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No. 63

ELECTRONICS

The Maplin Magazine

MARCH 1993 · £1.75

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EDITORIAL

Hello and welcome to this month's varied offering of electronic projects and feature articles.
Continuing this month is the LED Moving Message Display System. For those of you who have already built a display module or two, this month's instalment describes interfacing and software testing. The construction of the controller module, necessary for expanding the system, is also discussed.
If you're one of the many people who opted for the ill-fated BSB satellite TV system, then Martin Pipe's feature on renovating old satellite receivers will be of particular interest. He explains how you can give your old receiver a new lease of life – dealing not only with BSB receivers, but also how to add more features to Astra receivers as well.
Environmental issues are very topical at the moment, particularly in the respect of using renewable energy sources to reduce the amount of electricity generated by fossil fuel burning power stations. Stephen Waddington looks at the pros and cons of wind turbine based systems.
There is of course a whole host of other projects and features in this issue, plus all the usual 'regulars'. 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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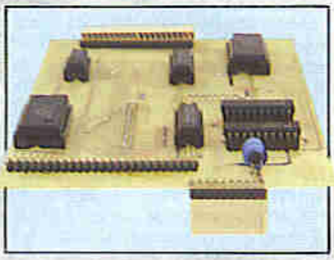
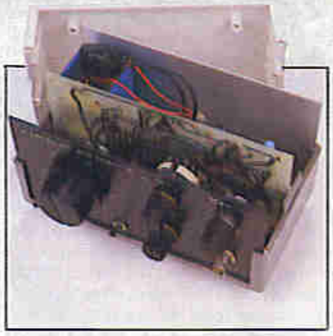
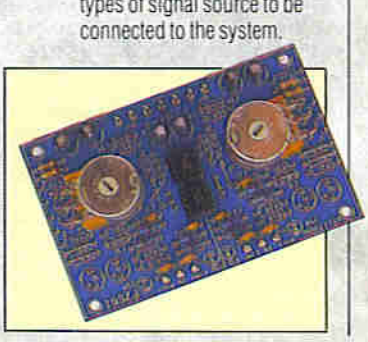
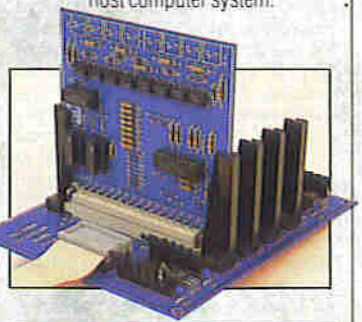
Cover Picture: Wind Generators, California, USA.

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 5th February 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

Longer-Life Bulbs

Long-life low-wattage bulbs from companies like GEC Thorn and Osram came to the fore only a few years ago. Employing a fluorescent design, the bulbs caught on with the 'green' desire to conserve energy and use natural resources to the full. Against their favour is the price tag of between £10 and £20, and the inability to dim the bulbs for those intimate moments.

Now a product costing less than a fiver promises to extend the life of normal incandescent tungsten light bulbs. Though not reducing energy consumption, Bulbsaver is guaranteed to extend the life of household bulbs more than ten-fold. Trials which commenced in 1979 are still in progress, with the lifetime of the bulbs now beyond 85,000 hours – 85 times rated life.

Essentially an elaborate transient suppressor, the Bulbsaver is mounted behind the wall switch, and any undesirable mains transients and spikes are 'swallowed' preventing damage to the bulb. Loading can be up to 1000W, suitable for circuits with multiple lights or even chandeliers.

Disappearing Data

Have you been plagued by disappearing data on your hard disk? The chances are that it is not due to a virus, but an operating system bug found in some versions of Microsoft IBM PC-DOS and MS-DOS versions 4.01 and 5.0.

The problem occurs when using CHKDSK with the /F switch on drives with more than 65,278 clusters – about 128 megabytes for those without calculators. If you have suffered problems we suggest you contact your software supplier or Virus News International for assistance.

HDTV – TV Hell?

The conclusion of a recently published report is that the horrors of modern day television could be amplified hugely by the introduction of High Definition Television (HDTV). The report from Worcester Polytechnic Institute, Massachusetts considers the technological and sociological implications of the introduction of the new screen format.

In its favour, the report intimates that television will become an even more real and influential medium. Current TV filming uses close-ups to make the best use of a small screen; with larger screens, producers are likely to use less active camera work and show more detail, so enhancing the viewer's intimacy and the reality of the image.

The possibility that the new medium will generate a new breed of armchair recluses is also considered. The days of the television seen as moving wallpaper will be over – it is claimed that viewers will find it hard to ignore a HDTV screen and television viewing figures will increase (what a horrible thought – what would those terrible soaps do to our brains if we actually watched them? – Ed).

A major concern of the report is that of the potential take-up of the new television format. HDTV enthusiasts claim that anybody who sees the images will never be satisfied with anything less again. Against that, research in the USA has shown that most of the NTSC TV sets have misset 'hue' controls and are permanently tuned to the video channel, the latter enabling channel-changing via the VCR's remote control so that only one remote is required. In addition, most video recorders are invariably set to one of the long-play modes to conserve tape usage (In the USA, VHS video machines can be set to run at a third speed – 'EP' – that runs at a third of the normal speed. It is often dubbed as 'extra poor' for obvious reasons...). All of this suggests that viewers are totally indifferent to image quality. The same comments apply here in the UK, where viewers are content to put up with the results of grey-scale, linearity and convergence errors on their TV sets, ghosting caused by badly-installed aerials, and the poor picture quality associated with Videocrypted satellite channels.

The more likely outcome is that the widespread introduction of HDTV will be driven by programme makers. For a transitional period programmes will have to be broadcast in both HDTV and traditional formats. Budgetary constraints will almost certainly prevent producers from making two versions of the same programme, and so the HDTV format will be selected for reasons of versatility. Viewers with conventional television sets will have to endure black bands at the top and bottom of the screen and only 75% of the broadcast picture – this is because the 16:9 aspect ratio of the HDTV picture is not compatible with the 4:3 aspect ratio of a conventional picture.

Though most of the main conclusions of the Worcester report are speculative, many of the questions posed are certain to arise; those likely to be involved in the future of HDTV would do well to take note.

Intel Finally Launch 387 SX Co-Processor

The Intel Corporation have at last announced the availability of their 33MHz 387SX maths co-processors, which are designed to work in 33MHz SX CPU-based desktop and portable systems.

Over 2,100 business and scientific software programs are specifically written to use maths co-processors, so that they run up to five times faster than they would if they used the microprocessor alone. These programs include spreadsheets, computer-aided-design (CAD), desktop publishing, graphics and database programs.

Having a manufacturer's suggested list price of £72, the Intel 387SX is now available from major retail outlets and Personal Computer distributors.

The Quango Speaks

An interesting read is the 'Telephone Service in 1992' report from OFTEL, the telecommunications watchdog. This is a compilation of statistics generated by various surveys that look at how competently BT and Mercury have provided their services in the past year. BT's rate of first-time connection failure has been reduced to 0·2% for local calls, and 0·3% for national calls, although we are not given last year's figures as a comparison. This improvement is one of the 'dividends' of the BT modernisation programme, according to the report. Unfortunately, the modernisation programme did not help in certain other areas, such as fault repair, installation and customer services, which have dropped in quality when compared to the same period in the previous year. Despite this, the proportion of people quoted as being 'very satisfied' with BT's service – 31% out of a NOP sample of 1,906 – is the same as it was in 1988, while the proportion of those fairly satisfied rose by 3% to 55% in the same period. In addition, the percentage of very dissatisfied users more than halved to 2%.

Most of the written complaints directed at BT concerned disputed accounts (3,424 out of a total of 10,127) – in descending order the next most significant complaints were: method of payment and payment difficulties (1,785); charges/prices (1,540); and quality of service (846). Payphones came way down on the list (168 written complaints), indicating that BT is doing its best to ensure that most are in good working order.

The OFTEL report congratulates Mercury for reducing its call failure rate to around 1% in the second quarter of 1992. This figure appears much higher than that of BT's, but cannot be directly compared as Mercury's test programme covers only the busy weekday hours, when failure is more likely.

One of the most interesting points raised in the report is that of ignorance on the part of the telephone user. For example, 10% of a sample of 2,043 people (aged 15 or over) did not recognise '0839' or '0891' as being premium service suffixes. Perhaps this is because certain providers of such services do not provide the obligatory calling rate information (Radio 1 take note!) that identifies a call as a premium rate one. Even '0898' was only correctly identified by 44% of the sample – the rest said that it was not, or that they didn't know! Half of those involved did not know, or would not guess, the cost of such calls. No wonder so many people gasp when they receive their phone bills. A clear case for educating the public – although the providers of such services would be reluctant to do so for obvious commercial reasons! On a positive note, a NOP survey carried out in March 1992 revealed that the majority of the sample (84% out of 1,922 people) knew that BT could provide itemised billing. Only 18% of a NOP survey of 1,932, however, knew that they could ask BT to inform them of price changes – a lesson to us all.

The number of nuisance calls (excluding telephone selling, a nuisance in its own right!) received in 1992 was estimated to be 10 million – the same number as in 1991. Recipients of nuisance calls might like to know that in most cases BT can trace such calls (not much point if the call comes from a phone box!) – apparently half of the women who reported such calls were not aware of this. A welcome development is that of CLI (Caller Line Identification), where the number of the caller is displayed to the recipient. Such a system has been implemented by certain American networks for some time now – and its consideration by BT and Mercury is clearly no bad thing, as was reflected in the inevitable survey; 76% of a sample of 1,922 people would welcome the general availability of such a scheme – provided they didn't pay too much for it! Most (two thirds) of the survey objected to an additional charge of 50p to stop the number being displayed at the other end.

A notable omission from the report is that of mobile phones – this is set to change with the publication of the 1993 report. In the words of Bill Wigglesworth, the Director General of Communications, it has "proved difficult to develop satisfactory measures of quality of service" in this area; thankfully, they now have. Whether mobile phone users are prepared to accept often appalling intelligibility and excessively high costs (in particular, you pay for a call to a mobile phone even if you don't get through!) as a trade-off for portability will be made clear – statistically at least!

Brighter Road-Side Flasher

The flashing yellow Belisha beacon, introduced by 1930s transport minister Leslie Hore-Belisha, has long since become invisible against a background of improved street lighting, dazzling shop fronts and a plethora of advertisement hoardings. To assist drivers and make the beacons more visible a company called Geo Safety Products, in collaboration with ICI Acrylics, have created a more effective design.

The reflective and refractive properties of the original beacon have been enhanced through the use of a fluorescent dye in the material, and by patterning the interior of the beacon with inverted rhombic pyramids. Now named 'Visibeacon', the new device combines a brighter shade of yellow with improved optical features whilst maintaining the existing shape and, within a slight margin, cost.

New Fax and Photocopier Combined

The fax machine is a wonderful invention. It's a pity, though, that most rely on an outdated thermal printer mechanism. The documents which curl out have to be re-copied to ensure that the information can be retained without risk of it fading – hardly an 'environmentally friendly' solution. One manufacturer who has, at last, caught onto this fact is Konica – a company which have just launched a combined plain paper fax and photocopier.

By using plain paper, the Konica 810L cuts running expenses by half, as there are no recopying costs and the need for expensive rolls of thermal paper is eradicated. Pages can be taken straight from the 810L, and circulated or filed without having to be copied, and there is no fear of documents fading.

Other cost-saving features include the ability to delay non-urgent transmissions until after 6pm, so taking advantage of cheap-rate calls. Up to thirty pages can be automatically faxed at a time; 99 copies can be made from one original and special modes ensure the best possible results, even when faxing or copying from poor originals.

The Konica 810L has a range of labour-saving features, including automatic dialling of up to 90 locations, group and chain calling, polling and automatic redialling.

Incoming documents are automatically cut to A4 and received face-down, so that the pages arrive in the correct order, ready for distribution. Other special features include a secure mailbox for confidential faxes, and a closed user-group option for restricting unauthorised access.

Portable Data Entry

ACS Data Ltd has entered the mobile computing market with its first product, TouchPC. Incorporating an analogue touch-sensitive screen, the device is likely to find its way into an array of data entry applications.

Ready to provide user-configured systems tailored to client requirements, ACS have previously based design solutions on other manufacturer's hardware. Having recognised that pen-based machines are too expensive, too big and impractical, the Salford-based company have spent efforts on developing a more user-friendly data entry interface.

Based on a 320 x 200 pixel CGA display, the TouchPC is totally PC compatible, aiding future application development. Measuring 213 x 115 x 52 millimetres, the new portable weighs in at one kilogramme – prices start at £1,050.

Citizen's Charter Published

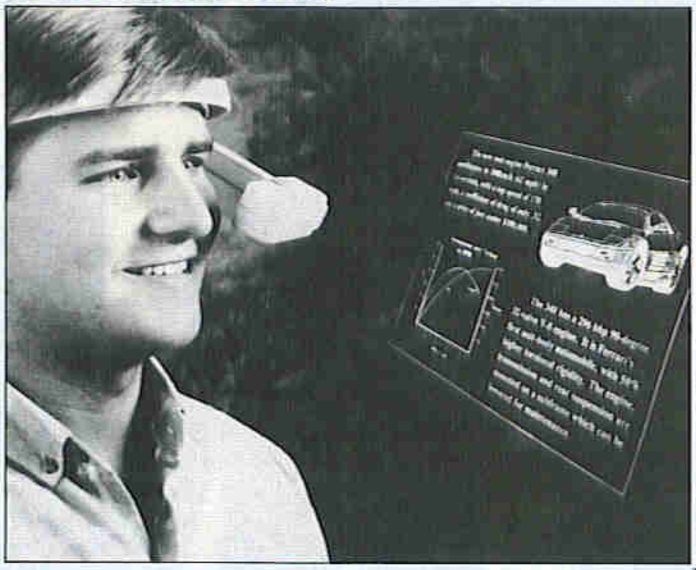
Oftel is calling on the performance standards that should be set for both BT and Hull based Kingston Communications under the Government's 'Citizen's Charter' initiative. Mercury, however, is exempt, as it does not have a big enough slice of the market to qualify. The new powers will relate to such services as voice telephony, directory services and public call boxes. The standards will relate to the speed of fault repair and the percentage of working call boxes.

Spider Comes First

A new Multi-Protocol Terminal Server has been announced, from Spider Systems. The company believes that their SpiderPort M250 is the first terminal server to support a fully GOSiP (GOvernment SPecification) ISO Virtual Terminal Protocol.
Details: (031) 554 9424.

Meanwhile, an independent survey has highlighted the lack of awareness and understanding of Open Systems outside the world of IT. Apparently the Hewlett-Packard survey found that 62% of respondents either did not know what Open Systems was about or had not heard of it. Other points highlighted covers training, data security and systems maintenance, and the need for more user-friendly machines.
Details: (0344) 369369.

Portable Visual Reality



According to VR authority Howard Rheingold "there is virtually no reality which cannot be simulated electronically". Now a remarkable, ultra-miniature display unit, the 'Private Eye', can create a virtual image of a 12in. screen floating in space approximately two feet in front of the viewer. The display can be held in the user's line of sight by mounting it on a headband, or attaching it to a headset or helmet, or, for occasional use, it can be worn on a wrist-strap or neck-band.

This achievement, which can display text or graphics, means that now computing power and mass data storage can be truly portable. The Private Eye, when added to other technologies such as CD-ROM mass storage, hand-held mouse controllers or voice actuated software, provides the potential for an amazing range of new products – such as pocket computers and electronic books. Other hands-free applications such as viewing technical data and instrumentation for maintenance, test and measurement are also possible.

Inside the module is a line of tiny LEDs. An oscillating mirror, driven at a nominal 50Hz by a piezo-electric actuator, makes a raster and as it does so video information is fed to the LED array to produce each line of the picture and create an image. Resolution of the standard version is 720 by 280 pixels, corresponding to 25 lines of 80 characters. The oscillating assembly is mechanically resonant, hence little power is consumed in operating it. A frame store chip eliminates the need to synchronise with the external video source. The kit is available from the UK agent InfoDisp at £632. Details: (0420) 479791.

Wake-up Call for Personal Computers

A device from Dallas Semiconductors is claimed to be the first PC-compatible time-keeper. Allowing scheduled tasks to commence without operator intervention, the DS1587 incorporates power control circuitry and an additional date alarm register to facilitate automatic power-up. The main area of application is expected to be computers that require database information at the start of a day prior to normal operation.

The device could also be programmed to switch on at the response of a modem ring signal. Combined with a computerised fax system, the DS1587 would allow faxes to be received after a computer had been switched 'off', so relieving the need for fax machines in small offices.

Surveys – a Growth Industry?

Cordless telephones, says an Ovum report, are big business. Yet the research organisations could turn their surveying attentions to the analysis of the production of industry reports. Ovum apart, who are forecasting that one in every five business telephones will be cordless by the end of the decade, Philips Business Communications has also weighed-in with a hefty report. Their new research finds that telecomms and office managers view the prospect of a completely cordless office appealing, and most believe that the cordless telephony revolution in the office will soon become a reality. With around three quarters of all calls not reaching their target person the first time around on a standard telephone system, it is not difficult to see why 57% of those questioned in the Philips survey believed that their organisation's service to top customers could be tangibly improved by the increased availability of staff that the cordless offers. Philips estimate that between 14 and 30 million European office workers will be carrying their own personalised telephones between their desks, photocopiers and coffee machines by the year AD2000.

So What's New?

A Reuter report from Paris confirms that 'Embarrassed French officials' have withdrawn threats to sue 15 families over debts of one-centime. An over-zealous family allowance computer had been automatically sending out summonses, despite instructions that claims should be dropped where less than 100 francs are involved.

PICTURE CAPTION CHALLENGE

It's roll on Spring for this month's Caption Competition. As per usual, there are no prizes, but just what is stirring?

- ★ Calling Little Bo Peep about her missing sheep.
- ★ Man cornered by savage lamb makes frantic call for help shock horror.
- ★ A quick call home to say Sunday lunch is on its way.
- ★ The prototype mobile public telephone box undergoing trials.

Not exactly. In fact the picture is of Britain's first windmill-powered, 'green' telephone box, located on a windy hillside in Wales.

The 3ft wide miniature windmill – a small wind turbine – is attached to a telegraph pole beside the box, and can generate enough power to light the box. Even a small breeze can generate the power that is needed, and other windmill phones are being put into rural areas of Wales and East Anglia for trials. Solar-powered telephone boxes have also been used experimentally by BT.

Events Listings

Now Open: 'Flight' Aeronautics Gallery, Science Museum, London. Tel: (0712) 938 8000.

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 (all Microsoft Windows-related products). Tel: (0256) 381456.

19 to 21 February. 7th International Computer Show, Wembley. Tel: (0726) 68020.

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.

23 to 25 April. 4th MIDI and Electronic Music Show, Wembley. Tel: (081) 547 1183.

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.

HARNESSING WIND POWER

by Stephen Waddington

History

Wind power is freely available to everybody, a fact which we are slowly beginning to realise – at the time of Christ, both the Persians and Chinese had designed ingenious sail machines to rotate shafts for milling. By the time of the sixth century, the Vikings had fixed sails to their ships, so relieving the work of hundreds of men. It was not until the twelfth century that other Europeans caught on – and even then it took a further five hundred years for the traditional Dutch windmill to come to the fore.

The Dutch can be credited with much of the early scientific investigation; experimental work, which subsequently led to the development of large machines capable of delivering mechanical power in excess of 50kW. By the start of this century, electrical wind power generation was fairly common – an American machine called the 'Multiblade' became popular, with an estimated ten million machines in use worldwide. By the First World War, small electricity generating mills were widely available, and it looked as if wind power was to be the energy source of the future.

Like so many promising alternative power generation technologies, wind suffered at the hands of cheap fossil fuels and nuclear power – for almost half a century, the potential of wind was forgotten. The reasons are numerous, putting aside for a moment the advantages offered by other generating schemes. Wind is not directly suited to the continuous requirements of a highly industrialised society. The unpredictable nature of the wind itself manifests itself as random variations in speed, direction and power – requiring counterbalancing by suitable storage mechanisms, better lighting systems and more electrically efficient equipment.

Aerodyn 480W 24V wind turbine, for economical small-scale power generation.

The 1970s saw a resurgent interest, as the scarcity of fossil fuels increased, and the original 'cheap clean energy' promises of nuclear power were not fulfilled. It was soon realised that wind power could offer the best economic option for a myriad of applications, from a small 200W aero-generator to the generation of electricity on the large scales required by the National Grid.

Availability

Like most renewable energy sources, wind power is a derivative of solar energy. It is estimated that approximately 1% of the solar energy reaching the earth's surface is converted to wind – as solar energy, it is, to all practical intents, inexhaustible and so will always be available. Crude calculation indicates that there is potentially enough energy in one day's wind to supply the whole world with electrical energy for almost a year. In reality, such calculations have little meaning since the cost of harnessing all of the available wind power would be impractical – turbines would need to be placed, both inland and at sea, across the length and breadth of the planet. Science fiction appeal apart, such conjecture does, however, provide an indication of the potential of wind generation schemes.

Resources

Winds are caused by differences in air pressure resulting from variations in the sun's heating of the equatorial and polar regions. Being flat, the sea offers little resistance to air flow, so consequently stronger winds are experienced at sea, and windward coasts are subject to the highest number of gales. As Leon Ferris, of London's Imperial College, qualified in his recent paper 'Inherit the Wind': "As well as land-based wind energy, there is an enormous resource offshore. The offshore potential benefits from higher wind speeds

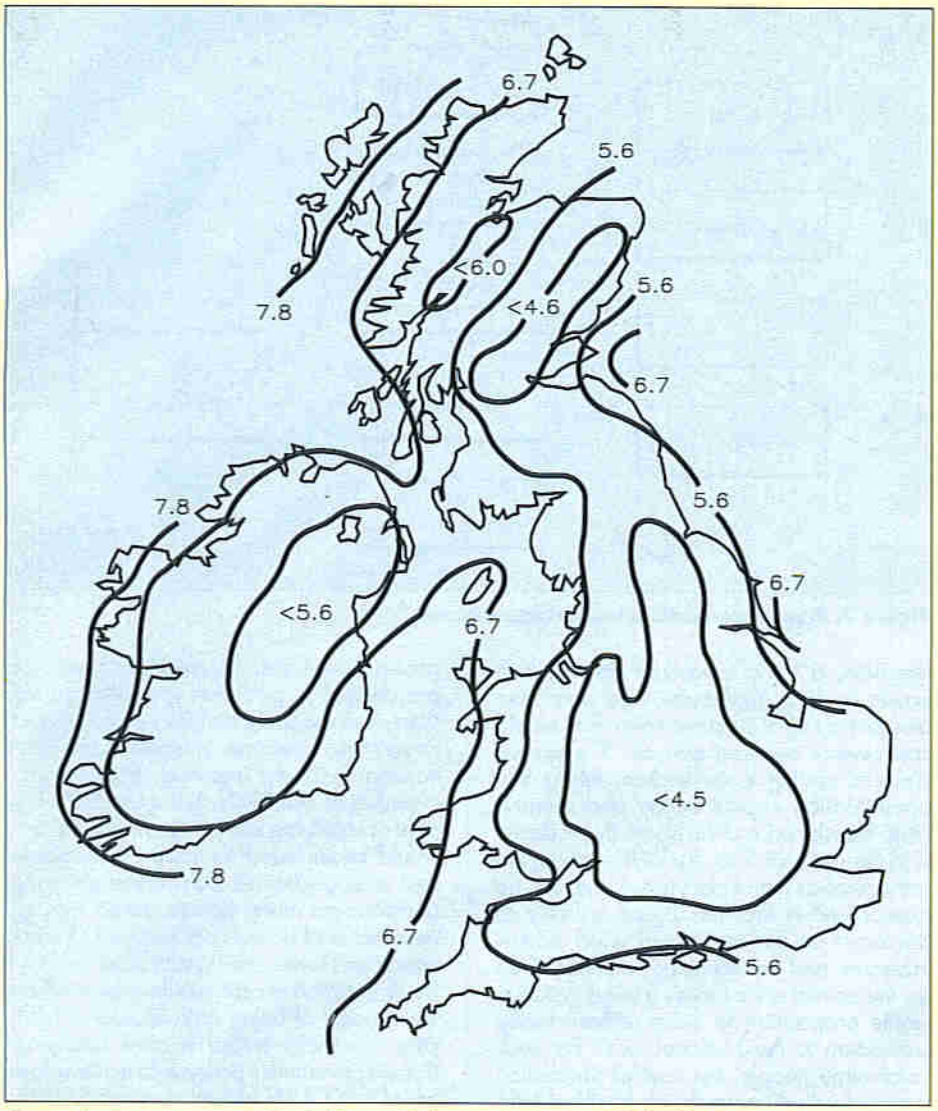


Figure 1. Average annual wind speeds (metres per second) in the UK.

(and not being in anybody's backyard), but is relatively inaccessible – and thus more expensive. Estimates of its value vary, but the exploitable resource is several times greater than the land based one."

In the United Kingdom, the highest winds occur along the west, north-west, north and north-east coasts, while inland areas are much calmer. Of all the developed countries in the world, we probably have the highest wind energy potential – more so than Holland or Denmark, where wind power is extensively exploited. It is an undisputed fact that the United Kingdom has 40% of Europe's total realisable wind energy potential. By way of illustration, Figure 1 details the average wind speeds in the United Kingdom; the contours shown refer to wind speeds in metres per second at a height of ten metres.

The actual power of the wind can be related to the cube of the wind speed; if the wind speed doubles, then the power of the wind increases by a factor of eight – a fact which is demonstrated by the powerfully destructive forces existing in high winds. Such forces became only too apparent during the violent storms of 1987, which devastated South East England. During storms or strong gales, wind speed is often five times greater than the average wind velocity to which a turbine is tailored. Consequently, the stresses on the turbine structure can increase to over twenty-five times the normal operating value. Obviously, the structure must be engineered to prevent damage in such extreme circumstances.

Conversion

The conversion of wind to actual energy is very simple – blades propelled by the force of the wind are used to drive a turbine and generator. It follows that the faster the wind, the faster the movement of the turbine and so the more energy generated. Generally, power output increases with wind speed. Conversely, there is no power output when the wind speed is too low. Most commercial machines start to produce a modest output in winds of 4 metres per second (ms^{-1}). As wind speed increases, so does the power output of the machine until the rated power output – the maximum output of the machine – is reached. Figure 2 provides an illustration of a power output curve for a 200kW wind turbine. Further increases in wind speed do not result in a greater power output. As the wind speed increases further, the rated power output is sustained until the cut-out velocity is reached. At this point, the machine will normally have some form of automatic shut-down to prevent damage. The power output, turn-on and cut-out velocity are all labelled in their appropriate position in Figure 2.

Blade Design

Wind assistance apart, the amount of energy produced by a wind turbine is dependent on the size and form of the blades. Although three blades are more stable for vibration-free operation, two blades are used more often since they produce a higher maximum speed. By increasing the area of the blades, and so the area of interaction with the wind, the wind energy supplied to the turbine is potentially increased. The power produced is proportional to the square of the blade diameter – for an ordinary horizontal-axis wind turbine, doubling the area of the circle escribed by the tip of the rotating blades doubles the power-generating potential.

Modern blade design makes use of aircraft technology, with the result that current designs are modelled on glider wings. The blades are fixed in such a way that the massive forces generated by the aerofoils force the rotor around in a circular path. An ideal design will achieve a balance between maximum lift and minimum drag. Most modern turbine blades rotate ten times faster than the basic wind speed.

Gearing

The turbine blades drive a generator – either directly, or through gearing to increase the

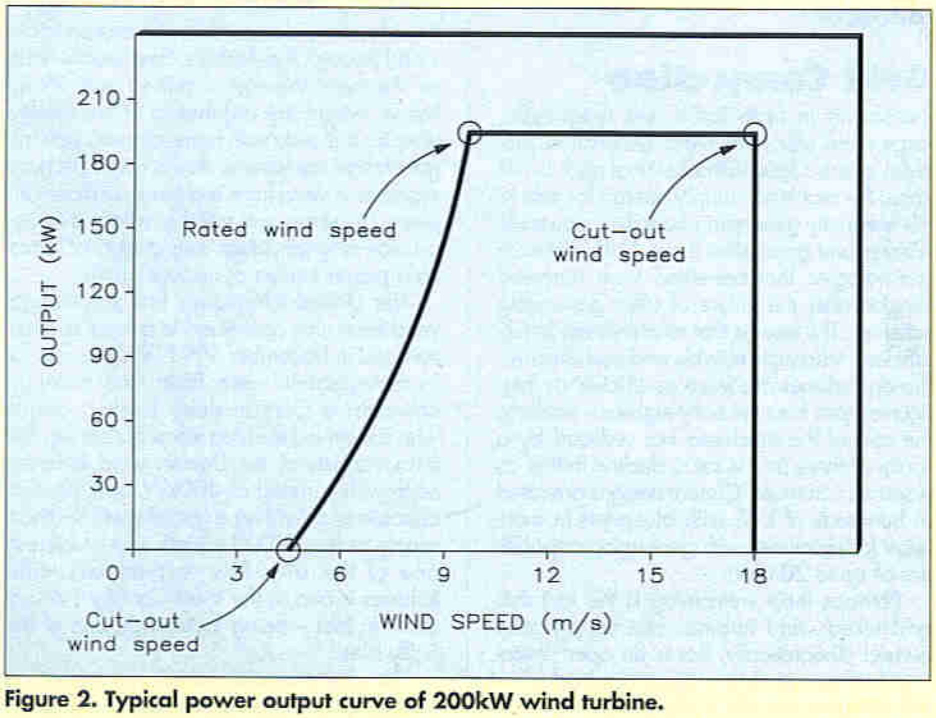


Figure 2. Typical power output curve of 200kW wind turbine.

speed. We have already seen that power generation is related to the speed of rotation, and so a crude turbine will require gearing while a state-of-the-art machine can be fast enough to directly drive a generator. In any mechanical design, gearing reduces efficiency and reliability whilst increasing noise, cost, weight and the need for maintenance.

Plane of Rotation

Turbines rotate on either the horizontal or vertical plane. During the seventies, a large amount of time was spent developing vertical axis machines. They were to offer increased speeds and earlier turn-on velocity than their counterparts in the opposite plane. Such claims have yet to be proven; problems such as low aerodynamical efficiency, structural failure and a fundamental lack of control remain unsolved.

Switching to the other axis, horizontal machines are tried and tested and do not suffer from the problems described – after all the Dutch had it worked out over four hundred years ago! As a further guarantee, investigation into more modern systems has been undertaken for over twenty years, and the reliability of present-day designs has been well proven.

Wind Pumps

In this country, most people are connected to mains water, but those in the developing countries of the Third World are not so fortunate. Almost always, water is available but the depth of the water table and the quantities required put the job of lifting water to the surface beyond the muscle power of a human being. Diesel pumps have been widely used but, like other precious Third World commodities, fuel is expensive and in short supply – additionally, maintenance is difficult and spare parts are hard to come by.

The essential feature of a wind pump is the ability to produce a high torque; speed is not essential, providing the pump is able to provide a large force. Consequently, the need for carefully designed rotors and super-accurately machined parts is not critical. Work in recent years has been directed at materials and designs that would enable local manufacture and repair. AbaChem Engineering Limited of Newark, Nottinghamshire, manufacture wind pumps able to raise water from a depth of 120 metres; pumping capabilities range from 500 to 37,000 litres/hour and running costs are virtually nil – lubrication is required twice a year only.

Small-scale Systems

Where small amounts of electricity are required and there is no Grid connection, small 12 or 24V turbines are often linked to low voltage lighting and power circuits, or storage batteries. Rated in the order of a few kilowatts, the machines produce a direct current – the energy can then be used immediately or stored in Ni-Cd or lead-acid batteries. A further option is to use an inverter unit which converts direct current to alternating current, usually at mains voltage. Interestingly, kits for medium power (250W) mains voltage inverters are available from Maplin, and may form the basis of an experimental system. Figure 3 shows a typical generator system.

For domestic use, a minimum system capable of running a few high-efficiency lights, a television, a Hi-Fi, a vacuum cleaner, low-power cooking appliances, and a refrigerator (but not all at the same time – Ed!) would cost several hundred pounds. If a proper financial costing is undertaken, taking into consideration capital outlay and running costs, then the price of the electricity produced is in the order of 3 to 5p/kWh – about the same price as mains electricity. What can be guaranteed is that this figure is likely to decrease as the interest in wind power increases, and the technology matures. Even so, the current price makes a wind system a viable proposition to those without ready connection to the National Grid. For such unfortunate people, the cost of installation (coupled with ever-increasing fossil-fuel bills) places a wind system as a highly cost-effective alternative.

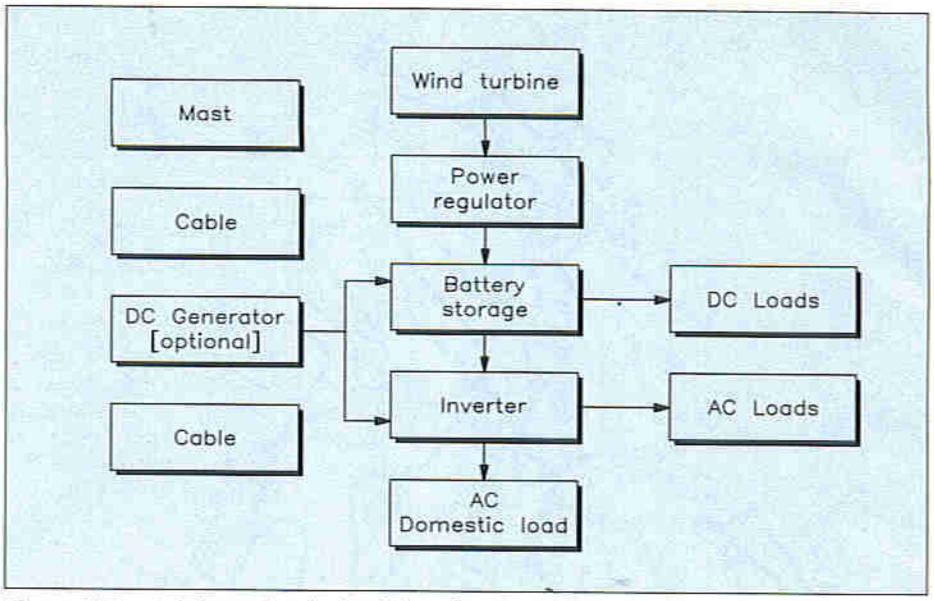


Figure 3. Typical domestic wind turbine scheme.

In May 1992, Rob Peacock and Beth Gaylard of Leicester became, they believe, the first owners of a terraced house in the United Kingdom with its own wind generator. If savings are as great as anticipated, the machine could pay back its costs within seven years. With energy prices set to rise significantly over the next few years under the proposed carbon tax, it could prove even more cost-effective.

Grid Connection

Increasing in both scale and magnitude, large-scale electrical wind generation provides a direct feed to the national grid. In this case, the machines supply energy for sale to the electricity generating boards. Large-scale wind power generation is one of the fortunate technologies that benefited from renewed support after the failure of other generating schemes. The result is that machines are highly efficient, inherently reliable and cost-effective. Present turbines are twice as efficient as their counterparts from the early eighties – similarly, the cost of the machines has reduced by a factor of three and is set to decline further as research continues. Current designs are rated in hundreds of kW, with blueprints in existence for machines with generating capabilities of up to 20MW!

Perhaps most welcoming is the fact that grid-linked wind turbines can be privately owned. Theoretically, this is an open invitation for any suitably-equipped individual to sell energy to the electricity generating companies. Even better, the electricity generators are obliged to purchase your output unless there are good technical reasons which prevent it. One can imagine many such constraints being imposed, however. For example, it is unlikely that generators capable of supplying less than a megawatt or so would be included for practical reasons – and such generators don't come cheap. In addition, too many stations would increase the amount of bureacracy required to totally impractical levels – this would offset the benefits of free-market competition. Nevertheless, the concept of being able to send a bill to your electricity board is most satisfying! Current government policy is 'to achieve a target of 1,000MW of total renewable energy capacity by the end of the century'. This compares poorly with countries elsewhere, a fact which former junior energy minister Colin Moynihan reluctantly acknowledged in November 1991. The current opinion of the Department of Energy is that 'renewables should realistically constitute 20% of the United Kingdom's electrical power by the year 2025.'

Alternative Farming

New farming ideas are usually broken to the world through the Archers, Emmerdale Farm or 'Farmers Weekly' – not so with Wind Farms, where the distribution of knowledge remains squarely with manufacturers of wind generation equipment. As the name perhaps suggests, a wind farm is a group of machines placed together in a suitably windy place to provide a large power output akin to a gas-fired power station or nuclear plant.

The United Kingdom's first commercial wind farm was connected to a local distribution grid in December 1991. Responsible for its inauguration were Peter and Phillippa Edwards, a Cornish dairy farming couple who conceived the idea ten years earlier. The farm consists of ten Danish wind turbines, each with a rating of 400kW, and together capable of providing a guaranteed electrical supply to over 3,000 homes. Out of interest, one of the UK's few vertical-axis wind turbines is also in the West Country – or just off it, in fact – being located on one of the Scilly Isles.

The most dramatic rise in large-scale wind energy production occurred in America during the 1980s. Generous tax incentives resulted in 1,500MW of installed capacity. About 500MW of wind power was being generated in Europe in 1991, most of which was in Denmark. As one of the few countries with a thriving wind generation industry, Denmark exports machines worldwide – during the peak of the Californian boom, this industry earned the country one hundred and thirty million pounds per annum. In addition, 2% of the national demand for such generators is met by privately-installed home-based machines. Individual turbines are owned and operated by factories, farms and rural homes – in most instances, a grid connection is maintained for periods of peak demand.

Environmental Lobby

Unlike fossil fuels or nuclear power, generation of electricity from wind produces no detrimental by-products; it is therefore ironic that the main opposition to wind farming comes from the environmental lobby. There are four main objections; excessive noise, the detrimental effect on the landscape, impact on local flora and fauna and the inappropriate use of land.

By definition, wind turbines must be sited in areas of high mean wind speed – areas which are usually upland moors or regions of open countryside. It is up to the local planning authorities to determine the merits of exploiting a clean renewable energy resource against the visual impact on the landscape. Past experience has shown that people will say 'yes', providing they are convinced that design and installation is undertaken in a sympathetic way, and they are involved in consultation at every stage of the project.

Technology	Cost pence/kWh
Coal	3·5 to 4·0
Gas (Combined Cycle Gas)	2·3 to 2·8
Nuclear	5·0 to 7·5
Wind	2·9 to 5·2

Table 1. Cost of electricity (pence/kWh) from numerous sources.

Noise is not such a problem. Figure 4 shows a typical noise level in dB(A) caused by a wind turbine – at a distance of 42·9m, the noise level is less than that experienced in a house during the day. For a wind farm of thirty 300kW machines, 45dB(A) at a distance of 500m from the nearest machine is typical.

Consideration of the impact of wind farms on wildlife is important. In particular, the effects on bird life have been the subject of numerous studies. Leon Ferris of Imperial College again; "Birds can be affected by injury or death following collision with a blade or tower, or by being disturbed in their breeding nest or feeding habits. A Dutch study of a 7·5MW coastal wind farm demonstrated that a 1km array of wind turbines was no more harmful than 1km of high voltage line. However, more research is needed, to assess the impact on migratory routes and in areas with high densities of breeding, nesting or foraging birds."

Wind farms are proving successful because they minimise operational costs by placing the machines close together, simplifying monitoring and maintenance arrangements. Additionally they have the advantage of dual land-use; once placed in position, all but 1% of the land can revert to its natural habitat, or continue in agricultural use.

The environmental case for wind energy is confusing; whilst wind power counteracts the damage caused by conventional fuel generation it does have an immediate effect on the local community and landscape. Perhaps cost will be the deciding factor; Table 1 details the cost of 1kWh of electricity produced by four different technologies, including wind. Although it is difficult to determine the price of an energy source when the costs of alleviating pollution are taken into consideration, these can only mitigate in favour of wind energy.

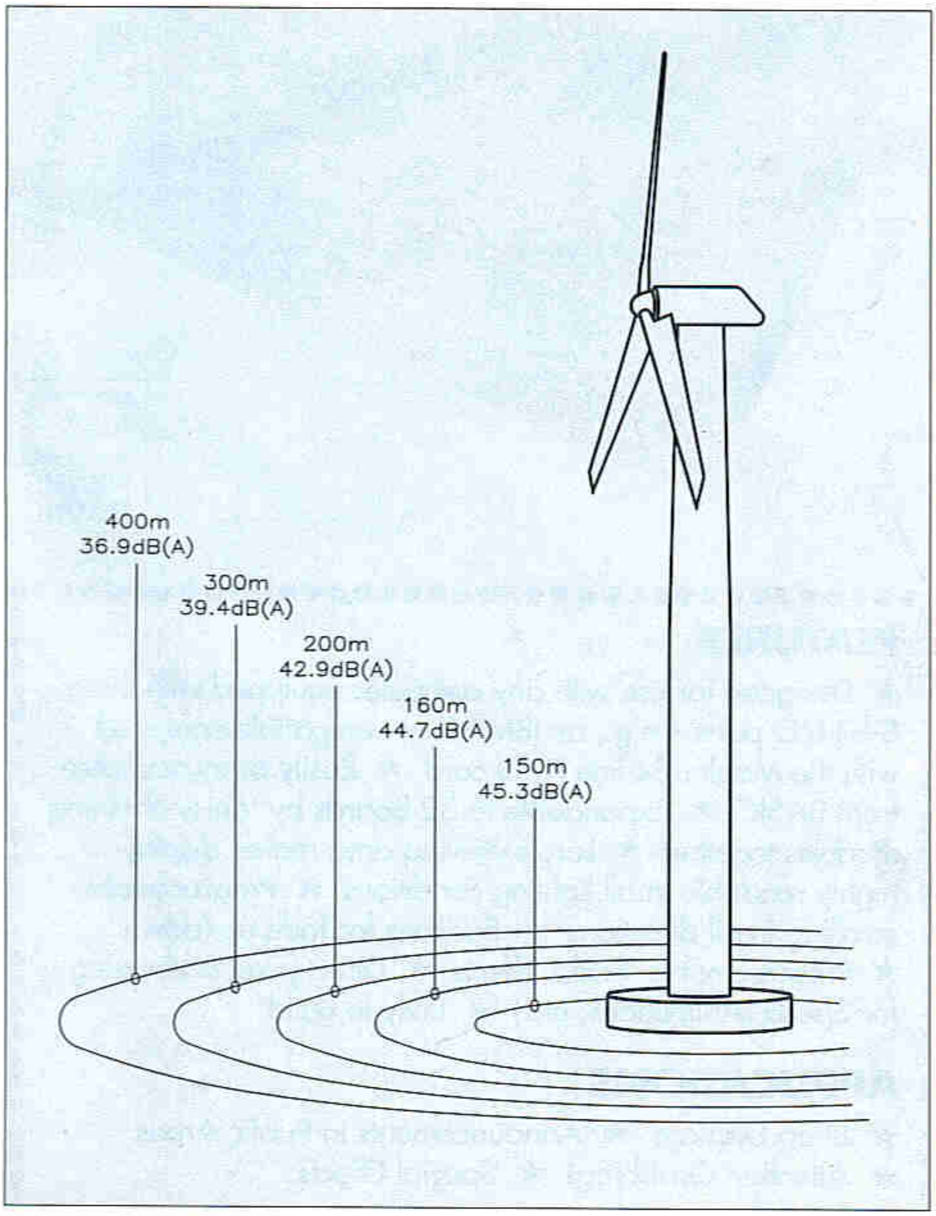


Figure 4. Noise levels for large-scale wind turbine.

The Future

What of the future? I'll leave the final say to environmental commentator and freelance journalist Denis Woodbridge: "Generation of electricity causes substantial pollution – it is responsible for one-third of all carbon-dioxide emission, and is a major source of nitrogen and sulphur oxides. The Chernobyl disaster, and alleged problems caused by Sellafield/Windscale have made us very wary of nuclear energy. Recent scares have warned us of holes in the ozone layer and global warming – at the same time, the Gulf War has brought the security of our future energy supply into sharp focus. Surely, we must now look beyond short-term gains towards more suitable and less damaging electrical generation. Perhaps wind power does not hold all the answers, but combined with other renewable sources, improved efficiency of electrical equipment and greater energy conservation, our burden on the fossil fuels and reliance on nuclear fuel would be greatly reduced – the day when we cease to rely on conventional fuel generation need not be so far away."

Information Sources

Aerodyn Wind Turbines: Energy Independence, John Shore Designs.

Inherit the Wind, Leon Ferris, Imperial College London, IEE Review April 1992.

Wind Energy, Centre for Alternative Technology.

Acknowledgments

Thank you to the following people and organisations for assistance in the compilation of this article;

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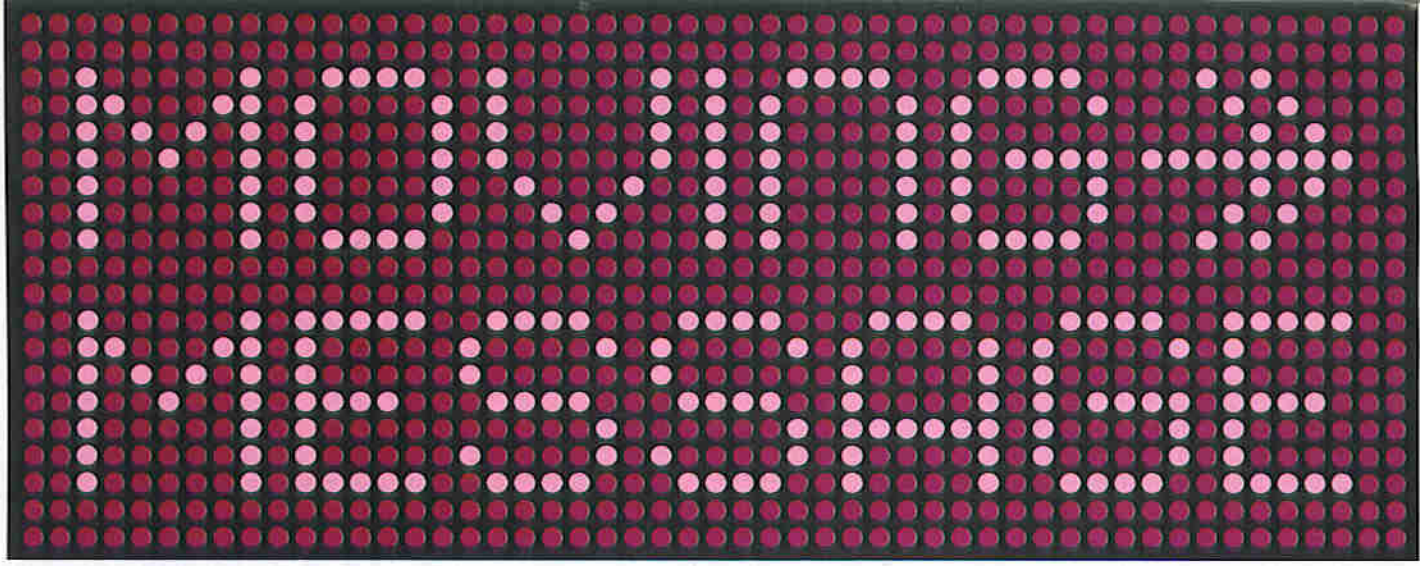


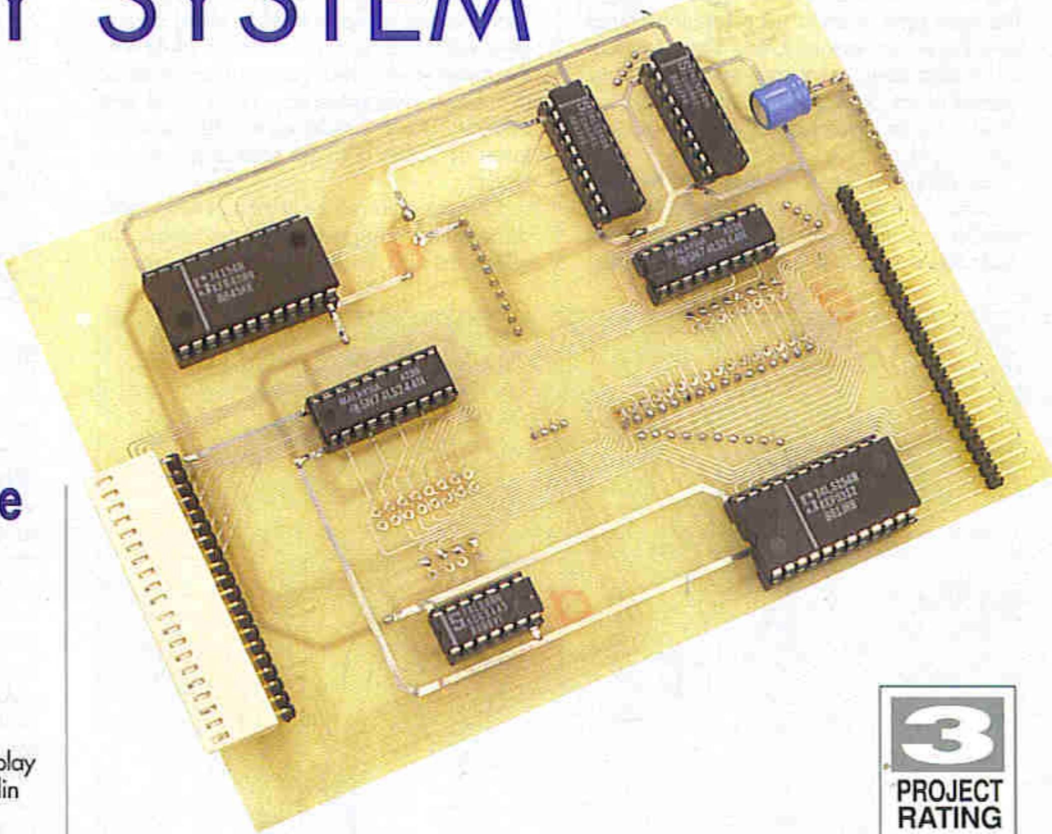
DISPLAY SYSTEM

PART TWO

Text by John Koushappas
and Martin Pipe

Design by John Koushappas

Development by
Tony Bricknell



3 PROJECT RATING

Software-Testing the Moving Message Display Module

Making the Lead

To software-test the Moving Message Display Panel, it should be connected to the Maplin PI/O card as shown in Figure 1. This Minicon-to-37 'D' way socket lead, which can be made from 18-way ribbon cable (preferably multi-coloured!), should not be longer than 1·5m in length, to preserve TTL data integrity. Two 10-way Minicon connectors are required for the display side of the cable; note that the first 2 connections of the second block are not used.

Assembly should begin with the Minicon connectors. Tear the ribbon cable into two halves, one of ten ways, the other of eight ways. Crimp and solder each wire and terminal carefully. The completed terminal can now be pushed into the Minicon socket until the terminal locks in the housing body – refer to Figure 2. This procedure should be repeated for all 18 wires of the ribbon cable. At the other end of the ribbon cable, the wires should be stripped, tinned and soldered to the relevant pins of the 37-way 'D' type connector, as shown on Figure 1. Table 1 gives a summary of the interconnections. After completing the lead, please check it – mistakes are easily made and will cause problems later on if they are not detected at this stage.

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

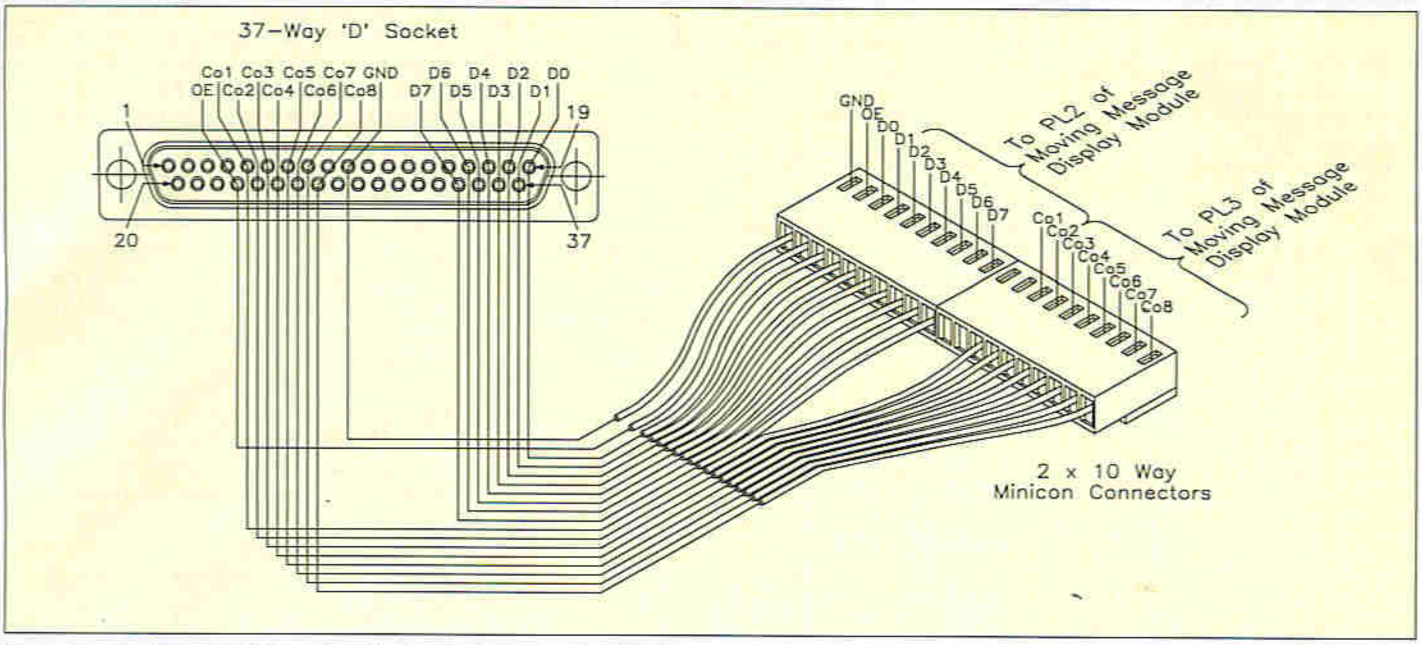


Figure 1. Assembly of PI/O card-to-Moving Message Display lead.

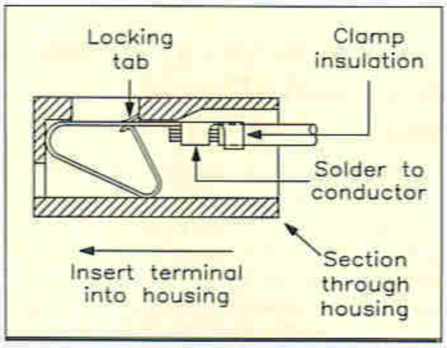


Figure 2. Fitting and inserting Minicon terminals (Moving Message Display end of interface lead)

Port Allocation

For details on the design and construction of the Maplin PI/O card, refer to Issue 43 (April/May 1991) of 'Electronics'. This card has an 8-way DIL switch which can be used to set the I/O port address. Follow the article details on setting an appropriate hardware address and make a note of this value. In the PI/O article, for example, the base address is set at 0300 hex, which is reserved for prototyping cards, and is a good choice here. This address will be the reference address used by all the test and development programs which follow. Table 2 shows how the ports are allocated.

MAPLIN PI/O		MOVING MESSAGE DISPLAY MODULE	
37-Way 'D' Socket Pin	Port Pin	Bus Function	Pin No.
10	GND	GND	PL2/1
23	PC0	Data Bus OE	PL2/2
19	PA0	Data Bus D0	PL2/3
37	PA1	Data Bus D1	PL2/4
18	PA2	Data Bus D2	PL2/5
36	PA3	Data Bus D3	PL2/6
17	PA4	Data Bus D4	PL2/7
35	PA5	Data Bus D5	PL2/8
16	PA6	Data Bus D6	PL2/9
34	PA7	Data Bus D7	PL2/10
5	PB0	Control Bus C01	PL3/3
24	PB1	Control Bus C02	PL3/4
6	PB2	Control Bus C03	PL3/5
25	PB3	Control Bus C04	PL3/6
7	PB4	Control Bus C05	PL3/7
26	PB5	Control Bus C06	PL3/8
8	PB6	Control Bus C07	PL3/9
27	PB7	Control Bus C08	PL3/10

Table 1. PI/O card-to-Moving Message Display lead interconnections.

PC I/O Address	8255 Port Name	Variable Name Reference	Program Variable Name
0300 Hex	PORT A	BASEADD%	Data port
0301 Hex	PORT B	BASEADD%+1	Control port
0302 Hex	PORT C	BASEADD%+2	OE
0303 Hex	CONTROL REG.	BASEADD%+3	CR

where OE = Output Enable (of display)
CR = 8255 Control Register

Table 2. Display controller port and variable name allocations.

Connecting Up to the Computer

You are now ready to connect up the moving message display module with the computer. With everything turned off, and the Maplin PI/O card plugged into one of the spare expansion slots of the PC, plug the data and control port connectors into the module, ensuring that the correct connector goes to the correct set of pins, and ensuring correct orientation on the control port connector. After plugging in the 37-way 'D' connector socket into the PI/O card, the system can be powered up – the moving message display first. As with the initial power-on tests (see Part 1), some (or even all) of the LEDs may come on – do not worry at this stage!

Test Programs

The moving message display module uses the 8255 PPI on the Maplin PI/O card in Mode 0 and with all three 8-bit ports set up as output ports. The instruction in the listings which does this is OUT CR,&H80. 'CR' refers to 'Control Register'; this is explained in the PI/O Card article.

Hardware blanking is achieved with bit 0 of port C, the OE port variable. Sending a data bit of value 0 to this port switches off all the LEDs in the display; conversely, sending a data bit of value 1 to this port switches the LED display output on.

