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ELECTRONICS

The Maplin Magazine

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No. 79
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Constructional details can be found in *Electronics* Issue 48 (XA48C).

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Full constructional details in *Electronics* Issue 48 (XA48C).

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Ideal for checking continuity, insulation, finding dry joints, high resistance switches and poor contacts etc.

Full details can be found in *Electronics* Issue 53 (XA53H).

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ZF40T Continuity Tester Label **£1.65**
Optional Item:
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JULY 1994
VOL 13. No. 79

IN THIS ISSUE...

PROJECTS *FOR YOU TO BUILD!*

MODEL STEAM TRAIN CHUFFER 4

This super project is an absolute must for any serious model train enthusiast. The chuff rate is automatically adjusted to match the train's speed by monitoring the track voltage. For added realism, when the train is stationary, an escaping steam sound is produced.

REUSABLE ELECTRONIC FUSE 20

When testing or developing extra low voltage circuits, it is easy to make mistakes and cause a short circuit. This low cost and easy to build project will protect both the power supply and circuit under test. Unlike conventional fuses, this one doesn't need replacing after it has 'blown' – it is self resetting and provides audible and visual indication of fault conditions.

INTELLIGENT Ni-Cd BATTERY CHARGER 35

Ensuring correct charging of Ni-Cd (nickel cadmium) cells has never been a straightforward task. Incorrect charging can result in reduced capacity and shortened operating life or even an explosion! This charger overcomes the shortcomings of basic chargers and ensures that your Ni-Cds will be in tip-top condition. Features include: temperature monitoring; under- and over-voltage protection; automatic discharge prior to charge; slow and fast charging; and charge pulse width modulation.

CAR ALARM ULTRASONIC INTERFACE 52

If you've purchased a basic current sensing only car alarm and later wished you could add an ultrasonic detector, then help is at hand! This ingenious interface allows you to do just that! Other sensors or switches can also be connected using this interface.

FEATURES *ESSENTIAL READING!*

DEVELOPMENTS IN PEDESTRIAN CROSSING TECHNOLOGY 12

Traffic light controlled pedestrian crossings are all to frequently the cause of frustration to both drivers and pedestrians alike – unfortunately accidents occur all to frequently. This is largely because such crossings are 'unintelligent'. Following an extensive study, a new intelligent, user-friendly, crossing control system has been developed. In this exclusive report, Stephen Waddington, reveals the practical answer to this everyday problem.

IMPLEMENTING COMPUTER-BASED VIDEO NETWORKS 15

Frank Booty looks at why it is desirable to integrate video into computer networks; the problems that will be encountered; and how such problems can be overcome.

THE QUIET COMPUTER REVOLUTION 28

Industry big-boys such as IBM, Apple, Intel, Motorola and Microsoft are engaged in the biggest technology upheaval since the introduction of the personal computer. Allies and arch-enemies are swapping sides, and exciting technology abounds. But strangely enough, considering the implications, not much has been reported in the popular press. Keith Brindley looks at what is happening, predicts the outcome, and the likely winners and losers.

SECRETS OF SURROUND SOUND REVEALED 46

In this superb, authoritative new series, John Woodgate reveals the secrets of surround sound and discusses the operation of past and present systems. The first instalment starts with a history lesson, covers the basic principles of stereo sound and laments the failed systems left by the wayside.

UNDERSTANDING TRANSMISSION LINES 55

More mysteries are answered in the final instalment of this three part series.

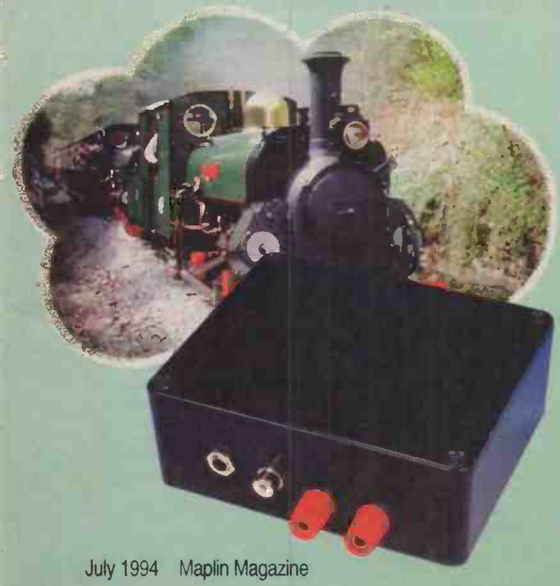
CHOOSING AND USING VIDEO CONNECTORS 59

This practical guide by Andrew Emmerson looks at the range of video connectors in use on video equipment, and explains how you can make you own connecting cables cheaply and easily.

HOW TO USE DIGITAL PANEL METERS 64

Ray Marston demonstrates how digital panel meters can be used in practical applications. Tried and tested circuits are included covering a multitude of possible uses.

REGULARS *NOT TO BE MISSED!*



ABOUT THIS ISSUE . . .

Hello and welcome to this month's issue! As usual there's a fine collection of projects and features for you to enjoy; I'm sure that you'll find them all a jolly good read!

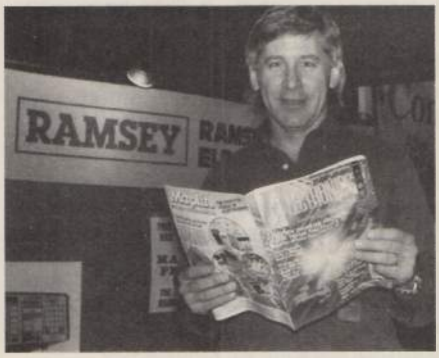
It gives me great pleasure to welcome Dean Hodgkins BEng (Hons) 'on board' the *Electronics* editorial team, he joins our other Technical Author, Robin Hall FBIS, G4DVJ, to further strengthen the capabilities of Britain's best selling electronics magazine! I'm sure that you'll soon look forward to reading Dean's articles just as much as those of the other long-established contributors.

I'd like to say a special "Hello!" to all of our overseas readers – copies of *Electronics* go to many different parts of the globe including Australia, The Falkland Islands, The Seychelles, Iceland, Yugoslavia, Brunei, and over sixty other countries. The fastest growing country in terms of readership at the moment is South Africa. Why not drop us a line and tell us about the hobby of electronics in your country, how you get your components, etc. we would love to hear from you!

Several letters I have received recently have enquired about whether overseas subscriptions are available. The answer is yes! The process of exporting *Electronics* to newsagents all over the world is a difficult task and it can take a long time for the magazines to arrive. So if you are having problems getting a copy of *Electronics* regularly a subscription is the answer to fast reliable delivery! Our Overseas Subscriptions Department can give details of many different payment methods so please contact them by phone, fax or by letter.

Similarly if you are having trouble obtaining parts for your projects locally, they can be supplied by Maplin Export or one of our overseas agents in the United Arab Emirates, Lebanon, South Africa, Malta or Pakistan. Please refer to page 19 for phone and fax numbers, and addresses of Maplin Export and overseas Maplin agents.

Over the past couple of months you'll probably have noticed the inclusion of some amateur radio projects designed by Ramsey Electronics. These projects are designed in the USA, reflecting the increasingly international 'flavour' of *Electronics* – pictured below is John Ramsey in Dayton, Ohio, reading last month's issue!



Continuing with international matters, Maplin has recently acquired a transshipment centre at Subic Bay, in the Philippines; this was set up by Maplin to consolidate shipments of electronic components and products from the Far East. Subic Bay, now a deep-sea free-port, was the former Pacific home of a massive US Military base. Stability in the region has enabled the military presence to be withdrawn, leaving behind an ideal site for international companies to set up shipping and storage operations. Maplin already has offices in Hong Kong and Taiwan; this latest acquisition will further increase the speed and efficiency of Maplin's international operations. Such improvements will benefit you, the customer, with the keenest prices and widest range of quality electronic components and products from all over the world.

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

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Towyn, by Brian Meldon
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Multimedia platforms allow the integration of video, voice, data and music into computing – optical disc is helping to solve the inherent storage problems.

EDITORIAL

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Published by Maplin Electronics plc.,
P.O. Box 3, Rayleigh, Essex, SS6 8LR.
Tel: (0702) 554155. Fax: (0702) 553935.
Lithographic Reproduction by
Planagraphic Studios, 18 Sirdar Road, Brook
Road Ind. Estate, Rayleigh, Essex SS6 7UY.
Printed in the United Kingdom by
St Ives (Caerphilly) Ltd.
Mid-Glamorgan, CF8 3SU.

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UK NEWSTRADE DISTRIBUTION

United Magazine Distribution Ltd.,
Castle House, 37-45 Paul Street, London EC2A 4PB.
Tel: (071) 490 2020. Fax: (071) 490 1239.

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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.

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Visit your local Maplin store, where you will find a wide range of electronic products. If you do not know where your nearest store is, refer to the advert in 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.

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

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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
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£60 to £79.99	£40
£80 to £99.99	£50
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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.

Write to: The Editor, Electronics – The Maplin Magazine, P.O. Box 3, Rayleigh, Essex, SS6 8LR.

TECHNOLOGY WATCH!

with Keith Brindley

There have been some significant developments over the last couple of weeks regarding the Government's position over funding of research and development within UK electronics companies.

In the longer term, over the last few years for example, UK electronics companies have been complaining about the lack of involvement from the Government in terms of finance. In effect, the Government's stance has been increasingly stand-offish – letting the companies themselves foot the bill more and more, for research and development costs. Whatever anyone in the Government has to say about this, they cannot deny that this has been – and is – the case. Funding for several projects has been all but stopped, and many more projects, large and small, have been concluded unsatisfactorily. In other words, these projects have been scrapped because of money problems, and as a result, the UK is now losing out to overseas technology.

Now, there are a few points to be made about this. Research and development, I believe, are *the* most important areas of industry. If a company does not research and develop new products today, its products – which may be eminently useful, reliable, serviceable, and saleable – will be junk tomorrow, with no hope of more products on-line to keep the company going.

Secondly, it *has* to be the responsibility of the companies concerned to ensure that sufficient funds go into research and development – nobody can deny or doubt that. Any company which does not make sure that sufficient funding goes into its own research and development, can only expect the worst outcome. Without undertaking sufficient research into what products it should be producing, and without undertaking sufficient development work on those products, it cannot hope to have the products available in the future to satisfy demand. If a company makes sufficient profits from today's products, then it *must* put an adequate proportion of those profits back into research and development to ensure that its future can be maintained. If a company has the funds to do this, it simply must do so. But, if a company has not got the funds to ensure research and development is maintained at a sufficiently high level, then it becomes its responsibility to seek them in other ways.

Finally, whether or not companies themselves have the responsibility to ensure that adequate research and development work is carried out, the *ultimate* responsibility of ensuring this lies with the UK Government! The Government *has* to take into consideration national, continental and indeed global aspects of our companies. If UK companies can afford to pile in funds to pay for their own research and development, then it is the ultimate responsibility of the UK Government to ensure that they do just that – by rules, regulations, and laws. If UK companies cannot afford adequate research and development funds, or if UK companies, as a whole, are seen to be falling behind those of other countries, then it is the ultimate responsibility of the UK Government to do something about it – to keep our companies at least equal, but preferably ahead, of the others.

When news, such as that from the Joint European Submicron Silicon Initiative (JESSI) recently, becomes apparent, then obviously something is wrong. Apparently JESSI has made a general complaint about the consequences of UK companies pulling out of electronics research programmes throughout the continent, due to lack of funding from the Department of Trade and Industry in the UK Government.

To be fair to the UK Government (which is more than I believe the UK Government has been to its own electronics industry over recent years), there is a small move to make dialogue between electronics companies and the Government easier. But dialogue is, after all, just talk. Just hot air. There is no move yet to increase funding, which is what the whole thing is about. If companies do not reinvest enough into research and development, and if the Government does not reinvest enough into research and development, then there is only worse to come.

On the Wire

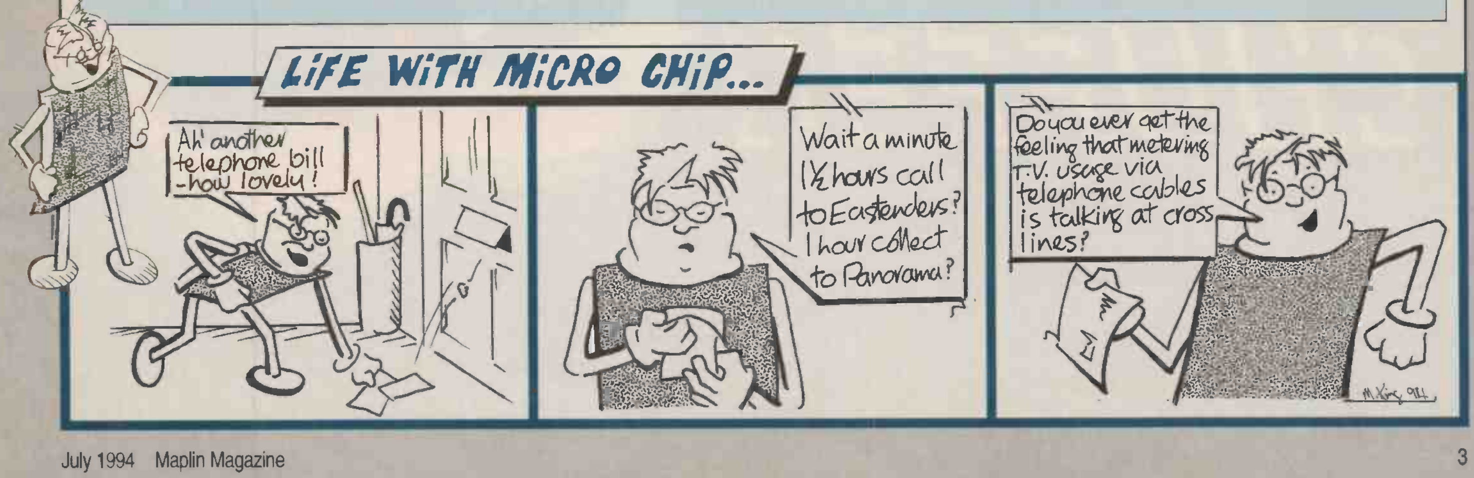
A reader, Mr R. H. of Liverpool, has responded to an earlier column which looked at cable television, suggesting a means of payment for subscriptions. Subscriptions, and their collection, are a bit of a tricky area in the multiplying new entertainments media. Do you charge a fixed monthly rate, do you charge for events, do you charge pay-per-view, or do you charge at all? What is fairest, what can the subscribers afford, and what is more, what can the providers get away with? (What, me be cynical?)

Nevertheless, R. H. of Liverpool has an idea which needs to be considered. He notices the obvious connection between cable television providers and telephone providers (well, they all come into the house on a wire, don't they?) and suggests that some form of tie-up could be made to allow metering of programmes coming inwards. Much like the telephone itself, gas, electric, and water are all metered.

What about it? A few 'free' channels – paid for by subsidy (from the UK Government?) or advertisements – could provide the basis for the cable network to exist at all. Then, a few specialist channels could exist, paid for purely by subscription, and the remainder of the channels could be metered, with watchers being charged by the hour, depending upon the material viewed.

Metering in this way could lead to a higher take-up rate to cable networks, and give everyone equal access to services – something which present charging systems do not (and cannot) – regardless of a household's income. Coupled with this, a metering system is probably much cheaper to install in the first place than a mass of decoders with different decryption standards.

Sounds plausible to me. Any ideas from the rest of our readers?



2
PROJECT RATING

Blanche and *Linda*, Ffestiniog Railway, Tan-y-bwlch.

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KIT AVAILABLE (LT39N) PRICE £9·99

Text by Alan Williamson and Robin Hall

Design by Alan Williamson

FEATURES

- Realistic chuff and hiss of steam
- Chuff rate automatically changes with speed of the train
- Hiss of escaping steam when the train is stationary
- Adjustable tonal quality
- Adjustable chuff rate

MODEL TRAIN CHUFFER

One effect that is normally missing from a model steam train layout is the sound of a chuffing engine. The Chuffer presented here produces a realistic chuff whilst the train is in motion, and also produces a hissing sound which emulates escaping steam whilst the train is at a standstill.

Please note: the optional box shown is not included in the kit and must be purchased separately.

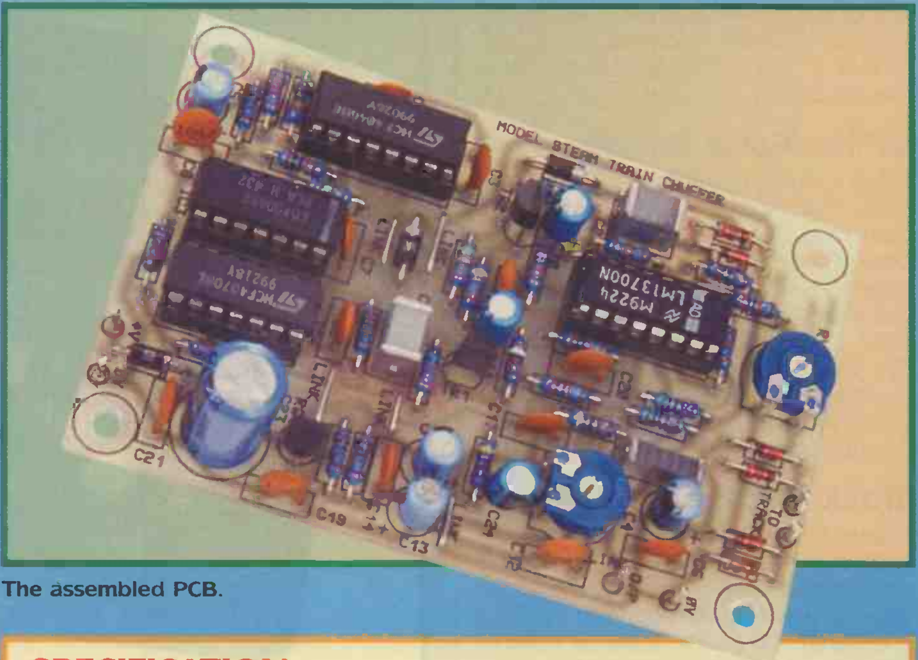
An external amplifier and a power supply of up to +36V DC (absolute maximum) are required for use with the Chuffer. Adjustment of the 'chuff' rate can be made to match the train speed. Once in operation the changes in track voltage will be picked up and the Chuffer rate will alter automatically and lend realism to the model steam train set up.

Circuit Description

The block diagram of the Model Train Chuffer is shown in Figure 1, and the circuit diagram in Figure 2, these will assist the reader in understanding the circuit.

The PSU

An external power supply of +16 to 20V nominal (+36V DC absolute maximum) can be used. Diode D9 prevents damage to the circuit from accidental reverse polarity connection. Capacitor C23 provides the reservoir function, and capacitor C21 provides the high-frequency decoupling. RG1 is a 12V regulator preventing supply variations from affecting circuit operation. Capacitor C19 provides high-frequency decoupling at the output of the regulator as well as



The assembled PCB.

SPECIFICATION

Supply Voltage DC:	+15·5 to 36V DC
Supply Current	
Quiescent:	15·3mA
Operating:	17·1mA
Output Signal Level (nominal):	1V rms
Track Control Voltage Range:	16V maximum

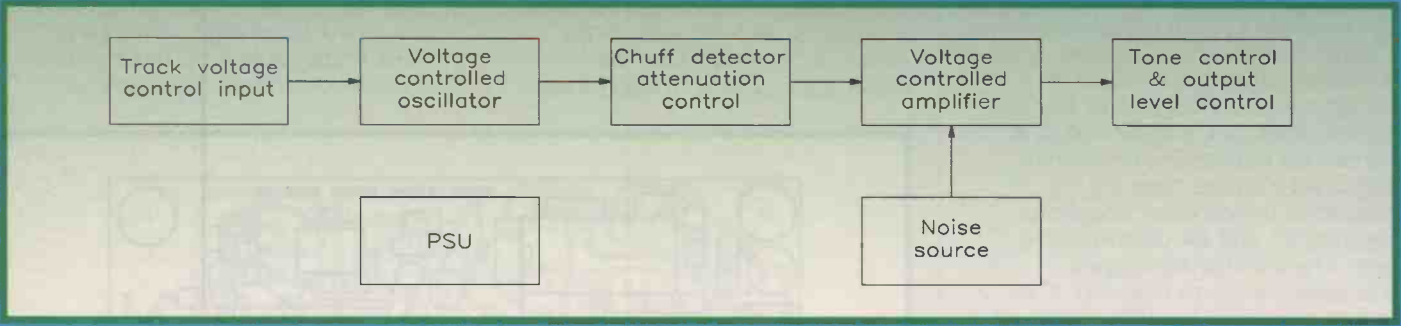


Figure 1. Block diagram of the Model Train Chuffer.

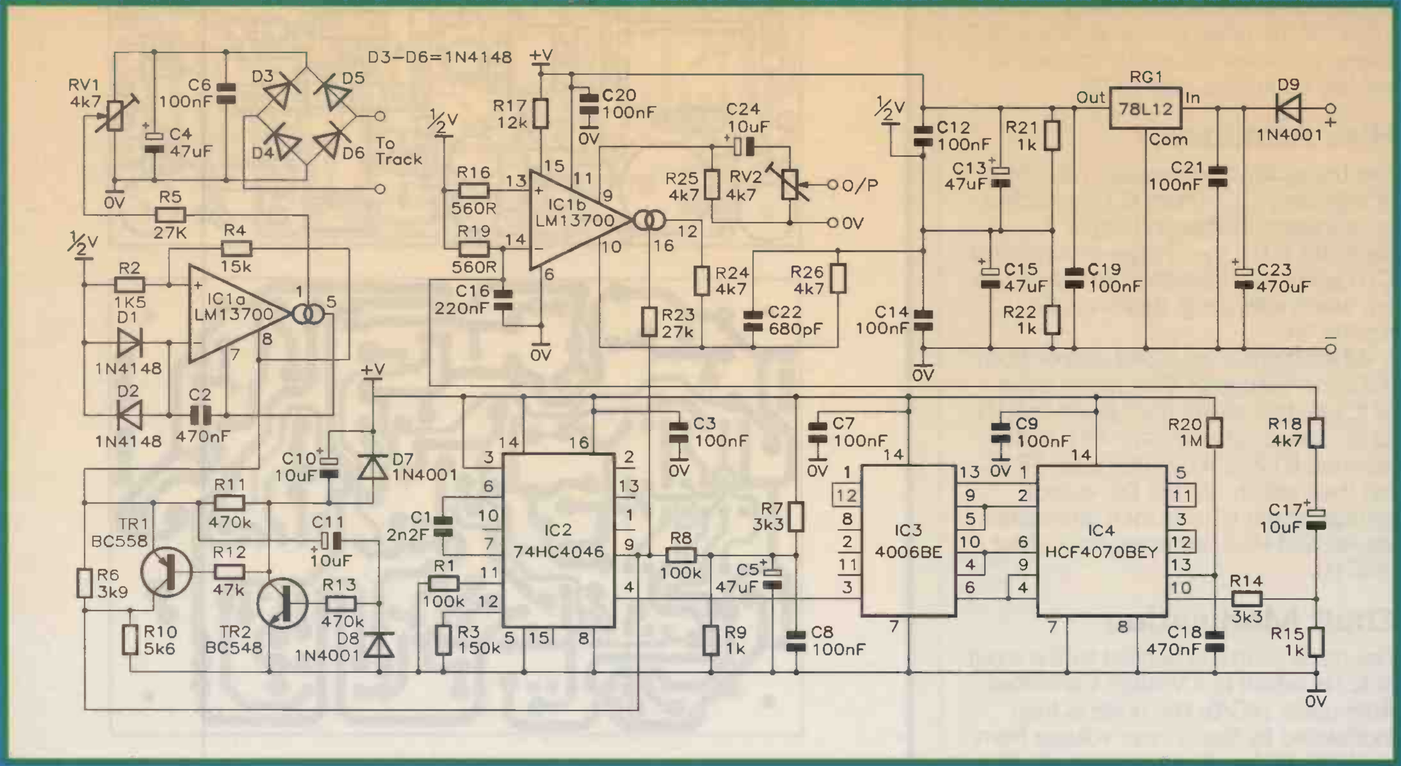


Figure 2. Circuit diagram of the Model Train Chuffer.

aiding stability. Resistors R21 and R22 form a half supply reference, capacitors C12 & C13 and C14 & C15 stabilise the half supply reference.

White Noise Source

IC2 is a 4046 Phase Locked Loop (PLL); with only the Voltage Controlled Oscillator (VCO) section used. The centre frequency of which is determined by C1, R1 and the bias voltage on pin 9. The clock output (pin 4) is fed into an 18 bit shift register, IC3; the several feedback loops around the register are manipulated by EXOR (EXclusive OR) gates IC4, to produce a pseudo random noise source.

Track Voltage Detection

Diodes D3 to 6 form a full-wave bridge rectifier (which is required to maintain the track control voltage with the same polarity, whatever direction the train is moving). C6 removes the HF noise generated by the train motor and C4 smooths the track voltage; as more often than not, train 'controllers' are a transformer/rectifier combination without decoupling. The preset RV1 is used to set the maximum chuff rate when the train is at realistic maximum speed.

Chuff Modulator

IC1 is an LM13700, a dual Operational Transconductance Amplifier (OTA); half of which is configured as a VCO (IC1a). The voltage from RV1 is converted to a current via resistor R5; the current combined with the capacitor C2 determine the oscillator frequency; resistors R2 and R4 determine the gain. The intentionally clipped triangular waveform output of IC1a is then applied to the VCA (IC1b) via TR1 and R23 as a modulation signal. The waveform is also fed to the hiss attenuator and IC2 (the voltage control input) of the noise source oscillator to sweep the noise source to emulate a voltage controlled filter (VCF).

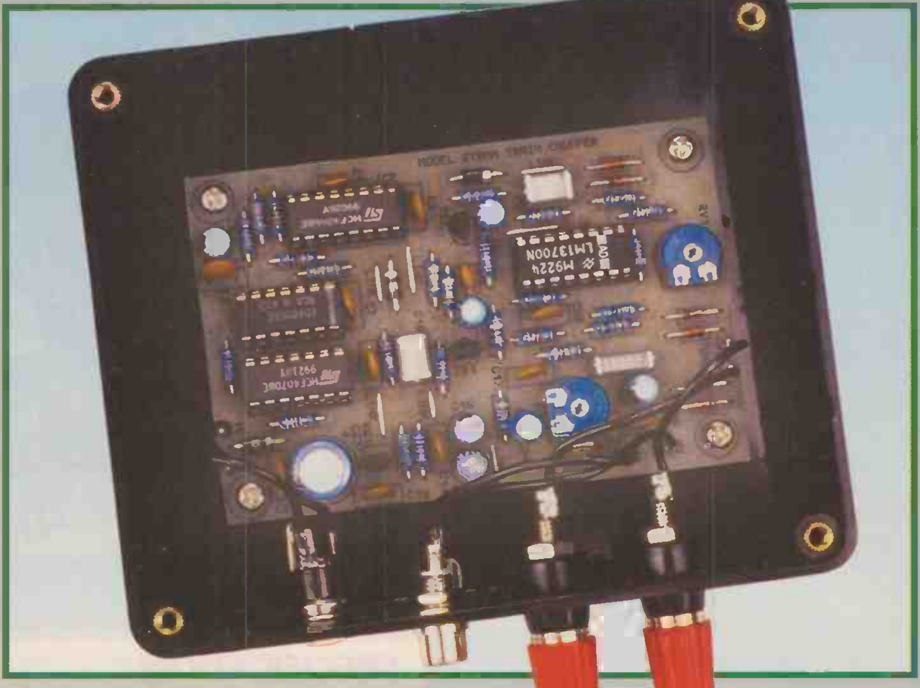
Hiss Attenuator

The triangular feed through waveform of capacitor C11 (from IC1a) switches on transistor TR2 and charges capacitor C10; the charge on capacitor C10 keeps the transistor TR1 switched on, which effectively short circuits resistor R6.

When there is no signal output from IC1a (no voltage at the control input of IC1a); this allows the capacitor C10 to discharge via transistor TR1 and resistors R12 & R10. Transistor TR1 will then switch off; the DC output voltage of the IC1a is then attenuated via R6 and R10, reducing the output of IC1b.

Chuff Modulation

The noise source is applied to the input of IC1b, which is a Voltage Controlled Attenuator (VCA); the noise is then modulated by the control voltage from the VCO (IC1a). The resulting 'chuff' output is then attenuated and filtered by R24, R26 and C22, then buffered by the Darlington emitter follower (internal to the IC1) before being fed to the output volume control RV2.



The assembled PCB in the optional case.

Construction

The PCB legend and track are shown in Figure 3, and will assist in the construction of the PCB. The construction is fairly straightforward, begin with the smallest components first and then work up in size to the largest.

Identify and fit the resistors, use the component offcuts for the wire links. Identify and fit the diodes making sure that they are orientated correctly on the board according to the legend. Next fit the capacitors, making sure that the electrolytic capacitors are

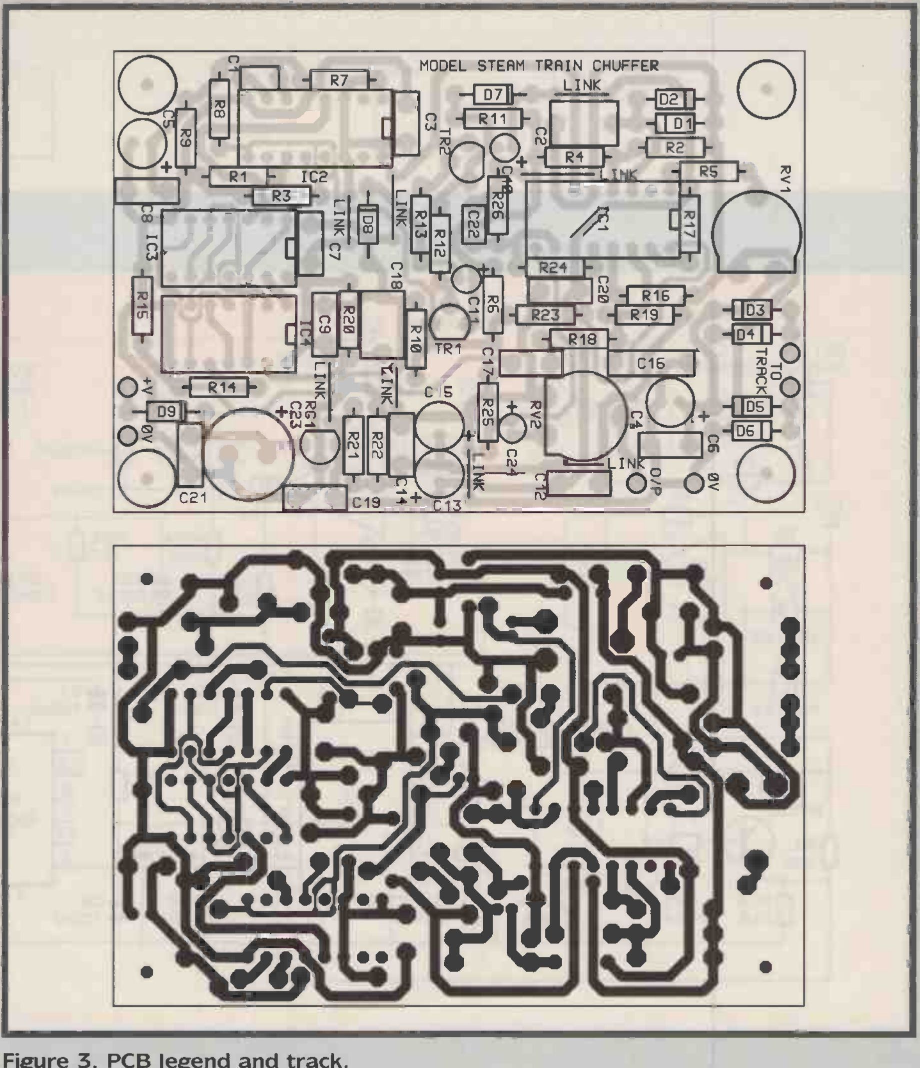
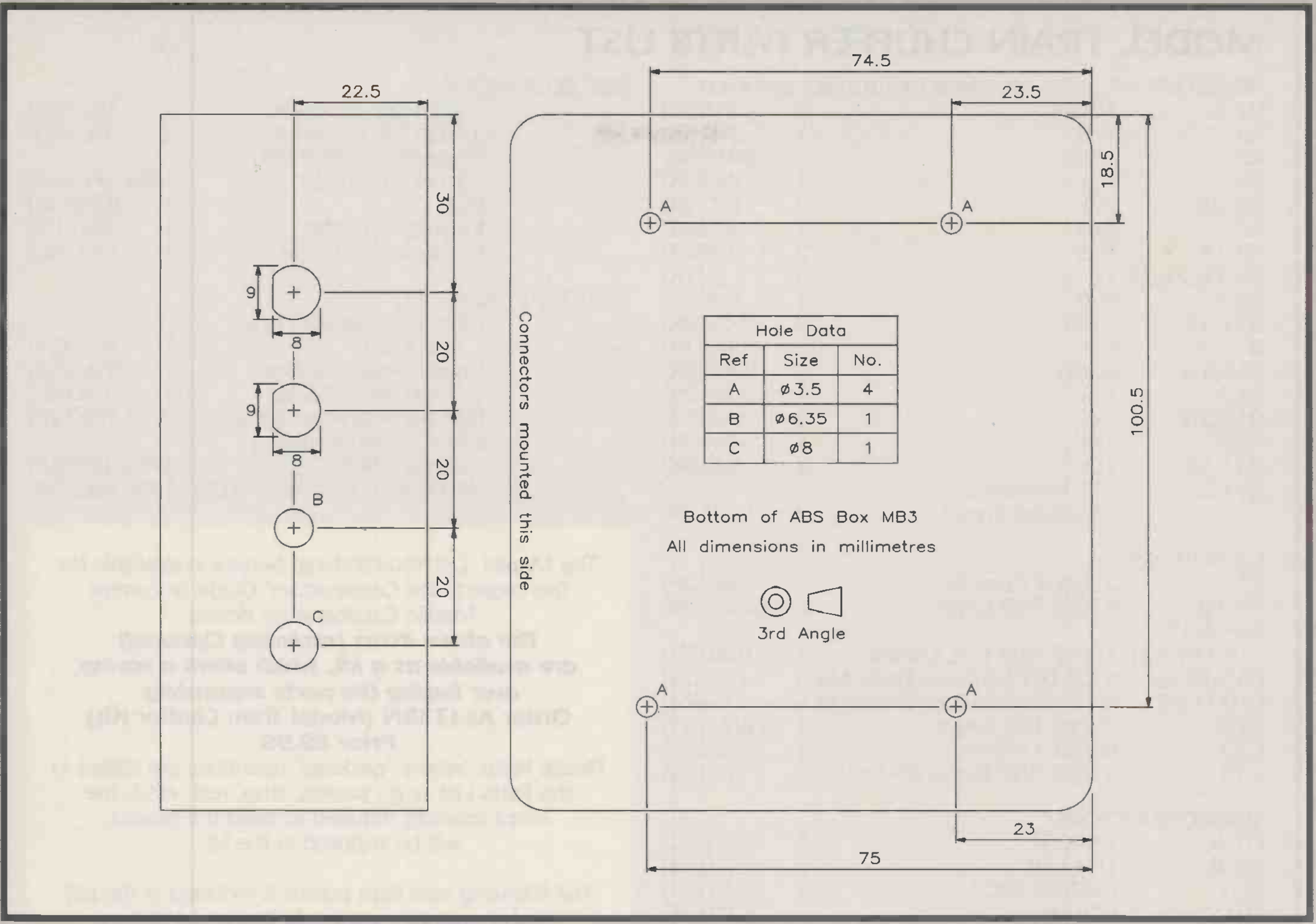


Figure 3. PCB legend and track.



Hole Data		
Ref	Size	No.
A	ø3.5	4
B	ø6.35	1
C	ø8	1

Figure 4. Box drilling details.

correctly orientated on the board. Identify, fit and solder the regulator, this has the same case style as a transistor. Identify the two preset resistors, fit and solder. Insert the PCB pins from the track side, and then fit the DIL IC sockets orientating the notch as per the legend and solder in position. The IC should be inserted into the sockets last of all.

Thoroughly check your work for misplaced components, solder whiskers bridges and dry joints. Finally, clean all the flux off the PCB using a suitable solvent.

Optional Case

The choice of case is left up to the individual constructor. A recommended optional case is the multi-purpose black plastic type MB3 (LH22Y). The optional box drilling details are shown in Figure 4, and these show the details for the positioning of the PCB, the phono audio socket, the 2·5mm power socket and the two terminal posts. Fit the PCB into the case on to the two insulated spacers, and fit the terminal posts and the sockets. Wire up the relevant connections using the hookup wire from the sockets and terminals to the pins on the PCB, refer to the exploded assembly and wiring diagram in Figure 5. Do not fit the lid to the enclosure as the next job is to test the module.

Testing

Turn RV1 and RV2 to the midway position (12 o'clock); connect the Chuffer signal output to a suitable amplifier; connect the track sense leads to the module, then connect a suitable PSU (+15·5 to 36V DC) to the module.

Turn the PSU and the amplifier 'ON'; place a train on the track and turn the supply 'ON'. Increase the track voltage until the train is moving; adjust RV2 for the required volume level.

Increase the track voltage until the train is at full-speed; then adjust RV1 until the 'chuff' rate matches the train speed. Reduce the track voltage to zero; the 'chuffing' should stop and a continuous 'hissing' should be heard; after a few seconds the hiss level will reduce.

The train Chuffer is now fully tested and adjusted; all that is left to do is to fit the lid on the box (and to find some way of emulating the smell of a steam train).

Happy train driving!

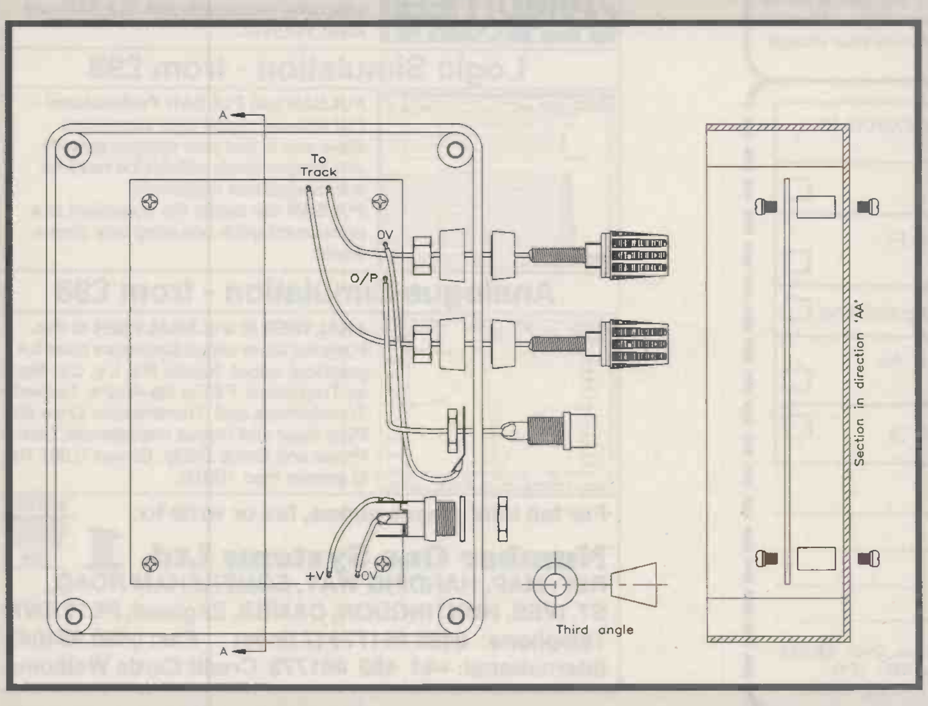


Figure 5. Assembly and wiring diagram.

MODEL TRAIN CHUFFER PARTS LIST

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

R1,8	100k	2	(M100K)
R2	1k5	1	(M1K5)
R3	150k	1	(M150K)
R4	15k	1	(M15K)
R5,23	27k	2	(M27K)
R6	3k9	1	(M3K9)
R7,14	3k3	2	(M3K3)
R9,15,21,22	1k	4	(M1K)
R10	5k6	1	(M5K6)
R11,13	470k	2	(M470K)
R12	47k	1	(M47K)
R16,19	560Ω	2	(M560R)
R17	12k	1	(M12K)
R18,25	4k7	2	(M4K7)
R20	1M	1	(M1M)
R24,26	10k	2	(M10K)
RV1,2	4k7 Horizontal Enclosed Preset	2	(UH15R)

CAPACITORS

C1	2200pF Ceramic	1	(WX72P)
C2,18	470nF Poly Layer	2	(WW49D)
C3,6-9,12 14,17,19-21	100nF 50V Disc Ceramic	11	(BX03D)
C4,5,13,15	47µF 16V Miniature Electrolytic	4	(YY37S)
C10,11,24	10µF 16V Miniature Electrolytic	3	(YY34M)
C16	220nF Poly Layer	1	(WW45Y)
C22	680pF Ceramic	1	(WX66W)
C23	470µF 35V Radial Electrolytic	1	(FF16S)

SEMICONDUCTORS

D7,8,9	1N4001	3	(QL73Q)
D1-6	1N4148	6	(QL80B)
RG1	LM78L12ACZ	1	(WQ77J)
TR1	BC548	1	(QQ17T)
TR2	BC558	1	(QB73Q)
IC1	LM13700N	1	(YH64U)
IC2	HCF4046BEY	1	(QW32K)
IC3	HCF4006BEY	1	(QX03D)
IC4	HCF4070BEY	1	(QX26D)

MISCELLANEOUS

16-pin DIL IC Socket	2	(BL19V)
14-pin DIL IC Socket	2	(BL18U)
Single-ended PCB Pin 1mm (0·04in.)	1 Pkt	(FL24B)
PCB	1	(GH80B)
Instruction Leaflet	1	(XU71N)
Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

Multi-purpose ABS Box Type MB3	1	(LH22Y)
Chassis Phono Socket	1	(YW06G)
2·5mm Power Socket	1	(JK10L)
Red Terminal Posts Small	2	(FD72P)
M3 x 10mm Insulated Plastic Spacer	1 Pkt	(FS36P)
2A Hookup Wire Black 10m	1 Pkt	(BL00A)

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 as a kit, which offers a saving over buying the parts separately.

Order As LT39N (Model Train Chuffer Kit)
Price £9.99

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 1994 Maplin Catalogue

Model Train Chuffer PCB
Order As GH80B Price £2.99

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312/314 High Street, Sutton, Surrey SM1 1PR.
Tel: 041 221 7373 (24 hours). Fax: 041 221 8151.

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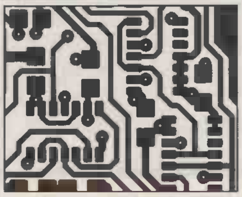

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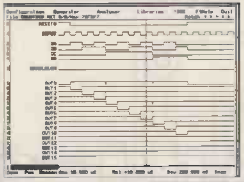

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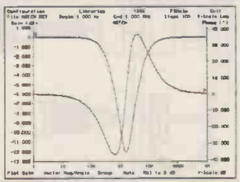

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BRITISH DESIGN AWARD 1989

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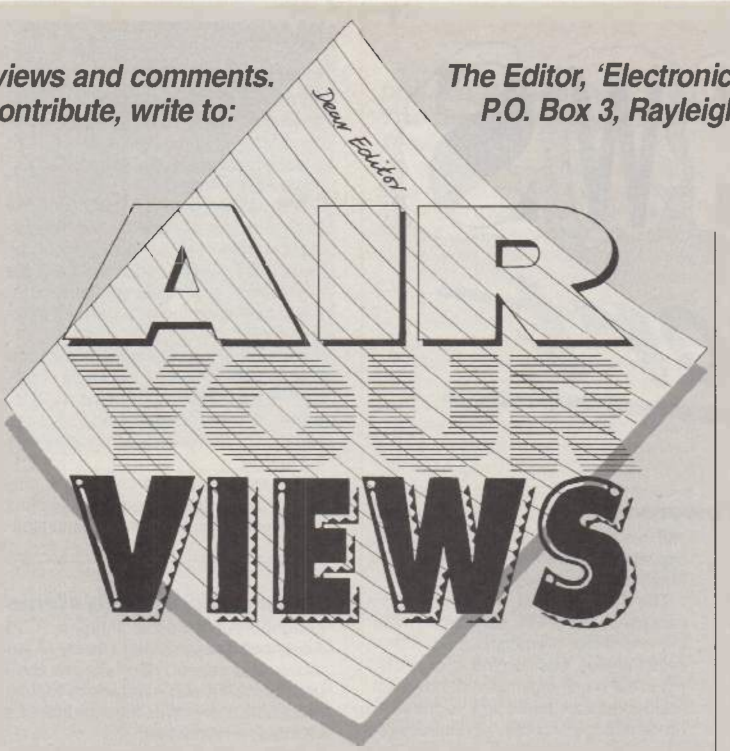
The Editor, 'Electronics – The Maplin Magazine'
P.O. Box 3, Rayleigh, Essex, SS6 8LR.



AIR YOUR VIEWS

Back to Basics

Dear Sir,
I am very interested in electronics as a hobby. I have a couple of years experience of building up various kits; with varying degrees of success. But I now find I don't completely understand everything about resistors. I keep looking in your magazine; which I subscribe to, for any good ideas, but as yet I haven't really found anything, I'm still left wondering. Please could you advise me where I can find out more about resistors, so that an enthusiastic amateur, like myself, could learn all about them starting right from the very beginning.
D. B. Pike, Swindon, Wiltshire.

Whilst to some more 'advanced' readers this may seem a trivial matter, it must be remembered that all of us had to start somewhere. A thorough understanding from the ground up is necessary to avoid pitfalls later – where better to start than with the most basic and most commonly used component, the resistor. I have consulted the great oracle (actually our Sanyo Icon mainframe computer) and am now enlightened with the knowledge that you started your subscription with Issue 59/November 1992 – what this basically means is that you have probably missed the articles that would help you most! Unfortunately, the issues in question have long since disappeared into the mists of time, but do not despair, help is at hand from those awfully nice Customer Services people, they can provide photocopies of articles from out of print issues (for a charge of course!); to contact them Tel: (0702) 552911. Hunting for those elusive articles published in previous magazines can be time consuming, but can be made very much easier if you have a copy of the Electronics Magazine Index, *XA87U, price 80p.*

The following articles and series are likely to be of interest:
Electronics Chronicles – A brief history of electronics: *Issue 10/March–May 84 to Issue 16/September–November 1985 (except Issue 15).*
Which Resistor: *Issue 21/December 1986–February 1987 (part of a series of six* Which Component *articles).*
Resistors in Series and Parallel: *Issue 47/November 1991.*
Passive Electrical Component Guide – Resistors: *Issue 51/March 1992 (part of a series of three articles).*

★★★★★★★★★★★★★★★★★★★★★★★

S·T·A·R L·E·T·T·E·R

This issue Mr J. J. Darlow, of West Midlands, wins the Star Letter Award of a Maplin £5 Gift Token for his letter about sub-woofer crossovers.

★★★★★★★★★★★★★★★★★★★★★★★

Movable Sub-Woofers

Dear Sir,
Further to your reply to Mr Thome's letter in your May issue, concerning active sub-woofer filters, would it be possible to *state* modifications to the circuits, to allow them to operate from a 12V car battery, especially for us non-technical readers? Also can the filters 'crossover' at say, 100Hz by dividing the low pass resistors and high pass capacitors by 0·5?

It is possible to alter op amp circuits, formerly designed for split rail operation, to work from a single-ended supply. In the referred example (Figure 19, page 50, Issue 75), it is simply a case of deriving a 'centre tap' from your 12V supply, by having two identical value resistors (e.g., 100kΩ each) in series across your 12V, and following the junction between the two with another unity-gain op amp, the output of which can be used as a low impedance source of 6V. The common line marked '0V' in Figure 19 connects to this, and you should also decouple it to ground (battery minus) with say 100µF. However, since I suspect you are going to treat the battery (–) terminal as 'earth', you will also need DC blocking capacitors in series with all inputs and outputs of the circuit, say 100nF at the inputs and 10µF at the outputs.
Of course the filter values can be altered for 100Hz, and it should be feasible to double the 10k resistors to 20k, and the 47nF capacitors to 100nF, to achieve the desired result. The actual performance should be verified though.

★★★★★★★★★★★★★★★★★★★★★★★

Hints and Tips

Dear Editor,
As a fellow scribbler of a certain vintage, I've been quite regaled by the backward glances in your own and some other current publications, e.g., *Hi-Fi World*. These are largely centred around valves and their technology, which I and other old hands have been inclined to dismiss in a vain attempt to be 'with it'. However, occasionally we recall a few valuable tricks which seem to have been forgotten, and I have a couple which are pertinent. Graham Dixey's series has been instrumental in bringing them back to mind.
The first 'trick' stems from Figure 10, Issue 72 (December) about which he remarks "it is impossible to realise the full gain of (the pentode) valve...." Jefferies in a 1940's *Wireless World* article showed how to reclaim most of it with but two extra components. If you divide the pentode anode load (250k in Figure 10) into two and take the junction via a capacitor to the bottom of the triode bias resistor (which can be advantageously shunted with 47µF) then the inherent high input impedance multiplier of the cathode follower part of the concertina, or 'top and tail' splitter is seen by the pentode as its anode load. This 'generated' high impedance means that the coupling capacitor can be much smaller, say 10nF and the added C perhaps 220nF.
The second trick relates to the long tailed pair made popular by Mullard and your latest Millennium amplifier. This arrangement is quite badly unbalanced at high frequencies because the shunting of the first stage pentode by the Miller capacity of the common cathode first triode is reflected at its anode feed to the upper output valve; an effect which produces a roll off and phase shift denied to the second triode whose grid is effectively grounded. A solution was put forward by Professor Baily of Bradford University in the 60s, and subsequently used in the Radford amplifiers. If the double triode used for the long tailed pair is replaced by a triode pentode and the latter used for the input section the Miller effect at the root of the problem is largely negated. Again only two extra components are required, a screen feed resistor and decoupling capacitor.
With regard to the Millennium might I suggest the omission of R12 and the insertion of a 10k preset at the junction of R10 and 11 with the slider to the HT rail. The omission of C12 & C13 and the substitution of 220 or 270Ω common cathode bias resistor with a parallel headphone jack would then permit accurate nulling on programme for an exact balance.
Geoffrey Horn, Oxford.

The first 'trick' you describe is perfectly valid and has also been used quite a lot in transistor circuits in various forms, and became known as 'boot-strapping'.
As regards the Miller effect of the first phase splitter triode, your suggested cure is obviously valid.
In Millennium's defence though I should mention that this particular configuration (as per Mullard) gets around the problem by exploiting its high open-loop gain (76dB), hence good HF response is maintained. In any case bandwidth is deliberately limited at the upper HF by the RC stabilising components around the anode load of V1.
The 10k preset idea is naturally preferred, but requires that you have test gear to set it up with, e.g., a dual trace 'scope and AF generator.
*The omission of C12 & C13 is **not** recommended, since maximum available open-loop gain is required for best performance from 'ultra-linear' mode. The cathodes could be commoned, but then you will need a matched pair of pentodes....*

Ni-Cd Phenomenon

Dear Editor,
Having been a 'dabbler' in electronics for around 50 years, I often get people asking me to fix things. This one, however, has me beat. At first I thought it was a bad set of Ni-Cds in a 'KERNOW' hand-held CB. Now I am baffled because it has happened three times with the same make of radio. So boffins, what do you make of this: Charge Ni-Cds either in set or separate charger. Turn radio on and wait 10 mins. Ni-Cds have dropped approximately 0·05 volts progressively, i.e. 1·5, 1·45, 1·40, etc., from the minus end to positive being the lowest. Wait another 10 minutes and the first three out of the ten in series at the positive end are flat! Recharge and swop round and the same thing happens. I have tried several sets of cells including ordinary batteries which do exactly the same thing. But ordinary batteries only drop voltage on the last three to any measurable extent; still at the positive end. Not allowed to dip into the CBs but that is not the point. Does anyone know what is going on?
David Eveleigh, Hertfordshire.

It rather sounds as though there is a low impedance leakage across the three cells for some reason, but this doesn't make sense if the phenomenon is common to other radios of the same model. One idea that occurred to us is that 4·5V from the positive end is being used for some additional lower voltage, higher current function, such as LED displays. Or it could have something to do with how much the transmitter is being used!

NEWS Report

Acorn's RISC PC is Arm Powered

Acorn's new range of RISC PCs launched last month use Advanced RISC Machines' (ARM) technology, demonstrating the versatility of the ARM family of microprocessors and peripherals. The machines incorporate three ARM-designed ICs – a high performance ARM RISC processor, an advanced video controller and an IO controller, configured in an innovative machine architecture.

Commenting on ARM technology, Sam Wauchope, Managing Director of Acorn Computers Ltd. stated; "The Acorn ARM partnership is all about combining world leading technology with creative systems knowledge to make advanced products affordable to the consumer. RISC PC underlines our firm commitment to the ARM architecture and its flexible design approach which will readily allow Acorn direct CPU upgrades as new members of the ARM family are introduced."

The ARM devices, combined with a multiple-bus structure, dual ported memory and direct memory access (DMA) data transfer, position the Acorn RISC PC in the emerging multi-media market. Multi-media systems are required to process large amounts of unstructured data and present this information in a high-quality graphical and audio format. This is difficult to achieve cost-effectively using conventional standard IBM PC-based systems.

To obtain the required processing capability Acorn is using the high performance 32-bit ARM610 microprocessor incorporating a 4KB cache and a Memory Management Unit (MMU). Video processing and IO operations are handled by customised devices, VIDC20 and IOMD, designed by ARM to Acorn requirements.

The VIDC20 video controller supports VGA, Super VGA and XGA levels of resolution with up to 16 million colours. The maximum pixel rate is 110MHz at a bandwidth of 38MB/s for the base machine, rising to 76MB/s with 1MB of VRAM and 152MB/s with 2MB of VRAM. This makes the Medusa RISC PC range ideal for manipulating the large amounts of video data associated with fast moving multi-media images.

The IOMD (Input Output Memory Device) directly services peripheral devices such as CD-ROM drives, keyboard, mouse and joystick. Interfacing to the main 32-bit system bus, the IOMD fully supports DMA data transfer into a maximum 256MB of main memory. These features allow data to be efficiently transferred around the system without waiting for spare CPU cycles or for data on an overburdened bus to clear. Contact: ARM, Tel: (0223) 400400.

Wafer Testing

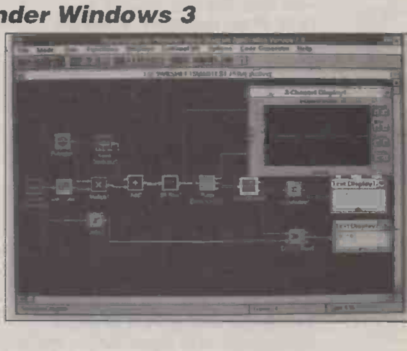
SiProbe is a new development in semiconductor test technology which incorporates tiny 25μm diameter probes with a density of up to 40,000 probes per square centimetre.

The new 'silicon probe' card from The Peak Group is designed to aid the testing of complex semiconductor wafers by incorporating probes positioned with the same levels of precision that are inherent in the integrated-circuit manufacturing process.

In addition, the card is made from silicon and therefore has the same coefficient of expansion as the semiconductor wafer, thereby compensating for the variations in temperature that occur during testing.

This technique allows the entire surface of a chip to be covered with reliable contacts and also allows the simultaneous testing of several integrated circuits. The flexible arrangement of the probes allows parallel probing in any configuration, so that individual chips on the wafer can be scanned along optimum paths. Contact: The Peak Group, Tel: (091) 387 1923.

Communication Systems Under Windows 3



Loughborough Sound Images (LSI) Advanced Transmission Library (ATL) allows designers of radio, wire and fibre-optic transmission systems to rapidly simulate and prototype their designs in a Windows environment.

Users construct their designs by interconnecting standard and custom function blocks on the PC screen. ATL provides a wide range of communications-specific standard blocks including: baseband transmission models; modulation/demodulation; carrier and clock recovery; arbitrary filter design; fibre-optic transmission; and system performance measures.

The new filter design facilities enable the modelling of transmission links, and the testing of various equalisation schemes, by allowing users to simply vary the filter parameters. Engineers can work in the time domain, allowing them to optimise pulse-response and reduce intersymbol interference.

For those analysing phenomena such as amplitude and phase distortion, frequency-domain optimisation is included. Contact: Loughborough Sound Images, Tel: (0509) 231843.

Satmaster for Windows

Communications expert DJ Stephenson has designed Satmaster for Windows targeted at satellite TV installers, designers, system engineers, managers and enthusiasts.

With this software package there is no need for tedious mathematical calculations to determine if a proposed satellite system will give sparklie-free pictures.

The program allows users to test performance before installation. It generates all the necessary 'look angles' for fixed and motorised dishes at any location in the World. It also calculates multiple full link budgets and indicates the minimum size dish to maintain quality images.

