PRACTICAL

ELECTRONICS

SEPTEMBER 1990 • £1.50

SCIENCE AND TECHNOLOGY

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Using your tv as an oscilloscope

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Cooly gain your degree in Celsius

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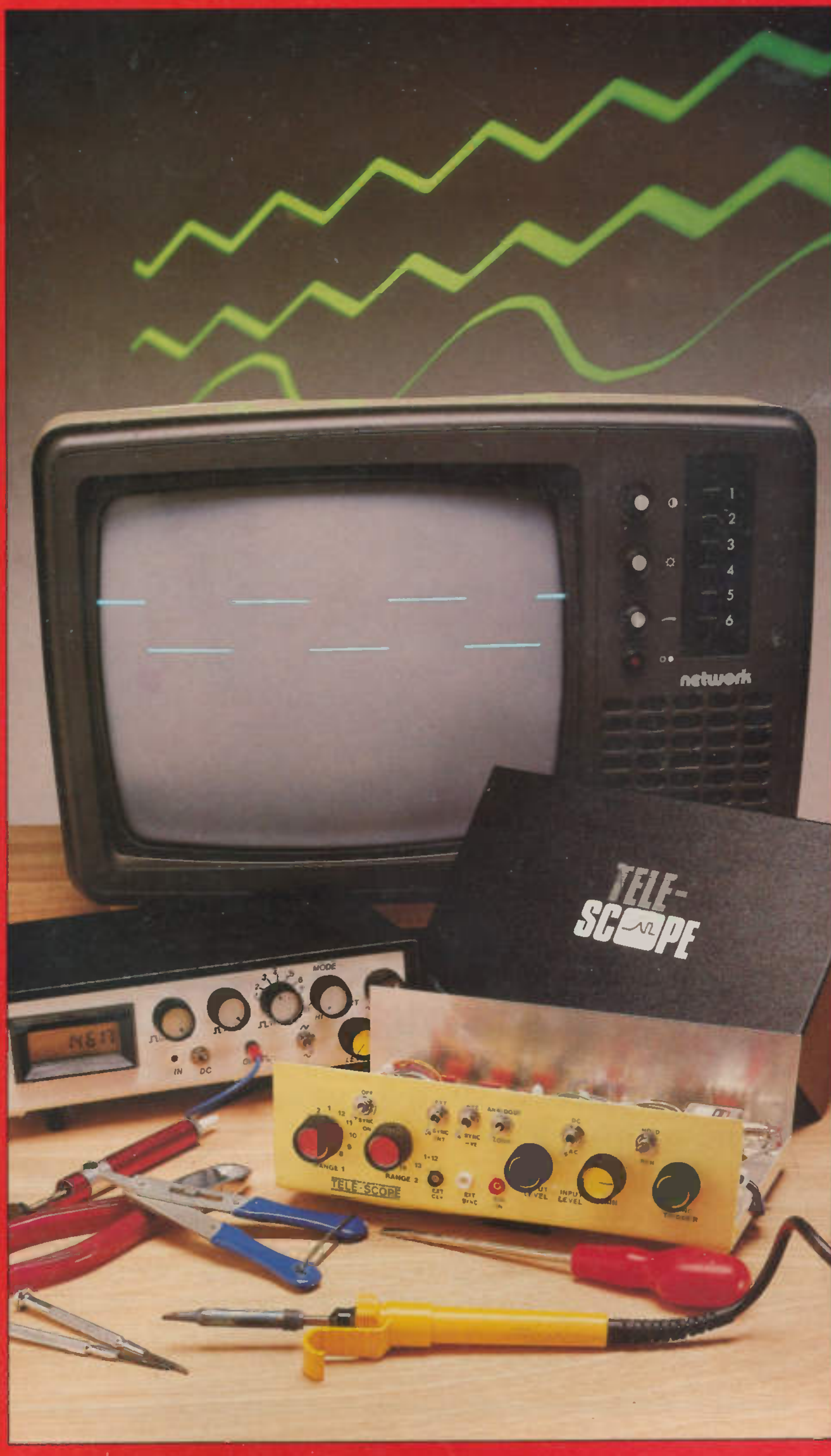
Look what's coming home from Chicago!

BASIC ELECTRONICS
Follow your guide to what's what in electronics



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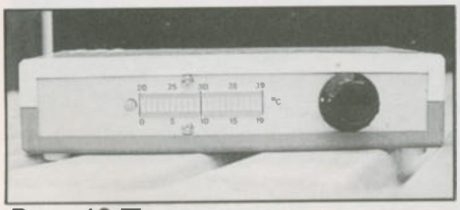

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PRACTICAL ELECTRONICS

VOL 26 NO 9 SEPTEMBER 1990

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CONSTRUCTIONAL PROJECTS

SPECIAL FEATURES

REGULAR FEATURES

NEXT MONTH

We've just the job for addictees of electronic design, building and testing: a really superb and versatile chip-tester. Our imaginative and unique Tele-Scope will be put into service. There's discussion of a revolutionary technique for futuristic monitoring of domestic gas and electricity reading. And we've a simple voice-operated switch that should really turn you on. Don't miss these or our regular great features.

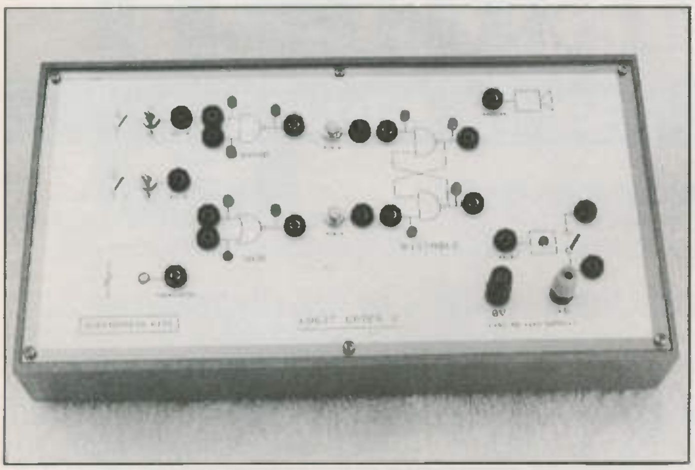
★ ALL ARE REVEALED IN OUR OCTOBER 1990 ISSUE

★ ON SALE FROM FRIDAY 7TH SEPTEMBER

PE TAKES TECHNOLOGY FURTHER – BE PART OF IT!

NEWS

TEACHING KITS



The new National Curriculum stipulates, we are pleased to say, that all secondary school children are to be taught the sciences. In many cases schools will have to consider purchasing more teaching aids to cover the information technology and basic electronics requirements.

To meet the potential demand, Electrotech Kits in conjunction with their local teaching staff have developed a small range of economically priced electronic teaching aids. The initial range of three units includes a basic transistor switch, the logic gates NOT-AND-OR, and the logic gates NAND-NOR plus the bistable.

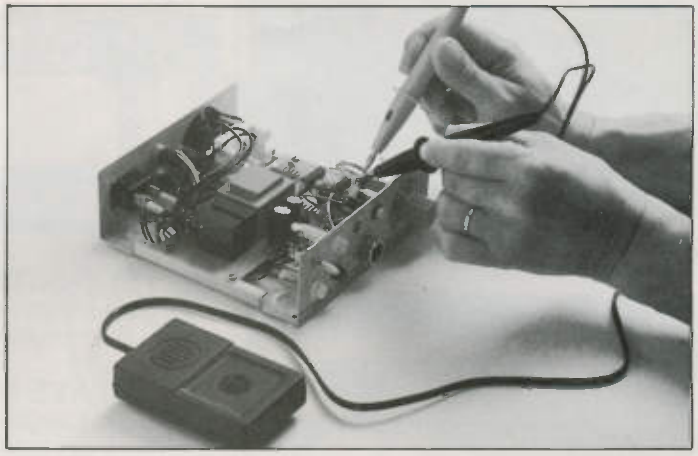
All units are built into standard sized rugged plastic cases having sloped panels. Transparent perspex front panels present the student with a schematic diagram of the unit's functions. The use of perspex significantly reduces the graffiti that can be written onto the front panel!

Components are contained within the plastic case to prevent accidental damage from occurring while in use. A standard format has been adopted where input devices are on the left hand side of the front panel, processing functions in the middle, and output devices on the right hand side. 4mm banana sockets are used, with appropriate connecting leads, for the student to interconnect sections of each unit.

All units operate from an external 9V to 12V dc supply. Supply terminals with integral 4mm sockets are fitted to enable the external dc supply to be easily connected to the unit. An internal mains power supply can be fitted on request.

Prices range from £52 to £65 for units purchased in quantities of one to nine, and from £46 to £59 for units purchased in quantities of ten or more.

For more information contact Electrotech Kits, 202 Aylesbury Road, Bierton, Aylesbury, Bucks, HP22 5DT. Tel : 0296 28961.



NOISY NOSER

Here's a good idea from Swissinco, a voltage and continuity probe tester which makes noises related to the probed condition. The Cirtest Type 84 incorporates a piezo-ceramic buzzer which emits a variety of tones which are different in frequency and loudness to indicate the test results, thus avoiding the need to visually check readouts whilst making tests.

This high-quality Swiss-made instrument is supplied in a very robust polystyrol casing and meets a variety of safety standards. Voltage protection up to 440V ac and the ability to indicate dangerous voltages are two particular features of what is claimed to be a maintenance-free product.

The probe works from a 4.5V power source, and instrument protection is provided electronically. It is supplied in six versions: resistance; voltages and current; resistance and current; resistance, voltage, current and dangerous voltage; with built-in spot light; for measuring resistance up to 10M; and a version which also features a switch-on frequency generator (1kHz), as well as a zero ohms comparison switch.

For further information contact Bruce Letchford, Swissinco, Units 1 and 2, Townsend Industrial Estate, Waxlow Road, London NW10 7NU. Tel : 081-965 9505.

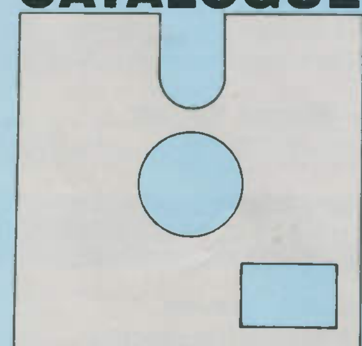
CELLULAR POLISH

British Telecom is part of a group bidding for a licence to build and run cellular radio mobile communications service in Poland.

The consortium is led by Swedish Telecom International, part of Televerket, the Swedish PTT, and includes Fintelcom as well as BT.

The group is proposing to provide a service based on NMT, the Nordic Mobile Telephone system which started in Scandinavia in 1981. NMT now has more than 1,100,000 customers in 12 countries in Europe.

CATALOGUE DATABASE



Our browse through recently received literature

Bull Electrical's catalogue and latest newsletter lists a good selection of those bargains for which the company are famous. The catalogue is in a new style, consisting of 30 pages in a handy A5 format, making it easy to read and use. Among the bargains highlighted in the newsletter are **tv sound decoders** which enable you to receive sound and video signals straight from a tv aerial, but without using a tv set. Mains fans, mylar cone speakers, and a **remarkably low priced lcd display** are featured too. So are mini (24 column) dot matrix printers, for only £10 each. Among the **1000 or so items in the catalogue** there are probably many which you would be hard pressed to locate elsewhere, if at all. The catalogue is priced 25p and is well worth obtaining. **Bull Electrical**, 250 Portland Road, Hove, Sussex, BN3 5QT. **Tel 0273 203500. Note this new number**, which has several lines on it and replaces the previous system.

Hills Components' catalogue looks as though it is probably of more **interest to those who are involved professionally** in electronics. We know there are a fair number of PE readers who are in the trade, in many instances running their own small electronics businesses of various types. The catalogue, in over 110 well-illustrated A4 pages, **covers the electronic spectrum**. Products range from aerial accessories, batteries, cables, connectors and computer hardware, to components, meters, test gear, speakers, tools and transformers. If you are a serious user of electronic products, **have a close look** through this interesting selection. **Hills Components Ltd**, Units 5-6, Melinite Industrial Estate, Brixton Road, Watford, Herts, WD2 5SL. Tel 0923 52000.

Babani's catalogue of electronics, radio and computer books should definitely be on your reference shelf. Whether you are wanting to learn about electronics and its allied subjects, or to build even more projects than you already do, you'll undoubtedly find there are **many books listed which will help you** in these and other aims. It's a nicely illustrated pocket-sized book which lists the titles in subject matter order, with a brief description of each book. **Bernard Babani (Publishing) Ltd**, The Grampians, Shepherds Bush Road, London W6 7NF. Tel 081-603 2581.

AUDIOPHILE SPEAKERS

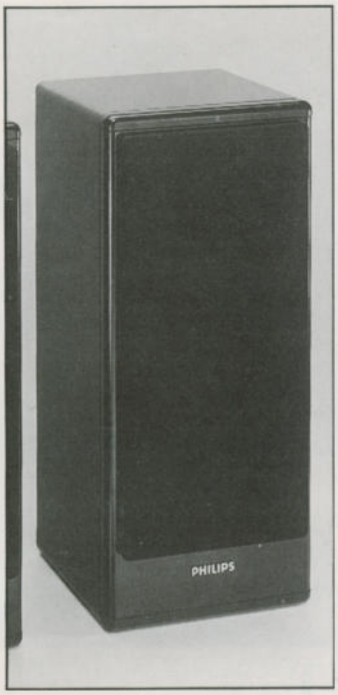
Bitstream pioneer Philips has displayed further commitment to audiophile sound with the introduction of a new high quality three-way 150 watt loudspeaker, the FB815.

The quality of this speaker is the result of extensive use of advanced computer design techniques and exhaustive listening tests at Philips' newly equipped sound lab in Dendermonde, Belgium.

Structural integrity was a priority in the design of the 815 which features a 19mm thick high density chipboard cabinet with a 30mm thick baffle.

The three-way system includes an eight inch bass driver and four inch mid range cone with soft coatings and a soft ring mounting. High end reproduction is handled by an 18mm soft dome tweeter manufactured in 'Supronyl' and featuring Philips' developed 'ferrofluid' cooling for high power applications.

Finished in dark walnut, the FB815 is a medium sized speaker measuring 630 x 270 x 270 mm with computer optimised crossover filters and an overload protection system. The speakers come complete with spiked stands and are priced at £229.00.



Ask your local Philips stockist for more details, or speak to Julie Harding at Mathieu Thomas Ltd, 8 Westminster Palace Gardens, Artillery Row, London, SW1P 1RL. Tel 071-222 0833.

EVENTS DIARY

If you are organising any event to do with electronics, big or small, drop us a line, we shall be glad to include it here.

Please note: Some events listed here may be trade or restricted category only. Also, we cannot guarantee complete accuracy of the information, so check details with the organisers before setting out.

Sep 18-21. EFTPOS 90. Exhibition and conference on electronic retailing. Alexandra Palace, London. 0273 722687.

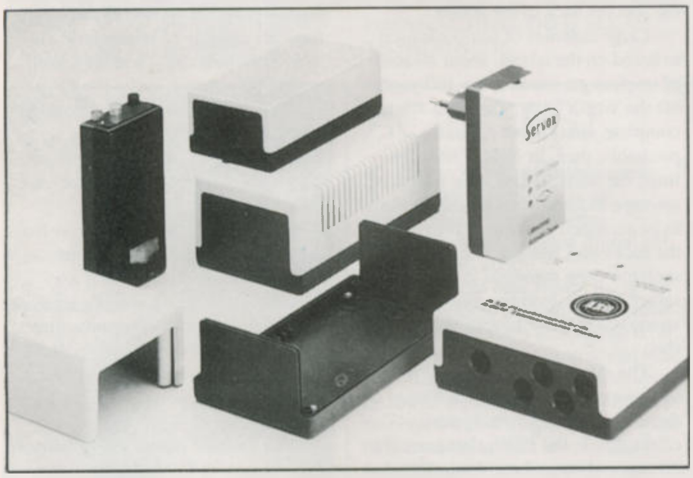
Sep 21-25. IBC Exhibition, Pier Pavilion, Brighton.

Sep 25-27. British Laboratory Week. Olympia, London. 0799 26699.

Oct 2-4. Eurostat 90. Barbican Red Hall, London. 0799 26699.

Oct 20-21. North Wales Radio Rally. Aberconway Centre, Llandudno. 0492 532459, or via callsign GW7EXH.

Nov 6-8. Total Solutions. NEC Birmingham. 0799 26699.



ELEMENTARY DEAR BOPLA

The enclosure known as Element is, according to Bopla, ideal for small instruments and electronic units. Bopla have now made available another version, this time having a mid-grey lower shell, while still maintaining the traditional colours of light grey upper shell and dark grey base.

The enclosure is made from two interlocking sections. It has the advantage that when the upper section is removed, components can be installed quickly and conveniently into the lower section. For mounting a chassis or pcb, threaded brass inserts are provided as standard in the lower section. The cases are moulded in high-impact polystyrene which is easily drilled or machined if required.

For more information contact Bopla Ltd, 29 Faraday Road, Aylesbury, Bucks, HP19 3RY. Tel : 0296 399999.

CALLBANK

A new personalised cellular answering and messaging service called Callbank has been launched by Millicom Cellular (UK) Ltd. Millicom says it is the first service provider to offer its own voice messaging system.

Operating on both Cellnet and Vodaphone networks, Callbank offers a full range of features and is priced more competitively than other similar services. Two levels of service are currently available with new additions to be introduced throughout this year.

Millicom have also told us of their new hand portable cellular telephone. It has a superior battery life and is one of the smallest and lightest phones on the market.

Millicom's phone, the Kokusai KE101, incorporates a high performance film battery which dramatically increases operation time. The standard model offers up to 100 minutes 'talk time' in Vox mode and 18 hours standby time. With the optional long life battery, these times are increased up to 250 minutes and 40 hours respectively. The battery is rechargeable.

For further information contact Frankie Delamain, Millicom Cellular (UK) Ltd, South Bank Business Centre, Ponton Road, London SW8 5BL. Tel : 071-757 5000.

Advertisers Awake!

Don't let your competitors steal all the glory of PE News Page Publicity – have YOUR interesting new products highlighted here as well as theirs! Send us concise details plus a good photo and we'll do our best to publicise them.

First come first served, and it must be interesting. It's up to you to keep us all informed!

BREWING SATCOMS

Three of the yachts which finished the Whitbread Round the World Race used a new Inmarsat satellite communications system throughout the race to keep in touch with their home base and with each other.

Merit, *Gatorade*, and *Equity and Law* were able to keep in constant contact while they raced through the Pacific and Atlantic Oceans using the Inmarsat-C satcoms system.

Inmarsat-C has been available as a pre-operational service for about a year throughout the Atlantic Ocean Region. Since December 1989, a limited test and demonstration capability has also been available in the Pacific Ocean. The system will offer two-way data messaging globally, including telex and data transmission.

Communications from the racing yachts sent via the Inmarsat-C system included position reports, communications with other yachts in the race and status reports back to their base stations. In one case, details of a yacht's technical difficulties were called ahead to the next port so that the spare parts they needed were waiting when the yacht arrived. The central base station in Southampton that monitored the entire race also relied on regular reports from the satcom-fitted yachts for up-to-the- minute status reports on the progress of the race.

According to Antonio Chiotto of Europ Assistance, one of *Merit* and *Gatorade's* sponsors, "satellite communications were absolutely indispensable to keep our operations centre in constant contact with the crews. Satcoms allowed us to give critical assistance to solve various technical and medical problems that arose during the race."

Inmarsat, with 59 member country investors, operates a global system of eight satellites to provide mobile communications for maritime, aeronautical and land mobile customers worldwide.

For further information contact Elizabeth Hess, Inmarsat, 40 Melton Street, London NW1 2EQ. Tel : 071-387 9089.

YOUNG WOMAN ENGINEER AWARD

With more young women forging ahead in the engineering industry, it is anticipated that the standard of competitors will be exceptionally high for this year's coveted Young Woman Engineer of the Year Award, now in its thirteenth year.

Nominations, from suitably qualified young women under the age of 30, are invited by the Institution of Electronics and Electrical Incorporated Engineers (IEEIE), and should be submitted by 1st October 1990.

Having successfully completed the necessary technical education and training, all entrants will be required to prove themselves capable of holding a responsible position at Incorporated Engineer level.

The aim of the Award, sponsored jointly by the IEEIE and the Caroline Haslett Memorial Trust (CHMT), is to highlight the exciting career prospects available for women in electronic and electrical engineering.

In addition to gaining prestige associated with the Award, the 1990 Young Woman Engineer of the Year will receive a silver rose bowl and a prize of £500. The most promising younger entrant will receive the CHMT's Mary George Memorial prize of £100.

Copies of the Award nomination form and brochure are available from The Secretary, IEEIE, Savoy Hill House, Savoy Hill, London WC2R 0BS. Tel : 071-836 3357.

BUCCANEERING WILD LIFE

The Shearwater Project is Dyfed Wildlife Trust's attempt to re-introduce a colony of Manx Shearwater birds to Cardigan Island. A vital part in the project is being played by AF Bulgin's tough waterproof Buccaneer cable connectors. The products are being used to connect up a solar-powered sound system, broadcasting the bird's calls, which experts hope will attract the species back to the island.

Large colonies of sea-birds used to breed on the island, about 40 acres of treeless grassland lying 300 yards off the Welsh coast. The birds were in complete safety from natural predators, then, in 1934 a 7000 ton liner, the SS Herefordshire, parted her towrope in rough seas whilst on route to be scrapped and was driven onto the rocks on Cardigan Island. Her skeleton crew managed to reach the safety of the island but, unfortunately, so too did the rats leaving the doomed ship.

The rats totally exterminated the shearwaters, and also the puffins there too. The rats in turn were eradicated in the 1960s, but even after 25 years of natural recolonisation, neither shearwaters nor puffins have returned to the island.

In an attempt to redress the situation, the island's management committee are experimentally using sound recordings to create an audible impression of an established colony.

A wide range of industries not normally involved in conservation have become interested in the project, supplying equipment and carrying out research on the Trust's behalf. The resulting sound broadcasting equipment comprises a sophisticated stand-alone solar powered static ram recorder capable of broadcasting up to 55W of bird call, switching itself on and off automatically. It was designed to operate unattended even in severe maritime weather for up to five years with minimal maintenance. Its amplifier is installed in a die-cast aluminium case and the Trust, recognising that the connections from the case to the rest of the equipment would have to be waterproof and rugged, asked the advice of specialist electronic component manufacturers, AF Bulgin. The company donated 22 Buccaneer connectors to the project, enough for the main system, its back-up recorder and amplifier.

For further information contact A.F. Bulgin & Co PLC, Bypass Road, Barking, Essex, IG11 0AZ. Tel : 081-594 5588.

MR SEMICONDUCTOR DIES AT 62

Dr. Robert Noyce, the co-inventor of the integrated circuit died at his home in Texas at the beginning of June.

Affectionately known by his colleagues in Silicon Valley as 'Mr Semiconductor', Dr Noyce played a vital role in the development of the world-wide semiconductor industry. He was a co-founder of Fairchild in 1957, and helped to set up Intel, of which he was still vice-chairman at the time of his death. For the last two years of his life he also spent much time working as chief executive of Sematech, the American semiconductor research consortium.

Dr Noyce was 62 and died from a heart attack.

NEWS

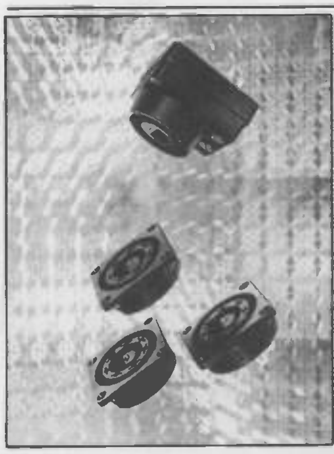
TRANSATLANTIC *BRAIN SWAP*

Micro Devices feel that "for the first time in the UK. designers can get hands-on experience with the latest advances in hardware Digital Neural Network (DNN) technology". The company, based in Florida, has signed an agreement with the English-based company Tubb Research, allowing them to provide full sales and engineering assistance for a range of ics which utilise 'brain-like' neural networks.

The ics have been designed to make very fast comparisons and decisions on real world data. One low cost chip can provide the performance of a 25 MIPS processor! Programming is eliminated because the network is trained.

By experimenting with this leading-edge technology, the UK designer can at last incorporate DNN into a vast range of products, to add 'learning' and 'intelligence', from office equipment to financial market analysis, from defence and space equipment, to robots and cars.

