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No. 62

ELECTRONICS
The Maplin Magazine

FEBRUARY 1993 · £1.75

Britain's Best Selling Electronics Magazine

Read all about the latest HDTV Developments

Build a Moving Message Display System

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See inside...

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Choosing and Using Passive Components

Learn How Satellite TV Scrambling Systems Work.

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EDITORIAL

Hello and welcome to this month's issue of 'Electronics'! This month sees the start of an exciting new major project: an LED Moving Message Display System. Over the years we have had many, many requests for such a system, and at last, here it is! The design is completely modular in its approach, allowing the user to construct a display of up to 2·6m in length – and it is every bit as good as commercially available systems! The complete display is driven by a host computer, an IBM PC fitted with a PIO card, running GW BASIC. However, if sufficient interest is shown, the 'backroom boys' could be persuaded to develop a stand-alone controller for the display system – your letters please!

If you're a Subscribers' Club Member, don't forget to take advantage of this month's special offer on the Texas Instruments Data Book Set at just £9.95!, see the loose insert for details. If you're not a subscriber, why not take out a subscription!, see page 21 and find out how you can save £££'s on purchases from Maplin, and benefit from exclusive special offers!

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!

R. D. Ball

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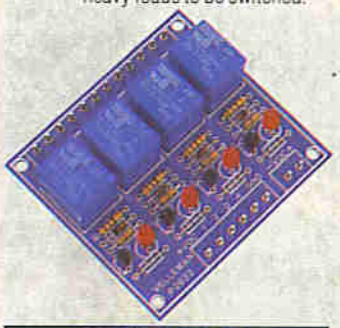
PROJECTS



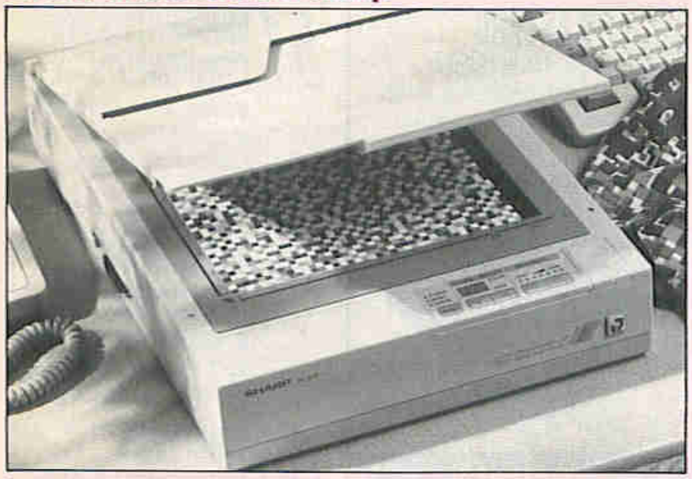
FEATURES

REGULARS

Prices of products available from Maplin, shown in this issue, include VAT at 17·5% (except items marked NV which are rated at 0%) and are valid between 8th January and 28th February 1993. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance.

NEWS Report

Colour Scanner from Sharp



Sharp last month introduced a further aid to the counterfeiter's toolbox. The new Sharp JX-320 colour scanner is capable of scanning an A4 image at 300 dots-per-inch (dpi), extendable to 600 dpi with software interpolation.

The JX-320 scans colour images in a single pass, quickly and with a high degree of colour registration, using Sharp's patented method of strobing three coloured fluorescent bulbs, through filters, onto a charge-coupled device (CCD). The mechanism provides complete control over 256 shading graduations of each primary colour – similarly a 'monochrome' mode offers 256 grey-scale graduations. A transparency scanning option transforms the JX-320 into a professional-quality scanner that works with both transparencies and prints.

Sharp has also introduced a 'direct print' facility; in conjunction with a Sharp JX-735 colour ink-jet printer, the JX-320 effectively becomes a low-cost colour photocopier at less than £3,000.

The JX-320 scanning modes are 24-bit colour, 8-bit grey-scale, and black/white. Its adjustable parameters include edge emphasis, lightness and brightness. Gamma correction enables complete shade management over 256 graduations of each colour, allowing any image to be corrected or enhanced.

Handy for bank notes maybe – that said, the price tag of £1,495 is likely to deter all but the most ardent criminal.

Fax with Integrated Encryption

Eavesdropping on fax transmissions is just as easy as tapping a telephone call – so we're told. Equally, a fax message could be intercepted, changed and then retransmitted, leaving the recipient unaware that its contents have been manipulated. The standard solution is to use an encyphering unit to code transmissions. Such systems are usually customised and are, by definition, expensive. A solution offered by Swiss company Ascom aims to bring coded fax systems within the grasp of every fax user.

The security system of the Ascomfax 260 Security is amazingly simple. It consists of a basic facsimile unit, an integrated encyphering module and a security card from which a coding inscription is read. Once the code has been read in, the fax machine operates like a conventional unit – however, messages can only be exchanged between machines with identical security cards. If the keys do not match, then no facsimile communication is possible. The flexibility of the system enables faxes from standard machines to be received without concern.

Security cards can be assigned to individuals or a group of people, and the supervisor can change them annually, weekly or even daily. Initial customers include renowned international companies and organisations. Ascom's most impressive client is the Swiss police department, with security transmissions via radio links and relay stations already in service.

Credit-Card Diction

Creative Technologies, an Isle of Man based company, will shortly be unveiling the Voice Memo Card, a revolutionary new personal recorder.

Advances in technology have allowed the voice recorder to be shrunk to literally the size and shape of a credit card. Recordings are made directly on to an integrated memory device, eradicating the need for both moving parts and magnetic tape. Four buttons on the surface of the card enable the user to record, stop, erase or play back messages.

Components from Texas Instruments enable the user to record up to 24 seconds of personal memos. Retailing at £24.95, the card can be kept in a pocket or on the dashboard, ready for those moments when a pen is out of reach.

Dirty Sport? Cleaner Picture!

BBC engineers have developed an improved 'radio camera' system for use with sporting events and the like. Radio cameras are used to give those incredible views often seen in sports programmes – Formula 1 racing, motor rallies, tobogganing – as well as for more conventional use during news broadcasts and the like. Radio cameras also played an important part during the 1992 Olympics. However, the major shortcoming of present systems becomes only too apparent during live programmes – signal fading and ghosting as the receiving aerial (mounted on a gantry) picks up reflected signals from nearby walls and buildings in addition to those directly from the camera. However, the BBC's newly-patented radio camera makes use of a novel transmitter system. Six horn antennae, mounted 60° apart from one another, each send out the audio and video together with a beam identification signal. This identification system enables the receiver to figure out which horn is providing the strongest (i.e. most direct) signal – and has been configured so that the receiver will select the optimum source for every picture frame (i.e. every 0·04 sec). Field trials have shown that the system offers significant improvements over the existing radio cameras in use, and the BBC have been negotiating with Japanese camera manufacturers about licensing the technology. Unfortunately, the overall cost of the BBC's system will undoubtedly be higher than that of existing radio cameras.

If only the same attention to picture quality was applied to remote electronic news-gathering. Most of you will have noticed the poor picture quality of various foreign news reports in past months – these are mostly being degraded by an obvious 'mush' of horizontal lines. This is because encryption (a variant of the Videocrypt system used by satellite broadcaster BSkyB) is commonly used by news agencies such as Viseurope. Since these 'news feeds' are delivered by satellite, unprincipled broadcasters not subscribing to such services could, prior to the introduction of 'scrambling', 'lift' sections of these feeds and insert them into their own programmes. Videocrypt (renowned for its high level of security) may protect their investment, it does not exactly improve the picture quality, as BSkyB viewers have known for sometime. The *real* satellite television enthusiasts are also disappointed, since with their large dishes they could once eavesdrop on the unedited news footage – and see/hear what the broadcasters would rather you didn't! Elsewhere in this issue you will find an article on the encryption of (satellite) television signals, where the problems of 'cut and rotate' systems such as Videocrypt are discussed.

Smile for the Camera!

The Metropolitan Police have recently announced that accidents have been cut dramatically on the capital's roads with the introduction of Gatso speed trap cameras.

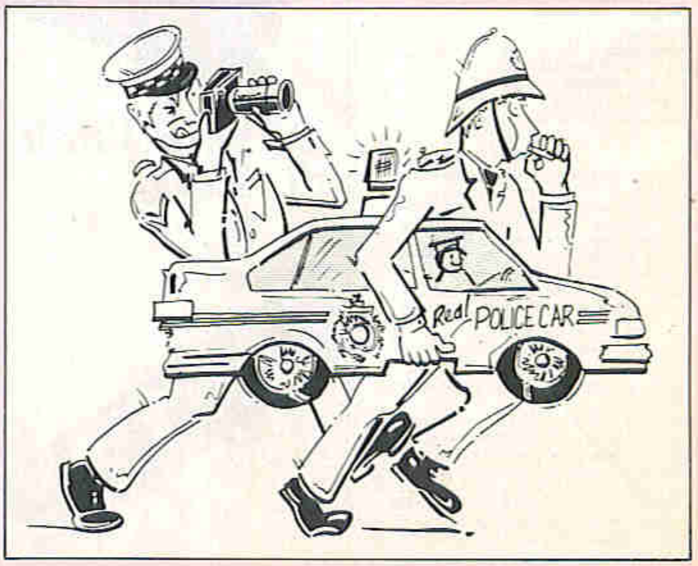
The cameras, triggered by radar beams or sensors buried in the road, automatically photograph speeding motorists. Motorists, who choose to ignore roadside warning signs in addition to speed restrictions, receive prosecution orders once films have been developed and registration plates identified and traced. In theory, drivers who speed past a series of cameras could tot up enough points to lose their licences in a single journey – c'est la vie!

Since the installation of thirty or so Gatso cameras throughout the West of London, there have been no major accidents on the trunk routes under surveillance. This is a record which both the police and the motoring organisations have proclaimed unusual.

Discussion among the dark-glassed sheepskin-clad members of the motor trade has centred around the possibility of applying a high-gloss finish to vehicle number plates, so causing a blur in the lens of the detection camera – the police claim this technique has little effect (in any case, it defeats the whole object of these cameras – that of preventing totally unnecessary loss of life – Ed). The police have nevertheless provided assurances that identification techniques are reliable – and that photographs and motoring records are being cross-checked after one driver received a summons by mistake a few days after the cameras went 'live'.

Away from London, the Gatso cameras are, so far, being limited to selective trials. The high costs of purchasing and installing the Gatso technology is expected to be a deterrent to already financially stretched forces.

Perhaps the best solution to prevent speeding comes from the Lancashire Police. The scheme, which is proving extremely successful, must be considered credible, if only because of the high level of innovation employed in its design. The Northern solution amounts to a fibreglass cut-out of a police Range Rover. Next time you are on the M55 near Manchester, or the M6 heading towards Cumbria, watch out!



Electronics in Potholing?

The ELF and VLF radio bands have hitherto been largely neglected by amateur radio and electronic enthusiasts. This is really quite surprising in view of the fascinating properties of this proportion of the electromagnetic spectrum. The evocatively-named 'dawn chorus', with its 'tweeks' and 'whistlers', comprises a whole range of natural phenomena generated in the earth's atmosphere. More practical uses of frequencies below 150kHz include the broadcasting of frequency standards, hyperbolic navigation and communication through sea water or solid rock to submarines, miners and potholers. With negotiations between the RSGB and the licensing authorities for an amateur VLF allocation well underway, the neglect of the bottom end of the radio spectrum could well be coming to an end. One British group which is already active in this field is the Cave Radio and Electronics Group of the British Cave Research Association. This group is intent in improving techniques of VLF radio communication, with a particular emphasis on its use in cave surveying and rescue. A journal containing a broad mix of practical and theoretical articles is published quarterly. Although most of the group's members are actively involved in caving, there is much here to interest those with a more general interest in VLF radio communication and miscellaneous electronic applications. Recent articles have covered the principles of inductive communication, antenna design, modulation methods, a design for an ultra-sensitive flash trigger, cave-proofing equipment, Ni-Cd battery charging, surveying software and cave detection using geophysical techniques. Full membership of the group, including a subscription to the Journal, is £7.50. For details, contact David Gibson at 12 Well House Drive, Leeds LS8 4BX, or Tel: (0532) 481218.

British Rail in Rat-Trap

As Autumn draws to a close, and the last of the fallen leaves have been swept from the railway tracks, commuters are facing new problems (you thought we might have been given some period of grace, just before 'the wrong type of snow' falls! – Ed). The latest excuse for two-hour delays on lines between Norwich and London is that of 'rats chewing signal cables'. The rodents have been nibbling cables in Chelmsford, Essex, forcing British Rail to operate signals by hand.

Sneaking Off

If you haven't already done so, check-out the new American film currently doing the rounds – 'Sneakers'. The story features a talented collection of cryptologists, wiretappers, cyberpunks and various security agencies. It also features Robert Redford, Ben Kingsley and Sidney Poitier. As college students, so the story goes, the team stood on the edge of the electronic frontier – computer pranksters who wired donations from the Republican Party to the Black Panthers. 25 years later, the same team of high tech experts (aka 'Sneakers') are on hire to penetrate systems and test their security. Seems well worth a visit. Incidentally, this film has a suitably impressive press kit – a high-density 3½in. disk for a VGA-equipped PC, containing digitised scenes from the film.

Events Listings

8 to 10 February. Microtech '93. Heathrow. Tel: (0344) 301491.

9 to 11 February. Integrated Communications '93, Wembley. Tel: (0234) 212988

14 February. 2nd Northern Cross Radio Rally. Rodillian School, A61 between Leeds and Wakefield (near junction of M1 and M61). Talk-in on 2m (S22). Tel: (0532) 827883.

16 to 18 February. The Windows Show, Olympia. The show that covers all Microsoft Windows-related products. Tel: (0256) 381456.

23 to 25 March. NEPCON. NEC Birmingham. Tel: (081) 948 9800. Don't forget to visit the Maplin Professional Supplies Stand!

24 to 31 March. CEBIT. Hanover. Tel: (081) 688 9541.

24 April. Marconi Birthday Exhibition. Wireless Museum, Puckpool Park, Seaview, I-o-W. Tel: (0983) 567665.

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

PICTURE CAPTION CHALLENGE

This month, we thought we'd add some glamour to the Caption Competition. No prizes – not even a . . . er . . . portable telephone – for guessing, but what's going on?

- ★ So that's what goes on behind the scenes of those 0898 'naughty' lines!
- ★ Home-shopping service for 'Happy Bunny' rabbit food launched amidst much hype.
- ★ Exclusive! Private life of BT director revealed!
- ★ 'If you buy this phone, you'll get a free year's subscription to a certain well-known tabloid newspaper!'

Er . . . no! That well-known celebrity Linda Lusardi has been enlisted to help promote the Rabbit cordless phone, marketed by Hutchison Personal Communications. Linda was voted 'top of the polls' by a randomly-selected group of men (and rabbits?), when asked who they would most like to have a romantic phone conversation with.

An Instrument for All Seasons – the Philips Scopemeter

Reviewed by Martin Pipe

When servicing complex electrical or electronic equipment in the field, engineers have traditionally 'made do' with a multimeter. Any servicing operations requiring more than such a device normally have to be done back 'at base', where oscilloscopes, signal generators and other test equipment can be found. As a result, field servicing is normally confined to locating faults to PCBs, rather than at component level – i.e. 'board swapping' – due to the fact that a fault can be isolated to a particular area. The faulty boards themselves are normally repaired at the base repair station. As a result, repair becomes a very expensive and time-consuming process, being a 2-stage process. The defective board also has to travel a lot, though not expensive in its own right still places the board at risk from further damage. The other option is for detailed fault-finding to take place at a customer's premises. This, however, usually requires several pieces of heavy equipment to be lugged around – not much fun if lengthy flights of stairs are involved!

With the introduction of an exciting new 'all-in-one' product from Philips/Fluke, this need no longer be the case!

Enter the Scopemeter

Combining the multimeter know-how of Fluke with Philips' considerable experience of oscilloscopes, the unique Scopemeter is one of those instruments which, once used, becomes indispensable. You can use it as a full-feature $3\frac{2}{3}$ digit multimeter, but that would just be scratching the surface. This is because the Dutch-manufactured Scopemeter offers all of the features of a 50MHz dual-trace oscilloscope, and many more that are not present on full-sized instruments of comparable specification. I refer specifically to 'full-sized instruments', because the Scopemeter's physical dimensions are a mere 60mm x 130mm x 260mm – i.e. approximately the same as two 10-packs of $5\frac{1}{4}$ in. disks placed side by side. For the purpose of this review I was loaned the top-of-the-range PM97 model; there are two others in the range, the PM93 and PM95 – more on them later.

Scope for Use

Let us start with the 'scope section first. Apart from the rather garish bright yellow holster (after all, this unit has got a ready market in BT!), the most striking feature is the large display screen. Bearing in mind the dimensions and the fact that a Ni-Cd battery had to be incorporated into the unit, a traditional CRT display was 'right out!' Instead of one of these rather fragile components, Philips have opted for a 84 x 84mm supertwist liquid crystal display. The company has realised that the 240 x 240 pixel resolution is somewhat limiting, and has overcome any potential problem with clever design – a 'zoom' facility with up to 1,000x magnification.

Apart from the screen, the 'scope section of the Scopemeter provides all the facilities of a comprehensive dual-channel 50MHz dual-channel DSO – and a good one at that. It also has the advantage of being considerably easy to use, by virtue of some clever operating software – after all, time is of paramount importance during field servicing. For example, if you just wish to get some idea of what a particular signal looks like, nothing could be easier. The probes are hooked up to the unit being examined, and the 'Autoset' key on the Scopemeter pressed. Upon this single keystroke, Scopemeter will adjust input attenuation, timebase, triggering and coupling so that you get the trace you need – quickly. Relays ranged in the bowels of the instrument, which switch in the relevant parts of the input attenuation network, chatter away for a moment, letting you know that you're in business. The parameters affected by the autoset operation are all, as can be expected, available on the front panel – accessible via menus or, for the most commonly used functions, via dedicated buttons. The PM97 model also features 10 user set-up memories that can be tailored for specific applications – power, signal and data, for example. For most applications, the user could get away with the 'Autoset' function – it really does take away the hassle of setting up a 'scope. It would, however, be a lie to say that the Scopemeter is the only unit with this function – Philips, amongst others, have incorporated it into their full-size oscilloscopes for some years.

One of the features of a DSO is that the waveform is 'digitised' by an analogue-to-digital converter (ADC) and then stored in a solid-state memory e.g., RAM. The waveform stored ('frozen') at that instant can be called up and displayed – ideal for capturing 'fast' phenomena such as power supply glitches in computer systems. The 25 megasample per second acquisition rate provides a 40ns time resolution – comparable to many full-sized instruments. Vertical resolution is 8 bits, with 25 levels per division. The PM97 offers eight trace memories; this feature is very useful in that the waveforms present on the relevant test pins of a fully working reference sample kept 'at base' can be stored and compared with those present on the customer's problematic unit. Two of the stored traces can

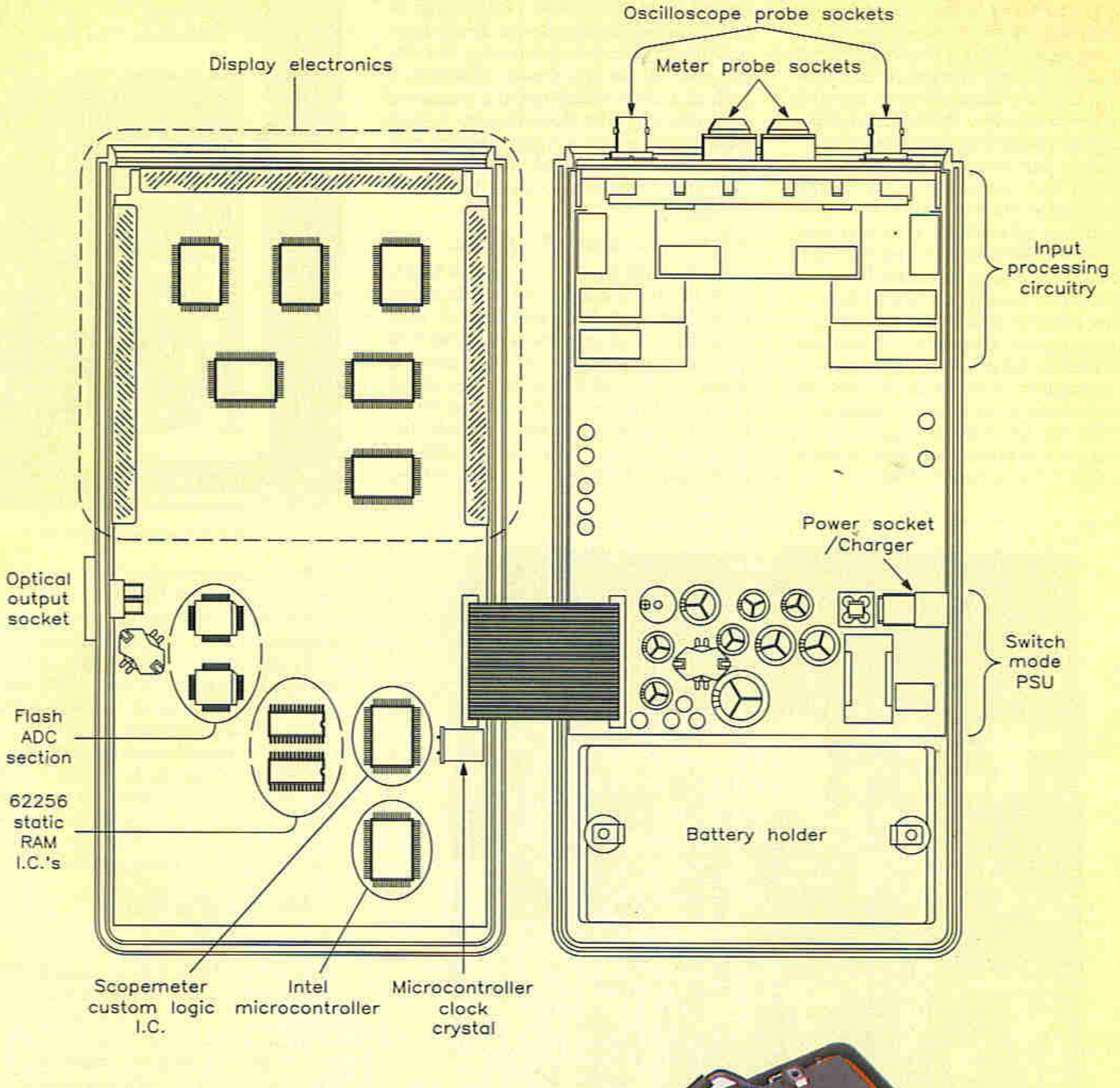
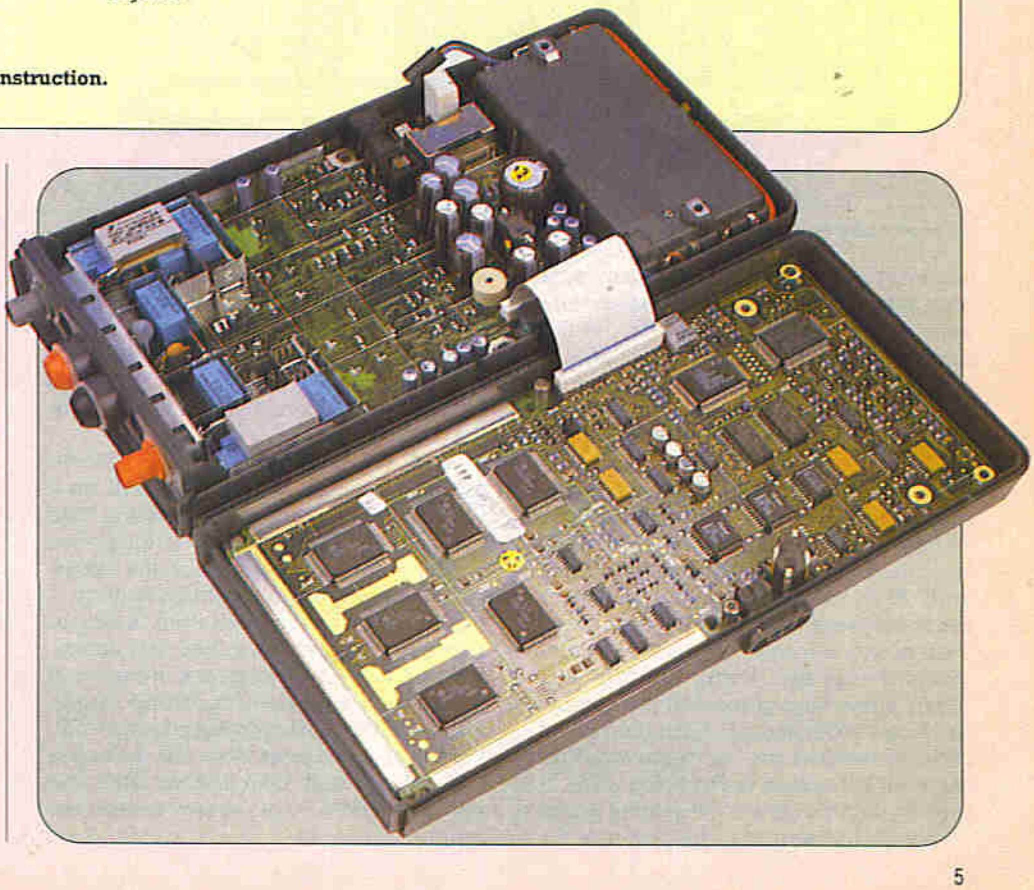


Figure 1. PM97 Scopemeter internal construction.



be on-screen at the same time as the two 'real time' traces for direct comparison. Pre-trigger waveforms can be viewed before the trigger event – essential in determining faults or design defects leading up to device failure.

The 'roll' mode, a feature common to most DSOs, enables data to be gathered at timebase speeds down to 60 seconds per division. This enables the Scopemeter to be used as a data logger, in addition to its many other possibilities. For example, the input could be a transducer of some kind; a thermocouple, strain gauge or pH probe. Effects of increased load or chemical reaction can now be monitored – in the field or occupying a fraction of the bench space taken up by a conventional DSO.

Another advantage of a DSO is that mathematical operations can be carried out on the signal being analysed. Such a feature can be very useful during development work, as well as servicing and data logging. Apart from basic functions present on everyday scopes such as adding and subtracting traces from each other, the roster of features available on the PM97 includes averaging and integration. Averaging helps to reduce visible noise, an annoying distraction and possible source of confusion, when viewing repetitive waveforms. This is done by displaying the mean of up to 256 samples.

When a particular area of interest on the trace has been marked using the 'Cursor' keys, other mathematical processing can take place. This includes the voltage difference between (vertical) cursors (dV), the time difference between (horizontal) cursors (dt), and the time difference between one of the cursors and the trigger point. Frequency, phase shift, and the RMS, mean, pk-to-pk, minimum and maximum values of the signal between cursors can also be displayed.

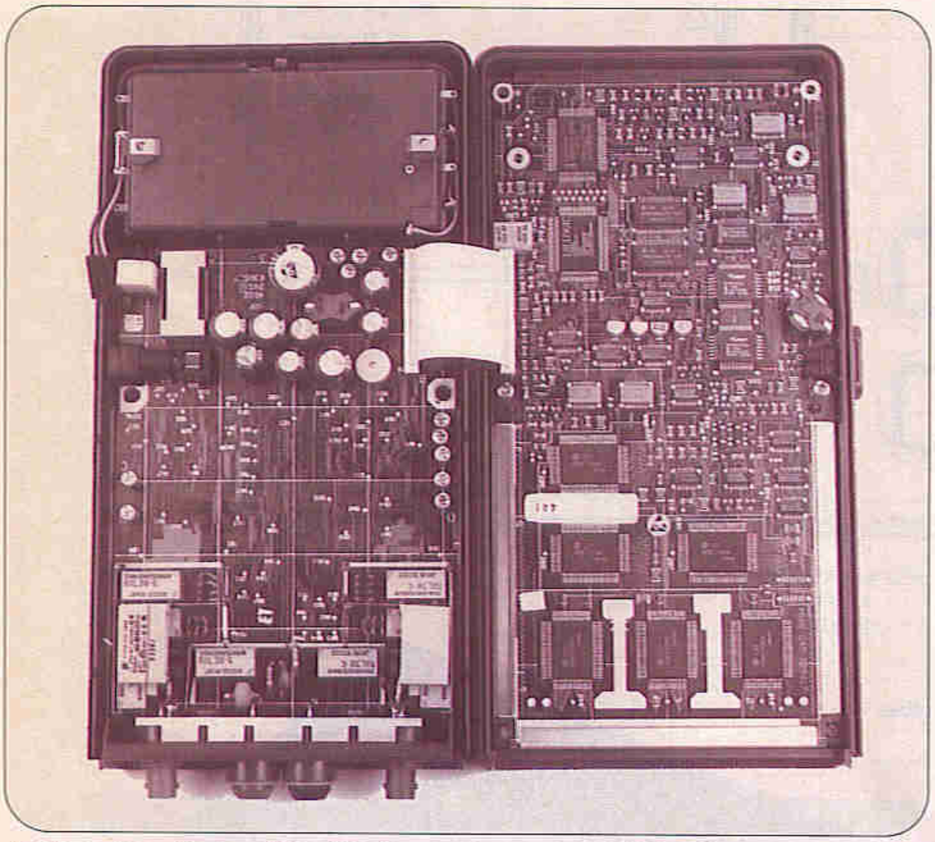
When the 10:1 probes supplied with the unit are employed, the voltage ranges are increased by a factor of 10 – a factor that must be remembered or things may get a little confusing as the probes are non-switchable between 10:1 and 1:1. In the case of the review sample, the lack of such a switch was particularly irritating as no 1:1 probes were supplied! This became a problem when monitoring very low-level signals.

One of the most distinctive user operations of the Scopemeter is the 'zoom' mode – a necessity due to the comparatively low resolution liquid crystal display screen used. A shame, therefore, that this function is not present on the PM93 instrument – but economies have to be made somewhere, I suppose. Using the 'up' and 'down' arrow keys to zoom in (magnification factor 1000) and out again, fine detail of the waveform can be observed. The centre of the screen is the zoom point. It must be said that this arrangement works very well; it more than compensates for the use of the LCD screen – which itself provides considerable advantages in other ways (such as power economy). Apart from the trace and menus, the display also shows any screen messages – such as battery condition and imminent shut-down (if the Scopemeter hasn't been used for some time, it beeps and announces to the world that it will turn itself off in 5 minutes, to conserve battery power).

More on the Display

Using the LCD key, the display can be set up to the user's requirements. Adjustable parameters include display contrast, grid dimensions and even the size of the dots that make up the trace. At this point it is worth saying that it is always the silliest things that ruin an otherwise excellent product. A backlight is essential with displays of this type, just to maintain visibility. For some strange reason, Philips have deemed this facility fit only for the flagship PM97 model – why? I trust that subsequent Scopemeter product ranges will rectify this problem. To change the subject, a probe calibration facility (a 5V pk-to-pk 1·95kHz square wave) is also available in the 'LCD' mode.

With the Scopemeter, I was able to trace a particularly annoying fault on a satellite TV receiver in my possession. This took the form of interference on the power supply that corrupted data on the microprocessor-equipped control section – leading to erroneous operation. A simple decoupling capacitor solved this annoying problem for a few pence. It may well have been a manufacturing defect – a suitable vacant space was present on the PCB. Perhaps I could have done the same job with a large and cumbersome DSO and my trusty DMM – but I simply haven't the space.



As shown above, the two PCBs of the Scopemeter are packed tight with components.

The combined Scope/Meter display.

The distinction between DSO and high-performance multimeter naturally becomes blurred with a device of the Scopemeter's capabilities. RMS, peak and mean amplitudes, frequencies, rise and fall times can be displayed. Pulse width and period can also be measured. Maximum and minimum signals beyond a certain threshold can be recorded – another useful tool in the armoury of the service technician seeking out those potentially disastrous glitches and other quick events, or barely perceptible changes on high-speed signals.

...But that's Only Half the Story!

The fact that Philips have crammed a DSO into such a small space is a miracle in itself. However, American multimeter supremos Fluke have contributed a superb auto-ranging multimeter into the bargain – after all, it's not called the Scopemeter for nothing. The meter display can incorporate some of the oscilloscope functions, and this makes for some pretty nifty features – unique, no doubt, to the Scopemeter. The vast computational power incorporated into the unit also means that the unit is a lot smarter than the average DMM, too! The most unique feature must surely be the 'mini scope' display that can be called up at any time. As a result, the 'whole story' can be made available when adjustments are being made to a circuit. For example, the amplitudes of certain signals can be set to specified levels whilst monitoring them for non-linearities.

In addition to four DC voltage ranges (between 300mV and 300V), four AC voltage ranges (between 300mV and 250V) and six resistance ranges (between 300Ω and 30MΩ), the Scopemeter's 3⅔ digit 3000-count multimeter will measure frequencies of between 1Hz and 5MHz.

The PM97 model loaned has a useful feature whereby the maximum and minimum measurements are retained. Whenever these values are exceeded, a warning bleep is emitted – very useful if your eyes cannot be on the display at all times! Readings relative to stored reference can be made – ideal for finding the differences between measurements (is it within tolerance?), and even nulling out the effect of test lead resistance. A 'dB' range is provided so that gains (and attenuations) of amplifiers and filters can be measured, without hassle, over a wide bandwidth. As can be expected from an instrument destined for the field, the ubiquitous audible continuity tester is incorporated, along with a diode tester for testing semiconductor junctions.

A feature patented by Fluke is 'Touch Hold'. After a press of the 'Hold Run' key, the meter beeps when the display has stabilised, and is consequently in a fit state to be read. This is another of those useful ideas that keeps your concentration on the job in hand, rather than the meter. The feature is also incorporated into some of Fluke's conventional DMMs.

Other Features (PM97 only)

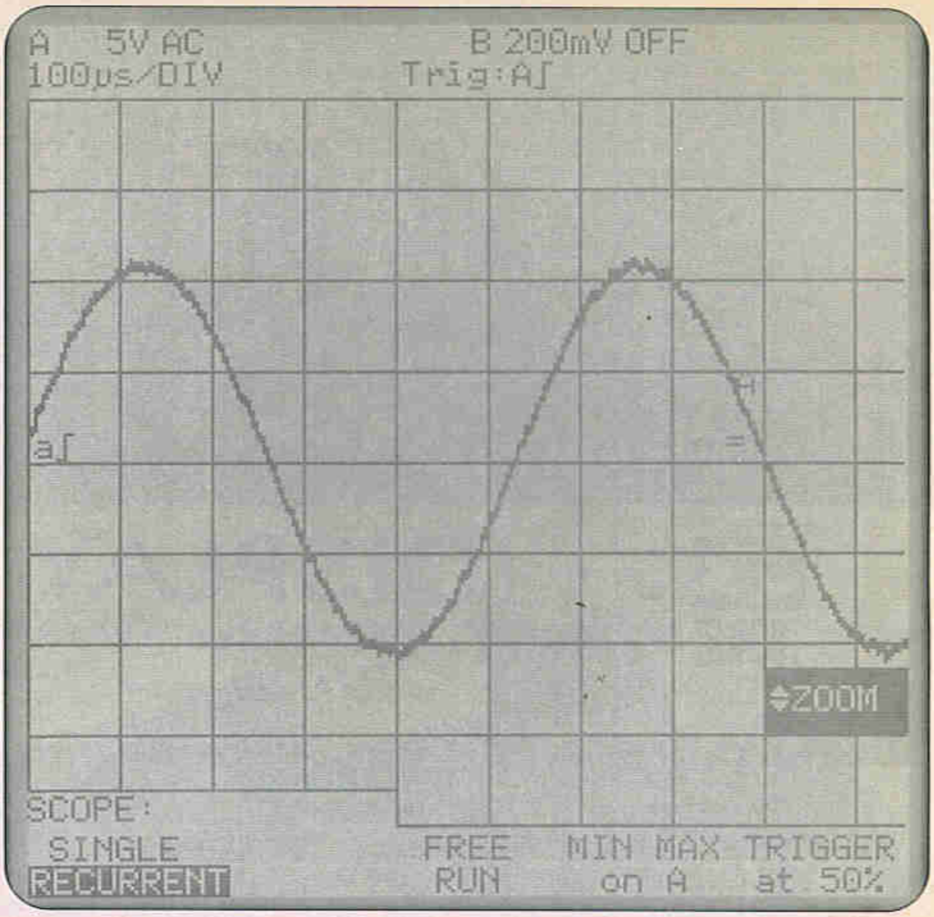
Via the 'Special Functions' menu, the Scopemeter may be hooked up to a printer via an optical RS232 interface, so that a permanent record of a waveform may be retained – useful for lab reports and those situations when eight trace memories are simply not enough! An optical interface is used to maintain isolation; it also has the advantage of providing better hermetic sealing. It's not just an opportunity for Philips to sell you yet another black box!

A mini-function generator, also available through the 'Special Functions' menu, is also built into the unit; a 976Hz sine wave can be generated, or square waves of 488Hz, 976Hz or 1·95kHz. Although not by any means perfect, they will be very handy for checking audio and logic circuits. Non-standard frequencies are chosen to prevent confusion or interference with the system under test. The function generator can also generate a slow voltage or current ramp for applications such as component testing.

Ergonomically Designed

But all this awesome technology would be to no avail if the user was unable to get to grips with the unit, and I am pleased to say that the unit is very simple to use. If you are a lateral thinker, you will have no problems. Each adjustable parameter can be accessed via a plethora of menus in much the same way as a well-designed piece of computer software (the only thing missing is a 'Help' function!). All user operations are carried out via the front panel buttons; there are no other controls. Rubber membrane keys are used; these are much easier to seal off from the outside world than other types of control.

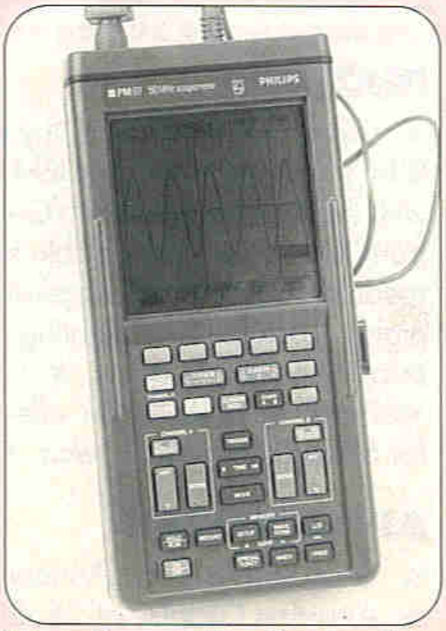
Each Scopemeter model, being of identical size, can be held reasonably comfortably in one hand – although not for prolonged periods, I must stress! All three models weigh in at 1·5kg/3·3lbs (1·8kg/4lbs with that garish holster!) – the result of that LCD screen and the use of VLSI ASIC ICs presumably. Don't forget that this figure includes a pretty hefty 4·8V



A sine wave of approximately 2kHz as it appears on the Scopemeter's LCD display. Zooming will produce greater detail (eg. superimposed noise) if it's required.

Ni-Cd battery pack which, on a full charge, will power the Scopemeter for 4 hours. Alternatively, the Scopemeter can be run off standard 'C' cells or an appropriately-rated DC power supply.

It must be said that the Scopemeter's case is a work of engineering art in itself. Taking it apart is fairly easy, too! Its double-insulated construction provides safe isolation with voltages of up to 600V rms (1,700V pk-to-pk). Such isolation extends to the connectors; the outer ring of each input BNC connector appears to be made of plastic. On closer inspection, the ground connection can be seen on the inside of the ring. Of course, the supplied

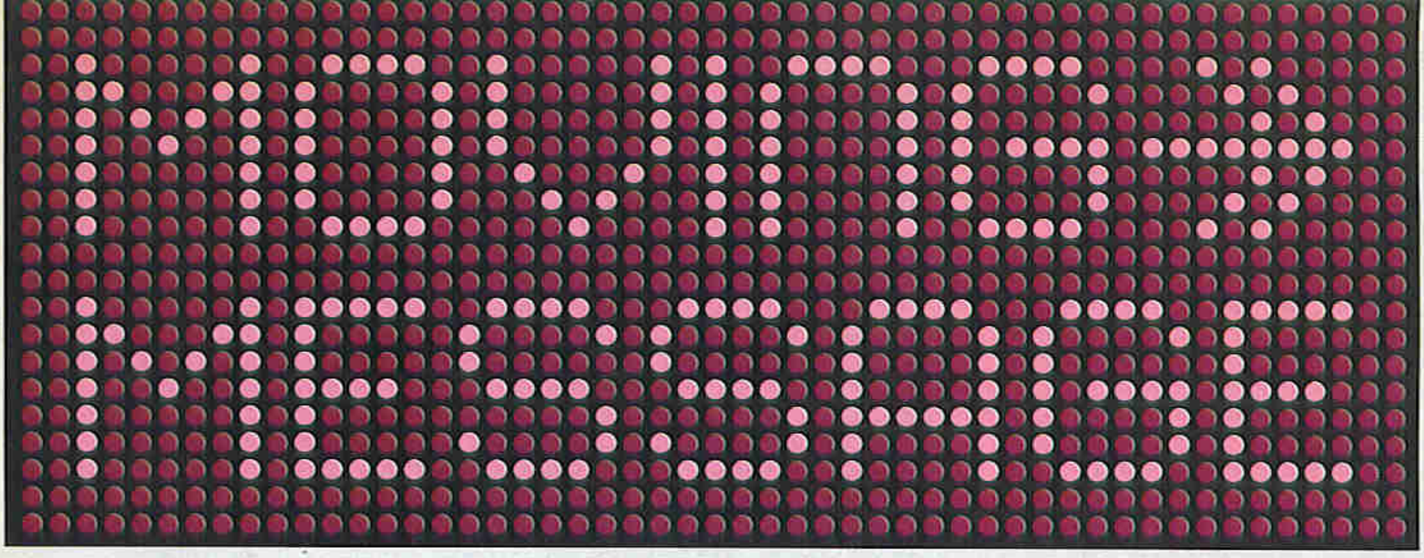


Scopemeter – ready for action where it's required.

enclosed Philips probes, or suitable replacements, must be used to maintain this isolation – it's no good 'spoiling the ship for a hap'orth of tar'! All connections, bar the optical RS232 interface (where fitted) and power supply/battery charger terminal, are available on the top edge panel. Apart from the two BNC male connectors for the 'scope probes, there are two sockets for the meter probes. When in the 'scope mode, an external trigger may be applied to these terminals. Alternatively, if the internal signal generator is being used, its output is available here.

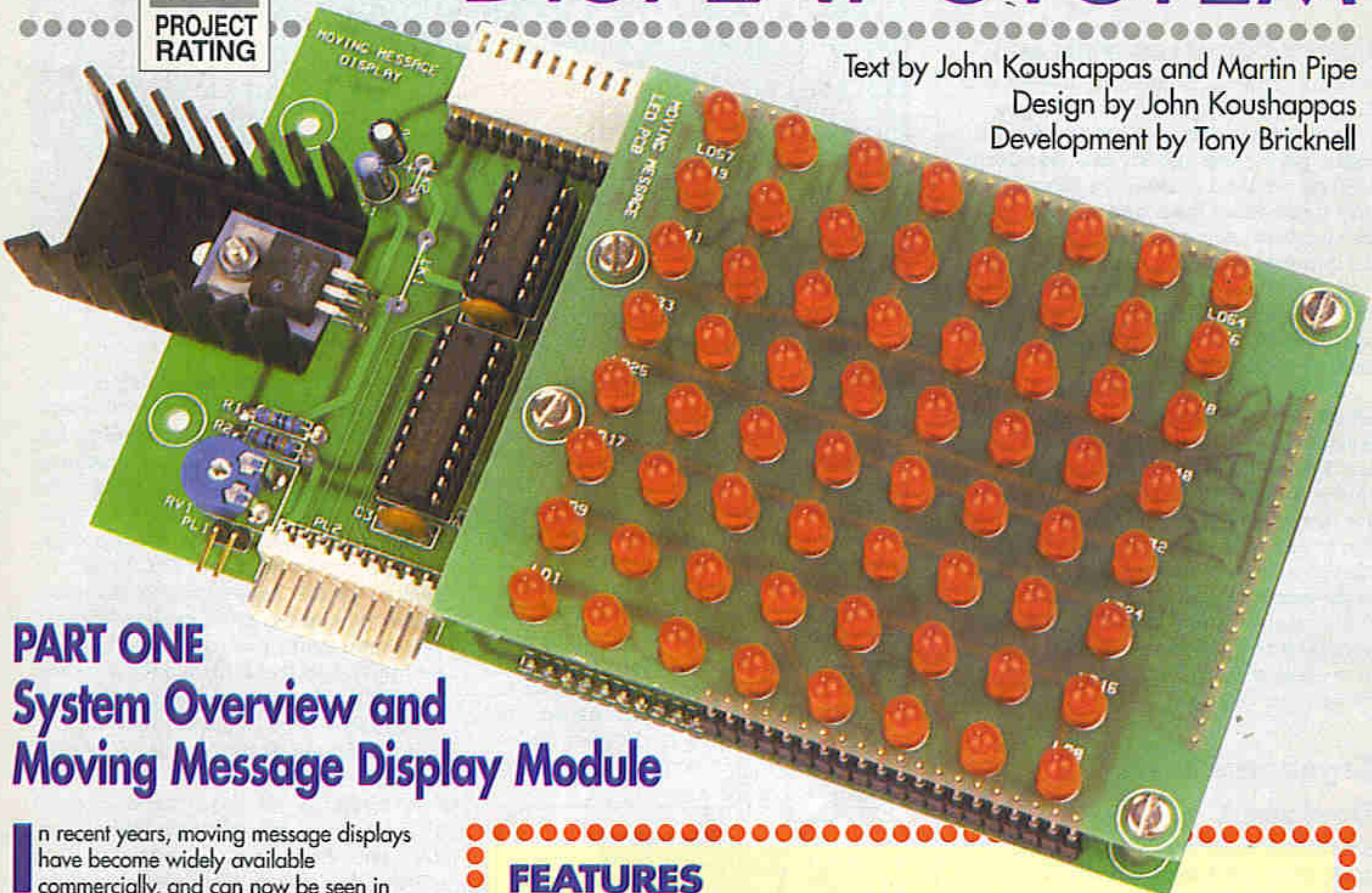
The case also features a clever double-jointed back-rest that allows the Scopemeter to be tilted at two different angles, or hung up with confidence wherever you think best. Hermetic sealing offers a high level of protection against dust, water and other contaminants, and is shielded from EMI – truly an instrument for all seasons (particularly the traditional British one! – Ed.) The Scopemeter normally resides in its shock-absorbent yellow holster; the unit itself is a rather more tasteful dark grey, with colour-coded keys.

The quality of the Scopemeter's case must be sharply contrasted with that of the horrible flimsy suitcase-type affair in which the review Scopemeter, along with the charger and a selection of probes, was supplied for transportation. Bearing in mind the cost of a Scopemeter, I feel that Philips could have done better. The 'suitcase' is held shut by two rather weak moulded plastic clasps – would you trust the safety of a £1,150 instrument to these? I know that Scopemeters have a certain amount of shock-resistance incorporated, but...! *Continued on page 19.*



DISPLAY SYSTEM

3 PROJECT RATING



Text by John Koushappas and Martin Pipe
Design by John Koushappas
Development by Tony Bricknell

PART ONE
System Overview and Moving Message Display Module

In recent years, moving message displays have become widely available commercially, and can now be seen in many shop windows, post offices, railway stations, airports and even on television. The basis of these systems is often a fixed-length light emitting diode (LED) display controlled by a microcomputer system, the messages being entered on a miniature keyboard and stored in non-volatile memory.

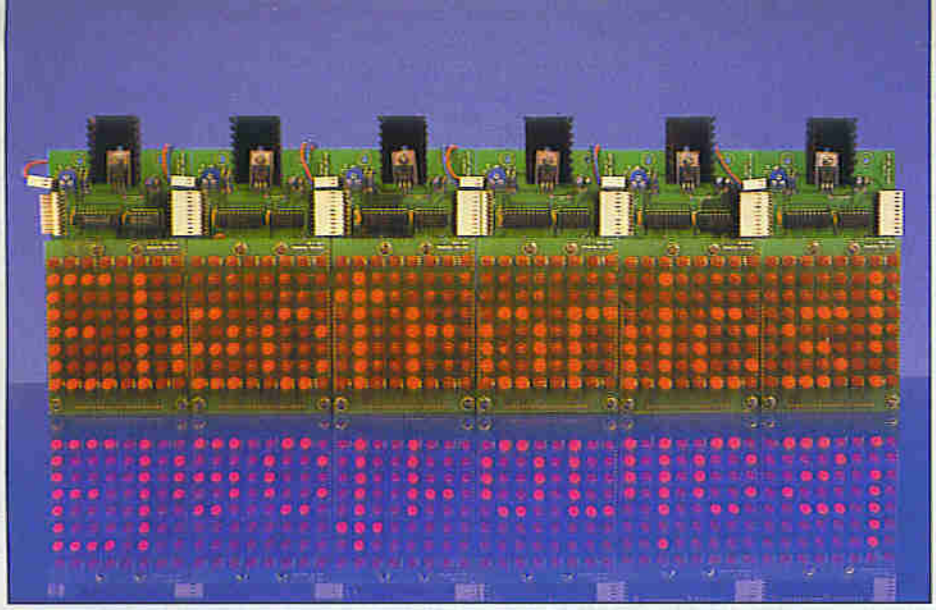
There are three basic addressing techniques that can be used to output messages to the LED displays. These are column scanning addressing, row scanning addressing and direct access addressing. Commercial message displays often employ row scanning addressing, whereby the relevant LEDs of only one row are on at any particular time, the data for the row being stored in a long shift register. As the display is scanned from top to bottom (or from bottom to top), there is a time lag between the rows and this results in the characteristic 'slant' in the letters of the message as it

FEATURES

★ Designed for use with any computer equipped with three 8-bit I/O ports – e.g., an IBM PC or compatible equipped with the Maplin 24-line PI/O card ★ Easily programmable from BASIC ★ Expandable to 32 boards by 'daisy-chaining' modules together ★ Large viewing area makes display highly readable in all lighting conditions ★ Programmable scrolling in all directions ★ Facilities for fade up/down ★ Programmable 'fizzle' effects ★ Direct pixel addressing for Speed (Animations, etc.) ★ Easy to Build

APPLICATIONS

★ Shop Displays ★ Announcements in Public Areas ★ Attention Grabbing! ★ Special Effects



A bank of display modules.

travels from right to left (or vice versa) across the LED display. Column scanning works on the same principles, but manipulates one column at a time instead.

This moving message display system uses a direct access architecture, and is fully controlled by a host computer. As a result, a wide variety of display techniques can be employed, all programmed in BASIC by the user. The system can, with appropriate programming, perform any of the functions seen on commercial displays.

A unique feature of this moving message display system is that it has been designed to be expandable. The unit module of this system is the Moving Message Display Module. The system is expandable from one module up to a maximum of 32 display modules, giving a 2·6m long high-resolution display, which is comparable with the largest commercial displays. All the necessary electronics to drive the LED display are also contained on the same board. As a result, the modules are easy to build.

0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	0	0	0	1	0
1	1	1	1	1	0
1	0	0	0	1	0
1	0	0	0	1	0

Figure 1a. Binary representation of the character 'A' in matrix form.

The Series

This four-part series will describe the design and construction of an expandable moving message display system. In this, the first part, we look at the display board and the expandable nature of the system.

In the second part, we will look at how the single display module can be interfaced with a computer. Also discussed will be the controller board, which is used to supervise each pair of display modules in the completed Moving Message Display, and the display configuration options available.

In the third part, the expandable PSU – which powers the complete display system – will be covered. In the fourth and final part, we will discuss how the overall system is put together, along with interfacing, testing and programming.

Computer Requirements

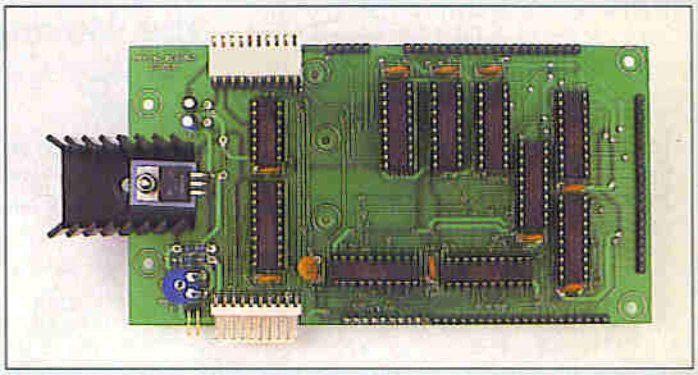
As the system is computer controlled, you obviously must have a computer to connect the hardware to! The computer can be any type provided it meets certain hardware and software specifications. The computer must have two 8-bit plus one 2-bit, parallel latching output ports. For example, the Intel 8155 and 8255 PPI (Programmable Peripheral Interface) are suitable. The 8255 PPI, out of interest, is used in the Maplin 24-line PI/O Card. Note that an IBM PC's printer port is not suitable.

From the software point of view, this project requires a BASIC interpreter (or compiler). For the expandable display, the BASIC interpreter must be capable of directly calling machine code routines. This will involve some advanced programming. This project will focus on the GWBASIC Interpreter running on an IBM PC compatible computer, but other types of BASIC can be used.

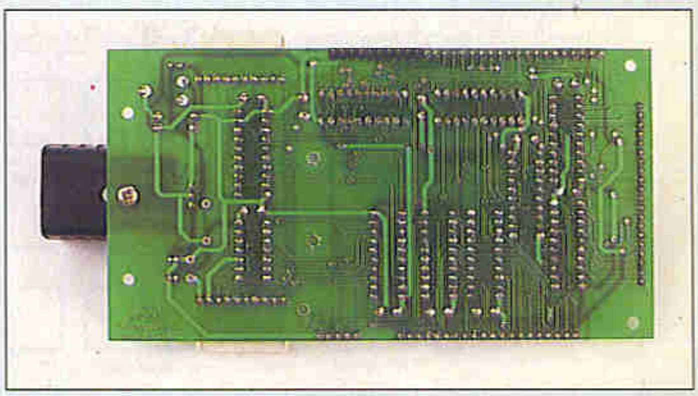
For interconnection of the display to the computer, knowledge of how to correctly connect to the parallel ports will be required. Examples will be given for connection to the Maplin 24-line PI/O card.

Bit Value	C 1	O 2	L 3	U 4	M 5	N 6
1			1			
2		1		1		
4	1				1	
8	1				1	
16	1	1	1	1	1	
32	1				1	
64	1				1	
Total	124	18	17	18	124	0

Figure 1b. Calculating bit values for the character matrix.



Component-side view of the control logic PCB.



Track-side view of the control logic PCB.

Moving Messages

Messages are made up by a computer program which converts the letters in the words of your messages into an array of '1's and '0's. This arrangement is called a *bit pattern*. For all the alphanumeric characters you want to use, you can design a corresponding bit pattern into the program. Figure 1(a) shows how the letter 'A' is represented.

When arranged to fit into the grid of Figure 1(b), it is possible, for any character, to calculate the totals for each of the columns 1 to 6. The numbers across the top of the grid show which column you are calculating for and the numbers down the left show the decimal value for each bit in the character. Adding up the decimal numbers corresponding to a '1' in each column will give a total for each column representing that part of the character. The set of totals for all six columns then describe the whole character's bit pattern. Thus the bit pattern for 'A' in our example is 124,18,17,18,124,0.

The method the computer program uses to choose these numbers is called the look-up table method. A *look-up table* is a *predefined* table of values corresponding to each letter or character. This look-up table may be embedded in the computer program itself, or may be loaded by the program as a data file.

The joining together of several bit patterns corresponding to words and sentences may be executed by the program in one operation. Thus the program which converts the text you type into it into one long bit pattern is called a *Bit Pattern Compiler*.

The compiled bit pattern is then held in a continuous piece of memory which stores the whole message ready for the displaying program to use.

The Moving Message Display Module

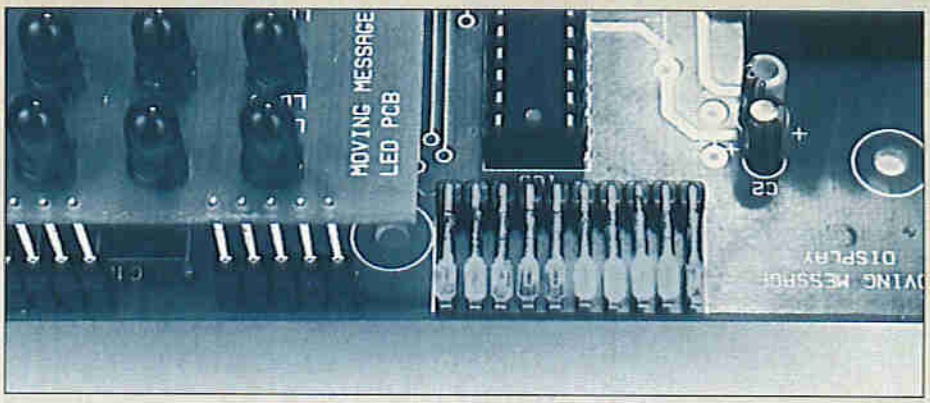
The architecture of the Moving Message Display Module is shown in the block diagram of Figure 2. The 8-bit computer port designated to be the 'data port' connects to the inputs of the data bus buffer. The outputs of this buffer feed eight octal data latches simultaneously from the module's data bus.

The 8-bit port designated to be the 'Control Port' generates the eight column control lines, Co1 to Co8. When octal data latch number 1 is selected by the Co1 line, that latch can read the data on the data bus. When that column is deselected, the octal data latch number 1 stores or latches that data.