Satmaster Pro comes with more than 30 satellite footprints already in the graphics file. Users can add their own via a scanner. In addition, there is a 20,000 word Hypertext technical guide with fault-finding, cable specs and site survey guide.

The Satmaster Pro for Windows provides displays beamwidth and lobe patterns for various size dishes, graphs and tables.

Satmaster Pro for Windows requires an IBM compatible PC/AT 286/386/486 computer with MS DOS, Windows 3.1 and 3MB minimum of hard disk space. Contact: Swift Television Publications, Tel: (0793) 750620.

Tape Streamer Performance Trebled

Transitional Technology International (TTi) has launched a new range of half inch streaming tape subsystems which, with a 20GB capacity and 2·5MB/second data transfer rate, offers two to three times the performance of any other tape drive in their class.

The TTi Series 2000 uses DLZ (Digital Lempel-Ziv) data compression to double the capacity of the 10GB cartridge media. The drive includes a dual-channel read/write head and data compaction to enhance further capacity and performance. A tape mark directory and adaptive cache buffer maximise data access time and absorb slower host data rates without interruption.

The new drive employs an embedded SCSI-2 interface, both differential and single ended, coupled with a set of configuration switches to enable the tape subsystem to be used on a wide variety of platforms including Digital, DEC Alpha, IBM RS/6000, Sun, Apple Macintosh, PCs and Novell networks.

An intelligent front panel display, monitors remaining tape capacity in megabytes, ECC error correction code usage, as well as tape movement, quality and wear; all in real time without host or user intervention. Contact: Transitional Technology International, Tel: (0295) 269000.

WordPerfect Provides Mobile Communication Tools

WordPerfect has unveiled a workgroup computing solution for mobile users, providing them with a variety of ways to send and receive electronic mail, schedule requests and tasks. The WordPerfect Office mobile computing solution allows users to access electronic information contained in WordPerfect Office through WordPerfect Office Remote for both Windows and DOS, two-way wireless technology, paging services, telephone access and public carrier access.

The WordPerfect Office mobile computing solution offers users remote access to: e-mail, calendars and program tasking through WordPerfect Office Remote for Windows and DOS; paging services through Motorola; wireless technology through RAM Mobile Data (Cellnet and Vodaphone); the telephone through the WordPerfect Office Telephone Access Server (TAS); and public carriers. Contact: WordPerfect, Tel: (0932) 850505.

Data Access

AT&T Microelectronics has produced a free 12-page booklet showing a wide variety of Data Access Arrangements (DAA) used to connect voice and data signalling circuits to the telephone line. Such functions are required in modems, fax machines, answering machines, and some types of telephone.

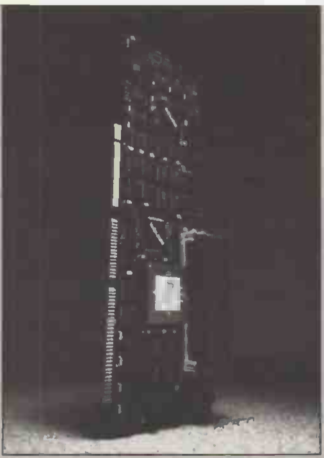
The booklet is illustrated with both circuit and block diagrams, and shows the designer how AT&T's solid state relays (SSR) can be used to implement functions such as on/off hook control, ring detection and loop current sensing. Contact: AT&T, Tel: (0732) 742999.

MIPS 64-Bit RISC and Intel Combined

Leading high-end computer manufacturer Direction Technology Ltd. is the first UK manufacturer to combine the versatility of MIPS 64-bit RISC and Intel-based CISC in a single machine.

Direction Technology will supply the MIPS 64-bit RISC NiTro-VLB Windows NT card from the ShaBLAMM! Computer Corporation in its 486 and Pentium based machines. The card combines a MIPS 100MHz 64-bit R4600 RISC microprocessor with a 15ns cache memory expandable from 16 to 64MB. Benchmark tests have shown up to six times speed improvement over 486 computers and twice the performance of Pentium 60MHz systems.

This option enables users who want to switch to Windows NT under the superior RISC environment to maintain existing DOS based applications while providing an affordable MIPS 64-bit RISC environment.



Fileserver and workstations are available now from Direction Technology ahead of other 32-bit environments. Information on price and delivery is available on request. Contact: Direction Technology, Tel: (0483) 454400

Intel to Appeal Microcode Case

Intel is to appeal against a verdict, which found that AMD has a licence to copy microcode in Intel's microprocessor and peripheral products such as the 287 maths co-processor. Intel will continue to pursue the remaining issues in the Am386 and Am486 lawsuits, pending the appeal of this verdict.

The jury's verdict followed a retrial of a case which first decided in Intel's favour in 1992. in that earlier trial, a jury found that AMD did not have rights to copy Intel's microprocessor microcode.

According to Intel Vice-President Thomas Dunlap, "This verdict impacts only one claim in Intel's case against the AM386 and AM486 microprocessors. Intel's case against those products is not limited to AMD's infringement on Intel's basic microcode programs. Those products also infringe Intel's copyrights for certain control programs and for its In-Circuit-Emulator (ICE) microcode, which was specifically excluded from any microcode licence. Whether AMD has rights to the ICE microcode will be decided at a new trial expected to begin in April". Contact: Intel, Tel: (0793) 696000.

High-Speed Locking for RDS

Fabricated using the company's SUBILO-N laterally isolated bipolar diffusion process, the TSA6060 PLL Frequency Synthesizer IC from Philips Semiconductors combines low power operation with high-speed frequency locking and on-chip loop amplifiers.

Targeted for use in applications such as RDS (Radio Data System) car radios, where fast channel switching capabilities are required, the TSA6060 incorporates phase-locked-loop that can be switched between a high-gain mode for fast frequency locking and a lower-gain mode for stable, jitter-free frequency synthesis.

Current mode switching to the inputs of its loop filter amplifier allows the TSA6060 to achieve very low noise levels – typically better than 60 dB in many applications. Separate on-chip prescalers and loop amplifiers are provided for frequency synthesis in the AM and FM frequency bands, with both the AM and FM PLL operating from the same 4 or 8MHz crystal frequency. Contact: Philips Semiconductors, Tel: (31) 40 72 20 91.

Novell Spearheads Open Integration

Networking software company Novell has announced the formation of a new consortium of telecommunications companies designed to drive forward computer-telephony integration.

The announcement marks further broad industry support for Telephony Services Application Programming Interface (TSAPI), which is an open software standard used by programmers to enable the integration of computer and telephone networks. The first members of the Novell Open Telephony Association (NOTA) are Alcatel, AT&T, Dialogic, Ericsson, Global Communications, GPT, Interconnect Mitel, Philips, ROLM and SDX. These companies will now support TSAPI in their own products.

TSAPI itself is based on the Computer Supported Telephony Applications (CSTA) standard, which is widely referred to in Europe as computer-telephony integration (CTI). This standard was initiated more than 5 years ago by the European Computer Manufacturers' Association (ECMA) and has achieved support from major computer networking and telephony companies. TSAPI is a server-based standard and so provides a cost-effective solution to the requirements of companies with distributed, client/server applications. Contact: Novell, Tel: (0344) 724000.

Terminal Block Goes Round the Bend

A new IMO range of terminal block connectors with the terminals angled at 45° will simplify connection procedures and protect board components when high density circuit boards are installed. Totally compatible with IMO's existing plug and socket range, the new 45° connectors increase the number of options available to IMO customers.

IMO 45° terminal blocks combine the functions of terminals and connectors. They make it easy to disconnect boards for repairs or servicing quickly without any risk of subsequent cross connection. Contact: IMO, Tel: (081) 452 6444.

Special Report from The European Computer Trade Show

The Spring European Computer Trade Show (ECTS) acts as a spearhead for its counterpart event in the Autumn. A sort of taster of what we can expect retailers to have in their shop-fronts come Christmas. Wandering around London's Islington Design Centre, we expected to find virtual reality and CD-ROM setting the pace; but there was very little to get excited about. There are going to be some very disappointed children around the Christmas tree this December.

A glimmer of hope from what appears to be a stagnating industry is the 3DO Company. The 3DO Interactive Multiplayer system is an innovative audiovisual TV set-top box. At the heart of the 3DO system is a custom chipset based around the ARM RISC processor, that generates photo-realistic graphics, fluid animation, CD-quality digital sound and fast-paced interactivity.

Based on digitised film reel, 3DO software is unique in allowing the game player to become part of an interactive film; but the Multiplayer offers more. The platform allows users to play almost any CD-format. The hardware supports conventional audio CD, Kodak's photo CD and video CD.

Complete speculation surrounds the launch date – it could be midsummer if the games press is to be believed, or anytime between mid-June and Christmas if you talk to personnel within 3DO.

A reassuring announcement for parents to come out of ECTS, is that ELSPA, (the European Leisure Software Publishers Association) is to introduce a system of self-regulation for the games industry. The scheme is designed to ensure responsible behaviour among ELSPA's members, which consists of computer and video games manufacturers throughout Europe.

Central to self-regulation is a system of rating computer and video games according to age suitability. The rating system will introduce four age categories of game; 3 to 10, 11 to 14, 15 to 17 and 18 plus.

Games published during the last month are the first to use the rating system, with many software houses keen to badge existing titles.

We would like to urge readers with strong comments on any electronic game to contact ELSPA. Please forward any correspondence to the Editor, Robert Ball or News Editor, Stephen Waddington.

Contacts: ECTS Tel: (081) 742 2828; The 3DO Company Tel: (415) 261 3236; ELSPA Tel: (0386) 830642.

DIARY DATES

Every possible effort has been made to ensure that the information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments, contact event organisations to confirm details.

25 May. Computing Exhibition – Windows NT, Olympia, London. Tel: (0256) 3812456.

4 to 5 June. Special Event Station on Southend sea-front, Southend & District Radio Society, Southend. Tel: (0702) 353167.

6 June. D-Day Commemoration Display, with working transmitters and receivers from World War II, Wireless Museum, Puckpool Park, Seaview, near Ryde, Isle of Wight. Tel: (0983) 567665.

7 June. Using Integrated Circuits, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

7 June. Multimedia Exhibition, Earls Court, London. Tel: (081) 742 2828.

8 June. Junk Sale, Lincoln Short Wave Radio Club, Lincoln. Tel: (0427) 788356.

8 June. Mobile Communications Exhibition – CELLEX, Barbican Exhibition Centre, London. Tel: (0883) 343139.

11 June. Record & CD Collectors Fair, Royal Horticultural Halls, London. Tel: (0273) 463017.

15 June. Walking Treasure Hunt, Lincoln Short Wave Radio Club, Lincoln. Tel: (0427) 788356.

18 June. Electromagnetic Compatibility (EMC), Crystal Palace & District Radio Club, All Saints Parish Church Rooms, Beulah Hill. Tel: (081) 699 5732.

19 June. Special Event Station in Halstead, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

19 June. Unipede – Electricity Conference, ICL, Birmingham. Tel: (081) 743 3106.

19 June. All Formats Computer Fair, Novotel, London. Tel: (0608) 662212.

20 June. Electrotech, National Exhibition Centre, Birmingham. Tel: (0483) 222888.

22 June. Computers in Personnel, Barbican Exhibition Centre. Tel: (0787) 277354.

25 June. Special Event Station at Great Cornard Middle School, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

27 to 29 June. 5th Satellite Systems for Mobile Communications & Navigation Conference, Institution of Electrical Engineers, London. Tel: (071) 240 1871.

4 to 7 July. HF Radio Systems & Techniques Conference, Institution of Electrical Engineers, University of York. Tel: (071) 240 1871.

5 July. Talk on Propagation, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

14 July. Special Event Station at Woodhall School, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

16 July. Annual Outing, Crystal Palace & District Radio Club, All Saints Parish Church Rooms, Beulah Hill. Tel: (081) 699 5732.

19 to 21 July. 6th Electronic Engineering in Oceanography Conference, Institution of Electrical Engineers, Churchill College, Cambridge. Tel: (071) 240 1871.

20 to 24 July. Electrotech '94, National Exhibition Centre, Birmingham. Tel: (071) 240 1871.

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

PUFFIN- Pedestrian User Friendly Intelligent Crossing?

by Stephen Waddington, B.Eng(Hons)., M.I.E.E.E., A.I.E.E., A.I.T.S.C.

How did the pedestrian cross the road? With great difficulty, according to results of a study by the Department of Transport. News Editor Stephen Waddington examines this claim and reviews the potential application of electronic technology to improve pedestrians' plight at UK road crossings.

THIS year sees the completion of a seven year review of pelican and pedestrian crossings at signalled junctions, that has resulted in the implementation of a prototype Pedestrian User Friendly Intelligent (PUFFIN) crossing at a live site in the UK.

The study was prompted by a poor pedestrian safety record, an apparent reluctance on the part of pedestrians to use signalled crossings, and a need to make crossings more responsive to their behaviour. It examined the frequency of accidents, signal phasing and pedestrian attitudes. The results forecast radical changes for the traditional pedestrian crossing, with benefits for both pedestrians and motorists.

Previous Work

Prior to the PUFFIN project, the most relevant study of accident frequencies at signalled junctions was published in 1986 by the University of Southampton. This work reported that the average accident frequency at a signalled junction was 2·65 per year, with 29% involving pedestrians. Considering that at the time of the study, the number of pedestrian crossings in the UK was approximately 17,000, this amounts to an incredible 13,000 pedestrian accidents annually.

By analysing accident statistics, the University of Southampton concluded that the majority of pedestrian accidents involved vehicles entering the junction at the beginning or end of a traffic phase – corresponding to the opposing end or beginning of a pedestrian phase.

This is an opinion shared by the Department of Transport as a result of the PUFFIN study. Pedestrians at signalled junctions – particularly the aged – are often confused at the end of the pedestrian phase if the green man goes out while they are still on the crossing. A similar observation is made about the flashing green man signal at pelican crossings.

Blackout Period

On both occasions both the green and red man pedestrian signals become blank or blacked-out prior to the traffic lights reverting to green. This matter is further complicated by the fact that the blackout period varies from region to region and crossing to crossing, depending on the phasing relationship employed by the local authority.

In some cases the blackout period lasts for only a few microseconds, though in extreme cases it can be up to ten seconds, with the traffic at standstill throughout this period. This is where confusion arises. Pedestrians are not generally aware of the blackout period and, seeing the stationary traffic, assume there is a fault with the pedestrian signals. In such cases, the pedestrian rarely has enough time to cross before traffic is given a green light. Accidents are inevitable.

Pedestrians aside for a moment, what about motorists? If you drive a vehicle you are sure to have been frustrated at having to stop at an empty pedestrian crossing. This results when a rogue demand is made by a pedestrian not wishing to use the crossing, when a pedestrian walks through stationary queues of traffic after making a demand, or when pedestrians have completed the crossing prior to the end of pedestrian phase.

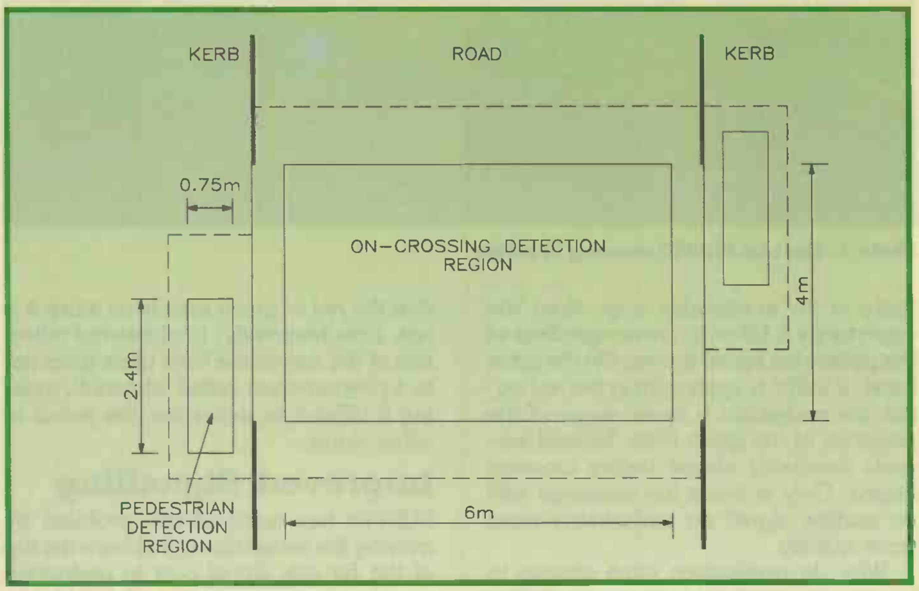
At a wide intersection the crossing period can be up to 36 seconds, which in a traffic cycle time of 60 to 90 seconds

PUFFIN benefits for pedestrians

Standardisation of pelican and signalled junction crossings.

Improved pedestrian displays.

Increased protection from traffic.



Top left: Photo 1. The kerbside sensor ensures that a pedestrian wishes to cross before the crossing controller proceeds to the pedestrian phase. An experimental infra-red sensor is also included, mounted on the top of the signal post.
Top right: Photo 2. Overhead sensors, in this case infra-red transducers, are used to ensure that the pedestrian phase is maintained while pedestrians remain on the crossing.
Above left: Photo 3. Poor lighting effects are eliminated by moving the pedestrian signal from the top of the far side signal pole to pedestrian eye level on the near side pole.
Above right: Figure 1. Kerbside and crossing detection footprints.

can make a substantial difference to junction capacity. During peak periods, repeated demands on the crossing, whether rogue, or valid, can leave the junction overloaded. A counter criticism made by pedestrians is that there is not enough crossing time. With traditional designs this period is set at a fixed duration regardless of pedestrian usage.

Solution

PUFFIN proposes to overcome problems for both the pedestrian and motorist by incorporating positive signalling and a variable length pedestrian crossing period using overhead sensors to respond to pedestrians on the crossing as shown in Photo 2. Under this scheme, once the pedestrian phase has commenced, pedestrians will be given priority as long as they remain on the crossing.

If there are only a few fit young people wishing to cross, the pedestrian period is short. Conversely an aged or disabled person would retain the traffic signals at red until clear of the crossing, although the pedestrian period is not infinite. Instead a maximum time duration is defined, preventing pedestrians from monopolising the junction or crossing.

To counter rogue requests or occasions when a demand is made that is subsequently not required, PUFFIN proposes a kerbside detection system. Figure 1 shows the scope of both the overhead and kerbside pedestrian detection schemes. Current designs for the kerbside sensor use a rubber mat set within the pavement as shown in Photo 1, though above ground schemes are being considered. Before proceeding to the pedestrian phase, the crossing checks if a pedestrian is standing in the vicinity of the push button unit. If a crossing request is made and the pedestrian subsequently walks off the detection mat, the call is ignored.

PUFFIN benefits for disabled and visually impaired pedestrians

Crossing time is a function of walking speed.

Audible signals standard for all crossings.

Pedestrian signal improved for visually impaired.

Road Side Scrutiny

During the course of the PUFFIN project, Kenneth Billings and Brian Walsh of the Department of Transport spent a considerable amount of time at actual sites observing both pedestrian and motorist behaviour. Continuous twenty-four hour video records were also made at four typical sites and closely studied afterwards. The overwhelming deduction from these observations was that pedestrians rarely observe the pedestrian signals.

The most general scenario was that pedestrians stand at the kerb and view the approaching traffic. If it is judged that

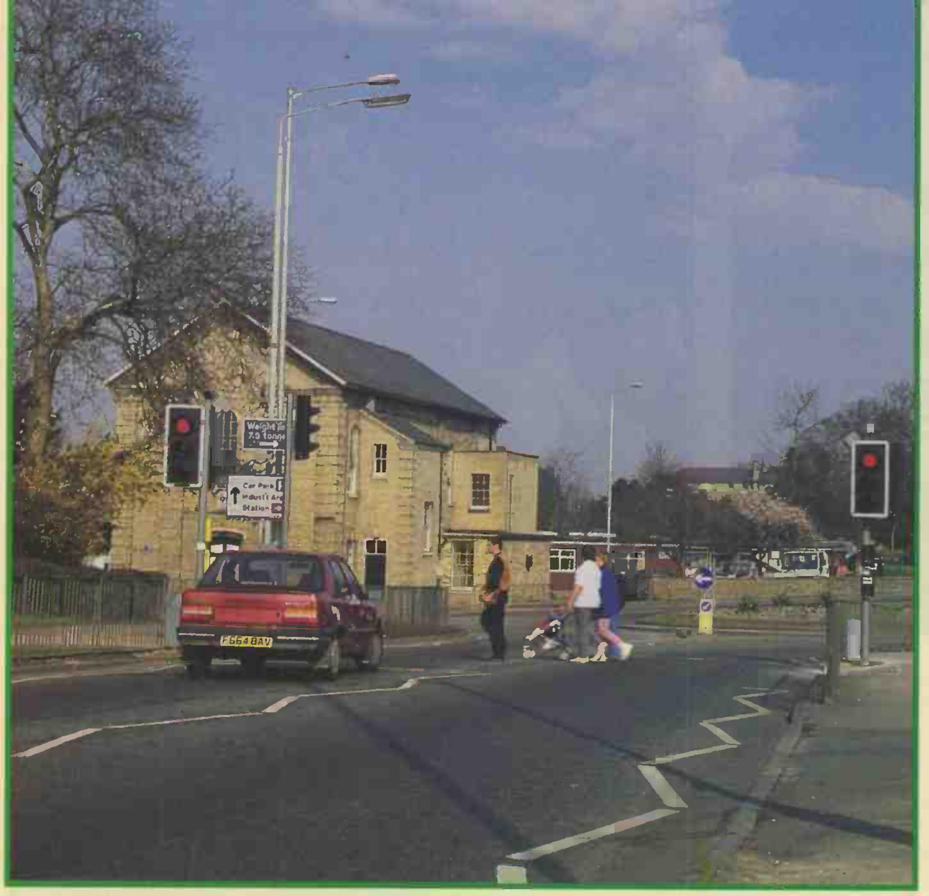


Photo 4. The trial PUFFIN crossing in action.

there is an acceptable gap, then the opportunity is taken to cross regardless of the pedestrian signal shown. On the other hand, if traffic is approaching the red signal, the pedestrian is rarely aware of the presence of the green man. Several seconds invariably elapse before crossing begins. Only at those few crossings with an audible signal do pedestrians react more quickly.

Why do pedestrians often choose to ignore the pedestrian signals? The PUFFIN study discovered that in many instances it is possible the signals are obscured by poor lighting. Phantom effects caused by the sun's reflection on the front of the signal give the impression that the red or green man is on when it is not. Less frequently, total internal reflection of the sun on the front glass gives rise to a phenomenon called 'whiteout', making it difficult to determine the status of either signal.

Improved Signalling

PUFFIN has resolved this problem by moving the pedestrian signal from the top of the far side signal pole to pedestrian eye level on the near side pole, as shown in Photo 3. Not only does this eliminate the effects of poor lighting, but also assists visually impaired people, who are at present unable to see the far side pole. Both sighted and visually impaired pedestrians are further aided by the inclusion of an audible bleeping tone during the pedestrian phase, intended as a standard feature for all road crossings.

Throughout the PUFFIN project, researchers identified the need to update crossing information to pedestrians continuously. Currently the status of the crossing is displayed to pedestrians using the pedestrians' signals and the push button unit. Included within the push button unit is the legend WAIT and a static advisory symbol providing information on the meaning of the pedestrian signals.

The WAIT legend is illuminated when a pedestrian call is registered and remains lit until the pedestrian phase commences. While this information is beneficial to the pedestrian, the value of the static symbols is dubious.

In response, PUFFIN proposes an alternative display in which the message displayed is changed according to the state of the signal sequence. For example, if there was no demand entered on the pedestrian phase, the message 'STAND ON MAT AND PRESS BUTTON' would be displayed, changing to 'CALL ACCEPTED PLEASE WAIT' once a call was registered. Perhaps more essential is the message proposed if the crossing controller detects a fault. Under these circumstances the message would change to 'LIGHTS FAULTY PLEASE TAKE CARE', indicating equipment failure.

Live Studies

The PUFFIN proposal was initially tabled in 1989, when the Department of Transport invited interested parties, including the police, engineers and representatives of both motorists and pedestrian groups, to test and comment on a working prototype at the Transport and Road Research Laboratory (TRRL) in Crowthorne, Berkshire. Following promising consultations, government consent was granted to convert an existing live junction to the PUFFIN strategy to test pedestrian and motorist reaction.

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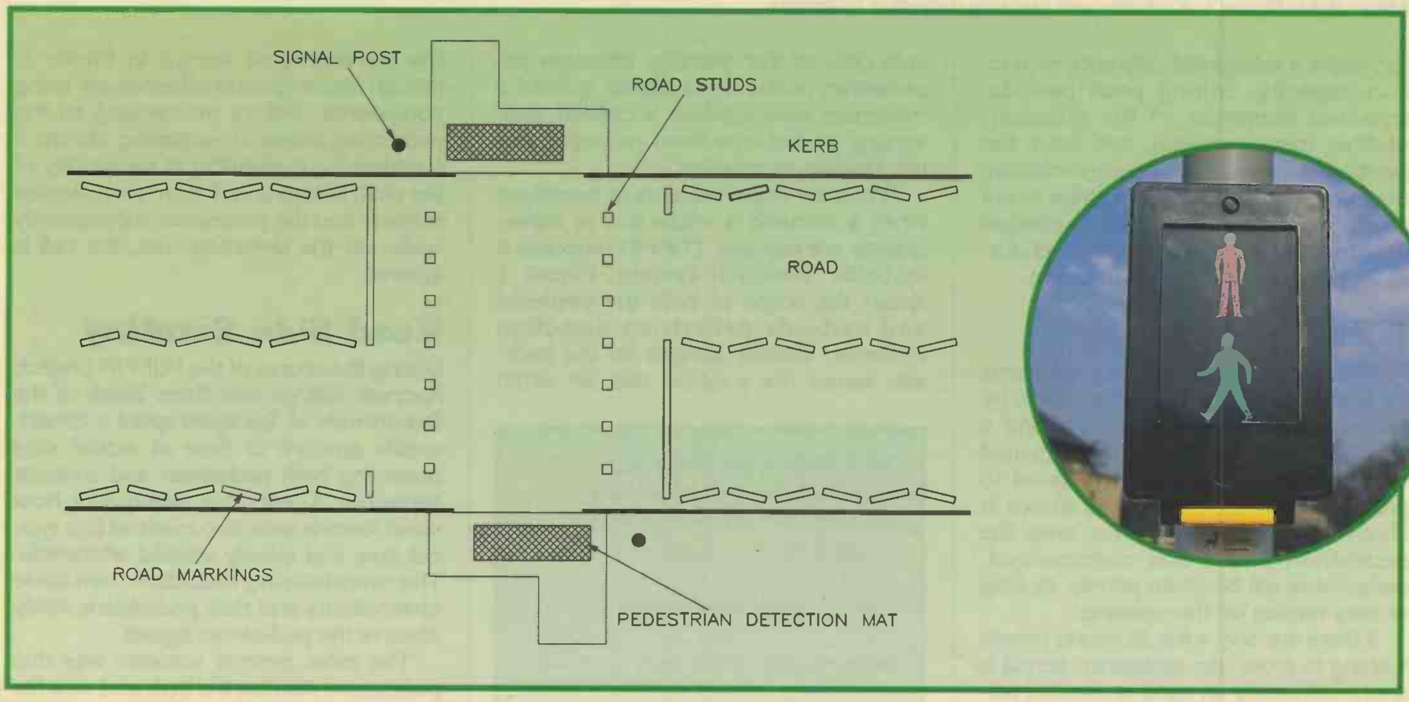
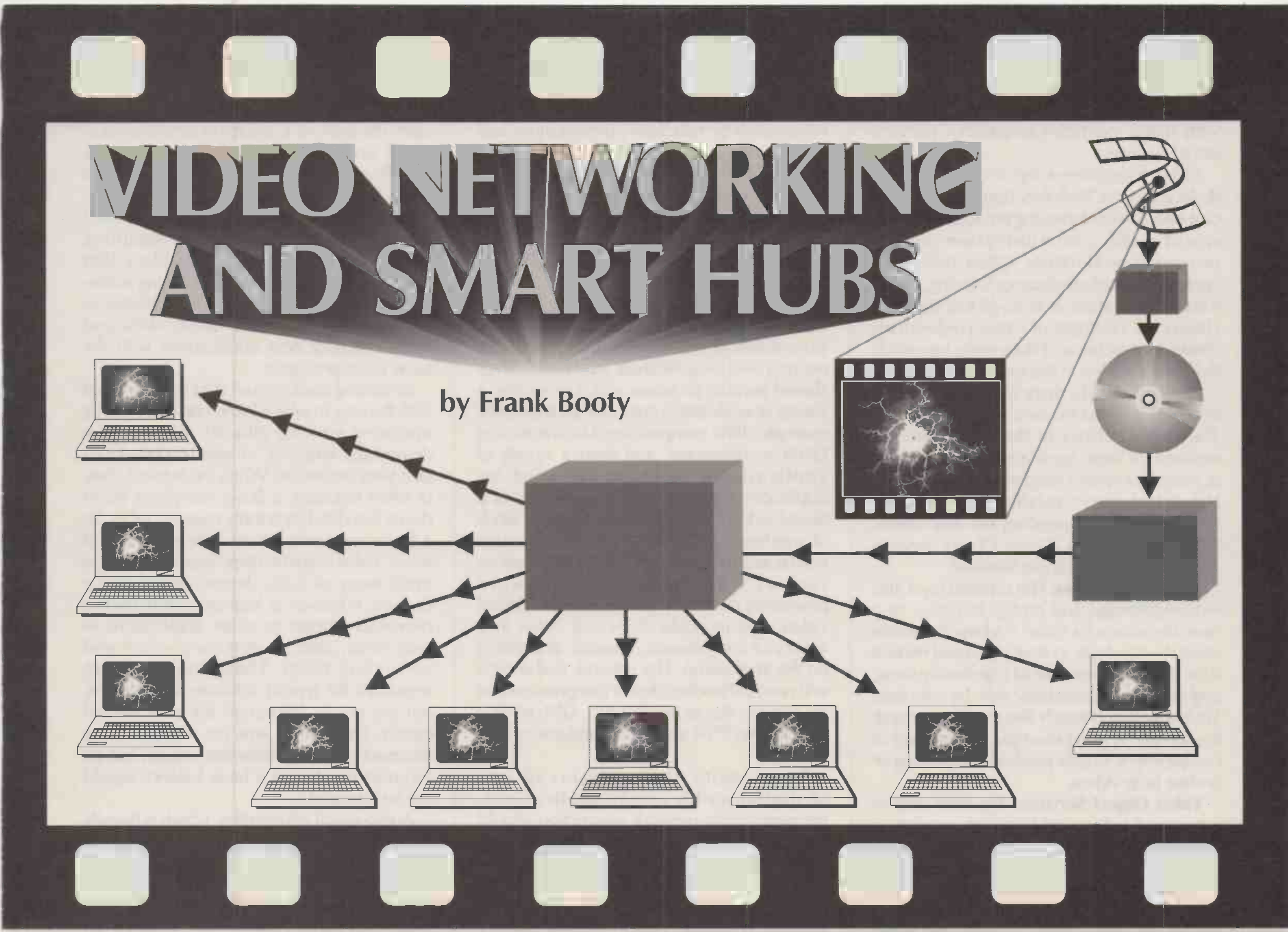


Figure 2. Layout for a single carriageway PUFFIN crossing with presence mat detectors, forming one arm of the T-junction.

VIDEO NETWORKING AND SMART HUBS

by Frank Booty



Desktop video is an emerging technology that will come in many variants in the near future. Applications in areas such as training and education, which use analogue video today, are moving from the classroom to the desktop. Video applications are becoming part of familiar office productivity software, such as spreadsheets and presentation applications. New ways of managing video applications with computers are on the horizon. Some applications are designed with single users in mind, but many applications will be more effective when used by widely distributed work groups.

THIS article will examine the applications for networked video, their characteristics, and the requirements for adding video to a network. The problems with handling video in today's networking environment will be examined too, as will the strategies for coping with those problems. Solutions will be discussed for improving hubs (which form the basis of 'star' type network systems), servers and clients (workstations) to make video networking convenient, reliable and relatively inexpensive.

Video Applications

Training applications are a natural choice for incorporating digital video on the computer. As an innovative training method, large businesses and other institutions are developing 'performance support systems' that revolutionise the way employees learn their jobs and perform their tasks. Instead of large amounts of 'up-front' classroom training, performance support systems provide training 'on demand' at the desktop. These systems call for network servers that deliver powerful audio-visual information to the desktop, so that training can be integrated with employees' daily work. Training costs decrease, while retention of information increases significantly, since students learn new information in context, and interactively, when they need to, rather than being presented with it all at once in the classroom.

Many major productivity software applications have VHS videotape training available today. Third party trainers are now moving to desktop video courses. In addition, people involved in the development of productive applications software are taking the next step – linking digital video directly to their software's on-line help resources. There are CD-ROM versions of software that include multimedia on-line help and references, and video help will soon be available for spreadsheets and word processing programs. In education, most of the major suppliers of educational software systems are marketing or developing 'integrated learning systems' consisting of student applications and teacher management systems. With an integrated learning system, teachers become better resource managers, assigning students to courseware according to their abilities and needs. Developers of such systems perceive network video as a vital tool in the classroom.

Businesses can use networked video presentation systems to send corporate resources to their employees' desktops instantly. Information, which could consist of sales videos or employee data, may be viewed on the spot, or captured to create customised sales presentations. Making the video available on a server allows many people to access the resources without them having to travel to a special audio-visual facility, or to buy a VCR and TV, to use the information.

Networked video documentation systems will allow institutions of all kinds to maintain multiuser audio-visual databases. Advertising agencies, for example, can have hours of video recordings, any of which can be called upon in a random fashion 'on-demand'. Today these agencies use hundreds of VCR tapes that must be located, copied and then delivered to account executives or clients. A video database would allow easier and quicker access to this information. Other potential users include: health care sites that have extensive audio-visual records; travel agencies who show videos about vacation destinations; public utilities which need to maintain records of power generation facilities and equipment; TV and film production facilities having hours of different video clips; defence institutions for purposes of intelligence, and meteorological offices with many examples of weather patterns stored on tape.

Video teleconferencing is coming to the desktop as well. With this, businesses can run cost-effective conferencing services to support world-wide communication needs, increasing productivity. Other live video applications include distance learning, where it is too far for students to travel to a common classroom. This type of video conferencing allows the teacher and students to interact as though they were in the same room.

As can be seen, there are many uses for distributing video to users at their desktops. The characteristics of the video 'service' required for these applications drive the type of computer system needed to support them. Networked video capabilities are envisioned in three levels, depending on user needs: Video File Services, Video Object Services and Stream Management Services.

Video File Services. The simplest level, this requires storage and replay facilities, or a basic file service for video. A video file service offers the capability to store video and retrieve it for viewing. The material is generally static, and so some access delay may be tolerable. Such a system is much like existing network file servers. A good example of this level of complexity is simple playback of training or on-line help videos.

Video Object Services. The next step in networked video sophistication consists of video object services, where an application is made highly interactive with video information by having supporting video and audio 'object' relationships that may change quickly. In other words, a video and audio database can be used to combine objects to produce a new video stream, to edit the video or to add video and audio to another document type instantly. This requires fast access to the video objects and the ability to change their relationships to one another. Users will want to access many objects at the same time. For example, an advertising agency would require this level of video service to combine many video clips to provide a quick look at a rough cut of a 'new ad concept'. This is an example of a system that needs more than just a store and play function.

Stream Management Services. This third category is required when many simultaneous users need access to live video. Desktop video teleconferencing and distance learning fall into this set of video applications. Video stream management service often involves sending live video from a variety of sources to many simultaneous users, and managing the video streams on the network. Users might require different data rates, or they may, for example, need to record a teleconference for later viewing. For these applications, users may be sharing CODEC pools (expensive devices that 'COmpress' and 'DECompress' the video), so that the video service can be provided to more desktops.

Requirements

It is expected that the demand for networked digital audio-visual systems will grow exponentially over the next few years, as businesses, government and other institutions increasingly turn to digital networks. They will use networks to distribute audio-visual information for education, presentations and reference applications. They will need systems that allow many people to view, simultaneously, audio-visual information from a server, while retaining their current network functions. Applications that function on a network now should remain undisturbed when video is added.

For the users, the added video facilities must be 'transparent', that is, not noticeably slow down or otherwise interfere with the normal working of their machine. They should be able to access video files using a variety of workstation computer protocols (for example, IBM compatibles, Macintosh and UNIX workstations), and from a variety of applications. To avoid the need for duplicating large video files, one copy of a digital video file should serve as many kinds of machines as possible. Over time, video will be incorporated into existing applications such as video annotation in a word processing document or spreadsheet. Digital video used in applications will come in a variety of compression schemes, depending on the application. The network and servers will need to handle different compression and file formats (for example JPEG, DVI, MPEG, QuickTime, P*64 and other standards as they develop).

To promote the widespread use of digital audio-visual applications, the workstation network connection should be standard and low-cost. This means the use of existing network connections in the work station rather than special or additional network connections to provide video services. The smart hubs serving the multiple connections of a full bandwidth Ethernet system will need to support many dozens of such streams simultaneously, requiring backplane speeds of over 1G-bit/s.

Problems and Challenges

Networking has become a critical technology for almost all segments of the computer market, particularly in business and education. Large and small businesses and institutions have come to depend on network servers for a variety of reasons. Today's Local Area Network (LAN) environments were designed to handle the data and file sharing needs of typical office productivity applications, which deal mainly with text and simple graphic files. Managing and transmitting digital audio-visual data, such as video or animation, poses two major challenges: dealing with the large size of the files, and handling the time dependent demands of audio-visual data types. This can be particularly difficult when sharing the information on different networks and servers.

The large file sizes associated with digital audio-visual information pose a need for large disk drives or multiple disk systems and high data transmission speeds. Even compressed video techniques, such as Intel's Digital Video Interactive (DVI), requires a continuous 1 to 2M-bit/s transmission speed and 0·5 to 1GB of storage for one hour's worth of video. A less obvious problem results from the very nature of the audio-visual information itself, which is fundamentally different from the kind of data that typically travels across a LAN (that is, word processing, database or spreadsheet data).

Digital audio-visual information takes the form of a stream of data that must arrive on time. Typical LANs operate by handling data in 'bursts'. File systems and most server communication buses are designed to handle this type of data burst traffic, but are inefficient at handling simultaneous, continuous, large block data transfers that are needed for streaming audio-visual data. It is also extremely difficult to manage both random, bursty data and streaming data type applications. with the same microprocessor.

Streaming audio-visual data also conflicts with the way in which LANs and multitasking operating systems allocate resources by democratic schemes, in which applications take turns in rotation. When the network, bus, or other resource, is busy, everything slows down. No data has priority over any other. To a typical network, bits are bits, regardless of what information they represent. The inefficiency of such democratic resource sharing schemes is compounded by the overhead needed to allow applications to take turns, and for detecting errors and correcting them. These functions are important for typical software applications, but are not as important for audio-visual media. The human eye can overlook one incorrect pixel in a television image, but an incorrect number in a bank balance would not be tolerated.

Audio-visual information, which is heavily dependent on timing, is not of much use if it slows down and speeds up in sympathy with network traffic flow. Even if the hardware and software can cope with slowdowns, the video would play back in slow-motion, which is not acceptable. Therefore managing data flow is the key to all multimedia computing, especially in networks.

Video demands that data has to arrive at the workstation computer on time. If the bandwidth is not available for a highly reliable connection (which would ensure that the video information arrives on time), one of two things must happen: the server must tell the requesting application that the data is temporarily unavailable, or the server must somehow reduce the amount of data (by dropping video frames, image size, resolution, etc.) to a level that the network can support reliably. Changing the video information to meet the bandwidth capability is known as 'scalable video'.

Any network's important function for the handling of audio-visual media is not to ensure fair allocation of the resources or checking of errors. It is to make sure that data flows at the proper rate between the server and the workstation, or between two workstations, and guarantee that that data arrives on time.

Digital Video Bottlenecks

Audio-visual data on a network hits a series of bottlenecks, which is not surprising since personal computers and networks were not designed to handle this kind of data. Along the digital path, which connects the disk drive in a server to a workstation computer, these bottlenecks limit the video stream speed or interrupt the video. The bottlenecks occur in disk drives, system buses, processors, network protocols, smart hubs and the various interfaces and buffers that are between the parts of the system. The problem areas are highlighted in Figure 1.

Consider now a typical setting for networked digital video: a training room with 30 DVI file format stations and an audio-visual server. Training that involves the completion of excercises requires that users be able to instantly view video when they want it. High resolution DVI, in this example, requires about 1·5M-bit/s per video stream. Thus each desktop must continuously handle 1·5M-bit/s, while the video server must handle an aggregate of 30 streams (45M-bit/s) simultaneously. Such a system will run into many problems, or high costs, if it uses ordinary workstation and server hardware, networking equipment and software. As the bottlenecks diagram in Figure 1 shows, the storage subsystem will have to handle 30 simultaneous users, even if they were to request the same 60 second video clip at two second intervals. The server will have to handle the same 45M-bit/s throughput internally. The network will have to handle 45M-bit/s from the server and 1·5M-bit/s per desktop, continuously and reliably. Finally, each workstation network interface will have to receive the video and *still* allow concurrent access to other network applications (for example E-mail, text, databases, etc.). Unfortunately, a normal networked server system could not accomplish this.

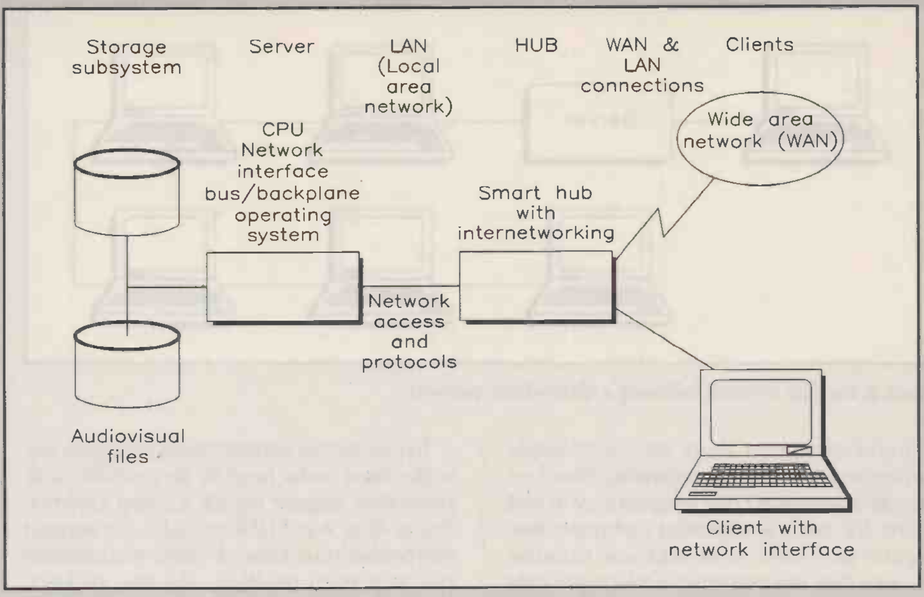


Figure 1. Bottlenecks in a network.

Solutions

A way to deal with the bottlenecks that confront networked multimedia data is to throw away all the software and hardware that cause the data streams to bump into one another, and replace them with *new* software and hardware that keep each stream running at the proper rate. This is workable, but it means something of great value to almost all computer users will also have been thrown away – the network software that allows them to use their servers for many other purposes. There are four strategies which can offer a range of solutions for dealing with the bottlenecks: do nothing; 'turbo-charge' the bottleneck areas; replace the bottlenecks with higher performance devices; or install a parallel system to circumvent the bottlenecks. We shall consider each of these alternatives in turn.

Doing nothing. Leave the system alone and make sure that the data stream never exceeds the limits of the bottlenecks. This is practical for workstation desktop computers, which never have to deal with more data than they can decode and play. By avoiding the need for workstation hardware changes, costs are saved since workstations far outnumber other network components. But doing nothing to the standard networks and servers will limit the number of users and the expected performance of the video services, since existing networks and servers have trouble handling video for multiple workstations, simultaneously.

'Turbocharge' bottleneck areas. Improve the offending hardware and/or software so that it can handle more data. Like adding a turbocharger to an engine, these improvements do not replace all the existing hardware, they just make it faster. This improves the general performance of the server and the network. However, it may not address the different processing requirements for video and traditional data applications, such as the time-dependent nature of audio-visual data.

Replace bottleneck devices. Replace the server and network hardware altogether with faster and more powerful hardware. For example, one way to increase a network's raw capacity is to replace Ethernet with FDDI (Fibre Distributed Data Interface) or CDDI (FDDI utilising copper conductors, such as unshielded twisted pairs). This is expensive and does not necessarily solve the problems of the hunger for bandwidth, and the time dependent needs for video, arising from the sharing of resources. By replacing the server with a higher performance computer that has more storage may help increase the 'horsepower' of the server, but the differences between video and other application data types are not addressed.

Parallel video solution. Install a system dedicated for video. This is all right if it means the addition of a separate server for video, but no one wants a separate physical network or a separate video computer. By establishing a parallel software world for video, while sharing the same network and workstation hardware, the system can be allowed to optimally handle both types of information. When using a parallel approach, it must be ensured that video and non-video information can be easily integrated within the same application.

As can be seen, no single strategy gives the best answer for solving the bottlenecks and meeting the requirements for adding video to the network. A better approach would be to take the best of each choice and change the network so it can cost-effectively handle data applications and video service. But how can this be accomplished? Consider again the training room example, and look at the work-station, the network and the server to show how video can be added to the network.

Since workstation computers typically only need one or two streams for video, bandwidth is not a problem. The data rate for a video stream is about 1·5M-bit/s, slower than the amount of data that comes from a typical hard disk. This data rate supports Intel's DVI compression technology. Even more extensive compression schemes such as the MPEG (Moving Pictures Experts Group) standard, currently in development, will suffice with Ethernet's 10M-bit/s. It still leaves plenty of capacity for other data or higher bandwidth video technologies such as MEPG II. Therefore, no special networking hardware is necessary at workstation machines, and existing 10BaseT Ethernet investments can be maintained.

Thus far, the discussion has concerned a single workstation. However, what if there were to be 30 or 40 workstations? In a typical network, all of the 1·5M-bit/s streams share the same cables, which quickly overwhelm a typical Ethernet network. Although upgrading to an expensive fibre-optic network (for example FDDI) will considerably increase the capacity, it is still a shared resource, and therefore has trouble dealing with the time-dependent needs of video or a large number of workstations (on top of its price penalty). A better solution can be found in a *star* network, such as 10BaseT Ethernet, which has dedicated, full capacity bandwidth connections to each work station computer, and a high capacity backplane to accommodate the multiple 10M-bit/s streams. 10BaseT is already the most common network configuration, and it can be turbocharged to support the video capacity needs without replacing the 10BaseT network interface cards and infrastructure (see later).

Star Networks

The need to exchange digital data between a variety of peripherals and computers with varying operating systems and applications has resulted in complex networks. Network hardware includes wires, such as the simple twisted pair wires that are also used for telephone networks, and more exotic wiring such as coaxial cable or optical fibres. Networks can be arranged in several physical structures or topologies. To create a bus or ring network, a wire snakes from one computer to the next (see Figure 2). Each computer on the network broadcasts data that is monitored by *all* computers on the network. However, *only* the intended recipient pays attention to the incoming data. As an analogy, a server on a bus or ring network is like a radio station that broadcasts a signal. While it is transmitting to one workstation, no one else can communicate.

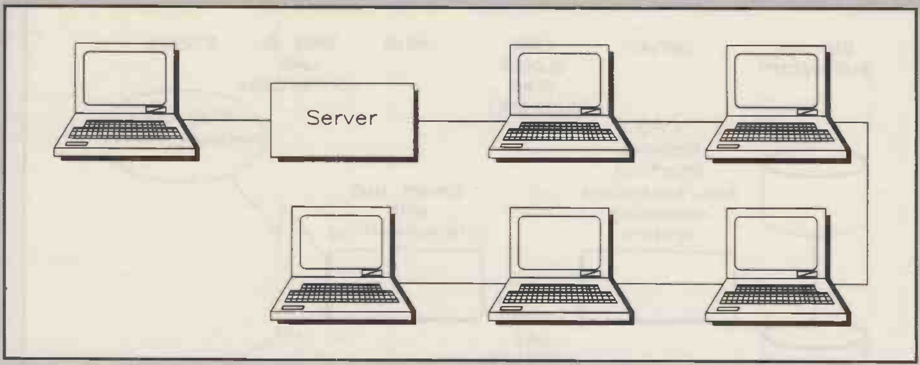


Figure 2. Familiar network following a 'daisy-chain' pattern.

Today computer users are increasingly turning to star topology networks, based on inexpensive twisted pair telephone wire and a line for each workstation computer (see Figure 3). These networks are popular because they use inexpensive telephone style wiring and are installed in the same way as a typical telephone system. Moves, additions, changes, diagnostics and control are simplified because, as with a telephone network, each workstation has its own cable (which can be individually turned on and off, and monitored). It can be connected or disconnected at the wiring centre for additions and changes, unlike the snaked cable of a bus network, which has to be re-routed for new workstations and other changes (and has no individual user monitoring and control).

For these reasons, networking experts see star networks, or structured wiring, as the dominant method to networking in the 1990s and beyond. These networks also offer the best topology for serving the bandwidth needs of video. To create a star topology, smart LAN hubs, placed in the wiring centres with support for most common protocols (Ethernet, Token Ring, FDDI, LocalTalk, RS232), have almost become a standard for installing new LANs. Over 80% of Ethernet and Token Ring LANs that are being installed today utilise twisted pair based hub installations.

Although today's 10BaseT Ethernet and Token Ring networks are wired as stars with hubs, most still operate like a bus or ring. This means that all desktops connected to the hub still share a common segment and a limited amount of bandwidth (10 to 16M-bit/s). This is not enough bandwidth to support typical applications, such as the example of the training room, which needs 45M-bit/s. The shared nature of bus or ring networks also makes it difficult to guarantee the dedicated bandwidth required for smooth and reliable video delivery.

One solution would replace Ethernet with 100M-bit/s FDDI or CDDI. Not only is this very expensive, it is still a shared medium that presents problems for the real-time needs of video. A better solution is to 'turbocharge' the Ethernet hub to achieve a dedicated 10M-bit/s per desktop, in effect giving users their own Ethernet networks (see Figure 4). Although this solution increases the cost of the hub, it does not require replacement of the wire or workstation hardware, so the total cost is reasonable. Note that a 10M-bit/s bandwidth meets each user's video and data needs. What is more, since the turbocharged network gives users dedicated connections, the real-time demands of the video can be handled reliably.

To provide the benefits of star wiring on any scale, these hubs need to be modular and, preferably, support regular existing Ethernet, Token Ring and FDDI modules. To support reasonable quantities of video workstations per hub with multiple streams of DVI, Quicktime, JPEG, MPEG, regular LAN applications traffic and high-speed WAN connections, such as SONET/SDH, simultaneously, these hubs need to be capable of supporting backplane aggregate speeds of well over 1G-bit/s. Such turbocharged hubs are already becoming available from network vendors. This approach can also work with Token Ring networks.

Smart hubs with turbocharged 10BaseT modules can handle the large amount of data required for video, giving each user enough bandwidth. However, this solution does not solve the second problem – the time dependent characteristics of video.

Video Network Protocols

Networked computers communicate using protocols which are standardised signals that govern the exchange of data. The computers send each other requests such as 'I would like this data', 'Begin sending', 'Stop sending' or 'Send that again, it arrived with an error'. These protocols are arranged in levels so that various parts of the computer – the hardware, the operating system and the applications, for example – can talk to one another without the need to know special information about one another. The two main purposes of the protocols are to ensure that the data arrives without errors, and to ensure that the 'traffic policeman' functions are carried out, regulating the data flow.

In today's typical network protocols, the emphasis is on data integrity through error control protocols. Flow control and timeliness of delivery are secondary. For the reasons already explained, these priorities need to be reversed for audio-visual data.

One way to handle audio-visual data streams more effectively, is to replace the existing networking protocols with special new ones. But if all old protocols are thrown out, compatibility with other software is lost. If existing ones are modified, the speciality performance required for each type of data is lost. Ideally, the network protocols for audio-visual data should peacefully co-exist with the standard network software. In such an environment applications would call for data from the server in a normal manner. The network, perceiving that audio-visual data has been requested, would use a special video protocol to make sure there is a highly reliable connection for an uninterrupted stream of data. For non-audio visual data, normal protocols would be used. With this parallel protocol approach, audio visual data becomes available to an application concurrently with other information on the same network.

The combination of turbocharged Ethernet and parallel software protocols addresses the workstation and network bandwidth requirements for our training room example. The last area to be satisfied is the server.

Improving the Server

Since the characteristics of video data differ from those of other data applications, it might be expected that the file server requirements would be different. Dedicated audio visual servers can eliminate the compromises that ordinary servers make between short 'bursty' data and large, uninterrupted streams of data, optimising performance for the latter. When dealing with audio visual data, the server architecture should bypass the normal, data contention avoidance schemes, substituting more of a real-time system that ensures reliable data flow.

Storage subsystems need to be managed such that many users can access audio visual data files at the same time. This means optimising the storage subsystem for many simultaneous accesses to large continuous

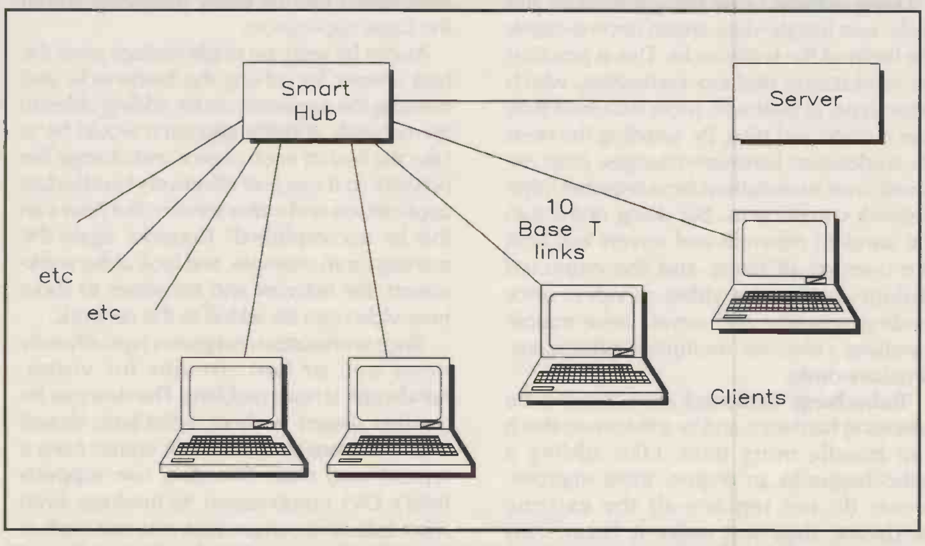


Figure 3. A 'star' topology network, where a 'smart hub' interfaces each workstation to the server via dedicated lines.

data files. Alternatives, such as analogue laser disk 'jukeboxes', allow access to large quantities of video, but have problems with access delays when multiple users play different segments of video. Arrays of hard disk drives offer a cost-effective method for storing large quantities of video data, and can be configured to support the training example of a group of 30 users.

To incorporate audio visual data into existing applications, the video data should look like ordinary data to any application. To an SQL database application, it should look like SQL, to a Lotus spreadsheet it should look like spreadsheet data. Then last but not least, the operating system, it should look like another part of the file structure. Ideally, this should be accomplished with only one copy of the data, and yet support a range of computer platforms and operating systems.

Finally, a video networking solution should be able to handle any type of video application, including desktop teleconferencing. This means that servers should be able to manage data streams in the same way as a telephone switch handles audio traffic.

This, then, is a brief description of how a server optimised for video can efficiently solve video network bottlenecks. To create such a server, an existing server can be enhanced, or an application specific server can be added to the network. Enhancing an existing server will probably result in many compromises, and have an impact on its ability to handle non-video data.

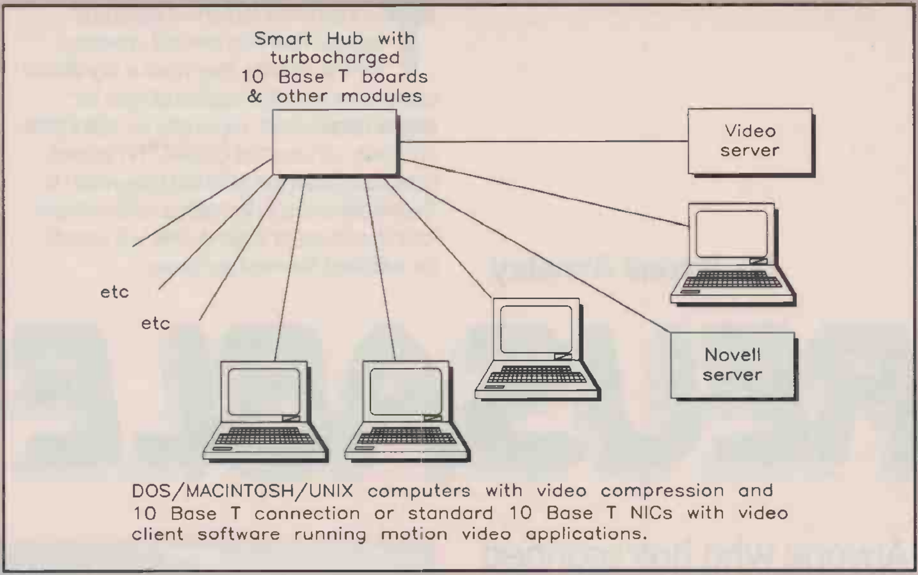


Figure 4. Typical multimedia network.