For further information contact Tubb Research Ltd. 7a Lavant Street, Petersfield, Hants. GU32 3EL. Tel : 0730 60256.



8 TO THE BAR

With more and more users of disco lighting systems turning to printed circuit board control, Bulgin have added a panel mounting connector with pc spills to their widely used Disco 8 family of connectors.

The new model PX0552/PC is an eight pole connector moulded from glass filled nylon, with a maximum rating per pin of 6A 250V ac. Its mouldings are polarised to prevent accidental misconnection.

For more information contact A.F. Bulgin & Co PLC, Bypass Road, Barking, Essex, IG11 0AZ. Tel : 081-594 5588.

ACID TEST

Litmus paper yet again seems further threatened as an endangered species with the introduction of ET's new digital pH meter, model 8000.

It is a hand held meter, using the latest electronic technology to make it simple to use and to measure 0.00 to 14.00 pH with an accuracy of 0.02 pH. All measurements are displayed on the 12.5 mm high liquid crystal display, which incorporates the mode of measurement and low battery indication.

For more information contact Mrs D. Prior at Electronic Temperature Instruments Ltd, 52 Broadwater Street East, Worthing, West Sussex, BN14 9AW. Tel : 0903 202151.

CHIP COUNT

MEGACELL MICROS

The powerful ST6 family of HCMOS single chip microcontrollers is now available from Impulse.

Manufactured in a proprietary low power HCMOS process by SGS/Thomson, the ST6 family comprises a range of applications-orientated microcontrollers. The 8-bit architecture of the range features a simple instruction set, and includes the ability to perform 16-bit manipulation. (The data we received actually says "1-bit" but we're pretty sure it means 16-bit!) A wide range of operating voltages from 2V to 6V is supported, and clock speeds can be up to 8MHz.

This family features a 'Megacell' modular approach to its specifications, meeting a wide range of applications requirements. Thus a core cpu can be complemented with a choice of memory sizes and an extensive variety of i/o and peripheral options. These include adcs, serial i/o, 16 and 8-bit counter/timers, DTMF generation, watchdog systems, lcd devices and so on. A range of standard configurations is available from Impulse.

Memory options include rom sizes of up to 8K bytes coupled with ram sizes of 64, 128 or 256 bytes. Versions using eprom for program memory are also available.

PC383C562 MICROCONTROLLER

The new PC383C562 cmos controller from Philips is an 80C51-based type with all the extra functions needed to enable it to control a variety of advanced consumer equipment such as satellite tv, video recorders and high-end cd players. The 'extras' include an 8-bit adc, a dual dac with pulse-width modulated outputs to drive stepper motors and another 16-bit timer/counter.

The basic elements of the chip are 8K bytes mask programmed rom, and 256 bytes of ram. Both are expandable off-chip to 64K bytes. A full duplex UART serial interface and five i/o ports are included.

In addition to the standard features of the 80C51, the new microcontroller has an extra 16-bit counter/timer (coupled to three compare and four capture registers), a 16-bit watchdog timer and an idle and power-down modes for low power operation.

The extra 16-bit time/counter makes the device well suited for applications such as automatic tuning. The on-chip 8-bit adc can be used to track parameters such as battery voltage or the position of a cd player's laser.

NE8392A TRANSCEIVER

Philips has just released a new transceiver, the NE8392A, for use in the interface chip sets for Ethernet and Cheapernet (Thin Ethernet) local area networks (LANS).

The transceiver is connected between the coaxial cable of the LAN and the data terminal equipment (via isolation circuits). The data terminal ics are available from other sources.

The device consists of a receiver, transmitter, collision detector, heartbeat generator and jabber timer. During transmission the jabber timer is initiated to disable the transceiver in the event of a 'longer than legal length' data packet. Collision detection circuitry monitors the signals on the coax cable. At the end of every transmission the heartbeat generator creates a pseudo-collision for a short time to ensure that the collision circuitry is functioning correctly. (Own up, how many of you thought the chip had medical applications?!)

MANUFACTURER'S ADDRESS

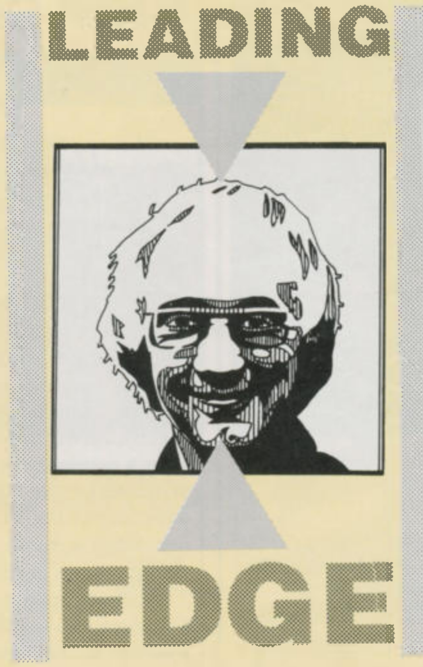
Impulse Electronics, Hammond House, Caterham, Surrey, CR3 6XG. Tel : 0883 46433.

Philips Components Ltd, Mullard House, Torrington Place, London WC1E 7HD. Tel : 071-580 6633.

MAPPING PERSPECTIVE

BY BARRY FOX
Winner of the UK Technology Award

Although cartographers welcome hi-d global cartography, will the rest of us be over the moon with fuzzy auto-focus?



The Department of Photogrammetry at University College London has for four years been working with British companies Thorn EMI and LaserScan of Cambridge on a technique of generating three dimensional maps from two dimensional pictures. Not surprisingly the military is in on the act. The Royal Signals and Radar Establishment at Malvern helped with the research, and the Ministry of Defence chipped in with £0.9 million on top of £1.6 million from the British Government.

UNDER-MAPPED

Essentially the system is a computer which builds three dimensional images of the earth's surface from pictures snapped by satellite. The project is part of the Alvey programme. Indeed, project leader Peter Muller of UCL says it is "the only Alvey project with a commercial future".

"The surface of the earth is appallingly badly mapped," says Muller. "There are no maps at all for large areas of Africa and Asia".

OVER-JARGONED

The press got a private briefing ahead of the University's Chancellor H.R.H. The Princess Royal. Although UCL had been smart and employed a PR agency to try and translate the technology into something halfway to understandable English, I did still wonder what on earth HRH made of the bumph she was given.

"Note the dense haze and jet contrails on the left image in a Lambert Zone-3 map projection ... image displayed in the UCL Dynamic Visualisation Toolkit program, DISP, on a Sun graphics work station ... an orthographically projected image is first created ... a planimetric flight path is first hand drawn as a wireframe view ... the first data-sets created will be global topography ... using the UK Along-Track Scanning Radiometer..." and so on and on and on.

Who says the royal family don't earn their living ?

It reminded me of the way Dennis Thatcher manages to look interested when obliged to follow wife Margaret round the latest Japanese factory in Britain to mass-produce widgets.

"Oh look", he says. "There goes another one, just like the last one."

SPOT-LITE

The UCL system is actually very clever, once you get past the jargon. UCL has been working with pictures of the Earth received from the French Spot satellite, which orbits the earth at an altitude of 840km. Spot's camera has a strip of 6000 solid state light sensors which scan the image line by line, in a raster of 6000 lines, like a very high definition tv camera.

To provide the information needed for 3-D analysis, the camera looks at the earth through a mirror which can be tilted by 27 degrees either way. On one pass over a selected area on the ground the mirror is tilted one way. On another pass over the same area, weeks, months or even years later, the mirror is tilted in the opposite direction. This provides two pictures of the same terrain, taken at a difference angle of 54 degrees. UCL uses a gang of 32 transputers, working in parallel, to compare the picture pairs, identify identical objects and deduce their height from the different perspectives. The computer then either generates a three dimensional image on a tv screen or adds colour to a flat paper image to signify height above sea level. The system is accurate to 10 metres on the ground. By working in parallel, the transputers can process around 200 picture points per second and build a full image in a few hours, compared to a fortnight per image with previous systems.

The same technology can be used to produce terrain models for mineral exploration, give patients a preview of what they will look like after facial surgery and predict earthquakes by pin-pointing strains in the earth's surface. The first commercial use will be to map volcanoes in Siberia.

FUZZY LOGIC

In Japan there has been a lot of talk recently about gadgetry that relies on "fuzzy logic". This is a way of writing computer programs so that they can cope with fuzzy information like "maybe it does this" and "probably it does that" and "perhaps it would go there". Normally computers deal only in the hard facts "yes" or "no". Fuzzy logic helps military systems decide, on balance, whom to attack. It helps computers fly planes. The Japanese are now trying it on consumer electronics equipment and the first publicity push is from Sanyo. The company recently unveiled a new camcorder with fuzzy logic in Japan, the US and Europe.

The theory makes some sense. The auto-focus and auto-iris exposure electronics take a lot of fine readings instead of a few coarse ones, and then follow a set of rules on how to interpret the results and adjust the camera. But the camera is only as good as its rules. It can't do what humans do and mentally over-ride visual cues - like listening to someone behind you at a cocktail party. Sanyo's focus system has 21 rules. The crunch question is how they cope with well known auto-focus crackers, like a white shirt seen through wire netting or someone in the audience walking in front of a telephoto shot of a band on stage.

OUT-FOXED

I wish I could tell you the good news that fuzzy logic beats these crackers. But, with what may sound to some like somewhat fuzzy logic, Sanyo UK wouldn't let me go to their demonstration of this interesting new technology because I have in the past referred in print to Sanyo UK's failure to communicate on interesting new technology.

However well the camera does or does not cope with difficult scenes, is it really wise for Sanyo (both in Europe and the USA) to boast the feature "Fuzzy Auto Focus" ? For most punters, the last thing an auto-focus system should be is fuzzy. PE

Man is a tool-using animal ... without tools he is nothing, with tools he is all.

So pronounced Thomas Carlisle sometime during the 19th Century, at a time when technology was, on an immense and glorious scale, making its impact felt on society.

We, at the end of the 20th Century, think our technology and accomplishments are incredible, that the tools we have today can achieve more than any of those invented by our predecessors. But is it necessarily so? It's a matter of perspective, and how you define the achievements wrought with the aid of tools. Had we lived a hundred years ago, our wonder at the marvels being worked around us and by us would surely have been no less than we experience today.

With interest, I have been following the progress of the Channel Tunnel. I've visited the Shakespeare Cliff site a few times and once the press waiting list shortens hope to tour the tunnel itself. The giant borer and its associated machinery are impressive examples of the precision to which we are capable of working with tools on a grand scale. The lasers and computers used to guide the cutting show our tooling capabilities at the other end of the scale. That we can manipulate electrons and photons is indeed a modern miracle. And yet, the Victorians believed that they also could put a tunnel under the Channel.

PRACTICAL ELECTRONICS

TOOLS FOR THE JOB

It's sometimes a mistake to think that today's tools are the only ones which could do the job. You've only got to look at the great railway tunnels built by the Victorians. They rightly had faith that they possessed the tools with a Chunnelling ability. It was only politics that prevented them from achieving it.

But *possessed the tools* is the key phrase. It's usually nonsense to attempt a job without the right tools. At times you may be lucky: you may find that a coin in your pocket is simply a screwdriver in disguise, or that your teeth really grew up to be bottle openers. But don't count on it. You won't always find that imaginative thinking can metamorphose mundane objects into the tools you need. You may come a cropper because you haven't given full thought to the implications of attempting something for which you may be ill-prepared.

A handful of readers found themselves in this predicament over the *Eprom Poly-Programmer*. They had read part one in *PE* May 90 and enthusiastically rushed out to buy the components. Very commendable! Except that they should have waited for part two in June so that they could better assess whether they had the tools for the job. Regrettably, they hadn't. The *Eprom Poly-Programmer* is a sophisticated device which is partly controlled by its own eprom. That eprom needs to be programmed on another programmer. These few unfortunate readers found themselves in a Catch-22 situation: they wanted a programmer but hadn't a programmer to program it!

So I chatted with Kevin Browne, the project's designer. Very kindly, he agreed to program readers' eproms for the project in return for a very nominal donation towards his expenses. Problem solved - he has the tools.

But take heed, however enthusiastic you are, before you start a job make sure you know what's involved *and that you've got the tools for it.*

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VISA

The aim of this project is to enable readers to use a television set as an oscilloscope. It has several applications. Primarily, it will have enormous appeal for anyone who is interested in electronics but does not wish to spend a few hundred quid on a true scope. This will cost you less than £100. For those who already have a scope, this interface will provide an additional visual means of monitoring signals and can be used in parallel to the scope. It has a third application as well: as an educational project allowing teachers to display signal waveforms on a large screen for the benefit of the whole class. Fourthly, it will give experience in high speed digital electronics and an insight into the nature of tv and computer screen control.

As a circuit design, the project is worth studying in its own right, even if you don't intend building it, for it is a good example of an interactive digital system in which the operation of each part is heavily dependent upon feedback from other parts in a semi-closed network.

PE TELE-SCOPE

After years of waiting for the technology to become available, John Becker presents a PE first – an interface that turns your tv into an oscilloscope!

WHAT IT DOES

The project is an interface which samples signal waveforms and converts them into a format which can be sent to a tv via its aerial socket. **It is not necessary to make any internal modification to the tv.** The tv will simply react to the interface signals as if they had originated from a tv transmitter, video recorder or computer video output. The only requirement for the tv is that it should be capable of being tuned to channel 36. This channel is the same one as required for use with many home computers, such as the BBC and Commodore 64, etc. The interface can be used with colour or black and white tvs.

Digital and analogue signals can both be handled by the interface and displayed on the tv screen. The input frequency range is from dc to in excess of 2MHz.

Many of the facilities found on true oscilloscopes are included: manual and automatic synchronisation control; ac and dc signal selection; input amplitude and gain control; triggering on either positive or negative edges of the waveform; frequency range selection; internal or external sync selection; internal or external time-base clock selection. An additional control allows the signal to be 'frozen' at any moment and displayed as a static waveform on the screen, remaining unchanged for as long as you want. In other words, it acts as a storage scope.

LIMITATIONS

Those are the 'pros'. There are, though, some 'cons'. The main drawback is that the displayed waveform is a sampled one. This means that with analogue signals (sine waves, triangle waves etc.) the displayed trace will consist of discrete steps and not be as smooth as with an ordinary scope.

For square waves I have used a different sampling technique to that used for analogue signals and the resulting display does not consist of discrete steps. The adverse effects of sampling square waves does not become significantly apparent until the input frequency approaches that of the sampling clock. When the sampling clock is not synchronised to the input frequency, the duration of each input square wave as seen on the screen will vary fractionally. The variation will be related to the phase of the signal and the clock at the moment the sample is taken.

The sampling technique also places limitations on the use of the unit to measure relative dc signal levels. These will only be displayed to within an accuracy of ±one vertical screen step. However, there are 64 vertical steps available, so the drawback is only a minor one.

Despite the limitations, the *'Tele-Scope'* is a very useful adjunct to the hobbyist's test bench. As a visual signal monitor and tracer it will open new horizons for those who feel blind-folded when only using a meter to check circuit operations.

REVIEWING TECHNOLOGY

So far as I know, no hobbyist magazine has ever published a project that enables a tv to be used as a high-speed scope. (If anyone knows differently, please let me know!) My own idea for designing one goes back many years to when much of my hobby time was spent messing around with old tvs. One year I had persuaded my home-built scope to display miniature green tv pictures. Could I reverse the situation, I wondered, using the tv as a scope? By hard-wiring into parts of the tv, I found that I could but, without completely modifying the tv's time-base generators (which was beyond my abilities at that time), the result had a very limited bandwidth.The limit, of course, was dependent on the tv's horizontal scan rate, which had been set by the manufacturers to be pretty tightly fixed.

Some years later I experimented with feeding a modulated signal into the tv aerial input to see if I could come up with a project suitable for PE readers to use without modifying tv circuitry. I achieved results, but could not give the unit the input frequency range I wanted. It also had the slight drawback of displaying the signal sideways! To achieve a vertical display without turning a tv on its side it is necessary to sample the vertical-going input signal and replay it horizontally. At that time, semiconductor technology was insufficiently advanced to allow sampled reorientation to be readily carried out at any meaningful speed. To have produced such a sophisticated unit in those days (20 years ago?) would have involved many, many components and pcbs.

I was reminded of my ancient experiments when the screen of my workshop computer (Commodore 3032) failed. Until I was able to obtain a circuit diagram for the display circuitry (ultimately offered and supplied by many kind PE readers) I had to use a portable tv as the monitor. This first required me build a uhf modulator and vdu signal mixer to interface between the computer and tv. Building the module prompted me to re-examine the feasibility of 'tele-scopes'. The technology required is well and truly with us now. Hence the *PE Tele-Scope*. Its functional block diagram is shown in Fig.1.

SIMPLE COMPLEXITY

The block diagram may look complex to some of you, and indeed there are a lot of parameters to be considered when designing a project such as this. However, the design complexity should not cause readers to worry unduly about building the project. You don't need to understand all the design logic in order to build and use the unit. Nearly all the chips are digital and there is no tricky setting-up to be carried out. Providing the components are bought from a reliable source and care is taken when soldering the pcb and wiring, assembly of the unit should be within most reader's capabilities.

The design has five main circuit sections: input signal conditioning, signal sampling, storage, synchronisation timing, and tv interface.

UP, DOWN AND SIDEWAYS

Conventionally, we regard a signal waveform as having an amplitude which varies vertically. If this amplitude is displayed on a screen then a high voltage will be displayed at a higher point of the screen than a lower voltage. We also regard time as travelling horizontally. In keeping with these basic man-made assumptions, an oscilloscope moves a glowing dot across its screen from left to right, representing the time factor. The dot can also be moved up or down the screen depending on the voltage level detected by the scope's circuitry at a given point in time. When the dot reaches the right hand side of the screen it shoots back to the left and restarts its travel across. With suitable synchronisation, the relationship between the horizontal timing and vertical deflection can be controlled so that a waveform becomes displayed on the screen.

With a scope, the vertical position of the screen dot is always relative to the signal level being monitored, and the rate at which it travels across the screen can be readily changed by varying the rate of a separate controlling oscillator. With a tv set, both the vertical and horizontal dot deflections are related to time (though of course it's voltage which causes the dot to be in a particular position). The tv set has two internal oscillators, one controlling the vertical position, the other controlling the horizontal. Vertically, the dot travels down the screen and back again to the top 50 times a second (60 times in some countries, and also see the notes at the end of part two). For each time the dot travels down the screen, it is also caused to travel across it a far greater number of times. With the tv sets in common use now the horizontal rate is 625 times for each vertical transition (though in earlier times the horizontal rate used to be 405 times). Neither of the rates can be significantly varied by the tv's user-accessible controls. Nor can we apply an external voltage to the dot in order to change its screen height. How, then, can we cause the tv to shows its dot in a position relative to an external signal voltage and timing factor? By a bit of jiggery-pokery!

BLANKING

A tv signal appears as a picture on the screen due to third option available with a tv tube (cathode ray tube, or crt), that of being able to vary the brilliance of the dot, from nil to full. These changes in brilliance are controlled by the signal transmitted to the tv by the broadcasters and are synchronised to the correct vertical and horizontal positions. We can also use this tube attribute in order to create the illusion of a scope-type waveform display, by turning the dot on and off at related points during its vertical and horizontal travels.

SAMPLING

Two processes are required. First, we take samples of the signal voltage at frequent intervals, storing the result each time as an

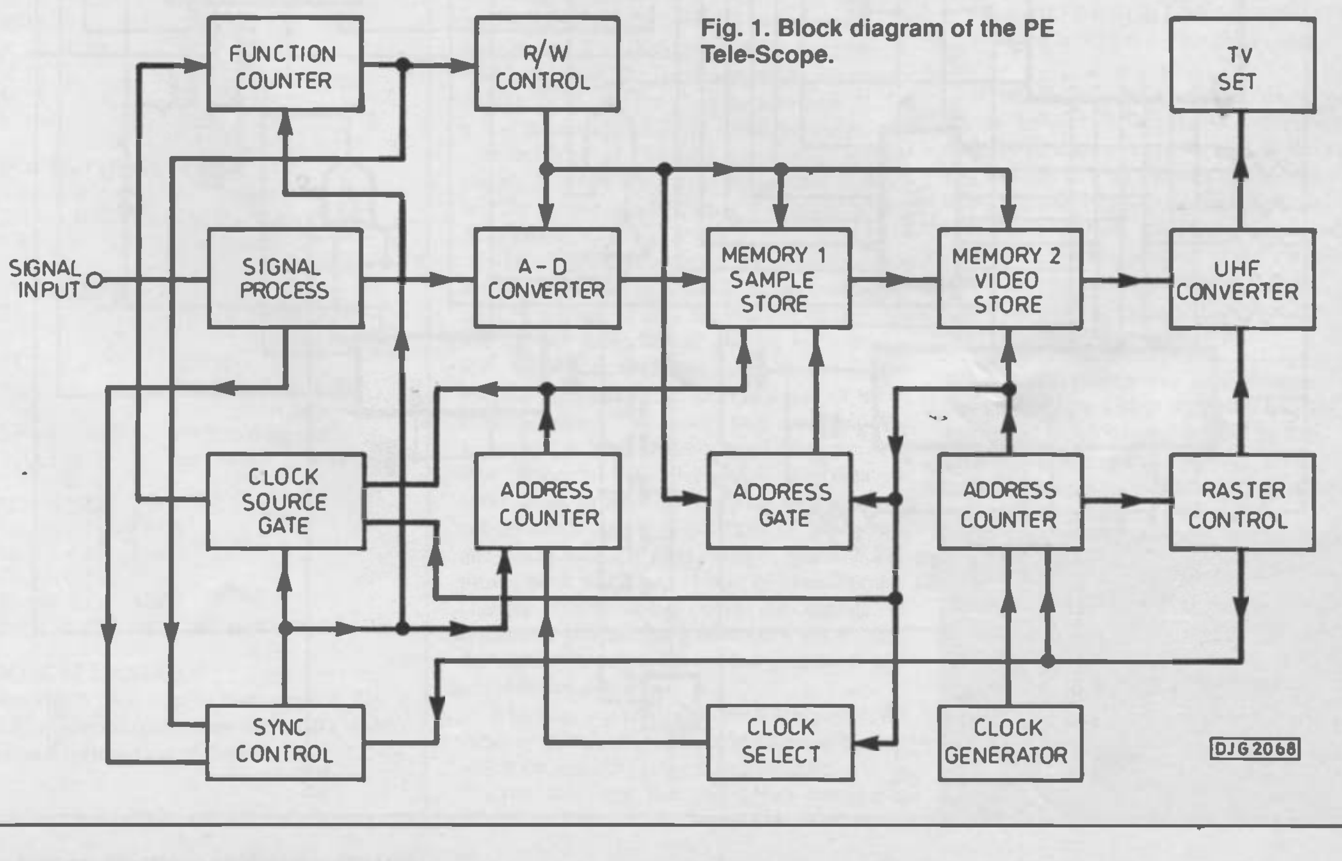


Fig. 1. Block diagram of the PE Tele-Scope.