Listing 1 – Simple Test

The short program of Listing 1 is a simple test to give you some idea of how data is sent to the moving message display module, and to show if the built module does anything. Type it in under BASIC, and run it. If it works you should see LEDs 1, 3, 5 and 7 turned on, and LEDs 2, 4, 6 and 8 turned off. All the other LEDs, i.e., those in columns 2 to 8, are not affected. To try out the other columns in the display, change the data in line 180 from 1 to 2, 4, 8, 16, 32, 64, or 128.

Listing 2 – Full Test Program Diagnostic

A full menu-driven diagnostic program is shown in Listing 2. This allows testing of

```
100 LET BASEADD%=&H300           :' Base Address pointer - set to suit
110                               :' All other ports reference this variable.
120 LET DATAPORT%=BASEADD%        :' Port A = Data Port
130 LET CONTROLPORT%=BASEADD%+1   :' Port B = Control Port
140 LET OE%=BASEADD%+2            :' Port C = Display Output Enable
150 LET CR%=BASEADD%+3            :' Control Register for initialising 8255
160 OUT CR%,128                   :' Initialise ports A, B, C as output ports
170 OUT OE%,1                     :' Turn display on
180 OUT CONTROLPORT%,1            :' First column of LEDs
190 OUT DATAPORT%,&H55            :' Alternate LEDs in column
200 END
```

Listing 1. Simple test program.

```
1000 KEY OFF
1010 SCREEN 9
1020 COLOR 15,7
1030 CLS
1040 PRINT
1050 PRINT
1060 PRINT
1070 PRINT
1080 PRINT
1090 PRINT"                              Moving Message Display Module"
1100 PRINT
1110 PRINT
1120 PRINT"                                Single Board Pattern Tests"
1130 PRINT
1140 PRINT
1150 PRINT"                                  By John Koushappas "
1160 PRINT
1170 PRINT
1180 PRINT"                        (C) Copyright 1992 Maplin Electronics Plc."
1190 PRINT
1200 PRINT
1210 PRINT"                                          V1.0"
1220 FOR F=1 TO 20
1230 GOSUB 2720
1240 NEXT F
1250 REM                 Main Menu starts here
1260 COLOR 15,1
1270 CLS
1280 PRINT
1290 PRINT
1300 PRINT"                                      _______"
1310 PRINT
1320 PRINT"                                      M E N U "
1330 PRINT"                                      _______"
1340 PRINT
1350 PRINT
1360 PRINT"                 1. Test by line across the screen"
1370 PRINT"                 2. Test by line down the screen"
1380 PRINT"                 3. Test bit by bit across the screen"
1390 PRINT"                 4. Test bit by bit down the screen"
1400 PRINT"                 5. Run Tests 1 - 4 "
1410 PRINT"                 6. Test single bit continuously"
1420 PRINT"                 7. End Tests"
1430 PRINT
1440 PRINT
1450 PRINT
1460 INPUT"                    Select :",SELECTION
1470 CLS
1480 COLOR 15,2
1490 IF SELECTION=7 THEN GOTO 1800
1500 PRINT
1510 PRINT
1520 PRINT "Initialising Parallel Ports..."
1530 '
1540 LET BASEADD%=&H300
1550 LET DATAPORT%=BASEADD%       :' Port A  = Data port
1560 LET CONTROLPORT%=BASEADD%+1 :' Port B  = Control port
1570 LET OE%=BASEADD%+2           :' Port C  = Bit 0= Display Output Enable
1580 LET CR%=BASEADD%+3           :' Control Register for initializing 8255 PPI
1590 OUT CR%,128                  :' Initialize Ports A, B, C as output ports
1600 GOSUB 2780                   :' Clear the display screen before switching
1610 OUT OE%,1                    :' Switch Display On ( Bit 0 Port C=1 )
1620 PRINT
1630 PRINT"Ports Initialised."
1640 FOR E=1 TO 8
1650 GOSUB 2720
1660 NEXT E
1670 CLS
1680 PRINT:PRINT:PRINT:PRINT
1690 PRINT"                 Moving Message Display Module"
1700 PRINT
1710 PRINT"                 Single Board Pattern Tests"
1720 PRINT:PRINT:PRINT:PRINT
1730 PRINT"                 Running test: ";SELECTION
1740 PRINT
1750 PRINT"                 ";
1760 ON SELECTION GOSUB 1820,1960,2120,2270,2640,2430,1810
1770 PRINT:PRINT
1780 INPUT"                 Test completed.  Hit RETURN key for MENU ",Q$
1790 GOTO 1250
1800 SCREEN 0
1810 END
1820 '                  Subroutine to test by line across the screen
1830 '
1840 PRINT"Line across the screen."
1850 '
1860 FOR X%=0 TO 7          :'       Loop Length Of Display
1870 OUT CONTROLPORT%,2^X% :'       Control Port Number
1880 OUT DATAPORT%,255      :'       Turn On All LEDs In Column
1890 GOSUB 2720             :'       Delay
1900 OUT DATAPORT%,0        :'       Turn Off All LEDs In Column
1910 NEXT X%                :'       Until Done
1920 '
1930 GOSUB 2780             :'       Clear display between tests!
1940 GOSUB 2720             :'       Delay
1950 RETURN
1960 '                   Subroutine to test by line down the screen
1970 '
1980 IF SELECTION=5 THEN PRINT:PRINT"                 ";
1990 PRINT"Line down the screen."
2000 '
```

Continued on page 11.

Listing 2. Full diagnostic test program.

the module by line across, line down, bit by bit across the display, bit by bit down the screen, and continuous flashing. It also has a composite test consisting of the four basic tests which must be passed in order to prove a fully working module.

Type the program in and save it as "DIAGNOSE.BAS" to disk. Each test allows you to visually check for specific possible defects that may result from constructional faults. Knowing the sequence in which the LEDs should correctly light up, you should check that no other LEDs turn on; if any do, you have a fault.

Test 1 lights up the LEDs a column at a time, and runs from left to right. Test 2 lights up the LEDs a row at a time, and runs from top to bottom. Test 3 tests each LED individually by flashing it once and then incrementing to the next LED on its right. Test 4 similarly increments from top to bottom. The continuous flashing test (test 6) flashes the LED, referenced by its entered grid position, continuously. This is to allow detailed fault-finding.

Troubleshooting Using Diagnostic Program and Logic Probe

If any column lights up out of sequence when Test 1 is run, check the column control lines at the connector, PL3. If the sequence is still incorrect, check your wiring of the connectors (refer once again to Figure 1 and Table 1). Slow the speed of the program by increasing the delay (currently set at 350, in the FOR... NEXT loop of lines 2740 to 2760) if the test runs too fast on your computer. If your PC has an extended keyboard, you can freeze execution of the program, when investigating the circuit with a logic probe, by pressing the PAUSE key; to continue program execution from its current position, simply press the <ENTER> key. If more than one column turns on at once, recheck several times to see that is a repeatable fault. If the faulty column is adjacent to the expected column, you should check for a short between the two adjacent control lines. The fault may also be a control line open or partial open circuit. This would be indicated by anything other than logic 1 appearing on the bad column. If the bad column reflects the data output to all other rows, that row has an open circuit column control line which means the 74LS373 octal latch is staying transparent (refer to Part 1).

Using Test 2, if any row of LEDs other than the intended row lights up, and this occurs when a specific intended row is accessed, then the probable fault lies in a bridged solder joint somewhere along the path of the data bus buffer – either the input to it, or the output from it. It is usual to test from the 'D' inputs of the latches, and work backwards until the fault clears. When you have isolated the locality of the fault, you can then continuity test with the adjacent ICs removed until the bridge is found and cleared. If the bad row stays permanently turned on, you have an open circuit on the bad row, either on the input or on the output of the 74LS244. Check, trace and rectify.

Using Tests 3 and 4, you can check each individual LED, and that no unwanted reflections appear. With Test 3, you can check for unwanted reflections in columns.

Listing 2 continued.

```
2010 FOR Y%=0 TO 7          :'        Loop height of display
2020 OUT CONTROLPORT%,255   :'        Open all control lines for data
2030 OUT DATAPORT%,2^Y%     :'        Output binary weight ( horizontal line )
2040 GOSUB 2720             :'        Delay
2050 OUT DATAPORT%,0        :'        Clear horizontal line
2060 NEXT Y%                :'        Until done
2070 '
2080 GOSUB 2780             :'        Clear display between tests!
2090 GOSUB 2720             :'        Delay
2100 RETURN
2110 '
2120 '                   Subroutine to test bit by bit across the screen
2130 '
2140 IF SELECTION=5 THEN PRINT:PRINT"                 ";
2150 PRINT"Bit by bit across the screen"
2160 '
2170 FOR Y%=0 TO 7          :'        Loop height of display
2180 FOR X%=0 TO 7          :'        Loop length of display
2190 OUT CONTROLPORT%,2^X% :'         Open weighted control line
2200 OUT DATAPORT%,2^Y%     :'        Bit by bit from top to bottom
2210 GOSUB 2720             :'        Hold bit on
2220 OUT DATAPORT%,0        :'        Turn bit off
2230 GOSUB 2720             :'        Hold bit off
2240 NEXT X%                :'        Until row completed
2250 NEXT Y%                :'        Until all rows completed.
2260 RETURN
2270 '                   Subroutine to test bit by bit down the screen
2280 '
2290 IF SELECTION=5 THEN PRINT:PRINT"                 ";
2300 PRINT"Bit by bit down the screen"
2310 '
2320 FOR X%=0 TO 7          :'        Loop length of display
2330 OUT CONTROLPORT%,2^X% :'         Select control line
2340 FOR Y%=0 TO 7          :'        Loop height of display
2350 OUT DATAPORT%,2^Y%     :'        Turn on one bit
2360 GOSUB 2720             :'        Hold bit on
2370 OUT DATAPORT%,0        :'        Turn bit off
2380 GOSUB 2720             :'        Hold bit off
2390 NEXT Y%                :'        Until last in column is done
2400 NEXT X%                :'        Unitl last  row is done.
2410 RETURN
2420 '
2430 '                    Subroutine to interrogate bit
2440 '
2450 PRINT"Interrogate LED on display"
2460 PRINT:PRINT
2470 PRINT"            LED coordinates ( top left =0,0 )"
2480 PRINT"                         ( bottom right =7,7 )"
2490 PRINT
2500 INPUT"            LED Coordinates X,Y --> ",X%,Y%
2510 PRINT
2520 PRINT"            Flashing ";X%;",";Y%
2530 PRINT
2540 PRINT"            Hit RETURN for the menu"
2550 OUT CONTROLPORT%,2^X%
2560 OUT DATAPORT%,2^Y%
2570 GOSUB 2720
2580 OUT DATAPORT%,0
2590 GOSUB 2720
2600 RESPONSE$=INKEY$
2610 IF RESPONSE$=CHR$(13) THEN GOTO 2630
2620 GOTO 2560
2630 RETURN
2640 '                    Subroutine to call tests 1 to 4
2650 '
2660 GOSUB 1820
2670 GOSUB 1960
2680 GOSUB 2120
2690 GOSUB 2270
2700 RETURN
2710 '
2720 '                    Delay subroutine
2730 '
2740 FOR C=1 TO 350         :'        Delay
2750 NEXT C
2760 RETURN                 :'        Return to main program
2770 '
2780 '                    Subroutine to clear the display
2790 '
2800 FOR X%=0 TO 7          :'        Loop length of display
2810 OUT CONTROLPORT%,2^X% :'         Control port number
2820 OUT DATAPORT%,0        :'        Zero that column
2830 NEXT X%                :'        Until done
2840 RETURN                 :'        Return to main program
```

Listing 2. Full diagnostic test program.

```
1000 KEY OFF
1010 COLOR 15,1
1020 CLS
1030 PRINT:PRINT:PRINT
1040 PRINT:PRINT:PRINT
1050 PRINT"                         Moving Message Display "
1060 PRINT
1070 PRINT"                          Triangle Wave Demo"
1080 PRINT
1090 PRINT"                           John Koushappas"
1100 PRINT
1110 PRINT"             (C) Copyright 1992 Maplin Electronics Plc."
1120 PRINT
1125 PRINT"                                V1.0"
1130 LET NOUGHT%=0
1140 '
1150 LET SCROLLSPEED%=10           :' Set the scroll / animation speed here
1160 '
1170 LET BASEADD%=&H300           :' Base Address pointer - set to suit
1180                               :' All other ports reference this variable.
1190 LET DATAPORT%=BASEADD%        :' Port A = Data Port
1200 LET CONTROLPORT%=BASEADD%+1   :' Port B = Control Port
1210 LET OE%=BASEADD%+2            :' Port C = Display Output Enable
1220 LET CR%=BASEADD%+3            :' Control Register for initialising 8255
1230 OUT CR%,128                   :' Initialise ports A, B, C as output ports
1240 GOSUB 1680                    :' Clear the display screen before start.
```

continued on page 12.

Listing 3. Triangle wave demonstration program.

If you see one, make a note of its co-ordinate so that you can test it continuously later. With Test 4 you can check for unwanted reflections in the rows.

Using the Test 6 routine, you can now enter the co-ordinates of the good LED which produced the fault. If the fault is still present, you can now trace it, again working backwards.

When you have run all the tests individually and are sure each test is passed correctly, run the composite test which runs through all the tests and when this is passed without any faults, the testing of the module is complete.

Demonstration Programs

Triangle Wave Demo

Listing 3 shows a program which runs through a simple 14-frame animation depicting a rolling triangle wave. This short program also shows just how easy general routines can be written for the display. The heart of the routine is the inner loop of lines 1430 to 1520. This displays the following 8 bytes from the current memory position, i.e, it is the display window. It just so happens in this example that the 14 frames of the animation are one byte apart, hence the unit increment in FRAME%. If you had 10 individual frames, each of the full 8 bytes, then this line would be:

FOR FRAMES% =1 TO 80 STEP 8

This type of animation is thus similar to how a cinema projector works, by showing a frame at a time with a controlled pause between each frame. By running through the animation fast enough, you appear to get continuous movement. You will see variations on this theme throughout the programming side of this project.

Save this program as "TRIANGLE.BAS".

Message Demo

In order to show the flexibility of the triangle wave demo, Listing 4 shows the changes you can type over the triangle wave demo in order to see an example of proper text being scrolled across the display. If you have not already done so, type in the "TRIANGLE.BAS" program (Listing 3). Now type over the lines of Listing 4.

Save this demo as "MAPLIN.BAS".

Parallel Access

The single Moving Message Display Module has a unique feature over the expandable system. Because the column control lines are simulated by direct connection to the 8255's 'B' parallel port, parallel access is available in addition to parallel load and direct addressing. Normally, the data is sent, a byte at a time, to each column but here you can also send data to any combination of rows instantaneously. You simply activate more than one column control line via port B.

The example of Listing 5 is a psychedelic demonstration of this. It lights alternate LEDs and then flashes them with their alternate neighbours. Don't stare at this too long because it can make you dizzy!

Save this program as "PARALLEL.BAS".

Listing 3 continued.

```
1250 OUT OE%,1                          :' Switch display on
1260 DIM ARRAY%(60)                     :' Create an array for the image
1270 FOR B%=0 TO 60                     :' Loop length of array
1280 LET ARRAY%(B%)=0                   :' Make sure array is clear
1290 NEXT B%
1300 DATA 1,2,4,8,16,32,64,128,64       :' Triangle Wave Data
1310 DATA 32,16,8,4,2,1,2,4,8,16        :'
1320 DATA 32,64                         :'
1330 '
1340 '
1350 '
1360 '
1370 '
1380 FOR B%=0 TO 20                     :' Loop length of triangle wave data
1390 READ ARRAY%(B%)                    :' Load array with triangle wave data
1400 NEXT B%
1410 FOR B%=1 TO 20                     :' Number of times to run through pattern
1420 FOR FRAME%=0 TO 13                 :' Number of frames to the animation
1430 FOR DISWINDOW%=0 TO 7              :' The diswindow is the part of pattern
1440                                    :' currently showing on the display.
1450                                    :' ( DISWINDOW = Display Window )
1460 OUT CONTROLPORT%,INT(2^DISWINDOW%)           :' Column of display
1470 OUT DATAPORT%,ARRAY%(FRAME%+DISWINDOW%)      :' Run through next 8 bytes to
1480                                              :' the frame
1490 OUT CONTROLPORT%,NOUGHT%                     :' Close the control line
1500                                              :' to save each byte
1510 OUT DATAPORT%,NOUGHT%              :' Clear the Databus
1520 NEXT DISWINDOW%                    :' Until diswindow is refreshed
1530 GOSUB 1630                         :' Now slow the frame update down; it's
1540                                    :' too fast!
1550 NEXT FRAME%                        :' Until we have run through the animation
1560 NEXT B%                            :' 20 times!
1570 GOSUB 1680                         :' Clear the display screen before end
1580 SCREEN 0
1590 KEY ON
1600 CLS
1610 END                                :' Phew!
1620 '
1630 '                      Delay subroutine
1640 '
1650 FOR Z%=1 TO SCROLLSPEED%           :' Pause between each frame
1660 NEXT Z%
1670 RETURN
1680 '                      Subroutine to clear the display
1690 '
1700 FOR X%=0 TO 7                      :' Loop length of display
1710 OUT CONTROLPORT%,2^X%              :' Control line
1720 OUT DATAPORT%,0                    :' Zero that column
1730 NEXT X%                            :' Until done
1740 RETURN                             :' Back to main program.
```

Listing 3. Triangle wave demonstration program.

```
1000 KEY OFF
1010 COLOR 15,1
1020 CLS
1030 PRINT:PRINT:PRINT
1040 PRINT:PRINT:PRINT
1050 PRINT"                       Moving Message Display "
1060 PRINT
1070 PRINT"                        Moving Message Demo"
1080 PRINT
1090 PRINT"                          John Koushappas"
1100 PRINT
1110 PRINT"            (C) Copyright 1992 Maplin Electronics Plc."
1120 PRINT
1130 PRINT"                                  V1.0"
1140 LET NOUGHT%=0
1150 '
1160 LET SCROLLSPEED%=100               :' Set the scroll / animation speed here
1170 '
1180 LET BASEADD%=&H300                 :' Base Address pointer - set to suit
1190                                    :' All other ports reference this variable.
1200 LET DATAPORT%=BASEADD%             :' Port A = Data Port
1210 LET CONTROLPORT%=BASEADD%+1        :' Port B = Control Port
1220 LET OE%=BASEADD%+2                 :' Port C = Display Output Enable
1230 LET CR%=BASEADD%+3                 :' Control Register for initialising 8255
1240 OUT CR%,128                        :' Initialise ports A, B, C as output ports
1250 GOSUB 1690                         :' Clear the display screen before start
1260 OUT OE%,1                          :' Switch display on
1270 DIM ARRAY%(60)                     :' Create an array for the image
1280 FOR B%=0 TO 60                     :' Loop length of array
1290 LET ARRAY%(B%)=0                   :' Make sure array is clear
1300 NEXT B%
1310 DATA 0,0,0,0,0,0,0,0,0             :' blank screen to start with
1320 DATA 255,2,4,2,255,0               :' M
1330 DATA 252,10,9,10,252,0             :' A
1340 DATA 255,9,9,6,0                   :' P
1350 DATA 255,128,128,128,0             :' L
1360 DATA 129,255,129,0                 :' I
1370 DATA 255,4,8,16,255,0              :' N
1380 DATA 0,0,0,0,0,0,0,0,0             :' blank screen to end
1390 FOR B%=0 TO 50                     :' Loop length of message data
1400 READ ARRAY%(B%)                    :' Load array with message data
1410 NEXT B%
1420 FOR B%=1 TO 20                     :' Number of times to run through pattern
1430 FOR FRAME%=0 TO 50                 :' Number of frames to the animation
1440 FOR DISWINDOW%=0 TO 7              :' The diswindow is the part of pattern
1450                                    :' currently showing on the display.
1460                                    :' ( DISWINDOW = Display Window )
1470 OUT CONTROLPORT%,INT(2^DISWINDOW%)           :' Column of display
1480 OUT DATAPORT%,ARRAY%(FRAME%+DISWINDOW%)      :' Run through next 8 bytes to
1490                                              :' the frame
1500 OUT CONTROLPORT%,NOUGHT%                     :' Close the control line
1510                                              :' to save each byte
1520 OUT DATAPORT%,NOUGHT%              :' Clear the Databus
1530 NEXT DISWINDOW%                    :' Until diswindow is refreshed
1540 GOSUB 1640                         :' Now slow the frame update down; it's
1550                                    :' too fast!
1560 NEXT FRAME%                        :' Until we have run through the animation
1570 NEXT B%                            :' 20 times!
1580 GOSUB 1690                         :' Clear the display screen before end
```

Continued on page 13.

Listing 4. Moving Message demonstration program.

For Trekkies!

This last demo is for Star Trek fans. Remember the Enterprise viewing screen? It had little lights along the bottom which would start (or was it end ?) in the centre, and move outwards (inwards?). At the same time a funny, out of tune, 'ping' noise could be heard in the background. Here is the Moving Message Display version (minus the 'ping'!). This also demonstrates parallel access, evident from the program comments.

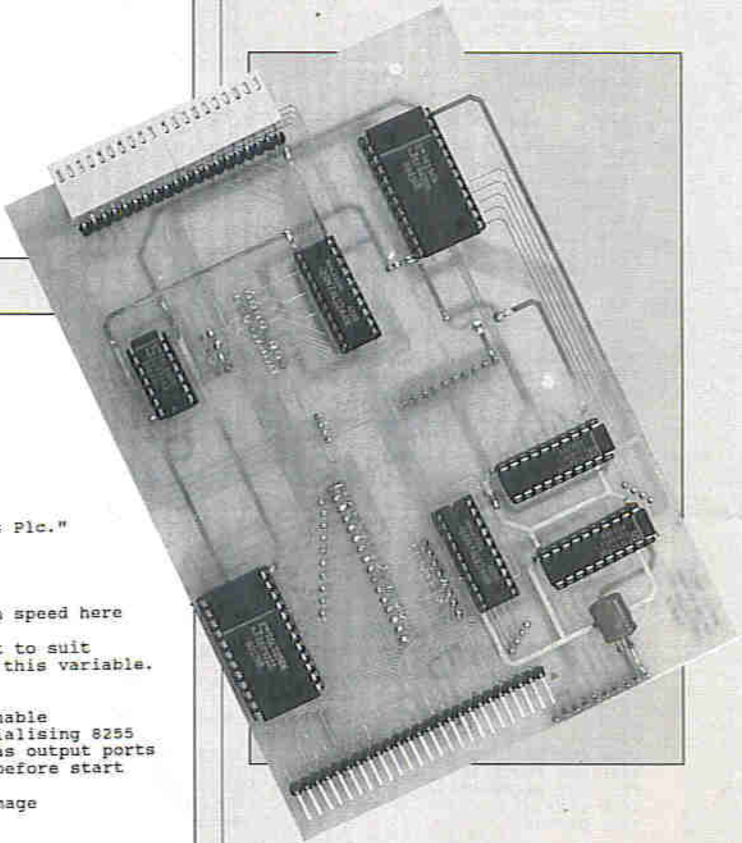
Save this program as "STARTREK.BAS"

Menu

The last listing is a menu program which joins all the programs together. An additional program line in all of the programs, added just before the END statement, will make this menu shell cyclic.

LOAD"MENU",R
END

When in GWBASIC, LOAD"MENU",R is also the command to start the whole thing off.



Controller board - component side

Moving Message Display System Controller Board/ Expansion

The moving message display module described in last month's magazine provided an array of 8 x 8 LEDs. This is fine for small or experimental displays but does not exactly make for legible messages because you can barely get two letters on the display at one time. The facilities provided on the moving message display module included full driving logic, display memory, and daisy-chained buffered outputs as standard. These buffered outputs are used as part of the expansion capabilities of the moving message display system.

Listing 4 continued.

```
1590 SCREEN 0
1600 KEY ON
1610 CLS
1620 END                                    :' Phew!
1630 '
1640 '                          Delay subroutine
1650 '
1660 FOR Z%=1 TO SCROLLSPEED%               :' Pause between each frame
1670 NEXT Z%
1680 RETURN
1690 '                          Subroutine to clear the display
1700 '
1710 FOR X%=0 TO 7                          :' Loop length of display
1720 OUT CONTROLPORT%,2^X%                  :' Control line
1730 OUT DATAPORT%,0                        :' Zero that column
1740 NEXT X%                                :' Until done
1750 RETURN                                 :' Back to main program.
```

Listing 4. Moving Message demonstration program.

```
1000 KEY OFF
1010 COLOR 15,1
1020 CLS
1030 PRINT:PRINT:PRINT
1040 PRINT:PRINT:PRINT
1050 PRINT"                    Moving Message Display "
1060 PRINT
1070 PRINT"                     Parallel Access Demo"
1080 PRINT
1090 PRINT"                      John Koushappas"
1100 PRINT
1110 PRINT"          (C) Copyright 1992 Maplin Electronics Plc."
1120 PRINT
1130 PRINT"                          V1.0"
1140 LET NOUGHT%=0
1150 '
1160 LET SCROLLSPEED%=1000                 :' Set the scroll / animation speed here
1170 '
1180 LET BASEADD%=&H300                   :' Base Address pointer - set to suit
1190                                        :' All other ports reference this variable.
1200 LET DATAPORT%=BASEADD%                 :' Port A = Data Port
1210 LET CONTROLPORT%=BASEADD%+1            :' Port B = Control Port
1220 LET OE%=BASEADD%+2                     :' Port C = Display Output Enable
1230 LET CR%=BASEADD%+3                     :' Control Register for initialising 8255
1240 OUT CR%,128                            :' Initialise ports A, B, C as output ports
1250 GOSUB 1450                             :' Clear the display screen before start
1260 OUT OE%,1                              :' Switch display on
1270 FOR F%=1 TO 30                         :' Number of cycles
1280 OUT CONTROLPORT%,&H55                  :' Alternate column parallel access odds
1290 OUT DATAPORT%,&H55                     :' alternate LEDs
1300 GOSUB 1400                             :' Delay
1310 GOSUB 1450                             :' Clear display between screens
1320 OUT CONTROLPORT%,&HAA                  :' Alternate column parallel access evens
1330 OUT DATAPORT%,&HAA                     :' Alternate LEDs
1340 GOSUB 1400                             :' Delay
1350 GOSUB 1450                             :' Clear display between screens.
1360 NEXT F%
1370 CLS
1380 END                                    :' Phew!
1390 '
1400 '                          Delay subroutine
1410 '
1420 FOR Z%=1 TO SCROLLSPEED%               :' Pause between each frame
1430 NEXT Z%
1440 RETURN
1450 '                          Subroutine to clear the display
1460 '
1470 OUT CONTROLPORT%,NOUGHT%               :' Close all control lines
1480 OUT DATAPORT%,NOUGHT%                  :' Zero the dataport
1490 OUT CONTROLPORT%,255                   :' Zero all LEDs
1500 OUT CONTROLPORT%,63
1510 OUT CONTROLPORT%,NOUGHT%               :' Close the control lines to save.
1520 RETURN                                 :' Back to main program.
```

Listing 5. Parallel access demonstration program.

```
1000 KEY OFF
1010 COLOR 15,1
1020 CLS
1030 PRINT:PRINT:PRINT
1040 PRINT:PRINT:PRINT
1050 PRINT"                    Moving Message Display "
1060 PRINT
1070 PRINT"                    Parallel Access Demo 2"
1080 PRINT
1090 PRINT"                      John Koushappas"
1100 PRINT
1110 PRINT"          (C) Copyright 1992 Maplin Electronics Plc."
1120 PRINT
1130 PRINT"                          V1.0"
1140 LET NOUGHT%=0
1150 '
1160 LET SCROLLSPEED%=500                  :' Set the scroll / animation speed here
1170 '
1180 LET BASEADD%=&H300                   :' Base Address pointer - set to suit
1190                                        :' All other ports reference this variable.
1200 LET DATAPORT%=BASEADD%                 :' Port A = Data Port
1210 LET CONTROLPORT%=BASEADD%+1            :' Port B = Control Port
1220 LET OE%=BASEADD%+2                     :' Port C = Display Output Enable
1230 LET CR%=BASEADD%+3                     :' Control Register for initialising 8255
1240 OUT CR%,128                            :' Initialise ports A, B, C as output ports
1250 GOSUB 1560                             :' Clear the display screen before start
1260 OUT OE%,1                              :' Switch display on
1270 FOR F%=1 TO 30                         :' Number of cycles
1280 OUT CONTROLPORT%,24                    :' Middle two columns
1290 OUT DATAPORT%,24                       :' Middle two LEDs
1300 GOSUB 1510                             :' Delay
```

Continued on page 14.

Listing 6. Startrek demonstration program.

The controller's function is to transparently break down, or decode, the 8-bit port designated as the control port into its 256 individual lines in blocks of 16 lines per board. These 16 lines then feed two moving message display modules. At the same time, the controller board must be daisy-chainable as per the moving message display module, thus providing a natural, proportional expansion programme, as discussed in the first part of the series.

Controller Specification

Power Supply:
3·5 to 4·1V DC,
120mA max (Master Controller)
100mA max (Maximum Slave Controller)
80mA max (Minimum Slave Controller)

Power Supply:
Derived from odd numbered Moving Message Display

Source:
Modules in system.

Outputs:
One of 16 decoded outputs generated from D0 to D3.
D0 to D3.
Module pair select, bits 1 to 16

Inputs:
Parallel Port B, bits 0 to 7,
Parallel Port C, bit 1 (Master Controller)
Module Pair select 1 to 16, D0 to D3 (Slave Controllers)

Variations on a Theme

This article describes the design and construction of the implementation of the controller board. There are three variations of the Controller Board which allow for daisy-chaining, as well as component minimisation. These three variations are as follows:

Controller Board 1 – Master Controller
Even subsequent controller boards – Slave Controller (Even)
Odd subsequent controller boards – Slave Controller (Odd)

In addition, there are three levels of construction to the moving message display system. In the first part of the series, we dealt with the first of these:

Moving Message Display Module (MMDM) – Minimum System Configuration
Two MMDMs and Master Controller – Base System
4 or more MMDMs, 2 or more Controllers – Expandable system
Each of these configurations will be dealt with in their logical order.

Controller Module Circuit Description

The full circuit diagram is illustrated in Figures 3 and 4. These show the expandable nature of the design in two parts. The lower nibble decoder (i.e., bits 0 to 3 of the control

Listing 6 continued.

```
1310 GOSUB 1560                      :' clear display for next parallel access
1320 OUT CONTROLPORT%,36             :' Columns 3 and 6
1330 OUT DATAPORT%,36                :' LEDs 3 and 6
1340 GOSUB 1510                      :' Delay
1350 GOSUB 1560                      :' clear display for next parallel access
1360 OUT CONTROLPORT%,66             :' Columns 2 and 7
1370 OUT DATAPORT%,66                :' LEDs 2 and 7
1380 GOSUB 1510                      :' Delay
1390 GOSUB 1560                      :' clear display for next parallel access
1400 OUT CONTROLPORT%,129            :' Columns 1 and 8
1410 OUT DATAPORT%,129               :' LEDs 1 and 8
1420 GOSUB 1510                      :' Delay
1430 GOSUB 1560                      :' clear display for next parallel access
1440 GOSUB 1510                      :' delay
1450 GOSUB 1510                      :' delay
1460 GOSUB 1510                      :' delay
1470 NEXT F%
1480 CLS
1490 END                             :' Phew!
1500 '
1510 '                       Delay subroutine
1520 '
1530 FOR Z%=1 TO SCROLLSPEED%        :' Pause between each frame
1540 NEXT Z%
1550 RETURN
1560 '                       Subroutine to clear the display
1570 '
1580 OUT CONTROLPORT%,NOUGHT%        :' Close all control lines
1590 OUT DATAPORT%,NOUGHT%           :' Zero the dataport
1600 OUT CONTROLPORT%,255            :' Zero all LEDs
1610 OUT CONTROLPORT%,NOUGHT%        :' Close the control lines to save.
1620 RETURN                          :' Back to main program.
```

Listing 6. Startrek demonstration program.

```
100 KEY OFF
110 COLOR 15,7
120 CLS
130 PRINT
140 PRINT"                         Moving Message Display Module"
150 PRINT
160 PRINT"                            Program Selection Menu"
170 PRINT
180 PRINT"                              John Koushappas"
190 PRINT
200 PRINT"                 (C) Copyright 1992 Maplin Electronics Plc."
210 PRINT:PRINT:PRINT:PRINT:PRINT
220 PRINT"      1. Diagnose"
230 PRINT"      2. Triangle Wave Demo"
240 PRINT"      3. Maplin Demo"
250 PRINT"      4. Parallel Access Demo"
260 PRINT"      5. Star Trek Lights Demo"
270 PRINT:PRINT:INPUT"                          Choose...",A%
280 IF A%=1 THEN LOAD"DIAGNOSE.BAS",R
290 IF A%=2 THEN LOAD"TRIANGLE.BAS",R
300 IF A%=3 THEN LOAD"MAPLIN.BAS",R
310 IF A%=4 THEN LOAD"PARALLEL.BAS",R
320 IF A%=5 THEN LOAD"STARTREK.BAS",R
330 END
```

Listing 7. Menu program.

port) is shown in Figure 3, while the upper nibble port decoder (i.e., bits 4 to 7 of the control port) can be found in Figure 4.

Lower Nibble Decoder

The lower nibble decoder has as its input the control port, bits 0 to 3. These bits enter the controller circuit via connector PL3a and pass to IC3, a 74LS154 4-to-16 line decoder. This supplies a low output on one of the 16 output lines with the rest of the output lines high (refer to Table 3). This is almost what the moving message display module requires, except the outputs have to be inverted. For this reason, two 74LS240 octal inverters (IC1, IC2) have been employed. The outputs from these two devices now provide active high column selection (see Table 4), which is how the latches are made transparent on the Moving Message Display Module (refer to Part 1).

Referring to Figure 3 again, there is an active low enable ($\overline{E}$) input to the decoder. This has the effect of disabling the outputs of the decoder when it is taken high; the effect of disabling the device is to make all outputs go high regardless of the data input on D0 to D3 (see last line of Table 3 – an X indicates 'don't care'). Consequently, the column control outputs will all go low when $\overline{E}$ is taken high (refer to last line of Table 4). This control signal is generated by the upper nibble decoder.

Upper Nibble Decoder

The circuit of the upper nibble decoder, shown in Figure 4, can be used for either of two functions. The first is the Master Controller, which is the first controller board in the expandable system, and the second is the Slave Controller, which is used as all subsequent controller boards in an expandable system. There are two variations of the Slave Controller – 'Odd' and 'Even' – that will be discussed later.

					OUTPUTS															
E	D	C	B	A	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
0	0	1	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
0	0	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
0	0	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
0	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
0	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	X	X	X	X	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

X = don't care

Table 3. 74LS154 truth table.

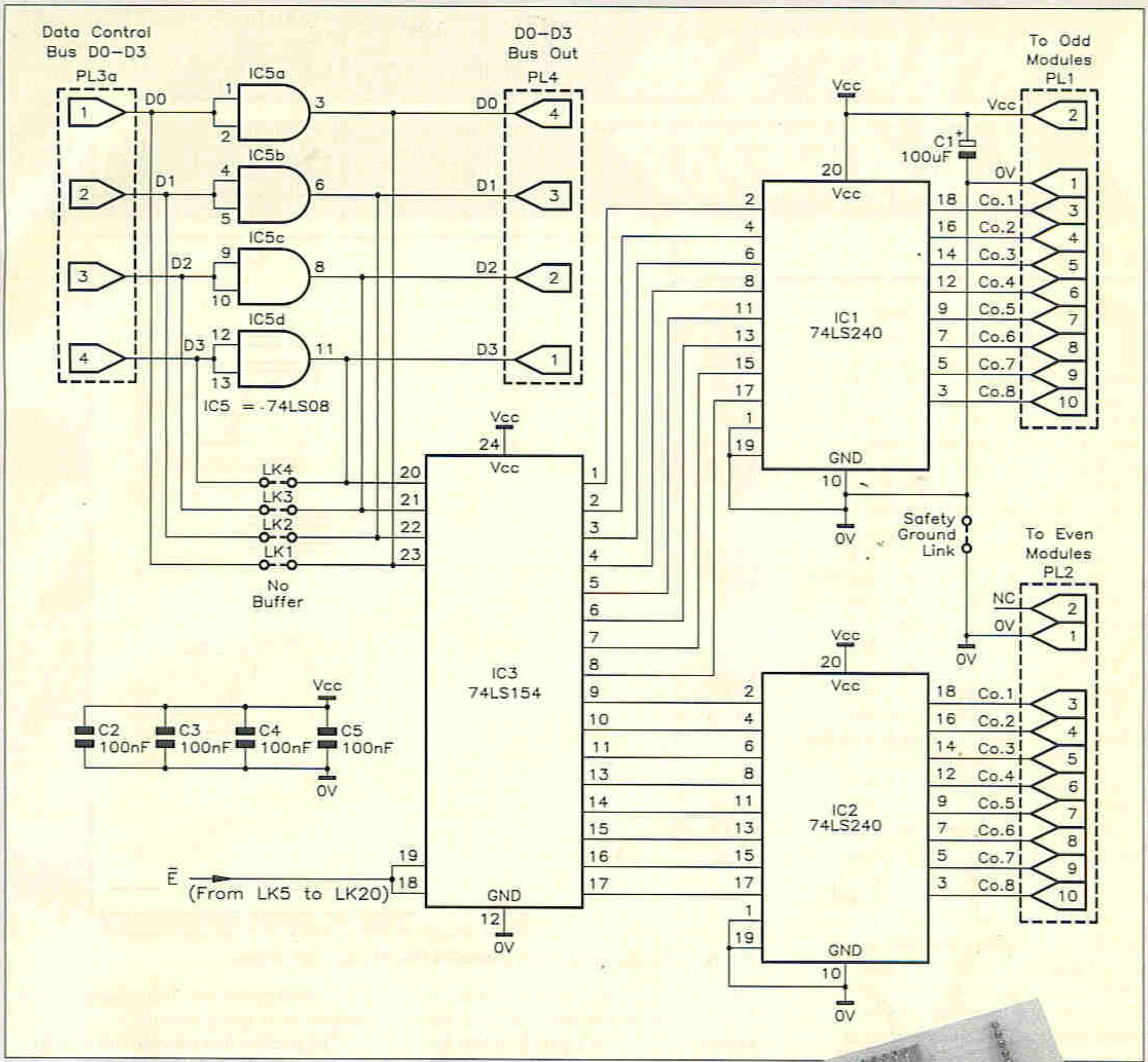


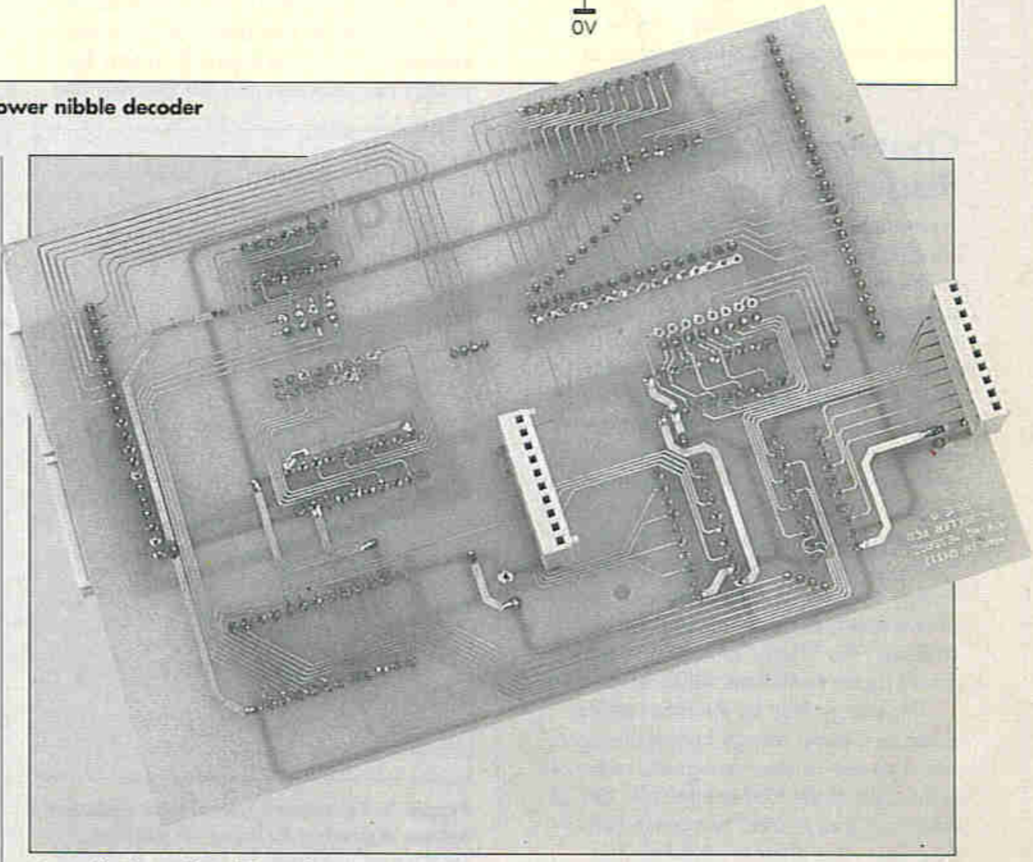
Figure 3. Display Controller circuit diagram - lower nibble decoder

Controller Variations

(a) Master Controller

In this case, the inputs are the control port bits 4 to 7. As with the lower nibble decoder, these lines go to a 74LS154 4-to-16 line decoder (IC4). The outputs are therefore as shown in Table 3. Thus, a low output on one of the 16 output lines is generated, with the rest of the output lines high. This data is generated only by the board being used as the Master Controller and is passed on to the subsequent Slave controller boards by a daisy-chain. The data is now dropped on to the 'Module Pairs' bus (MP1 to MP16), and is picked off the bus by a bank of links (LK5 to 20). This bank of links is called the 'MMD Module Pair Select Bank', because only one link out of the 16 available is used, and this selects which controller board, and thus which pair of moving message display modules are currently selected. The Master Controller board has LK5 selected – this selects the lower nibble decoder, as the data passes from the output of the link bank to the E input of IC3.

Continued on page 35.



Controller board - solder side

WHAT'S IN A LASER?

by Douglas Clarkson

The term 'laser' is used so often nowadays that there is a risk that the unique nature of 'laser' radiation is not appreciated. The word 'LASER' is an acronym for 'Light Amplification by Stimulated Emission of Radiation'. While, strictly speaking, lasers should relate to optical (visible) radiation, the term is also used to describe X-Ray lasers and lasers which generate infra-red wavelengths.

Where the term 'radiation' is used this means electromagnetic radiation. While this type of radiation varies from ultra short wavelength/high energy gamma rays to very long wavelength/low energy radio waves, practical applications mostly use a narrow band of wavelengths between about 20nm to 10,000nm (X-ray to infra-red).

A range of technologies have been adapted to generate laser radiations within this band. Where lasers make use of gases or even liquids, they are almost always bulky, require a great deal of power and are expensive. Solid state lasers such as Nd:YAG are finding increasing application, but such lasing materials are expensive and need elaborate and expensive optical structures built round them. Diode lasers have found particular application in many technologies due to their highly compact nature, low power consumption and low-cost. Increasingly, therefore it will be laser diodes which will provide the lasers of tomorrow.

Characteristics of Laser Radiation

Atoms and molecules in the various conditions of gas, liquid or solid can exist in various so called energy levels. In the example of the He-Ne (Helium-Neon) laser, for instance, Figure 1 shows the energy levels at which atoms may exist. These levels of energy are in fact determined by the various orbits which electrons may occupy. Where two atoms collide, one atom may absorb energy and 'promote' an electron to a higher orbit. The atom is said to be in an excited state. On the law of averages, however, the atom will release its energy within a short timescale. This form of emission is termed spontaneous emission. The 'decay' of energy is determined by the conditions within each atom.

The energy 'lost' by the atom settling down to a lower energy level is changed into a photon of electromagnetic radiation. In the case of the He-Ne example, one of the major lines emitted is a green line of 632·8nm. This photon, however, can induce stimulated emission of another

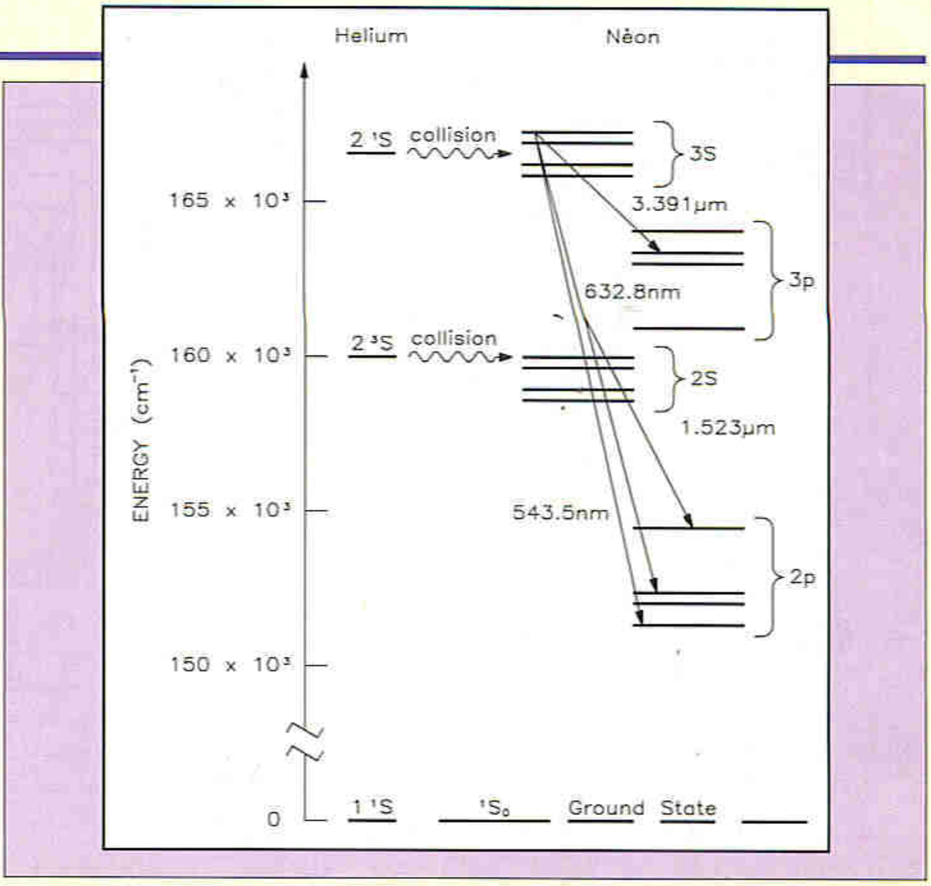


Figure 1. Energy levels with indicated line of main transition.

atom which is in an excited state when it 'interacts' with it. This action of simulated emission is shown in Figure 2. In turn the photon thus released can induce other like

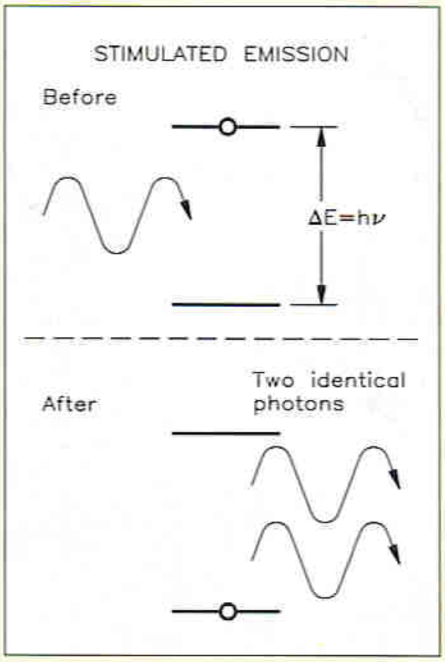


Figure 2. Process of stimulated emission where a photon induces an excited atom/ion/molecule to release a similar photon.

photons to be emitted. This general principle applies to all lasing systems.

The photons thus released are alike by energy (wavelength), direction and phase (coherence). In many respects the 'stimulated' photons can be thought of as 'cloned' photons of the original. Where a single transition energy is utilised, the output, if in the optical spectrum, will be a 'pure' single colour.

It is not enough, however, to merely excite atoms and hope that pencil like laser beams are produced. Where, in the ionised gas example, there will be stimulated emission taking place, the output light is not contained within a finite optical path. The laser system requires an optical resonator device – in general terms, as that shown in Figure 3 where at one end of the resonator a totally reflecting mirror reflects all incident radiation, and at the other end reflection does also take place, but a portion of the beam is transmitted.

Where a photon is emitted in the parallel direction between the reflecting mirrors, it can induce other photons to be emitted in the same direction. These photons are reflected from the mirrors and provided atoms can be excited at a sufficient rate a stable lasing beam will be established.

The faces of the laser diode are 'cleaved'

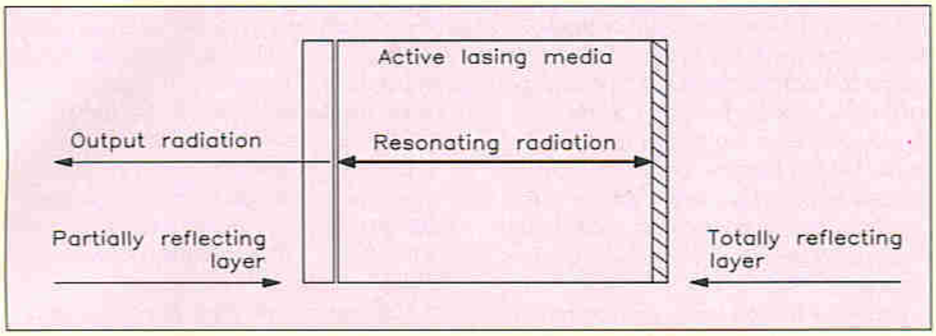


Figure 3. Diagram of simple optical resonator. One face is normally totally reflecting while radiation can 'leak' out of the other face.

to provide naturally reflecting faces. One face is usually made totally reflecting by the addition of an appropriate reflecting layer. Thus one of the key elements of a laser structure can be implemented simply in device fabrication.

The output beam 'leaks' out through the partially reflecting mirror. If a 'slice' is taken across the output beam at any point, then the photons will have the same phase. The distance over which the beam maintains the same phase, however, may only be several millimetres. Laser diodes can be specifically constructed to have long coherence paths for specific applications.

In relation to laser diodes, the key attributes of such a system relate to the energy of the level transition, the spread in energies around this and the degree of divergence of the output beam. Aspects of energy transitions relate to the energy levels within the laser diode structures. This is largely determined by the dictates of quantum theory.

Laser Diode Structures

In many respects, Light Emitting Diodes (LEDs) are an indication of the energy level transitions within simple semiconductor junctions. Figure 4 shows how current flowing across a simple P-N junction results in electrons falling from the conduction band down to the valence band. The energy released in this process is output as a photon of radiation.

In order to utilise such an effect for a laser function, the area around the junction needs to be made into an optical resonator, and the semiconductor material is required to be heavily doped to create an inverted population of excited states.

Homojunction lasers are made by P and N doping of the same semiconductor. While the first laser diodes were of this simple homojunction type, the commonest types today use sandwiches of material such as doped GaAs and GaAlAs. Single-heterojunction diode lasers are made by fusing two layers of different semiconductor material together. Such single types, however, are not efficient and are not ideal for continuous or high duty cycle operation.

Figure 5 shows a simple structure using layers of P and N doped layers of GaAs. The upper layer of P GaAs is heavily doped to allow good current conduction. This sandwich confines the electrons and holes to a narrow junction between the P and N GaAs, and helps improve the laser gain of the device. In this configuration, the laser radiation is confined to the full extent of the junction.

Subsequent developments allowed the area of laser action to be confined to a localised strip of junction using gain-guided or index guided techniques. In the gain guided laser, a so-called double-hetero-junction is used where the current carriers are confined to the middle 'sandwich'. This ensures that the photons released are initially confined to this small volume. This zone of confinement is a function, however, of the current passing through the device, so that at higher power levels the zone increases in size and the output beam changes in shape accordingly. Larger output powers up to 1W can be achieved by increasing the guide width up to 100 microns.

More recent technology has tended to utilise what are described as 'index guided' techniques, where a specific layer with a 'groove' or trough is established next to the lasing junction. The refractive index of this groove is higher than that of the surrounding material to encourage photons to remain within the waveguide groove.

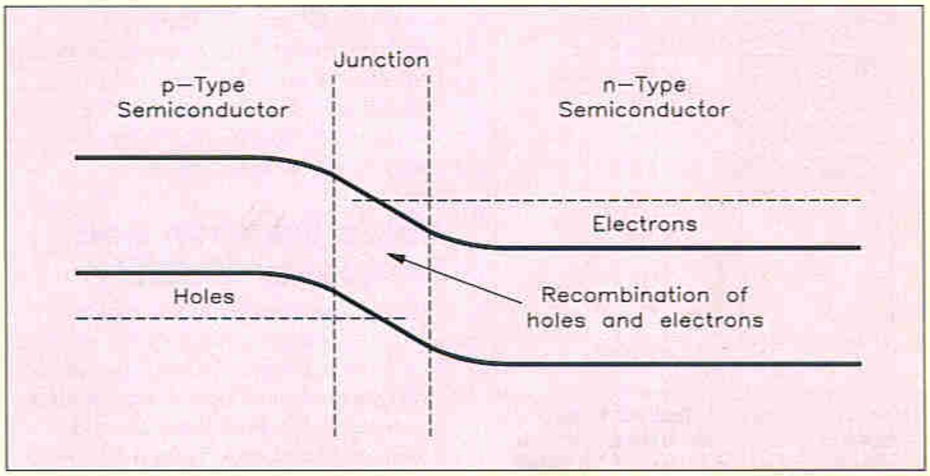


Figure 4. Level transition at a simple semiconductor junction.

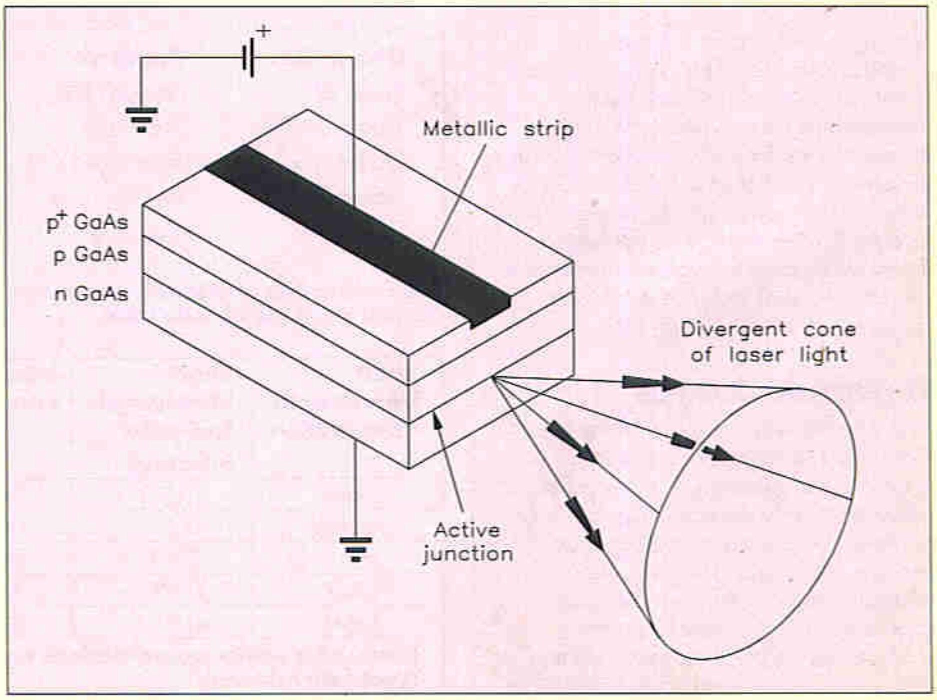


Figure 5. Simple structure of P and N doped layers of GaAs where the upper P GaAs layer is heavily doped to allow good ohmic contact.

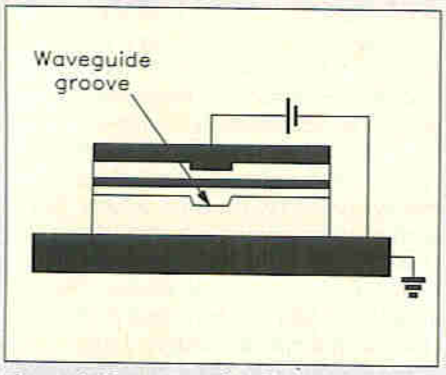


Figure 6. Structure of index guide fibre where light is contained within an optically guided groove in the diode.

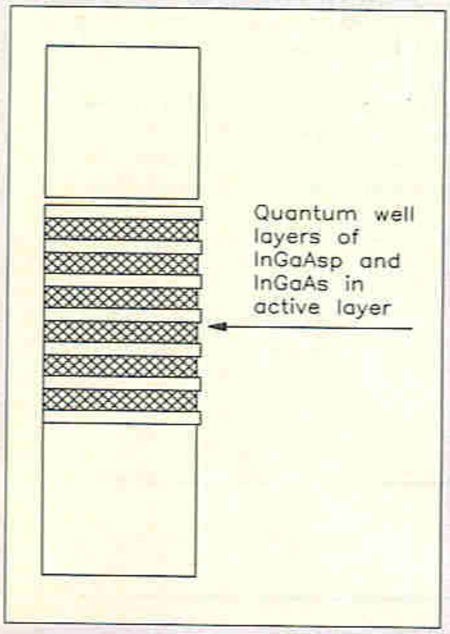


Figure 7. Diagram of strained layer multiple quantum well structure where, in this example, thin layers of InGaAsP and InGaAs form the active layer of the device.

Such a device is shown in Figure 6.

The catchily-titled 'strained-layer multiple quantum well structures' have been developed as the active layer of a range of laser diodes. Figure 7 shows the layering of very thin strips of InGaAsP and InGaAs within a long wavelength diode laser. The layers within the structure do not behave as if they were part of a large crystal structure. The efficiencies of such quantum well structures can be surprisingly high.