Summary

The solution for networked multimedia does not have to be an expensive, very high-speed network or a parallel video network. Today's star wired networks can do the job at very reasonable costs, without special workstation networking hardware. A high-speed backplane hub, with turbocharged 10BaseT modules that recognise and know how to handle video, allows the video workstations to be served within a current network environment. With parallel video specific network protocols that co-exist with today's standard networking protocols, compatibility with current applications can be maintained and reliable video services can be delivered on the same network. Finally, a specialised server can handle the processing and storage management needs of audio-visual media, and provide superior video support without compromising current network applications. A typical example of such a network, where standard LAN services co-exist with video services is shown in Figure 4.

PUFFIN PELICAN CROSSING – *Continued from page 14*

The first live site to be converted was in the midst of a busy shopping centre at Rustington in West Sussex. Here two crossings on a three way T-junction have been modified as shown in Figure 2. Pedestrian flows are relatively heavy over much of the day, but dwindle to nothing at night, while traffic flows are busy in the morning at around 8.30am, and in the evening approaching 5.30pm.

Each of the proposals from the PUFFIN study has been adopted, except for the variable message indicator suggested as a replacement for the WAIT legend. The trial crossing is shown in Photo 4. The four crossing detectors are passive infra-red transducers, supplied by Microsense Systems, while the kerbside detectors are rubber mats with in-tegral piezo-resistive sensors supplied by EMC of France.

Progress To Date

Live studies of the PUFFIN scheme still have many months to run, although initial tests, performed shortly after commissioning, look promising. During a busy afternoon period, the average duration of the pedestrian stage was 14·24 seconds, compared with the previous period of 13 seconds. At less busy periods the average duration of the pedestrian phase reduced to 9 seconds. One in every 13 pedestrian phases was cancelled, while the pedestrian period only extended to its maximum setting on two occasions.

So could 1994 see the end of motorist frustration and the adoption of a user friendly road crossing scheme? Let's hope so. If the results of a TRRL report on before and after behavioural studies at the Rustington crossing prove positive, it will give a green light to the adoption of the PUFFIN proposal at road crossings throughout the UK.

PUFFIN benefits for motorists

Fewer traffic delays as capacity of signalled junctions is improved.

Elimination of unnecessary stops at empty crossings.

Consistent signal displays for pelican and signalled junction crossings remove ambiguity.

Further Information

Department of Transport, Network Management and Driver Information Division, St. Christopher House, Southwark, London SE1 0TE.

References

New Pedestrian Facilities at Signalled Junctions, Kenneth Billings and Brian Walsh, Department of Transport, September 1991.

The Use of Pedestrian Crossings, Network Management Advisory Leaflet, Department of Transport Network Management and Driver Information Division, March 1993.

by James Aynsley

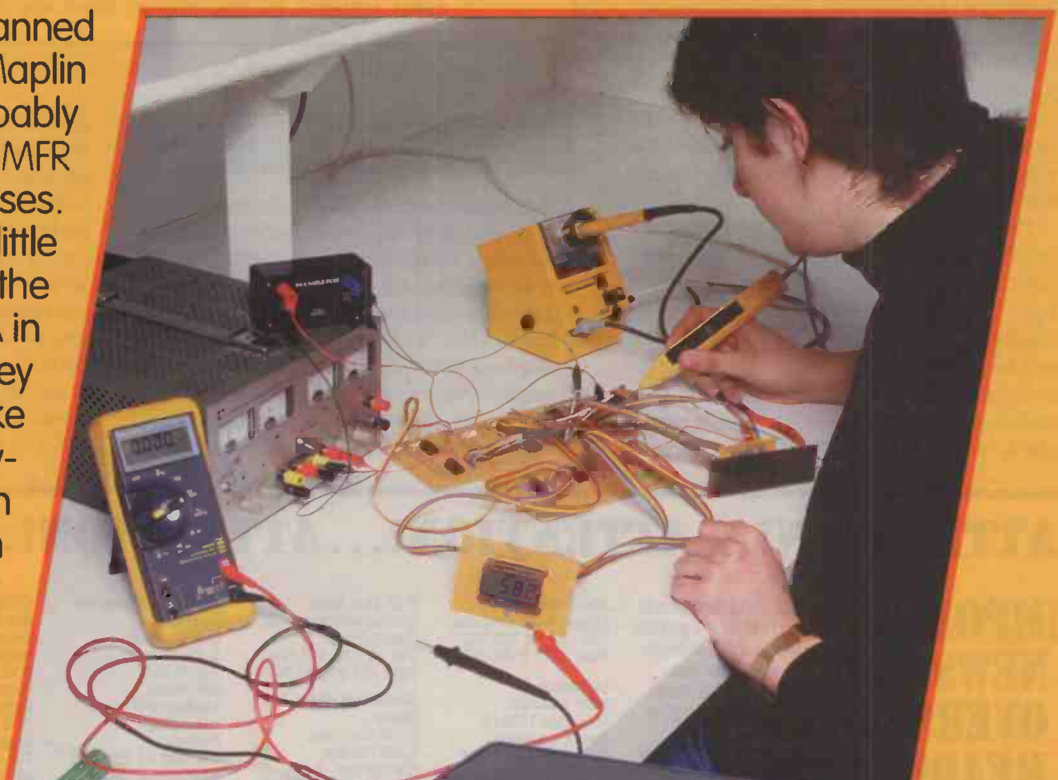
THE important feature of electronic fuses is that they are self-resetting. For this reason, they have a significant advantage over the traditional type for experimental work, especially for initial trials on newly constructed circuits. This project uses as a basis the MFR020 fuse which is the smallest one in the range and suitable for currents up to 200mA. This will usually be sufficient for most purposes.

Accidental short-circuits and other faults causing excessive current are very common in experimental work. These are often caused by wires or component end-leads touching. Another cause of trouble is a multitester intended to be used as a voltmeter but accidentally left on a current range. Excessive current may also result when a resistor having a lower value than necessary is used – perhaps due to misreading the colour code

REUSABLE FUSE

WITH LOCKOUT INDICATION

Anyone who has scanned the pages of their Maplin Catalogue will probably have noticed the MFR series of electronic fuses. These are useful little devices which cover the range 200mA to 6A in eight units. They behave rather like conventional slow-blow fuses and can replace them in many applications.



1
PROJECT RATING

KIT AVAILABLE (LT70M) Price £12.99

FEATURES

- Audio and visual warning
- Easy to use
- Low holding value
- Self-resetting

APPLICATIONS

- Protection for test circuits
- Added protection for low-voltage circuits

or a slip-up in an Ohm's Law calculation. Circuits using the stripboard construction method bring their own problems because adjacent copper tracks often become 'bridged' with solder or fine slivers of copper. Incomplete broken tracks are also very common. The effect of high current is excessive local heating which, in turn, leads to destruction of components and burnt-out PCB tracks. It also quickly drains batteries.

The Reusable Fuse is an 'intelligent' fuse which is fitted between any test circuit and the power supply. It guards against any of the problems mentioned above. Thus, if the current exceeds 200mA for any reason, a buzzer gives a short bleep and the LED flashes continuously. The current then falls to a very low holding value until the fault has been corrected.

The device is suitable for circuits needing a supply voltage between +4 and +18V DC and this covers the majority of circuits which the electronics enthusiast is likely to construct. In fact, the prototype unit works down to 2·5V but operation is then rather erratic. The supply may be any type of battery or mains-operated power supply unit. Note, however, that an existing output fuse in a commercial power supply may blow before the electronic one 'locks' out. Fuses must never be increased in value in an effort to prevent this from happening. Also, the device must on no account be connected in the mains supply line – it is strictly for low-voltage use only.

The Reusable Fuse is built in a small plastic enclosure with the LED showing through a hole in the lid. Further holes allow the sound to pass out from the buzzer. There are also two pairs of screw terminals – one set to connect the power supply, and the other the circuit under test.

EXCESSIVE CURRENT

If a short-circuit is applied to an alkaline battery, the current will be limited to a few amps by its own internal resistance. The effect will be to ruin the battery after a short while, although it is also possible for thin wires and copper tracks to melt. If the supply is derived from nickel-cadmium cells, their lower internal resistance will allow a heavy current to flow, leading to similar but worse effects. Short-circuits applied to a lead-acid (car) battery can be catastrophic due to the exceptionally low internal resistance of this type of supply and hundreds of amps can flow. Even fairly thick wiring can become red-hot in seconds causing burns and presenting a significant fire risk. Using this device while testing any experimental automotive project would therefore be very wise.

The assembled PCB.

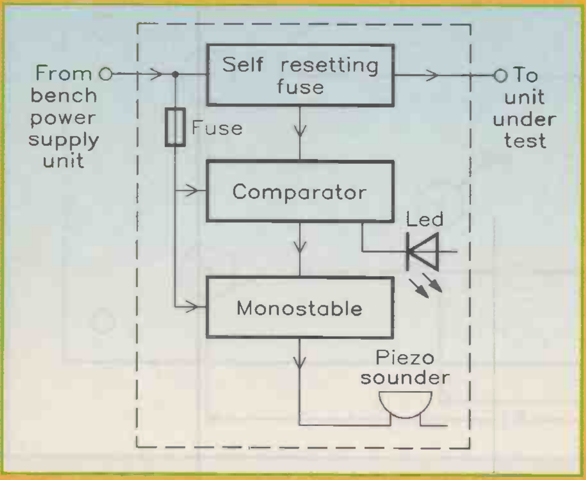
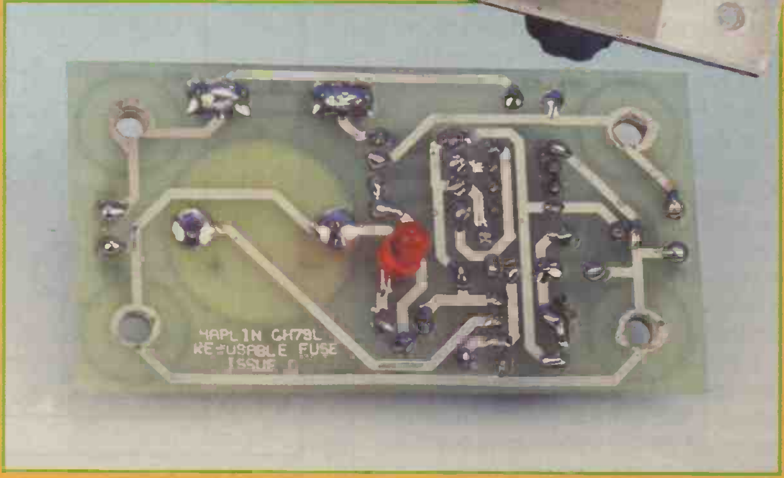


Figure 1. Block diagram of the Reusable Fuse.



Underside of the PCB showing how the LED is mounted.

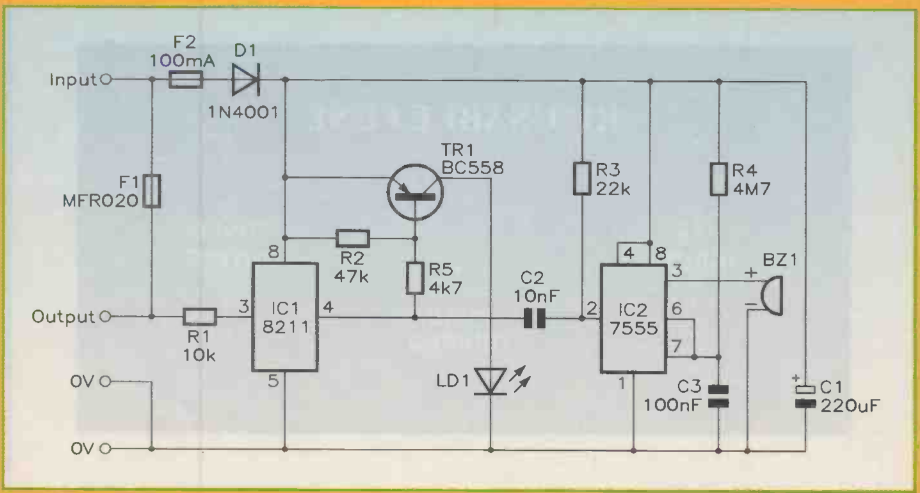


Figure 2. Circuit diagram of the Reusable Fuse.

A GOOD TRIP

The way in which an electronic fuse operates is different from the traditional variety. Here, excessive current flowing through a piece of thin wire causes it to melt and so break the circuit. In an electronic fuse, the fault current causes a gentler heating of the material which in turn causes it to latch in a high resistance state. When a traditional fuse blows, the circuit is completely broken. However, in an electronic one a small holding current continues to flow; this keeps it hot and maintains the locked-out condition. When the fault is removed, or the power supply switched off, the fuse material quickly cools down and reverts to its original low resistance state.

The nominal cold resistance of the MFR020 electronic fuse is 2·67Ω In a 12V circuit of otherwise negligible resistance and unlimited current capacity if a short circuit were to occur a large current will flow in the order of about 4·5A. This results in almost instantaneous heating of the material and a rapidly tripped state. This will happen before any significant overheating of wires or tracks in the test circuit occurs.

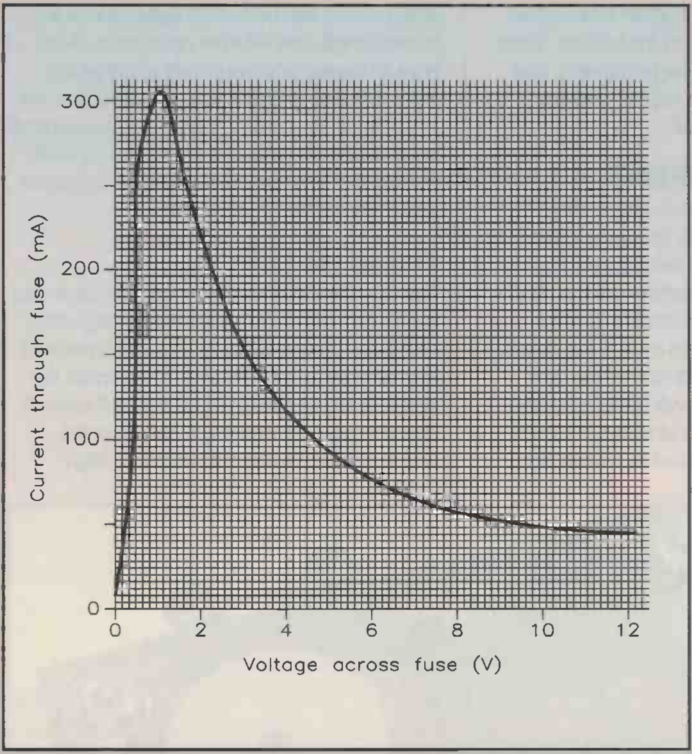


Figure 3. Characteristics of the MFR020 multifuse.

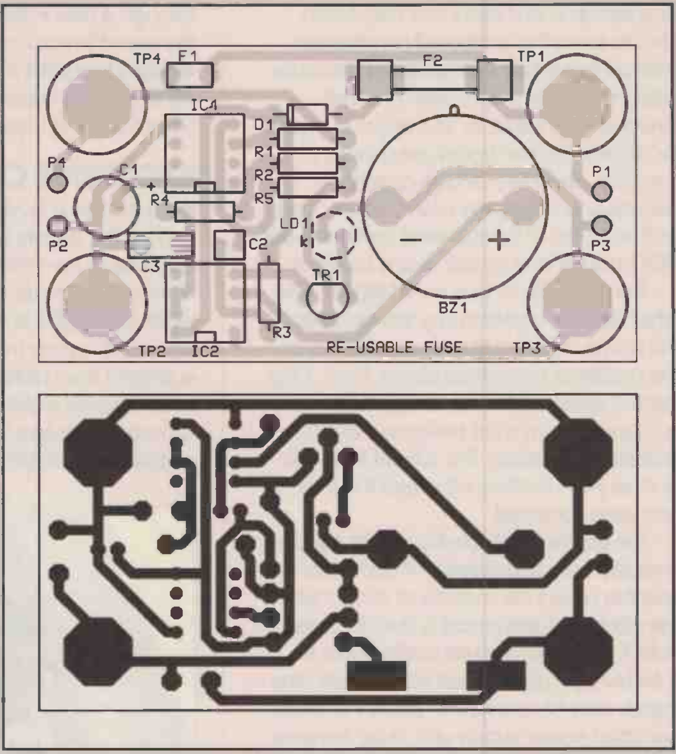


Figure 4. PCB legend and track.

CIRCUIT DESCRIPTION

The block diagram in Figure 1 of the Reusable Fuse shows the constituent parts that make up the fuse. In conjunction with the explanation refer to the complete circuit diagram shown in Figure 2.

F1 is, in fact, the electronic fuse, and it will be seen that the current powering the circuit under test (shown as being derived from the power source between Input and 0V) flows through this. In addition, current flows through the conventional fuse F2 and diode D1 to the fuse monitoring circuit.

It will be found useful to refer to the characteristics of the multifuse in Figure 3 at this point. This illustrates the way in which F1 behaves as the current through it changes. The exact figures will vary from one device of the same type to another but it shows the general pattern of behaviour. Up to a current of 200mA there is 0·5V approximately developed across the fuse. Although this voltage is 'lost' as far as the test circuit is concerned, it is too small to have any significant effect. Applying the Power Formula: (P = I x V), at 200mA, the power dissipated by the fuse will be 100mW. This will result in very little self-heating and it will remain cool and stable.

With about 300mA flowing and 1V appearing across the fuse (giving a power dissipation of 300mW), a sudden inversion takes place. There is considerable self-heating and a significant temperature rise. This results in an increased resistance and rising voltage across the fuse. Although the current falls, the power dissipated by the fuse actually rises resulting in an increased temperature. A vicious circle is established with the fuse on a slippery slope to lockout. However, the dissipated power soon becomes substantially constant, with the current falling at the same rate as the voltage across the device rises. After a short time, practically the whole of the supply voltage appears across it.

This may be illustrated by looking at the point on the graph where 2V exist across the fuse with about 220mA flowing. The power developed will be 440mW and the resistance about 9Ω With 6V across it and 75mA flowing, the power is virtually the same with a fuse resistance of some 80Ω With 8V and 55mA the power is again practically the same but the resistance now 145Ω With 10V and a current of 50mA, the resistance has risen to 200Ω.

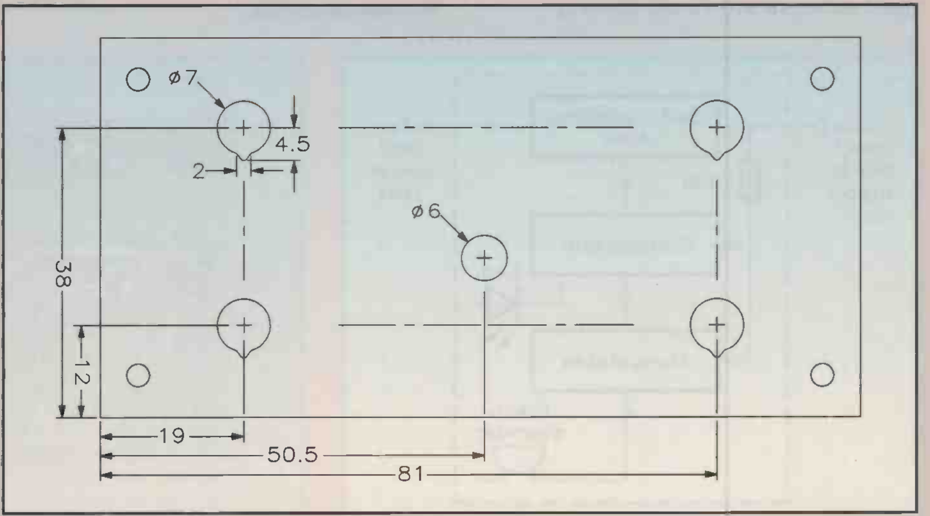


Figure 5. Box Drilling.

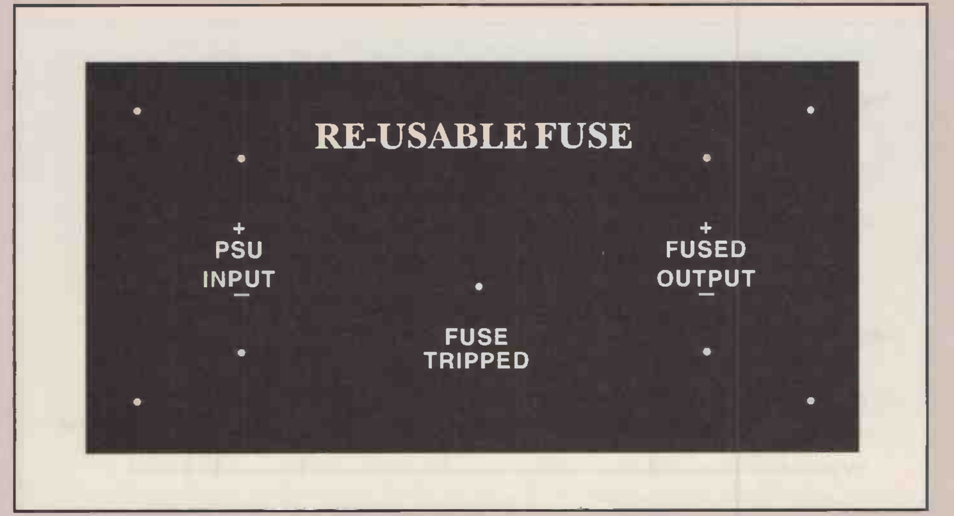


Figure 6. The Reusable Fuse front panel label.

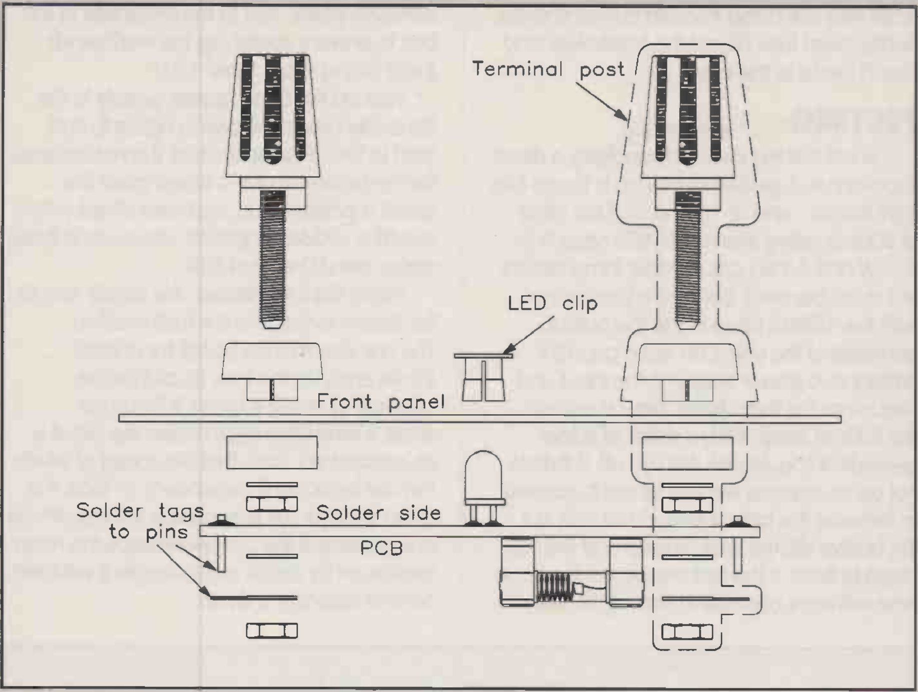


Figure 7. Exploded assembly diagram, showing fitting of terminal posts to front panel and PCB.

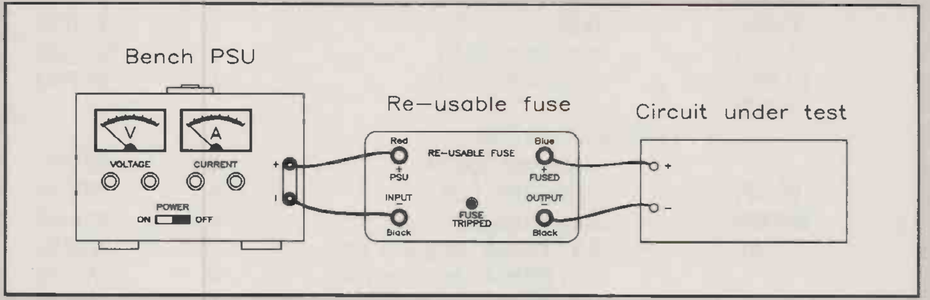


Figure 8. Wiring diagram.

OVER THE THRESHOLD

To detect impending lockout, it is therefore necessary to sense the voltage across F1 and to use it to trigger the LED and buzzer. In this circuit, voltage sensing is provided by IC1 – a precision voltage detector. When the voltage applied to its threshold (pin 3) is greater than 1·15V (an internally-set reference), the output at pin 4 – is high. TR1, a PNP transistor with an open-collector output, is biased off and thus LD1 does not illuminate. C2 which is connected to pin 4 on one side, and to the supply rail via R4 on the other, is stopped from being charged, as the potential across it will be virtually the same.

When a fault occurs in the load across Output and 0V, a higher current flows; F1 will heat up and its resistance will increase, and the supply voltage will be developed across it. The voltage on pin 3 of IC1 falls and, when it drops below the threshold voltage of 1·15V, the output on pin 4 drops. TR1 will turn on with base current flowing via R5. The flashing light-emitting diode (LED), LD1 in the collector circuit, will then operate.

To provide an audible indication of the tripped state, IC2 and associated components are called into play. This section is configured as a monostable. The transition on pin 4 of IC1 from a high state to low state also allows C2 to charge and a negative pulse is then generated; this is applied to pin 2 of IC2. Thus, when activated by applying a low pulse to trigger input pin 2, the output (pin 3) will go high for a certain time and then revert to low. The time during which it remains high depends on the values of components R4 and C3 and with those specified will be 0·5s approximately. On triggering, therefore, buzzer BZ1 will give a brief bleep.

The monostable is triggered by the change in state of the output from IC1, that is, when the fuse has tripped. To prevent continuous triggering, capacitor C2 allows only a momentary pulse to flow. This is necessary since constant operation of the buzzer would be annoying to the user.

Protection will be afforded by F1 as long as the fault exists, or until the problem is removed, thus allowing F1 to reset and the flashing LED to extinguish.

CONSTRUCTION

Note that the LED *must* be of the constant current type specified in the Parts List. This obviates the need for a series resistor as with a conventional LED, and has the added advantage of providing a more or less constant brightness over the entire range of operating voltages, although below 4V it does become rather dim. Note that the buzzer must be of a type which can operate over a wide voltage range, and the specified unit is ideal for the purpose.

Construction of the Reusable Fuse is based on a single-sided printed circuit board (PCB). Legend details (parts placement diagram) and the track (copper-foil view) are illustrated in Figures 4a and 4b respectively. Solder the components in the following order. First, mount the two IC sockets, fit and solder the four PCB pins, then all resistors and capacitors taking care over the polarity of C1. Follow with diode D1 again taking care over the polarity, and the light-emitting diode LD1 (fitted to the reverse side of the PCB) which should be soldered so that its tip stands 3·5mm above the circuit board, see Figure 7. Add the transistor, then fuse F1 with the preformed bends in the wires against the board (this will provide a small clearance with the circuit panel which is necessary because the fuse becomes hot in operation). Solder the buzzer (the polarity is marked on the underside) flush to the circuit board. Do not insert the ICs into their sockets yet.

BOX DRILLING

To prepare the case, box drilling details are given in Figure 5. Mark the positions of the mounting holes for the terminal posts. Remove the panel and drill these holes. The holes drilled for the terminal posts will have small notches filed in them so that the posts can be located in position without turning. In the prototype, red and black terminals were used for positive and negative input respectively, and blue and black for the output. Measure the position of the LED and drill a hole in the lid. A front panel label is

Photo 3. The complete unit.

available (which is included in the kit) and is shown in Figure 6. Attach the front panel label and then fit the LED clip in position, see Figure 7. The collar part is not required.

Attach the terminals through the lid using the bushes on top. Fit the plastic bushes, washers and nuts on the underside and tighten up (see Figure 7 for the exploded assembly). The terminals also serve to hold off the PCB. Next fit the PCB, making sure that the LED locates correctly into its clip. Fit the washers and attach the solder tags to the PCB pins, and solder these in position. Fit the remaining nuts.

Unpack the ICs and insert them into their DIL sockets taking care over the orientation. Note that these are CMOS devices and could be damaged by static discharge, (static may exist on the body). To avoid possible damage, either touch something which is earthed (such as a water tap) before handling them, or avoid touching the pins while they are being inserted in their sockets. Finally, insert fuse F2 into the fuseholder and attach the lid to the case.

TESTING

Do not test the device by applying a direct short-circuit. A gentler approach is to use two 6·5V lamps – one of 150mA and the other of 300mA rating (the round MES types 6·5V 0·97W and 1·95W are suitable; lampholders are available also). Connect a lampholder with the 150mA lamp in it to the output terminals of the unit. Connect a good 6V battery or a power supply to the input and check that the lamp lights. Now substitute the 300mA lamp. After a delay of a few seconds, it should dim then go off. If it does not do so, connect the two lamps in parallel to increase the load. As the circuit cuts out, the buzzer should emit a bleep and the LED begin to flash. If this test works, the Reusable Fuse will work correctly in service. Fit self-adhesive plastic feet to the underside of the box to prevent scratching the workbench [read dining-room table – Ed.].

Wire up the bench power supply to the Reusable Fuse as shown in Figure 8, and then to the circuit under test. It is not unusual for the buzzer to give a bleep when the circuit is powered-up, and sometimes when a load is suddenly applied. However, in these cases, the LED will not flash.

When the fuse latches, the supply should be disconnected and the fault rectified. The unit should then be left for at least 20 seconds for the fuse to cool before attempting to use it again. If this is not done, it may latch again when the circuit is re-established. Note that the speed at which the unit locks out is dependent on load. If a direct short-circuit is applied, it will trip almost immediately. If the current exceeds the rated maximum by only a small margin it will take several seconds to do so.

REUSABLE FUSE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1	10k	1	(M10K)
R2	47k	1	(M47K)
R3	22k	1	(M22K)
R4	4M7	1	(M4M7)
R5	4k7	1	(M4K7)
CAPACITORS			
C1	220µF 16V Radial Electrolytic	1	(FF13P)
C2	10nF 50V Miniature Disc Ceramic	1	(BX00A)
C3	100nF 16V Miniature Disc Ceramic	1	(YR75S)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
LD1	High Brightness 5mm Flashing Red LED	1	(UK36P)
TR1	BC558	1	(QQ17T)
IC1	ICL8211CPA	1	(YH43W)
IC2	ICM7555IPA	1	(YH63T)
MISCELLANEOUS			
F1	MFR020 Electronic Fuse	1	(CP58N)
F2	T100mA 20mm Fuse	1	(UJ92A)
	20mm Fuse Clips	2	(KU27E)
BZ1	Low Profile PCB Buzzer	1	(KU58N)
	Single-ended PCB Pin 1mm (0·04in.)	1 Pkt	(FL24B)
	8-Pin DIL IC Socket	2	(BL17T)
	Black Terminal Post	2	(HF02C)
	Red Terminal Post	1	(HF07H)
	Blue Terminal Post	1	(HF03D)
	LED Clip	1	(YY40T)
	Front Panel Label	1	(KP67X)
	PCB	1	(GH79L)
	Instruction Leaflet	1	(XU70M)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Plastic Box Type T4	1	(KC93B)
	Small Plastic Feet	4	(FE32K)
	Solder Tags M3	4	(LR64U)
	6·5V 150mA Lamp (See Text)	1	(BU00A)
	6·5V 300mA Lamp (See Text)	1	(WL79L)
	Lampholder (See Text)	1	(JX87U)

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 as a kit, which offers a saving over buying the parts separately.

Order As LT70M (Reusable Fuse Kit) Price £12.99

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 items (which are included in the kit) are also available separately, but are not shown in the 1994 Maplin Catalogue.

Reusable Fuse PCB **Order As GH79L Price £2.49**

Reusable Fuse Front Panel **Order As KP67X Price £1.29**

NEXT issue

There are more terrific projects and features winging your way in next month's super issue of *Electronics – The Maplin Magazine*, including:

AERIAL ACTIVATOR

The Maplin Aerial Activator is designed as an add-on device for your LW/MW/SW receiver. It is designed to increase the strength of the radio signals being received over a wide range of frequencies. For LW/MW broadcasts and shortwave listeners using a general coverage receiver, the unit offers an improvement in reception even when used in conjunction with a small aerial.

CAR LAMP MONITOR

It is surprising how few people take the trouble to check that their car's lights are fully functional. This can be a hazard to the driver of the vehicle itself, as well as other road users. This project is designed to provide an indication of lamp failure and is based around a custom designed IC. The Car Lamp Monitor has been designed to be very flexible to cater for most makes and models of car. The module may also be used with a caravan or trailer.

ANTI THEFT DEVICE

This is a small low-cost device which can be used to protect individual items such as a TV, video, Hi-Fi or computer. The device can be hidden inside almost any domestic appliance or piece of furniture, and it will remain silent until the appliance is moved; if moved, the alarm will emit a very loud 'screeching' sound until either the battery becomes flat, or the alarm is turned off.

MAX293/7 DATA FILE

The MAX293 or 297 integrated circuits can be used in a number of audio or data applications that require low-pass filters, including voice and data signal filtering. Both ICs contain 8th-order (eight-pole), low-pass, elliptic, switched-capacitor filters, with an uncommitted op amp and internal oscillator.

FEATURES

Special features include a fascinating look at the history and future of 'Cold Fusion'; 'Video Conversion' explains how broadcasters convert television pictures; 'Workgroup Computing' examines the networking strategy in business. New series beginning next month: 'Audio Power Amp ICs', covers practical IC-based audio power amp circuits; also, 'Test Equipment', the first part deals with multimeters and oscilloscopes. Other features continue with the second instalment of 'Surround Sound'. All this, plus all your favourite regulars as well!

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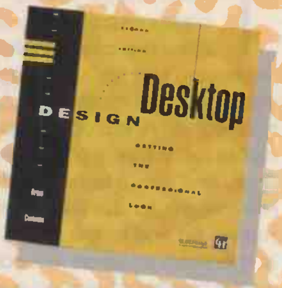


WordPerfect: The Joy of Six

by Darren Ingram

While at least over 600 new features have been added to WordPerfect 6.0, this book is not designed to be a guide to every feature, quirk or tool of WordPerfect 6.0. The more commonly-used and useful commands are explained in a clear, easy to understand way that should allow the reader to grasp the concepts quickly. After reading this book, a novice or an experienced wordprocessor user, should be able to produce more effective documents. It answers commonly asked questions and explains the significant new and enhanced features, of WordPerfect 6 such as 'Network Setup Utility', 'Page Mode', etc.

The first chapter enables the reader to start with fundamental functions such as screen layout, opening and editing your documents, saving your work etc. Further chapters guide you through the use of the various dictionaries available, which include spell checker, grammar checker and Thesaurus. Also contained in the book is information on using special and foreign characters, and document statistics/information.

As one gains confidence, then the complexity of the tasks increase, as the reader is introduced to topics such as headers, footers and footnotes, watermarks and labels, a table of contents and indexing, lists and tables. The final chapters describe the desktop publishing capabilities of WordPerfect 6 and include the graphics capabilities.

1993. 160 pages, 230 x 185mm, illustrated.

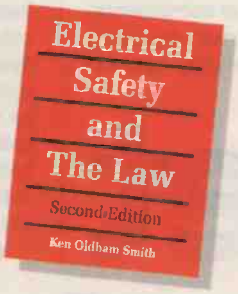
Order As AA67X
(W/Perfect The Joy of 6) *£11.95 NV*

Electrical Safety and The Law – Second Edition

by Ken Oldham Smith

This book summarises EC and British electrical safety regulations, including the Electricity at Work Regulations and the non-statutory Institute of Electrical Engineers Wiring Regulations. This latest edition takes into account the recent changes in legal requirements and deals extensively with the 16th Edition of the IEE Regulations.

The book is primarily intended for the electrician, electrical engineer and safety officer and presents the facts in a simple and practical manner. It deals with electrical hazards and how they arise, accident and dangerous occurrence reporting, safety precautions, testing flammable atmospheres and the particular problems associated with underground cables and construction.



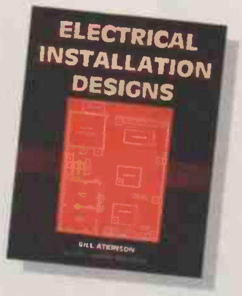
The author was an HM Senior Electrical Inspector of Factories, and therefore is more than qualified to write about such an involved topic. His experience has shown that there is a general ignorance of electrical safety legislation, its extent and application. It has to be appreciated that there is now more legal protection than ever before, against defective electrical apparatus and installations, and this book will prove to be indispensable in understanding these legal requirements.

1993. 223 pages. 234 x 156mm, illustrated.

Order As AA66W
(Elec Safety And Law) *£22.50 NV*

Electrical Installation Designs

by Bill Atkinson



The majority of electrical contractors have an understanding of the requirements that are related to their own, regular, everyday activities. Normally, work is carried out using rule-of-thumb methods and repetitive designs. Many installers claim they are not designers, and are now increasingly concerned that they are required to certify the adequacy of an electrical installation design. Fortunately, problems only arise when an unusual project is undertaken, or there is a change in regulations.

There is nothing wrong with using standardised designs and this book is a varied collection of typical projects that are examined to produce designs that will fit current standards. The installer may select a suitable design that corresponds as near as possible to the contract in hand and can use it accordingly. The designs illustrate methods that could be used for particular types of installation, ranging from a house to an industrial workshop.

Although the emphasis is on tried and tested methods, new techniques are introduced such as the option to use 'tree' circuitry as an alternative to the ring final cricuit.

Electrical installations contractors, students and non-electrical associates in the construction industry will appreciate the user-friendly approach, but this book is not intended as a do-it-yourself for the untrained person.

1994. 216 pages. 243 x 172mm, illustrated.

Order As AA68Y
(Elect Install Design) *£14.99 NV*

Desktop Design Getting the Professional Look

by Brian Cookman

This is a teaching book primarily intended for those readers who want to learn and practise the art of 'Computerised Integration of Text and Graphics'. The Desktop Publishing system (DTP) replaces smelly adhesives, ever-blunting scalpels and the eternally shaking drawing pen.

In the second edition of his book Brian Cookman sets out the best way to use a desktop system with regard to design. He includes many of the tricks of the trade, that he has picked up over the years, which will hopefully alleviate hours of frustration. In 'Design Basics' covered in Chapter one, the author emphasises the importance of each step and why. In each subsection the main points are summarised in one-liners under the headings of keypoints or checklists. Some of the topics explored, embrace titles such as 'Grids', 'Crossheads', 'Typefaces','Drawing packages and Reversals.'

After the basics have been covered, the next section incorporates them in practical applications. Chapter two outlines the actual use of the DTP in action covering such topics as 'Logos', 'Advertisements', 'Company Reports and Presentations' and 'Slides and Graphs'.

The final section looks at ways of producing the finished article, and the practical ways of ensuring the smooth running of final publication. Such topics covered are bureaux, laser printers and typesetters, disc conversion, MODEMs, health and safety.

This book is full of illustrations to back up what the author has written. Ideally suitable for all levels of DTP users as it will not only inform the beginner, but will refresh the memory of the expert. The book is not intended to be for any particular system, as most of those available will handle the designs without any trouble.

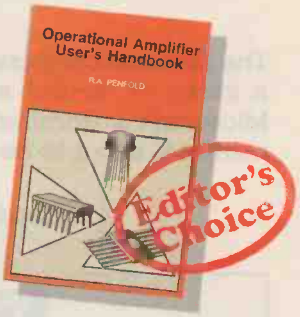
1993. 126 pages, 210 x 206mm, illustrated.

Order As AA74R
(Desktop Design) *£19.99 NV*

Operational Amplifier User's Handbook

by R. A. Penfold

Operational amplifiers were originally designed for use as DC amplifiers in analogue computers, but they soon became widely used in the field of linear electronics. Many of the early operational amplifiers are still widely used today. The standard 741C has probably been made in larger numbers than any other semiconductor device.



Many of these early operational amplifiers had quite respectable levels of performance, but as technology improved new devices were steadily introduced. These devices offer a considerable improvement over the humble 741 such as lower audio noise, greater precision in DC applications and wider bandwidth.

This book deals with the properties and applications of modern operational amplifiers. Chapter one covers the standard operational amplifier building blocks, with the emphasis on the improvements that can be made by using modern devices. Chapter two deals with practical applications using the devices, such as very low noise, precision DC, high output current and wide bandwidth types. Many practical circuits are included such as low noise tape and RIAA preamplifiers, audio power amplifiers, DC power controllers, the audio millivolt meter, temperature monitor and many more.

A useful and invaluable book for all those involved in electronics.

1994. 126 pages, 177 x 112mm, illustrated.

Order As AA78K
(OpAmp Users H/Book) *£4.95 NV*

The Quiet Revolution

The personal computer world is in a state of 'limbo' as Intel and Microsoft's domination of the market is about to be challenged!

by Keith Brindley

THINGS move pretty quickly where personal computers are concerned; from the dawn of the personal computer era, just ten years ago, several generations of integrated circuits have come and gone. A lot of computer manufacturers have made fortunes and bitten the dust, and just a handful of manufacturers now seem to survive. But that is by no means an end to the story. This year there is the start of what will come to be seen as the biggest shake-up ever known in the industry, with conventions overthrown and market percentages renegotiated to an extent never seen before. Yet users could be forgiven for not even realising what is going on. Most of the changes have occurred so far in the background, with little noise and a great deal of stealth.

The cause of this quiet revolution is a new microprocessor architecture known as PowerPC. While it is not a name particularly prominent at present to anyone not in the know, it soon will be. Already PowerPC computers are available, and by the end of this year there will be a multitude of such personal computers around, capable of running *all* popular applications from any of the major platforms. It is this multi-platform ability which will help PowerPC manufacturers take a bigger slice of the marketing pie than they have been able to in the past. It is this multi-platform ability which will challenge finally the domination enjoyed for so long by Intel/Microsoft-based computers, and it is this multi-platform ability which will make the quiet revolution so transparent and seamless that many users will not even know it has taken place. In fact, the only difference noticed by casual users will be the availability of faster, cheaper and easier-to-use computers.

The Last Ten Years

To get an idea of what the future is for personal computers we have got to look at the history of the main personal computer type – the IBM personal computer (and all its clones). IBM's entry to the personal computer market began just over a decade ago with a machine based on an Intel-designed and manufactured chip (the 8086 series), coupled with an operating system (PC-DOS – for *personal computer disk operating system*) which was written and licensed by Microsoft. The scene was set then for this almost (but not quite – see later) unique combination of hardware, software, and manufacturing and marketing ability to virtually overrun the personal computer market. Indeed, it was not until this IBM machine came along that the term *personal computer* had any real meaning.

Other manufacturers began to use Intel's chips and Microsoft's operating system for their own personal computers and – simply because they were able to call themselves *IBM-compatible* – the basic machine (thereafter known as a *PC*) became the *de facto* standard. Most people looking for a computer wanted (and to a large extent, still want) – rightly or wrongly – one which was compatible. Because of this, the IBM-compatible computer became the norm.

Throughout the 1980s and into the 1990s several new generations of both hardware and software were developed. The 8086 became the 80186, the 80286, the 80386, the 80486 and finally (to date) the 80586 which goes more usually under the name *Pentium*. PC-DOS (or its non-IBM computer equivalent MS-DOS – more commonly known as just DOS) has currently developed up to version 6·2. A few years ago a new type of operating system became available for use on IBM-compatible personal computers; it allows information within the computer and its operating system to be viewed in boxes (called windows) on-screen. The program, as readers will no doubt be aware, is even called Windows, and its latest incarnation (version 3·11) has become very popular, with millions of copies of the program in use world-wide on personal computers.

Yet IBM-compatibility does not totally

The Power Macintosh 8100/80 – the most powerful PC in the world?

rule the world; its combination of hardware, software and manufacturing ability is not unique. It just happened to create the biggest personal computer type simply because of the weight of the IBM name. Other personal computer manufacturers with totally different architectures have continued to thrive, and some 15% of the market-place is filled by them. Many of these have been specific to a particular locality, however. In the UK the obvious example is the Acorn BBC range of computers, which possibly no school in the land was without during the latter part of the 1980s. Outside the UK, though, Acorn was a non-contender. A pity for a manufacturer whose personal computers taught most of the UK population most of what it knows about them.

Ten years ago, almost to the very date, Apple Computers launched its new personal computer – the Macintosh. From the start, the Mac was a windows-based machine; with an integrated operating system which used windows as a way of life, not as an add-on. This contrasts strongly with IBM-compatible personal computers, which now run Windows almost as a separate entity. It is true to say that Windows has only really been of any use to personal computers over the last four years (since version 3 became available), while the Mac's operating system has been useful since its inception in 1984.

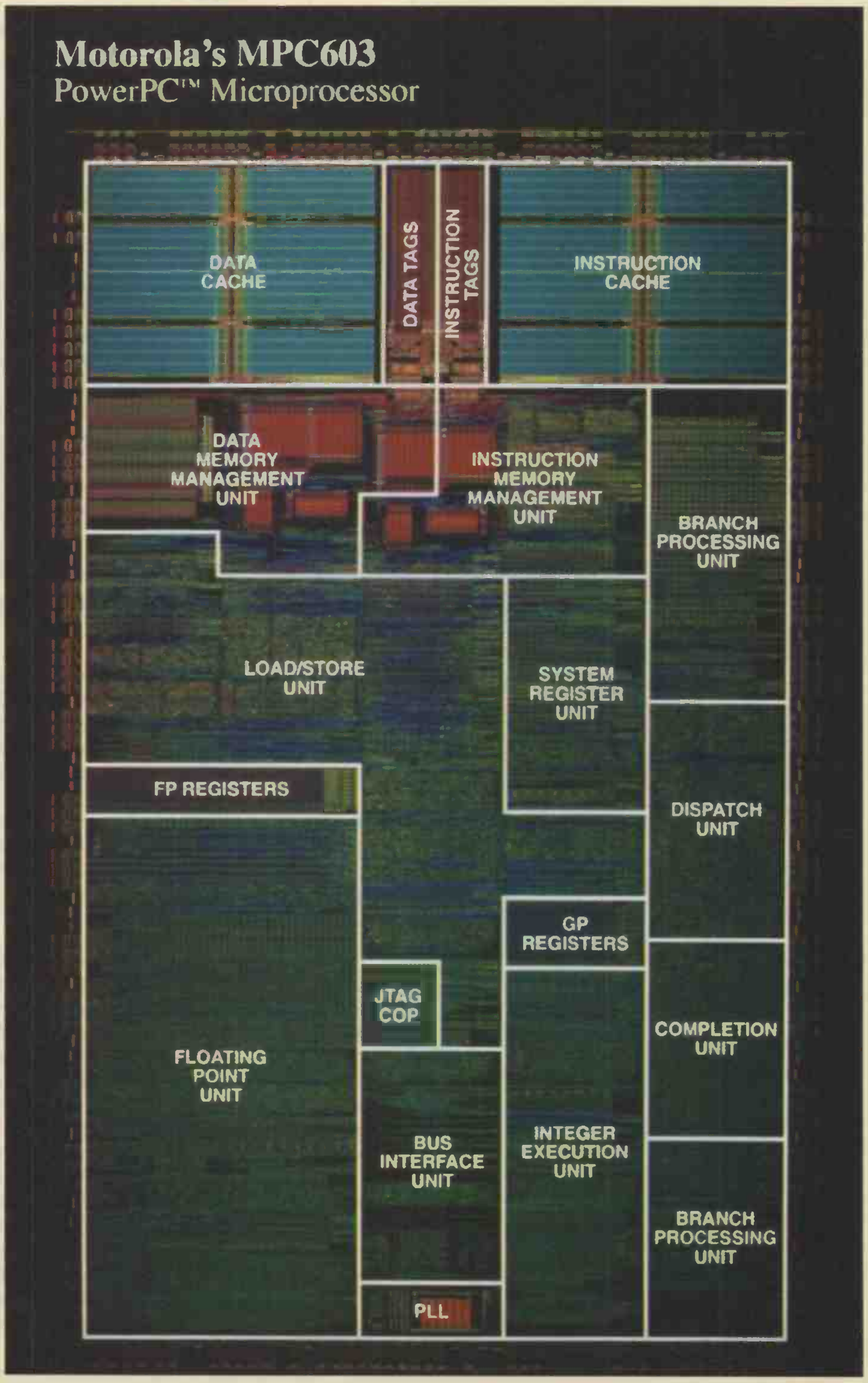
The Mac is extremely popular worldwide (the Mac LC is the world's best selling computer – ever), and without doubt has always been one of the easiest computers to use. It is the preferred – if not the accepted standard – choice for graphics and publishing environments; mind you, it too has undergone upgrades in hardware and software. It uses the Motorola microprocessor family (the 68000-series), which has gone through several generations: the 68000; the 68020. 68030 and 68040. The Mac's operating system is known simply as System 7 – the number reflecting the current upgrade. The big difference between the Mac (simply because it is a wholly integrated personal computer) and IBM-compatibles is that any Mac (from the year dot) is capable of running any Mac software (albeit, maybe, more slowly than faster and newer Macs can). The original Mac of ten years ago can run just about any modern Mac application. Try asking an 8086-based IBM-compatible to run a modern Windows-based application!

For the last ten years Apple (while little known in the UK, because it has long been almost shunned by the business environment) has been one of the world's largest computer manufacturers. In fact, it is the second largest overall and only IBM keeps out in front. Indeed, last year (probably due to temporary problems in IBM's sales) Apple sold more personal computers in the USA than even the great IBM did. It is probably true to say that if IBM had not arranged the combination of hardware and software between itself, Intel and Microsoft a decade ago, then we would probably all be as familiar with the Mac as we are now with IBM-compatible personal computers.

Over the last decade, however, IBM and Apple have seemed always to be at loggerheads and, as if adding insult to injury, the stark facts of finance rear their ugly heads. While both IBM and Apple have experienced troubled times over these last ten years, only just managing to make any significant profit, both Intel and Microsoft take billions of pounds-worth of profit each year.

The Next Ten Years

So that leads us to where personal computers are going from here. The IBM-Intel-Microsoft domination is set to be challenged simply because IBM has decided



Above right: Motorola's MPC603 PowerPC chip – to be launched by the end of the year.
Right: Motorola's MPC603-microprocessor architecture.

that it no longer wants to remain in the three-way partnership – through no fault of its own. IBM wants (needs) a bigger slice of the profit. Further, Intel chips are CISC (complex instruction set computing) devices and Intel has no wish to change them, while IBM sees them as limited in the long-term.

Instead, IBM's future lies in RISC (reduced instruction set computing) devices; these are easier [read cheaper – Ed.] to make, lower-powered (they run cooler) and yet can give several orders of magnitude of performance improvements for comparable devices. From IBM's point of view there will be a bigger profit margin too!

CISC microprocessors contain many different instructions to handle many different tasks. Indeed, microprocessors like Pentium have so many instructions available that nearly all of a computer's tasks can be handled by separate coded instructions. RISC microprocessors, on the other hand, are streamlined and have only a small number of basic instructions – when a more complex instruction is needed the processor builds it from a combination of basic ones.

RISC-based computers have been around for a little while, in the form of workstations from companies like Sun Microsystems, Hewlett Packard, DEC, and indeed IBM itself (in the form of its RS/6000 workstations). Some smaller manufacturers have even attempted to build personal computers using RISC devices. But this is the first time that a large-scale move to RISC processing has been taken by any large personal computer manufacturer. Given the extra power, speed and manufacturing advantages, it is probably no surprise (to everyone except Intel, that is) that IBM is set to do this.

What *is* surprising, on the other hand, is that IBM seems to have swapped bed partners to conceive its little baby. In a number of stages IBM has distanced itself from both Intel and Microsoft. The first stage began in July, 1991 when IBM and Apple (of all companies) met to define exactly what the future personal computer would look like. This was an extremely unlikely combination. Rumour has it that at the very first meeting, Apple engineers (the Mac has an extremely *cool* image, and just about all Apple employees are reputed to wear jeans and T-shirts) wore suits and ties, while IBM's staff, in deference, turned up casually dressed.

Rock-and-Roll

Rumour, and humour, aside, what IBM and Apple decided at those meetings between July and October 1991 forms the bulk of the quiet revolution in personal computers. They agreed to co-develop the computing platform which they named PowerPC – an RISC-based computing architecture which is fast enough and capable enough to run any, in fact, all of today's modern applications. Not only this, the architecture is defined so well and is so capable that it can run (or, at the very least, emulate) other operating systems, too.

To develop and manufacture the integrated circuits used for IBM's and Apple's new personal computers, they contacted Motorola – long-time chip maker for Apple. Motorola worked so fast on the design that within a single year prototype PowerPC personal computers were running. Before long, benchmark tests proved that even the most basic of PowerPC microprocessor (the PowerPC 601) will run faster (over 30% so in floating-point calculations) and cooler than equivalent Pentium devices.

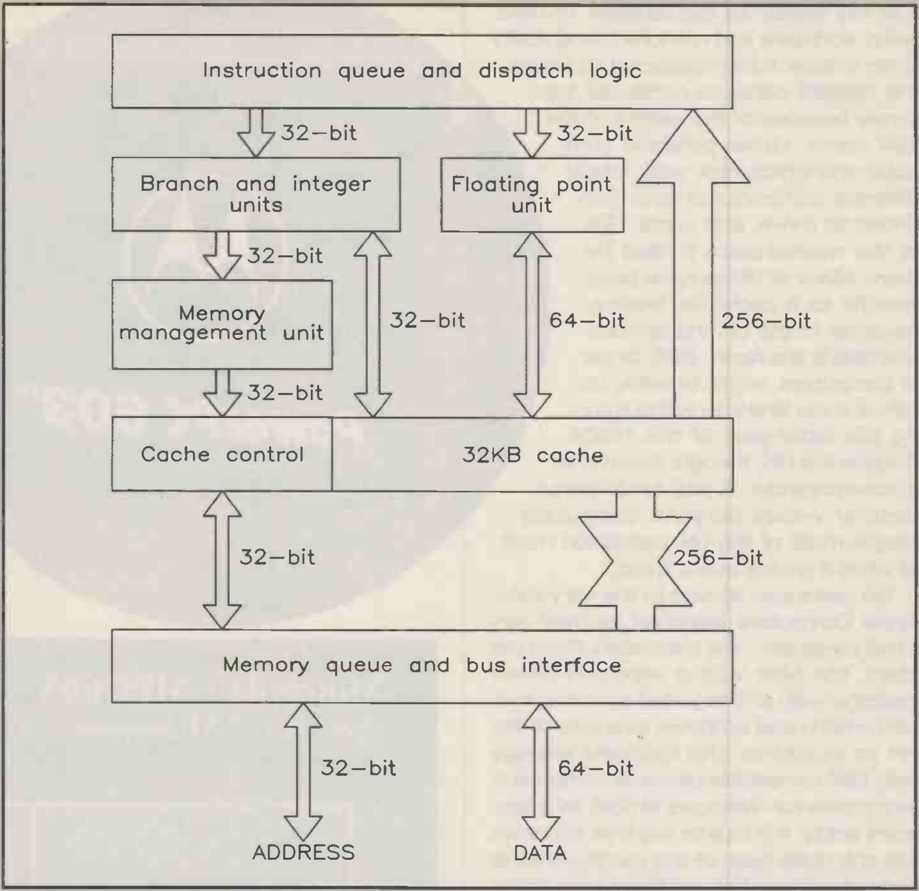


Figure 1. PowerPC architecture.

For the operating system software itself, both companies decided to develop their own, although leaving the structure available for either operating system to run on the other's machines, and for that matter other operating systems too. IBM's is a derivative of its AIX (a Unix-based operating system IBM uses for its own workstations), while Apple's is simply its own Mac's System 7.

COMPARING THE PLATFORMS

PowerPC

The PowerPC architecture (shown in Figure 1) has several advantages over Pentium, not the least being separate (rather than multiplexed) data and address buses. It also incorporates inherent support for multiple processors to use shared RAM. In other words, several PowerPCs can function together to bring true multi-processing capabilities to personal computers.