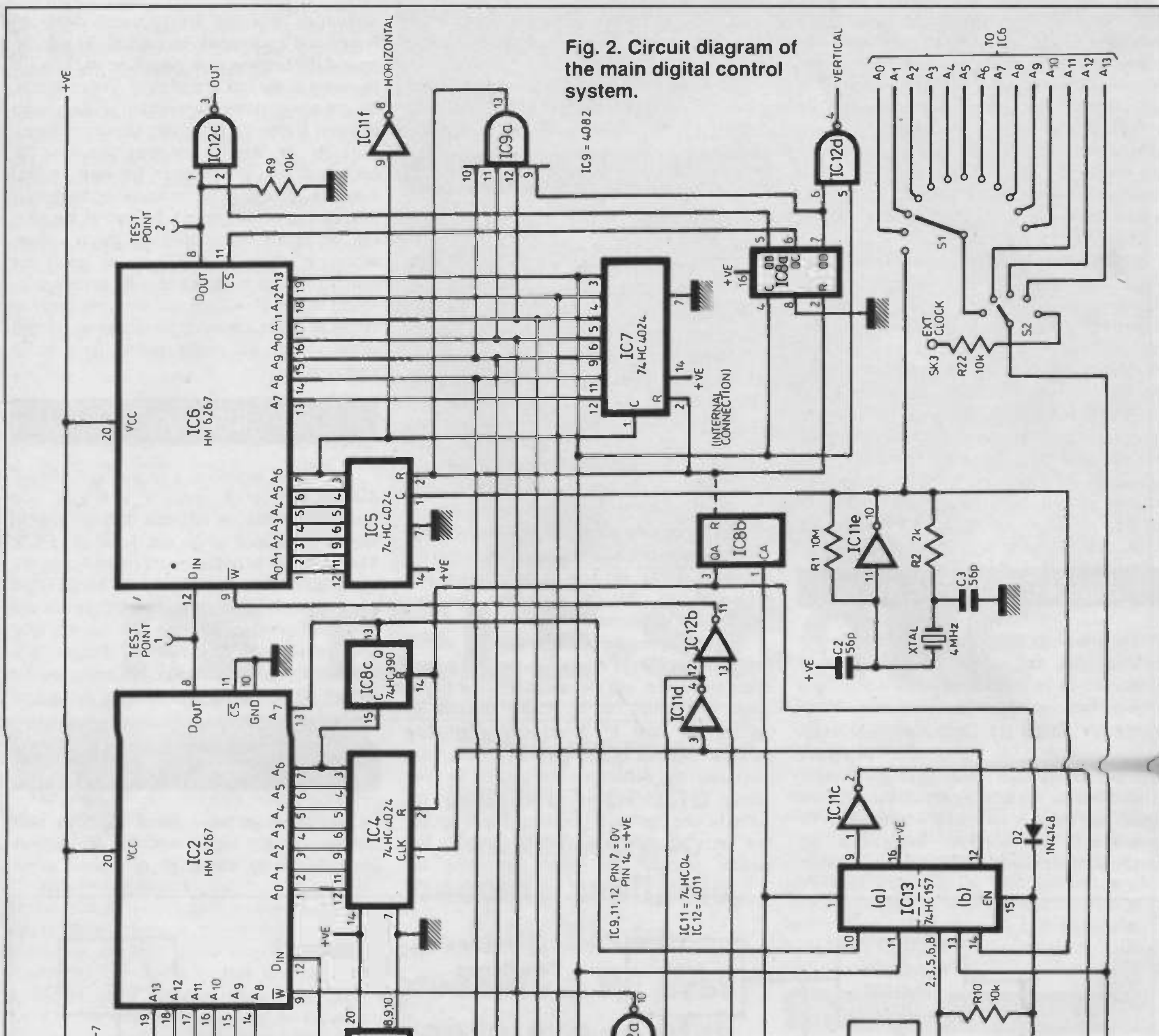


Fig. 2. Circuit diagram of the main digital control system.

equivalent digital number. The number is related to the equivalent height of the voltage. We can also regard the number as being related to the number of times that a dot has travelled across a tv screen before it has dropped to a particular screen height. The sample number can therefore be regarded as representing the screen line number.

For example, suppose that we are able to sample the signal at 625 different points during its vertical travel. We could then regard point 1 as representing the highest possible voltage, and point 625 as representing the lowest possible voltage. If an individual sample shows that a voltage is present when point 13 is sampled, then that sample can be considered as occurring on tv line 13, likewise point 14 would relate to line 14, point 97 to line 97, and so on. Having taken a group of samples of the signal and stored it, we then replay the store telling the tv to turn on its dot only if the line count corresponds to the same number held in store. If the same number is not in store, then the screen remains blank for that line. In the example above, only lines 13, 14 and 97 would have the dot displayed on them.

Of course, we also have to tell the tv at what point along each line the dot should be turned on or off. We don't necessarily want the screen to show the dot moving across its full width, that would just look like streaks on the screen. It is also necessary, then, to relate the taking of each sample not only to the voltage, but also to the time at which it is taken. The process needs to be synchronised.

COMPONENTS

MAIN UNIT AND SIGNAL BOARD

RESISTORS

R1	10M
R2	2k
R3-R10, R15, R19, R20, R22	10k (12 off)
R11, R16-R18	100k (4 off)
R12	1M
R13, R14, R21	4k7 (3 off)

All 0.25W 5% carbon film

CAPACITORS

C1, C4-C10	100n polyester (8 off)
C2, C3	56p polystyrene (2 off)
C11	220n polyester
C12	1n8 polystyrene
C13-C15	33µ 6.3V elect (3 off)
C16	100p polystyrene

SEMICONDUCTORS

D1, D2	1N4148 (2 off)
IC1	CA3306
IC2, IC6	HM6267 (2 off)
IC3	74HC541
IC4, IC5, IC7	74HC4024 (3 off)
IC8	74HC390
IC9	4082
IC10	4017
IC11	74HC04
IC12, IC15	4011 (2 off)
IC13	74HC157
IC14	TL084
IC16	7805

POTENTIOMETERS

VR1, VR2	4k7 preset
VR3, VR5, VR6	1M lin rotary (3 off)
VR4	10k preset

SWITCHES

S1	1p12w break-before-make rotary
S2	2p6w break-before-make rotary
S3	dpdt min toggle
S4-S7	spst min toggle (4 off)

SOCKETS

14-pin dil ic (8 off)
16-pin dil ic (3 off)
18-pin dil ic
20-pin dil ic (3 off)
2mm sockets for inputs (see text) (3 off)

MISCELLANEOUS

Knobs (5 off), box to suit (approx 210 x 150 x 40mm), pcb supports (8 off), 4MHz crystal, printed circuit boards.

CELL BLOCKS

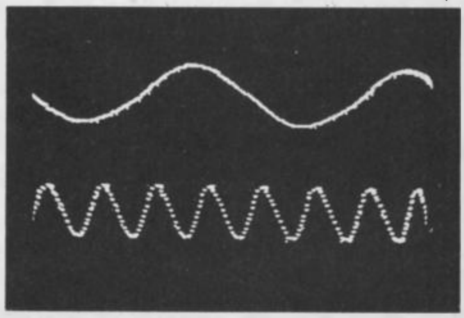
To achieve sync we don't actually store the sampled number as such. Instead, we regard the number as being the address in memory at which a 1 or 0 is stored. Before each group of samples is taken, the memory contents are all set to zero. We then regard the memory as consisting of several blocks of addresses. Each block is treated as the storage area relating to an individual screen line. A separate automatically controlled clock counter is also used which sets another set of addresses which relate to individual memory cells within each block.

In the example above, suppose the clock counter has reached a count number of 20. The first sample produced a number of 13. The memory thus selects block 13 and places a 1 at its 20th cell. The clock steps on by one place, at which moment the next sample is taken. Its number is 14, and the clock number now 21. So a 1 is stored at cell 21 of block 14. Again the counter steps on by one place and another sample is taken. This time the counter is at 22 and the sample is at 97. So a 1 is stored at cell 22 of block 97.

The sampling takes place for as many times as there are cells in a block. If the number of cells in a block is 256, the number of samples that will be taken before playing back is also 256. At the end of the sampling batch, the memory then has all its address lines put under counter control. The counter now waits until the screen dot is back at the start of line one. It is then triggered to play back its data in consecutive order, first stepping through each cell of block one, then each cell of block two, and so on until the final count is reached. The timing is set so that the change of block number changes synchronously with the change of screen line number. Each time a cell has a 1 in it the screen dot is turned on, but turned off if a cell contains a 0.

When the full replay has been completed, the memory is then reset with 0s in all its cells, after which the sampling process begins again.

(You will spot that the circuit contains a second memory. This will be discussed later; it is used to enable the screen to constantly display the previous samples while the first memory is busily recording another batch.)



Photographs taken of the author's tv screen using the Tele-Scope to display two analogue waveforms at different frequencies. It can be seen that the definition is dependent on the sampling rate.

ILLUSTRATION

To illustrate the sampling point, let's take a couple of examples, just looking at a section of memory having five blocks each of 21 cells. Suppose that during sampling the following sample numbers are produced consecutively during cell count numbers 1 to 21.

1, 2, 3, 4, 5, 4, 3, 2, 1, 2, 3, 4, 5, 4, 3, 2, 1, 2, 3, 4, 5

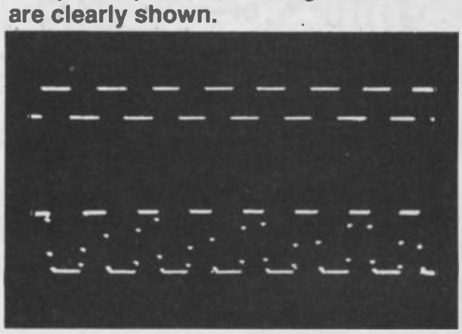
At each sample a 1 is stored in the relevant cell. This can be visualised in tabular form, with the cell count horizontally, and the sample/block number vertically:

100000001000000010000
010000010100000101000
001000100010001000100
000101000001010000010
000010000000100000001

If you squint your eyes you should see that the 1s follow a triangular waveform pattern. And if that data were to be sent to the tv as a series of bits turning the screen on or off, 105 of them, consecutively along each line and down each block in turn, the screen would actually show a triangular waveform at the top left hand corner, five lines deep and 21 bits long.

On another occasion, the memory might record this next sequence:

Also taken using the Tele-Scope, these photos show a digital signal sampled both digitally and in the analogue sampling modes. The sample steps in the analogue mode are clearly shown.



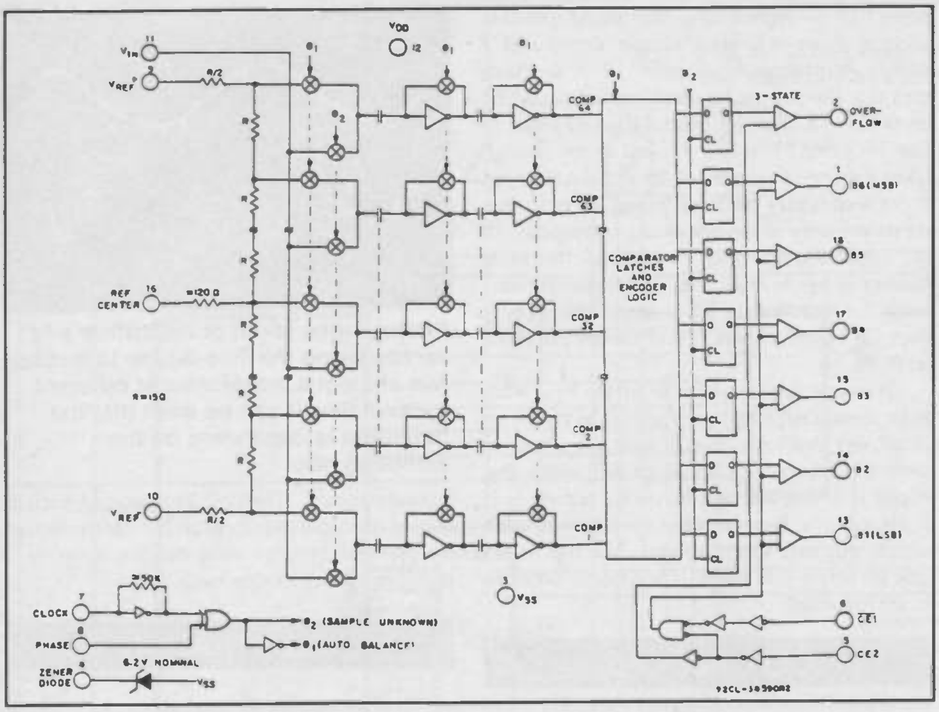
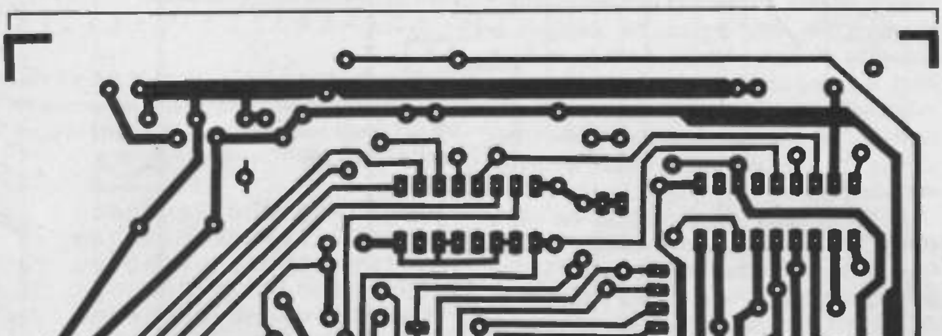


Fig. 3. Block diagram of the CA3306. Kindly supplied by Harris Semiconductors.

Fig. 4. Main printed circuit board track layout for the digital system of the Tele-Scope.



1, 1, 1, 1, 1, 5, 5, 5, 5, 5, 1, 1, 1, 1, 1, 5, 5, 5, 5, 5, 1.

In tabular form again, the results would be:

111110000011111000001
000000000000000000000
000000000000000000000
000000000000000000000
000001111100000111110

... which is getting on towards being a square wave. A true square wave would of course be expected to show an instantaneous change between high and low. But any transition, however fast, always take time to complete, and there will always be a slope between opposing aspects of a square wave (though it will be too fast to see except on the most sophisticated equipment). This will be especially true of digitally sampled waveforms where only one sample can be taken at any given moment. The next sample will always be placed in the next memory cell.

This is the reason why I have used two different sampling techniques in the unit, one for digital and the other for analogue signals, as you will see shortly.

SCREEN MEMORY OPTIONS

The tabular examples above are a very coarse representation of waveforms and we can achieve far better results if we use a very fast sampling rate, squeezing as many dots as we possibly can onto each screen line. There are practical matters to consider, though, such as the maximum rate at which circuitry can handle all the necessary procedures, and the availability of memory space. Suppose we want 1000 dots on each line and we want to use all 625 lines. We would need a memory of 625000 bits. Not an unreasonable demand it would seem. But those 625000 memory cells have to be accessed once every 50th of a second, requiring an address clock rate of 31.25MHz. Memories of that size and speed are beyond the pockets of those for whom this project is intended. And if money is no object, you'd be better advised to spend it on a true scope. The main intention of this project is to offer visual test bed facilities at a lower cost.

Let's look at the situation from that side, then. What high speed 1-bit memories are available at a reasonable price? A 16K x 1-bit memory such as the 6267 is an obvious choice. It costs about £8.00 at full retail price but by shopping around can probably be bought for less.

We have to partition the chip into blocks and lines, and with a 16K memory (having 16384 locations) we have to compromise between dot definition and screen area usage. I have opted for a split for 64 lines with 256 bits available for each line. Accessing 64K 50 times a second requires a minimum clock speed of around 820kHz, though of course we actually need a faster clock than this since we are now only using part of the screen, and we must also synchronise with the screen line generator built into the tv.

SAMPLING CONSIDERATIONS

The speed, cost and availability of the signal sampling chip is the next consideration. Many of you will be familiar with well-established analogue to digital converters such as the ZN427 and ZN448. These, though, have a maximum conversion rate of 10 microseconds, meaning that only 100,000 samples can be taken each second. For analogue signals, sampling must be carried out at least three times faster than the signal's frequency, consequently a sampling rate of 100kHz allows a maximum input frequency of about only 33kHz. The ZN427 and ZN448 are thus far too slow for a unit which I wanted to be able to handle signals of at least 1MHz.

A chip which allows that rate and which is available at a reasonable cost (about £7) is the CA3306 flash adc, (see Fig. 3). This is a 6-bit converter which can handle in excess of 10 million a-d conversions per second. Its 6-bit output produces 64 separate address numbers, which suits the memory split discussed above. Being a slightly specialist chip, the CA3306 may not be widely available from hobbyist suppliers. If you have any difficulties purchasing it, or the memory chip 6267, contact the manufacturers' UK distributors, such as Electromail (a company related to RS Components) on 0536 204555. But give your regular supplier a call first since he may stock them and not have told me about it. He may also offer to get them for you - tell him they're useful chips to have on sale.

SAMPLING CIRCUIT

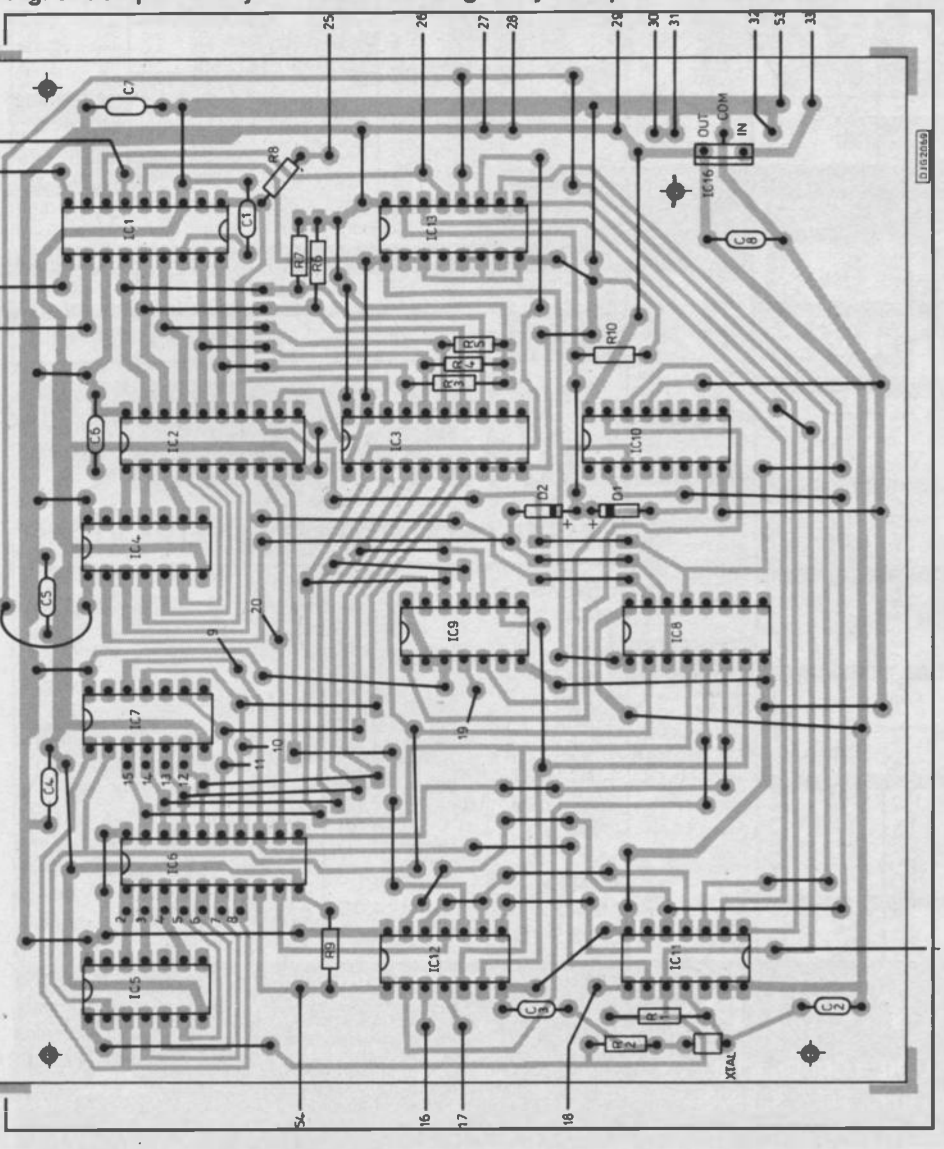
The d-a chip CA3306 is shown as IC1 in the main circuit diagram, Fig.2. The input signal to be converted is brought into the chip's pin 11. Inside the chip is a ladder network of resistors which preset separate comparison voltages against which the input signal is judged. The judging is performed by a series of comparators whose outputs are fed to coded latch gates. The gates need to be triggered by an external clock pulse allowing them to pass their data to the outputs.

The clock signals can come in to the chip via its pin 7 at any (preferably consistent) rate up to at least 10MHz. The unit has been designed to allow the clock to come from an external signal generator, or directly from within the unit. Internally, the clock source is derived from the 4MHz master oscillator circuit around IC11e which controls the address counters.The signal can be applied at the full 4MHz rate, or as a binary subdivision of it via the counters IC5 and IC7. Between them, switches S1 and S2 select the clocking rate.

The voltage range across which IC1 will produce its full selection of output numbers, 0 to 63, is determined by two reference voltages, one each for the upper and lower limits. The inclusion of VR1 and VR2 at IC1 allows these levels to be preset. There is nothing tricky about setting the best levels as the effects of adjusting the presets will be clearly seen on the tv screen.

IC1 has tri-state outputs, meaning that in addition to being able to deliver the converted code as high and low logic states, a third state exists in which the outputs are turned off. In this mode they have a very high impedance and have no affect upon other circuitry connected to them. Both pins 5 and 6 of IC1 can control the chip's on/off output state. One is used in the analogue conversion process, the other during digital conversion, as described later.

Fig. 5. Component layout on the main digital system printed circuit board.



RECORDING

In the analogue conversion mode, the outputs are held open by a high voltage applied to IC1 pin 5 by IC10 pin 3. The output numbers act as one address code sent to the first memory chip, IC2. These numbers represent the block address codes referred to earlier. The second set of address codes is delivered sequentially to IC2 from the counter IC4, whose clock source depends on whether the memory is recording or playing back.

During recording, IC4 is clocked at the same rate as IC1, although the signal is routed via the multiplexed gate IC13 (in to pin 13, and out of pin 12). The same clock signal also controls IC2's read-write mode, though it is routed by an inverter, IC11d, and another gate, IC12a.

On receipt of the clock's positive-going pulse, IC1 is triggered, passing its conversion code to IC2 lines A8 to A13. Simultaneously, the read/write pin of IC2 goes high, putting the memory into playback mode. Counter IC4 is unaffected by the positive clock level. When the clock goes low, IC1's outputs retain their conversion code, IC4 is stepped on by one place, and IC2 is put into write (record) mode. (In other applications IC1 could be triggered by the negative-going pulse edge by taking the Phase pin 8 to 0V instead of +5V.)

At this moment, the address seen by IC2 represents the block number from IC1 and the line number from IC4. Into that address is written a logic 1, as supplied by the currently-high pin 3 of IC10 (a decade counter). When the clock goes high again, the process will be repeated and logic 1 placed into the next consecutive line address at the new block address from IC1.

The process continues until IC4 has cycled twice through its count, finally triggering IC8c so that its Q output, pin 13, goes low. IC8c can simply be regarded as an extension of IC4, allowing for an 8-bit count rather than a 7-bit one. The low-going output of IC8c is taken into pin 10 of the multiplexer IC13, out through its pin 9, via the inverter IC11c, and then to the decade counter IC10, clocking it on by one place.

We shall learn next month what happens now! PE

RADIO PAGING

Mike Sanders turns over to a new pager and gets the message.

British Telecom's series 1200 Message Master radio pager.

Radio paging was meant to be a quick and simple method of getting in touch with people on the move, rather like a tap on the shoulder. No long messages to the recipient, just a bleep; this would save on the radio spectrum. Pagers now exist for receiving and storing messages.

Neither are there any facilities for the recipient to communicate with the sender via the pager. The recipient has to get to the telephone to communicate with the sender. This results in a pager that is small and light and requires low power, to power a receiver only.

Therefore pagers are usually small and light, weighing 80 gm to 120 gm. They are also rugged, some of them being designed to withstand up to six drops on a concrete surface from a height of 1.2 metres.

The Electrical Research Association carries out tests on pagers. These are attached to the body in eight different position to stimulate real life situations. With a 10 µV/m signal, a call success rate of 80% is achieved with most pagers. Pagers must also be capable of working from within fast moving vehicles and from within buildings. The pagers must be capable not only of detecting signals but also correcting errors.

The kind of people who use pagers are the ones who need to be contracted right through the working day but are so mobile that they may not be at a desk or even a car phone for any length of time. Such people are salespersons, service engineers, medical personnel, drivers, people in the construction industry, etc. These people may have to be contacted in order to redirect them elsewhere or for consultations.

ON SITE AND WIDE AREA PAGING

The main coverage areas for paging are on site (within a building or compound) and wide area (in a portion of the country).

On site paging is usually restricted to about a quarter of a mile. Wiring encircles the building and acts as an aerial which is connected to a central transmitter and encoder.

With wide area paging, customers carry equipment which is bought or rented and the pagers are centred on the telephone network.

Wide area networks can cover cities, counties and even the whole country as with British Telecom's Mobile Communications which encompasses more than 400,000 pagers.

In the USA, wide area paging networks started in the 1960s. In the UK, a trial system started in Reading in 1973. The trial was a success and the London network was started in 1976 with just one paging code then two operating at five calls per second. The national service with forty zones was started in 1981 and now uses 380 base stations which use radio equipment for transmitting the messages.

PAGER TYPES

Pagers used in wide area paging are of three types: tone, display and voice. Specialist pagers also exist. For instance, safe pagers are required in the petrol, chemical and mining industries where there is the risk of an explosion.