Designer Diodes

Within semiconductor materials, the key factor which determines the bandgap energy is the separation of atoms in the lattice structure. In the case of 'pure' GaAs or 'pure' InAs, the respective bandgap energies are roughly 1·4 and 0·4eV (electron volts), and the corresponding photon wavelengths would be about 0·86μm and 3·2μm. If, however, starting with 'pure' InAs, the percentage of In is decreased and that of Gallium is correspondingly increased, then the band gap energy is correspondingly increased. This has to do with the increased potential energy of electrons above the base energy level of the atoms in the lattice. In this regard, Gallium has a smaller atomic radius, but has bonding properties identical to that of Indium. Thus, within this set of end points of chemical composition, there is as it were a potential continuum of wavelengths possible.

Another transition series exists in the case of InP and InAs where the mix of P and As in the compound varies between the limits of 0 to 100%. Table 1 shows the details of the sets of elements in groups IIIa and Va of the periodic table, indicating the elements with similar bonding characteristics.

Table 2 summarises the range of semiconductor materials which can be created by changing the relative mixes of elements from groups IIIa and Va.

The energy of the transition between the valence band and the conduction band is a function of the materials used to dope the semiconductor material. There is a significant demand, for example, for diodes to function at the 1·3μm and 1·5μm 'telecommunication windows', as they are known, which arise due to the specific characteristics of optical fibres.

Mode Selection and Frequency Stability

The basic laser diode has two reflectors which form part of a Fabry-Perot Cavity. Many sets of standing waves, however, can terminate at the end faces of the resonator. In a typical laser diode these are about 0·5nm apart and, potentially, a number of these can be selected over a total wavelength range of about 50nm. The actual mode which the device will resonate at, will be the one which attracts highest optical amplification. This, in turn, is determined by the precise dimensions of the device and the composition of the active layer.

Group IIIa	Group Va
Boron (B)	Nitrogen (N)
Aluminium (Al)	Silicon (Si)
Gallium (Ga)	Arsenic (Ar)
Indium (In)	Tin (Sb)
Thallium (Tl)	Lead (Pb)

Table 1. Families of elements in Groups IIIa and Va of the periodic table.

Changes in temperature will result in a general wavelength change due to the change in refractive index of the active zone of the diode. Where a significant degree of drift is present, this can cause the device to 'hop' into a mode which has higher optical gain.

The effect of change of wavelength with temperature is a basic function of the semiconductor device and cannot be overcome by design changes.

Fluctuations in temperature can cause both gradual wavelength drift and also 'mode hop' where the diode laser resonates at a slightly altered frequency. Such changes in wavelength are highly undesirable in telecommunications applications where signal losses in fibres and amplifying stages can significantly degrade performance.

Some applications demand both a high stability of wavelength and also narrow line spread of the set wavelength. The design of the resonant cavity of a laser diode can improve the selectivity of the resonant mode. In the distributed feedback laser, a grating pattern corresponding to a specific wavelength is deposited in the active layer structure of the diode channel. This technique can produce spectral line widths of the order of 20MHz. It can be replicated, but with less complexity in fabrication, by use of the Distributed-Bragg reflection laser, where the grating element is external to the current carrying element of the laser diode.

These two types of feedback laser function essentially at a fixed wavelength, since the spacing of the grating and the angle of the incident radiation are fixed. The external cavity laser, however, uses a separate grating with a focusing lens. The grating can be rotated in order to vary the angle of incidence of the laser beam to the grating.

Using DFB and DBR techniques, devices have been produced with bandwidth below 2MHz across a range of wavelengths of 6nm and 145kHz across a wavelength range of 145kHz.

The level of drive circuit has a slight

Short Wavelength Composition	Short Wavelength End-point (microns)	Intermediate Composition	Long Wavelength Composition	Long Wavelength End-point (microns)
Ga(P)	(0·67)	Ga(PAs)	Ga(As)	0·86
Ga(As)	0·86	Ga(InAs)	InAs	3·1
In(P)	0·89	In(PAs)	InAs	3·1
(Ga)P	0·52	(GaIn)P	InP	0·89
(Al)As	0·55	(AlGa)As	GaAs	0·86
Note: value within sqaure brackets represents an end-point wavelength which is not fully achieved.				

Table 2. Outline of five major 'families' of semiconductor devices which are used to produce laser diodes.

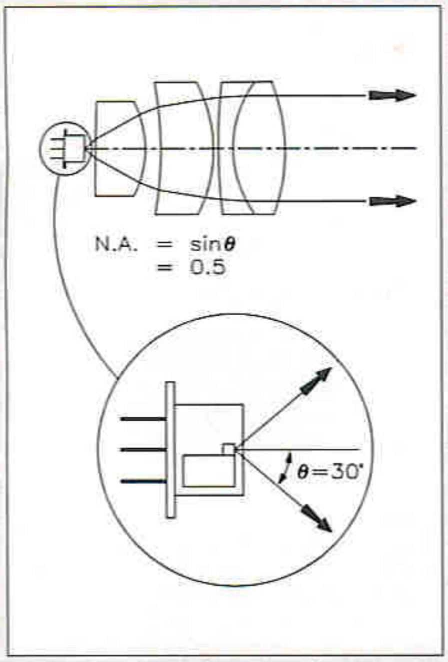


Figure 8. Lens triplet system for producing a parallel beam from divergent diode laser output.

influence on the wavelength of the output radiation. An effect in the order of an increase of 0·025nm per mA of current is typical for GaAlAs laser diodes. The effect of temperature, however, is more significant and the output wavelength typically increases by about 0·3nm per degree Centigrade. Where stability of the wavelength is critical, thermoelectric coolers are used to maintain the diode temperature within narrow limits.

Beam Characteristics

The strip of the diode actually generating the output can be as small as 0·1 by 5µm wide. The laser radiates out in an elliptical cone with a half angle typically between 12 to 30 degrees. This contrasts significantly with the extremely low divergence of, for example, a He-Ne laser. The beam of the He-Ne laser will also be more uniform than that of the laser diode.

Astigmatism also occurs in laser diodes, where the rays, when focused, are not brought to a single focus. This level of astigmatism can be described as the 'spread' over which rays are focused. This can be in the region of 10µm.

Where such laser diodes are required to be used in demanding applications, the quality of the output beam has to be improved using external correcting lenses. One option is to use a triplet of lenses as shown in Figure 8 to produce a parallel beam from the initial diverging beam.

Drive Characteristics

One of the very great advantages of the laser diode is that the output laser signal can be directly modulated by varying the drive signal. This is of direct relevance in, for example, telecommunications applications, where electrical signals are used to directly modulate diode laser outputs. Figure 9 shows the typical drive characteristics of a GaAlAs diode in the medium to low power class. The device is functioning very much like a normal signal diode.

The curve indicates that there is a threshold voltage above which laser output is observed. Most laser diode drive circuits control output by the means of adjusting the forward current since this is more easy to control.

Figure 10 shows the modulated signal characteristics of a typical laser diode. There is an initial delay in rise of light output with times varying between 0·1ns and 1ns. The relaxation oscillations are caused by the initial rapid increase in the population of the higher energy levels. Present data rates using state-of-the-art laser diodes are in the tens of GHz.

The lattice structure within a laser diode, particularly the active region, is very sensitive to surges in current drive levels which can cause local heating and degradation. Great care usually has to be taken to ensure that power supplies do not deliver current spikes to such devices.

Laser diodes are surprisingly efficient devices. Typical efficiencies range from 10% to 35% in commercial devices and up to 60% in laboratory systems. (Could these be the street lamps of the future?)

Applications

There is no doubt that one key application of laser diodes is in communications systems. However, the criterion here for such use relates to reliability and stability.

Diode lasers are of course extensively used in Compact Disk technology. Existing AlGaAs types operate typically in the region of 780nm to 830nm, i.e. in the non-visible infra-red region. A range of complex optics is used (see Figure 11) to focus the laser beam onto the media surface. The spot size generated is inversely proportional to the wavelength of light used. This means that, in terms of the recording density of the data in two dimensions, the term is inversely proportional to the square of the wavelength. At the same time, the reading speed is inversely proportional to the wavelength.

While shorter wavelength laser diodes operating at around 670nm are available, and could provide around a 50%

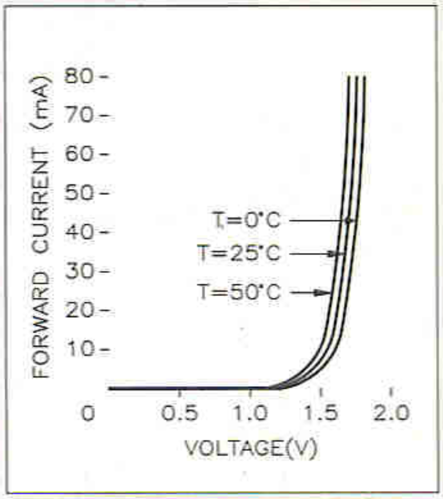


Figure 9. Drive characteristics of low power GaAlAs laser diode

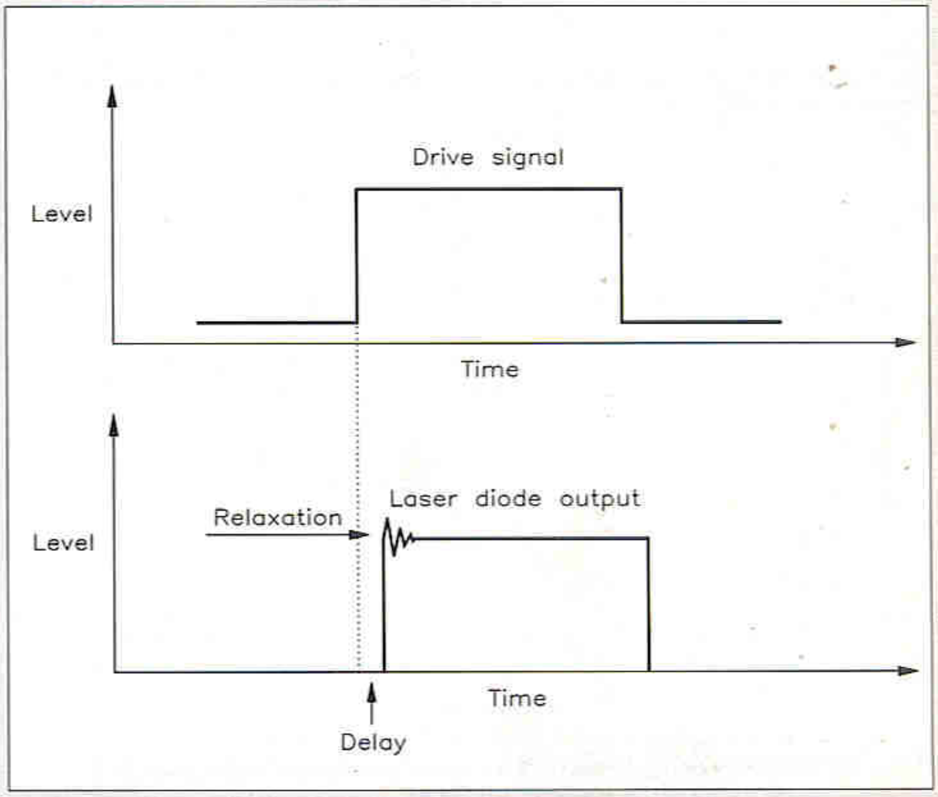


Figure 10. Signal drive characteristics of a typical laser diode.

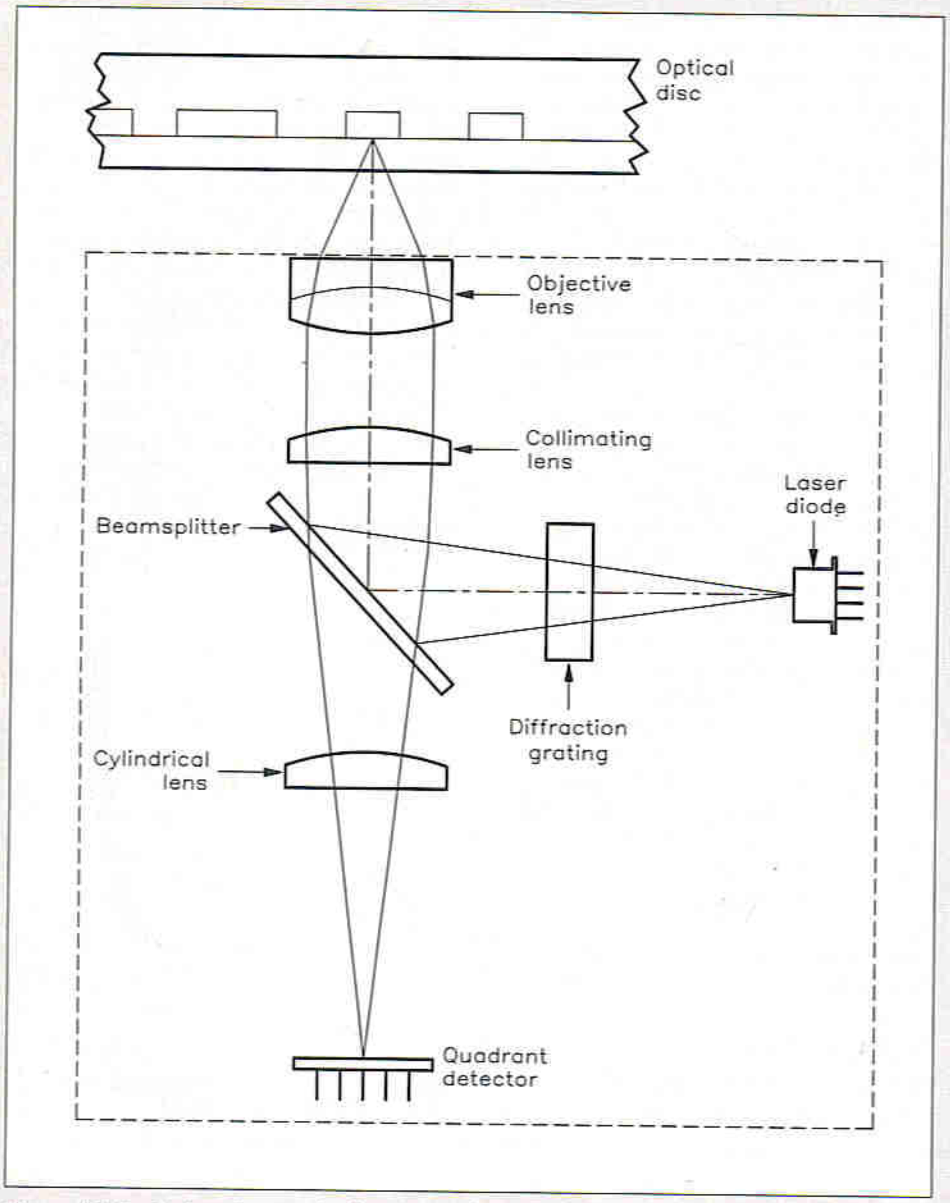


Figure 11. Typical optics required to create focused spot from divergent laser diode output in CD applications.

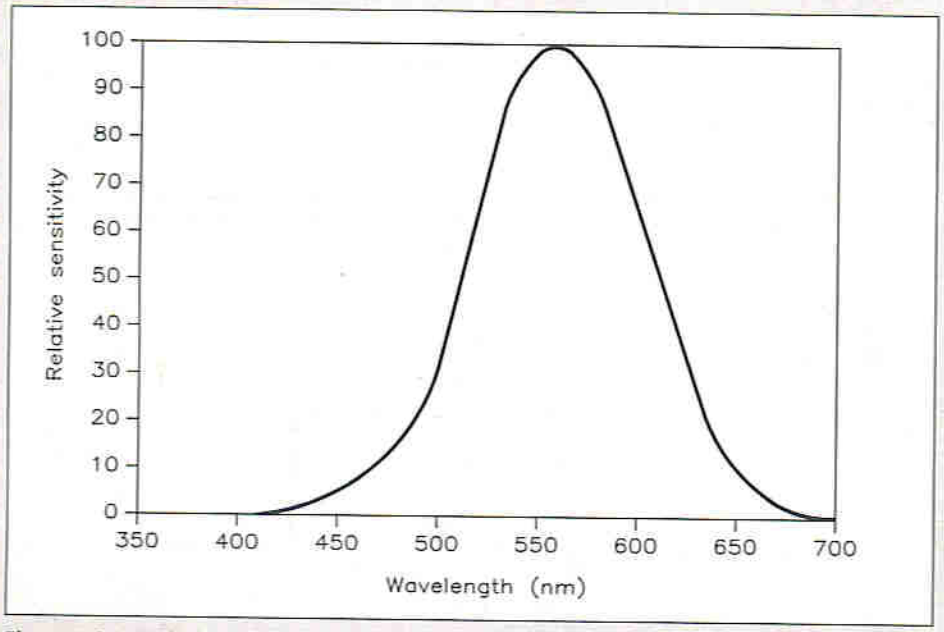


Figure 13. Sensitivity of the human eye as a function of wavelength. The eye is significantly more sensitive to radiation at 633nm (He-Ne) than 670nm (typical laser diode output).

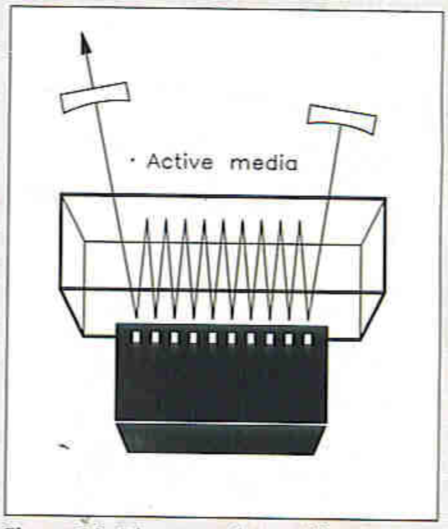


Figure 12. Diagram of use of laser diodes to 'pump' active solid state laser material such as Ti:Sapphire

improvement in data read/write density, this level of improvement is not considered of major significance. There is marked interest, however, in developing blue light laser diodes. Researchers at 3M (St. Paul, MN) have demonstrated a device based on elements in groups II and VI of the periodic table, which produces blue light at 502nm at room temperature. The quantum well structure, based on thin layers of CdZnSe sandwiched between ZnSe confinement layers and ZnSSe cladding layers, is currently undergoing further development in order to improve ohmic contacts to the device.

While current interest relates to the reading data using such laser diodes, there is considerable scope for laser diodes to be used in WORM (Write Once/Read Many) technology.

Diode lasers are being increasingly used as pumps for other laser systems. The use of laser diodes at 808nm to pump Nd:YAG allows such lasers to be significantly more compact compared to Xenon flashlamp excitation systems. This should lead to both cheaper and more reliable Nd:YAG systems. Figure 12 shows how a laser diode array can be interfaced to an 'active' laser media in order to initiate laser transitions in the materials such as Ti:Sapphire.

Red laser diodes, delivering output at 670nm, are commonly used as pointers. Prices are in the region of £100.00 for self-contained units. Such units, however, do not appear as bright, mW for mW, as He-Ne lasers which lase at around 632nm. This is because the eye is much less sensitive at the wavelength of 670nm compared with 632nm, as indicated in Figure 13. One supplier in the UK of such devices is Ealing Electro Optics plc of Watford.

Laser diodes are also used in an extensive range of surveying and distance ranging equipment. In summary, the 1990s will certainly extend the range of applications for laser diodes and almost certainly will make more cost-effective the use of a broad range of lasers in the future.

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Three exciting projects for you to build

Don't miss out! These projects have been previously featured in 'Electronics – The Maplin Magazine', but are not in the 1993 Maplin Catalogue.

3 PROJECT RATING

Temperature Controlled Soldering Iron Station

This extremely practical project can control a suitable 24V iron (included) over the range 70°C to 450°C making it ideal for precision soldering, thermal fault finding and pyro-graphic art. This kit offers the home constructor a considerable saving over a comparable off-the-shelf unit.

For Optional Parts, not in kit, see Issue 59, page 14.

LT13P (Soldering Station) £59·95 D

Telephone Ring Simulator

2 PROJECT RATING

PROHIBITED from direct or indirect connection to public telecommunication systems. Action may be taken against anyone so connecting this apparatus.

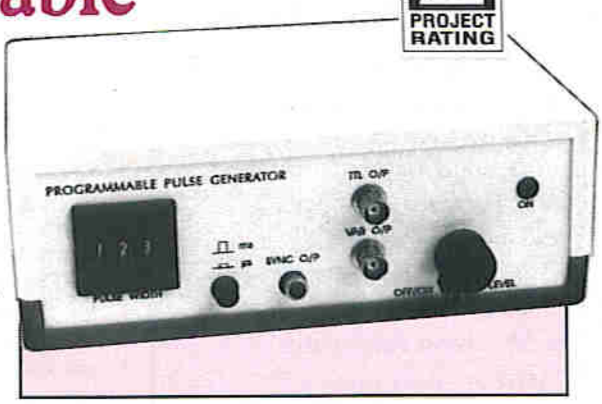
This clever unit simulates the correct telephone ringing pulses for UK or USA systems, or can produce your own 'designer' ring. It can ring a normal telephone, plugged into the unit, or an optional internal bleeper. As it can be easily cued and stops ringing when the telephone is 'answered', it is ideal for amateur dramatics, plays, films, sound effects, telephone testing or just for laughs, playing tricks on your friends or workmates. Note: Under no circumstances should this unit be connected to a public telephone network socket.

For Optional Parts, not in kit, see Issue 61, page 35.

LT19V (AutoRing) £14·95

Programmable Pulse Generator

2 PROJECT RATING



Programmed by three binary-coded decimal (BCD) switches, this crystal controlled unit can produce pulsewidths of 1µs to 999ms with an accuracy of 1%. Output voltages are TTL compatible or variable by means of a front panel control. The unit is ideal for oscilloscope calibration, timing, development work and for providing general test signals.

For Optional Parts, not in kit, see Issue 61, page 13.

LT20W (Programmable Pulse Generator) £22·95

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3 PROJECT RATING

Audio Frequency Sine/Square Wave Generator

Text by Martin Pipe

An audio frequency (AF) oscillator is an essential piece of test apparatus for the construction and servicing of audio products, such as Hi-Fi, PA and disco equipment. Because of the very low distortion sine wave output from this oscillator, it is suitable for use with even the most sophisticated Hi-Fi equipment. In conjunction with an oscilloscope, 'nasties' such as crossover distortion (incorrectly biased amplifier output stage), intermodulation by hum (power supply smoothing capacitors suspect) and the effects of clipping (overdriving) can all be investigated. This essential piece of test equipment can also be switched to produce square waves; these, being rich in harmonics, are useful for evaluating the frequency response and phase shift characteristics of an amplifier. The many uses of a signal generator and oscilloscope for servicing or design work are beyond the scope (no pun intended) of this article, but many books and magazine articles cover the subject well. For example, 'Electronics' issues 34 (October/November 1989) to 37 (April/May 1990) contain an excellent series by John Woodgate, "Measuring Distortion in the Home Workshop", which will be a good source of further reading material.

The unit may be used to make test tapes for the alignment or evaluation of tape recorders. In conjunction with a suitable amplifier, this unit could also be used to drive various transducers; this may be of benefit in certain types of scientific experiment – physics, structural engineering and so on.

FEATURES

- ★ Economical Sine and Square Wave Generation over the Audio Frequency Range
- ★ 3 Frequency Ranges
- ★ Low Distortion
- ★ Single 9V DC Power Requirement
- ★ Precision Attenuator

APPLICATIONS

- ★ Testing and Designing Low-frequency Circuits
- ★ Setting up Audio Systems
- ★ Producing Test Tapes
- ★ Scientific Experiments

Circuit Description

The operational amplifier, IC1, is at the heart of a standard Wien bridge oscillator, shown

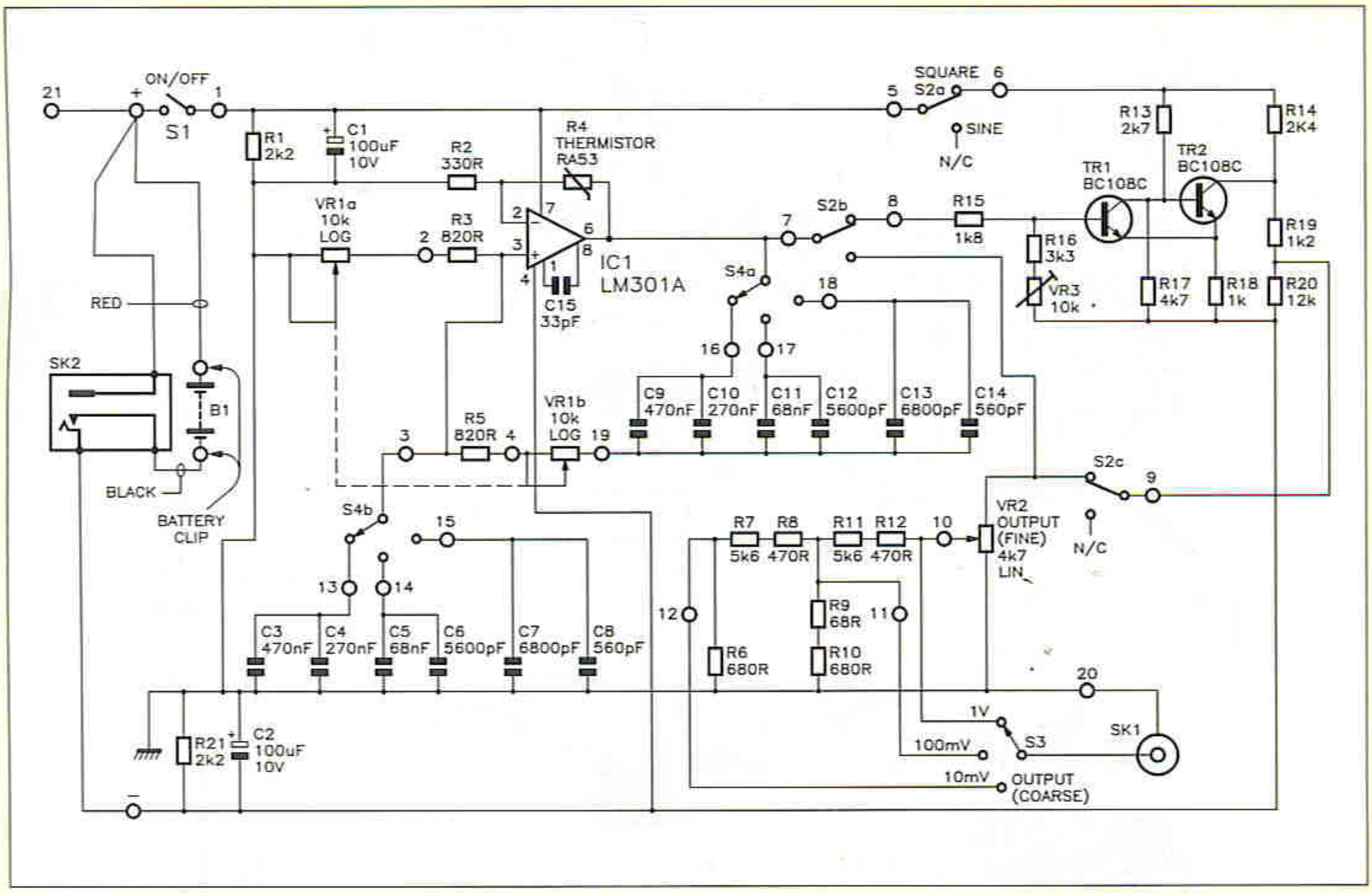
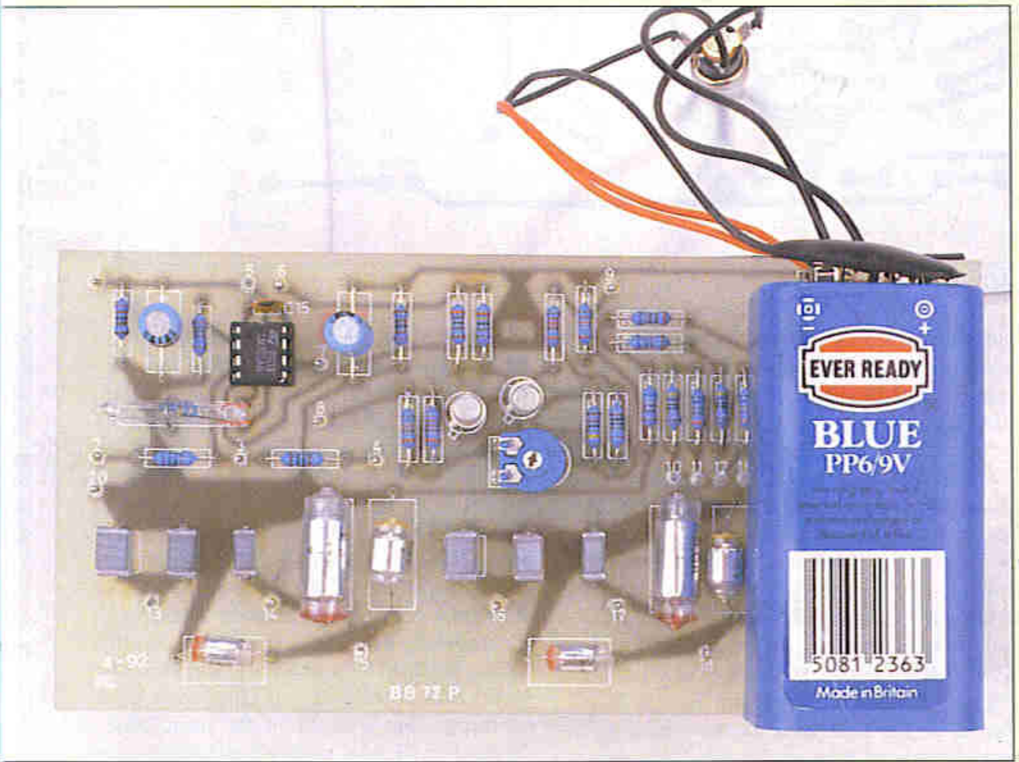


Figure 1. AF Signal Generator circuit diagram.



The assembled PCB.

Prototype Specification

Frequency Range:	17·5Hz to 22·8kHz in 3 ranges
Sine Wave Distortion (1kHz, maximum output):	<0·05%
Sine Wave Distortion (1kHz, $^2/_3$ maximum output):	<0·042%
Attenuator:	3 ranges; continuously variable
Sine Wave Output:	4V pk-to-pk
Square Wave Output:	2V pk-to-pk
Off-load Current Consumption:	8mA maximum

in the circuit diagram of Figure 1. The frequency of the oscillator is dependent upon the capacitors selected by the range switch S4a/b and by the position of the dual potentiometer RV1a/b, which gives a reasonably linear scale. A negative-temperature coefficient (NTC) thermistor, R4, in the feedback loop of IC1 maintains a constant output signal amplitude over the frequency ranges. One of the conditions of oscillation (the 'Barkhausen' criteria) is that the overall loop gain is 1 (0dB). Due to the insertion losses of the feedback filter, the output has a third of the amplitude of the signal applied to the filter's input, at the desired frequency. As a result, the Op-amp must have a gain of 3 to compensate for this. But things are seldom as easy as this, as changes in temperature significantly cause the circuit's component values to change disproportionately to each other. In addition, the Op-amp itself may behave differently at the different frequencies across which the oscillator is expected to operate. This is why gain stabilisation – in this case, provided by R4, is required. R4, a thermistor which has a fairly long thermal time-constant, is heated by the oscillator's mean power output level, and at the desired output level (i.e. when the Op-amp's gain is 3), has a resistance value double that of R2. As a result, the overall loop gain is maintained at unity. If the output's amplitude rises, the temperature of R4 will rise correspondingly; its resistance will therefore fall reducing the gain, and thus maintaining the output level. The converse applies if the output's amplitude starts decreasing.

Also shown in Figure 1 are TR1 and TR2 which, in conjunction with associated components, form a Schmitt trigger; the function of this circuit is to convert the sine wave from

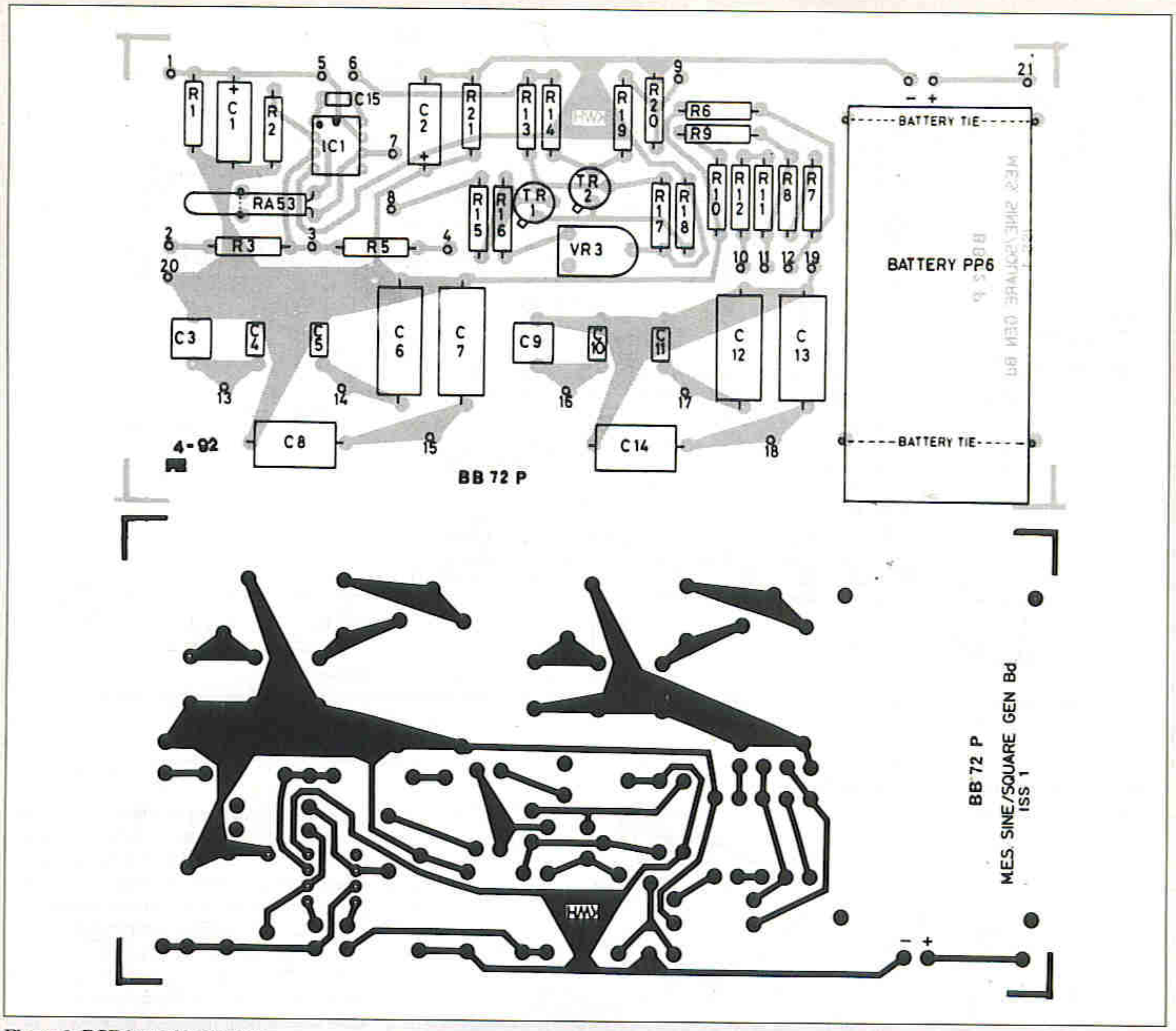


Figure 2. PCB legend and track.

IC1 into a square wave; the preset resistor RV1 allows adjustment to optimise the mark/space ratio to 1:1 (50% duty cycle).

Switch S2a/b/c selects between sine or square wave output; to extend the life of the optional internal battery, the Schmitt trigger circuit is disconnected from the power supply when the sine wave mode is selected.

The output, from either the oscillator or Schmitt trigger, is then fed to an attenuation network; switch S3 and resistors R6 to R12 determine the output level range (10mV, 100mV or 1V), while VR2 allows fine adjustment over the selected range.

PCB Construction

Population of the PCB is fairly straightforward; begin construction with the smallest components (i.e. resistors) first, working up in size to the largest. The track layout and component legend are reproduced in Figure 2. When installing the RA53 thermistor, R4, locate it within the space shown on the board legend. Under no circumstances must the glass envelope of the thermistor protrude over the edge of the PCB, or it could be damaged. If the PCB is fitted into the recommended optional box, it is important to ensure that the end of the thermistor is at least 6mm from the edge of the board. If this is not done, the thermistor's vacuum seal may be broken off by the PCB mounting guides (located in the centre of each case section) that will accept the finished board.

Note that the two electrolytic capacitors, C1 and C2, are polarised devices and must be correctly installed; the negative (–) lead of the capacitor must be furthest away from the positive (+) symbol printed on the PCB legend. In addition, the leads of each electrolytic capacitor will require preforming. The notch on the IC socket should be aligned with the notch of the legend; IC1 should be installed after all the wiring has been completed. The double-sided PCB pins are inserted from the track side of the PCB; please note that a pin is not supplied in the kit for position 21, as it is not required.

Mechanical Assembly

If you intend to use the optional box, drill the hole in the back panel for the power socket, referring to Figure 3. If you are using the signal generator with a 9V battery (PP6 recommended), pillars mounted in the top and bottom of the case will need to be removed. Carefully remove either the top left (or bottom right) mounting post from each half of the case, as viewed from the inside. This can be achieved with a pair of wire cutters. Trim the shafts of the potentiometers and switches VR1a/b, VR2, SW3 and SW4 to 9mm, as shown in Figure 4. Install all switches, potentiometers and the BNC socket onto the front panel; the switches SW1, SW2 and BNC socket can be locked into position – the lock-nuts of the remaining controls should be 'semi-tightened' so that they can be repositioned if required. Temporarily fit the knobs of these controls (VR1, VR2, SW3 and SW4), and align the potentiometers and switches with their corresponding legends on the front panel. Remove the knobs, and tighten the securing nuts of each control; the knobs can then be refitted.

Once the controls have been secured to the front panel, they may be wired to the PCB as shown in Figures 5 and 6. Figure 5 shows the ground (0V) wiring, which should be completed first, using the supplied tinned copper wire – don't forget to solder the 0V link to the case of VR1a/b. The rest of the wiring is done with the black hook-up wire supplied with the kit. When connecting the controls to the PCB (refer to Figure 6), use the minimum practical lengths of wire; you might find it helpful to place the board and

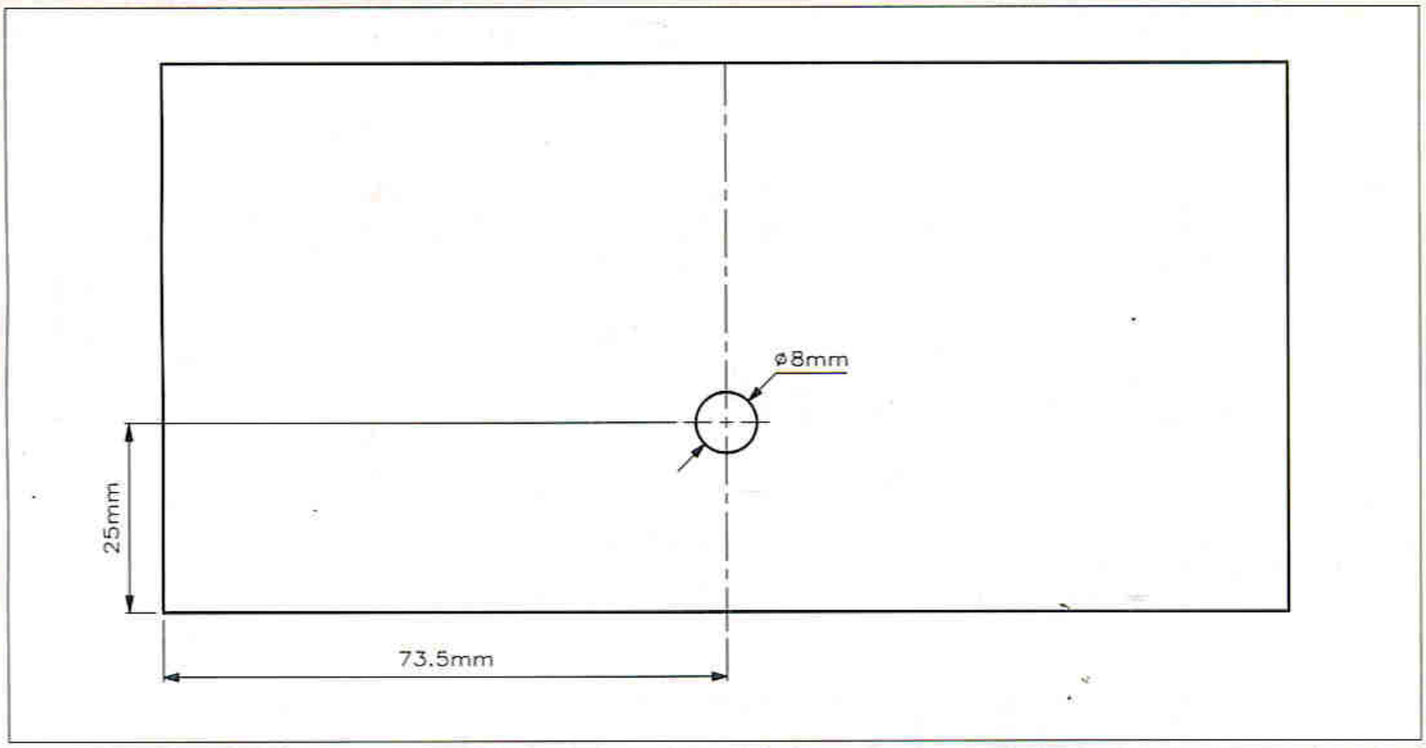
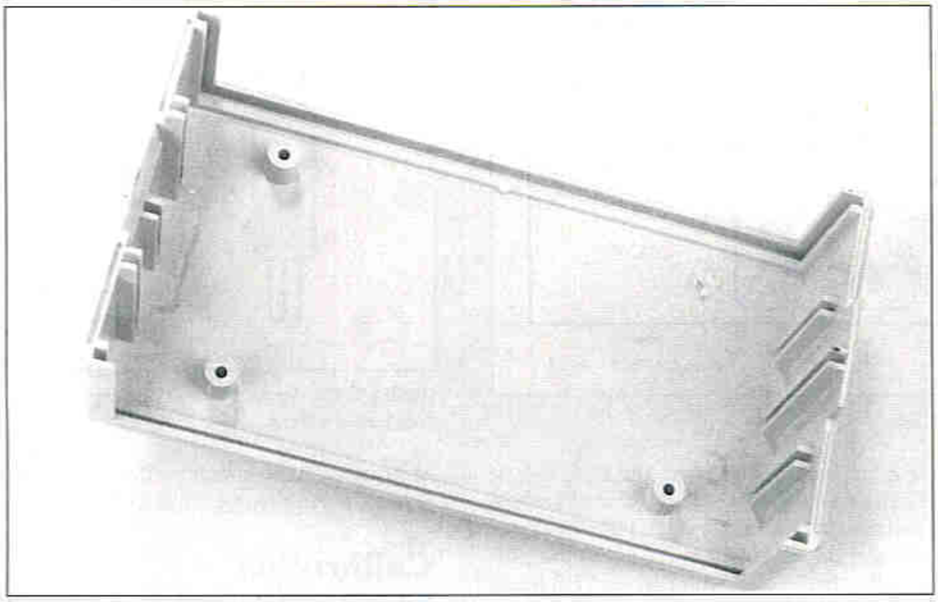


Figure 3. Rear panel drilling details (for optional box).



Top half of case, showing mounting pillar (carefully!) removed to accommodate the battery in the finished unit. The corresponding pillar in the bottom half of the case is also removed.

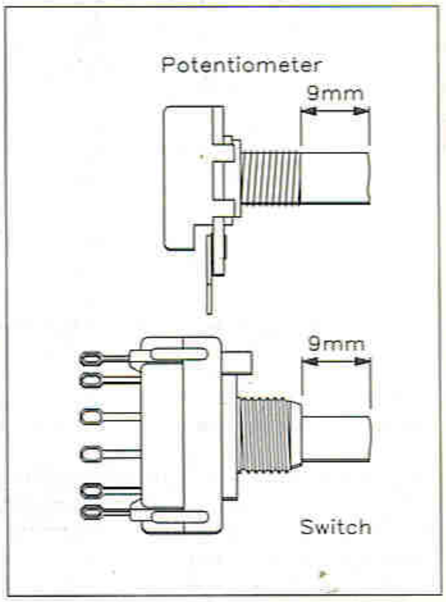
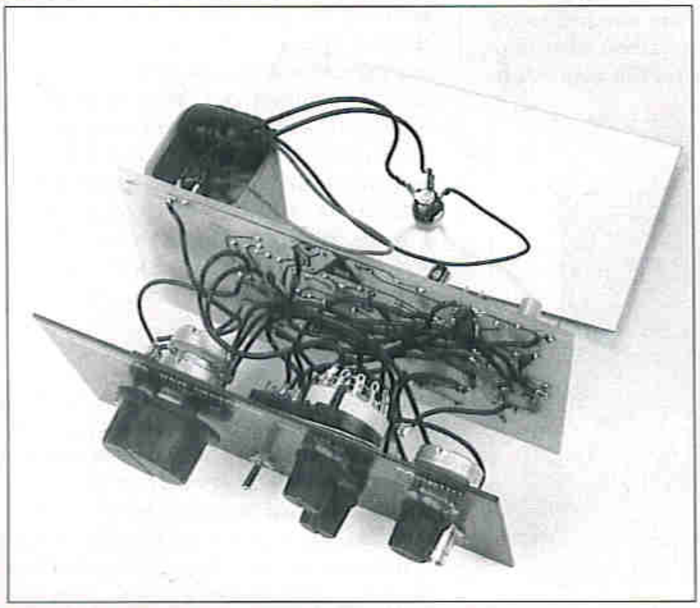
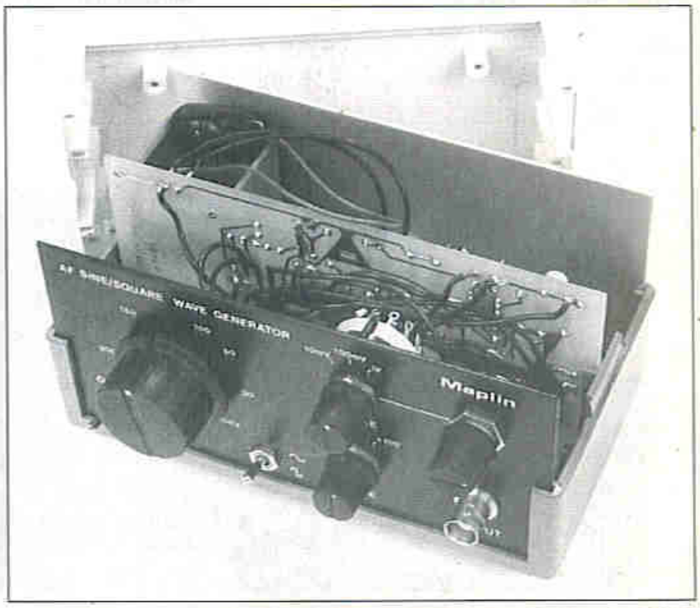


Figure 4. Trimming control shafts to required length.



Assembled AF Signal Generator, just prior to fitting in case.



Completed AF Signal Generator with top lid removed, showing PCB in place. Note that it is fitted in the central guide.

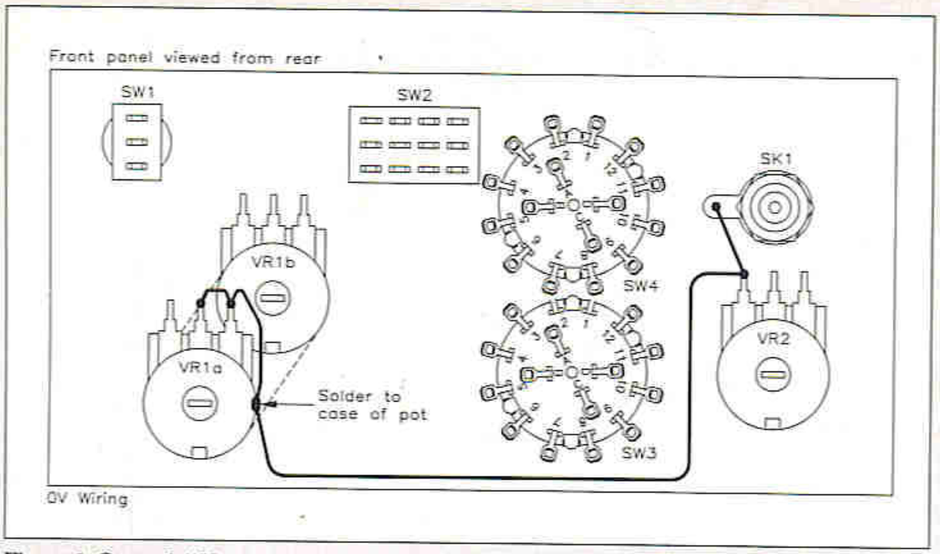


Figure 5. Ground (0V) wiring.

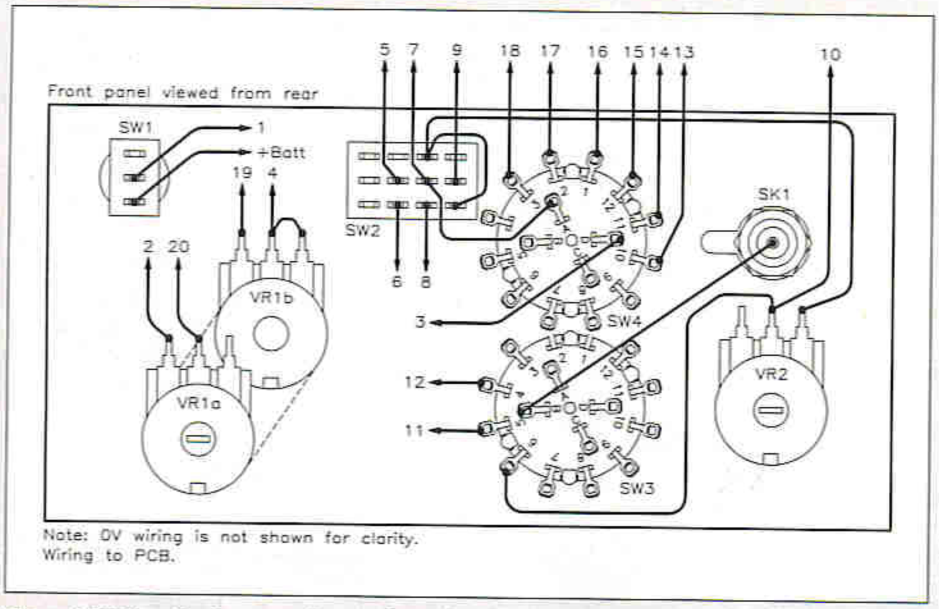


Figure 6. Wiring the front panel controls to the PCB.

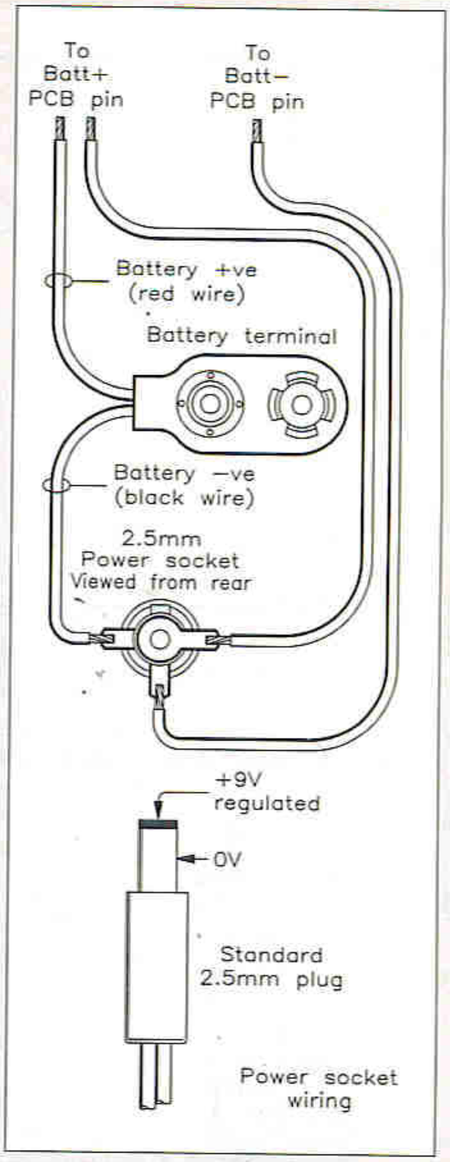
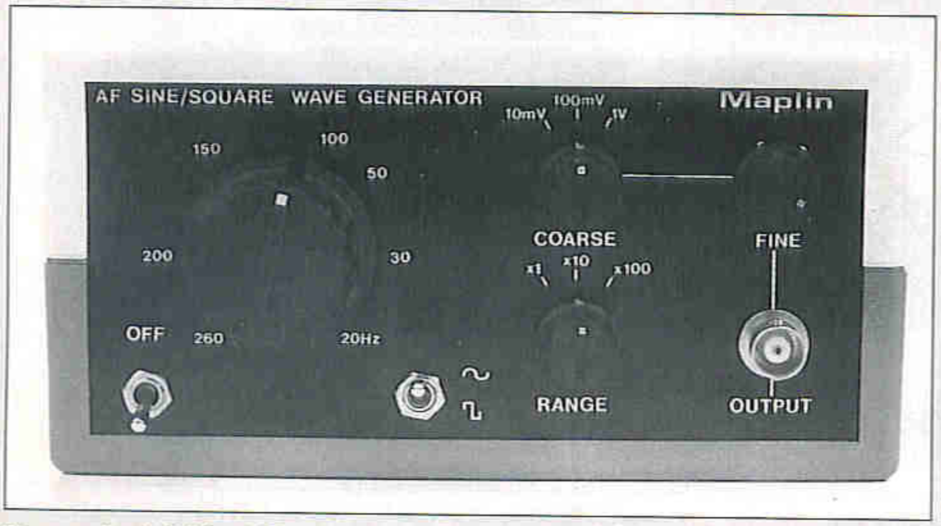


Figure 7. Power socket and battery connector wiring.

panel in one of the case sections so that you can gauge the amount of wire required for each connection. Note that the wiring (numbered in the drawing) from the front panel is connected to the relevant pins from the track side of the PCB (for your reference, each pin is correspondingly numbered on the component side).

Wire the battery terminal and power socket to the pins on the component side of the PCB, as shown in Figure 7. If the optional box is to be used, the PCB can be fitted into the guides in the middle of the box, and the control panel held in place by one of the end guides. However, do not fit the back panel onto the case yet, as preset VR3 needs to be set up. If a battery is to be used, three quickstick pads should be attached to the top, middle and bottom of the battery. Note that the side of the battery attached to the PCB should be the one furthest away from the terminals, or the two PCB pins will be obstructed. After attaching the pads to the battery, it can then be stuck to the PCB.



The completed AF Signal Generator.

Calibration

If you have an oscilloscope, connect the output of the Signal Generator to the oscilloscope, select the square wave output and switch on the generator. Preset resistor VR3 should then be adjusted to give a 1:1 mark/space ratio (i.e., the positive and negative-going pulses should be of equal width). After sweeping through the ranges to make sure that the rest of the generator is working properly, switch it off and disconnect from your 'scope. Alternatively, if you don't own a 'scope, adjust VR3 to approximately halfway between 9 and 10 o'clock (with the centre wiper leg at 12 o'clock).

Final Assembly

Fit the power connector to the back panel, and then slide the panel into the box. Finally, clip the lid onto the box – your new piece of test equipment is now ready for use! If you are mounting the unit into a housing of your own choice (e.g., if you are building the unit into a control console, with the supplied front panel mounted on the surface), then your individual circumstances will dictate how the unit is installed.

AF SIGNAL GENERATOR PARTS LIST

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

R1,21	2k2	2	(M2K2)
R2	330Ω	1	(M330R)
R3,5	820Ω	2	(M820R)
R4	R53 Thermistor	1	(FX62S)
R6,10	680Ω	2	(M680R)
R7,11	5k6	2	(M5K6)
R8,12	470Ω	2	(M470R)
R9	68Ω	1	(M68R)
R13	2k7	1	(M2k7)
R14	2k4	1	(M2K4)
R15	1k8	1	(M1K8)
R16	3k3	1	(M3K3)
R17	4k7	1	(M4K7)
R18	1k	1	(M1K)
R19	1k2	1	(M1K2)
R20	12k	1	(M12K)
VR1	10k Dual Pot Log	1	(FX09K)
VR2	4k7 Pot Lin	1	(FW01B)
VR3	10k Hor Encl Preset	1	(UH03D)

CAPACITORS

C1,2	100μF 10V PC Elect	2	(FF10L)
C3,9	47nF Poly Layer	2	(WW49D)
C4,10	270nF Poly Layer	2	(WW46A)
C5,11	68nF Poly Layer	2	(WW39N)
C6,12	5n6F Polystyrene	2	(BX40T)
C7,13	6n8F Polystyrene	2	(BX41U)
C8,14	560pF Polystyrene	2	(BX33L)
C15	33pF Ceramic	1	(WX50E)

SEMICONDUCTORS

TR1,2	BC108C	2	(QB32K)
IC1	LM301A	1	(QH36P)

MISCELLANEOUS

S1	Sub-Min Toggle A	1	(FH00A)
S2	4-Pole Sub Miniature Toggle	1	(FH08J)
S3,4	Rotary SW3B	2	(FF76H)
SK1	BNC Round Skt 50Ω	1	(HH18U)
SK2	Pan Mnt Pwr Skt 2·5	1	(JK10L)
	DIL Socket 8-pin	1	(BL17T)
	PCB	1	(BB72P)
	Front Panel	1	(BB73Q)
	Knob K14 A	3	(FK38R)
	Knob K14 D	1	(FK41U)
	Wire 7/0·2 10M Black	1 Pkt	(BL00A)
	TC Wire 0·71mm 22swg	1 Reel	(BL14Q)
	Pin 2144	1 Pkt	(FL23A)
	Quickstick Pads	1 Strip	(HB22Y)
	PP3 Battery Clip	1	(HF28F)
	Instruction Leaflet	1	(XU08J)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

	Verobox 213	1	(LL10L)
	PP6 9V Battery	1	(FM03D)
	AC Adaptor Regulated	1	(YB23A)

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 LT25C (AF Signal Generator) Price £29.95.