While the particular chip here (the PowerPC 601) is a 32-bit device, future devices (say, the PowerPC 603) are to be 64-bit, and as a result of forethought by the designers, even the 601 can use 64-bit code.

These two factors ensure that the PowerPC family is ready for future use and upgradability will be easy!

Pentium

The Pentium microprocessor is effectively formed by two standard 32-bit 80486 arithmetic logic units (ALUs) on one chip (shown in Figure 2). To input and output data to and from these processors there is a 64-bit interface, and separate dual-ported code and data caches. Effectively such an arrangement means the interface can write data to each cache simultaneously, the dual-ported caches can be read similarly – and this can all occur at the same time. To speed up mathematical calculations a pipelined 64-bit floating point unit (FPU) is coupled directly to a register set adjacent to the ALUs. It is an elegant architecture which can be expanded upon for a couple more generations at least.

One of the immediate problems for Pentium-based personal computers is the fact that code optimised for 386-based microprocessors is not properly optimised for Pentium. Also (yes, you've guessed it!) code optimised for Pentium is not optimised for 386 microprocessors. In effect, different versions of operating systems are needed to get the best out of each processor type. While this is no problem if all personal computers are Pentium-based, for a while (if not forever) 386-based and 486-based versions of personal computers will be more popular than their Pentium counterparts.

Effectively, in a single swoop therefore, both Intel and Microsoft have been discarded by the world's two greatest manufacturers – makers and sellers of well over 20% of the world's personal computers. This was no big deal for Apple, having never used Intel chips or Microsoft operating systems anyway. However, for IBM it marked the beginning of what could be the end of the personal computer as we know it.

Other events have moved IBM further away from Intel and Microsoft. Since forming the PowerPC architecture with Apple, IBM contented itself with still developing Intel-based products, presumably in case PowerPC development fell through. In February though, IBM got down from its fence and finally cut short its Pentium development, selling its development rights back to Intel. While still holding the rights to manufacture 486-based personal computers for the time being, this has got to be just a short state of affairs. Once PowerPC personal computers come on tap in numbers there will probably be little need to continue making 486-based computers at all. They will not provide much cost advantage, and they will be considerably less powerful and slower than the new alternatives.

There are also rumours abounding that IBM is developing a version of PowerPC which will run native 486 code, thus making available the whole raft of existing IBM-compatible applications on the PowerPC platform (see later, however, for Apple's solution).

So are Intel and Microsoft in serious trouble? Well, remember (initially at least) that if IBM and Apple make about 20% of the world's personal computers, there are about 80% left. Many of the manufacturers of these personal computers are as yet committed to the Intel/Microsoft route. There is no doubt that 486 and Pentium derivatives, together with DOS and Windows, will abound for years to come. There are simply too many existing computers which use the architecture and software for them to be cut off just like that.

FEATURE	POWERPC 601	PENTIUM (P5)
Architecture	64-bit RISC	32-bit CISC
Age of architecture	3 years	15 to 20 years[1]
Primary operating system	32-bit[2]	16-bit[3]
Transistor count	2·8 million	3·1 million
Core logic transistor count	~1·2 million[4]	~2·3 million[4]
On-chip cache size	32K	16K
Die size	118·8mm^2	262·4mm^2
Heat dissipation at 66MHz	9W	16W
Performance – integer at 66MHz	>60 SPECint92	64·5 SPECint92
Performance – floating point at 66MHz	>80 SPECfp92	56·9 SPECfp92
Estimated manufacturing cost	$76	$483
Maximum instructions per cycle	3	2
General-purpose registers	32 32-bit regs.	8 32-bit regs.
Floating-point registers	32 64-bit regs.	8 80-bit regs.
Follow-on processors	PowerPC 603, 604, 620	P6, P7

[1] Number of years depends on whether the 8080 or the 8086 is used as the starting point.
[2] System 7
[3] MS-DOS and Windows 3·1
[4] Total transistor count minus the number of transistors devoted to on-chip cache.

PowerPC vs Pentium – some technical details.

In truth, as we have seen, IBM will still manufacture and sell its own Intel-licensed 486-based machines, capable of running DOS and Windows, for a short while. However, other manufacturers, probably for the same reason that manufacturers joined the IBM-compatible bandwagon ten years ago, will slowly at first then more rapidly start to use the PowerPC architecture. Within two to three years it is easy to foresee a situation where no CISC-based new personal computers exist at all; Intel may have problems.

Intel is currently the world's largest manufacturer (by far) of computer integrated circuits. Recently, the Pentium microprocessor (code-named the P5) has become its flagship device. It is currently developing the next generation of Pentium (the P6) and has even announced development of the following generation (the P7). It is investing heavily in fabrication plant (a brand new factory was opened in the Republic of Ireland in February) to cope with expected demand for Pentium devices. New lower-powered and faster Pentium devices are currently in development, so it can be seen to remain fully committed to its CISC-based stance. Current users can rest assured they will not be left out in the cold.

But (and this is a big *but*) there is a doubt

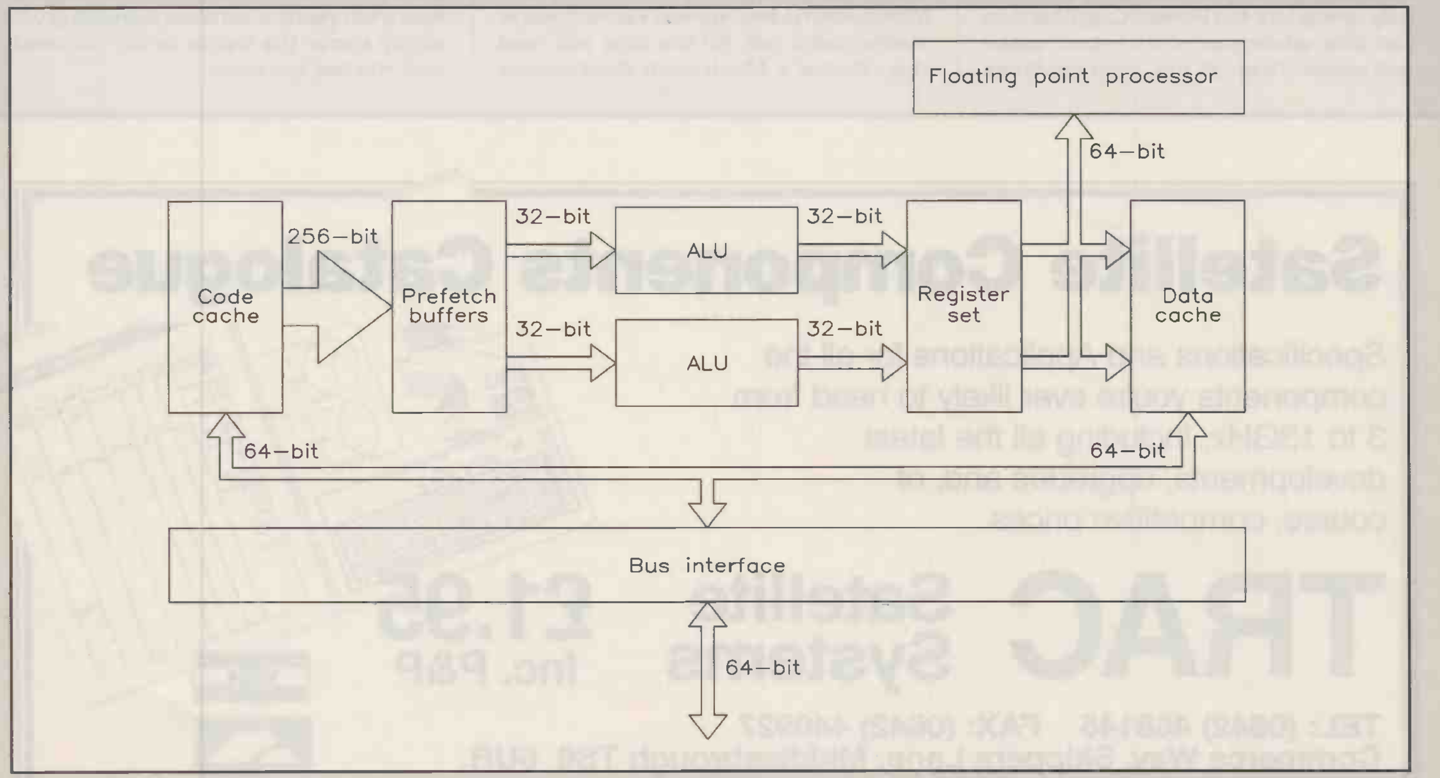


Figure 2. Pentium architecture.

that CISC-based devices are restricted in the levels of performance they can achieve for any viable price. RISC-based machines will be cheaper (Apple's new range starts at less than £1,400, for a personal computer far more capable than any existing Pentium-based machine and, of course, much cheaper). To commit itself to an architecture which is old-fashioned and expensive may be Intel's obituary.

As far as Microsoft is concerned, it has several eggs in several baskets. While DOS and Windows themselves are by far Microsoft's greatest assets, they are not the company's only products. They also develop, manufacture and sell many best-selling applications which simultaneously provide a significant income. Anyway, even if the worst scenario occurs (where all computer manufacturers turn to PowerPC over the next few years) DOS and Windows will continue to sell in bulk for existing personal computer users. There are reputed moves afoot within Microsoft to develop Windows for the PowerPC platform, too. Already, Apple ships models of the PowerPC range with a Windows emulator (written, incidentally, by a UK company, Insignia) known as SoftWindows. This is a Microsoft-licensed derivative of the Windows code, so to all intents and purposes, Macintosh PowerPC users can run Windows and DOS (together with any subsequent application for those platforms) on their PowerPC at the touch of a command-key switch. While this *is* an emulation, PowerPC itself is so fast that even the cheapest new Mac PowerPC still performs the emulation at the speed of an existing fast 386-based personal computer.

In effect, the PowerPC platform is open. Operating systems from several computing platforms (UNIX, OS/2, System 7 and, yes, even Windows and DOS) will run on it. Hence every application that users already have, and are likely to ever want, will run on it.

That is not really PowerPC's forte; it has the added benefit that applications specifically written for the PowerPC architecture can take advantage of its in-built speed and power. They will run up to ten times faster than on any non RISC-based personal computer alternative. Most of the world's leading applications manufacturers (over 150 of them, including WordPerfect, Aldus, Quark, Adobe, and even Microsoft itself) have announced such native PowerPC software to run on the new Macs that in the end there could be no need to run DOS and Windows at all.

Try Me and You'll Never Go Back

Apple has even gone to the unprecedented step of saying that it may license its operating system, System 7, to manufacturers of PowerPC personal computers who want to have access to the wide range of Macintosh PowerPC native applications. This has never happened before in the company's history; jealously guarding its integrated environment has always been a feature of Apple. This is one of the main reasons why the Mac has a look and feel totally of its own, which even Microsoft's Windows does not decently emulate (and falls a good way short of in ease-of-use). You could go so far as to say that another of the reasons why Macs have never been as popular as IBM-compatibles is that they used to be expensive; they were only built by Apple, and the operating system was not available on any other (cheaper) manufacturer's personal computer. By making System 7 available on licence to other manufacturers heralds a totally new approach which could shake the personal computing world. Apple's advanced production lines making computers as cheap as any manufacturer's, yet System 7 usable on all PowerPC platforms; surely, the best of both worlds? In truth, although Apple will license its system, there are no plans yet to license the program which gives the Mac its computer screen desktop – the Finder. So PowerPC users of other manufacturers still will not be able to have a computer which looks like a Mac – yet! However, Sun Microsystems and Hewlett Packard workstation users will. By the time you read this, Apple's Macintosh Application Environment will be available on those platforms, running the Mac environment together with its applications.

Whatever the outcome though, this all goes to show that PowerPC is truly 'open'. The Intel CISC-based route of 486 and Pentium, on the other hand, is as yet closed. Whether Intel eventually capitulates to the RISC requirement, or Pentium becomes an open architecture in the same way PowerPC was designed to be – are questions remaining as yet unanswered. There will inevitably be a slide of personal computer manufacturers away from Intel and towards PowerPC, simply because the weight of IBM and Apple together with all their open applications will start to tip the balance. It has already started – several personal computer manufacturers are already in talks to develop PowerPC products, and PowerPC devices are being used in other products too. Canon and Ford for example are two manufacturers who are using PowerPC devices in future com puters, office equipment and car man agement systems. As the slide continues the balance will tip even further, until Intel sees an avalanche away from itself which might finally change its mind as to RISC-based 'open' personal computing.

In the worst case, Intel's dominance of the personal computing integrated circuit market will cease. Maybe Intel itself will cease. Motorola will become as big a manufacturer as, if not bigger than, Intel. True 32-bit operating systems will become the norm, taking over from Microsoft's 16-bit Windows as the world's leading operating systems. At the very least, however, cheaper PowerPC computers than Pentium will force lower and lower prices throughout the industry yet again, and no longer will there be such a dominance of a single hardware/software alliance.

Over the next ten years of personal computing, only the user can be guaranteed to benefit. Faster, more and more open, and ever cheaper personal computers will become the norm. In effect, the future ten years of personal computing will simply mirror the trends which occurred over the last ten years.

Low cost data acquisition for IBM PCs & compatibles

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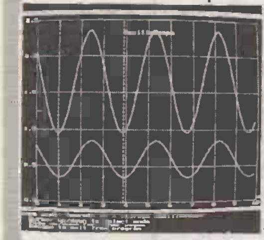
A unique range of easy to use data acquisition products designed for use with IBM compatible computers. Combined with the software they allow your PC to be used as a host of useful test and measurement instruments, or as an advanced data logger.

Installed in seconds they simply plug into the parallel port (except the ADC-16 which connects to the serial port). They are self contained, require no power supply and take up no expansion slots.

Each device comes with a comprehensive manual. C, Pascal and Basic drivers are included for users who wish to write their own software. Software supplied on 3.5″ disk.

PicoScope



'Virtual instrument' software package. Storage oscilloscope with trigger, timebase, rulers and offset functions. Realtime spectrum analysis with min/max frequency and signal averaging. Multiple meters on screen (digital and bargraph). Printer and file handling support.

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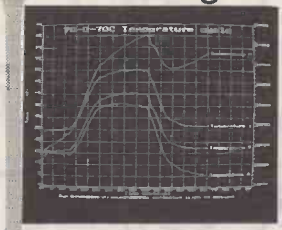

Collect, store, display and print data from 1 sample per ms to 1 per day. Record average, min/max values or scaled values (linear, equation, table look up). Report types: monitor (with min/max alarms), y-t graphs, x-y graphs, tabulation.

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NEW *ADC 100* Virtual Instrument

Dual Channel 12 bit resolution

The ADC 100 offers both a high sampling rate (100kHz) and a high resolution. It is ideal as a general-purpose test instrument either in the lab or in the field. Flexible input ranges (±200mV to ±20V) allow the unit to connect directly to low output sensors such as microphones or to high level signals (±200V with a x10 scope probe).

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NEW
from
PICO

- Digital Storage Scope
- Spectrum Analyser
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ADC 10

1 Channel 8 bit

- Lowest cost
- Up to 22kHz sampling
- 0-5V input range

The ADC 10 gives your computer a single channel of analog input. Simply plug into the parallel port and your ready to go.

ADC 10 **with PicoScope £49**

Also Available from Maplin (KR40T)

ADC 11

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- Digital output
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The ADC 11 provides 11 channels of analog input in a case slightly larger than a matchbox. It is ideal for portable data logging using a "notebook" computer.

ADC 11 **with PicoScope £85**

PicoScope and PicoLog £95

ADC 12

1 Channel 12 bit

- High resolution
- Up to 17kHz sampling
- 0-5V input range

The ADC 12 is similar to the ADC 10 but offers an improved 12 bit (1 part in 4096) resolution compared to the ADC 10's 8 bit (1 part in 256).

ADC 12 **with PicoScope £85**

PicoScope and PicoLog £95

ADC 16

8 Channel 16 bit + sign

- Highest resolution
- 220Hz sampling
- 2Hz sampling – 16bit

The ADC 16 has the highest resolution of the range, it is capable of detecting signal changes as small as 40µV. Pairs of input channels can be used differentially to reject noise. Connects to serial port.

ADC 16 **with**
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PicoLog for ADC 10/11/12 £25. Oscilloscope Probes (x1, x10) £10. Carriage UK free, Overseas £6

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Stray Signals

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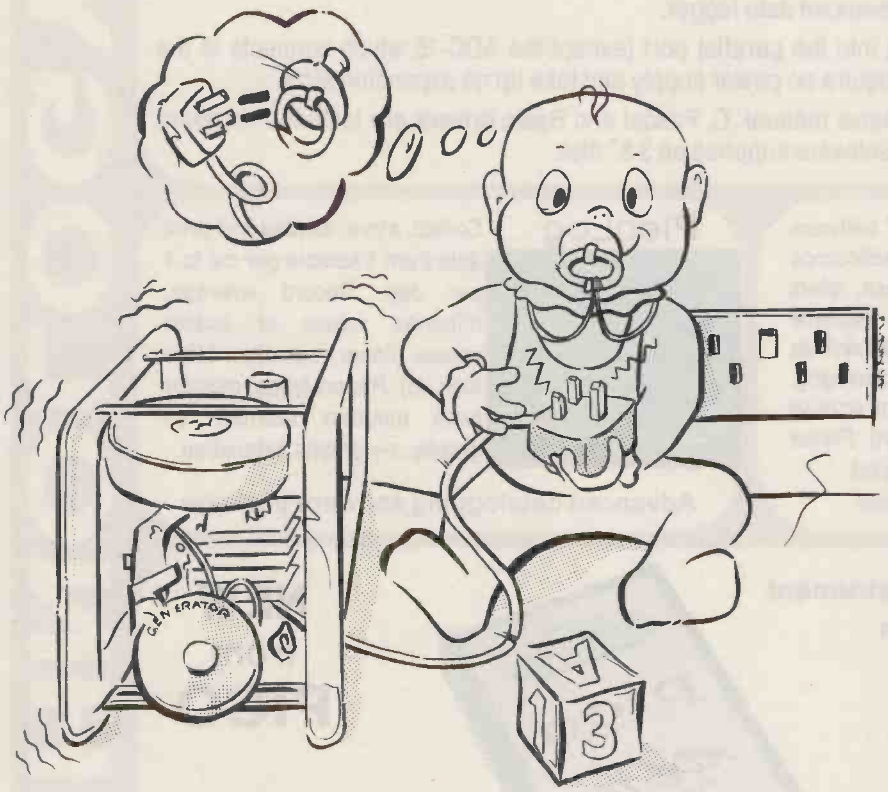


When PC worked as a student assistant in the Solid State Physics Laboratory at Central Research Laboratories (in the fifties), on several occasions I was required to go down to the 'battery room' and patch through some DC power from the huge bank of lead acid accumulators, up to the lab via the heavy duty wiring which ran all over the premises. On the first occasion I was shown how to do it; the importance of doing it *right* being duly emphasised. The bank of accumulators was accessed via a row of sockets, providing 0 to 100V in 2V steps, whilst the circuits to the various labs were terminated in a similar row of sockets. To pipe the required power to one's lab, two leads, with a plug at each end were used – all the plugs being identical. The routine was to plug both leads into the lab circuit FIRST, with their other ends lying safely on the floor, and only THEN plugging into the required tappings on the accumulator bank. This was a very necessary precaution against short-circuits as there were no fuses in the system and the prospective fault current was hundreds if not thousands of amps. Disconnecting was done strictly in the REVERSE ORDER. PC understood the importance only too well, having seen a 24V bank of rather smaller accumulators accidentally short-circuited in the Senior Physics Laboratory at school – within a few tens of seconds they were boiling and giving off steam laden with droplets of sulphuric acid. The unfortunate culprit was a new Physics Master, but he managed to clear the fault before any irreparable damage was done. What a good job the mains is liberally supplied with fuses!

As I write, winter is fast approaching although by the time you read this, it will be next year. This heralds the season when power cuts are more likely, or likely to last longer when they do occur. As an insurance against this, PC has a 1kW petrol-driven motor-generator set which is run from time to time to ensure that it will function when required for real. Five minutes running every six week period throughout the summer is the routine, and once a month in winter. 1kW is hardly enough to power the whole house, and of course activities such as electronics and word processing end during a cut. It does keep the freezer and central heating pump going, with enough in hand for a light or two. The dodgy part is starting up. First, the main switch is thrown, isolating the meter and company's fuse, then the generator output is connected to a switched ring-main socket (set to OFF) in the conservatory, where the generator lives. The generator is started and run up next, and finally the ring-main socket is set to ON. When power is restored, indicated by the next door neighbour's lights coming on, the whole sequence is repeated in strict reverse order. So what's dodgy? – it's the necessary mains lead with a plug on each end, a potentially lethal contraption, normally kept under lock and key. I can't figure out any other way to use the generator to power the house circuits, can you? At least the live and neutral cannot short directly, unlike the leads used with the accumulator plug-bank mentioned above, and if the plug accidentally came into contact with metal, the generator's cut-out would open. The thought of a live plug lying around is disturbing, hence its incarceration in the absence of a power cut. Ideally, one would have the freezer and pump on a separate circuit brought out to the conservatory, where a lead to that circuit could be plugged into the ring main or generator as required. Unfortunately with solid floors that would not be easy to implement and would still leave the problem of lighting circuits. So the existing arrangements are likely to remain, strictly operated when required by no-one but the master of the house. If there's a power cut when I'm away, Mrs PC will just have to put on extra woollies, rely on candles for light, and the insurance for the contents of the freezer.

I read somewhere recently about an electronics subcontractor who was contracted to produce some equipment (racks and backplanes or something like that) to the specification supplied, for a customer. This was very detailed on mechanical aspects such as fits, clearances, tolerance's, etc., but simply specified the resistance between all points on each cable or backplane run as 0Ω precisely. The subcontractor contacted the customer and diplomatically explained that any connection must have some finite resistance, however small, and that therefore they could not proceed with the contract until they received an appropriate amendment to the specification. After some delay and one or two prods from the subcontractor, the amendment duly arrived. The required figure for the continuity tests was now quoted as 0Ω ±5%.

Yours sincerely,

Point Contact

3
PROJECT RATING

INTELLIGENT Ni-Cd BATTERY CHARGER

Please note: the optional box shown is not included in the kit and must be purchased separately.

KIT AVAILABLE (LT55K)
PRICE £39.99

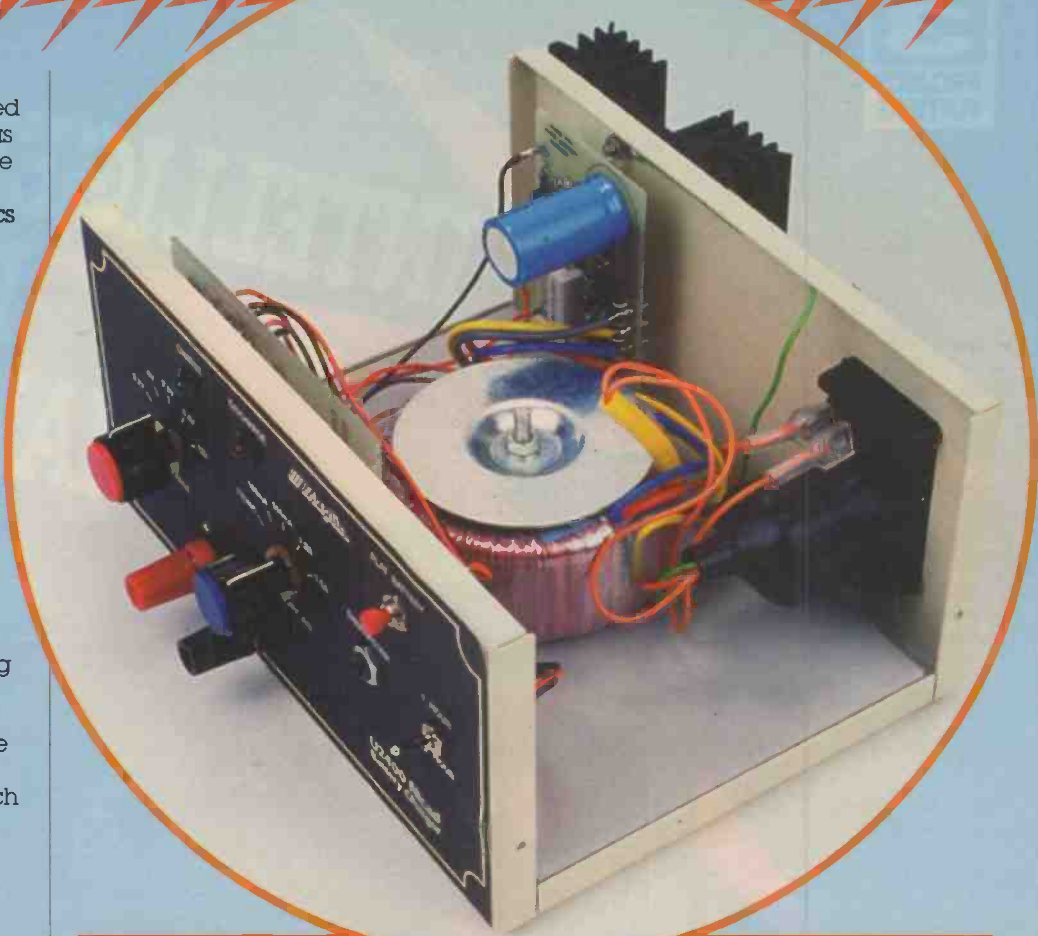
FEATURES

- ✱ 1h or 12h charge time with subsequent trickle charge
- ✱ Battery temperature and contact monitoring
- ✱ Charging interrupt for overvoltage or excessive temperature
- ✱ Automatic predischarge cycle
- ✱ Constant current charge and discharge
- ✱ Charge pulse width modulation for battery capacity matching
- ✱ LED status output for mode indication
- ✱ Timer clock via internal oscillator

APPLICATIONS

- ✱ Charging/Discharging Ni-Cd cells
- ✱ Reviving damaged or misused cells

Design by Alan Williamson
Text by Alan Williamson and Robin Hall



THIS project is an 'intelligent' Ni-Cd battery charger. It is based around the U2400B IC which has been specifically designed to handle the needs of Ni-Cd batteries. The IC itself contains much of the electronics required, which include (amongst other things) a processor unit, battery voltage and temperature monitoring comparators, PWM comparator, open collector charge and discharge outputs, LED status output, an oscillator, voltage reference and mains synchronisation. However, not all the features obtainable from the IC are used in this application.

The use of this charger can improve the performance of a cell or cells with 'reduced capacity' by providing constant current discharge to a flat condition first before the constant current charging cycle commences. Once the charge cycle is completed (giving a 95% charge), the battery is then (by pulse width modulation (PWM)) 'trickle charged' for 100ms every 16·8s, which equates to a 'form factor' of 0·6%.

To enable different voltage and lower capacity batteries than 1·5Ah to match the charger, two rotary switches are provided. The voltage select switch, divides the potential terminal voltage to provide the correct level for the voltage comparators; and the battery capacity selector switch which alters the PWM of the charge circuit, thus preventing over charging.

SPECIFICATION

Power Supply:	240V AC 50Hz
Power Consumption:	33W maximum
Input Connector:	IEC plug
Output Connectors:	4mm terminal posts
Overall Dimensions:	205 x 106 x 197mm (WHD)
Battery Voltages:	1·2V, 6V, 7·2V, 8·4V, 12V
Battery Capacity:	110mAh, 180mAh, 500mAh, 1·2Ah, 1·5Ah
Charge Time:	1hr or 12hr
Overtemperature Threshold:	45°C
Charge Current:	1·5A, pulse width modulated
Discharge Current:	500mA
Minimum/Maximum Cell Voltage:	0·8V/2V

A fully functional single cell will have a terminal charge voltage of 1·4 to 1·6V. However, a reduced capacity (or damaged) battery will rise above the nominal terminal voltage. The voltage monitoring comparator will then be active and increment the event counter. It will then interrupt the clock and turn off the charge output until the terminal voltage falls below the predetermined maximum voltage (an overheating battery will have the same effect). Once the voltage and /or temperature have dropped, the charger will then begin to charge the battery again. If another violation occurs (whether it be over voltage or over temperature) the LED status indicators will flash alternately, see Table 1. Should this situation occur, the cell or battery should then be 'cycled', i.e. charged and discharged several times.

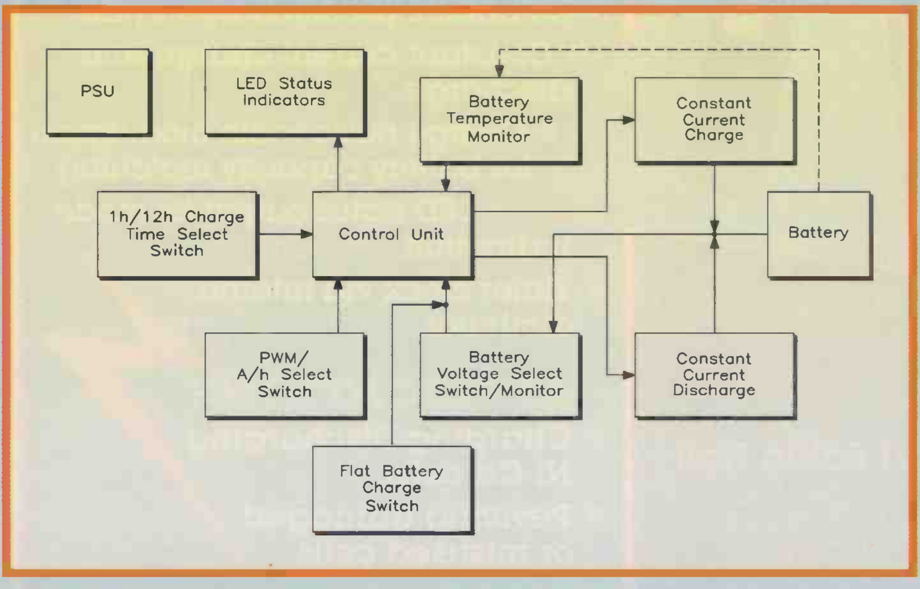


Figure 1. Overall block diagram.

Circuit Description

To assist the reader in understanding the circuit description, first refer to the block diagram in Figure 1 – this shows the overall concept of the project. Figure 2 shows the flow chart with the sequences and operation of the U2400, the heart of this project, and Figure 3 shows in more detail the internal operation of the IC.

Charge and Discharge Circuit

Refer to Figure 4, the circuit diagram of the U2400 Ni-Cd Battery charger. TR1 and TR2 combined with R1 and R2 form the 'constant current' charge circuit. TR5, TR6 and R11 and R12 form the 'constant current' discharge circuit, in each case R1 and R12 set the current rate. The charge rate is set at approximately 1·35A, and the discharge rate at 500mA.

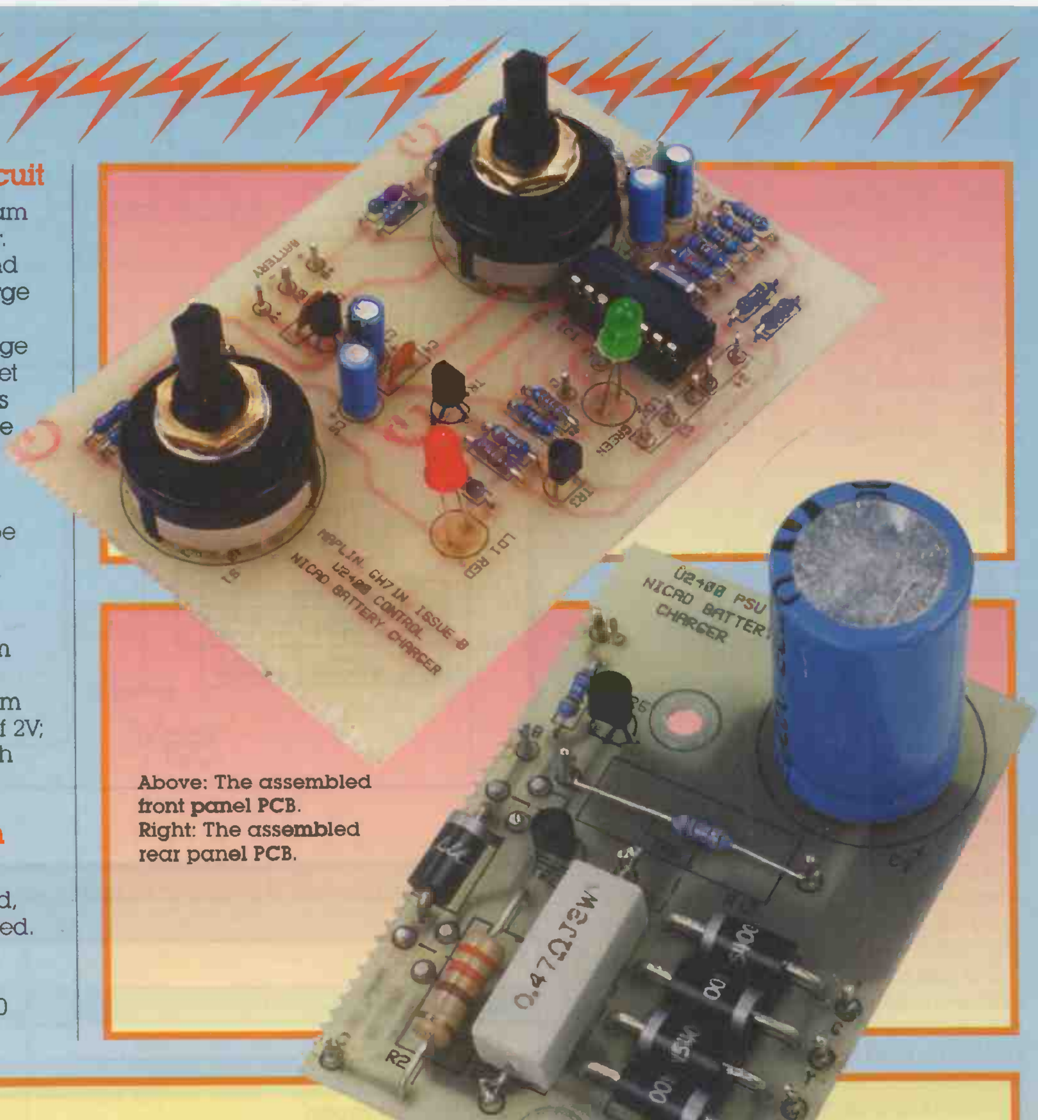
Diode D5 prevents discharge of the cell or battery via the constant current circuit, should the circuit be powered down.

Battery Voltage Selection

R14 to R19 determine the minimum and maximum voltage per cell. The values chosen set the minimum voltage to 0·8V and a maximum of 2V; the recommended current through the divider chain is ≥ 20μA.

Calculating Cell Minimum and Maximum Voltages

If alternative voltages are required, all the values will have to be altered. However, the total resistance must remain the same (assuming the voltage selector resistor chain (R20 to R25) remains unchanged).



Above: The assembled front panel PCB.
Right: The assembled rear panel PCB.

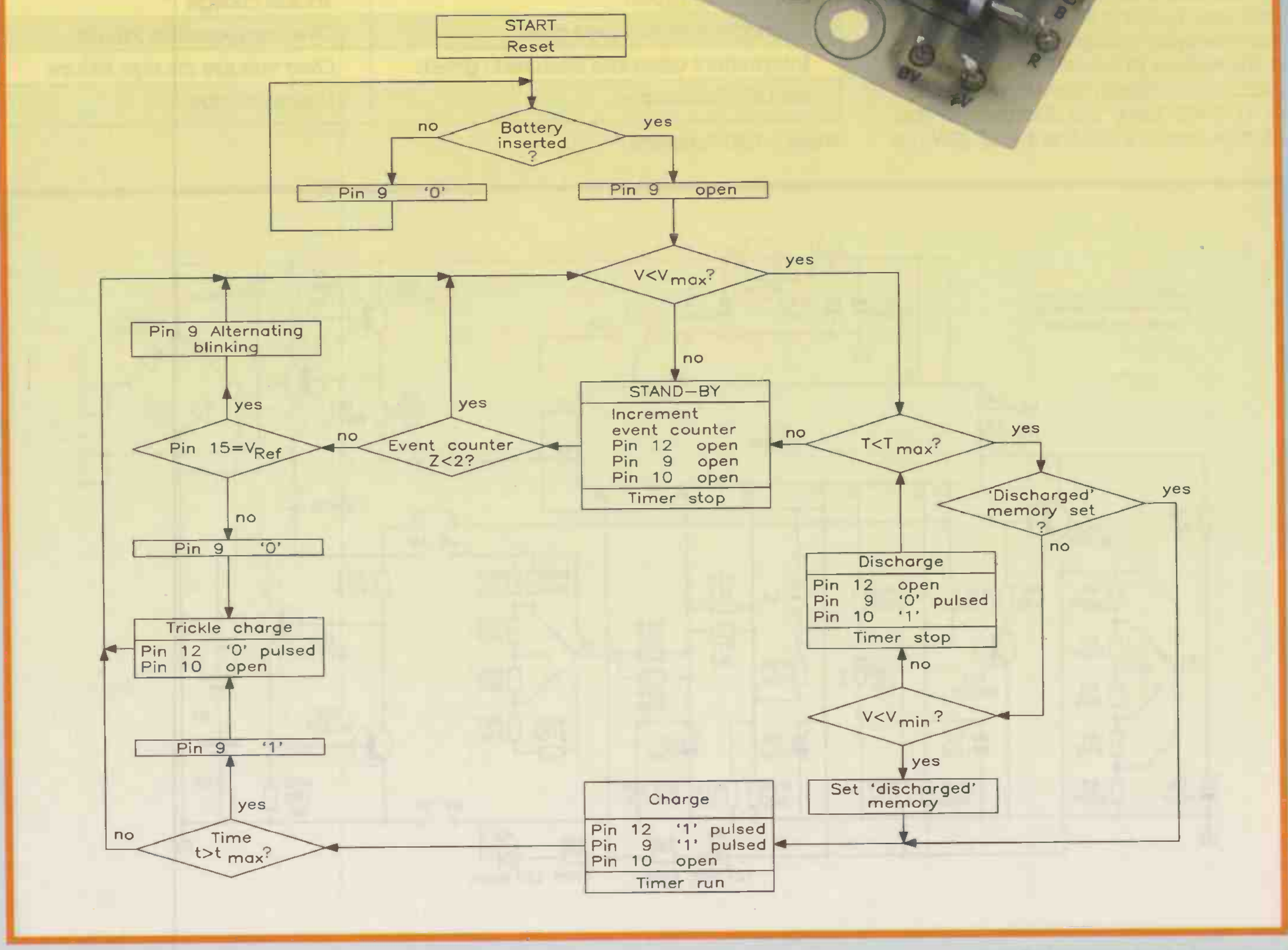


Figure 2. Flowchart.

To calculate new maximum and minimum voltages; a little bit of simple mathematics is required:

$R_p = (R1 \times R2) \div (R1 + R2)$

$R_t = R_a + R_b + R_c$
$R_a = (R14 \times R15) \div (R14 + R15)$
(or use the reciprocal method)
$R_b = (R16 \times R17) \div (R16 + R17)$
$R_c = (R18 \times R19) \div (R18 + R19)$
$R_x = R_b + R_c$

$R_a = (0{\cdot}53 \times R_t) \div V_{max}$
$R_c = R_t - (0{\cdot}53 \times R_t \div V_{min})$
$R_b = R_t - R_x$

If different battery voltages are required, use the formula below:

$R_t \times (\text{No. of cells} - 1) = R20$
upwards (to R_x)

Battery Contact Monitoring

The U2400B IC also includes a 'battery contact monitor' comparator to detect the presence of a cell or battery; the comparator requires a minimum input of 180mV, or a voltage of 500mV per cell.

If a cell or battery is discharged below the minimum contact voltage, the charger will not recognise its presence and therefore will not be charged. Switch SW3 has been included to overcome the 'flat battery' problem. Pushing SW3 will connect the reference voltage (pin 7) through a 10k resistor to the cell or battery maximum voltage comparator (pin 4). This will 'force' the charger into the charge mode while the switch (SW4) is

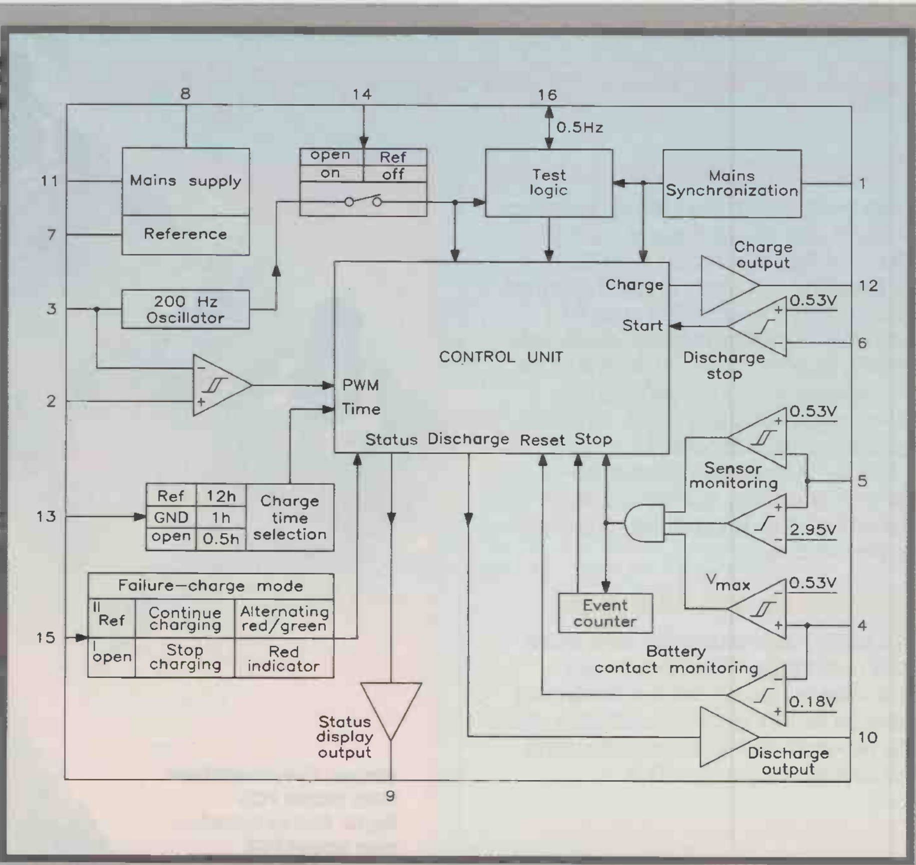
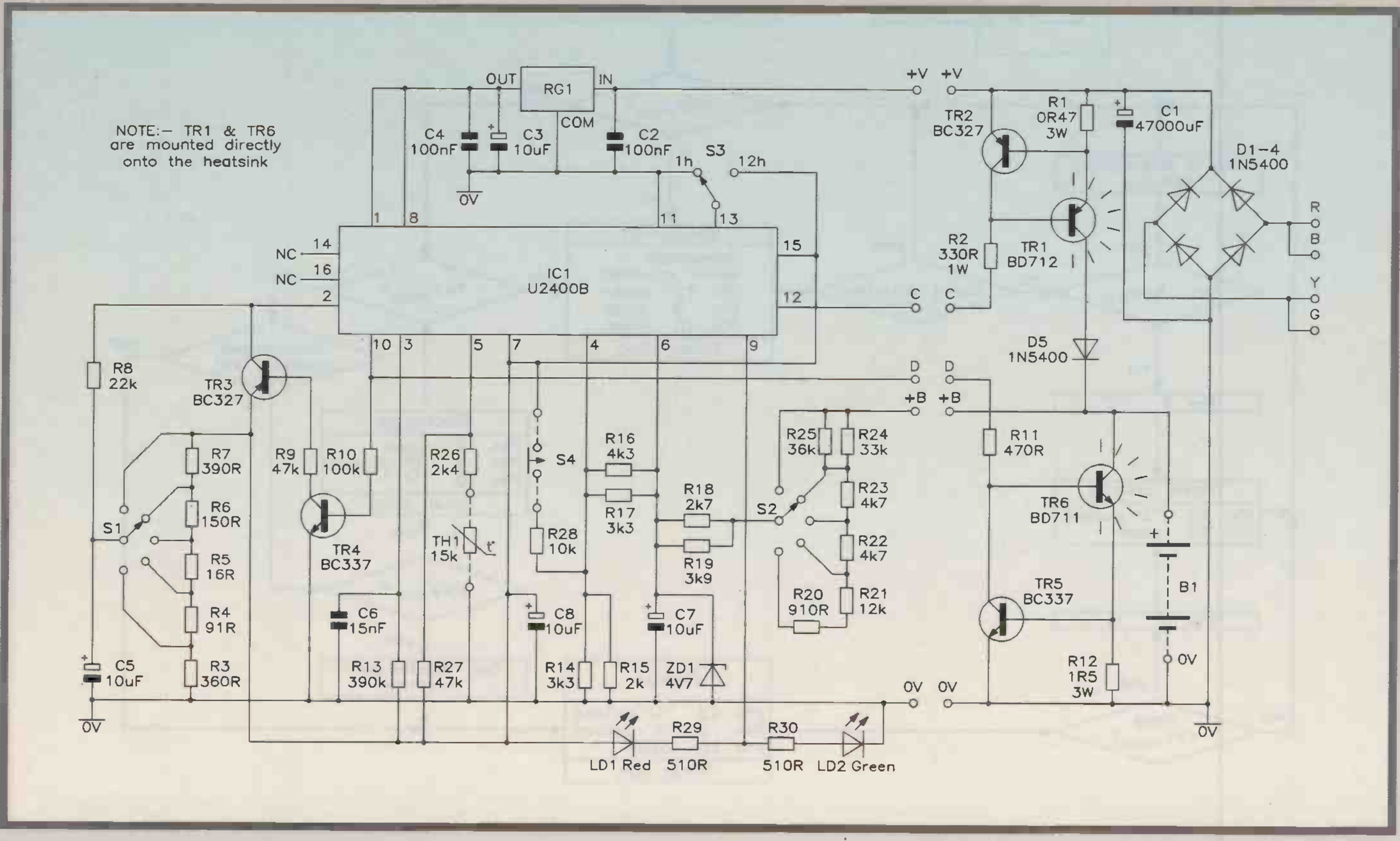


Figure 3. Block diagram of U2400B IC including pin-out.

LED STATUS	FUNCTION
Continuous red	Standby
Flashing red	Discharge cycle
Flashing green	Charge cycle
Continuous green	Trickle charge
Alternate flashing red / green	Over temperature failure
Intermittent alternate flash red / green	Over voltage charge failure
No LED illuminated	Under voltage

Table 1. LED Functions.



Rear panel of the assembled unit.

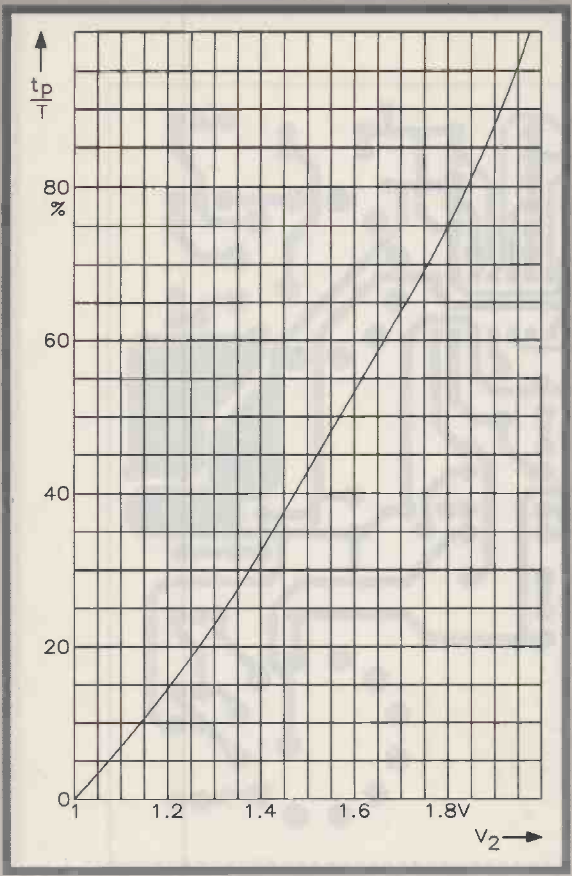
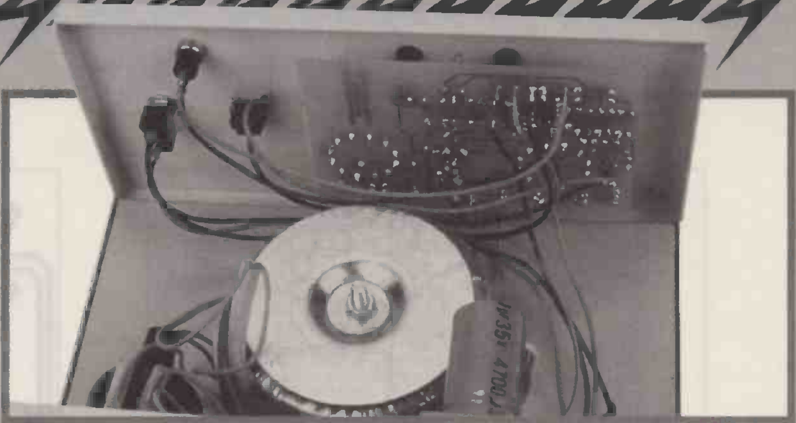
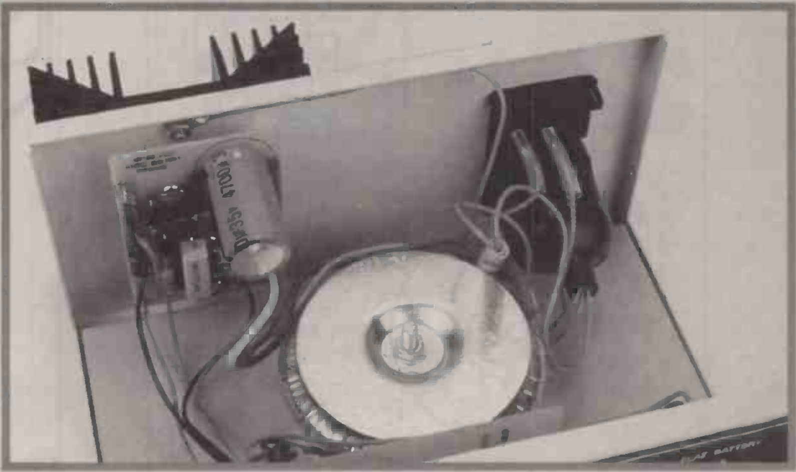


Figure 5. Pulse width versus input voltage graph.



Close-up of wiring – front panel.



Close-up of wiring – rear panel.

depressed, or until the cell or battery has sufficient charge to activate the 'battery contact monitoring' comparator.

A time lapse of 2s should be allowed between disconnection and reconnection to 'inform' the charger that a new cell or battery has been connected.

Pulse Width Modulation (PWM)

The resistor chain R3 to R8 determines the PWM characteristics of the charge circuit. An input voltage in the range of 0·9V to 2·1V will have a PWM ratio of 0 to 100%, refer to Figure 5; the divider current should be in the range of 20 to 200μA.

During the discharge cycle TR3 and TR4 connect the reference voltage to the PWM comparator input therefore different capacity cells or batteries are discharged at the same low rate to ensure that a complete discharge is achieved.

Charge Time

The switch SW3 selects between a 1 hour fast charge or a 12 hour slow charge. Selecting the 12 hour position will automatically PWM the charge circuit at a ratio of 1:11 (1 on, 11 off) which effectively will give the same amount of charge to a cell as a 1 hour charge cycle. The 100ms charge pulse width will also be PWMed if the cell or battery capacity switch (SW2) is set lower than the maximum.

Temperature Monitoring

Another useful feature of the IC is that it has a 'battery temperature monitor' circuit which consists of R26, R27 and TH1. Should the cell or battery temperature rise above a preset point (with the chosen components greater than 45°C) the temperature comparator will be activated, a second violation will turn off the charge and discharge outputs. The status indicator LEDs will then flash alternately. The battery temperature must then drop to approximately 30°C before the charger continues the cycle (the comparator has 15mV of hysteresis).

If you are wondering what the second comparator on the block diagram is for; its function is to determine whether the thermistor is connected or not; as the charger will not function without it!

Unused Features of the IC

A 0·5Hz frequency is available at pin 16; this can be useful for checking that the oscillator and divider circuits within the IC are functioning.

Rear panel of the assembled unit.

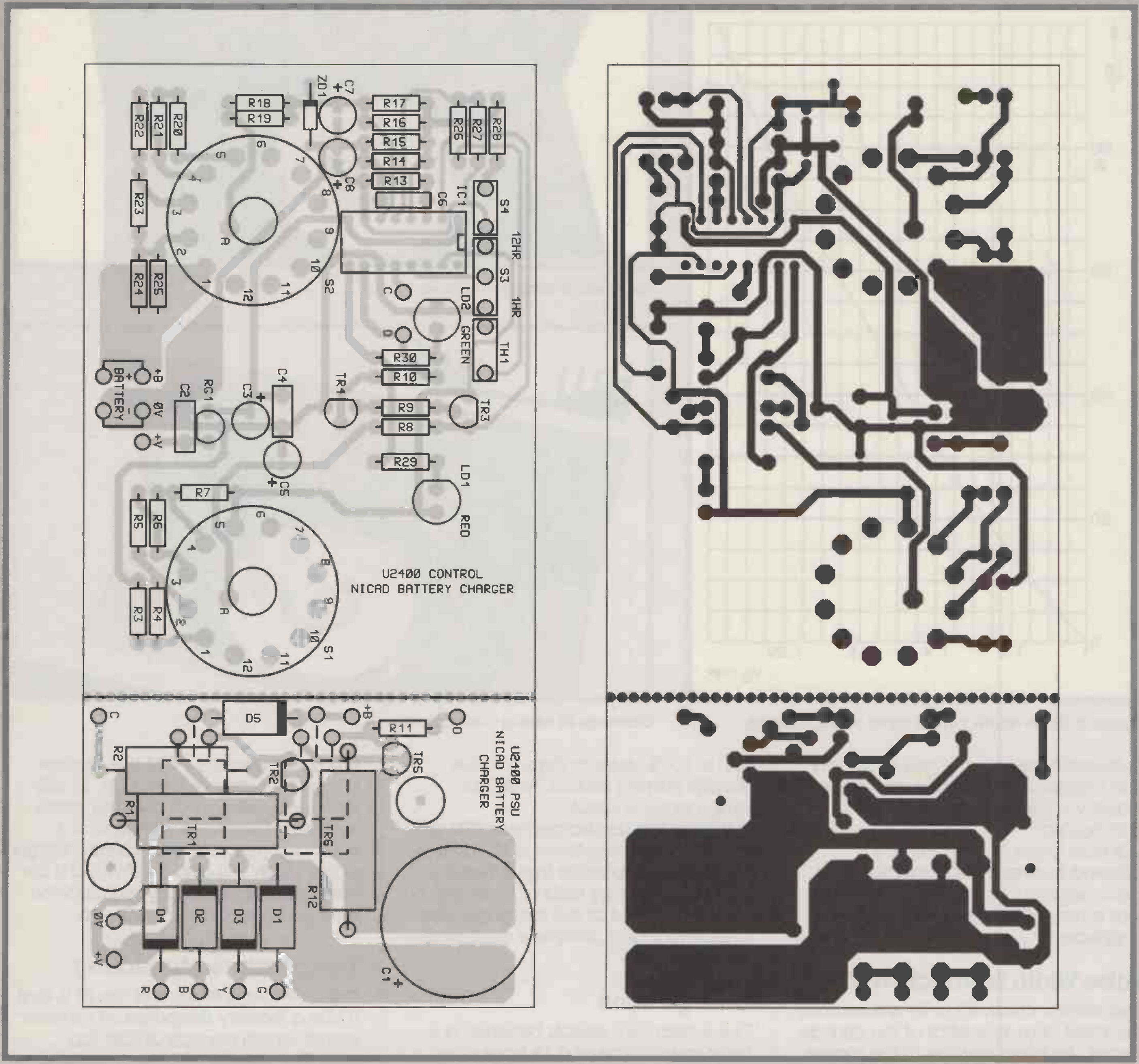


Figure 6. PCB legend and track.