Silent pagers are required in noisy environments where a bleep would not be heard and also at a meeting where one would not want to be disturbed. These silent pagers are equipped with a flashing light or a vibrator so that the wearer can feel a message coming in.

But to return to the standard pagers, the tone pager emits a bleep. The caller dials the pager number from a telephone and the call is routed over the telephone network to a base station where it is transmitted by radio to the called pager. Four to eight different tones of bleep are available depending on the manufacturer, though in noisy environments it would be difficult to distinguish between the tones.

As pagers have grown in popularity, there has been a need for better and more sophisticated display type pagers. Two types exist displaying numeric and alphanumeric information. The numeric type displays telephone numbers only whereas the latter can also display messages.

The advantage of a display pager is that the recipient knows who the message is from and whether an urgent return call is required. This is a far cry from the original two tone pager - one tone usually meant 'call the office' and the other 'call home'. This has meant more air time and therefore a pressure on the radio spectrum.

In order to send a message, the sender calls an office and dictates his message to the operator who then transmits it to the recipient. The more expensive pagers can receive a greater number of alphanumeric characters and store a greater number of messages. When the memory is full, the first message is deleted so the pager works on a first in, first out principle. The owner can protect

Fig. 1. Simple radio paging network.

whichever messages he wishes to retain.

Pager memories vary from 10 messages of 40 characters each, to 20 messages of 400 characters each. In addition, pagers exist with a printer option. This is another departure from the original pager which was supposed to be small and light and nudge one in the ribs to say 'call the office'.

With the desire for speedier communications, networks are being set up where there is no need for the caller to get in touch with a central bureau by phone to send a message. Instead messages can be created on a computer which are then downloaded to the bureau computer for automatic transmission.

Bureaux that offer radio paging in addition to British Telecom's Mobile Communications are Inter City, Air Call and Digital Mobile Communications. Some bureaux offer special services like advising which subscribers are out of the country.

In spite of extra air time taken by message paging, one of the useful applications is for a broker to update the price of a commodity to all his contacts. For instance "the price of oil is 10 cents a barrel". (JR would have a fit if he received that one! Ed.)

TECHNICALITIES

A small radio paging network may be thought of comprising an encoder to select the called pager, the base section transmitter and the pagers themselves as in Fig.1. The pager codes may be generated either by a sequence of binary pulses or a combination of audio tones.

One system using audio tones in sequence is known as the ZVEI 5-tone system. Another system adopted by The Consultative Committee for International Radio (CCIR) is shown alongside the ZVEI system for comparison in Fig.2.

The CCIR scheme was meant for marine use but is used by some UK operators for land mobile paging. A modified form of the ZVEI code is also used for the UK 12.5 kHz radio system. As can be seen in Fig.2, the tones last for 70 ms but a modified form of the CCIR used in the UK employs a lower tone duration of 40 ms.

It can be seen from Fig.2 that these are twelve different tones representing digits 0 to 9 and a special function tone X and repeat tone. If five tones (five digits) are used to represent each pager code then 100,000 code combinations can be obtained.

In order to transmit a five digit code the transmitter receives a turn on command for 100 ms followed by each of the five tones for a period of 70 ms each. The total time taken is therefore:

$$100 + 5 \times 70 = 450 \text{ ms}$$

At the end of the sequence the transmitter switches off and awaits the next command. The pager in turn decodes each tone and if, say, only the first two tones are valid but the third is not valid then the pager begins a time

Tone Frequencies in Hz

Digit	ZVEI	ZVEI modified	CCIR/EEA	EIA
1	1060	970	1124	741
2	1160	1060	1197	882
3	1270	1160	1275	1023
4	1400	1270	1358	1164
5	1530	1400	1446	1305
6	1670	1530	1540	1446
7	1830	1670	1640	1587
8	2000	1830	1747	1728
9	2200	2000	1860	1869
0	2400	2200	1981	600
Repeat	2600	2400	2110	459
X	970	825	1055	2151
Tone duration (ms)	70	70	100CCIR 40EEA	40

Fig 2. 5-tone systems.

out sequence. If the third code is not received after about 110ms the pager resets and waits for the next transmission.

ZVEI stands for Zentralverband der Elektrotechnischen Industry, the Central Association of the German Electrical Industry. Since it is designed to operate on channel separations of 20kHz there is a problem in transmitting the highest tone of 2800Hz on a 12.5kHz band and the modified ZVEI or depressed ZVEI uses a tone of 825Hz instead of 2800Hz.

Another system developed by the Electrical Industries Association (EIA) is also shown in Fig 2. In general, the systems employing longer timings result in a slower call but increased reliability.

When digits are repeated the repeat tone is used. An example will make this clear. Suppose the number of the called pager is 54226, the pager decoder would respond to only one of the twos and the received code would be 5426. To prevent this, 542R6 is transmitted. Similarly for 55555, 5R5R5 would be transmitted, and so on.

Although 5 tone codes have been discussed, other systems exist using two, three and up to seven tones. The X or alternative tone is used when there is a repeater in the communication link to prevent a burst of interference from keying the repeater link.

The 450MHz (uhf) band is good for radio paging within a city since man-made noise (electrical sparking from motors, etc.) is lower at uhf. Also small wavelengths at uhf are better at penetrating gaps in buildings than vhf. In addition, at these small wavelengths a receiving aerial is easier to include within the paper.

At 450MHz, a field strength of 10µV/m to 15µV/m is required for tone only pagers and a field strength of 40µV/m to 50µV/m for tone and voice systems. Several factors will decide these levels:

i) the kind of buildings in the area
ii) the range required
iii) the power radiated
iv) the height and type of aerial.

In order to obtain a satisfactory signal inside a building, the field strength outside the building may have to be as high as 400µV/m to 600µV/m.

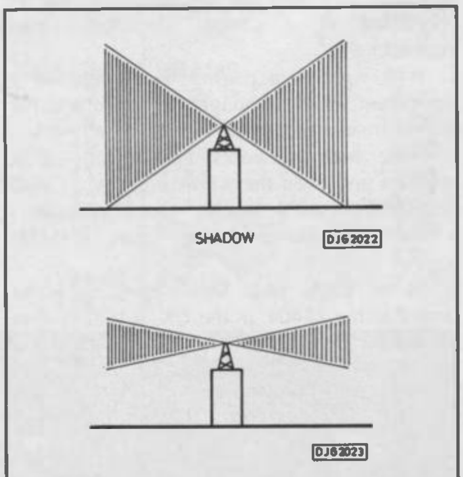
The height and gain of an aerial will also determine the area of coverage. Fig.3 shows a low gain aerial on a building and the area of coverage. Fig.4 shows an aerial with a much higher gain than that in Fig.3 and making the aerial directional throws a larger shadow near the building. This means that the signal will be far too weak near the building.

Before a radio paging system is set up, field strength measurements are taken by means of a quarter wave aerial mounted on a car which drives around the area.

BT RADIO PAGING

There are five main paging control centres in London, Birmingham, Manchester, Bristol and Edinburgh which control 40 zones. In order to provide flexible coverage there are also six regions in addition to zones. The regions are larger than zones for those that require large coverage and include the Home

Figs 3 and 4. Low and high gain aerials.



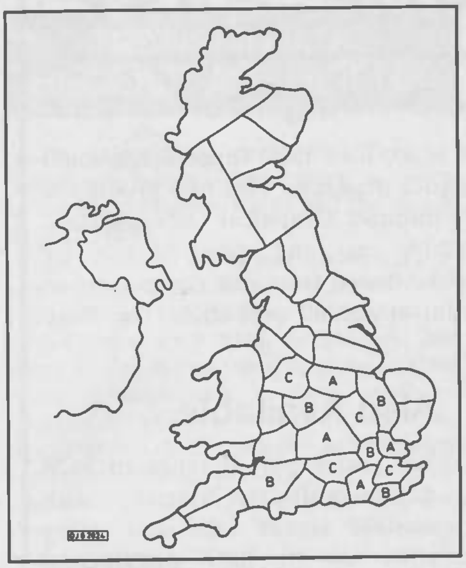


Fig 5. Frequency re-use.

Counties, Midlands, North East, North West, Scotland and West/South Wales.

The British Telecom radio paging network uses transmission frequencies as shown in a honeycomb fashion, as in Fig.5, so that no two frequencies share a common boundary and therefore the likelihood of interference is reduced.

The five main paging control equipment (pce) systems use GEC 4180 mini-computers and are interlinked and each has its message unit for storing and forwarding messages, as in Fig.6. Up to eight zone transmission controllers (ztc) are linked to a pce and up to 24 transmitters to each ztc.

Each pager is parented onto a pce and also allocated a four digit national number followed by six digits which are unique to the pager. Instead of dialling the pager number, a caller can dial the BT radio paging centre directly and get an on-line connection to the pce.

The pce then performs all the translations by looking up tables in its memory regarding the number called, method of routing, call queuing, zones called, etc.

Three 25kHz radio channels are allocated nationally in the 153MHz band. The messages are digitally encoded using the Radio Paging Code number 1 (RPC1) recommended by the CCIR.

The digital signals then modulate a carrier since it is meaningless to transmit a digital train by radio unless it modulates an rf carrier. The type of modulation used is frequency shift keying (fsk) where two frequencies are used, one to indicate mark and the other space. The deviation from the centre frequency is + 4.5kHz and the data rate is 512 bits per second.

Each pager can have up to four unique numbers and the procedure for sending messages is different from bleep only calls. To send a message, the caller telephones a manual bureau and gives the required paging number and message. Alternatively, a message paging number allocated to the home pce can be contacted by telex on dial-up data facilities.

British Telecom radio-paging also offers a voice message storage bank. If this is destined for a pager with tone only facilities, the message is intercepted and recorded. The recipient is then alerted and can receive the message at any moment after that, by using the telephone.

The transmitters can output 100W and are duplicated at each site but use the same aerial with changeover arrangements. Remote monitoring of each transmitter is achieved from each ztc with each transmitter constantly updating its status.

PAGING CODE 1

In 1975 the Post Office Code Standardisation Advisory Group (POCSAG) was formed to recommend a new paging code because it was realised that the codes in existence at the opening of the London zone would not satisfy the call rate or numbering capacity. The meetings were attended by manufacturers of pagers in Europe, Asia and America.

In 1978 POCSAG published its recommendations for tone only calls. Its capacity was more than two million pagers, each pager having four unique numbers and a call rate of 15 calls per second. The CCIR adopted the recommendations in 1982 and the name was changed from the POCSAG code to the Radio Paging Code Number 1.

Each transmission begins with a preamble consisting of bit reversals and lasting 1.125 seconds. Then follows a string of 32-bit code words encoded in BCH (Bose Chaudhuri Hocquenghem) and made up of:

21 information bits
10 check digits
1 even parity bit.

The code has a Hamming distance of five and corrects 2-bit errors and detects 3-bit errors.

The earliest tone-only pagers accepted two errors per codeword and corrected one error per message but the capability is improving all the time.

The first numeric message RPC1 pagers were produced in 1983 and the sensitivity was nearly as good as tone only pagers, the loss being about 2dB for a 10 character message.

The inclusion of message paging (numeric and alpha-numeric) reduced the air time slightly. With a traffic load of 70% the delay is 2.5s for a mixture of calls while for tone only calls and a 70% load, the delay is 1s.

The RPC1 code is good and consideration is being given to increasing the transmission rate from 512 bit/s to 1200 bit/s.

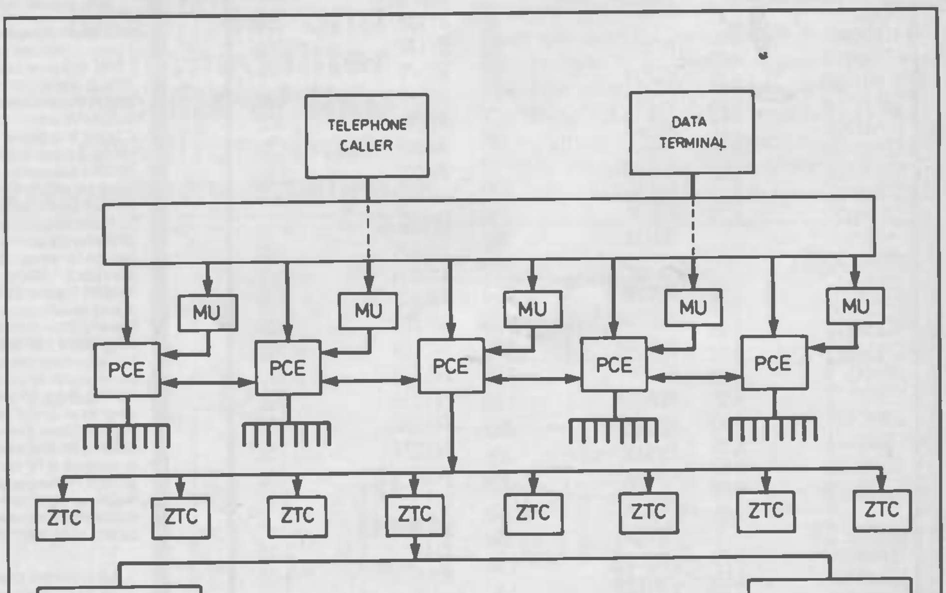
CONCLUSIONS

The need for radio paging was felt by a highly mobile society as early as the 1960s and 1970s. Paging coverage can be regarded as on-site or wide area. The on-site being restricted to the building but the wide area being as wide as the network is able to cope.

Types of pagers considered were tone only, numeric, alpha-numeric and voice. The codes in most common use are five tone codes and because there are so many different standards, the networks are incompatible. An advanced code the RPC1 which has received CCIR approval was then discussed.

Modern pagers offer users more than just a bleep, which puts an added strain on air time. Pagers are improving all the time both in memory capacity as well as in the ability to detect and correct errors. All this has been brought about by the large scale integration of circuits. PE

Fig 6. Radio paging network.



AF OCTAVE MEASURING

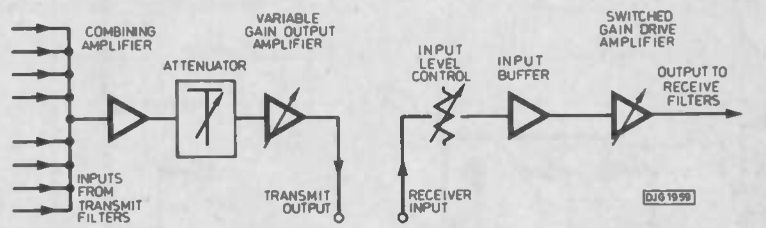
Part Two, in which Joe Chamberlain details the amplifiers and switched filter circuits of this multifunction frequency analyser.

TRANSMIT AND RECEIVE AMPLIFIERS

The transmit and receive amplifiers are housed on a common circuit board as shown in the block diagram Fig.14 and the circuit diagram Fig.15.

The first stage of the transmit section is a combining amplifier using the virtual earth configuration. The amplifier is designed to have a loss of some 20dB. At first sight this seems strange but the signal level through the filters is maintained at about +6dB to minimise the effects of noise in the filters and this level has to be reduced before being applied to the output amplifier. The maximum transmitter output signal level for a single tone is limited to 0dB in order to maintain an adequate overload margin when all ten signals are present, so it is necessary to reduce the filter output level to achieve this. The combining amplifier is followed by a switched attenuator having 10dB steps. This attenuator is interesting in that with accurate components the accuracy of the attenuation steps is better than 0.2dB using standard E24 range component values. The attenuator setting selected by switch S1 is fed to the output amplifier. The output impedance of this amplifier is largely defined by R23 and is 600 ohms. The specified output level is obtained when the output is terminated with a 600 ohm resistive load. The level at the amplifier output is thus +dB for a 0dB output signal. The feedback over the output stage is adjusted by potentiometer VR21 to provide a continuous output level adjustment range of 10dB. The maximum output level of 0dB is produced when the potentiometer is set to maximum resistance. It should be noted that the design does not incorporate a blocking capacitor in the transmit output. If the output is used to feed a high impedance load it is practical to provide a blocking capacitor of say 470nF. However, if the output is terminated in 600 ohms the size of capacitor required to prevent loss of signal level at 25Hz would be about 47 uF, which could only be realised by using an electrolytic capacitor, and if you use one in which polarity do you connect it? Far safer to use a high quality audio transformer if it is required to isolate the output when feeding a low impedence load.

Fig 14. Amplifier board schematic diagram.



In the receive section provision is made to terminate the input in 600ohms before the receiver blocking capacitor when switch S3 is closed. Blocking capacitor C1 then prevents any applied dc being fed to the amplifier input. The potentiometer VR24 is provided to allow adjustment of the signal level into the receive amplifier. The second amplifier stage has its gain adjusted by switch S2 to provide controlled steps in receiver sensitivity of 10dB. Standard E24 range components are used.

S3, R24, C1, VR24 and R25 are all mounted on the front panel of the instrument and all other components on the circuit board. The printed circuit track layout is shown in Fig.16 and the component layout in Fig.17.

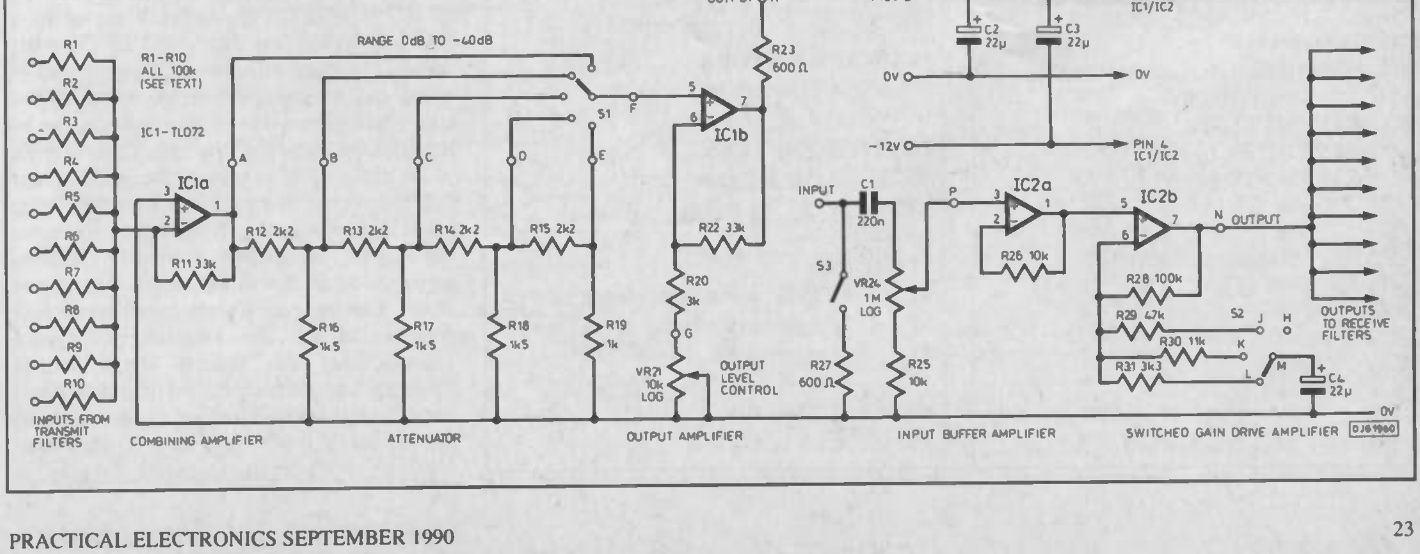
SWITCHED CAPACITOR FILTERS

Having looked at the conventional method of implementing a band pass filter design it is now time to consider an alternative approach, that of using switched capacitor filters.

One of the problems with using conventional analogue filters is the necessity of making up awkward component values. With switched capacitor filters, provided a suitable circuit configuration is chosen, the response of the filter is defined by resistors (which may be chosen in this application to be standard values) and the frequency of an applied switching signal. The switching signal is 100 times the centre frequency of the filter. This at first sight seems to be an ideal solution to all the filter construction problems but life is never that simple! One of the snags with using any digitally controlled device is that by one mechanism or another spurious products are generated when the frequency of the signal applied to the device approaches that of the switching frequency controlling it.

This phenomenon is known as "aliasing" and occurs due to the production of

Fig 15. Amplifier board circuit diagram.



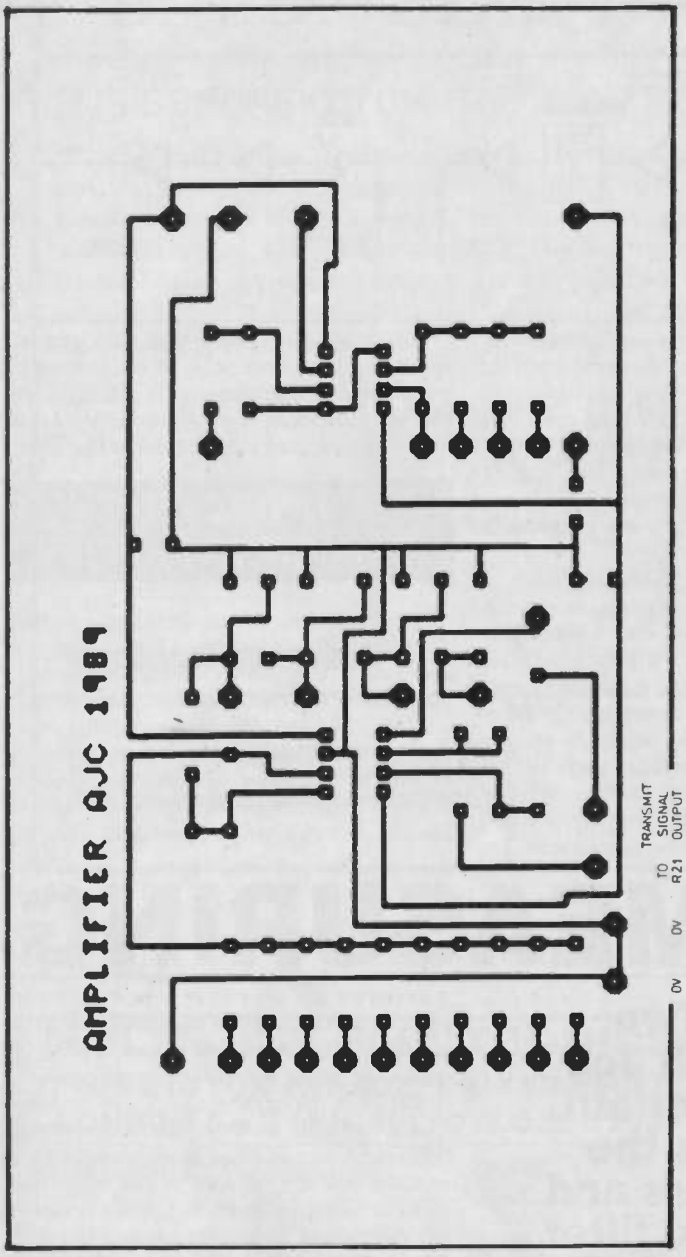


Fig 17. Track layout for transmit and receive amplifiers. When copying this and other tracks ensure that ic pin spacing is exactly 0.1 inch.