If a different piece of data is placed on the data bus by the computer via the port and the buffer, this does not affect data latch number 1, which is currently storing the previous data sent on the bus. Data latch number 2 can now be used to read the new data on the data bus. This is repeated for all the latches in the module.

With all eight octal data latches now holding data, the data can now be output whenever it is required. This is achieved by enabling the tri-state buffers from the Display Control buffer line. This is a special control line which is controlled from another of the computer's ports. When it is low, all the buffers are disabled and the display is turned off. When this control line is taken high, all the buffers are turned on and the LEDs are turned on corresponding to the data in each of the latches.

Physically, to save space the Moving Message Display Module is built up on two PCBs – one with the control logic, and another with the 64 LEDs on it.



Close-up showing Minicon terminals fitted to the right angle pin strip.

The Moving Message Display Controller Board

When more than one moving message display module is required in your display system, the 8-bit 'Control Port' has to be decoded.

The purpose of the controller circuit in this system is to generate individual control output (Co) lines for each column of LEDs that are selected. A parallel access architecture was adopted so that any column of LEDs could be accessed with one computer program instruction. This parallel architecture is evident from the board's block diagram, shown in Figure 3.

There are two stages of decoding. The first decoder decodes the upper nibble (i.e. bits 4 to 7) of the control port into 16 individual lines. Each one of these lines can then select a second stage (4 to 16 line decoder), which decodes the lower nibble of the control port. Out of each second stage decoder emerge 16 control lines, each of which selects a column of LEDs on the moving message display module.

The architecture of the controller thus simply breaks down the 8-bit control port into a maximum of 256 individual control lines. Of course, if only two display modules are used, then only the upper nibble decoder chip and one lower nibble decoder chip are required. Therefore the controller system is sub-divided into modules proportional to the number of display modules required. There are two decoders on the first controller board in an expandable system, and only one decoder on each subsequent controller board. Each controller board thus supplies control lines for two display modules.

How the Two Modules Link Together

The data bus buffer and display control buffer outputs of the Moving Message Display Module are sent out of the module in the same parallel fashion as they entered. These outputs can therefore pass the same data to another identical module connected to the first module. This type of expansion is called *daisy-chaining*.

Similarly, the idea of daisy-chaining has been applied to the controller board. The result is a moving message display system which is completely expandable, from one display module up to a maximum of 32 display modules. The minimum system is a single module with no controller board. The minimum expandable system, or 'Base System', is two display modules and one controller board. Expansion continues at a rate of two display modules to one controller board up to a maximum of 32 display modules and 16 controller boards. The expandable structure of how the modules link together is shown in Figure 4.

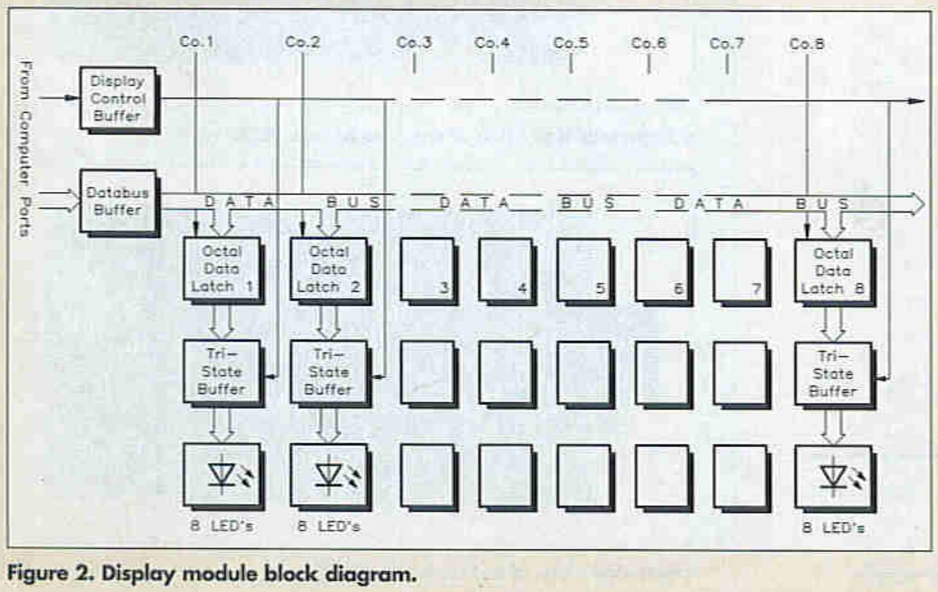


Figure 2. Display module block diagram.

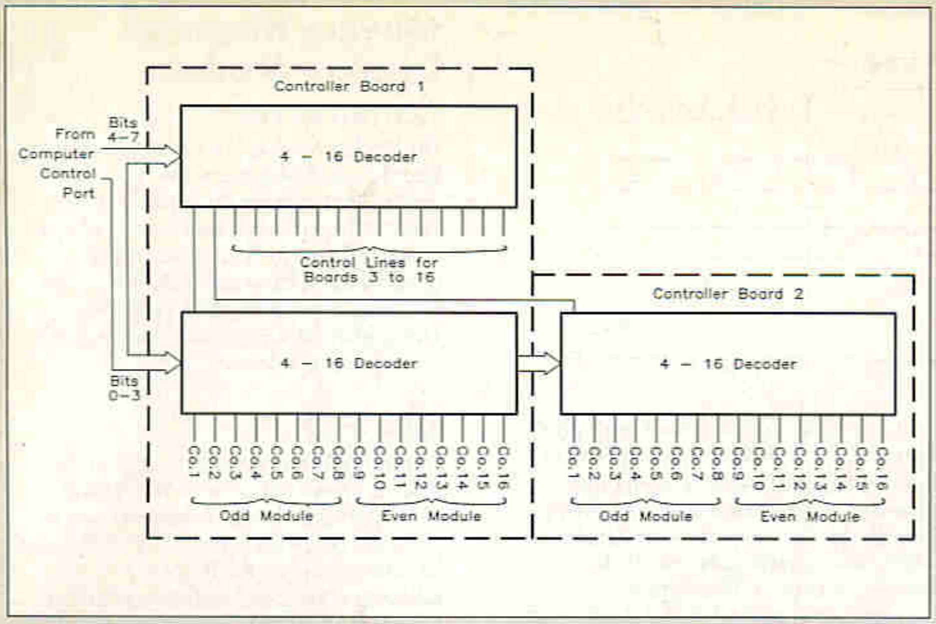


Figure 3. Controller board block diagram.

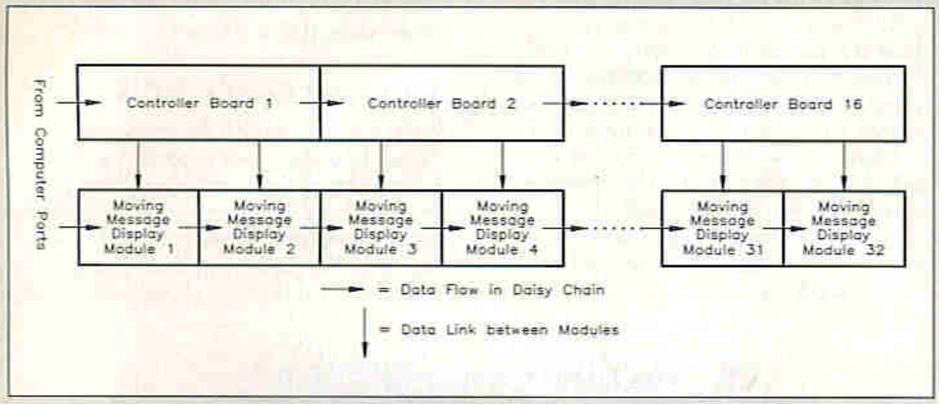


Figure 4. Moving Message Display System overall block diagram.

Any data present on the inputs (D0 to D7) will pass directly to the outputs when the LE (latch enable) pin is high, as shown in the timing diagram of Figure 6. (A cross-over in the data input and data output timing diagram indicates a general transition for each of the eight bits denoted by the word 'data'). When LE is taken low, the data is latched on the outputs (Stage 'C' of Figure 6). Any subsequent change in the data while LE is low is not registered on the outputs because the latch is not in transparent mode (Stages 'A' and 'C' of Figure 6). The data thus latched can be output to the LEDs which form the display. The LEDs will show this data when the $\overline{OE}$ pin is held low.

The LEDs' anodes connect directly to the Q outputs and all the cathodes are commoned to ground. There are no current limiting resistors used in this design – the reasons for this will become evident later. As a result, quite a high current is made available to each LED, which can give the display a high level of brightness, even with standard LEDs. The LED can theoretically draw a current of up to 58mA, although in practice the current is around 16mA. However, this does not adversely harm the TTL driver; in practice the 74LS series of ICs with buffered outputs will cope with the heavy load placed on them by direct LED coupling indefinitely. The chip body may run warm but it will not be affected or damaged. This method of driving the LEDs is explained later.

There are eight of these circuits, based around IC4 to 11, for each column of LEDs. The first column, controlled by IC4, consists of LD1 to 8 inclusive; the second, controlled by IC5, consists of LD17 to 24 inclusive, and so on.

Moving Message Display Module – Circuit Description

As can be seen from Figure 5, the circuit diagram, an 74LS244 octal non-inverting buffer, IC2, is included on each Moving Message Display Module. This serves two functions. It isolates the eight octal latches of the display from the driving output port which supplies the data, via PL2. It drives, or fans out to, the eight octal latches, thus maintaining TTL data integrity. It also drives a ninth device, namely the data bus buffer on the next moving message display module, in the complete system.

The OE (active high enable) display control buffer carries out the same functions as the data bus buffer in that it isolates the display from the output port of the host computer whilst driving the eight octal latches. It also performs another function in that it performs two inversions. Firstly, it generates an $\overline{OE}$ line from the active high one (present on the PL2 input) for IC4 to IC11. Buffering is also provided by the gate – remember that there will be nine devices driven from it. The $\overline{OE}$ line is then inverted again to give an output of OE to leave the module as it entered.

The heart of the circuit is the 74LS373, which is an octal transparent data latch. Eight of these devices are used (ICs 4 to 11) – one for each column of LEDs. Each 74LS373 has eight data inputs (D0 to D7) and eight outputs (Q0 to Q7), each of which has an LED connected to it.

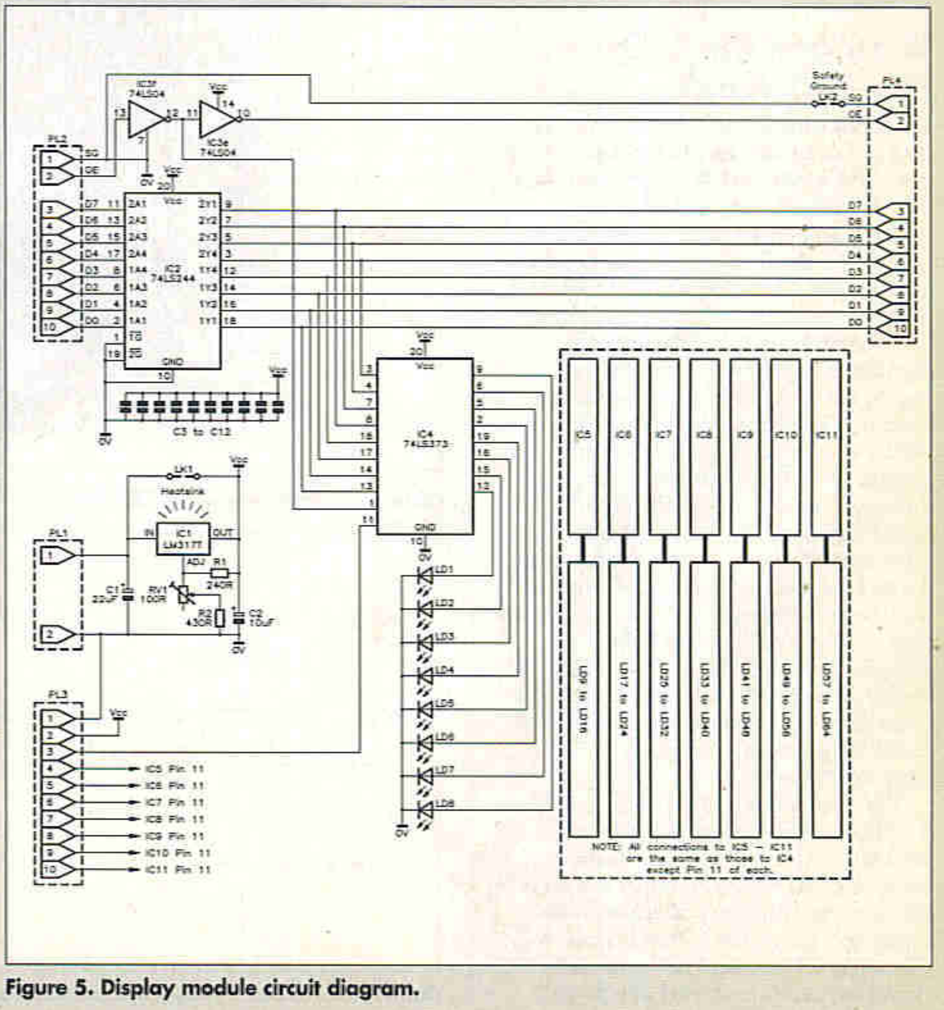


Figure 5. Display module circuit diagram.

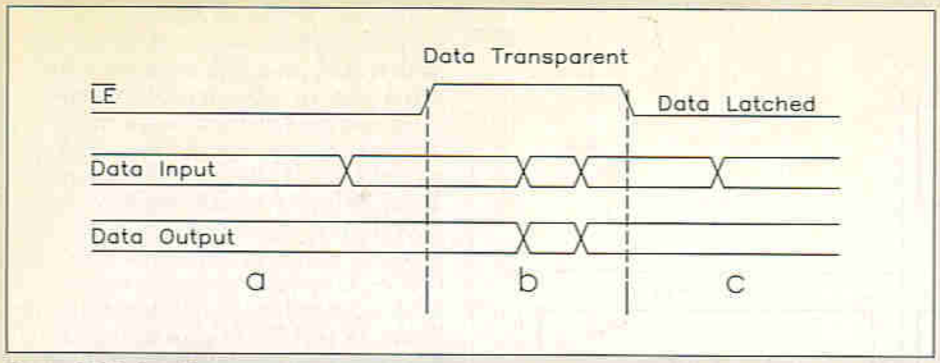


Figure 6. Timing diagram.

The column control lines enter the module via connector PL3. Each line connects to the 74LS373 Latch Enable (bar) input. For the single module, the source of the control lines is directly from the second parallel output port from the computer. The circuit detail shown boxed around IC4 and LD1 to 8 is repeated for ICs 5 to 11 and LEDs 9 to 64.

The moving message display module has its own voltage regulator on board, which is based around the standard variable voltage regulator, the LM317T. Employing a variable voltage regulator reduces the overall current consumption to approximately 1A, by reducing the TTL supply voltage. It also yields two useful consequences, in that it allows a simple yet powerful unregulated power supply to be the external power source for the display module (this will be covered in the final part of the series). In addition, the intensity of the LED display can be preset and fully controlled by hardware, as a result of having control of the output voltage of the regulator, as well as by software. Capacitors C3 to 12 (0·1μF) decouple the power supply for IC2 to 11.

Why are the LEDs Direct-Driven?

LS TTL gates have a limit to the number of devices that can be driven from their outputs since, unlike their CMOS counterparts, their input impedance is rather low.

The output of one LS TTL gate can drive typically 10 LS TTL inputs; in order to achieve this, the output impedance of an LS TTL gate has to be very low.

An experiment to find the output impedance of an LS TTL driver can be carried out using the theory of impedance matching. This states that maximum power will be transferred when the load impedance matches the output impedance. In Figure 7a, this would be when R_L equals the LS TTL output impedance R_o. This is found by first measuring V_o without R_L connected – giving the no load voltage, V_t. A load, R1, is then introduced. The resistance of R1 is decreased until V_o falls to $V_t/2$ (R_L and R_o form a potential divider); at this point, its value will be that of the LS TTL output impedance. The value of the output impedance for a typical LS TTL buffer device will typically be in the range of 35 to 40Ω.

This information is given because it shows that LEDs can be connected directly to the outputs of LS TTL gates without resistors being required. Figure 7b shows that an LED will draw approximately 58mA with full supply voltage applied to the TTL gate. A LS TTL output will thus regulate the current drawn by an LED connected directly to it.

It should be noted that the theory given above has been deliberately simplified to illustrate the point made. It is not a fully accurate representation of the actual output impedance; there are many other factors which have a bearing on the output impedance (e.g., R_o increases as V_s decreases, and power transfer is non-linear when R_L is not equal to R_o – as will be the case with an LED used in place of R_L).

The discussion of output impedance above is a general theory used in the field of amplifiers which can be used equally well in this case. However, the output impedance calculations/measurements discussed here do not relate directly to calculations of TTL fan in/out. For these, V_o must be maintained at, or above, the minimum voltage considered to represent logic 1 which is, typically, 2·4V. Buffers can drive devices down to a load of 133Ω.

Moving Message Display Module Construction

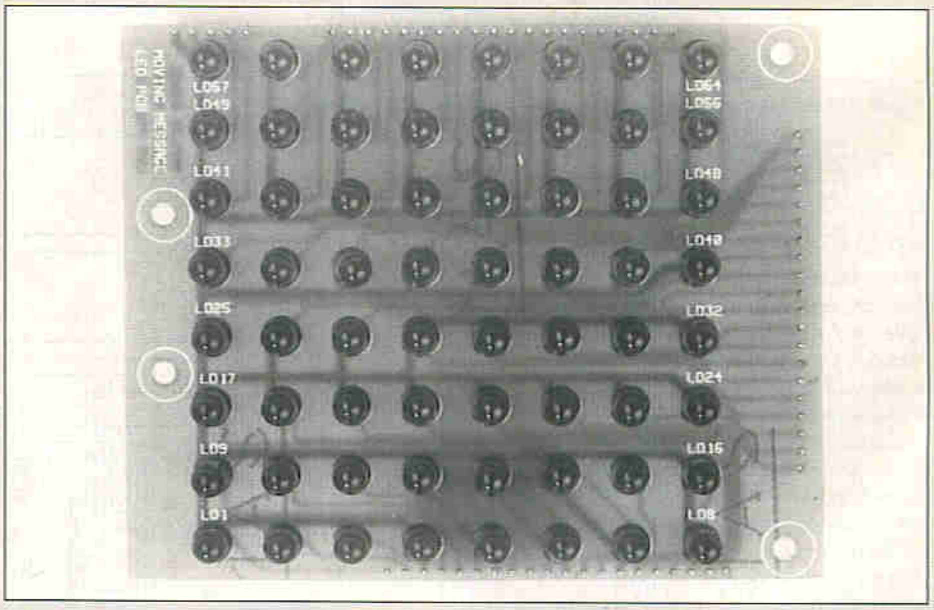
The Display Module consists of two separate boards; one that contains the LEDs, and another that contains the controlling logic. The PCB legends and track layouts of each PCB are shown in Figures 8a and 8b. Construction is fairly straightforward if the following information, along with that provided in the Constructors' Guide (supplied with the kit), is followed.

LED PCB

Fit each LED so that it is flush against the PCB, as shown in Figure 9. The flat side of the package should be lined up with the corresponding PCB legend. Each LED should be pressed against the PCB just prior to soldering it into position; this ensures flush mounting (and hence a tidy appearance) without having to reposition the device – unnecessarily reheating the joint may damage the LED and board.

Control Logic PCB

Begin construction with the resistors and the preset, followed by the capacitors and IC sockets. Attach the heatsink, regulator and insulator to the PCB using the M3 nut, shakeproof washer and 10mm bolt, as shown in Figure 10. Cut the supplied 12-way right angle pin strip into separate 2-way and



Component-side view of the LED PCB.

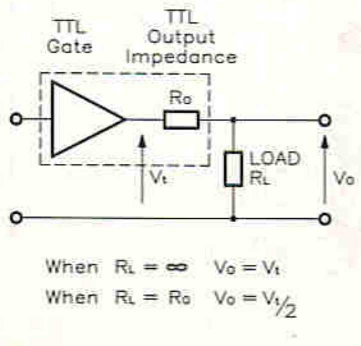


Figure 7a. TTL output impedance calculations.

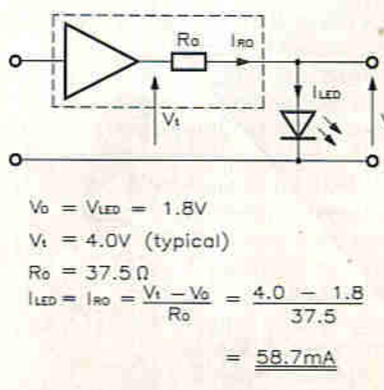


Figure 7b. LED drive current calculations.

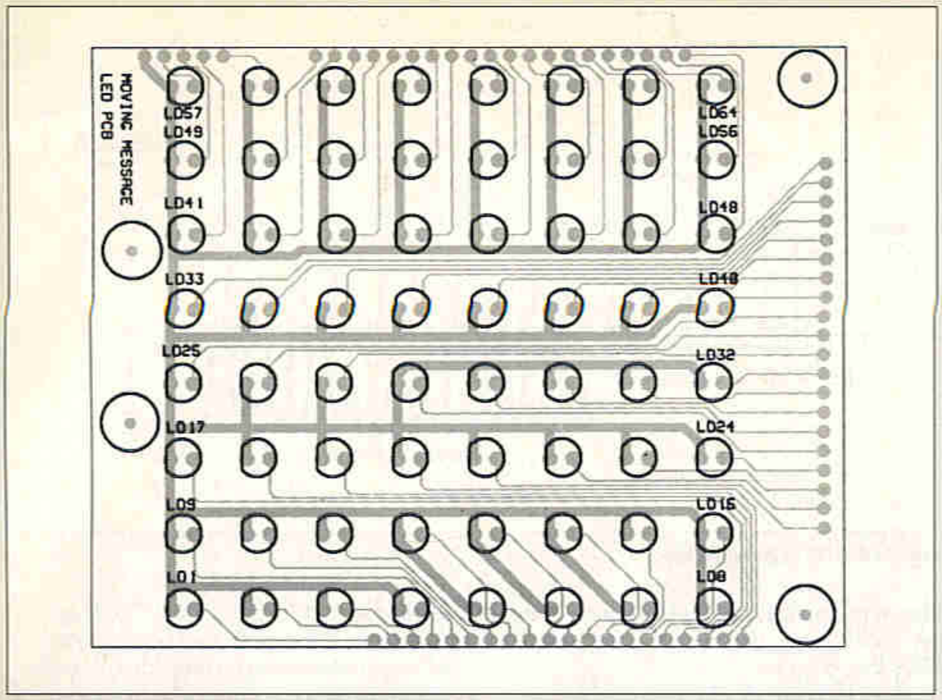


Figure 8a. LED PCB legend.

10-way strips (note that if you are buying the components separately, the smallest size available is 36-way (JW60Q)). Solder the Minicon terminals to the 10-way right-angle pin strip, as shown in Figure 11. Note that the end of the pin should line up with the second tag, so that the 10-way Minicon housing will fit into place properly.

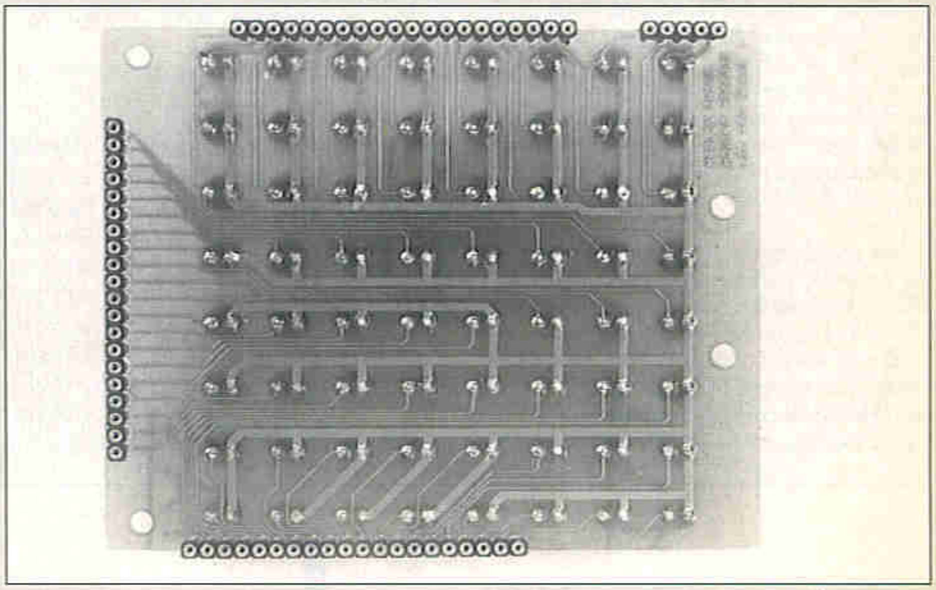
Figure 12 shows the PCB positions of all connectors. Note from this diagram that PL3, the 10-way straight pin strip (square cross-section) is fitted from the *solder* side of the PCB.

All other connectors, including the 10-way right-angle pin strip with Minicon housing prepared earlier, are fitted on the component side of the board. Supplied in the kit are two 32-way, and one single-way, pin strips (these are characterised by the round cross-section of the pins). Single-way pin strips are not available separately; if you are buying components separately you will have to buy another 32-way, discarding the unwanted 31 sections! 20-way lengths should be cut off each of the 32-way strips, and mated with two of the 20-way socket strips (the thinner pins mate with the socket).

Two 12-way sections should be left; one of these should have a strip of four removed to leave a 8-way length. This, together with the remaining 12-way section, should be mated with the third 20-way socket strip.

The remaining pin, together with the 4-way section prepared earlier, should be mated with the 5-way socket. Again, if you are purchasing the components separately, you will have to buy another 20-way socket strip, cutting off the unwanted 15 sections.

Assemble the PCBs and connectors as shown in Figure 10 (the pin end of the connectors are fitted to the main PCB); use the M3 spacers, screws, nuts and washers to temporarily hold the whole assembly together. Solder the pin connectors to the main PCB, and partly solder the socket connectors to the LED PCB. Note that you cannot fully solder these connectors as only the outer side of the joint is accessible – the important thing is to make sure that the sockets are at the correct



Track-side view of the LED PCB.

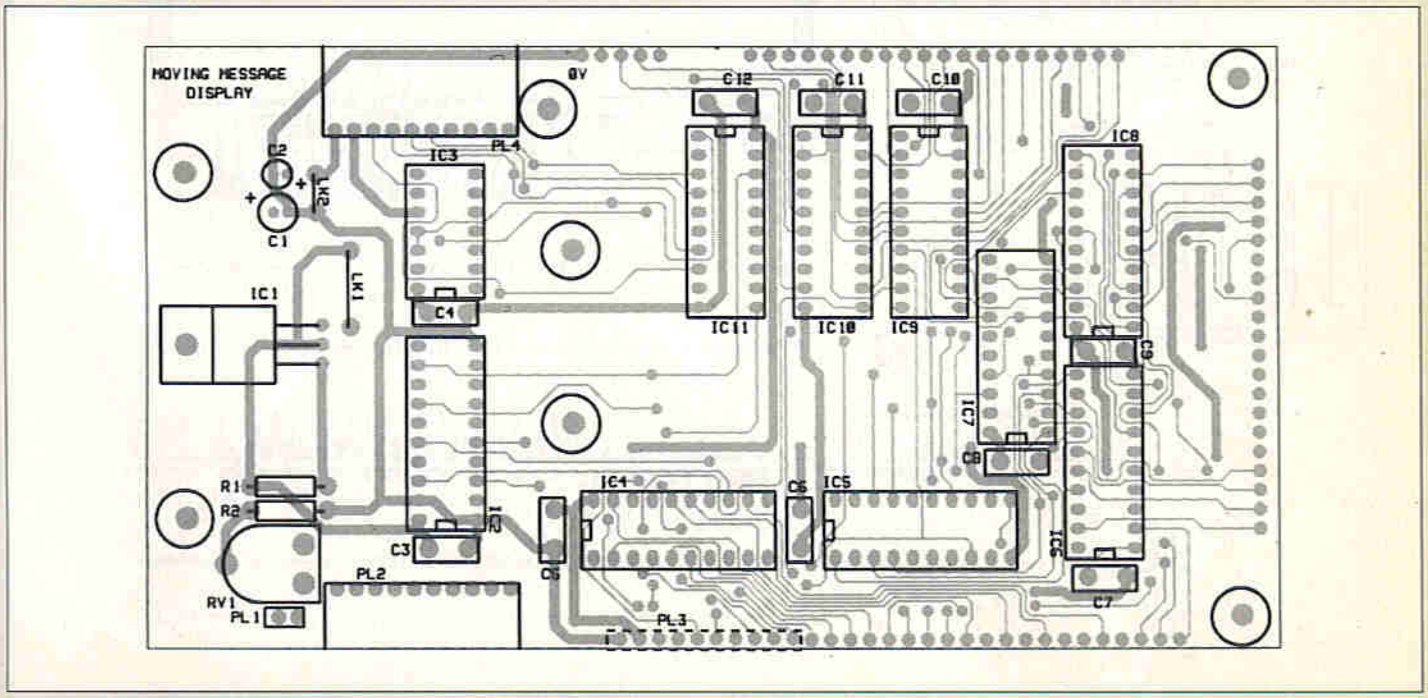


Figure 8b. Driver PCB legend. Note: DO NOT fit LK1 or LK2.

height when the time comes to solder them properly.

Next, separate the two PCBs and complete the soldering of the connectors on the LED PCB. Insert the ICs into the appropriate sockets. After a thorough inspection for misplaced components and soldering problems, the two PCBs can now be permanently reassembled together.

Circuit Link Options

There are two optional links, LK1 and LK2. LK1 is a Module Supply bypass, while LK2 is concerned with maintaining a signal ground between two moving message display boards in an expandable system. The links will be covered in subsequent articles; at this stage of the project, these links are not used and MUST NOT be fitted.

Moving Message Display Module Testing

To check the Moving Message Display Module, a 9V power supply capable of sourcing at least 1A is required. An appropriately set-up bench PSU is ideal; if you do not have one of these, a large battery (e.g., PP9) will suffice.

Before tests can begin, it is probably worth checking the assembly of the complete module again – any mistakes rectified at this stage could save money, time and frustration later. RV1 should now be turned fully anti-clockwise.

The power supply should be applied to PL1, as shown in Figure 13. After connecting a DMM between the output and ground, RV1 should be turned clockwise until a reading of 3·9V is obtained. All of the LEDs should light up, since the output enable (OE) and data inputs normally float 'high'. When the OE line (present on pin 2 of PL2, as shown in Figure 13) is grounded (note that pin 1 of PL2 is a ground connection), the LEDs should go out.

If the LEDs do not all come on when power is applied, do not panic, as the inputs may be floating low.

The other eight pins of PL2 are the eight data inputs (D0 to D7). When OE is high (i.e. all the LEDs are lit) and one (or more) of these data inputs are grounded, then the corresponding rows should be blanked out. If one or more fail to respond to this treatment, check your work again for solder bridges, misplaced components or dry joints.

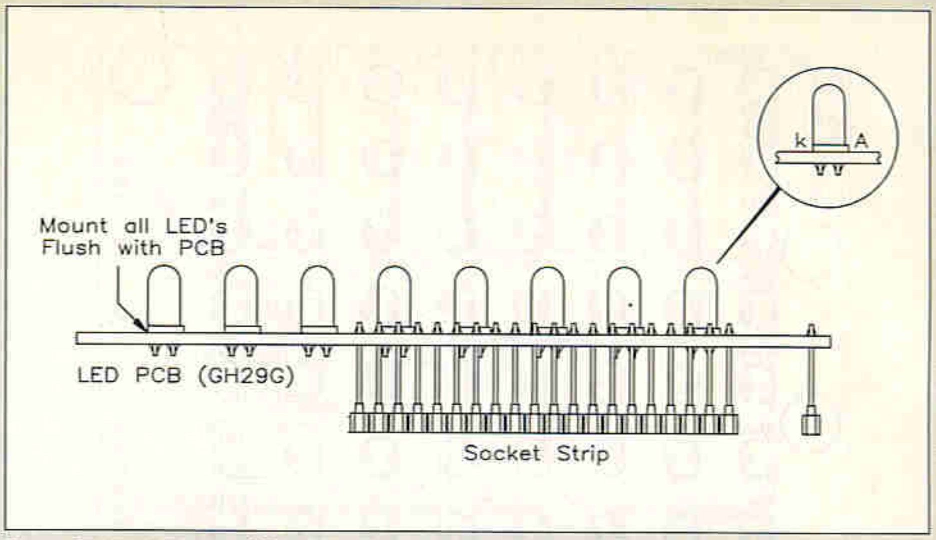


Figure 9. LED PCB assembly.

Specification

Power Supply Requirement:	9V unregulated, 1A maximum
Computer Interface Required:	2 x 8-bit and 1 x 2-bit parallel latching output ports
Data Feed:	Parallel Load
Hardware Control:	Direct Addressing, Hardware Blanking
Display type:	64 5mm Red LEDs in an 8 x 8 matrix with 10mm spacing
PCB Dimensions:	5·8in. x 3·2in.
Viewing area:	3·2in. x 3·2in.
Test Programs (Part 2):	BASIC
Message Effects:	Scroll left, scroll right, scroll up, scroll down, fade up, fade down, flash, animations.

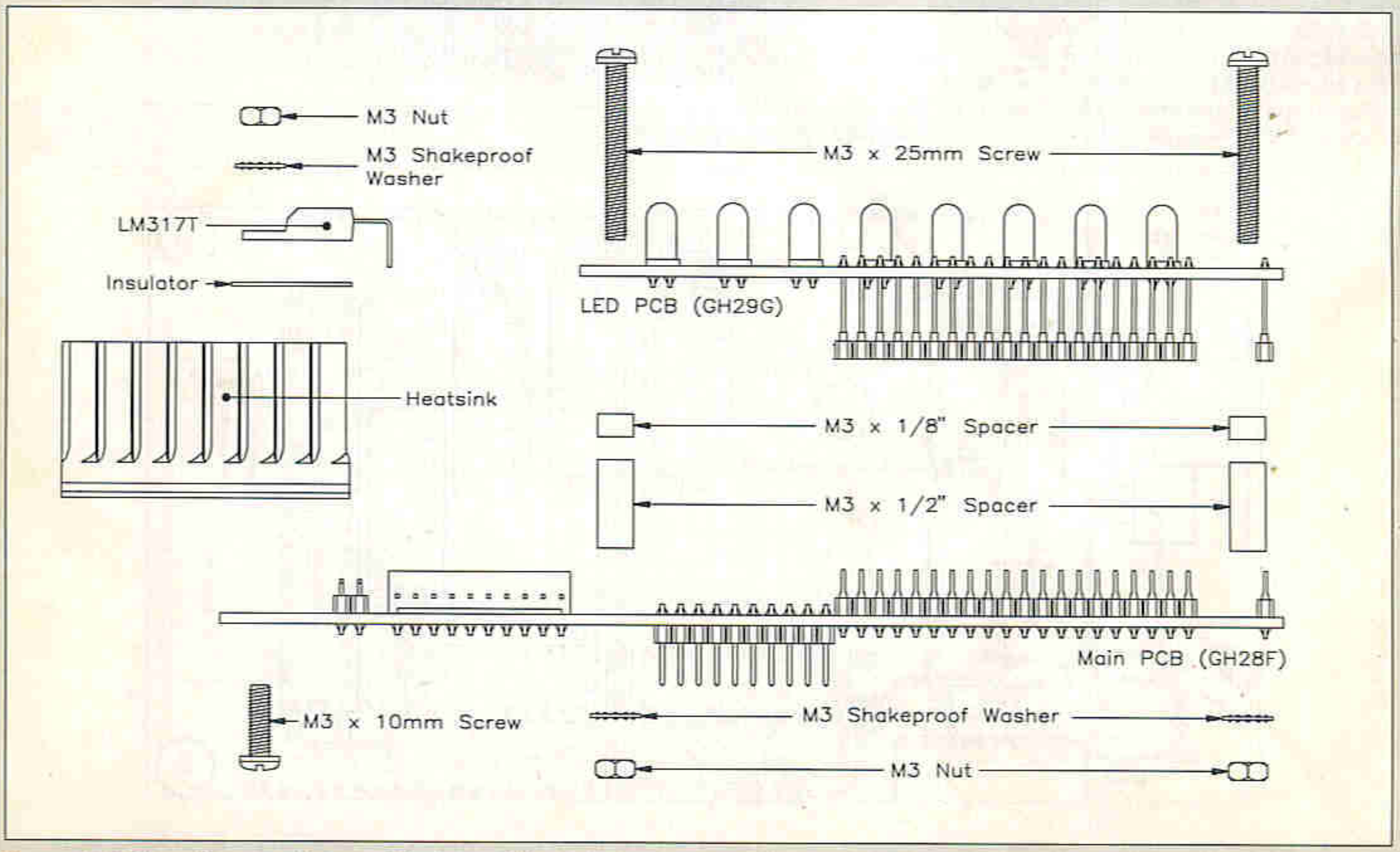


Figure 10. Fitting voltage regulator and final assembly.

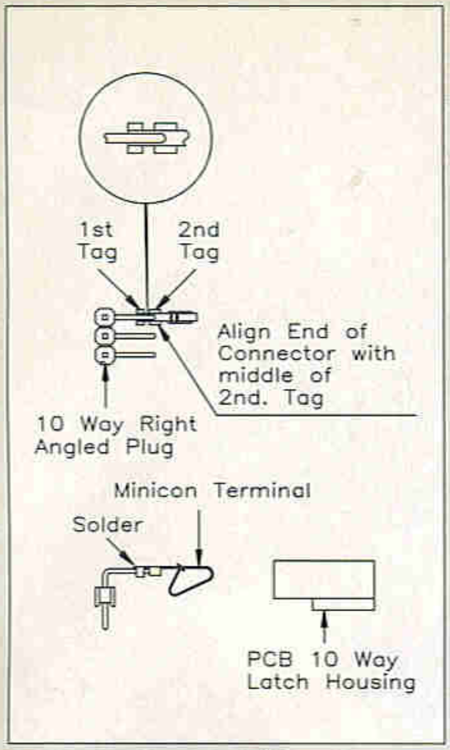


Figure 11. Minicon assembly.

Acknowledgments

Acknowledgments are due to the following, for the considerable help that they have contributed to this project: Mr. Ken Bone, Senior PCB Technician, for making 7 excellent prototypes. Mr. Michael Robinson, for building up some of the prototypes. Middlesex University's Electronic and Mechanical Engineering laboratories and technicians, for providing excellent facilities and assistance. Professor George Goldspink, Head of School of Electronics, for giving his approval to the go-ahead of this project.

Next Month

In Part 2, we take a look at the interfacing, and software testing, of the Moving Message Display Module, and an in-depth look at the Controller Board.

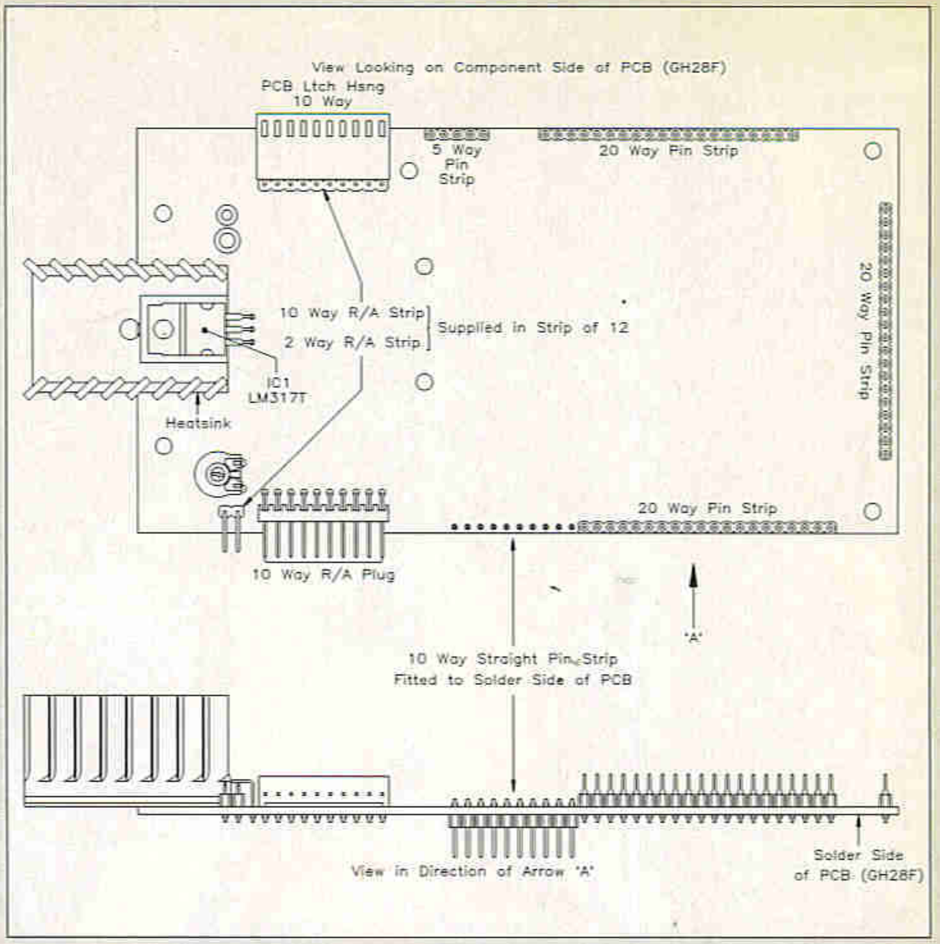


Figure 12. Fitting connectors to control logic PCB.

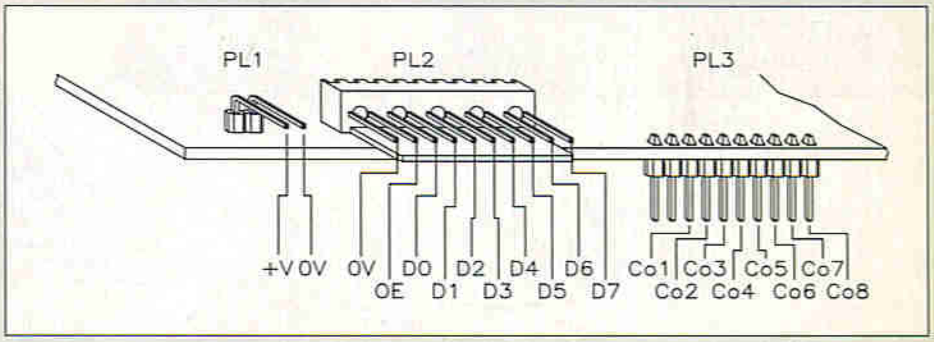
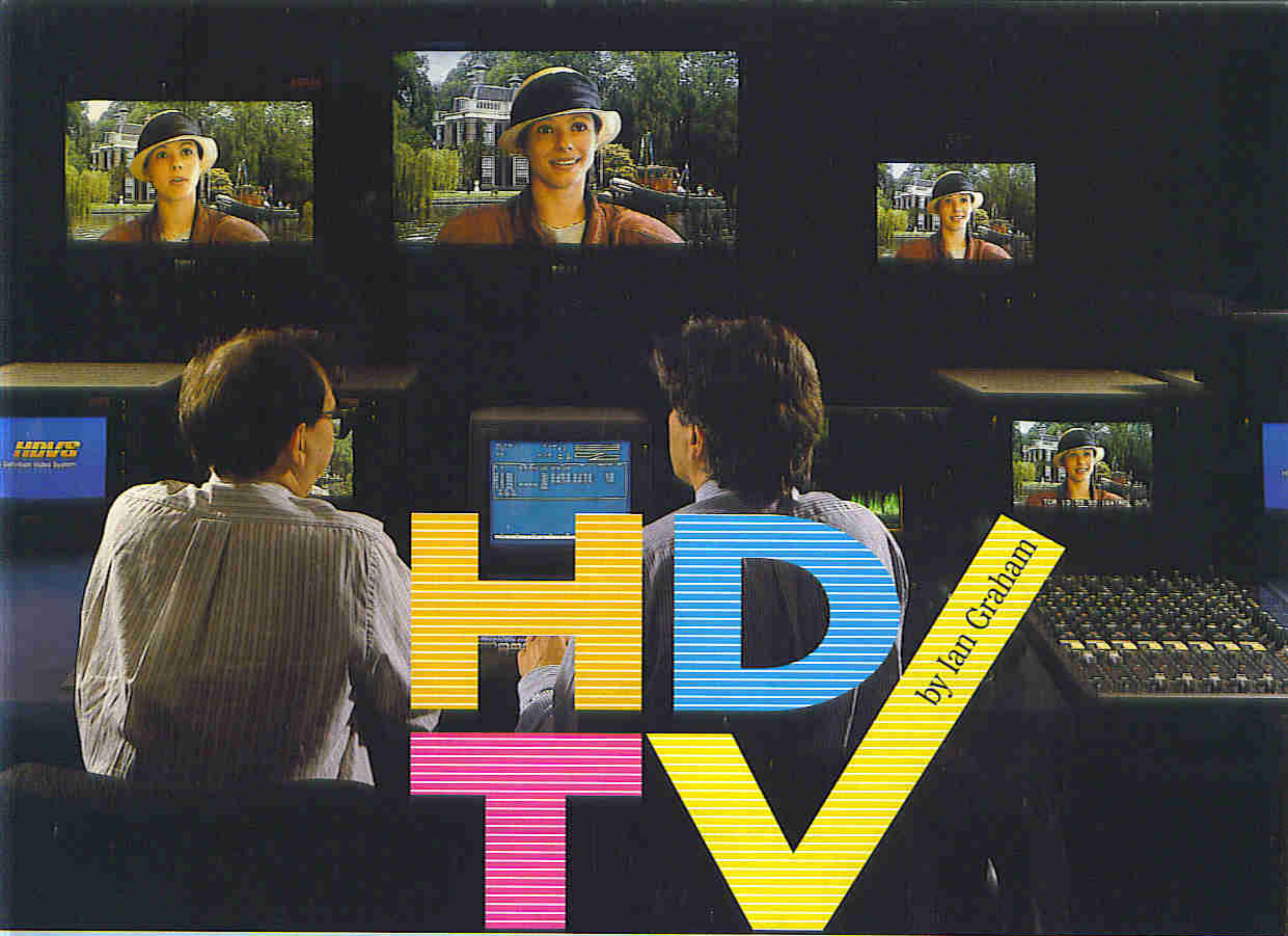


Figure 13. Connections for test purposes.

Glossary

Column scanning	Illuminate one column at a time continuously from left to right.
Direct access	Access any column at any time, in any order. Not necessary to continuously scan the display.
Row scanning	Illuminate a whole row at a time continuously from top to bottom.
Bit Pattern	Arrangement of '1's and '0's which defines a complete character or picture.
Bit Pattern Compiler	Program which converts text into bit patterns.
Daisy-chaining	Identical units joined together to make one large unit.
Data	One byte of a bit pattern.
Decoder (4 to 16 line)	Takes 4-bit binary input and outputs to only one line out of the 16 available output lines.
Fizzle	Message builds up by lights turning on in a random order.
Look-up table	Predefined table of bit patterns for each of the characters used. A look-up table is usually structured such that the data it contains can be easily looked up, for example, by a mathematical formula or relationship.
Non-volatile memory	Memory which does not lose its contents when the power supply to it is removed.
Nibble	Group of 4 bits (half a byte)
PPI	Parallel Peripheral Interface. A special IC which allows the computer to connect with an external piece of equipment or circuit.
8255 PPI	A programmable IC containing three 8-bit parallel input/output ports; when set up as output ports, they are latching; when set up as input ports, they are non-latching. Used in the Maplin 24-line PIO (Programmable Input/Output card) for the IBM series of PCs and their clones.
8155 RIOT	RAM Input/Output Timer. Similar to above but contains two 8-bit, and one 6-bit parallel input/output ports. It also contains some RAM and a timer. More common on older 8-bit Intel-based systems.

Continued on page 20.



HDTV

by Ian Graham

The Next Phase

Like Wimbledon and the World Cup, the Summer Olympics is one of those events that hijacks our television screens and dominates broadcasting during its short lifespan. The 1992 Summer Olympics in Barcelona was notable for something other than the battle for gold medals. The event was selected to introduce high definition television (HDTV) to the European public. French viewers had a chance to see HDTV broadcasts during the Winter Olympics from Albertville, but Barcelona was Britain's first public HDTV demonstration. If, during the Olympics, you passed through Gatwick or Heathrow airport, a host of railway stations and shopping centres around the country, Harrods or the National Film Museum in Bradford, you may have caught sight of a widescreen television set demonstrating the future of European broadcasting.

The equipment manufacturers and television networks may have shown that they can cover a demanding event like the Olympics with the new HDTV system but there is not a complete system waiting in the wings for us to rush out and buy. The demonstrations have thrown up problems that still have to be ironed out, there's still a lot to be done before you can flash your flexible friend and buy an HDTV set for the living room!

Boosting Brightness

We have become accustomed to bright, high contrast television pictures. The advent of Breakfast and Daytime TV meant that viewing television was no longer confined to the evenings in subdued lighting. TV screens had to be able to produce bright pictures in full daylight. Manufacturers solved the problem in two ways. They made the screen background blacker by coating the back of the glass screen with black stripes, a 'black matrix'is formed, between the stripes of phosphor dots that glow to make the picture. Secondly, they boosted the electron beam current so that the electrons smashed into the phosphor dots with greater force and unloaded more energy into the phosphors.

HDTV sets pack 1,250-lines on to the screen instead of the 625-lines that we are use to now, with each line containing double the current number of coloured spots, or pixels. The upshot is that the phosphor dots on an HDTV screen have to be much smaller than those on a 625-line screen to deliver the maximum picture resolution, but unfortunately, smaller dots produce less light. Many of the HDTV demonstrations that the press and trade have been treated to, in the past year or so, have been held in darkened corners to make the most of the reduced picture brightness. But if 625-line picture brightness can be increased by boosting the electron beam current, then can it not be tweaked again to bring up the brightness of an HDTV set?

A perforated metal sheet behind the screen, the shadow mask, ensures that the electrons from each of the three electron guns at the back of the cathode ray tube (CRT) fall on the correct phosphor dots. If the electron beam carrying the picture's green component, for example, were to land on the red phosphor dots, the picture's colour purity would go haywire. The shadow mask prevents this from happening, but to work properly and reliably, it is vital that the shadow mask is positioned very accurately and stays in place. The electrons that don't pass through the mask strike it and give up their energy to it in the form of heat. The mask is made from metal and, like all metals, it expands as it heats up. If it warps due to this electron beam heating, then picture quality nose-dives. This effect sets a limit on electron beam current. The tendency of a metal sheet, like the shadow mask, to warp increases with larger sheet areas, so warping due to overheating is more of a risk with the larger screen sizes at which HDTV really comes into its own.

The CRT is a bit of an anachronism in this day and age. Considering the advances being made in cameras, video recorders, image processing and transmission, it is curious that we still use a 100 year old technology to display television pictures. Unfortunately, the cathode ray tube is still the most convenient way of doing the job, but it's fragility and bulky size, compared to the electronics around it, make CRT technology impractical for the bigger screen sizes that HDTV requires.

There are several modern flat panel TV display technologies available including LCD, plasma and electroluminescent panels and so on, but so far none of them has rivalled the CRT for cost and ease of manufacture. Just to give you an idea of the cost differences, a 14in. CRT costs about US$40 to manufacture while a 14in. LCD display costs around US$300.

The mini TV sets available now use LCD screens, but LCD technology isn't economical for much larger screens. An LCD screen production line involves the same fixed cost overheads as a microchip production line, but whereas the chips roll of the line in millions, the trend towards larger screens means that fewer and fewer screens would come off a production line with the same fixed costs. Whereas one chip failing in a hundred still leaves 99 perfect chips on a silicon wafer, one pixel failing in an LCD screen, with several hundred thousand pixels, ruins the whole screen. These two factors both drive the unit cost of the screen up. Manufacturing costs continue to rise with inflation, but as screen sizes increase and failure rates also rise, productivity falls. It's not a very promising recipe.

A different way of using LCD technology may provide an answer, in the short term at least. An LCD projector uses small LCD flat panels that can be made more economically and, despite the smallness of the panels, it can produce high quality pictures on a thin, flat screen up to 2·1 metres (more than eight feet) across. The LCD panels are used as light valves. An intense white light is split into its red, green and blue components. These three rays of light are shone through monochrome LCD panels that are 'switched' by the picture's red, green and blue information respectively. The outputs from the three LCD panels are combined and projected onto a screen. The brightness of the picture is therefore a function of the lamp power and is not related to the picture-forming elements as in a CRT.

LCD projectors are available now, but they are expensive. So, despite its shortcomings, the CRT will probably continue to reign supreme. HDTV sets with screen sizes above 90cms (36in.) are unlikely to be popular in the home until an economically viable flat screen becomes available, or less expensive LCD projectors come along.

Cameras

At the other end of the system, cameras are posing problems too. The technology is not the problem. The best HDTV cameras can turn in stunning picture quality. The problem once again is cost. The full bandwidth (30MHz) HDTV cameras used to broadcast some of the Winter Olympics coverage cost up to £100,000 each. Not surprisingly, these "crown jewels" of the network were reserved for the studio shots, while less advanced, less expensive, lower bandwidth cameras were used for most of the outside broadcasts. All but a handful of the cameras employed picture tubes instead of the more advanced solid state CCD technology used by domestic camcorders. The trouble with tubes is that they suffer from defects called comet-tailing and lag, which can lead to colour blurring, burnt-out pictures and ghostly trails following bright spots around the screen – especially in poor light conditions. CCDs don't suffer from these defects, so a generation of video enthusiasts who haven't experienced them with their own £500-£1,000 amateur/domestic camcorders are unlikely to accept them in a brand new 'television-of-tomorrow' system that costs the earth. Yet the cost of re-equipping with full bandwidth CCD HDTV cameras, never mind the recording, editing and distribution equipment, is currently prohibitive for most large broadcasting organisations, and certainly for the smaller regional outfits.

Transmission and Coding

Between the camera and the screen, a massive amount of information in each frame of the picture has to be compressed, transmitted and then decoded by the TV set. HDTV will use some clever electronic trickery to cut down on the amount of information that has to be broadcast. The transmitted signal will probably tell the TV set whether or not there is any motion in the picture.

In parts where there is no motion, the information from several fields will be combined by the set to increase the resolution and produce a sharper image. A field is composed of all the odd-number or all the even-number lines in the TV picture. The fields are transmitted alternately with two successive fields forming one complete frame of the picture. In parts of the picture where there is motion, the fields will be displayed independently as they are received. The result should fool the eye and brain into believing that the whole picture is as sharp as the stationary parts of the image, when in fact that is not so!

When Can I Have One?

When will HDTV be used other than at a one-off Olympic spectacular? Well, if you lived in Japan and money was no object, you could have HDTV now. About eight hours of HDTV test broadcasts go out in Japan every day. But, and it's a whopping great big BUT, the cost of the TV sets is measured in thousands of pounds. Last year, 36in. HDTV sets were selling in Japan for about 4,000,000 yen – that's about £20,000! Since then, manufacturers have shown prototypes for a new generation of HDTV sets that are expected to sell for around 1,000,000 yen or about £5,000. These are clearly not viable price levels in terms of mass market appeal.

As for Europe, even when all the transmission, coding standards, and all the hardware problems are sorted out, we are still left with one of those chicken and egg situations i.e., hardware/software, that often dogs new developments in consumer electronics. Why should you buy the hardware if there's no software? But why should the software producers, in this case the programme-makers and broadcasters, produce any software while few people are buying the hardware?

In fact, we will not make a single jump from PAL 625-line terrestrial TV to 1,250-line HDTV delivered by satellite. It looks like the television industry will gradually try to move us to widescreen 625-line PAL television first. Widescreen TV sets are already on sale in many European countries including Britain, France, Spain, Italy and Germany – some of these sets, notably from Ferguson, Thomson, Nokia and Philips, are HDTV compatible. That is, with the addition of a satellite dish and an HD-MAC decoder, they will be able to display the pictures received from space, but not in high definition. HD-MAC is the transmission standard that will probably carry our HDTV programmes from space to us.

The next step is to persuade satellite television broadcasters to switch from PAL to a different transmission system called D2-MAC, which is the essential forerunner to HD-MAC. Thomson has already exhibited a prototype HD-MAC decoder which should be available for about 5,000DM (about £1,760) towards the end of 1993. At the moment it's about the size of a video recorder, but by 1997 it should be small enough to fit inside the TV set. By then, the price of the whole package (TV plus decoder) should have been brought down to 5,000DM. We will probably have to wait until the start of the next century before an HDTV satellite TV service is operating, with readily available HDTV sets in the shops at prices that might tempt us.

HD Recorders and Disc Players

Behind the scenes, engineers are already working on developments such as the HD-VCR and the HD laserdisc player, and also more advanced developments for the future, in particular all-digital high definition television. Several all-digital systems are being tested in the United States. The advantage of digital television is that no matter how many times a picture is relayed, bounced off satellites, recorded and re-transmitted, the picture quality remains unaffected. Every time analogue pictures are processed in any way, there is an inevitable, though usually imperceptible, drop in quality.

Meanwhile, film production companies are already making promotional and industrial 'films' on high definition video. An army of printing, publishing, medical imaging, cinema and video entertainment companies are waiting in the wings to explore the use of high definition images instead of conventional film images. It looks like only a matter of time before some form of high definition video becomes a production standard in Hollywood – Kodak has developed one such system with a much higher resolution than 1,250-line HDTV. Television drama productions, even those made on film, are frequently transferred to video when the time comes to add visual effects, mainly because it's much cheaper to do the effects on video than film. Peter Greenaway's film 'Prospero's Books' featured high definition video sequences. Blockbusters are usually made in studios that are now largely owned by Japanese companies like Sony, who are also involved in high definition video and television development.