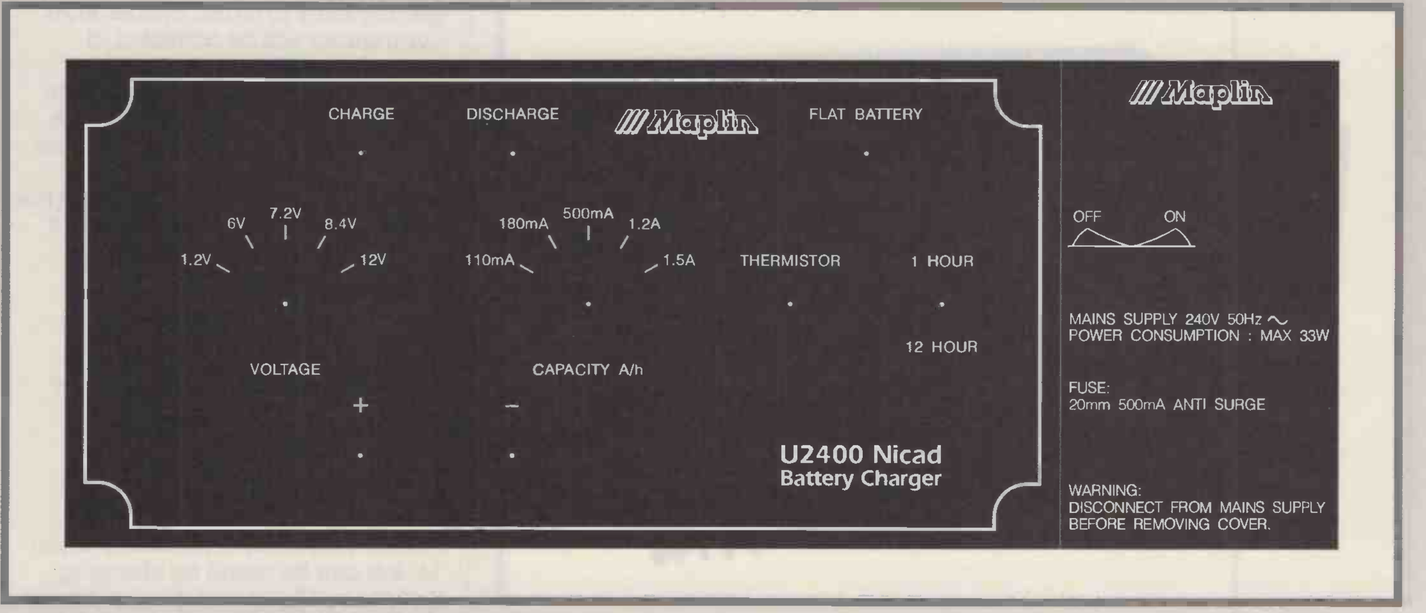
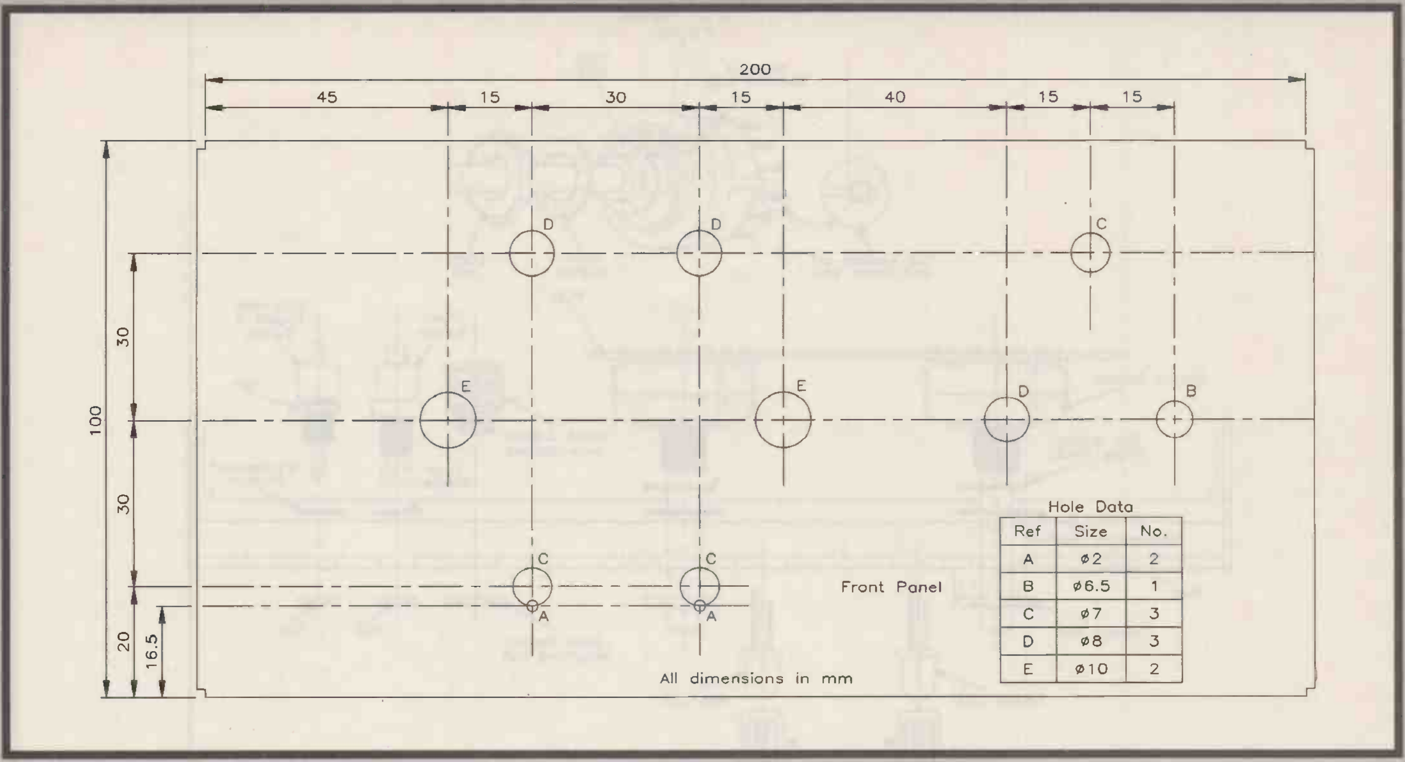


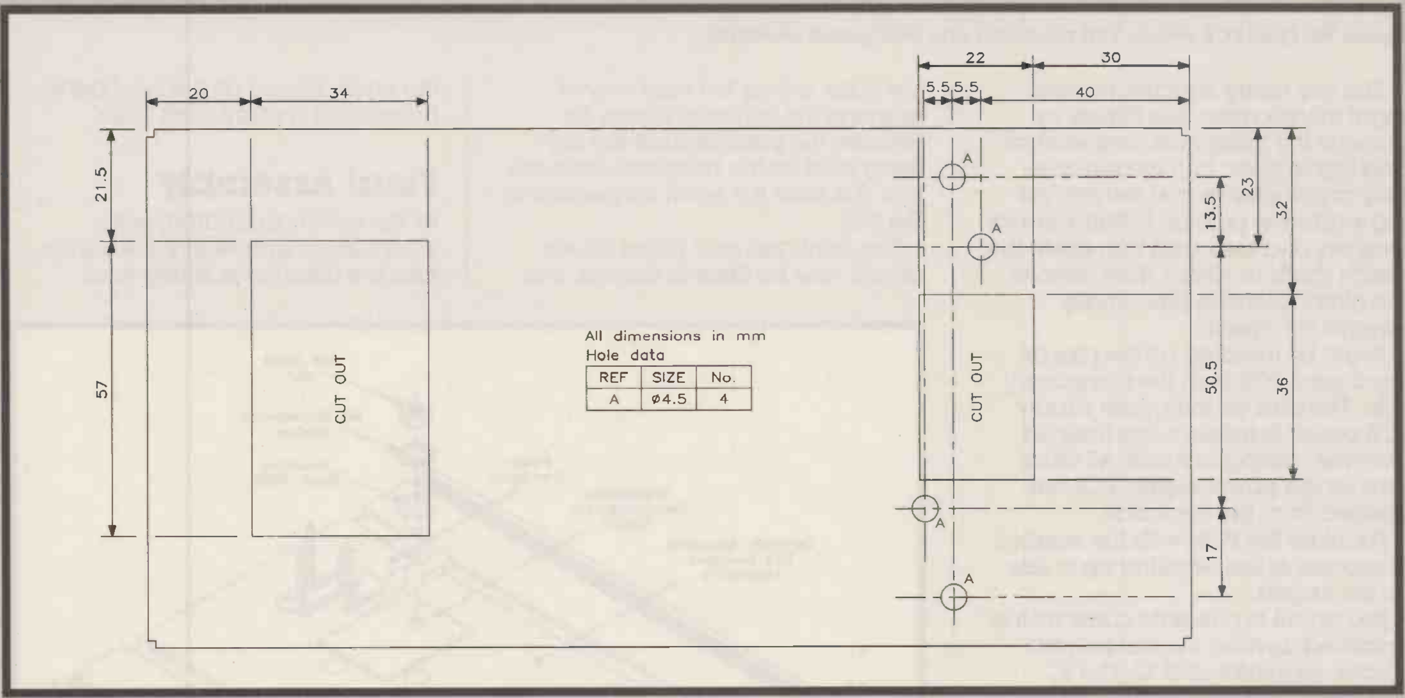
Figure 7. Front and rear panel labels, shown ⅔ scale.



Hole Data

Ref	Size	No.
A	ø2	2
B	ø6.5	1
C	ø7	3
D	ø8	3
E	ø10	2

Figure 8a. Front panel drilling.



Hole data

REF	SIZE	No.
A	ø4.5	4

Figure 8b. Rear panel drilling.

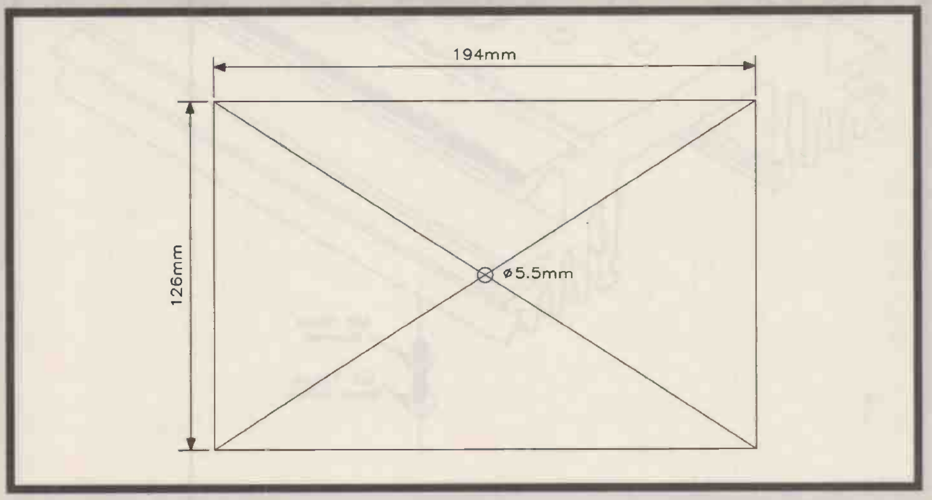


Figure 8c. Base drilling.

Connecting pin 14 of the IC to the reference voltage (pin 7) will disconnect the internal 200Hz oscillator from the internal control unit, allowing an external oscillator to be connected to pin 16 for alternative charge/discharge cycle timing periods.

Pin 1 of the IC is the 'mains synchronisation' input (*not* direct mains), allowing the mains frequency to be used as the clock as well as turning on the charge output at the appropriate time.

Construction

Construction is fairly straightforward; fit all components except the LEDs and power transistors. For the PCB legend and track, see Figure 6.

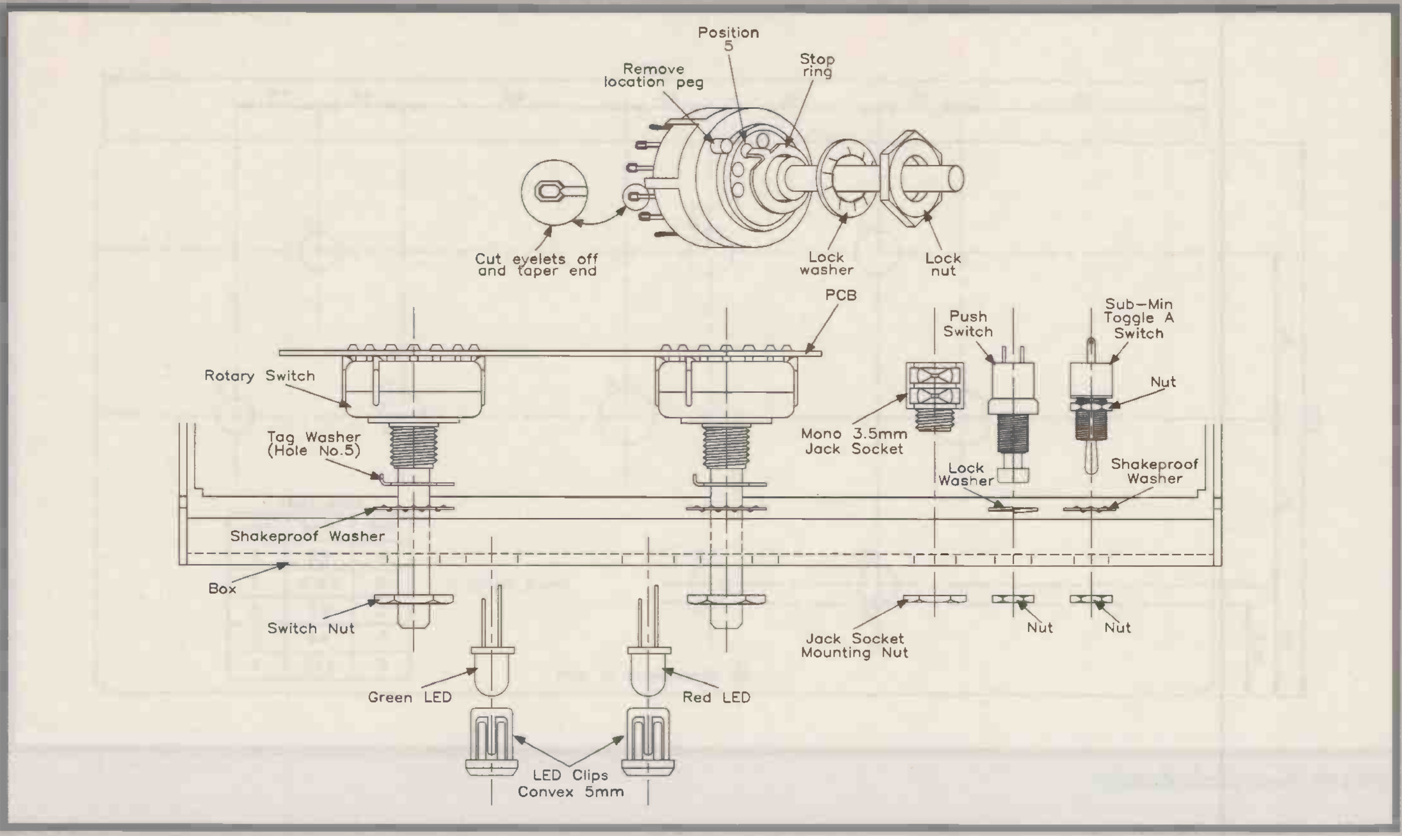


Figure 9a. Front PCB switch, LED mounting and front panel assembly.

The two rotary switches require slight modification, see Figure 9a. Remove the fixing nuts, lock washer and tag washer; turn the switches fully anticlockwise and reinsert the tag washer in position 5. Refit the lock washers and nuts, and trim down the switch shafts to 10mm; then remove the plastic location pins; finally remove the eyelets.

Begin by inserting all the pins on the control PCB from the component side. The pins for the power supply PCB power transistors, are inserted from the component side. All other pins for the power supply PCB are inserted from the track side.

Populate the PCBs with the smallest components first, working up in size to the largest.

Be careful to orientate correctly the polarised devices, i.e. electrolytics, diodes, regulator and IC. The IC should be inserted into the socket last of all.

Thoroughly check your work for misplaced components, any solder whiskers, bridges and dry joints. Finally, clean all the flux off the PCB using a suitable solvent.

Box Preparation

The front and rear panel labels for the optional box are shown in Figure 7 – pre-printed labels are included in the kit.

Refer to Figure 8a for the front panel drilling. Mark out, then drill, cut and file all the holes as required. Do the same for the rear panel as shown in Figure 8b, note the two large cut outs. Included in the optional box is a chassis, this is where the transformer will be situated. Mark out the hole in the base, noting the easy way of marking the centre in Figure 8c. Remove the paint around the top fixing hole for the heatsink inside the box, this is for the earth connection to the box.

The front and rear panel labels should now be fitted to the box; trim the label around all the front panel holes using a sharp craft knife.

Final Assembly

Fit the terminal (binding) posts into position; ensure that the solder tags are fitted horizontally, then

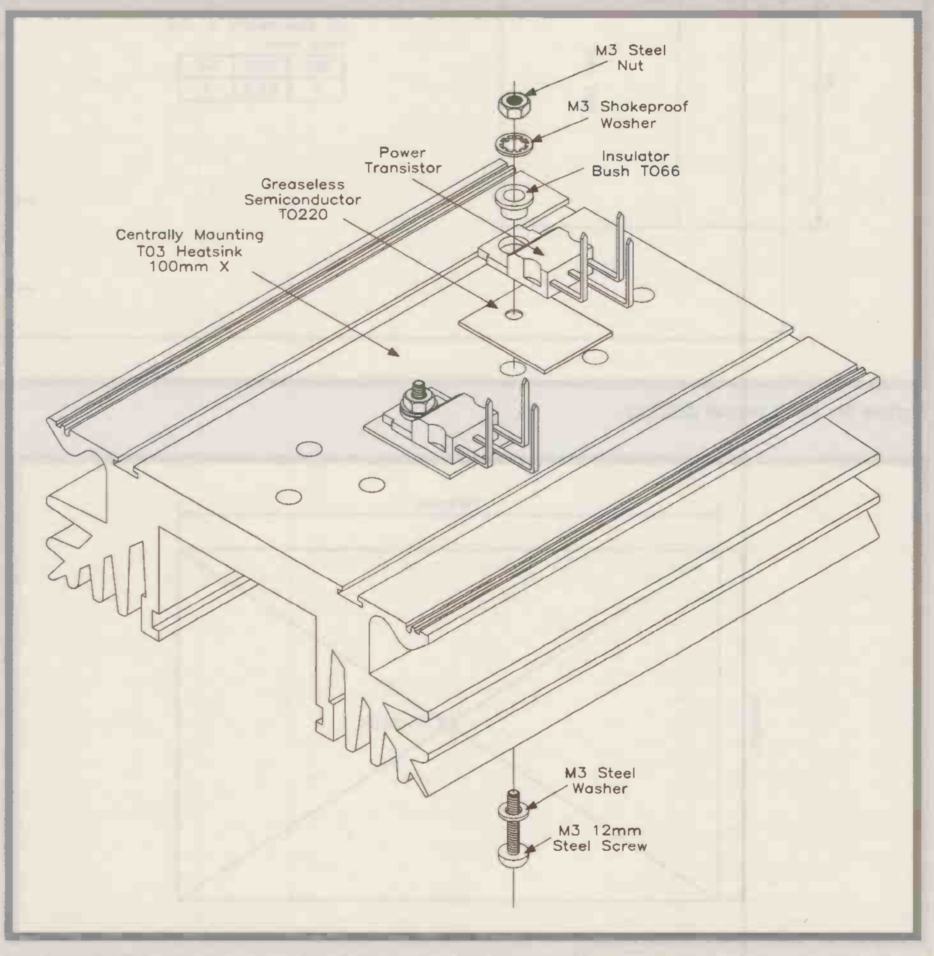


Figure 9b. Mounting power transistors on to the heatsink.

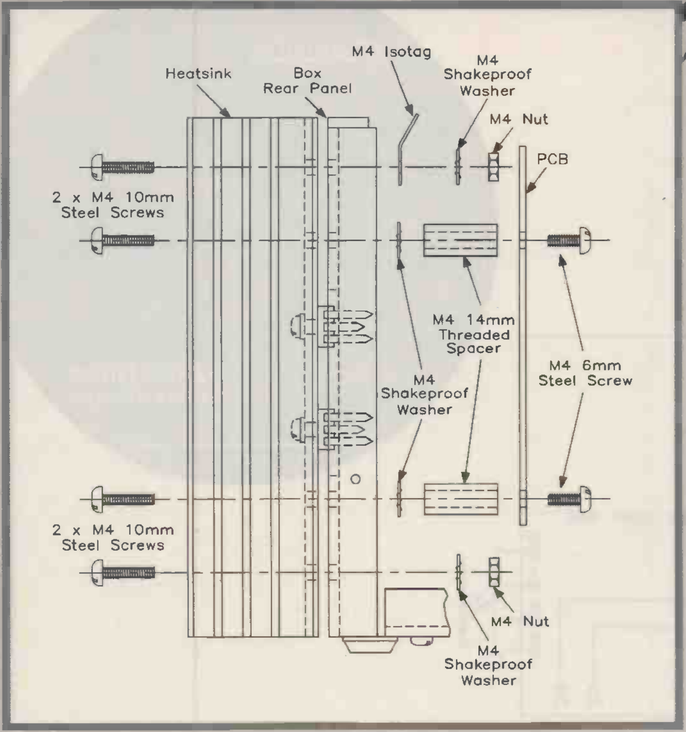


Figure 9c. Rear panel assembly – heatsink mounting.

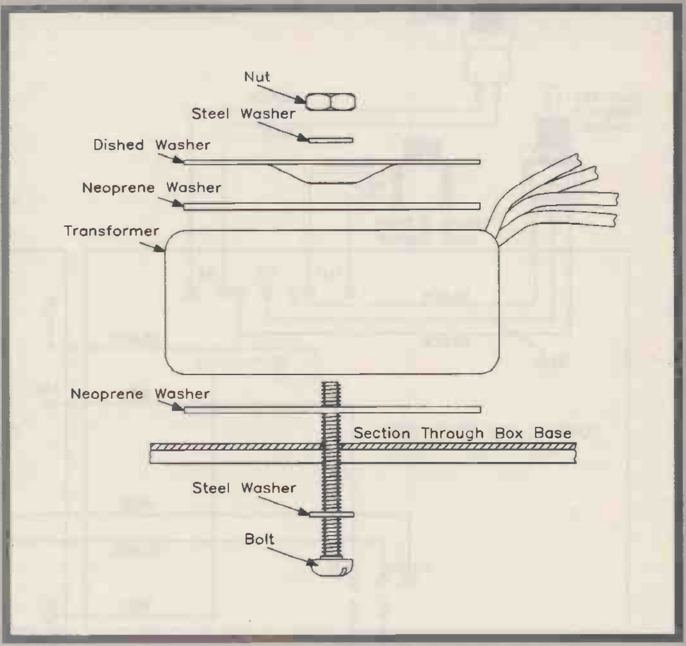


Figure 9d. Mounting the transformer on to the chassis.

attach short lengths of red and black wire.

Refer to Figure 9a and remove only the fixing nuts from the rotary switches; fit the PCB into the box and fix in position with the switch nuts. Insert the LEDs into the bezels then fit the bezels into their respective holes (keeping the shorter cathode lead aligned with the flat side of the legend) and solder the LED leads to the board. Fit the rest of the front panel hardware.

Assemble the power transistors onto the heatsink as shown in Figure 9b; note the heatsink orientation. Using a multimeter, set on the highest resistance range; check the insulation between the transistor mounting tabs and the heatsink; an 'out of range' reading should be obtained.

Preform the power transistor leads then bolt the heatsink assembly to the box (do not forget to fit the M4 solder

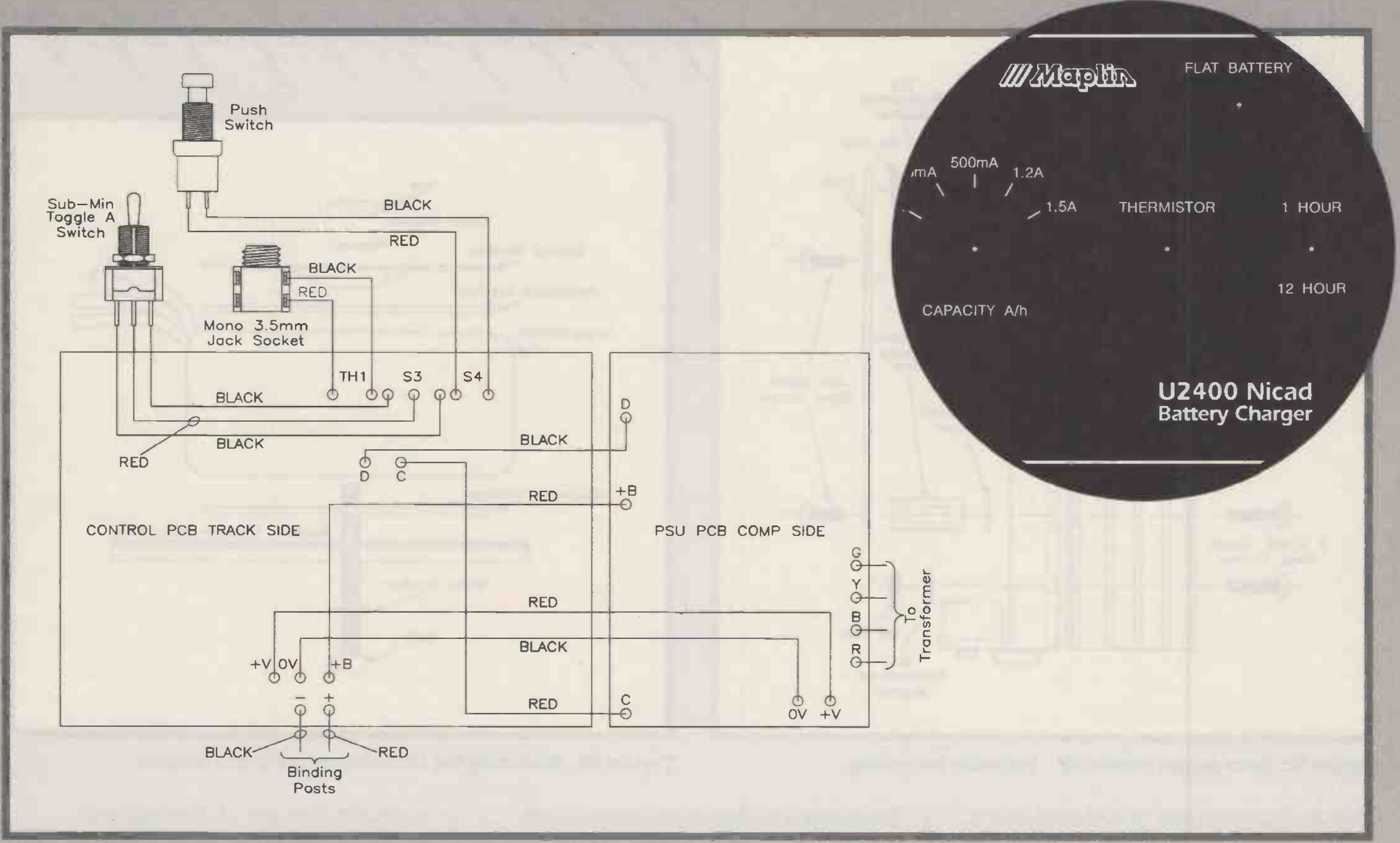


Figure 10a. Low voltage inter-PCB wiring.

tag). Solder the green lead to the solder tag; fit the switch-fuse-IEC socket assembly to the rear panel, then solder the free end of the green lead to the EARTH pin of the IEC socket; do not forget to fit the insulation boot.

Fit the M4 spacers to the PSU PCB shown in Figure 9c; then bolt the PSU assembly to the heatsink; solder the power transistor leads to the PCB pins.

Next assemble the transformer onto the chassis, supplied with the optional box, refer to Figure 9d, and then place the chassis inside the box and fix in position.

Wire up the low voltage and inter-PCB wiring as shown in Figure 10a, noting the connections to the switches and the socket.

Figure 10b shows the fitting of the fused mains inlet chassis plug with switch, and the mains wiring including the earthing arrangements. Thoroughly check all wiring before proceeding any further; once checked, the enclosure lid can then be fitted.

Complete the project by connecting the thermistor to the screened lead (insulate with the heatshrink sleeving) and fitting the 3·5mm jack plug to the other end. Finish by fitting the knobs to the rotary switches and inserting the fuse into the fuse drawer of the IEC socket.

Testing

To test the unit, a multimeter and a partially charged Ni-Cd battery is required. Make a suitable patch lead for your battery or battery pack to plug into the charger; plug the thermistor into the charger.

Connect an IEC mains lead to the charger and plug into the mains supply. Switch on the mains and charger; the red LED should illuminate continuously; select the appropriate charge voltage to match the battery or battery pack. Set the battery capacity switch to 1·5A/h and set the charge time switch to 1 hour.

Connect the multimeter (set to read 2A minimum) in series with the battery or pack, then connect to the charger. The charger should do one of three things, if the battery is partially charged the red LED will start to flash, indicating that the battery is being discharged; a current reading of (approximately) 500mA should be obtained. If the green LED flashes, the battery is being charged; a current reading of (approximately) 1·35A should be obtained. Selecting a lower capacity (A/h) range will cause the ammeter reading to flicker; if you have an oscilloscope, you will be able to see the PWM of the charge current.

If the battery is totally flat the charger will not 'see' it; in which case, pushing the 'flat battery' switch for a few seconds at a time, will force the battery to be charged. When the battery is sufficiently charged, the charger will detect its presence, and begin to charge it.

Reselect the maximum battery capacity, then select the 12 hour charge time; the current reading will begin to flicker again.

Selecting a lower capacity setting will reduce the average current even further; if you are able to see the charge current, you will notice that

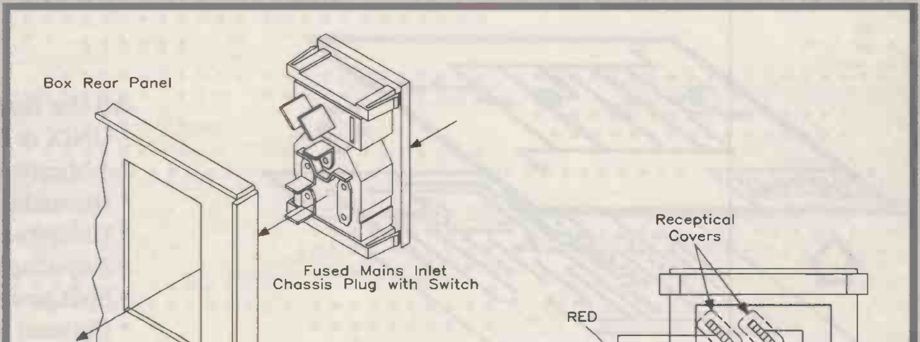


Figure 10b. Mains wiring and earthing arrangements.

the current pulses are PWMed by the 12 hour charge setting.

Heat the thermistor above 45°C; the charge or discharge current will stop and both LEDs will extinguish. When the thermistor has cooled down, the charge or discharge cycle will begin again; but, on reheating, the LEDs will flash alternately, indicating that a violation has occurred.

Disconnect the battery and the red LED will illuminate continuously.

The Ni-Cd battery charger has now been fully tested and is ready for use.

Important Safety Note:

It is important to note that mains voltage is potentially lethal. Full details of mains wiring connections are shown in this article.

Every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit. Safe construction of the unit is entirely dependent on the skill of the constructor, and adherence to the instructions given in this article.

If in any doubt as to the correct way to proceed, seek advice from a qualified engineer.

INTELLIGENT Ni-Cd BATTERY CHARGER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless Specified)			
R1	0Ω47 3W Wire Wound	1	(W0·47)
R2	330Ω 1W	1	(C330R)
R3	360Ω	1	(M360R)
R4	91Ω	1	(M91R)
R5	16Ω	1	(M16R)
R6	150Ω	1	(M150R)
R7	390Ω	1	(M390R)
R8	22k	1	(M22K)
R9,27	47k	2	(M47K)
R10	100k	1	(M100K)
R11	470Ω	1	(M470R)
R12	1Ω5	1	(M1R5)
R13	390k	1	(M390K)
R14,17	3k3	2	(M3K3)
R15	2k	1	(M2K)
R16	4k3	1	(M4K3)
R18	2k7	1	(M2K7)
R19	3k9	1	(M3K9)
R20	910Ω	1	(M910R)
R21	12k	1	(M12K)
R22,23	4k7	2	(M4K7)
R24	33k	1	(M33K)
R25	36k	1	(M36K)
R26	2k4	1	(M2K4)
R28	10k	1	(M10K)
R29,30	510Ω	2	(M510R)
TH1	Thermistor 15k@25°C B=3740	1	(FX22Y)
CAPACITORS			
C1	4700μF 35V Electrolytic	1	(JL30H)
C2,4	100nF 50V Disc Ceramic	2	(BX03D)
C3,5,7,8	10μF 50V Electrolytic	4	(FF04E)
C6	150nF Poly Layer	1	(WW43W)
SEMICONDUCTORS			
ZD1	BZX 4V7 Zener	1	(QF45Y)
D1-5	1N5400	5	(QL81C)
TR1	BD712	1	(WH16S)
TR2,3	BC327	2	(QB66W)
TR4,5	BC337	2	(QB68Y)
TR6	BD711	1	(WH15R)
IC1	U2400B	1	(AH40T)
RG1	LM78L12ACZ	1	(WQ77J)
LD1	Red LED 5mm 2mA	1	(UK48C)
LD2	Green LED 5mm 2mA	1	(UK49D)
MISCELLANEOUS			
S1,2	Rotary Switch SW12B	2	(FF73Q)
S3	Sub Miniature Toggle Type A	1	(FH00A)
S4	Push Type Switch	1	(FH59P)
	16-pin DIL IC Socket	1	(BL19V)
	Single-ended PCB Pin 1mm	1 Pkt	(FL24B)
	LED Bezel 5mm Convex	2	(UK14Q)
	Knob RN18 Red	1	(FD67X)
	Knob RN18 Blue	1	(FD65V)
	Large Terminal Post Red	1	(HF07H)
	Large Terminal Post Black	1	(HF02C)
	3·5mm Jack Socket Chassis	1	(CX93B)
	3·5mm Jack Plug	1	(HF80B)
	Fuse/Switch Inlet	1	(JK71N)
	Insulating Boot	1	(JK67X)
	Push-on Receptical Cover	1 Pkt	(FE65V)
	Fuse 20mm T 500mA	1	(WR18U)
	Transformer 18V 50VA	1	(DH59P)
	Heatsink TO3 100mm	1	(KW50E)
	Plastic Bush TO66	1 Pkt	(JR78K)
	Insulator TO220	2	(QY45Y)
	Heatshrink Sleeving CP32	1m	(BF88V)
	Heatshrink Sleeving CP24	1m	(BF87U)
	M4 Solder Tag	1 Pkt	(LR63T)
	M4 x 10mm Bolt	1 Pkt	(JY14Q)
	M4 x 6mm Bolt	1 Pkt	(JY13P)
	M4 Shakeproof Washer	1 Pkt	(BF43W)
	M4 x 14mm Threaded Spacer	1 Pkt	(FG39N)
	M3 x 12mm Bolt	1 Pkt	(JY23A)
	M3 Nut	1 Pkt	(JD61R)
	M3 Shakeproof Washer	1 Pkt	(BF44X)
	M3 Washer	1 Pkt	(JD76H)
	3A Black Wire 10m	1 Pkt	(FA26D)
	3A Red Wire 10m	1 Pkt	(FA33L)
	3A Green Wire 10m	1 Pkt	(FA29G)
	Single Lapped Screen Cable	1m	(XR13P)
	PCB	1	(GH71N)
	Front & Rear Panel Labels	1	(KP69A)
	Instruction Leaflet	1	(XU62S)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Blue Case Type 237	1	(XY47B)
	Euro Lead	1	(MK41U)

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 as a kit, which offers a saving over buying the parts separately.

Order As LT55K (Intelligent Ni-Cd Battery Charger Kit) Price £39.99 C2

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 items (which are included in the kit) are also available separately, but are not shown in the 1994 Maplin Catalogue

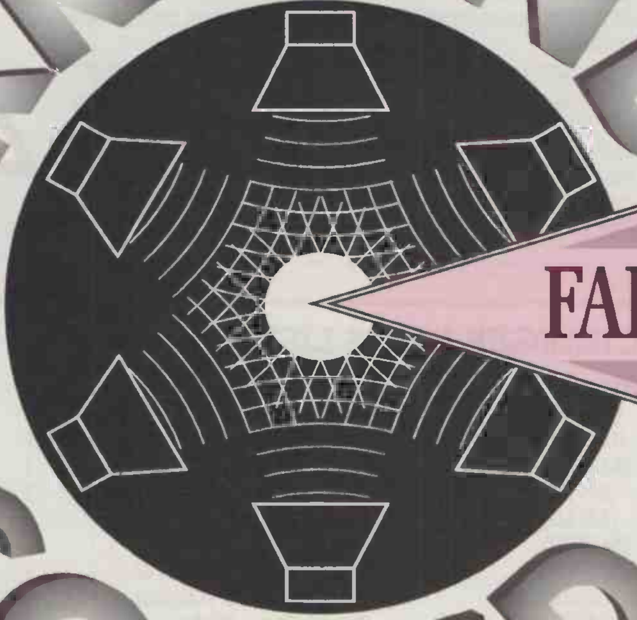
Intelligent Ni-Cd Battery Charger PCB

Order As GH71N Price £4.49

Ni-Cd Battery Charger Panel Labels

Order As KP69A Price £1.99

SURROUND SOUND - FAD OR FANCY ?



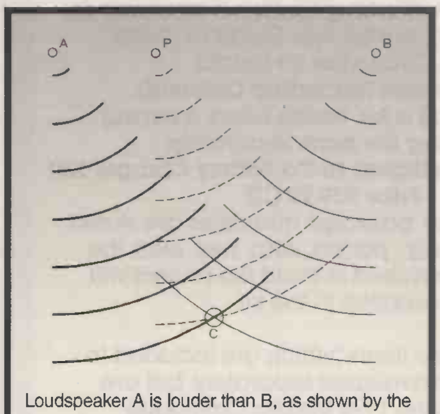
Part One The First Four Channels

NO AUDIO technique has had a more chequered history than 'surround sound'. We shall be looking at everything from two-channel stereo to the latest developments. Each stage is peppered with romantic names and symbols for particular systems, most of which are lying wrecked along the tortuous road of progress.

by J. M. Woodgate B.Sc.(Eng.), C.Eng., M.I.E.E., M.A.E.S., F.Inst.S.C.E.

THE VERY EARLY DAYS

The story probably begins in France around the turn of the century, when all sorts of applications of the then new telephone technology were actually tried out. No business plans or cash-flow forecasts in those days: the supremacy of the bean-counters was sixty years in the future! The application we are concerned with was a scheme to install a row of microphones, perhaps eight, along the front of the stage of a theatre, and connect each by a separate telephone circuit to a corresponding row of what were effectively primitive horn loudspeakers in the homes of people who could pay for the privilege. It wasn't technically very good or very economical (although the discovery that only two channels gave quite a good impression of the directions of sound sources was made at this time). It ignored the social dimension: socially active people went to the theatre to see and be seen (and still do), and staying at home was no substitute. Such lessons as these are rarely learnt: home shopping by computer suffers from the same drawback: it's DULL!



Loudspeaker A is louder than B, as shown by the thicker lines. So P is nearer to A than to B.

Figure 1. Two-channel stereo: wavefronts from loudspeakers at A and B combine (more or less) to produce the effect of a wavefront coming from P, as far as the listener at C can tell.

THE TWENTIES AND THIRTIES

The advent of electrical recording was perhaps responsible for a new surge of interest in 'more-than-one-channel'. Probably the greatest electronics genius so far (he was personally responsible for the development of most of electronic television and the non-linear techniques of electronics, in two decades of incredible achievement), Alan Dower Blumlein was in a good position, first at Columbia and subsequently at EMI (now part of Thorn-EMI), to do something about it. He developed the two-channel stereo technology that we use today, and investigated much further into multi-channel systems. Much of his work is lost or only known in fragments. Figure 1 shows the general idea: two loudspeakers A and B produce sound waves which spread out like ripples on a pond. The sound from A is louder, as indicated by the thicker 'ripples', so that when the ripples meet at the listener C, he gets the impression that the sound comes from a single source at P.

Commercial secrecy and other factors led to the more-or-less independent repetition of much of Blumlein's work in the USA a few years later. The Americans explored some aspects which Blumlein had not, and this has led to the usual controversy over who invented what. Blumlein's many patents provide a reliable but incomplete record of his work.

WORLD EVENTS

The development and exploitation of surround sound was held up by the intervention of Adolf Hitler and his Nazi Germany in 1939. Blumlein's work on airborne radar led to his death in an aircraft crash in 1942. Post-war austerity gave little room for new developments in consumer goods and in any case European countries wanted to start or restart television services and supply new receivers before bothering about audio.

THE FIFTIES

In the mid-Fifties, the time was judged right for beginning commercial exploitation of two-channel stereo. In England, Clark, Dutton and Vanderlyn developed the EMI 'Stereosonic' system, using $^1/_4$in. reel-to-reel magnetic tape, which not only priced the system out of most people's reach but was not a popular medium even with audiophiles. However, stereo disc records (using Blumlein's technology) soon followed, and these made stereo sound readily accessible to the mass market at low-cost. Some of the equipment offered, however, made drastic compromises in order to minimise the size of the second loudspeaker, and proved to be less than satisfactory.

THE SEVENTIES

On the apparent basis that twenty years of two-channel stereo was enough, attempts were made in the Seventies to introduce four channels, and it was to prove a complete disaster. The audio industry was taught a lesson, which it has only recently forgotten; that too many incompatible rival systems just ensure that everyone loses money! We had three major systems, known as SQ, QS and CD4. SQ and QS were 'matrix' systems, in which four original channels were condensed into two for recording on disc or tape, and expanded into four again for reproduction. CD4 was a discrete system for disc recording: it used the two baseband channels of ordinary stereo, plus two more channels modulated on a high-frequency carrier. All of the systems suffered from technical difficulties: SQ and QS because the correct way of handling the matrix operations was far more complicated than it appeared, and CD4 because of the need to record, and recover, very high frequencies from a vinyl disc record. There was a fourth 'system', invented, or anyway, commercialised, by David Hafler, which had certain advantages:

- it cost very little
- it worked with many ordinary stereo records, whereas the other systems needed special ones

> ***"Some of the equipment offered, however, made drastic compromises in order to minimise the size of the second loudspeaker, and proved to be less than satisfactory."***

While it sometimes did not work very well, neither did the other systems. One problem common to them all is that you can't put four loudspeakers in the average European living room without at least one being in the way of a door or window. I understand that rooms in the USA are designed differently. We shall be looking at the Hafler system and its relatives in more detail later. It was at this time that mathematician Michael Gerzon appeared in the audio arena, and contributed to the early experiments and theoretical work.

THE EIGHTIES

The early Eighties saw a considerable amount of fairly abortive research by the BBC (culminating in 'Matrix H'). The evolvement, by Michael Gerzon and Peter Fellgett, of the necessary mathematical theory allowed the development of a rational system of multichannel 'surround sound'. This system is called 'Ambisonics', and if it hadn't originally been developed under the dead hand of the (British) National Research and Development Corporation it would probably be universally exploited now. Using up to four signal channels, reproduction can be satisfactory through anything from one to six loudspeakers: furthermore, only three channels are needed for 360° 'surround sound' in the horizontal plane. Four signal channels, and six loudspeakers (or more, if you want) give full spherical coverage!

Later in the Eighties, the exploitation of digital techniques and wideband transmission systems (such as satellite broadcasting and wideband cable) introduced the prospect of several discrete audio channels being available in one transmission channel. This has led to much speculation (and not a little commercially motivated hanky-panky) about the number of audio channels to be supplied with high-definition television signals. There has, perhaps, been too little consideration of what the average TV viewer will be prepared to install: five loudspeakers seem unlikely to be popular, at any rate with Mrs Joe Public! In fact, a 'new' development, 'Front Creation', resurrects some ideas from the Seventies to simulate five loudspeakers with only three boxes: one in the TV set or its stand and one on either side of the screen. Effectively, this makes no more disturbance to the room layout than a mono TV set and a pair of loudspeakers for two-channel stereo.

> ***"Effectively, this makes no more disturbance to the room layout than a mono TV set and a pair of loudspeakers for two-channel stereo."***

THE NINETIES

The main development so far has probably been the introduction into the public cinema of the Dolby Surround sound system, which has resulted in video films being made available with Dolby-Surround encoded sound tracks for home playback. This has created a market for domestic Dolby decoders. We shall be looking at Dolby-Surround decoders, later.

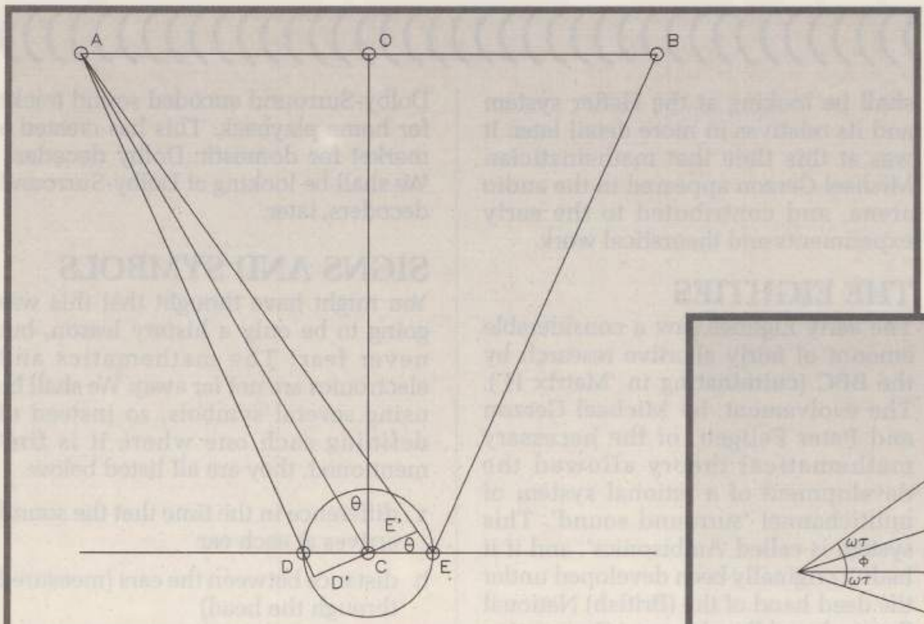
SIGNS AND SYMBOLS

You might have thought that this was going to be only a history lesson, but never fear! The mathematics and electronics are not far away. We shall be using several symbols, so instead of defining each one where it is first mentioned, they are all listed below.

τ	difference in the time that the sound arrives at each ear
h	distance between the ears (measured through the head)
c	speed of sound in air (340ms^{-1})
θ	angle between the central listener's straight ahead direction and the direction of the loudspeaker
ϕ	phase difference at the ear between the sounds from the two loudspeakers
ω	angular frequency of the signal ($2\pi \times$ frequency in Hz)
A	amplitude of sound pressure from loudspeaker at point A
B	amplitude of sound pressure from loudspeaker at point B
R	phasor sound pressure at the ear (i.e. expressing both amplitude and phase)
L	RMS value of the electrical signal output from the left-channel between each microphone or input to the left-channel loudspeaker
R	RMS value of the electrical signal output from the right-channel microphone or input to the right-channel loudspeaker
L' R'	signals modified to preserve the correct image position at high frequencies

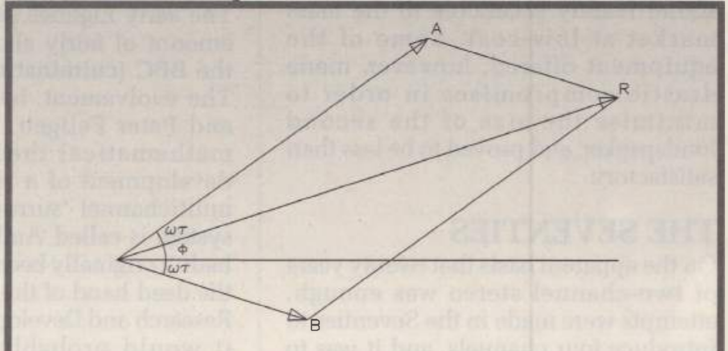
BASIC TWO-CHANNEL STEREO THEORY

To get at the basics, we have to go back to one of the original papers on the 'Stereosonic' system, because later papers have either fudged the issue with some very dodgy mathematics or concentrated on other details. An example is the small difference in path length for sound going round the head from the front to the ear, and that for sound assumed to pass through the head as if it were acoustically transparent. Even Dutton and his colleagues did not include any details of the derivation of their basic equation, but did include a diagram like Figure 2, from which we can obtain good insight. We have two loudspeakers, at A and B, with O at the midpoint of AB, and to begin with our listener C is on the line CO,



Distance DE=h. If h is small, the sound from A arrives at C, D' and E' simultaneously. The distances DD' and EE' are both equal to h sinθ/2, so the left ear at D receives the sound early by h sinθ/2c and the right ear at E receives it late by the same amount.

Figure 2. Basic geometry for two-channel stereo.



The four angles of the parallelogram add up to 2π radians or 360°, and opposite angles are equal. So the angles at A and B are each π – 2ωτ radians.

Figure 3. Phasor diagram for two-channel stereo.

perpendicular to AB. The circle represents the listener's head (not to scale!), D is the left ear and E is the right ear. Since D is a bit nearer to A, the sound from A arrives there before it does at E, and this time delay causes a phase difference between the sounds at the two ears. From Figure 2 the time delay is very nearly:

$$\tau = h\frac{\sin\theta}{c}$$

and the phase difference is

$$\omega\tau \text{ or } \omega h\frac{\sin\theta}{c}$$

If we apply the same signal (such as 1kHz tone-bursts) to both loudspeakers, in phase but not necessarily at the same level, and consider the sound at, say, E, we get a phasor diagram like Figure 3. The simplest way to find the resultant of the A and B signals is to use the cosine rule for the amplitude, and to find the phase angle by resolving the phasors parallel and perpendicular to the zero-phase line. The cosine rule gives:

$$\mathbf{R} = \sqrt{A^2 + B^2 - 2AB\cos(\pi - 2\omega\tau)}$$
$$= \sqrt{A^2 + B^2 + 2AB\cos 2\omega\tau}$$

while resolving A and B gives (A + B) cosωτ in phase and (A – B) sinωτ in quadrature, so that:

$$\arg\mathbf{R} = \phi = \arctan\left(\frac{A-B}{A+B}\tan\omega\tau\right)$$

Provided ωτ is small, $\tan\omega\tau \simeq \omega\tau$, and if ωτ is small, φ is small, so that $\phi \simeq \tan\phi$, giving:

$$\phi = \omega\tau\ \frac{A-B}{A+B} = \omega\tau\ \frac{\sin\theta}{c}\ \frac{A-B}{A+B}$$

Now, we saw above that a single source at angle θ produced a phase angle at the ear of ωh sinθ/c, so a phase angle of φ is produced by a single source at angle ψ, where:

$$\phi = \omega h\ \frac{\sin\psi}{c}$$

Therefore,

$$\frac{\sin\psi}{\sin\theta} = \frac{A-B}{A+B}$$

an equation due to Ben Bauer, one of the chief perpetrators of the SQ system of quadrophony, and called 'the stereophonic law of sines'. The question now arises is, how small must ωτ be to keep this equation reasonably valid? This is quite important, because, of course, ω is proportional to the signal frequency. The whole analysis clearly breaks down when φ = 360° (or 2π radians), because that is equivalent to no phase difference at all. The image position becomes completely ambiguous; a slight movement of the head produces either an image at the centre, or two images at the same points as the loudspeakers. At higher frequencies, multiple images appear under ideal listening conditions. You can measure the distance between your ears by shutting your head in a door and measuring the gap: it usually comes out at about 160mm. θ is typically 60°, although as we shall see, a smaller angle may be better. h sinθ/c is then about 4×10^{-4}, so the frequency at which the ambiguous image appears is about 2·5kHz. Various estimates of how close one can get to this frequency, before the stereo effect collapses, have been made over the years, with disputes about the sizes (and shapes) of heads, and how much error is too much, but a recent paper by Gerzon repeats the figure of 700Hz which was quoted by Dutton *et al* and originally by Blumlein. Luckily, it turns out that altering the balance between the (A + B) and (A – B) signals by attenuating the (A – B) signal by approximately 3dB above 700Hz, allows a fairly consistent image position to be retained up to several kilohertz. (An exact value would have to take into account the directional responses of the loudspeakers.) This can only be verified by extensive and complex subjective testing in an anechoic room (because reflections in an ordinary room affect test signals differently from real programme signals), and there is still controversy, but the system works well enough.

JUST A MOMENT

The 'law of sines' has never seemed to me to be very satisfactory. From Figure 2, we can see that OA = OC tanθ. Similarly, if the image is at a point P on OA, OP = OC tanψ. So the distance of the image from O is OA tanψ/tanθ. Since this equation contains the angle θ, the image position depends on the loudspeaker layout, whereas the original source position clearly doesn't. If the system is to give predictable results, the original source must produce a pair of signals from the stereo microphone which uniquely determine its direction. In other words, the image position relative to the two loudspeakers should depend only on the (in phase) sound pressure amplitudes A and B, and not on anything else. Since equal values of A and B put the image in the middle, it is tempting to regard the sound levels of the loudspeakers as weights on a beam balance, and the image position P as the fulcrum. Referring to Figure 4, we find that the condition for the 'beam to balance' is that the 'turning effects' or 'moments' are equal and opposite at P:

$$Aa = Bb, \text{ or } \frac{A}{B} = \frac{b}{a}$$

and some simple algebra gives:

$$\frac{A-B}{A+B} = \frac{b-a}{b+a}$$

(b – a) is twice the image distance from the centre position, while (b + a) is the

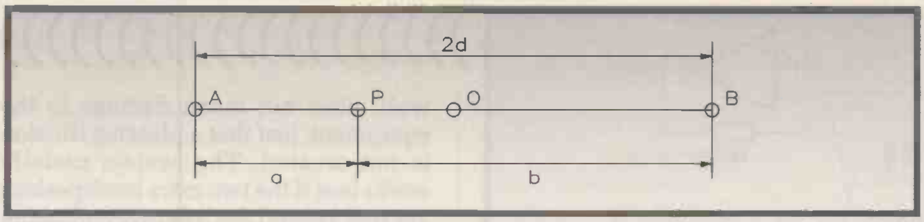
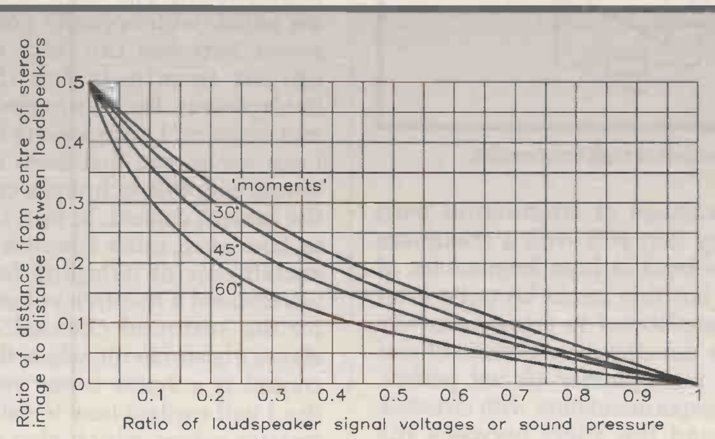


Figure 4. Diagram for the empirical 'moments law' for image position.



The three lower curves show how the image position varies with the θ (see Figure 2) according to the 'sines law'. The top curve shows the image position according to the 'moments law', which agrees with the 'sines law' for a very distant listener. Note how the image moves towards the centre, for a given ratio of signals, as the listener moves closer to the loudspeakers.

Figure 5. Image positions given by the 'sines' and 'moments' laws.

distance between the loudspeakers. It turns out that this 'moments law' gives an image position very close to that given by the 'sines law', between that and the position given by another 'law' which has been proposed, and for which the assumptions may be more valid, where 'sin' is replaced by 'tan'. Figure 5 shows this, moreover that the difference between the true and apparent image positions decreases as θ decreases. It is impracticable to listen at home a long way from the loudspeakers, but θ = 30° clearly gives less error than θ = 45°.

MICROPHONES FOR TWO-CHANNEL STEREO

Blumlein had only omnidirectional microphones at the beginning, and could only produce directional information from two of these by spacing them about 200mm apart and going through a complex frequency-dependent sum-and-differencing (matrixing) operation on the original output signals. Later, one omnidirectional microphone was used, together with a velocity microphone (ribbon microphone) having a figure-8 directional response, the microphones being as close together as possible. The signals from these represent a monaural signal (M) and a directional or stereo signal (S), so this arrangement is called 'M-S stereo', and I hope to do an article specifically on this system, later (including an M-S loudspeaker). The abbreviation is also interpreted as 'mid-side stereo'. Later recordings were made with specially built twin ribbon microphones, mounted one above the other, with their axes at right-angles.