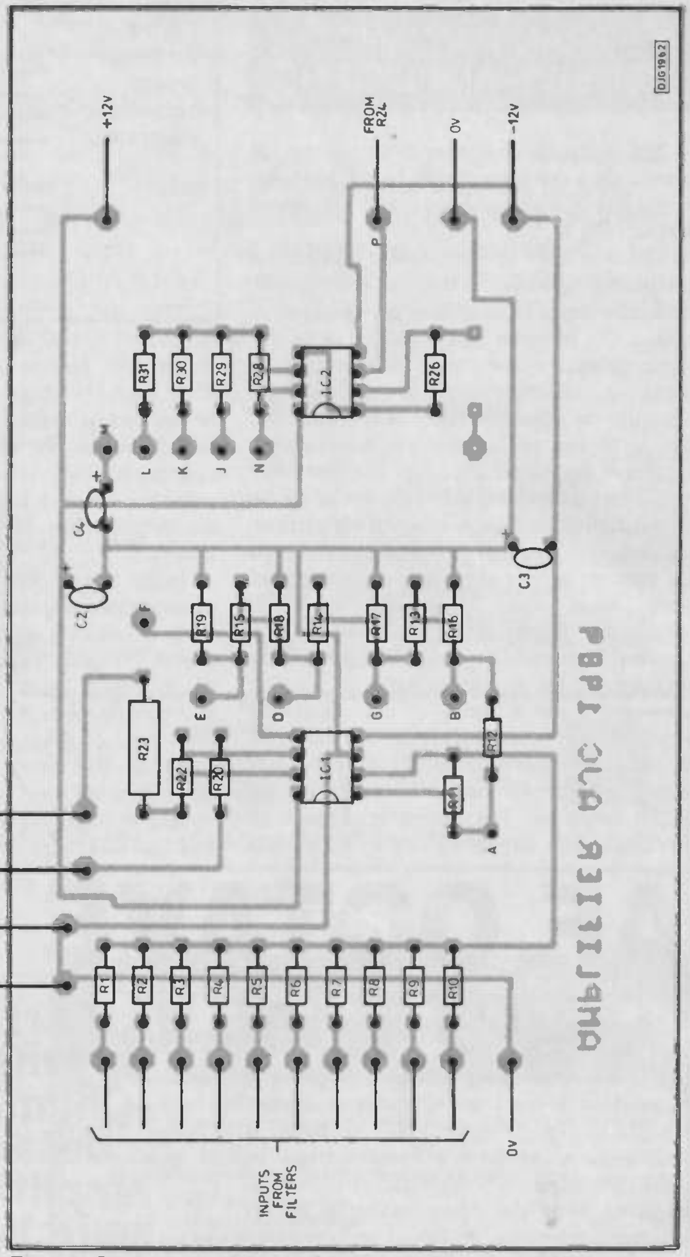


Fig 16. Component layout for transmit and receive amplifiers.

AMPLIFIER BOARD COMPONENTS

RESISTORS

R1-R10	100k (nominal value but see text) (10 off)
R11,R22	33k (2 off)
R12-R15	2k2 2% (4 off)
R16-R18	1k5 2% (3 off)
R19	1k 2%
R20	3k
R23,R27	600ohms 2% (2 off)
R25,R26	10k (2 off)
R28	100k
R29	47k
R30	11k
R31	3k3

All 0.25W 5% unless marked

CAPACITORS

C1	220n polycarbonate or polyester
C2,C3	22µ 25V electrolytic (2 off)
C4	22µ 6V tantalum

SEMICONDUCTORS

IC1,IC2	TL072 (2 off)

POTENTIOMETERS

VR21	10k log rotary
VR24	1M log rotary

SWITCHES

S1	2p6w make before break rotary
S2	3p4w make before break rotary
S3	spco toggle

MISCELLANEOUS

8 pin dil ic sockets (2 off)

intermodulation products generated by the switching signal (fo) and its harmonics beating with the signal frequency (fs). This produces signals having frequencies of fo+fs, fo-fs, 2fo+fs, 2fo-fs and so on. If any of these products fall in the pass band of the filter spurious outputs will result. The same sort of effect can be seen with analogue to digital converters. In most cases, the problem can be resolved by putting a low pass filter in front of the active filter to prevent frequencies near the switching frequency reaching the filter input. As the switching frequency is 100 times the signal frequency a simple resistor-capacitor network will suffice for the transmit filters. Problems can also be experienced with components of the switching frequency leaking onto the filtered signal output. Spurious input signals to the transmit filters can be removed by inserting shunt capacitors across the driver board output attenuator, although with even moderate lengths of

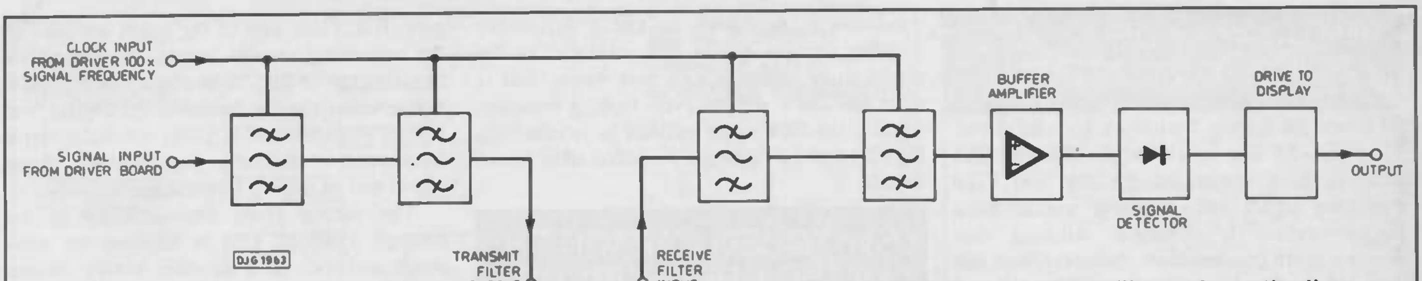


Fig 18. Switched capacitor filter schematic diagram.

screened lead to connect the driver to the filter such capacitors are generally unnecessary. The receive filters would require low pass filters on their inputs to achieve maximum accuracy but for the degree of resolution provided on the display this degree of complication is not necessary.

The schematic and circuit diagrams for the switched capacitor filter are shown in Fig. 18 and Fig. 19.

On the switched capacitor filter board the output spurious contents are removed by R7 and C1 for the transmit filter, and R14 and C2 for the receive filter. Although the switched filters are designed to have a nominal pass band gain of unity there is still a danger that dc offset potentials may be present at the filter output, so to ensure that these do not cause errors in the precision detector circuit, an ac coupled buffer amplifier stage is used to isolate the detector. In other respects the detector and display circuits are similar to the analogue filter board.

The overall performance of the switched capacitor filter is similar to that of the analogue filter but some problems may be experienced with the highest frequency unit (12.8kHz) as the switching frequency for this

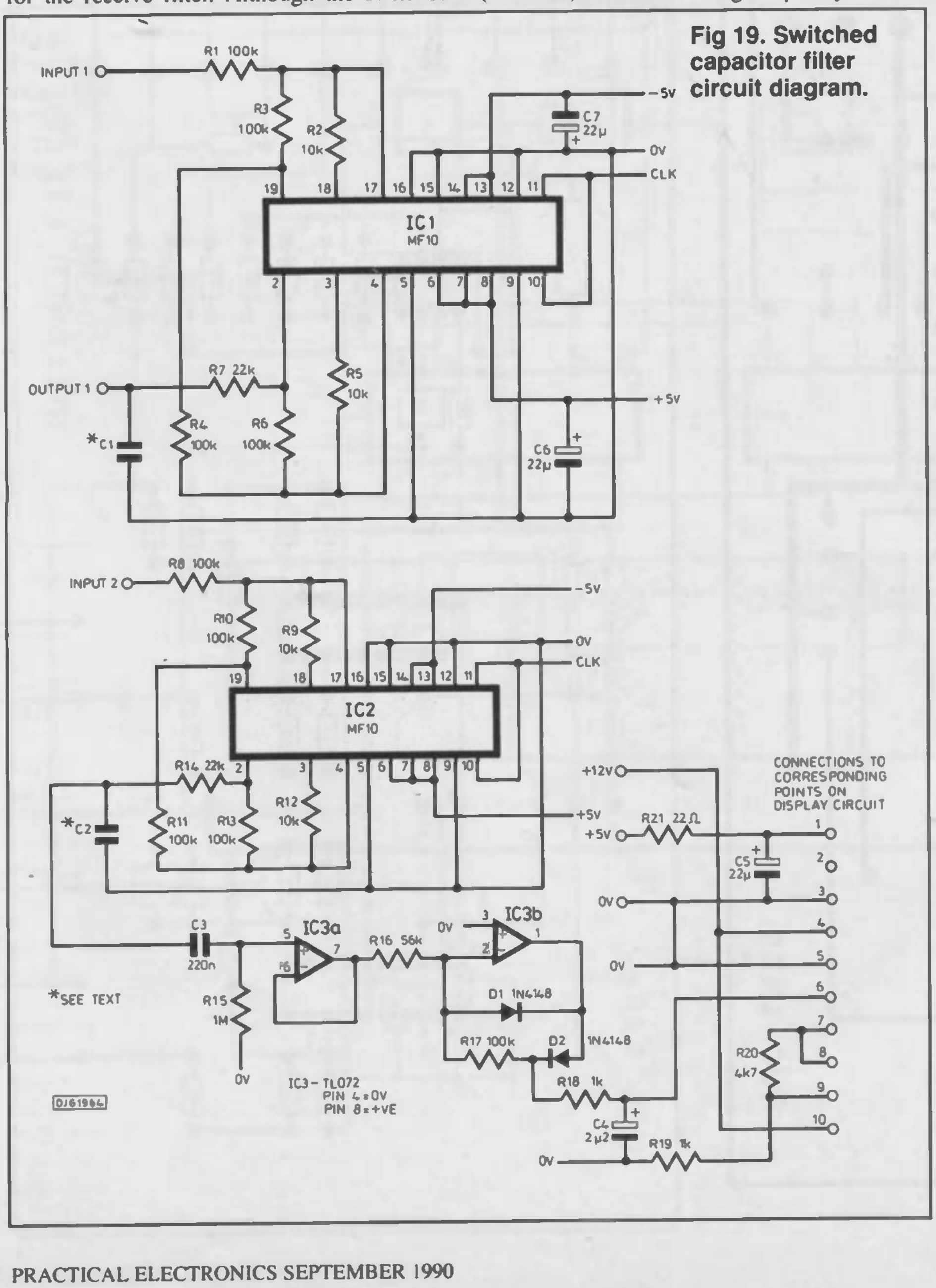


Fig 19. Switched capacitor filter circuit diagram.

SWITCHED CAPACITOR FILTER COMPONENTS

RESISTORS

R1,R3,R4	
R6,R8,R10	
R11,R13	100k 2% (8 off)
R2,R5,R9	
R12	10k 2% (4 off)
R7,R14	22k (2 off)
R15	1M
R16	56k
R17	100k
R18,R19	1k
R20	4k7
R21	22ohms

All 0.25W 5% unless marked

CAPACITORS

C1,C2	see table
C3	220n polycarbonate or polyester
C4	2μ2 6V tantalum
C5-C7	22μ 25V electrolytic (3 off)

SEMICONDUCTORS

IC1,IC2	MF10 (2 off)
IC3	TL072

MISCELLANEOUS

NSM3915 10 element log bargraph display module
20 pin dil sockets (2 off)
8 pin dil sockets

FREQUENCY SENSITIVE CAPACITORS C1 AND C2

Frequency	Capacitor
25Hz	47n
50Hz	22n
100Hz	10n
200Hz	4n7
400Hz	2n2
800Hz	1n2
1600Hz	680p
3200Hz	330p
6400Hz	150p
12800Hz	68p

All 20% tolerence or better

is 1.28MHz which is reaching the limit for the specified performance of the MF10. It is possible to change the filter configuration to make it operate with a switching frequency of 50 times the tuning frequency by taking pin 12 to the +5V line instead of the 0V line. The filter is then controlled by the 640 kHz switching signal and a similar overall pass band response is obtained. Aliasing can become more of a problem, however, and the value of the low pass filter capacitors C1 and C2 should be doubled.

While on the subject of low pass filters, C1 and C2 are the only two components of the filter which have to be specially adjusted for different pass band frequencies. The frequency determining element being the switching frequency which is selected from the driver board.

The precision rectifier circuit is a half wave detector. Where asymmetrical signals are to be detected, for example speech or music, it is necessary to use a full wave rectifier version but in this instance, as the signal to be detected is a sine wave (that is what the filter selects even from a complex signal), the half wave rectifier is satisfactory. Figs 20 and 21 show the switched filter board details.

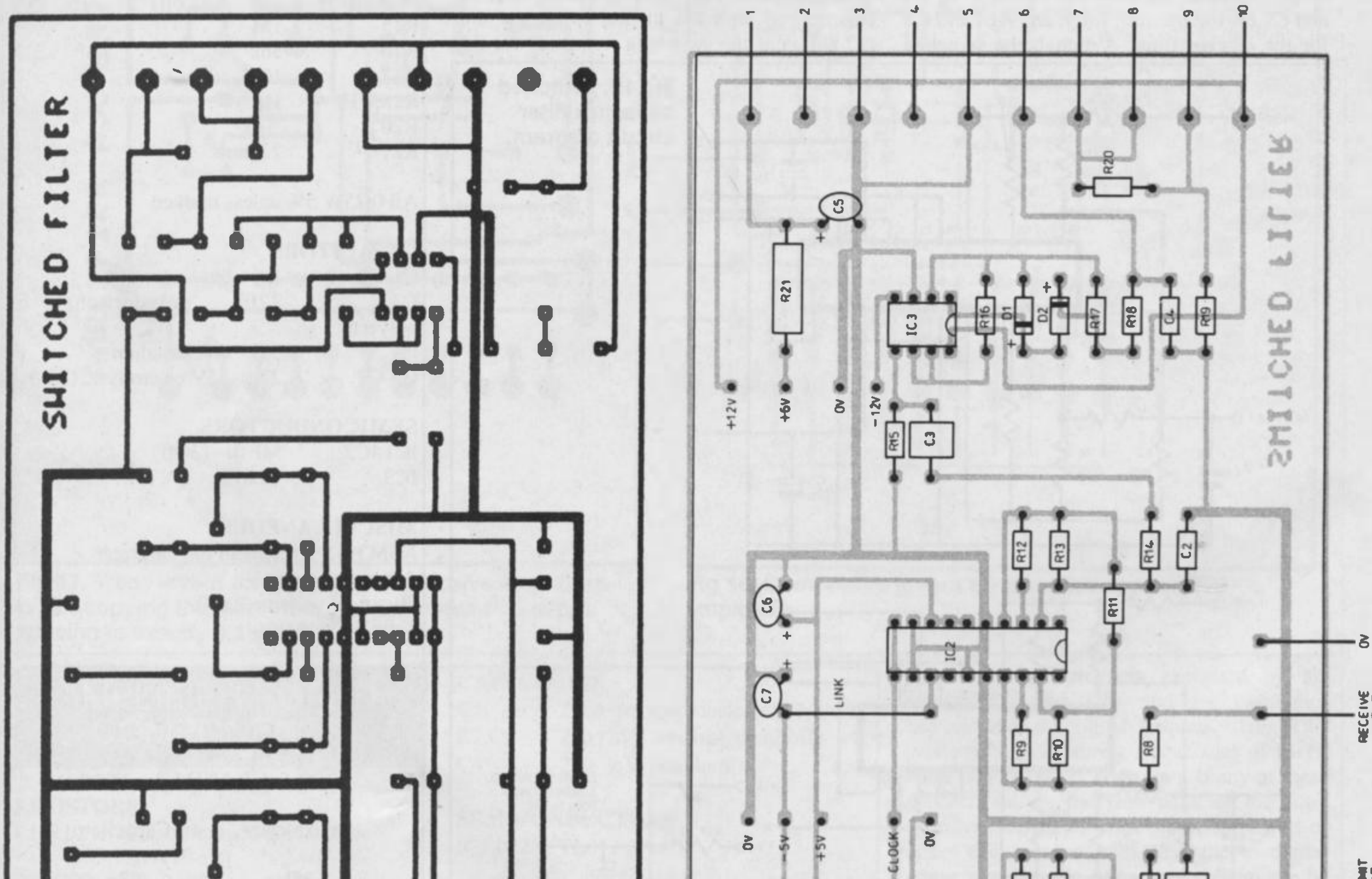
SWITCHED CAPACITOR FILTER DRIVE CIRCUIT

The signal source and switching waveforms for the switched capacitor filters are derived from a slightly more complex circuit that is used for the analogue filters. The block schematic diagram of the driver board is shown in Fig.22 and the circuit diagram in Fig.23.

The primary signal source for this version of the driver is a 5.12MHz crystal controlled oscillator built around a 4011 quad NAND gate, IC1. Only two of the gates are used so the remaining unused inputs are tied to the negative power line. A frequency of 5.12MHz was chosen simply because the crystal was readily available and is easily divided down in frequency to produce the required output signal and switching frequencies.

The output from the oscillator is fed through a second gate to improve the wave shape and then to a 12-stage binary counter IC3, which is a 4040. Output Q1 from the counter is used to drive a dual BCD counter, IC2, connected as a divide by 100 counter. Ten of the remaining outputs from IC3 (Q2 to Q11) are used at the clocking drives to the various filter stages. The output from the divide by 100 counter is connected to the input of a second 12-stage counter, IC4, the outputs from which form the signal sources for the filters. The output attenuators from each stage of IC4 are similar to those used for the analogue version except that provision is

Fig 20 and 21. Component and track layouts for the switched capacitor filter circuit.



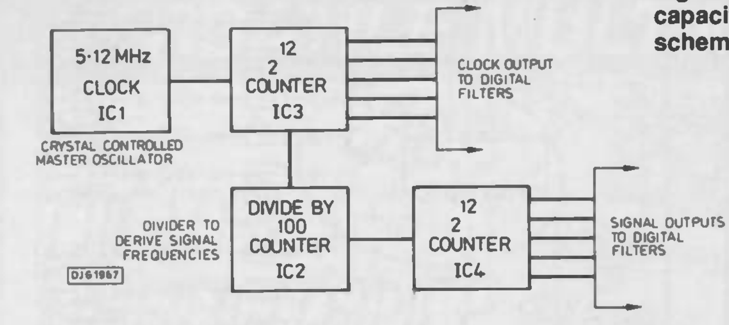


Fig 22. Switched capacitor driver schematic diagram.

SWITCHED CAPACITOR FILTER COMPONENTS

RESISTORS

R1	330k
R2-R21	10k (20 off)

All 0.25W 5% carbon or better

CAPACITORS

C1-C10	same values as for C1 and C2 in the switched capacitor filter, depending on frequency (10 off)
C11,C12	22µ 25V electrolytic

MISCELLANEOUS

X1	5.12 MHz crystal
IC1	4011
IC2	4518
IC3,4	4040
14 pin dil sockets	
16 pin dil sockets (3 off)	

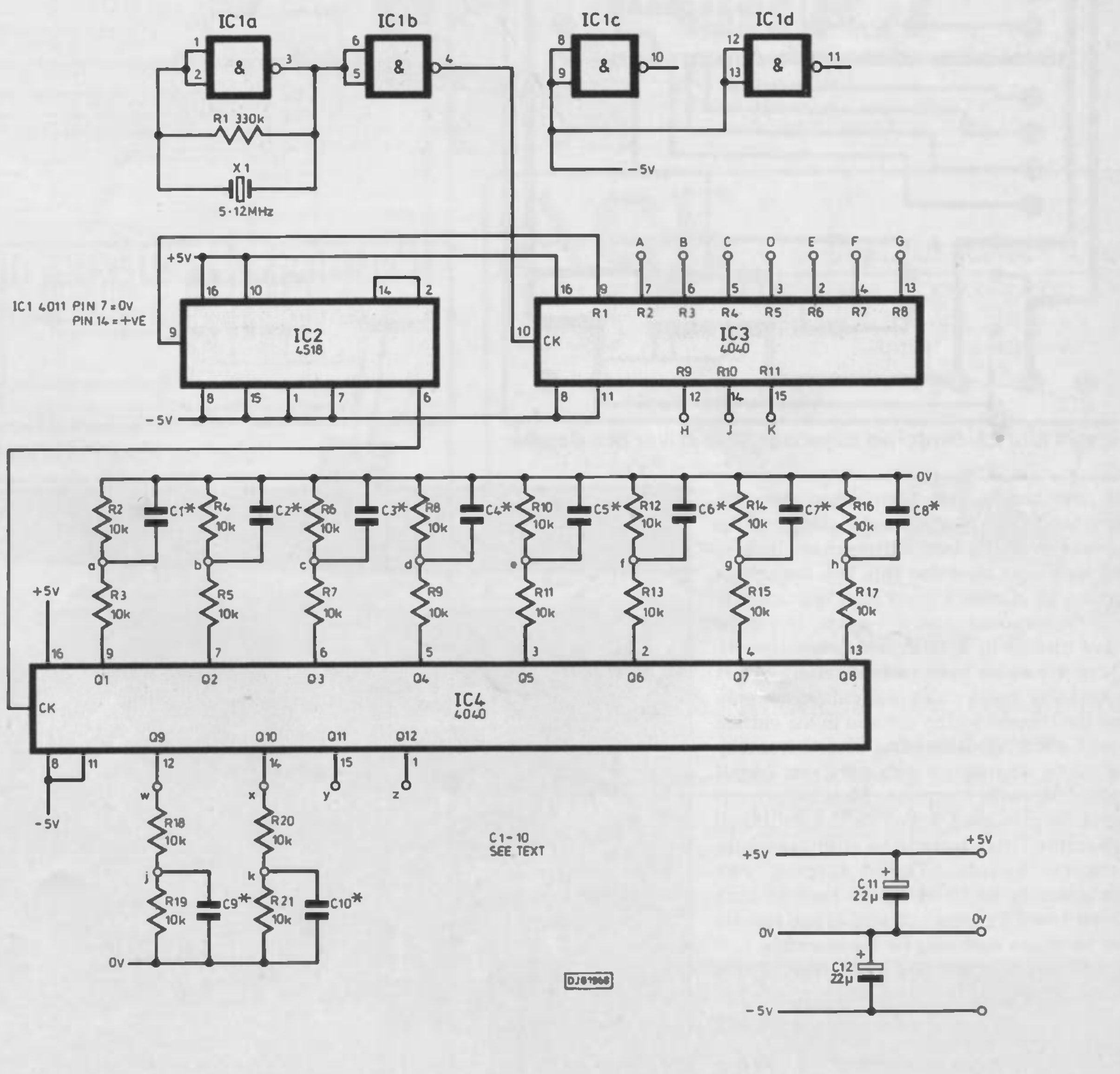
made to incorporate a shunt capacitor to help with aliasing problems, although in practice, I have experienced no problems in the transmit filters with aliasing.

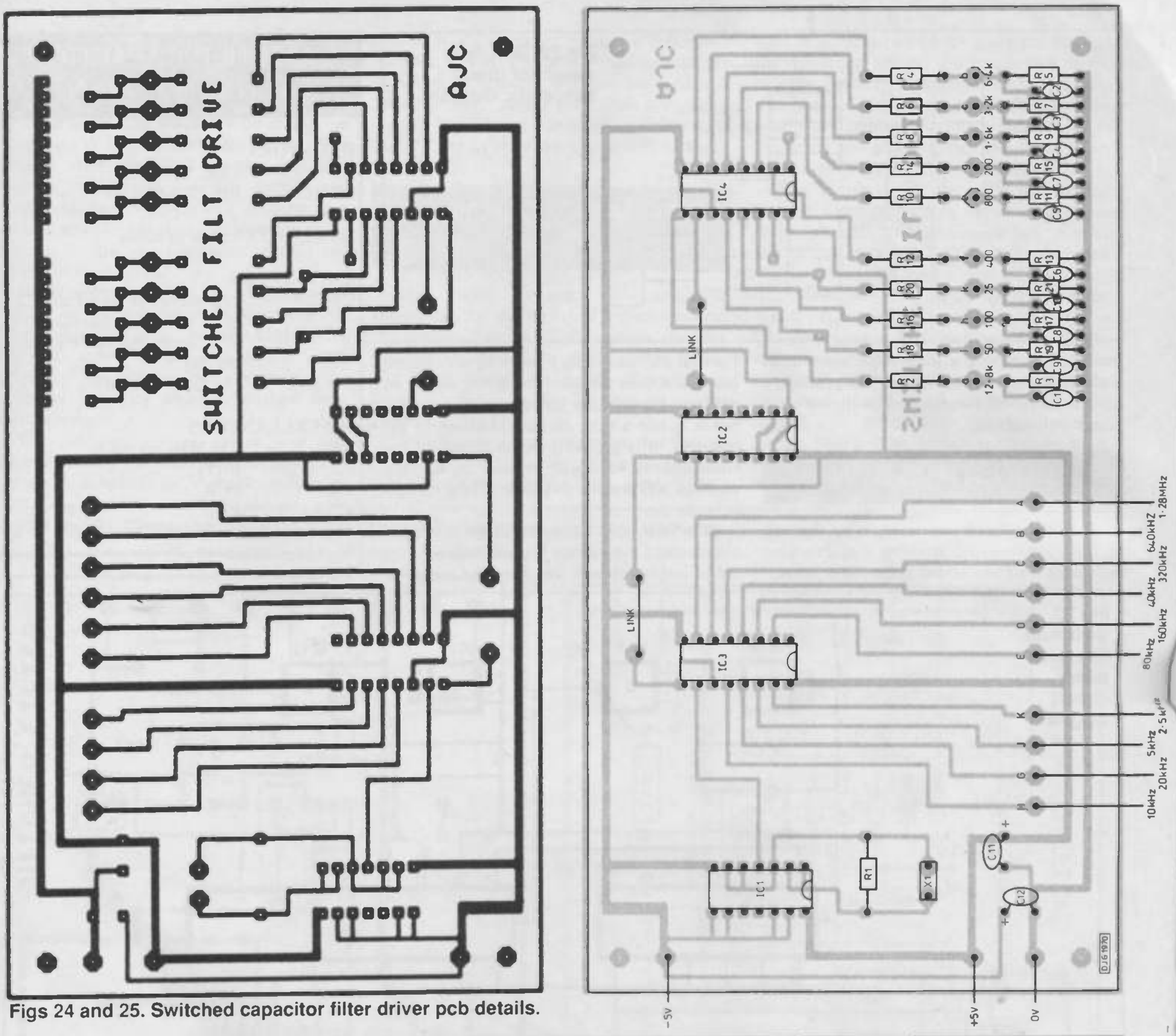
CONSTRUCTION

A minor difficulty in constructing the unit is in mounting the display devices and providing the connections to the filter boards. I wired all the display units to a common board and then mounted the whole board on the front panel of the instrument. This works, but it is not a very elegant solution to the problem. It is probably better to mount the filter boards vertically behind the display modules and provide a flexible wiring harness between them.