The high definition ball is rolling. Who knows how fast or where and when it will stop?

NEXT issue

In next month's super issue of 'Electronics – The Maplin Magazine', there are some really great projects and features for you to get your teeth into! The March issue is on sale February 5th, available from Maplin's regional stores, and newsagents countrywide, and of course by subscription (see page 21 for details). To whet your appetite, here's just a taster of some of the goodies on offer:

WHAT'S IN A LASER?

Lasers – what they are, how they work, where they're used and, most importantly, what the term 'laser' stands for (yes, it's an acronym!) – are all looked at in this fascinating feature by Douglas Clarkson.

MOVING MESSAGE DISPLAY CONTROLLER

In this month's issue you'll find the Moving Message Display Module, which will work extremely well on its own – fine if you want to display one character at a time. However, the key to expansion (32 display modules!) is the Controller Module – and you'll have to wait till next month for that!

BSB SATELLITE SYSTEMS – BEYOND THE GRAVE

Martin Pipe takes apart an old Ferguson BSB receiver, rendered obsolete at the end of 1992 when Marcopolo was shut down and, with a little help, manages to turn it into a full-specification PAL/MAC receiver/transcoder.

DUAL INPUT MODULE

This versatile little module, designed for use in an audio mixer, may also be the answer to a seemingly unrelated problem. Want to fit a magnetic cartridge to that old music centre? Assuming of course that the tone arm will take it, preamplification and equalisation is required – and this module will provide it. Hum playing havoc with your microphones? The Dual Input Amplifier module will enable you to use balanced-line mics with existing equipment. It's all here!

WIND POWER

With the costs of fossil fuels ever spiralling upwards, the race is on to develop renewable alternatives. And what better natural resource to exploit in good old Blighty than the wind? Stephen Waddington investigates.

AUDIO FREQUENCY SIGNAL GENERATOR

If you plan to build or service audio equipment – amplifiers and tape recorders in particular – a good quality sine wave source is essential. The thermistor-stabilised Wien bridge unit, to be described, provides minimal distortion right across the audio frequency range, and will also provide square waves at a 'flick of a switch' – ideal for evaluating frequency response and phase shift characteristics.

BEHIND THE AUTOCUE

Another helping of satellite television for you! This 'Out and About' feature takes Alan Simpson on a tour of the Sky News studio in West London. Lots of wonderful technology abounds there – from video effects from program scheduling – as you will discover!

Plus of course there's all the usual features for you to enjoy!

'ELECTRONICS – THE MAPLIN MAGAZINE'

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE

The Philips Scopemeter continued from page 7.

Brief summary of specifications

Digital Multimeter Mode (all models)

DC voltage	
Ranges channel A:	300mV, 3V, 30V, 300V 600V with 10:1
mV (external trigger) input:	300mV, 3V
Resolution:	0·1mV, 1mV, 10mV, 1V
Accuracy:	±(0·5% + 5 counts)
Full scale reading:	3000 counts
Peak voltage:	2·5 x full scale, 375V on 300V range
Normal mode rejection:	>50dB @ 50 or 60Hz
AC or AC + DC true RMS voltage	
Ranges:	300mV, 3V, 30V, 250V 600V with 10:1 probe
Resolution:	0·1mV, 1mV, 10mV, 100mV, 1V
Accuracy DC to 5MHz:	±(10% + 25 counts)
Full scale reading:	3000 counts
Peak voltage:	2·5 x full scale, 3·75V on 250V range
Common mode rejection ratio:	>60dB, DC to 60Hz
Resistance	
Ranges:	300Ω, 3kΩ, 30kΩ, 300kΩ, 3MΩ, 30MΩ
Resolution:	0·1Ω, 1Ω, 10Ω, 100Ω, 1kΩ, 10kΩ
Accuracy:	±(0·5% + 5 counts)
Diode test (all models)	
Open voltage:	≤4V
Full scale voltage:	2·800V
Measurement current:	500μA
Oscilloscope (all models)	
Vertical frequency response:	DC to >50MHz (–3dB)
Sensitivity:	1mV to 100V/division (models 95 and 97) 5mV to 100V/division (model 93)
Input impedance:	1MΩ, 25pF direct, 10MΩ with 10:1 probe
Horizontal modes:	Recurrent, single shot, roll
Trigger sources:	Channel A, B, external
Trigger sensitivity channel A or B:	<0·5 division to 10MHz <1·5 division to 60MHz <4·0 divisions to 100MHz
External:	+0·2V or +2V level (TTL compatible)
Trigger input impedance:	1MΩ, 25pF direct, 10MΩ with 10:1 probe
General Specifications (all models)	
Display:	Super twist liquid crystal, 84 x 84mm
Resolution:	240 x 240 pixels, 25 pixels/division
Power:	Internal 4·8V nicad typical 4 hours operating time
Size:	260 x 130 x 60mm 275 x 140 x 65mm with holster
Weight:	1·5kg, 1·8kg with holster
Case:	Splash proof and dust proof

All the models are supplied with a Ni-Cd battery pack, 240V AC mains adapter/battery charger, probe set, banana plug to BNC adapter, multimeter test leads, protective holster and accessory case.

Table 1. Scopemeter core specifications.

Technology

Behind the Scopemeter lies some pretty awesome technology, which is revealed, in all its glory, in Photo 1. There is a densely-populated multi-layer double-sided PCB in each half of the case, and the use of surface-mounted components is predictably widespread. Environmental protection around the case joints is provided by flexible sealing gaskets. Low-power CMOS devices are used, the 'static sensitive' label being prominently displayed at various points inside the unit.

The left-hand PCB, mounted on the display/control half of the case, contains the computer electronics (based around an ASIC and a powerful Intel microcontroller), the ADCs (extremely fast flash converters are used) and a number of Hitachi ICs that control the display.

The top section of the other PCB contains the analogue circuitry responsible for input conditioning. Eight relays are used to switch in various parts of the attenuation network, depending on the range selected. Normally, a screening cover is fitted – particularly as there is a switch-mode power supply directly underneath it. This provides higher voltages to the circuit areas that need it, such as the display backlight. Underneath this is the battery compartment, which accommodates 4 'C' type cells (alkaline recommended!) or the Ni-Cd battery pack.

Meet the Family

As has been revealed, there are three models in the Scopemeter family; the PM93, PM95, and the PM97 – as loaned for the purpose of this review.

The PM93 offers the basic 50MHz scope without maths functions or waveform memories, and the multimeter without minimum/maximum capture or decibel ranges.

The PM95's 'scope section adds the waveform averaging function, cursor-related functions and 10 trace memories. Its multimeter is also expanded to include the capture and dB ranges not included on its little brother.

The top-of-the-range PM97 offers, in addition to all of the PM95's capabilities, 10 setup memories, the signal generator, RS232 printer interface and electroluminescent backlight. The maths functions (add, subtract, divide, multiply, filter, invert or integrate waveforms) are also only available on this model.

Supplied Accessories

Apart from a three-year parts and labour warranty, each Scopemeter is supplied with a large number of accessories. These include a battery pack and charger, 10:1 probes, multimeter test leads, protective holster and instruction book. Another item supplied with each kit is a 'Quick Operating Guide' which offers, in summary form, most of the information in the handbook. Credit card sized, and printed on plastic impregnated paper, it has magnetic 'covers' – as a result, it will adhere to any convenient steel surface. Good thinking, eh? (don't put it in your wallet next to your credit cards though! – Ed.).

A wide range of optional items are available from Philips for an even wider range of applications. These include carrying cases, power supply options, current probes, temperature probes, additional isolated test leads and the obligatory service manual.

Conclusion

So what did I think of the Scopemeter. Minor niggles cast aside for the moment (if you can count the lack of a backlight on the PM93/95 a minor niggle!), I was extremely impressed. After all, it provides all of the features of a top-quality DMM with those of a comprehensive DSO – and it takes up a fraction of the bench space. A device of this type is exactly what the field service engineer has been crying out for all these years, but it is only fairly recently that the technology required to design such a beast has been available. During my acquaintance with the Scopemeter, I can only say that there were many of my colleagues here at 'Maplin Towers' who would have gladly taken it off my hands for a wide range of applications, from servicing their cars to analysing a MIDI interface.

Prices

PM93	50MHz	Scopemeter	£899
PM95	50MHz	Scopemeter	£1,116
PM97	50MHz	Scopemeter	£1,351

These prices are correct at the time of writing. Please note that these products are not stocked by Maplin. However, if you are interested in purchasing a Scopemeter, please contact MPS Enquiries on (0702) 552961.

Acknowledgements

I would like to thank Philips Test and Measurement of Watford, and in particular Nigel Hedges, for the loan of the PM97 over an extended period of time.

Moving Message Display System continued from page 15.

MOVING MESSAGE DISPLAY MODULE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1	240Ω	1	(M240R)
R2	430Ω	1	(M430R)
RV2	100Ω Hor Encl Preset	1	(UF97F)
CAPACITORS			
C1	22μF 16V Minelect	1	(YY36P)
C2	10μF 16V Minelect	1	(YY34M)
C3-12	100nF 16V Minidisc	10	(YR75S)
SEMICONDUCTORS			
IC1	LM317T	1	(UF27E)
IC2	74LS244	1	(QQ56L)
IC3	74LS04	1	(YF04E)
IC4-11	74LS373	8	(YH15R)
LED1-64	LED Red 5mm	64	(WL27E)
MISCELLANEOUS			
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 20-pin	9	(HQ77J)
	Powerfin Heatsink	1	(FG55K)
	Insulator TO220	1	(QY45Y)
	Skt. Hsg Terminal	1 Pkt	(YW25C)
	Socket Housing 10-way	1	(FY94C)
	Plug Assm 10-way R/A	1	(RK68Y)
	Pin Strip 36-way R/A	1	(JW60Q)
	Pin Strip 36-way	1	(JW59P)
	Pin Strip 32-way	3	(JR74R)
	Socket Strip 20-way	4	(KP51F)
	Spacer M3 x ½in.	1 Pkt	(FG34M)
	Spacer M3 x ⅛in.	1 Pkt	(FG32K)
	Steel Nut M3	1 Pkt	(JD61R)
	Shakeproof Washer M3	1 Pkt	(BF44X)
	Steel Screw M3 x 10mm	1 Pkt	(JY22Y)
	Screw Screw M3 x 25mm	1 Pkt	(JY26D)
	Control Logic PCB	1	(GH28F)
	LED PCB	1	(GH29G)
	Instruction Leaflet	1	(XU05F)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	PP9 9V Battery	1	(FM05F)
	PP9 Battery Clips	1 Set	(HF27E)

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.

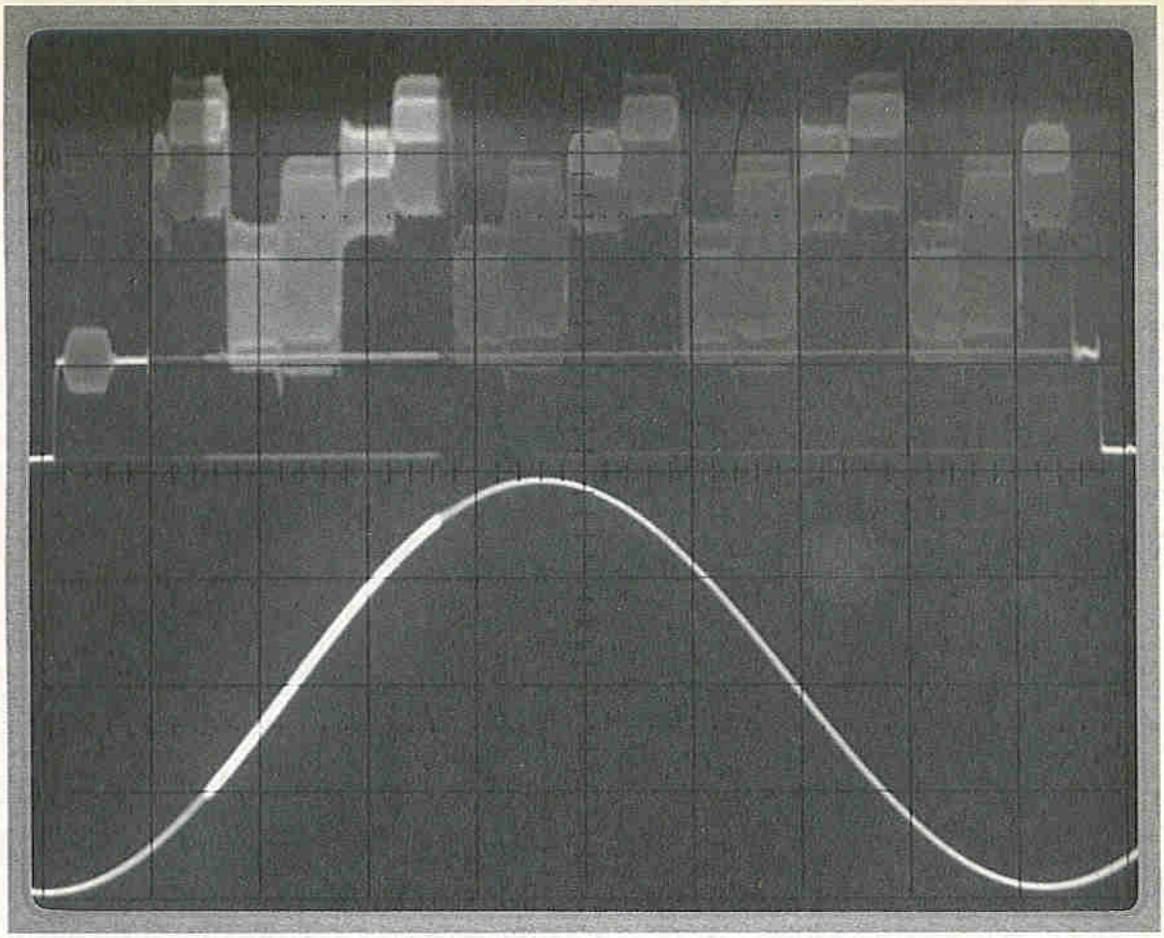
Order As LT21X (Moving Message Display Module) Price 1+ £24.95 4+ £22.95.

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

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

Move Mess C/Logic PCB **Order As GH28F Price £9.95.**

Move Mess LED PCB **Order As GH29G Price £2.95.**



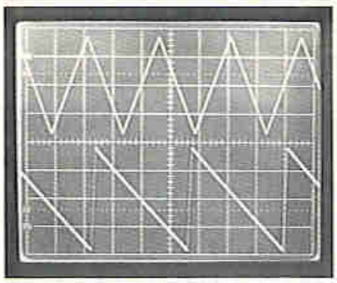
SAVE UP TO *£70

ON OSCILLOSCOPES

*For a limited period only we are offering this superb range of oscilloscopes at **SPECIALLY REDUCED PRICES,** but they will only be **AVAILABLE AT MAPLIN STORES,** so hurry down to your nearest Maplin store TODAY!*

From the sophisticated 20MHz 7025 to the delayed sweep 40MHz 7046, advanced design and high quality combine to bring you features such as; 1mV/div sensitivity, advanced 6-inch CRT with percentage markers and internal graticule, eliminating parallax error and ensuring a highly accurate display. X-Y mode allows Lissajous patterns to be produced and phase shifts measured.

The 7025 has all the capabilities required of a general purpose oscilloscope and will accept signals from DC to at least 20MHz with a high degree of accuracy. The 20MHz 7026 incorporates a delayed sweep time base, which can be used to magnify a portion of the waveform, and makes accurate time interval measurements and the study of short duration events possible. The sophisticated 40MHz 7045 includes a 40ns delay line to help show very short duration events in their entirety. A delayed sweep oscilloscope of advanced design and high quality is found in the shape of the 40MHz delayed sweep 7046, having an increased magnification along with a 40MHz bandwidth and capable of displaying complex signals with precision and accuracy.



**** Please note items on this page are available at these SPECIALLY REDUCED PRICES in MAPLIN STORES ONLY, and are not available at these prices through Mail Order.***

SAVE £50 GL29G Catalogue Price £299.95 [H] **NOW £249.95**
SAVE £20 GL30H Catalogue Price £349.95 [H] **NOW £329.95**
SAVE £70 GL31J Catalogue Price £449.95 [H] **NOW £379.95**
SAVE £40 GL33L Catalogue Price £499.95 [H] **NOW £459.95**

(GL33L illustrated).

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Maplin ELECTRONICS

CAR PARKING RADAR SYSTEM

Text by John Mosely

FEATURES

✻ Easy to install ✻ Adjustable range
✻ Audible warning of obstacles

Assist your parking skills (or your partners!), by adding this short-range ultrasonic RADAR system to your vehicle. It will detect objects and 'measure' their distance by means of sensors mounted on the back of your car. The unit will allow you to accurately judge the amount of clear space behind your vehicle and detect possible unseen hazards within the radar range. The unit emits an audible 'bleep' when your car has reached a preset minimum distance from the obstacle.

Circuit Description

The circuit diagram, Figure 1, illustrates circuit operations for the transmitter and the way in which the receiver is used to produce a warning signal. Reflected ultrasonic pulses require a significant amount of signal processing before they can be used to activate the preset minimum distance alarm signal. It is the propagation delay of the 40kHz ultrasound waves passing through the atmosphere, when reflected by a large object, i.e., a car, that is used to calculate the distance between the radar unit and the object. The distance can be set in the range measuring 5cm to 1·5m. As soon as the preset minimum distance is reached, an acoustic alarm signal will be heard. In practice, this means you are about to hit the obstacle!

IC1 along with crystal X1, and C1, C2 and R1 produce a clock signal which is used to drive IC2, a 14-stage binary ripple counter, and gate N4 of IC4. The output from N4, a Schmitt trigger, drives gates N6 to N10 of IC5 which are used to provide a gated 40kHz pulse to transmitter transducer SEN1.

The reflected ultrasonic pulses are picked-up by the receiver transducer SEN2 and amplified by A2 and A3 of IC6, a low noise J-FET amplifier, and converted into a trigger pulse by A4 of IC6. These are fed to the time/delay comparison circuit formed by IC3 and N1, N2 an N3 of IC4. N5 of IC5 provides the drive to the buzzer, BUZ1.

Resistors R7 and R8 provide a half-supply reference voltage to A1 of IC6 which sets the switching threshold for A4 of IC6. Diode D5 provides protection in the unfortunate event of reverse battery connection.

Specification

Measuring range:	5cm to 1·5m
Transmission frequency:	40kHz
Power supply:	10 to 15V DC 16mA max.

PCB Assembly

The kit is in two main parts, the main PCB (marked P3502B) containing the majority of the ICs and other components, and the receiver PCB (marked P3502S) supporting both transmitter and receiver ultrasonic transducers. Included in the kit is an instruction booklet which lists the complete easy to follow, step-by-step, construction details; so construction should proceed smoothly. The Maplin project construction rating for this kit is set at a 2, indicating that it is easy to build, but not suitable for absolute beginners as setting-up and testing is required.

Bend and fit two wire links at the points marked J on the main PCB. Next mount the five resistors and the five diodes, observing the correct polarity of the diodes. Install the 5·2428MHz crystal by laying the crystal flat against the PCB and securing it by means of a wire strap before soldering the connections. The five IC sockets can now be soldered into the board, followed by the capacitors, again observing the polarity of both the IC holders and the capacitors. The trimmer RV1 and the two 4-pole screw connectors, J1 and J2, can now be soldered to the board followed by the buzzer. Be sure to insert the longest lead of the buzzer into the positive marked hole. Finally insert the five ICs into their respective sockets (all of them orientated towards the 'free' side of the PCB).

Assembling the transmitter/receiver PCB follows a similar method to the main PCB: Firstly the resistors, followed by the IC socket, the transistor T1, the capacitors and finally the six-pole screw connector J1.

The sensors can be soldered either directly into the PCB board or soldered to terminals to provide a vertical mounting. This will depend on how you intend to mount the unit in a box for use in your car. The terminals of the sensors which are connected to the housing must be soldered to the terminal marked '–'. Note SENS1, the transmitter is type MA40A5S or equivalent and SENS2, the receiver, is type MA40A5R or equivalent. Insert the IC, a TL074, into its socket observing the correct orientation.

This completes the assembly of the two PCBs. You should now check your work very carefully making sure there are no dry joints, and the components are in the correct position and orientation.

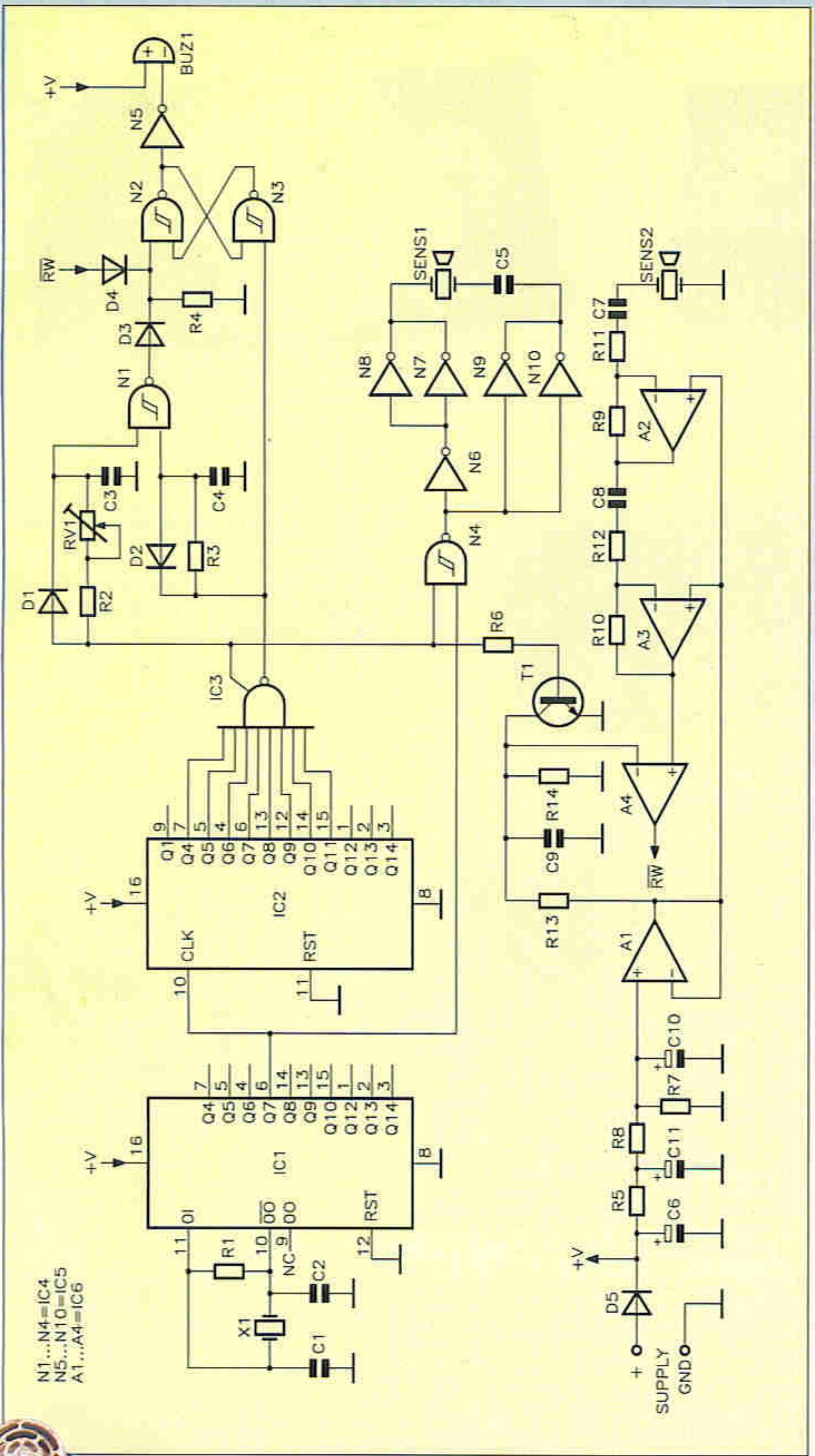
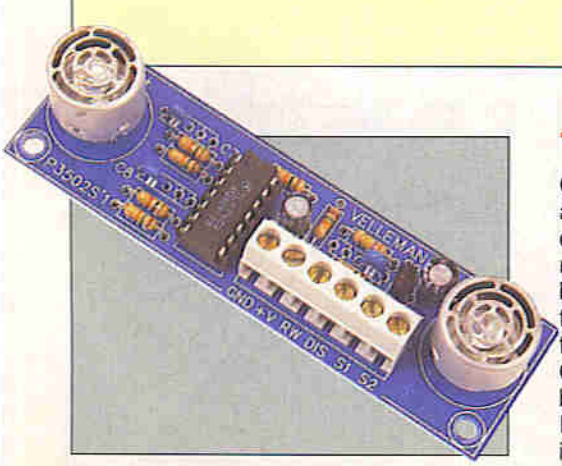


Figure 1. Circuit diagram.



The Receiver PCB with the sensors mounted vertically.

Testing

Connect the points GND, +V, RW, DIS, S1 and S2 on the main PCB to the corresponding points on the transmitter/ receiver PCB. Make sure that the distance between the transmitter/receiver PCB and the main PCB is at least 50cm – adjust the trimmer RV1 to its mid-way position. Connect a 12V DC power supply (or a battery) between the points GND and +V. If you hold your hand, or a sheet of paper, in front of the sensors you should hear the sound of the buzzer when the distance from the object to the sensors decrease to about 70cm. If you do not, then check the PCBs and wiring for short circuits etc.

Installation

Mount the transmitter/receiver PCB in a suitable plastic box, which can be in either of two different ways (depending on where the unit is to be fixed on the car):

1) With the sensors in the horizontal position (Figure 2): Fit the four terminals for SENS1 and SENS2 and solder the sensors to the terminals so that they are horizontal with respect to the PCB. Drill two holes in the box as shown. Install the PCB behind the holes using plastic pillars, so that the sensors are aligned facing the holes without touching the box.

or

2) With the sensors in the vertical position (Figure 3): In this case the sensors are simply mounted on the PCB. Now drill the holes in the box as shown on the drawing. Install the PCB behind the holes using plastic pillars, so that the sensors are facing the holes without touching the box.

To help keep water out of the unit, cover the holes on the inside of the box with a piece of very fine wire gauze (see Figure 3). If the meshes of the wire gauze are to wide to prevent water penetration, the gauze should be doubled up two, or four times before fixing it to the holes.

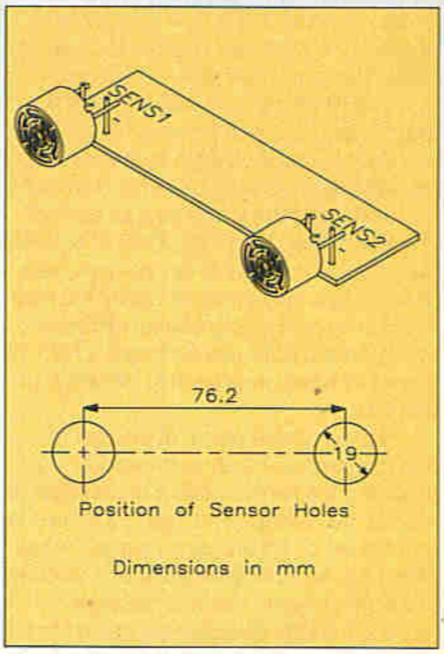


Figure 2. Horizontal method of mounting the sensors.

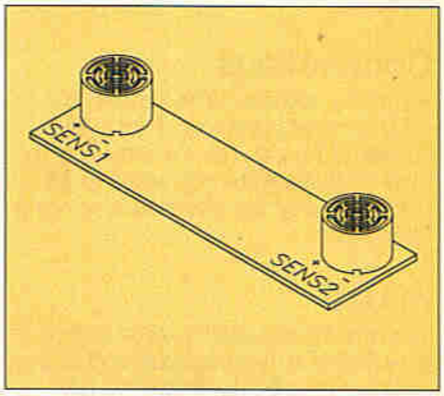
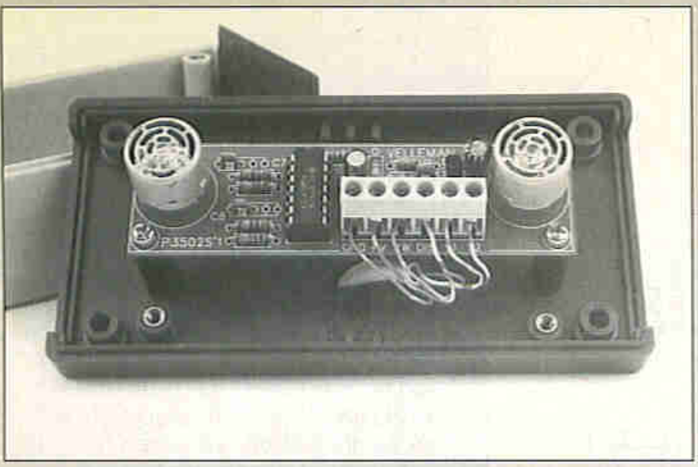
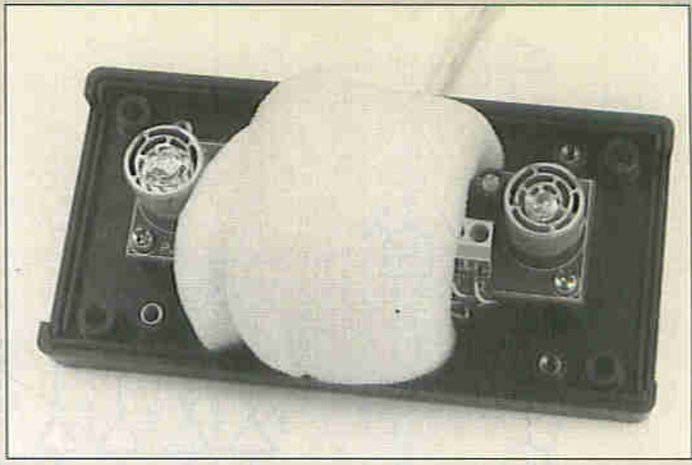
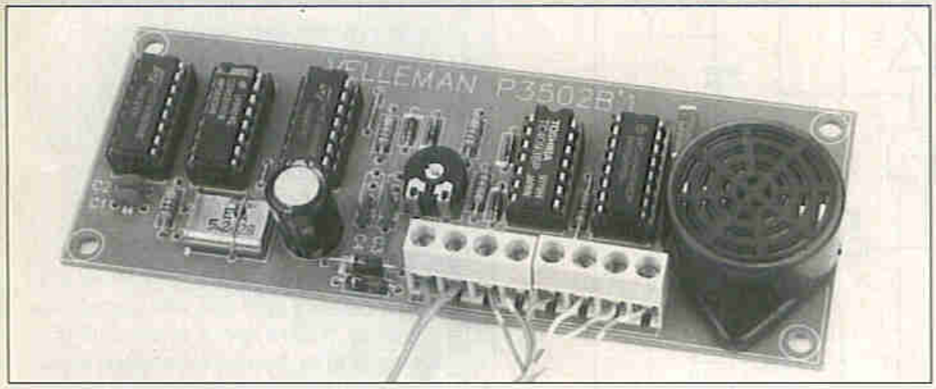


Figure 3. Vertical method of mounting the sensors.







Above left: The completed Receiver PCB mounted in its box.

Above right: The foam rubber supplied with the kit is used to fill the space between the sensors.

Left: The completed main PCB. If preferred, the buzzer may be positioned remotely from the PCB and connected by flying leads.

Fill the space between the two sensors with the piece of foam rubber which is included in the kit. Make a small hole in the bottom of the box in order to allow any water that may have entered the box to run out. When you are satisfied with the installation it is worth sealing the box joints with silicon rubber to help make the box as water tight as possible. Find a suitable place somewhere in the boot or back of the car, to install the main PCB (if possible as close as possible to the sensors, see below). You may prefer to mount the main PCB in a small plastic box for protection, so that the buzzer can be heard a hole, or series of holes, may have to be drilled in the box.

Find a suitable place, at the rear of the car, approximately in the middle, for installing the sensors either underneath or above the bumper. The sensors should be positioned on an horizontal plane. Before fixing the transmitter/receiver unit, connect a length of 6-core cable (or screened 5-core, with the shielding connected to the GND). This cable is then connected to the corresponding connectors on the main PCB.

Connections

Assuming negative earth, connect the GND terminal of the main PCB to the chassis of the car. The +V terminal of the main PCB should be connected to the positive lead on the reversing lamp, via a 100mA fuse.

In Use

The circuit is activated as soon as the gear stick is shifted into reverse (this is indicated by a 'bip' tone) and will now detect any obstacle within the range of the sensors. The detection distance (i.e. the

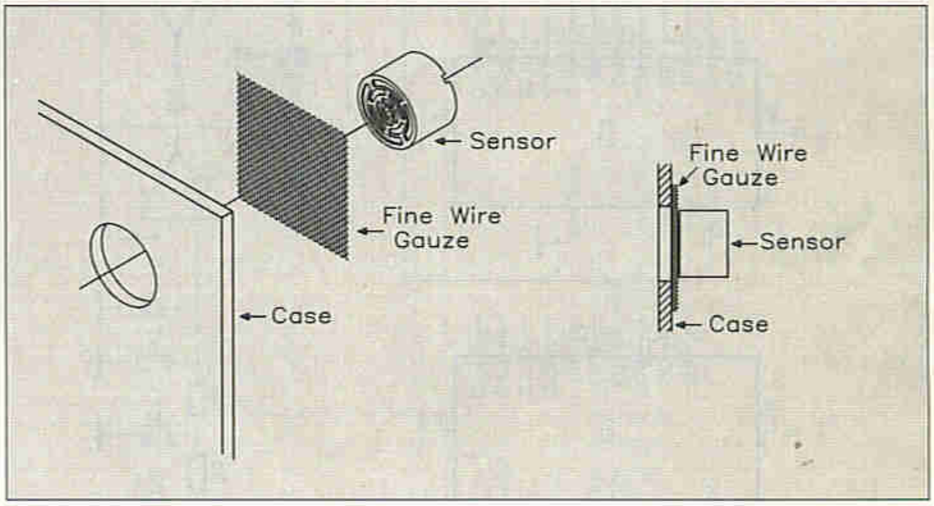


Figure 4. Fitting the fine wire gauze.

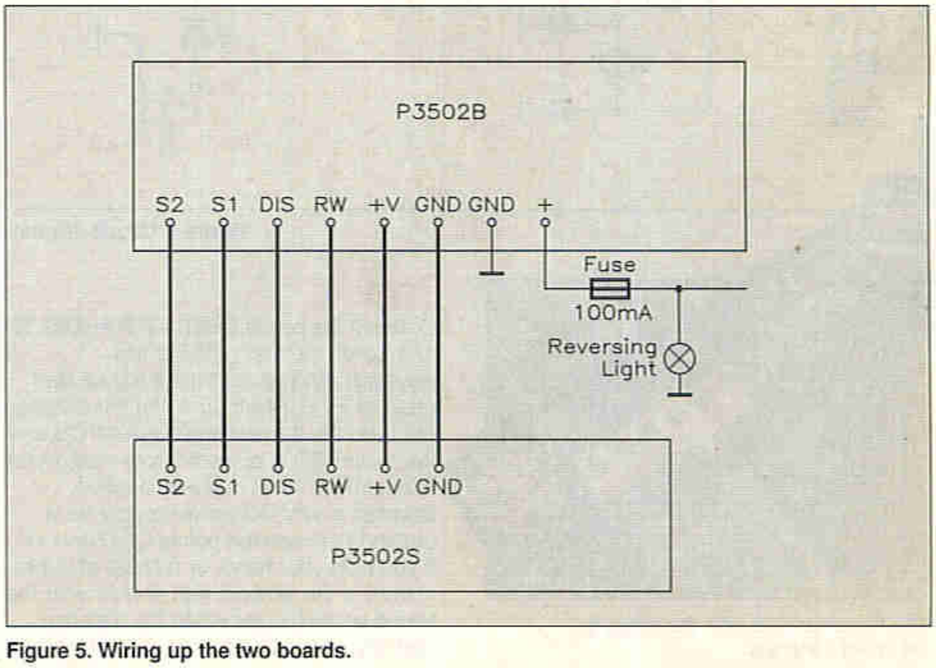


Figure 5. Wiring up the two boards.

sensitivity) can be adjusted by the trimmer RV1 – a practical distance is approximately 25 to 30cm from the back of the car. You will find it easier to adjust the trimmer with the help of a second person who can judge the distance from outside car (this should stop you damaging a neighbour's car!). If the buzzer cannot be heard easily, try repositioning the buzzer nearer to the driver's seat – this will require the buzzer being connected to the main PCB by a suitable long flying lead.

IMPORTANT: It is recommended that you cover the sensors with adhesive tape when washing the car, so that no water gets into the transmit or receiver sensors.

The completed Receiver Unit with protective gauze.

PARKING RADAR PARTS LIST

MAIN PCB

RESISTORS		
R1	10M	1
R2	22k	1
R3, R4	27k	2
R5	470Ω	1
RV1	470k	1
CAPACITORS		
C1, C2	12pF Ceramic	2
C3	22nF Ceramic	1
C4	10nF Ceramic	1
C5	100nF Ceramic	1
C6	470µF Radial Electrolytic	1
SEMICONDUCTORS		
IC1	4060BE	1
1C2	4020BC	1
IC3	4068BE	1
IC4	4093BP	1
IC5	4049BC	1
D1-4	1N4148 (or equivalent)	4
D5	1N4000 Series Diode	1
MISCELLANEOUS		
JI, J2	4-pole PCB-mounting Terminal Block	2
BUZ 1	Buzzer	1
X1	5·2428MHz Crystal	1
	PCB	1
	14-pin DIL Socket	2
	16-pin DIL Socket	3

TRANSMITTER/RECEIVER PCB

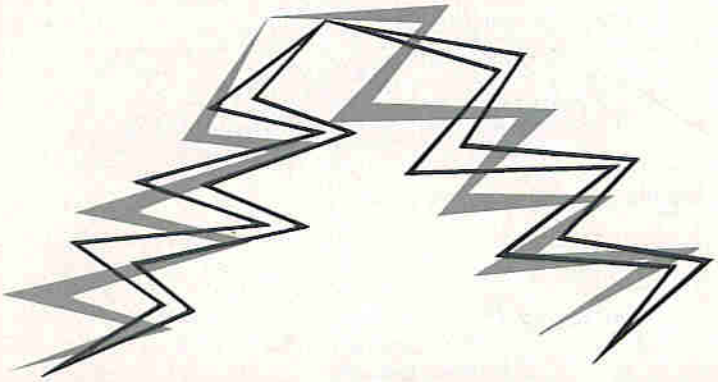
RESISTORS		
R7-10	15k	4
R11,12	1k	2
R13	10k	1
CAPACITORS		
C7,8	10nF Ceramic	2
C9	100nF Ceramic	1
C10	10µF Radial Electrolytic	1
C11	100µF Radial Electrolytic	1
SEMICONDUCTORS		
IC6	TL074CN	1
T1	BC547	1
MISCELLANEOUS		
JI	6-pole PCB-mounting Terminal Block	1
SENS1	MA40A5S (or equivalent)	1
SENS2	MA40A5R (or equivalent)	1
	PCB	1
	14-pin DIL Socket	1

OPTIONAL (Not in Kit)

	Plastic Box D-003	1	(ZB01B)
	Plastic Box MB8	If req.	(KC90X)
	M3 Insulated Spacers	1pkt	(FS38R)
	6-Core Cable	As req.	(XS54J)
	Zip Wire	If req.	(XR39N)
	Wire Gauze	As req.	
	Silicon Rubber Sealant	As req.	
	In-line Fuse Holder	1	(RX51F)
	100mA 1¼in. Fuse	1	(WR08J)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available in kit form only.
Order As VE08J (Parking Radar) Price £32.95
Please Note: Some parts, which are specific to this project (e.g., PCBs), are not available separately.

STATIC ELECTRICITY



FRIEND AND FOE

by Stephen Waddington

Electricity has always existed, but while observations of its effects can be traced to the ancient Greeks, it was not until the sixteenth century that scientists first observed electrical phenomena in a laboratory. In those days, the generation of static electricity and suitable storage mechanisms provided great interest. Work continued through the centuries and in 1932 physicists Cockcroft and Walton produced a potential difference of two million volts using an electrostatic generator to drive their Particle Accelerator – an experiment which led to the first nuclear reaction induced by artificially accelerated particles. Since then, the advent of the transistor has left static electricity condemned as a rogue, despised throughout the electronics industry for its damaging effects on semiconductor components.

Fundamentals

One of the fundamental building blocks of science is the electron; chemistry defines the differences in individual populations and thus the type and form of a material. Electrostatic Discharge (ESD) results as an excess of charge when two dissimilar materials meet and the electrons, in each, attempt to reach equilibrium. Electrons pass from one to the other as nature attempts to equalise the distribution of charge; this results in the acquisition of positive charge by one material and an equal but negative charge by the other. Whilst contact between the two materials is maintained, the electric field between the charges of differing polarity is wholly confined to the connecting interface. Separation of the two surfaces results in the appearance of an external field across the two, although practically speaking there is usually one last point of contact. The potential difference between the two surfaces increases with separation, resulting in a gradient along the surfaces to the point of contact. Once contact ceases, the field breaks down producing an intense impulse of charge, displayed dramatically in some instances as a bright flash or spark.

Conductors permit the migration of charge between two materials to the point of zero potential difference. This is known as 'neutralisation' – a stable situation in which the electrons in each material are balanced. The mobility of charge in insulators is, however, very small and so charge is retained.

Generating Charge

Continual activity involving repeated contact and separation between particular insulating materials produces increasing surface charge, the potential rise being dependent on the local capacitance to ground. Early electrostatic generating machines used this effect and consisted of a glass barrel and friction pad as illustrated in Photo 1. As the barrel was rotated, static electricity formed at the interface between the glass and the friction pad. A brass comb ensured that electricity could be drawn off when the crank handle was rotated. Storage took the form of a Leyden jar, which was a early form of capacitor consisting of a circular metal container, a tubular insulator insert and a dielectric lining. A development of this machine was the Van de Graaf (or belt) generator, which could produce several million volts.

Another static electricity-generator is the Wimshurst machine, well-known to high school students and fans of early science-fiction films! Incorporating two contra-rotating plates with metallic brushes, these machines were actively employed during the First World War for the generation of X-rays. Many examples remain in operation today, the finest of which are said to be capable of generating a constant charge in excess of half a million volts.

A Problem

ESD was not considered to be a problem by the electronics industry until the invention of the metal-oxide silicon field-effect transistor (MOSFET). Most electronics companies now regard all semiconductor components as static sensitive – the fact that individual electronic devices can be damaged by voltages in excess of the dielectric strength of their oxide layers is well documented. Indeed most components have protection diodes in between their lead-out pins and the delicate gates within, an attempt by design engineers to improve component durability. Table 1 quotes the approximate breakdown voltages of various device technologies. Note that the figures quoted should be taken solely as an indication of device capabilities – definitive values should be obtained from manufacturer's data sheets.

As individual devices are made ever

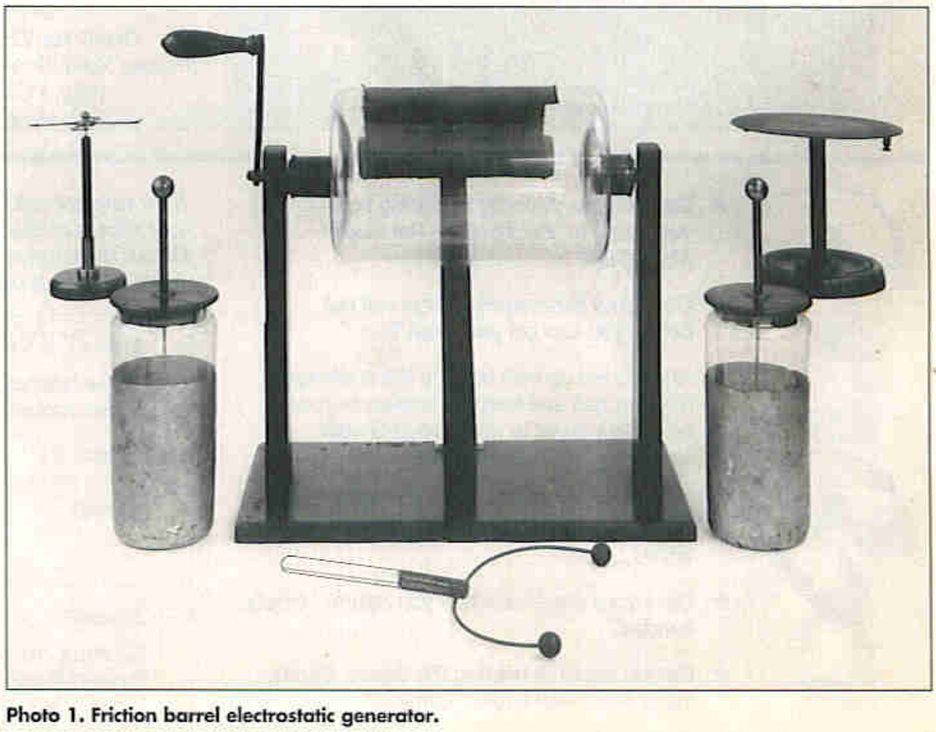


Photo 1. Friction barrel electrostatic generator.

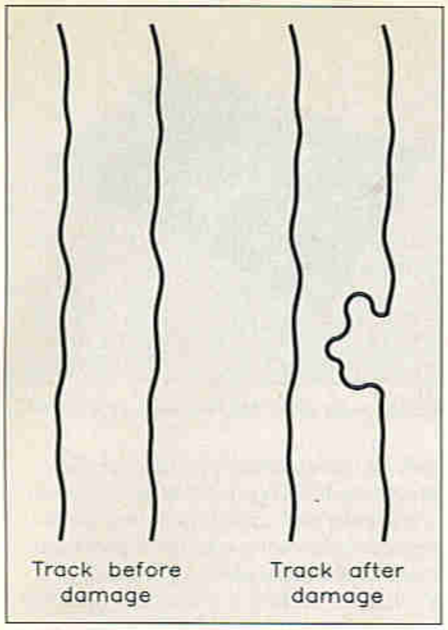


Figure 1. Damage to a conductive track on the chip surface – a cause of eventual failure.

smaller in size, the number that can be crammed onto a piece of semiconductor material increases. Since the cost of an integrated circuit is roughly proportional to the area of the die, even higher densities and finer device geometries are likely to appear in the future. As a result, the space available for electrostatic protection devices also continues to decrease, and most modern large scale integrated devices are at risk from electrostatic levels as low as 50V.

Damage

The actual voltage to which a device may become charged may, in fact, not be critical. Damage occurs when the device is *discharged*; if the discharge rate is slow enough to prevent a high current flow, most devices will work unscathed after being subjected to 100V. If the discharge rate is fast, conversely, there is a risk of damage. Any situation where widely varying voltages could develop across different areas of an integrated circuit must also be avoided for similar reasons.

The damage caused by electrostatic discharge may completely disrupt an interconnecting track on the chip die, effectively 'blowing a fuse'. This renders the integrated circuit useless, and it should be discarded. This is inconvenient and can be expensive although faults can normally be easily detected and remedied. Another possibility, and one which causes service engineers headaches, is one in which a track, like a cable or fuse which has suffered the passage of an excessive current, may be only partially melted. Although a connection may still exist when the track cools, there may well be stress cracks or molten fractures. The end result is an intermittent fault, although the 'freezer spray/hairdryer treatment' may normally locate it. Similarly, dielectric breakdown leads to sparking, which causes cratering – this may destroy most of the width of the track, leaving only a narrow bridge to carry the device current as indicated in Figure 1.

Concealed damage can be the most troublesome of all. Components may operate for a considerable period of time after being damaged – degradation and eventual failure results only after thermal or vibrational stresses once the component is in use. A failure after a piece of equipment has been commissioned and put into service is expensive, requiring field servicing and component replacement.

Detection

The detection and accurate measurement of static electricity requires elaborate equipment, which must be able to withstand the high voltages associated with the phenomenon. Such equipment must be regularly calibrated – an expensive exercise which is both complex and involved.

The gold-leaf electroscope, illustrated in Figure 2, was an essential piece of apparatus during the early work in electrostatics. It is essentially a capacitor; the leaf and attached rod form one plate, while the case acts as the other. When a potential difference is applied to the 'plates', a small charge flows onto the leaf, and an equal but opposite charge is induced on the inside of the case. The forces of the resulting electric field between the 'plates' deflect the leaf, providing a crude indication of potential.

Humble perhaps, but it does demonstrate that detecting the presence of an electrostatic charge, as with any other source of electricity, is relatively simple provided that a suitable method is employed. A modified Wheatstone bridge can be used to demonstrate the presence of electrostatic potential. Figure 3 shows the basic Wheatstone bridge; if the circuit is balanced (i.e. the meter centred) by the adjustment of VR1, changing the value of R3 will result in a deflection of the meter. The object of this exercise is not to balance the bridge, but to observe the amount of imbalance occurring when an external resistance is introduced.

In Figure 4, R3 is replaced with a field-effect transistor (FET), the resistance of which varies dependent on the voltage applied to the gate terminal. The bridge must now be balanced again using VR1, ensuring that there is no additional charge present on the gate of the FET – this can be reliably done by connecting the terminal to ground. In its 'zero' position, the meter now demonstrates an absence of charge, whilst a move away from zero indicates the presence of an electrostatic potential.

The meter can be any type of 1mA full-scale-deflection (fsd) or less. It should preferably be a centre-zero type, since static electricity can be of either polarity. A normal meter can be used; however, it is

Device Type	Electrostatic Discharge Breakdown (Volts)		
EPROM	60	to	100
MOSFET	100	to	200
GaAsFET	200	to	300
JFET	140	to	1700
CMOS	250	to	2000
SCR	680	to	1000
TTL	1000	to	2500

Table 1. Breakdown voltages of various semiconductor technologies.

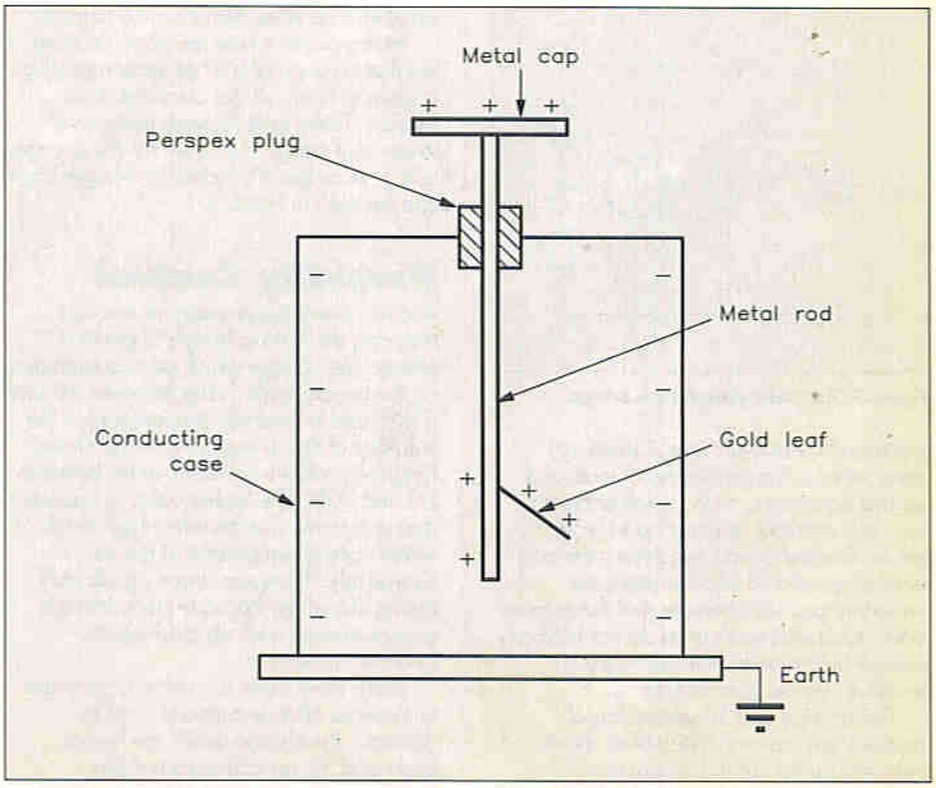


Figure 2. The gold-leaf electroscope.

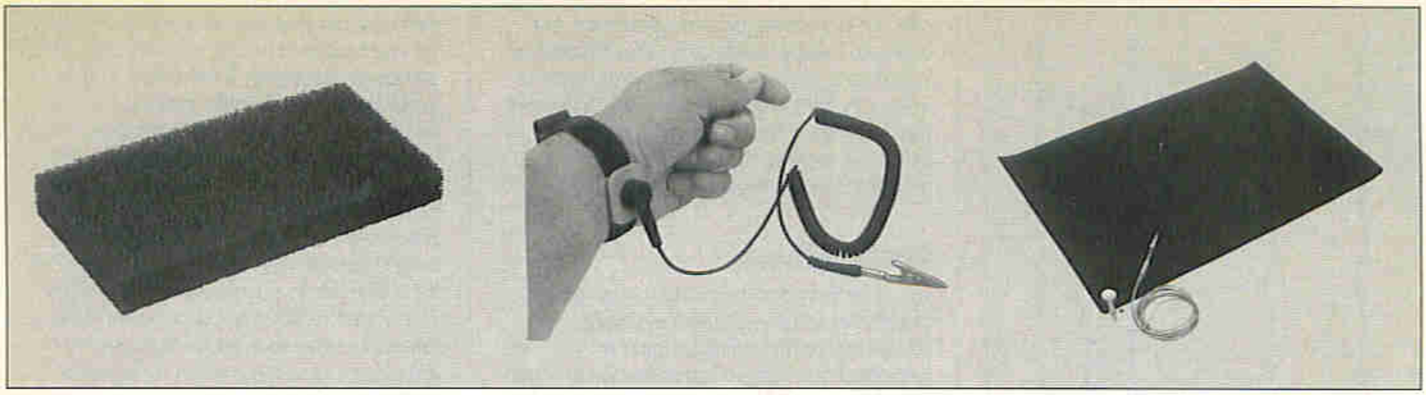


Photo 2. Three of the anti-static protection aids available from Maplin. From left to right: conductive foam (FA83E); wrist strap (FE29G); work mat (YJ90X).

suggested that it is set at centre scale when initially balancing the bridge. Suitable FET devices include the 2N3819 which is so sensitive that it will react to a charge present at its gate terminal without any electrical contact being made at all. The gate leakage current of the 2N3819 is such that any charge induced will leak away slowly over several seconds. As a result, damage to the FET is unlikely.

The probe connected to TR1's gate terminal should be long and slim. A needle or stiff piece of wire, as illustrated in Figure 5, would be ideal. In an area of sufficiently concentrated charge density, an intense electric field will arise near the point.

Avoidance

There are many precautions that can be taken to minimise the risk of ESD-related damage. Power must always be disconnected, and any stored charge dissipated before devices are removed from a circuit board, or maintenance is allowed to commence. Once a circuit board has been deemed 'safe' to work on, contact with device pins or circuit tracks should be avoided. Often, touching a grounded surface is sufficient. However, wrist straps connected to ground should be used in particularly sensitive cases. Commonly overlooked is the grounding of tools and service equipment, such as soldering iron tips, screwdrivers, spanners and work areas. Earthed conductive table-mats and wrist straps should also be used; the important point is to ensure that the human body, tools and work area do not hold any charge before work with electrostatic sensitive devices commences.

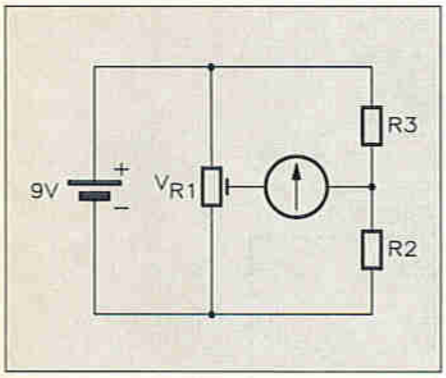


Figure 3. The basic Wheatstone bridge.

The storage and transportation of sensitive devices and assemblies should only be carried out in ESD-protected enclosures. Such enclosures should be packed tightly to prevent motion which in itself might generate an electrostatic charge during transportation. Once they have arrived at their destination, electrostatic sensitive devices should be stored on appropriately grounded conductive shelving and kept in conductive foam until used. Appropriate labelling, such as that shown in Figure 6, ensures that all personnel are aware of the nature of any mysterious packages and will (hopefully) apply suitable care when handling the contents.

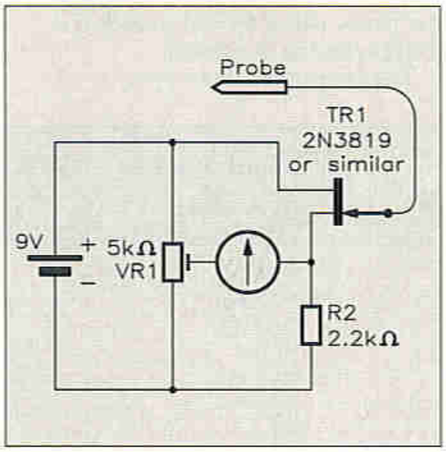


Figure 4. Wheatstone bridge modified to detect static electricity.

At this point, it may be worth pointing out that a range of ESD protection products (shown in Photo 2) are available from Maplin. These include work mats, wrist straps and conductive foam for the storage of ICs. A range of conductive storage bags can be seen in Photo 3.