It isn't easy to find a ribbon microphone these days, and it seems that the only other figure-8 type which is available is the double-diaphragm capacitor microphone, made for recording studio and broadcasting work, and very costly. However, it can be shown that a pair of identical microphones with a cardioid (heart-shaped) directional response, mounted as close together as possible and with their axes at 120°, produce signals which are very suitable for two-channel stereo. The directional responses are shown in Figure 6a, while Figure 6b shows that the sum of their outputs is a 'sub-cardioid' (a squashed circle). This gives a basically omnidirectional response but with about 10dB more sensitivity for centre-front sounds than for centre-back sounds, which is often a good thing, while the difference signal has a figure-8 directional characteristic with maximum responses to sounds at the sides. All that is necessary is to arrange that 3dB attenuation of the difference signal (corresponding to the S signal) above 700Hz that we saw above was necessary in order to prevent an incorrect image position at higher frequencies. To do this, it might appear that we would need a matrixing circuit,

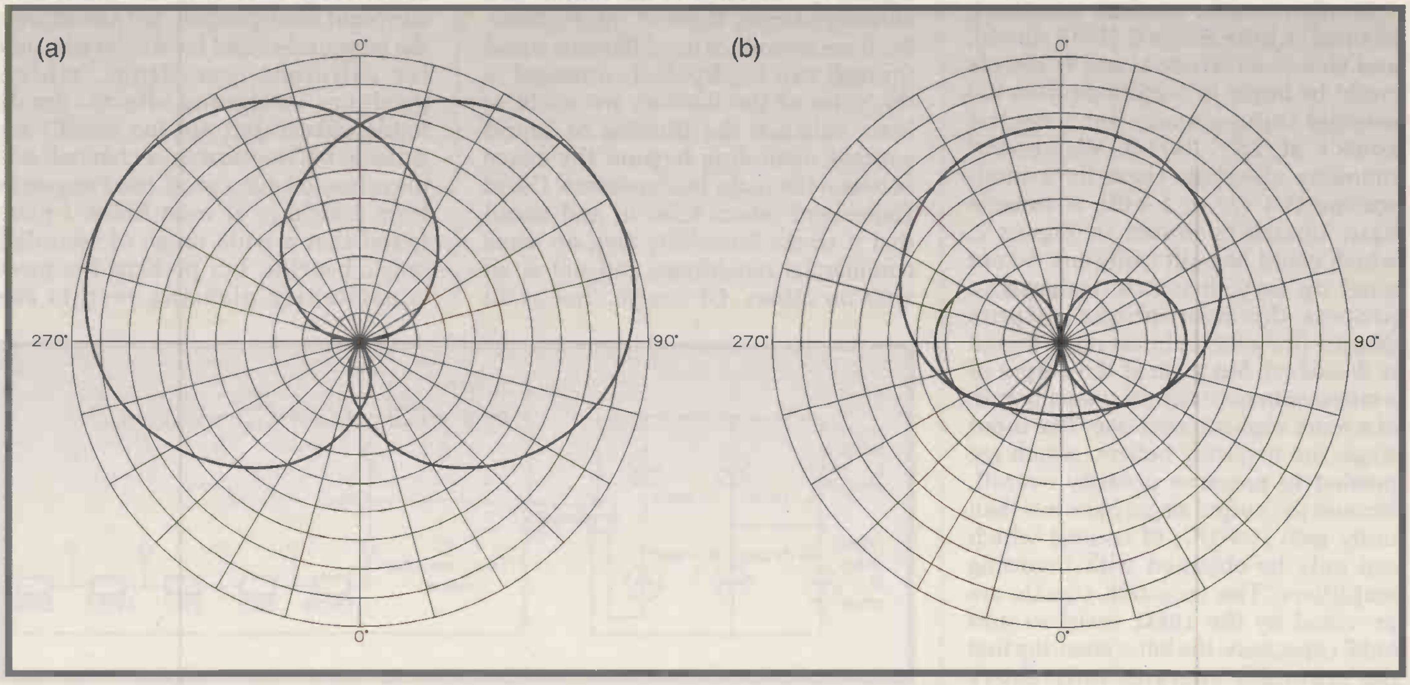


Figure 6: (a), Directional responses of two cardioid microphones with axes at 120° (linear scale); (b), Directional responses of the sum and difference signals from two cardioid microphones with axes at 120° (linear scale).

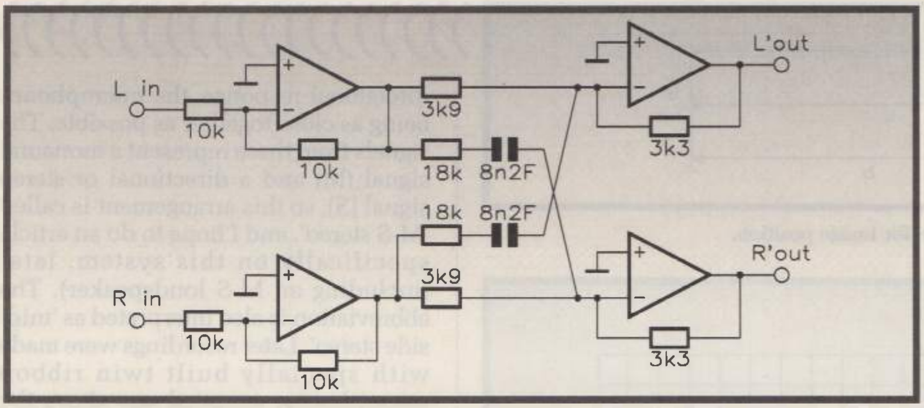


Figure 7. Controlled-crosstalk circuit for correcting image position at high frequencies.

which produced (L + R) and (L – R), attenuated the (L – R) signal by about 3dB above 700Hz, used a second sum-and-difference operation to produce new signals, L' and R', suitable for amplification and applying to two loudspeakers. However, it is simpler to operate on the L and R signals directly, using a process known as 'controlled crosstalk'. Considering only signals well above 700Hz, the sum signal has to remain as (L + R), while the difference signal has to be attenuated by 3dB, to become 0·71(L – R). If these were matrixed to obtain the L' and R' signals, we would get:

$$(L + R) + 0{\cdot}71(L - R) = 1{\cdot}71L + 0{\cdot}29R$$

and

$$(L + R) - 0{\cdot}71(L - R) = 0{\cdot}29L + 1{\cdot}71R$$

The multiplication of the original L and R signals by 1.71 simply represents some gain, which we do not want to be mixed up in the matrixing, so we scale the output signals from the (imagined) matrix to get:

$$L' = L + \frac{0{\cdot}29}{1{\cdot}71}R = 1 + 0{\cdot}17R$$

and

$$R' = 0{\cdot}17L + R$$

In other words, we feed into the L channel, a little R signal (15dB down), and vice versa. These L' and R' signals could be larger in amplitude than the original input signals (for a central source at, say, 2kHz). We should therefore attenuate them by a small amount (1/1·177 or 1·4dB). A suitable basic circuit is shown in Figure 7, which could be built using any decent quad op amp. It is not designed to process the microphone outputs directly (for which a lower noise design is desirable), but to sit at the output of a mixer, or in two channel 'insert points' of a more sophisticated one. The input stages are inverting buffers, which are needed to preserve polarity overall, because the output stages have less than unity gain (1/1·177, of course) which can only be obtained with inverting amplifiers. The crosstalk signals are provided by the 18kΩ resistors and 8n2F capacitors, the latter ensuring that the crosstalk operates only above 700Hz. It might be an improvement to use a crosstalk network with a greater rate of change of attenuation with frequency (but still with a maximum injection level at high frequencies of –15dB), but this could be quite a bit more complicated to achieve. In any case, the directional responses of real cardioid microphones are not perfect, so some experimentation with crosstalk levels (and the angle between the microphones) is in order.

LOUDSPEAKER MATRIX SYSTEMS: SURROUND SOUND AT LAST?

When I began to research this article, I found the useful information scattered far and wide, interleaved with much waffle, and some in papers of considerable vintage which may not be very accessible in future. So it seemed right to start with a thorough grounding in two-channel stereo, as the only way of leading to some insight into the far more difficult theory of multichannel systems. Not only that, much of the simple technology of the Seventies is well worth reviving by a new generation of enthusiasts.

We have seen above, that for coincident-microphone stereo, the difference between the two loudspeaker signals corresponds to the output of a sideways-facing figure-8 microphone. So, if we reproduce the difference signal through two loudspeakers arranged at the sides of the listener, we might at least enhance the illusion of sound sources extending beyond the space between the main loudspeakers. David Hafler and others tried it, and found that it works incredibly well on some commercial recordings, and not at all well on others. Of course, 'not at all well' does not mean damage to the equipment, just that a pleasing illusion is not created. The system usually works best if the two extra loudspeakers are well behind the listeners and rather further apart laterally than the two main loudspeakers. The extra loudspeakers are wired, with opposite polarities, in series between the 'hot' amplifier output terminals for the main loudspeakers. Do I hear cries of horror and derision? Loudspeakers in series!!! I can assure you that there is nothing wrong with that technique, certainly in the present context. In fact, I am going to take even more liberties with the sacred cow of damping factor, and recommend a *resistive volume control* for the surround channel! Figure 8 shows a basic circuit, where the volume control is a 2-pole 6-way switch (one day I will explain how to calculate the resistor values which give even 2dB steps of attenuation, and do *not* cause a disastrous loss of electromagnetic damping). It also turns out that, although the values are optimised for two 8Ω loudspeakers in series, only the first step of attenuation goes somewhat wrong if you use two 4Ω, or two 16Ω loudspeakers. The rest of the steps stay close to 2dB, which, when you hear it, is a surprisingly small change of loudness. Actually, the original Hafler circuit simply used a variable series resistor as the rear volume control. The volume control is in a separate box with a trailing lead and a separate switch to turn the surround effect on and off. This is so that you can really assess the improvement while sitting in your favourite seat, while the other box of tricks, and all its wiring, lives next to the amplifier. The volume control not only compensates for some difference in sensitivity between the main and surround loudspeakers, but also allows the surround-sound level to be adjusted for different recordings, which produces intriguing effects. Small loudspeakers (but not too small!) are suitable for the surround channel, but they should have a good, level response from 200Hz to at least 6kHz. I have found that a wide range of recorded music benefits, but perhaps the most consistently pleasing results are

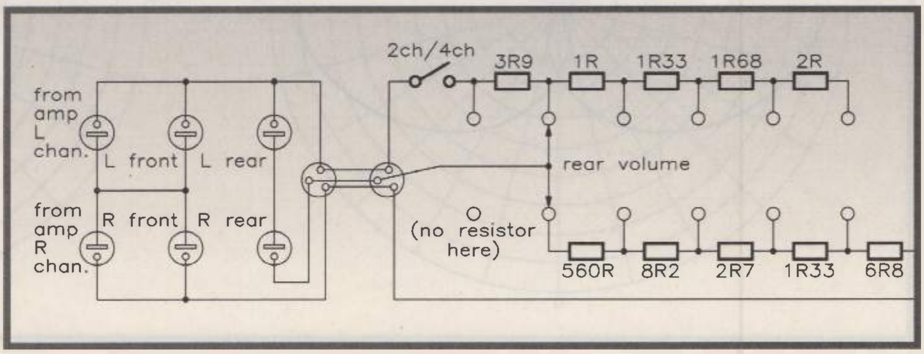


Figure 8. A simple loudspeaker matrix for surround sound, usually attributed to David Hafler (except for the dual-chain attenuator).

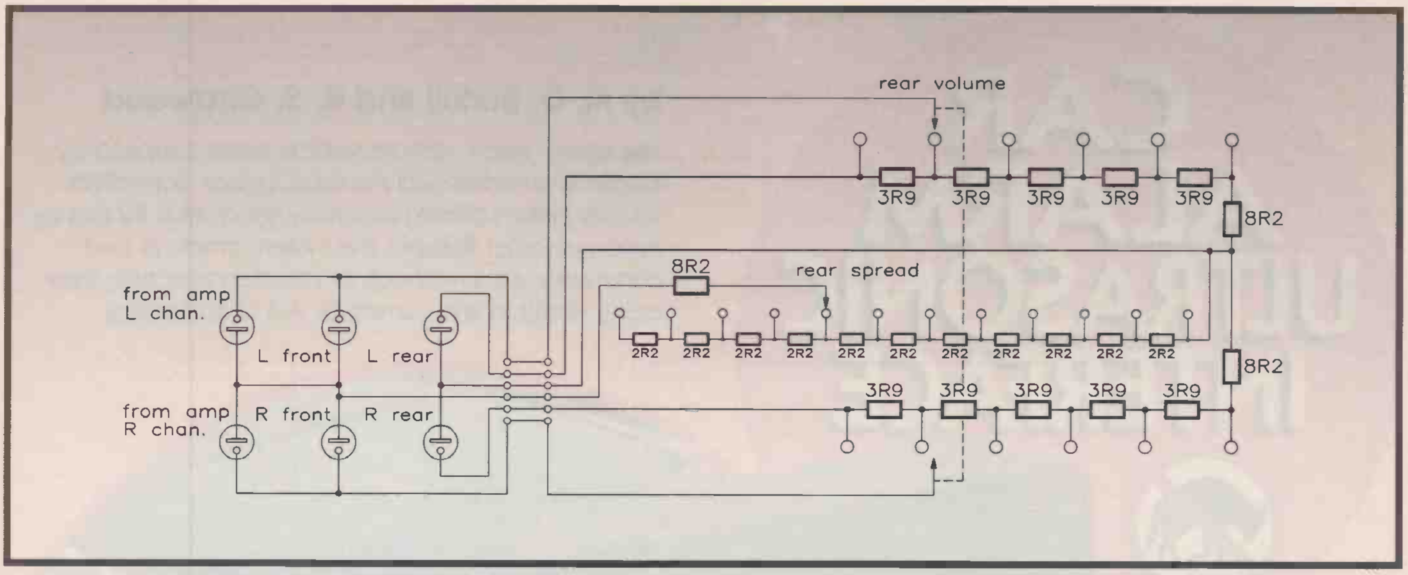


Figure 9. Loudspeaker matrix for Gerzon's simple surround sound system of 1972.

obtained from recordings made in the 60s and 70s, as featured on Radio 2. Of course, the station must be broadcasting in stereo, so Breeze AM and the like lose out, I fear. Modern, multimiked and randomly reprocessed offerings are much less successful. It is perhaps thought-provoking to note that Dutton and his colleagues, in the original 'Stereosonic' paper, suggested that stereo mixers for recording would need only two main channels, with perhaps two auxiliary channels for spot-mixing particularly quiet sources, instead of the eight or so used in those days for mono recording!

GERZON'S 'NEW SPATIAL STEREO' (VINTAGE 1972)

Michael Gerzon developed an improvement of the Hafler system, which, on some recordings, suffers from an overemphasised difference signal. Figure 9 shows the necessary circuit, which is similar to the basic Hafler circuit but contains an extra variable resistor between the common point of the two rear loudspeakers and that of the front pair. This resistor effectively adds some (L + R) signal into the rear channels, so that the two rear loudspeakers no longer reproduce the same signal but with reversed polarity. Instead, we get signals like, for example, 0·7(L – 0·8R) in the left rear and 0·7 (R – 0·8L) in the right rear. The factor of 0·7 represents a 3dB attenuation, which is an unavoidable loss due to the use of low-cost resistive matrixing while the fact that the two rear channels signals are different means that directional information appears to the rear as well as to the front. For this simple circuit, we cannot easily use the dual-chain resistive attenuator as in Figure 8, because we need two of them and we don't have low-cost 4-pole 6-way switches. However, we also don't have 2-gang low resistance pots, so we use the 2-pole 6-way switch to make two ganged 6-step variable resistors to act as the rear volume control and one 1-pole 12-way switch to act as the 'rear spread control', varying the amount of (L + R) signal fed to the rear channels. There is some interaction between the controls, which is minimised by a careful choice of circuit values.

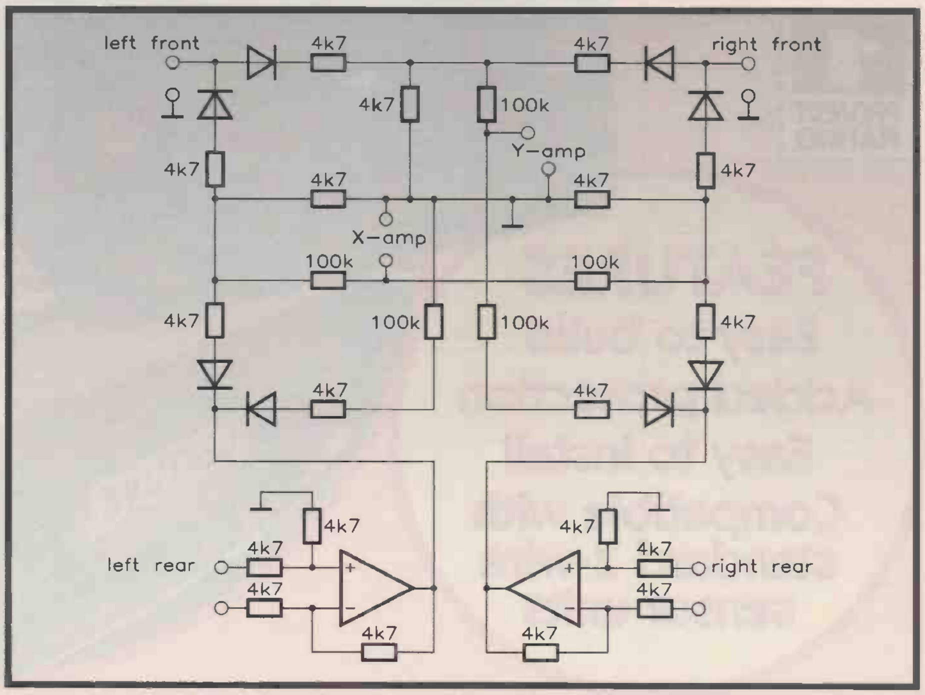


Figure 10. Matrix circuit for four-channel vector display on an X-Y oscilloscope.

FOUR-CHANNEL VECTORSCOPE

You may have met the term 'vectorscope' in connection with colour television, but the same sort of display can be useful at audio frequencies, especially to examine the effects of applying the simple matrixing operations described above to different recordings. What we do is to matrix the four signals yet again, using steering diodes: so that a right front signal produces equal positive-going signals for the X and Y amplifiers of the oscilloscope; a left front signal produces a positive Y signal but a negative X signal; centre front and back signals produce positive and negative-going Y signals only; and side signals produce only X signals. Since the rear signals from the loudspeaker matrix are not earth-referenced, we have to include balanced-input unity-gain buffers before the vectorscope matrix. A 1458 or TL072 op amp will do this nicely, as shown in Figure 10. You can spend hours looking at the trace patterns instead of listening to the music!

ACKNOWLEDGMENT

Thanks are due to Trevor Butler of *Hi-Fi News and Record Review* who was extremely helpful in retrieving information from twenty-year-old issues of that journal.

NEXT TIME

Next time, we will look at why multichannel theory is so difficult, and the more sophisticated Ambisonics system, while the (current) ultimate, the Dolby Pro-logic decoder and LucasFilm THX reproduction system, will follow in Part 3, together with some ideas for low-cost (well, relatively!) home experimental systems.

CAR ALARM ULTRASONIC INTERFACE

by M. D. Burkill and R. S. Girdwood

The basic 'Vixen' remote vehicle alarm supplied by Maplin is an advanced microprocessor controlled security system offering extremely good value for money. Amongst other features the system employs two commonly used methods of intruder detection; they being vibration and current or volt drop sensing.

1
PROJECT RATING

FEATURES

- Easy to build
- Added protection
- Easy to install
- Compatible with standard 3-wire sensor units

Use in conjunction with current sensing alarms to protect areas not normally covered

The assembled Ultrasonic Interface PCB.

In most cases for security purposes these detection methods are adequate, although vibration sensing can sometimes be prone to false triggering due to passing traffic. In many cases, the unit may have to be set in a desensitised state to avoid annoying false alarms.

Current trends in vehicle crime involve smash and grab offences, with forced entry through parts of a vehicle not protected by current sensing equipment, or areas that do not activate the interior light such as the boot, hatchback, rear passenger doors and soft tops.

This project was designed with the above points in mind, and provides a facility to interface an ultrasonic sensor to the alarm system adding a further dimension to the 'Vixen' and other similar remote vehicle alarms at low cost.

The interface described is designed for negative earth vehicle electrical systems and is intended to be used with the 'Moss' range of ultrasonic units which are readily available from Maplin.

Circuit Description

Referring to Figure 1, which shows the block diagram for the ultrasonic Interface, and Figure 2, the circuit diagram, circuit operation is as follows:

C3 and C4 help reduce any high frequency noise that may be present on the supply – cars are notorious for producing electrical noise.

With the ignition 'ON', D4 conducts, pulling the input to IC1d high. Since IC1d is configured as an inverter, its output will be low. TR1 is therefore biased off, thus removing the negative supply to the ultrasonic detector and effectively inhibiting the rest of the circuit.

With the ignition 'OFF', the input to IC1d is pulled low by R2, the output of IC1d goes high, which in turn causes TR1 to conduct providing the negative supply to the ultrasonic detector circuit unit, thus powering it up.

The input to the interface is connected to IC1a via Vsig and pulled high by R1. When

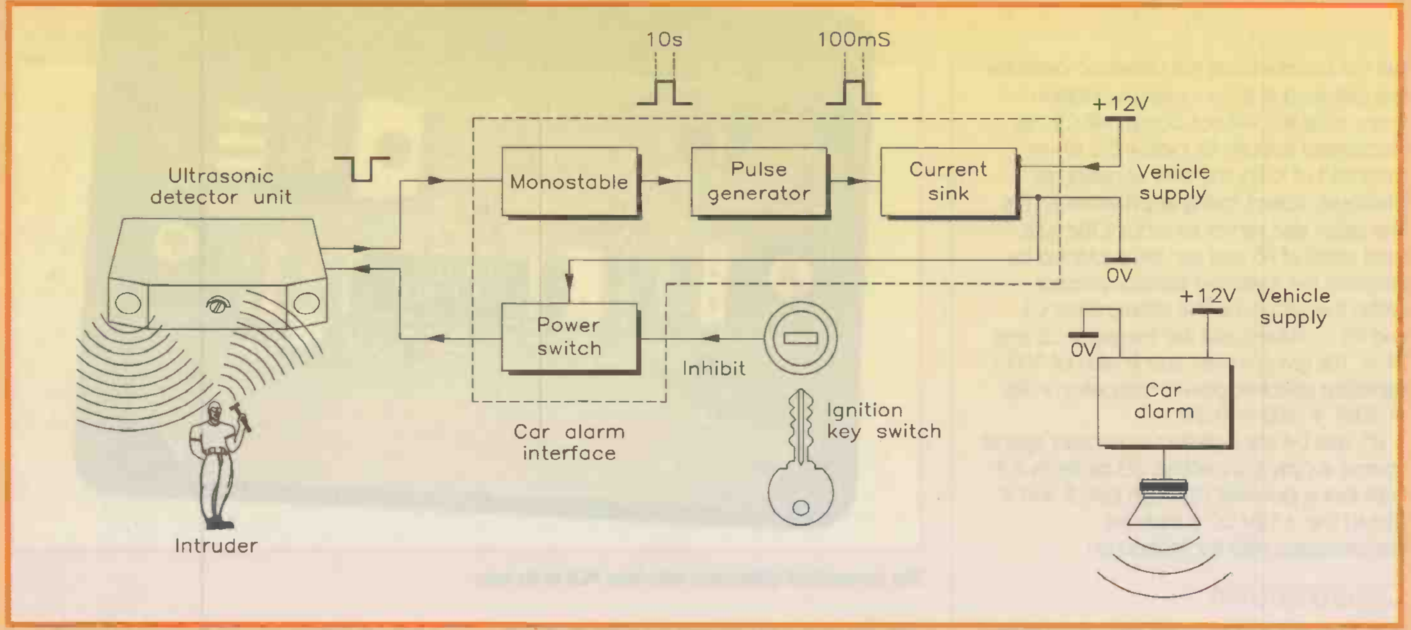


Figure 1. Block diagram of the Ultrasonic Interface.

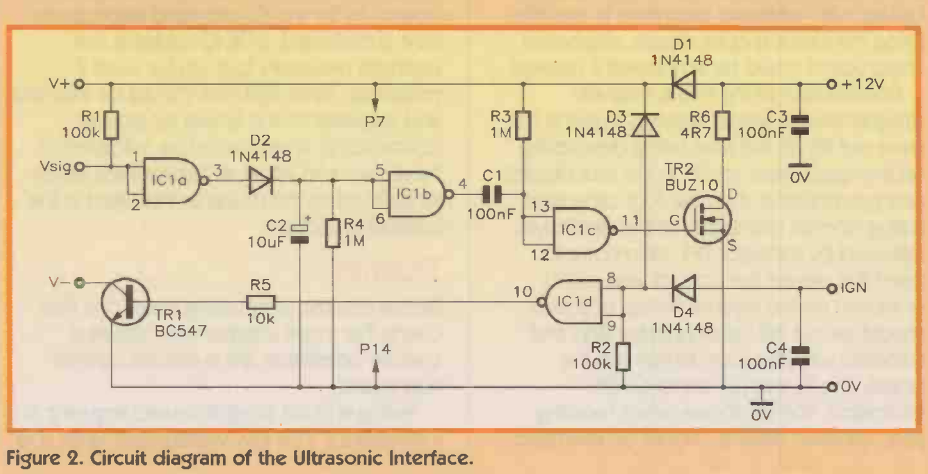


Figure 2. Circuit diagram of the Ultrasonic Interface.

the ultrasonic unit is triggered, an open collector transistor within the unit pulls pins 1 and 2 of IC1a low. Since IC1a is also configured as an inverter, its output changes state from low to high.

IC1b and associated components form a monostable and a pulse generator. A positive-going pulse appearing at the anode of D2 will charge C2 and cause the normally high output of IC1b, which is configured [yes, you've guessed it – Ed.] as an inverter, to go low. The duration that IC1b's output stays low is set by timing components C2 & R4 and is approximately 10s.

IC1c is configured [getting a bit predictable this – Ed.] as an inverter, since its input is pulled high by R3 its output is normally low. TR3, an N-channel enhancement mode insulated gate field effect transistor (IGFET), is held in the non-conducting state by the low output from IC1c. A negative going pulse from IC1b charges C1 and causes the output of IC1c momentarily to go high, the duration of which is set by C1 & R3 and is approximately 100ms.

The high output from IC1c biases TR2 on and causes current to flow through R6. The current flowing is approximately 2·5A, giving an instantaneous power dissipation of approximately 30W. But since the period of time that the current is flowing is very short, a low wattage resistor can be used without it overheating, as explained below.

The current flowing has a brief loading effect on the car's electrical system; with the 'Vixen' vehicle alarm in its armed condition this brief loading is sufficient to trigger the current sense circuitry. The loading effect of the interface appears to be considerably higher than that of an interior light, which is normally 5W, but the instantaneous power dissipated by a 'cold' filament lamp is somewhat higher. Experimentation revealed that approximately 30W simulates that of an interior light switching on from cold.

To avoid multiple switching of IC1c (hence continuous loading of the car battery), TR2

Important Safety Warning

Before starting work, consult your car owners' manual regarding any special precautions that apply to your vehicle. Since a car battery is capable of delivering extremely high currents, it is imperative that every possible precaution is taken to prevent accidental short circuits occurring. Remove all items of metal jewellery, watches, etc. Before connecting the module to the car electrics, the battery should be disconnected. Helpful hint: Remove ground connection first, to prevent accidental shorting of the (+) terminal to the bodywork or engine, assuming negative earth vehicle. It is essential to use a suitably rated fuse in the supply to module. The wire used for the connections should also be rated to safely pass the required current. If in any doubt as to the correct way to proceed, consult a qualified automotive electrician.

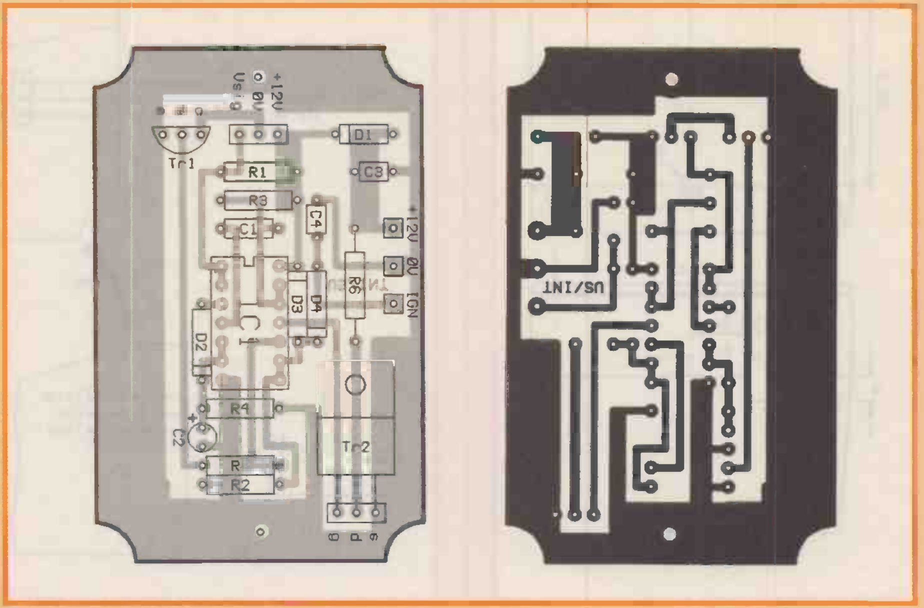


Figure 3. PCB legend and track.

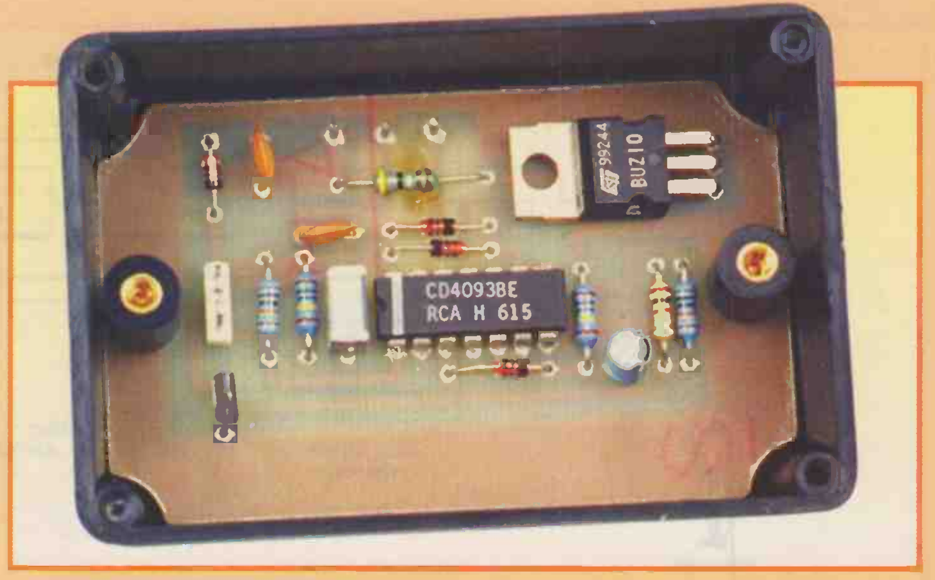
will not conduct until the ultrasonic detector has stabilised in a 'no motion' condition. In any case this will not occur until C2 has discharged through R4 below the lower threshold of IC1b, the time constant, as previously stated, being approximately 10s. This delay also serves to reduce the size (and cost) of R6 and can be explained by analysing the switching periods present within the circuit, i.e. the differentiator C1 and R3 = 100ms and the integrator C2 and R4 = 10s giving a mark space ratio of 100:1, therefore effective power dissipation in R6 = 30W ÷ 100 = 0·3W.

D1 and D4 are included to protect against reverse supply connection. D3 protects IC1 from being powered through pins 8 and 9 should the +12V DC supply be disconnected with the ignition on.

Construction

A PCB legend and track are shown in Figure 3. PCB fabrication is left up to the individual builder with whatever technique is available. Since the circuit is quite simple, stripboard construction could be employed if desired.

Construction of the PCB is relatively straightforward. Solder resistors in place first, leave out R6 for the time being (see testing section later). Next solder in the four diodes noting orientation, then the four capacitors noting correct orientation of the electrolytic followed by transistor TR1, taking care to insert this device the correct way round, as shown on the legend. A strip of 3 pins should be cut off the connector strip and soldered with the short length into the board. The IC and FET are of CMOS fabrication. The usual care when handling static sensitive devices should be exercised.



The assembled Ultrasonic Interface PCB in its box.

The legs of the FET should be bent at 90° so that the full length of the tab rests against the board. As for the IC, provided appropriate care is exercised, a DIL IC socket is not deemed necessary but can be used if preferred. Three PCB pins should be inserted and soldered to the board for power connections. Wires should be soldered to these pins and left at an appropriate length to connect to the points as indicated in the installation section.

Testing

Before commencing testing make one final check that those components requiring specific orientation are in fact the correct way round.

Testing is quite straightforward requiring at a minimum a 12V low wattage test lamp and a power supply or 12V battery. Connect the test lamp across the supply and drain (tab) of TR2, then the power, and allow the ignition connection to 'float.' Take Vsig to ground momentarily (short out Vsig to the middle ground pin of the connector plug), TR2 should conduct and the test lamp light up briefly. Check that TR2 does not conduct again by taking Vsig to 0V – allow 8 to 12 seconds to pass and again short Vsig to 0V, by this stage C2 will have discharged and TR2 will conduct.

With bench testing now complete R6 can be soldered in place. The box should be cut as dimensioned in Figure 4, following which the PCB can be secured to the lid of the box using the 10mm spacers. Complete assembly of the box bringing the three wires out through the slot in the side.

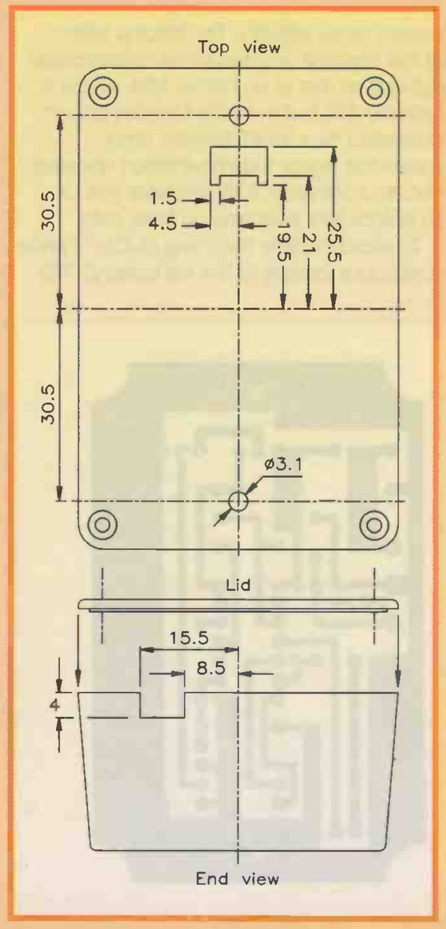


Figure 4. Box drilling details.

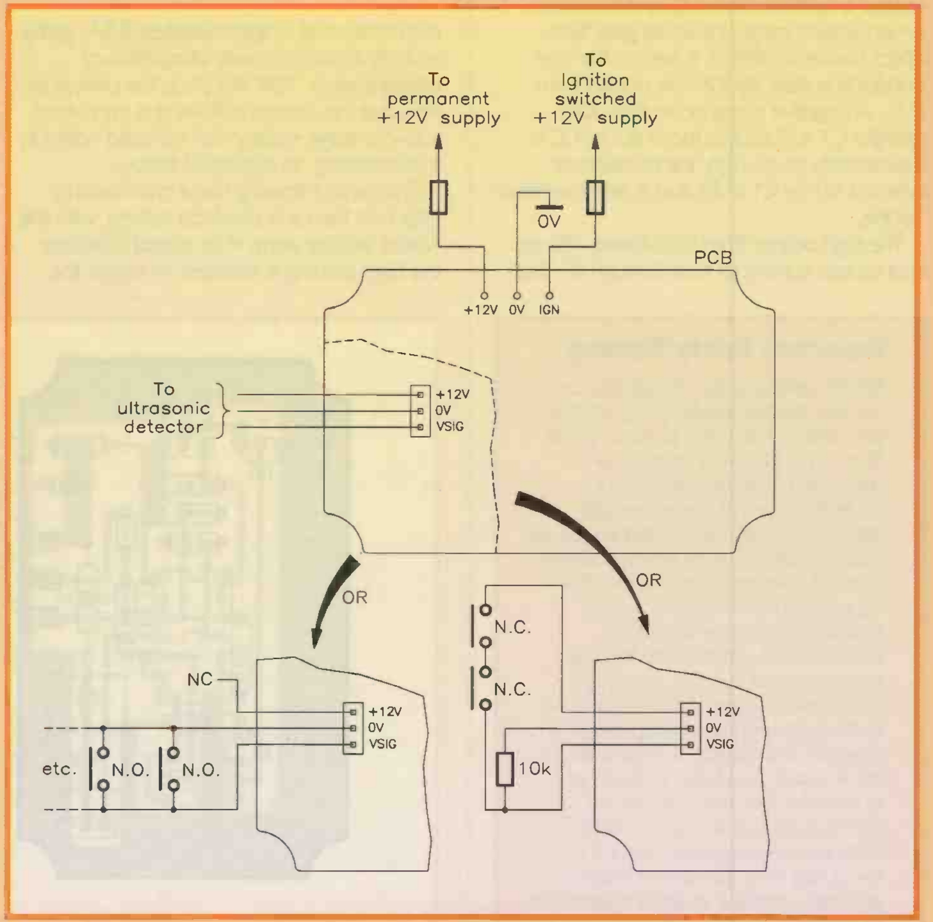


Figure 5. Wiring diagram.

Continued on page 58

PULSES ON LINES

A Beginner's Guide

by Bryan Hart

PART THREE

Terminal Cases

THE final part of this series supplies answers to some questions that arise with system connections, and offers practical guidance on methods of termination in digital systems.

Lumped or Distributed?

First we consider the choice of a criterion that will enable us to determine whether the line-over-ground interconnection system of Figure 25 is to be considered as 'lumped', and thus amenable to ordinary circuit calculations, or 'distributed' and requiring the application of the transmission line theory and arithmetic outlined in Parts One and Two.

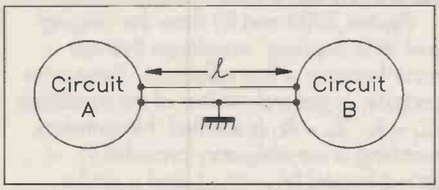


Figure 25. Lumped or distributed interconnection?

In Figure 26(a), Circuit A is represented by an equivalent generator v_G with output resistance R_G, and Circuit B by a single equivalent resistor, R_T.

Although a perfect step is useful in explaining the mechanism of pulse propagation and reflection phenomena, it is not an acceptable choice of signal shape for v_G because it is never met in practice. A sensible choice is a waveform with a positive-going edge, as shown in Figure 26(b), because that is the approximate shape encountered with pulsed and digital circuits driving resistive loads. The edge rises at a constant rate between levels V_{OL}, V_{OH}. Thus, the pulse amplitude is $(V_{OH} - V_{OL}) = E$ and the transition time between levels is t_c. Assume, as in Example 2 of Part Two, that $R_G = R_O$, $R_T = \infty$. For these conditions there is a match at $x = 0$, and v_T is a delayed replica of v_G.

Figures 27, 28 and 29 indicate how v_I depends on t_d for three values of t_c. In each of the corresponding sets of diagrams, (a) represents v_G, (b) shows the edge being sent down the line, and (c) shows it after it has been *reflected* back from the load. The algebraic sum of (b) and (c) produces (d), the input waveform v_I.

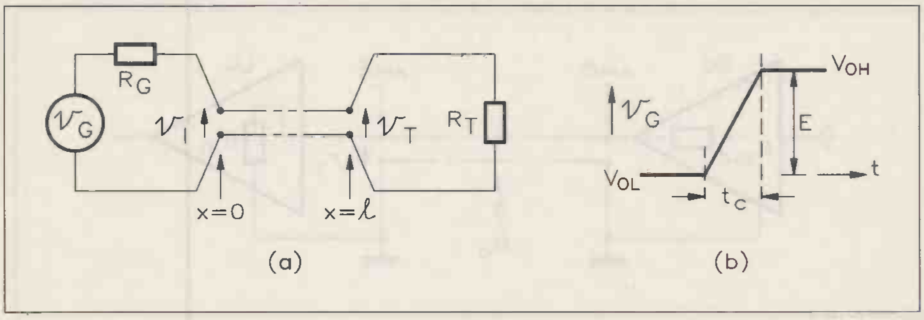


Figure 26: (a), pulse equivalent circuit for Figure 25; (b), waveform adopted for v_G.

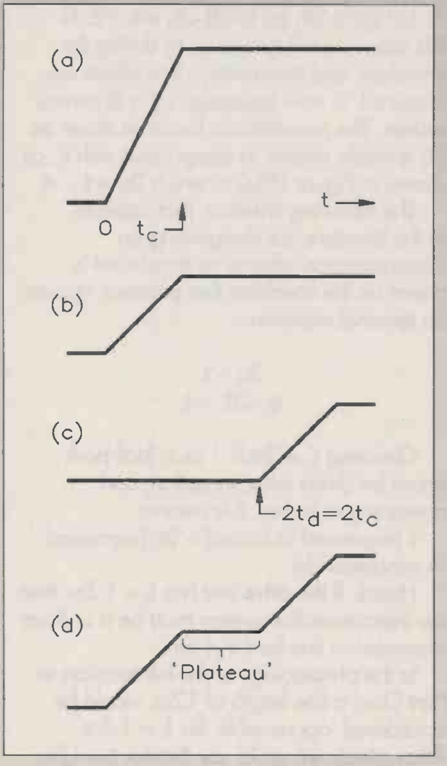


Figure 27: (a), v_G; (b), pulse edge sent down line at $x = 0$; (c), pulse edge reflected back to $x = 0$ for $t_d = t_c$; (d), v_I, the algebraic sum of (b), (c).

In Figure 27, $t_d = t_c$ and the generator only receives 'news' of R_T after the pulse generator output transition is completed. Hence, there is a plateau section in (d).

For Figure 28, $2t_d = t_c$. Here the plateau does not appear because the drive circuit receives 'news' of R_T just as v_G is completing its transition.

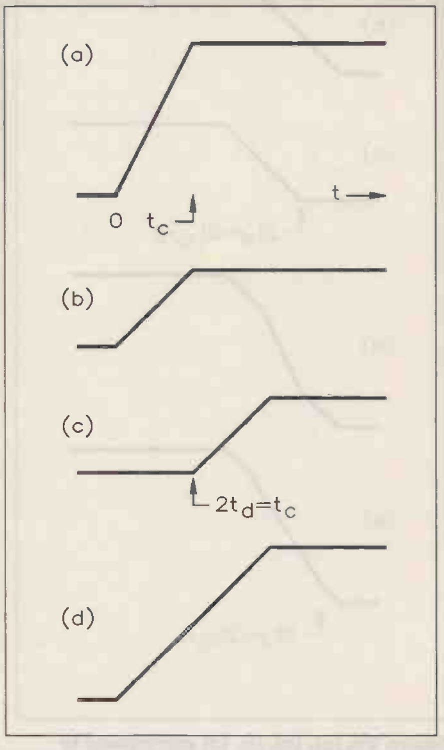


Figure 28. Waveforms corresponding to those of Figure 27 but with $t_d = t_c \div 2$.

In Figure 29, (a) to (d), $2t_d = t_c \div 2$. In this case v_I is influenced by R_T during the transition, and transmission line effects are obscured. v_I now resembles v_G in its central section. The resemblance becomes closer as $2t_d$ is made smaller in comparison with t_c, as shown in Figure 29(e) in which $2t_d = t_c \div 4$.

The following criterion, that appears in the literature, for designating an interconnection scheme as distributed is based on the condition that plateaux appear on terminal waveforms:

$$2t_d > t_c$$
$$\text{or, } 2\ell t_u > t_c$$

Choosing $t_u = 2\text{nsft.}^{-1}$ as a 'ball-park' figure for direct interconnection, and converting to inches, this means:

ℓ (expressed in inches) > $3t_c$ (expressed in nanoseconds).

Hence, if the drive unit has $t_c = 1{\cdot}5$ns then the interconnection system must be a uniform transmission line for $\ell > 4{\cdot}5$in.

In the phraseology of the introduction to Part One, a line length of 12in. would be considered 'appreciable' for $t_c = 1{\cdot}5$ns. Alternatively we could say that for $\ell = 12$in. a transition time of 1·5ns was 'fast'.

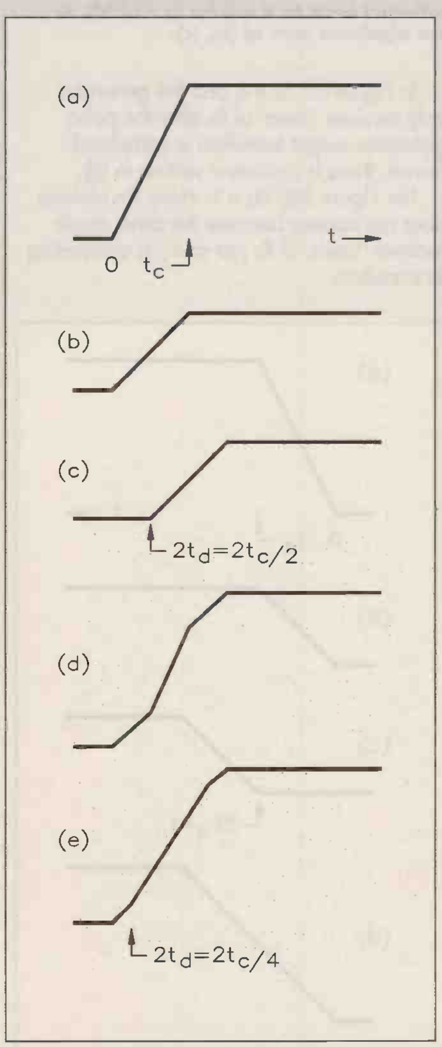


Figure 29: (a), (b), (c), (d) correspond to waveforms in Figures 26 and 27 but with $t_d = t_c \div 4$; (c), $t_d = t_c \div 8$.

Note that if the transmission path is not direct, but capacitively loaded by stubs at points along its length, then the criterion needs numerical revision because t_u is increased. This is dealt with elsewhere (see for example Reference 1 at the end of this article).

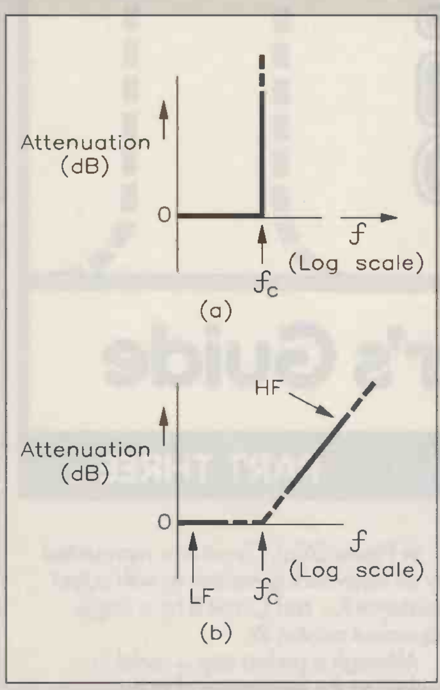


Figure 30. Filter characteristic used in lumped/distributed analogy.

The discussion leading to the formulation of the criterion has been based, for simplicity, on the particular conditions $R_G = R_O$, $R_T = \infty$. Nevertheless, the criterion can be assumed to hold generally, though it is somewhat tedious to demonstrate this graphically.

Finally, the criterion, as set out above, must be regarded as an engineering compromise and applied flexibly. It errs on the side of generosity in ℓ. In the following discussion, to save needless repeating of dimensions, it is to be taken as understood that ℓ is expressed in inches and t_c in nanoseconds.

If $\ell >> 3t_c$, the interconnection must be a line and treated accordingly: if $\ell << 3t_c$ it can definitely be regarded as lumped and, depending on the magnitude of R_G and R_T in relation to R_O replaced by an open circuit, a capacitor or an inductor. It is the 'grey' area, where ℓ and $3t_c$ are comparable in magnitude, that needs care in interpretation. A conservative approach is to assume distributed behaviour if $\ell > 3t_c \div N$, where $N(>1)$ is a safety factor, but this leaves open to argument the numerical value to be allocated to N. The choice N = 3 is an attractive one for experimental work with high-speed systems, because it allows a margin for upgrading system operating speed at a future date and gives the simple relationship $\ell > 3t_c$. However, used indiscriminately it would lead to expensively over-engineered systems.

In the application of the criterion there is an analogy with the classification of the frequency of a signal applied to a filter. An 'ideal' low-pass filter has the characteristic of Figure 30, which shows a sharp cut-off at $f = f_c$. We can define as 'low' frequencies for which $f << f_c$, and 'high' if $f >> f_c$, where the attenuation increases at a rate 6dB per octave. However, a frequency comparable with f_c cannot be classified simply as 'high' or 'low'.

Gate-Gate Interconnections

Figure 25 refers to any system in which pulses are transferred between its constituent parts. In contrast, Figure 31 refers specifically to a digital system. DG and LG are binary logic gates and are shown with triangular symbols for generality. They have an output resistance R_{out} and an input resistance R_{in}. Twisted-pair is used to connect the gates, and the transmission is single-ended, which means that one of the conductors is earthed at both ends of the line.

Is it *obligatory* to connect resistors to give some form of matching if, using the criterion discussed previously, $\ell > 3t_c$? To answer this question, consider Figure 32(a). This shows the preferred shape for the positive-going input edge to LG. V_{IH} is the maximum voltage level that qualifies as a '1', while V_{IL} is the maximum level that counts as a '0'. V_{NH} and V_{NL} are noise margins. For TTL, $V_{NL} = 0{\cdot}4V$, $V_{NH} > 0{\cdot}4V$.

Figures 32(b) and (c) show the 'ringing' and 'stair-stepping' waveforms that can occur because of line reflections. These arise because, in general, neither of the conditions $R_{out} = R_O$, $R_{in} = R_O$ is satisfied. Nevertheless, *matching is not obligatory* provided v_b, v_c do not exceed $(V_{OH} - V_{NH})$, and a similar condition, involving V_{OL}, V_{NL} holds for a negative-going logic edge.

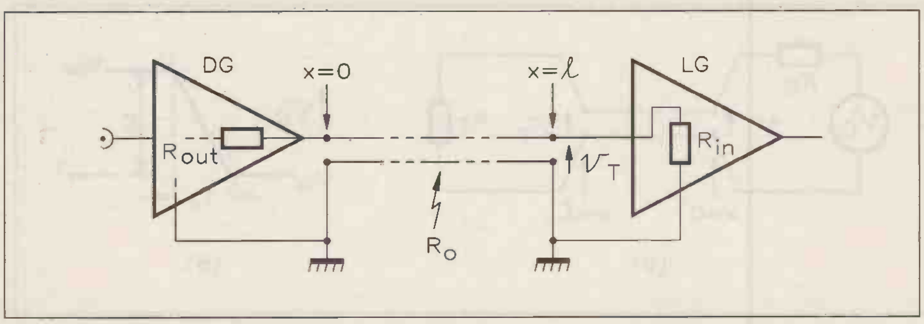


Figure 31. Interconnected logic gates.

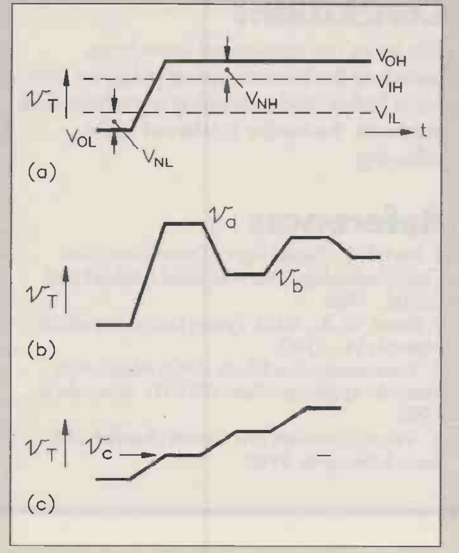


Figure 32: (a), ideal waveform for v_T in Figure 31; (b), practical waveform with 'ringing' (compare with Figure 23(b) in Part Two); (c), waveform with 'stair-stepping'.

The object of matching is to change the shape of the waveforms in Figures 32(b) and (c) so that they resemble that of Figure 32(a). *Matching is obligatory* if noise margins are degraded unacceptably and if maximum operating speed is required. A subsidiary reason could be if a peak such as v_a caused the voltage rating of LG to be exceeded. However, that is normally avoided by the use of protection diodes built into the input circuit of a gate. These prevent the input voltage from exceeding the rail supplies by more than the voltage drop across one diode.

The location of matching components is shown in Figure 33. The nature and numerical values of the components depend on the particular matching method used. There are four basic types, coded A, B, C and D in Table 1. Most of this is self-explanatory, but the following points deserve a mention. The circuit loading the line at the input to LG for case B is shown in Figure 34(a). If Z_2 and Z_3 have the values indicated in Table 1, then the equivalent circuit, looking between the terminals J and K, is that of Figure 34(b). The value for *n* is set by the system designer. The popular choice, $n = 2$, for saturating logic gives an equal gate loading for the '0' and '1' output levels that is only one half of that for method A. For non-saturating logic, the standard choice is $n = 2{\cdot}6$.

Code	Termination	Z_1	Z_2*	Z_3†	Comments
A	Parallel	0	R_O	∞	High-speed operation Heavy drive gate loading
B	Potentiometer	0	$\frac{nR_O}{n-1}$	nR_O	Reduced gate loading, but two components used
C	A.C.	0	Series R_O and C	∞	Low gate loading, but choice of C needs care
D	Series	$(R_O - R_{out})$	∞	∞	Low gate loading, but reduced speed

* For $R_{in} >> R_O$. † See Figure 34.

Table 1. Matching techniques A, B, C, D, summarised.

	A	B	C	D
ECL	●	●		●
FAST CMOS			●	●
FAST TTL		●	●	

Table 2. Dot entries show safe matching options for methods A, B, C, D of Table 1.

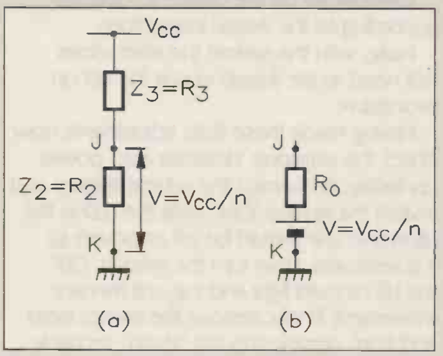


Figure 34: (a), technique B in more detail; (b), equivalent circuit for R_1, R_2 values shown.

With method C, the value chosen for the capacitor is usually several hundred pF. Too large a value causes the input level to LG to be sensitive to the pattern of the logic waveform. Table 2 shows matching options that both theory and practice have shown to be safe for three popular logic families.

Standard TTL was not originally designed to drive matched lines. However, a twisted pair line (R_O ~ 100Ω) can be driven without the use of terminating resistors, because the input and output characteristics of TTL provide a satisfactory termination. When system speed requirements dictate the use of high-speed TTL methods B and C are recommended.

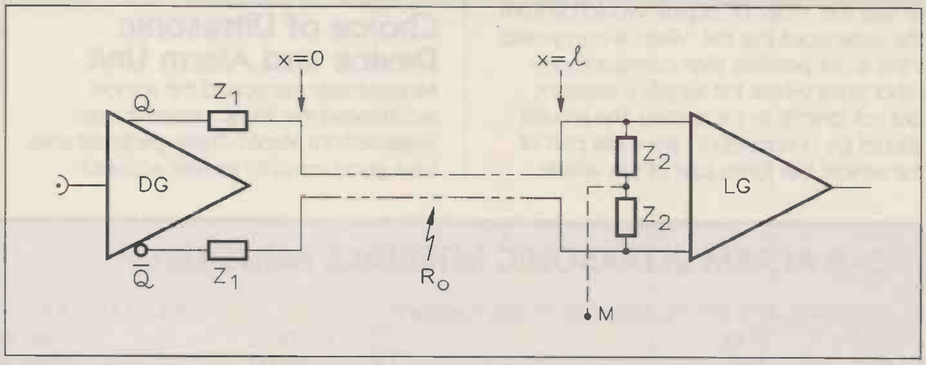


Figure 35. Location of matching components for 'double-ended' drive.

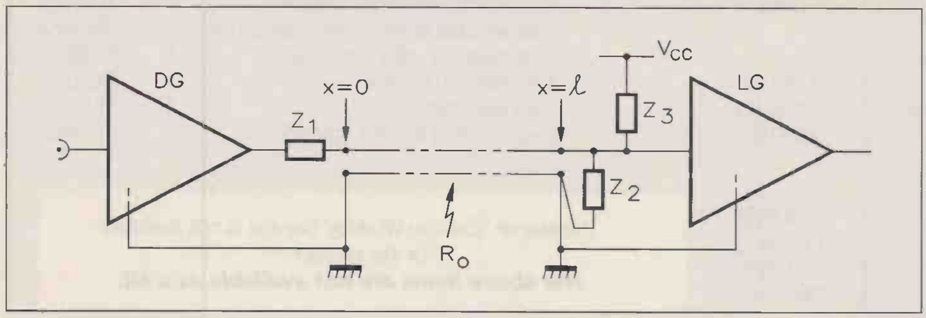


Figure 33. Showing the location of line-matching components for single-ended drive.