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.

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R1155 EX-RAF WARTIME RADIO with circuit diagram and literature. DF section removed. Any offers? Tel: (0722) 790484 (Salisbury).

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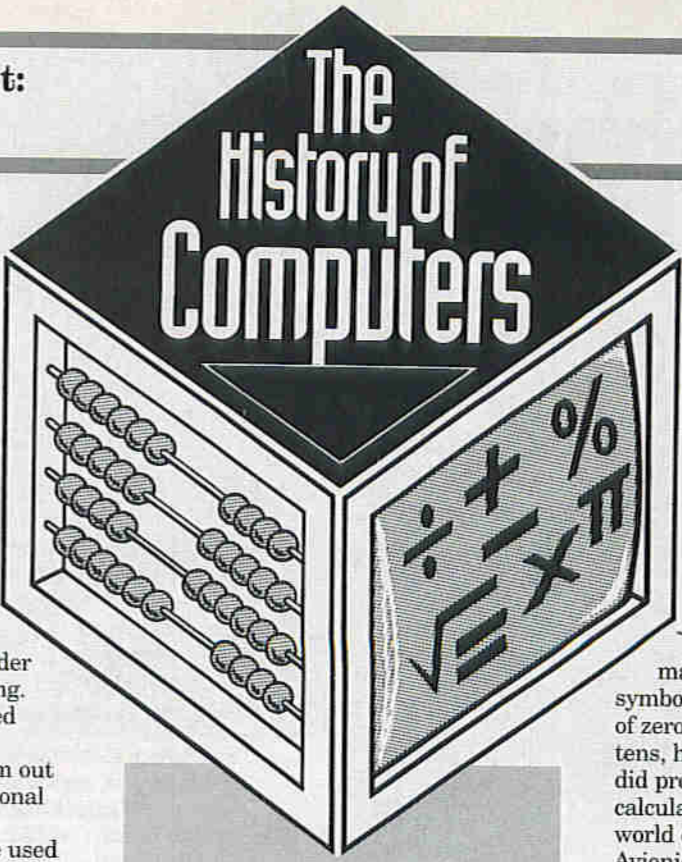
1. The First Attempt: The Abacus.

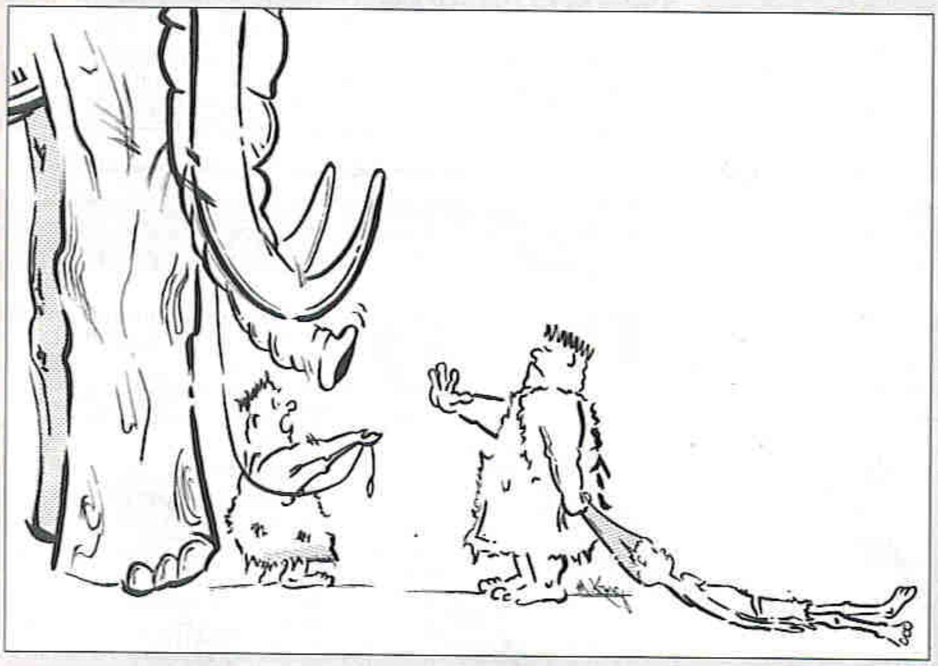


by Gregory M. R. Grant

From the beginning, man regarded calculation as nothing less than a damned nuisance. Most of our forebears refused to have anything to do with figures, and those early civilisations, or groupings, that still survive in our world, take an identical attitude to the numbers game. To the Bushmen of the Kalahari, and the Outback Aborigines, any number above 5 is simply 'many'.

Sometime after the beginning of agriculture, man began to consider ways around the tedium of counting. For example, the Egyptians handed the business to the priests, and so became the first civilisation to farm out calculation to others – the professional mathematician was born.

On the other hand, the Chinese used their fingers, easing this activity somewhat, by numbering their finger joints! Today, we occasionally copy them, using our fingers for both counting, and itemising any points that we may wish to stress in our daily conversation.



Eventually, man began to consider sturdier ways around the problem – he turned to machinery. His first effort was a row of shallow grooves, or lines, traced on the ground. The grooves represented units, tens, hundreds and so on, and the amount of counters in the grooves numbers.

When or where this took place is unknown, but what paper thin evidence we have suggests the areas around the Eastern Mediterranean, or the Fertile Crescent, as being the most likely locations. The word Abacus derives from two sources; firstly, a Semitic word for dust, and secondly, a Greek word Abax, meaning slate or tablet. What's more, some of the rounded stones used as counters, have been found in many of the ancient historical sites of these areas. In its present form, the abacus first appeared in Babylonia sometime before 3000 B.C.

The Babylonians were formidable mathematicians, and perhaps the earliest of peoples to develop a written number system. However, the system was awkward to manipulate, for it had complex symbols, and was devoid of the concept of zero and a place notation for units, tens, hundreds and so on. The system did produce the sexagesimal system of calculation, on which so much of our world depends, not least my own field, Avionics. All these drawbacks were not a real problem, because this strange system was not used to calculate as such but to record the results of calculation. The hard graft was done by a machine – the abacus.

Now come the questions – How did it work? Did they spread elsewhere in the world? What were they called in other regions and were they improved over time?

The answers are – very easily; yes of course; several things; no, not all that much!

An abacus operates in exactly the same way, regardless of its origin. The beads are only significant if they are in a specific area, whereas beads that are located elsewhere are in storage, and are waiting to be assigned a task. The wires are equally spaced, and represent different digital positions with regard to the number being either operated on or stored. In short a bead on one wire has a different value from that on an adjacent wire. Furthermore, if you've got enough counters on your device – be they plastic

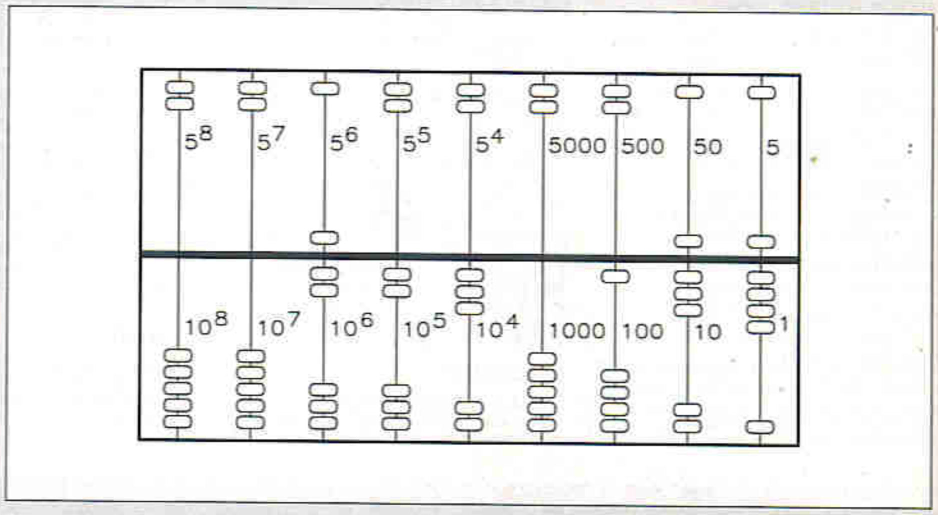


Figure 1. A Chinese abacus, these were sometimes accompanied by an instruction board.

discs, decorative pebbles or metallic emblems – any operating system can be used whether it's binary (2), denary (10), octal (8) or hexadecimal (16).

In Figure 1, the wires from right to left represent units, tens, hundreds etc., whilst beads above the bar are valued at five-units, five-10's, five-100's and so on. The beads, immediately below the bar, are valued at one unit, one-10, one-100 etc. – the quantity displayed is 7,230,189. One of the simplest abacus designs was that from Egypt, Greece and the area, formerly known to British diplomats, as the Levant. There the abacus was known as the Bead Calculator, or Counting Board.

In Russia, the Tschoty was even simpler, consisting of a set of wires through which nine, and occasionally ten, counters were strung. It was easy to use too, the operator moving the beads he was counting with to one side, and simply ignoring the rest.

In China, the Suan Pan, or Calculating Plate, was an invaluable aid, since their numerical system was every bit as involved as that of the Babylonians. Sometime around A.D. 300, the Chinese improved their original model, and it is this version that is still in use today. I've seen this model in operation at market stalls in Guangdong province, Szechuan restaurants in Hong Kong, Batik workshops in Malaysia and airline offices in Indonesia. There is no faster calculating device this side of the electronic calculator – believe me!

In the Japanese Soroban, the abacus developed to such a state that it was near to perfection. The Japanese introduced a central beam, on one side of which there was one or two beads. This area was referred to as 'Heaven.' On the other side, known as 'Earth', there were four or five beads. Each bead on the 'heavenly' side represented denary '5', whilst each bead on the 'earthy' side counted as '1'. Of all abacuses, this version was the fastest in operation.

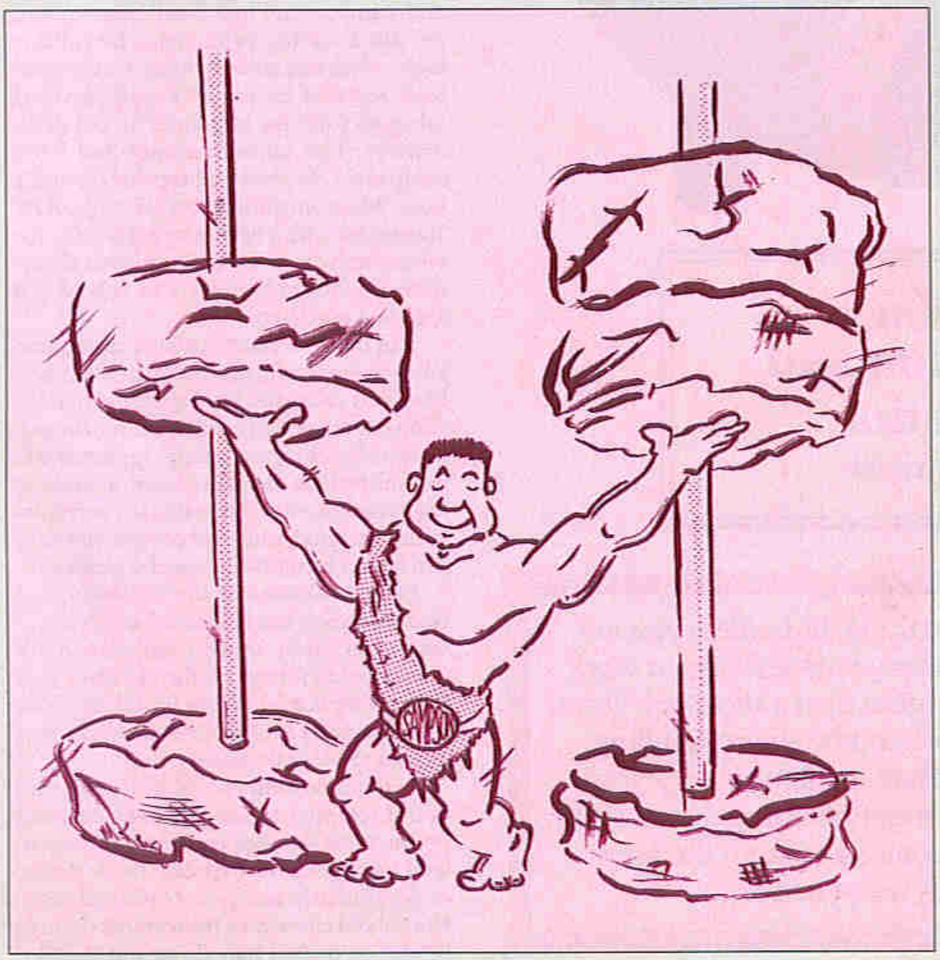
The abacus became the most universal of all machines prior to the European renaissance, due primarily to its simplicity and secondly to its portability.

You didn't need any knowledge of number systems to operate an abacus, in fact, you didn't even need an elementary education. This meant that the abacus was one of the very few machines, designed by man, that could be operated by illiterates – prior to the 16th century A.D., that meant the great majority of the world's population.

The portability of the abacus was an enormous plus too, for it could be used by merchants and traders wherever they conducted business, whether on land, on an ocean-going dhow, or on the back of a horse or camel.

The Islamic conquests of the 8th and 9th centuries brought many gifts to Europe, the greatest of which was undoubtedly Indo-Islamic numerals. However, the system spread very slowly prior to the late 15th century, due to the very successful medieval version of the abacus. This differed from its oriental cousin in that it was a wooden board with metal-type counters, the whole arrangement being supported on legs. Another aspect of this slow spread was the illiteracy mentioned earlier. However, the printing press soon reduced the number of illiterates, and Europe began not only to take an interest in numbers, but also in their manipulation in the light of the new ideas, such as 'zero' and 'place notation'.

This led to the second attempt at a calculating machine, one for the more initiated. The abacus was about to be replaced by the slide-rule.



To be continued...

THE FASCINATION OF VINTAGE RADIO

Part Four Preservation and Restoration

by Geoff Arnold

Getting the equipment is one thing, but unless you are extremely lucky it will need at least some restoration work done on it – even if it is nothing more than a thorough clean of the cabinet. Restoration work can be a very fulfilling pursuit, as a radio receiver that has spent over forty years mouldering in a loft slowly becomes transformed into a fine example of its genre, like a Pheonix risen from the ashes! Servicing the electronics is just one area...

You may start out with the idea of buying only well-preserved vintage radio sets, or those that are already refurbished, where the hard work of cleaning, repair and restoration has already been carried out by someone else. Sooner or later, though, you will find yourself buying an irresistible bargain in a state very much less than perfect. You will then be faced with tasks involving skills appropriate to several different trades.

Important decisions will need to be made. First, should the set be refurbished to a state compatible with its age – in other words, what it might have looked like had it been lovingly looked after since new – or should it be made to look as if it had just been unpacked from its carton for the first time? There are arguments for both approaches, and to some extent the choice depends on the material and finish used for the cabinet. Plastic, painted metal or Rexine/leatherette-covered cabinets can usually be restored 'as new' without looking too out of place. Polished or varnished wood can be a very different matter, however.

I recently saw a 1929 Marconiphone receiver, shortly after it was rescued from the loft of a Wiltshire farmhouse in a terrible state, with scratched and peeling veneers, tattered loudspeaker fabric and leather carrying handle, and internal damage to components and woodwork due to past sulphuric acid leaks from the low-tension accumulator. Six months later, I was privileged to see that same set following complete restoration by its young owner.

Two faulty inter-stage transformers, and the voice coil of the moving-iron loudspeaker, had been painstakingly dismantled and rewound. All metalwork and components had been cleaned, and perished wiring replaced. The cabinet back, which had suffered most damage, had been replaced by well-seasoned plywood salvaged from the bottom of an old desk-drawer. The whole cabinet had been completely stripped and repolished, and a new 'Marconiphone' transfer applied. Topped off with a new carrying handle, the whole set was in virtually original showroom condition and a joy to behold – it sounded good, too!

Not every wooden cabinet restoration job is so successful, for many modern polishes and varnishes tend to exaggerate the grain pattern of the wood or veneer, imparting a really 'cheap and nasty' appearance to the finished job. For that reason, it is best to keep work on such cabinets to the very minimum required, unless of course, you happen to be a furniture restorer by profession.

Plastic cabinets of the old-fashioned Bakelite variety can be cleaned and polished very successfully using a preparation originally made for use on the old black Post Office telephones, which is still available from specialist outlets catering for vintage radio and TV enthusiasts.

I would recommend considerable caution if tempted to use domestic cleaning products on vintage equipment, particularly on 'crackle' or 'wrinkle' finish paints, or on similarly-textured plastic cabinets. Household cleaners of the sort that claim to lift dirt on contact may do so, but unfortu-

The 1929 Marconiphone Model 55 receiver mentioned in the text, pictured after a quick dusting down following its retrieval from the farmhouse loft . This 5-valve medium and long-wave battery set cost 18 guineas (£18.90) new, and was the first to be sold with an instruction booklet providing a list of spare parts, presumably to encourage owners to do minor repairs for themselves.

nately they deposit it straight back in the natural crevices of such finishes, so that they look no better once they have dried! My own favourite method is to use an old toothbrush and toilet-soap and water.

With the toothbrush slightly damp, pick up a little soap on the bristles and apply it over a small area, rubbing well into the crevices. Obviously you must avoid getting water into the innards of the equipment. Rinse the toothbrush, shake off surplus water and brush over the same area using short gentle strokes, whereupon you will find the dirt drawn up the bristles as if by magic. Repeat the last step to remove the last traces of dirt and dry off the surface by dabbing it with a piece of terry towelling. Stubborn, greasy dirt may well require preliminary treatment with a stronger cleaner, the residual deposits being removed by the method just described. When cleaning is complete, any remaining traces of moisture should be removed by placing the unit in a warm place, such as a airing cupboard, for 24 hours.

Removing dust from a chassis, or around control knobs, etc., is best accomplished with a clean, dry paint-brush. Removing deposits of oil or wax from overheated capacitors will require solvents such as white spirit or methylated spirits – again, take care that they do not get into vital parts where they may do damage. It is best to avoid stronger solvents such as 'switch-cleaner', which can soften some thermoplastic materials employed in components, unless you are sure there are no such parts present.

Probably the most difficult components to clean are the old-fashioned variable capacitors used for tuning. Dust and dirt between the vanes can cause noise, or even a total failure due to a short circuit. Depending on the spacing between the vanes, careful cleaning with a folded slip of paper or a smokers' pipe-cleaner may be possible. Alternatively, judicious use of a vacuum-cleaner may do the trick.

Materials for Restoration

Although it is possible to carry out a lot of restoration and repair work on a piece of radio equipment without too much detailed knowledge of its circuit and technical characteristics, you could soon find the need to identify component values or choose correct alignment frequencies for optimum performance.

The excellent series of books entitled Radio and Television Servicing, originally published by Newnes and more recently by Macdonalds, was mentioned in Part 3 of this series. Individual service sheets for vintage equipment are of course no longer available from manufacturers, but they are often on sale at vintage swapmeets, and there are firms specialising in offering photocopies of sheets for both domestic and military/professional equipment. These firms advertise regularly in the vintage and amateur radio magazines.

Obtaining spare parts and components for repairs to vintage equipment can often be quite a problem. There are still some stocks held by enthusiasts and by specialist vintage dealers, who have acquired the contents of radio service departments and the workshops of old-time enthusiasts.

Cabinet parts are probably the most difficult items, since it is near-impossible to produce acceptable substitutes for broken, damaged or missing originals. Parts such as fascias and control knobs carrying legends which have been moulded or engraved and then filled with paint can usually be refinished quite successfully. Those that have been silk-screen printed are a different matter entirely. Tuning dials, particularly the type made of glass with the wavelength or frequency scales printed on the inside face, can be wiped totally clean in a few seconds by the injudicious use of the wrong cleaning methods and materials! Where the ultimate disaster has occurred, cannibalisation of parts from otherwise scrap sets may be the only remaining solution.

Electrical components, such as resistors and capacitors, are easier to substitute with present-day components, since the modern version will always be smaller, and can usually be fitted inside the emptied case of the original component to preserve the set's original appearance.

Another Marconiphone Model 55 (unfortunately not the one shown in the 'before' picture!), restored in all its glory.

Materials like loudspeaker cloth, and original or reproduction manufacturers' cabinet transfers, are still available from dealers advertising in the vintage radio press.

Programme Material

If your aim is to have a working broadcast receiving set at the end of your restoration work, the you need programmes – radio or TV – to reproduce over it. There are still transmissions on medium and long waves, of course, although they're not the same stations whose names appeared on the tuning dials of bygone days.

Television programmes are another matter altogether, for although the vintage period for TV sets has now edged forward into the 625-line era, most are still from 405-line days, and as mentioned in Part 1 of this series, all 405-line transmitters closed down some years ago. The only way round this problem is to use a small modulator/transmitter operating on the appropriate frequencies, plus a video player and tapes of 405-line programmes.

To Modify or Not...?

In general, broadcast receivers do not invite modifications, except where it is necessary to substitute a different valve for a type no longer available. This may necessitate changes to component values to give the supply and bias levels required by the new valve, and sometimes also a totally new valve base, with connections transferred to the appropriate pins.

Communications equipment, whether originally designed for military or other professional markets, or for the amateur market, is widely modified. This might involve changes to power supply arrangements, for example replacing the original 28V DC or high frequency AC supply arrangements in ex-aircraft equipment, or changing frequency coverage, as in private mobile radio (PMR) VHF equipment modified to work on an adjacent amateur band.

Communications receivers from all but the final years of the valved era tend to be notoriously 'deaf' on the upper HF bands. Many have been fitted with pre-amplifiers to boost performance on the 28MHz (10m) amateur band, but others have had front-end valves replaced with more modern high-gain types, accompanied by component modifications. This is all well and good where the owner wants the satisfaction of using a vintage set, but yearns for a more modern standard of sensitivity. For the purist collector, such modifications are anathema, and in fact there are some who devote their time and energies into reversing the modifications, restoring sets to their original state. Some modifications have proved so popular in the past that no unmodified sets now exist!

Round-Up

This series has really only scratched the surface of the subject, but I hope that it has given some idea as to why people find vintage radio so absorbing. As with any interest that centres upon the exploits and artefacts of bygone days, there are several reasons.

Above left: Some vintage receivers have suffered simple indignities such as dust, damp and woodworm. Others fare far worse, like this smoke-blackened chassis from an Alba Model 540 awaiting restoration and fitting to a new cabinet, following its rescue from a house-fire.
Above right: Sometimes you can have a lucky find, as with this 30-year-old Eddystone 940 communications receiver from the author's collection. Following the removal of layers of dust, including a complete strip-down of the front panel assembly to clean the tuning scale and window, it required only the replacement of one cracked control knob and a quick tweak of the RF and IF alignment to restore it to near-mint condition.

Even in these days of constantly developing technology, there is much to be learned from the exploits of the pioneers. What shaped their character and development? What technical, commercial and political constraints did they have to fight their way through? A good set of encyclopaedias will provide an introduction to the backgrounds of these pioneers, but a deeper understanding can only come from reading some of the many specialist books and biographies which have been written over the years.

The personal reminiscences of the less famous can be no less fascinating. They will often present a user's view of technology, sometimes even giving an insight into where the famous names got it wrong on occasion – no matter how famous or how lowly we may be, we all make mistakes! Such reminiscences generally tend not to warrant the interest of book publishers, with their high production costs, but do appear regularly in specialist magazines such as Radio Bygones and Morsum Magnificat (further details of both magazines from 9 Wetherby Close, Broadstone, Dorset BH18 8JB).

It may be that you have personal memories of the equipment of bygone days – a radio set owned by your parents when you were a child, perhaps. Coming across an example of that same model today can be quite an experience, indeed a most salutary one if the set happens to be preserved in a museum. There is no more potent reminder of the passage of years!

Collecting sets which evoke personal memories, restoring each one to working order and preserving them in your home, can be a source of great personal satisfaction. Some friends may well dismiss such relics as just so much junk, and even go so far as to question your sanity. Do not be dismayed, for other friends will undoubtedly admire your collection, expressing a yearning for similar reminders of their younger days.

This may give you the idea of taking up the restoration of sets for other people. It can make money for you, though it can be hard work too. If you enjoy working with your hands, converting an object worthy only of consignment to the local tip into a working thing of beauty, this could be a rewarding pastime for you. Do not expect to make your fortune at it, though!

Today's Junk – Tomorrow's Treasures?

If you have the yen to assemble a wider collection, illustrating some period or theme of the development of radio technology or design, remember that today's collectibles were once the 'state of the art', and by extension today's 'latest thing' will all too soon become history.

Circumstances have changed, of course. Mass production techniques now allow many, many thousands of an item to be made, so that the likelihood of it becoming a rarity in the future are greatly reduced compared with the sets from the earliest days of radio. On the other hand, today's 'throwaway society' means that sets replaced simply because they do not provide the latest facilities or conform to the latest fashion trends, are likely to be thrown out, rather than tucked away in the loft or cellar as was done in days gone by.

Keep an eye open for equipment trends; take note when last year's bright idea is branded an obsolescent failure. Probably the most fertile ground of recent decades has been in superseded audio and video recording methods. To name but two examples (after all, I don't want to give all my ideas away), how about 8-track cartridges and the original Philips VCR?

The car boot sale, that modern phenomenon, is a happy hunting ground for discarded domestic technology. But don't tell everyone what you're looking for. We don't want to push the price up just yet, do we?

Moving Message Display continued from page 15.

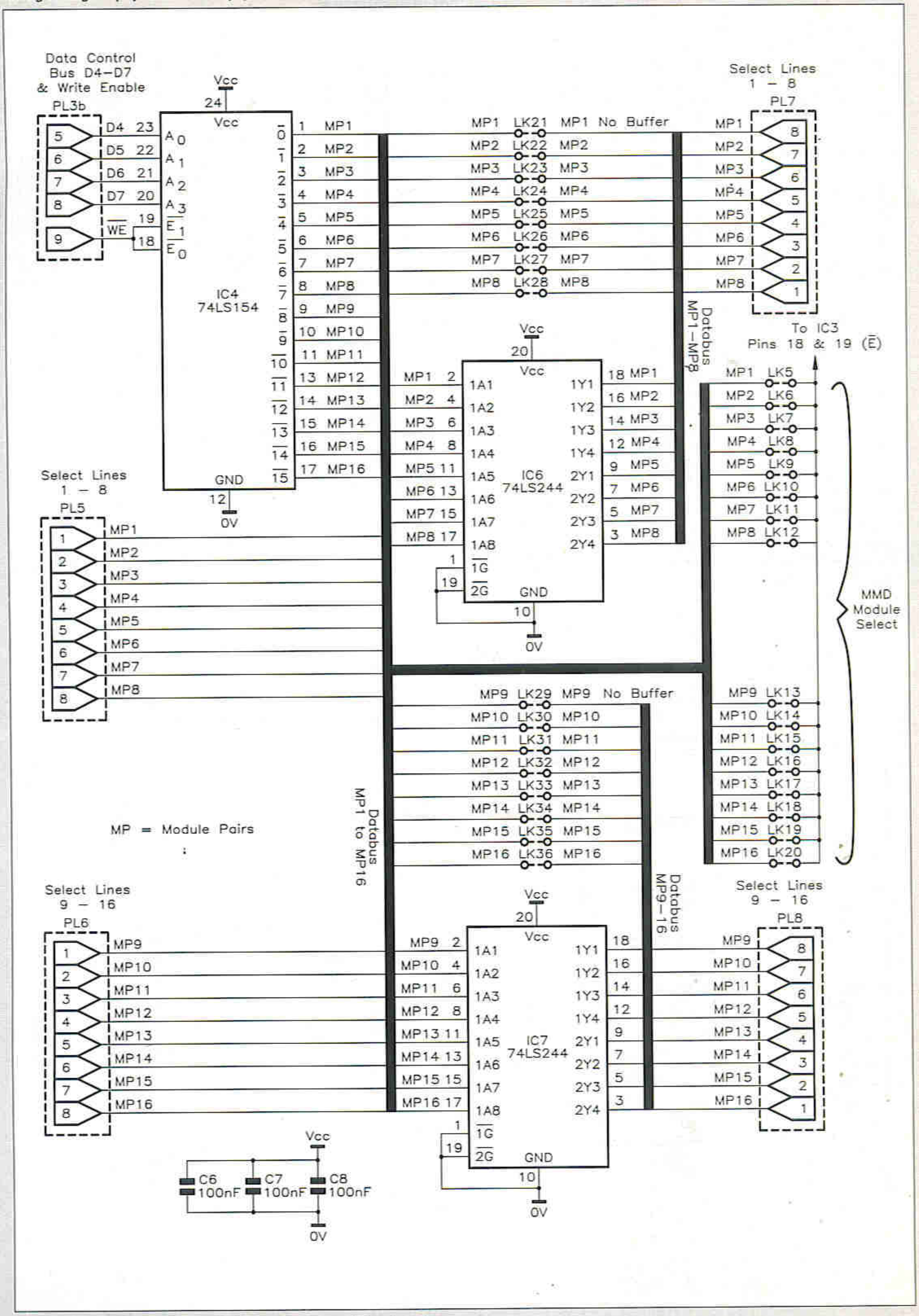


Figure 4. Display Controller circuit diagram – upper nibble decoder.

					COLUMN OUTPUTS															
					PL1								PL2							
WE	D	C	B	A	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	X	X	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

X = don't care

Table 4. Display controller column control outputs truth table (PL1 and PL2).

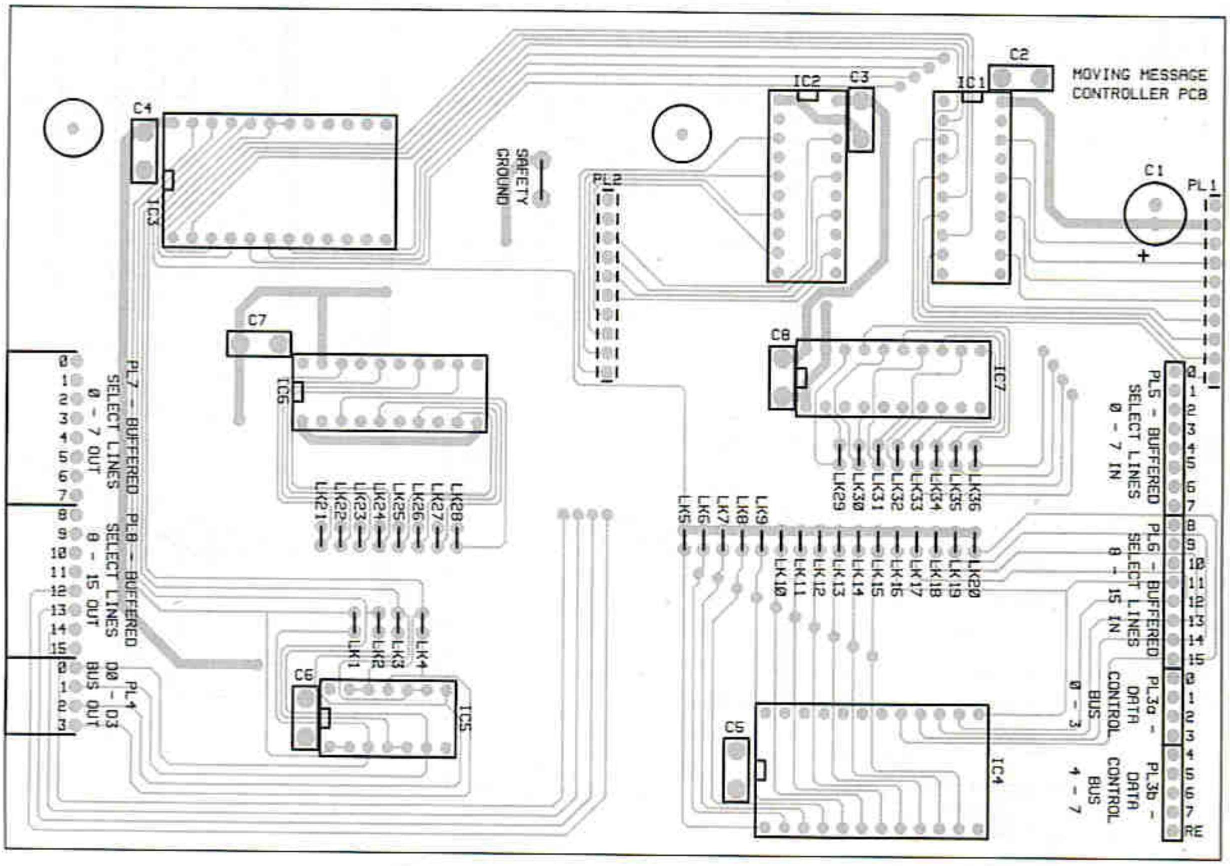


Figure 5. Display Controller PCB legend.

(b) Slave Controller

The Slave Controller is named as such because on all subsequent controller boards required, the upper nibble decoder (IC4) is not required. Instead, its output data is repeated down the Module Pairs bus which is designed as a long daisy-chain. Thus, the inputs to a Slave controller are via PL5 and PL6 (which carry the Module Pairs select lines 1 to 8 and 9 to 16, respectively), and the outputs to the next Slave controller in the daisy-chain are via PL7 and PL8. In an expanded system, the Slave Controller (even) differs from the 'odd' version only in that the buffer ICs are linked out – buffers are required every 2 boards along the chain to maintain data integrity. This buffering is carried out by IC5a to d (D0 to D3 of the data control bus), IC6 (Module Pairs data bus lines 1 to 8), and IC7 (Module Pairs data bus lines 9 to 16). When these buffers are not installed, they are bypassed by links LK1 to LK4, LK21 to 28, and LK29 to 36 respectively.

Write Enable Input

With the expansion of the moving message display module to an expandable system, a new control line (WE) has been introduced. This has an important effect on the system because this single line can be used to 'clock in' the data to the display by allowing selection of the control and data ports. This may not always be required but it does complete the comprehensiveness of the system's facilities, allowing the full addressing range (of 256 LEDs, or 32 boards across) to be accessed, and makes for good, logical programming techniques.

The input is active low and, when active, selects a control line according to D0 to D7 on PL3a & b. When it is taken high, all the controller boards in the system are deselected and the control line, which was currently selected by D0 to D7 on the control port, is disabled.

Construction

The same PCB, the legend of which is shown in Figure 5, is used for all three versions of the Display Controller. Different versions, however, have varying component requirements and link settings. The construction of each board type is therefore discussed separately.

Controller Board No.	Controller Board No.	LINKS			
		LK1 to 4 Buffer Bypass	LK5 to 20 Pair Select	LK21 to 28 Buffer Bypass	LK29 to 36 Buffer Bypass
1	Master	Do not fit	5	Do not fit	Do not fit
2	Even Slave	Fit links	6	Fit links	Fit links
3	Odd Slave	Do not fit	7	Do not fit	Do not fit
4	Even Slave	Fit links	8	Fit links	Fit links
5	Odd Slave	Do not fit	9	Do not fit	Do not fit
6	Even Slave	Fit links	10	Fit links	Fit links
7	Odd Slave	Do not fit	11	Do not fit	Do not fit
8	Even Slave	Fit links	12	Fit links	Fit links
9	Odd Slave	Do not fit	13	Do not fit	Do not fit
10	Even Slave	Fit links	14	Fit links	Fit links
11	Odd Slave	Do not fit	15	Do not fit	Do not fit
12	Even Slave	Fit links	16	Fit links	Fit links
13	Odd Slave	Do not fit	17	Do not fit	Do not fit
14	Even Slave	Fit links	18	Fit links	Fit links
15	Odd Slave	Do not fit	19	Do not fit	Do not fit
16	Even Slave	Fit links	20	Fit links	Fit links

Table 5. Display controller link summary.

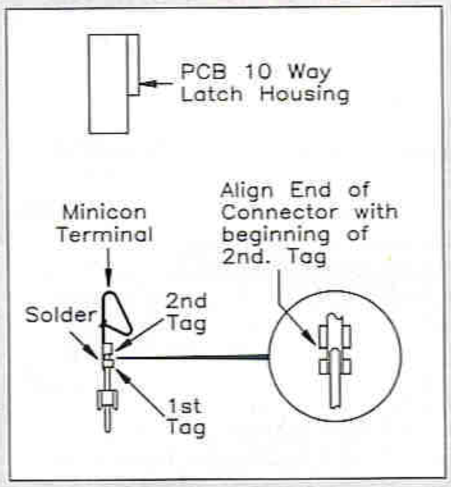


Figure 6. Assembling PL1 and PL2.

(i). Master Controller Board (1st Controller – for 'Base System' Upwards)

The Master Controller board is the first level of expansion for the moving message display system, and gives rise to a two-display module system known as the 'Base System'.

Referring to the PCB legend of Figure 5, PL1 and PL2, the connector subassemblies that will interface to the Moving Message Display, can be seen clearly. Each should be made up as shown in Figure 6, and the complete assembly fitted to the solder side of the PCB, as shown in Figure 7.

Next, fit the sockets for ICs 1, 2, 3, 4 and 5. The pin strip connectors, PL3a and PL3b (9 pins in all), should be made up from right-angled pin strips. In each case, the longer pins should point to the nearest edge of the PCB, as shown in Figure 7.

Make the LK5 link (display module pair select) with a piece of single core wire – refer to Table 5. The last components to solder in are capacitors C1 (observe polarity!), and C2, C3, C4, C5 and C6. Next, insert ICs 1 to 5 into their sockets, making sure to observe correct orientation.

If only the 'Base System' is anticipated, then the Master Controller board is now complete. However, if one or more additional 'slave' controllers are anticipated (an expanded system), then sockets for IC6 and IC7 (20-pin) should be fitted, along with capacitors C7 and C8.

PL4, 7 and 8 should also be added (see Figure 7) so that they can be physically connected together. The collective total of 20 right-angled pins should be fitted with two 10-way Minicon housings – preparation of these connectors is shown in Figure 8.

Finally, the buffer ICs (IC6 and 7) should be fitted.

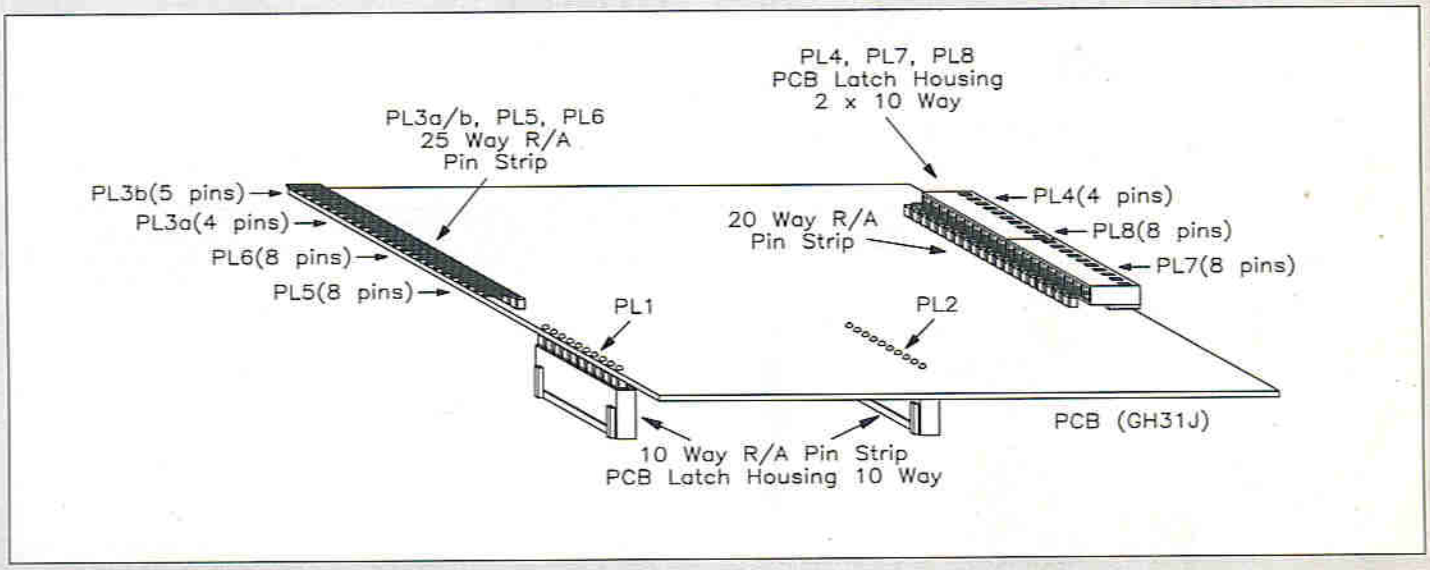


Figure 7. Positions of connectors on Display Controller PCB.

(ii). Slave Controller Board (Even)

This is the next stage of expansion to the moving message display system. The controller must be configured as a Slave Controller (Even) if it is an even number with respect to the quantity of controller boards in the system. Thus the Slave Controller Board (Even) will be used as the 2nd, 4th, 6th, etc., up to, and including, the 16th controller in the system.

Begin by making up the subassemblies for PL1 and PL2 as described earlier, and shown in Figure 6. Once assembled, they can be installed on the solder side of the PCB, as shown in Figure 7. Next, insert and solder the sockets for ICs 1, 2, and 3. Insert and solder in the right-angled pin strips of PL3a, PL5, and PL6 (20 pins in all). Observing the display module pair select link bank (LK5 to 20) on the previous controller in the system, increment the number of that link by 1 and make this link on the new board. For example, if link LK5 was made on the previous controller board, then link over LK6 on the current board (note the even number). Fit Buffer Bypass links LK1 to LK4. The last components to solder in are C1 (observe polarity), C2, C3, and C4. Construction is completed with insertion of ICs 1 to 3, making sure to observe correct orientation.

If subsequent controller boards are to be added, PL4, 7 and 8 should be added (see Figure 7) so that they can be physically connected. The collective total of 20 right-angled pins should be fitted with two 10-way Minicon housings – preparation of these connectors is shown in Figure 8. In addition, buffer bypass links LK21 to LK28, and LK29 to LK36 should also be fitted.

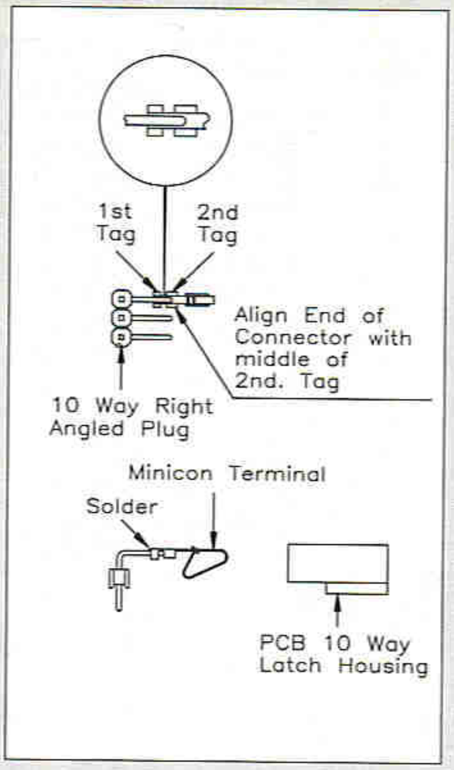


Figure 8. Assembly of PL4, PL7 and PL8.

(iii) Slave Controller Board (Odd)

This is the next stage of expansion to the moving message display system. The Slave Controller (Odd) should be used when the controller is an odd number with respect to the quantity of controller boards in the system (i.e. the 3rd, 5th, 7th, etc., up to, and including, the 15th controller in the system).

Begin by making up the subassemblies for PL1 and PL2 as shown in Figure 6, and then fit them to the PCB as shown in Figure 7, along with the right-angled pin strips of PL3a, PL5 and PL6 (20 pins in all).

Fit the sockets of ICs 1, 2, 3 and 5; insert and solder in the right-angled pin strips that constitute PL5, PL6, and PL3a (see Figure 7). Next, solder in PL1 and PL2, ensuring correct orientation. Observing the display module pair select link bank (LK5 to LK20) on the previous controller in the system, increment the number of that link and make this link on the new board. So if link LK6 was made on the previous controller board, then link over LK7 on the current board (note the odd number). The last components to solder in are capacitors C1 (observe polarity), C2, C3, C4 and C6. Construction is completed with the insertion of ICs 1 to 3 and IC5 making sure of correct orientation.

If subsequent controller boards are to be added, PL4, 7 and 8 should be added, as shown in Figure 7, so that they can be physically connected. The collective total of 20 right-angled pins should be fitted with two 10-way Minicon housings – preparation of these connectors is shown in Figure 8. The buffer components should be added. Sockets for IC6 and IC7 (20-pin) should be fitted, along with capacitors C7 and C8. Finally, ICs 6 and 7 should be fitted into their sockets.

Build Schedule – A Summary

Table 6 shows a complete summary, for the assembly of each of the variations of the controller board, in the form of a 'build schedule'. This may help you when making quick references to the construction of a controller board in the future. In addition, the link requirements are summarised in Table 5.

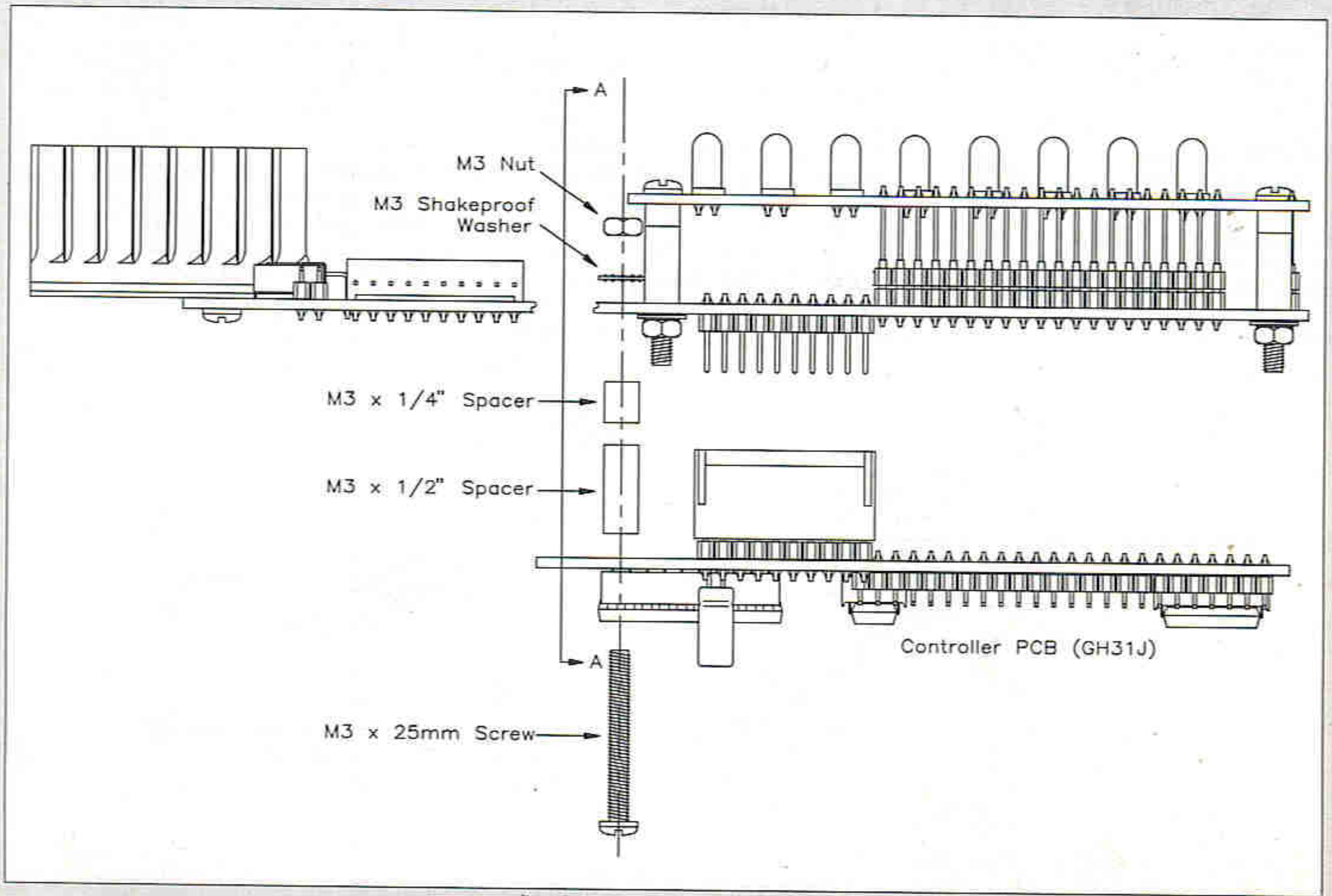


Figure 9a. Fitting the Moving Message Display Module to the Controller Board (Side View).

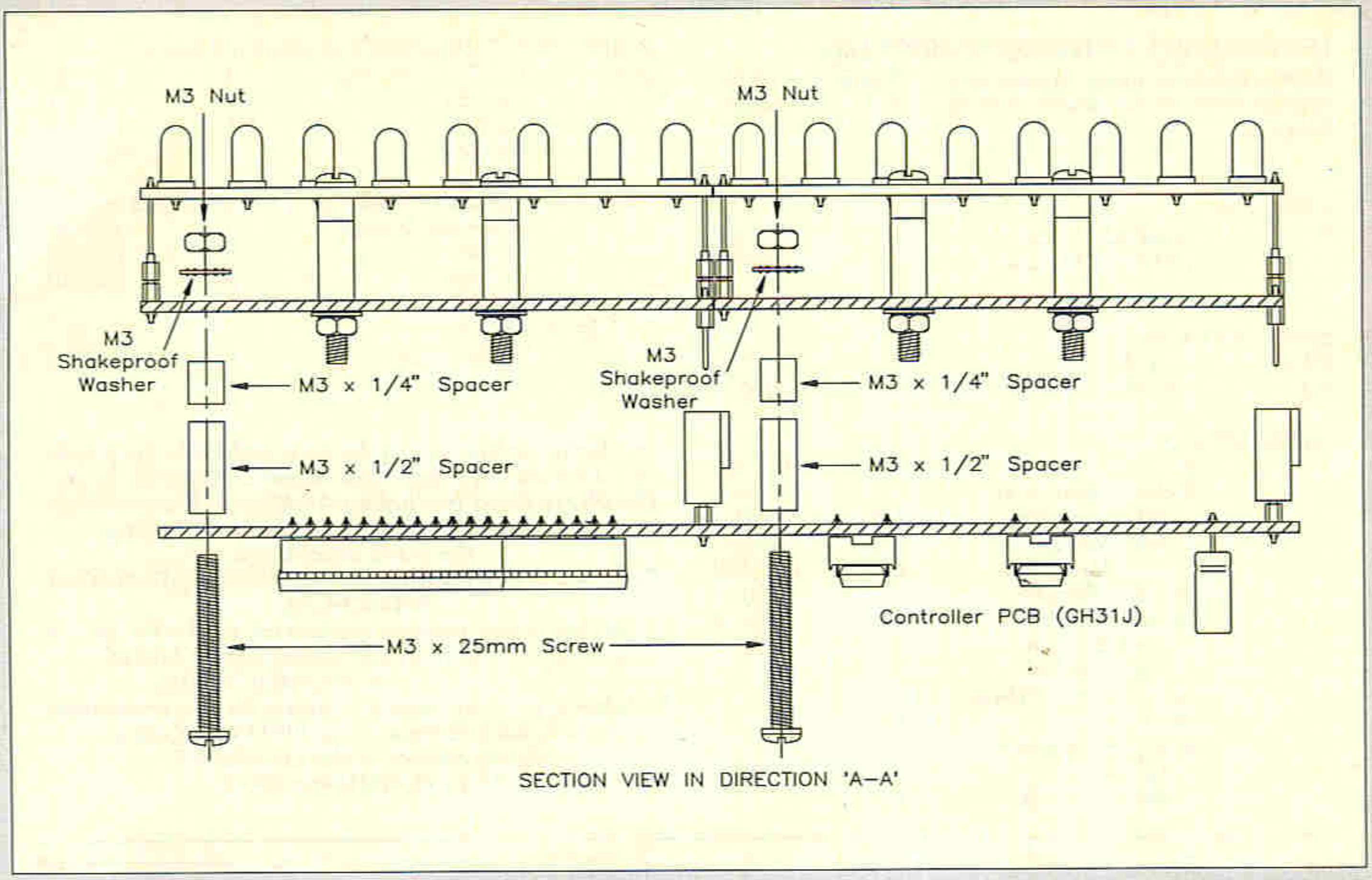


Figure 9b. Fitting the Moving Message Display Module to the Controller Board (Rear View).

Master Controller		Even Slave Controller		Odd Slave Controller	
ICs	IC1, IC2, IC3, IC4, IC5	ICs	IC1, IC2, IC3	ICs	IC1, IC2, IC3, IC5
Plug Assemblies	PL1, PL2, PL3a, PL3b	Plug Assemblies	PL1, PL2 PL3a, P25, P26	Plug Assemblies	PL1, PL2 PL3a, PL5, PL6
Module Pair Select Link	LK5	Module Pair Select Link	See Table 5	Module Pair Select Link	See Table 5
Buffer Bypass Links	Do not fit	Buffer Bypass Links	LK1 to LK4	Buffer Bypass Links	Do not fit
If expanding the system, add the following components		If expanding the system, add the following components		If expanding the system, add the following components	
Buffer ICs	IC6, IC7	Buffer ICs	Do not fit	Buffer ICs	IC6, IC7
Plug Assemblies	PL4, PL7, PL8	Plug Assemblies	PL4, PL7, PL8	Plug Assemblies	PL4, PL7, PL8
Buffer Bypass Links	Do not fit	Buffer Bypass Links	LK21 to LK28 & LK29 to LK36	Buffer Bypass Links	Do not fit

Table 6. Display controller build schedule.

Assembling the 'Base System'

The base system comprises the Master Controller Board, and two Moving Message Display Modules. These are fitted together as shown in Figures 9a and 9b. Figure 9a shows the assembly from the side, while Figure 9b is a rear view. Before fitting to the controller board, the two display boards should be mated (PL2 on the left-hand board to PL4 on the right-hand board). When fitting the mated display boards to the controller board, PL3 of each display board should couple correctly with either PL1 or PL2. To avoid damage of the boards, it is imperative that all hardware is fitted as shown in Figures 9a and 9b.

Further Expansion – Up to 32 Display Modules

Further expansion can be carried out up to a maximum of 32 display modules and 16 controller boards. The rate of expansion is two display modules to one controller board. Assembly is simply carried out as described above to give subsequent base system modules (although the subsequent controllers after the first controller are Slave Controllers and not a Master Controller as described, the mechanical assembly is the same). The subsequent base system modules are then simply added to the daisy-chain.

Next Month

In the next part of this series, we shall look at the final assembly, and testing of the complete system ('Base System' upwards), the Upgradable Power Supply, interfacing and software.

Acknowledgments

Acknowledgments are due to Mr Ken Bone, Senior PCB technician at Middlesex University, for making two excellent prototype PCBs of the controller board.

References

National Semiconductor Logic Databook, 1984.

LED GRAPHICS CONTROLLER PARTS LIST

Please note that depending on application, additional parts will be required, which are not included in the kit, see text and Additional Parts Lists.

CAPACITORS			
C1	100µF 25V PC Elect	1	(FF11M)
C2-4	100nF 16V Minidisc	3	(YR75S)
SEMICONDUCTORS			
IC1,2	74LS240	2	(YF87U)
IC3	74LS154	1	(YF58N)
MISCELLANEOUS			
	PCB	1	(GH31J)
	Socket Housing 10-Way	4	(FY94C)
	Socket Housing Terminal	1 Pkt	(YW25C)
	Pin Strip 36-way	1	(JW59P)
	Pin Strip 36-way R/A	2	(JW60Q)
	DIL Socket 24-pin	1	(BL20W)
	DIL Socket 20-pin	2	(HQ77J)
	Spacer M3 x ½in.	1 Pkt	(FG34M)
	Spacer M3 x ¼in.	1 Pkt	(FG33L)
	Steel Screw M3 x 25mm	1 Pkt	(JY26D)
	Steel Nut M3	1 Pkt	(JD61R)
	Shakeproof Washer M3	1 Pkt	(BF44X)
	Instruction Leaflet	1	(XU06G)
	Constructors' Guide	1	(XH79L)

MASTER CONTROLLER ADDITIONAL PARTS LIST (Not in Kit)

C5-8	100nF 16V Minidisc	4	(YR75S)
IC4	74LS154	1	(YF58N)
IC5	74LS08	1	(YF06G)
IC6,7	74LS244	2	(QQ56L)

ODD SLAVE CONTROLLER ADDITIONAL PARTS LIST (Not in Kit)

C6-8	100nF 16V Minidisc	3	(YR75S)
IC5	74LS08	1	(YF06G)
IC6,7	74LS244	2	(QQ56L)

OPTIONAL (Not in Kit)

	IBM PI/O Card	1	(LP12N)

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

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

Order As LT22Y (Moving Message Display Controller) Price £14.95.

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

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

Moving Message Display Controller PCB

Order As GH31J Price £9.95.

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 April issue is on sale March 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:

PROFESSIONAL AUDIO

A new series written by Tim Wilkinson, a BBC sound engineer, that looks at audio systems from a professional perspective. In the first part, interconnection standards and operating levels (including a detailed appraisal of the much-misunderstood decibel) are discussed.

BENCH AMPLIFIER

No test-bench should be without this low-cost and easy-to-build unit. Designed for monitoring audio signals on the test-bench (for example, during signal tracing), the robust Bench Amplifier has an in-built loudspeaker, a high input impedance (to avoid loading the test circuit) and a good deal of circuit protection.