Humidity Control

Another preventative measure involves reducing the human body's capacitive effects. The voltage which can be sustained by the human body varies between 10 and 25kV, and is inversely proportional to the humidity of the atmosphere. In the United Kingdom, relative humidity varies between 20 and 70%. The higher value is apparent during summer months when high levels of water vapour are present in the air. Conversely, the figure drops significantly during the winter because the colder air cannot support such abundances of airborne moisture.

There have been a number of attempts to increase relative humidity, and so decrease the charge which the human body and the air can sustain. New buildings are often fitted with humidifiers built into air-conditioning units. Additions to existing buildings include humidifiers in work areas and carpet sprinklers, whilst decorative fountains attempt to provide a more aesthetically pleasing solution. Whichever method is employed, a relative humidity level of around 50% is a good target figure – higher levels are better for electrostatic discharge control but lead to environmental problems such as corrosion and staff discomfort.

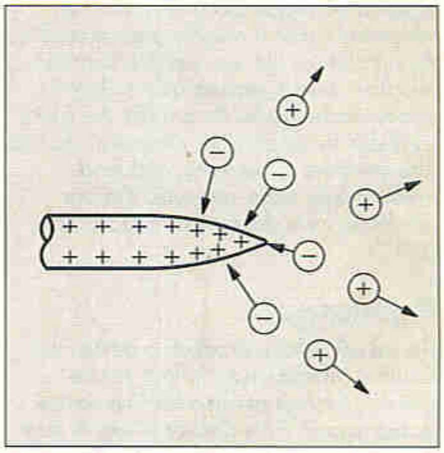


Figure 5. Action at the probe of the electrostatic detector.

Discipline

Most preventative measures amount to nothing more than common sense. However, there is very little point in applying one rule without the rest. Equally, discipline must be maintained throughout the industrial process from manufacture right through to installation. Every person who is in contact with an electrostatic-sensitive device can undo the safe handling practices applied by others. One

Photo 3. A range of conductive storage bags from KWR Chemicals, which provide static screening for components and PCBs.

manufacturer recently described a situation where very strict discipline was kept within a factory yet the circuit boards being produced were continually failing once installed as part of a complex computer control system. The customer was far from impressed and in an effort to locate the source of failure, the manufacturer called in his component supplier. All the components

Figure 6. Warning label for electrostatic-sensitive devices.

entering the factory were inspected and tested with the result that no faults were found. After a period of weeks during which every stage of the production process was scrutinised, it was realised that the sub-contractors installing the circuit boards on-site were totally disregarding ESD protection practice – boards were handled in a manner usually attributed to scaffolding on a construction site!

Elimination

The avoidance of damage caused by electrostatic discharge does not rely solely on preventative measures; clearly there are instances where the generation of static electricity is unavoidable. Air ionisation is the most reliable and a universally accepted method of neutralising electrostatic charge in the atmosphere. By introducing artificially-generated charged ions into the air, electrostatic charge is neutralised in two ways. Firstly, charges combine with ions of the opposite polarity, and secondly neutralisation occurs as a direct ground is formed through the ionised air.

Meech Static Eliminators Ltd, based in London, manufacture and supply electrostatic elimination equipment.

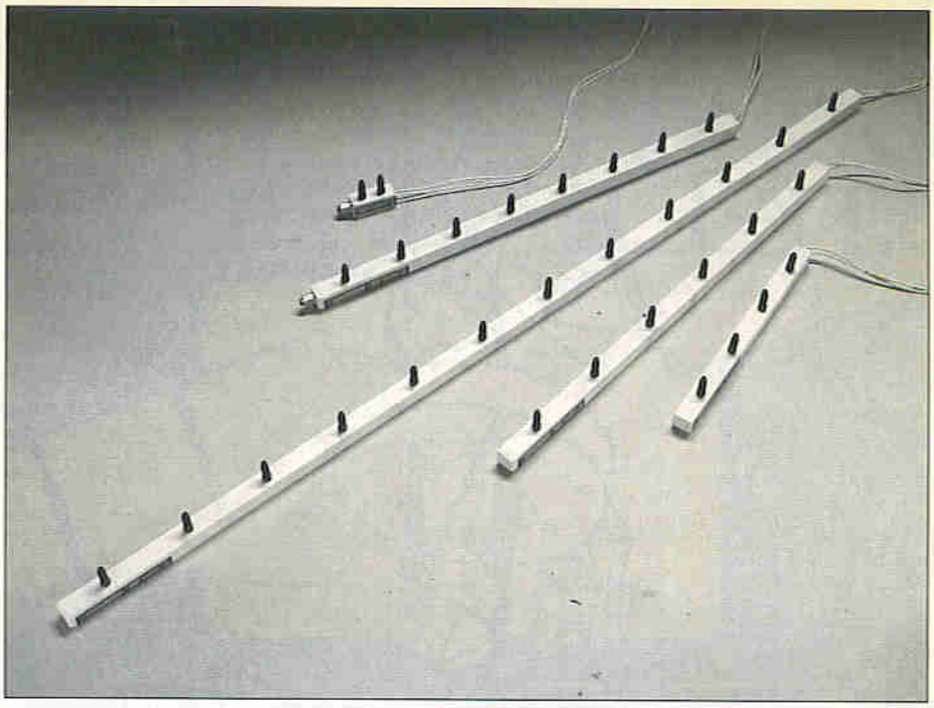


Photo 4. Meech Static Elimination Bar.

Specialists in the field, their equipment was developed originally for the electronics industry although it is now used in many other fields of manufacture including plastics, packaging, printing, food, textiles and chemicals. Their most exciting development, a 'Static Elimination Bar', is illustrated in Photo 4. Most static eliminators use an AC (50Hz) high voltage source. AC is used because the ionised corona created is compact, powerful and roughly balanced between positive and negative ions. The Meech system, however, uses pulsed DC – as a result, both the frequency and polarity of the high voltage supply can be varied. The benefits provided are a potentially longer range performance, and a degree of control over the ion balance – ideal in situations where varying degrees of neutralisation are required. A fast pulse will result in a compact and intense coverage pattern similar to that produced by AC generators. If the pulse rate is reduced, ions are emitted in wide bands, followed by equally wide bands of ordinary air. The ionised bands are propelled away from the emitters as illustrated in Figure 7. As they travel, the ions mix with the oppositely charged particles and neutralise them.

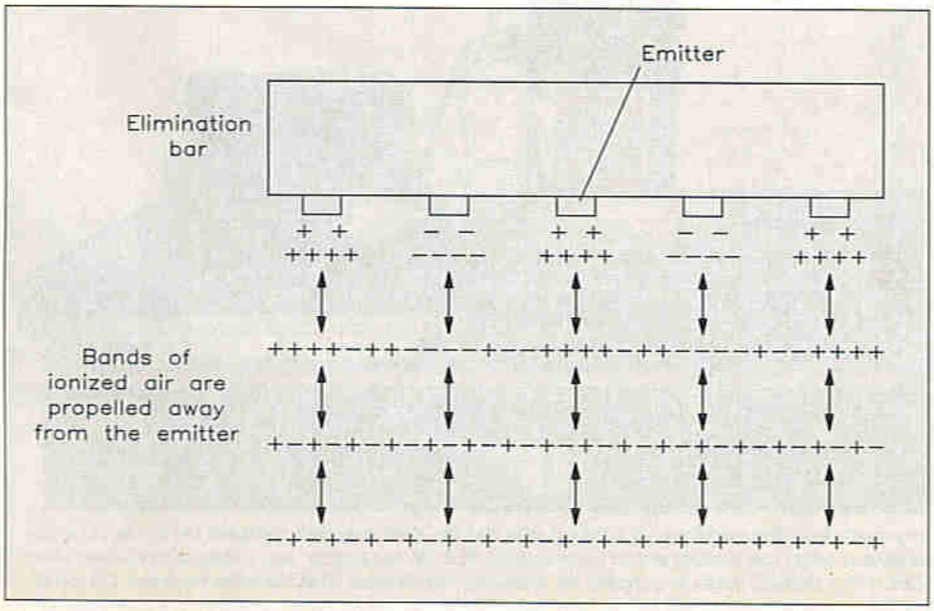


Figure 7. Operation of an elimination bar.

Accentuate the Positive

Mention has not been made, so far, of the *positive* applications that electrostatics offer. Apart from numerous present-day uses within branches of physics and chemistry, there is a vast range of industrial applications which rely on electrostatics. For example, electrostatic precipitation is used to retain ash and flue gases which would otherwise be released by factory chimneys into the atmosphere. Electrostatic spraying of paints, plastics and powders is also a reality. In nuclear physics, electrostatic generators are employed to produce potentials of up to 14 million volts. More recent technological applications, which employ electrostatics to make an impression on paper, include photocopiers, ink-jet and laser printers.

Clearly, electrostatics has a number of unsung beneficial applications It remains rather ironic that the phenomena which prompted the discovery of electricity is now condemned as a bugbear by the industry.

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Acknowledgments

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F. Hillyer, Director, MEECH Static Eliminators Ltd, London.

DISCOVERING SATELLITE TELEVISION

Part Three
Europe Sans Frontières? – The Scrambling Phenomenon

by Chris Yates and Martin Pipe

Television viewing in England prior to the satellite television revolution was relatively simple; through the living room television set, one could access four stations – all of which broadcast a wide selection of programmes, mostly in colour, using a common standard and available on a free-to-view basis (apart from the licence fee, that is!). Whilst the satellite revolution has broadened that choice, it has also introduced an entirely new set of problems.

We have already discovered that satellite television signals are transmitted at much higher frequencies than those of terrestrial television, requiring specialist receiving equipment in order to convert them to pictures and sound on domestic sets. However, a scan across the Clarke Belt will reveal no fewer than five main transmission standards currently in use – PAL, SECAM, NTSC, DMAC and D2MAC. Only one of these (PAL) is suitable to view in the UK without the addition of ancillary equipment, other than the dish/LNB and receiver of course. As if that were not enough to deter the average non-technical viewer, many of the transmissions are rendered unwatchable by the scrambling of the picture and/or sound – limiting their reception to those viewers willing to pay for the (sometimes questionable) privilege. In some cases the viewer does not even have the choice of paying, as reception is often limited to geographical boundaries and cable subscribers!

Scrambling, normally restricted to premium service channels, involves making the picture and sound unintelligible to all but those authorised to receive the signals. There are twelve different encryption systems currently in use, ranging from the much-hacked Satpak as seen on Filmnet's now-defunct PAL illumination, to the very secure VideoCrypt which renders BSkyB channels unwatchable.

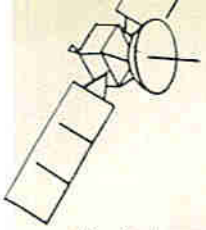
Ensuring income from subscriptions is not the only reason for encryption. In the pre-Astra days, the original Sky Channel (predecessor of Sky One) was scrambled for an interesting reason. It was carried on the Eutelsat ECS-1 (IF1) satellite at 13° E (a low-power predecessor of IIF1) for distribution to cable networks. At the time (1982), ECS-1 was designated as a telecommunications satellite, rather than a television broadcast satellite. International regulations prohibited the transmission of a TV service via ECS-1, and so the picture was encoded using the Oak-Orion system. In this way, the Sky Channel could theoretically be categorised as a communications signal! Copyright is another reason for scrambling – Dutch Astra-borne channel RTL-4 is sometimes scrambled in Luxcrypt for this reason.

Many of the original encryption systems are still in use today – at least for the time being. Most of these analogue systems can be defeated – particularly as all the information and signals required to regenerate the picture are normally available in the baseband signal. With satellite TV increasing in popularity over the last few years, 'pirate' decoders (for channels such as Teleclub, Filmnet and RTL-4) have become big business, a cottage industry producing a range of 'black boxes' that range from the ineffective and electrically dangerous! to professionally-manufactured multi-channel units.

The reception of scrambled material without having the necessary legitimate decoding equipment is in fact illegal, as detailed in the special anti-piracy provisions of the Copyright, Designs and Patents Act 1988. Anyone making, importing or trading such pirate decoders is also in breach of the provisions of that act.

Indeed, in a recent case before the House of Lords, it was decided that BBC Enterprises Limited had a cause of action against Hi-Tech Xtravision Limited of Camberley, Surrey, in the instance where BBC Enterprises

Any more decoding standards to contend with and the shelf may well collapse! On top of the multi-satellite receiver (on the left) are an experimental SECAM transcoder, and a Ferguson BSB receiver fitted with a D2MAC upgrade supplied by Middlesbrough-based TRAC Satellite Systems. On top of the video recorder (going up) are an Amstrad SRD400 (for Videocrypted channels), a now-defunct Filmnet/RTL-4 decoder and an early 'Digisync' sync inserter.



Limited were supplying an encrypted, satellite-delivered television service consisting of BBC programmes for transmission and reception in European countries other than the United Kingdom. Hi-Tech Xtravision were manufacturing and selling suitable decoders at a lower price than legitimate decoding equipment, and as a result of this the House of Lords ruled that makers and sellers of infringing apparatus were guilty of copyright infringement if they enabled or assisted persons to receive programmes or other transmissions, regardless of whether the assisted persons were inside or outside the United Kingdom. It can therefore be seen that the Copyright, Designs and Patents Act 1988 has far-reaching consequences, and is not strictly limited to regulating conduct within the United Kingdom.

The problem with pirate decoders, other than being illegal, is that they can be rendered useless by subtle changes to the scrambling process, necessitating costly upgrades by the somewhat unscrupulous manufacturers of such units – sometimes several times a year. Some manufacturers go to great lengths to ensure that hackers cannot modify the decoders themselves by scratching away all the device numbers off the chips!

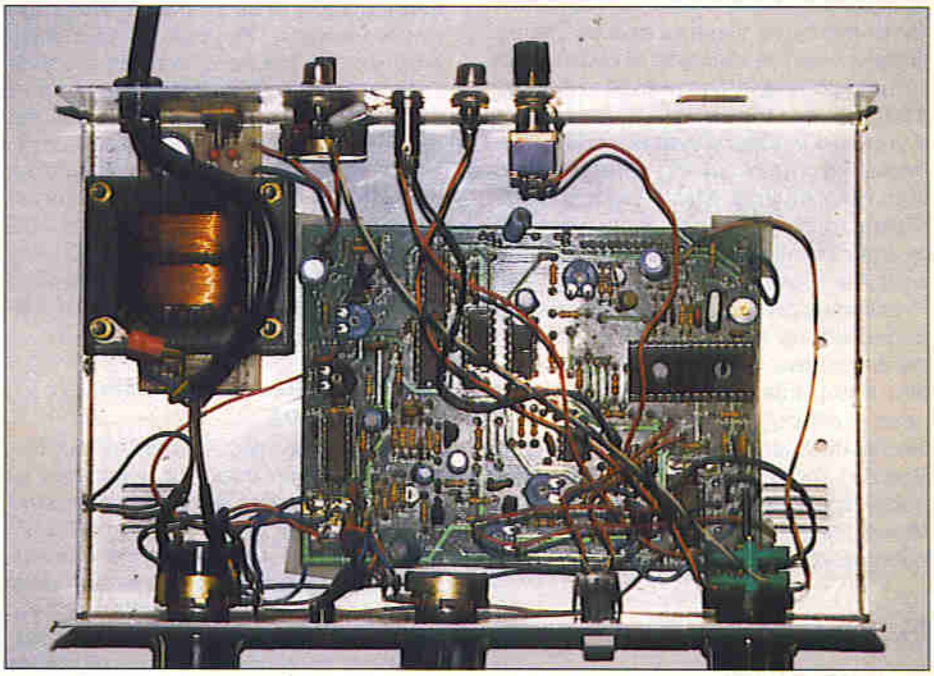
The Filmnet Saga

Since most of their films retain their original English soundtrack, Filmnet have been worst hit by the pirate decoder craze – particularly as their service is regarded by many as being a lot better than those provided by BSkyB – at least in the 'adult movie' department! Unfortunately, Filmnet (as much as they would like to!) cannot market their service in the UK, or for that matter most of the countries in the Astra footprint, as they only have broadcast rights for Denmark, Finland, Norway and Sweden. Film-producers have granted the Direct To Home (DTH) broadcast film rights to companies in rigidly-defined non-overlapping regions – in the UK and Ireland this is BSkyB – thus maximising their profits.

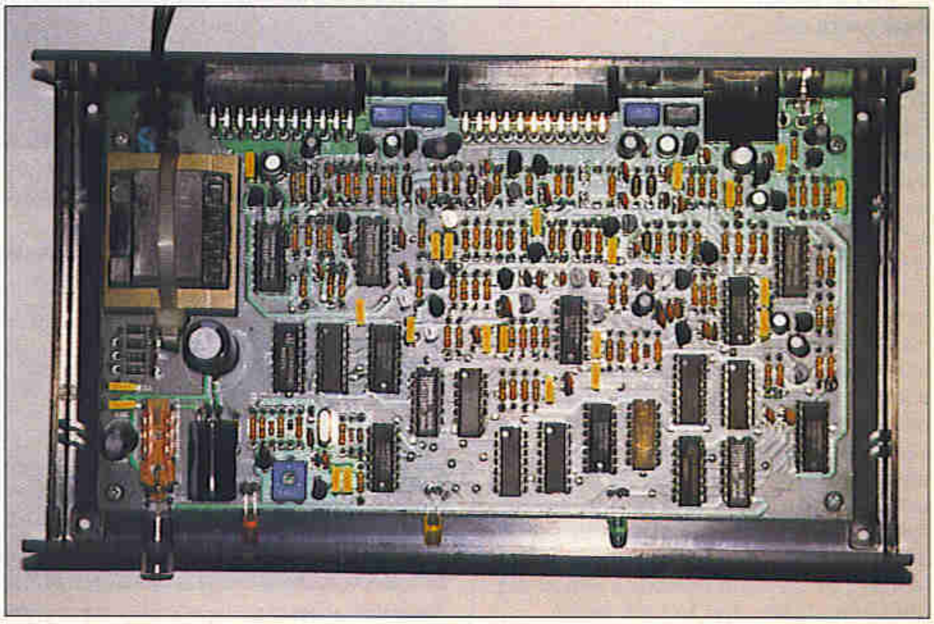
In 1986, when Filmnet commenced scrambling, it opted to use the Matsushita-developed Satpak system – one of only a few available at the time, after all there was little need for scrambling in those days. Several changes have been made to the system, in an attempt to thwart the growing pirate decoder industry. All have, however, posed little threat to the hackers.

Seeing as their video scrambling system was easily cracked, the channel introduced digital audio – a nasty variant of the excellent NICAM stereo system now in use in many European countries. This was intended as a move aimed at outsmarting the pirates, leaving an estimated million or so illegal viewers with picture but no sound. Of course, equipping its legitimate viewers with the required equipment cost the Belgium-based company a lot of money (passed on as increased subscription costs, no doubt) – but it was under considerable pressure from the film companies to do something. Lest we forget, with no films you cannot have a movie channel!

When the Filmnet digital audio system was introduced in 1991, only a couple of pirate decoder manufacturers were prepared to invest time and money in developing illicit digital audio decoders by 'reverse engineering' the official Filmnet decoders. One of the companies in question has reputedly sunk a quarter of a million pounds into developing such a unit. This system was only, however, intended as a 'stop gap' until a real alternative was found. Earlier in 1992, Filmnet started dual-illuminating on Astra with a D2MAC Eurocrypt service, tests having been carried out on Eutelsat IIF1 (13° E) previously. By early September, the required receiver/decoders had been



Above is an internal view of the Digisync unit. An early decoder (late eighties), the standard of construction is somewhat poor internally. In addition, the component references have been scratched off the ICs. Despite this, the unit will still give a watchable picture from Filmnet – unlike the unit shown below, which is neatly laid out and of a high construction standard. Unfortunately, the latter has been 'knocked out' by minor changes to the encoding process – and modifications to the decoder are simply not economically viable.



circulated to the majority of DTH subscribers, and the Astra PAL service was shut off – the 'worst case' scenario as far as the pirates were concerned. However, at the time of writing a PAL service remains on Eutelsat IIF1 – for the cable networks – but for how much longer?

Sky Sports

Interestingly, a similar state of affairs exists for scrambled BSkyB channels in mainland Europe, there being a booming market in exported (OK, they do originate from Thomson-CSF, a French company!) VideoCrypt decoders and Sky cards. Of great horror to overseas viewers and ex-patriot Britons was the decision of Sky Sports to 'hard scramble'; up until 31st August 1992, you could see the service for free if you had a VideoCrypt decoder connected to your receiving set-up; a card was not required. Many thousands of VideoCrypt decoders, now useless to their owners, ended up in homes across Europe for this reason. Pressure is on Sky to provide overseas subscriptions for Sky Sports; bear in mind that the restrictions imposed by film companies do not apply in this case – although those applied by the Football Association do! With Sky Sports encrypting in this manner, hackers are feverishly trying to crack VideoCrypt – particularly now that it is being adopted throughout Europe.

Scrambling Systems

1. Analogue

Most of the information on how the signal has been scrambled can be 'gleaned' from merely studying the output video waveform of the encoded channel. In fact, this is how most of the pirate decoder manufacturers develop their products.

Satpak

This is (was?) the system used by Filmnet on its original channel. The composite (vertical and horizontal) synchronisation ('sync') signal is suppressed, but is available on a 7·56MHz subcarrier. The dreadful noise produced by a satellite receiver with audio tuned to this frequency will confirm this! In some of the modifications implemented, one or more fields in a particular sequence would be inverted. To combat pirate decoders, various tricks were used – such as the insertion of various interference signals in the sync region. In one case, this was a sine wave close to the unaffected colour subcarrier frequency – used in some decoders as a timing reference. The result confused the decoder, which did not know which one to lock onto!

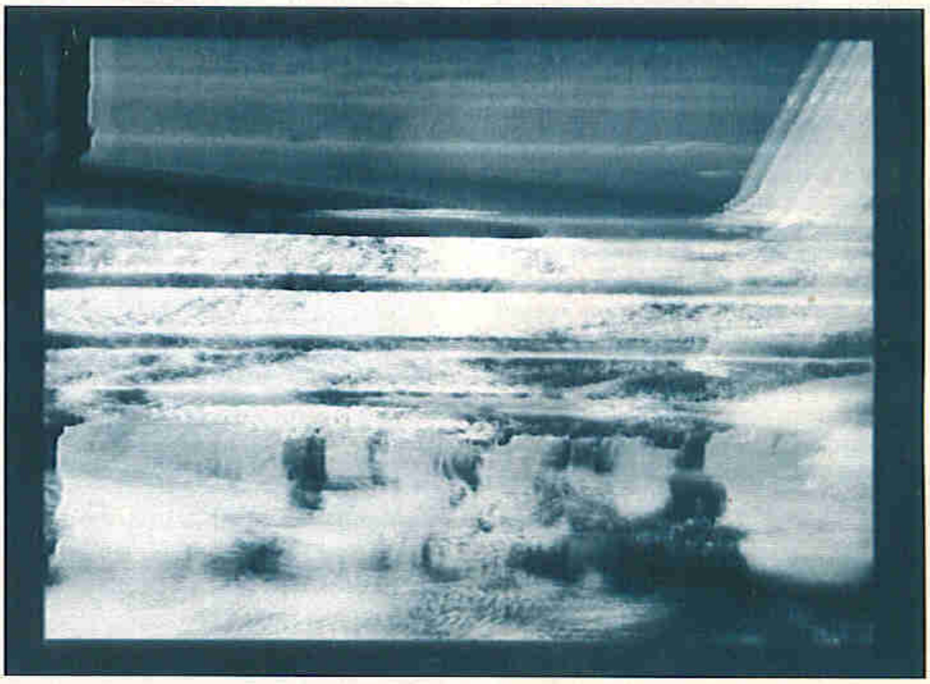
Payview

This system is used by Teleclub, a Swiss German-language film channel based, like Filmnet, on Astra. Again, simple manipulation of the video signal is used to ensure that the picture is unrecognisable to those without the required equipment; in fact, it appears dark – like a blank screen. This is because the video signal is inverted, and the blanking level is shifted above that of the encoded channel's highest video level (peak white). In the system used by Teleclub, the audio remains clear (the full Payview specification includes digital audio, but even if this were to be implemented, the German soundtrack is of secondary importance to UK viewers). Payview is thus easy prey for the hackers, and as a result Teleclub are considering upgrading their system, presumably to one of the more secure digital systems. As a temporary measure, Teleclub introduced a pseudo-line delay; here, the horizontal sync pulse was reduced in size and allowed to vary slightly in period.Giving the effect of line delay, this modification effectively knocked out most of the pirate decoders.

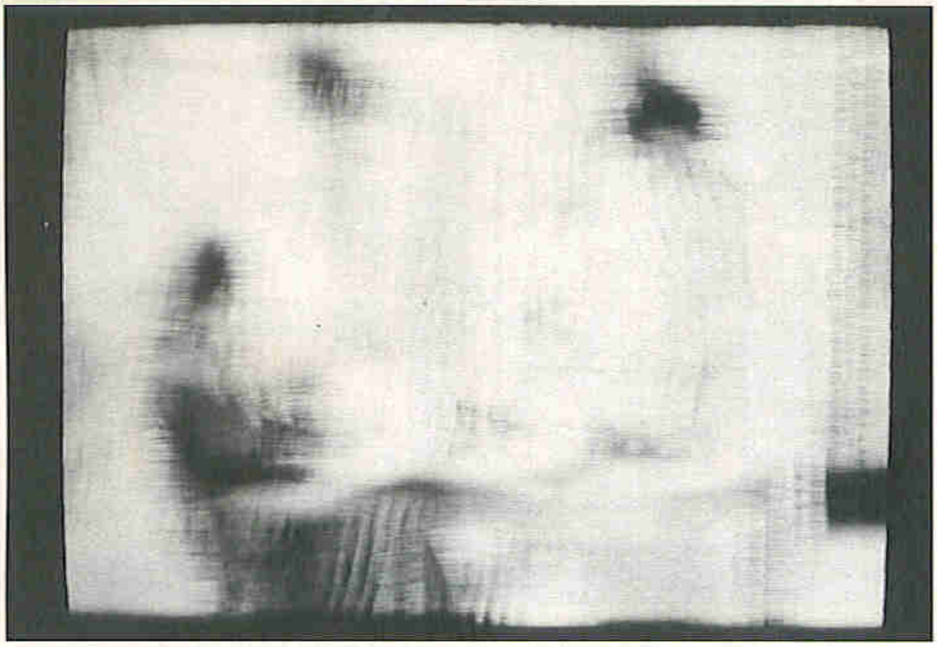
SAVE (Sound And Vision Encryption)

This rather archaic method of scrambling has been used for a number of channels, most of which have resided at some point at the Intelsat 27·5°W slot. BBC Enterprises' World Service Television, the original European user of SAVE, together with United Artists' 'oldies but goodies' film channel Bravo, can both be found there encrypted in this way. Another now-defunct film channel, Premiere (not to be confused with the German Premiere currently broadcasting on Astra) used the system a few years back, in addition to a now-defunct Spanish channel known as Canal 10. A new 'adult' channel 'Red Hot Dutch', downlinked from Eutelsat IIF1 (13°E) uses SAVE as a temporary measure. Thanks to the latter, vintage (and hitherto obsolete) Premiere decoders have been changing hands at silly prices to satisfy the cravings of the 'brown paper bag brigade'! Red Hot Dutch is uplinked from Holland, outside British jurisdiction, where the laws relating to hardcore pornography are somewhat more lenient! Exactly what Essex clean-up campaigner, Mary Whitehouse, thinks of this latest affront is not known, but can be imagined in no uncertain terms! The fact that the programme material, which if it originated from Britain would be banned under the Obscene Publications Act, is being radiated directly into British homes is at least, very worrying. Perhaps this is the type of problem that a Government select committee could tackle, with a view to introducing amendments to existing British and European legislation.

SAVE decoders are being used mainly by multi-satellite enthusiasts capable of steering their dish towards the VI-F4 satellite currently occupying the 27·5°W slot. Of course, in the UK there is very little use for a BBC decoder, but many thousands of pirate decoders have found their way into Europe (BBC Enterprises charges a high premium for its 'official' decoder). As a result, the channel is set to change its encryption method sooner or later. The new system will be D2MAC/Eurocrypt, and may well have



The visible effect of a simple analogue encryption process. The lack of synchronisation is noticeable.



Line-shifting scrambling system; in this case, the picture is watchable but is visually disturbing. This channel is mostly clear, but encrypts during certain programmes for copyright reasons. Sound is scrambled using a spectrum-inversion type system.

started by the time that you read this article.

SAVE works by simply reducing the video level by 6dB, inverting the video and injecting a sine wave of around 94kHz in frequency. The interference frequencies vary from channel to channel, otherwise a BBC decoder could be used to view Bravo. Unlike the official decoders, some pirate SAVE decoders use a tracking filter or cancelling network to cope with all interference frequencies commonly used – as a result, they can be used to watch all relevant channels. Around three years ago, another well-known electronics magazine published details for such a circuit, proudly billing it as a 'BBC Decoder'. BBC Enterprises were most upset at this, and got their lawyers to serve an injunction to prevent publication of the second part of the article, their attention having originally been drawn to the already-published first part. However, a circuit diagram and theoretical details – everything required to build a working decoder – were published in the first part, and so BBC Enterprises were effectively wasting their money!

Since then, modifications have been made – multiple interference frequencies have been introduced to 'fool' some of the decoders, and a spectrum inversion system is now used on the audio. However, the hackable nature of SAVE must surely mean that its days are numbered.

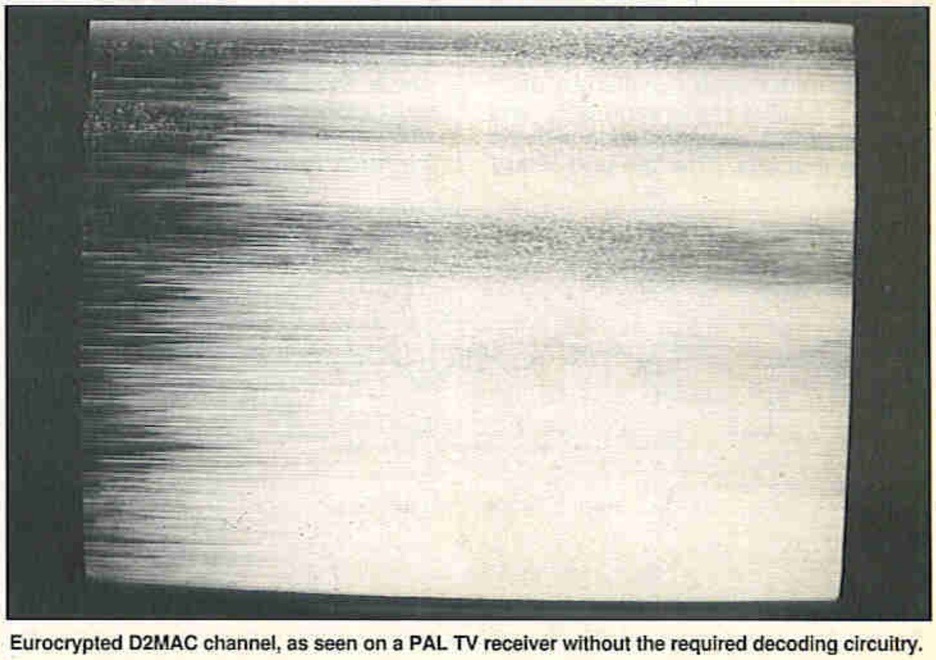
Line Shifting Systems

Several of these more advanced analogue systems are used in Europe. Discret, for example, is occasionally used by RAI Uno, which is bounced off Eutelsat IIF2 (10°E). Past users of Discret have included the French Canal Plus (it now uses the more advanced Nagravision, like Astra's Premiere dubbed-German film channel), and terrestrially by the BBC during 1989 for an after-hours professional pay-TV service (similar in concept to the current BBC Select). Unlike the previous systems discussed, the sync and colour burst are left alone. The actual picture ('active') part of the video waveform, however, is delayed on a line-by-line basis; the resulting picture is watchable – but not for any great length of time!

In the original Canal Plus system, the delays used for each group of three lines were 0ns (undelayed), 902ns and 1804ns in that sequence – different sequences could be used, depending on the algorithm used. Other versions of Discret use different delay config urations. The delays are achieved in decoders (pirate and legitimate) using CCD or gyrator delay lines, or by digital means. Like SAVE, a spectrum inversion method is used to encode the sound; single sideband is used with a suppressed carrier of 12·8kHz.

Other Analogue Systems Encountered in Europe

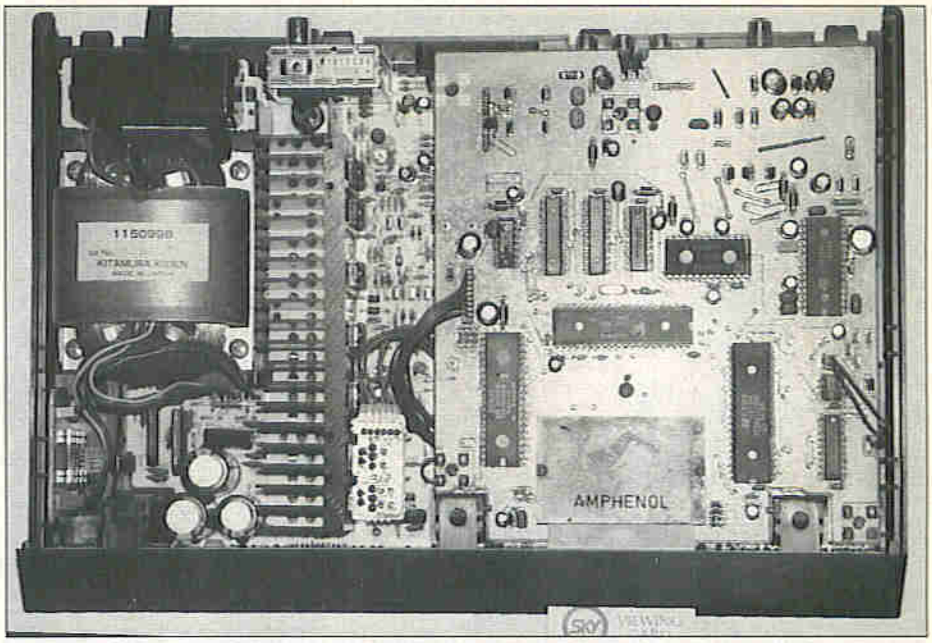
Many other systems have been used to make sure that only those authorised to watch channels can do so. The Oak Orion system used by Sky Channel removed the sync pulse, normally present during the line blanking interval, and replaced it with a 2·5MHz 6-period burst, followed by a digitally-encoded sound-in-sync signal. Field blanking was replaced by a 2·5MHz burst of longer duration. The colour burst (and the FM sound channel, to the relief of the pirates) was left alone. Decoders used the 2·5MHz bursts to control sync generation circuitry. In addition, the video could be inverted on a line basis – a tiny pulse transmitted at the beginning of each line indicated its polarity. Inverting large groups of lines at a time cleverly gave the impression of field or frame inversion. The Oak Orion system is no longer used, in Europe at any rate; if the provision of a normal sound channel had been abandoned then it might have had a longer life, as the digital audio would have proved a more difficult nut for the pirates to crack. In the case of Sky Channel, this was rather academic as scrambling was discontinued as soon as the ECS-1 satellite was re-classified.



Eurocrypted D2MAC channel, as seen on a PAL TV receiver without the required decoding circuitry.

A sound-in-sync (SIS) system is also used on EBU newsfeeds (commonly found on one of the early Eutelsats now parked at 21·5°E) for a different reason – that of bandwidth economy. The lack of a conventional FM subcarrier means that more power can be diverted to where it counts – the video. Because the digitally-encoded sound is inserted into the line blanking interval, the sync separator of a TV set is confused and the picture seems to 'have no synchronisation'; appearing unstable and ragged. To obtain a watchable picture, a replacement sync signal is simply inserted into the correct position. As early scrambling systems involved the distortion or removal of sync, early pirate decoders have be used for this purpose. Some decoders can also be used to lock clear MAC transmissions so that the luminance packet is visible on-screen as a black-and-white picture. In such cases, as with SIS channels, specialist equipment is required to retrieve the sound information.

More in common with conventional forms of encryption is Luxcrypt, as used by Dutch channel RTL-4 on Astra. Interestingly, Luxcrypt system has apparently been in operation for many years, presumably on cable networks, as it predates the Oak Orion system. It is very similar in operation to the Oak Orion system, although the syncs are replaced by bursts of 4MHz, rather than 2·5MHz.



Inside the Amstrad SRD400 IRD (integrated receiver-decoder). On the right is the Videocrypt decoder PCB, complete with smart card. The small size of the decoder, when compared to that of a 'first generation' unit, is due to the liberal use of surface-mounted components on the solder side of the board.

2. Digital Systems

These systems, which have been made possible with the introduction of cheap, fast A-to-D and D-to-A converters, have started to replace the older analogue systems. They are much more secure than the systems they replace, and as a result are very attractive to the pay-TV providers. Both of the main systems using this method, VideoCrypt and Eurocrypt, employ a 'cut and rotate' system, whereby each line is cut into several segments, and each segment changes place with the rest on that line. The 'cut and rotate' principle is illustrated in Figure 1. The cut points along each line are determined from a stored algorithm. In the case of VideoCrypt and Eurocrypt, this algorithm originates either from a 'smart card' – or as data transmitted in the vertical blanking interval of the channel's video signal, in the case of VideoCrypt scrambled 'free' access channels. In the case of D2MAC channels 'soft scrambled' with Eurocrypt, the access information is transmitted in the data packet, along with the digital audio.

In both cases, the data channels also provide information on legitimate subscribers – cards can be turned off 'over the air', as victims of the 'card swap' scandal know to their cost. Here, unscrupulous companies took BSkyB's VideoCrypt cards in part-exchange for Filmnet Eurocrypt cards. The Sky cards were then offered in Filmnet's catchment area on the same basis, but in reverse, and so on – until the broadcasters found out someone was making a lot of money!

Due to the use of smart cards, Eurocrypt and VideoCrypt are said to be 'ultra-secure' – in other words, uneconomical to commercially hack. If the cards were copied and distributed illegally, the original cards – and thus all the clones – could be switched off 'over the air', and a new set of cards supplied to legitimate subscribers. To make things worse for the pirates, new cards (with different algorithms) are supplied every few months or so. Which brings us to an important point – there must be an 'overlap' region during which the new cards are being circulated. Either both algorithms are valid (unlikely), or each card contains both – and possibly a 'back-up'. Of course, all this is speculation at present.

One of the subjective problems with digital 'cut and rotate' systems is the fact that it can leave a particularly noticeable effect on the picture. Hardly surprising, as a lot of processing is done on the video signal. The picture

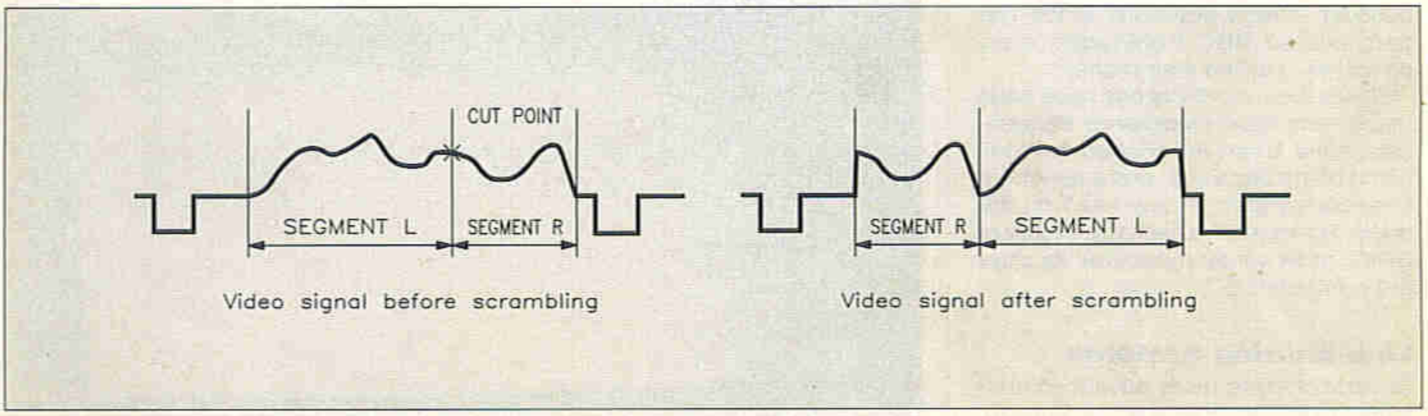


Figure 1. The 'cut and rotate' principle, as used by ultra-secure digital scrambling systems such as VideoCrypt and Eurocrypt.

is firstly digitised, using a TDA8703 8-bit ADC. The digitised information is then manipulated by the cut-and-rotate circuitry, based around some complex custom logic which is under the control of no less than three 8-bit microcontrollers (two in the decoder, one in the card), before being reassembled in the correct order by a TDA8702 DAC. As a result of this manipulation, it is hardly surprising that an effect is noticeable on the picture. Some of the recorded material shown by VideoCrypted channels is of poor quality (converted American NTSC programmes, for example) – but the effects are particularly noticeable on live programmes such as Sky Sports. A British manufacturer, Mimtec, claims to have significantly improved the VideoCrypt picture quality by the use of a patented interface – this apparently uses anti-aliasing filters on the input (will this reduce the video bandwidth?), and hash filters on the output. Of course, these are merely speculations floating around the trade press, and Mimtec have kindly agreed to loan us the new high-specification Spirit S2 for a future review.

The Eurocrypt system would presumably use twice as many converters as Videocrypt, as the luminance and chrominance components of a D2MAC signal are handled differently. Nevertheless, the same comments would apply for this system.

Eurocrypt

Eurocrypt has been developed with the MAC standards in mind and utilises a double 'cut and rotate' principle, in which the separate chrominance and luminance packets (refer to Part 2) are each cut at one of 256 different random points, and then broadcast in a reverse order.

Within the card there is a powerful microprocessor which is capable of decrypting the data needed for the decoder to go about its business. These chips use 'buried bus' architecture that makes it difficult and prohibitively expensive to reveal their contents. It was originally believed that the card held nothing more than a resistor or diode matrix -but careful disassembly shows this not to be the case. We wonder how much those cards must cost Sky – even in bulk!

There are two variants of Eurocrypt. The variation relates not to the actual decoding process but to the method by which the Eurocrypt decoder communicates with the D2MAC decoder – remember, a D2MAC decoder is required for any D2MAC signal – encrypted or otherwise. The Eurocrypt 'S' variant uses a serial data link, while the 'M' variant uses an 8-bit parallel interface. The latter system has apparently been designed to provide additional user features, which have not yet been fully implemented.

Very little interest has so far been shown in Eurocrypt here in the UK. The spreading use of D2MAC in Europe, plus of course the fact that it will shortly be Filmnet's sole system, will of course change all that!

VideoCrypt

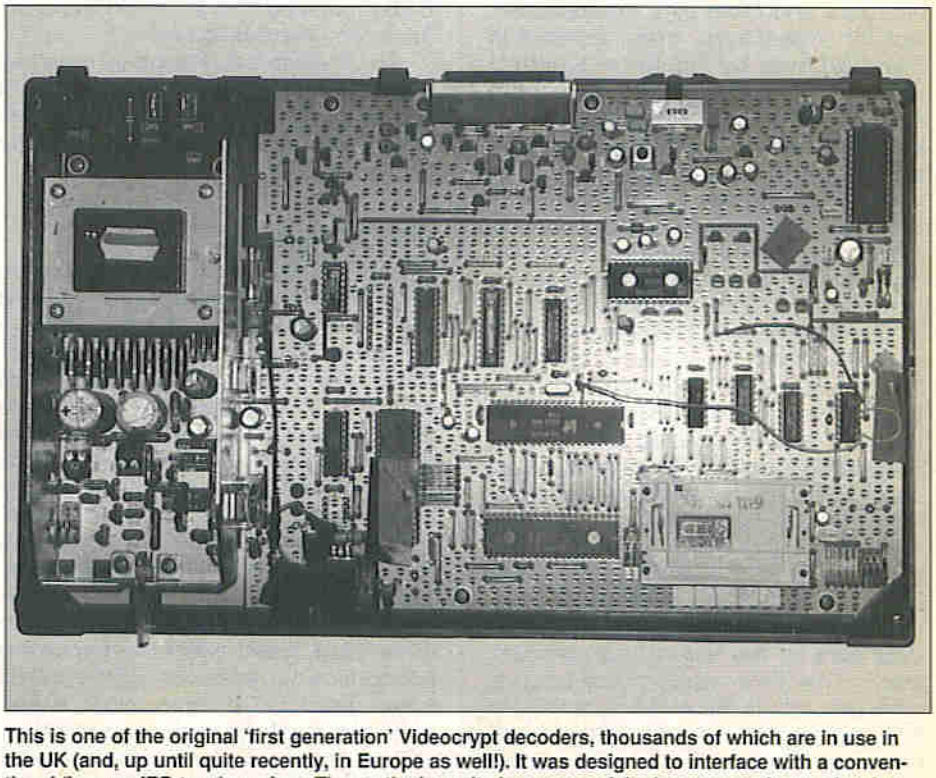
VideoCrypt, developed by French company Thomson-CSF, is used by BSkyB and an increasing band of PAL broadcasters (the Adult Channel, TV Asia, Viseurope newsfeeds and Armed Forces broadcaster SSVC, to name but a few). It is similar to Eurocrypt in so far as it too uses the 'cut and rotate' principle to scramble pictures, and Smart Card technology to prevent unauthorised viewing. There any similarity ends, because VideoCrypt employs a single 'cut and rotate' system (after all composite, rather than component video, is used). In addition, authorisation data and free access control words are transmitted in the vertical blanking periods (along with Teletext information), making the two systems all but incompatible.

Both Eurocrypt and VideoCrypt offer such secure video scrambling that many broadcasters choose not to encrypt the audio portion of the signal, although Eurocrypt can support sound encryption. Fortunately, the present VideoCrypt specification does not support this. The reason for this appears to be simple – let the public hear what they are missing, and then they will (hopefully) subscribe. Nevertheless, this has advantages – particularly in the case of those 'live' concerts broadcast by Sky Movies+ (Pavarotti, Dire Straits, Genesis, Whitney Houston, etc.). After all, the music can still be enjoyed without a picture!

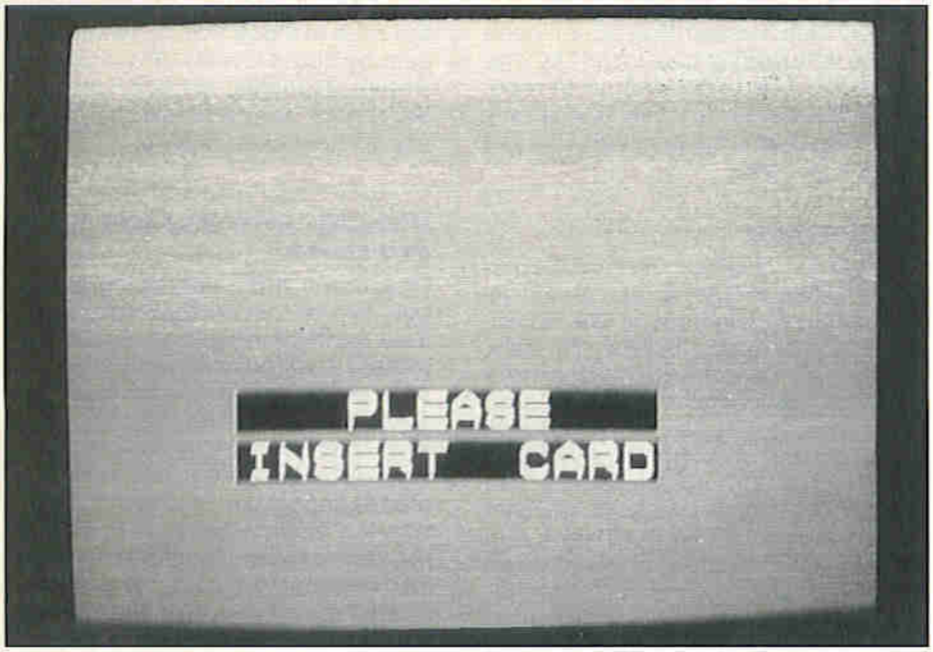
VideoCrypt's Pay-per-View Provision

One of the more interesting features built into the VideoCrypt specification from the beginning is a 'pay-per-view' system – as evidenced by the provision, on all decoders and IRDs (integrated receiver-decoders), of an 'Authorise' button. Pay-per-view works very well in the States, and with certain broadband cable systems equipped with the facility – but why has BSkyB not yet implemented it? It is certainly a lot fairer to the customer, as only movies or sporting events watched are paid for. It also dissolves at a stroke the arguments made by those who pay for three channels, but can only watch one at a time. This situation will get worse as the programme providers begin to encrypt more channels and offer them under 'joint subscription packages.'

For movie channels, nothing could be easier. BSkyB could charge a fixed £50 a year (which will more than cover basic operating costs). Films could then be charged for at a rate of £1 per film – or less depending on the number of previous screenings (undercutting video rental). In some cases (such as BSB's highly-regarded Movie Channel), older films could be broad-



This is one of the original 'first generation' Videocrypt decoders, thousands of which are in use in the UK (and, up until quite recently, in Europe as well!). It was designed to interface with a conventional (i.e. non-IRD type) receiver. The particular unit shown was picked up at a car boot sale – its previous owner had originally paid a substantial sum of money for it as an 'everlasting Sky decoder'.



The sign of things to come?

cast free of charge. Obviously, special events such as critical Premier League football matches would attract premium rates – say £3 per match. It will be interesting to see whether BSkyB adopt such a policy – after all, it is a lot fairer and will attract more subscribers – particularly those (ex-BSB viewers included) who see BSkyB as, to quote one disgruntled satellite viewer, 'an operation run on no more than pure unadulterated greed.'

Attempted Hacks on VideoCrypt

As more and more PAL broadcasters opt for VideoCrypt, great interest is being shown by hackers. Several attempts have been made – all of them thwarted so far. An interesting hack circulating around the 2m amateur radio packet network involved stopping the card from being 'deprogrammed' once it had expired. This involved removing the programming voltage from the card, using a high-powered zener diode to bring it down permanently to its the normal state; needless to say, it got rather hot! As a result, an extra month's use could be obtained from the original card. BSkyB got round this hack by issuing subsequent sets of replacement cards. The original cards used EPROMs to save on costs; the new ones, however, use a different form of memory (EEPROM), that can be erased through commands issued by the smart card's microprocessor, which in turn is controlled by the serial data sent by the VideoCrypt decoder itself. This is a much more secure arrangement as the erase operation is entirely contained within the card, rather than depending on the vulnerable and accessible link between card and decoder.

Another hack tried was something known as 'code stripping'. When BSB's Sports Channel (once upon a time, this channel was free to Marcopolo viewers) was taken under the wing of Sky Television (as it was then known) in the spring of 1991, the Astra illumination was soft-scrambled in VideoCrypt. Hackers found the serial data stream transmitted along with the video of the aptly-renamed Sky Sports and, using a second receiver and a VideoCrypt decoder, attempted to use it with the pay-TV channels (Sky Movies and the Movie Channel – another of the ex-BSB channels). It didn't work of course; the codes were different!

Needless to say, the serial data link between the card and decoder could be exploited as a shortcoming of the VideoCrypt system – but we won't say any more than that!

Conclusion

With so many different European channels distributed via satellite, it is a shame (despite the introduction of a so-called 'United Europe') that scrambling is becoming more and more apparent. Once satellite TV gave the viewer a chance to look into the culture and customs of other countries. This, to the detriment of schools contemplating the purchase of satellite equipment for language classes, appears to be diminishing as more channels encrypt, for both commercial and copyright reasons. An advantage of the smart-card based systems is becoming predominant, however – little cards travel through Customs much easier than big black boxes, although they can be decommissioned just as easily! Several of the key economic and ethical issues of scrambling were covered in an article entitled 'Up Above or Down Below – Satellite or Cable?', which was published in Issue 58 of 'Electronics'.

Of greater concern to the English-speaking satellite viewer is the planning, of several clear channels, to encrypt their channels in the not-too-distant future. On Astra, MTV, the Children's Channel, the remaining BSkyB channels and even the newly-arrived CNN are talking about charging for their channels. In some cases, they are planning joint subscription packages with channels yet to arrive (at the time of writing) on Astra – such as Discovery, which is presently unencrypted on Intelsat VI-F4 (27·5°W), and the proposed Thames/BBC 'old gold' channel. The criticisms levelled at BSkyB's currently scrambled channels will then apply – why are multiple-receiver households effectively forced to watch one channel at a time, despite the fact that they are effectively paying for several simultaneously?

Whichever way you look at it, watching satellite television is likely to become considerably more expensive in the coming years – something worth thinking about if you are contemplating purchasing a receiving system.

Footnote

Scrambling is a very complex subject and it has been impossible to cover all of its aspects in a single magazine article. However, it is hoped that the reader has gained at least some insight into this fascinating area of electronics technology.

This article has explained 'how and why' the various techniques and methods of scrambling are used, and discusses the technical differences, merits and shortcomings of such systems. The article has also raised certain moral issues, dealing with the content of broadcasts and the differences in legislation governing such broadcasts in European countries. It is not the intention of the Publisher, Editor or Authors to encourage people to defraud television companies, film companies, broadcasters or their agents of rightful revenues. The reader is reminded that anyone who makes, imports, trades or uses equipment designed to receive programmes illicitly is liable to prosecution under the Copyright, Designs and Patents Act 1988.

Acknowledgments

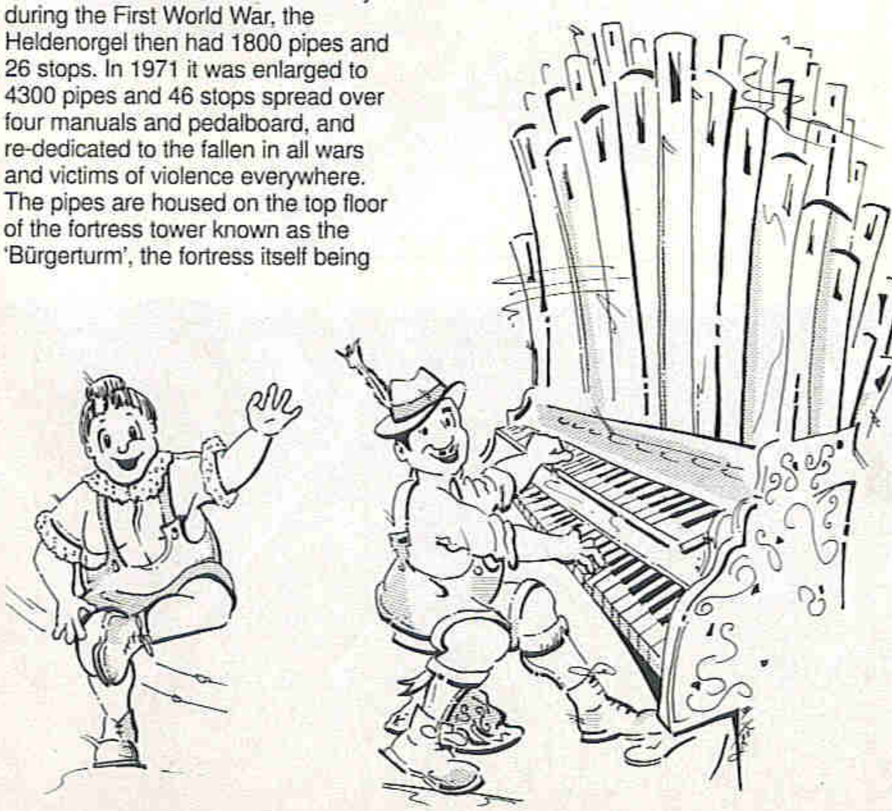
The authors and publisher wish to thank Thomson Consumer Electronics for granting permission to reproduce Figure 1. We would also like to thank William Jones CPA of York, specialist advisors on copyright and other matters, for their appraisal of this article prior to publication.

Stray Signals

by Point Contact

In the summer, Mrs PC and yours truly took a walking holiday in Austria. A gentle 10 miles, or so, per day was about our limit, but even that was more energetic than one might imagine, as we were in the mountainous Tyrol. There, the bergpfads (we steered clear of those), fusswegs and wanderwegs are never horizontal except for more than the odd metre or so where they change from going up to going down or (more often, it seemed) vice versa. So we had rest-days, when we visited some of the interesting towns and cities of the locality, such as Innsbruck and Kufstein. You have more than likely heard of the former, but not the latter? Well, PC had a particular purpose in visiting Kufstein. Regular readers of this column will know of PC's interest in electronic organs and, like many other members of the Electronic Organ Constructors' Society, also takes an interest in pipe organs. Now Kufstein boasts the largest pipe organ (of its kind) in the world, so it was a sight not to be missed. One is always very wary of that innocent-sounding rider 'of its kind'; after all, a cow with two heads would undoubtedly be the largest 'of its kind' in the world, even if it were no larger than a Shetland pony – and sure enough the Kufstein 'Heroes Organ' is no match for the monster in Atlantic City. But it does have its own claim to fame. Built originally in 1931, to commemorate the fallen from Austria and Germany during the First World War, the Heldenorgel then had 1800 pipes and 26 stops. In 1971 it was enlarged to 4300 pipes and 46 stops spread over four manuals and pedalboard, and re-dedicated to the fallen in all wars and victims of violence everywhere. The pipes are housed on the top floor of the fortress tower known as the 'Bürgerturm', the fortress itself being built on a high bluff beside the river Inn. Kufstein is the last town in Austria that the river passes as it flows north into Bavaria, where it eventually joins the Danube. Owing to its elevated position, the organ can be heard up to ten kilometres away and even up on the peaks of the WilderKaisergebirge, if the wind is in the right direction. Talking of wind, the organ owes its great volume of sound to the high air pressure used, namely 470mm or (for those of us still familiar with Imperial units) 18½ins. of water – or about $\frac{1}{20}$ of one atmosphere! This compares with around 50mm of water for a normal church or concert organ.