For high operating speeds and high noise environments, 'balanced', or 'double-ended', operation is necessary for lines of extended length (>20m, say). Figure 35 in this the driver, DG (see also Figure 6), supplies a logic signal Q to one conductor of the line and complement Q to the other. LG is a differential receiver which produces a logic level output that is dependent on the difference in voltage between the conductors. For series matching $Z_1 = R_O \div 2$ and $Z_2 = 0$, and for parallel matching $Z_1 = 0$ and $Z_2 = R_O \div 2$. DG and LG can be ECL units,

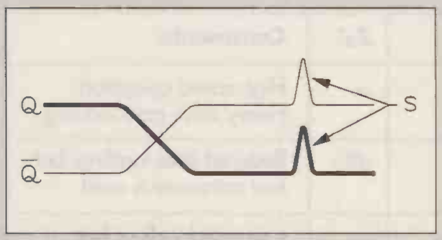


Figure 36. Line signals with identical pick up spikes 'S'.

in the case of gate-gate interconnections, but for bus-system operation they are specially designed units with additional features.

One obvious advantage of balanced operation is the rejection of noise spikes picked up from miscellaneous sources of interference. These can range from radio and radar transmitters, to heavy electrical machinery switching on and off, and domestic electronic equipment.

In Figure 36, a noise spike 'S' is picked up by each conductor of the line. Although the amplitude of this might well exceed the logic swing, it produces no output from the receiver because it only responds to differential inputs. The receiver behaves like a differential amplifier (followed by a limiter), rejecting a common-mode signal.

The amplitude of 'S' can be minimised by having a low incremental resistance from each conductor to earth at its input to the receiver. This can be achieved by connecting point M (Figure 35) to earth for saturating logic and −2V for ECL.

Conclusions

This series has considered some basic aspects in the transmission of pulses on lines. For a further study, including a mathematical treatment, the reader is referred to the following.

References

1. Hart, B. L., 'Digital Signal Transmission: Line Circuit Technology', Van-Nostrand Reinhold (UK) Co. Ltd., 1988.
2. Blood, W. R., 'MECL System Design Handbook', Motorola Inc., 1983.
3. 'Transmission Line Effects in PCB Applications', Motorola Application Note AN1051, Motorola Inc., 1990.
4. 'Industry Standard Line Circuits', booklet LL8E, Texas Instruments, 1985.

CAR ALARM ULTRASONIC INTERFACE – *Continued from page 54.*

Installation and Setting Up

For safety, before commencing work, disconnect the vehicle's battery and observe the precautions given at the beginning of this article.

Refer to the wiring diagram in Figure 5, this shows the suggested wiring of the ultrasonic detector, and a couple of alternative ideas.

Details regarding installation of the 'Moss' ultrasonic detector can be found in the instruction book accompanying the device. The setting up procedure should be read in conjunction with the proceeding paragraphs. The concealed cable should be routed to the interface. The interface can be fixed with double sided tape behind the dash.

The ignition connection can be taken (using 'Scotchlock' or similar connectors) either directly off the ignition switch or to the supply of ancillary equipment such as a radio-cassette unit. The most effective point to take the +12V DC supply would be from the same point that the 'Vixen' is connected. If this is not possible then connect to any other point where the supply is constant, but not directly to the battery. The ground should be connected to any metal part of the vehicle that forms part of the vehicle ground circuit. With the interface supply connected the ultrasonic detector can be plugged into the socket noting the polarised cut-out.

Carefully set up the ultrasonic detector according to the 'Moss' instructions.

Note, with this system the alarm does not need to be armed during the set up procedure.

Having made these finite adjustments now check the ultrasonic detector auto power up facility. Reconnect the vehicle battery and switch the ignition 'ON', note the LED in the ultrasonic unit should be off as power to it is removed. Now turn the ignition 'OFF'; the LED should light and the unit monitor movement. Finally, remove the interior lamp and from outside arm the 'Vixen'; recheck the sensitivity of the ultrasonic unit by causing it to trigger the audible alarm. Replace the lamp – testing is now complete.

Choice of Ultrasonic Device and Alarm Unit

As previously mentioned the authors recommend the 'Moss' ultrasonic units available from Maplin. These particular units have good immunity to false activation requiring two movement detections before triggering, they also have good sensitivity adjustment plus an LED indicator which not only serves as an aid to setting the sensitivity but also provides a visible deterrent to would be thieves.

Although the circuit was designed to complement the 'Vixen', it should work with any unit that monitors the battery supply.

Note: The circuit and information presented here must be considered as a basis for your own experimentation. No warranty is given or implied for suitability in particular applications – Maplin cannot support this information in any way. However, where possible, we endeavour to check that information is correct and that circuits will function as stated.

CAR ALARM ULTRASONIC INTERFACE PARTS LIST

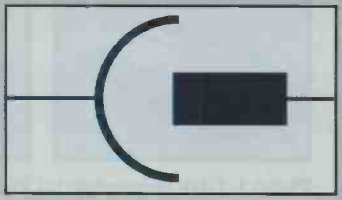
RESISTORS: All 0·6W 1% Metal Film (Unless Specified)			
R1,2	100k	2	(M100K)
R3,4	1M	3	(M1M)
R5	10k	1	(M10K)
R6	4R7	1	(M4R7)
CAPACITORS			
C1	100nF Polyester Layer	1	(WW41U)
C2	10μF 16V Sub-Min Radial Electrolytic	1	(YY34M)
C3,4	100nF Miniature Disc Ceramic	2	(BX03D)
SEMICONDUCTORS			
D1 to D4	1N4148	4	(QL80B)
TR1	BC547	1	(QQ14Q)
TR2	BUZ10	1	(UJ32K)
IC1	4093BE	1	(QW53H)

MISCELLANEOUS		
Vixen Remote Vehicle Alarm	1	(ZF47B)
Ultrasonic Sensor MS703	1	(ZC27E)
Pin Connector Strip	1Pkt	(JW59P)
M3 x 10mm Insulated Spacer	1Pkt	(FS36P)
Copper Clad Board Single Sided (SRBP)	1	(HX00A)
Multi-purpose ABS Box Type T3	1	(KC92A)
1·4A Black 10m Wire	1	(BL00A)
1·4A Red 10m Wire	1	(BL07H)
Single-ended PCB Pin 1mm (0·04in.)	1	(FL24B)

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

The above items are not available as a kit.

MAKING THE RIGHT CONNECTIONS IN VIDEO



Wiring usually follows set rules but that does not always mean it is simple. One of the benefits of a British upbringing is that it teaches you that you cannot put a square peg in a round hole. All those games pushing wooden shapes through slots are a good training-ground for later life, although with video connections even finding matching plug and socket connections is not necessarily a guarantee for success!

by Andrew Emmerson

LOOKING AT THE VIDEO BASICS

Before we launch into detailed wiring diagrams or descriptions of connectors, it is worthwhile taking a refresher course on the video signal. This information is not easy to find in concise form elsewhere. It applies equally to all monochrome systems, whilst the colour information is valid for PAL and NTSC but not SECAM.

The standard video signal is normally generated and distributed as either a composite or non-composite signal. By composite we mean a 'raw' video signal to which has been added blanking and synchronising (sync) signals. Generally this signal has an amplitude of 1V Peak-to-Peak (Pk-to-Pk) in amateur and broadcast video circles but 1·4V Pk-to-Pk in some closed-circuit TV applications. Non-composite video has an amplitude of 0·7V Pk-to-Pk and is generally confined to studio situations where switching, mixing or other processing is to take place; synchronising signals (syncs) are added afterwards to make the video composite. Non-composite signals are also used in connection with RGB colour.

Composite video is sometimes abbreviated to VBS (video, blanking and syncs) or BAS, its German equivalent. The similar expression for non-composite video is VB or BA. Colour composite video is called CVBS or FBAS.

In traditional broadcast video applications, cameras and other picture sources are either driven from a number of separate centrally generated pulses, or arranged to self-synchronise themselves (*genlock*) to these pulses. This is to ensure there is no picture break-up or rolling when switching between video sources. Modern equipment is able to lock automatically to a reference source of 'black and burst' or 'colour black', a mixture of mixed syncs, blanking and colour burst. In addition, vision mixers and effects generators are nowadays generally provided with synchronisers which delay incoming signals as necessary in order to perform the mixing or cutting cleanly. You may still come across older equipment on the surplus market which uses separate pulses, so here they are:

LINE OR HORIZONTAL DRIVE (LD OR HD)

This is a synchronising signal which initiates the horizontal scan in cameras, monitors, TV receivers, etc. In the case of a 625 line picture its frequency is 15,625Hz.

FIELD OR VERTICAL DRIVE (FD OR VD)

In a similar way this signal starts the vertical scan; its frequency is usually related (although not normally locked) to the mains frequency. In European 625 line systems these pulses are at 50Hz.

Mixed Blanking (MB) pulses suppress the video signal during the retrace period at the end of the horizontal and vertical scans.

Mixed or Combined Syncs (MS or CS) are the signals used for synchronising monitors and receivers.

These four pulses are essential for all video, monochrome or colour. Colour television also uses Burst Gate (BG) alias Burst Flag (BF). All these pulses are normally distributed at 2V Pk-to-Pk, although some British, and most American and Japanese equipment require 4V Pk-to-Pk.

CONNECTORS AND IMPEDANCE

Video and pulse distribution cables should be coaxial, of 75Ω impedance. In the professional domain the most commonly used series of connectors used for video and pulses used to be the UHF type (also known as PL-259, M or F&E): these are cheap, robust and reliable. Newer equipment uses the more compact and handier BNC series connectors. Where video connections are frequently changed (also in British Telecom establishments), the MUSA plug or video plug is preferred. Belling & Lee connectors are seldom used on professional equipment and are not suitable for any application where they will be fitted and removed frequently.

Hobbyist and semiprofessional (or *prosumer!*) started off using UHF and BNC plugs but manufacturers soon discovered they could get away with the less robust Phono, RCA or Cinch connector. Phono plugs are more compact and simple; they do work of course but their quality sometimes is suspect and they do not lock firmly in place as a professional connector does. For applications involving multiple connections a multi-pin connector is essential. A number of patterns are used in professional and consumer video, and we'll treat them in due course.

DOWN TO WORK!

Welcome to the world of wiring! Ready-made video leads are available from Maplin and many other suppliers but if you need something special (or want to save money) you will wish to make up your own. It goes without saying that plugs, sockets and cables must be of good quality and well soldered (or crimped) to avoid losing precious signals. This applies particularly if you are making your own leads: make really solid soldered joints (not *dry* ones) and ensure no loose strands of cable can short out signals to ground. Ready-made leads produced by the video manufacturers or by quality component dealers are very good, but bargain leads by unknown suppliers are best avoided. The latter often skimp on shielding, are poorly soldered or have plugs with indifferent plating.

Good quality flexible coaxial cable should be employed (the impedance

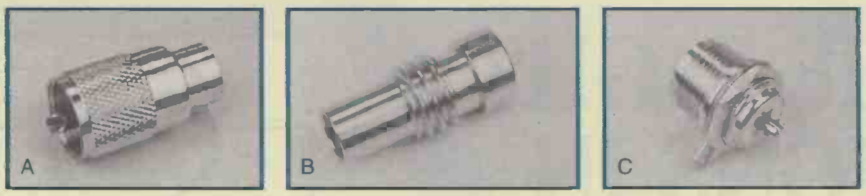


Photo 1. UHF connector; (a) PL259 plug; (b) cable reducer; (c) SO239 socket.

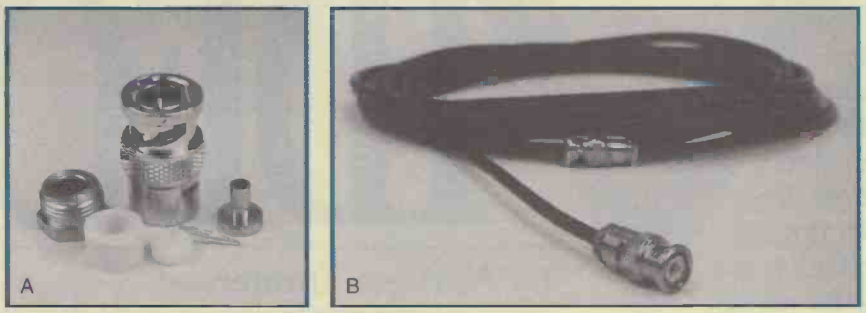


Photo 2. BNC connector; (a) the component parts; (b) assembled with cable attached.

should be 75Ω, but 50Ω and other nondescript coax will work in many undemanding situations). Certainly there is no need to go overboard with oxygen-free silver-plated pure copper cable in a Teflon jacket and with rhodium-plated connectors as the Hi-Fi faddists do! Good old RG59B/U or broadcast-industry type PSF 1/3 will be just fine. Note, that if you are combining video signals with audio or pulses in one multicore cable you need to ensure that each separate cable is screened. Any skimping in this respect will likely result in hummy, scratchy or indistinct audio and noisy, grainy video, possibly also breakthrough from one signal into another.

VIDEO CONNECTORS IN DETAIL

UHF CONNECTOR

This is the oldest connector used for video and is also known as an F&E, in Europe as a PL-type and in Japan as an M-type. The name UHF is confusing as it recalls the connector's wartime radar use, whilst F&E (Films and Equipment Ltd.) made many kinds of connector, not just this one (they are now called Cannon UK Ltd., by the way). The American military designation of the plug is PL-259. The general symbols for coaxial sockets and plugs are given in Figures 1a and 1b.

It is a screw-on connector, very robust and somewhat bulky, as can be seen in Photo 1a. Reducers are available separately, which are screwed inside the barrel of the PL259, and shown in Photo 1b. This enables smaller sizes of coaxial cable to be fitted. It is also somewhat difficult to solder successfully, which is probably why crimp and twist-on variants are popular (although the cheaper solderless twist-on types should be confined to short-term lash-ups). The socket which is designated as SO259 is available for panel mounting as shown in Photo 1c. In general, the connector is cheap, reliable and readily available – but also out of date. Modern equipment uses BNC connectors.

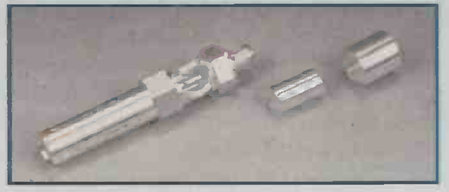


Photo 3. Musa plug.

Photo 4. S-Video connector (4-pin mini DIN).

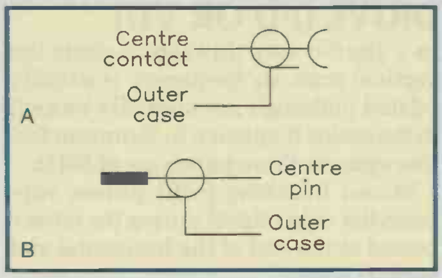


Figure 1. General symbols for: (a) coaxial socket; (b) coaxial plug.

BNC CONNECTOR

As can be seen in Photo 2a this is a neater, more compact type which also has some technical advantages over the UHF type. The plugs have a twist on, bayonet fitting, and can be difficult to fit without some practice. The correct method of assembling a BNC plug is detailed in Figure 2, and the completed plug and coax shown in Photo 2b. Crimp and solderless versions are also made.

Note that this connector is made in both 50 and 75Ω versions and both types tend to be used indiscriminately in video applications. Some damage can be caused by mating 50 and 75Ω connectors, and technically speaking, only 75Ω types should be used in video.

MUSA PLUG OR VIDEO JACKPLUG

At one time this connector, shown in Photo 3, was quite common in professional video circles, at least in patch panels where its quick push-in, pull-out qualities were appreciated. Nowadays most video routing panels are computer controlled and the only place it is still widely used is in BT facilities (London BT Tower and other network switching centres). In the 'good old days' when the Post Office had the spending power to specify the design of the video monitors it bought, this kind of connector was always fitted; you can still come across surplus PO equipment using them.

S-VIDEO CONNECTOR

The 'S' stands for separate luminance and chrominance, not for Super as in S-VHS. Confused? Never mind, the connector is at least standardised and is used to connect picture sources to recorders or monitors, the plug is shown in Photo 4. The symbol for the socket is shown in Figure 3a, and in Figure 3b for the plug, with the pin numbers and signal designations shown in Figure 3c.

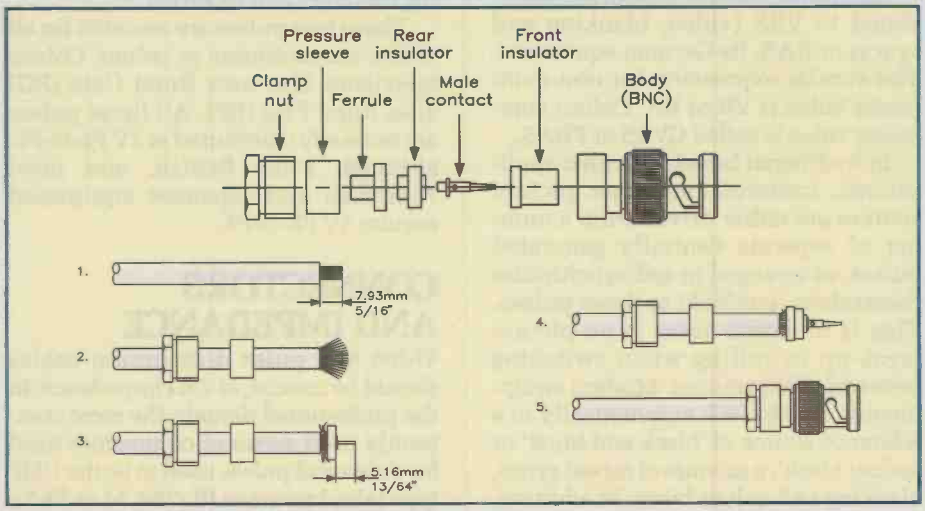
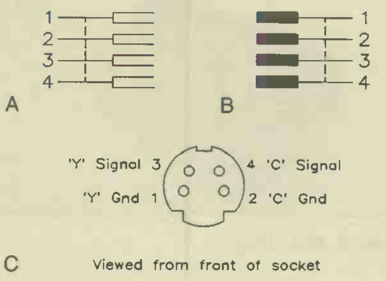
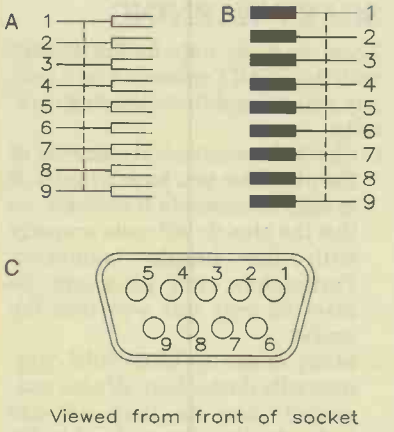


Figure 2. How to assemble a BNC plug.



PIN	FUNCTION
1	Ground
2	Ground
3	'Y' (luminance) signal
4	'C' (chrominance) signal

Figure 3. S-Video connector: (a) symbol for socket; (b) symbol for plug; (c) pin numbers and signal designations.



PIN	FUNCTION
1	Ext VD or Ground
2	Ground
3	R(RED) signal output
4	G(GREEN)/Y signal output
5	B(BLUE)/C signal output
6	VBS (composite video)
7	Sync output
8	GND
9	EXT HD/or Ground

Figure 4. 9-way D-type connector: (a) symbol for socket; (b) symbol for plug; (c) pin numbers.

9-WAY D-TYPE CONNECTOR

This is used on some Japanese colour cameras, used for industrial, computer graphics and surveillance purposes, and can carry both RGB and composite video. The plug and socket arrangements are shown in Photos 5a and 5b. A metallised cover which can be used for both is shown in Photo 5c. The symbols for the socket and plug are given Figures 4a and 4b, and the pin numbers as viewed from the front of the socket given in Figure 4c.

PHONO CONNECTOR

This is an old-established connector which has stood the test of time. It is easy to solder, and of course it works, yet something says it should be avoided in professional installations. It is only just adequate for serious use, and also with frequent use it tends to work loose in the socket, which is why professionals prefer latching connectors. For all this, it is widely used for video in domestic set ups but not from choice. A metal screened plug with a metal barrel and coiled spring cable relief sleeve is shown in Photo 6a, and a chassis mounting single hole socket in Photo 6b.

COMBINED AUDIO/ VIDEO CONNECTORS

These are also sometimes called AV connectors, although that term is not particularly explicit and not specific to any one pattern of connector.

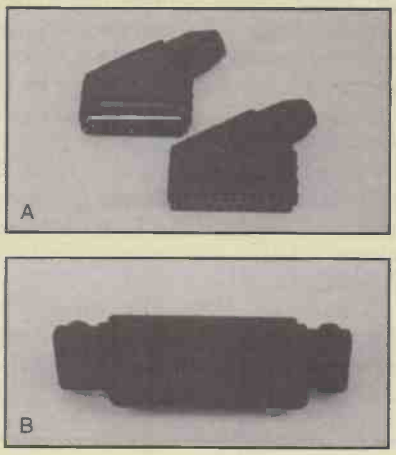


Photo 7. Peritel (SCART) connector: (a) line plug and socket (b) chassis socket.

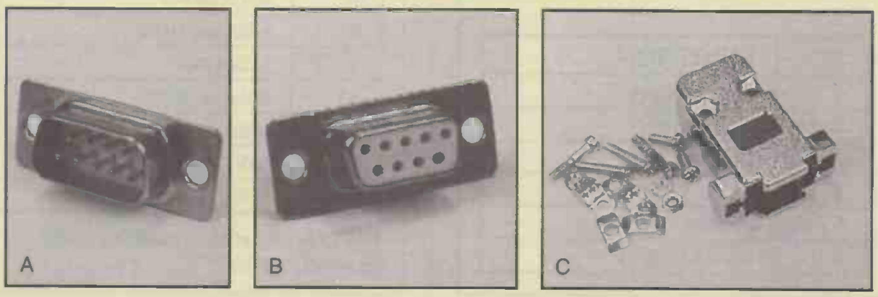


Photo 5. 9-way D-type connector: (a) plug; (b) socket; (c) cover.

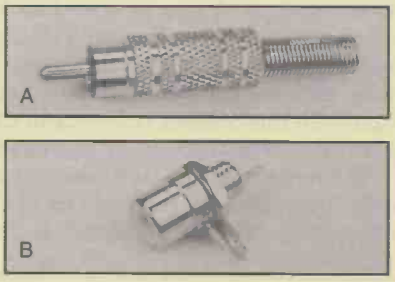


Photo 6. Phono connector: (a) line plug; (b) chassis socket.

THE SCART CONNECTOR

The SCART system is also known as the Peritel connector or Euroconnector; the cast name is misleading since there are other plugs known as Euroconnectors and the plug is used all over the world anyway.

The original intention was praiseworthy, to simplify the connection of TVs, video recorders, home computers and TV games. The French deserve the credit for devising a universal connec-

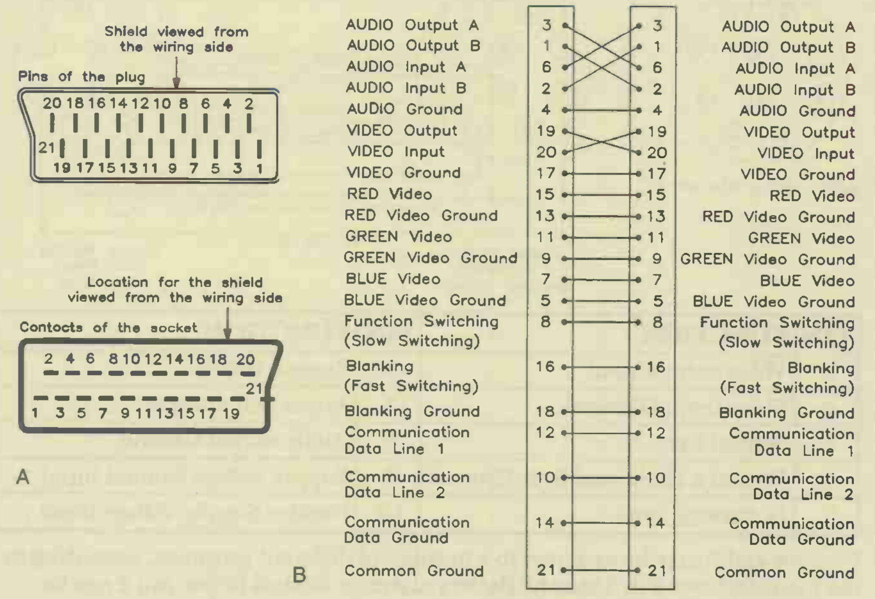
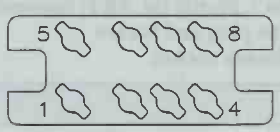


Figure 5. Peritel (SCART) connector: (a) plug and socket pin numbers; (b) crossed connection diagram for interconnecting AV equipment.

tor catering for all options, and bypassing modulator and tuner compromises to give viewers a better picture. Wicked people say it was really a ruse by the cunning French to restrict imports, because it was made mandatory on all TV sets sold in France since 1980. Far from discouraging foreign TV manufacturers, the SCART socket was adopted (fairly) enthusiastically by all concerned.

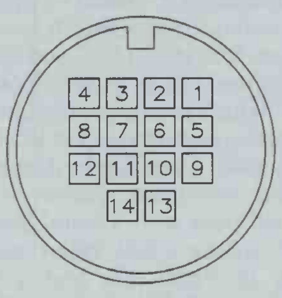
There's an old saying among engineers: "Sure, we're in favour of rigid standards; that's why we support so many of them!" This is particularly true of the SCART system which, for all its mechanical weaknesses, did start to look as if it might become a world standard for audio-video connections in the consumer field. Sadly people started making modifications and exceptions to the standard, with the result that there are now several variants in the wiring and pin-assignment of the connector. Never mind: most SCART connections conform to the main, most common wiring system. A line plug and socket are shown in Photo 7a and a chassis socket in Photo 7b. Figure 5a shows the plug and socket pin numbers, and Figure 5b the crossed connection diagram for interconnecting AV equipment.

The names, by the way, are derived as follows. SCART reminds us of the committee which invented it, the Syndicat des Constructeurs d'Appareils Radiorćepteurs et Téléviseurs (association of radio and TV receiver manufacturers). Peritel connects peripheral equipment to the *tele*vision.



PIN	FUNCTION
1	Audio input
2	Video input
3	Ground
4	Video output
5,6,7	Ground
8	Audio output

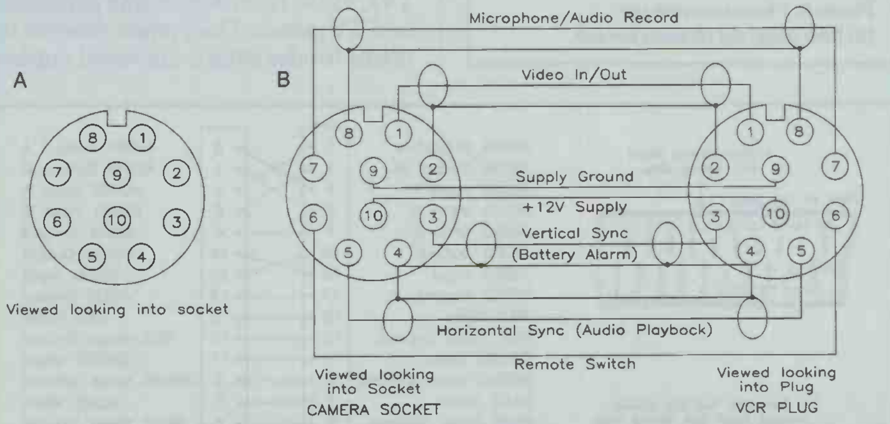
Figure 6. Pin numbers for EIAJ connector.



PIN	FUNCTION
1	Video out
2	GND
3	Video in
4	GND
5	Remote
6	Tally signal
7	Mike out (2CH)
8	$\overline{\text{REC}}$ Control
9	Mike out (1CH)
10	Mike GND
11	Mike in (1CH)
12	Mike in (2CH)
13	12V
14	GND

Pin 12 is sometimes used for GND (ground, earth).

Figure 8. K-type connector pin numbers.



PIN	FUNCTION	PIN	FUNCTION
1	Video output/input	6	Remote switch
2	Video output Ground	7	Audio output/input
3	Vertical Sync.	8	Audio output Ground
4	Vertical & Horizontal Sync Ground	9	Supply Voltage Ground input
5	Horizontal Sync.	10	Positive Supply Voltage input

Pins 3,4 and 5 may be assigned to a number of different purposes, according to the manufacturer. Pin 3 may be Battery alarm or Vertical Drive; pin 5 can be Audio playback or Horizontal Drive. Pin 4 is always ground.

Figure 7. J-type connector: (a) pin numbers; (b) camera/VCR connections.

Photo 8. EIAJ Plug.

Photo 9. J-type connectors.

SCART WARNING

There are many traps for the unwary with the SCART connector so it may pay you to read the following carefully.

1. Check the mechanical assembly of the plug after you have wired it. It is easy to assemble it wrongly, so that the pins do not mate properly with the female connector. Fortunately, the plug can be inserted only one way into the socket.
2. Many made-up leads sold commercially do not have all pins connected, nor do they all use individually screened cable for each connection. The former can lead to mysterious malfunctions, the second to patterning on the picture due to breakthrough between the separate R, G and B signals. You have been warned.
3. Some VCRs connect pin 8 of the SCART connector to +12V, whilst some connect it to ground. If two dissimilar machines are connected with a straight-through connection between their respective pin 8s, fuses will inevitably blow. Again, you have been warned (thanks to Steve Beeching for this tip).

Most of the connections are self-explanatory but some are not. Pins 10 and 12 are for communication purposes and are undefined. Remote control was their original designation, being intended for D^2B, the domestic data bus (now called the digital data bus). This was an ambitious scheme for controlling all household appliances by computer, but has yet to take off. Some of the terminology must have got mangled in translation and the so-called fast-blanking input (pin 16) is a supremely meaningless term. In reality it is no more than a toggle between normal TV viewing and RGB display; it is inactive during TV reception, and active when the TV display is used for anything else. Source switching (pin 8) is inactive during TV reception, and active when the TV is to be used as a video monitor. It also switches the TV between internal and external syncs, and on some TVs is used as a control signal to switch to reduced-height *widescreen* mode.

EIAJ

Also known as the Honda plug, Photo 8, this 8-pin connector was widely adopted during the 1960s and 70s by Sony and other Japanese manufacturers. It is found on video monitors, open reel and U-Matic video recorders. Figure 6 shows the pin numbers for the EIAJ connector.

JAPANESE J-TYPE

The main manufacturer of this 10-pin connector is Hirose (pronounced Hiroshi) and for a while it looked as if the pin assignments were going to be standardised. In the event, most of the pins were (and recognising this, the Akai VX-2 camera came equipped with a configuration switch to match different recorders!). The connector is found on older VHS cameras and recorders; it tended to fall into disuse once camcorders replaced separate cameras and portable recorders. Photo 9 shows the inline socket, plug and chassis socket for the J-type. On mains recorders it has been replaced by the SCART. Figure 7a shows the pin numbers, with Figure 7b showing the wiring between the camera/VCR connections.

Photo 10. K-type connector.

Photo 11. 8-pin mini DIN AV connector.

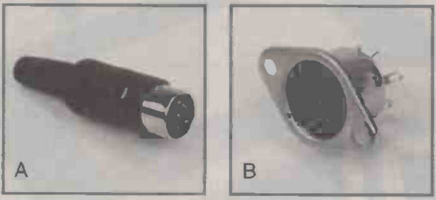


Photo 12. (a) 6-pin DIN AV plug; (b) socket.

JAPANESE K-TYPE

For its Betamax video recorders and cameras Sony could hardly adopt the same standard as the VHS camp, so they developed their own style, with 14 pins, see Photo 10, (not to be confused with a similar but different connector on their broadcast gear). The J-type was, however, used on some Sony professional cameras and recorders. Because the K-type connector was not used by other manufacturers it was only supplied as a spare part by Sony and was not found in general catalogues. The K-type connector pin numbers are shown in Figure 8.

8-PIN MINI DIN AV CONNECTOR

This is another connector that started off with a standardised pin assignment, but then some manufacturers had to break ranks. Since then manufacturers have added Y/C video and stereo sound functions to certain pins, which vary from one manufacturer to another. The connector is shown in Photo 11, and if

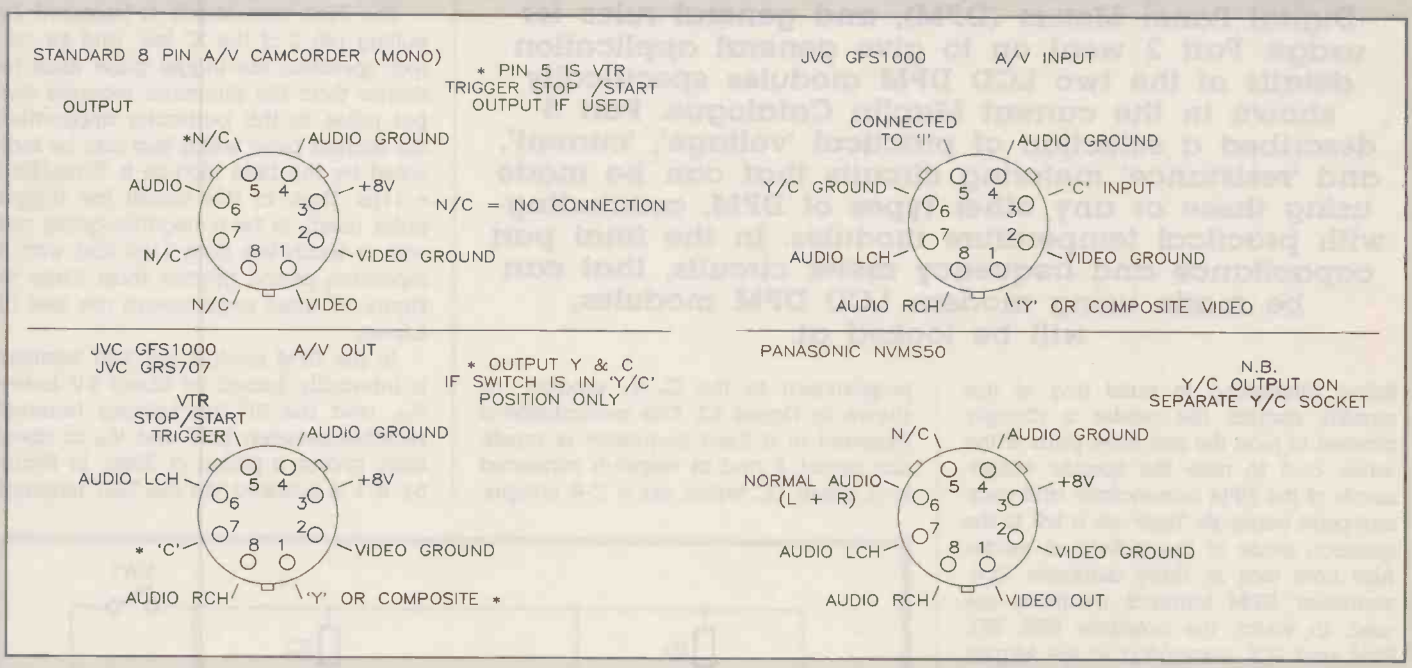
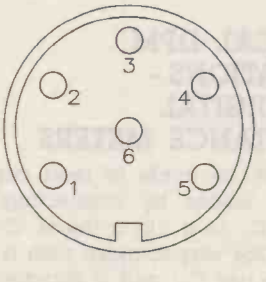


Figure 9. Examples of 8-pin mini DIN AV connector signal designations.

PIN	FUNCTION (RECORD)	FUNCTION (REPLAY)
1	Switching input, 0V	Switching input, +12V
2	Video output	Video input
3	Ground	Ground
4	Audio 1 output	Audio 1 input
5	No connection (DIN 45322) or Supply input, +12V (DIN 45482)	No connection (DIN 45322) or Supply input, +12V (DIN 45482)
6	Switching voltage, +12V (DIN 45322) Audio 2 output (DIN 45482)	Switched to pin 1 (DIN 45322) Audio 2 input (DIN 45482)



Allocation of pins 5 and 6 varies, according to the manufacturer; pin 6 can also be used for colour burst.

Figure 10. 6-pin DIN AV connector.

Continued on page 69

PART FOUR

by Ray Marston

HOW TO USE LCD DIGITAL Panel Meters

Part 1 of this series explained the basics of LCD Digital Panel Meters (DPM), and general rules for usage. Part 2 went on to give general application details of the two LCD DPM modules specifically shown in the current Maplin Catalogue. Part 3 described a selection of practical 'voltage', 'current', and 'resistance' metering circuits that can be made using these or any other types of DPM, concluding with practical temperature modules. In the final part capacitance and frequency meter circuits, that can be made using modern LCD DPM modules, will be looked at.

Before attempting to build any of this month's circuits, the reader is strongly advised to read the first three parts of the series, and to note the specific assignments of the DPM annunciator and decimal-point terminals. Their use is left to the common sense of the individual reader. Also note that in these diagrams 'conventional' DPM terminal notations are used, in which the notations RFH, RFL, ROH, and ROL correspond to the Maplin module notations 'REF HI', 'REF LO', 'REF +', and 'REF –' respectively. Similarly, 'conventional' DP notations are used, in which DP1 corresponds to the left-hand decimal point, etc.

PRACTICAL DPM APPLICATIONS – BASIC DIGITAL CAPACITANCE METERS

A DPM can be made to read capacitance (C) values by connecting the unknown 'C_x' to it via a linear 'C'-to-V converter. One way to make such a converter is to use 'C_x' and a standard resistor (R_x) as the timing elements in a precision monostable. This generates an output pulse with a width (W) linearly proportional to the C_x-R_x product, as shown in Figure 52. This monostable is triggered at a fixed frequency or repetition period, P, and its output is converted to a mean DC value via a C-R integrator. This mean value equals the peak pulse amplitude multiplied by W/P and, since Rx and P are fixed, is directly proportional to C_x; the DPM thus acts as a digital Capacitance Meter when this voltage is fed to its input.

In Figure 52 the DPM's reference (RFH) voltage is derived from the monostable's supply rail via divider R2 and R3, so (since the DPM reads the ratio of the input and reference voltages) the unit's calibration is independent of variations in supply rail voltage, but can be varied by altering the ratio of R2 and R3. The circuit can be made to read different capacitance ranges by switching R_x in decade multiples.

A PRACTICAL CAPACITANCE METER

Figure 53 shows a practical example of the basic Figure 52 circuit. It uses a 7555 timer IC (a CMOS version of the 555) as its precision monostable, with decade values (1k to 10M) of R_x used for range selection. This monostable generates a pulse width of 1·1 x C x R, thus giving a full-scale pulse width (at '1999' on the DPM) of 22ms with C and R values of 1·999nF and 10M, or 19·99μF and 1k, etc. To give the 7555 adequate recovery time between pulses the clock period must be at least 50% longer than the maximum pulse width; it must be at least 33ms.

The 7555 monostable is triggered by pulling pin 2 of the IC low, and for correct operation the trigger pulse must be shorter than the minimum required output pulse. In this particular application the shortest pulse width that can be indicated by the DPM module is 22ms/2000 = 11μs. Thus, in this circuit the trigger pulse needs to be a negative-going one with a width less than 11μs and with a repetition period greater than 33ms. In Figure 53 these requirements are met as follows.

In the DPM module the TEST terminal is internally biased at about 5V below V_{DD}, and the BP (backplane) terminal switches between TEST and V_{DD} at about 50Hz, giving a period of 20ms. In Figure 53, IC1 is powered via the TEST terminal,

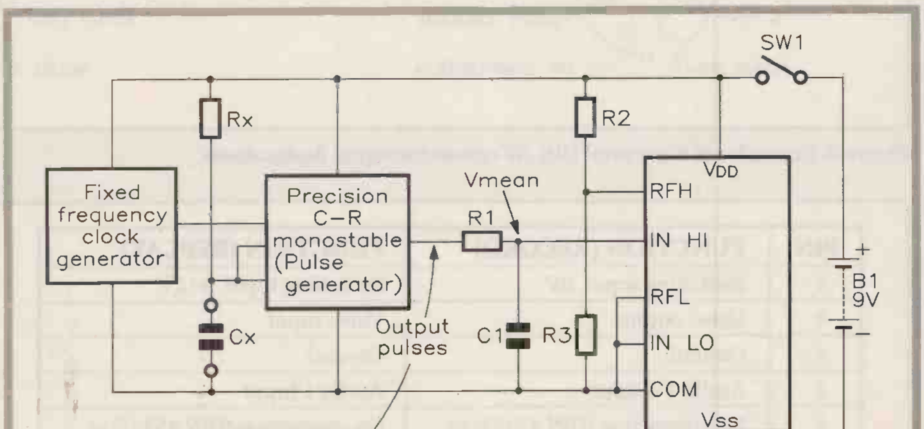
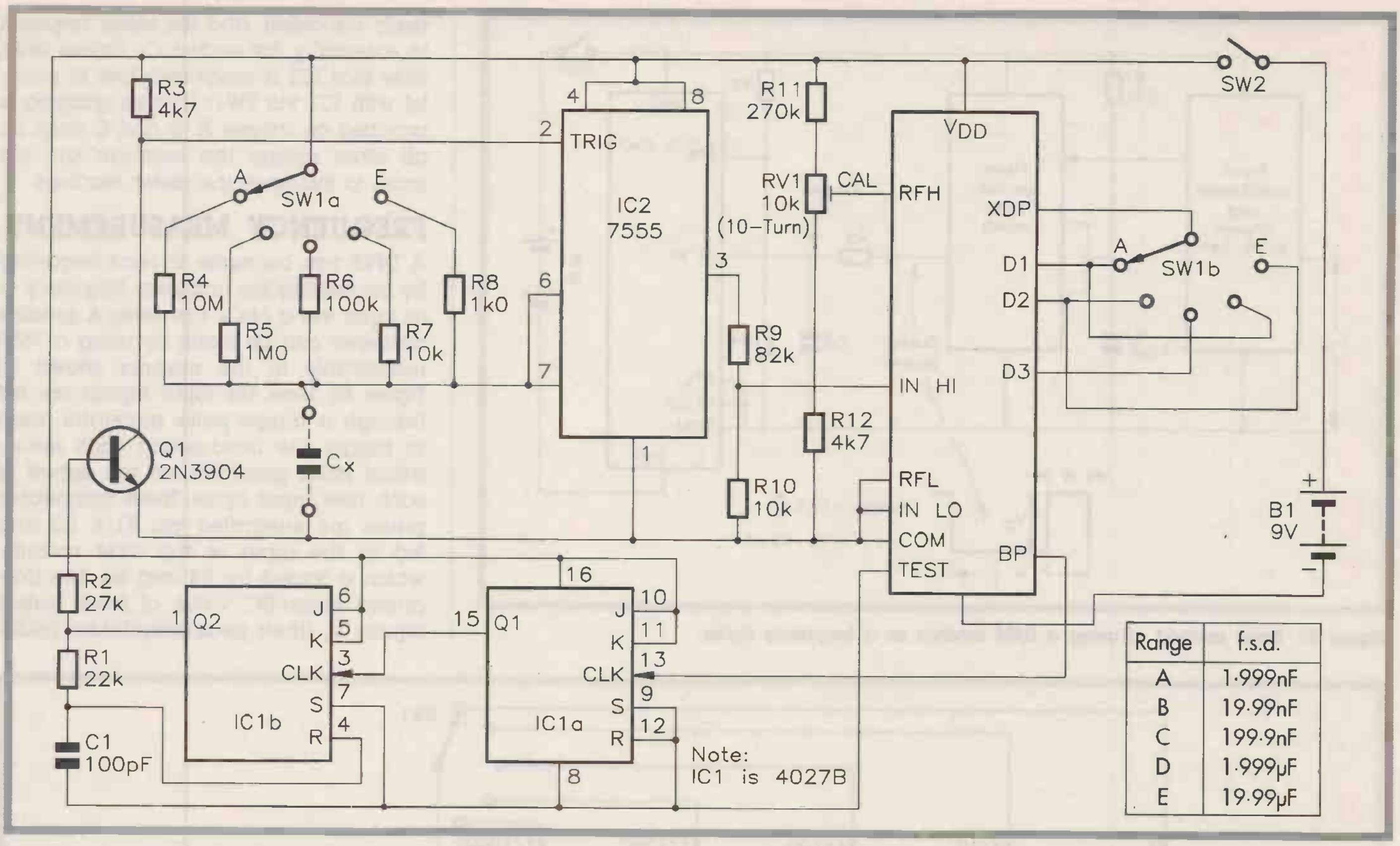


Figure 52. Basic operating principle and circuit of a Digital Capacitance Meter.



Range	f.s.d.
A	1·999nF
B	19·99nF
C	199·9nF
D	1·999µF
E	19·99µF

Figure 53. Digital Capacitance Meter.

and the BP signal is divided by 2 by flip-flop IC1a. The resulting 25Hz (40ms) signal clocks IC1b, which is configured as a monostable and generates (using R1 and C1) positive-going output pulses of 2µs width. These pulses are inverted and level shifted by transistor Q1, to produce negative-going 2µs trigger pulses with periods of 40ms on the pin 2 TRIG terminal of monostable pulse generator IC2.

IC2's pulse width is controlled by C_x and range resistors R4 to R8. Its output is attenuated by R9 and R10 to give a mean value of about 100mV at the mid-scale ('1000') setting of the DPM, and the resulting signal is fed to the DPM's IN HI terminal, where it is integrated by its internal 1M and 10nF filter. Divider R11, RV1 and R12 feeds nominally 100mV to the RFH terminal of the DPM, and RV1 is used to adjust the precise calibration of the Capacitance Meter.

The precision of the Figure 53 circuit is determined mainly by its R4 to R8 range resistors, which should be 1% or better types. To calibrate the circuit, simply connect a precision capacitor (say 100nF) in place as C_x, switch to the appropriate range, and trim RV1 for the appropriate meter reading. Calibration is then valid on all ranges.

A PRECISION CAPACITANCE METER

The Figure 53 circuit suffers from two minor defects. The first is that the periods of its BP-derived 40ms clock signals (and thus the circuit's calibration accuracy) drift by as much as 0·5% with variations in temperature and battery voltage. The second snag is that the circuit reads ALL capacitance, including residuals, appearing between its C_x terminals, and these total about 32pF with no external C_x connected. These residuals are too small to be read on ranges C to E, but (for maximum accuracy) must be subtracted from all readings obtained on ranges A and B.

Figure 54 shows how the circuit can be modified so that residual capacitance is effectively cancelled out and the meter reads zero on all ranges when no external capacitance is connected to the C_x terminals. In this case the BP-derived signal is used to trigger two 7555 monostables simultaneously. Their outputs are EXclusive-ORed by IC4 to give a pulse equal to the difference between their pulse widths, and this 'difference' pulse

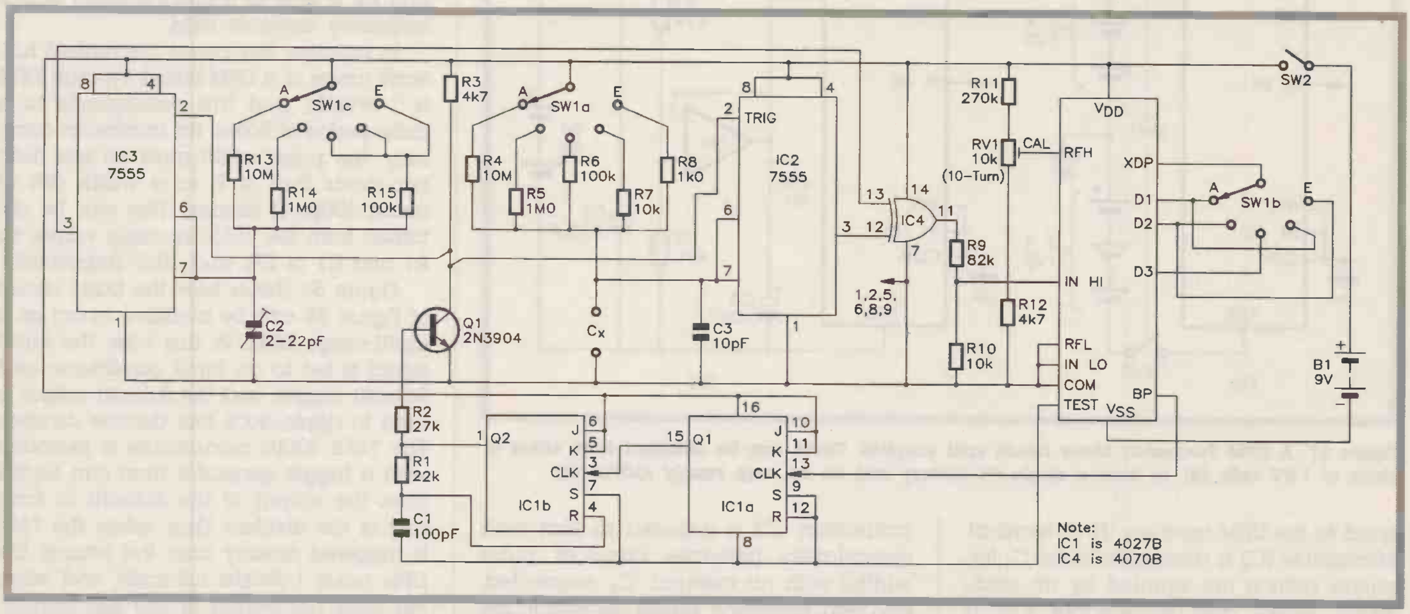


Figure 54. Precision Capacitance Meter with zero residual reading.

is fed to the DPM module's IN HI terminal. Monostable IC2 is connected to the C_x terminals (which are shunted by an additional 10pF), and monostable IC3 is 'timed' by trimmer capacitor C2. During calibration, C2 is adjusted so that both monostables generate identical pulse widths with no external 'C_x' connected, and zero 'difference' pulses are sent to the DPM. The circuit's residuals are thus effectively cancelled, and the meter responds to externally connected C_x values only. Note that IC3 is range-switched in parallel with IC2 via SW1c. Precise ganging is provided on ranges A, B and C only; on all other ranges the residuals are too small to influence the meter readings.

FREQUENCY MEASUREMENT

A DPM can be made to read frequency by connecting the unknown frequency to its input via a f-to-V converter. A suitable converter can be made by using a 7555 monostable in the manner shown in Figure 55. Here, the input signals are fed through a trigger-pulse generator, used to trigger the fixed-period 7555 monostable pulse generator, on the arrival of each new input cycle. These monostable pulses are integrated via R1 & C2 and fed to the input of the DPM module, which is scaled by R3 and R4. The integrated mean-DC value of these pulses equals V_p (their peak amplitude) multiplied by W (their Width) and f (the input frequency). V_p and W have fixed values, however, so the DC signal reaching the DPM is directly proportional to f. Thus, when the DPM is suitably scaled by R3 and R4, it acts as a direct-reading digital frequency meter, or DFM.

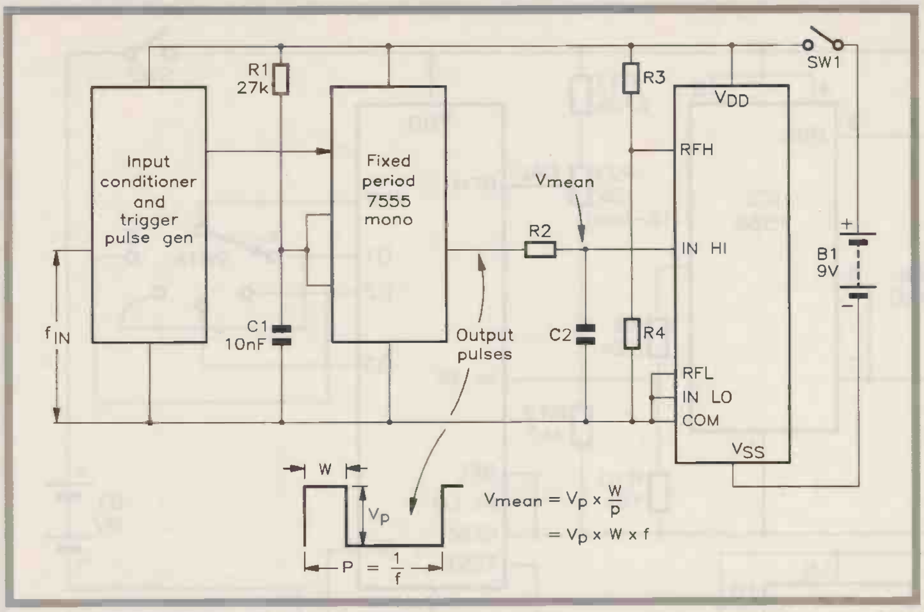


Figure 55. Basic method of using a DPM module as a frequency meter.

In practice, the lowest convenient full-scale range of a DPM-based 3½-digit DFM is 1·999kHz, and this corresponds to a pulse period of 500µs. For maximum accuracy, the pulse width must be less than two-thirds that of P, so a width (W) of about 300µs is needed. This can be obtained from the 7555 by using values for R1 and C1 of 27k and 10nF respectively.

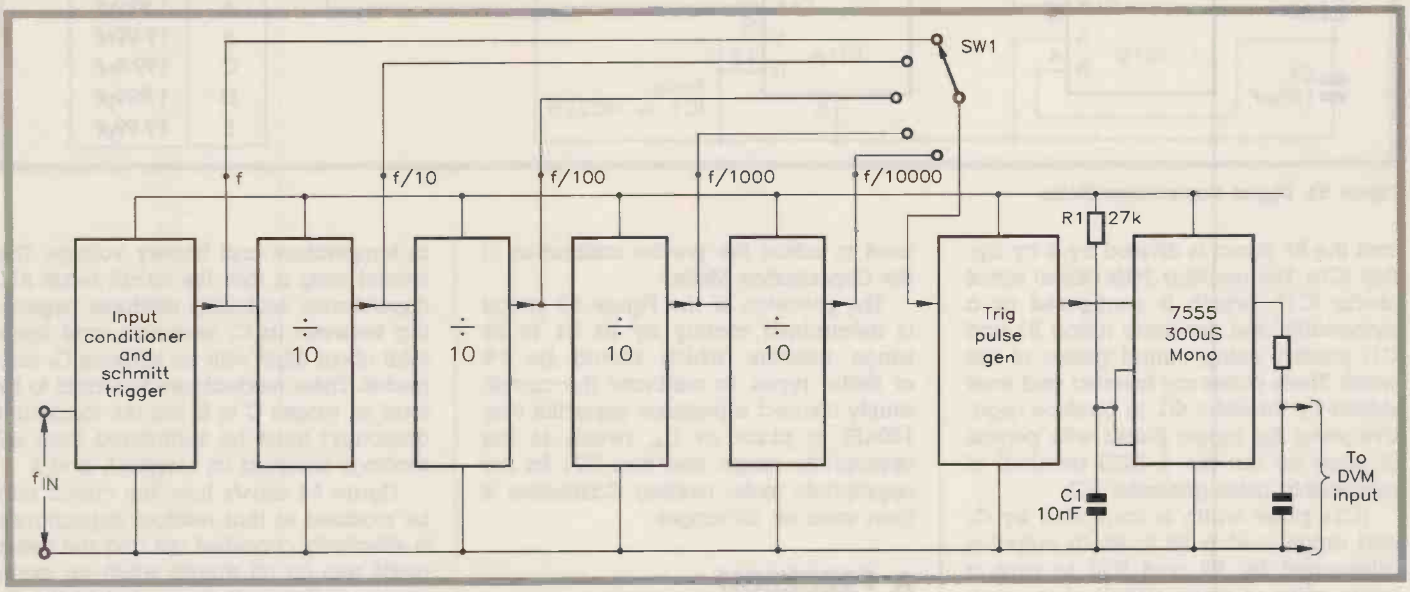


Figure 56. Basic method of using a DPM as a multi-range Frequency Meter.

Figure 56 shows how the basic circuit of Figure 55 can be modified to act as a multi-range DFM. In this case the input signal is fed to an input conditioner and Schmitt trigger, and the Schmitt output is used to ripple-clock four decade dividers. The 7555 300µs monostable is provided with a trigger generator than can be fed from the output of the Schmitt or from any of the dividers. Thus, when the 7555 is triggered directly from the Schmitt the DPM reads 1·999kHz full-scale, and when fed from the output of the last divider, 19·99MHz full-scale.