AMSTRAD SATELLITE UPGRADES

And now for our second battle with that all too-familiar monster known as obsolescence. Sometimes the monster strikes too early, as we found out in last month's investigations into BSB equipment. The Amstrad SRX200, however, has been somewhat more fortunate – after all, it can still be used as intended. The monster only rears its ugly head if you want to gain quick and easy access to more than 16 channels, retrieve the primary subcarriers from other satellites or, for that matter, listen to those more elusive satellite radio stations. But help is at hand, in the form of some inexpensive upgrades. Apart from a detailed look at these (one of which costs less than £3 to implement!), we look at how to combine an Amstrad SRX200 with the modified Ferguson BSB receiver to give a first-rate set-up.

IN-SITU TRANSISTOR TESTER

One of the problems with most transistor testers is that they require the device to be isolated from the rest of the circuit, and so out comes the desoldering tool! Removing components, as we all know, is generally a real pain, and it also risks damaging transistors that are functioning correctly. This simple yet effective circuit changes all that – one for the service technician!

WEIGH-IN-MOTION

It is estimated that the annual cost of repairing Britain's roads is a staggering £1·2 billion – not to mention the frustration and wasted time experienced by motorists and lorry drivers stuck in the 10-mile tailbacks that can result from roadwork bottlenecks on major thoroughfares. The vehicles believed to contribute the most road wear are, as Stephen Waddington observes, heavy goods vehicles. Since these vehicles are often illegally overladen, the introduction of weigh-in-motion systems at motorway checkpoints and bridges is being considered; such systems also have obvious implications for air, sea and rail freight. This special feature looks at the technology and the politics.

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

'ELECTRONICS – THE MAPLIN MAGAZINE'

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE.

NEW BOOKS

Projects for Radio Amateurs and S.W.L.s

by R. A. Penfold

Short wave radio is a fascinating hobby and one that is pursued in a number of ways. One of the main attractions for many short wave enthusiasts is tinkering with different aerials and gadgets in order to get the highest possible performance from their installation. This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems. Even those who are not interested in building receivers and transmitters are often keen to experiment with home built aerials, and to construct some accessories for their ready-made equipment.

The designs are mainly to aid short wave reception, so they are mostly for both licensed radio amateurs and short wave listeners. The circuits include an aerial tuning unit, audio filters (notch and a high performance bandpass types), a volume expander, add-on BFO, simple active aerial, a CW/RTTY decoder and other useful projects.

Where appropriate there are details of how to set up and use the equipment, plus notes on any unusual aspects of construction. No precise constructional details are provided, as some experience of electronic construction is assumed. Some of the projects are very simple, and should be within the capabilities of practically anyone who has previously built one or two simple projects, and providing the experience to progress to the more complex circuits.

1992. 92 pages. 178 x 111mm, illustrated.

Order As WZ69A (Prjts For Radio Hams) £3.95 NV

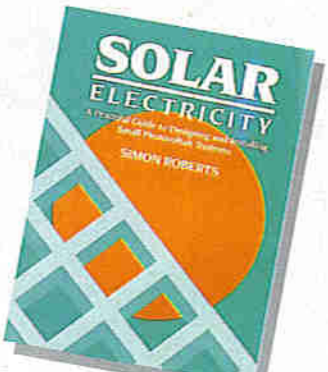
Solar Electricity

A Practical Guide to Designing and Installing Small Photovoltaic Systems

by Simon Roberts

Millions of solar modules are in constant use throughout the world, supplying electricity for communications, transport aids, health care, security systems, and numerous other applications. A small solar electric system in a home can run lighting, a cassette player, a television and other low power appliances.

The book is divided into three parts. Part one gives an introduction to solar electricity, describes solar modules, battery storage of electricity, control units, distribution at low voltage and electrical appliances, inverters and lighting. Part two covers planning, installation, operation and maintenance.



Part three describes the building of electronic units associated with solar electric power. The first chapter gives an introduction to electronic components and circuit building, and is followed by chapters dealing with the construction of expanded-scale voltmeters, voltage adaptors, charge regulators for nickel-cadmium cells and control units for appliance circuits.

Whether you are interested in solar power for a lamp, radio, workshop application or whatever, this guide provides you with the methods you need to design solar electric systems and components. The non-technical language makes this book suitable for the lay person, but it is also suitable for students on undergraduate courses in power systems and solar electricity.

The Maplin Catalogue contains a wide range of solar cells and panels that may be suitable for projects described in this book.

1991. 440 pages. 234 x 173mm, illustrated.

Order As WZ67X (Solar Electricity) £15.99 NV

The New Stereo Soundbook

by F. Alton Everest and Ron Streicher

This book sets out in a very readable and non-mathematical way to answer the question - What is stereophonics? By incorporating many of the most recent findings in auditory perception and current developments in surround sound, the concept of stereophonics is expanded from the simplistic one of sound coming out of two loudspeakers to a 3-dimensional sound system.

The book is suitable for the beginner and novice alike, as no previous knowledge is required, although an interest in stereo or audio production would be useful.

The opening chapter gives an interesting and informative history of stereophonics. There are chapters on how stereo information is conveyed to the ear, and how the ear and brain interpret stereo information. Two chapters are devoted to the philosophical and pragmatic implications of stereo production techniques, while five chapters examine in detail modern stereo microphone practices. Other chapters explore 'auditory spaciousness', colouration of sound, and optimising the stereo listening environment.

The essence of stereo lies not in elaborate microphone pickups, nor does it rely on exotic amplifiers or loudspeakers, rather the secret lies within us. The amazing process of encoding sound with our bodies and decoding it with or brains.

This profusely illustrated book is packed with tips and techniques you can use to get the most out of your stereo system.

1992. 294 pages. 235 x 189mm, illustrated. American Book.

Order As WZ68Y Soundbook £16.50 NV

Windows 3.1 the Pocket Reference

by Allen L. Wyatt

In just over a year Microsoft has sold millions of copies of their latest version of Windows, which has some appealing improvements over earlier, less powerful versions. Windows 3.1 has built on the strength of Windows 3 to provide a solid user platform for the future.

This pocket reference attempts to present the most commonly used Windows 3.1 commands in a manner that is clear, concise, and useful. In addition, near the back of the book is a Task Reference, a collection of co mmon Windows problems and their solutions.

This small, compact book is designed to serve as a memory jogger or a quick reference and is divided into three sections. The first section gives information that is fundamental to understanding Windows 3.1 and fully absorbing the information in the other two sections. For the reader who is familiar with Windows, this section can be skipped, or just scanned.

The second section is the Command Reference section, and covers, in alphabetical order, the most commonly used Windows 3.1 commands. Commands come from the following programs: Control Panel, Program Manager, File Manager, Print Manager, Clipboard, Windows Setup, Control Menu and Help Screen.

Discussed, again in alphabetical order, in the third section are Task Reference commands. This section is for those of us who have a tendency for task-based learning as opposed to command-based learning e.g., "How do I do...?"

It is important to read the first several pages of these last two sections as they explain how commands and tasks are presented in each section.

The command structures, menu wording and illustrations all correspond to Windows 3.1. The book will be of use to Windows 3.0 users, but to get the most from this pocket guide, you need Windows 3.1.

This pocket reference book is a handy memory jogger for the newest release of Windows that you will not want to be without.

1992. 220 pages. 202 x 118mm, illustrated. American book.

Order As WZ64U (Windows 3.1 Pckt Ref) £7.95 NV

AMATEUR RADIO ON VHF & UHF

by Ian Poole

Amateur radio is a hobby which enthrals many millions of people the world over. One of the advantages of it is that there are many different aspects which can be enjoyed. Some people like constructing equipment, and some like operating on the High Frequency (HF) bands below 30MHz. However, one of the fastest growing areas of the hobby is associated with the VHF and UHF bands between 30MHz and 3GHz. Here, there are a number of bands which offer interesting challenges whilst being convenient to use because enormous aerials or very high powers are not required to achieve useful results. There is plenty of equipment available for the base station at home, in the car or even for portable use. The equipment is reasonably priced and is fun to operate. In addition to this a Class B licence can be used to operate on these bands, and this can be obtained without the need for passing a Morse test.

Bands

There are a total of six bands in this portion of the spectrum. With the lowest amateur band at 50MHz and the highest one reaching 2450MHz, there is a great deal of variety in the bands. Everything, from the types of station that can be heard, to the propagation modes experienced, is different.

The lowest band in frequency is 6m. This stretches from 50 to 52MHz. It has only been released for amateur operation comparatively recently. As such, it is not used as widely as some of the other bands. Even so, it can give some very interesting results. Being only just above the HF part of the spectrum, it is often affected by the same ionospheric propagation conditions that are seen on the short waves. This means that contacts are sometimes possible across the Atlantic, or even to the other side of the world.

Above six metres, the 4m band can be found. It stretches between 70·00 and 70·50MHz. It is capable of supporting contacts over distances of 100 miles or more, under normal conditions. However, it is limited in that it is only allocated to amateur operation in a handful of countries.

Dorking and District Amateur Radio Society (G3CZU/P) operating on 4m from a horsebox during the 1991 VHF National Field Day (NFD).

This means that there is very little commercial equipment available. As a result, most (if not all!) of the amateurs operating on 4m do so with homebrew equipment – a taste of what it was like before the Japanese black box invasion!

Moving up in frequency, the next band is 2m. This is the most popular and widely used band above 30MHz. Whilst this means that there is a greater possibility of interference between stations, it does have the advantage that there is a better possibility of having a contact with someone. The band carries a wide variety of activity. There are a large number of mobile, portable and local contacts which can be made, with activity reaching peaks in the evenings and at weekends. In addition to this, DX (long distance) activity is fairly high at the moment. Under normal conditions it is possible to make contacts of up to fifty or sixty miles with an average aerial, but when propagation conditions are good this can rise to a few hundred miles – or even just over a thousand. Another advantage of the band is that commercial equipment is plentiful, and prices are keen.

70cm is the next band. In many respects it is similar to 2m, but it is a wider band allowing for more different types of activity. However, it is not as popular as 2m, and as a result there is less interference.

Moving further up the spectrum, there is the 23/24cm band. This covers 1240 to 1325MHz. Although the band is becoming more popular because new equipment is being launched onto the market for it, activity is still less than on 70cm. However, it is a good band for experimentation and it is surprising what distances can be reached under the right conditions.

The highest band in the UHF part of the spectrum is 13cm, which stretches from 2310 to 2450MHz. Activity is quite low, being restricted mainly to enthusiasts who build their own equipment. Even so, it is very interesting and during contests the level of activity rises, and contacts can be made into the Continent if locations and aerials are good.

Modes

A wide variety of different modes are used for transmission on these bands. The choice of mode will vary upon the type of contact being made, as each different one will have its own advantages and disadvantages.

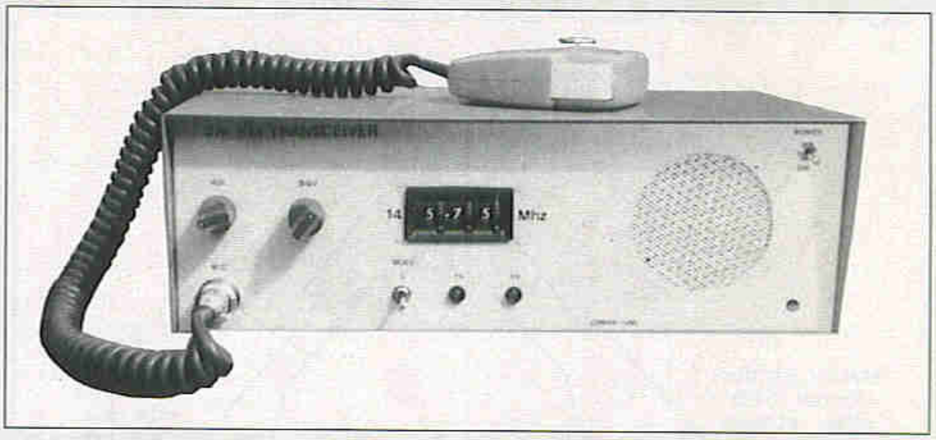
Frequency modulation (FM) is probably the most widely used, particulary on 2m and 70cm where there is a lot of mobile and portable operation. It is ideal for this, because with FM it is possible to remove most of the effects of signal strength variation. This is particularly important for mobile operation where the signal flutter would become very annoying and make it difficult to copy. In addition to this, the accuracy of tuning required for FM is not nearly as high as that needed for Single Sideband (SSB). This, too, is important to reduce the need for the operator to keep adjusting the set – particularly when driving.

Whilst SSB is not widely used for mobile, portable and local contacts it comes into its own for long-distance work. Owing to the fact that an SSB signal can be copied at a lower strength than an FM one, it often has the edge and accordingly it is used exclusively for DX (long-distance) speech operation.

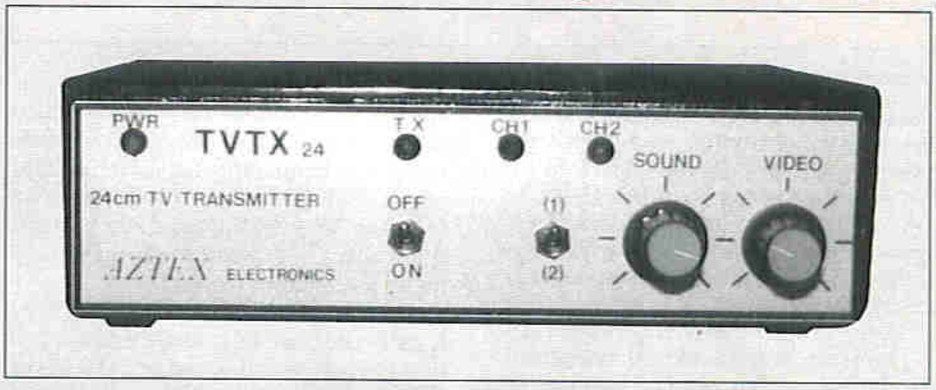
CW (morse) is also used, and again this is very good for DX contacts. However, activity is very low in comparison with its use on the HF bands below 30MHz. Despite this some good CW contacts can be made, especially at weekends when activity is higher.

A growing area of VHF/UHF interest is that of data communications. With the increase in the use of computers it is now possible to use more sophisticated means of sending data, with error checking and a host of other facilities. Packet radio is the most popular form, being very easy and flexible to use. Not only is it possible for stations to talk to another directly, but it also possible for a third station to relay the messages so that much greater distances can be reached.

If this was not enough, then a system of 'mailbox' stations has been inaugurated. The outgoing message is stored at the sender's local mailbox until traffic reduces. It can then be sent from one mailbox to the next until it reaches its destination; it is stored in the final (i.e. that nearest the recipient) mailbox until it is collected. In theory this system could cover the whole world if there was a large enough network built up – but that is looking into the future, although there are a few links with other countries at the moment.



You don't have to buy Japanese equipment to 'get going' on the popular 2m band. The July and August 1992 copies of 'Radio Communication', the RSGB member's magazine, published details on how to modify cheap and readily available ex-PMR gear with a homebrew frequency synthesiser.



On the VHF and UHF bands, you're not limited to just voice, Morse and data communications. You can, with suitable equipment, transmit television pictures as well! Depending on the band being used, fast or slow-scan modes can be used. Pictured is the Aztex 24cm fast-scan ATV transmitter.

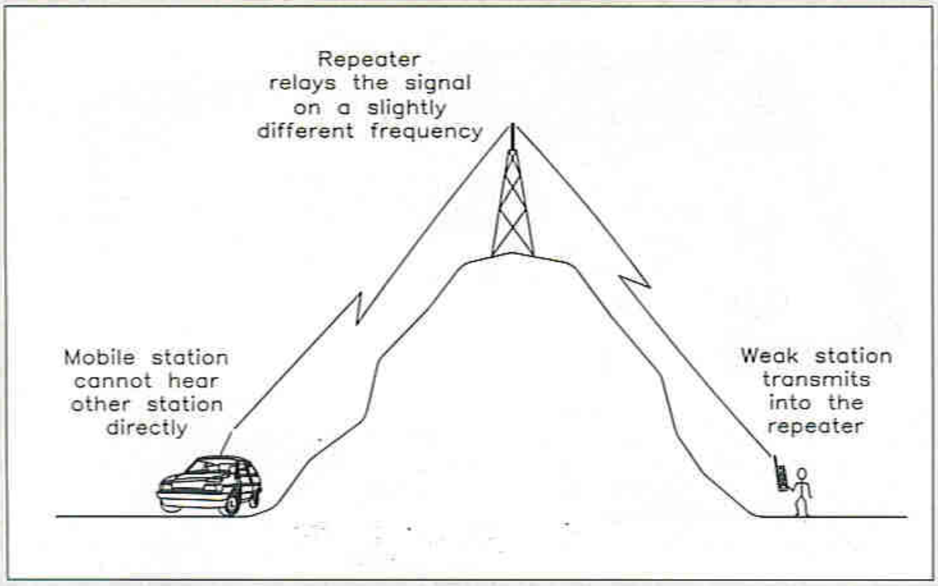
The Alinco DJ-580. Just one of the excellent value amateur radio products available through Maplin from Waters and Stanton.

Repeaters

A large number of people operate their equipment from cars, or use hand portables. In either case the signals from these stations will not be as strong or steady as those from fixed stations with good aerials and on a good location. To overcome this problem a network of repeaters has been set up, mainly on 2m and 70cm.

Essentially, a repeater is just a unit that receives signals on one frequency, and transmits them on another. They are located in good positions and have a wide coverage area. This enables them to pick up signals from weak stations that have a poor coverage, and then retransmit them over a much wider area. In this way, repeaters enable stations with weak signals to make contacts they would not normally be able to make.

For the repeater to transmit and receive at the same time, it has to use one frequency for receiving (input channel) and another for transmitting (output



Operation of repeater.

channel). This is known as 'duplex' operation. On 2m the difference between the two frequencies (the 'repeater shift') is 600kHz, whereas on 70cm it is 1600kHz. Out of interest, 'simplex' operation is where 2-way communication occurs on the same channel. Most non-repeater contacts are made in this way.

Using a repeater is fairly simple, but it is necessary to know how they operate. When no signal is present on the input for a while the transmitter will shut off, periodically sending its call sign in Morse so it can be identified. This is generally known as the 'beacon' mode. To activate the repeater, a transmission on the input must have a short audio tone ('tone burst') of 1750Hz. This prevents the repeater being activated by spurious noise. Once this has been done, the repeater will retransmit the signal on the input frequency. Once the first station has finished transmitting, he will be able to hand transmission over to another person without the need for another tone burst – provided that the gap between transmissions is not too long. In this way a normal contact can be held, but each station will have to transmit on the repeater input channel and listen on the output channel. Once the contact is over, and no more transmissions are present, the repeater will shut down and return to beacon mode.

Although the operation of repeaters may seem a little complicated at first sight they are very easy to use, especially as today's equipment caters for the split frequency operation without any trouble. As a result repeaters are a real boon to mobile or portable stations.

Band Plans and Channels

To make the best use of the available spectrum, and to ensure that the minimum amount of interference is caused by different users, the bands are split up into different sections. The tables show how 2m and 70cm are split up. On 2m, most of the top 1MHz is taken up by FM operation, although there is a section for satellite use. In the bottom half of the band, there are allocations for beacons which give an indication of propagation conditions, and frequencies set aside for data modes, SSB and morse. 70cm is split up in a similar way, but as there is more space there is a greater amount of flexibility for different modes.

Operation on FM is channelised. This is particularly useful because it makes frequency changes much easier, and it keeps stations a fixed distance apart, minimising the interference. Each channel is given a designation. Simplex channels are numbered starting with the letter S for 2m, and SU for 70cm. For example, S20 is on 2m, and SU20 is on 70cm. Similarly, repeater channels start with R on 2m, and RB on 70cm.

For simplex operation, initial calls are made on the calling channel. Once contact has been established the stations move off to another channel convenient to both of them. By adopting this system, people only have to monitor one channel for calls.

Propagation

Although repeaters enable many stations to reach longer distances, the range of fixed stations is generally governed by the equipment and in particular the aerial, its location and the propagation conditions present at the time.

Often stations with large aerials and high transmitter power can make contacts over distances of a hundred miles or more on bands such as 2m or 70cm. However, for those people with more modest equipment it is not unreasonable to expect to make contacts over distances of around 50 miles with a reasonable aerial.

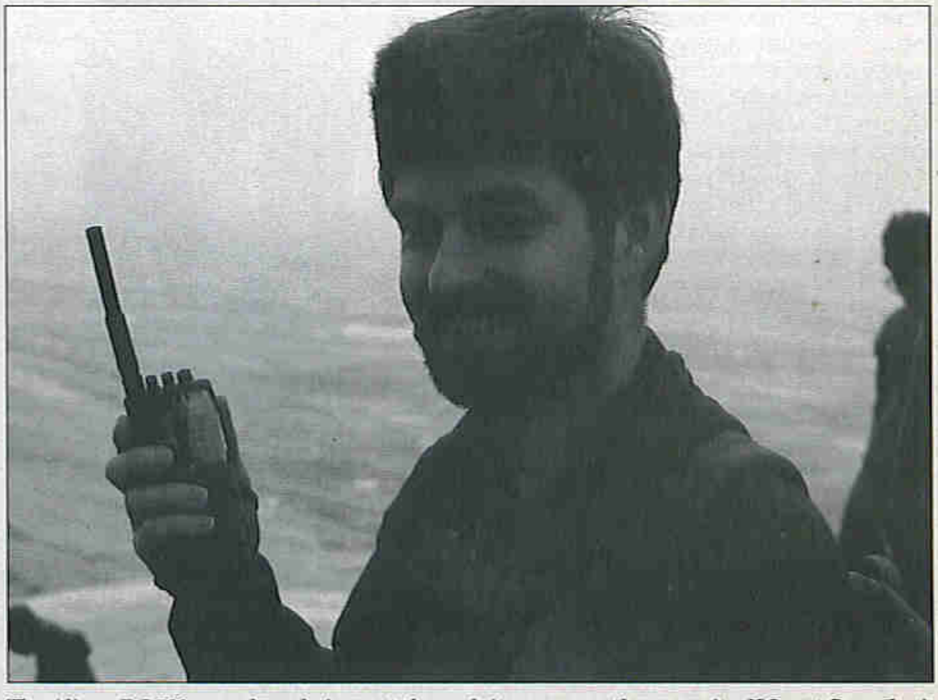
The distances covered on the various bands can be greatly increased when the propagation conditions are right. Tropospheric ducting, sporadic 'E' and a number of other types of propagation (to be described in a future article) can enable long-distance contacts to be made.

Equipment

To demonstrate some of the many aspects of VHF and UHF operation an Alinco DJ-580 was put through its paces. This unit is a compact hand-held transceiver covering both the 2m and 70cm bands. It is capable of giving two watts output on 2m, and 1·5W on 70cm with its standard Ni-Cd battery pack. If it is used with a high-current 12V pack, or if it is run from a decent external 12V supply, it can give a full 5W.

When the unit is run from a battery pack there are a number of features to help extend the battery life. There are three levels of transmitter power output; it can be reduced from its maximum to 1W, or even to 300mW. In addition to this, there is a battery-saving facility which can be activated on receive. This feature activates the receiver for 300ms every second when no signals are actually being received.

If the DJ-580 is being run from dry batteries, the Alinco-patented power supply



The Alinco DJ-580, seen here being put through its paces on the summit of Mount Snowdon!

circuit allows the unit to continue operating when the battery voltage falls below 5V. Whilst the power output and sensitivity are reduced, operation can continue until the supply voltage falls to 3·8V.

Being capable of full dual-band operation, the set can receive signals simultaneously on two bands. In fact, it will receive on one band whilst transmitting on the other. Because of this, it is possible to use the DJ-580 as a cross-band repeater if the correct code is entered onto the control keypad.

The set covers the whole of 2m and 70cm. It can transmit simplex, or can have split transmit and receive frequencies for repeater use. The offset required can easily be programmed in.

In addition to the basic amateur band coverage, the receiver will cover additional frequency ranges. There is an AM band between 108·000 and 142·995 MHz, and then three FM bands covering 130·000 to 173·995MHz, 400·000 to 469·995MHz and 825 to 945MHz. Handy for scanner enthusiasts! It also has three different scan modes that can be used. These allow a whole band, part of a band or the memory channels to be scanned.

Finally the set offers a DSQ (Digital Squelch) facility. This can be used when a large number of people monitor a given frequency. By using DSQ it is possible to activate a specific set compatible with this system, or a group of such sets. This could be useful if a club had its own calling frequency. A club member could call up a specific person, or a group of people, without activating everybody's sets.

Controls

The unit measures only 140 x 58 x 33mm with its standard battery pack. This means that it is truly pocket-sized, and very portable. There are a number of controls on the transceiver. On the top are separate volume and squelch controls for the UHF and VHF sections. In addition, there is a tuning knob that will tune either the VHF or UHF section. Tuning can be in increments (which can be programmed in), or alternatively via preprogrammed memories.

On the front of the set is the LCD display. This indicates everything from the frequencies of both the VHF and UHF sections to whether the unit is in battery-saving mode, and if it is transmitting. A signal strength meter is also included.

The control keys are located below the display. Whilst the keys are fairly small they are reasonably well-spaced and no trouble was experienced in using them. They can also be illuminated along with the display – a very useful feature for operation at night.

The PTT (push-to-talk) bar is conveniently located on the side of the set. If the top part is pressed then it acts in the normal way to enable the set to transmit. If the bottom section is pressed, a tone burst is generated at the beginning of the transmission for repeater access.

Just above the PTT bar there is a function button. This allows the secondary functions of the other keys to be accessed. It is located away from the other keys to prevent unwanted functions being accessed by mistake.

Accessories

The DJ580 comes complete with its own 7·2V battery pack, charger and 'rubber duck' aerial. However, there is also a wide range of accessories that are available. This includes a high-power battery pack enabling the full 5W to be generated, a dry cell battery box, speaker-microphone and so on. There is also a leatherette case which is useful if a lot of portable operation is envisaged. It will help protect the set from the inevitable knocks and scratches.

In Use

The DJ-580 performed well in a variety of roles. It naturally took a little while to master all of the facilities packed in. Once this had been done, it was very easy and flexible to use.

On the air, it also performed well. Around the house with its 'rubber duck' aerial, it gave some very good contacts. Simplex contacts were often limited to a range of about ten miles, but access could be gained to repeaters more than 20 miles away. With a full-sized aerial mounted outside the house, these distances were considerably increased and reception was made much easier.

Frequency (MHz)	Modes Allowed or Use
144·000 to 144·50	CW only
144·000 to 144·025	Moonbounce operation
144·050	CW calling frequency
144·100	Meteor Scatter (CW)
144·150 to 144·500	SSB and CW
144·300	SSB calling frequency
144·400	Meteor Scatter (SSB)
144·500 to 144·850	All modes
144·500	Slow Scan TV
144·600	RTTY
144·625	Packet Radio
144·650	Mailboxes
144·675	Packet Radio
144·700	Fax calling frequency
144·750	TV calling and talkback frequency
144·845 to 144·990	Beacons
145·000 to 145·800	FM Simplex and Repeaters
145·800 to 146·000	Satellite operation

Table 1. Band Plan for 2m.

Frequency (MHz)	Channel Designation	
145·000	R0	Repeater Input Channels
145·025	R1	
145·050	R2	
145·075	R3	
145·100	R4	
145·125	R5	
145·150	R6	
145·175	R7	
145·200	S8	Simplex Channels
145·225	S9	
145·250	S10	
145·275	S11	
145·300	S12	
145·325	S13	
145·350	S14	
145·375	S15	
145·400	S16	
145·425	S17	
145·450	S18	
145·475	S19	
145·500	S20	
145·525	S21	
145·550	S22	
145·575	S23	
145·600	R0	Repeater Output Channels
145·625	R1	
145·650	R2	
145·675	R3	
145·700	R4	
145·725	R5	
145·750	R6	
145·775	R7	

Table 2. 2m Channel Designations.

Being so compact, it goes without saying that the DJ-580 is very portable. It can be slipped into a pocket and carried almost anywhere without any trouble. To prove this fact, the unit was taken on holiday. All that was needed was the transceiver itself and the charger.

A number of contacts were made from the places stayed in. However, it was also taken on a number of outings. One interesting location for radio operation was the summit of Snowdon, which is about 3,500 feet above sea level.

Carrying the receiver on the walk to the top was no trouble due to the light weight and compact size. Once there, the view gave an indication of the possibilities for radio transmission. Despite this potential, the first contact was with another amateur on the summit – only about 20 metres away! However, with this contact complete, a longer look was made round the bands. Contacts were made with other stations in Wales, and repeaters in both Northern and Southern Ireland could be accessed, as could a number well into England. Not bad for such a tiny unit!

The experiment was repeated a week later when climbing Skiddaw, a peak of just over 3,000 feet, above sea level, in the Lake District. Reception here was not as good because of the other high peaks around. Even so, repeaters in Ireland were audible and contact was made through a repeater over 30 miles away. This again proved that the unit could be taken and used almost anywhere with virtually no extra effort or problems.

Licences

In common with all other amateur radio transmitting equipment, a licence is required to operate the DJ-580. However, it can be used by those holding a number of different licences. Ordinary class A and B licensees can use it on both bands. In addition to this, novice licensees can use it on their 70cm allocation. Such licences are not difficult to obtain, although they do entail some examinations and tests. Full details of all licences and how to obtain them are available from the Radio Society of Great Britain, Lambda House, Cranborne Road, Potters Bar, Herts., EN6 3JE (telephone 0707 49855).

Summary

The DJ-580 was great fun to use. It performed well under a number of different circumstances. Reports of audio quality were good and the receiver sensitivity was good. Coupled to the fact that it was easy to use, its very competitive price (£369.95, Maplin order code CM93B) makes this set an ideal choice for anyone considering both 2m and 70cm operation. If transverter units (advertised widely in the amateur radio press) are used, other bands (such as 6m and 23/24cm) are also within the realms of possibility.

In addition to the DJ-580, Alinco make a range of other products. These include single band handhelds, and a range of mobile sets for VHF and UHF. Full details of all this equipment can be found in the 'Communications' section of the 1993 Maplin Catalogue.

Frequency (MHz)	Modes Allowed or Use
432·000 to 432·150	CW only
432·000 to 432·025	Moonbounce
432·050	Centre of CW activity
432·150 to 432·500	SSB and CW
432·200	Centre of SSB activity
432·350	Microwave talkback
432·500 to 432·800	All modes
432·500	Centre of Slow Scan TV activity
432·600	Centre of RTTY activity
432·625	Packet Radio Links
432·650	Packet Radio Links
432·675	Packet Radio
432·700	Centre of Fax Activity
432·800 to 433·000	Beacons
433·000 to 433·375	Output for 1·6MHz shift Repeaters
433·400 to 434·600	FM Simplex
433·625	Packet Radio
433·650	Packet Radio
433·675	Packet Radio
434·600 to 435·000	Input for 1·6MHz shift Repeaters
435·000 to 438·000	Satellite operation
434·000 to 440·000	TV operation

Table 3. Band Plan for 70cm.

Frequency (MHz)	Channel Designation	
433·000	RB0	
433·025	RB1	Repeater Channels
433·050	RB2	
433·075	RB3	
433·100	RB4	
433·125	RB5	
433·150	RB6	
433·175	RB7	
433·200	RB8	
433·225	RB9	
433·250	RB10	
433·275	RB11	
433·300	RB12	
433·325	RB13	
433·350	RB14	
433·375	RB15	
433·400	SU16	Simplex Channels
433·425	SU17	
433·450	SU18	
433·475	SU19	
433·500	SU20	
433·525	SU21	
433·550	SU22	
433·575	SU23	
433·600	SU24	
434·600	RB0	
434·625	RB1	Repeater Channels
424·650	RB2	
434·675	RB3	
434·700	RB4	
434·725	RB5	
434·750	RB6	
434·775	RB7	
434·800	RB8	
434·825	RB9	
434·850	RB10	
434·875	RB11	
434·900	RB12	
434·925	RB13	
434·950	RB14	
434·975	RB15	

Table 4. 70cm Channel Designations.

TECHNOLOGY WATCH!

with Keith Brindley

A number of thoughts struck me while I was window shopping the other day. I'd been prowling round Hi-Fi shops, looking at Philips' digital compact cassette (DCC) and trying to catch a (rare) glimpse of Sony's MiniDisc system. I wanted to observe people using them, and get sales people's ideas of what the two systems can offer. My first thought was how many sales were being made. Or, rather, how many sales *weren't* being made. Oh yeah, quite a few people, like me, were there trying out the goodies, but all the time I was looking no-one *actually* bought one.

My second thought was how the sales people themselves viewed the systems. Probably because of punters' attitudes, maybe because of the Christmas Spirit (I write *Technology Watch* some 5 weeks prior to publication), I don't really know, but nobody was giving any hard-pitch sales-talk. As interested parties came up to look at the new digital recordable systems, salespeople merely pointed out the features, showed how to use them and stood back. At one Hi-Fi shop, I was simply given a couple of albums and a pair of top-of-the-range headphones and pointed in the direction of the display.

The only time I can ever remember anything like this was when personal computers were first available – you more-or-less stood in a queue to see the Commodore Pet – no-one was trying to sell them; they were simply an amusing curiosity. As we are all now aware, somebody did in fact sell more than just one or two personal computers, and maybe the same will happen to DCC and MiniDisc. Time will tell. Meanwhile, they're both fabulous systems in terms of sound quality. They just cost rather a lot.

These things are merely observations about sales techniques. The third thought I had about them has more of a technical perspective, however, and contradicts what I'd previously thought about them. I always considered Philips' DCC to have an edge over Sony's MiniDisc, simply because a DCC player can play back cassettes recorded on a conventional cassette recorder. So, after buying a DCC machine, you can scrap the old cassette recorder. This, so it seems, avoids the problem of having to keep backup formats in an old and inferior medium – much like most people still have a turntable to play old albums, while having a CD player too.

Sony's MiniDisc, on the other hand, like CD was to vinyl, is a new format totally incompatible with previous formats. On first sight, therefore, many people would go for DCC over MiniDisc.

But if you consider how you're going to actually *use* the tapes and discs, things look different. Wherever you are you'll use whatever is most convenient. In the house, a disc format is probably best. You have quicker access to tracks, and there's less likelihood of damage to the format – whatever you think of tape, it has a greater risk of damage simply because it *is* tape.

That's the house. Where else do you listen to music? Hmm, that's right, in the car. Now these new formats are still pretty expensive, and unless you're going to fork out around *another* £500 to buy a car-based DCC or MiniDisc player you'll still be using an analogue cassette player there.

So if you want to listen to music in the car you probably still have to transpose your music (from CD, DCC or MiniDisc) onto a cassette. And this means you *still* need your old cassette recorder.

Looked at this way, there's no difference between having DCC or having MiniDisc. In fact, because MiniDisc is a more permanent medium (with less risk of damage) it perhaps has the edge over DCC.

In Operating Terms

Computers, as readers will be fully aware, need operating systems to be able to do their jobs. Without an operating system, a computer is about as much use as a television without a screen.

When you buy a computer these days, the operating system is usually pre-installed by the manufacturer onto the internal hard disk. By comparison, in days of yore a computer's operating system had to be installed from floppy disks before any other programs could be installed and run. This always meant a considerable wait between turning the computer on and being able to use it. Not many computers are sold without a hard disk nowadays and so pre-installation of operating system software provides a useful way of getting the hardware up-and-running without any floppy disk-swapping and mental agitation.

However, it's essential to keep a copy of the operating system on floppy disks anyway, just in case the hard disk is corrupted in any way that might prevent the operating system from working. Also, users may well want to reinstall the system to their own requirements after reformatting the hard disk to bypass fragmentation and so on. Of course, manufacturers *always* supply the operating system on floppy disks as well, for these very reasons – or, at least, that's what any manufacturer *should* do.

But there's been a significant drop in computer prices for the last year or so. Computers generally are getting cheaper, and there has been a price war between manufacturers that has benefitted no-one except the buyers. You can pick up a fat computer with much more power and greater speed for much less than you'd have paid for a skinny, slow and weak machine just a few months back. While a floating pound stopped the march down in prices and has indeed reversed it slightly in some instances over recent months, the computer price war still rages and many smaller companies have been bombarded into bankruptcy by narrower and narrower margins.

Maybe margins are being cut too narrow, or maybe a particular manufacturer's marketing department has missed a trick, but it has come to my attention recently that a computer company called Ambra has been supplying computers with a pre-installed operating system but with no backup floppy disk set. This was only noticed by a reader after he got the thing home. No mention of this is given in the sales literature.

Now, at risk of a libel suit, I'd like to point out that this should not be. Any computer should be supplied with a backup floppy disk set of its operating system. When all is said and done, if a hard disk crashes or the operating system becomes corrupted in *any* way, the computer becomes unusable without floppy disk backup.

Ambra might like to dispute this proposition. After all, computers are far more reliable than they used to be and any risk of operating system corruption is arguably slight. I agree totally. But would *you* buy a computer if you knew it had no floppy disk backup of its operating system? Would you buy a car if you knew it had no jack?

Whatever, Ambra (admirably) has said it will repair and recover any data which is held on a hard disk if the operating system crashes, and this may allow users some measure of security. But it *still* means you have to contact Ambra, and wait for your computer to be repaired. And is Ambra likely to send an engineer to do the job for you? It's my guess they're more likely just to send you a set of floppy disks with the operating system on, for you to reinstall yourself (but what happens when your on site maintenance agreement/guarantee expires – Ed.). Some users of computers without a backup floppy disk set might even wish to contact their manufacturer's Technical Support department saying their computer is down, and requesting a floppy disk copy of the operating system – it's just an incey-wincey white lie, after all. I wouldn't blame them if they did.

As far as I know Ambra is the only supplier with this sort of attitude. But it may not be the case. Have any other readers had the same problem? Have you approached the supplier? What happened? Let me know if you have, it's something I'd like to follow through. You can contact me through the Editor.

Oh, and incidentally, Ambra was set up to market cheaper computers from a much larger and more expensive range. If you're not already aware, you might be amused to know Ambra is a subsidiary wing of IBM!

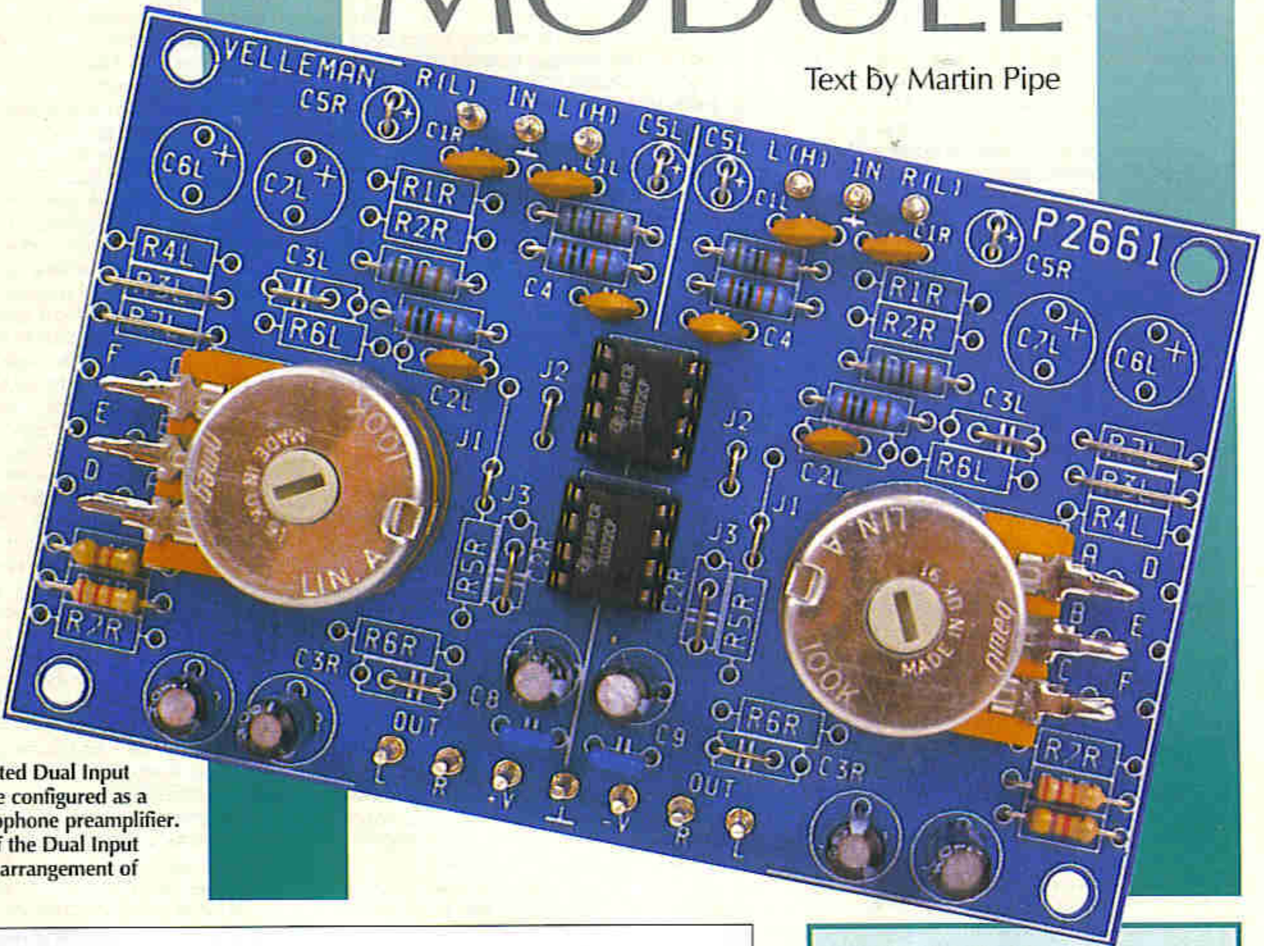
MODULAR MIXING SYSTEM

PART FIVE

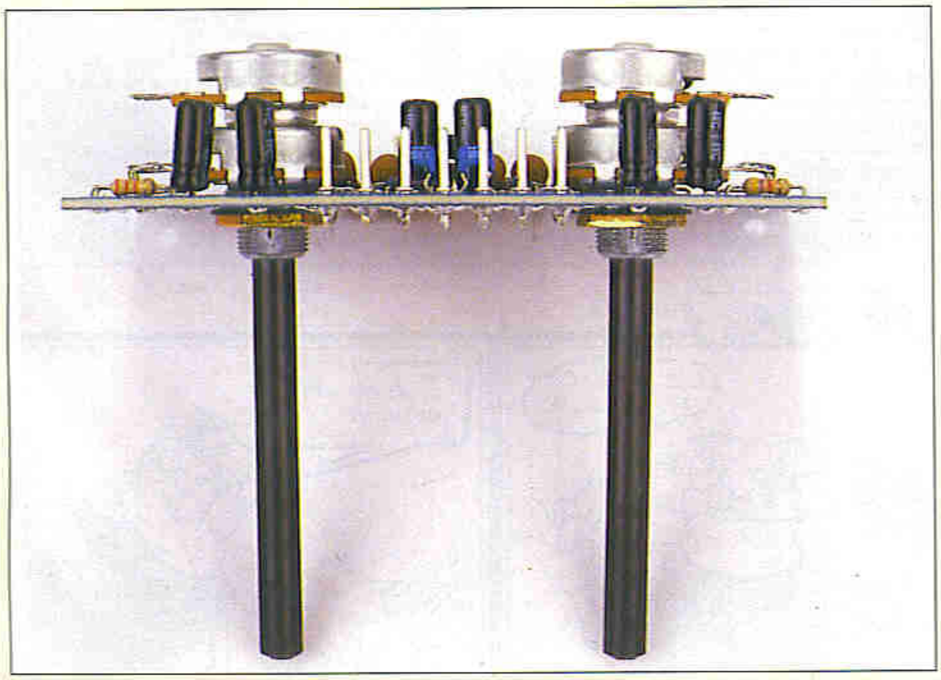
DUAL INPUT AMPLIFIER MODULE

Text by Martin Pipe

2 PROJECT RATING



Above: The completed Dual Input Amplifier, seen here configured as a balanced-line microphone preamplifier. Below: Side view of the Dual Input Amplifier, showing arrangement of potentiometers.



FEATURES

* Highly Flexible
* Low or High Impedance Line/Mic Inputs
* Mono or Stereo Configurations
* Can be configured as RIAA-Equalised Phono Preamp
* All Components Supplied (for listed configurations)

APPLICATIONS

* Modular Mixers
* Updating Existing Systems
* Hi-Fi Equipment

The Dual Input Amplifier Module is a very flexible building block for use in mixers and amplifiers. Each half of the module can be configured in one of four different ways; these are: stereo line (unbalanced), stereo phono (unbalanced), mono microphone (balanced or unbalanced) or mono line (balanced or unbalanced). The unbalanced microphone and line inputs can also be configured for high or low impedance. As a result, this module has a wide variety of applications ranging from a phono preamplifier, suitable for use with magnetic (or high output moving-coil) cartridges in a power amplifier or elderly music centre, through general input modules for a mixer, to providing a PA amplifier with a balanced-line microphone input. The kit contains all the parts necessary to build any of these options; for some configurations, different component values or a wire link may be required for a particular position.

Circuit Description and Operation

Note that there are two identical circuits on each module, for maximum flexibility. For example, the first could be configured as a balanced-line mic preamp, while the second could be configured as a stereo line amp.

1. Microphone (Medium/Low Impedance Balanced)

The input module should be configured as shown in Figure 1 if the use of medium/low impedance (typically 600Ω) balanced-output microphones – for example, professional dynamic and ribbon types – is anticipated. Note that the input impedance of the circuit is 5k6. The screen of the microphone is connected to 0V, while the in-phase and out-of-phase signals are applied to the non-inverting and inverting inputs of the differential amplifier IC2 (refer to the connection drawing of Figure 2). The output of IC2 is then fed to IC1, which has a gain variable from unity to aproximately 13dB (a factor of 4·5). The gain of IC1 is determined by the position of the wiper of RV1; the higher the resistance in the feedback loop, the higher the gain. The 'back-to-back' capacitors, C6 and C7, form a bipolar capacitor, the function of which is to form a high-pass filter, preventing very low (subsonic) frequencies from being amplified.

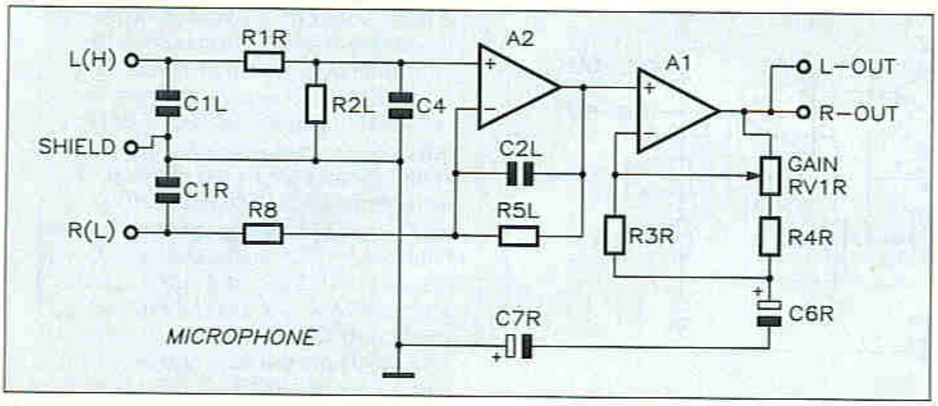


Figure 1. Balanced-line preamplifier configuration.

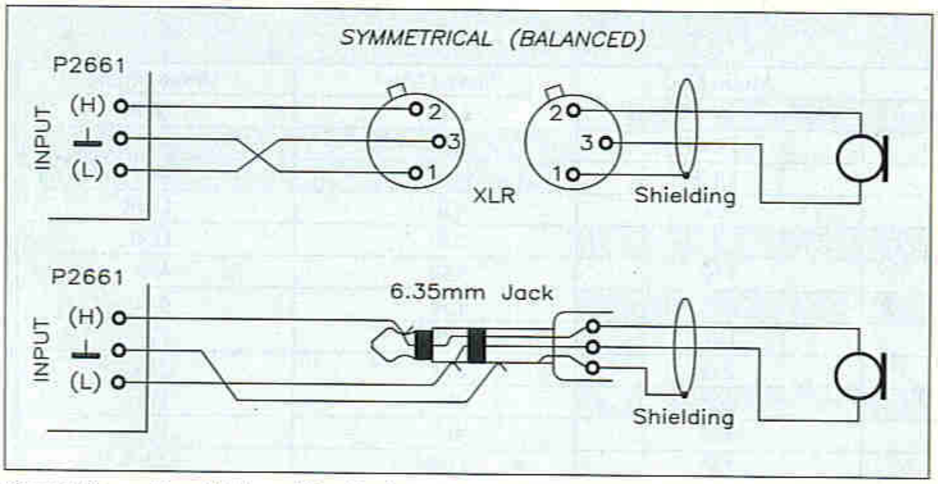


Figure 2. Connection of balanced-line signal source.

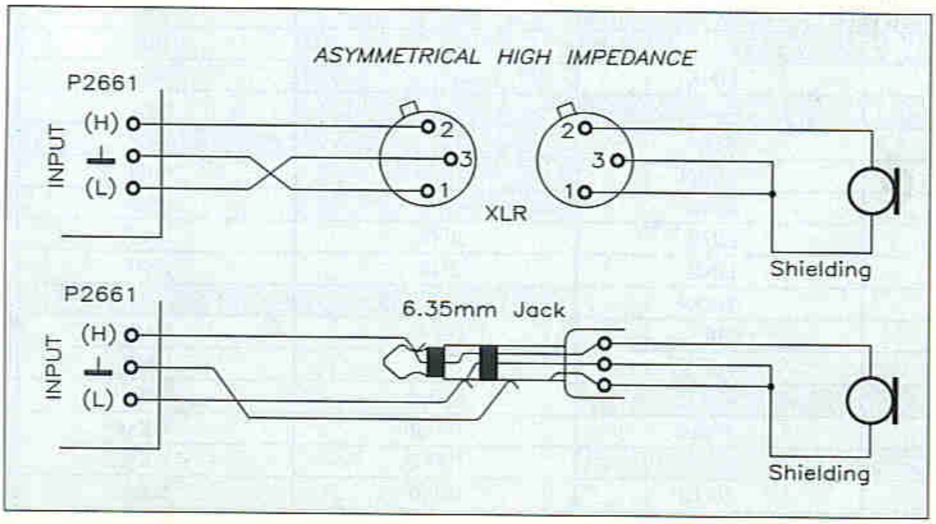


Figure 3. Connection of unbalanced high-impedance source.

2. Microphone (High Impedance Unbalanced)

The unbalanced high impedance mode is achieved by shorting the inverting input of the balanced-input circuit of Figure 1 to ground (0V). In this case, the input impedance will be increased to 100kΩ . A microphone input of such high impedance is seldom required these days, but those who hang onto their crystal microphones for sentimental reasons will be glad to know that they have been catered for! But seriously, most guitar pickups (particularly the cheaper ones that employ crystal transducers) require a high impedance input, and may be used with a Dual Input Amplifier configured in this way. The connection diagram is shown in Figure 3.

3. Microphone (Low-Impedance Unbalanced)

The unbalanced low-impedance mode, intended for use with semi-professional and domestic-quality electret microphones, is achieved in a similar way to the high-impedance version. On this occasion, however, the non-inverting input is shorted to ground; the input impedance then becomes 5k6. The wiring diagram is shown in Figure 4. Note, however, that as the signal is applied to the inverting input of A2, the circuit will invert the phase of the signal – ideally, the signal will be inverted somewhere further on in the mixer chain so that the correct phase is maintained. If the module is intended as a preamp for use with an amplifier, a phase inverter (which need only be an op amp configured as a standard inverting buffer) should be used.

4. Mono Line (Unbalanced/Balanced Low/High Impedance)

'Line level' refers to the high-level outputs of tape machines, tuners, CD players and the like. Generally, in these situations 0dB relates to a standardised voltage of 0·775V RMS. Bearing in mind the few millivolts produced by a microphone, it is important never to apply such (comparatively) high-amplitude signals to the input of a microphone (or, for that matter, a phono) preamplifier, otherwise severe overloading could result – producing harmonics that may cause your tweeters to 'fry'. For these reasons, the Dual Input Module is capable of being configured for use with line-level signals.

The mono line amplifier, shown in Figure 5, is essentially the same as the microphone preamplifier, and is configured in the same way. The only differences are that input coupling capacitors have been added (to cope with any DC offsets that may be present on the input signal) and that some of the resistor values have been changed; the most significant role of R1 and R2 is now that of an input attenuator. Used in the same way as the microphone amplifier, the input impedance in balanced and unbalanced low-impedance mode is

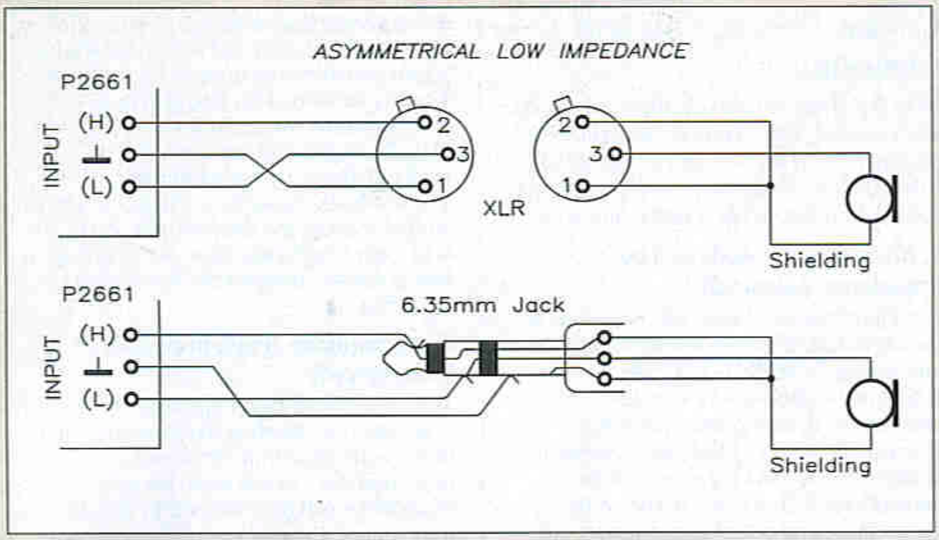


Figure 4. Connection of unbalanced low-impedance source.

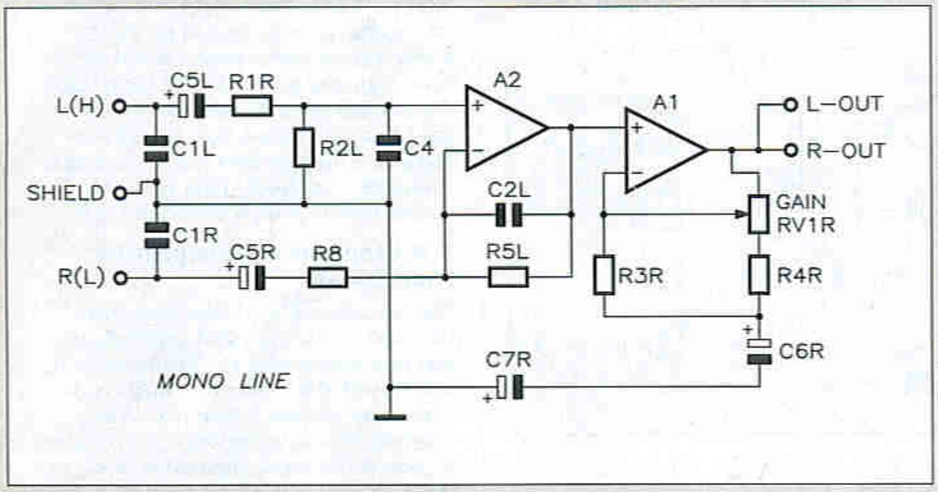


Figure 5. Mono line amp configuration.

47k, and the unbalanced high-impedance mode has an input impedance of 68k; note that in the low-impedance unbalanced mode, the signal is inverted, and so the comments made earlier relating to subsequent phase inversion apply.

5. Stereo Line

The stereo line amplifier, shown in Figure 6, is a straightforward AC-coupled non-inverting amplifier. Its gain is variable between unity and 13dB (4·5), and its input impedance is 47kΩ.

6. Phono Preamplifier

The 'phono' stage, shown in Figure 7, is a DC-coupled AC amplifier with frequency selective network in the feedback loop. The gain of the amplifier is dependent upon frequency; this characteristic is required to correct the RIAA (Recording Industry Association of America) response from a turntable's magnetic cartridge to give the amplifier a flat response (to 15kHz). Such equalisation, which involves attenuating lower frequencies whilst boosting the amplitude of higher frequencies at the recording end, is required to make records (remember them?) a practical viability. If the lower frequencies were used to control the cutting head at the record mastering stage, the cutting head would not last long without such frequency tailoring (come to think of it, neither would the record!), and the stylus of the record player would have some trouble trying to track the finished disc! Correction is applied at the playback end; low frequencies are boosted while the higher ones are cut, in accordance with the RIAA curve. In the case of the Dual Input Amplifier, deviation from this curve is less than 1dB.

Component	Microphone	Mono Line	Stereo Line	Stereo Phone
J1	—	—	LINK	LINK
J2	LINK	LINK	—	—
J3	LINK	LINK	—	—
R1L	5k6	47k	33k	LINK
R1R			33k	LINK
R2L	100k	15k	15k	47k
R2R	—	—	15k	47k
R3L	LINK	LINK	22k	22k
R3R	22k	22k	22k	22k
R4L	—	—	4k7	12k
R4R	4k7	4k7	4k7	12k
R5L	100k	15k	LINK	470k
R5R	—	—	LINK	470k
R6L	—	—	—	39k
R6R	—	—	—	39k
R7L	LINK	LINK	—	5k6
R7R	—	—	—	5k6
R8	5k6	47k	—	—
C2L	100pF	100pF	—	6n8F
C2R	LINK	LINK	—	6n8F
C3L	LINK	LINK	LINK	2n2F
C3R	LINK	LINK	LINK	2n2F
C4	100pF	100pF	—	—
C5L	LINK	1µF	1µF	LINK
C5R	LINK	1µF	1µF	LINK
C6L	—	—	100µF	100µF
C6R	100µF	100µF	100µF	100µF
C7L	—	—	100µF	100µF
C7R	100µF	100µF	100µF	100µF

Table 1. Component options.