It is important to use screened wiring to interconnect the various boards. Although the signal levels between the input and output of

Fig 23. Switched capacitor driver circuit diagram.



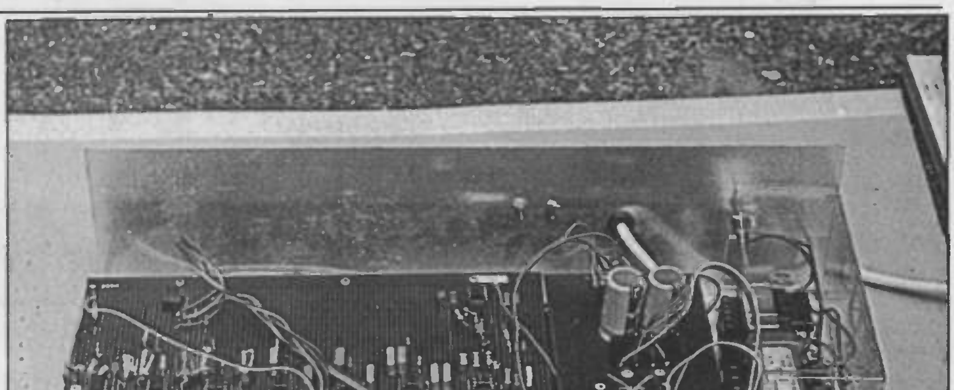


Figs 24 and 25. Switched capacitor filter driver pcb details.

the filter boards, for example, are about the same level there is considerable danger of the harmonics of the transmitter driver leaking into the output or, worse still, into the receive section. It is also a good idea, particularly with the switched capacitor driver, to put the drive circuit in a screened compartment. There are some very fast switching edges around this board which will radiate not only into the internal wiring but also to the outside world where, as with home computers, they can cause interference with television signals and/or fm radio reception. Metallic screens must be provided between the switched capacitor filter boards to stop crosstalk between boards. These screens can conveniently be fixed on the back of each circuit board by means of screws and spacers and serve as a mounting for the assembly.

The photo on the right shows the interior of the boxed unit.

Next month we shall give further constructional information plus details of the power supply and alignment. PE



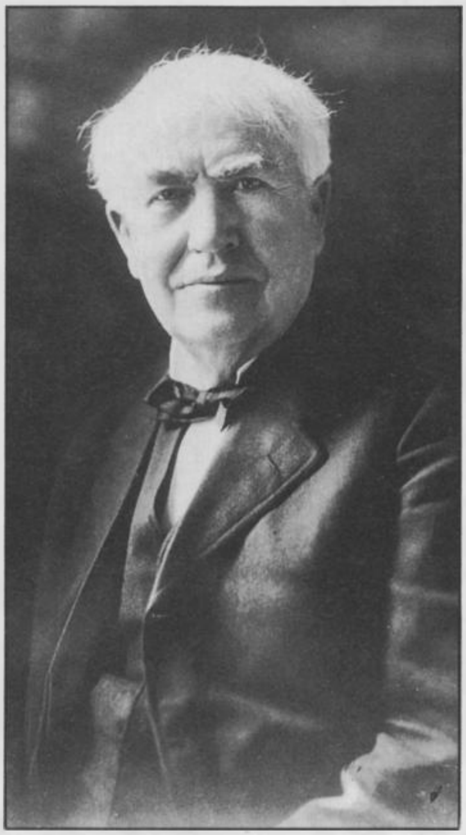
EDISON

Ian Poole highlights how Edison's prolific ideas resulted in many patents, and an invention-factory, but that the semi-conductor effect, though observed, was never exploited.

There can be few people who have made as many inventions as Edison. He was one of the most exceptional inventors there has ever been, and at one time he was making a new invention about every week. During the whole of his life he took out well over one thousand patents, many for inventions which are in every day use even now.

BIRTH

Thomas Alva Edison was born on the 11th February 1847 in a town called Milan, in the state of Ohio, USA. His father, Samuel Edison was a harsh man who often beat his son. This and his hearing disability resulted in the young Edison being backward at school. In fact, his formal schooling only lasted for three months before he was expelled because he showed no educational ability. Fortunately, his mother, Nancy could see more ability in the boy and she continued to teach him at home. She proved to be very successful because she brought his inquisitive nature to the fore. She even went as far as building a small chemistry laboratory in the basement of their house for him. This proved to be very successful because Edison was able to perform his own experiments and observe many scientific effects. It also started to bring out his interest in electrical and mechanical devices. He even made some batteries himself and carried out a number of tests and experiments with them.



IN BUSINESS

Money was short in the Edison house and his father earned very little. As a result, Edison himself went out and started to earn some money himself at the age of 12. He did this by selling newspapers on the trains which ran in the district. As he had to sell them on board the trains and had plenty of spare time on his hands he did plenty of reading and he even set up a small laboratory on the train. He later looked back on these times as the happiest days of his life.

As he grew older, Edison trained himself to use the new telegraph systems which were just beginning to be introduced and between 1863 and 1868 he earned his living as a roaming telegraph operator, even operating behind the enemy lines in the civil war.

During this time he kept up his reading, buying a copy of one of Faraday's books. Inspired by the book he decided to become an inventor. This idea soon started to become reality when he took out his first patent in 1868.

Photograph Courtesy of The Institution of Electrical Engineers.

THE TIDE TURNS

The year 1869 saw Edison down and out. He was unable to secure a steady job despite the fact that he was looking for one, and his money soon ran out. He had to resort to any small jobs he could find. One which he came across was to repair a telegraphic "tic-a-tape" machine. This he did so well that the company asked him to stay on to repair other machines when they stopped working. Edison soon settled in and true to style he even modified and improved a new printer which was just coming into use. This earned him the enormous sum of $40,000 from the manufacturer and with this he was able to set himself up in business as an inventor in Newark in New Jersey. This was what he enjoyed most of all and soon his laboratory started to produce a number of useful inventions and improvements, most of which were related to the telegraph.

LABORATORY MOVES

Edison's set-up at Newark was not ideal for him in a number of ways and he soon found the need to move. As a result, he decided to set up a new laboratory, but this time in a village called Menlo Park which was also in New Jersey. He took with him a number of the skilled men from Newark and before long inventions of all sorts were turning out of the new laboratory.

Here he made a tremendous number of inventions and some of the more innovative ones like the phonograph gained him recognition all over the world. In fact, Edison aimed all his work at ideas which would have an application and could be sold. This is a major reason for his success. There were even larger projects on the horizon.

LIGHTS IN THE DARKNESS

At this time, the vast majority of lighting was by gaslight. Edison saw that it might be possible to use electricity to fulfil this role. If it was possible, he thought, it would be far more convenient, flexible and safe. However, there were tremendous problems to overcome as nobody had built a large electrical system at this time, at least not one on a scale to compete with gas lighting. Undaunted, in 1878 Edison started to devote his energies to devise a system which could do this.

The first hurdle he had to overcome was to raise sufficient money for his research and an initial system. This did not present too much of a problem as his past record meant that he was a fairly safe risk for the banks and he soon raised £300,000. Then he set up a new company specifically for the research into his lighting project. This he called the Edison Electric Light Company, but later he also set up other companies to manufacture and sell the lights and systems.

Next he had to devise how he would actually organise the lighting system. Very basic decisions, like the voltage and whether bulbs would be run in parallel or in series, all had to be made. In addition to this, new bulbs had to be developed which would be reliable over long periods of time. At this time a number of incandescent bulbs had been made but their life was very short. The only other form of electric light at the time was the carbon arc lamp and this was far too large and bright for domestic households.

The development was carried out with the utmost urgency as Edison wanted his

Continued on page 45

HOME-BASE

Ian Burley strides into the future at the Summer Consumer Electronics Show

This month and next I'm concentrating entirely on the Summer Consumer Electronics Show which was held in Chicago.

Summer CES is a smaller affair than the Las Vegas based Winter event held each January, but that didn't rule out any interest in Chicago. An estimated 70,000 visitors attended CES this time, to see the exhibits from over 1,000 companies.

Sony's founder and living legend, Akio Morita, gave an inspirational keynote speech looking back over the history of consumer electronics and he stressed the importance of the relationship between consumer electronics manufacturers and the providers of "software" - music and video recordings, for example, which bring all the gadgets to life. Morita humbly admitted that Sony had been forced to learn from its mistakes when the video recorder first appeared on the scene. Sony Beta machines were generally considered to be technically superior compared with the competition, but Sony failed to gain software industry support for the Beta format until it was too late. Today, Sony makes VHS recorders, based on the standard developed by its rivals.

Akio Morita, founder of Sony

An example of conflict today is that hifi manufacturers are still at sixes and sevens with the music software industry. Digital audio tape was ready for the market several years ago, but the record industry's piracy paranoia has meant its refusal to support dat with pre-recorded software. This has put the future of dat in jeopardy. Akio Morita looks forward to a time when electronics manufacturers and the Arts work in harmony. The successful introduction of music compact disc technology is a happy example of successful cooperation. Morita, whose company exhibited at the first CES event 40 years ago, even cheekily suggested that one day CES might stand for the Consumer Entertainment Show.

GOODIES

So what goodies pulled the crowds in Chicago this year? In January the CES organisers promised the attraction of high definition television. In the end only Barco actually had any hardware to show and that was only prototype a hdtv video projector. This time we weren't disappointed. Toshiba and Panasonic turned up with hdtv demos on their impressive stands and Barco announced the availability of its hdtv projector.

JVC, Sony, Olympus and Panasonic were showing tiny hand held camcorders with advanced features and a degree of "artificial intelligence" built in. With FCC approval now granted, US households will be able to link televisions, videos and video cameras around the home with short range household wireless broadcasting accessories. There was news of the American quest for a comprehensive set of home-automation standards.

Computer firm, Commodore, stole a hefty chunk of the lime-light with the unveiling of its cd rom based multimedia machine, called cdtv. Based on Commodore's Amiga computer technology, do we have a serious threat to the aspirations of Philips' cd-i in the leisure multimedia stakes?

We also had a good look at the latest electronic personal organisers, translators, encyclopaedias, phone accessories, electronic games and more; read on:

Commodore Amiga with infra-red mouse, tracker ball and remote control

CDTV

First of all, Commodore's cdtv effort. While Philips and Motorola finally ready themselves for a cd-i assault on the fledgeling home multimedia market next year, Commodore has decided that the waiting has gone on long enough. With some undoubted inspiration from the original inventor of the video game and founder of Atari, Nolan Bushnell, Commodore has put together a cd-rom player married to Amiga computer technology which Commodore confidently predicts will thwart cd-i before that gets off the ground.

Using the Amiga's impressive video chips, the cdtv will be able to display and manipulate full colour high resolution computer images and video stills as well as chunks of motion video. The ISO 9660/High Sierra cd rom standard is used and the player will also read cd+g (cd with graphics) discs and play standard music cds.

The success of cdtv rests in its software support. A cd rom disc has a 550Mb capacity, or 250,000 pages of text, or up to 14 hours of sound - depending on the sampling rate, or several hundred full-screen uncompressed pictures. The software companies will hopefully take these attributes and produce multimedia encyclopaedias, interactive learning courses, games with huge scenarios and life-like graphics and, and much more. Theoretically, multimedia systems like cdtv and cd-i are only limited by the imagination.

The central cdtv unit is a rather anonymous and conventional looking front-loading cd player, though the discs actually load in a protective cartridge. It wouldn't look out of place in a hifi stacking system. The entry level just includes a relatively simple infra-red remote control. With this you will be able to use the cdtv as a music cd player and look around the contents of a cd rom application. Options will include: a mouse, tracker ball, joysticks, external floppy disc drive and a computer keyboard. It will be possible to expand the cdtv to near enough the specification of a Commodore Amiga 500 computer. Commodore also promises an Amiga computer to cdtv specification upgrade kit.

The cdtv is not intended to be a technical competitor with cd-i. The latter will offer full screen digital motion video with the help of some technically very advanced hardware. Commodore has to make do with software driven motion video for the cdtv, though this was not demonstrated at CES. Nonetheless, Commodore is about a year ahead of Philips in getting its product to market, assuming the promised September shipping date is met and you get a very useful computer into the bargain. The cdtv is expected to sell for around £500-£600, about the same price as Philips' predictions for the first cd-i machines which aren't due until the middle of next year. The multimedia revolution is already hitting the computer industry hard. 1991 will see multimedia coming of age in the home too.

HDTV

I have been very fortunate to see high definition tv for myself. The pin-sharp wide-screen image offered by hdtv is quite remarkable when compared to conventional tv, especially the very tired American NTSC standard. At CES this time, lots more people were granted the privilege of being able to wonder at hdtv for the first time courtesy of Toshiba and Panasonic. The former was content to show an hdtv video played back continuously on an hdtv monitor, while Panasonic showed a rear-projector and a picture filing system using hdtv. In Japan, several "art galleries" have opened up which display artistic treasures through the hdtv med ium. Panasonic showed a 12" optical disc used for recording still images and moving sequences rather like an over grown cd-i system. Round the corner, hdtv monitors were hooked up to a computer system with image digitizers and colour printers.

Both Toshiba and Panasonic drew awe-struck crowds. Barco ran basically the same hdtv projector demo in a small private theatre I saw back in January. Second time around, the magic when the hdtv projector took over from the NTSC one, in mid presentation, was just as intoxicating, especially with a little help from the superb Fosgate surround sound system used.

Representatives from the huge French Thompson television manufacturing group attended the show but didn't have a stand. It's Thompson's aim to introduce an intermediate hdtv or advanced tv which incorporates the wide-screen dimensions of the Japanese hdtv proposed standard but without the expense of very ambitious definition specifications. Meanwhile, the American television industry remains fearful that unless it organises itself quickly, it may not have a say in the standard setting for hdtv. Unfortunately, it's still difficult to predict exactly when hdtv will hit the consumer - 1995 seeming to be the majority guess.

More next month!

Ian Burley is the News and Features editor for BT Micronet, an on-line computer and technology magazine published on Prestel by British Telecom.

Panasonic HDTV back projector

SCOPE EXPANDER

Part Two. In which John Becker describes the testing and use of this scope trace multiplier, data store and logic analyser.

By now you should have completed the pcb assembly and are urgently awaiting the control wiring details. Fig.10 reveals all!

INITIAL TESTING

The only setting up that needs to be done is that of VR3, plus the scope sync, time-base, and amplitude settings. As said last month, VR3 should be adjusted for satisfactory display height while watching the screen. On my own scope, the amplifier input amplitude control was set on the 0.5V/cm range to give adequate screen coverage. The choice may vary depending on your scope. The dc setting is preferable to the ac one if you have a choice on this aspect.

Since the illusion of eight traces depends on scope time-base speed and sync, these will need adjusting on the scope in order to see the data correctly. First connect the scope's signal probe to the trace output socket, SK1, and set the scope channel amplifier for the range which will allow a swing of about 3.5V to just about fill the screen vertically. Set the time-base for a sweep speed of 50 to 100µs. Connect the unit's sync output to either the external sync input or the second signal input channel (if you have one), and switch the scope's sync switch for triggering on a positive-going signal from the selected channel. (Syncing via the channel connected to S1 will not produce the desired effect.) Connect the unit to a suitable clock and data source, for example to the parallel output socket of a computer. It is preferable at this time that the data source should produce random output codes.

Set the data source and its clock running. Switch S1 down, so that the input sync is derived from the external clock source. Switch S3 up so that IC9b will be triggered by the NAND gate IC6. Switch S2 up to hold the system at reset. Switch all address line switches S4-S10 upwards, so setting the memory to the lowest data block address once sampling has been completed. Turn VR1 fully anticlockwise, so that no signal data will be superimposed on the output ramp waveform.

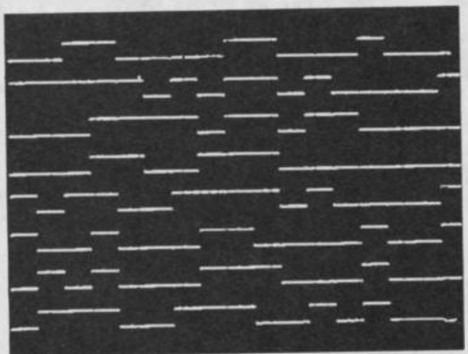


Photo 3: Typical traces photographed on the author's oscilloscope and generated using this project coupled to an 8-bit logic source.

Now switch S3 down allowing the sampling routine to commence on the first available input clock pulse. Observe the scope screen. The rate at which this shows trace changes will depend on the input clock rate. Providing it's of a reasonable speed, of say, at least 2-3kHz, you will see the scope trace gradually step up the screen, perhaps jerking slightly between steps. Having reached the top of the scope screen, the trace will drop back down again, and start climbing once more. It will repeat this action several times until the full count sequence has been completed.

MULTIPLE DISPLAY

At the end of the sequence you should see the screen jump to display several traces simultaneously. The actual apparent quantity may vary at this time until the scope controls are adjusted. You could see eight lines straight away, though you could equally possibly see only four, perhaps with additional steps on them. It's also feasible that you might only see a rising stepped waveform, possibly with additional sub-steps on each step. Adjust the sync lock control on the scope until the traces become static. If necessary, then switch the time-base to a higher or lower setting until you clearly see eight traces. You may also need to switch the scope input amplifier to a different gain or attenuation setting, so that the traces better fill the screen.

Now you can adjust VR1 so that the data stored in memory is multiplexed out onto the screen traces. Slowly turn VR1 clockwise and you should see steps appear on some or all of the lines. It is assumed at this point that a fair mixture of logic 0 and logic 1 has been recorded in the block you are examining. If

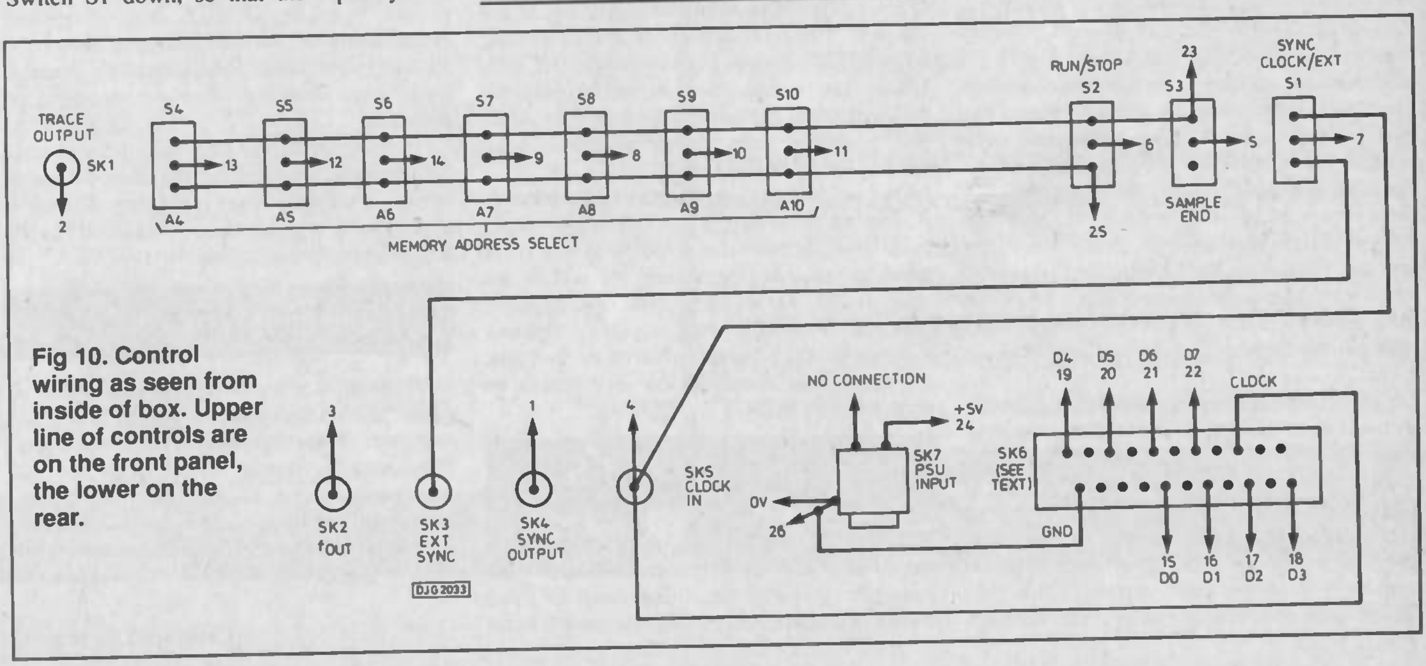


Fig 10. Control wiring as seen from inside of box. Upper line of controls are on the front panel, the lower on the rear.

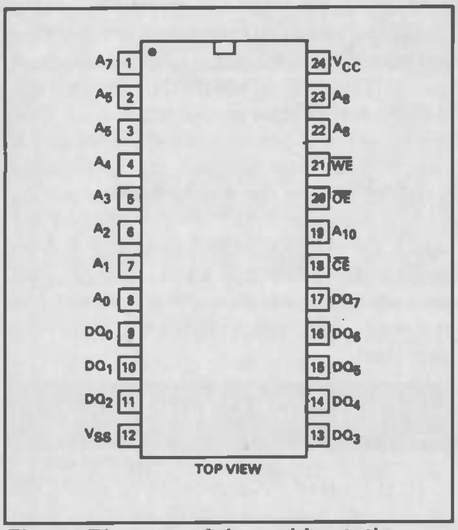


Fig 11. Pin outs of the unit's static random access memory (sram).

you don't see any change, the most likely reason, apart from a circuit malfunction, will be because your signal data source was placing zeros on all the lines. It's equally possible that your data source has been placing all logic 1s on the lines, in which case you will see all lines rise up as you turn VR1. If, as expected, a mixture of data has been recorded, increasing VR1 will increase the amplitude steps on each line. Continue turning VR1 until the steps are clearly visible yet do not encroach on the line above them. On my own scope the best step heights were about 200mV high. Photo 3 shows a shot of the scope screen displaying traces produced by the unit.

BYTES AND BITS

Once you've set VR1 satisfactorily, you can check that other memory data blocks hold different data. You do this by switching on any combination of S4-S10 to bring a different memory block onto the lines.

The maximum number of data bits that will normally be displayed on any one line is 16, as dictated by the size of each memory block. If it is obvious that fewer than 16 bit positions are on screen, then reduce the scope time-base setting until 16 bits are catered for. By slowing down the time-base speed even further you can display more than 16 bits per line, but after the 16th bit, the other bits will be a repetition of the first 16, as the unit will be recycling through the same block for another time. You may alternatively increase the time-base speed so that you can deliberately examine fewer bits, though these will always be the first bits in any memory block.

If you have a programmable data source it is possible to make further checks on the unit. Program the source to repeatedly send the binary codes for decimal numbers 0 to 255 in sequence out to the unit. Set all address switches up. Set S1 down, S3 up, and then take S1 down and then up. This primes the unit to wait for an input sequence. Now run the programmed source. As it cycles through its 0-255 sequences, the unit will record them, finally switching back to replay mode at the end of the full cycle.

Now you can examine that the unit has recorded the binary digits correctly. The lower trace will contain the least significant bits and will thus show more steps. The line above will show half the number, the one above half of that, and so on. The top four lines should all be low since the code on display only represents decimal numbers 0-15, requiring only a 4-bit code. You will need to switch on some of the address switches to show a representation of the higher numbers. Do this and see what happens, checking your estimation of the binary number shown at each point on the screen against a binary to decimal chart.