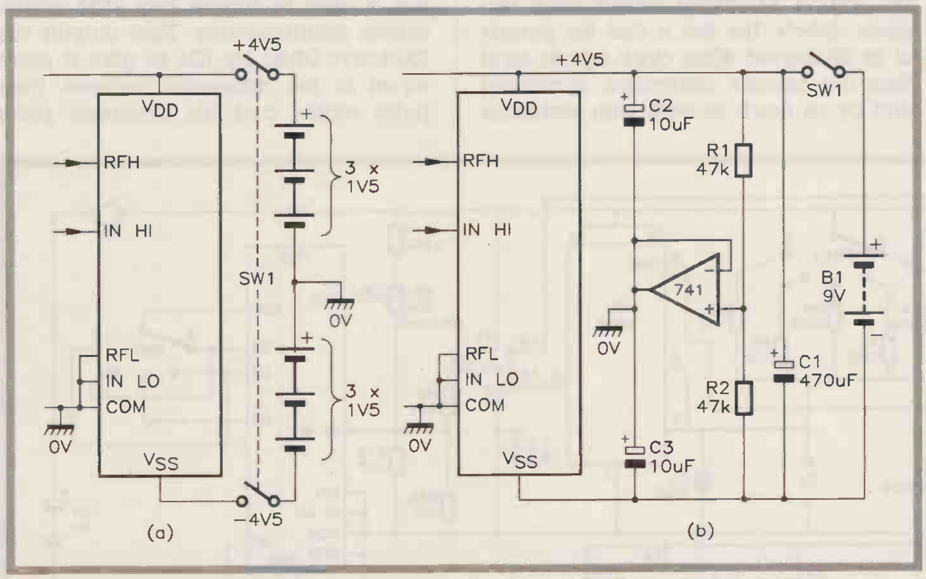


Figure 57. A DPM Frequency Meter needs split supplies. These can be obtained from either a stack of 1·5V cells (a), or from a single 9V battery and an op amp supply splitter (b).

PRACTICAL FREQUENCY METERS

The DPM module, as a DFM, must be interfaced to the divider chain so that its COM terminal is maintained below the normal 'V_{DD} - 2·8V' value by external means. This is because standard CMOS ICs need a supply of at least 3V. With COM at '0V', the DPM V_{DD} and V_{SS} values are about +4·5V and -4·5V respectively, making +4·5V available for the divider chain. Figure 15 (see Part 1) shows one way of obtaining these supplies. Alternatively, Figure 57a shows how the supplies can be obtained from a stack of six 1·5V cells, or Figure 57b shows how they can be obtained from a single 9V battery using an op amp supply-splitter. The supply-splitter of Figure 57b adds a quiescent current consumption of about 2mA to that already being drawn, but it can supply additional currents of tens of mA to circuitry connected between +4·5V and 0V.

Figure 58 shows the practical circuit of a DPM-based DFM that reads up to 19·99MHz full-scale in five decade ranges. When used with the Figure 57b power supply the circuit consumes about 3mA quiescent from a 9V battery, rising to 4mA at 1MHz, and (when calibrated) has a reading accuracy of ±1 digit. The circuit accepts input signals in the range 200mV to 5V rms, and operates as follows:-

Input signals are fed, via C1 and R1, to the input of IC1a, a very fast Schmitt trigger, which is biased at half supply level by R2 and R3. The Schmitt output is used to clock four ripple decade counter stages. Ordinary CMOS dividers operate up to maximum speeds of only 1MHz when operated from a supply of 4·5V, so to achieve the required high operating speed, 'HC' types of silicon-gate CMOS counters are used in the first two (IC2 and IC3) counter positions. On the prototype unit these operate well up to about 18MHz.

The outputs of the Schmitt trigger stage IC1a and the four divider stages are fed to a range-selector SW1a, and then passed on to the 4µs trigger-pulse generator C4, R4, IC1b and IC1c, which triggers the 7555 monostable using transistor Q1. The output of the 7555 is fed to IN HI of the DPM via a potential divider R8 and R9, while a calibration 'reference' voltage is presented to RFH via RV1. The circuit is calibrated by feeding in a signal of known frequency, switching to the appropriate range, and trimming RV1 for the appropriate reading on the DPM module. Once the initial calibration is complete, accuracy is influenced only by variations in the 7555's pulse width, caused by thermal variations in the values of R7 & C5. For optimum calibrated accuracy, R7 should be a high stability metal-film resistor, and C5 a polycarbonate capacitor.

The circuit of Figure 58 can be modified in a variety of ways, to satisfy individual needs. Figure 59 shows a 1MHz crystal calibration oscillator, designed around one section of a 4007UB CMOS IC, which can easily be added to the DFM and consumes a mere 300µA when active. Figure 60 shows two simple pre-amplifiers that can be used to improve the basic sensitivity of the meter. The design of Figure 60a, based on one section of a 4007UB, has an input impedance of about 1M and improves sensitivity by about 20dB (to 20mV) at audio frequencies, but is useful to only a few hundred kHz. The simple design of Figure 60b also gives a gain of about 20dB at low frequencies, but has a low input impedance (about 2k2) and is useful to several MHz. Each circuit consumes a couple of mA.

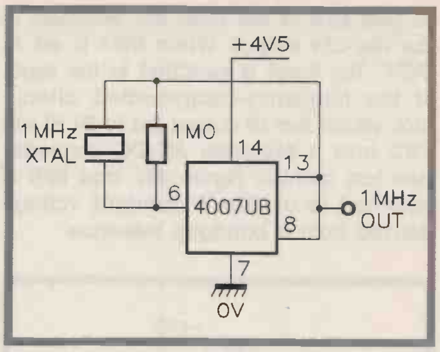


Figure 59. This 1MHz crystal calibration oscillator can easily be added to the DFM circuit.

Figure 61 shows, in basic form, how the DPM module can be used to read both frequency and AC volts (or any other desired parameter). With SW1 switched to 'f', the input is switched to the input of the f-meter circuit, and IN

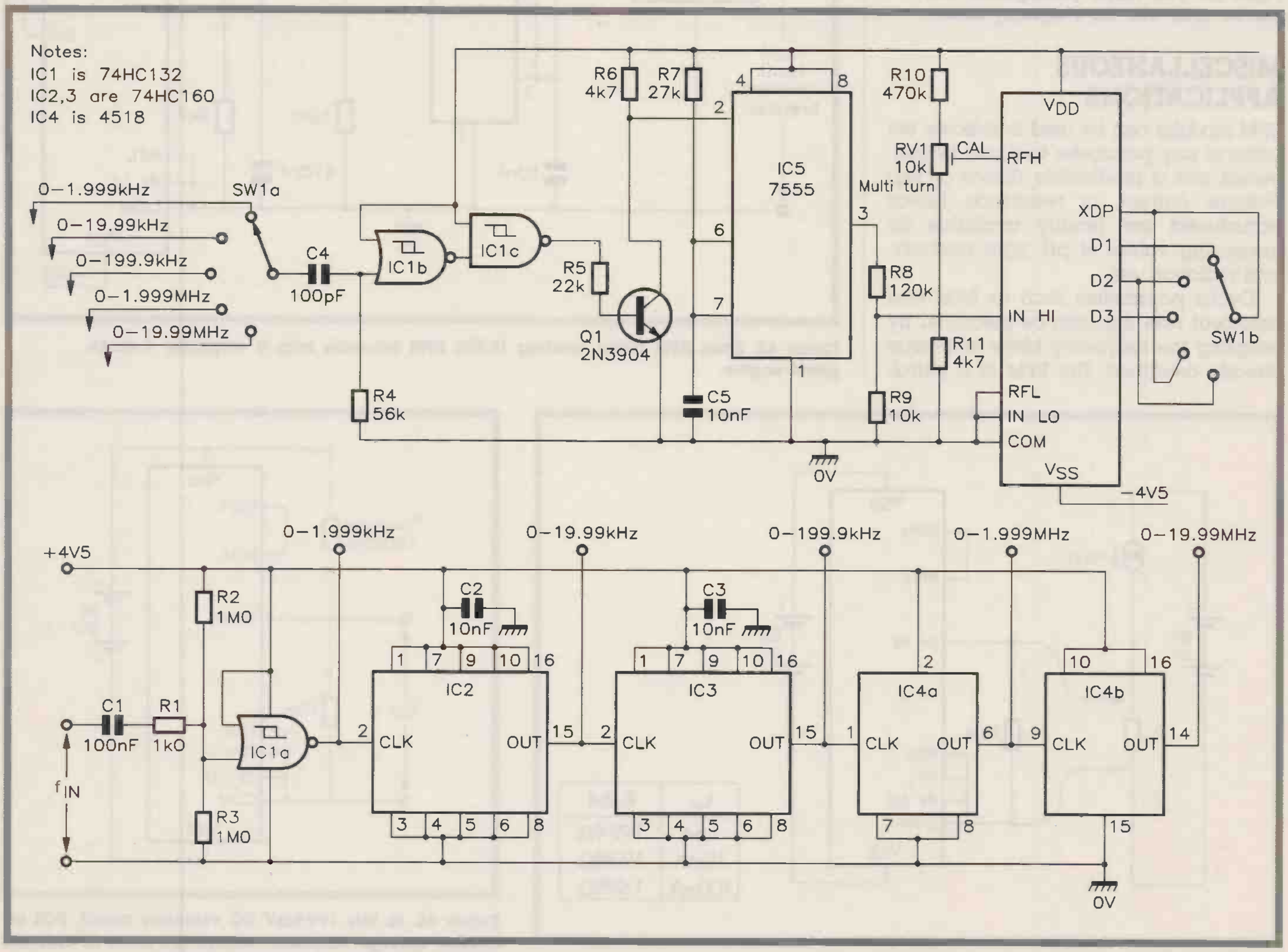


Figure 58. Digital Frequency Meter, reading 0 to 19·99MHz in five decade ranges.

HI and RFH of the DPM are switched to the circuit's output. When SW1 is set to 'ACV', the input is switched to the input of the frequency-compensated attenuator, which has its output fed to IN HI via SW2 and a precision AC/DC converter (see last month's Figure 42), and RFH is switched to a 100mV standard voltage derived from a bandgap reference.

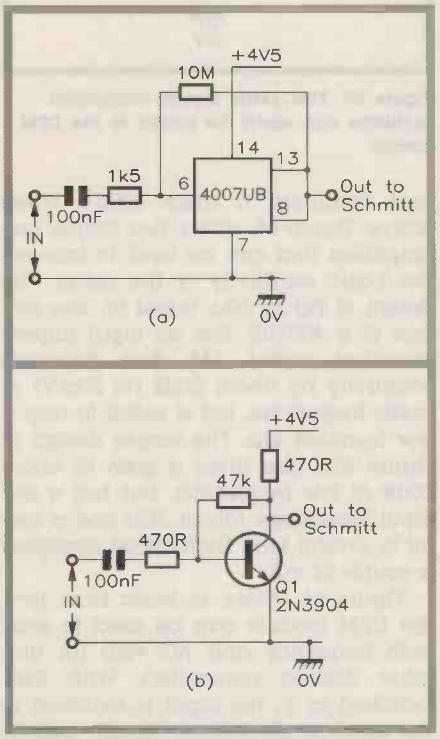


Figure 60. Two simple preamplifiers that can be used with the Frequency Meter.

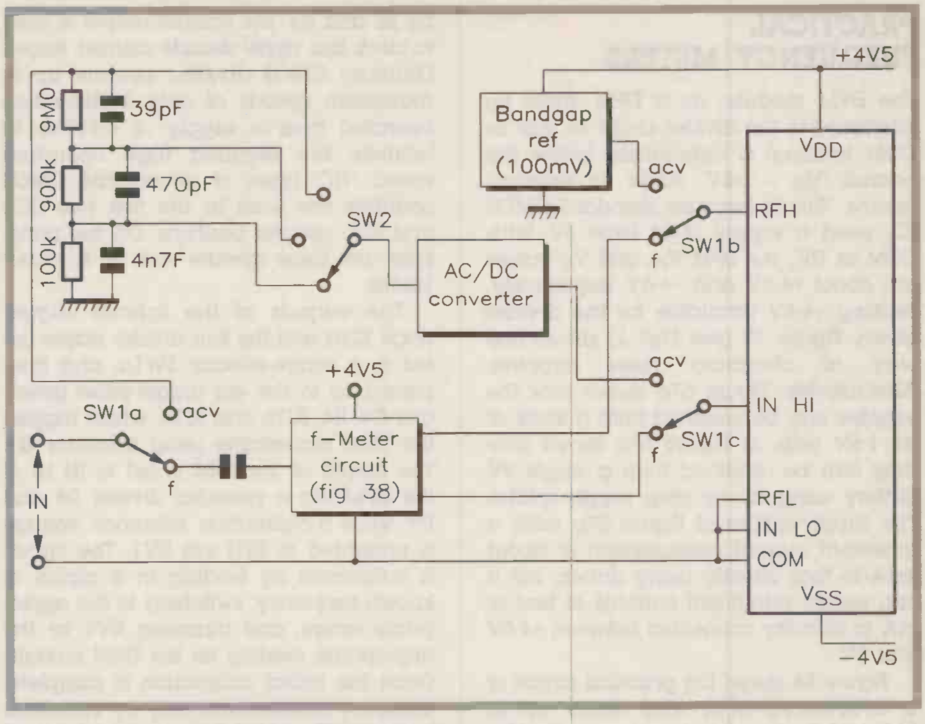


Figure 61. Combined Frequency/ACV meter (basic circuit).

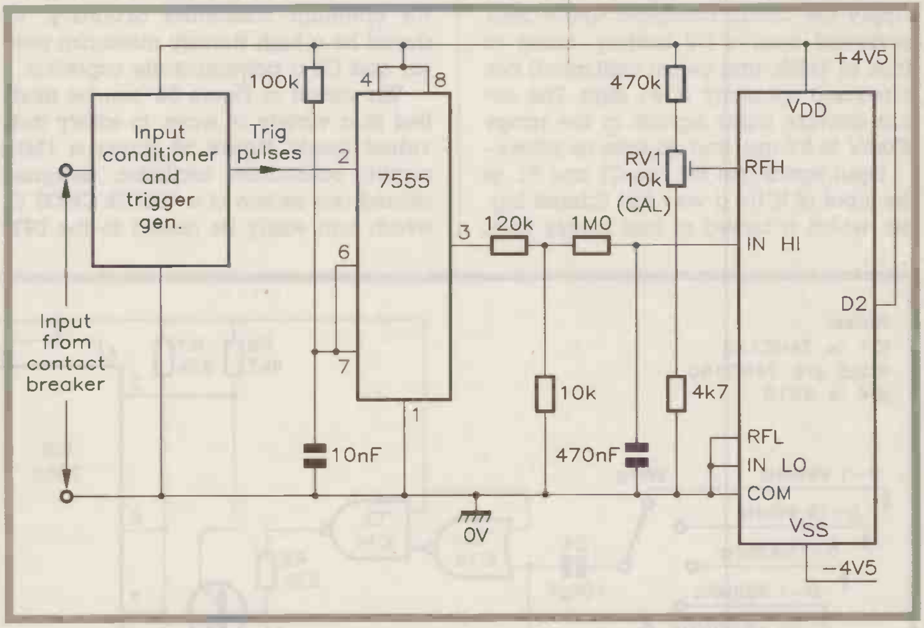
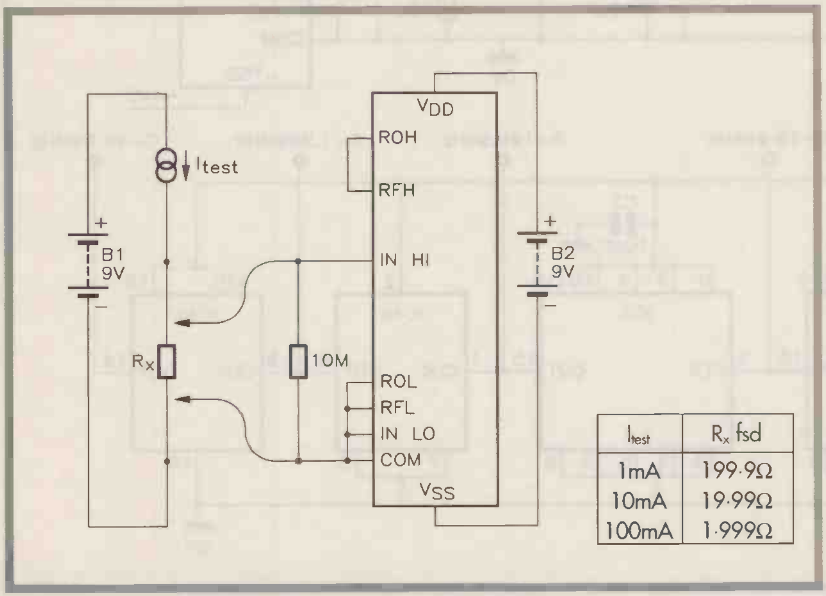


Figure 62. Basic RPM meter, reading 19,990 RPM full-scale from a 4-cylinder 4-stroke petrol engine.

MISCELLANEOUS APPLICATIONS

DPM modules can be used to indicate the value of any parameter that can be converted into a predictable (linear or log) voltage, current, or resistance. Linear transducers are readily available for measuring values of pH, light intensity, and radiation, etc.

Cyclic parameters such as RPM and heartbeat rate, etc., can be measured by adapting the Frequency Meter technique already described. The RPM of a petrol-



I_{test}	R_x fsd
1mA	199·9Ω
10mA	19·99Ω
100mA	1·999Ω

Figure 63. Basic milliohmmeter, using 4-terminal measurement technique.

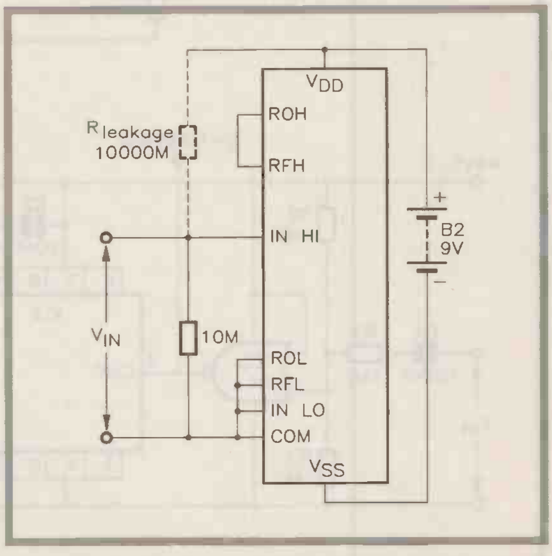


Figure 64. In this 199·9mV DC voltmeter circuit, PCB or module leakage resistance causes the meter to indicate 28·0mV with no external input applied.

powered engine, for example, is directly proportional to its contact-breaker (CB) frequency, f. On a 4-stroke engine, f = N x RPM/120, where N is the number of cylinders. Thus, on a single-cylinder engine 10,000 RPM gives a CB frequency of 83·3Hz, and on a 4-cylinder engine a frequency of 333·3Hz. Figure 62 shows the basic circuit of a digital RPM meter, designed to read 19,990 RPM full-scale (10,000 RPM at mid-scale) on a 4-cylinder 4-stroke engine; the 7555 monostable output pulses have a 1ms width.

When measuring low values of resistance, care must be taken to ensure that the resistive effects of range switches and terminals, etc., are excluded from the measurement results. The best way of achieving this is to use the 4-terminal technique of Figure 63, which uses two independent circuits. The unknown resistor is connected between the R_x terminals and fed with a constant current from B1, and the voltage drop directly across R_x is measured by a 199·9mV full-scale DC voltmeter powered from B2. Thus, when 10mA is fed through R_x, the DPM indicates 19·99Ω full-scale.

CONSTRUCTIONAL NOTES

When using DPM modules, two vital points must be noted. The first arises from the DPM's high sensitivity, and is illustrated in Figure 64, where the DPM is wired as a 199·9mV DC voltmeter with a 10M input resistance. Thus, if a leakage resistance of 10,000MΩ appears between V_{DD} and IN HI, the meter will read 28·0mV with no external input applied. Leakage resistance of this magnitude can be caused by minute amounts of moisture, dirt, or oil, etc., between the tracks of the module's PCB. To counter this effect the PCB and its terminals must, after project construction is complete, be coated with a good quality insulating varnish.

The final point concerns the use of external components, which in all cases must be high stability types. All resistors should be metal film, while critical capacitors should be polycarbonate types.

The reader is asked to note that this mini-series is based on Chapter 7 of the author's *Instrumentation and Test Gear Circuits Manual* (published by Butterworth-Heinemann Ltd.), with extra material, derived from data sheets supplied by Lascar Electronics Ltd., added. The book is available from Maplin, Order As AA37S Price £16.95*NV*.

MAKING THE RIGHT CONNECTIONS IN VIDEO – ***Continued from page 63.***

you are making leads to connect a camcorder to another video recorder you certainly need to know which pins are used for each purpose on your particular model. See Figure 9 for examples of 8-pin mini DIN AV connector signal designations.

THE TRUE ORIGIN OF CONNECTOR NAMES

BNC	Baby (or Bayonet) Neill Concelman. A baby-size combination of the designs of Neill and Concelman.
C	Concelman. Developed by Carl Concelman of Amphenol.
DIN	Deutsche Industrienormen Ausschuss (German standards-making authority, similar to our British Standards Institution).
EIAJ	Electronics Industry Association of Japan.
MUSA	Multiple Unit Steerable Array. Developed in the 1930s by the GPO.
N	Neill or Navy type. Originated in 1942 by Paul Neill of Bell Labs and standardised on a Navy Bureau of Ships drawing.
RCA	Radio Corporation of America.
UHF	Ultra High Frequency. Developed in 1940 by E. C. Quackenbush of the American Phenolic Corporation (later Amphenol). At the time this connector was designed, UHF meant what we call VHF today.

6-PIN DIN AV CONNECTOR OR EUROCONNECTOR

Yes, this is another contender for the title of Euroconnector! For a while it was quite popular on VHS machines and TVs but has been supplanted by SCART connectors. Photo 12 shows the 6-pin DIN AV plug and Figure 10 shows the connections.

AUXILIARY FACILITIES

A variety of plugs and sockets are used on some cameras for auxiliary facilities, and these use multipole connectors similar to the combined audio and video ones (generally DIN and various Cannon designs). They are, however, too complex and varied to detail here, and although there were several standard wiring schemes the item's service manual is the best guide to connections.

Note: A series by T. A. Wilkinson (A Guide to Professional Audio, parts 1 and 2) dealt with professional audio connectors and cables; these appeared in the April and May 1993 Issues of *Electronics*.

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VARIOUS

BEARCAT 55XLT SCANNER as new, boxed. 29 to 512MHz, £55. Tel: Alan (021) 707 1269 evenings (Birmingham).

DATA BOOKS. Integrated circuits linear and digital. All recent editions. Tel: Cliff (0602) 522646.

FOR SALE 49 copies of *Electronics* Mag. No. 7, Nos. 13 to 39 (not 32 & 38), Nos. 44 to 67 (not 54). £10 the lot. Buyer collects. Croxson, 38 King Street, Felixstowe IP11 9DX.

QUALITY RF RELAYS, N-Type and BC versions. Cost New £35. Yours for £4 each, Swiss Electromechanical Pulse Counters made by Sodeco, £5 each. For details call Mike (0604) 756380.

TELEQUIPMENT SERVISCOPE S51B £45, Tekrontix 555 Dual Beam Oscilloscope £45, Rikadenki X-Y Plotter RY-11Z £60, Avo Model 8. £35, Scientifica Gas Laser B/17L (needs attention). £15. Tel: (0732) 740533 (Sevenoaks).

NEW COMPONENTS plus free PCB mounting Ni-Cd, assorted mixture. List price £50 plus. £12 per bag inclusive of postage and packing. Mr D. J. Brown, 2 Glentworth Avenue, Whitmore Park, Coventry, West Midlands CV6 2HW.

WANTED

SIEMENS SAB8748-8-D microprocessor chip (obsolete) and data if available please. Is there a current pin/pin replacement? Frank Cosgrove, 59 Fenton Road, Bournemouth BH6 5BS (Tel: 0202-432973).

DISASSEMBLER PROGRAM for Intel 8085 microprocessor to run on 8085 or IBM PC compatible. Derek Slater, Rear 25 New Market Street, Colne, Lancashire BB8 9BJ.

MICROPROFESSOR MPF-IP CPU Board (and case?) required by college student for experimental EPROM programming, will also consider sound boards. Cash waiting, Tel: Alex (0691) 623703, (after 4.00pm).

FOR ATARI XL/XE COMPUTER. Atari 850 Interface Serial/Parallel connection, or Datari; RS232 interface with manual and driver program on disk or cassette. Tel: Chris Thorpe (0252) 393832 (daytime).

MAPLIN 61-NOTE MUSICAL KEYBOARD (XB16S). David Pickett, 4418 Blackstone Court, Bloomington, IN 47408, USA. Tel/Fax: 010 1 812 332 9233.

COMPUTERS

CASIO FX730P COMPUTER complete with tape interface and compatible recorder £30, also C.S.I. cordless intruder alarm, inc. 2xPIRs and siren. Requires repair, offers please. Tel: (0960) 322593.

BBC MODEL B CIRUIT DIAGRAMS. Send a £2 cheque or postal order to: Clive Roberts, University Hall, Pen-y-Lan, Cardiff CF2 5YB.

MUSICAL

MIDI SCAN UNIT (Sept. Maplin Mag.) with power supply, fitted to uncased pedal-board. Working, £45. Sansui A40 Amp £28. Audiom 12in. Full Range Speaker Uncased £20. All carriage paid. Tel: Seon (041) 959 7466.

CLUB CORNER

WIRRAL AND DISTRICT AMATEUR RADIO SOCIETY meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF hunts, demonstrations and junk sales. For further details, please contact: Paul Robinson (G0JZP) on (051) 648 5892.

SOUTHEND & DISTRICT RADIO SOCIETY. Meets at the Rocheway Centre, Rochford, Essex every Friday at 8pm. Details F. Jensen (G1HQQ) P.O. Box 88, Rayleigh, Essex SS6 8NZ.

THE LINCOLN SHORT WAVE CLUB meets every Wednesday night at the City Engineers' Club, Waterside South, Lincoln at 8pm. All welcome. Further details from Pam, G4STO (Secretary) Tel: (0427) 788356.

ELECTRONIC ORGAN CONSTRUCTORS SOCIETY. For details of meetings. Tel: (081) 902 3390 or write 87 Oakington Manor Drive, Wembley, Middlesex HA9 6LX.

CRYSTAL PALACE & DISTRICT RADIO CLUB. Meets on the third Saturday of each month at All Saints Church Parish Rooms, Beulah Hill, London SE19. Details from Wilf Taylor, G3DSC. Tel: (081) 699 5732.

WIRRAL AMATEUR RADIO SOCIETY meets at the Ivy Farm, Arrowe Park Road, Birkenhead every Tuesday evening, and formally on the 1st and 3rd Wednesday of every month. Details: A. Seed (G3FOO), 31 Withert Avenue, Bebington, Wirral L63 5NE.

TESUG (The European Satellite User Group) for all satellite TV enthusiasts! Totally independent. TESUG provides the most up-to-date news available (through its monthly 'Footprint' newsletter, and a teletext service on the pan-European 'Super Channel'). It also provides a wide variety of help and information, contact: Eric W. Wiltsher, TESUG, Rio House, Stafford Close, Ashford, Kent TN23 2TT. England.

THE BRITISH AMATEUR ELECTRONICS CLUB (founded in 1966), for all interested in electronics. Four newsletters a year, help for members and more! UK subscription £8 a year (Junior members £4, overseas members £13.50). For further details send S.A.E. to: The Secretary, Mr. J. F. Davies, 70 Ash Road, Cuddington, Northwich, Cheshire CW8 2PB.

MODEL RAILWAY ENTHUSIAST? How about joining 'MERG', the Model Electronic Railway Group. For more details contact: Mr. Eric Turner, Treasurer MERG, 38 North Drive, Orpington, Kent BR6 9PQ.

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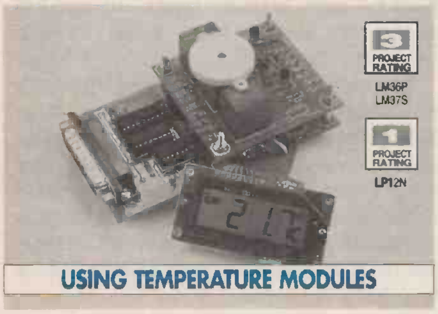
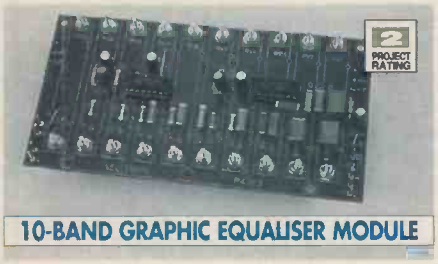


USING TEMPERATURE MODULES

This very practical *Electronics* article details the use of the following projects which, when used in conjunction with the range of temperature modules available from Maplin, can provide some extremely versatile environmental control functions.

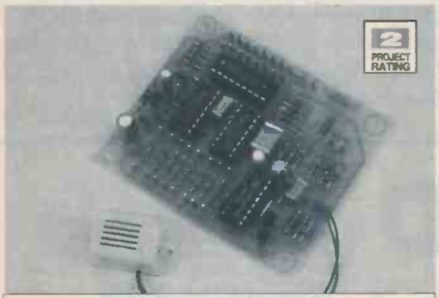
Order as: LM37S (Relay Interface Card Kit), **Price £12.45**; LM36P (Serial/Parallel Converter Kit), **Price £14.95**; LP12N (24-line PC I/O Card), **Price £21.95**. Details in *Electronics* No. 71 (XA71N).



10-BAND GRAPHIC EQUALISER MODULE

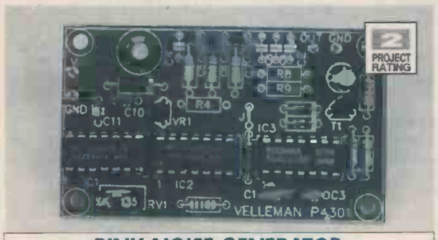
This easy to build equaliser project has ten frequency bands that allow you to adjust audio response to your particular preference.

Order as: VE44X, **Price £34.95**. Details in *Electronics* No. 71 (XA71N).



PRIORITY QUIZ BUZZER

No more arguments about who got the answer first! This versatile system allows up to eight contestants to battle it out without altercation, and can be expanded in blocks of eight by simply adding more units. Order as: LT41U, **Price £9.95**. Details in *Electronics* No. 72 (XA72P).



PINK NOISE GENERATOR

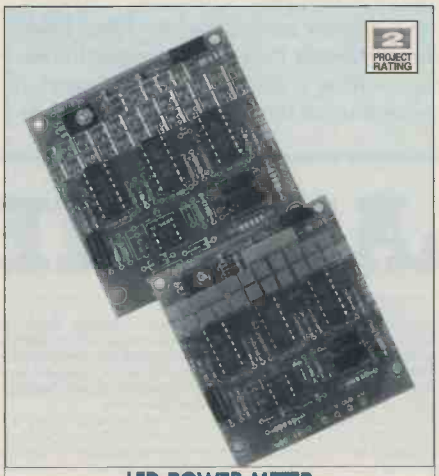
This easy to build pink noise generator employs a pseudo-random digital noise source and can be easily adapted to produce white noise if required.

Order as: VE43W, **Price £11.95**. Details in *Electronics* No. 72 (XA72P).

DIGITAL MODEL TRAIN CONTROLLER

This versatile project allows you to control up to fourteen locomotives on a single layout, with up to four locomotives being active at any one time. The basis of the system is a Common/PSU board, to which one controller is added for each active locomotive. All locomotives require a receiver. To complete the project, a smart, pre-drilled case is available.

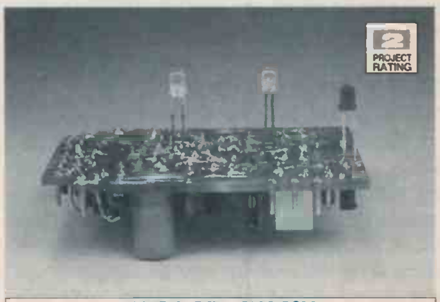
Order as: LW61R (Common/PSU), **Price £39.95** C4; LW62S (Controller), **Price £9.95**; LT29G (Receiver), **Price £12.95**; XG09K (Case), **Price £24.95**. Details in *Electronics* No. 71 (XA71N).



LED POWER METER

A pair of LED power meters for the Velleman Stereo MOSFET Amplifier, VF17T. The meters can be used in either stereo or mono configuration. Order as: VF18U, **Price £34.95**. Details in *Electronics* No. 72 (XA72P).

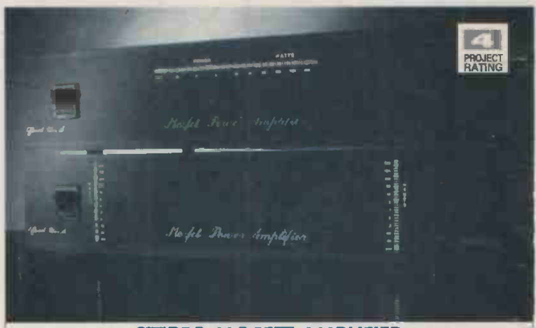
You'll find a variety of projects at Maplin for the beginner, intermediate and advanced hobbyist



INFRA-RED SWITCH

Look, no hands! This versatile remote control switch can operate a multitude of electrical or electronic equipment without you even touching it.

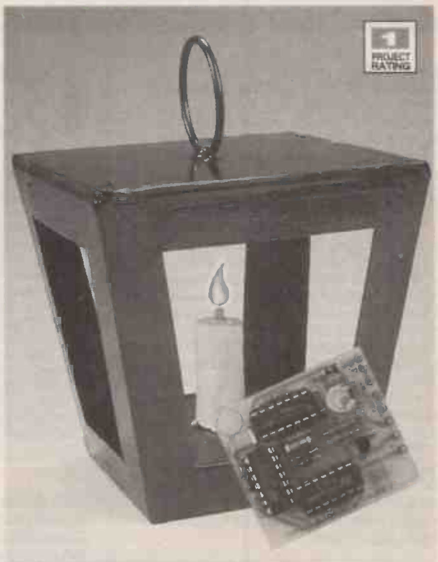
Order as: LT38R, **Price £9.95**. Details in *Electronics* No. 71 (XA71N).



STEREO MOSFET AMPLIFIER

A superb high power stereo amplifier that sounds as good as it looks. Bridged configuration transforms the unit into a 600W (music power) mono amplifier.

Order as: VF17T, **Price £299.95** H29. Details in *Electronics* No. 71 (XA71N).



TWINKLING CHRISTMAS CANDLE

This simple to build, high tech electronic candle has a realistic pseudo-random flicker, but won't burn a hole in your pocket–or anything else for that matter. Ideal for decorations or plays, as there is no danger of fire, or of the flame being blown out. The kit includes constructional details of a suitable cardboard lantern for the festive season. Order as: LT40T, **Price £6.95**. Details in *Electronics* No. 72 (XA72P).

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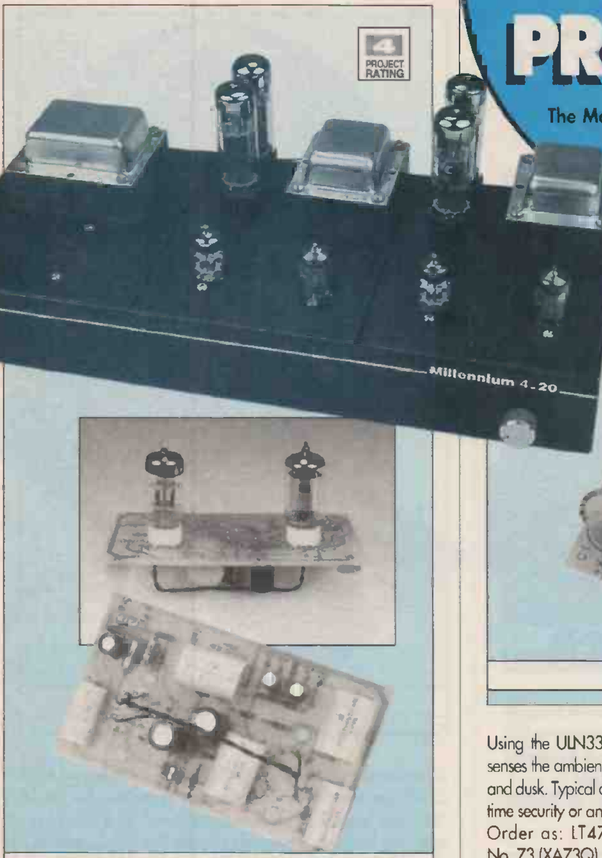
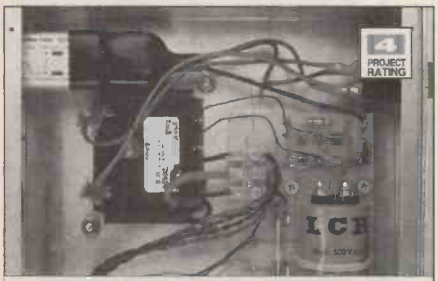


MILLENNIUM 4-20 VALVE POWER AMPLIFIER

A superb 4-valve, non-hybrid, class AB1 push-pull amplifier with an output of 20W r.m.s. and low output distortion, producing that characteristic valve sound. Construction is simplified by the use of printed circuit boards and no setting up is required.
Order as: LT45Y, **Price £74.95** C6. Details in *Electronics* No. 74 (XA74R).

SAVE MONEY by buying these combined Millennium Amplifier kits:
Save £10! Complete Millennium Monobloc Amplifier Kit (1 x PSU & 1 x Amplifier kit)
Order as: LT71N, **Price £114.90** H12.
SAVE £20! Complete Millennium Stereo Amplifier Kit (1 x PSU & 2 x Amplifier kits)
Order as: LT72P, Price **£179.85** H18.



MILLENNIUM VALVE AMPLIFIER PSU

A Power Supply kit for the Millennium 20W Valve Power Amplifier. The supply is capable of powering up to two amplifier modules for a stereo system, or alternatively you could use two PSU kits and two amplifier modules to produce a pair of 'monobloc' amplifiers.
Order as: LT44X, **Price £49.95** C6. Details in *Electronics* No. 73 (XA73Q).

TWILIGHT SWITCH

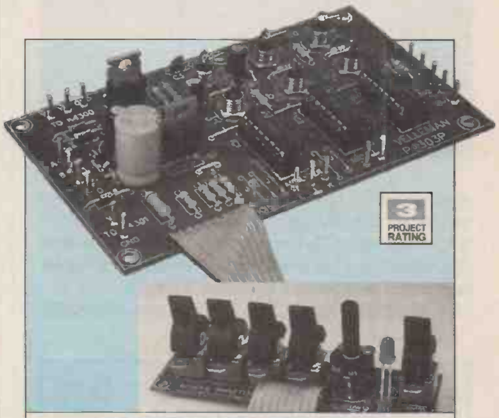
Using the ULN3390T opto-electronic switch, this versatile project senses the ambient light level and operates the built-in relay at dawn and dusk. Typical applications are automatic control of lighting, night-time security or anywhere that daylight related switching is required.
Order as: LT47B, **Price £5.95**. Details in *Electronics* No. 73 (XA73Q).

EXTRA LARGE LED DISPLAY

A choice of two 20cm (7 $^1/_2$in.) 7-segment LED displays, catering for open-collector and open-anode circuits. Ideal for educational equipment, public displays, exhibitions, demonstrations, clocks etc. Connects to existing 7-segment display drivers. Operating voltage: 22 to 26V DC, maximum supply current: 400mA.
Order as: VF01B, Common Cathode Version, **Price £32.95,** or: VE63T, Common Anode Version, **Price £32.95**. Details in *Electronics* No. 74 (XA74R).

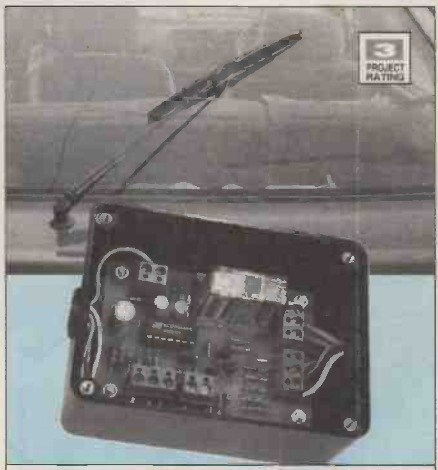
MODULAR GRAPHIC EQUALISER FRONT PANEL

A pre-drilled front panel and pre-printed foil to give a professional look to your completed equaliser project. The panel is suitable for a standard 19in. housing having a height of 2 units (2U).
Order as: VE41U, **Price £32.95** A1. Details in *Electronics* No. 74 (XA74R).



GRAPHIC EQUALISER PSU & SWITCHING UNIT

Part of the Modular Graphic Equaliser System. This project provides a regulated power supply for various of the other units in the system, a front panel mounted line input sensitivity control and also provides all of the necessary switching functions.
Order as: VE45Y, **Price £32.95**. Details in *Electronics* No. 73 (XA73Q).



AUTOMATIC REAR WIPER CONTROL UNIT

At last! Comprehensive control for rear window wipers, tied into the operation of the front windscreen wipers and gearbox. Facilities include: Single shot (when front wipers turned on), Intermittent operation (when front wipers on), and Auto wipe (Reverse gear selected and front wipers on).
Order as: LT46A, **Price £9.95.** Details in *Electronics* No. 74 (XA74R).

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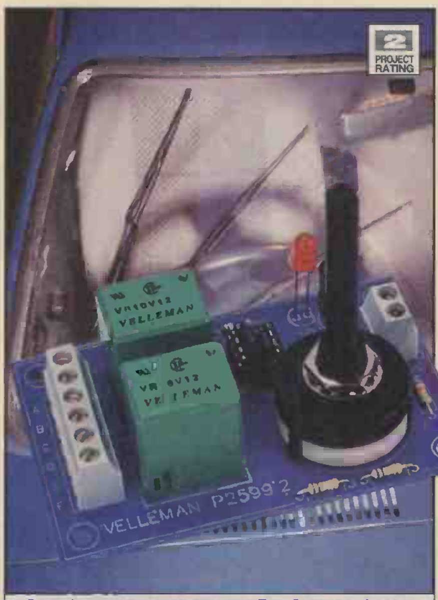
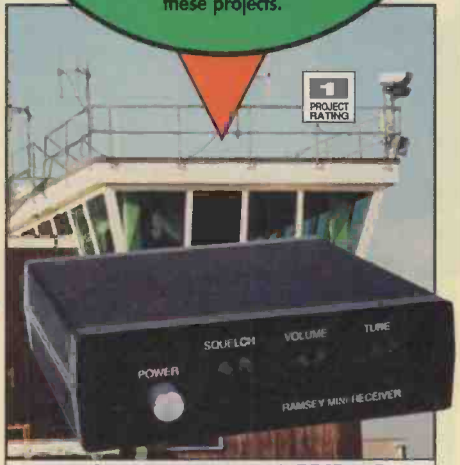


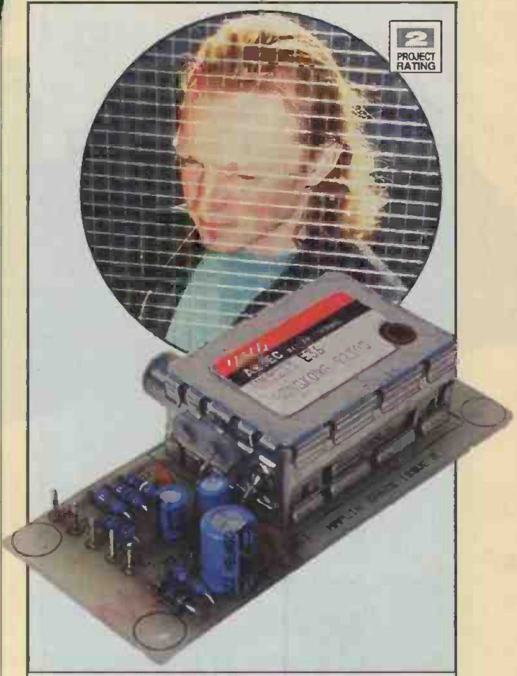
CAR INTERMITTENT WIPER CONTROLLER

An essential device for those of us with older cars and classics, that weren't built with anything more sophisticated than an on/off switch on the wipers! This simple to build project produces three delay periods, and has an LED indicator which lights during the delay period, reminding you that the unit is operating.
Order as: VE03D, **£12.95**. Details in *Electronics* No. 75 (XA75S).



AIRCRAFT BAND RADIO RECEIVER

Listen in on pilot and control tower communications with this super AM airband receiver. The kit is simple to build and requires little alignment. Frequency range is 118 to 135MHz and the receiver operating voltage is 9V. (Optional case not included.)
Order as: CP17T, **£29.95**. Details in *Electronics* No. 75 (XA75S).



CCD CAMERA TV MODULATOR

A low-cost unit which allows the Maplin colour and black & white CCD Camera Modules to be linked to any normal domestic TV with UHF aerial input. Applications include closed-circuit security systems, and interfacing equipment that only has video outputs to a normal TV receiver.
Order as: LT37S, **£9.99**. Details in *Electronics* No. 75 (XA75S).

The assembled receiver
in its optional case
(not included).

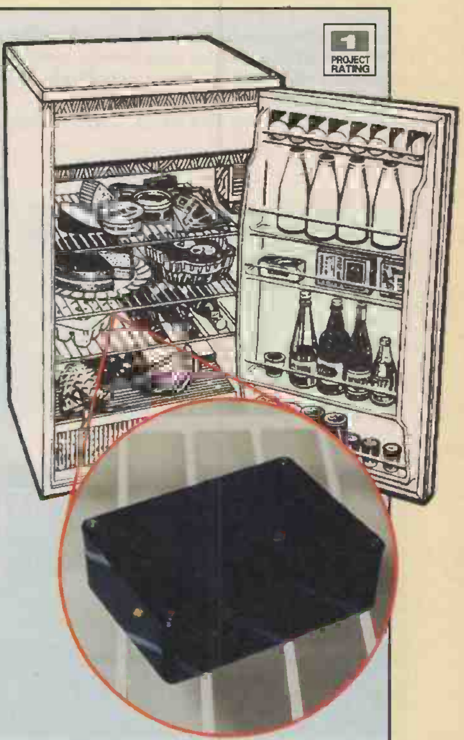
20 METRE ALL MODE RECEIVER

A 'direct conversion' 'DC' type receiver that is both simple-to-build and easy-to-use as there is no 'intermediate frequency' (IF). Frequency range is 13·85 to 14·50MHz and the receiver operates from a standard 9V PP3 battery (not supplied).
Order as: CP13P, **£31.95**. Details in *Electronics* No. 76 (XA76H).

The assembled transmitter
in its optional case
(not included).

20 METRE CW TRANSMITTER

A crystal controlled CW transmitter operating on the 20m band. The crystal frequency can be shifted by up to 5kHz by the VXO control. The transmitter operates from a +12 to +15V DC supply and has an RF output of 1W. Note: To operate this transmitter legally, either a full Class A Amateur Radio Licence or a restricted Novice Licence is required.
Order as: CP09K, **£31.95**. Details in *Electronics* No. 76 (XA76H).



FRIDGE CHECK

Is your fridge always as cold as it should be? This easy-to-build unit constantly monitors the temperature inside your fridge. If it exceeds a preset limit the alarm sounds, alerting you to the potential dangers of bacterial growth and food poisoning.
Order as: LT53H, **£8.49**. Details in *Electronics* No. 76 (XA76H).

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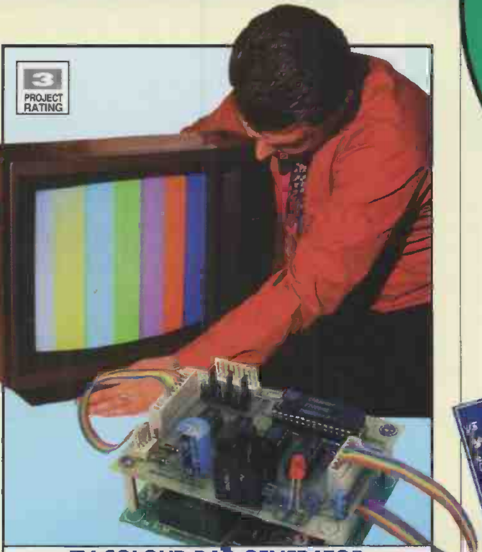
To order Project Kits or Back-numbers of *Electronics*, 'phone Credit Card Sales on (0702) 554161. Alternatively, send off the Order Form in this issue, or visit your local Maplin Store.

See advertisement elsewhere in this issue for locations of Maplin Stores.

Maplin: The Positive Force In Electronics

All items subject to availability. Prices include VAT.



TV COLOUR BAR GENERATOR

Essential for accurately setting up TV and video equipment. The generator consists of two modules, a colour bar generator and a colour encoder. Although the modules are available separately, both are required for this project. The generator has both PAL composite video and PAL UHF RF outputs and can produce EBU, 100% and 75% colour bars.

Order as: LT50E, Colour Bar Kit, **£19.99**. Order as: LM66W, Colour Encoder Kit, **£24.95**. SPECIAL OFFER – buy both kits and save £4.95, Order as: BE75S, **£39.99.** Details in *Electronics* No. 77 (XA77H).

LIVE WIRE GAME

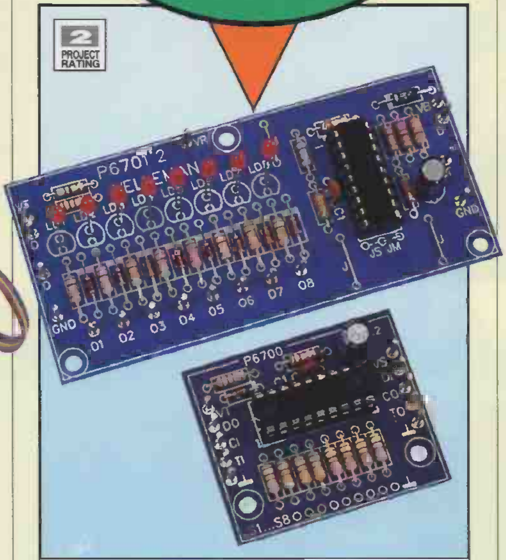
Roll-up! Roll-up! All the fun of the fair – and less of the hassle! This electronic variation on the traditional theme puts an end to the problem of whether a gentle touch actually rang the bell or not. A contact is clearly registered and the number of 'lives' can be preset helping to ensure fair play.

Order as: LT57M, **£19.99**. Details in *Electronics* No. 78 (XA78K).

12V DC/230V AC INVERTER

Ever wished your car or shed had a mains outlet in it? Now it can, with this high efficiency 230V AC inverter. Powered from a car battery or alternator, the unit is ideal for emergency power backup and field service applications. Maximum continuous power output is 250W, drawing a maximum current of 25A from the DC supply.

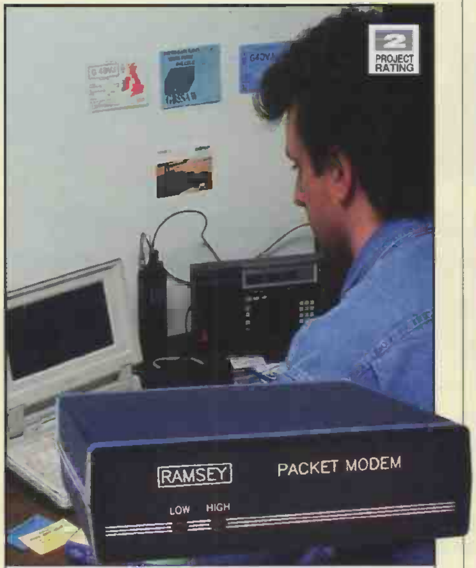
Order as: VF35Q, **£119.95** B4. Details in *Electronics* No. 78 (XA78K).



2-WIRE MULTI-CHANNEL SIGNALLING

How do you get up to 16 channels and a power supply down two wires? This clever project scans the transmitter inputs and converts them to serial data pulses superimposed on the DC power supply. The data is then decoded by the receiver and operates the relevant channel. Each transmitter and receiver pair can handle 8 channels, expandable to 16 by adding further modules.

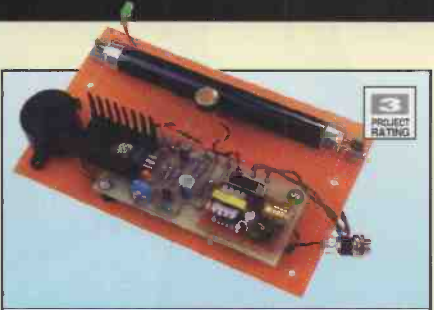
Order as: VE70M, Transmitter, **£9.95**. Order as: VE71N, Receiver, **£17.95.** Details in *Electronics* No. 77 (XA77H).



PACKET RADIO MODEM

Combine your amateur radio and computing hobbies with this radio MODEM! The project is supplied with software compatible with the IBM PC/AT but could also be used with other computers provided suitable software can be obtained. The unit communicates via the host computer's RS232 port and operates at 1200 baud. Power consumption is very small and the unit can, in fact, be powered direct from the serial data port of most compatible computers!

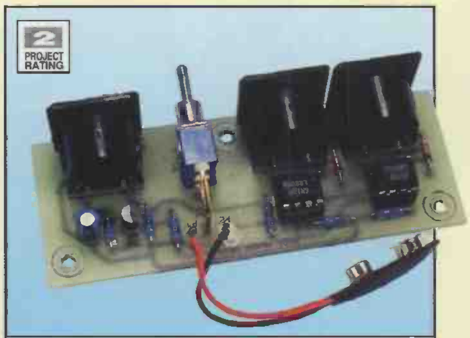
Order as: CP36P, **£59.95** A0. Details in *Electronics* No. 78 (XA78K).



FORGED BANK-NOTE DETECTOR

Sort out fake bank-notes with this notable Maplin project! Unlike counterfeit notes, the genuine article absorbs ultra-violet light from the built-in UV tube. A light dependent resistor in the detector changes its resistance depending on the amount of light reflected. If the note is genuine, an LED indicator lights and a buzzer sounds.

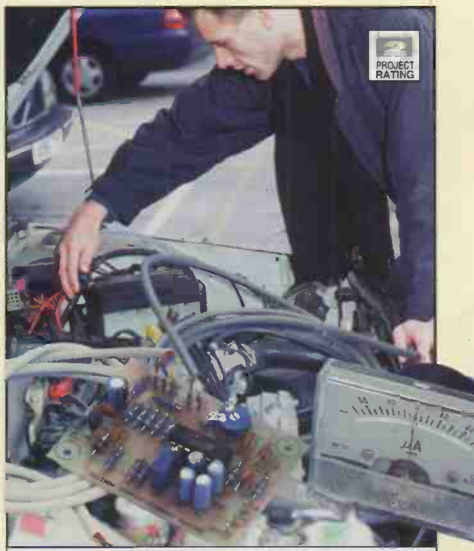
Order as: LT54J, **£14.99**. Details in *Electronics* No. 77 (XA77H).



SIMPLE MIDI MERGE UNIT

This easy-to-build project allows you to control a single MIDI sound module from two different sources. Apart from simultaneous operation from two MIDI sources, this simple unit can perform all the tasks normally undertaken by complex microprocessor controlled units costing many times more.

Order as: LT52G, **£14.99.** Details in *Electronics* No. 77 (XA77H).



CAR BATTERY CHARGE/DISCHARGE IDLE INDICATOR

Is your car's battery being charged as you drive, or is it waiting for the next cold, rainy morning for you to find out that it isn't? Keep an accurate eye on where the current is going with this inexpensive project. A 3-colour LED, mounted on the dashboard, indicates whether the battery is being charged, discharged or if a balanced condition is achieved.

Order as: LT56L, **£7.99**. Details in *Electronics* No. 78 (XA78K).

Full details of how to build this superb valve amplifier yourself may be found in the January and February 1994 issues of *Electronics – The Maplin Magazine.*

Electronics – The Maplin Magazine January 1994 Issue	(XA73Q)	**Price £1.95** *NV*
Electronics – The Maplin Magazine February 1994 Issue	(XA74P)	**Price £1.95** *NV*
Power Supply Kit Only	(LT44X)	**Price £49.95** Ⓒ
Amplifier Kit Only	(LT45Y)	**Price £74.95** Ⓒ
Complete Monobloc Amplifier Kit (1 x Power Supply Kit + 1 x Amplifier Kit)	(LT71N)	**Price £114.90** Ⓗ **Save £10!**
Complete Stereo Amplifier Kit (1 x Power Supply Kit + 2 x Amplifier Kit)	(LT72P)	**Price £179.85** Ⓗ **Save £20!**

Carriage: kits marked Ⓒ add £2.65, kits marked Ⓗ add £5.70. If ordering several kits maximum total carriage is £5.70. Handling: add £1.40 to each order. Please note: carriage and handling charges apply to Mail Order only – you do not pay carriage or handling if you purchase these kits from Maplin Regional Stores.

Photograph shows Stereo Millennium 4-20 Amplifier (LT72P). The Millennium 4-20 Amplifier is not available ready built. The kits listed are rated 4 (Advanced) on the 1 to 5 Maplin Construction Rating Scale.

Maplin Electronics plc., PO Box 3, Rayleigh, Essex, SS6 8LR. Tel: (0702) 554161. Fax (0702) 553935.
For details of your nearest Maplin Regional Store Tel: (0702) 552911.

Prices include VAT at 17·5% except items marked *NV* which are rated at 0%.
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