All agog, we took our seats in the Orgelhörerraum, an open sided stand opposite the little building housing the Heldenorgelspieltisch (console). The organist, Herr Professor Reinhold Hindinger, said a few words of introduction over an almost inaudible PA system prior to a short recital. He pointed out that the organist's task is not an easy one, since the keyboard is 100 yards away from the pipes – resulting in a third of a second delay between pressing a note and hearing it sound – and on an organ like that, practice is obviously impractical. Still, electronics to the rescue: a small loudspeaker by the keyboard relays the sound of the pipes via a microphone in the organ loft, whilst the installation of 30 electronic pistons in 1986 enables the organist to set up most of the registration he requires beforehand. The recital (midday, every day, with an additional recital at 6pm during the summer) nicely demonstrated the good points of the organ as well as the lack of power in the bass which is inevitable in an open-air instrument. The recital finished, as always, with the valedictory 'Guten Kameraden'. Yes, it must be quite a privilege to be able to boast that you have the biggest organ (of its kind) in the world.



Recently PC bought, by post, a widely advertised radio doorbell, out of interest mainly, though it could just come in useful for something or other. Curious to see what made it tick, it was soon in pieces and proved to consist of a simple LC oscillator in the bellpush (transmitter) unit and a super-regenerative receiver in the beeper (receiver) unit. The frequency stability of the transmitter, with temperature and battery voltage, can be safely predicted as poor to shocking, but the poor selectivity of the super-regen RX prevents there being a problem. The super-regen RX, of course, probably radiates as much energy as the TX, such is the nature of the beast. The claimed range of 50ft proved to be spot on, with both units mounted at shoulder height and in line of sight. Mind you, the accompanying leaflet showed a little old lady weeding her back garden, with the beeper on the ground beside her – with the RX at ground level the range proved to be only 15ft even in line-of-sight! The operating frequency checked out at around 330MHz, and following a recent committee meeting at the Radiocommunications Agency, I showed the device to the chairman who said, "Oh! I've got one of those!" However, he was surprised to learn that the operating frequency was around 330MHz – there just is no frequency allocation for radio doorbells anywhere near 330MHz, at least not in the UK. This far Eastern product was probably designed originally for the US market, and I have recently seen it advertised as 'Approved by the Home Office'! Which Home Office it means is open to question, but it is certainly not approved to any specification issued by the Radiocommunications Agency (formerly the radio regulatory division of the DTI). So beware, you could be in breach of the law.

Yours sincerely

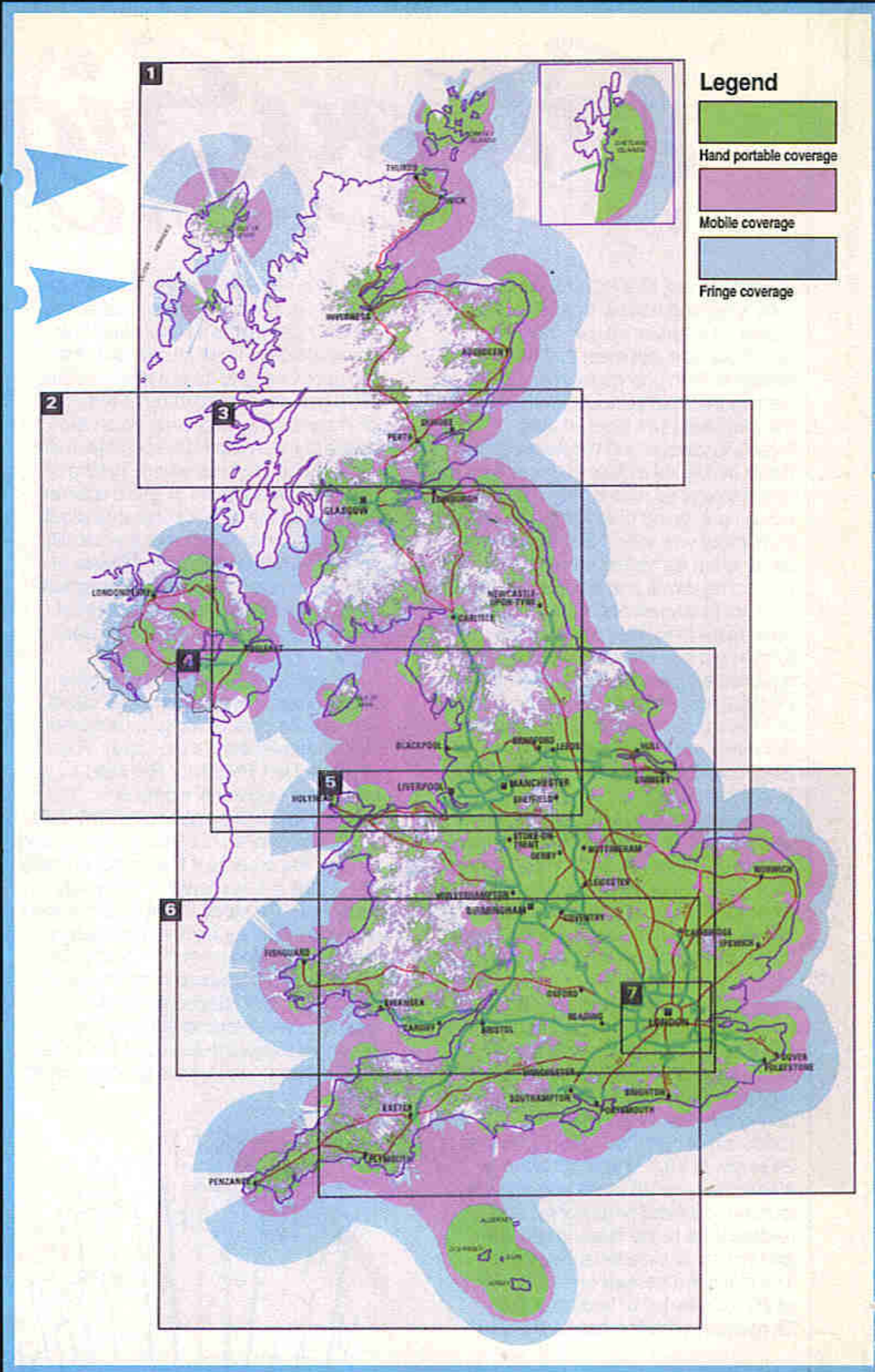
Point Contact

cellnet DRIVES HOME THE QUALITY MESSAGE

by Alan Simpson

Have you ever wondered just how the cellular radio network manages to track its users down? Whether they are hanging out in Soho, enjoying the Cotswold scenery or even shopping in their local Maplin store, it always seems to be able to find them. Well the answer is that the cellular mobile system makes use of two channels – one data or control channel, which keeps tabs on where each active mobile unit is located, and of course one voice channel. This information, plus a lot of other cellular facts and figures, was provided to your regular Out and About correspondent during his visit to the hub of the cellular world, Cellnet's Network Management Centre, based at Slough, Bucks. You can discover for yourself even more behind the scenes facts, if you enter this month's competition, the winners of which get an all expenses paid visit to the centre.

Despite the objections by certain Government Ministers, cellular radio phones have caught on in a big way in the UK. Even in these depressed times, new subscriptions are running at close to 40,000 a month with estimates suggesting that by the turn of the century, some seven million of us will be hooked on 'mobile'. There may be many people who believe that cellular phones are only for city brokers and the like, but for many users, and there are already well over one million, cellular phones have a much more practical use. For a one-man business, such as a plumber, electrician,etc., cellular phones are now an indispensable tool-of-the-trade providing a link to the office, home and further business. For the motorist trapped in a traffic hold-up between junctions 16 and 22 on the M25, phoning ahead to warn of a delay is one less worry. As a method of calming the traffic weary driver, cellular phones have no equal.



A Pocketful of Power

Cellnet, a joint venture between BT and Securicor, is one of the two UK cellular radio operators. Set up in 1983, the Cellnet network, with over half a million customers and capacity for at least half a million more, embraces over 98% of the British Isles –including exclusive coverage of the Channel Islands and the Isle of Man. For all practical business purposes, this means that a cellphone, operating on the Cellnet network, can now be used virtually anywhere in the country.

Mike Tiplady, Cellnet's director of engineering, claims that cellular technology allows the customer to make and receive calls to and from virtually any other telephone in the world. To achieve total coverage over a large geographical area, a network of radio stations, known as cells, have been installed, each equipped with a number of low power radio transmitters and receivers. Thanks to economic use of the radio spectrum, Cellnet engineers have enabled the same radio frequencies to be re-used over and over again throughout the country. Each radio channel used by the cellular system is duplex (two-way) and comprises of two frequencies spaced 45MHz apart. The base-station to mobile direction uses the higher frequency (in the 935 to 950MHz range), and the mobile to base-station direction uses the lower frequency (in the 890 to 905MHz range). There are 600 channels in the bands, which are known as TACS (Total Access Communication Systems). As the cellular network has grown, further bands were allocated and are known as ETACS (Extended Total Access Communication Systems). See Figure 1.

Speech is carried by means of an analogue FM signal with a relatively high frequency deviation of 25kHz to optimise interference protection. Control function data is carried digitally with forward error protection and repeated transmission to avoid data errors.

Making a Call

Each cell (or base-station) is connected via digital links to an Electronic Mobile Exchange (EMX) which routes calls in the appropriate direction, either to other EMX's or via an Area Exchange (AXE) to the public telephone system. By keying a number

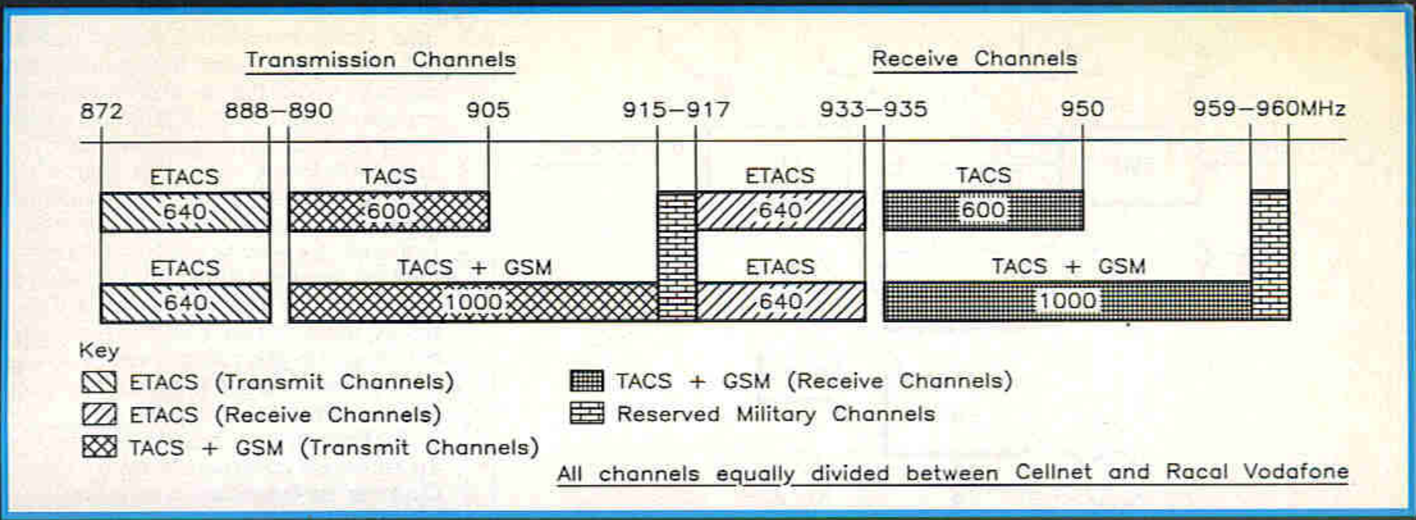
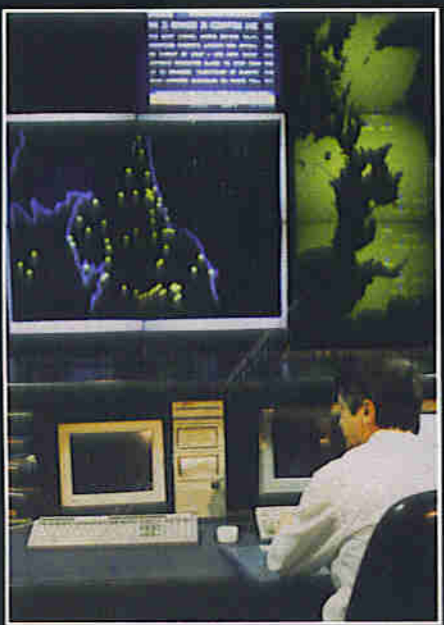


Figure 1. UK Cellular Frequency Spectrum Allocation.

OUT AND ABOUT



Above: Construction workers erecting a transmitter site.
Left: An engineer at his station. Part of the 'Video Wall' can be seen in the background.

on the cellphone and pressing the 'send' button, a signal is transmitted to the nearest EMX. This signal contains information on the caller's own mobile number, the unit's unique electronic serial number and the number dialled. This information is then routed to the EMX where the caller is registered. The exchange then processes this information and checks that the mobile unit is authorised to operate on the system and the services that are available to that subscriber. See Figure 2.

The UK is divided up into a honeycomb of cells. Any given channel in use at one base station (cell site) operates on a specific radio frequency which is different from the channel used in adjoining cells. However, the channel can be used again in the next, but one cell site. As the cellphone user moves from one cell to another, the system automatically switches control of the call from the cell they are leaving, to the one being entered. This process is known as 'Hands off' and takes around 300 milliseconds to perform, making the change-over virtually transparent to the user.

Getting Cellnet into Focus

In dense urban areas cell sites are relatively small, and can be as little as 500m in radius. As users move to the suburbs and then on to rural areas, the area the cells cover becomes progressively larger. As a result, within a large city the same frequency may be used dozens of times, and will accommodate tens of thousands of customers in that city alone. Special consideration is given to trunk-roads and motorways where high volumes of traffic are experienced as is the case with motorways. Here directional cells pointing up and down the motorway are employed with large numbers of channels. In special areas of high capacity requirements, Cellnet has 'sectorised' its cells, splitting each of the cells into three or six sectors, with each sector having its own dedicated radio frequencies. Thanks to 'sectorisation', the radio frequencies can be re-used more often in the cell plan without risk of interference, so the capacity can be increased.

Mike resolutely decries the yuppie image tag which politicians bestow on mobile phones. Demand for cellular communications over the past six years has been phenomenal, and cellphones are now firmly established as an essential business tool, improving efficiency, time-management and, most important of all, profitability. There are many facilities associated with cellphones, such as call forwarding, three-party conferencing, data access to computers, fax, electronic mail and telex, plus a direct link into the network from the company switchboard. However, Cellnet Ltd. believes that its new service CallBack, which uses a Voice Messaging Database (VMD), will make the most impact, and is set to transform the use of the cellphones. During times such as when the cellphone is switched off, engaged or possibly out of range, the callers message is recorded and played back when the phone is switched on again, or the message is requested.

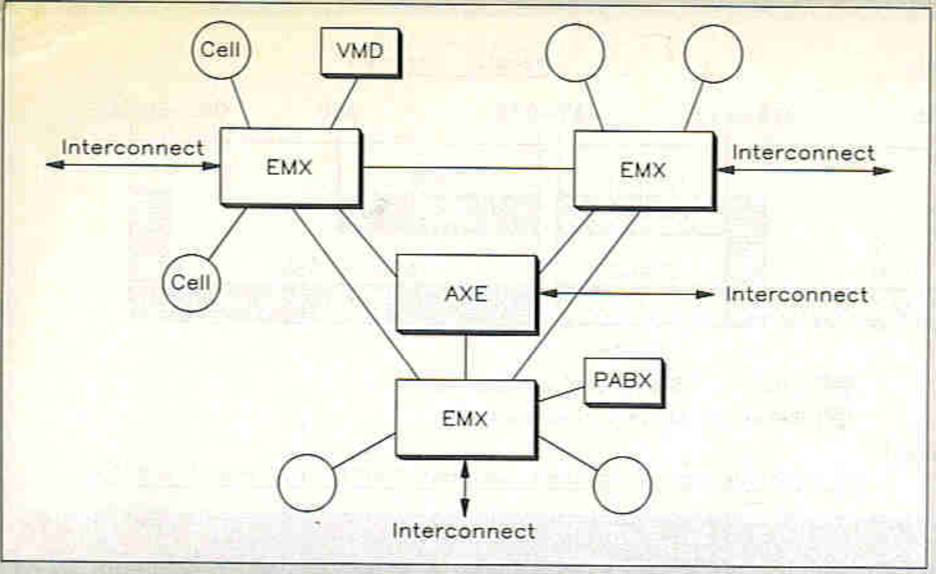


Figure 2. Cellnet Network Configuration. EMX = Electronic Moile Exchange, AXE = Area Exchange, VMD = Voice Messaging Database.

Nerve Centre

The nerve centre of the network operation, and possibly the showcase of high technology in Europe, is Cellnet's national Network Management Centre (NMC). Dominated by a massive video wall, it would not look out of place in Star Trek or as a base for 'ET' to phone home! Staffed by engineers 24 hours a day, 365 days a year, the centre can rectify, or if necessary reconfigure, the world's largest capacity cellular phone network. With over 30,000 voice channels operating through more than 800 radio cell sites, 27 Motorola mobile exchanges and four major inter-network switches, the team certainly has its hands full!

For Cellnet, the quality and reliability of their network is paramount as it is only by setting high quality standards that growth can be achieved. Given the complexity of cellular radio, current network performance enables over 90% of calls to meet the specified targets. The customer should be able to get a line and maintain a good quality call for at least two minutes – slightly longer than the average telephone call. Meanwhile, over 9 out of 10 calls to Cellnet's operator and directory enquiries are answered within 15 seconds.

The Hub of the Affair

The ultimate goal of all network management systems is the detection, isolation and correction of faults and abnormal conditions before the user becomes aware of the situation. Cellnet's solution was to create an integrated network management centre where engineers can keep tabs on every network component. Responding to events as they happen, the team can divert resources, such as additional capacity, to areas where a sudden increase in demand could affect efficiency. The problem could be national, or a very local cell unit, to help, the team have the ability to 'switch back in time' to see how the problem developed, and whether it is getting better or worse.

Getting the Video Picture

Without doubt, the focal point of the centre is one of the world's largest 'video walls'. The wall, which was mostly developed in-house, consists of 27 colour video screens in a 3 x 9 grid, providing a realtime digital overview of the status of the entire network. If necessary, the wall can be partitioned down to the level of individual devices in any of the cell sites or individual links in the network. The screens display alphanumeric and graphic data generated by three network management systems, but can also display external information sources such as Ceefax and Oracle teletext. This provides the network centre team with knowledge of any local or national emergency which is likely to trigger an increase in normal cellular traffic levels. In fact, on-duty engineers can spot motorway congestion quicker than anyone else, as any hold-up results in a flurry of calls warning home, office or business appointments of possible delay. It would certainly make sense for the road traffic reports to have a direct interface into the Cellnet centre to keep them in touch with the real world.

Fluctuations in traffic demand can be identified on the innovative screens, which draw out a map of the UK, this allows remedial action to be taken and if necessary to spread the load across the network. Additionally, network components can be just 'tweaked' or fine tuned to achieve better performance. In day to day operations, each of the workstations is responsible for a different geographical part of the network, and the video wall is the sum of all the individual workstations. However, it is possible to display any particular workstation on the video wall.

Below: A wider view of the 'Video Wall', with various information display.

Problems on the network generate 'fault data' information which is flagged back to the centre and filtered through real-time computers. With the aid of UNIX engineering tool software, the fault is given a priority rating from one to four and then displayed as a single line of information. Overall, the system decides on the priority of faults that occur and displays the ten most serious problems, enabling technicians to concentrate on a particular network trouble spot and to identify the nature of the fault. If necessary, traffic can be re-routed around the trouble spot to give full continuity of service while a member of the 400 strong field engineers resolves the problem.

Additionally, the problems identified by the centre are continuously fed to Cellnet's Customer service division and the front-desk helpline to keep user's informed of potential or actual trouble spots – Mike believes customers need to be told why, when and where. Apart from the technicians, the management centre houses a central data management group which controls the database for the entire network as well as a base-site control group which schedules the work programmes of base-site engineers.

On the Road

Cellnet users can provide a very high level of practical and immediate assistance to fellow motorists who have broken down, by using their cellular phones to call for help. Hopefully, the stranded motorist has not broken down in a lengthy tunnel which impedes the transmission of radio signals. If you must break down, Mike suggests that you avoid areas surrounded by embankments or high rise buildings. Apparently, it is OK to break down in the Picadilly underpass, since the radio waves bounce of the walls naturally!

"Other trouble spots", says Mike, "include leafy avenues where trees in full leaf absorb a lot of radio energy, causing noise and, in some cases, calls to drop out". In fact there is seldom a dull moment where radio signals are involved. There is always a risk that two sites overlap on certain frequencies or that interference is created when cells are swapping calls. Meanwhile, radio propagation over water is notably good – by connecting to the Dover mast, it is possible to use your car phone in Calais. Good radio mast site planning – and that takes in the environment – is the key.

Taking a Lifeline

Right now, much planning is being devoted to accommodate the new Cellnet 'Lifetime'

mobile phone service which is aimed at non business users. Based on an alternative pricing package to attract low-use customers, Cellnet is expecting to sign 200,000 new subscribers in its first 12 months of operation. Although the existing Cellnet network can handle the new service, many more micro cells are being installed, especially in town centres to provide additional network capacity for the hand-portable user. However, Cellnet has developed more efficient, environmentally friendly, radio masts which given their small footprint, do not require planning permission. In cash terms, Cellnet have already spent some £700 million building the existing network and are now investing a further £30 million getting the micro cell service off the ground.

Proposed subscription charges for the new consumer service are modest for cellular phones – a connection charge of £25 and a monthly line rental of £15. But with calls costing a whopping 50p peak and 20p off peak per minute, many potential users will find it more cost-effective to go for the business tariffs (higher rentals but lower call costs). Just enter our competition – rental and airtime costs for a month will not be a matter of concern to the fortunate winner.

Going Digital

Cellnet is working on the next cellular revolution, that of a Global System for Mobile Communications (GSM). Although Mike believes that intense marketing of the pan-European service will not start until the end of 1994 – Cellnet is totally committed to the new technology. However, like all things high tech, don't rush to place your orders. The anticipated starting price for a digital handset is a bulky (in size and price) £1,000. Which brings us to the troublesome matter of battery life. Present handset units have an eleven hour standby but a life of just one hour when in use, but as batteries and low power semiconductor technology improve so too will battery life.

"Life at Cellnet is very exciting", says Mike Tiplady. For over the next couple of years, cellular radio battlelines will be drawn up, with operators and services competing for a rapidly growing market.

Life will be very exciting for you if you win this month's prize, the use of a Lifetime portable cellular phone for a month plus free airtime plus a visit to the exciting Cellnet Management Control Centre. The two runners-up will each win a visit to the Cellnet Network Management Control Centre – all expenses paid. Also we have six Cellnet T-shirts to give away. Just answer correctly the four questions and the first names out of the editor's hat, could experience the world of cellular for themselves. So don't delay, write your answers on a postcard or on the back of a sealed envelope to: Cellnet Contest, The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR. The closing date for the competition is 28th February 1993.

Please note that employees of Maplin Electronics and family members of same are not eligible to enter, also multiple entries will be excluded from the draw.

cellnet Competition

1. What is the total number of telephones used worldwide?
(a) 820,000,000.
(b) 20,000,000.
(c) 160,100,741.

2. The first public telephone exchange opened in London in 1912 with how many subscribers?
(a) 1000.
(b) 7
(c) 15,000

3. Spot the odd one out!
(a) Bell
(b) Edison
(c) Ericsson
(d) Alan Sugar

4. When were Cellular phones first demonstrated in the UK?
(a) St. Valentines Day 1930
(b) Guy Fawkes Day 1940
(c) 1984
(d) Spring Bank Holiday 1950.

COMPETITION WINNERS

Hit Factory Competition

The questions and correct answers to the Hit Factory competition which appeared in issue 56 (August) were as follows:

1. 'Top of The Pops' can be seen where?
On BBC TV

2. Where is the Royal Albert Hall located:
South Kensington, London

3. Spot the 'top twenty' odd one out:
The Phantom Tadpole

4. Who heads the Rolling Stones?
Mick Jagger

The first lucky winner, to be drawn out of the editor's worn-out hat, was Chris Cooper of Stockport, who wins a personally conducted tour, for himself and a companion, around The Hit Factory Studio.

There are three additional winners, who will each receive a copy of the Rolling Stones CD 'Flash Point'. They are:

Paul Debenham, High Wycombe, Buckinghamshire; S. P. Law, Norton Lindsey, Warwickshire; Ron Mitchell, Stonehaven, Grampian.

RAF Hendon Competition

The questions and correct answers to the RAF Hendon competition, which appeared in issue 57 (September) were as follows:

1. Except for gliders, balloons, jets and helicopters, all aircraft have to have one of these to drive them through the air:
Engine

2. In legend, he flew to close to the sun and crashed into the sea. Who was he?
Icarus

3. What did fighter pilots do to get into the air as quickly as possible?
Scramble

4. Which brothers were the first to make a sustained powered flight?
Wright Brothers

The six lucky winners, drawn out of the old bin this time, who will be enjoying a day out with their families at the RAF Hendon Museum, are:

M. W. Divall, Hartley, Kent; L. Myers, East London; J. Beeching, Rayleigh, Essex; P. G. Knott, Waltham Abbey, Essex; S. B. Skinner, Stoke-on-Trent, Staffordshire; D. M. Evans, Milton Keynes, Buckinghamshire.

NETWORK MANAGEMENT

by Frank Booty

Multi-vendor, multi-protocol networking of information systems is a present-day fact of life, and is here to stay. Networks are increasing in both size and complexity. The results of a recent survey, carried out by the market research organisation Benchmark Research over a hundred or so major corporates, revealed that over 80% of sites used three or more different networking protocols. At the same time, as networking technology matures, organisations are relying on their networks for every aspect of their business. As a result, network management is one of the hottest issues in computing today.

It has been said that people are only concerned about network management when their network 'goes down' on them. People don't manage their networks, they wait until they break down, and then go and fix them. Users are not aware of potential problems on their networks. Damning comments, but sadly true nonetheless. Gaining that competitive edge depends on information availability, and so networks should be maintained properly to prevent failure.

The goal of the Information Services Manager is to ensure that the information is provided when it is required. This dictates that the network that delivers the information must be secure and available 24 hours a day. Networks must be secure and easily recoverable in the case of catastrophic failure.

Effective network management is beneficial during the installation of, and in operating, the network, and goes a long way towards meeting the above goal without significantly adding to capital costs. It can pay for itself during installation. Management problems increase with network complexity, in proportion to the number of added networks, links, applications and resources. But a network without management is a ticking time bomb.

The ultimate aim of network management is to be able to control, monitor and co-ordinate all the devices on a network from a centralised point. The problem for a network administrator is that the different devices installed on the network frequently use proprietary protocols, with the result that whenever a device is added to a network from yet another vendor, another network management console must be added to the operations centre. The problem is further complicated by the fact that devices may be geographically dispersed and connected to other outside devices.

The International Standards Organisation (ISO) has identified the need for a standard for network management with the aim of simplifying the task of the network manager. ISO's Common Management Information Protocol (CMIP), currently under development, will attempt to provide a standard management protocol for large heterogeneous environments. Unfortunately, CMIP is a long way off and network managers must look elsewhere to find a solution to their present-day networking problems. ISO, however, has published a set of guidelines for the relationship between the various software components of a network; this is known as 'Open Systems Interconnection' – or, perhaps rather confusingly, OSI!

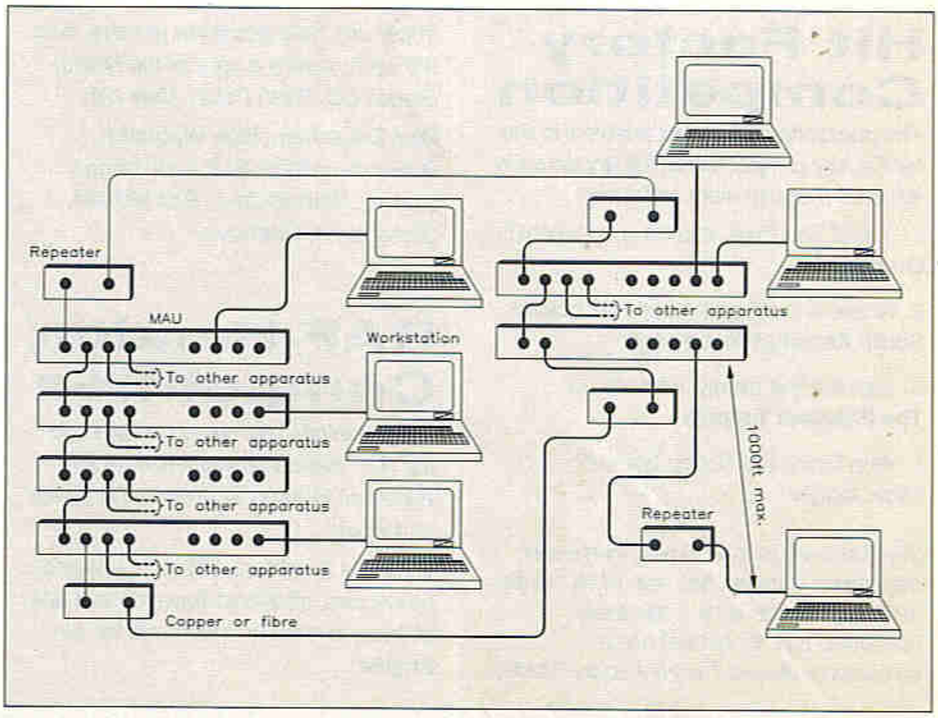
SNMP – an abbreviation for Simple Network Management Protocol – has proved to be the pragmatic solution to these network management problems and has become a de facto standard. Approved in 1988, SNMP was created specifically to provide management for Internet, the largest collection of heterogeneous and wide area networks in the world, and the US Government's nationwide data network, which links governmental, research and educational facilities.

TCP/IP stands for Transmission Control Protocol/Internet Protocol and is not OSI compliant, but the protocols do parallel the OSI model. The advantage of TCP/IP is its historical status as a de facto standard for LAN operation. Therefore, more flexibility is offered for interworking and compatibility than with any other non-OSI protocol.

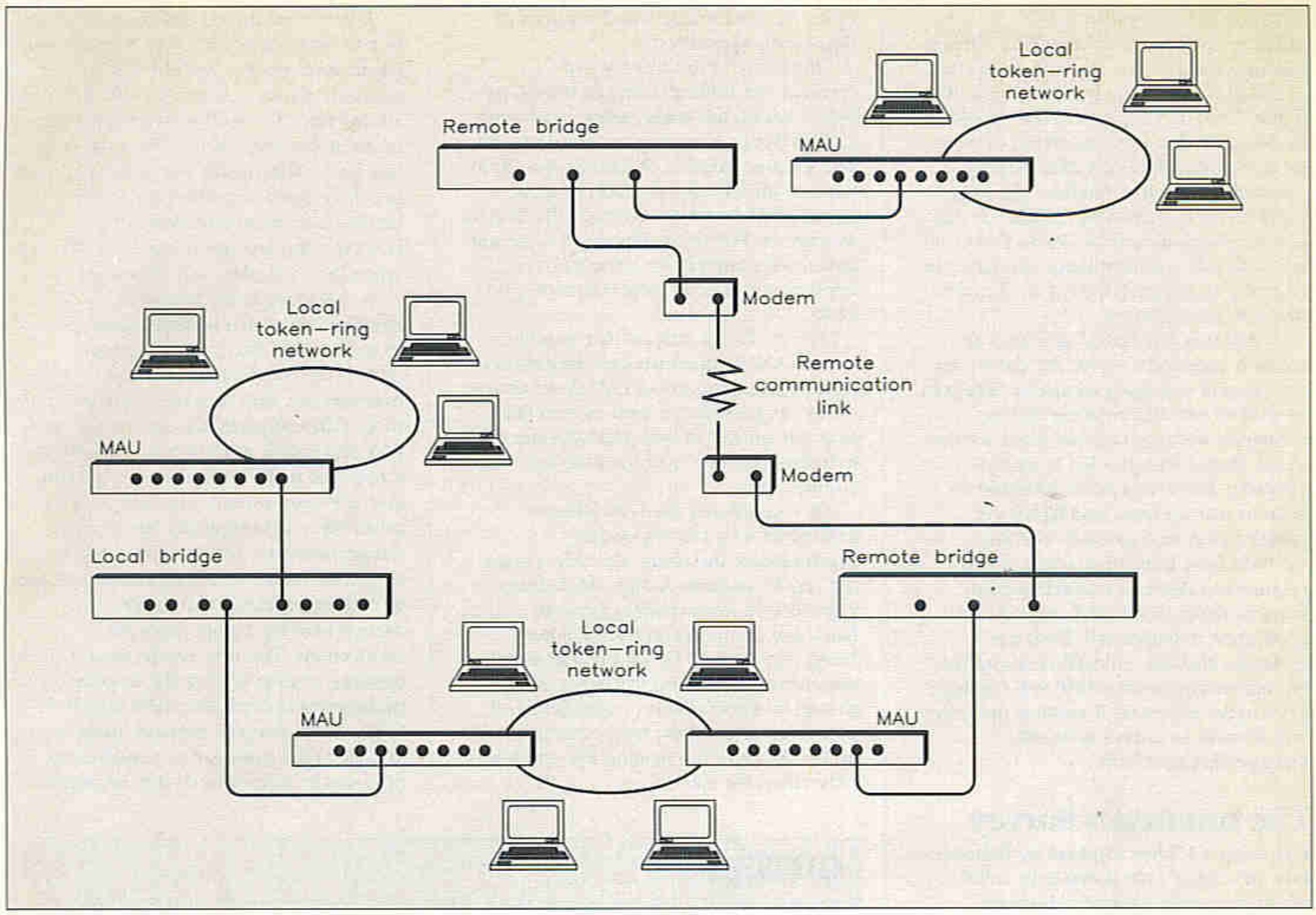
Its disadvantages are that it is not OSI conformant, and that it was originally designed to operate on a Wide Area Network (WAN) and not a LAN. WANs generally have a much higher error rate than LANs due to the lower quality of network links. Therefore TCP/IP operates a great deal of error-checking which reduces performance, although some of this has been overcome by better design in recent developments.

It is now generally accepted that TCP/IP will be superseded by the ISO system but, as with any de facto standard, it will continue to be used for a considerable period, and all new networks will need to retain some compatibility with existing TCP/IP networks.

The SNMP specification gives both the protocol and the management information that should be used by TCP/IP-based network management systems. Although normally applied to the management of TCP/IP routers and bridges, it is applicable to the management of all network equipment, and can even be used for managing non-network devices. SNMP is currently the dominant network management protocol, largely due to its openness and relative simplicity. The fact that it is a mature and time-proven technology for connecting multiple, distant networks has meant that it has gained rapid acceptance amongst any vendor serious about standardised network management. During 1991 the number of vendors giving support to the protocol has risen from a mere handful to over 40.



An example of a Token Ring network illustrating that, by using repeaters, workstations may be connected across a large physical area. Trunk segments between repeaters may be copper coaxial or fibre optic cable.



An example of how three Token Ring networks can be interconnected using bridges. A communications link is used to connect the remote network to the main network.

Some vendors, such as Sun Microsystems, are even providing SNMP management platforms which other equipment suppliers can tailor and extend to support their own products. For example, the SunNet Manager, now available from the Slough-based company Logical Networks, is used as a basic network management platform by both Retix and SynOptics. SunNet Manager is the first truly open, extensible management platform. Based on the ISO's management framework it is the ideal management platform for heterogeneous networks, providing an infrastructure for managing any open network. Through SNMP, SunNet Manager allows administration of any network-based device, service or application.

So how does SNMP operate? SNMP does not specify the way in which information is displayed, analysed or recorded, nor the user interface of the management station; it is in these areas that the different vendors are characterising themselves. SNMP consists of protocol, allowing agents and network management systems to communicate, and a Management Information Base (MIB) which defines the format and content of the information that they exchange.

MIBs are fundamental to both SNMP and CMIP systems, with each MIB controlling a particular aspect of a device's operation. Public MIBs are generic and non-proprietary, and contain basic network information such as user statistics. Private MIBs are proprietary, normally designed by the individual manufacturers, and contain most of the control functions of a network device.

For a network management station to be able to control a network, it must contain the MIBs for all devices on the network. Typically, the public MIBs will already be incorporated into the management station when it is shipped. This is not the case for the proprietary private MIBs, which will need to be sourced from the manufacturer of each device and laboriously loaded onto the management station. This situation is made worse by the fact that many of the private MIBs are not available in machine-readable form and need to be keyed in from a printed document, which is typically up to 100 pages long.

To alleviate this problem, the Internet Activities Board is coordinating research efforts into the development of new expanded public MIBs containing much more detailed information. These current 'experimental MIBs' will contain standard generic information for each type of network device, and will sit alongside the manufacturers' private MIBs.

The aim of this is to eliminate the duplication contained in the private MIBs and to reduce the amount of proprietary information that needs to be loaded onto the management station. Standardised public MIBs for routers, bridges and terminal servers, for example, could be already incorporated into the management station when shipped, so that in setting up the management system, the network manager need only load the now smaller proprietary private MIB for each network device.

At the beginning of 1992, there were 24 experimental MIBs under development (compared to the 220 private MIBs already in existence). At the Interop communications exhibition in San Jose in the Autumn of 1991, eight major manufacturers (including Hewlett-Packard, Novell and Spider) announced support for RMON (a remote-monitoring MIB), the first of the experimental MIBs to be demonstrated. Full support for other experimental MIBs followed, with MIBs for bridges and FDDI (Fibre-Distributed Data Interface) next.

FDDI is a token ring network specification developed by ANSI, implementing dual optical fibre rings. The network operates at 100M bit/s and can be up to 100km in length.

The launch of the experimental MIBs, as new public MIBs, is the most important enhancement to the SNMP standard since its formation. Standardised MIBs for each networking device will greatly simplify network management. Whichever source a network manager selects for his bridge requirements, for example, he can be sure that the new public bridge MIB will be effective for all bridges on his network. For the network manager, this eliminates the need for loading long private MIB files, for each manufacturers' equipment, onto his management station.

The support given by major manufacturers for the new public MIBs at Interop indicates that the next generation of SNMP products are not far off into the future. Until they arrive – and it should not be forgotten that announcement of new products frequently precedes general availability by many months – the biggest problem for the network manager is that few suppliers understand MIBs. Fewer still know where to source them and have the expertise to integrate them into complete management solutions.

SNMP was developed as a tactical solution intended to solve the day-to-day problems of managing wide-area networks. Its ease of use and implementation, combined with the fact that there are few viable alternatives, has led to its rapid adoption. But it was never intended for systems management and high-level configuration management. For this, we must look forward to CMIP which promises to deliver a comprehensive framework for distributed network and application management. Until it is available, and this may still be some way off, enhancements to SNMP will continue to increase its power. It remains the only real solution to today's network management problems.

The Infonetics Survey

Following a US investigation by Infonetics into the cost of LAN down-time, a UK-based company approached several exhibitors at a networking exhibition, and a selection of major users, to sponsor a study into the causes and implications of LAN failures in the UK. Originally, some 20 to 25 sponsors had been anticipated, of which 70% were expected to be users. The final list, however, ended up being industry-biased.

The users were British Gas, National Power, Bankers Trust, the DTI and Total Oil Marine. Industry sponsors included 3Com, Spider Systems, Sintrom Datanet, Siemens-Nixdorf, BT and Granada Information Systems.

The UK report, closely mirroring the findings of its US counterpart, concluded that the failure of LAN interconnect devices (e.g., bridges and routers) affects large numbers of users with long failure durations.

Components have become more and more reliable as networks have grown. This has led to greater levels of reliance on networks by companies, which means the costs of any failures are much higher than they used to be. However, network growth to date has left many network managers trying to integrate too many protocols, multiple cabling systems and a mix of LAN topologies. A common theme from the down-time report was that all organisations have committed to networking as a business tool and are thus dependent on reliable networks to achieve overall objectives.

Networks require a high degree of support competence. Too few organisations have the staff to support even their existing networks adequately. This is aside from the anticipated increases in the number of users and volumes of data being transmitted.

The study found that 75% of respondents suffered some form of LAN failure within the study period, with over 20% of these exceeding one working day. The average number of failures was 20·31 per annum with the duration of these failures 4·14 hours on average, affecting an average of 39·8 users. These are worrying statistics for companies intending to applications, vital to their operations, on LANs.

The study determined that standards-based LANs outperform their proprietary counterparts in terms of LAN down-time. Token Ring LANs are seen as benefiting from the greater in-built management and inherent topology over the Ethernet competition.

By categorising the LAN failures experienced by the respondent organisations, the study was able to pick out regular patterns in the LAN failures experienced, with cabling, network hardware and power-related failures being experienced by 25% of the sample size. It was concluded that more effort should be expended on controlling and containing a problem, rather than on finding a solution – treating the symptoms rather than the cause.

It has been shown that most problems in any network occur at the transmission media level (cables, optical fibres, connections, etc.) A recent study in Japan shows that 35% of all network problems occur at this level, with 25% at the data link layer. This means that 60% of all LAN problems have something to do with hardware or internetworking. It is, however, the area given the least attention when network plans are drawn up.

A cost/complexity barrier has been identified, at which network costs escalate to such a level that further network growth or modification becomes uneconomic. Any network using three or more different protocols and two or more LAN topologies will approach this barrier if network traffic volume/grows at more than 25% per annum. The only way to avoid the cost/complexity barrier is to design networks according to a much simplified model, enabling cheaper, easier growth by reducing the number of internetworking components and connections. The new model would shield network managers from the responsibility of the interconnections which they have today. Very complex network paths would appear to the manager as a single hop, as opposed to today's multi-hop situations.

GLOSSARY

LAN
LAN is an acronym for Local Area Network. Becoming as common today as PCs themselves in modern office environments, a LAN can be defined as a method of linking together individual PCs ('workstations'), terminals, file/program servers and shared peripherals such as printers, within a limited geographical boundary (normally between 50m and 10km).

WAN
Wide Area Network. Similar to the above, but over a larger area (typically greater than 10km). Standard protocols, such as X.25 and IBM 3270, exist for WANs. Due to the nature of the transmission medium (telephone lines), error rates are much higher than those of cable-linked LAN systems.

Ethernet
The industry-standard IEEE 802·3 CSMA/CD high-speed (10M bit/s) LAN system developed in the mid-'70s by Rank Xerox. CSMA/CD, by the way, stands for Carrier Sense Multiple Access/Collision Detection; this gives us some clues as the the operation of this system. Ethernet is a 'bus' system; all networked equipment taps into this bus, which is nothing more than an appropriate length of 50Ω coax with terminating resistors at each end. The electronics is somewhat more complicated.

Token Ring
In LANs using this technique, a packet of data known as a 'token' travels around the network; all networked equipment is connected together in a loop ('ring') by twisted-pair cable. A station can only transmit data when it has the token. IBM's own PC networking system is based on a token ring. Other network topologies exist other than rings; these include the self-explanatory 'bus', 'star' and 'tree' structures.

Bridge
These simple 'store and forward' devices, as the name suggests, connect multiple networks together, forming a single large network. The networks in question can be separated by quite large distances (remote bridging), or by a few metres (local bridging) Apart from reducing the cabling problems associated with remote LANs, bridges allow the networked devices in different departments to be logically grouped together. If properly implemented, traffic flow can be reduced, making the overall system faster.

Router
A router has much the same function as a bridge, but enables the network data to be transmitted over a wide-area network (WAN), rather than the dedicated point-to-point link required by a bridge.

Repeater
Repeaters, installed at regular intervals on LAN interconnect cables, 'recondition' the signals allowing greater network sizes/distances to be achieved.

MAU
Multistation Access Unit. This piece of hardware provides several pieces of networked equipment with access to a token ring.

TECHNOLOGY WATCH!

with Keith Brindley

In the beginning was Babbage's computing engine. True, there had been significant steps before this – the abacus, for example, and Pascal's adding machine – but Charlie-boy was the first to design a mechanical digital calculator. Babbage's computing engine begat the punched card, which was used to store and sort data in much the same way that non-mechanical digital computers were to do in later years.

Punched card computers, of course, only recently died out. They came into their heyday at the end of the last century when Hermann Hollerith (who later went on to found the company which evolved into International Business Machines – IBM) developed working mechanical computers.

Mechanical computers turned into electromechanical computers (using solenoids and relays) in the early 1940s, and these turned into electronic computers in the late 1940s. All these types of computers, however, used the punched card as a means of entering and outputting data, as well as storing and sorting it. It wasn't until much later that other forms of input, output and storage became feasible.

In the first days of electronic computing, valves acted as the electronic switching device, but it didn't take too long (about 10 years) to develop the transistor, and another 10 years to develop the integrated circuit switching device. Each generation of switching device gets smaller, complex and more reliable, and current microprocessor-based integrated circuits hold the key to modern computers.

Although it may be obvious, it's still worth stating: with each smaller and more complex switching generation, computers themselves get smaller and smaller. The first computers were as big as office blocks. Now you can carry around, in a briefcase, a computer whose power easily exceeds what used to fill those office blocks. But it's not going to stop there.

As a gadget lover I'm rather excited about the imminent prospect of personal digital assistants (PDAs). If you're not sure of what they are, or maybe haven't even heard of them, PDAs can be loosely described as the next generation of computers. Obviously they'll be smaller and more complex (pocket-sized instead of notebook-sized). In an elementary way, I guess you could say they're akin to current personal organisers in the sorts of things they're going to be able to do – but in reality that's only half the story!

It's the other tasks they'll perform, and how they go about doing them which form the really exciting prospect. Being even smaller than notebook computers there is an immediate problem of entering data. If you think about it, a notebook computer is about the smallest computer system you can get with a full-sized keyboard. So instead these PDAs will use a pen-entry system in which you write on the display, while the PDA translates your input into computer data.

Before you jump to any conclusions about pen-based PDAs, don't try and compare PDAs with the unsuccessful pen-based computers which hit the market with a resounding flop a year or so back. Potential users stayed away in droves, didn't they? But this is hardly surprising mind you, as pen-based computers are merely existing computers adapted, using the same commands, formats, and applications any old personal computer can use. They really didn't stand a chance, because they simply haven't got the extra oomph which is required. PDAs are very much different – in fact, *oomph* could be their middle name.

Imagine a filofax-sized device which you use to jot down ideas, drawings, phone numbers and so on – roughly as a filofax might be used today. Imagine, however, the PDA taking all your input; filing it, presenting it neatly, and allowing you to print, fax, phone, organise, remember, play, and so on. Now you're only just starting to see what PDAs can do.

This is tremendously complex when you consider. First, the PDA has to decide what it is you're writing or drawing, then do what you're telling it to do – all with just a few strokes of your pen across its display. As you'll guess, the computing engine is rather more complex than most computers around today: reduced instruction set computer integrated circuits (RISC) will need to be the norm simply to allow the thing to work. Operating systems will be far more complex than personal computing operating systems. Communications, database, processing and other applications are all built-in.

If this all seems like a fairy-tale, bear in mind prototypes of these PDAs have already started to appear. One developer, EO Corp in the States, has even got a working model out, and is about to ship production versions at a list price of just $2,000. Many others are a long way past the drawing-board stage. There's a race to develop PDAs which, because of the diversity of manufacturers, is destined to be fairly fast and very ferocious.

AT&T, the telephone and network company, is said to look at PDAs as being in the same class as telephones (that is, just about everyone will have one) over the next decade. Apple, the Macintosh computer manufacturer, sees PDAs as having an effect as profound as the car had on our lives. Companies like these – effectively the largest communications and computing companies in the world – aren't going to commit themselves in this manner unless they really do believe in the products.

As you'd expect, the companies spreading the word about how good PDAs are have a stake in them, so they are bound to tell us how PDAs are going to change our lives. AT&T, for example, has a significant stake in EO Corp's PDA – the AT&T Hobbit RISC processor is integral to it. Apple has a stake in its own PDA, called Newton, which is about to come to fruition. Incidentally, there's good news for us here in the UK regarding Newton: the processor in Newton is built by Cambridge-based Advanced Risc Machines (ARM), the company partly owned by both Acorn (yes, Acorn – the BBC computer maker) and Apple. The 610 is the chip, and it's already in production so Apple's Newton is about to fall on our heads, shortly.

Newton is an exciting product. Where most of the existing dreams of PDAs rely on each product having conventional interconnection cables and the resultant plugs and sockets, Newton goes one step further. Wireless networking built-in to the Newton PDA allows instant and uncabled communications between other people's Newtons, and conventional desktop personal computers.

Other novel features separate Newton from the rest of the barrel, too. For instance, where most of the existing PDA drams centre on providing users with a workable hand-held pen operated computer, Apple sees Newton as being a complete tool. A computer's a computer, after all – someone still has to operate it. Newton, on the other hand, acts on the simplest of instructions yet does the most complex of tasks to assist users in everyday operations.

Further, Newton is seen as just the first of a complete range of PDAs, which could include such diverse products as complete fax/phones, children's draw-and-spell games, architect's sketchpad and so on. If the technology is versatile enough (which it is) and cheap enough (Apple aims to get the first Newtons of the production line at around $1,000), the sky's the limit.

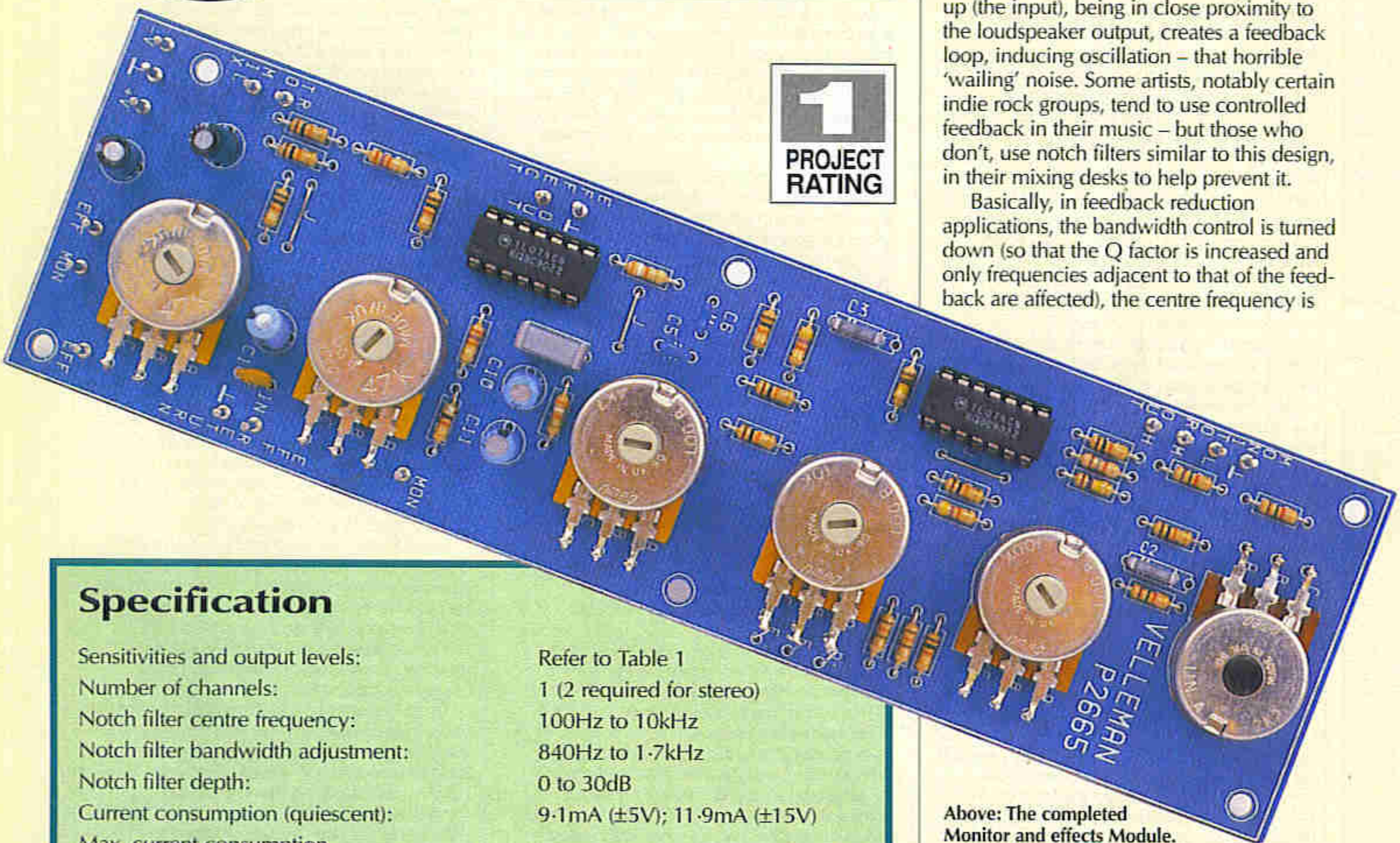
Given Apple's commitment to workable and easily usable computers, and the company's record in innovation (Macintosh computers have had a windows-based graphical user interface since the computer's inception in 1984), it's more than likely that Newton PDAs will lead the marketplace with standard features, the rest are merely trying to imitate.

Try and remember, a PDA isn't just a new stage of computing, it's a complete leap into the void of the interface between us and machines. While there has always been a gradual convergence between telecommunications, computing, miniaturisation and the human/computer interface there never has been a total convergence. PDAs offer this like no product before!

MONITOR AND EFFECTS MODULE

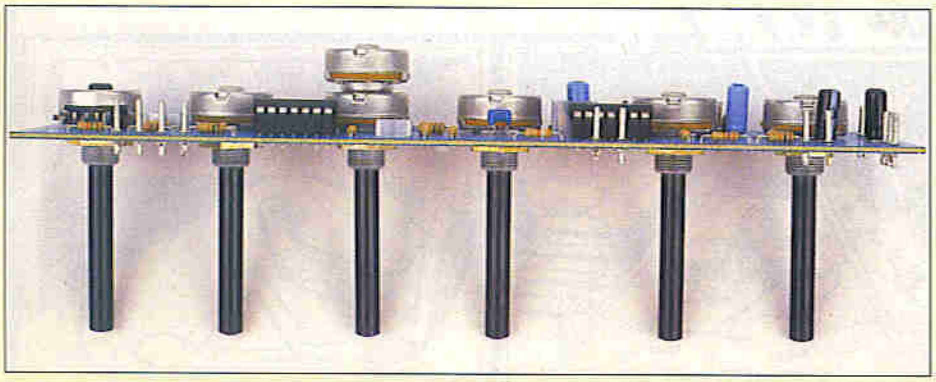
MODULAR MIXING SYSTEM
PART FOUR

1
PROJECT RATING



Specification

Sensitivities and output levels:	Refer to Table 1
Number of channels:	1 (2 required for stereo)
Notch filter centre frequency:	100Hz to 10kHz
Notch filter bandwidth adjustment:	840Hz to 1·7kHz
Notch filter depth:	0 to 30dB
Current consumption (quiescent):	9·1mA (±5V); 11·9mA (±15V)
Max. current consumption (both monitor and effects outputs into 1k load):	10·4mA (±5V); 13mA (±15V)



This module incorporates all the buffering and amplification for 'effects send' and 'effects return' loops for one of the stereo master channels in a mixing desk, such as the 'Modular Mixing System'. Two are therefore required, one for each channel.

An interesting feature is the notch filter provided for the monitor channel. Apart from simple level attenuation (i.e. a 'volume control'), this circuit provides control over two parameters. Firstly, the Q-factor of the active filter – the 'width' of the notch – is adjustable between 0·4 and 2·5. This corresponds to an –3dB bandwidth variable between 840Hz and 1·7kHz. Secondly, the centre ('target') frequency can be varied across a significant part of the audio band – 100Hz to 10kHz. An adjustable notch filter is considerably useful in greatly reducing, or eliminating, acoustic feedback. Live performers often use 'foldback' speakers, which are arranged to face them so that they can monitor themselves playing. Under certain conditions this can create a terrible din, if the foldback level is advanced too far, since the microphone or guitar pick-up (the input), being in close proximity to the loudspeaker output, creates a feedback loop, inducing oscillation – that horrible 'wailing' noise. Some artists, notably certain indie rock groups, tend to use controlled feedback in their music – but those who don't, use notch filters similar to this design, in their mixing desks to help prevent it.

Basically, in feedback reduction applications, the bandwidth control is turned down (so that the Q factor is increased and only frequencies adjacent to that of the feed-back are affected), the centre frequency is

Above: The completed Monitor and effects Module.
Below: Side view of the Monitor and Effects Module, showing the arrangement of the potentiometers.

adjusted to that of the feedback, and the attenuation (notch filter depth) adjusted to the optimum level. In some cases, a further 'fine tweak' of the controls may be required for best results.

Although primarily intended for use in mixers, such as the Modular Mixing System, but it could find uses elsewhere – such as guitar amplifiers and public address systems – where the problem of feedback rears its ugly head. Amateur radio enthusiasts may also find a tunable notch filter of great value when 'chasing DX' – a purpose-designed Maplin kit (LM16S) is available for this

Supply Voltage (±)	Monitor Levels (V_{rms})				Effects Send Levels (V_{rms})		Effects Return Levels (V_{rms})
	Input	Output*			Input	Output	Output**
		Low	Mid	High			
5·0V	2·0	0·6	1·3	2·0	2·0	2·2	1·2
15·0V	5·7	2·9	5·7	9·9	5·7	9·9	4·5

*** with gain of IC2(a) set to 1 ** with gain of IC2 (b) set to 1**
Note that all input measurements were made from a 1kΩ source; impedance of the load was also 1kΩ.