Capacitors C8 to 11, shown in Figure 8, decouple the split-rail power supply (±15V ideally) required by the Dual Input Amplifier.

Construction

First of all, decide which of the four options you wish to build for each of the module's two independent circuits – for example, a microphone input on one half of the PCB, and a stereo phono preamp on the other. Begin construction by fitting the required links and components, which are shown in the relevant column of Table 1. The electrolytic capacitors require the leads preforming to fit properly on the PCB; as these are polarised devices, therefore ensure that they are correctly orientated before soldering.

Having now completed fitting all the links and components from the table for the appropriate version(s), the capacitors common to all configurations (C1L/R, C8, C9, C10 and C11) should be fitted.

The capacitors are followed by the IC

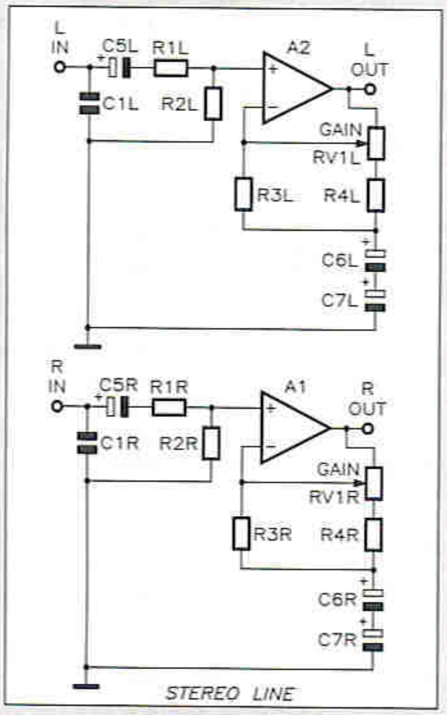


Figure 6. Stereo line amp configuration.

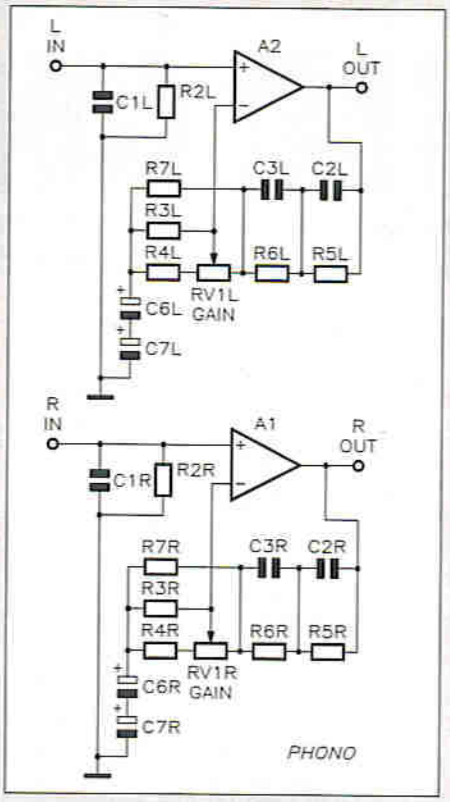


Figure 7. Stereo RIAA phono preamp configuration.

sockets (the notch of the socket should be lined up with that of the legend), and the PCB pins. Both sockets and pins should be fitted from the component side.

Fit RV1L/R from the component side (the control shaft should be visible from the solder side) of the PCB. Use the supplied

Specification

Number of independent channels:	Up to 4
Gain adjustment range:	25dB
Signal to noise ratio:	80dB
THD:	<0·05%
Frequency response:	20Hz to 20kHz (±0·5dB)
Deviation from RIAA equalisation curve:	Less than 1dB
Power supply:	±5 to ±15V DC; 100mA per rail

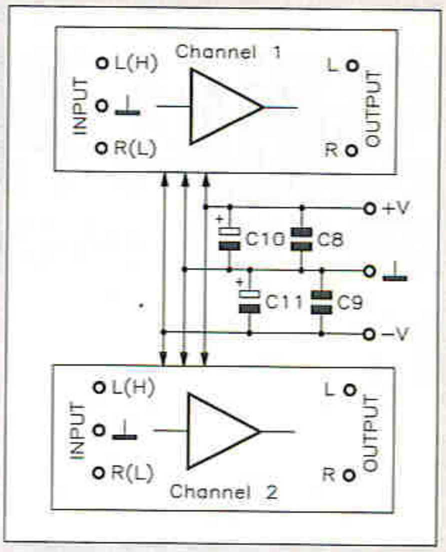


Figure 8. Dual Input Amplifier power supply arrangement.

wire links to wire up the terminals of each potentiometer to the relevant connection points. If you have chosen either the microphone or mono line input, then only the links A, B, and C need to be fitted – only one of the potentiometer's two ganged sections are required under these circumstances.

Finally, IC1 and IC2 should be installed in their sockets – the notch, or spot, on each IC package should be aligned with that on the IC socket.

Testing and Installation

The PCB is now complete; but before attempting to use the module, carefully check your work for poor solder joints, bridges, whiskers and misplaced components. The best way to test the module is to use it for its intended application. Note that all audio connections, to and from the PCB, should be made with screened cable to avoid the possibility of hum pick-up (this is particularly true of low-level microphone and phono inputs). For balanced-line signals, twin-core overall-screened cable should be used. A split-rail power supply capable of supplying 100mA is required; for maximum dynamic range, ±15V should be used, although the unit will work with power supplies rated as low as ±5V.

DUAL INPUT AMPLIFIER MODULE PARTS LIST

RESISTORS			
Refer to Table 1	5k6 (1%)	4	
	15k (1%)	4	
	47k (1%)	4	
	100k (1%)	4	
	4k7	4	
	12k	4	
	15k	4	
	22k	4	
	33k	4	
	39k	4	
	47k	4	
RV1L/R	100k Stereo Linear Potentiometer	2	
CAPACITORS			
Refer to Table 1	100pF Ceramic	4	
	180pF Ceramic	4	
	2n2F Poly Layer	4	
	6n8 Poly Layer	4	
	1µF PCB Electrolytic	4	
	100µF Electrolytic	8	
C8, C9	100nF Resin-dipped Ceramic	2	
C10, C11	10µF PCB Electrolytic	2	
SEMICONDUCTORS			
IC1, IC2	TL072 or NE5532 Dual Op Amp	2	
MISCELLANEOUS			
	PCB	1	
	PCB Pins	2 Pkts	
	Bandoliered Wire Links	15 (approx.)	
	Leaflet	1	
OPTIONAL (Not in Kit)			
	Constructors' Guide	1	(XH79L)
	Single Core Screened Cable	As Req.	(XR15R)
	Twin Core overlapped Screen	As Req.	(XR08J)

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 VE30H (Dual Input Amplifier Module) Price £19.95.

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

SERIAL PACKET CONTROLLERS

by Frank Booty

Using a serial packet controller as a virtual UART, a Personal Computer's (PC's) COM port (serial port) can accept most synchronous or asynchronous communications protocols, while still looking to the PC host as a conventional asynchronous UART. Continuing with the subject of computer networked communications, this article explains the technology, and shows how it can be used in a typical application. The application selected is that of a fibre optic link to another computer at data rates of up to 1·2M-bit/s.

Applications for a virtual UART stretch the imagination. It can be used as an Input/Output controller for any PC or workstation, regardless of the operating system. When built into a modem, it demonstrates good design flexibility. For the prototyping of communications links, it is a wonderful emulator. For Local Area Network (LAN) and Wide Area Network (WAN) applications, it is a powerful packet controller. It is also ideal for multi-tasking applications, such as allowing the PC to communicate with another device, whilst simultaneously running a non-communications program.

Such unique functionality is embodied in a serial packet controller from Silicon Systems, Inc. Although this is known as the SSI73M650SPC, let's call it the 650 for convenience. To the PC host, the 650 always looks like a common 550 type asynchronous UART. But to a device communicating with the PC, the 650 can emulate virtually anything, including an 8530 type synchronous UART. With Manchester encode/decode capability (see separate panel) the 650 can even be used with fibre optic communications links. In addition to Manchester encoding, the 650 also supports NRZ, NRZI and FM encoding. Since the device is ideal for laptop or portable PC applications, it includes a power-down mode to extend the computer's battery life. If the application calls for V42 error control, the 650 includes 32-bit CRC error checking for full V42 compatibility.

Designing a Communications System

The first step in designing a system using the 650 is to select the operating mode. Two basic modes are available: single processor and dual processor. Single processor mode can be further broken down into two basic architectures (see the section on design decisions).

The foremost reason for using a single processor design is to save costs, but the capabilities are far more limited than with a dual processor design. The single processor configuration must be dedicated to a single task. It must share the host CPU. In most applications it is limited to a data rate of 9,600 bit/s due to the interrupt handling limits of the host CPU. And, while it is compatible with the V22 bis data communications standard, including compression, it cannot be used in designs requiring compliance with more advanced specifications, such as V32 and V42 bis. V32 is a 9,600 bit/s modem data pump modulation standard. V42 bis is a CCITT compression standard that is capable of compression ratios up to 4:1. (Compressing data prior to transmission means that it can be sent in less time, saving transmission costs.)

Dual processor designs offer the increased flexibility of multi-tasking. However, it also requires a dedicated microprocessor, albeit an inexpensive one. Much higher data rates can be handled, and compatibility can be achieved with standards such as: V32 with compression; V32 at 9,600 bit/s; V32 bis at 14,400 bit/s; V42 bis with 4:1 compression; and V22 bis at 2,400 bit/s. In fact, data rates of up to 10M-bit/s can be achieved with a dual processor design, if Manchester encode/decode is used on a fibre optic link.

If the single processor is selected, several questions must be asked by the designer. The first has to do with the method of addressing the part. There are three addressing modes for the 650: 550, 8530 and 8530 in the 550 address space. The method of addressing that is selected depends on the host software being used. If it expects to see a 550 UART, the 550 addressing mode must be used. Likewise, the expectations of the host software will also determine if either of the other two modes is correct.

Separate addressing and chip select pins are available for the 550 and 8530 blocks. When the 8530 must be addressed in the 550 address space, the chip selects for both blocks have to be wired together. In addition, an external device, for example, an intelligent data pump, may be mapped into the same address space as the 550 register set.

Next the designer needs to know whether the 650 will address external devices within the 550 address space. If the designer wishes to utilise the 650's internal decoder to address external devices, the external devices must be compatible with the bus timing produced by the 650.

Finally, the designer must decide whether to configure the 650 in a mailbox mode, utilising the 550 block's 16 byte FIFO as a mailbox. In mailbox mode, applications are possible where the 550's register set is required to interface to standard software, but the additional functionality of the 8530 is required for either synchronous communications or data compression.

The main advantage of the dual processor mode is the addition of a dedicated microprocessor to control the 650. A simple inexpensive 8-bit microprocessor can be selected, such as an Intel 8051 or equivalent device. With such a dedicated microprocessor, it is no longer necessary to steal machine cycles from the host PC's CPU to control the synchronous section of the 650.

Together with the dedicated microprocessor there'll be buffer storage, i.e. RAM. If a lot of buffer storage is required for the application, inexpensive dynamic RAM is suggested.

For a particular application under design, a decision has to be made about how much buffer storage is required, and what type of buffer storage will be used. The minimum buffer size is one packet of data. However, several packets should be stored to improve link efficiency. From a flow control standpoint, the buffer needs to store

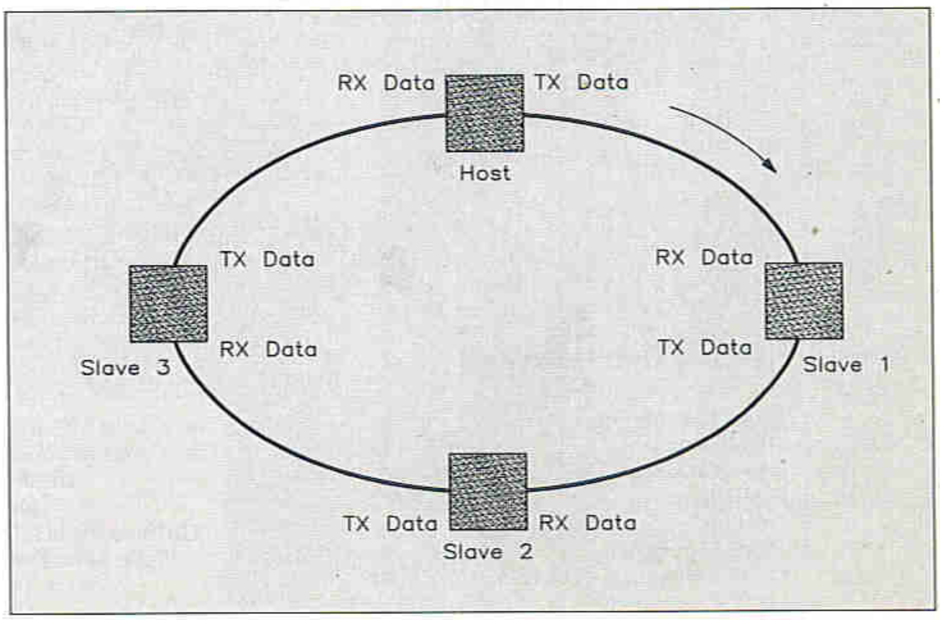


Figure 1. SDLC loop transmission.

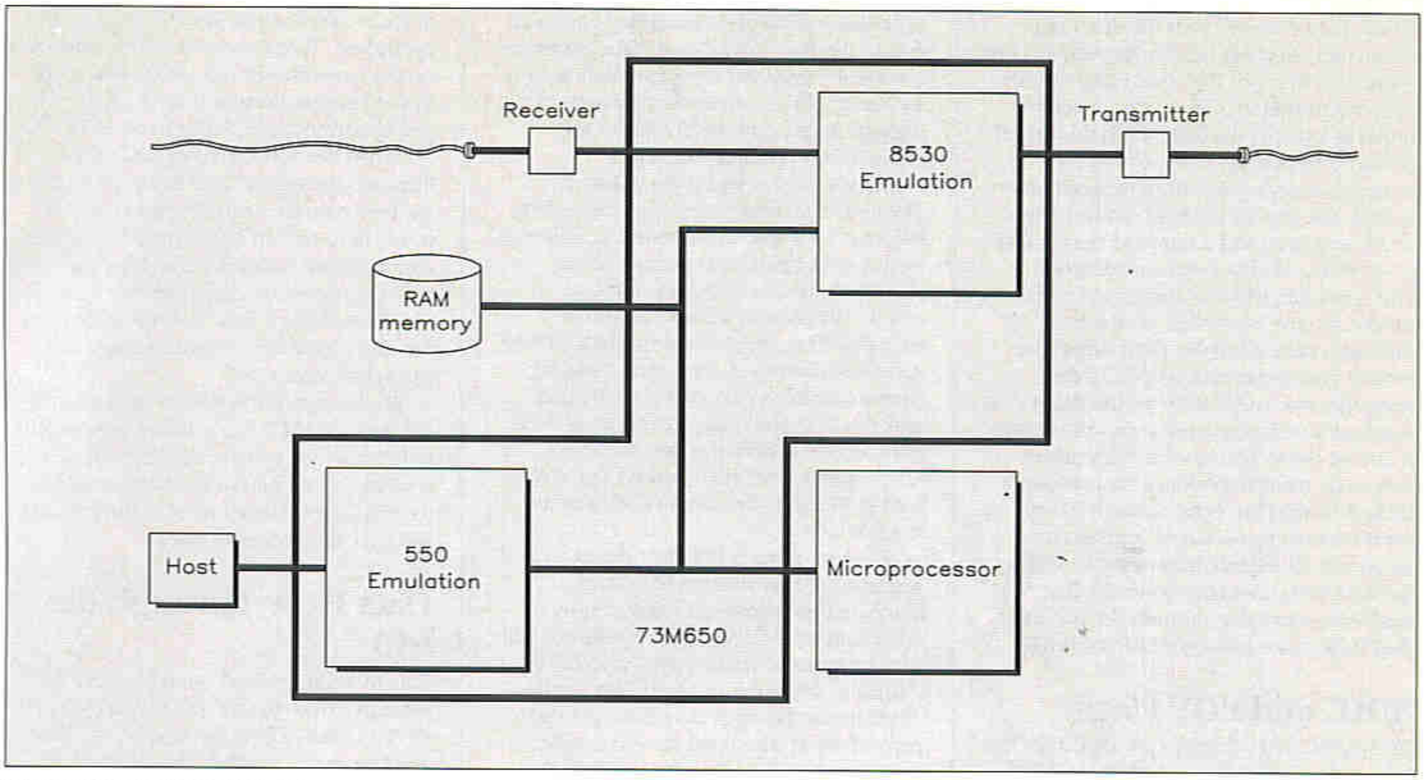


Figure 2. SSI 73M650 SDLC loop.

enough data so that, when a control word is detected, the control action can be taken at the proper point in the data stream. Here the amount of buffer storage is related to the data rate and the time required to provide a signal to the other end of the link.

The designer needs to determine whether the control code will be resident in the dedicated microprocessor, or somewhere else in the system RAM. There are maintenance advantages to storing control code in RAM and downloading it to the microprocessor.

The next design decision is how to pass control information from the host CPU to the dedicated microprocessor. It is advantageous to use the scratch register for loading data path flow control information. If the flow control information is not put into the scratch register, it would have to be loaded in the data path itself. In this circumstance, additional intelligence is required to strip the flow control codes out of the data stream, and to act upon them.

Finally, the designer needs to decide whether to use the DMA lines to the host processor to speed up memory access. In most cases, however, this will not be necessary.

Designing a High Speed Fibre Optic Network

A good example of the use of the 650 is in the design of a high speed fibre optic data network. This network ties together several IBM compatible PCs, as well as an assortment of peripheral devices, which can be shared on the network. In this case particularly high rates of data transfer are required, since large graphic files will be sent around the link, in order that the laser printer and plotter on the link can be used to print those files. Rather than using an expensive hub file server, the network will have a ring configuration with no central file server (see Figure 1). Fibre optic cable is the choice for the transmission medium due to its inherent resistance to RFI.

Each station on the network must look like a 550 type UART, so as to use conventional communication software on the network. A serial form of communication protocol will be used for the devices to communicate together. This protocol will provide error detection and retransmission, to ensure that data is transferred without being corrupted, and the protocol will provide a means for equal sharing of the resources between the demands of the users, preventing the network from being dominated by the demands of a single user.

A synchronous communications protocol such as SDLC will be used, since these protocols contain the desired error checking facilities. SDLC has the drawback of requiring a clock to recover data from the network. However, SDLC can be transmitted, with Manchester clock encoding (see separate panel), to encode the data clock with the serial data, to allow the clock to be recovered at the receiver. Encoding the clock along with the data has the advantage that any changes in the timing, due to effects of bias distortion occurring on data transmitted, will be performed on the clock information stored in the data stream as well.

This ensures that the data clock will always have the same timing in relation to the data being transmitted on the network. When the clock is recovered from the data path, the data clock will always occur with the correct timing for the serial communication controller to sample the serial receive data.

In order for the standard PCs on the network to communicate with conventional software, they need to see a conventional 550 type UART. However, a 550 type UART is an asynchronous device that cannot understand a synchronous protocol such as SDLC. Hence some sort of protocol converter is required, e.g. the Silicon Systems Inc. 73M650 serial packet controller, which can accept most protocols and convert them to a signal that looks to the PC host like a standard 550 type UART.

Selecting the Mode of Operation

Single processor mode is not acceptable in this application, since in this mode the 650 looks to the PC host like either a 550 type asynchronous UART, or an 8530 type synchronous controller. However, it will not allow the PC host to see a 550 type UART while the network sees an 8530 type synchronous controller, so as to accept SDLC.

Therefore a dual processor mode of operation will be used (see Figure 2) with a dedicated microprocessor and a RAM buffer. The built-in Manchester encoder will be used to transmit SDLC on a high speed fibre optic network. Although only 1K of buffer RAM is needed for data and about 3K are needed for control code, 32K of RAM will be used. 32K of RAM is one of the smallest, least expensive modules that can be readily used. Both data and control code will be stored in the buffer, with the control code being down loaded to the microprocessor when needed. The scratch register in the 550 block will be used to load the control code.

To see how the 650 is used, look first at the data flow. Data that is loaded in octets in the 550 registers can then be read as octets by a control communications processor from the back end of the 550 register set. This data is normally moved into a temporary RAM storage location until there is enough data to form an SDLC data packet. The data is then moved from the temporary RAM buffer to the synchronous emulation block in the 650. The data is transmitted out in a packet, according to the protocol rules of the SDLC loop transmission, with the synchronous controller forming the start flags and the data packet, with zero data is then encoded with the data clock information through the Manchester encoder circuitry in the 650. The serial data stream is then transmitted to a fibre optic driver for transmission over the link. When the last bit of data is transmitted to the 650 by the control microprocessor from the temporary storage, the 650 transmits the correct frame check sequence and a required closing flag.

In SDLC, all data is transmitted from one controller, which is designated as the master, to slave controllers on the loop. All data on a slave controller passes from the receive port to the transmit port. If the controller is actively 'on loop', the data that is received is reclocked and retransmitted with a one bit delay. This one bit delay allows data to be retimed to reduce bias distortion caused by the fibre optic network. Every slave controller passes data from its own receiver to its internal transmitter, to pass to the next slave controller down the line. The final slave controller transmits the packet of data back to the host controller's receiver.

SDLC and EOP Flags

In an SDLC loop, the network starts with the host controller sending out an End Of Poll (EOP) flag. This is a flag that looks like a normal flag of, in binary, 01111110, 07E hex, but which is modified slightly to 11111110, 07F hex (note that in serial communications the LSB is transmitted first, and hence the bit pattern is shown rather than the actual binary number). This EOP flag is used by each slave controller to determine when it should transmit to the host controller.

When a slave controller encounters an EOP flag, it changes the EOP flag to a normal SDLC flag and transmits a data packet to the host controller. When the controller has finished transmitting, the controller attaches the correct frame check sequence (FCS) to the data packet and closes the frame with an EOP flag.

Since the first detected EOP is changed by the actively transmitting slave controller on the network to an SDLC flag, any downstream controllers are prevented from transmitting, since no EOP will be encountered. The downstream slave controller must wait until an EOP is encountered before the controller is allowed to transmit a packet of data to the host controller. A slave controller is normally restricted from transmitting for a set period of time after a frame has been shipped, to prevent domination of the network by upstream controllers.

In the network under discussion, a destination address byte is transmitted first, followed by a source address byte, followed by a control byte that contains a frame sequence number. The host software requires the host to acknowledge the reception from the slaves at least once every seven data frames. A slave data controller cannot transmit a data packet to the host until the last seven data packets have been acknowledged from the host controller. The host controller will not acknowledge a slave until EOP frames are detected back at the host's receiver.

The host receiver will only detect an EOP sequence of two adjacent EOP flags if a 'no transmission' was attempted by a slave controller. Receiving two adjacent EOP flags indicates all slaves have had a fair chance to utilise the network. This method of arbitration prevents domination of the network by an upstream slave controller.

Using this method of flow control, the host controller can modulate the use of the network by any slave controller. If data is being received from an upstream controller, the host may receive only a maximum of seven packets of data from a slave. This allows new EOP flags to make their way to the receivers of the downstream slave controllers. These controllers may place data on the network with the destination to the host controller, thereby using the EOP flag and changing the EOP flag to an SDLC flag.

When the host controller senses more than one contiguous EOP flag in its receiver, the host controller can determine that all slaves have had an opportunity to utilise the communication channel. The host controller may then acknowledge the oldest frame, or all frames, from a slave controller, allowing the slave controller to transmit more data to the host controller.

The slave controller software is simple: it comprises RAM buffer routines to store data in RAM, which will be later transmitted, and a simple controller device driver to control the 650. The 650 does most of the protocol work for the microprocessor.

Data Flow Through the 650

Data to be transmitted is read by the microprocessor from the 650 through the 16 byte FIFO in the 550 from the B channel of the synchronous controller. This data is transferred to RAM for storage. When the RAM storage is full, the microprocessor no longer reads data from the 550 FIFO, causing the host processor to wait. When a 256 byte packet of data is formed in the storage RAM, the controller waits for a valid EOP flag.

SERIAL PACKET CONTROLLER THAT IS A VIRTUAL UART

The 650 serial packet controller can be used to accept almost any communications protocol from a communications link, while always looking to a PC host like a standard 550 type UART. It can be operated in either a single or dual processor mode, depending on the communication standards and protocols to be supported.

It features: register compatibility with a basic 550 type UART; functional compatibility with a single channel 8530 type synchronous communication controller; DMA signals available in its 44 pin package configuration; NRZ, NRZI, FM and Manchester encode and decode; 32-bit CRC (cyclic redundancy check) for V42 compatibility; oscillator disable for low power standby in battery operated applications; and a space saving 28 pin version.

Figure 3 shows a functional block diagram of the 650, while Figure 5 shows both the 28-pin and 44-pin PLCC pinouts.

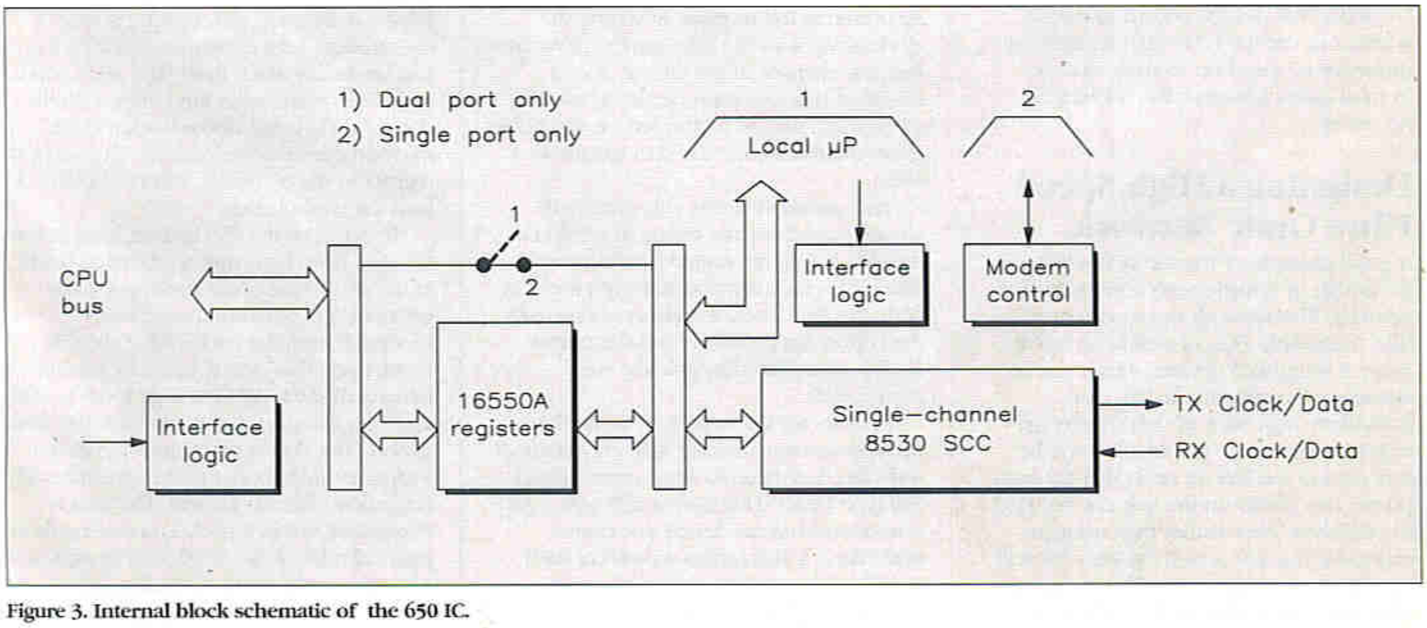


Figure 3. Internal block schematic of the 650 IC.

MANCHESTER ENCODING

Fibre optic communications has a problem with 'bias distortion', where the duty cycles of the data information can be distorted. To get around this problem, it is important to know where the centre of the data bit cell is, even when this information is distorted by the communications link. Manchester encoding is a scheme that always places a transition in the middle of each data bit cell (see Figure 4 for a comparison of Manchester and other popular encoding methods).

The 650 can encode and decode Manchester in both asynchronous and synchronous modes. Manchester encoding is simple to remember. During the first half of the data cell, the data is sent in its logical true form. During the second half of the data cell, the data is complemented (inverted).

Because Manchester encodes the clock with the data, it is useful for finding optical communications links that are working. A simple test box can be fabricated that simply looks for transitions on the optical communications link. When these transitions are found, the link can be assumed to be transmitting clock pulses. Also, if the test box can identify the frequency of the clock in a rough manner, a diagnostic tag can be created for sorting out a number of communications links.

If a baud rate frequency is chosen for each link just for testing, the test box can then identify the link according to the clock frequency that is received. This is a truly beneficial feature when setting up a communications link with numerous fibres in the system.

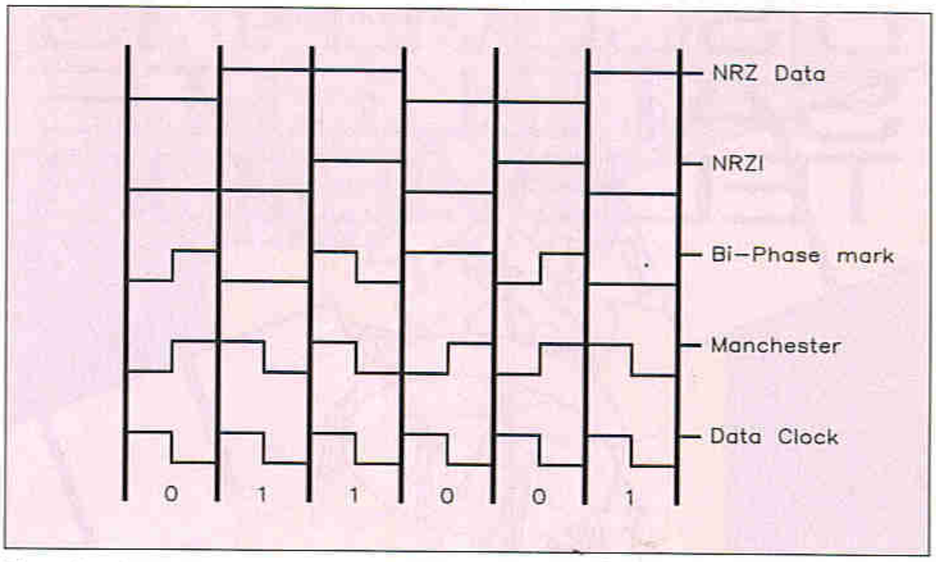


Figure 4. Various types of data encoding compared.

The controller will also send a packet of less than 256 bytes when a receive FIFO time-out occurs, indicating that the host has no more data to transmit. When a valid EOP is indicated by the 650 to the microprocessor, the microprocessor adds a destination address byte, a source byte, a control byte and then data is transferred to the three byte transmit FIFO within the 650 synchronous controller.

The microprocessor control software keeps a copy of the data received from the host until a message is received from the host controller that the data has been received correctly. When an acknowledgment packet is received from the host controller, the data is cleared from the directory in the slave controller. If an acknowledgment packet from the host controller indicates that the data frame was received corrupted, the packet and all newer packets waiting for acknowledgment from the host are transmitted back to the host controller.

Using a fibre optic network, with SDLC synchronous transmission protocol, and a Silicon Systems Inc. 650 serial packet controller, in each PC around the ring network, data can be transmitted at data rates of up to 1·2M-byte/s. If external clock recovery circuitry is used, this data rate can even be higher.

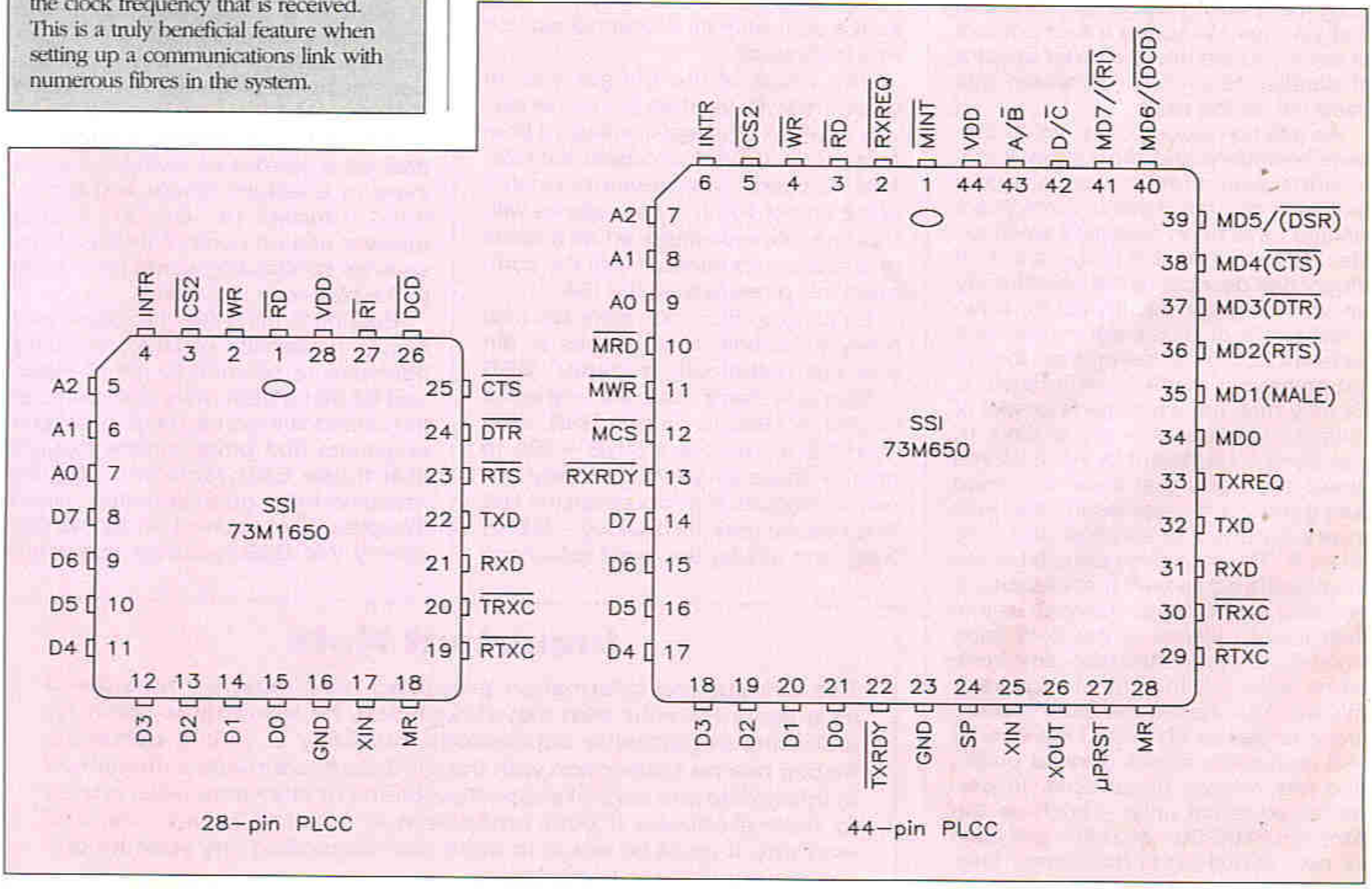
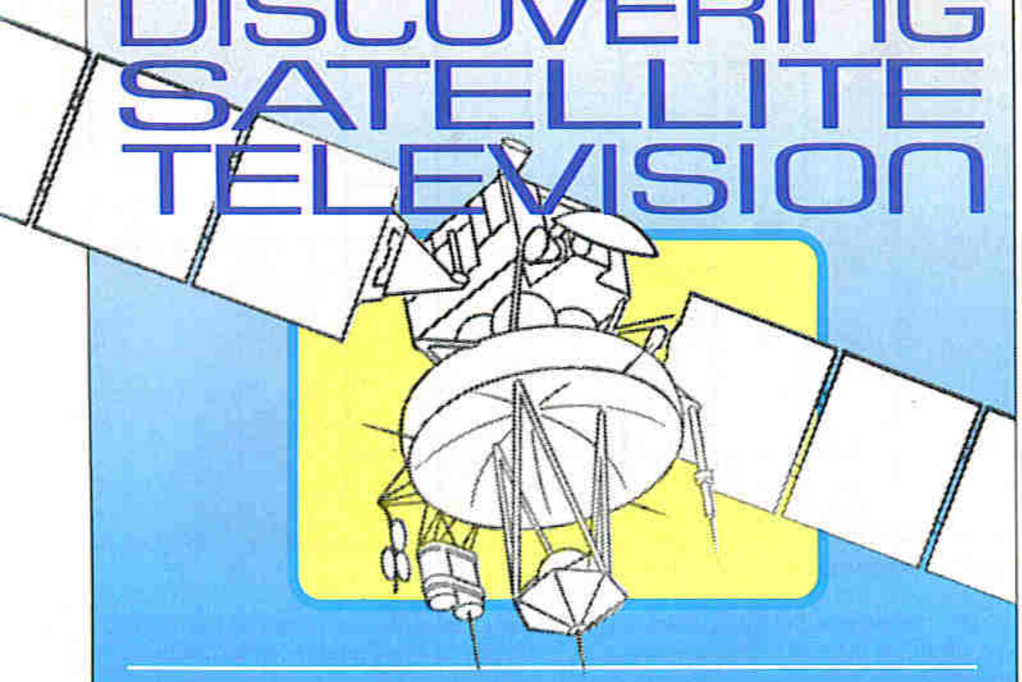


Figure 5. Pin-outs of both the 28-pin and 44-pin PLCC packaged versions of the chip.

DISCOVERING SATELLITE TELEVISION



Part Four
Beyond The Grave
by Martin Pipe

As has been revealed in previous parts of this series, there is a lot more to satellite TV than would appear on first inspection. Apart from the burgeoning number of broadcasters on Astra, other satellites provide an even greater choice of programming. Many purveyors of satellite equipment are trying to convince you that you need to spend a vast amount of money to tap into the wider spectra of satellite television. However, this need not be the case.

As with home computers, video cassette recorders and most other items of consumer electronics, satellite receivers of a mere two or three years vintage have been classified as obsolete. Perhaps they don't have a built-in Videocrypt decoder or the latest trendy on-screen graphics. Ironically, however, some of those early receivers were a lot easier to set up than the latest on-screen menu-driven monsters. Or they may have a limited number of presettable channels – at one time, 16 was deemed sufficient for Astra (Some would still argue that it still is – even with three Astra satellites in orbit, how many English channels can you count?). The marketing people behind the satellite equipment manufacturers, and their agents, try to convince us that their latest receiver is the best thing since sliced bread. And who can blame them; after all, they're out to make money. As a result, the older models are regarded as 'obsolete' by a finnicky and market-conscious general public, and are virtually unsaleable. In particular, ex-rental units – such as the Amstrad SRX200 – are often available for next to nothing in real terms. This, as we will find out in due course, can be used to our advantage!

What to do with Those Old BSB Receivers

A different form of commercial pressure saw the demise of satellite broadcaster British Satellite Broadcasting (BSB) towards the end of 1990 – less than a year after its 5-channel service was introduced.

The result of the merger was of course BSkyB, the then 5-channel service of which was dual-illuminated from Astra and BSB's Marcopolo satellite. This Marcopolo service was terminated at the end of 1992, in accordance with ITC requirements imposed as a result of breaching its contract with the commission's predecessor, the IBA.

Leading on from this, there are now many hundreds of thousands of old (yet still technically superior) BSB receiving systems out there – whether bought in 1990 to receive BSB, or in 1991/92 to receive BSkyB – not to mention those languishing in dusty corners of stock rooms throughout the UK. Yet, despite their technology – BSB's was (and still is) the most advanced domestic broadcasting system yet experienced in the UK – these units are, to all intents and purposes, useless. The only broadcaster to use BSB's DMAC system is the Norwegian state broadcaster NRK, which broadcasts 'in the clear' on the Tele-X DBS satellite. Even if you could point your Squarial or compact dish at Tele-X, you wouldn't receive anything as the footprint is weak in the UK (a 1·2m dish and low-noise DBS LNB is the minimum requirement in the South of England; for a change, smaller dishes are required as you go 'oop north'!) and, in any case, left-hand circular polarisation (LHCP) – rather than the right-hand circular polarisation (RHCP) of BSB – is required. Even with suitable outdoor equipment, an unmodified BSB receiver would be useless to all practical intents and purposes – as the sound, being transmitted in a different 'sub-frame' to that of BSB – would not be recovered.

Many European satellite broadcasters, with a little encouragement from the EC, are using the D2MAC transmission standard. These include a cluster of satellites (Olympus, TDF1 and TVSAT) allocated at the Western European DBS slot at 19°W. Again, because the transmission rate is half that of the 20·25Mbits/second of DMAC, a BSB receiver will not lock into a D2MAC transmission, the result being a picture that 'swirls' from left to right at a fairly rapid rate. The sound/data, chrominance and luminance packets can be seen in succession, giving us an insight into how the system works.

But all this is largely academic – after all, a satellite receiving system is there to entertain, inform and (hopefully) educate us. So far, a BSB receiver can do none of these things, save for contributing some juicy items to the high-tech junkbox!

Bearing in mind the cheapness and ready availability of BSB receiving hardware (it seemed to get cheaper, and for that matter more abundant, as the closedown loomed closer), several engineers and programmers thought that these BSB receivers may be rescued from obsolescence. Such thoughts were spurred on by the discovery that BSB receivers use either

Important Note

The circuits and information presented here must be considered as a basis for your own experimentation, no warranty is given for suitability in particular applications, reliability or circuit operation. Maplin has no connection with the third-party companies mentioned in this article and cannot support problems or answer queries related to their products. If your equipment is covered by an extended warranty, it must be borne in mind that attempting any such modifications are likely to invalidate it.

an ITT (the most common) or Plessey MAC chipset. These chipsets could be used for various MAC standards. Apart from BSB's DMAC, they could be used to decode BMAC, CMAC and – last but not least – D2MAC. Armed with this information, these people set to work disassembling the control software inside BSB receivers, examining it and altering it so that D2MAC reception was enabled.

I had the chance to see for myself one of the first modified BSB receivers (in this case a Ferguson) in late 1991. I say see purposefully because the individuals concerned had not yet found the program code that was concerned with controlling the MAC audio circuitry. Nevertheless, the picture – that of superb French pop music station MCM Euromusique – was instantly recognisable, with a superb picture. Unfortunately, the BSB Eurocypher decoder would be sporadically triggered for a few seconds, rendering the picture similar to that of a non-decoded Videocrypt picture. The unmodified BSB dish used to receive the signal had simply been repositioned from Marcopolo (31°W) to TDF1 (19°W) – like Marcopolo, RHCP is used on the French DBS satellite. The fact that MCM was a pop music station served as an impetus for 'sorting out the sound' – which was duly done a few days later, NICAM stereo sound thundering through the speakers set up on either side of the monitor screen.

Things have moved on considerably since then. There were four models of BSB receiver made, due to the fact that BSB contracted only four manufacturers to produce the equipment – the product lifetime of which greatly exceeded that of the service! The four receivers in question were manufactured by Ferguson, Philips, Tatung and ITT Nokia. To go with them are three different dish designs – including the much-heralded 'Squarial' – more on these later. The Ferguson receiver (the SRB1) has proved the most popular choice for modification, presumably as its ITT microcontroller appears to use the 6502 instruction set familiar to so many programmers. In addition, the operating software is held in a readily-accessible (socketed) ROM (so, for that matter, is that of the Philips). Various organisations are now – to the dismay of the original equipment manufacturers – marketing software for the Ferguson, Philips and Tatung units. To my knowledge, nothing has been yet done with the ITT Nokia unit.

The Trac PAL/ D2MAC/DMAC Upgrade

One manufacturer, Trac Satellite Systems of Middlesbrough, has been involved with reprogrammed BSB receivers since early 1992, selling modified receivers and suitably-programmed EPROMs for the DIY enthusiast. The company deals primarily with the Ferguson unit, although it has recently been advertising upgrades for Tatung receivers. Recently, however, they have been selling a £49.00 Ferguson DIY upgrade. What makes this upgrade interesting, however, is that it makes the receiver compatible with non-MAC (e.g., PAL from Astra) transmissions. Trac refer to the non-MAC signal as 'PAL', but what if you're receiving a SECAM or NTSC programme off a motorised dish? Sorry, just nit-picking! Since the upgrade also

Satellite	Channel	Frequency (GHz)	Polarisation	Transmission Format	Comments
Astra (19·2°E)	TV3(SW)	11·244	Horizontal	D2MAC*(0)	Swedish entertainment channel.
Astra (19·2°E)	TV1000	11·303	Horizontal	D2MAC*	Swedish film/entertainment channel.
Astra (19·2°E)	Filmnet	11·362	Horizontal	D2MAC*(0)	Famous Belgian film channel.
Astra (19·2°E)	TV3 (Den)	11·612	Horizontal	D2MAC*(0)	TV3 with Danish soundtrack/subtitles.
Astra (19·2°E)	TV3 (Nor)	11·671	Horizontal	D2MAC*(0)	TV3 with Norwegian soundtrack/subtitles.
Eutel sat IIF3 (16°E)	Eurostep	10·987	Horizontal	D2MAC*(0)	English educational channel.
	TV+	11·678	Horizontal	D2MAC*(0)	Experimental Belgian 16:9 film channel.
Eutel sat IIFI (13°E)	Kabel kanal	11·055	Horizontal	D2MAC*(0)	German entertainment channel for cable.
	Eurospace	12·563	Horizontal	D2MAC*(0)	English educational channel.
Tele-X (5°E)	NRK	11·322	LHCP	DMAC	Norwegian state broadcaster. Also Radio Roks (other sub-frame).
Intel sat 513 (1°W)	SV2	11·177	Horizontal	DMAC*(0)	Swedish general broadcaster. SRP2 radio station also available.
	SV1	11·684	Horizontal	DMAC*(0)	Swedish general broadcaster. SRP1 radio station also available.
TDF 1 (19°W) French DBS Satellite	MCM Euromusique	11·727	RHCP	D2MAC	Fabulous French-originated pop music channel. Victor pop radio station also available.
	Canal+	11·804	RHCP	D2MAC*(0)	Film/general entertainment – often clear at weekends.
	Arte	11·881	RHCP	D2MAC	Arts and Culture – even Monty Python (still in English!).
	Antenne 2	12·034	RHCP	D2MAC	French state broadcaster. Occasional HD-MAC. Hector classical music station also available.
TV SAT 2 (19·2°W) German DBS Satellite	RTL+	11·747	LHCP	D2MAC	German entertainment channel, as on Astra.
	SAT 1	11·823	LHCP	D2MAC	German entertainment channel, as on Astra. Radio France Internet also available.
	3 SAT	11·900	LHCP	D2MAC	German arts channel, as on Astra. Opera sounds so much better with NICAM digital sound, though!
	Eins Plus	12·054	LHCP	D2MAC	German public broadcaster, as on Astra.

* = Eurocrypt scrambling used; (0) = occasionally clear

Notes: (1) TDF1 and TV SAT 2 are strong enough to be picked up on Squarial/Compact Dish originally intended for use with BSB. To pick up channels from TV SAT 2 (which use LHCP), modification to the LNB feed assembly, or repositioning of Squarial's aerial sheet, is required.
(2) Occasional (eg. HD-MAC) test transmissions found on Telecom 2A (8°W) are Intelsat IIF3 (16°E), for example.

Table 1. European MAC channels available at time of writing.

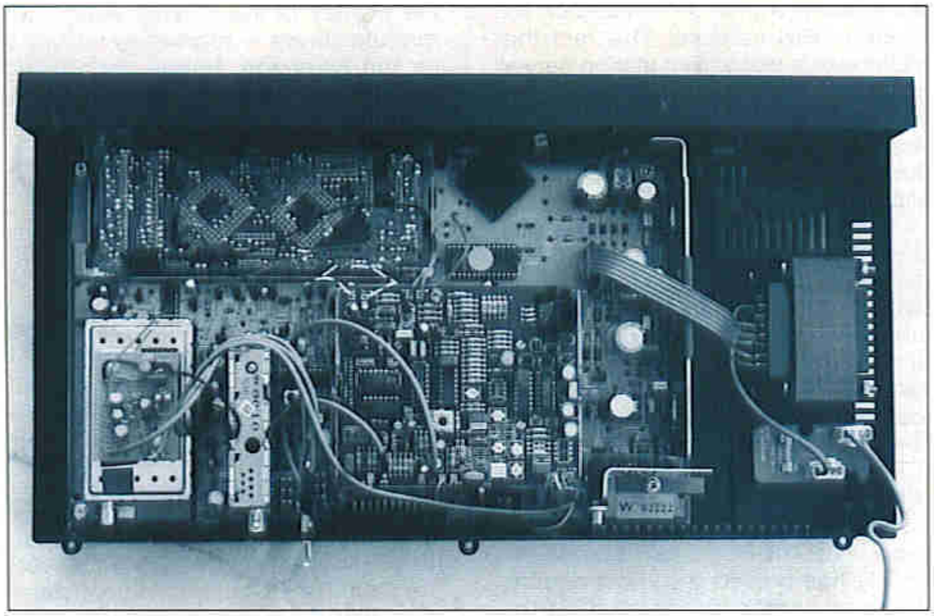


Photo 1. Ferguson BSB receiver fitted with Trac D2MAC/DMAC/PAL conversion kit. The stripboard circuit (refer to Figure 4) enables the unit to be used a transcoder – fine if you've already got a multi-satellite receiver (conventional transcoders start at £250.00!). The rear-mounted toggle switch enables the unit to revert to operation with the built-in tuner/demodulator (DBS aerial, Astra dish, etc.).

promises D2MAC, DMAC (NRK – and with sound!) operation, as well as providing tunable audio (which is still not found on certain full-priced Astra receivers!) and a roster of easy-to-use onscreen graphics, the Trac unit seemed far too good to be true. Bearing in mind that I have seen Ferguson BSB receivers advertised for as little as £15, a complete multi-standard receiver for £64.00 is a proposition not to be laughed at – if it works, that is.

The upgrade arrived a lot later than was promised – Trac were apparently waiting for certain components to arrive (Perhaps they should try MPS! – Ed), and the documentation had to be written. It takes the form of a PCB (containing the de-emphasis filters, clamp and so on associated with the PAL video, the tunable audio circuitry, an analogue switch for external decoder and PAL/MAC changeover, and some additional circuitry (device numbers scratched off!) that interfaces all of this to the I2C bus of the host receiver. A handful of other components are supplied to fit to the Fergie's PCB, including a 27256 EPROM containing the new software. Apart from the PCB and components, four support pillars are supplied to mount the PCB on top of the BSB ACM's screening can, and last (but not least) that documentation!

Installation

Let's start with the documentation. This consists of two sets of leaflets, both of which are very well produced. The first is the installation guide, while the second consists of user instructions. The installation guide is extremely thorough, having being prepared for people who are not necessarily technically-minded. The highlights are almost certainly the DTP-produced drawings, showing the points on the Ferguson receiver PCB to which the 13 wires of the Trac board are attached. Close-ups of the area of PCB track to which the relevant wires are attached are included, and co-ordinates are given relative to the right and bottom edges to the Ferguson board. Apart from soldering the wires to the PCB, a resistor associated with the LNB supply regulator had to be changed (this modification is associated with the 13/18V LNB switching voltage – more on that later), and a resistor and capacitor had to be added. And finally, the Ferguson BSB ROM is replaced with the Trac EPROM which carries the magic software. Suffice to say that installation was straightforward enough if the leaflet's instructions are followed correctly. 'Electronics' readers should find it a doddle – it took me little over an hour.

The instruction booklet is an introduction to the use of the modified receiver, and is that supplied with other versions of the unit (Trac also sell a ready-converted receiver with dish and LNB for £149.00, or a £69.00 ready-modified receiver circuit board that takes the place of the existing one in your receiver. However, thanks to a well-designed set of on-screen menus, operation soon becomes intuitive. The instructions also contain some very useful information on how to convert the Squarial, and the compact dish fitted with the 'bullet' LNB, to receive LHCP. The former involves disassembling the unit, changing the position of the plastic etched aerial sheet, and then reassembling it. Modifying the latter involves twisting the LNB's feed through 90°. This modification is only relevant to the European DBS satellites co-located at 19°W, as only these have a sufficiently strong UK footprint to ensure good reception on such a small dish. The four TV Sat 2-delivered German channels (mirroring some of those on Astra – but with superb NICAM sound – just the thing for 3Sat's opera!) use LHCP, to avoid mutual interference with the quartet of French channels carried by TDF1 (La Sept/Arte, MCM Euromusique, etc.). Table 1 lists all of the European MAC channels operating at the time of writing.

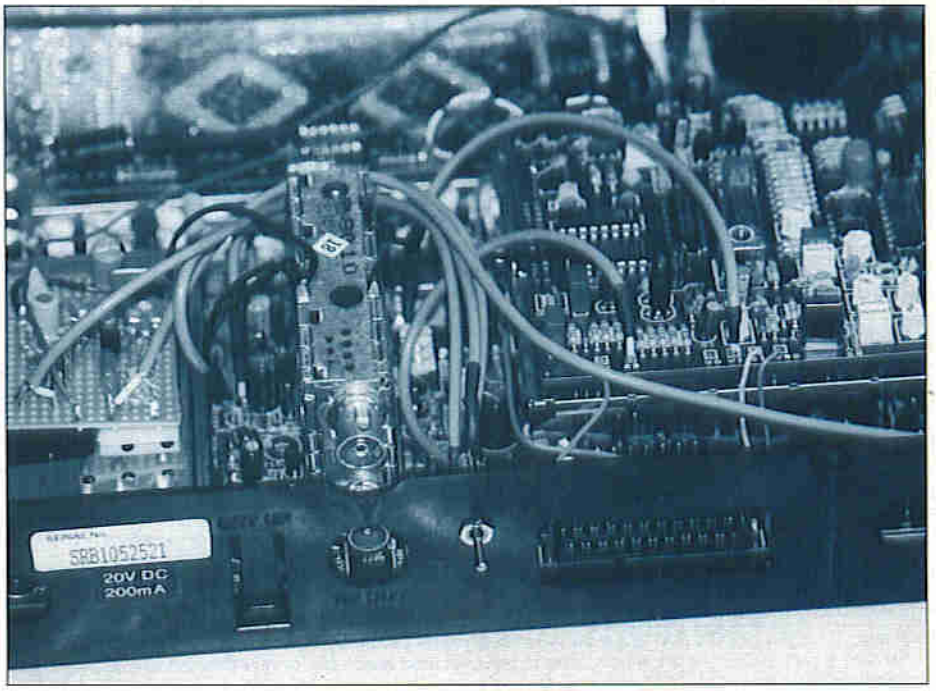


Photo 2. Close-up rear view of modified Ferguson BSB receiver, showing transcoder/receiver switch. The 'DATA' and 'ACM' sockets now have somewhat different purposes!

Setting Up

When the modified receiver is first switched on, it goes into a 'self-test' mode before going into 'standby'. It is now ready for use. Before powering up again, the relevant dish and LNB should be connected to the receiver, along with the TV or monitor. Trac recommend the set up shown in Figure 1. 21-pin SCART (Peritel) or UHF outputs are provided – with a press of a rear-mounted 'set up' button, a nice blue screen with copyright message greets you once your TV set has been tuned in. For best results, a monitor with full-specification SCART should be used, as the MAC channels provide a RGB output; in addition, the MAC stereo sound, where broadcast, can only be enjoyed via this socket. Only one SCART socket is fitted unfortunately; this is a criticism of the original receiver – and I remember reading reviews in 1990 satellite television magazines noting this shortcoming. The BSB receiver manufacturers said that 'second generation' models would remedy the situation. Sadly, these were not to be!

In Use

The modified unit has 60 programmable channels, most of which have been preprogrammed for various Astra, Eutelsat and DBS satellite channels. All can be reprogrammed, but the original settings can be reverted to at anytime.

A press of the MENU key on the handset activates the main menu. As with most satellite receivers in this enlightened age, to save costs, few buttons adorn the fascia of the receiver (up/down and standby). Of course, this is a complaint about the original receiver. Some might argue that these three buttons were sufficient for the pre-tuned 5-channel (later to be 10-channel) service for which the unit was originally designed.

From the main menu can be accessed eight sub-menus. The first of these is the video tuning menu – the first IF can be tuned from 950 to 1700MHz in 3MHz steps (the last 50MHz are knocked off, which precludes receiving MCM, which is low enough in the DBS band to be received on most standard LNBs. A shame...). For some reason, the on-screen display is only visible when tuning whilst in one of the MAC modes – when in the non-MAC (hereafter referred to as 'PAL') mode, you have to rely on the receiver's LED display, which counts from 0 to FF in hexadecimal. In the MAC mode, the station's ident, if transmitted, is displayed – a nice touch.

Sound tuning is evoked from the second sub-menu. In the PAL mode, the audio subcarrier is tunable between 5·5 and 8·5MHz. No mention is made of bandwidth, but I suspect that it's a compromise – it adequately serves both the full bandwidth of the primary subcarrier and the narrow bandwidth of the Wegener subcarriers. It's a pity they didn't take the tuning up as far as 9MHz (to get those obscure radio stations on the French Telecom 2B satellite (5°W)) – but you can't expect everything at this price. Stereo would be nice as well! In the MAC mode, a list of the auxiliary audio services (radio, etc.) is displayed, and these can be selected by pressing the appropriately-numbered button on the handset.