It is conceivable that the unit may have ignored the first zero, recording only from the first 1. This will be due to the unit's reaction time to the starting sync pulse. The result will be that you see the binary equivalents of 1 to 16 on screen.

TESTING OPTION

The device I used to program a check data sequence was my good-old Commodore 3032 Pet. (It's still without its own screen, but I've designed an interface for it so that it now feeds via a uhf modulator into a portable tv. More on that in the PE Tele-Scope article!) This is the program I used:

```
100 DRT=59459: OUT=59471: AT=59468:
DN=205: UP=237: POKE OUT,255

110 FOR A=0 TO 255: POKE OUT,A:
POKE AT,DN: POKE AT, UP: NEXT A:
GOTO110
```

DRT is the data direction register, which is set as an 8-bit output by poking it with 255. OUT is the output register into which data is written and from which the data is sent to the output port. AT is the ATN (attention) line register. This is used as the clock source for the unit. The ATN line is set low by poking AT with DN, and set high by poking AT with UP. If you intend using a similar program with your own computer, all the register codes will probably need changing (check your manual for the equivalents).

As written, the above routine increments A, poking the resulting number to the output port. You can poke the output with any other number you like, providing it's within the range 0-255. For example, you could poke it with the contents of the computer's memory location relating to the value of A. For this, the second statement in line 110 would be changed to POKE OUT, PEEK(A).

OTHER TRACES

If you have a scope with more than one trace, a dual or triple-trace scope for example, you can use the second or third traces simultaneously with the unit's octal tracing. You will need to adjust the scope controls to make room for the additional traces, then you simply use the other probe or probes to monitor the additional lines you want to examine.

The scope must still be synchronised from the specified sync point in the unit, but the unit itself can be synchronised to any other point in the circuit you're examining. The required sync point is brought in to the sync input socket SK3. S1 should now be switched up to route the sync signal to IC9a.

BRILLIANCE

When the scope's additional channels are used in parallel with the unit you will notice that there is a difference in the apparent brightness of the additional channel traces. The unit's multiplexed signal will be less bright than the additional traces. This is because you are seeing the additional traces at their normal screen-crossing rate, whereas the multiplexed signal is in reality crossing the screen at only one eighth of this rate. Why only one eighth? Visualise what is actually happening to the trace. It crosses the screen in order to display the lowest line. It then jumps up by the height of the first step, and again it crosses. It does this repeatedly until all eight steps and transitions have been made. In the meantime the trace from the second true channel has crossed the same point on the screen eight times. You're dealing with an illusion for the multiplexed lines, but that illusion results in the eye seeing each line for less time than that of the true additional channel.

A further point to be aware of is that by switching on the scope's additional channels you may, depending on the nature of your scope, be changing the rate at which all the traces occur. If your scope generates its second trace by alternating between the two input channels, then every second step of the multiplexed trace may disappear. Adjustment of the scope's time-base rate should compensate for the scope's internal switching, allowing all eight channels to reappear.

If using a second true channel you can, for example, monitor the unit's clock signal while observing the multiplexed traces. This clock signal is also available for triggering external equipment, via SK2.

LOGIC ANALYSING

From all that has been said you will have gathered that unit enables you to check the sequence of events on eight different digital lines simultaneously. These lines do not necessarily need to be 8-bit data lines associated with, for example, a computer output or similar 8-bit data source. They

Continued on page 43

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All packs are £1 each Note the figure on the extreme left of the pack ref number and the next figure is the quantity of Items in the pack, finally a short description.

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BD263	2 Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress.
BD268	1 Mini 1 watt amp for record player. Will also change speed of record player motor.
BD305	1 Tubular dynamic mic with optional table rest.
BD653	2 Miniature driver transformers. Ref. LT44, 20k to 1k centre tapped.
BD548	2 3.5V relays each with 2 pairs changeover contacts.
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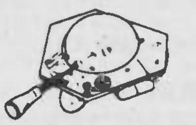

ELECTRONIC SPACESHIP. Sound and impact controlled, responds to claps and shouts and reverses when it hits anything. Kits with really detailed instructions. Ideal present for budding youg electrician. A youngster should be able to assemble but you may have to help wiht the soldering of the components on the pcb. Complete kit £10. Our ref. 10P81.

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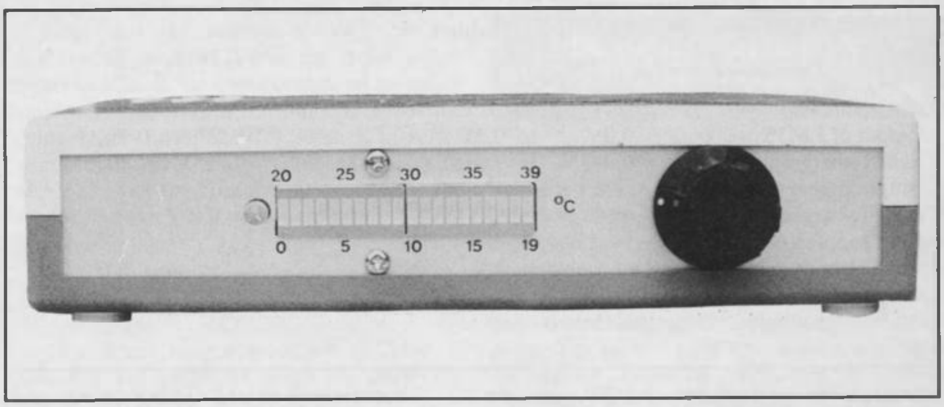
DESK THERMOMETER

Whatever the weather, you'll warm to Owen Bishop's easy-to-calibrate led display.

Electronic thermometers with lcd numeric displays are common nowadays and may be purchased ready-made for far less than the cost of the individual components. They usually display the temperature to a tenth of a degree - but are they *really* that precise? This circuit has a bargraph display instead, which indicates temperature to the nearest degree on the Celsius scale. Many people prefer such a display since, at a glance, it gives a clearer visual impression of temperature than is given by a series of digits. The illuminated display of the instrument is a distinctive and attractive addition to any desk-top. The display is reminiscent of the conventional liquid-in-glass thermometer. A row of 20 leds indicates temperature within one of two 20-degree ranges, 0°C to 19°C and 20°C to 39°C. This fully covers the range likely to be encountered in the average living-room or workshop. It is possible to adapt the design to cover other ranges between 40°C and 100°C, as will be explained later.

The similarity of the display to an ordinary thermometer is enhanced by the 'bulb' at one end of the bar. But the bulb is not the part that senses temperature. It is an led, of the type that can be made to glow with different colours. It glows green when the display is switched to the lower range and it glows red when it is switched to the higher range. In this way it acts as a range indicator.



One of the advantages of the LM35, as compared with sensors of other types such as thermistors and diodes, is that it draws very little current. Its operating current is only 56uA, and thus very little power is dissipated in the device. This means that there is virtually no self-heating effect to upset the accuracy of measurements.

Fig.1 shows that the output from the sensor is passed to an adder. This is an operational amplifier which adds various voltages to the output voltage to match it to the input required by the bargraph display. Since the range of inputs to the bargraph ics is larger than the output range of the sensor, we also need a multiplying amplifier. Table 1 sets out the calculations that these two amplifiers have to perform. Use the table as a model for your own calculations, should you wish to adapt the design to other temperature ranges.

Consider the low range first. While the temperature rises from 0°C to 20°C, the output of the sensor rises from 0V to 0.2V. The sensor and amplifiers are operating on a split supply, +4.5V, and the values in the table are with reference to the 0V rail. On the other hand, the bargraph ics must receive the increasing input needed to light up the leds one by one. The bargraph ics accept an input in the range 0.015V to 1.5V below the positive supply (ie 7.5V with a 9V supply). For convenience, we have settled on an input range of 0.015V to 7.015V, so that an increase of 1°C is equivalent to 0.35V increase in input. These figures are shown in the third line of Table 1. However, when we are working out what the amplifiers have to do, we must relate the bargraph input voltages to the amplifier split supply voltages. We must subtract 4.5V from bargraph inputs to show what the amplifier outputs must be. This has been done in the fourth line of the table.

We now have to find out what the amplifiers must do to convert a voltage ranging from 0V to 0.2V into a voltage ranging from -4.485V to +2.515V. The conversion is made by adding a certain fixed voltage and then multiplying. The multiplying factor is the easiest to work out. The voltage range from the sensor is 0.2V, and the

HOW IT WORKS

The main sections of the circuit are shown in the system diagram (Fig.1). The temperature sensor is an LM35 precision Celsius temperature sensor. This ic, which operates on any supply voltage in the range 4V to 20V, has an output which is linearly proportional to the Celsius temperature. When temperature is 0°C the output is 0V. As temperature increases, the output rises by 10mV per degree. Thus, as 25°C, for example, the output is 0.25V. This easily understood relationship between temperature and output voltage makes calibration of the circuit very straightforward. It also makes it easy to adapt the circuit to other ranges of temperature.

The LM35 is manufactured in two versions, LM35CZ and LM35DZ. The CZ version covers the range -40°C to 110°C. To measure temperatures below zero, it is powered by a split supply and gives negative output voltages at such temperatures. In this circuit we use the cheaper DZ version, which has a smaller range, 0°C to 100°C. This can be powered with a single supply but this makes it less precise at temperatures below 2°C. We use it with a split supply to obtain full precision (+0.9°C) over the entire range. Precision is better than this (+0.6°C) at typical room temperatures.

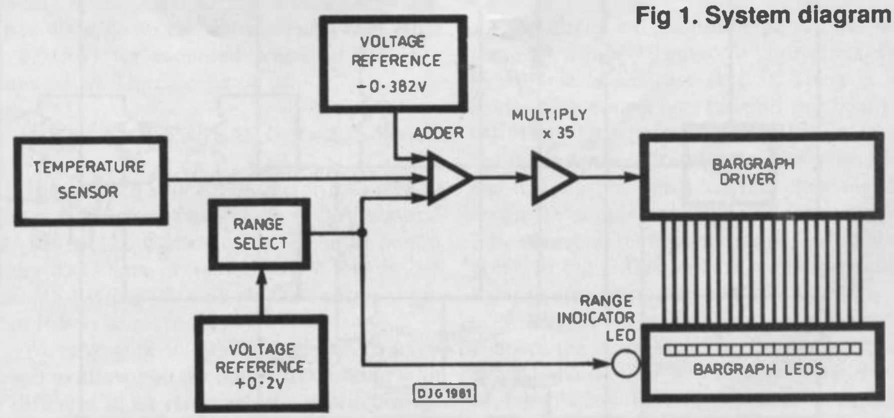


Fig 1. System diagram

Table 1

Range	1) Low		2) High
Temperatures	0°C	to 20°C	20°C to 40°C
Output of LM35	0.0V	to 0.2V	0.2V to 0.4V
Input to bargraph (single supply)	0.015V	to 7.015V	0.015V to 7.015V
Input to bargraph (split supply)	-4.485V	to +2.515V	-4.485V to +2.515V
Conversion - add	-0.128		-0.328
multiply	X35		X35

bargraph in put range is 7V, so the multiplying factor is 7/0.2 = 35.

Now we can work out the voltage to be added. Call this v. The conversion equation can be written for the low end of the scale (0°C):

$$35(0 + v) = -4.485$$

Solving this equation gives: v = -0.128. You can check that the equation for the upper end of the scale (20°C) gives the same value for v.

On Range 2, the output from the sensor varies from 0.2V to 0.4V, a range of 0.2V, as before. The bargraph input is to be the same as on Range 1. The multiplying factor is 35, as before. At the low end of range 2 (20°C) we find:

$$35(0.2 + v) = -4.485$$

Solving this equation gives:

$$v = -0.328$$

Thus we have to add -0.128V on Range 1, and -0.328V on range 2. There are various ways of doing this. In this circuit, we add -0.328V on *both* ranges, and switch in an *extra* voltage of +0.2V when the instrument is on range 1. A rotary switch is used to connect the +0.2V when on range 1, and to control the colour displayed by the range indicator led.

CIRCUIT DETAILS

The 9V power supply (see later) is split by a potential divider (R1,R2) to give +4.5V, 0V and -4.5V rails (Fig.2). The sensor (IC1) is powered from the 0V and +4.5V rail, but has a pull-down resistor (R3) connected to the -4.5V rail to give a 0V output at 0°C. These connections can also be used with the LM35CZ, if you are building a thermometer to operate at temperatures below zero. The amplifiers (IC2, IC3) are powered from the +4.5V and -4.5V rails.

The opamps are cmos types, specially designed to operate on low-voltage supplies. IC2 is connected as a summing amplifier, with three inputs to the inverting input, each by way of a resistor (R4-R6). These and the feedback resistor (R7) all have the value 15k and, to reduce errors, should all be of 1% tolerance. The -0.328 input is provided by a band-gap reference voltage device (D23). This produces a reference voltage of -1.26V (typically) at the point indicated. A variable potential divider (VR1) taps off 0.328V which is fed through R6 to the amplifier. Another voltage reference (D2) produces a reference voltage of +1.26V (typically) at the point indicated. A variable potential divider (VR1) taps off -0.328V which is fed through R6 to the amplifier. Another voltage reference (D2) produces a reference voltage of +1.26V, which is tapped by the potential divider VR2 to give +0.2V. When Sib is in the range 1 position, this voltage is fed to the amplifier through R15. Since a summing amplifier of this kind produces the *inverse* of the sum of its inputs, the output of IC2 on Range 1 is:

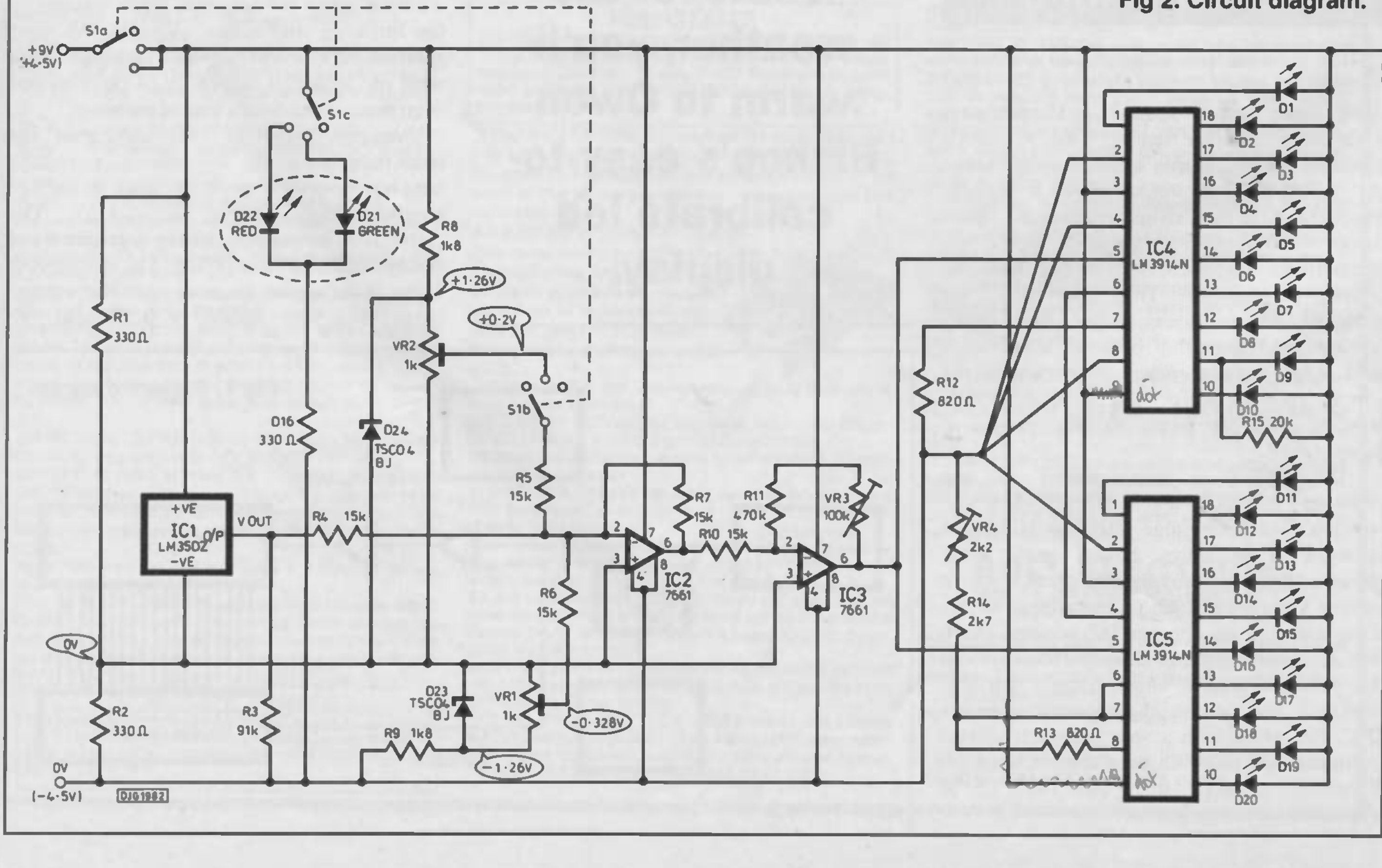
(Vout - 0.328 + 0.2) = -(Vout - 0.128)

On Range 2 the output is:

(Vout - 0.328)

Note that the setting of VR1 can be slightly adjusted to allow for input offset errors in IC2. IC3 is connected as an inverting amplifier with gain of 35. Since R10 has the value 15k, we adjust VR3 so that, in series with R11, it gives a total feedback resistance of 525k. Since the polarity of the output is the inverse of the input, the output of IC3 on Range 1 is:

Fig 2. Circuit diagram.



(Vout - 0.328 + 0.2) = -(Vout - 0.128)

On Range 2 the output is:

(Vout - 0.328)

COMPONENTS

RESISTORS

R1, R2	330, 1% (2 off)
R3	91k
R4-R7, R10	15k, 1% (5 off)
R8, R9	1k8 (2 off)
R11	470k
R12, R13	820 (2 off)
R14	2k7
R15	20k
R16	330

(Carbon 0.25W, 5% tolerance, unless otherwise specified)

POTENTIOMETERS

VR1, VR2	1k horizontal sub-miniature preset
VR3	100k horizontal sub-miniature preset
VR4	2k2 horizontal sub-miniature preset

CAPACITORS

C1	220n tantalum

SEMICONDUCTORS

D1-D20	10-bar dil led array (green or red) (2 off)
D21/D22	tri-colour led
D23, D24	TSC04BJ band-gap voltage reference. 1.26V (2 off)
IC1	LM35DZ precision Celsius temperature sensor
IC2, IC3	ICL7611 cmos operational amplifier (2 off)
IC4, IC5	LM3914N bargraph driver (2 off)

MISCELLANEOUS

S1 4-pole, 3-way rotary switch
Knob for S1
Strip-board (a) 12 strips by 67 holes, (b) 26 strips by 11 holes, (c) small scrap for mounting sensor
1mm terminal pins single-sided (27 off) and double-sided (4 off) transistor socket
8-way dil sockets (2 off)
18-way dil sockets (2 off)
20-way dil sockets (2 off)
15cm 20-way ribbon cable
Instrument case 180mm x 120mm x 40mm
Bolts for mounting display panel
(Optional) 9V 400mA regulated mains power supply unit and 3.5mm mono jack socket.

Note that the setting of VR1 can be slightly adjusted to allow for input offset errors in IC2. IC3 is connected as an inverting amplifier with gain of 35. Since R10 has the value 15k, we adjust VR3 so that, in series with R11, it gives a total feedback resistance of 525k. Since the polarity of the output is the inverse of the input, the output of IC3 on Range 1 is:

(35 x -(Vout - 0.128)) = 35(Vout - 0.128)

This is the output specified in Table 1. Similarly, the output on range 2 is 35(Vout - 0.328).

The two bargraph ics (IC4, IC5) are connected in cascade. Each receives its input from IC3 at pin 5. The ics contain a series of comparators which compare the input voltage against voltages found along an internal change of resistors. We have to arrange that the voltage at one end of the chain is -4.5V and is +2.515V at the other. The low end of the chain in IC4 (pin 4) is connected to the -4.5V rail. The high end of the chain in IC4 (pin 6) is connected to the low end of the chain in IC5 (pin 4). The high end of the chain in IC5 (pin 6) is connected to a stabilised reference voltage (pin 7). This is set to give a reference voltage of +2.515V. To work out how to obtain this, it is simpler to return to considering the power supply to the bargraph ics as being 0V and 9V. We need to set the reference to 7.015V. The reference is set by setting the ratio between two resistors, R13 and the combined resistances of R14 and VR4. For simplicity we refer to R14+VR4 as Rc. The reference voltage obtained is given by:

VREF = 1.25(1 + Rc/R13)

or:

Rc/R13 = VREF/1.25 - 1

For a reference voltage 7.015V we get:

Rc/R13 = 7.015/1.25 - 1 = 4.6 (approx)

Now we have to take into account the fact that the value of R13 also determines the current through the display diodes. In other words, it determines the brightness of the display. If the power supply is able to provide up to 400mA, we can allow about 15mA (Il_ed = 0.015A) for each led when all leds are illuminated. The calculation is:

R13 = 12.5/Il_ed = 12.5/0.015 = 833 ohms

This gives a suitable value for R13 as 820 ohms. A resistor of this value is also required for IC4 (R12). Consequently, Rc must be 4.6 times 833 ohms, or 3833 ohms. If R14 is 2k7 and VR4 is 2k2, this allows the voltage at pin 7 of IC5 to be set to 7.015V.

We have gone into this calculation in some detail to allow you the option of working with a different input range and to adjust display brightness according to the capabilities of your power supply.

POWER SUPPLY OPTIONS

This circuit is designed to be powered by a stabilised mains psu, with an output of 9V at up to 400mA. Such units are cheaply available ready-built for plugging into a 13-amp mains socket. The advantage of having the psu external to the instrument case, is that this avoids heating the interior of the case, producing falsely high temperature readings. If you are intending to mount the sensor externally, this advantage does not apply, but there are still the advantages of low cost and avoiding the hazards of building the parts of the circuit which have live mains voltages. Mains powered psus often have a switchable output range. Make sure that the one you buy has a 9V output and that it is stabilised (the cheapest psus are not stabilised and are useless for this application). Make sure too that it is capable of delivering up to 400mA, without a drop in output voltage. Some psus are not protected against overloading and simply burn out if required to supply more current that they are intended to do.