Table 1. Sensitivities and output levels.

application, however. The effects send and return amplifiers would also be useful in guitar amps. If the unit is to be used independently of a mixing desk, however, additional components will be required – see the 'Construction' section.

Note that this circuit requires a symmetrical supply which can be from ±5V min to ±15V max; the power supply voltages dictate the maximum signal levels that can be fed into the module (see Table 1).

Circuit Description

This section should be read with reference to the circuit diagram reproduced in Figure 1. IC2(a) and IC2(b) are input buffers; the gain of each is dependent upon the output impedance of the previous circuit and the values of R1 & R2 respectively (see 'Construction' section). Three of the op amps, IC1(a), IC1(b) and IC1(c), form the filter. RV2 sets the 'Q' of the filter circuit, which is variable from 0·4 to 2·5, and hence its bandwidth. The overall effect is shown in Figure 2. RV6(a) and (b) set the centre frequency, as shown in Figure 3. RV1 controls the amount of attenuation of the selected frequency. The filter network produces a signal in phase with the original; IC1(d) adds the buffered monitor signal, which is inverted, to the output from the filter. Phase cancellation then occurs, the frequencies affected and level of cut, depending on the response of the filter, are determined by the user. As a result, the circuit acts as a 'notch' filter. If an amplifier (with high input impedance) and speaker were to be attached to the wiper of RV1, a signal applied to the input of IC2(a) would sound very 'hollow' around a certain frequency, depending on how the controls have been set.

Note that IC1(d) inverts the signal again, so that it is in phase with respect to the input. There are three different levels available from the monitor output – high, medium and low – that are determined by divider network R11, R18, R19 and R22. IC2(c) is the effects driver amplifier; RV3 controls the level of signal sent to the effect units. IC2(d) is the fixed-gain effects return amplifier, RV4 providing attenuation as required. The effects output is sent to both channels, via R8 and R9 so as to avoid crosstalk at a later stage.

Construction

Construction is fairly straightforward, and full details are given in the leaflet supplied with the kit. If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful practical advice on how to solder, component identification and the like.

When assembling the PCB, it is best to leave the potentiometers till last as some of the components are located between them – and once the potentiometers are in place, access to these areas of the board is limited. Otherwise, construction is mostly straightforward. Be sure to insert the electrolytic capacitors the correct way round; in addition, note that their leads will need pre-forming before they can fit neatly to the board prior to soldering. The orientation of IC1 and IC2 are also critical; note that these two components are fitted in IC sockets. The sockets, rather than the ICs themselves, should be soldered in place – the ICs should be inserted just before testing.

Each control potentiometer is fitted from the component side of the PCB, and a shakeproof washer is fitted under its securing nut as shown in Figure 4. Before tightening the nut, each potentiometer should be aligned so that its pins line up with the corresponding legend on the PCB; the supplied lengths of tinned copper wire are used for the interconnections as shown in Figure 5. These lengths of wire (or alternatively the component lead off-cuts) are also used for the three wire links on the board.

When fitting the PCB pins, note that they are also fitted from the component side. After completing assembly, it is prudent to check your work – finding any incorrectly-placed components could save considerable time and expense later on. Other gremlins to watch out for include solder bridges/whiskers and poor joints.

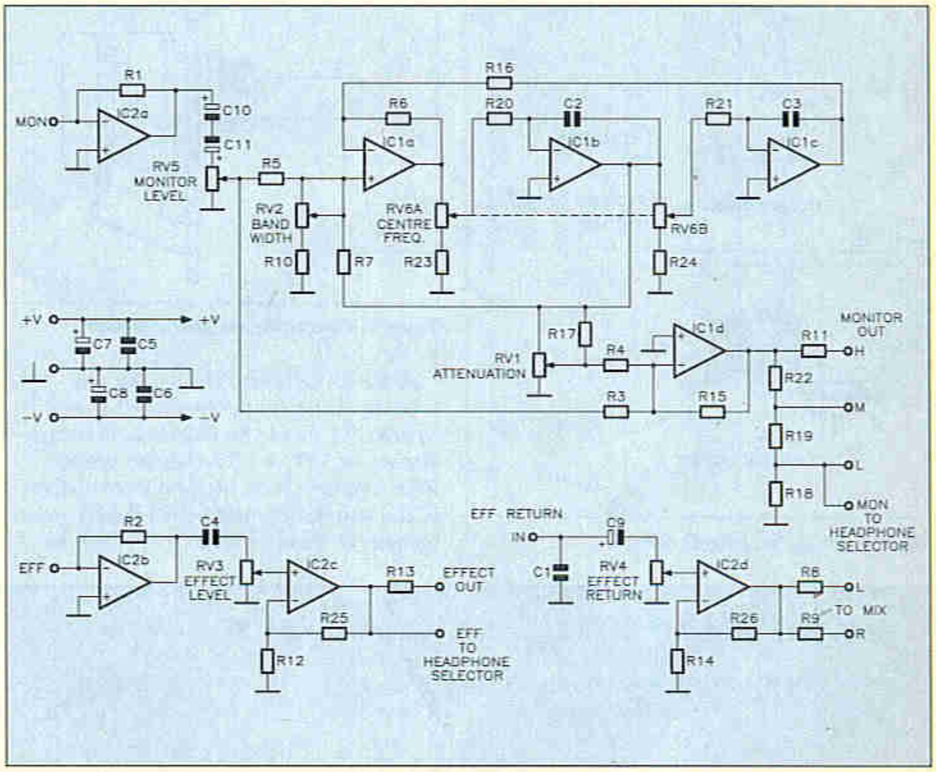


Figure 1. Circuit diagram of the Monitor and Effects Module.

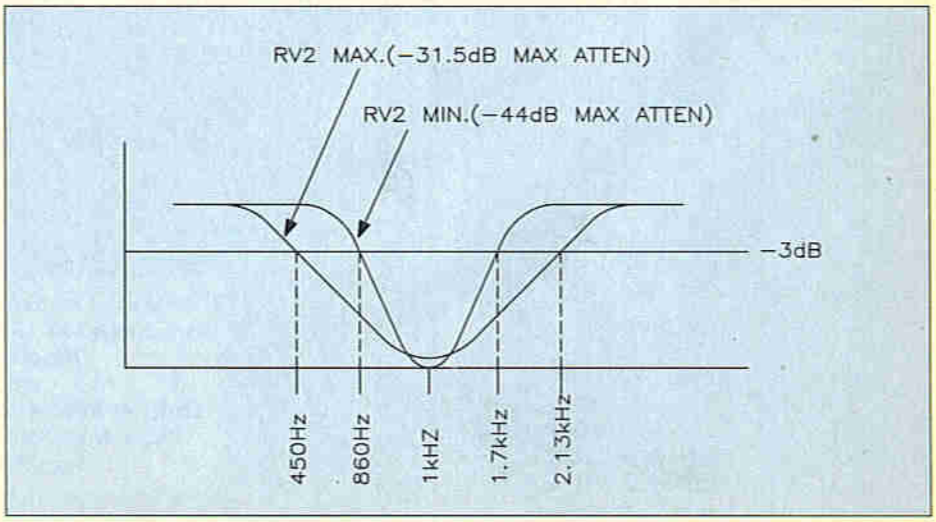


Figure 2. Notch filter bandwidth adjustment.

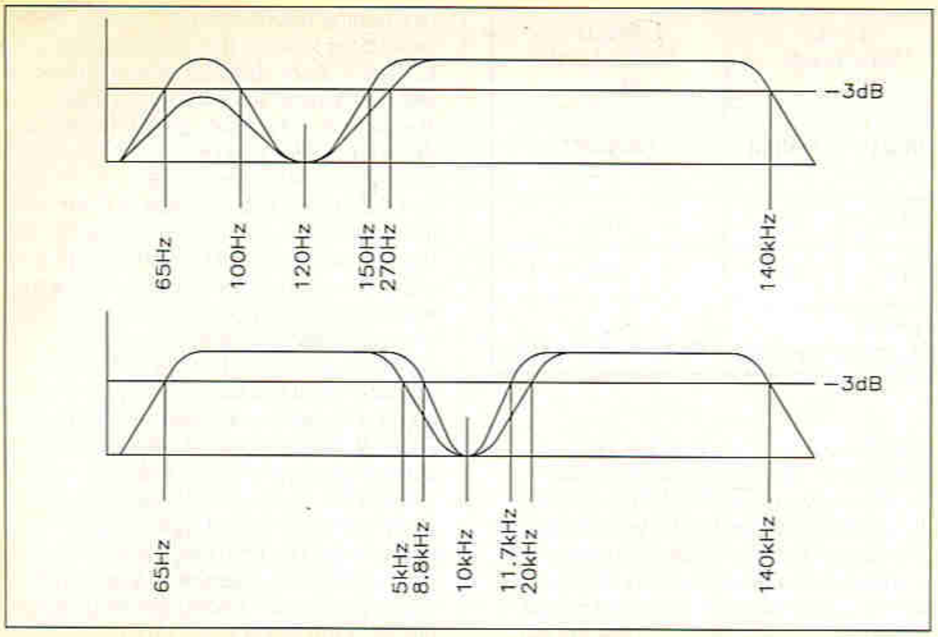


Figure 3. Notch filter centre frequency adjustment.

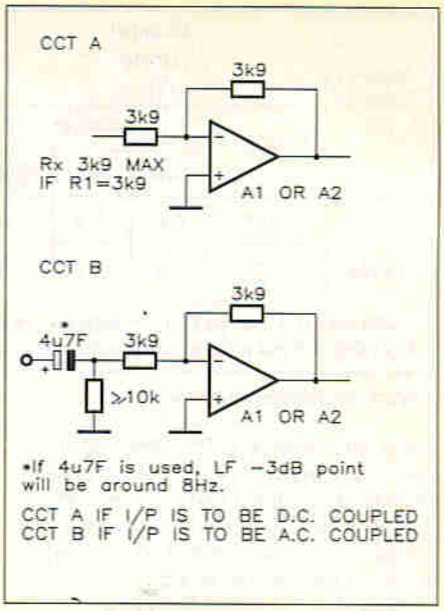


Figure 6. Modifying input stages of Monitor and Effects Module for 'stand-alone' use.

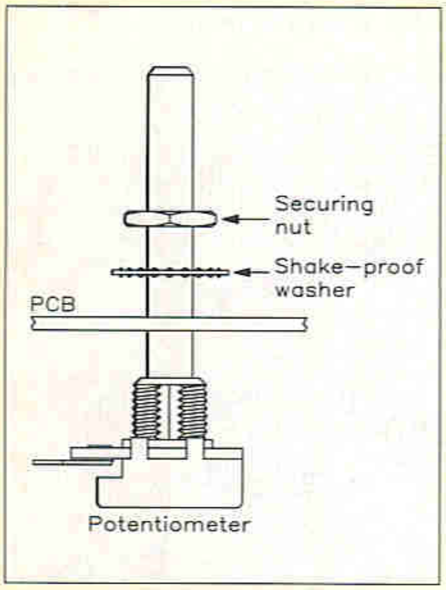


Figure 4. Fitting the potentiometers.

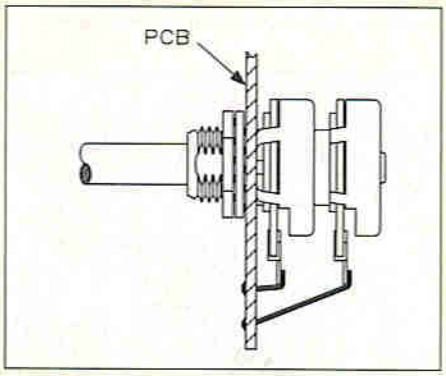


Figure 5. Connecting the potentiometers.

If the Monitor and Effects Module is being used with the Modular Mixing System, R1 should be 8k2 for a 6-channel system, or 3k9 for a 12-channel system. If the circuit is to be used on its own, then IC2(a) and IC2(b) must be fitted with input resistors as shown in Figure 6. This is so that the gain of the input buffers is kept at unity; of course if gain is required, different values may be used.

Testing and Installation

The best form of testing is to use the Monitor and Effects Module in its intended application. Ensure that each power supply rail can provide the required current. For best dynamic range, the full ±15V supply voltage should be used – see Table 1.

The module should be installed away from any strong mains fields (power transformers and the like), in a screened case. If the completed board is to form part of a modular mixing system, it should be built into a decent metal case anyway! Screened cable (such as XR15R) should be used for all audio connections to reduce the possibility of hum pick-up. Once the installation has been inspected, the ICs can be inserted and the system powered up.

MONITOR AND EFFECTS MODULE PARTS LIST

RESISTORS: All 0·25W Metal Film (Unless specified)

R1,2	3k9 or 8k2 (see text)	2 of each value
R3-9	10k	7
R10-14	1k	5
R15,16	100k	2
R17-19	1k5	3
R20,21	4k7	2
R22	1k8	1
R23,24	120Ω	2
R25,26	2k7	2
RV1	2k2 or 2k5 Lin Pot	1
RV2	100k Log Pot	1
RV3,4	47k Log Pot	2
RV5 4k7	Log Pot	1
RV6 10k	Dual Log Pot	1

CAPACITORS

C1	180pF Ceramic	1
C2,3	1nF Ceramic	2
C4	220nF Poly Layer	1
C5,6	100nF Monores	2
C7,8	10μF 10V PCB Elect	2
C9	1μF 50V PCB Elect	1
C10,11	2μ2F 50V PCB Elect	2

SEMICONDUCTORS

IC1,2	TLO74CN Quad Op Amp	2

MISCELLANEOUS

PCB	1
DIL Socket 14-pin	2
PCB pins	2 Pkts
Construction Leaflet	
Tinned Copper Wire	

OPTIONAL (Not in Kit)

3k9 5% Metal Film	2	M3K9
4·7μF Minelect 63V	2	RA53H
Constructor's Guide	1	XH79L
Screened Cable	As required	XR15R

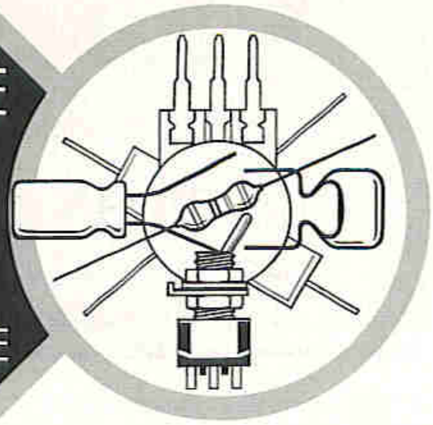
The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

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

Order As VE34M (Monitor and Effects Module) Price £22.95.

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

PASSIVE ELECTRICAL COMPONENT GUIDE
PART ONE



Ray Marston takes an in-depth look at modern resistors in the first part of this special three part series.

Modern electronic circuit design is based on the interaction between various types of passive components, transducers and various types of active 'electronic' rectifying or amplifying devices. Resistors and capacitors etc. are referred to as passive components, transducers are photocells, relays etc., while diodes, transistors, ICs, etc. are referred to as active 'electronic' devices. As far as 'passive' components are concerned, the humble first-year student of electronics needs only a superficial understanding of these elements to pass his exams. However, the practical electronics design engineer must gain a far deeper knowledge of them, if he is to generate good cost-effective and reliable designs that will continue to function correctly under hostile operating conditions.

This new series aims to provide the reader with a concise but comprehensive guide to the symbology, pertinent formulae, basic data, major features, and identification codes, etc., of the five major types of modern passive component, i.e., resistors, capacitors, inductors, transformers, and switches.

Guide To Modern Resistors

Symbols

Either of two basic symbols can be used to represent a resistor, and Figures 1 and 2 show their major family 'sets'. Internationally, the most widely acceptable of these is the 'zig-zag' family of Figure 1 – note that these symbols may be subjected to some artistic variation, with the number of zig-zag arms varying between two and five. The alternative 'box' symbols of Figure 2 are rarely used outside of Western Europe and aspiring writers and publishers should be aware that artwork using this box symbology will be rejected by most American publishers.

Formulae

The most widely used 'resistance' formulae are the simple 'ohms' and 'power' as listed in Figure 3, and the series and parallel 'equivalents' shown in Figures 4 and 5. However, it is important to note that these formulae are only valid under DC and low-frequency AC conditions. Practically all resistors exhibit a certain amount of inductance and capacitance, which may significantly influence the component's impedance when operating at high frequencies.

A calculator can be used to derive precise values from the above formulae. Alternatively, a whole range of 'Ohms Law' and 'power' values can be quickly found (with a precision better than 10%)

$$I = \frac{E}{R} = \frac{W}{E} = \sqrt{\frac{W}{R}}$$

$$E = IR = \frac{W}{I} = \sqrt{W}$$

$$R = \frac{E}{I} = \frac{E^2}{W} = \frac{W}{I^2}$$

$$W = EI = \frac{E^2}{R} = I^2R$$

E = Voltage (volts)
I = Current (amperes)
R = Resistance (ohms)
W = Power (watts)

Figure 3. Basic DC 'Ohms Law' formulae.

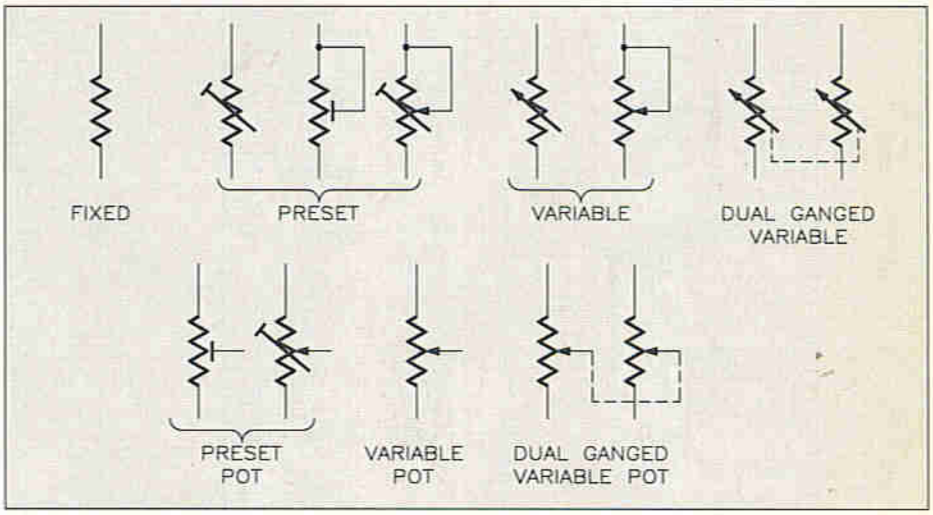


Figure 1. Internationally-accepted symbols for various types of resistor and variable potentiometer (pot).

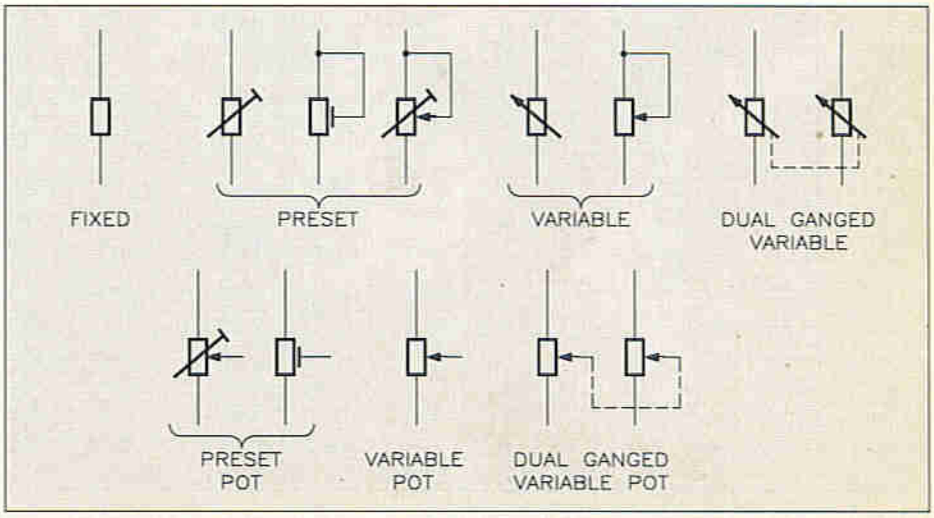


Figure 2. Alternative resistor and pot symbols, popular in many West European countries.

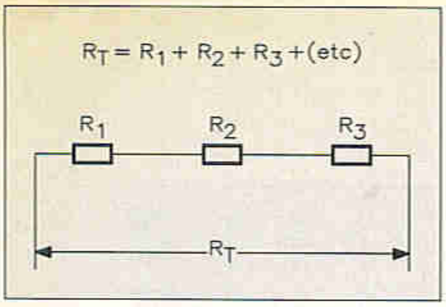


Figure 4. Method of calculating combined value of resistors in series.

with the aid of the nomograph of Figure 6, and a straight edge or ruler. By following the instructions described in the caption, it can be seen that a 1kΩ resistor when used with a 10V supply will pass 10mA and dissipate 100mW.

Basic Construction

There are three basic types of fixed-value resistor that are in general use and most likely to be encountered by practical engineers – carbon composition

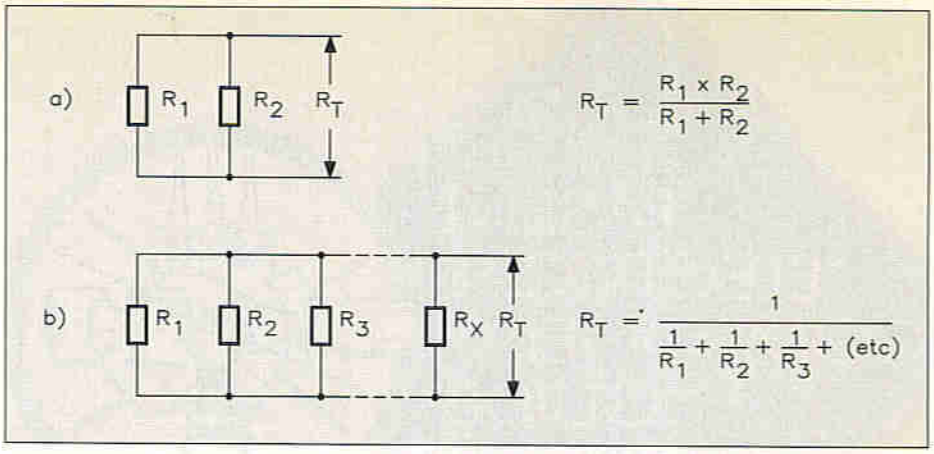


Figure 5. Method of calculating combined value of (a) two or (b) more resistors in parallel.

or 'rod' types, 'film' types, and 'wire wound' types.

Carbon composition resistors are now obsolete, but are often found in old (pre-1985) equipment. They consist of a rod made from a mix of finely ground carbon and an insulating/binding resin filler, to the ends of which are attached a pair of wire leads. The rod and lead contact points are protected by a layer of insulating material to prevent moisture penetration, etc. The ratio of the mix determines the value of the rod's resistance. Figure 7 shows the three most widely used types of construction for these resistors. In Figure 7(a) the leads

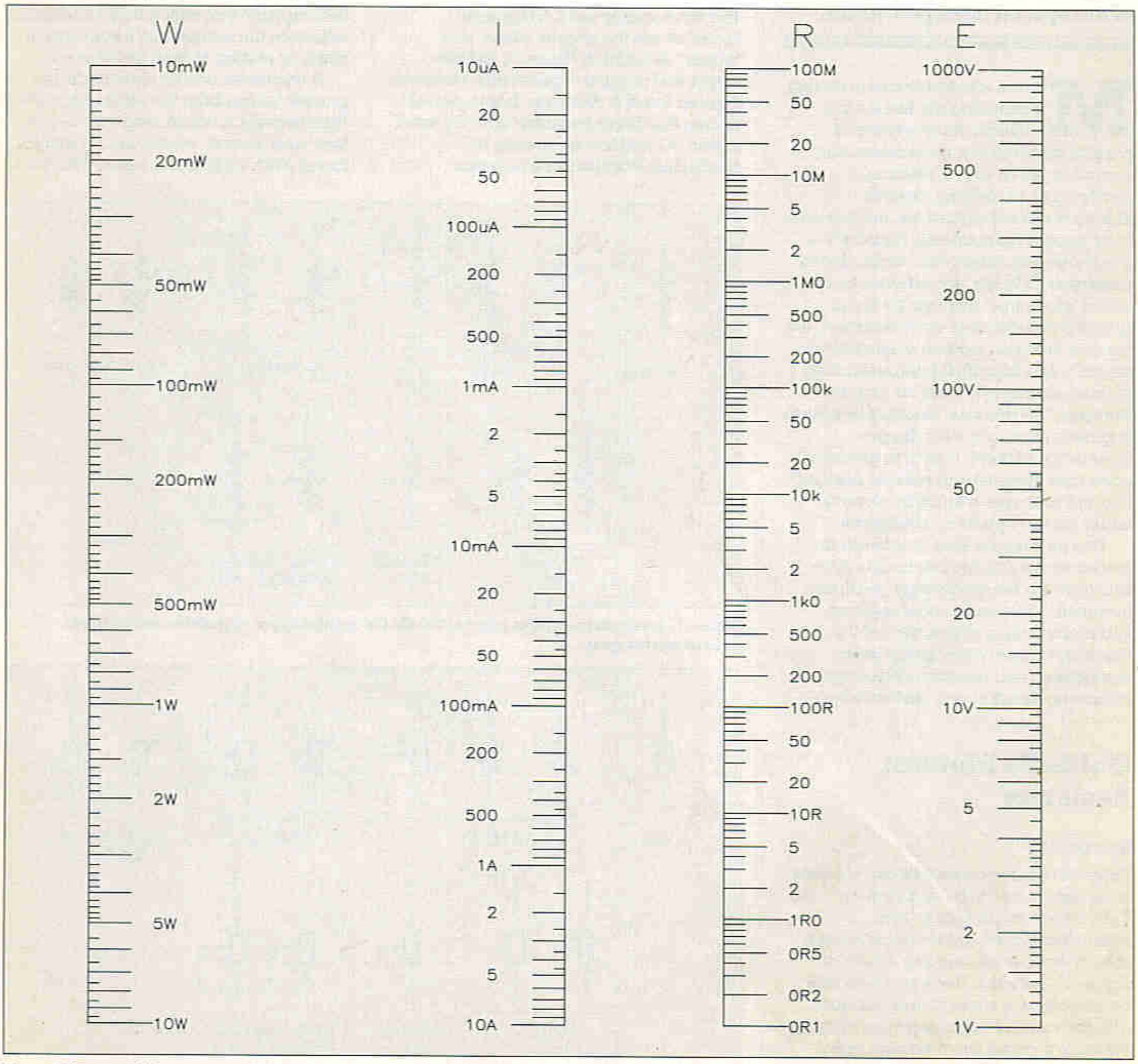


Figure 6. To use this nomograph, lay a straight edge so that it cuts any two vertical columns at known reference points, then read off the remaining two unknown parameter values at points where the edge cuts the other two vertical columns.

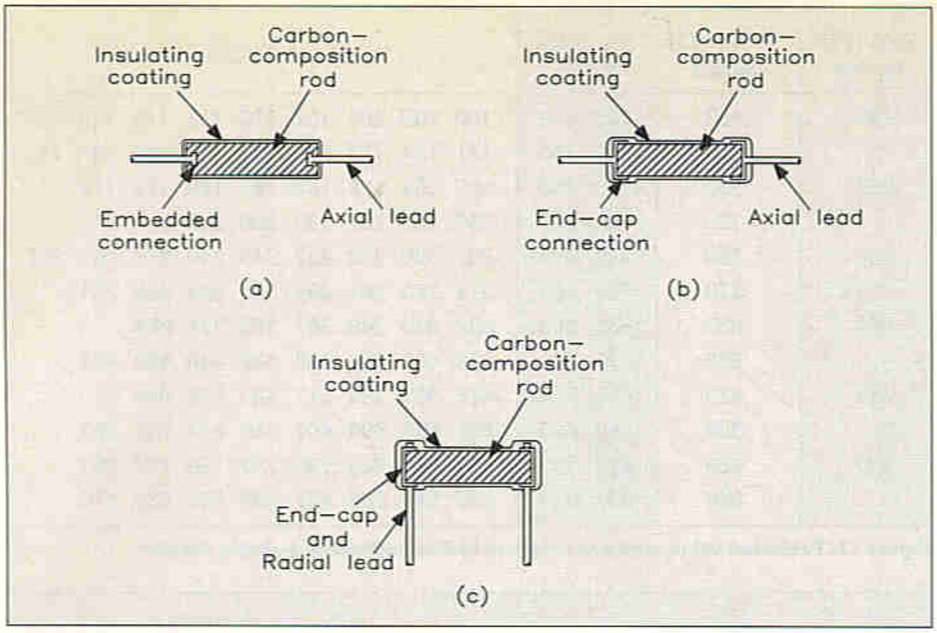


Figure 7. Construction of various types of carbon composition (rod) resistor.

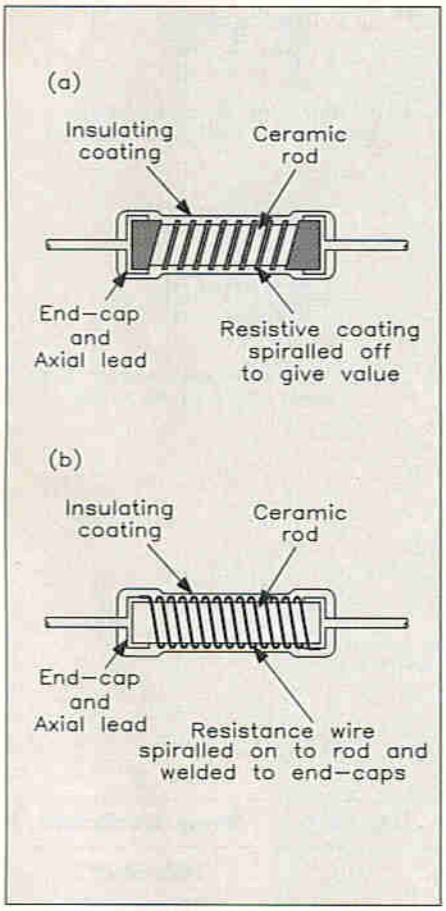


Figure 8. Typical construction of (a) film-type and (b) wire-wound resistors.

are in line with the component's axis (axial) and have expanded ends, around which the rod is electrically and mechanically bonded. In Figure 7(b) and 7(c), the leads are soldered or welded to end-caps, either axially or radially, and then attached to the ends of the rod using a compression-fit.

The most widely used modern resistors are the 'film' types, which use the basic form of construction shown in Figure 8(a). Here, a resistive film of carbon compound (in 'carbon film' resistors) or metallic oxide (in 'metal film' or 'oxide film' resistors) is deposited on a high-grade non-porous ceramic rod. An axial lead, attached to a cap, is fixed to each end of the rod, either by a compression fit or some other means. The film is then machine-cut, usually under computer control, to form a helical spiral the length of which sets the desired resistance value. Finally, a high-quality insulating coating is applied to the machined assembly.

Figure 8(b) shows the construction of a wire-wound resistor. High-quality Nichrome, Eureka, or similar resistance wire is spirally wound onto a ceramic former, with the individual ends joined to external leads via suitable ends-caps, etc. If the resulting component has been built to exploit it's inherent 'precision', it is given a conventional insulating coating. However, if the component has been built to exploit its inherent 'high power dissipation' capability, it may be fitted with a heat-dissipating jacket of vitreous enamel, ceramic compound, or solid aluminium.

Practical Resistor Characteristics

All practical resistors have the electrical equivalent circuit of Figure 9. Each lead exhibits self-inductance (typically 8nH/cm or 20nH/in.), and the resistor body is shunted by stray capacitance (approximately 1pF). Also, the resistor body exhibits a certain amount of self-inductance. In carbon composite types, this inductance is negligible, while in 'film' types the inductance is small (due to the spiral form of construction), but may be significant at high-frequencies. In wire-wound types the inductance is inherently quite high.

Several factors can vary the actual value of a resistor e.g., temperature, age, the applied voltage, humidity, etc. The magnitude of these changes varies with resistor type. Figure 10 lists the most important typical parameter values of

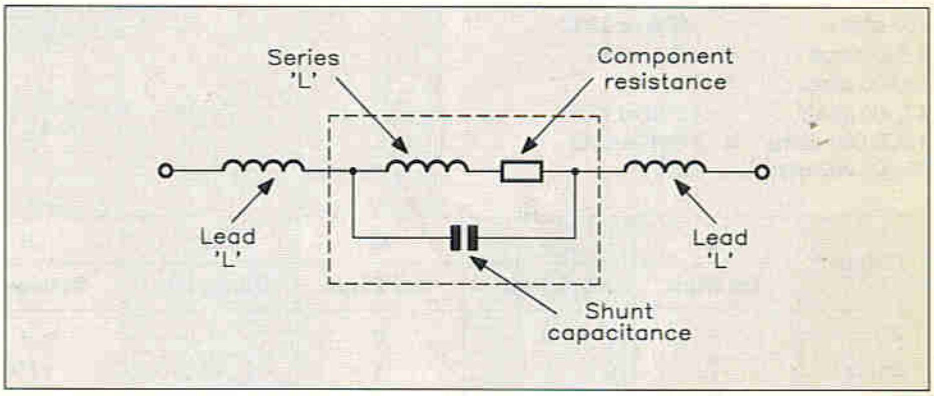


Figure 9. Equivalent circuit of a practical resistor.

Resistor Type	Resistance Range	Power Rating	Tolerance (±)	Ambient Temperature Range (°C)	Temperature ±ppm / °C	Coefficient ±% / °C	Noise Level µV/V	Shelf Life Change in One Year
Carbon Composition	2Ω2 - 22M	⅛W to 1W	10%, 20%	−40 to +105	−1200	0·12	2·0	5%
Carbon Film	10Ω - 10M	¼W to 2W	5%	−45 to +125	300 - 1000	0·03 - 0·1	0·5	2%
Metal Thick Film	33Ω - 100M	½W to 1½W	5%	−45 to +130	100 - 300	0·01 - 0·03	0·25	1%
Metal Film	10Ω - 1M0	⅛W to ½W	2%, 5%	−55 to +125	50 - 100	0·005 - 0·01	0·1	0·1%
Metal Film (Precision)	1Ω0 - 10M	0·6W	0·1% to 1%	−55 to +155	15 - 50	0·0015 - 0·005	0·01	0·02%
Vitreous W/Wound	0Ω1 - 22k	2W to 25W	5%	−55 to +200	75	0·0075	–	0·01%
Precision W/Wound	10Ω - 47k	⅓W	0·1%	–	5 - 15	0·0005 - 0·0015	–	0·003%

Figure 10. Typical parameter values of various types of fixed-value resistor.

various types of resistor. Here, the 'temperature coefficient' is listed in terms of both 'parts-per-million' (ppm) and 'percent' change per degree Centigrade. The 'shelf life change' column lists the typical percentage limits of component value change when the component is stored in a stable temperature controlled environment for one year – this change may be an order of magnitude greater if the component is stored in a hostile and highly-variable environment, such as in an attic or garden shed, etc.

It can been seen from Figure 10 that carbon composition resistors are very noisy and have shockingly poor thermal and long-term stability. This type of resistor is best replaced by carbon film types. The best general-purpose resistors are metal film types, which offer excellent thermal and long-term stability, with the benefit of low noise. Wire wound vitreous types offer very high power dissipation, where as wire wound precision types offer superb overall stability.

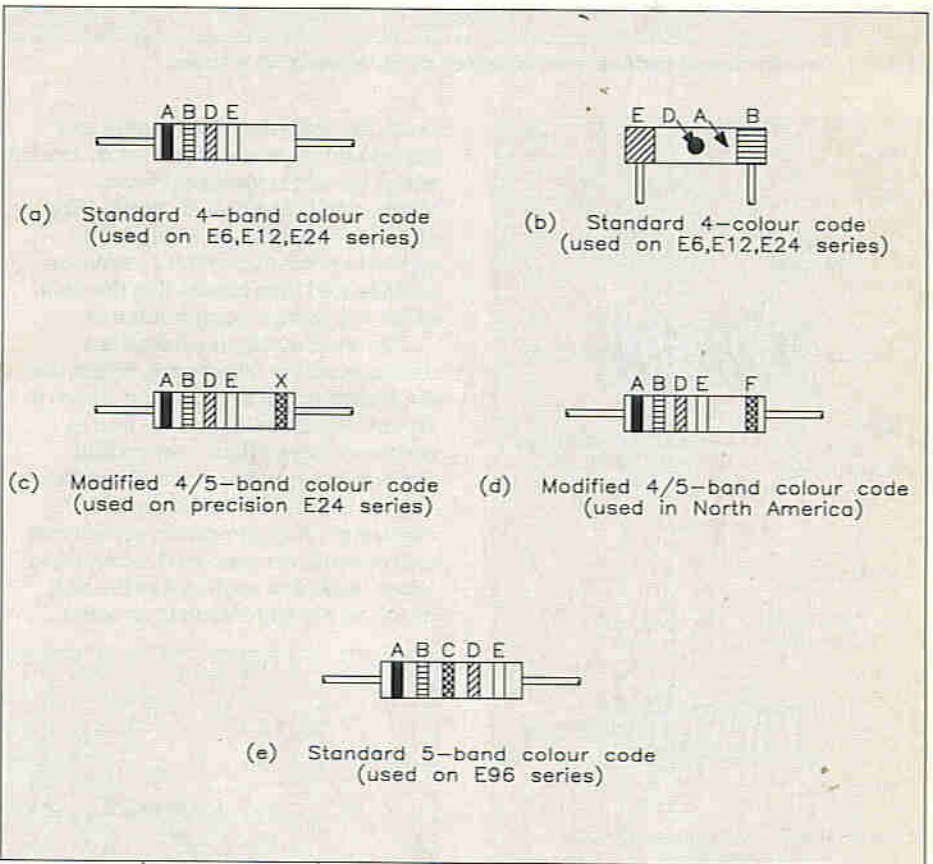
Resistance Value Notation

Resistance is measured, and denoted, in ohms, which may be abbreviated to ohm, R, or Ω. When values of thousands or millions of Ohms are denoted the abbreviations k (for kilohms) or M (for Megohms) may be used. When a denoted resistance value requires the use of a decimal point indicator, the 'point' may be replaced by the appropriate R, k, or M sign. The following examples illustrate these facts:

0·1 ohms	=	0·1Ω or OR1
6·8 ohms	=	6·8Ω or 6R8
120 ohms	=	120Ω or 120R
4,700 ohms	=	4·7k or 4k7
12,000 ohms	=	12k
47,500 ohms	=	47·5k or 47k5
1,200,000 ohms	=	1·2M or 1M2
22,000,000 ohms	=	22M

20% (E6) Series	10% (E12) Series	5% (E24) Series		1% (E96) Series								
100	100	100	110	100	102	105	107	110	113	115	118	
	120	120	130	121	124	127	130	133	137	140	143	147
150	150	150	160	150	154	158	162	165	169	174	178	
	180	180	200	182	187	191	196	200	205	210	215	
220	220	220	240	221	226	232	237	243	249	255	261	267
	270	270	300	274	280	287	294	301	309	316	324	
330	330	330	360	332	340	348	357	365	374	383		
	390	390	430	392	402	412	422	432	442	453	464	
470	470	470	510	475	487	499	511	523	536	549		
	560	560	620	562	576	590	604	619	634	649	665	
680	680	680	750	681	698	715	732	750	768	787	806	
	820	820	910	825	845	866	887	909	931	953	976	

Figure 11. Preferred value series of resistors and capacitors in a single decade.



Colour	A	B	C	D	E	F	X
	1st Digit	2nd Digit	3rd Digit	Multiplier	Tolerance	Stability	Temp. Coefficient
Black	–	0	0	1	–	–	200ppm/°C
Brown	1	1	1	10	±1%	1%	100ppm/°C
Red	2	2	2	10^2	±2%	0·1%	50ppm/°C
Orange	3	3	3	10^3	–	0·01%	15ppm/°C
Yellow	4	4	4	10^4	–	0·001%	25ppm/°C
Green	5	5	5	10^5	±0·5%	–	–
Blue	6	6	6	10^6	±0·25%	–	10ppm/°C
Violet	7	7	7	10^7	±0·1%	–	5ppm/°C
Grey	8	8	8	10^8	–	–	1ppm/°C
White	9	9	9	10^9	–	–	–
Gold	–	–	–	10^{-1}	±5%	–	–
Silver	–	–	–	10^{-2}	±10%	–	–
Blank	–	–	–	–	±20%	–	–

Notes: **(1) STABILITY = relative percentage change in value per 1000 hours of operation.**
(2) 'Grade 1 Hi-Stab' resistors may be distinguished by a salmon-pink fifth band or body colour.

Figure 12. Standard resistor colour code systems and notations.

Preferred Resistance Values

By international agreement, general-purpose resistors are manufactured in a limited number of 'preferred' nominal values. The values are related to one another in a logical order, and in which the number of values per decade is related to a particular 'spread' of desired resistance precision. Thus, if a precision of ±20% is adequate for some particular set of design requirements, the entire spectrum of possible resistance values in the 80R to 800R decade can be adequately spanned by just six 'preferred' resistors, with the following nominal values and tolerance 'spreads':

100R nominal;	±20% spread	=	80R to 120R
150R "	; " "	=	120R to 180R
220R "	; " "	=	176R to 264R
330R "	; " "	=	264R to 396R
470R "	; " "	=	376R to 564R
680R "	; " "	=	544R to 816R

Note that these values increase logarithmically, in increments of about 50%. This range of preferred values can be expanded in decade multiples and submultiples, to span all possible resistance values from below 1R0 to above 10M. Throughout most of the world, this particular set of values is known as the '20% tolerance' series, but in most of Europe is known (because it uses six values per decade) as the 'E6' series. Several other series are also available in the 'preferred' family of resistor values – Figure 11 gives details of the most widely used members of the family, which are also used to set the preferred ranges of capacitors, etc.

Resistor Coding

The value and tolerance, etc., of a resistor may be marked on the component's body either directly (i.e., as 4k7, 5%, etc.) or by using some form of easily recognised colour or alpha-numeric code system. The most widely used system is based on the standard, and well known, 'black, brown, red, orange, etc' colour code system, as shown in Figure 12.

A feature of all E6, E12, and E42 preferred values of resistance is that each value can be represented by just two digits and a decimal 'multiplier' indicator. Consequently, the value and tolerance of any resistor in these series can be indicated by a four-colour code, in which the first three colours indicated the resistance value, and the forth colour indicates the component's tolerance. On resistors with axial leads this colour code is set in the form of four bands, which are read from left to right as shown in Figure 12(a). On resistors with radial leads, the code is arranged as a set of body colours, as shown in Figure 12(b). Figure 13 lists a few examples of the use of this code.

The basic 4-band colour code system is a simple and delightfully unambiguous one. However, some resistors use a modified version of this basic system, with a fifth colour band added (but well separated from the main 4-band group), and used to convey additional information, as shown in Figures 12(c) and (d). Usually in Europe, this fifth band is carried on precision Hi-Stab E24-series resistors only, and denotes the component's temperature coefficient, as shown in column 'X' of the Figure 12 table. However, in North America it denotes the component's specified stability in terms of percentage change in value per 1000hrs of operation, as shown in column 'F'.

In the E96 series of preferred resistance values, each value can be represented by just three digits and a decimal 'multiplier' indicator. Consequently, the value and tolerance of any resistor in this series can be indicated by a five-band colour code. The first four bands indicate the resistance value and the fifth colour indicates the component's tolerance, as shown in Figure 12(e). Thus, the colour sequence Orange-Black-White-Brown-Brown indicates a 3K09, ±1% resistor value. Superficially, this 5-band system may seem quite unambiguous, but in practice great confusion can result if a resistor using a true 5-band system is mistaken for one using a modified 4/5-band colour code. For example, a component marked Red-Red-Orange-Gold-Red with a true value of 22R3, 2%, may be mistaken for a 22k, 5% resistor with a 50ppm/°C temperature coefficient, or 0.1% stability factor, if read as 4/5-band component.

Regarding alpha-numeric resistance-coding, the two most widely used of these systems are shown in Figures 14 and 15 – each of these systems may be subject to some detail variations. In the Figure 14 system the component value is printed in normal alpha-numerical terms (e.g., as 3k3 or 3.3kΩ, etc.), and the component's tolerance is denoted by a direct indication (such as 5%, etc.) or by one of the five code letters shown in the diagram. Thus, a 47Ω 5% resistor may be notated 47RJ, for example.

The alternative system of Figure 15 uses a purely numeric three-digit coding system. The first two numbers equal the first two digits of the resistor value, and the third number gives the number of zeros to be added to those two digits. In some variations of this system, the component's tolerance may also be indicated, in the same ways as in Figure 14 – the notation 100J indicates a 10R, 5% resistor.

A	B	C	D	Value
Orange	Orange	Silver	Gold	0·33Ω, 5%
Red	Red	Gold	Silver	2R2, 10%
Yellow	Violet	Orange	Gold	47k, 5%
Brown	Black	Yellow	Brown	100k, 1%
Red	Red	Blue	Blank	22M, 20%

Figure 13. Examples of resistor valves, using 4-band or 4-colour coding.

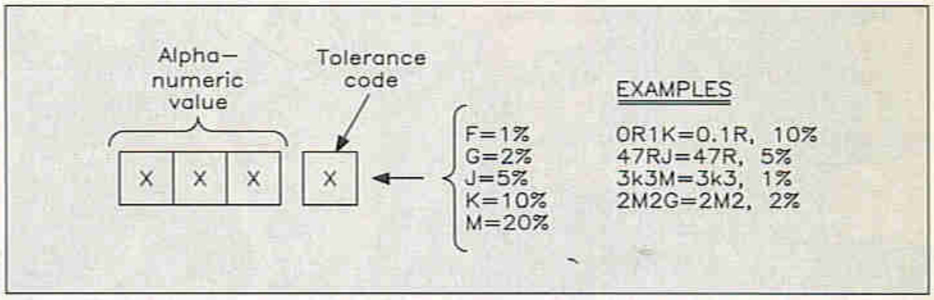


Figure 14. Typical alpha-numeric resistor-coding system.

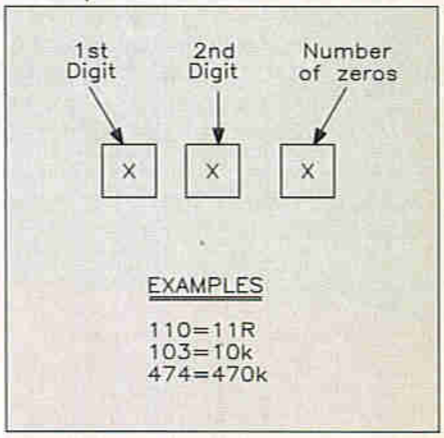


Figure 15. Typical numeric resistor-coding system.

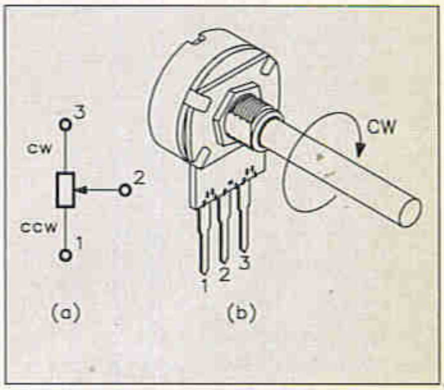


Figure 16. Symbolic representation (a) and typical appearance (b) of a modern potentiometer.

Variable and Preset Resistors ('Pots')

Nowadays, these components are universally known as potentiometers

Continued on page 59.

When the Computer Chips are Down - Help is at Hand!

by Alan Simpson

What a Disaster

Bomb blasts in the City of London, destructive fires at the Digital Equipment computer centre and communications outages in the US have become regular industry press headlines. But when the computer installation goes up in flames, or disc-drive head-crashes cause a total shut-down, it is not only the site temperature that rises. Management temperatures also rise as the dire implications of coping with installation down-time sink in. In fact, for many companies – especially banks, credit card operators and airline reservation systems – even the thought of mainframe computer downtime is sufficient to induce that 19th nervous breakdown. With companies increasingly dependent on their computers and communications systems for their very existence, avoiding such breakdowns has become big business.

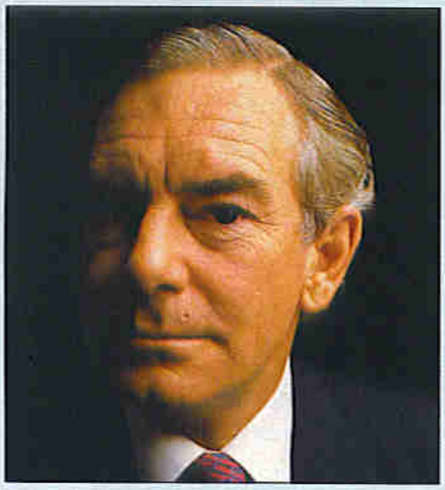
The contingency planning industry, says the industry research organisation Frost & Sullivan, will generate as much as $1 billion a year in revenues by 1995. Much of this growth is the result of well documented 'disasters' over the past few months. Not so long ago, trading on Wall Street was delayed for over two hours as a fire and explosion closed down the securities data centre. Just a few days later, damage to an AT&T fibre optic cable in New Jersey caused major communication problems in New York. This particular 'outage', as the Americans call their disasters, also interrupted aviation voice and radar communications and traffic problems at East Coast airports. The local stock exchanges were also hit. Of course, such outages are almost standard affairs in New York. Not infrequently, major electrical faults close the exchanges, halt elevators and shut down air-conditioning systems.

Closer to home, Mercury Communications had what it described as a catastrophic failure, when the carrier's public network was put out of action across most of England for a day. Engineers were blamed (typical...) and the carrier is now taking steps to prevent any recurrence.

Further high-tech redeployment was involved when the biggest bomb blast since World War II hit the City of London back in April of last year. BT engineers reacted swiftly to ensure companies in the Square Mile could get up and running as quickly as possible. Caravans housing telephones and fax facilities, report BT, were operating in the area just one working day after the blast, offering essential calls free of charge. By the end of the day, 800 lines had been diverted, and 5,000 new direct exchange lines and 61 private circuits established.

A Time Bomb at your Feet

There are, says Michael Naughton of IT consultancy Applied Network Research, a dozen



Storm Larkins.

major risk areas – apart, presumably, from a direct-hit bomb. They embrace fire, flood, gas, explosion, storm damage, lightning, hardware or power supply failure, vehicle impact, vandalism, arson and corruption of data. ANR adds that disaster can strike anyone, anytime: "Apart from such basic issues as air-conditioning, and related environmental problems as power and lighting, users have to contend with fires. These can originate either from the equipment or wiring, or from neighbouring premises – as can, of course, floods from leaking taps, pipes and radiators. Even more dramatically, floods can be caused by local rivers overflowing, while gale force winds can blow off the installation roof".

Come in "Red Adair"

But as far as the users of the affected services are concerned, continuity of the service matters more than contingency planning and this is where the Red Adair of the computer world and his team step in. Storm Larkins, who heads the international Hardware Environmental Protection Agency (HEPA), doesn't spend his time fighting out-of-control oil blazes – or computer installations on fire. But he does provide expert assistance for fighting installation down-time. Alongside the installation of uninterruptible power supplies, and the provision of off-site back-up data storage, many companies are now adding HEPA to their list of emergency resources.

However, Storm prefers to be called in before disaster hits 10 on the Richter scale. Not all computer disasters, he says, take the form of fire, or are hardware or software-related. Nevertheless, time bombs lurk in every installation. Much of this lurking takes place under the floor panels, or above the false ceiling. Here the time-bomb is created by concrete dust or rust from air-conditioning trunking. In fact, Storm believes that up to 75% of such installations are inadequate for today's high technology requirements.

This subfloor is just waiting to cause problems!

Don't Blame the Computer

When a problem happens in a system, time is not on the company's side – especially if the company's operations have come to a grinding halt. Usually, by the time HEPA gets called in, much time has been lost and tempers are fraying as sundry teams of hardware, software and systems engineers, together with earnest teams of data storage experts and on-site installation engineers, have had their probes. But rarely does anyone think about calling in the installation engineering experts when the trouble starts.

The environment is getting so complex that only experts can identify the real causes of

Blocked air filters reduce the efficiency of cooling equipment.

disc-drive head-crashes. Even a specially designed and constructed state-of-the-art clean room, with environmental monitoring and back-up power facilities, cannot totally provide the level of protection required, says Storm. Particularly vulnerable are the growing number of installations incorporating thin-film disc heads. These new storage systems need much stricter environmental purity than earlier disc technologies. Thin-film heads fly a mere 12 millionths of an inch above the disc; not only is there less space between head and disk, but the heads are also less durable than the older ferrite-based devices.

To illustrate the problem, a minute piece of concrete or rust of a mere 15 millionths (or so) of an inch in diameter could cause a read/write error – or, rather more dramatically, a head crash. In more graphic detail, Storm compares the lurking danger to that of "a Jumbo Jet flying at 170 mph, one foot above an eggshell runway".

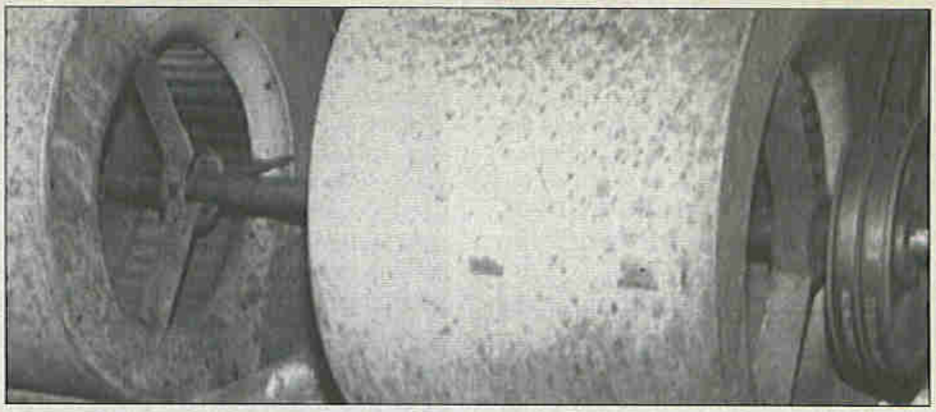
When Being Safe is Far Better than Being Sorry

So just what does the HEPA troubleshooting team do first when it arrives at the troubled site – apart, that is, from administering large doses of confidence and reassurance? With installation teams tearing their hair out and time being of the essence, HEPA often have to ignore the claims and counter-claims of the hardware, software and installation teams. Most often, the first task is a close inspection of the sub-floor. "The space", says Storm, "is usually 8 to 12 inches deep, and is often half-filled with cables. The air flows through unwanted ducts created within these narrow spaces with a pressure some 10 times that of the data centre.

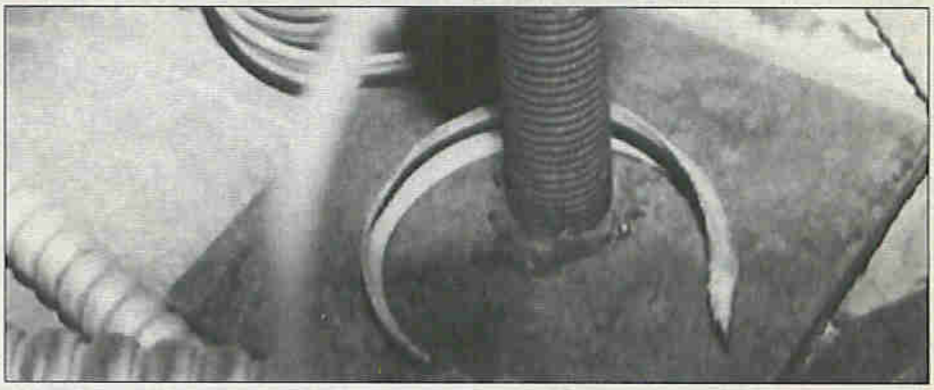
Just reflect on the rush of air that you feel when you enter a computer room, and then imagine the gale under the floor blowing contaminants into the equipment".

If, as expected, HEPA find traces of crumbling concrete, the problem area can be speedily tackled. Other prime suspects will be the air-conditioning and related pipework. Air-conditioning systems apart, humidity – or rather, incorrect humidity – is a major source of trouble. Humidity causes condensation to form on equipment, leading not only to rust but, in some cases, to short circuits. In addition, seepage of water into the building caused by plumbing leaks, clogged drains and sprinkler systems can be sources of potential damage.

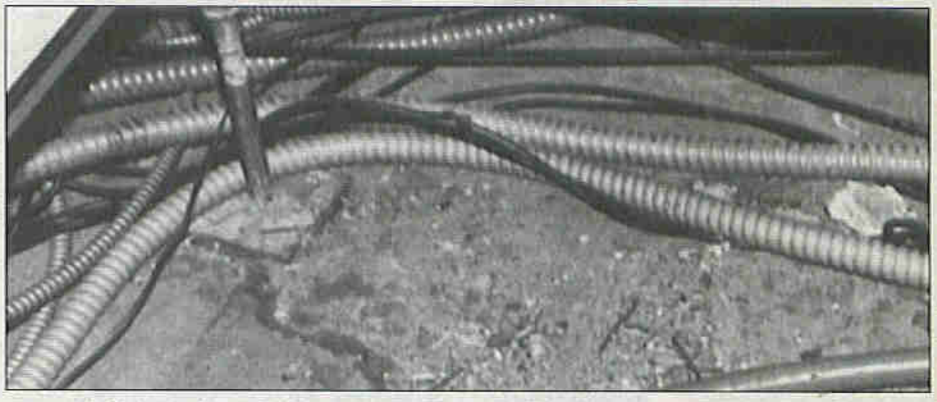
HEPA use an veritable armoury of equipment that accurately measures levels of contamination, damp, humidity and temperature at all vulnerable points. When the problem area is identified, HEPA seal it with a special encapsulant that results in the level of airborne contaminants being dramatically reduced.



