers of 'Electronics' can be obtained, subject to availability, at £1.75 per copy (Issue 66 and 67: £1.95 each).
Carriage Codes – Add; [A]: £1.40, [B]: £2.00, [C]: £2.55, [D]: £3.05, [E]: £3.60, [F]: £4.10, [G]: £4.95, [H]: £5.50.

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