The action of the third sub-menu depends upon the receiver's operating mode. In the PAL mode, it is used to switch in a Videocrypt decoder connected to the redesignated 'DATA' socket at the rear of the receiver. In the MAC menu, the picture format can be controlled. Many experimental HD-MAC transmissions (which have a 16:9 aspect ratio) have recently been taking place on the Eutelsat, European DBS and Telecom satellites. The '16:9' mode expands the width of the picture if a conventional 4:3 set is being used (so that it doesn't look 'squashed up'). Since the information at the sides of the screen will inevitably be lost, an automatic and manual panning facility is provided so that you can see what's missing. When the automatic panning feature is active, the picture area visible is under the control of the broadcaster i.e. you see what they feel you should see! Alternatively, you could use the manual panning feature to give yourself control over the picture. Apart from overriding the personal taste of the programme editor, manual panning is essential with certain widescreen transmissions (a large number, surprisingly) where the automatic panning or widescreen identification data is not present. Although this information is not supplied in the instruction manual, pressing 'shift' and 'enter' together allows you to use the left and right arrow keys to manipulate the picture to your personal preferences.

It must be noted that the provision of the widescreen compatibility – and 'Softscram', another (exceptionally useful) facility – are dependent upon the vintage of the MAC decoder chip in your receiver. 'Softscram', by the way, enables the receiver to decode soft-scrambled Eurocrypt broadcasts – e.g. Canal+ at certain times – by retrieving the 'free access' control words from the MAC data packet. Similar, in fact, to the soft-scrambled Videocrypt system as used by UK Gold, although the latter system transmits the required data in the vertical blanking interval.

Unfortunately, however, widescreen compatibility and Softscram will only work if the ITT DMA2285 MAC decoder IC (the right-hand 60-pin PLCC device located on the MAC sub-PCB) inside your receiver is suffixed '30' or more. If your existing receiver has an earlier MAC chip, it is probably worth paying the extra £20.00 in order to get a new receiver board that has been 'vetted' by Trac, and hence a fully-specified receiver. In addition, you also get a supply of spare parts (tuner/demodulators and UHF modulators tend to suffer the most when there's a nearby lightning strike...). On the other hand, if you're buying a receiver specifically for the purpose of modifying it, you now know where to check!

Mode select, the fourth sub-menu, sets the receiver up to receive D2MAC, DMAC (two modes – one for each sub-frame) and PAL. The DMAC modes are primarily intended for use with the

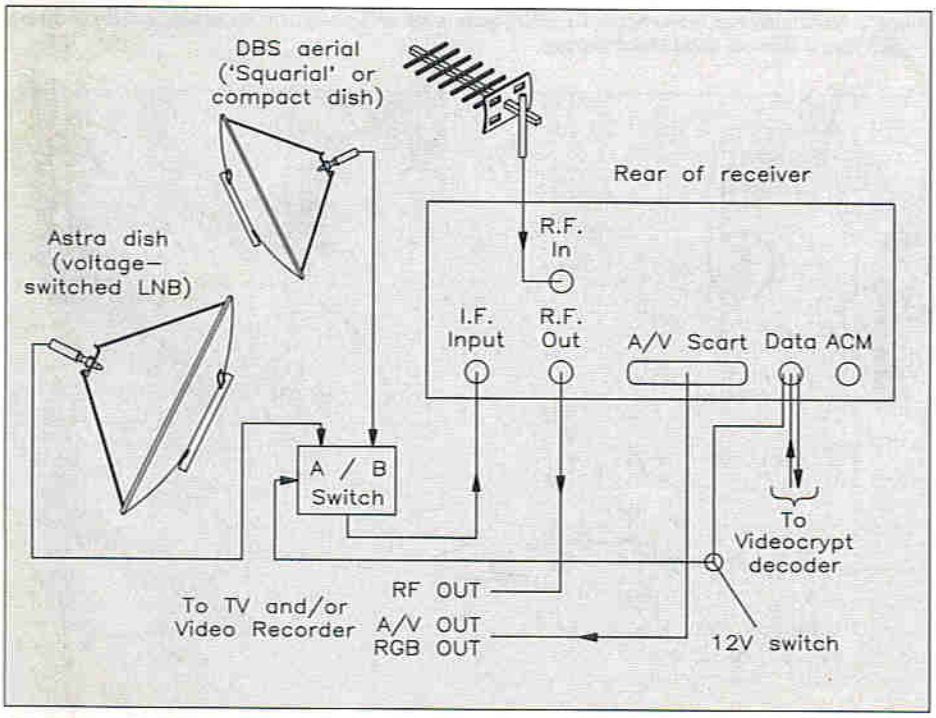


Figure 1. Typical set up using Ferguson SRB1 BSB receiver fitted with Trac upgrade.

unscrambled Norwegian NRK service described earlier. There is a lot of interest in this broadcaster since it shows a lot of American and British material, preferring to retain the English soundtrack and superimpose relatively unobtrusive subtitles on the picture (Also useful if you want to learn Norwegian – Ed!). Most MAC equipment currently on the market doesn't include such a facility, despite the extensive use of the ITT chipset. Trac have proved that MAC mode control lies in the operating software (relatively inexpensive to implement), so why don't manufacturers include such a facility in their equipment? Apart from alienating themselves from the lucrative Scandinavian market, they are also denying a useful feature to UK viewers and expatriates living in Western Europe. C'est la vie!

To ensure that the frequency displayed is correct, the fifth sub-menu allows you to define the LNB type that you are using – FSS (conventional), BSB DBS or Telecom. In addition, the engineer set up menu allows you to compensate for variations in LNB local oscillator (LO) frequency, so that the frequency displayed is accurate. The engineer set up screen is activated by pressing shift and 9 together from the main menu, when the unit is in the MAC mode. Other features available from the engineer set up menu are specific to MAC operation – individual red, green and blue levels can be altered to obtain correct colour balance (or for 'weird' effects – a hot beach scene doesn't look quite right with a prominent blue tint now, does it?), and even the relative foreground and background levels of the soundtrack, if the broadcaster provides such a facility.

Polarity selection, from the sixth sub-menu, controls the supply voltage being sent up to the LNB via the coax. In the 'Vert/Left' mode, 13V is supplied, with 18V being sent if in the 'Horiz/Right' mode. If a triple-band LNB is being used, then the supply voltage will determine the band selected. In this case, alternative methods of controlling polarisation will need to be sought out. Two variants of a general-purpose magnetic polariser controller are shown in Figures 2 and 3. Just to put things in perspective, though, even the cheapest triple-band LNB costs the same as four Trac upgrades!

And, would you believe, there is still yet another sub-menu for controlling the picture! Sub-menu 7 allows you to adjust the colour saturation and contrast levels whilst in the MAC mode; in the PAL mode you can toggle between two contrast levels, nondescriptly referred to as 'medium' and 'high'. To be quite honest, I didn't notice the difference!

The final sub-menu, 8, operates a switched 12V (max. 25mA) supply, which is available at pin 1 of the 'DATA' socket. This is intended for use with a LNB switch box (e.g., a 60cm dish aimed at Astra, and a squarial or compact dish aimed at the European DBS cluster). However, it could also be used to control a magnetic polariser, if the circuit of Figure 3 is used.

Performance

So what did the converted BSB receiver (remember, total cost £64.00) perform like. In a word, excellently. Despite the fact that the baseband FM demodulator, being based on the elderly Plessey SL1451 PLL device (threshold extension – what's that?) stops working at signals with a carrier-to-noise (C/N) of 9dB or less, bright

Photo 3. MAC onscreen menu of the Trac/Ferguson receiver, shown here superimposed on excellent French music channel MCM Euromusique.

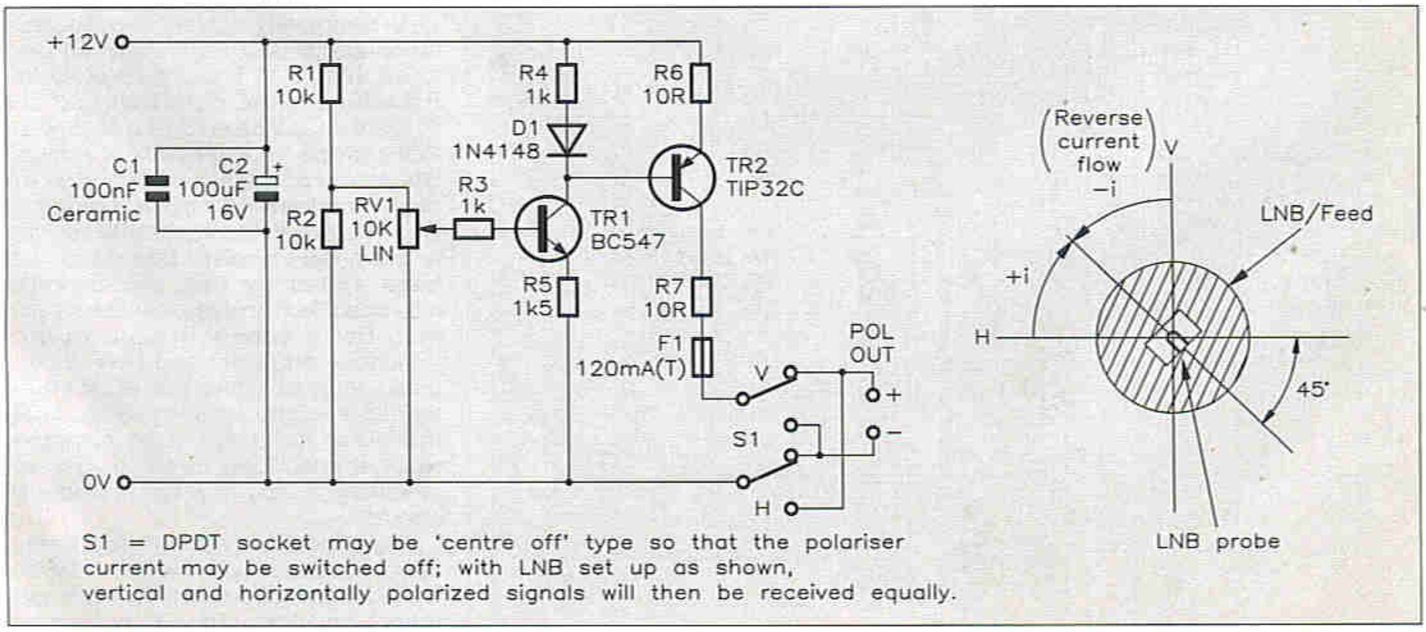


Figure 2. Stand-alone magnetic polariser driver (± current)

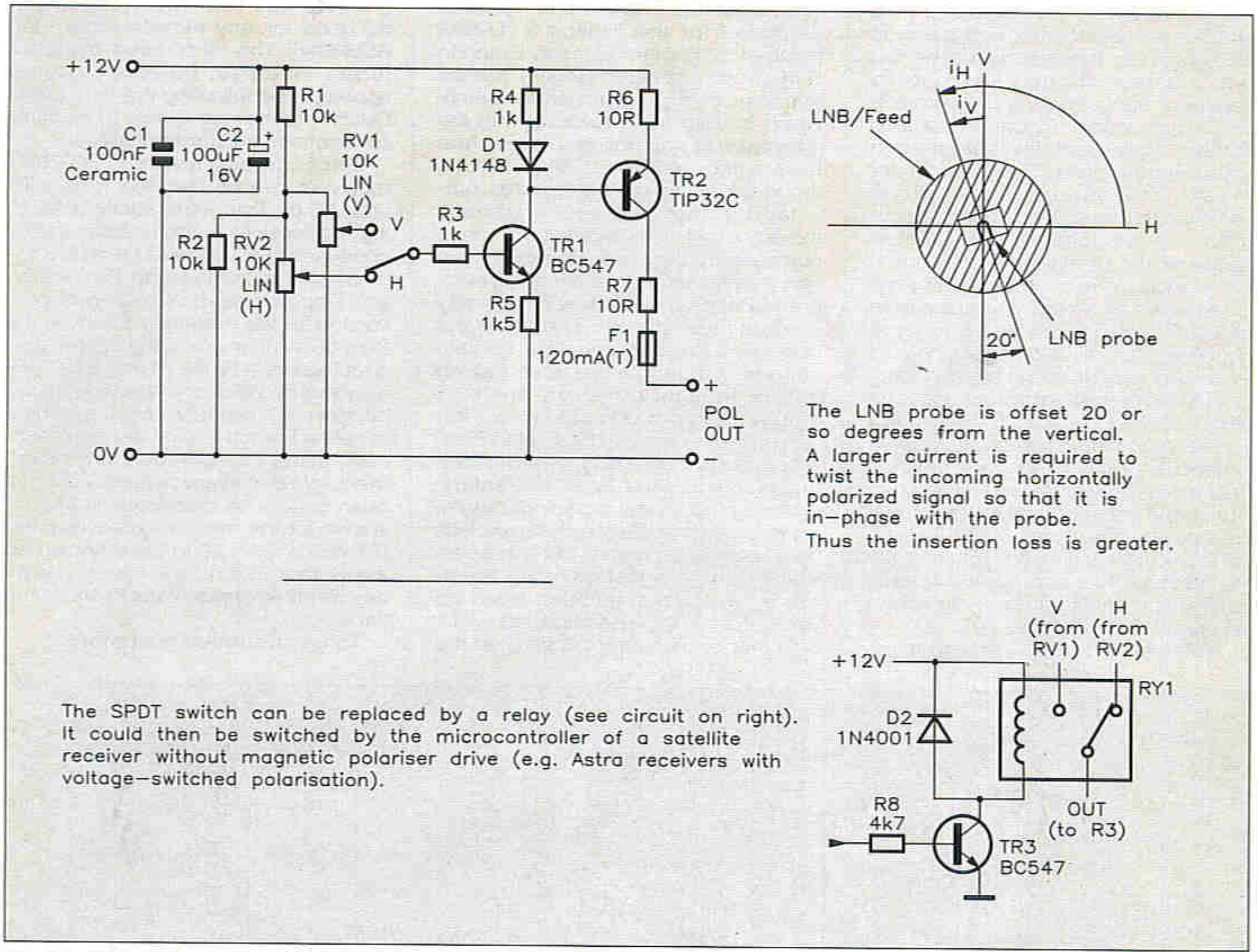


Figure 3. Alternative magnetic polariser driver (+ current only). This could be built into, and controlled by, a host satellite receiver if required. Although results will not be as good as with the circuit of Figure 2 (polariser insertion loss greater with horizontal channels), better control is offered.

and clear PAL pictures on Astra were obtained using an 80cm dish fitted with a Marconi-type LNB, at the review site here in the South of England. Such good results are to be expected; after all, a 60cm dish is specified by Astra for such areas. Some faint 'shimmering' noise was noticed on the picture, however, and I attribute this to the fact that non-screened leads are used to carry the video in close proximity to noisy (e.g., microprocessor) circuitry. The Trac sub-board is, after all, located on top of the ACM module's screening can – as the ACM module is responsible for generating the on-screen graphics, this explains why alphanumeric characters can sometimes be made out amongst the noise. Screened leads apart, improved screening around the ACM module may improve matters. It must be emphasised, though, that a fairly large TV set (25in. screen) was being used in a fairly large room; the noise experienced was faint and is unlikely to mar everyday viewing, particularly on smaller sets in larger rooms. However, on weaker signals (particularly TVN from Intelsat VA-F12), received using a 1·2m offset dish coupled with Swedish Microwave tripleband LNB and Racal feed/polariser, the performance was not so good due to the poor threshold rating, and I suspect that with a 60cm dish honed in on Astra, the picture may well suffer from sparklies under adverse weather conditions. One can assume that demodulator threshold was not of critical importance during the BSB receiver's original design, bearing in mind the tremendous EIRP (61dBW) emanating from Marcopolo over the UK! Out of interest, the polariser control circuit of Figure 2 was used for the TVN test. Note that VA-F12 may have been replaced by a more powerful satellite (Intelsat 513) since this article was written. Consequently the signal strength, and hence quality of reception, may improve in the UK – depending of course on how the transponders have been configured.

The sound quality (the well-known TBA120S quadrature demodulator is used) is also very good, particularly considering that the filter bandwidth is a compromise.

In the MAC mode, the unit really comes into its own. Watch MCM Euromusique, the French pop music channel (mainly Western stuff, but some of the French music, generally undiscovered in the UK, is brilliant!) and you'll know what I mean! Routed as RGB/sync into a decent SCART-equipped TV set, with the sound fed through your Hi-Fi, it really does show MTV up – the sound quality of the NICAM digital stereo is vastly superior to that supplied by MTV's Wegener Panda 1 (typ. 3% distortion). In addition, MCM's source material seems to be of much better picture quality than that used by MTV, as well – despite the fact that most of it is supplied as PAL or SECAM composite video, before being transcoded to D2MAC prior to its uplink to the satellite. Remember that MTV uses PAL throughout, from studio to TV set.

Could it be improved? In my opinion, Trac have done a marvellous job. Perhaps, though, an in-built magnetic polariser interface and stereo sound for the PAL channels could be the next step. The company are rumoured to be working on a compatible Eurocrypt reader at the present.

Perhaps the ultimate use of this unit,

when suitably modified, is that of a MAC transcoder for existing set ups. In this instance, the unit would be fed with a baseband signal from another receiver, rather than directly from a dish. The circuit of Figure 4 was used for this application; this consists of a video amplifier (TR1, TR2) and inverter (TR3). The output of this circuit replaces that from the tuner/demodulator – if capacitor CV06 (located between the tuner/demodulator and RF modulator) is removed, the output of the transcoder interface can be fitted to where the positive side of the capacitor was originally. Note that the video emanating from the tuner/demodulator is inverted, requiring the presence of TR3. A switch could be fitted, as shown in the diagram, so that the tuner/demodulator can be used – perhaps with a BSB dish aimed at 19°W. Apart from MAC transcoding, the transcoder also provides tunable audio – brilliant for receivers without such a feature, or for adding a second audio channel (stereo/second language) to mono receivers. A nice bonus!

As far as the other four receivers go, I have seen a D2MAC-only upgrade designed for the Philips STU-902 receiver by Richard Russell, Brandon Butterworth and Steve Rogers. It takes the form of a program code 'patch' which is used in conjunction with the original Philips operating software. You have to blow your own 27512 EPROM, though. Seeing as the features provided include 99 preset channels, stereo sound, 16:9 widescreen mode compatibility with user panning, radio service selection and audio mute, owners of Philips ex-BSB equipment may find it of great interest. The patch is, I believe, available as public domain software on the Compuserve bulletin board. Philips, however, are very 'uppity' about modification to their equipment, and are trying to stop Zeta, a commercial company, from marketing modified STU-902s on 'safety' grounds. Quite how replacing a memory chip can drastically make a unit less safe is anyone's guess, but it appears that Philips are just covering themselves in case something *does* go wrong. Or are they, perhaps, still awaiting compensation from BSkyB on the grounds that their receivers cannot be used for any service other than BSB/Sky? The other three manufacturers involved, however, do not appear to be following the lead of the Dutch electronics giant, in publicly condemning such modifications.

Deccacolour/Tatung TRX2801 receivers can be modified to receive D2MAC by Trac – this involves sending the receiver to them, along with a cheque for £59.00 (and £8.50 p&p) – presumably a complex job. Out of interest, Trac also sell a D2MAC-only conversion for the Ferguson SRB1, in the form of rewritten operating software on a replacement ROM. At only £19.00, it may well be ideal for those on a limited budget – for example, schools wishing to obtain French and/or German channels, using cheap redundant equipment, for educational purposes. As has been stated, no modifications are yet known for the remaining receiver, the ITT Nokia SAT 3300 (also known as the Salora 5903). If anybody knows any different, please write in and let us know!

To be continued next month.

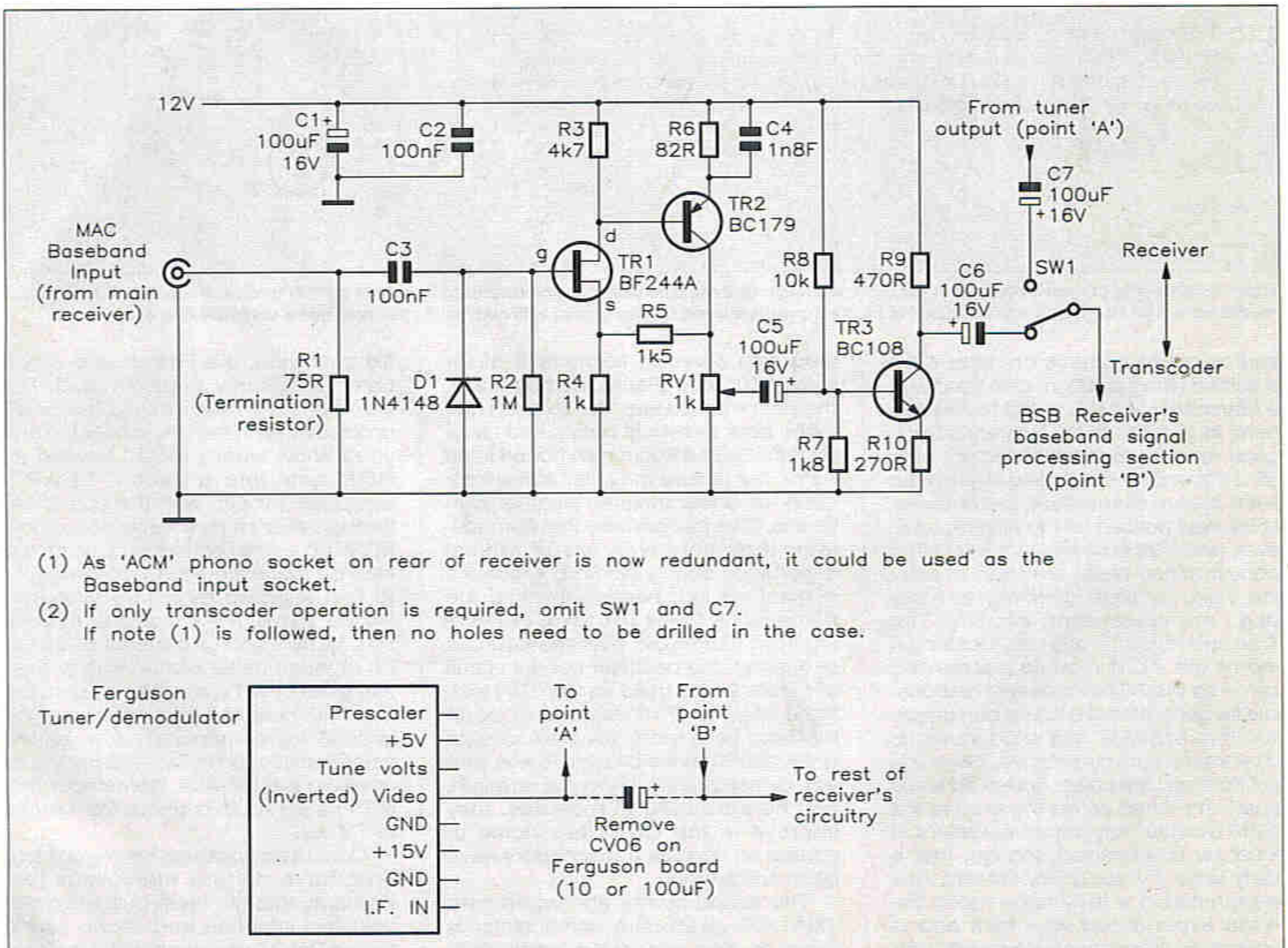


Figure 4. Converting the modified BSB receiver into a transcoder. RV1 controls the video level; this should be adjusted to give the best picture with a conventional (e.g. PAL) transmission; the MAC decoder features an AGC circuit.

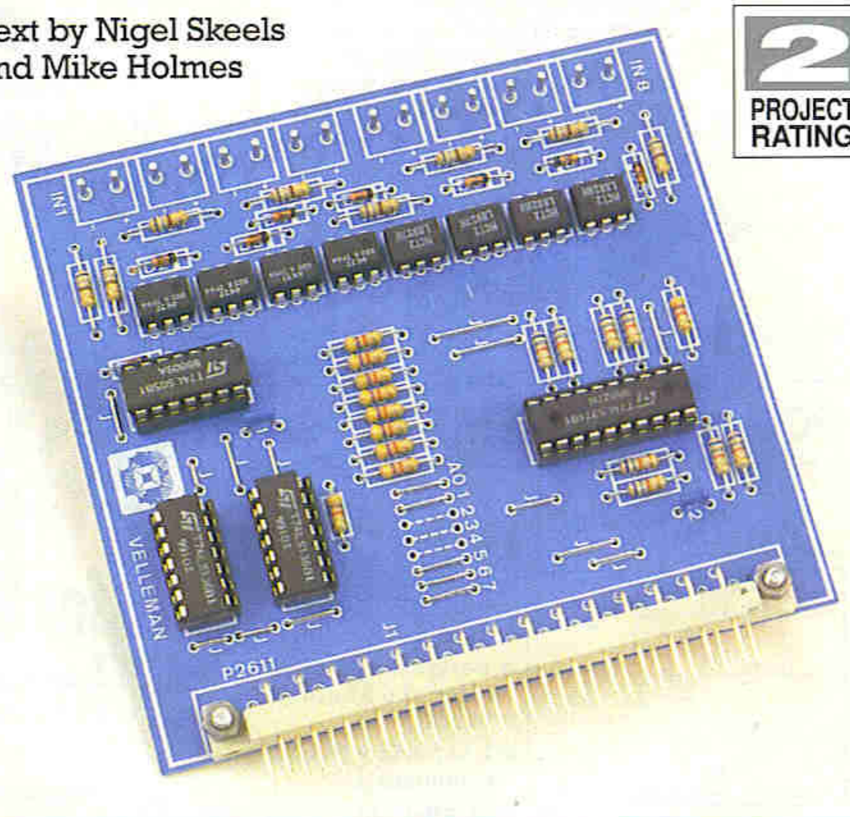
RS232 SERIAL PORT EXPANSION SYSTEM

PART FIVE

Opto-Coupler Input Card

Text by Nigel Skeels and Mike Holmes

2 PROJECT RATING



FEATURES

* Up to 8 Electrically Isolated Inputs
* Several Cards can be Combined
* Programmable from BASIC
* Inputs have High Immunity to Interference
* No Additional Power Supply Required

APPLICATIONS

* Detection of Switch State and Voltage Level
* External Parallel Data Input
* Machine Control and General Purpose Control

The Opto-Coupler Input Card is intended for use with the Intelligent Motherboard for the RS232 Serial Port Extension System, as described in issue 59 of 'Electronics'. The card is initially designed to allow the intelligent motherboard to receive information on the state of switches (ON or OFF). This would be useful for such applications as alarm systems, registration of machines (position and end-of-travel sensors) and the like.

The inputs are electrically isolated from the board and the rest of the extension system circuit by the use of opto-coupler devices. Each opto-coupler comprises an LED and a photo-transistor in one 6-pin IC housing. If the LED emits enough light (not visible from the outside) the photo transistor will conduct. Thus the opto-coupler can be used to isolate the card from an external circuit.

However, despite what the Velleman instructions say, mains voltage SHOULD NOT be applied to the board! The correct maximum voltage input should be 35V.

Circuit Description

As with any of the other plug-in cards for use with the extension system, a connection is made between the Opto-Coupler Input Card and the computer via the Intelligent Motherboard and extension card, which buffers the data signals, generates the necessary auxiliary signals and provides the power supply for the interface plug-in cards.

The circuit of the card, as shown in Figure 1, is essentially quite simple and mainly comprises an octal latch which receives up to 8 bits of input from the bank of opto-coupler ICs. However, since several of these cards can be installed in the motherboard extension card at the same time, each is required to be uniquely addressed to prevent addressing contention between the cards. This is achieved through the fitting of links at the positions 'A0' to 'A7' on the PCB. IC2 and IC3 between them provide eight 2-input, exclusive-OR gates, which together form an 8-bit logic comparator. An 8-bit address bus from the motherboard is presented to A0 to A7 in Figure 1, while wire links may or may not be fitted between R1 to R8 and ground at 'A0' to 'A7' on the legend.

Each gate has an open-collector non-inverting output, and in each case, the exclusive-OR action requires that the two inputs must be at different logic levels to achieve an active high (output off) at the output. If both inputs are at the same level, either '0' or '1', the output is always '0' (output low, or on). Wherever a wire link is fitted at 'A0' to 'A7', there MUST be a logic '1' bit from the address bus corresponding to the same position, A0 to A7; similarly, where a link is omitted, the corresponding address bit must be '0'. Such a condition allows all the gates to release the common output line pulled up by R9, and thus this card is properly selected.

IC4 provides two inverters which also have open-collector outputs. Once the eight exclusive-OR gates, properly addressed, are all off, it only remains for the I/O request control line IORQ and the read enable line RD to both go low to

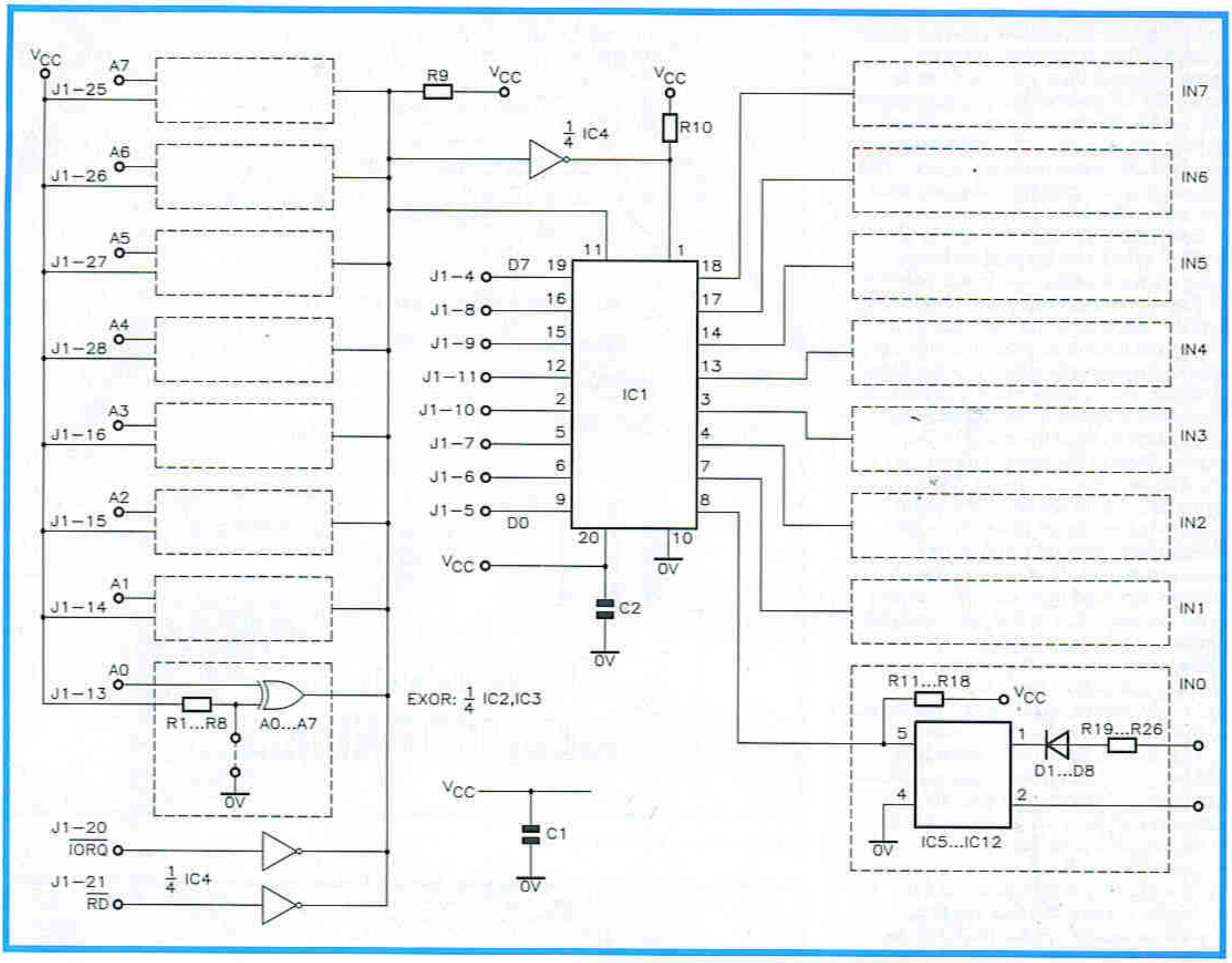


Figure 1. Circuit diagram.

completely release the common output line, producing a positive going pulse at IC1 pin 11.

IC1 is an octal, D-type, positive edge triggered flip-flop, meaning that on each occurrence of the clock pulse input, pin 11, going high, the data bits from all of the available opto-couplers are transferred to the outputs at D0 to D7 and latched by the flip-flops. D0 to D7 is the data bus of the extension card, and since the output buffer of IC1 is a 3-state type, this data appears on the data bus by virtue of pin 1 (Out Enable) going low by courtesy of an inverter from IC4 going low at R10. When the read operation is ended, IC1 returns to the high impedance state, releasing the data bus.

Construction

Construction is quite straightforward and is dealt with in greater detail in the leaflet supplied with the kit. However, the following notes are also worth mentioning.

As a recommended sequence of events, first mount the wire links between the PCB holes marked 'j'. After fitting these the card's address must be chosen; this is according to what other addresses you will be using for other cards, i.e. if this is the first card on the extension board then it can be given the address

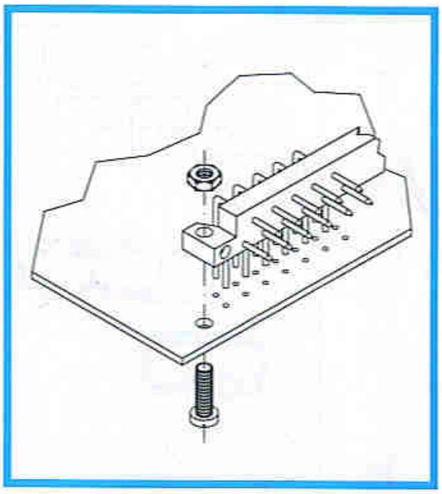


Figure 2. Mounting the card edge connector.

'1', which would be set by installing wire links at 'A0', 'A5', 'A6' and 'A7' (see Part 1 for a table showing the different addresses available including special addresses for the multiplexer and an external real time clock).

However, be warned that once the addressing links are fitted, the pattern may not be easily modified without risk of damage to the PCB. One recommendation therefore is that; if you want the facility of being able to alter the address

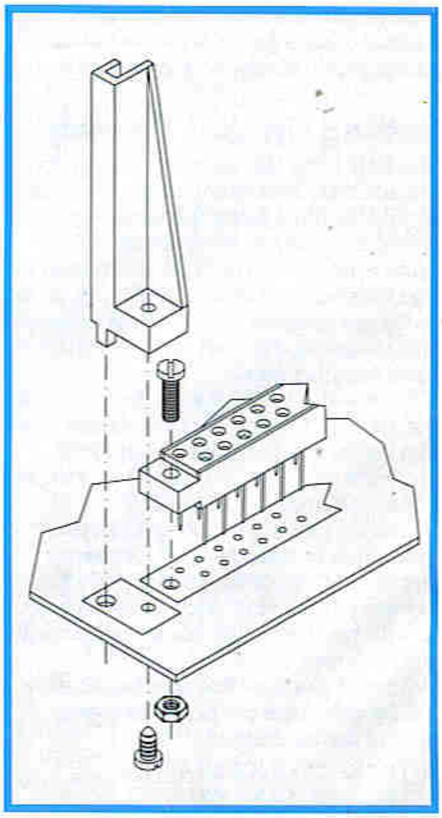


Figure 3. Mounting the motherboard PCB socket and card PCB guides.

settings at any time for greater flexibility and to better mix different plug-in cards, to be inserted at any position in the extension card; then you could use an octal SPST DIL switch (XX27E) at positions 'A0' to 'A7'. The hole spacing in this area is deliberately compatible with the standard DIL layout for this purpose. This will allow you to quickly and easily alter the card's address at any time.

Insert the PCB pins at positions 'IN 1' to 'IN 8', which can be pushed home using a hot soldering iron, to aid insertion.

Next fit the resistors; it is a good idea to insert these all in the same direction as regards their colour coding, although this has no electrical effect it helps value checking later if there are any problems. These are followed by the IC sockets, taking care to align the notch to the legend. Next fit the capacitors C1 and C2. Although the ICs are not CMOS types and should not be at risk from static damage, do not insert them into their sockets yet until all other work has been completed. However, you can fit the four provided opto-coupler devices in the positions IC5 to IC8, and again the notches should match the legend. No sockets are provided for these as they are of non-standard 6-pin DIL pattern. They only contain an LED and a transistor, so therefore can be soldered safely.

Now fit the right-angled male PCB connector to the card by bolting in place using two M3 screws and nuts BEFORE soldering, as shown in Figure 2. Similarly fit the female connector to the extension motherboard, and solder. Then attach the upright PCB edge guides to the motherboard with the self- tapping screws as shown in Figure 3. All these latter parts are supplied with this kit. Finally ICs 1 to 4 can be inserted into their respective sockets, again ensuring correct orientation with respect to the package markings and the PCB legend.

Setting Up and Testing

The only thing that requires setting up is the address, as mentioned earlier. This should be done using the table supplied with the Intelligent Motherboard. This table shows which jumper wires need to be included, and which are left out, to set a desired address. This address is chosen by the user and it must be different for each separate card.

To test the card a simple program can be used. To begin with each usable input can be temporarily connected to the motherboard +V2 (9V) supply in turn as illustrated in Figure 4 for 'IN 1'.

Before running the program it is a good idea to clear the memory using the "CLRM" function, followed when prompted by "YES". Now the memory should be clear, a list can be performed to check this.

Please note that line numbers below are for reference purposes only and should not be entered.

```
001 EPEX XX XX XX
002 EPTX XX XX XX
003 RDBI 3 X XX XX XX
```

This program will print to the screen

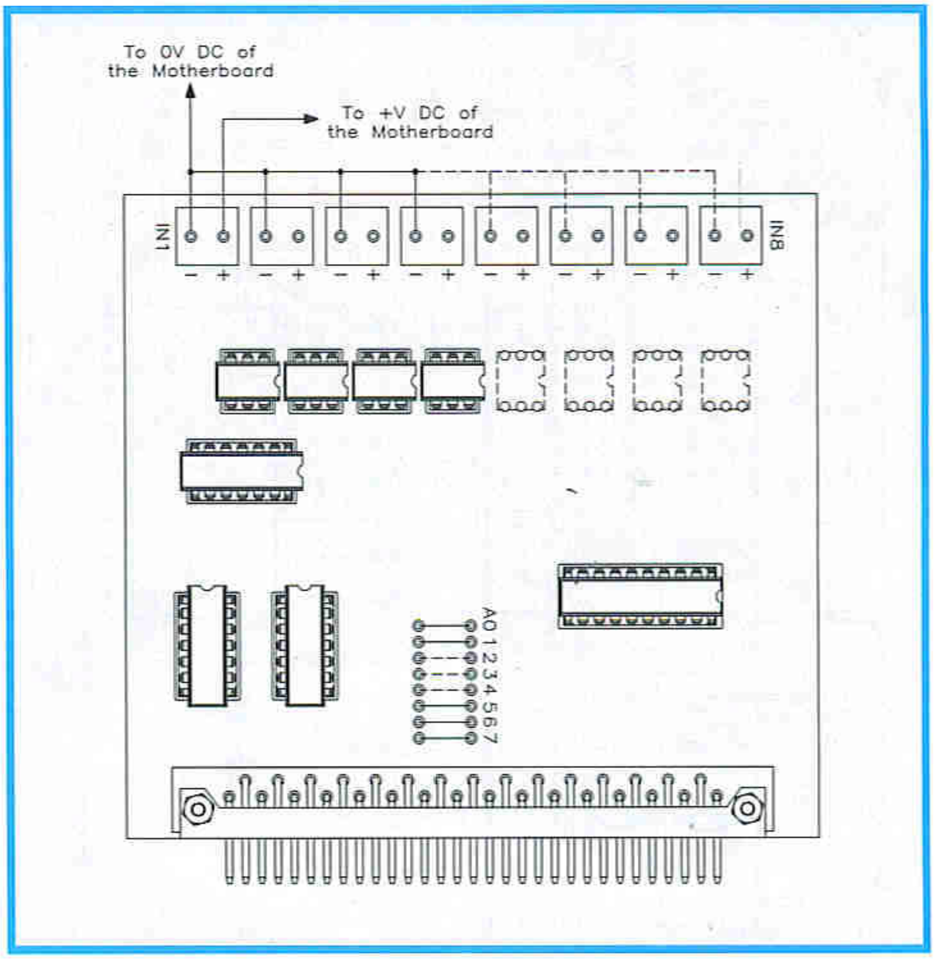


Figure 4. Connection for testing.

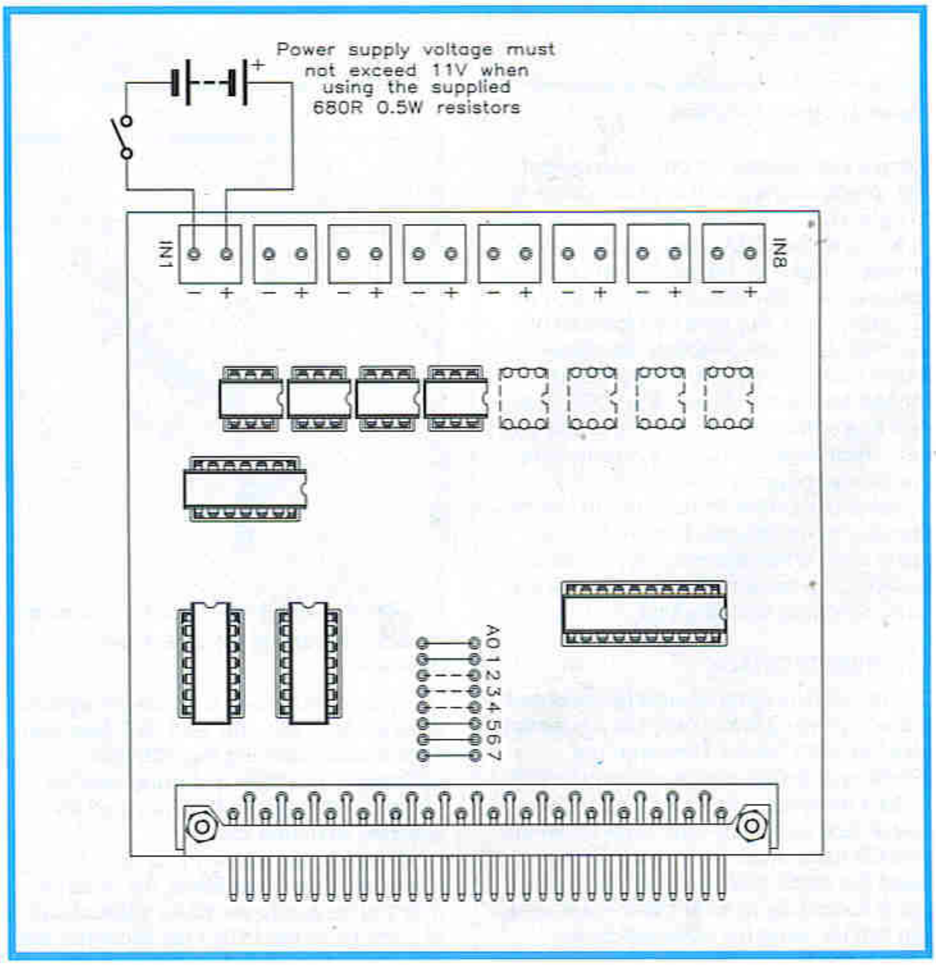
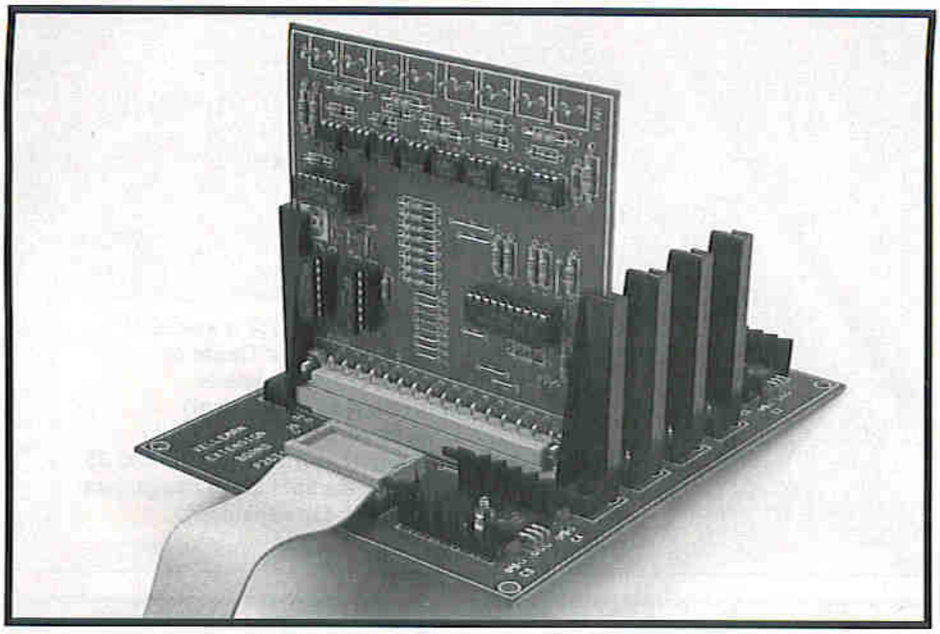


Figure 5. Connection of input.



The Opto-Coupler Input Card installed in the expansion unit.

the state of the inputs to the board (eight will be shown but only those inputs with opto-couplers fitted will operate). If nothing is connected then the output to the motherboard will be high, if something is connected then the output will be low. This can be checked by connecting the ground of all the inputs to the ground of the motherboard. The program should now be run by typing "RUNP", again all inputs should be high, the negative of each input should be connected to the ground of the motherboard. Now connect a test lead to the positive supply of the motherboard and attach it in turn to each one of the positive inputs. By doing this the display should show a low "L" corresponding to the appropriate bit or input.

An example is:

RDB 3 X HHHHHHHL

where 'IN 1' is tied to +9V as in Figure 4. Note that the result is inverted in that a positive input results in a zero bit in the data, and no or zero input produces a high bit.

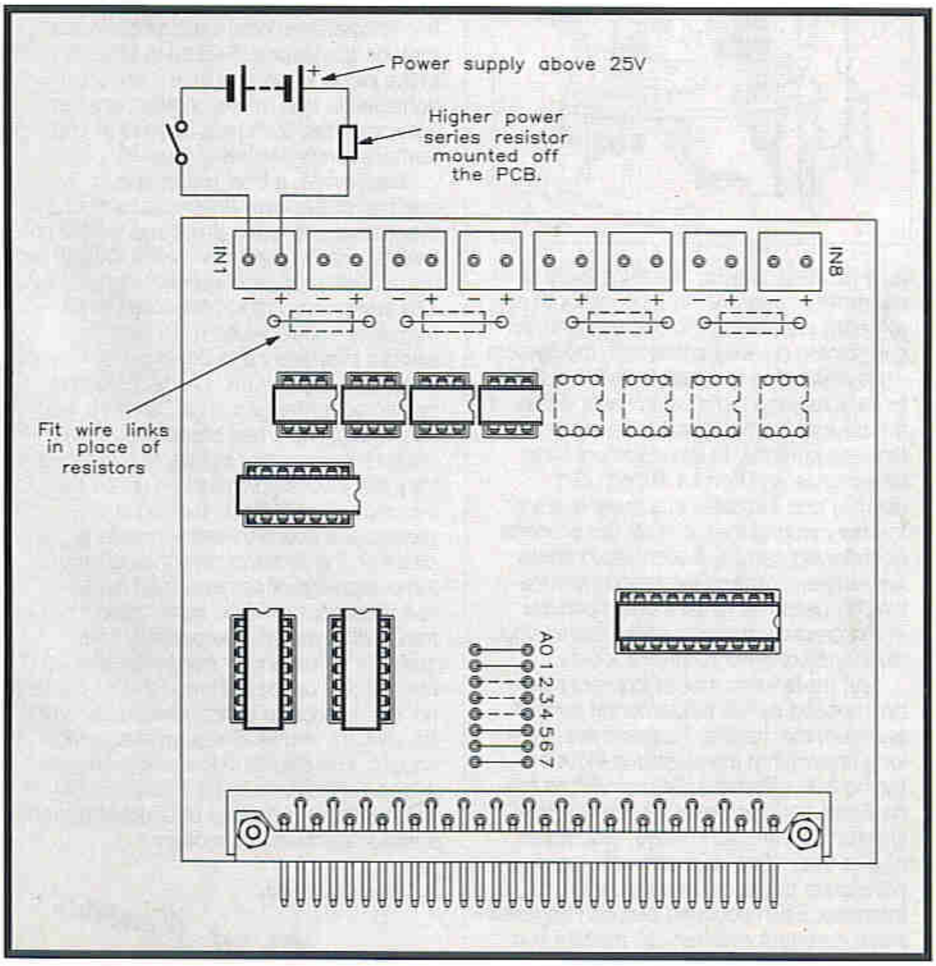


Figure 6. Mounting larger resistors off the board.

The Open Collector Card in Use

The card is normally plugged into the motherboard using the supplied connecting sockets. Only four opto-coupler ICs are provided, but more can easily be added, as Order Code WL35Q.

DC Voltage Inputs

An important consideration before using the Opto-Coupler Input Card is selecting suitable series resistors to protect the opto-coupler LEDs from damage. These resistors are numbered R19 to R26. The supplied 680Ω 0·5W resistors are suitable for voltages up to 11V, see Figure 5.
If inputs greater than this, but less than 25V, are needed then a greater value 0·5W resistor should be used, replacing R19 to R26 as appropriate. For anything above 25V a wire link should be fitted in place of the series resistor on the board, and a larger wattage resistor should be mounted off the board, see Figure 6.

To calculate the correct value resistor (R) the input voltage should be added to the following calculation:

$$R = \frac{V_{in} - 1{\cdot}5}{0{\cdot}015}$$

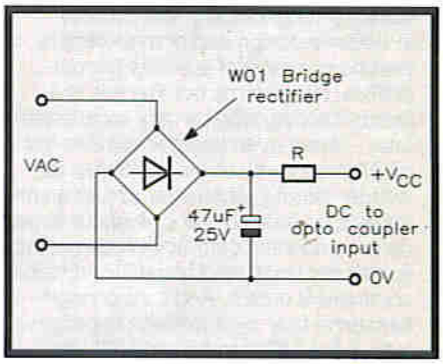


Figure 7. AC voltage input.

AC Voltage Inputs

If an AC voltage input is required then it is necessary to convert it into DC. This can be done by using the circuit of Figure 7, which uses a diode bridge to fully rectify the current. A W01 bridge rectifier would be ideal for this purpose (Order Code QL38R). It is necessary to use the following calculation to ascertain the correct resistor value R in this circuit. Where V AC is the AC voltage to be input, then:

$$R = \frac{(V\,AC \times 1{\cdot}41) - 4}{0{\cdot}015}$$

Once the resistor value is calculated then the correct wattage of the resistor needs to be worked out, this can be done with the following calculation:

$$P = ((V\,AC \times 1{\cdot}41) - 4) \times 0{\cdot}02$$

OPTO-COUPLER INPUT CARD PARTS LIST

RESISTORS: All 5% Metal Film			
R1-10	4k7	10	
R11-18	6k8	8	
R19-26	680Ω	8	
CAPACITORS			
C1,2	100nF Epoxy	2	
SEMICONDUCTORS			
D1-8	Diode 1N4148 (1N914)	8	
IC1	74LS374	1	
IC2,3	74LS136	2	
IC4	74LS05	1	
IC5-8	Opto-Isolator	4	
MISCELLANEOUS			
	DIL Socket 14-pin	3	
	DIL Socket 20-pin	1	
	PCB Pins	16	
	PCB Plug 31-Way	1	
	PCB Socket 31-Way	1	
	PCB Guides	2	
	Screw M3 x 4mm	4	
	Nut M3	4	
	Self-Tapping Screw	2	
	PCB	1	
	Assembly Instructions	1	
	Program Listing Example Leaflet	1	
OPTIONAL (Not in Kit)			
	Opto-Isolator	4	(WL35Q)

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 VE94C (Opto-Coupler Card Kit) Price £26.95
Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

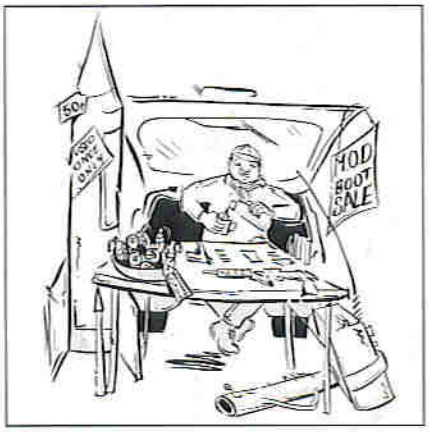
Stray Signals

by Point Contact

In his scribblings in the April 1992 issue, PC commented on the difficulties presumably encountered by firms, in the defence electronics industry, wishing to diversify into commercial activities. The problem being the requirement for a uniform level of MOD approved QA activity throughout any site involved in defence design and/or manufacture, making commercial activities uncompetitive. Now it turns out that this is a misconception, albeit a very widespread one – I have even heard it from the lips of QA men themselves. PC began to wonder about it, soon after writing on the subject, on hearing that one of our largest defence oriented companies had secured some very large (and hopefully profitable) commercial orders. And sure enough, sometime later a reader with experience in both the MOD and private industry wrote in stating that it *is* permissible to run two entirely separate quality standards on the same site, indeed it is apparently possible to manufacture civil and military equipment even in the same building – provided precautions are taken to prevent any possibility of military standard and commercial components being mixed or interchanged; so now you know.

Thank you C.L. of Essex for setting the record straight.

To forestall any possible complaints that PC witters on about any and every subject under the sun *except* electronics (I'm glad to say there have been no such complaints yet), both my remaining items are distinctly of an electronic nature, culled from American journals. Firstly, an article in "Spectrum", the Journal of the IEEE, entitled 'Approaching the Quantum Limit', caught my eye. We are used to a doubling or quadrupling, every few years, of the number of active devices that can be packed within a given area of silicon,



as a result of 'scaling'. Feature sizes of the order of one micron (one millionth of a metre) are now commonplace and, as sub-micron devices proliferate, the system voltage is being reduced from 5V to 3·3V or less, to keep the electric fields within the devices to manageable levels. Devices currently in development have dimensions as short as 100nm (0·1 micron) and it is clear that there is a limit to how much further, if at all, the process of shrinking can go. According to some researchers, 100nm may represent the limit for useful devices, if only because of the practical problem of the increasing resistance of on-chip interconnects.

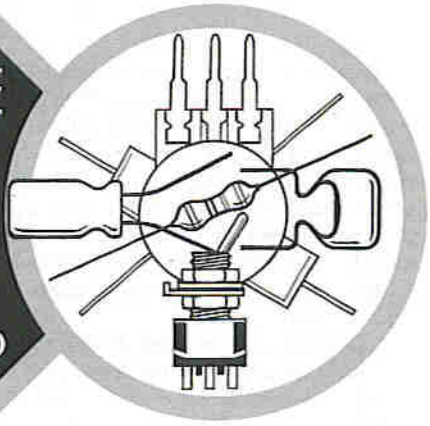
But more fundamental barriers may be imposed by the fundamental laws of quantum mechanics. Researchers have long known that the electrons induced by the field effect in MOS transistors are confined, by a potential barrier which is created by the gate voltage, to a depth of less than 10nm in the direction perpendicular to the oxide-semiconductor interface. Each confined electron behaves like a quantum mechanical 'particle in a box', exhibiting an energy higher than it would if free to roam in the crystal. The length of the 'box' will be a multiple of the electron's associated de Broglie waves, which define the amplitude probability of the electron being found. So far this has not been a device design problem, indeed the greater mobility and lower effective electron mass have been beneficial. Once feature sizes reach 5nm though, quantum effects will assume a major importance, even at room temperature, restricting the further scaling down of device dimensions. But if the quantum effects, whereby individual electrons behave both as particles and waves, can be harnessed, then new classes of device may be developed. Switching speeds in the picosecond region are already achievable, and mesoscopic structures with predicted switching speeds of 150 femtoseconds are being studied.

Meanwhile, a brief paragraph in another well-known American technical magazine, outlines a proposed method of making many more channels available for broadcasting by the re-use of frequencies. The technology, called Impulse Radio, transmits and receives radio signals without interference to other transmissions in the radio spectrum. The technique is optimised for ranges up to 30 miles, and uses a specific timed sequence of very short (1·5ns or less) pulses to transmit a very low level signal over an ultra wide frequency band. Each sequence produces a specific communications channel, the receiver recognising only the pulse sequence generated by a specific Impulse Radio transmitter. The transmitted power is apparently less than 1% of the power transmitted by a household cordless phone, and so causes no interference to other users in the same bandwidth, and FCC approval is being sought. The details in the article are exceedingly scant, but it sounds to PC like another application of direct-sequence spread-spectrum technology.

Yours sincerely

Point Contact

PASSIVE ELECTRICAL COMPONENT GUIDE
PART TWO



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

This series of articles 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 Capacitors

Symbols

Internationally, the most widely used set of basic capacitor symbols is that shown in Figure 19, in which the capacitor's plates are represented by a pair of parallel lines, but in North America a different set of symbols (in which one plate is shown curved) are used, as shown in Figure 20.

Formulae

In its simplest form, a capacitor consists of a pair of parallel conductive plates, separated by an insulating layer of dielectric material. The device's capacitance value (C) is proportional to the area of the plates (A), and to the relative dielectric constant (K), of the insulator, but is inversely proportional to the thickness (t) of the dielectric, as shown by the formulae of Figure 21.

Figures 22 and 24 show the basic formulae used to calculate the effective value of several capacitors wired in series or parallel.

The reactance (X) of a capacitance is inversely proportional to the frequency (f) and to the capacitance value, and Figure 23 shows the formula that relates these parameters to one another. If precise parameter values are needed from these formulae, they can easily be found with the help of a calculator. Alternatively, a whole range of values can be rapidly found – with a precision better than 20% – with the aid of the nomograph of Figure 25 and a straight edge or ruler. To use this chart in this way, simply lay a straight edge so that it cuts two of the C, f, or X columns at known reference points, then read off the remaining unknown parameter value at the point where the straight edge cuts the third column.