Air-conditioning equipment, being required to constantly adjust temperature and humidity, is often found to be suffering from corrosion.



Floor voids require frequent examination for dust and debris. Corner-cutting installation teams are often the cause of such contamination.



Dust and debris can be easily blown into equipment by differences in air pressure caused by air-conditioning and ventilation equipment.

ENVIRONMENTAL HAZARDS

Dust and Smoke

Carbon and smoke particles are the most damaging. Carbon, a sticky, electrically conductive particle can result from the ink or drive belt in a laser printer, or by the unburnt hydrocarbon of vehicle exhausts managing to infiltrate the building's air supply. Normal dust (human detritus), and smoke particles – liberated by any fires in or near the building – can cause similar problems.

Concrete Dust

This substance is highly abrasive, and is usually thrown up into sensitive installations by air blowing up from an unsealed sub-floor.

Humidity and Temperature

Discrepancies in the relative humidity of the atmosphere must be examined – or moisture damage could result through condensation. If the temperature is excessive, the long-term reliability of the system will be affected, or it will be shut down by automatic safety systems – causing loss of data and operating time.

Rust

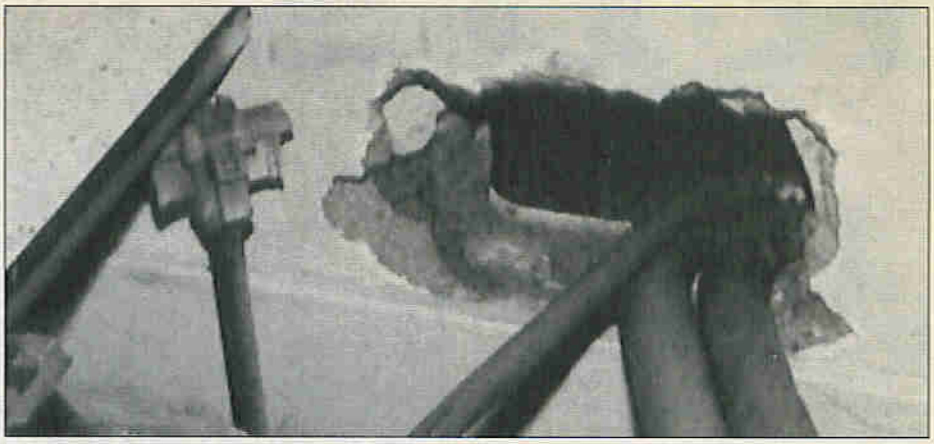
Commonly discovered on floor jacks, coils and cable casings. Fingers of suspicion can normally be pointed at elderly air-conditioning or humidity control systems. Flakes of rust, or even fine dust, can contaminate delicate systems. In addition, dust particles have a fairly low electrical resistance – creating problems when lodged in PCBs, for example.

Planning for Disaster

Last summer's hot weather saw the HEPA team working to full capacity as a combination of hot weather and lightning strikes rendered many computer installations non-operational. In most cases, the air-conditioning systems were simply unable to combat the rising temperatures in the computer room, causing automatic shut-down systems to be triggered. HEPA diagnosed failed or worn-out main compressors in the air-conditioning units of several of the installations dealt with. On one of their call-outs, it transpired that lightning had managed to interrupt an 'uninterruptible' power supply!

Keep It Mobile

Increasingly, Storm Larkins is asked to look at the operational bases for various forms of mobile communications. If the control centre goes down, then confusion will result – business will be lost on a wide scale, and lives could even be put at risk. With important computer-generated traffic zapping around the world's time zones, dependability is all important. The HEPA team can themselves zap around to the world computer trouble spots – almost at the drop of a cellular phone.



This hole should have been properly sealed – it will allow movement of airborne contaminants and may also allow rodents to enter the building.

No one is more aware than Storm Larkins that his arrival on the scene is often a 'last resort'. With the survival of the company often depending on minimising system downtime, the team always pack an airline timetable along with the customary workshop manuals.

Passive Components continued from page 55.

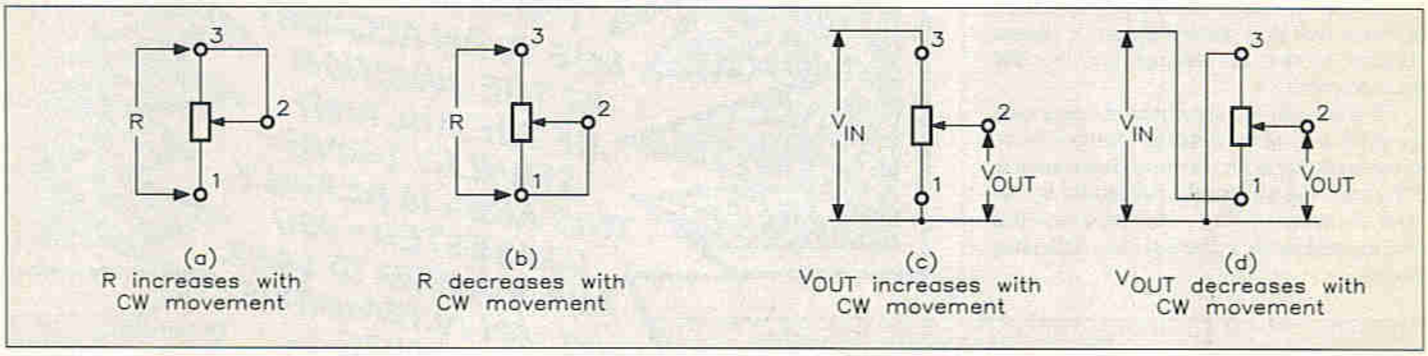


Figure 17. A potentiometer can be used as a variable resistor [(a) or (b)]or as a fully-variable attenuator [(c) or (d)].

or 'pots', although the name 'potentiometer' was originally coined to describe an early ratiometric type of voltage-measuring instrument. A modern pot is the equivalent of the 3-terminal resistive unit shown in Figure 16(a). A resistive track is formed between pins 1 and 3, and electrical access to any point on the track can be made via a movable wiper that is in contact with pin 2. Pots come in a variety of shapes and sizes, but the best known is the 'rotary' type shown in Figure 16(b). The wiper, pin 2, moves towards pin 3 when the spindle is rotated clockwise (CW) and towards pin 1 when it is moved counter clockwise (CCW).

A pot can be used in any of two basic ways, as shown in Figure 17. It can be used as a variable resistance that either increases or decreases in value when the wiper moves CW, by using the connections of (a) or (b). Alternatively, the pot can be used as a fully-variable attenuator or potential divider, in which the output either increases or decreases when the slider moves CW, by using the connections of (c) or (d).

If a rotary pot's resistance value varies in direct proportion to the angular movement of its control shaft, it is said to have a 'linear law'. Rotary pots can be designed with a variety of different 'laws', the four most popular of these are depicted in Figure 18. The 'S'-law type gives a semi-linear response. Rotary pots are often produced in 'ganged' form, with a single shaft controlling several pot wipers.

Not all pots are of the simple rotary type. 'Slide' pots, have a linear element, whereas 'multi-turn' pots have a helical track that needs several control-shaft rotations to make the wiper span its full length. Preset pots are often called 'trimpots', and usually have a linear law.

Three different basic families of pot are generally available. 'Carbon' pots use a resistance track made of carbon composition, in either solid or film form. 'Cermet' pots use a resistance element from a ceramic base, coated with a metal-oxide film-type track, and have far better stability and durability than carbon types. 'Wire-wound' pots have a track made from resistance wire, and are useful in applications that call for a low resistance or high power-dissipation capability.

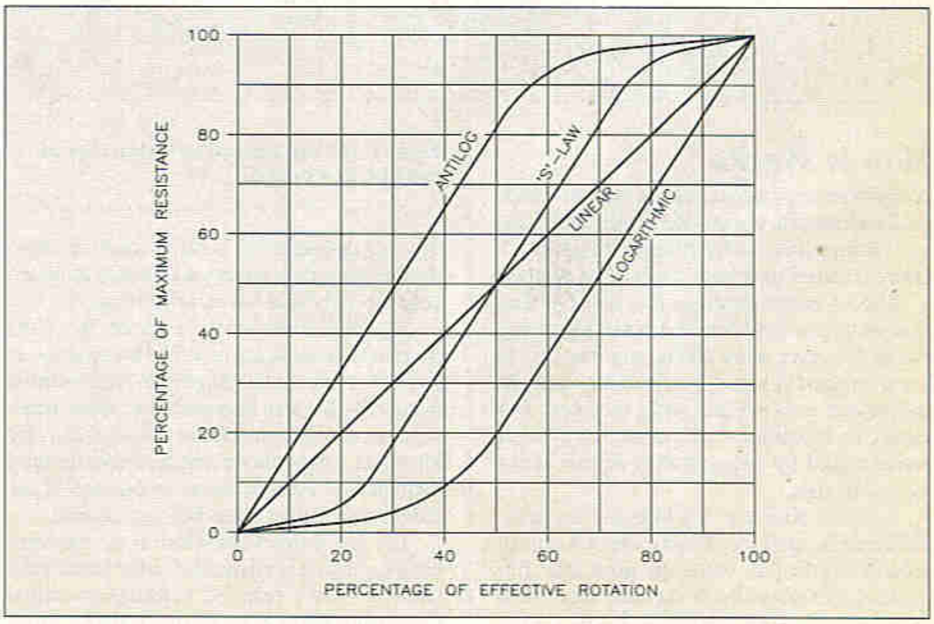
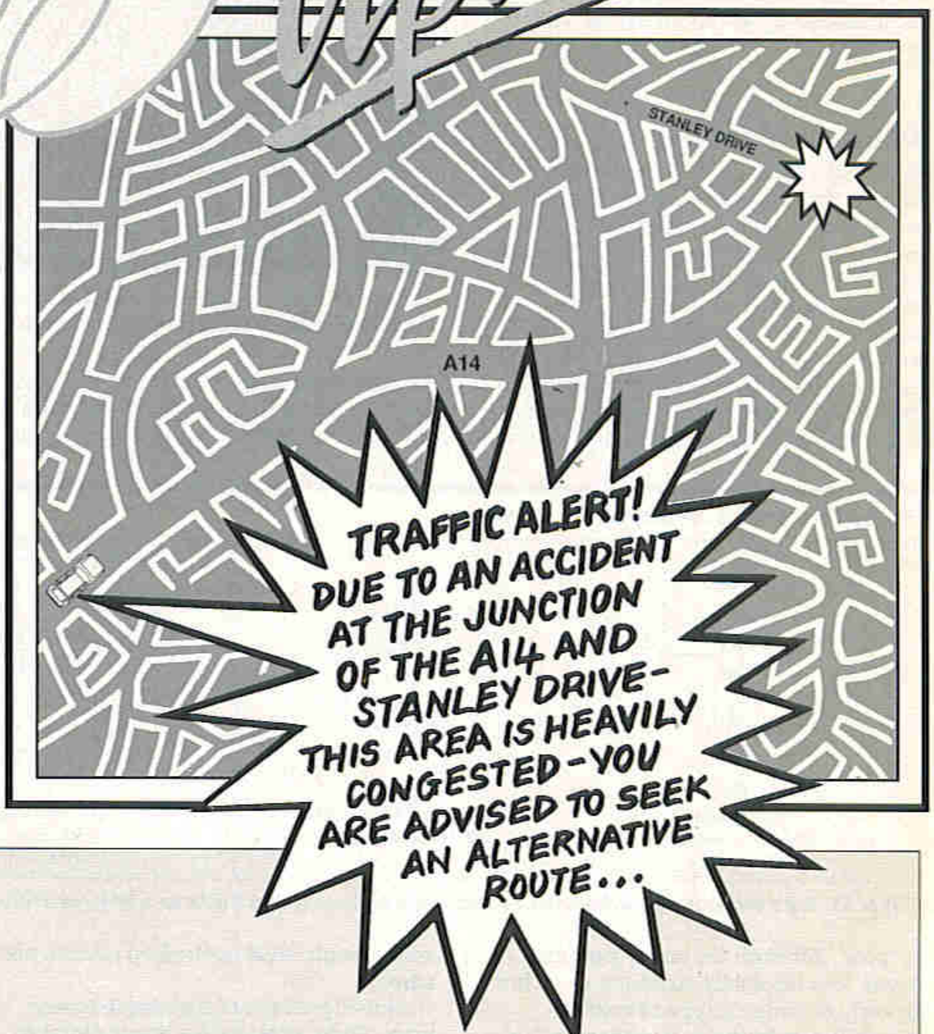


Figure 18. Resistance/rotation laws for four types of potentiometer.

R·D·S Update



RDS is one of the most important developments to affect domestic radio transmissions in recent years. Although intended mainly for use with car radio receivers, it is also of great benefit to home users as well. In fact RDS is set to shape the radio tuners and radio receivers of the future, making them more efficient and easier to use.

RDS stands for Radio Data System, it uses inaudible data signals that are added to FM transmissions to bring a wide range of information services and automatic tuning facilities to the listener.

It enables car radios to handle detailed traffic reports more easily. When they are broadcast, the radio will stop playing a tape or change stations, so that the listener can hear the announcement.

RDS also provides a number of tuning aids. It enables a car radio to change from one transmitter to another as the car moves from one area to the next. It also allows the radio to display the name of a station – a very useful feature now that so many stations are active and often difficult to identify.

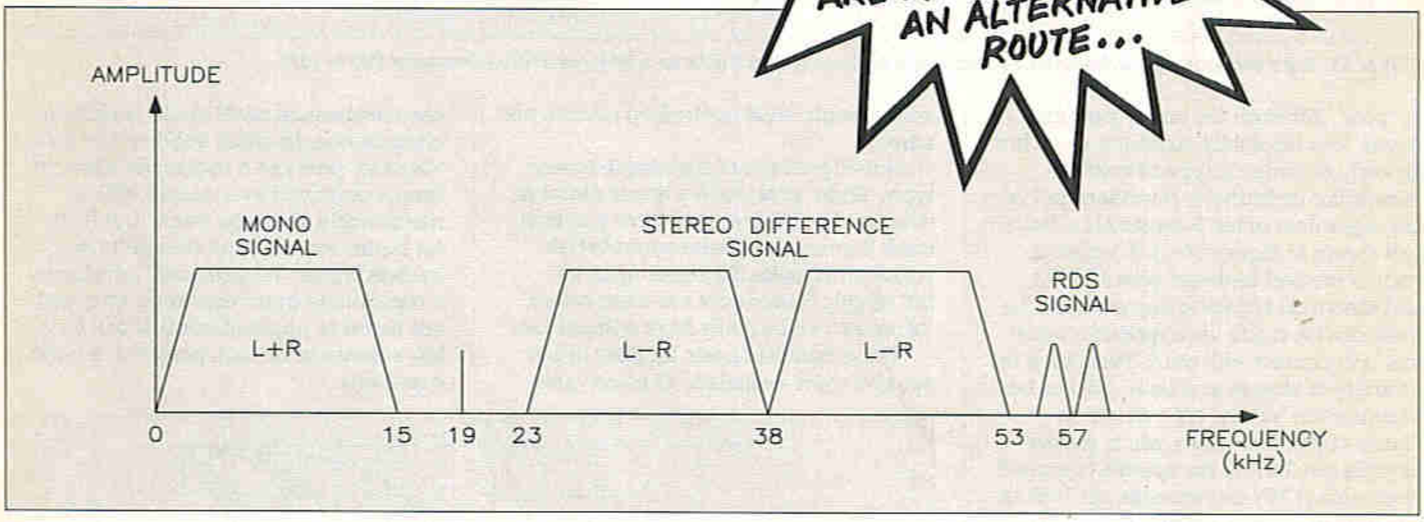


Figure 1. FM Radio Signal with Mono, Stereo and RDS Information.

How It Works

A complete explanation of the way in which RDS operates was given in the March 1988 Issue of 'Electronics – The Maplin Magazine'. However, to recap, a basic explanation follows:

RDS operates by adding a data signal to other signals which modulate the radio frequency carrier. However, when adding anything new to a transmission standard, compatibility must be maintained with existing radio receivers. For stereo, compatability with mono receivers is accomplished by adding further signals above the audio range.

A 19kHz pilot tone is added and the stereo difference signal (Left – Right), which is centred around 38kHz (i.e. twice the pilot tone frequency), is also added.A normal mono radio receiver only detects the signals below 15kHz, which contain the mono signal (Left + Right). In this way compatibility is maintained – a stereo receiver uses both signals and is able to regenerate the individual left and right channels.

The RDS information is placed above the stereo difference signal on a 57kHz subcarrier as shown in Figure 1, this happens to be three times the stereo pilot tone frequency. For stereo transmissions the RDS subcarrier is locked onto the pilot tone. It can either be in-phase with the third harmonic of the tone, or as in the case of the BBC transmissions it can be in quadrature.

The actual subcarrier which is used to carry the information is phase modulated to carry the data. It uses a form of modulation called Quadrature Phase Shift Keying (QPSK) which gives good immunity to data errors caused by noise, whilst still allowing the data to be transmitted at a suitable rate. The use of QPSK also minimises the possibility of interference to the audio signals.

Baseband Coding

The rate at which data is transmitted is 1187·5 bits per second; this is equal to the frequency of the RDS subcarrier divided by 48. By adopting this data rate, the decoding circuit operate synchronously; this reduces problems with spurious signals in the decoding circuits.

Data is transmitted in groups consisting of four blocks. Each block contains a 16-bit information word and a 10-bit check word as shown in Figure 2. This means that with the data rate of 1187·5 bit per second approximately 11·4 groups can be transmitted each second.

A 10-bit check word may seem to be long, but it is very important in view of the poor signal conditions that can exist. This can be particularly true for car or portable radio receivers. The check word enables the RDS decoder to detect and correct errors and provide a method for synchronisation.

The data groups are structured so that data can be transmitted as efficiently as possible. Different stations will want to transmit different types of data at different times. To cater for this there are a total of 16 different group structures. Their applications are outlined in Table 1.

Group Number	Application
0	Basic tuning and switching
1	Programme key number
2	Radio text
3	Other network information
4	Clock, time and date
5	Transparent data channels
6	In-house data
7	Radio paging
8	Traffic message channel
9-13	T.B.D.
14	Enhanced other networks
15	Fast tuning and switching information

Table 1. RDS group types.

Mixing of different types of data within groups is kept to a minimum. However, the coding structure is such that messages which need repeating most frequently normally occupy the same position within groups. For example, the first block in a group always contains the Programme Identification (PI) code while Programme Type Selection (PTY) and Travel Service (TP) will be found in block 2.

In order that a radio knows how to decode the data correctly, each type of group has to be identified. This function is performed by a four bit code occupying the first four bits of the second block.

A typical example, from Kenwood, of a high quality RDS radio-cassette.

Once generated, the data is coded onto the subcarrier in a differential format, this allows the data to be decoded correctly, regardless of whether the signal is inverted or not. When the input data level is '0' the output remains unchanged, but when a '1' appears at the input the output changes its state as shown in Table 2.

Previous Output (Time = Ti-1)	New Input (Time = Ti)	New Output (Time = Ti)
0	0	0
0	1	1
1	0	1
1	1	0

Table 2. Differential Encoding of RDS Data.

With the basic signal generated, the spectrum has to be carefully limited in order to avoid cross-talk in phase-locked loop decoders. The power density close to 57kHz is limited by encoding each bit as a biphase signal, this coded data is then passed through a low-pass filter.

Facilities

The RDS system offers a wide range of useful facilities. The most widely publicised one is that of being able to provide travel news – available on most local radio stations. The stations transmit the TP code to identify that travel messages are flagged by RDS so that when the radio is set for travel news it will only tune to stations which carry the TP indication. As the station is about to broadcast a travel announcement the TP code is transmitted. If a cassette is being played then most receivers will actually pause the tape and allow the travel announcement to be heard. In addition to this the volume may also be set slightly higher to allow the announcement to be heard more easily.

Autotuning

RDS brings 'intelligence' to the tuning of a radio. The autotuning facility comes into its own on long journeys as the car moves from the service area of one transmitter to the next. Without RDS, the radio has to be manually tuned to the next station, but this is not always easy because it is difficult to reliably detect which is the strongest station.

An RDS set will look for the PI code. A national radio station e.g., Radio 4 will transmit

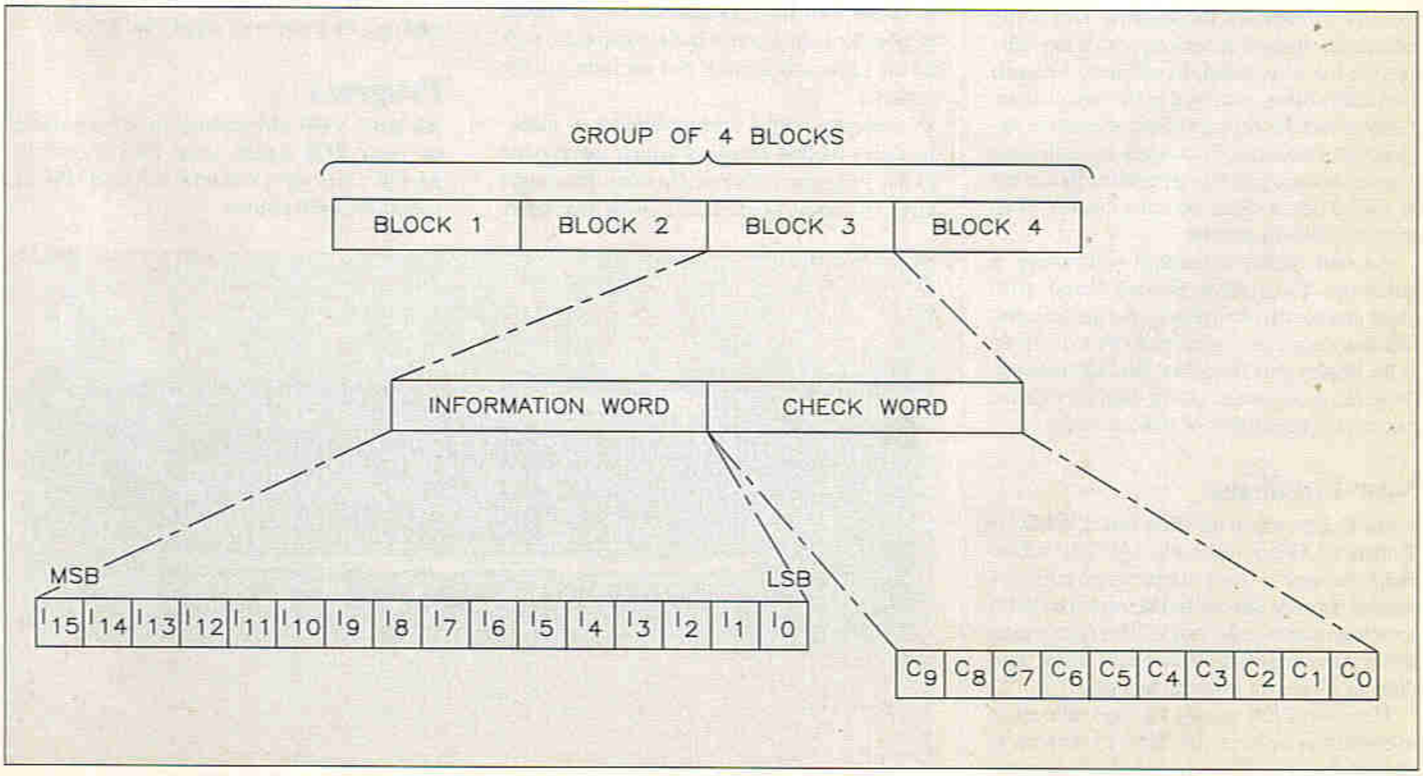


Figure 2. Structure of an RDS Data Group.

from a large number of different transmitters around the country, and will broadcast its own unique PI code. When the radio moves out of the range of one transmitter, it will seek the strongest signal which has the same PI code, allowing the radio to remain tuned to the same radio station.

When radios fitted with RDS store a station frequency, they also store the PI code alongside it. This has the advantage that when the radio is turned on, in a place outside the coverage area for the radio station (and associated transmitter frequency) last selected, the radio will seek the strongest signal which has the same PI code.

Local radio stations also have a PI code but in view of the local nature of these stations, the PI code works slightly differently.

If the station has two or more transmitters then the PI code will operate in the normal way when it is in range of these transmitters. However, when the radio moves outside this coverage area, it wil retune to the strongest signal of the same type of station.

The PI code consists of four characters. The first character indicates the country of origin – for the UK this is C. The next one indicates the type of coverage e.g., '2' indicates a national station, and the final two characters are the programme reference. So Radio 3, for example, has the PI code C203 while BBC GLR has C311.

transmit a traffic message this is flagged to the computer. In turn, the computer directs the relevant national radio transmitters to indicate that a traffic message is imminent, thereby enabling the radios to change frequency to the local radio station to receive the message. Once the message is complete the radio will return to its original station.

EON is relatively new and the first receivers to feature it only appeared in 1991, and although the number of receivers featuring EON is increasing, the majority still do not have it. However, with manufacturers constantly bringing new receivers onto the market, EON should be included on far more receivers in a year or two.

Availability

In terms of the consumer market, RDS is a comparatively new feature, but it has gained a real foothold in the market. Its popularity is growing fast and it is estimated that there are already nearly a million RDS equipped receivers in the UK. This figure is set to rise much further as RDS becomes more accepted.

Car manufacturers like Ford, Vauxhall, and Toyota all fit RDS radios into their cars. However, it is usually only the more expensive cars that are fitted with radios complete with RDS. The base models are unlikely to have this feature at the moment.

Radio manufacturers produce a wide range of receivers equipped with RDS. It used to be true that only the most expensive models were fitted with RDS capability. This is not necessarily true today as it is possible to obtain mid-priced receivers with RDS. Before too long it should be possible to buy even a fairly cheap radio with RDS, although it may not include all the facilities.

Currently only a limited number of manufacturers market receivers which incorporate EON. Panasonic, Philips, Grundig, Blaupunkt and a few others have receivers with it included.

In addition, Panasonic radios also offer the PTY facility. However, with fierce competition in the market-place, it should not be long before most radios offer at least EON. In the meantime when buying a radio receiver, it is worth checking exactly what facilities a radio offers, particularly in respect of EON.

RDS is also entering the home tuner market. Facilities such as the programme name and so forth are particularly useful, making tuning much easier. Although the number of companies manufacturing RDS tuners is limited, names like Bang & Olufsen, Grundig, Philips, Pioneer, Sansui and Sony are leading the way. In fact, Grundig even manufacture an RDS portable radio!

A high quality RDS stereo FM tuner for home use from Sony.

Instant Tuning

It takes a number of seconds for the radio to search for the strongest signal with the correct PI code. During this time the radio would mute itself and the listener would have an annoying gap in listening. To enable the set to tune itself very quickly from one transmission to the next, each transmitter broadcasts a short list of frequencies for adjacent transmitters. This vastly reduces the amount of seeking which the radio receiver has to perform. In addition, a second front end is often employed in the radio to constantly detect the strength of the alternative frequency transmissions. This results in much faster changes in setting, so that the listener should not be able to detect when the radio changes from one transmitter to another.

Another facility associated with tuning is called the 'Programme Service Name' (PS) which enables the set to display the station name. This normally takes a second or two to come up on the display after the station has been tuned in. However, it is a most useful facility with the ever increasing number of stations on air.

New Facilities

A new feature which has been added to RDS is 'Enhanced Other Networks' (EON), which allows the user to listen to one station such as a national network, but still be interrupted by travel news from a local radio station. This feature even allows announcements to be heard whilst travelling in silence, or listening to a tape.

However, EON requires a large amount of co-ordination between the different stations, to achieve this, the BBC use a dedicated central computer. When a local radio station is about to

Components

A number of manufacturers make chip-sets for RDS receivers. Many of them are manufactured for radio manufacturers for their own exclusive use and are not available on the open market. However, some companies including Philips, SGS Thomson and Sanyo have made their chips available.

The functions performed by these ICs fall into three main categories. The first is a 57kHz filter which is used to isolate the RDS signals from all the other signals which are present in the transmission.

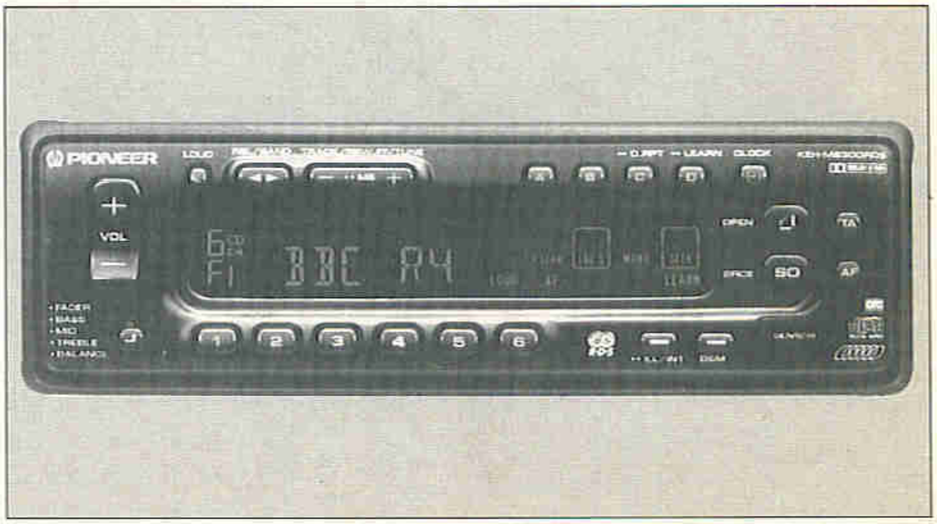
A demodulator is also required, and this is used to extract the RDS data from its 57kHz subcarrier. Most manufacturers make ICs which contain both the filter and demodulator functions. SGS Thomson make the combined ICs as well as separate ICs to perform these functions individually.

The last stage is to process the raw RDS data so that it can be used by the receiver. As virtually all RDS receivers have microprocessor control, decoding the RDS data is taken on board by this chip as well.

Philips make a receiver controller IC which is based around an 8051 microprocessor. However, it is specifically tailored for car radio use. In addition, they can also supply all the peripheral ICs, from the frequency synthesiser to the IF chips and the audio amplifiers, to make a LW, MW and VHF FM radio. To complete the package, they can even supply the software!

Progress

All BBC VHF FM stations have transmitted the basic RDS signals since 1988. However, the full travel service is now being introduced onto more local stations.



A Pioneer in-car entertainment system showing the radio station identification.

This is being done in a number of phases. Phase one was completed at the end of September 1991 and included GLR (London), WM (West Midlands), Kent, Bedfordshire and Essex. This gave a coverage of about 30% of the population.

Phase two included Radio Surrey, GMR, Sheffield, Leeds, Bristol and CWR. This phase was complete by December 1991 and meant that just over 50% of the population could receive the service.

Phase three was completed by April 1992 and meant that a total of nearly 80% of the population was able to receive RDS traffic service using their BBC local radio stations. In this phase, a total of ten stations were updated. They included Radio Oxford, Nottingham, Sussex, Lancaster, Merseyside, Berkshire, Newcastle, Northampton, Leicester and Solent.

The remaining stations in England should be completed by the end of April 1993, and plans will be in hand for the rest of the UK by this time.

RDS is not only used within the UK. It is a worldwide standard and it is currently available in the majority of countries in Western Europe, and a number of other European countries including Yugoslavia. Outside Europe the system is installed in Hong Kong and Singapore, and some stations in the USA are evaluating it.

Summary

RDS is one of the most exciting developments to be applied to radio for many years. Technically, little has changed to radio transmissions since stereo was first introduced. Now RDS allows today's computer technology to give facilities that fall into line with what is expected in the 1990s.

Terminology

TERM	MEANING
AF	Alternative Frequencies. A list of a station's frequencies in adjacent transmitter areas.
CT	Clock Time and Date. Data containing time and data information so that the receiver can display. Using this signal has the advantage over a self-contained clock in the radio that it adjusts itself to changes between BST and GMT (UTC) and it does not loose or gain time.
DI	Decoder Information. This signal allows for the miscellaneous function in the radio to be controlled.
EON	Enhanced Other Networks. Information transmitted giving the radio a cross reference to other stations for travel service and other features.
MS	Music/Speech. This allows for the relative levels of speech and music to be altered.
PI	Programme Identification. This is a station code used in conjunction with AF data to provide automatic tuning to the best signal for a chosen service.
PIN	Programme Identification Number. This signal identifies a given programme and allows the radio to turn itself (and possibly a recorder) on for that programme.
PTY	Programme Type Selection. A signal which allows for the selection of listening by one of the 15 types of programme rather than by the station.
PS	Programme Service Name. A signal which enables the name of the station to be displayed.
RT	Radio Text. This allows information about the programme to be displayed by the radio.
TDC	Transport Data Channel. This allows for data to be down-loaded via RDS.
TP/TA	Travel Service. These signals enable the travel information to be heard, regardless of the choice of listening.

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WIRRAL AND DISTRICT AMATEUR RADIO CLUB meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF Hunts, demonstrations and Junk Sales. For further details, contact Paul Robinson (G0JZP) or Tel: (051) 648 5892.

ELECTRONIC ORGAN CONSTRUCTORS SOCIETY 2.30pm, May 16, St Pancras Church Hall, Lancing Street, near Euston station, all welcome. Regional meetings. Tel: (081) 902 3390. 87 Oakington Manor Drive, Wembley, Middlesex.

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 for its members. For further information, contact: Eric W. Wiltsher, TESUG, Rio House, Stafford Close, Ashford, Kent, TN23 2TT, England.

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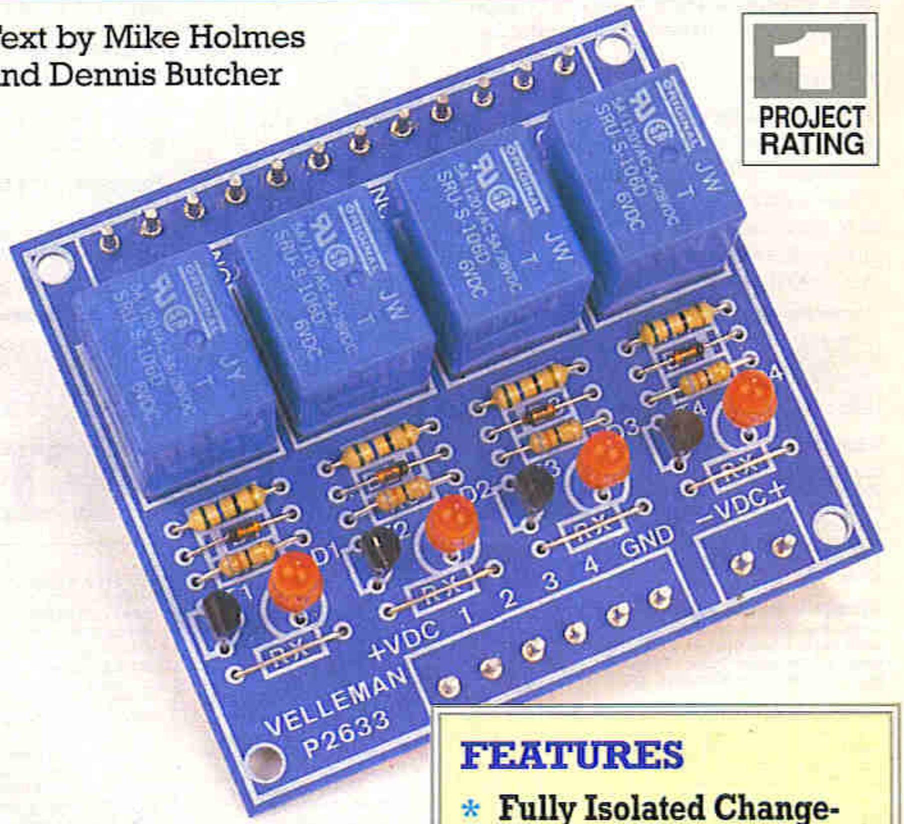
RS232 SERIAL PORT EXPANSION SYSTEM

PART FOUR

Add-on Relay Card

Text by Mike Holmes and Dennis Butcher

1 PROJECT RATING



The completed Analogue to Digital Converter Card.

FEATURES

* **Fully Isolated Change-Over Contacts**
* **LED 'On' Indicators**
* **Remote Installation**

APPLICATIONS

* **Model Train Control**
* **Flashing Signs**
* **Motor and Solenoid Control**
* **Security Applications, Door Locks, etc.**

This module is intended for use with the Open-Collector Card (VE92A) previously described in 'Electronics' Issue 60, and serves to increase the versatility of the RS232 Serial Port Extension System still further (although of course there is nothing to stop you using the Relay Card in other applications).

The module enables the RS232 Extension System to switch heavier loads with isolated supplies than would otherwise be possible with the transistor switches on the plug-in Open-Collector Card. To save cost the module only has four relays (all of which are single-pole change-over types), but if you need more, two modules can be connected to one Open-Collector Card thus providing eight independently operated relays. In fact, if the Extension Card is filled with four plug-in Open-Collector Cards, it is possible for the Extension System to drive a total of 32 relays.

Circuit Description

The circuitry for the card is, as you might imagine, quite simple and merely consists of four duplications of the circuit shown in Figure 1. In this instance the input is from one output of an Open-Collector Card and component 'Rx' should be ignored for the moment (more on this later).

RY1 is the relay, and is energised by transistor switch T1. Because the Open-Collector Card output is effectively open circuit when 'off', R1 is included to ensure that T1 is fully off by pulling up its base to +V DC. The recommended level for +V DC is 9V; this provides sufficient 'overhead' for reliable operation of RY1, which is a 6V operating type. The difference is taken up by R5, and in fact the circuit is quite tolerant of supply voltage range which may be increased up to +15V, at which point the 'on- time' current consumption of RY1 will still only be 61mA, it being a low current type.

D1 is provided to protect T1 from the usual collapsing-field generated, voltage spike across RY1 at switch-off. Visual indication that this relay is active is provided by LD1, which is included in the input path. This means that the input current needs to be >=12mA to achieve sufficient voltage drop across R1 to bias on T1. When connected to the output of an Open-Collector Card, 'Rx' is omitted and replaced with a wire link, since the output path of the Open-Collector Card includes a 560Ω resistor (R18–25, also see Issue 61). You may consider that this arrangement is somewhat unusual, but it means that the card is *current,* as opposed to voltage, operated, which will ensure excellent immunity from interference over long cable runs. This is important if the card is remote from the Open-Collector Card.

It's worth noting that, with these values and with the Relay Card powered from a 9V source, this divider chain somewhat precisely sets the bias level for T1 base at just over 0·6V, taking into account the voltage drop across LD1, which may result in unreliable operation of the Relay Card should its supply level fall below +9V. (This may be obviated by reducing the value of the appropriate resistor(s) at position(s) R18–25 on the Open- Collector Card to 470Ω, for example.)

If the values of resistors R18–25 on the Open-Collector Card are significantly reduced, or replaced with wire links for some (very good) reason, or if the Relay Card is intended to be used separately from the Serial Port I/O System for some other purpose, then you MUST install a current limiting resistor at position 'Rx', and NOT use a wire link! (In the latter case either LD1, the base/emitter junction of T1, or both will 'blow' as soon

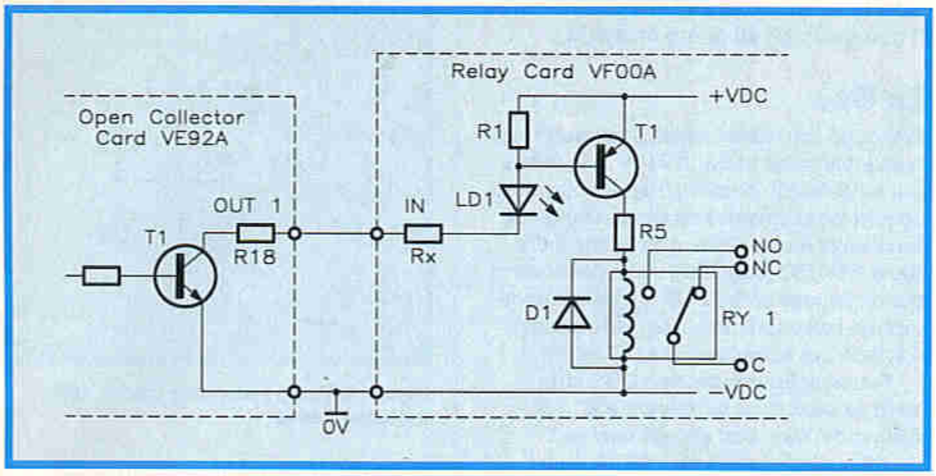


Figure 1. Circuit of one relay and driver on the Relay Card.

as the input is connected or switched to 0V.) Four 820Ω resistors are provided in the kit for use in the positions 'Rx' for this purpose, but be advised that these values will only really be suitable in situations where the card is powered from a DC supply in the range of 12 to 13V. For 9V operation they should be 560Ω each in order to maintain the LED current and base bias for T1.

To calculate the value of 'Rx' from a given supply voltage the following simple formula can be used:

$$RX = \frac{(+Ve - 2{\cdot}7)}{0{\cdot}012}$$

For example if +Vs = 15V, then

$$\frac{(15 - 2{\cdot}7)}{0{\cdot}012} = 10250$$

where 2·7 is the combined voltage drop across both LD1 and T1 base/emitter, and 0·012 is the recommended LED current. From the above example the next lowest resistance value in the E24 scale of resistor values will be 1000Ω, to be used in position 'Rx'.

Construction

The board is quite simple to build, once you have decided how it is going to be used, as explained above. It will be helpful to leave the relays until last, as these take up the most space and can restrict access to some of the smaller components. Begin by inserting the double-ended PCB pins at positions '+VDC', '1' to '4' and 'GND' on the PCB, and also at '–VDC +'.

The remaining pins may be inserted at the opposite edge of the card at all positions 'NO', 'C', 'NC', etc., but at this stage you can decide to opt for PCB mounting screw terminal blocks instead (see Optional Parts List), allowing more convenient, non-permanent connections to the relay contacts. Four 3-Way PCB terminal blocks can be stacked and fitted in these positions forming a single 12-Way block.

Next fit resistors R1 to R8, and then use offcuts from these to form the wire links for the four locations 'RX' if the card is going to be driven from an Open-Collector Card. Otherwise current limiting resistors must be fitted, as already mentioned, choosing a value according to the Relay Card external supply level as indicated in the following table:

Card Supply	Rx Value
9–11V	560Ω
12–13V	820Ω
14V	910Ω
15V	1k

You can now fit diodes D1 to D4, making sure to align the cathode identifiers (black stripe on the diode body) with the white markers on the legend (the orientation alternates across the board). Transistors T1 to T4 can then be installed, followed by the four red LEDs. Note that the card can be fitted on pillars behind a panel, in a situation where it is remote from the remainder of the Extension System, and these LEDs can then be visible indicators through appropriately positioned holes. In this event you should make the tops of the LEDs slightly higher that the tops of the relays (21mm) in order to reach the panel.

When fitting each LED, note that the shorter of the two leads is the cathode (corresponding to the flat on the LED body) and must be inserted in the hole nearest positions 'RX'. To set the height accurately, lightly solder one lead only, and then briefly re-melt to alter the height then hold it till the solder sets. When satisfied, the other lead can be soldered permanently and the first lead re-soldered properly, before removing the excess leads with side-cutters.

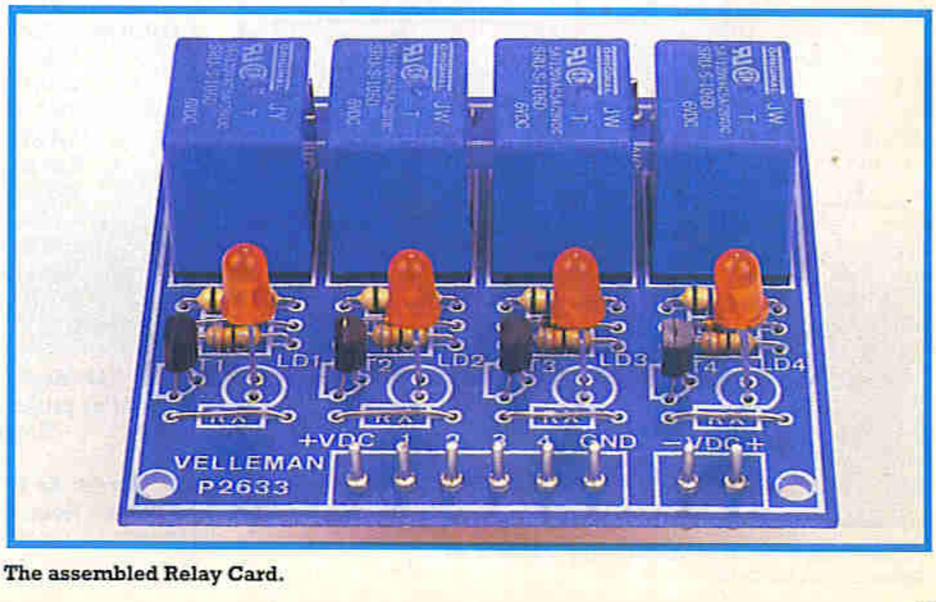
Finally each of the four relays RY1 to RY2 can be installed, making sure to use good, strong solder joints. This completes construction of the card and, after double-checking correct placement of components, the quality of solder joints and ensuring that there are no solder bridges, etc., the Relay Card can be tested.

Connecting Up

The row of PCB pins opposite the relays will be used to connect the four inputs '1' to '4', and the common supply and input 0V 'GND' to the Open- Collector Card on the Serial Extension System extension board. The pair '–VDC +' are commoned through to 'GND' and '+VDC' respectively, and it is to these that the external supply is connected. Pin '+VDC' is only used to carry this supply to any further cascaded Relay Cards, and must not be connected to any supply pin on the System Extension Card!

Figure 2 illustrates this by showing how two Relay Cards are combined to give full 8-bit control of eight relays. All pins 'GND', including that on the Open-Collector Card, are commoned; inputs '1' to '4' of Relay Card No. 1 connect to outputs '1' to '4' on the Open-Collector Card, while inputs '1' to '4' of Relay Card No. 2 connect to outputs '5' to '8'.

The '–' terminals of both cards for the external 9V supply are commoned together but, while the external supply '+' connects to the '+' of card No. 2, it is transferred via pin '+VDC' to card No. 1. In this way several Relay Cards can be cascaded together. The external 9V supply must be able to supply 300mA for



The assembled Relay Card.

each card. For example mains adaptor XX09K can be used to power one Relay Card, and YM85G for two (see Optional Parts List). The supplies need not be stabilised.

Relay Connection and Testing

Connecting to the relay contacts is very simple: each group is marked 'NO', 'C' and 'NC' where 'NO' = Normally Open, 'C' = Common (the 'pole' of the switch) and 'NC' = Normally Connected when the relay is in the 'off' state. In use the Open-Collector Card merely has to send a logic 0 for 'off' or a logic 1 for 'on' on the relevant data line. The last program listed near the end of the Open-Collector Card article in Issue 60 (under the heading 'Another Test Program') can be used again to perform a running test on the Relay Card, operating each relay in sequence. The Relay LEDs will show which one should be active, and the relay itself should be heard to click. An ohmmeter or continuity tester may then be used to prove that each set of contacts is changing over properly. Initially all relays will be switched on for one second, and then each in turn, starting with number 1 (bit 0), will be switched on individually for one second, and then all off before the cycle resumes. (If only four relays are present there will be a five second delay between number 4 going off and all going on again.)

In Use

Although the leaflet states that each relay contact is rated at 3A at 240V AC, this is not necessarily correct. The actual rating should be displayed on the housings of the relays themselves, and is normally 5A at 28V DC (and 120V AC). Because of the closeness of the PCB tracks connecting the relay contacts, you are strongly advised not to exceed the DC rating.

For switching inductive DC loads such as motors or higher power solenoids, etc., you should connect rectifier diodes such as 1N4001 (see Optional Parts List) across both the load and the relay's contacts, as illustrated in Figure 3. These will prevent arcing across the contacts themselves and reduce RFI.

Ribbon cable is mentioned in the Optional Parts List, which will be most convenient for quickly connecting together Relay Cards and Open-Collector Cards, having ten, colour coded wires in a strip. Of these, 'black' can be used for the common '0V' and 'GND' connections and 'white' for the '+V DC' connections, the remainder used as signal carriers.

Ideas for applications of the Relay Card are limited only by your imagination, especially where such switching capability is teamed up with an intelligent device, a computer. One or two ideas include model railway layout control, where trains can be controlled on independent sections of track and made to start and stop at stations and signals, and points and motorised crossing gates can be operated in unison. Alternatively, as an intelligent 'zoned' security controller, the system can disable and enable switch sensors for an alarm system, such as door contacts, PIRs, pressure mats, etc., for variable periods according to preset times of the day or week. In fact the system is ideal for all manner of timed switching functions.

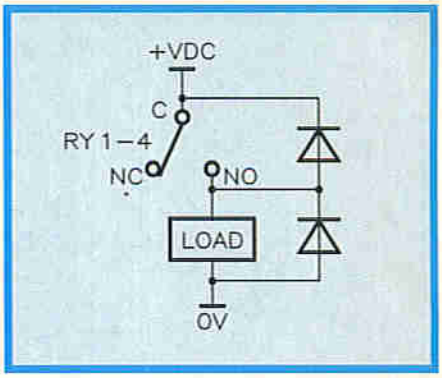


Figure 3. Using protective diodes with inductive loads.

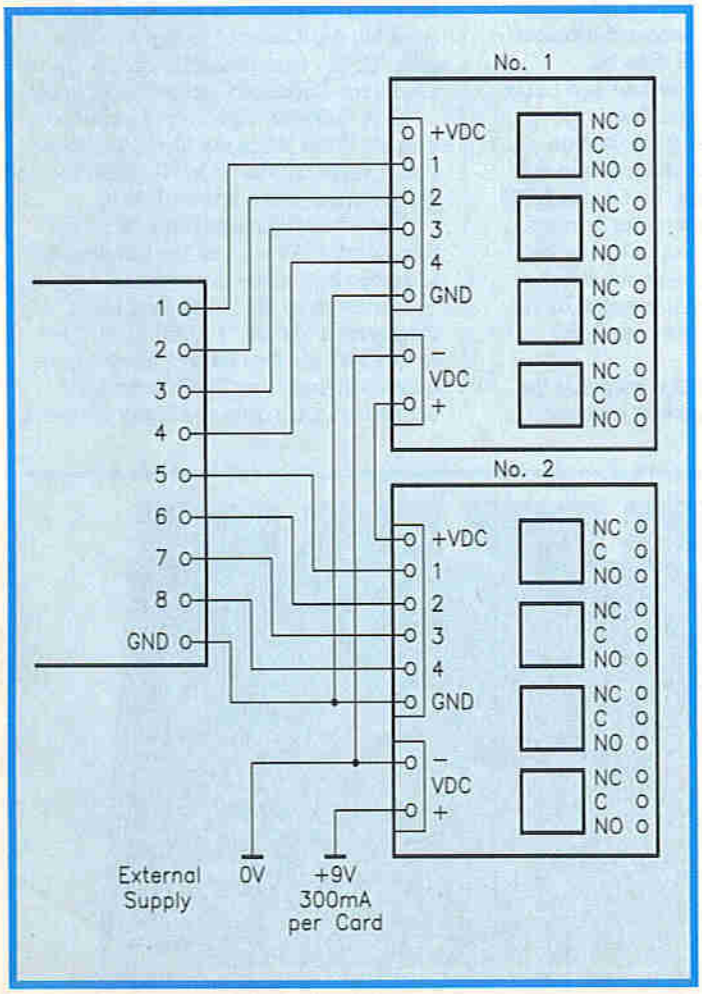


Figure 2. How to interconnect Relay Cards to an Open-Collector Card.

SERIAL SYSTEM RELAY CARD PARTS LIST

RESISTORS: All 5% Metal Film			
R1-4	56Ω	4	
R5-8	82Ω	4	
Rx	820Ω	4	
SEMICONDUCTORS			
D1-4	1N914 (1N4148)	4	
LD1-4	Red LED	4	
T1-4	BC557 (BC558, BC559, BC307, BC308, BC309)	4	
MISCELLANEOUS			
RY1-4	Relay SPCO 5A 28V	4	
	PCB Pins	20	
	PCB	1	
	Instruction Leaflet	1	
	Component Identification Guide	1	
OPTIONAL (Not in Kit)			
	560Ω	4*	(M560R)
	910Ω	4*	(M910R)
	1k	4*	(M1K)
	1N4001	As req.*	(QL73Q)
	For single card:		
	AC Adaptor 9V 300mA	1	(XX09K)
	or for two cards:		
	AC Adaptor 9V 800mA	1	(YM85G)
	Ribbon Cable 10-Way	As req.*	(XR06G)
	PC Terminal Blocks 3-Way	4	(JY94C)

(*see text)

The Maplin 'Get-You-Working' Service is available for this project, see Current Maplin Catalogue for details.
The above items (excluding Optional) are available in kit form only.
Order As VF00A (Serial Sys Relay Crd) Price £15.95
Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

by Douglas Clarkson

The World of the Photon

Before beginning an in-depth study of this rapidly developing application area, it is appropriate to say something about photons – the particles which allow us to perceive images of our world, and which are now made to travel along optical fibres in order to meet society's seemingly insatiable demand for communications.

Photons interact very weakly with each other. It is possible, for example, to pass intense beams of light through each other and not be aware of any interactions taking place.

Electrons are, in fact, classed as 'fermions' and interact with each other by means of a strong electromagnetic force. Not only are electrons influenced by each other, but they can also be deflected by magnetic fields. Many of these effects are exploited in modern technology – excellent examples include electric motors and the cathode ray tube inside your TV set. These electron characteristics are, however, undesirable for signal transfer applications.

As a comparison, photons (as indicated previously) do not interact with each other, and are not influenced in any significant way by electrical or magnetic fields. There can be some interaction, however, from the passage of light through magnetic fields, in which case its polarisation is altered.

A Century of Progress

The increased use of photons as information carriers comes at a time when many of the disadvantages of electron-based data transfer have been identified, yet the potential of systems working at very high optical frequencies has barely been tapped.

The intuitive realisation that light could be used to transmit information was in fact demonstrated by Alexander Graham Bell, better known as the inventor of the telephone. Using a device called the 'photophone', an individual could transmit his voice using selenium cells and reflected sunlight. The transmitter comprised a mirror, which was vibrated by the person's speech. The beam of light produced fluctuated in intensity as a result and, when focused on a selenium cell, it correspondingly varied the current fed to a telephone receiver. Apart from being a good party trick, it demonstrated the ultimate means of communications – laying the foundations of a multibillion dollar global communications industry.

While the possibility of fibre optic technology had been considered for some time, it was not until the early 1960s that researchers in the UK and USA had begun to develop fibres that demonstrated significantly lower losses – to the extent that they could be developed for communications applications.

To put this development into perspective, the attenuation figures of early glass fibres of the '50s were as high as 5dB/cm. By the mid-1970s, however, losses were down to about 20dB/km, falling to around 4dB/km by the late '70s. At these levels of attenuation, linkage within a specific office area or compact university campus was conceivable. AT&T in the USA undertook some key product trials during 1985 with optical fibres of even lower loss – 2 to 3dB/km. In the late '80s, losses were further reduced to around 0·2dB/km – close to the theoretical limit of Rayleigh-scattering in silica. At these levels of efficiency, a path was cleared for the implementation of long-haul light-wave links.

While optical fibre development has produced very efficient silica-based fibres, research has also been undertaken into developing new ultra low-loss materials, such as metal fluorides which, in theory, could achieve levels of loss as low as 0·01dB/km.

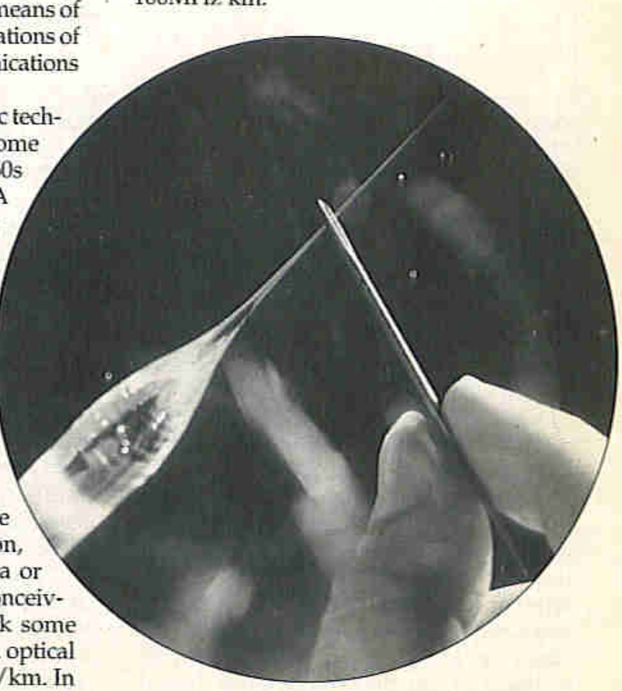
Basic Principle of Operation

How exactly does an optical fibre work? To obtain their characteristics, silicon fibres (the 'core') are doped with elements such as germanium and fluorine to obtain refractive indices that are high compared to those of the surrounding 'cladding' layer. Initial levels of purity must be very high; impurities will scatter light and reduce the efficiency of the fibre. The core's function is to transmit the light waves, while the cladding guides the light waves and helps to minimise surface losses.

The arrangement described will result in light waves propagating down the inner core in a series of 'wavefronts' (also known as 'modes') due to total internal reflection, a phenomenon familiar to GCSE students. Depending on the structure and diameter of the core, one (SM (single-mode) fibres) or a series of many (MM (multi-mode) fibres) wavefronts can be transmitted.

SM fibres operate at higher wavelengths due to a lower core diameter; the attenuation is therefore lower. They are ideal for use in long-haul telecomms systems, particularly bearing in mind their tremendous information capacities (bandwidth-length products typically ranging from 40 to 50GHz km). Unfortunately, they are difficult to manufacture due to the narrow aperture – and are consequently expensive.

MM fibres are cheap to manufacture but allow only comparatively slow data signals to be passed, the bandwidth-length products typically ranging from 1MHz to 100MHz km.



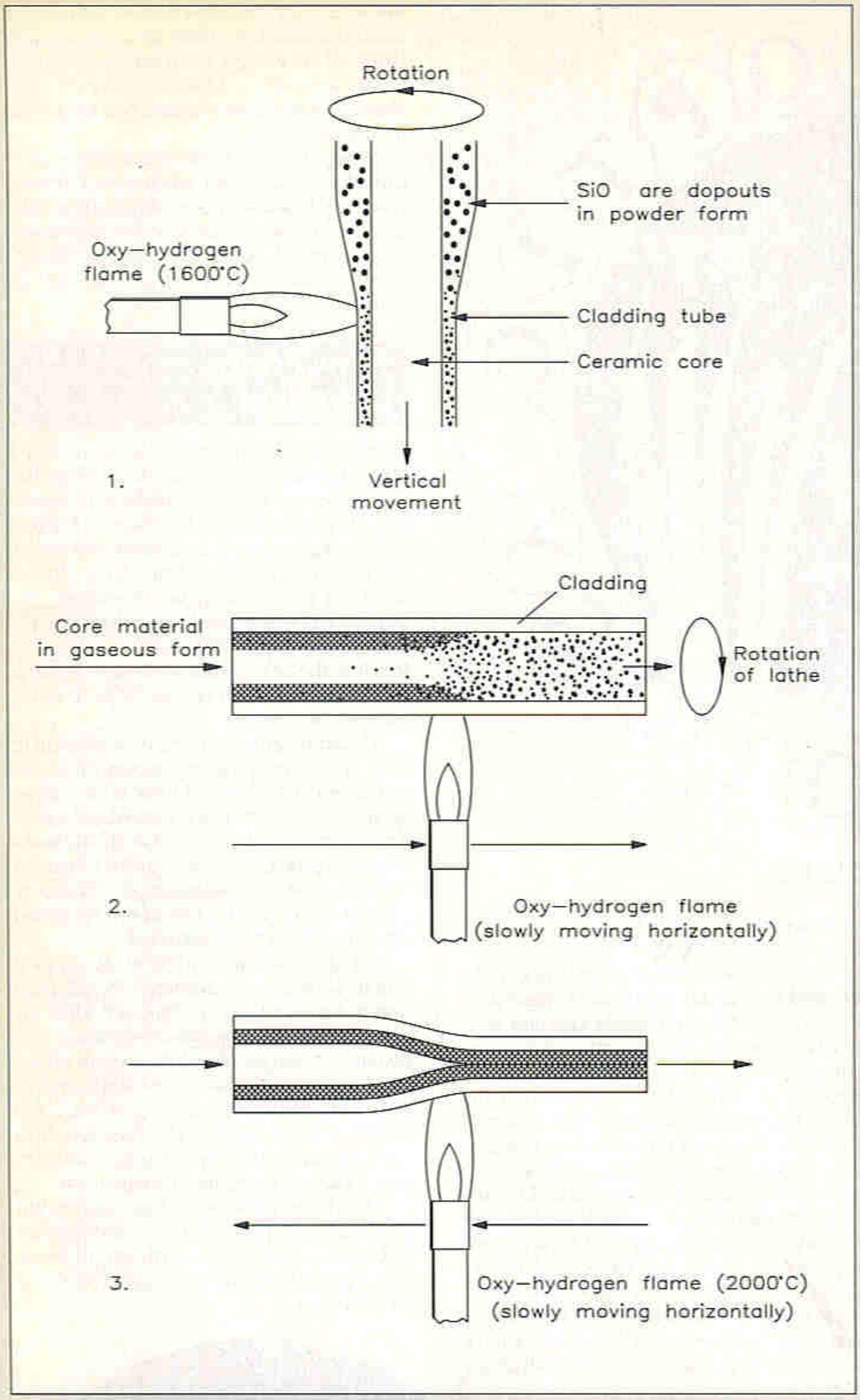


Figure 1. Summary of manufacturing process of optical fibres using modified chemical vapour deposition (MCVD). There are four main stages; manufacturing the cladding tube, depositing the core material, collapsing the preform, and drawing out the fibre.

Manufacturing Optical Fibres

The manufacture of optical fibres has been the subject of extensive research and development, since the physical characteristics and optical properties relate closely to the cost of installing and maintaining networks based on these carriers.

One method, Modified Chemical Vapour Deposition (MCVD), used by AT&T for creating a 'preform' for SM fibres, is shown in Figure 1. The preform is a large tube of glass that has the same refractive index as the core of the finished optical fibre. Each is normally 2 or 3 cms in diameter, up to 1m in length, and can provide several kilometres of finished optical fibre when drawn! Initially, a quartz tube is produced; this is done by depositing silicon dioxide and a selection of dopants onto a revolving ceramic former. An oxy-hydrogen torch heats up the tube to 1600°C and fuses the silicon dioxide and dopants to form a solid glass layer on the outside of the former. The former itself is then removed, leaving what will eventually be the cladding. At this stage, a chlorine atmosphere is maintained in order to minimise the formation of OH radicals in the glass.

Next, the tube is placed on a lathe and rotated. The core material, in gaseous form, is passed through the tube, depositing on its inner surface. As this deposit forms, another oxy-hydrogen flame sinters the core material into glass. Once the required amount of material (dependent on the intended core diameter) has been incorporated into the tube, the core gas is removed and the tube is subjected to intense heat (around 2000°C), causing it to collapse and, as a result, sealing the tube. The preform is now complete, and ready for drawing. This is done using a 'pulling tower'; here, the lower part of the preform is kept, by a furnace, in a semi-molten state. A 'strand' of glass (the fibre itself) is drawn from the tip of the preform; the outer part of the preform draws off to form the cladding, while the central section simultaneously forms the core. Before being wound on a drum (note that it cools down by the time it reaches the drum), the fibre is coated with a protective plastic.

The process of fibre drawing requires extremely critical control of zone temperatures, processing atmospheres and drawing rate.

Figure 2 shows the typical spectral attenuation of SM fibre with an OH concentration of less than 60 parts per billion. Compare this with Figure 3, which is a graph of attenuation data for a fibre with greater levels of OH. At 1.6 microns, the beginning of the so-called IR 'edge', where attenuation rises sharply, is visible. It is important that signal sources, optical fibres and detectors use wavelengths that maximise overall efficiency.

Figure 4 shows the typical variation of refractive index within a specific SM fibre. The region of lowest refractive index is in fact that area which suffered no dopant deposition.

Modes of Fibre Transmission

While the laws of refraction and reflection can be applied in simple terms to the end faces of optical fibres, and to their cylindrical boundaries, it was not until 1910 that a 'full' solution of Maxwell's equations in a cylindrical rod (equivalent to an optical fibre environment) was announced.

These solutions determine the highly specific ways in which the E (electric) and H (magnetic) fields are distributed within a specific fibre. In general terms, the light becomes transmitted in a range of modes – each with its distinct E/H vector distribution. Distinct modes can also travel at different speeds along the fibre. Only when these factors have been taken into consideration can we obtain an accurate appreciation of how a fibre will perform.

Figure 5a shows the entrance of a ray of light into the core of the fibre, which is assumed to have a refractive index, n, of 1. The ray is 'bent' when it moves from air, for example, to a medium of higher refractive index. In Figure 5b, the ray is reflected when it contacts the interface between the core and the cladding. Figure 5b, however, shows a ray incident from air at an angle, from which it is possible for a refracted ray to run parallel to the core/cladding.

This is the limiting angle at which total internal reflection takes place. If the angle is increased, then the light will pass into the cladding material and be lost.

The example cited has been that for a 'step' fibre, where the core and the cladding have specific refractive indices of 1 and 2.

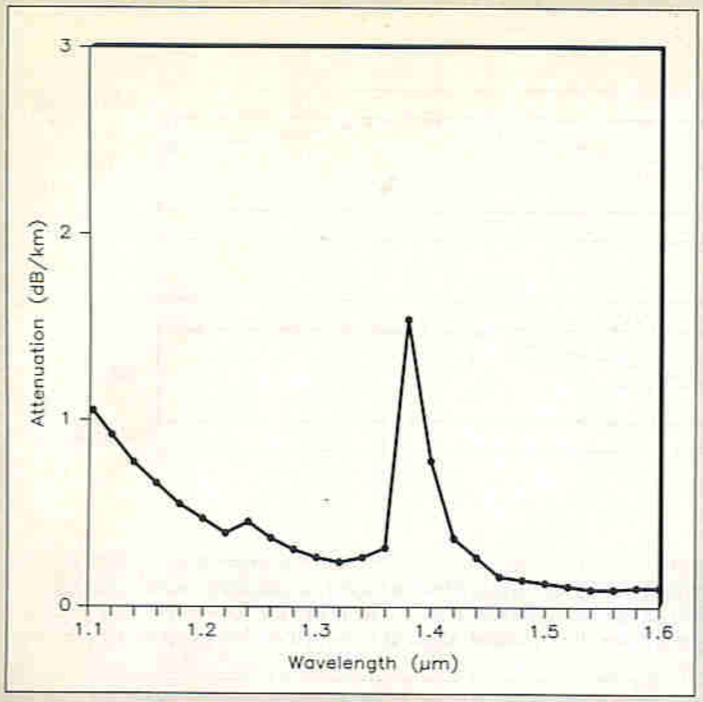


Figure 2. Typical attenuation curve of single-mode fibre, shown as a function of wavelength. The peak is due to absorption by OH radicals, and is closely controlled by manufacturing processes.

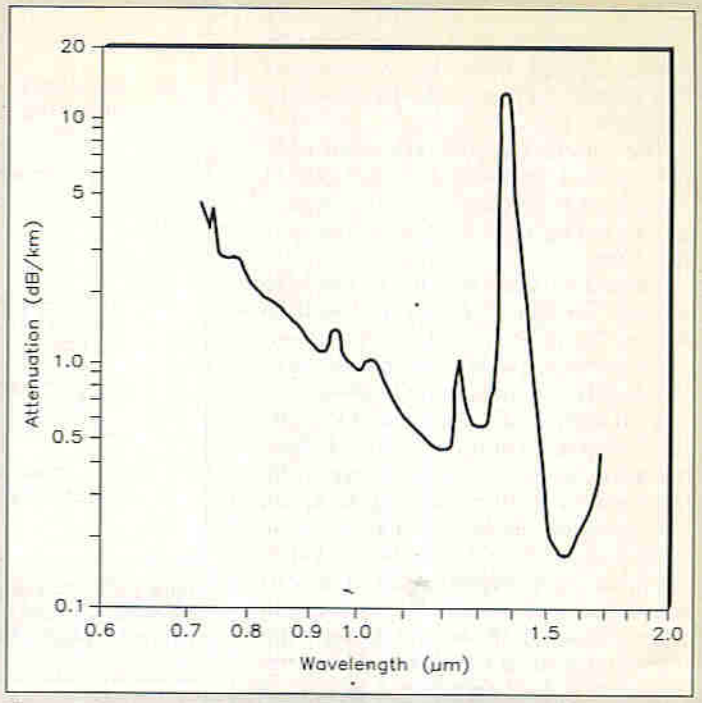


Figure 3. More detailed attenuation characteristics of higher-loss optical fibre. The 'infra-red edge' is visible at around 1·6 microns.

So-called 'graded index fibres' have a variation of refractive index between the core and the cladding.

The numerical aperture (NA) of a fibre is the sine of the maximum entrance angle from which a ray can enter and still propagate along the fibre.

It can be shown that

$$NA = \sqrt{n1^2 - n2^2}$$

A typical value is 0·2, which corresponds to an angle (A) of 12 degrees.

There is a fundamental difference in transmission properties between single-mode and multi-mode fibres. Single-mode fibres typically have core diameters of around 8 microns, while multi-mode fibres have diameters of 50 microns or more. A pulse of light fed in at one end of a multi-mode fibre can be carried as a series of different modes within the fibre – each one with slightly different velocity, so that the sharp edge of an input pulse will be spread out when it arrives at the receiver end. In a way it is like a 100 metres race – everybody starts out together but there is a spread at the finishing line. The amount of 'spread' determines the maximum frequency of signal that the line can carry. To continue further the analogy there would need to be a minimum time interval between successive races, otherwise the 'strugglers' from one race will be caught up by the leaders of the next.

The single-mode fibre, however, utilises a principal 'pure' mode to transmit data so that there is less dispersion of light signal. In many ways the fibre provides a means of carrying data that is still significantly under-utilised.

Signal Drivers

The 'quality' of transmission along a fibre optic cable is considerably influenced by the 'quality' of the signal source – typically a light emitting diode, laser or laser diode. Key factors relate to the spread of wavelengths about a central frequency and any variation in output wavelengths as a function of operating point and device temperature. Lasers typically have significantly higher performance specifications on all of these factors. Lasers typically have lower coupling losses into fibres due to the low divergence of laser radiation. There is increasing interest in using the fibre optic material itself as the lasing medium for communication applications.

Exploiting Fibre Bandwidth

Even considering the window of wavelengths between 1 micron (3×10^{14}Hz) and 1·5 microns (2×10^{14}Hz), there is a potential bandwidth of 100,000GHz. Part of the challenge of future light-wave communications is to pack more channels at distinct frequencies into the one fibre. There have been investigations conducted, their aim being to make the most of this vast bandwidth. All have centred around multiplexing data channels onto the one fibre, as shown in Figure 6.

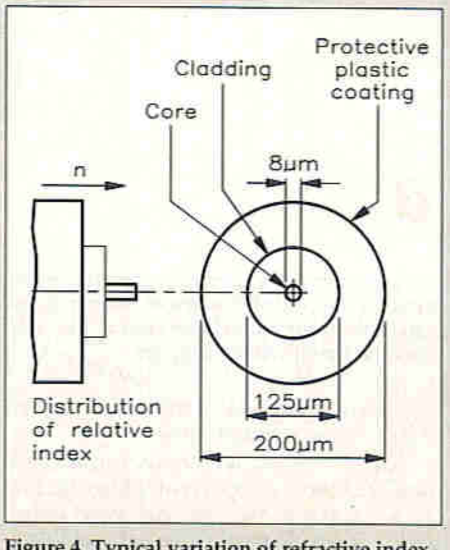


Figure 4. Typical variation of refractive index within a specific single-mode fibre.

There are a number of problems associated with passing sets of distinct wavelengths through a fibre. Firstly, a range of 'pure' very narrow line width and stable (non-drifting) lasers are required. Each light signal has to be modulated with digital data, coupled onto the fibre and detected again as specific outputs at specific central frequencies. There is also the problem of repeater stages. These constraints add to the technical sophistication, and hence to the cost of such systems.

One key experiment, undertaken by researchers at AT&T Bell Laboratories to demonstrate signal multiplexing, successfully combined a set of 10 separate laser signals, each of which was modulated with signals in the order of 2Gbits/sec. As a result, the data-carrying ability of the total fibre was 20Gbits/sec. Where a single fibre has a specific upper limit of data rate per single channel, it will apply to *each* of the specific wavelengths carried. Provided the wavelengths are kept separate and do not overlap, the data carrying ability of the fibre is still vastly increased.

What has been demonstrated in the laboratory, however, does not necessarily carry over immediately into the commercial marketplace. Data carriers are more concerned about the reliability of services than the peak data carrying function of a single line. Most lines, at present, operate as single data stream lines, but will eventually change.

Signal Regeneration

Even with the low present-day losses of around 0·15dB/km for silica fibres, it is necessary to regenerate the signal by separate stages. In original systems, the signal is recovered using a photodiode. After electronic processing and amplification, the 'refurbished' signal is used to remodulate a light-emitting diode or laser device attached to the next stretch of optical fibre. In this system, the photon signal is effectively converted to electrons and then back to photons. A number of these 'repeaters' are required if the spanning of large distances was anticipated; the recently completed TAT-8 transatlantic cable, for example, makes use of 109.

The complex electronic systems used in these systems tend to restrict operation to fixed bit rates. This can hinder the upgrading of existing fibre-optic links to higher data rates.

There has been a general move to develop 'all optical' signal regeneration devices. The first family of devices investigated for this role were semiconductor optical amplifiers, in which photons are coupled into a small semiconductor waveguide, and amplification occurs as light emitted by another laser is stimulated by photons from the attenuated original signal.

In conventional lasers, such as He-Ne devices or semiconductor laser diodes, individual light photons make numerous passes between parallel end-mirrors, in order to build up the equilibrium population of photons in the device. The semiconductor optical amplifier, however, is designed as a single-pass device, where photons (from the original signal) incident at one end of the device propagate through it and stimulate the emission of photons of similar direction, phase and polarisation. Atoms are raised to an excited state in the device by the passage of current through the diode.

The optical gain of such devices, however, tends to vary with the polarisation of incident light, which can be affected by changes in temperature and pressure along a fibre's length. In addition, the signal levels propagated through the device can influence the photon concentrations in the excited states, resulting in a variation of gain as a function of signal pattern.

Significant coupling losses can occur at the interface between the fibre and the semiconductor amplifier if there is any mismatch in the optical properties of the materials used. Because the light amplification takes place in a much shorter transit area through the lasing medium (at most a few mm, compared with several mm for conventional lasers), devices require to be driven at higher currents of around 200mA compared with typically 50mA for laser diodes.

Some of these devices can provide as much as 30dB of gain, over a 30 to 50nm window centred around 1500nm, enabling a single device to act as an amplifier for a range of channels separated by a few nanometres of wavelength. This indicates that such devices also have the inherent property of 'transparent' light amplification as a result of the stimulated emission of radiation within the semiconductor laser. It is likely, for all their present limitations, that semiconductor amplifiers will be further researched and developed in the hope of overcoming their known weaknesses.

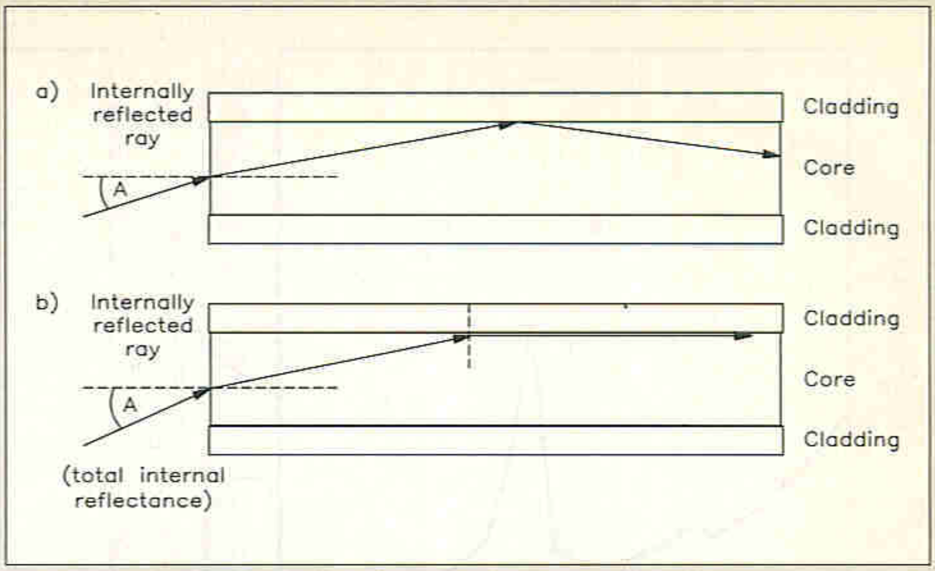


Figure 5. Ray diagram of light entering an optical fibre. In (a), the ray cannot be refracted to the cladding layer since the entry angle, A, is too small. In (b), the ray in the core strikes the cladding at the critical angle. This determines the maximum angle of a ray that can be 'accepted' by the fibre.

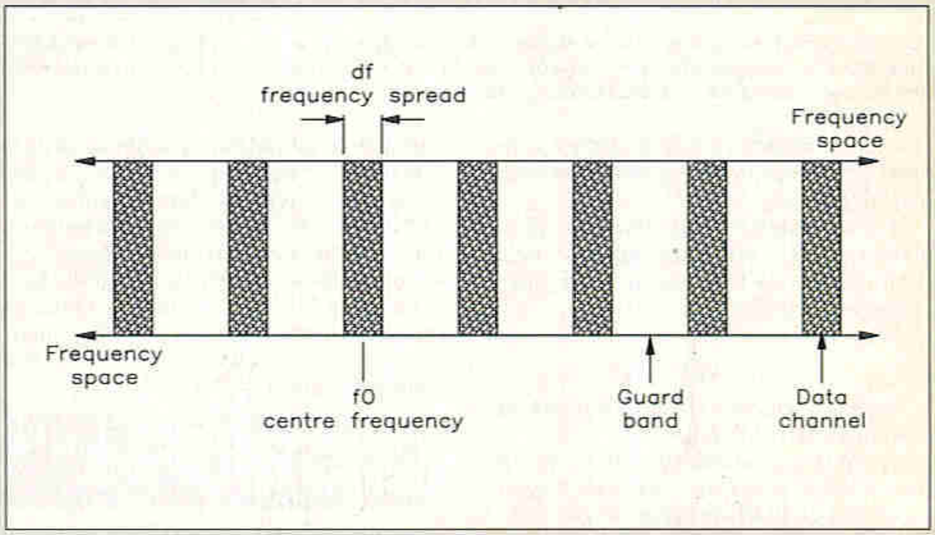


Figure 6. A possible way in which the wide bandwidth of an optical fibre can be used. Separate channels can be allocated within the frequency space available.

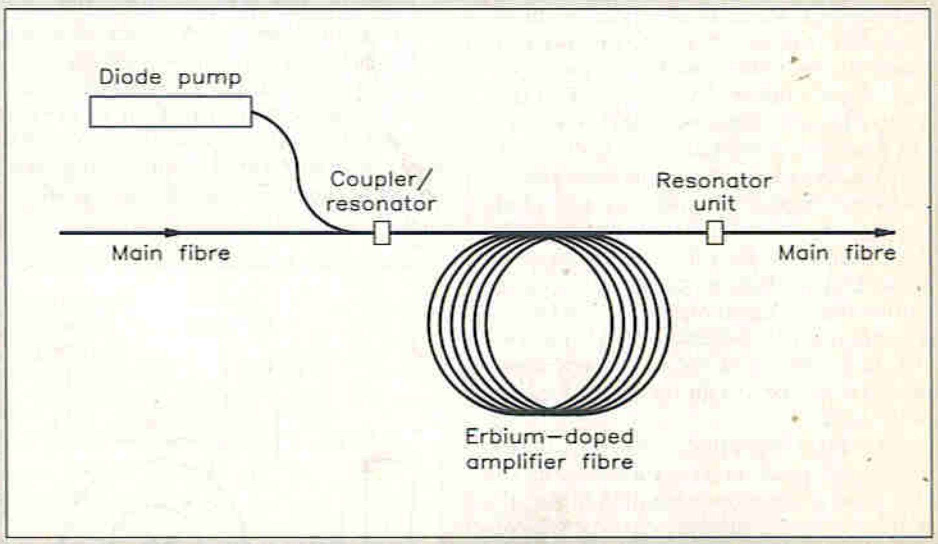


Figure 7. Simplified diagram of erbium-doped fibre signal amplifier. Photons from the main signal fibre pass through the erbium fibre and stimulate the emission of radiation, achieving all-photonic amplification of signals.

Erbium Fibre Amplifiers

Innovative work, started in 1985 at the Optical Research Institute of the University of Southampton, has now made it possible to utilise an 'all-optical' repeater stage, shown in Figure 7, using specialised erbium-doped fibres. It will be seen that this is a very elegant way to solve the problem of light-wave repeater sections.

The immediate advantages of using a fibre element as an optical amplifier are that the problems of coupling losses and polarisation-dependent gain are essentially eliminated. The inverted population of excited erbium ions is maintained typically by a laser diode, which is coupled to the doped fibre by means of a dichroic coupler. Considerable work has subsequently been undertaken at Southampton to determine the optimised operating conditions of such fibres.

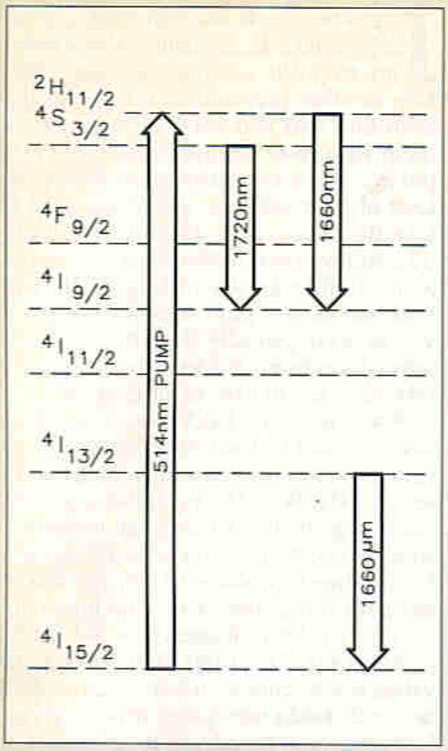


Figure 8. Typical energy-level transitions associated with 'pumping' and 'stimulated emission' in Erbium-doped fibres. The example given is that of an erbium-doped fluorozirconate fibre operating at 1·66 and 1·72 microns.

The main fibre optic cable is coupled optically to a section of erbium-doped fibre, which is spliced onto a circuit whose photons are 'pumped' at a wavelength shorter than that of the carrier wavelength. The fibres employed are typically 5m long. This pumping action causes electrons to be raised up to higher energy levels within the erbium-doped section.

Photons of light passing along the erbium section can cause these electrons to release their 'pumped' energy in the form of stimulated emission of radiation. 'All-optical' amplification has taken place. More importantly, it has taken place without the need to convert the photons to electrons and back again. Figure 8 shows the energy level diagrams for an erbium-doped ZBLANP fibre pumped at 514nm.

While it is possible to show optical gain at a number of wavelengths, there is a considerable variation in pump efficiencies. In particular, gains per unit of pump power are considerably higher at 532nm and 980nm, when compared to other wavelengths. Good performance has also recently been reported, using a pump wavelength of 1·49 microns.

Particularly encouraging results have been obtained from the use of erbium fibre pumped with light from a 978nm GaInAs/AlGaAs quantum-well diode-pump laser. While initial gain values of 20dB were achieved with a pump input power of 6·2mW, it is currently anticipated that gains of at least 40dB will be possible, with devices able to pump to 20mW of power. Figure 9 shows a typical performance curve of output power, as a function of input power, for an Er/Yb doped fibre pumped with up to 12mW of power derived from a 810nm GaAlAs laser diode.

As the technology of erbium-doped fibres develops, there is confidence among the group at Southampton that their system will significantly out-perform their direct rival, the semiconductor optical amplifier. Setting aside problems relating to polarisation dependence and coupling losses, the signal pattern-dependent gain variations of semiconductor optical amplifiers remain their most serious drawback at present.

The technology of erbium-doped fibre amplifiers has indeed passed out of the laboratory and into the commercial marketplace – 'taking the world by storm'! Significant research is still continuing, however, into optimising the function of such devices. Key areas being investigated include increasing gain, and improving the efficiency of amplifier stages.

One critical factor of these systems relates to the reliability of the laser diode – bear in mind that they are driven hard. Reliability is particularly important in undersea links, where a life of 25 years or so is expected.

There has been increasing interest in the use of thulium-doped fibres for a range of applications including light-wave amplification, gas sensing and ranging. There is also growing interest in using erbium-doped fibres as lasers in their own right, for signal injection in telecommunications applications, and not just as signal regenerators. Their main attractions are that they can be readily coupled into fibre links, and that laser fibres have much smaller line widths compared to diode lasers. Rare-earth doped fibres with line widths as low as 10kHz, compared with 1MHz for diode lasers, have been reported. In terms of multiplexing signals along a specific fibre, this implies that 100 times as many rare-earth channels could be accommodated in the same spectrum occupied by a single diode laser channel.

There would also appear to be considerable scope for 'designer' laser fibres, which could be conditioned to perform in highly specific ways. Researchers appreciate that they have so far only investigated a very small set of the total possible range of fibre structures. The group at Southampton stress, however, that future work is likely to extend significantly the range of applications of such technology.

The fabrication technology being developed for specialised fibre-optic links is also paving the way for the conception of planar waveguides and the optical 'printed circuits' of the future. Clearly it is this type of technology which is 'going places'.

New Means of Fibre Channel Connectivity

It is one thing to be able to pass signals at very high data rates along fibres; problems arise, however, when it is wished to switch data between fibres in a flexible and economic way. Developments in wider aspects of optical transmission technology are now paving the way for 'all optical' methods of switching fibre channels. This is analogous to the 'all optical' methods of channel amplification. In the future, all possible processes will be implemented at the level of photon-photon interaction. This does away with the need to convert between light and electronic signals.

Fibre Communications and Society

The process of global integration is taking place mainly as a result of growth in communication structures – now highly dependent on fibre optics. As the number of telephone subscribers in the world increases, and the amount of traffic grows through developments in commerce and industry, research into improving the cost-effectiveness of telecommunications infrastructure will be motivated correspondingly. A country with high-cost telecommunications is going to be more and more at a trading disadvantage.

In this 'information age', vast amounts of data on virtually every topic is constantly being generated. We should examine if the best use is being made of this data – for personal use, commercial and industrial development, education, environmental monitoring, health care and national security. Fibre optic technology is, as it were, a key link in making a global circuit on all of these aspects. It is up to key groups of individuals in all of these areas to ensure that the available facilities are used for the good of all. After all, the use of technology these days does not really concern the technologist.

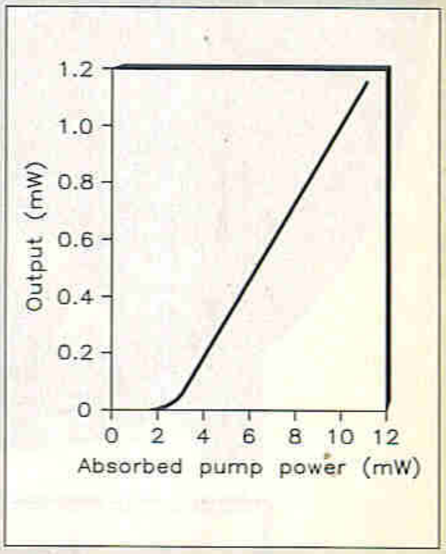


Figure 9. Typical amplification characteristics of an erbium-doped fibre amplifier pumped with 15mW of power from a 980nm dye laser.

Acknowledgements

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THE FASCINATION OF VINTAGE RADIO

Part Three Devices, Instruments and Data

by Geoff Arnold

Putting together a collection of vintage radios is one thing, but unless you simply want to restore the cabinets, a collection of relevant data is essential. Back in the days when valves reigned supreme, many books and magazine articles catered for the novice and expert alike, of which most are still eminently readable. The sources of such material, vital if you need to understand how valve circuits work, are given in this article. Of course, such information is collectable in its own right, as are 'point-of-sale' advertising displays, vintage QSL cards, the valves themselves – and even the corrugated cartons in which they were packed!

If you become hooked on collecting vintage radio sets, no matter whether they are from the amateur, domestic, military, or other professional fields, you will soon find that you need valves to repair them. Of course, you may intend simply to put the sets on a shelf to admire the appearance of their cabinets, and never plan to take the back covers off. In that case the odd empty valve holder does not matter, although if you have a liking for the sets from the earliest days of radio, when the valves were proudly displayed to view rather than being hidden away inside the cabinet, you will have to think again.

Some types of valves are now much easier to come by than others. Most difficult of all to find are the very early 'bright emitter' variety. With the primitive materials technology available at the time, it was necessary to heat the filament to a very high temperature to produce the required flow of electrons inside the valve. The high temperature made the filament glow as brightly as that in an electric lamp. The light from the valves was so intense, in fact, that you could reputedly read a newspaper whilst enjoying listening to a broadcast programme of music. An early form of energy conservation, I suppose!

If, like most collectors, you want your treasures to look authentic, and preferably to work as well, you do need valves. Obviously, if the sets are to work, the valves fitted must be of the correct type – as originally specified by the set manufacturer – or at least an acceptable equivalent or alternative type. Sometimes, as a last resort, a set for which one or more valve types are now totally unavailable can be modified by making a few wiring or component changes, so that comparable valves can be substituted.

The purist collector will rebel violently at such an idea, and a set modified in this way is likely to fetch a lower price should it subsequently be sold. In the end, the decision is up to you. You can rest assured, though, that slotting a valve of the wrong era into an otherwise vacant holder will soon be noticed by an expert who sees it. The replacement valve need only be a year or two out to attract comment!

Valves and Tubes

Searching for rare and interesting valves and tubes, and putting together a collection of them, can become an end in itself. I am using the term 'tube' to cover the cathode ray tubes used for the display in oscilloscopes, and also those, now more commonly called 'picture tubes', used in television receivers. It is well to remember, though, that 'tube' is also the American name for the valve.

As with any other branch of collecting, there are all manner of themes which can be followed when assembling a collection of valves. The valve collector has one important edge over the set restorer, in that the valves in a collection do not have to be in a working state. They can have burnt-out heaters or filaments, even internal inter-electrode leaks or short circuits which would render them useless in a working set. The only unacceptable damage would be the cracking of the glass valve envelope – allowing air to enter, producing that characteristic 'milky' deposit on the inside of the glass.

Left: On the left is an American Audion valve, made in about 1914. The 3·5V 'Hudson' filament is mounted at the centre, between two zigzag wire grids with the two anode plates on the outside. A Hudson filament used fine tantalum wire, a good emitter of electrons when heated, wrapped around a tungsten heater which gave improved mechanical strength, reducing the chance of the filament assembly warping and touching the grid. On the right is a Naval triode Type NT.9X, manufactured by the MO Valve Co. circa 1920. The filament connections are made via the E12 screw base and two wires stretching up the outside of the valve to the top. The anode and grid connections are on flying leads.

Bottom Left: A display of receiving and small transmitting valves dating from 1915 to 1965, photographed at the Amberley Chalk Pits Museum in West Sussex.

Bottom Right: In 1925, the Metropolitan Vickers Electrical Co. Ltd. (Metrovick) introduced the SP.18 series. SP stood for 'short path', a totally new design principle that allowed a closer electrode spacing, and therefore higher gain, than had previously been possible.

Another advantage of a valve collection over an equipment collection is that it will occupy a lot less space, unless of course you decide to collect large transmitting valves or TV picture tubes. A very attractive display of receiving, and small transmitting, types can be put together in a glass-fronted cabinet or showcase, or on a large board with the valves secured to it by means of looped wire.

A variation on the valve collection theme is a collection of the cardboard cartons in which the valves were supplied by the manufacturer. In the early days of valves, there was an enormous variety of small manufacturers as well as the famous names who survived to later years. Many of the cartons were very colourful, and some also carried technical details of the valve contained within. Further details were often found on leaflets tucked inside the carton or wrapped around the corrugated cardboard packing which surrounded the valve.

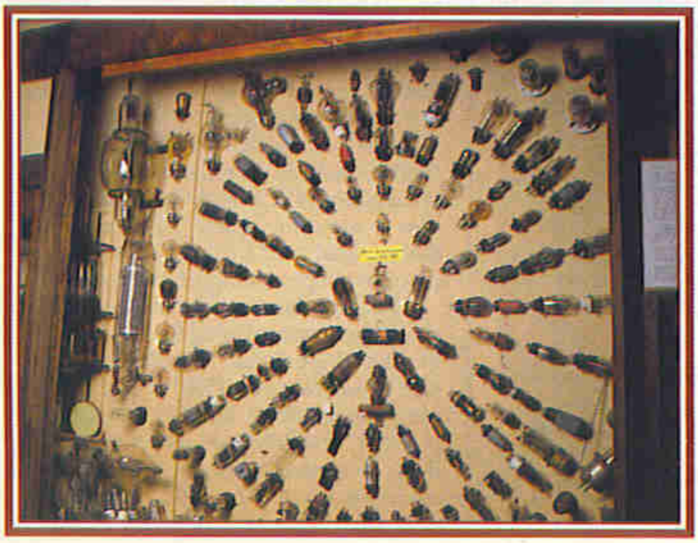
Obviously, the cardboard used for the carton will have deteriorated and yellowed to some extent over the years, depending on how it has been handled and stored. You may find end flaps torn or perhaps missing altogether. The printing inks used will have faded too. For these reasons, you will be very lucky indeed to find many cartons in a bright, 'mint' condition, but for a really rare item this is not the end of the world. For an item that is not quite so rare, there is always the chance of finding a sample in better condition at a later date.

Valve Data

If you are involved in the restoration and repair of valved equipment, you will very soon find a need for some sort of technical data to help you identify the pins carrying the various electrode connections in a particular valve, and find out typical values of working voltages and currents. You may well have a circuit diagram, or even a full service sheet, for the equipment you are working on and, in theory at least, all of the essential information will be included there. Unfortunately, this isn't always the case. Should you be faced with a faulty set without any circuit data, the valve type numbers will provide you with a starting framework from which to build your knowledge of the set and, with luck, to restore it to working order.

Valve manufacturers have, over the years, provided all manner of data for users of their products. The form and extent of this data falls basically into three categories. First, there are bulging volumes of tables and graphs giving full performance and design parameters for use by R & D engineers. Typified by the Mullard Technical Handbook series, a collection of these from a major manufacturer may take upwards of a foot of space on your bookshelves. Somewhat less comprehensive, and certainly less demanding of storage space, are the data manuals produced by the likes of Brimar in the UK, and RCA in the USA. These give a broad sweep of information on a manufacturer's complete product range in a paperback book around half an inch thick. Finally, there are the pocket-books containing brief details of pin-outs and nominal voltage, current and gain figures for service engineers. Unless you are planning to get involved in circuit design and analysis at a fairly advanced level, I would say that the second and third categories are probably more useful overall, since they usually contain helpful tables giving type numbers of equivalent and comparable valves, and sometimes typical circuits using that manufacturer's products.

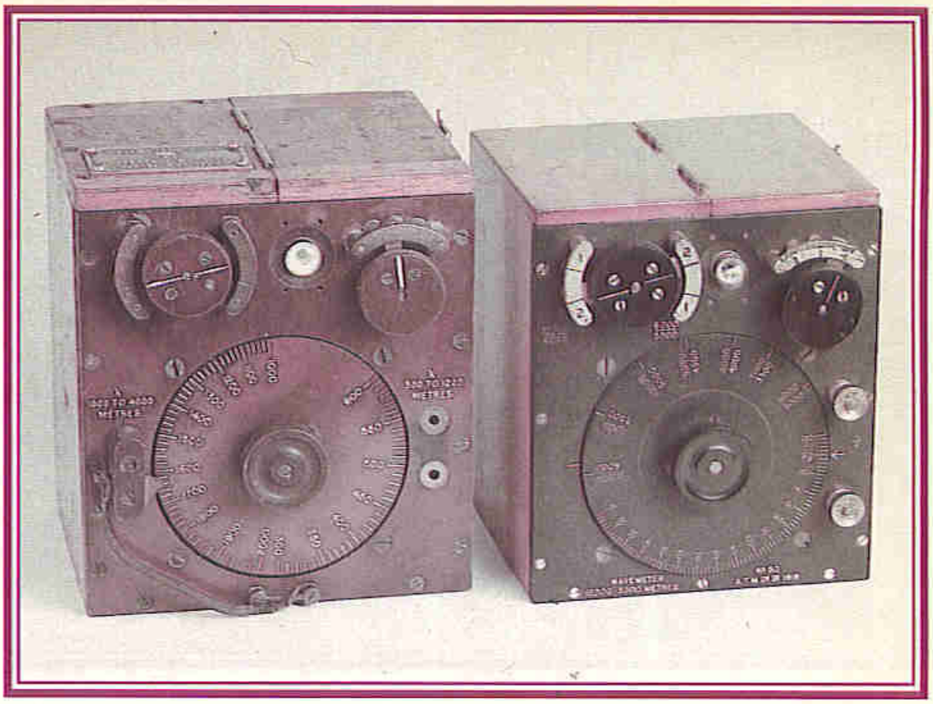
Following the enormous growth in the number of valve types that occurred during the Second World War, several publishers began to produce data books giving brief details of the characteristics and pin-outs of all the major valve manufacturers' products. Perhaps best-known of these was *Radio Valve Data* produced by Iliffe



(publishers of *Wireless World*) which first appeared in 1949 and ran through some ten editions, expanding later to include semiconductors. Other well-known books were the set of five compiled for Bernards Publishers by Bernard Babani between 1951 and 1963, and the *International Radio Tube Encyclopaedia* from the same stable. Unfortunately, all of these books are long out of print, but copies do turn up at radio rallies, car-boot sales and second-hand book shops from time to time. If military radio equipment is your field of interest, look out for copies of official publications which were produced. These give a similar range of data for valves used by the armed forces, including listings of type-numbers of commercial equivalents indexed against the military type and stores codes.

If valve collecting for its own sake becomes your interest, you will soon find the need for information on who made what types and over what period, the backgrounds of the different manufacturers, company takeovers and so on. There are some unexpected names from the early days of valves. For example, the logo of Ever Ready, now well-known for torches and batteries, once appeared on valves, although these were made for them by Mullard. Similarly, the name of BSA Radio Ltd, an offshoot of arms and bike manufacturer BSA (standing for Birmingham Small Arms) once appeared on valves made for them by Standard Telephones and Cables (STC).

This sort of information can be painstakingly gathered from catalogues and advertisements of the period, and occasionally from company histories, but is far easier to find in reference books produced by other enthusiasts who have already carried out the hard research. Perhaps the two best-known titles are *Saga of the Vacuum Tube* by Gerald F. J. Tyne, published by Howard W. Sams, and *70 Years of Radio Tubes and Valves* by New Zealand valve historian John W. Stokes, published by The Vestal Press. Although both are American publications, they cover manufacturers from all parts of the world. They are stocked in the UK by the Vintage Wireless Co. Ltd, Tudor House, Cossham Street, Mangotsfield, Bristol, BS17 3EN.



Two Townsend wavemeters from the First World War era, covering between them the range 300 to 12,000 metres (25kHz to 1MHz).

Lamps

The valves used for radio detection and amplification had their origins in experiments carried out on electric filament lamps by Thomas Edison at the end of the last century. This affinity between the lamp and the valve has led some valve collectors to include examples of early lamps in their collection. Indeed, they can be a fascinating field in their own right.

Semiconductors

Collectors whose interest in vintage radio comes to an end with the passing of the valve era consider any device not containing a filament or heater to be beyond the pale. However, in reality the semiconductor diodes and transistors of the 1950s have now become collectors' items which merit preservation as examples of just another stage in the development of radio. In this, they are already being followed by the early integrated circuits.

Test Equipment

Serious work in restoration and repair of any radio or electronic equipment requires a workshop equipped with a basic complement of suitable instruments. First, and most important, of these is a suitable multimeter. Voltage readings given in manufacturers' equipment manuals and service sheets will have been based on the sensitivities of the multimeters of the day. These are likely to have ranged from 333 to 1000 Ω/V in the 1930s and 40s, to match the DC sensitivities of the AVO Model 40 and Model 7 and the like, rising to 10k to 20kΩ/V over the 1950s and 60s (AVO Model 8 and 9, etc.).

Voltage checks using a modern high-impedance DMM may produce very different answers to the figures recorded in the service data, and you would need to make due allowance for this in any fault-finding analysis. To reduce the number of calculations which might be involved, it is best to use a multimeter of similar sensitivity to that used by the equipment manufacturer in producing his service data.

The second test instrument required is a signal generator covering the frequencies of interest. These should at least be the broadcast bands between 150kHz and 22MHz, plus perhaps 88 to 108MHz for the more modern VHF/FM sets. For communications receivers, however, a wider range could be involved. Published data for broadcast receivers does not generally

Three lesser-known names from the early 1920s. The 362 Radio Valve Co.'s range included a special version of the SP2, for use in the Scott-Taggart ST600 receiver. Lowden was a trade mark of the Fellows Magneto Company. The Thorpe K4 was a space-charge tetrode, produced by Bower Electric for use in the Unidyne receiver, a revolutionary design which claimed to work without any HT supply! The rarity of this valve amply justifies the inclusion of this somewhat tatty and faded carton in the Journeaux Historic Wireless Collection.

include sensitivity figures, so you would be simply aligning for maximum response. For communications receivers, the data provided is usually sufficient to carry out full sensitivity and selectivity performance checks as well as realignment.

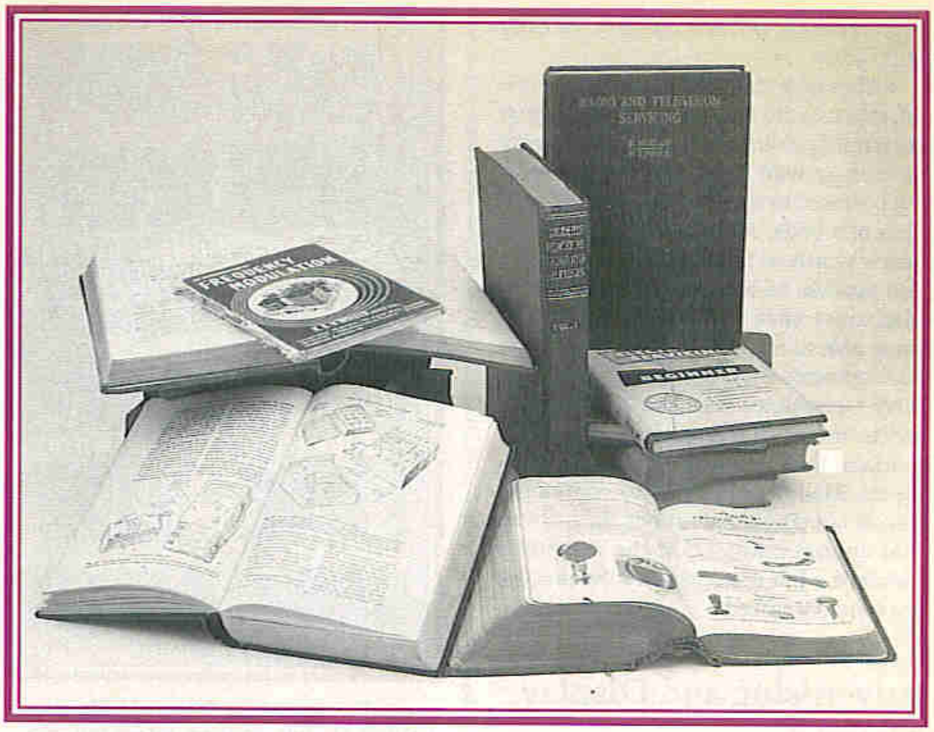
Because the selectivity in the IF amplifiers of valved receivers depended upon LC tuned circuits, rather than the pre-tuned crystal, ceramic or mechanical filters used today, a sweep oscillator or 'wobbulator' may also be essential. At the very least, such a piece of equipment will be a great time-saver when IF realignment is called for. You will, of course, need an oscilloscope to display the swept frequency response.

The last instrument that I would put in the 'essential' category is a valve tester. The days of being able to pop down to your local radio shop to have a set of valves tested are long gone, and you will require your own tester, or perhaps access to that of a friend. Luckily, ex-military valve testers such as those produced by AVO are fairly widely available at radio rallies at reasonable prices, but if you invest in one make sure that you get a copy of the accompanying valve data book with it. As a last resort, copies of the last book published are still available from AVO, but one will set you back almost as much as the tester itself!

A versatile valve tester, the 'Test Set, Electronic Valve CT-160', produced by AVO for the Ministry of Defence, and now widely available on the surplus market.

By the time that you've collected together this minimum set of instruments, you may well find your interests aroused in the instruments themselves. Yes, there are people who collect just test equipment; in fact, some even specialise in particular instruments. I recently heard of someone who collects valve testers, and apparently has around forty different models!

As with communications receivers, the controls fitted to most test instruments are many and varied, and it is absolutely vital that you obtain at least an operating handbook, or better still a full technical manual, for any instrument that you buy.



Just a small selection of the old wireless books that you can find if you look in the right places. Among them are several of the famed *Radio and Television Servicing* guides – essential information for those wishing to restore more recent valve equipment (1950s onwards). Reference copies can often be found in the larger libraries.

Books and Magazines

As mentioned in an earlier part of this series, a number of books have been written in recent years on the subject of vintage radio. However, it is the collecting of old books and magazines that I shall be looking at in this section.

It is fascinating now to read text-books on radio engineering from the first half of this century. If your interests extend to electrical engineering and to telegraphy, you will find even earlier books to catch your imagination – the earliest title in my own library is on the subject of landline and submarine telegraphy, and dates from 1878. Each book will provide a 'snapshot' of what was often the 'state-of-the-art' technology of the time.

Continuing research over the ensuing years has of course improved our knowledge, and you will find explanations in the old books which we now know to be untrue – and even occasionally downright rubbish! However, much more material is still valid, often providing a useful introduction to topics which present-day texts can tend to over-complicate.

I could not begin to list all the thousands of books on radio engineering that have been written since the turn of the century, but I shall try to pick out a handful of the most interesting and useful. You should be able to pick up any of them second-hand.

On the general theory side, the *Admiralty Handbook of Wireless Telegraphy* is arguably the best known, many of today's more mature engineers, technicians and enthusiasts (myself included) having been raised on the 2-volume edition dated 1938. Produced under the editorial direction of a naval officer called Louis Mountbatten, it contains some material (for example on wire aerials) which has never been bettered for its clarity of explanation. Because it was reprinted in large quantities until well after the Second World War, the *Admiralty Handbook* is quite widely available on the second-hand market.

For a comprehensive treatise on valves, and the design of valved receivers and audio equipment, together with their associated loudspeakers and power supplies, etc., there is none better than the *Radio Designer's Handbook* by Langford-Smith, published by Iliffe. No valved-equipment enthusiast should be without a copy on their bookshelf.

Another standard title from Iliffe is Scroggie's *Radio Laboratory Handbook (Radio and Electronic Laboratory Handbook* in later editions), which explains the features and use of a wide range of test instruments. It also includes circuits for DIY versions and add-on bits and pieces, and gives guidance on setting up a lab, recording and analysing results, etc.

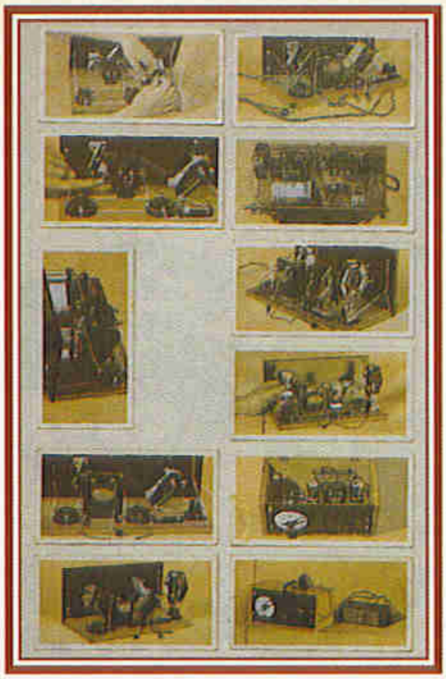
For circuits and servicing data on domestic radio and TV receivers, the *Radio and Television Servicing* series of volumes published by Newnes (later taken over by Macdonalds) is probably the best known. Be warned, though, that putting together a set of these can be a frustrating exercise, since between 1950 and 1961 no fewer than ten editions were published, each comprising anything between one and seven volumes. In each edition, the new season's sets were added, some information on earlier sets was repeated while some was deleted. The snag is that no publication dates or edition numbers were included in any of the editions produced over those years. To take an extreme example, a volume covering radio sets from 1955-56 could have come from any one of six editions.

Look out, too, for books from the pens of the likes of F. J. Camm, John Scott-Taggart, Ralph Stranger and F. E. Terman – and for almost any of the annual 'yearbook' or 'pocketbook' publications from the early radio years.

Although a single edition of a textbook informs us as to the state of technology at the time of publication, the development of technology with the passing of the years can be traced by a study of succeeding editions of a book. A glance through several year's worth of technical magazines can also provide us with similar information. Magazines have the dual advantages of being able to report more quickly on new developments than books can. They also carry (sometimes fascinating) advertisements, in which manufacturers proudly proclaim their new models and developments. Many textbooks also commonly carried advertisements at one time – even that august publication the *Admiralty Handbook* – but more recently the practice has virtually ceased.

Advertising and Display Material

Advertisements in magazines and books have already been mentioned, but radio manufacturers have also, over the years, produced much in the way of posters and displays intended for use in shop-windows, at exhibitions, and so on. Being largely composed of paper or card, such material has unfortunately for the most part been destroyed, and its rarity imparts a high price to that which has survived.



A set of 25 cigarette cards issued with Godfrey Phillips cigarettes, giving full step-by-step instructions on how to build a 2-valve (detector plus audio amplifier) receiver. They carry no date, but were probably produced around the mid-1920s.

Cards

Anyone familiar with amateur radio will have come across the often colourful and inventively designed 'QSL' cards exchanged between two stations in acknowledgment of a radio contact between them. ('QSL' is a radio procedural code meaning 'I acknowledge receipt'). Collections of QSL cards – for example those received by early amateurs famous for their pioneering research and experimentation – are much sought after by some enthusiasts. There is also scope for 'theme' collections, such as the cards related to Morse communication featured in a series currently appearing in *Morsum Magnificat*, the Morse magazine published by G. C. Arnold Partners, 9 Wetherby Close, Broadstone, Dorset, BH18 8JB.

There have been other forms of cards with radio associations. For example, there was a set of playing cards for a game similar to 'Happy Families', which was based on the early UK national and regional broadcasting stations rather than tradespeople.

Then there were sets of cigarette cards, patiently collected packet by packet, which gave fully illustrated instructions on how to build a radio receiver. These last two categories, together with occasional postcards which have appeared on radio topics, are quite rare, and you will be very fortunate indeed to come across any being offered for sale. Keep looking, though, for you never know your luck!

Next Month

In the fourth and final part of this series I shall be looking at the methods and materials involved in the restoration of vintage radio sets, how to maintain an original appearance, and the pros and cons of making modifications.

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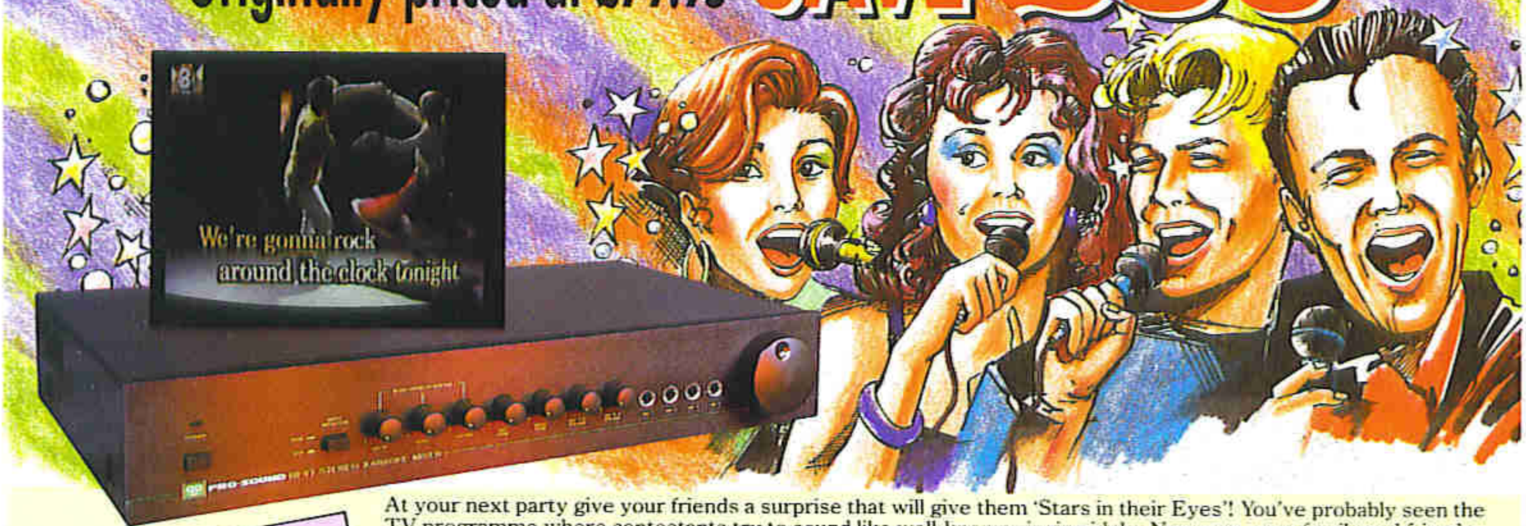

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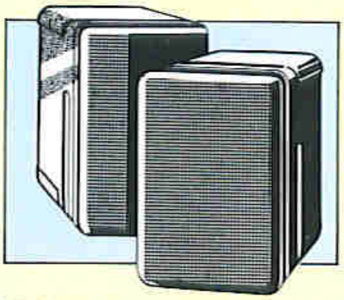

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	£2.55	AMPLIFIED SPEAKERS	50065	£49.95	
	£1.40	3 MICROPHONE PACK	50066	£19.95	
				Total Carriage	
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