Note that the chart of Figure 25 can also be used to established the approximate resonance frequency (f) of an L-C network by using the straight edge to connect the L and C columns at the appropriate 'value' points, and then reading off the 'f' value at the point where the edge crosses the 'f' column.

Basic Construction

The simplest type of capacitor consists of a pair of electrically conductive plates in either solid or metallised-film, separated by some type of dielectric material, as shown in Figure 26. If the plates are rectangular the capacitor is known as a 'plate' type, as in (a), and if they are circular then it is known as a 'disc' type, as in (b). In either case the actual capacitance value is proportional to the area of the plates and to the 'permittivity' (the dielectric constant) of the dielectric, but is inversely proportional to the dielectric thickness, as shown by the formulae of Figure 21. A dozen or so different basic types of dielectric are in common use, and the approximate permittivity values and electrical strengths of these are listed in Figure 27.

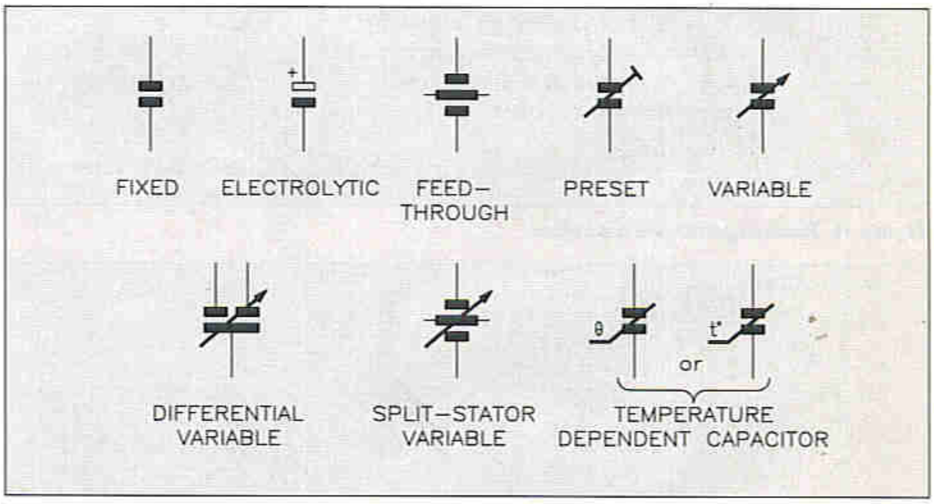


Figure 19. Widely-accepted symbols for various types of capacitor.

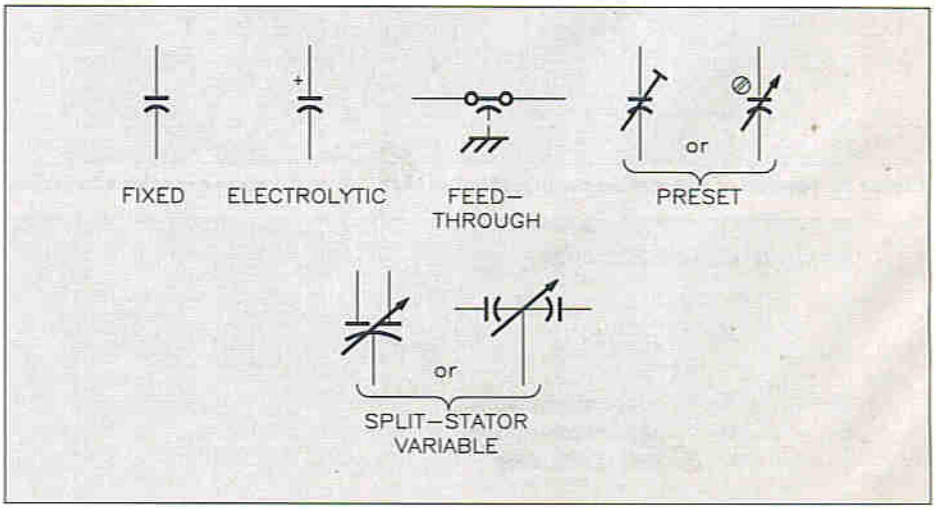


Figure 20. North-American symbols for various types of capacitor.

To give the reader a 'feel' of the practical meaning of the above data, take the example of a disc or plate capacitor having a plate area of 1 square centimetre. If this capacitor uses an air dielectric with a spacing of 0·5mm, it will have a capacitance of 17·7pF and a breakdown value of 262V. Alternatively, a polyester dielectric may be used; this material is strong but flexible and may be very thin; if it has a thickness of only 1 mil (0·04mm or 0·001in.), which is equal to about half the thickness of a human hair, the capacitance value will be 730pF and the breakdown value will be 250V. Again, a ceramic dielectric may be used, but this material is rigid and brittle and thus needs to be relatively thick. If a 1mm, high-K ceramic dielectric with a permittivity of 10,000 is used, the capacitance will be 88·5nF and the breakdown value 5,000V, and so on.

In practice, simple disc and plate capacitors are readily available with values ranging from below 2·2pF to about 100nF. Larger values can be obtained by 'stacking' layers of plates and dielectrics, as shown in Figure 26(c). This 'multi-layer' or 'monolithic' technique enables maximum values of about 1µF to be created, using an eleven-plate construction.

Relatively large values of capacitance (up to about 10µF) can be created by using lengths of flexible foil instead of plates, and rolling these and two layers of dielectric into the form of a tight swiss-roll, as typified by the 'layered foil' type of construction shown in Figure 26(d). A modern variation of this concept uses the 'metallised film' technique shown in Figure 26(e), in which the foil is replaced by a metallic film that is deposited directly onto one side of the dielectric; a non-metallised margin is left at one edge of each dielectric, to facilitate the making of external connections during the manufacturing stage.

Irrespective of the basic type of construction used, the completed fixed-value capacitor is always given some form of protection against environmental contamination, either by coating it with lacquer, dipping it in resin, or encapsulating it in some type of plastic or metal jacket, etc.

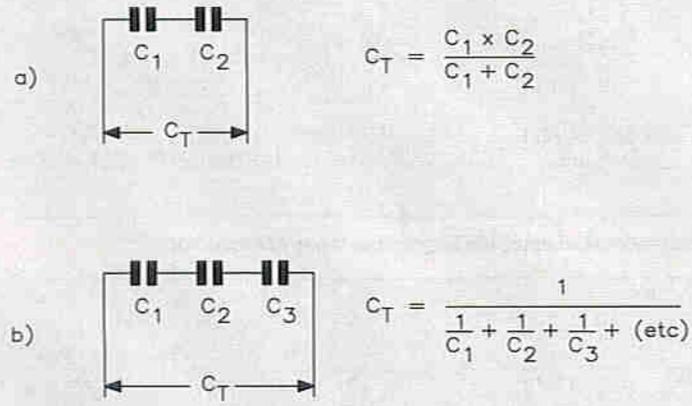
The capacitance value of a parallel-plate capacitor is given by:

$$C = \frac{0{\cdot}0885\,K.A.}{t}\ (n-1)$$

where
- C = capacitance in picofarads
- K = dielectric constant (air = 1.0)
- A = area of plates, in square cm
- t = thickness of dielectric, in cm
- n = number of plates

NOTE: $C = \frac{0{\cdot}224\,K.A.}{t}\ (n-1)$ if A is in square inches and t is in inches

Figure 21. Basic capacitance formulae.



a) $$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

b) $$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{(etc)}}$$

Figure 22. Method of calculating combined value of (a) two or (b) more capacitors in series.

Reactance (X_C) of a capacitor:

$$X_C = \frac{1}{2\pi f.C} \qquad f = \frac{1}{2\pi C.X_C} \qquad C = \frac{1}{2\pi\,f.\,X_C}$$

where
- X_C = reactance in ohms
- C = capacitance in Farads
- f = frequency in Hz

Figure 23. Capacitive reactance formulae.

$$C_T = C_1 + C_2 + C_3 + \text{(etc)}$$

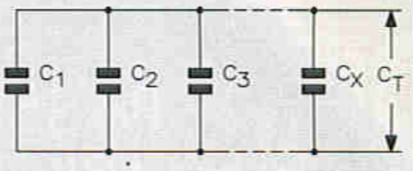


Figure 24. Method of calculating value of capacitors in parallel.

Electrolytic Capacitors

Very large values of capacitance (up to about 100,000µF) can be created by using the so-called 'electrolytic' technique. The construction of this type of capacitor is vaguely similar to that of the layered foil type shown in Figure 26(d), but with some very important differences. In 'aluminium oxide' electrolytic capacitors the two foils are made from high-purity aluminium. One of these (the cathode or 'negative' foil) has its surface covered with a thin insulating film of aluminium oxide, and this film, which may typically be only 0·01 mil thick, forms the dielectric. In the capacitor the two foils are separated by a layer of tissue that is soaked with an electrolyte which, being an excellent conductor, operates in conjunction with the plain foil to form the true cathode of the final capacitor. Note that, thanks to this conductive electrolyte, the effective thickness of the capacitor's dielectric is equal to the thickness of the aluminium oxide film on the anode foil, and is independent of the actual thickness of the electrolytic layer.

Because of the thinness of this oxide film, electrolytic capacitors can have very large capacitance values. An aluminium oxide type with a foil size of 2cm x 100cm and an oxide thickness of 0·01mil will, for example, provide a capacitance of about 35µF. A tantalum oxide capacitor using a similar form of construction and the same dimensions would provide a capacitance of about 120µF. These values can be increased by a factor as high as four by chemically etching the aluminium foil prior to the forming process, thus greatly increasing the foil's effective surface area.

The film of oxide on the anode foil is formed during the manufacturing stage by using the foil as one of the electrodes in an electrolysis bath. When a DC voltage is first applied to this electrode it conducts readily, and as it passes current

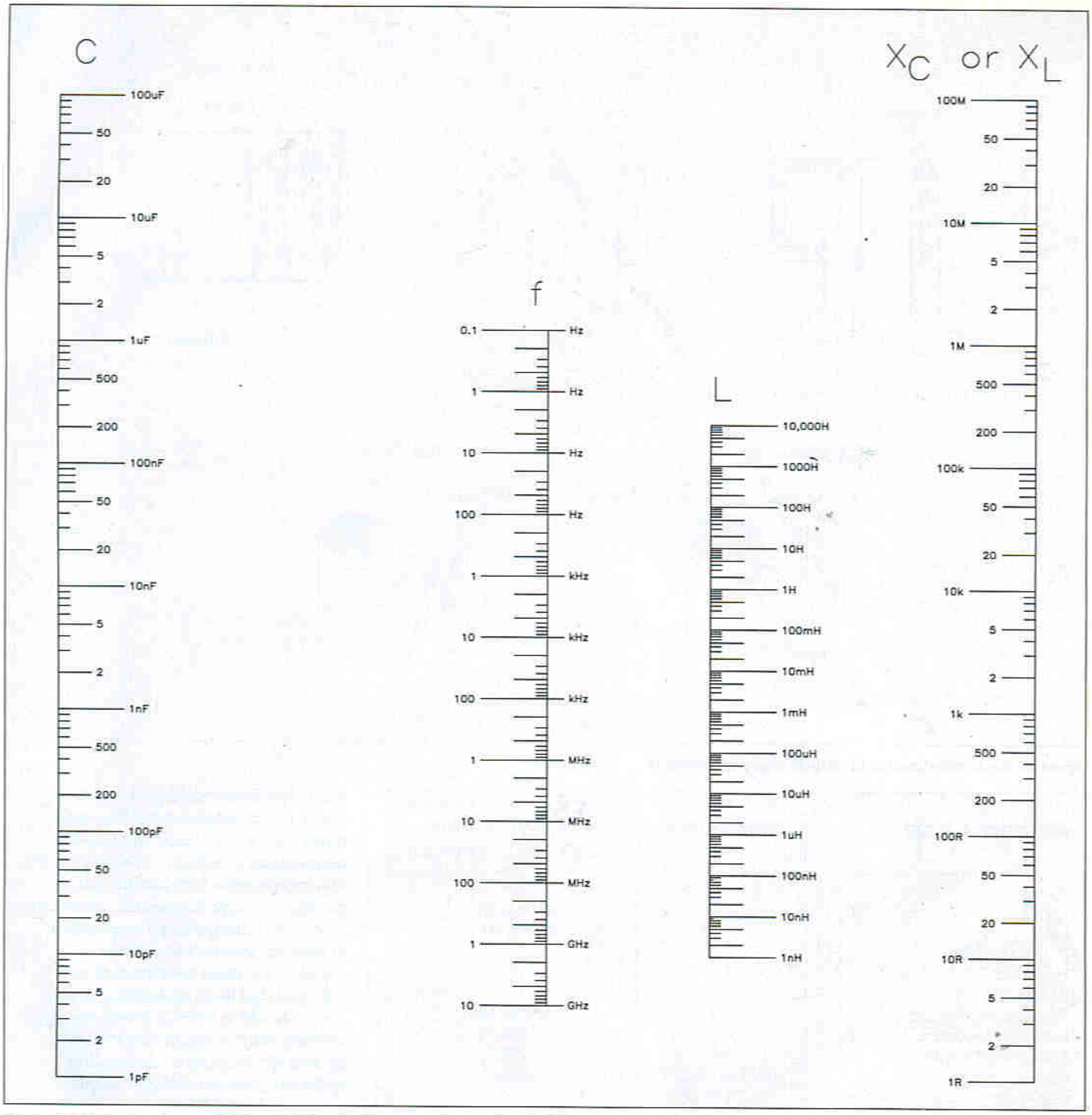


Figure 25. This chart can, with the aid of a straight edge, be used to find the reactance of a capacitor or inductor, or the resonant frequency of an L-C network. See text for explanations.

the film of highly resistive oxide begins to form on its surface. As the film builds up, its resistance progressively increases, thus reducing the current and the rate of deposition at a proportionate rate, until the film reaches 'adequate' thickness. Consequently, this 'forming' process results in a capacitor that inherently passes a significant leakage current when in use. Typically, in aluminium oxide electrolytic types, this leakage value is roughly equal to:

$I_L = 0{\cdot}006CV\ \mu A$

where C is in μF and V is in volts. Tantalum oxide electrolytic capacitors have far lower leakage currents than aluminium oxide types.

Practical Capacitors

All practical, fixed-value capacitors have the electrical equivalent circuit of Figure 28(a), in which C represents pure capacitance, R_S represents dielectric losses, R_P represents parallel leakage resistance, L_S the inductance of electrode foils, etc., and L_L the self-inductance of the component's connecting leads (about 8nH/cm or 20nH/inch). At high frequencies this circuit can be simplified into the form shown in (b), which shows that all capacitors in fact act as series resonators; the resonant frequency (f_R) of a high-value electrolytic may be as low as a few kHz, while that of a small ceramic capacitor may reach hundreds of MHz (Figure 29 shows typical f_R values of a range of ceramic capacitors with specific 'total' lengths of connecting lead). A capacitor's impedance is capacitive below f_R, resistive at f_R, and inductive above f_R. Note that the impedance of an electrolytic capacitor may be quite large at high frequencies, preventing it from removing spikes or other high-frequency components from supply lines, etc. (This explains why you may often see a small value ceramic type in parallel with a supply smoothing capacitor in circuit diagrams.)

At low frequencies, a capacitor's self-inductance has little practical effect, but R_S and R_P cause a finite shift in the capacitor's voltage/current phase relationship. This same phase shift can, at any given fixed frequency, be emulated by wiring a single 'lumped' resistor in series with a pure capacitor, as shown in the equivalent circuit of Figure 28(c). The ratio between R_S and X (the pure reactance) is shown as the 'D' or 'loss factor' of a capacitor, and indicates the component's purity factor, i.e. the lower the 'D' value, the better the purity.

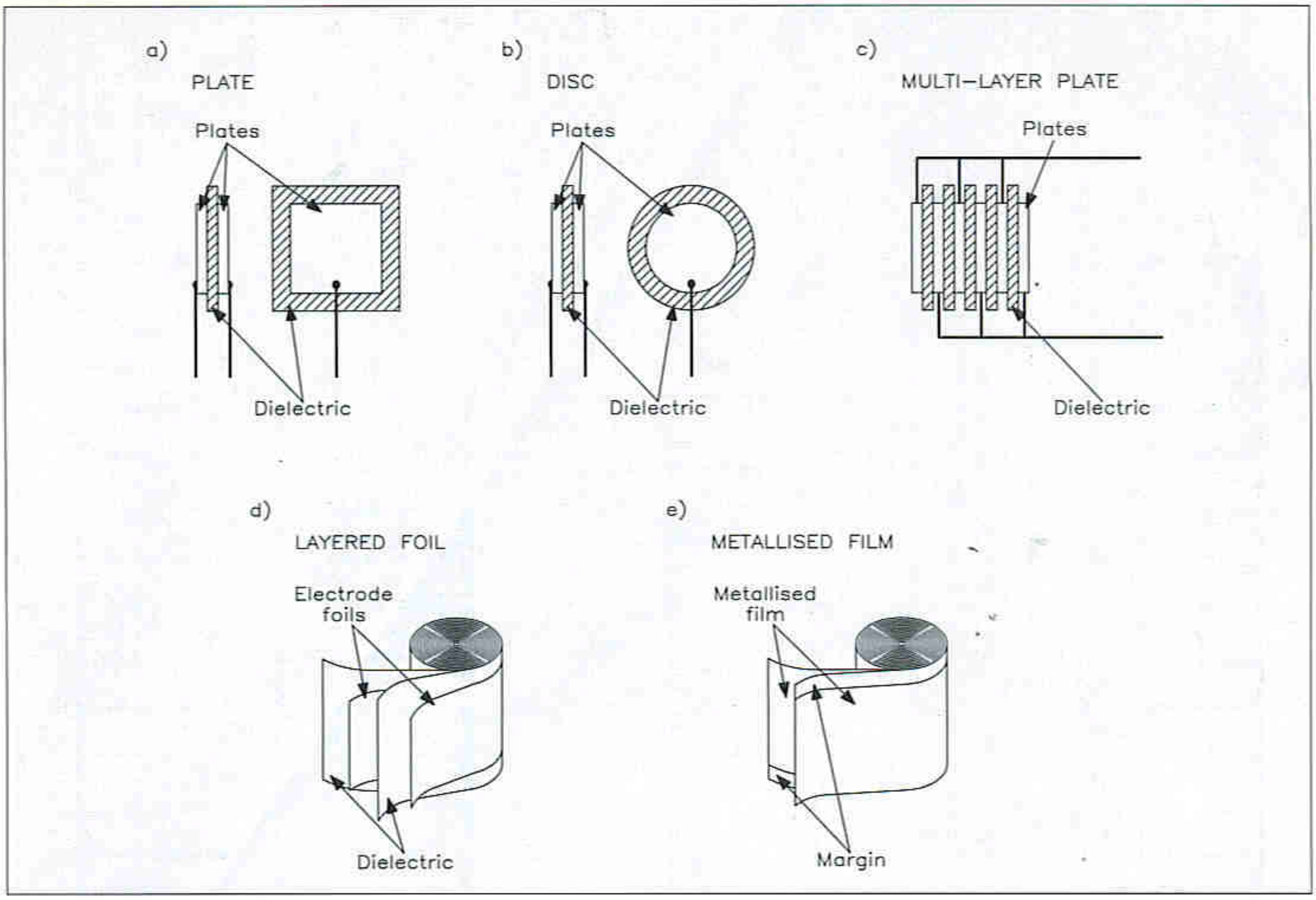


Figure 26. Basic construction of various types of capacitor.

DIELECTRIC TYPE	PERMITTIVITY	ELECTRICAL STRENGTH IN VOLTS PER MIL (1 mil = 0·001in. = 0·04mm)
Air	1	21
Paper	2·5	200 to 1200
Mica	3 to 8	600 to 5000
Polycarbonate	2·8	200
Polyester	3·3	250
Polypropylene	2·2	600
Polystyrene	2·4	400 to 700
Low-Loss Ceramic	7	300
Medium-K Ceramic	90	250
High-K Ceramic	1000 to 40,000	200
Aluminium Oxide Electrolytic	7 to 9	–
Tantalum Oxide Electrolytic	27	–

Figure 27. Dielectric constants and breakdown voltages.

Stability

The actual value of a capacitor tends to vary with temperature, with the passage of time, and with frequency and applied voltage, etc. The magnitude of these changes varies with the capacitor type; Figure 30 lists the most important typical parameter values of various types of readily-available capacitor. The following notes explain the most important features of the various capacitor types.

Silvered Mica

These capacitors have excellent stability and a low temperature coefficient, and are widely used in precision RF 'tuning' applications.

Ceramic Types

These low-cost capacitors offer relatively large values of capacitance in a very small, low-inductance package. Their major disadvantage is that they sometimes have a very large and non-linear temperature coefficient, which is usually marked (in code form) on the device package; in high-K types the coefficient is often so massive that it is specified in terms of percentage change in capacitance value over the device's full spread of thermal working limits (typically –55 to +85°C). These capacitors are best used in applications such as RF and HF coupling or decoupling, and spike suppression in digital circuits, etc., in which large variations of the component value is of little importance.

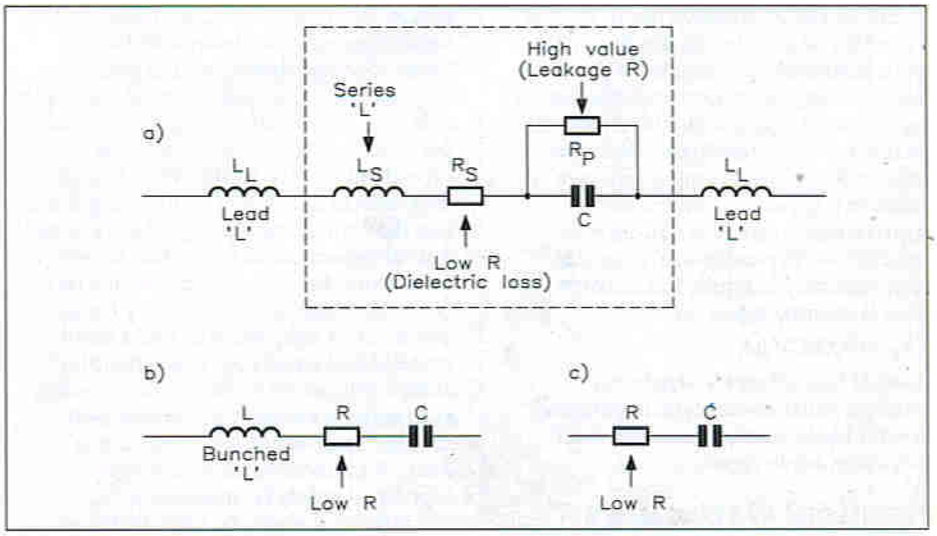


Figure 28. The full equivalent circuit (a) of a capacitor can be simplified to (b) at high frequencies, or to (c) at low-value fixed frequencies.

CAPACITOR VALUE	SELF-RESONANT FREQUENCY (MHz)	
	1cm Lead Length	1 inch Lead Length
10n	13	11
3n3	25	20
1n0	46	38
330pF	80	62
100pF	145	120
33pF	240	205
10pF	440	380

Figure 29. Typical self-resonant frequency of ceramic (disc or plate) capacitors.

'Poly' Types

Of the four main 'poly' types of capacitor, the polystyrene gives the best performance in terms of overall precision and stability. Each of the remaining three types (polyester, polycarbonate, and polypropylene) gives a roughly similar performance, and is suitable for use in general-purpose applications. 'Poly' capacitors usually use a layered 'swiss-roll' form of construction. Of these, metallised film types are more compact than layered film-foil types, but have poorer tolerances and pulse ratings than film-foil types. Metallised polyester types (sometimes known as 'greencaps') are particularly popular in some circles.

Electrolytic Types

These capacitors, which are usually polarised and must be installed the correct way round, offer high values of capacitance in a relatively compact package. Aluminium foil types have poor tolerances and stability, and are best used in low-precision applications such as smoothing, filtering, and energy storage in PSUs, etc., and for coupling and decoupling in audio circuits and such like. Tantalum types offer good tolerance, excellent stability, low leakage, low inductance, and a very small physical size, and should be used in all applications where these features are a positive advantage.

Value Notation for Capacitance

The basic unit of capacitance measurement is the Farad, but this is far too large a unit for general use in electronics, so the microfarad (µF) is used as the basic practical unit of measurement and equals 0·000,001 Farad. This rather curious state of affairs arises from the fact that the Farad was originally derived from the basic formula that a charge of 1 volt per second across 1 Farad produces a current of 1 ampere, which seemed to be a reasonable derivation for a unit of

CAPACITOR TYPE	RANGE	TOLERANCE	TEMPERATURE COEFFICIENT	f_R	D	LEAKAGE RESISTANCE	STABILITY
Silver Mica	2·2pF – 10nF	±1%	+35ppm/°C	1 – 10MHz	0·002	Very High	Excellent
Ceramic, Low-K	2·2pF – 330pF	±2%	Variable*	5 – 100MHz	0·001	High	Good
Ceramic, Medium-K	390pF – 4·7nF	±10%	±10%*	5 – 100MHz	0·03	High	Fair
Ceramic, High-K	1nF – 100nF	–20% to +80%	+22% to –82%*	5 – 100MHz	0·2	High	Fair
Ceramic, Monolithic	10pF – 0·47µF	±10%	Variable*	10MHz	0·02	Very High	Good
Polystyrene	22pF – 0·1µF	±1%	–150ppm/°C	10MHz	0·0005	Very High	Excellent
Polyester	1nF – 2·2µF	±10%	+200ppm/°C	1MHz	0·01	Very High	Fair
Polycarbonate	100pF – 10µF	±10%	±60ppm/°C	0·1 – 1MHz	0·005	Very High	Fair
Polypropylene	100pF – 4·7µF	±10%	–200ppm/°C	0·1 – 1MHz	0·0005	Very High	Fair
Electrolytic (Aluminium Foil)	0·1µF – 47,000µF	–10% to +50%	±1500ppm/°C	50kHz	0·2	Very Low	Fair
Electrolytic (Reversible)	1·5µF – 100µF	±20%	±1000ppm/°C	500kHz	0·1	Very Low	Fair
Electrolytic (Tantalum)	0·1µF – 100µF	±20%	±500ppm/°C	1MHz	0·1	Low	Good
Note: * = See Text							

Figure 30. Capacitor comparison chart.

COLOUR	1st AND 2nd DIGITS	DECIMAL MULTIPLIER	TOLERANCE (PERCENT)	TEMPERATURE COEFFICIENT (PPM/°C)	VOLTAGE RATING
Black	0	1	–	0	–
Brown	1	10	±1	–30	100V
Red	2	100	±2	–80	250V
Orange	3	1k	±3	–150	–
Yellow	4	10k	–0, +100	–220	400V
Green	5	100k	±5	–330	–
Blue	6	1M	±6	–470	–
Violet	7	10M	–	–750	–
Grey	8	100M	–	+30	–
White	9	1000M	±10	+100 to –750	–
Gold	–	–	±5	–	–
Silver	–	–	±10	–	–
No Colour	–	–	±20	–	–

Figure 31a. Colour coded system once used to indicate value of tubular-ceramic (now obsolescent) and older polyester capacitors .

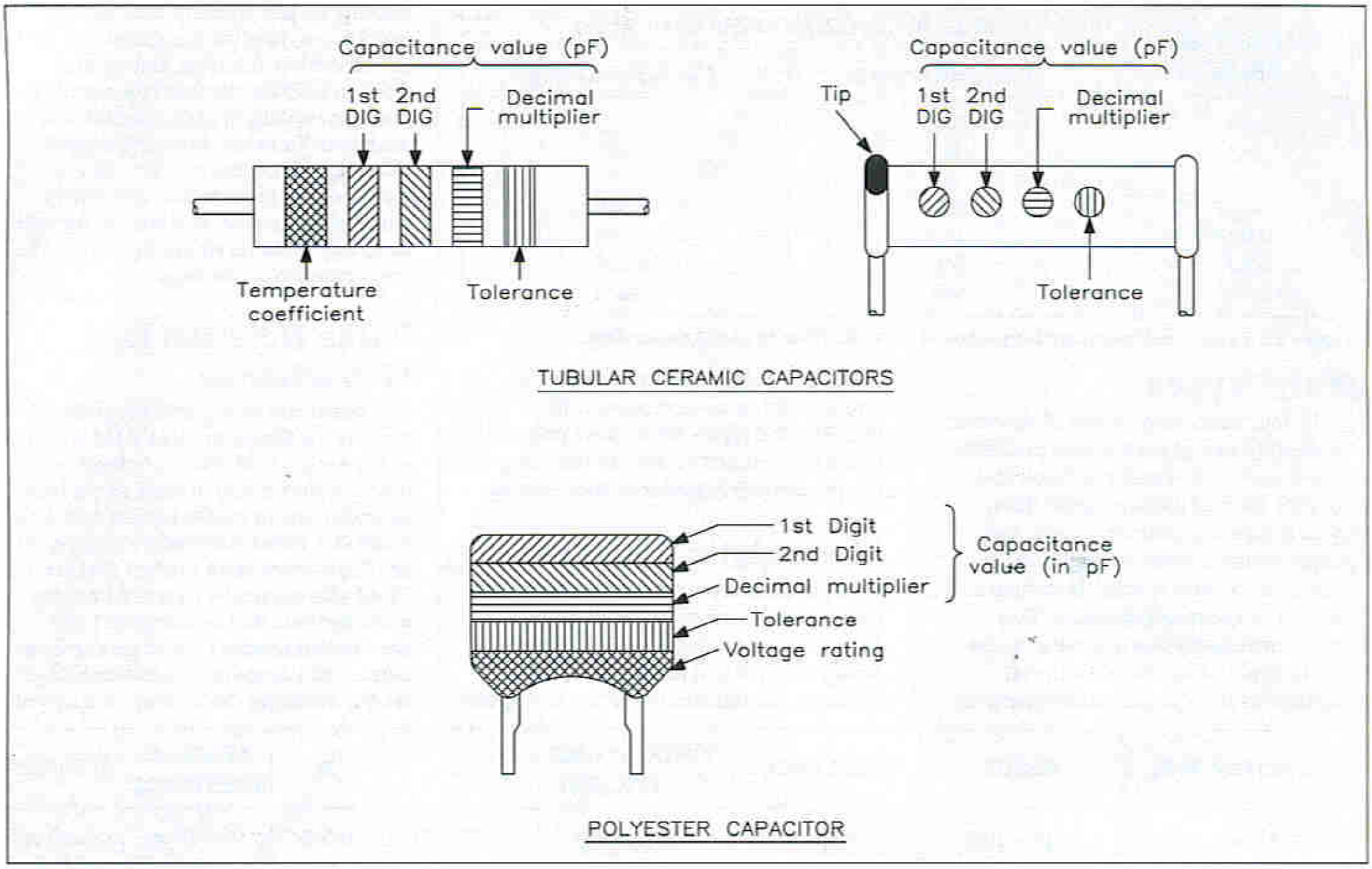


Figure 31b. Colour coded system once used to indicate value of tubular-ceramic (now obsolescent) and older polyester capacitors.

capacitance at the time (18th century).

The μF is further divisible, in thousandths, into the sub-units nanofarads (nF) and picofarads (pF), in which 1nF equals 0·001μF, and 1pF equals 0·000,001μF (i.e. 1nF equals 1,000pF, and 1μF equals 1,000nF).

Practical capacitors are readily available in the standard E6, 20% (100, 150, 220, etc.) and E12, 10% (100, 120, 150, 180, 220, etc.) range of preferred values. The actual value of a component may be denoted in a variety of ways, as illustrated by the following set of examples:

0·1μF = 100nF.
6·8nF = 6n8 = 0·0068μF = 6800pF.
220pF = 0·22nF = 0·000,220μF.
4·7μF = 4μ7 = 4700nF.

Capacitance Coding

On most modern capacitors the component's nominal value and tolerance is, where space permits, printed in clear and reasonably unambiguous terms such has 4n7, 10%, or 68nF, 5%, etc. If the value is given in purely digital form, such as 120 or 4,700, this indicates the value in pF. Often, the capacitor is also marked with its specified working voltage, such as 63V (or 63U), 100V (or 100U), etc.

Up until the late 1980s the values (in pF) of tubular-ceramic and some polyester capacitors were often marked by a colour coding system, rather like that for resistors, as shown in Figures 31a/b. Thus, a ceramic dot-coded 680pF, 5% capacitor would be coded Blue-Grey-Brown-Green, and a polyester type 470nF, 10%, 400V capacitor would be coded Yellow-Violet-Yellow-White-Yellow. This system of coding is now rarely used on new components.

Some Tantalum electrolytic capacitors have their value (in μF) and their working voltages marked by the simple colour coding system shown in Figure 32(a), but others use a plain numeric system, as in (b).

The values of modern ceramic disc and plate capacitors may be indicated by a variety of code systems; the most popular of these are illustrated in Figure 33. The simplest is the one shown in (a), in which the three-figure code contains two digits plus the symbol n, p, or μ, and gives a self-evident indication of the capacitance value, as shown by the examples. In some cases this code may be followed by a capital letter, which indicates the components tolerance value, using the Electrical Institute of America (EIA) code system of Figure 34.

The most widely used coding system is that shown in Figure 33(b) in which the capacitance value is indicated (in pF) by a three-digit code, where the first two figures give the first two digits of the value, and the third figure gives the number of zeros to be added to give the full value. This three-digit code is followed by a capital letter, which indicates the component's tolerance (see Figure 34). Sometimes, the capacitor's temperature coefficient may also be

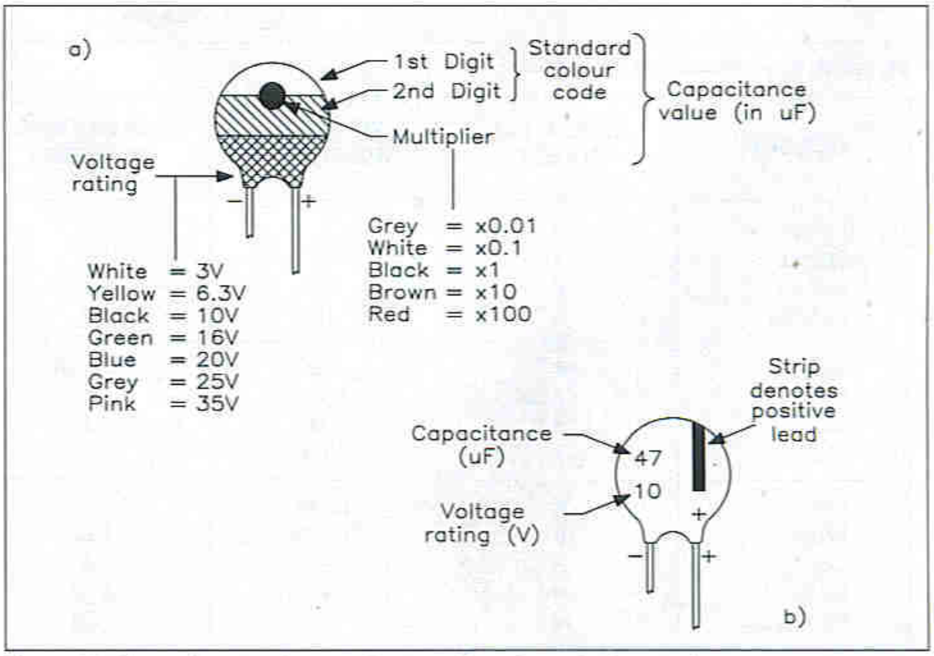
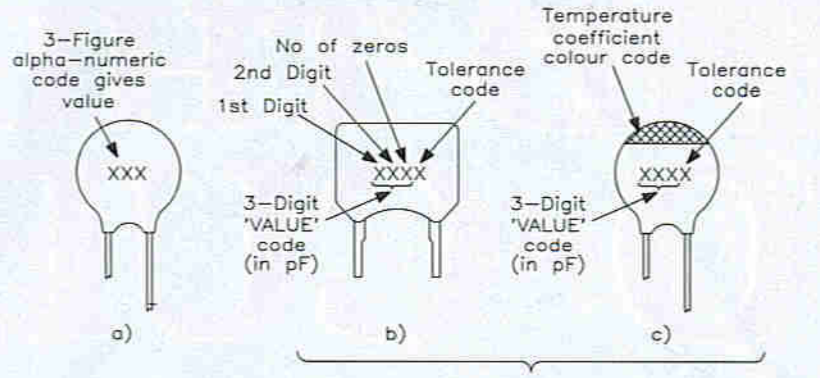


Figure 32. Alternative notations used on tantalum electrolytic capacitors.



EXAMPLES

1p8 = 1.8pF
27p = 27pF
n33 = 0.33nF(=330pF)
1n2 = 1.2nF

EXAMPLES (DIGITAL CODE ONLY)

270D = 27pF, ±0.5pF
102K = 1nF, ±10%
103M = 10nF, ±20%
474Z = 0.47uF,−20+80%

Figure 33. Coding system used on modern disc and plate ceramic capacitors.

TEMPERATURE COEFFICIENT (PPM/°C)	COLOUR CODE	INDUSTRIAL CODE	EIA CODE
+100	Red/Violet	P100	—
±0	Black	NPO	C0G
−33	Brown	N033	S1G
−75	Red	N075	U1G
−150	Orange	N150	P2G
−220	Yellow	N220	R2G
−330	Green	N330	S2H
−470	Blue	N470	T2H
−750	Violet	M750	U2J
−1500	Orange/Orange	N1500	P3K
−2200	Yellow/Orange	N2200	R3L
−3300	Green/Orange	N3300	—
−4700	Blue/Orange	N4700	—

Figure 35. Code systems used to indicate capacitor temperature coefficients.

1st FIGURE	2nd FIGURE	3rd FIGURE	
Minimum Temperature	**Maximum Temperature**	**Maximum Capacitance Change Over Temperature Range**	
X = −55°C	2 = +45°C	A = ±1%	P = ±10%
Y = −30°C	4 = +65°C	B = ±1·5%	R = ±15%
Z = +10°C	5 = +85°C	C = ±2·2%	S = ±22%
	6 = +105°C	D = ±3·3%	T = −33 to +22%
	7 = +125°C	E = ±4·7%	U = −56 to +22%
		F = ±7·5%	V = −82 to +22%

Examples of use of the code:

Code		Temperature Range		Maximum Capacitance Change Over Full Temperature Range
X7R	=	−55°C to +125°C	=	±15%
Y5V	=	−30°C to +85°C	=	−82 to +22%
Z5U	=	+10°C to +85°C	=	−56 to +22%

Figure 36. EIA temperature characteristic codes for ceramic capacitors.

CODE		DIELECTRIC TYPE
MKT	=	Metallised Polyester Film (PETP)
MKC	=	Metallised Polycarbonate Film
KS	=	Polystyrene Film/Foil
KP	=	Polypropylene Film/Foil
MKP	=	Metallised Polypropylene Film
KP/MKP	=	Dual Dielectric: Metallised Polypropylene and Polypropylene Film
KP/MMKP	=	Dual Dielectric: Polypropylene Film, Foil and Double Metallised Polypropylene Film
MKT-P	=	Dual Dielectric: Metallised Polyester Film and Paper

Figure 37. Dielectric material codes, used by Philips and some other European manufacturers, on film capacitors.

C = ±0·25pF	M = ±20%
D = ±0·5pF	Q = −10, +30%
F = ±1pF or ±1%	S = −20, +50%
G = ±2pF or ±2%	T = −10, +50%
J = ±5%	Z = −20, +80%
K = ±10%	

Figure 34. Popular EIA capacitor tolerance codes.

indicated, using either a colour code, as in (c), or an industrial or EIA alphanumeric code, as shown in Figure 35. Thus, a capacitor with a temperature coefficient of −220 ppm/°C may have a yellow tip or carry the code N220 or R2G.

In some cases a ceramic capacitor (or its specification sheet) may carry a three-figure EIA code that details the full thermal specification of the component, as shown in Figure 36. In this code the first two figures (an X, Y, or Z, and a single digit) give the component's thermal working limits, and the third figure (a capital letter) specifies the maximum capacitance change expected to occur over those limits. The diagram gives three practical examples of the use of this popular EIA code.

Some film-type capacitors carry a code that indicates the type of dielectric used in the component. Figure 37 gives details of the most popular of these code systems, which is used by Philips and some other European manufacturers.

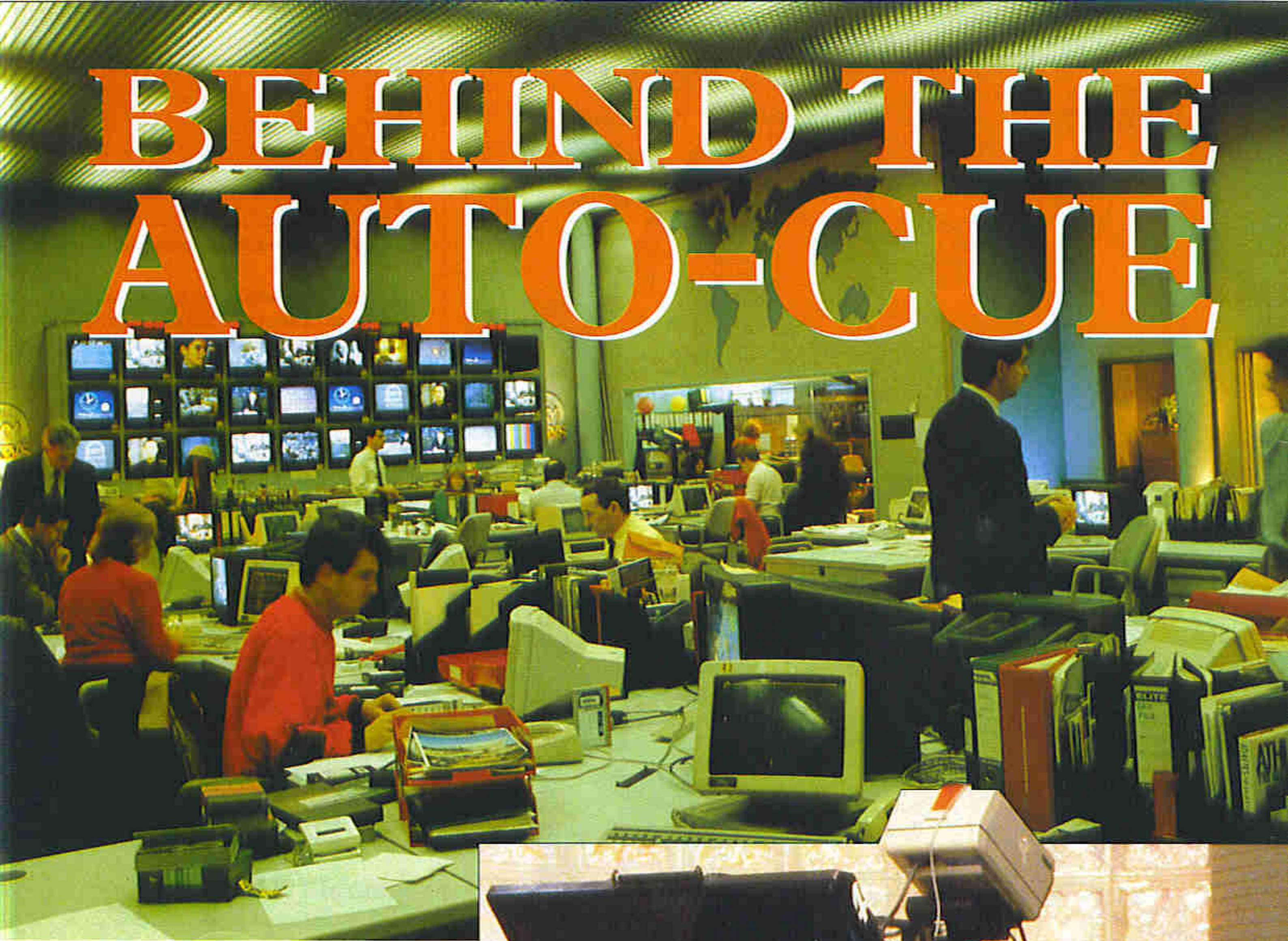
Variable Capacitors

Variable capacitors come in two basic forms; fully variable ones, most often known as 'tuning' capacitors, and preset ones, known as 'trimmers'.

Tuning capacitors have a semi-circular set of rotatable plates that intermesh with a set of fixed plates, so that capacitance is greatest when the two sets of plates are fully intermeshed, and least when the two sets of plates are rotated out of mesh. The precise shape of the rotatable plates may be designed to produce a linear, semi-linear (S), logarithmic, or square-law variation of capacitance as the plates are rotated; the dielectric used between the two sets of plates may be air, plastic film, or some other insulating material. Often, two or more tuning capacitors are ganged together, so that they vary in unison, but such units are rather expensive and have, in recent times, largely been superseded by matched sets of varicap diodes.

Most trimmer capacitors are only meant to be adjusted (varied) occasionally, and several basic types are available. 'Vane' types are similar to the conventional tuning capacitors, and may use an air or plastic film dielectric. Plastic film types are very popular. Ceramic 'disc' types can be regarded as simple 'vane' types, having only one fixed and one rotatable half-vane; they offer excellent high-frequency performance (with a very high Q), but may have a very large temperature coefficient. 'Compression' and 'piston' type trimmers give a fairly limited range of capacitance adjustment.

BEHIND THE AUTO-CUE



by Alan Simpson

"Hold the top story" or even "kill the dead donkey" are cries which have been well and truly banished from the TV news rooms. Also replaced are those vintage typewriters on view, until recently, in the TV newsrooms. Now any change in the 'headline' news is accomplished by a quick press of a computer terminal function key.

While much of the Information Technology world has been busy preaching the merits of LANs and WANs, Global Messaging, Desk Top Publishing, voice conferencing and fibre optic cabling technology, TV and radio stations around the world have been busily implementing electronic newsrooms. Traditional editors wearing their badge of rank, an armband plus plastic eyeshades on the forehead, are a thing of the past. Today editors take their place among an impressive array of screens, terminals and keyboards, plus sundry videotapes and satellite connections. Noticeably absent are reams of paper, noise and confusion, normally associated with newsrooms and production control units. Instead, journalists now silently key-in to the multiple array of terminals, which update and access data files held on central databases.

The suave team of presenters receive more than a helping-hand from a specially designed and developed electronic newsroom system involving the whole newsroom – editors, journalists, technicians and pre-

senters, keep tabs on programme content and scheduling. The system maintains an event diary, news agency 'wires' and stories sourced from local and national correspondents, all of which are held on a computer together with detailed scripts and listings. A typical listing schedule can contain up to 90 items and the system allows editing or rescheduling – even when the news programme is 'on air'.

Not only does the electronic mailroom keep tabs on stories, and the running order, but can also handle support information such as transport and payment together with full back-up of library pictures. If you want a picture of a particular footballer scoring a goal then the choice of picture is massive. The editor can indicate a UK league clip, an International at Wembley, a key world fixture in Europe – or even missing a goal. Before you can say World Cup, the selected pictures have been down-loaded to the newsroom. Similar clips are available of any world sports star – covering all sports events. It's not just the sporting world which is covered. If you want clips of Tom Cruise, Kim Basinger or Michelle Pfeiffer in boxer shorts then the system comes up trumps.

modems, terminals, screens, printers) to a figure closer to 200. Not only that, but the station now provides the news for TV AM broadcast on ITV.

Grows with You

"We have been using Basys since day one", says Dave. "There are about three major newsroom systems available in the world, but Basys with its ability to grow with you, clearly had the edge."

The original Basys system was installed at Sky in December 1988 in preparation for the launch of Sky TV in February 1989. The system has grown considerably since its inception and now caters for over 200 users at its Osterley site, in Middlesex, alone. The system itself runs on a dual DEC Microvax 3300, while the archive storage system is currently being upgraded to run Basys Archive II software on a DEC system 5000-240 RISC machine to provide greater capacity and flexibility.

According to Janet Weaver of Basys, Sky TV is one of the most enthusiastic users of the Machine Control System (MCS) which allows studio production equipment such as cart systems, stills stores, character generators and multi-cartridge machines and even robotic cameras, to be controlled directly from the Basys Newsroom System. MCS software enables the newsroom system to control the wide variety of production devices which Sky has already installed such as drivers for the Sony Betacart, Quantel DLS 6001 still store and the Chyron Scribe. As Dave says, the present automation system is designed and built around products from Basys and Sony. Not only do the systems provide an essential key role in the newsroom operations, but also support the movie channel for script writing and archiving. Each of the Sky channels has its own control room, which is responsible for all programme and spot announcements, as well as transmission quality. A master control room has oversight, but its main role is that of co-ordinating and monitoring the incoming and outgoing feeds and inserting teletext data into the six channels.

Above: Sky News editing suite.
Below left: Robotic camera Auto-Cue as used in the Sky News studio.

Electronic News

One of the many enthusiastic users of Basys Automation Systems, the world's leading supplier of news, automation and management systems to broadcasters, is B-Sky-B the major European satellite broadcaster. Here station engineer and manager Dave Sparks (an apt job title/name if ever there was one) presides over six satellite channels – with the Basys automated system having a key role in the Sky News and Sky Sports channels. This key role is also being extended to certain other channels including, The Movie Channel.

"Essentially", says Dave Sparks, "Basys is a very clever, but simple to use, word processing and retrieval system. Our aim here at Sky is to keep it simple, thereby making it easily available to all our newsroom staff." Certainly that concept has helped Sky to move from some 80 devices (PCs, laptops,

Although a relative newcomer to the industry, Basys has an action-packed history. The system, which was designed in one of those legendary Californian garages, first saw the light of day in the CNN studios in 1980. Since that time, the product has been installed in more than 400 broadcast newsrooms world-wide, including NBC, ABC, BBC Radio and TV, as well as ITN. In fact, so impressed was ITN with the product, that they bought the company in 1984. Now having hit on difficult financial times, ITN have sold out to Digital Equipment Corporation. Basys said, "DEC has a strong heritage of innovation in broadcasting, while we lead in open systems and services. As a long time OEM supplier to Basys, the marriage will provide even more 'firsts'."

How it Was

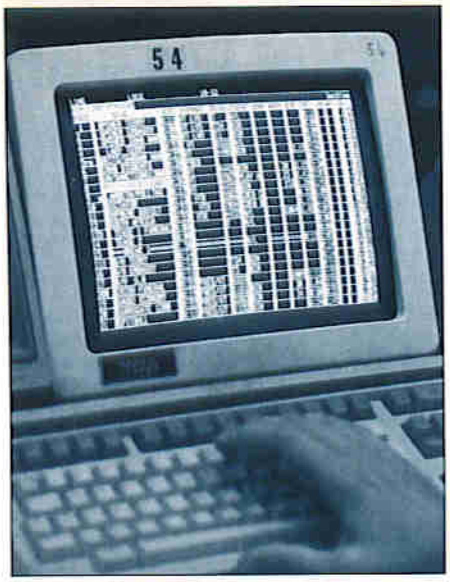
As those of you with longish viewing memories will recall, a typical newsroom backdrop heavily featured typewriters and paper. Technology was the nearby telex machine with the automated coffee machine close to hand. In the old days, journalists had to thump out their stories on a portable typewriter possibly on a cramped desk or even out on location. The text together with the film would be conveyed to the nearest airport from where, with luck, it would reach London. At that point, a motor-cycle courier would make the final dash to the studios.

Today technology is less motor-cycle, but more satellite and microwave. Instead of the telex news item being monitored by an editor, then rewritten and typed up for the autocue, the copy is now loaded directly into the network. If necessary, news items can be rescheduled during the live news broadcast. Now, experienced journalists would find it difficult to compose even a brief intro, on anything other than a computer screen. However, the time when the news will be fed straight onto the screen in front of the presenter is far away. All the news organisations like to check their news stories before transmission.

Automation On Air

So just what does Basys, and its competitors, provide? For a start, they bring automation to the newsroom. With world-wide events taking place almost before our eyes, a system to handle the news is essential. Incoming stories from the agencies are captured and sorted according to user defined category codes and keywords. Specific stories can be retrieved using the keyword search feature. Users are notified of late-breaking news items which can be accessed immediately from anywhere in the system.

The powerful word processing facilities increase the speed and accuracy of the writing, and revising of stories. Background material can be collected in the system's electronic notepad and simply inserted into the story along with other changes. The system automatically counts words and calculates read-times based on each news-reader's read-rate. In addition, users can set up personal files for retention of personal material, research material, background information, contacts and leads. These files can be made available to all users or they can be 'locked' if the information is confidential.



One of many BASYS terminals at Sky News.

File Sort

All users of the Basys system can send messages and text to other users of the system. Should a user not be using the system at the time he is sent a message, then he will be automatically informed of any message the next time he does use the system. At the same time, electronic card indexes can be set up to enable easy access to regularly used information such as contacts lists and telephone numbers. Users can search for the required information using the contact name, job title, address or a variety of codes. Basys also has the ability to monitor line plans. These are listings of timed data-communication feeds into the building which are used for up and down-loading video information for broadcast programming.

"Once we have a story", says Dave Sparks, "our newsroom journalists write a script for the news-reader to read". This text then appears on the right-hand side of the screen. The video tape and still store identification numbers, camera positions and caption detail instructions (that is pictures from videotape, captions for picture plus details of who is speaking in the clip), are displayed on the left side of the screen. Before the news broadcast starts, all information is down-loaded to the relative pieces of equipment, that is VTs, character generators, slide stores, and the auto-cue displays. If at any time the producer changes the running order of the newscast, then all the related services follow.

Right at the centre of the Electronic Newsroom is the electronic diary, which can hold information three hundred and sixty five days prior to transmission. Its flexibility, however, is such that amendments can be made right up to the last moment, "hold the top story" type items being entered, auto-cued and screened within minutes of receipt from the news desk. Feeding directly into the diary are the major news agency feeds. The old style newsroom paper-chase is replaced by a coded news item which can be amended as required and incorporated into the running programme diary. "News", says Dave, "has a habit of not being static and Sky has to respond accordingly. Our list of stories has to be kept flexible allowing those essential last minute changes. At times, I believe that Basys should get a credit line alongside the news presenter".

News at the Speed of Light

"Sky news", says Dave, "is a 24-hour channel, putting out a live 30 minute news report on the hour, every hour". In some cases, the news can run for the whole 60 minutes, but more usually, the second half of each hour is filled with recordings. During the recent Gulf War, with an average of 180 line and satellite feeds coming in every day, the programme was live on air virtually 24 hours a day.

News tape is edited in suites alongside the newsroom, where bar coding is added to the tapes. News tape playback is handled by a 40-cart unit which interfaces to Basys, and is backed up by three standalone machines. Also connected into the network is the archive computer database which can be linked directly into picture libraries worldwide, with direct links into Visnews. Similarly four terminals are multiplexed on 9,600 baud lines that are leased from BT to Sky's studios in Westminster.

Sky TV is also closely looking at the Basys Resource Management System (RMS) which permits the user to improve the management of the station's resources through such modules as lines booking, tape tracking and input recording. RMS has been developed in response to demands from a number of broadcasters for a cost-effective management system. Operating round the clock, the system will increase efficiency and link smoothly with existing hardware in a modular way, and will be capable of expanding to help manage a station's entire resources. The RMS integrates with the newsroom system and uses the information to control equipment while actually on the air. The system claims to achieve more efficient usage of manning levels on the transmission of video tape by means of automated cart machines. In each cart tower, nearly 300 VTR cassettes can be loaded at random with a robotic arm sorting them into the correct running sequence. The system will also automatically cue the tape to the required point and play it out at the right time. However, with each cart machine costing in the region of £600,000, much evaluation is necessary.

Selina Scott has presented numerous B-Sky-B programmes.

A more positive move is Sky's introduction of the Basys system controlling the newsroom camera. Studio cameras are normally controlled by live operators in what Dave suggests is a dull and repetitive job. Now four robotic cameras can be operated by one man with the aid of a console. Dave is already looking at touch screen technology as a way to allow the news director to control the robotic cameras.

Meanwhile, future Basys developments include extending beyond text storage to providing sophisticated document and image storage capabilities. Basys have not lost sight of the fact that their system could have major relevance for many industries, apart from newsrooms. Major building contractors, for instance, could be assisted by a flexible, on-line, programme and control system as could advertising agencies working to tight time schedules.

"Basys", says Dave Sparks, "has made life a lot easier for the newsroom. The pressures are so high we'd be lost without it. It really is a package for all reasons that no newsroom should be without."

COMPETITION

Now instead of watching the news from the comfort of your armchair, you can see the action at first hand. Just be one of the first three all correct names to be drawn from the battered editors hat (the hat that is) [steady on Alan, your anecdotal comments are getting a bit near the mark! – Ed.] and you could find yourself at Sky studios in West London. Or wearing the latest in fashionable garb – six runners-up will each receive a Sky T-shirt. Just answer correctly the following basic questions and send your answers on a post card or the back of a sealed-down envelope, to:

"Sky News Contest", The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex, SS6 8LR, to reach us by 31st March 1993. Employees of Maplin Electronics and family members of the same are not eligible to enter. Also please note that multiple entries originating from one and the same family group will be disqualified.

So get switched on now!

1. Who would use an Auto-cue?

a) A snooker player.
b) A news-reader.
c) A politician.

2. Which broadcaster will be covering the Soccer Super League.

a) B-Sky-B.
b) Channel 4.
c) The BBC.

3. Which of the following broadcasters does not have subscription only programmes?

a) ITV.
b) B-Sky-B.
c) The BBC.

4. What area is covered by Astra transmissions?

a) The British Isles.
b) Europe.
c) Golders Green.

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*Suitable for phono inputs on your hi-fi, phono, DIN or SCART audio output on your VCR.

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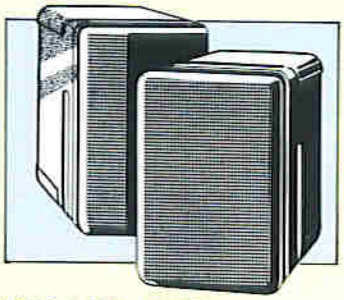

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