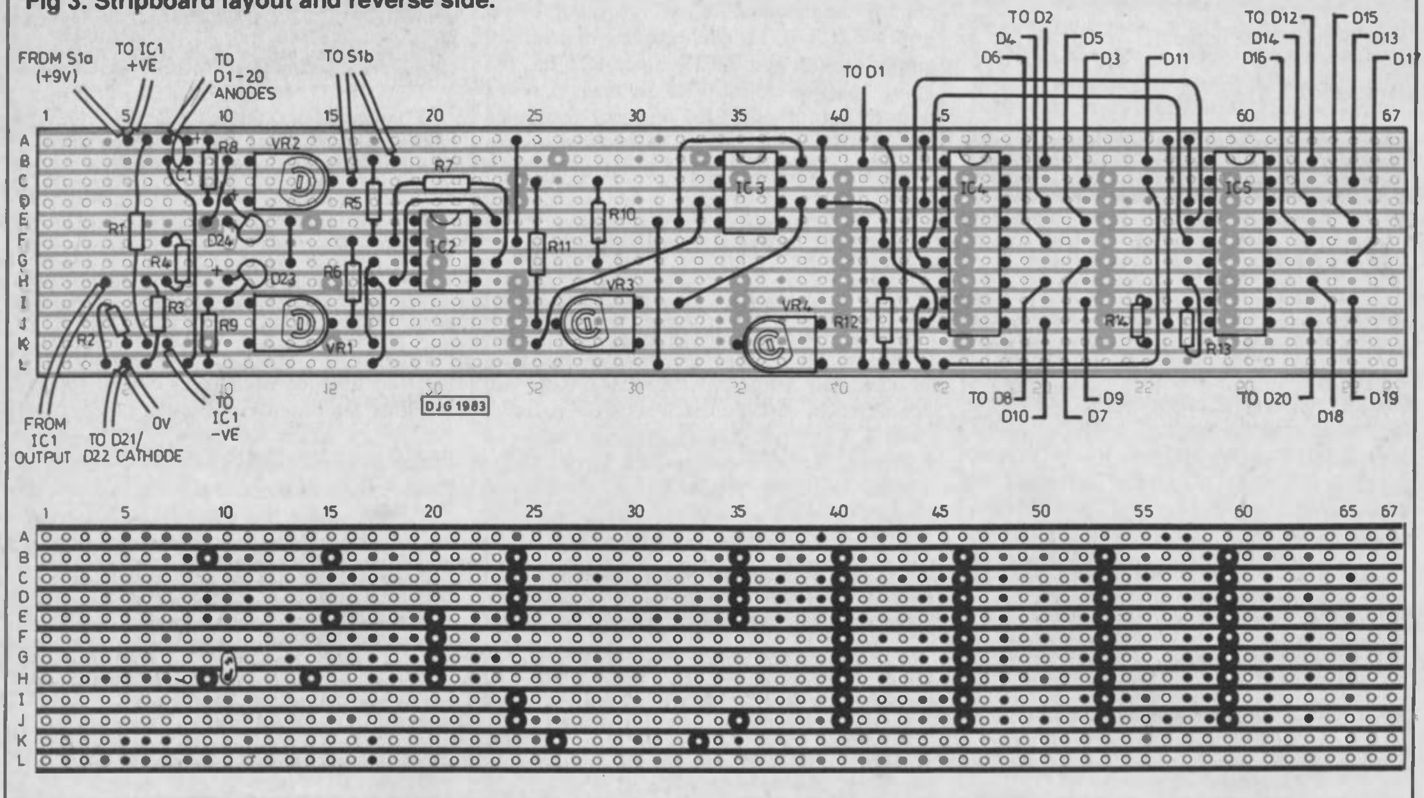
Alternatively, the thermometer may be powered by a 9V battery, either a PP3, or a six cells in a 9V battery box. A battery may be housed inside the instrument case as it does not produce appreciable heat. The difficulty with a battery is that the bar leds consume large amounts of current. The battery soon becomes partly discharged and the accuracy of readings is badly affected. The brightness of the display can be reduced to save power, as described above, but power requirements are still large enough to run down the battery fairly quickly. A much better way of saving power is to change the display to 'dot mode'. Instead of the whole bar, only one led (the top end of the bar) is illuminated. To change to dot mode, omit the connections between the 9V supply rail and pin 9 of IC4 and IC5. This puts the ics into dot mode. Then connect pin 9 of IC4 to pin 1 of IC5 (which is also connected to D11 cathode). This ensures that D10 is turned off when the input voltage exceeds the maximum for IC4.

CONSTRUCTION

The circuit of the prototype is built on a piece of strip-board cut to fit into vertical slots in the instrument case (Fig.3). There is one solder-blob connection beneath the board, at G10/H10. One point to remember in laying out the board is that several of the pins of IC4 and IC5 must be grounded very close together on the 0V supply rail. This is indicated in Fig. 2 by taking all these connections to a common point. In Fig. 3 this point is the portion of the lowest copper strip between L39 and L45.

A length of 20-way ribbon cable is used to connect the main board to the display board (Figs.4 and 5). The +9V supply to the anodes of the display leds is taken by a separate flexible lead from a point close to where the +9V supply joins the main board. The current

Fig 3. Stripboard layout and reverse side.



to the leds may be several hundred milliamps and the capacitor C1 is required to damp out oscillations as leds are switched on or off.

The leds are purchased as dil arrays, each of 10 leds. The arrays plug into two 20-way dil sockets on the display board. The strips between opposite pins of the sockets are cut beneath the board. So that the board can be mounted to the front panel, it is preferable for the wiring to the board to be inserted on the strip side of the board. The 20k resistor (R15) is required only for a dot mode display, but it does not affect the display in bar mode. Use double-sided terminal pins on this board so that other leads can be soldered to the rear of the board.

S1 acts as an on/off and range selecting switch. The figure shows a 4-pole 3-way switch, but a 3-pole 4-way switch could be used instead.

The sensor can be mounted inside the enclosure or externally. In the prototype it is mounted at the rear of the enclosure. A transistor socket is soldered to a small piece of strip-board and this is held in position by a short length of pcb adhesive-backed guide. You could bolt the board in position, or use Bluetack or a 'sticky fixer', instead. The bottom rear and top of the case is bored with ventilation holes in the region of the sensor. it is a good idea to insulate the part of the enclosure in which the sensor is situated by walling it off with expanded polystyrene. This prevents heat from the circuit (and particularly the ribbon cable) from affecting the sensor. This is important if the instrument is to run continuously, rather than to be switched on only when a temperature reading is required. Mounting the sensor externally eliminates heating problems. To mount the sensor externally, run the leads from the main board to a stereo jack socket mounted on the rear panel.

SETTING UP

You need a room thermometer, preferably an accurate mercury-filled type, graduated in degrees Celsius. Measure the room temperature and then switch on the instrument to a range that includes this temperature. The 'bulb' led glows green or red, depending on the range selected.

Connect a voltmeter between the 0V *supply* (the pin at L5 on the main board) and pin 6 of IC5. Adjust VR4 until the reading is 7.015V (or as close to it as your voltmeter can indicate). Connect the voltmeter to the 0V rail of the sensor and opamps (the junction of R1 and R2). Check that Vout from the sensor is in the region 0V to 0.4V, depending on room temperature. Since you know what the room temperature is, you will be able to work out what Vout should be (see earlier).

Adjust VR1 so that the voltage at its wiper

Fig 4. Display board.

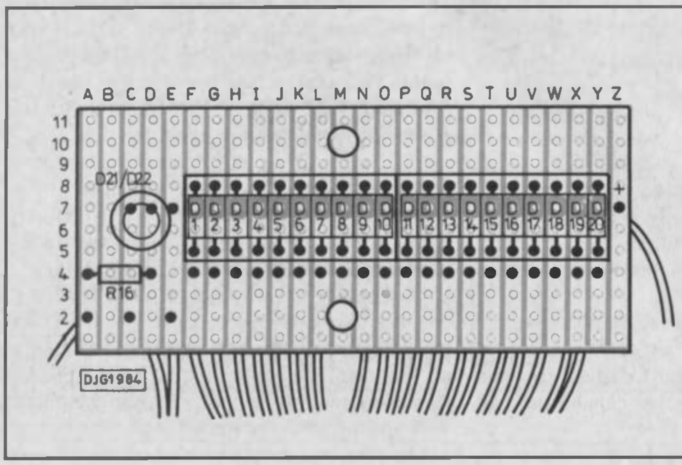
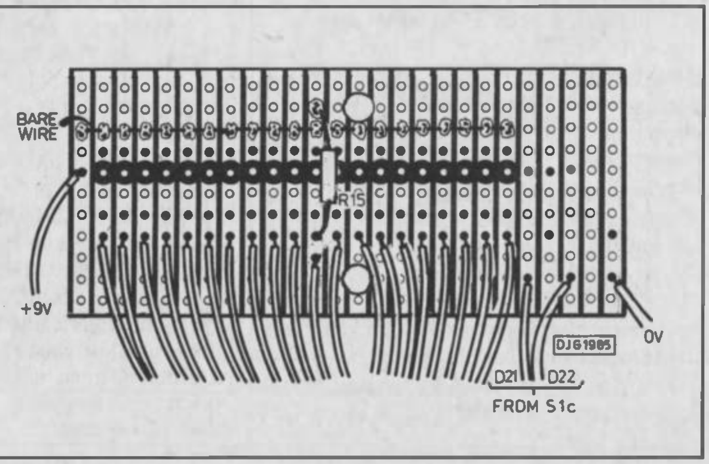


Fig 5. Display board reverse side.



is -0.328V (or as close to it as your meter can indicate). Adjust VR2 to +0.2V. Check and note the output of IC2, at pin 6. This is -(Vout - 0.328). Connect the voltmeter to the output of IC3, at pin 6. Adjust VR3 until the output is -35 times the output of IC2.

The number of leds illuminated on the display depends on the room temperature. Grip the sensor gently between thumb and fore-finger. The bars extends in length. Release your grip and the bar contracts as the sensor cools down. If the turning on of the leads is slow, so that the 'top' of the bar consists of two or three half-on leds, you are having problems with oscillations in the circuit. Try increasing the value of C1, and check that all power line connections are securely made. If you are using a battery, check that its voltage is at full strength. Put the thermometer in a room in which the temperature is a little below 20°C Switch to range 1. Now grip the sensor between your thumb and finger to warm it. By gripping or releasing the sensor you can make the temperature increase or decrease in the region of 20°C. Switch between ranges and, if necessary, adjust VR2 until there is a smooth transition between ranges.

This completes the initial calibration. Try putting the thermometer in situations at different temperatures and compare its readings with your standard room thermometer. Leave both in a new situation for five minutes or more to give them time to reach the new temperature. Do not expose

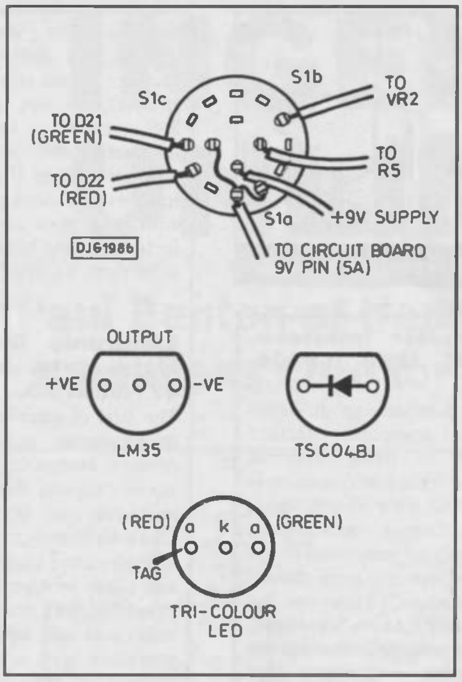


Fig 6. Switch wiring and pin-out details.

either the room thermometer or the sensor to direct sunlight as this will result in spurious readings. You may find that it is necessary to make slight adjustments to the settings to take account of inaccuracies in the original settings or small errors inherent in the amplifier circuits. PE

SCOPE EXPANDER

Continued from page 36

had the unit at the time I was designing the Rugby Clock I would most certainly have used it to monitor several different aspects of that circuit at the same time, storing and holding them for examination. This would have saved me the trouble of writing several diagnostic machine code programs so that I could use the Pet as a monitor. I have also used the unit extensively in analysing the behaviour of another circuit I am working on.

You will have also spotted that the project I'm describing now can be used as a logic analyser as well as an event monitor. You have, of course, just seen how it can be used in this way when I was referring above to checking the scope screen data states against the binary to decimal chart. The unit can't perform the binary to decimal conversion for you, as a computer would, but for simple analysis you can use it in conjunction with a b-d chart, with good effect.

This is most certainly a versatile and worthwhile piece of test equipment which I am pleased to have introduced to my workshop. I'm sure you'll be pleased to do likewise. PE

bookmark

Your Ed looks at some of the new books recently received.

Build Your Own Universal Computer Interface. Bruce Chubb. Tab Books. £19.05. ISBN 0-8306-3122-4.

In over 300 pages, this American book provides an in-depth coverage of how you can build a universal computer interface system (UCIS) that is readily attachable to many different computers. Among the computers for which detailed information is given are the IBM PC, XT, AT, System/2 and their compatibles, various models of TRS80, Apple II, VIC20, Commodores 64 and 128, and Heathkit/Trionix H8. The BBC family of machines is not mentioned so far as I can see. (Have the Americans been denied access to one of the UK's more popular computers?) However, the author advises that "If you have a computer that I haven't covered, please don't give up on the UCIS. Study the reference manual for your computer and compare its bus description to examples I've covered." The book claims to detail the complete technology of universal computer interfacing from theory to step-by-step assembly instructions. Both hardware and software are covered. You are shown how you can use interfacing circuits with your computer to control just about anything, from home security systems and robotics to model train layouts and all types of industrial control systems. This is a book full of useful information that should spark off your imagination to make better use of your own computer.

Troubleshooting and Repairing VCRs. Gordon McComb. Tab Books. £17.20. ISBN 0-8306-2960-2.

In the USA, from where this book originates, it is estimated that 50% of all households have at least one video cassette recorder (vcr). For Americans, troubleshooting, repairing and maintaining vcrs is both a lucrative business for repair technicians and an expensive proposition for consumers. If you are of the opinion that a similar situation applies in the UK, then you could well find benefit from this book. Gordon McComb is a regular author for Tab and he is also a certified electronics technician who owns and operates a successful vcr and electronics business. This book thus comes straight from the horse's mouth, and it is designed specifically for the consumer. It offers complete schematics and step-by-step details on general upkeep and repair of home vcrs, from the simple cleaning and lubricating of parts, to troubleshooting psu and logic circuitry problems. The author explains, in a non-technical manner, the care and repair of all types of vcr, though you should not expect that your own specific model will be mentioned by name. He introduces the vcr, giving you the basics of operation and installation, and explaining general preventative maintenance procedures. He describes troubleshooting techniques and procedures for the vcr itself, as well as citing problems not caused by the vcr, such as bad tapes, improper hook-up, malfunctioning tv and others. Flowcharts are provided for vcr malfunctions, including decks that don't turn on, won't play tapes, start/stop problems, and many other situations. If your vcr is out of guarantee and misbehaving, this book could put you on track to inexpensively solving the problem.

Advanced BASIC Scientific Subroutines. B.V.Cordingly and D.J.Chamund. Macmillan. £9.50. ISBN 0-333-43569-9.

I am not sure that this book will necessarily help you directly with your electronics problems, though some of the routines given may help solve a particularly troublesome logic problem. The book is really aimed at those who are more involved with computing, but I know that many of you are deeply involved in both disciplines. Contained within the book is a valuable selection of program subroutines in structured Basic. It will be of immediate practical use for the solution of a wide range of mathematical and statistical problems. The subroutines are written in a highly portable version of standard Basic and are suitable for use with IBM PCs and compatible machines. They cover generation of random numbers, probability, density and distribution functions, general statistics, analysis of variance, linear regression, matrix operations, interpolation, numerical analysis, calculus, solution of equations, and complex numbers. If you are involved in these areas the Basic routines presented will be invaluable and remove the need to write and debug your own programs. Even if your machine is not an IBM PC compatible, the routines will need only very slight modification (if any) to use them with your own computer. A diskette, containing all the programs included in the book for use on an IBM PC is also available from the publishers. Currently the disk is priced at £22 plus vat.

Electronic Display Devices. Edited by Shoichi Matsumoto. John Wiley and Sons. £39.95. ISBN 0-471-92218-8.

The first chapter sets out basic knowledge regarding the history of development, principles and construction of electronic display devices, comparing their performance and characteristics. The other seven chapters discuss particular display devices, in the areas of: principles of operation and systems; materials and physical properties; structure and manufacturing processes; drive methods and circuitry; display characteristics and performance; applications and uses; problems and outlook. To facilitate understanding, in all chapters many drawings, tables and photographs are provided, as are references and bibliographies at the end of each chapter. This is a specialist book and is best suited to those who have an advanced interest in electronic display devices. The editor is part of the Toshiba Corporation and the book is a translation from the original Japanese text.

Practical Digital Control. A.M. Zikic. Ellis Horwood Ltd. £57. ISBN 0-7458-0479-9.

Even if the price were to be lower, this book should still be regarded as a book for the advanced electronics designer. It is a two part study of computer controlled systems which is intended to familiarise the reader with digital control aspects, requirements and techniques. The book contains an introduction to the practical aspects of computer usage for control purposes, interfacing and implementation problems and limitations. It includes discrete direct and state space design techniques, with necessary mathematical introductions at appropriate points throughout. An extensive list of references where further theoretical or practical information can be found.

OP-AMP CIRCUITS MANUAL. R.M. Marston. Heinemann Newnes. £12.95. ISBN 0-434-91207-7.

The opamp is one of the most popular and versatile building blocks used in modern electronic circuit design, and will be a device close to the heart of practically all readers. The devices are available in three basic forms, the 'standard' (741, etc) type, the Norton (LM3900, etc), and the OTA (CA3080 and LM13600, etc). This book explains how each of these device families works and shows how to use them in practical applications. Over 300 circuits, diagrams and tables are presented. Although the manual is specifically aimed at the practical design engineer, technician and experimenter, it will be of equal interest to the electronics student and the amateur. It deals with its subject in an easy-to-read, down-to-earth, non-mathematical, and very comprehensive manner. I recommend this book to any reader who wants to gain more knowledge about opamps.

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INGENUITY UNLIMITED

Paul Benton of Hednesford, Staffs offers a painless cure for persistant flashers.

FLASHER ALARM

Anyone who drives a car must be quite aware of the problem of flashers! The flashers, that is, which indicate whether cars are turning right or left.

If the vehicle is turned sharply once the flashers have been set, the indicator will usually cancel. But, if the direction of the vehicle is relatively straight, the off switch may not trigger. Net result: the driver can become a flasher, often oblivious to the fact that the indicator continues to flash for several miles. This can be a potentially dangerous situation, and also an aggravating one to other road users.

In some cars the flasher unit ticks loudly enough to be heard by the driver, but not in all cars. My first idea to remedy the situation, for my own car was to instal a buzzing reminder in which the buzzer was attached to the feed wire of the lamps, using a couple of diodes. This was tried for two miles before the wires were pulled off and the buzzer stamped on! The sound of the buzzer 'doing its thing' on every flash was too much to take.

A happy medium was found by then using the circuit in Fig. 1, which uses a decade counter to trigger the buzzer once for every ten flashes. A simple solution that's kinder to the ears and other drivers!

PE

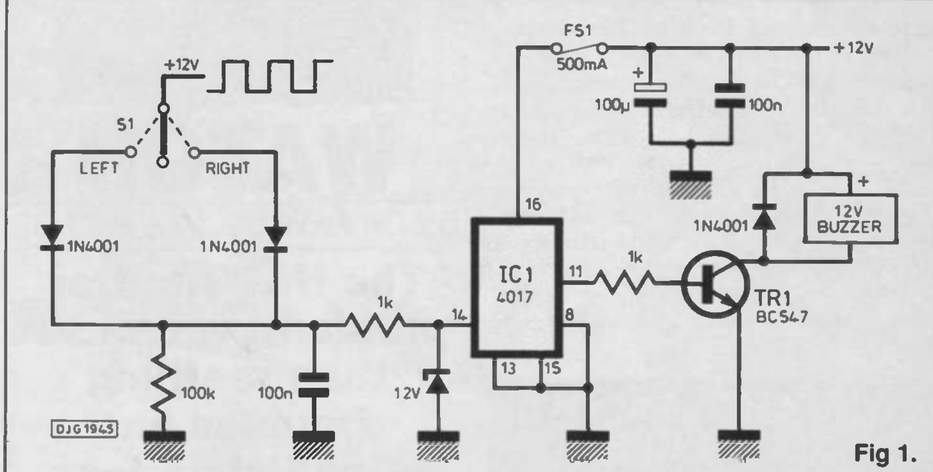


Fig 1.

EDISON
continued from page 31

system to be the first and there were other people, like Swan in England, who were also working on developing better light bulbs. Then in 1879 Edison demonstrated the bulb he was to use. It had a carbon filament, and although it was nowhere near as reliable as today's bulbs it was a massive improvement on anything else which could be made at the time. Edison also demonstrated the system he was going to use. It would have the bulbs connected in parallel, so that if one bulb blew others could still operate. In addition to this they could also be turned on and off independently.

With the work progressing at tremendous rate the first system was soon opened. This happened on 4th September 1882 when Edison himself switched on the first commercial lighting system. It illuminated part of New York from a power station on Pearl Street in the centre of the city. This was a major milestone as it was the first time that electric lighting had been available in this way and it soon caught on.

SEMICONDUCTORS

Even so, work was still going on the prevent the blackening which occurred on the inside of the bulbs. Several ideas were tried to overcome the problem. One of these was to place a second electrode into the bulb. When this was done Edison noticed that if he placed a battery between the two electrodes current would flow, but only in one direction. As he could see no application for this he did not investigate it any further. Even so he did demonstrate the effect (which he called the Edison Effect) to other people including Professor J.A. Flemming who was later to develop the diode valve for radio. Had it not been for Edison making the first observations of this effect then electronic technology would undoubtedly not be where it is today.

YEARS PASS

Edison's light company grew rapidly as the number of people using electric lights increased. He also found that the amount of work his inventors were having to do to keep pace with all this was increasing. As a result, Edison had to move his laboratories again, but this time it was to West Orange in New Jersey.

Not everything which Edison turned his hand to was successful. One major set back came when he had to unsuccessfully end a project for magnetically separating iron ore from low grade deposits. He had spent colossal amounts of money on it and he had borrowed heavily from the banks. Consequently he lost control of his major company, The Edison General Electric Company. This was merged in 1892 with a number of other electrical companies to form the General Electric Company which is still one of the giants in America today. Although this was obviously a major blow for him he took it philosophically and continued with his other inventions.

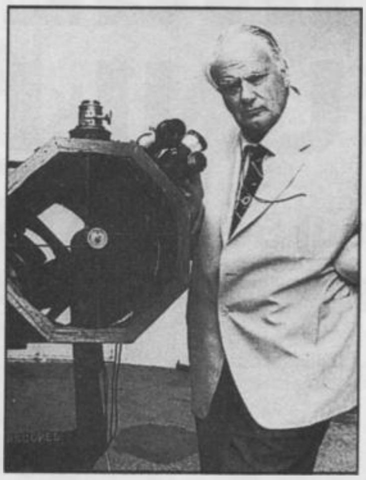
LAST YEARS

As Edison grew older he carried on with his work and did not retire. If anything, his life became more varied as he took on different types of work. As one example, he became head of a naval research board during the first world war and this gave him the opportunity to work on weaponry. Apart from this he spent a lot of time trying to devise ways of obtaining rubber from garden weeds, as well as whole host of other ideas.

Edison died in 1931 at the grand age of 84. During his life he had invented more than any other person and was probably the only person ever to own an invention factory - which is what he called his laboratories.

PE

SPACE WATCH



BY DR PATRICK MOORE CBE

The HST's mirror problems are more than teething troubles but remedial options are being discussed

On August 10 the Magellan space-probe is scheduled to enter a closed orbit round Venus. Magellan, launched in May last year, has one aim only: to complete and improve the radar maps of Venus' surface - which we can never see directly, because of the constant layer of dense cloud. Magellan is on course, and at present all the instruments seem to be in perfect working order. Radar mapping should go on for some years, at least for much longer than one 'Venus year' of 224.7 Earth-days.

Other probes have also been in the news. Giotto, which flew through Halley's Comet in 1986, passed by the Earth in July this year, and will be sent on to rendezvous with Comet Grigg-Skjellerup; much of its equipment is still functioning, though unfortunately the camera, which took those magnificent pictures of the Halley nucleus, is no longer operative. The Galileo probe is continuing its tortuous path to Jupiter, and approval has been given for the launch of the Cassini space-craft to Saturn in the mid-1990s.

The new office of the Royal Greenwich Observatory, at Cambridge, has been officially opened; the fate of the telescope at Herstmonceux Castle is still undecided. Meanwhile, Dr Paul Nurdin, the famous astrophysicist, has been appointed Deputy Director of the RGO.

HUBBLE SPACE TELESCOPE

As most people know, there are serious problems with the Hubble Space Telescope - the great 94-inch reflector which was sent into a path round the Earth earlier this year, and which was expected to produce results far superior to anything possible with ground-based telescopes which have to look through the whole of the unsteady, obscuring atmosphere.

Preliminary "teething troubles" had been expected; for example, there were vibrations caused by the heating and cooling of the British-built solar panels, as the space-craft moved in and out of the sunlight, and radiation effects were also more pronounced than had been anticipated, periodically 'wiping' the memory of some of the on-board instruments. However, all this could be coped with. Much more serious is the revelation that there is something very wrong with the optical system. The trouble may lie with the main mirror or with the secondary; in any case, it prevents the images from being brought to a sharp focus - and unless it can be remedied, the Hubble Telescope will not be able to do nearly as much as had been hoped.

What went wrong? There are several possibilities. One is that the main mirror has been wrongly constructed - and remember, a tiny error can have catastrophic results with regard to the telescope's performance. Another suggestion is that the tests with the primary and secondary mirrors acting together were not carried out with sufficient rigour. It is also possible that the trouble comes from the fact that the telescope ought to have been launched years ago, and has been 'lying around' waiting.

NONSENSE

Inevitably, the whole situation has been seized upon by those people who are always anxious to belittle the whole space programme. It has been claimed that "heads will roll".... that the telescope is "a white elephant" and that it is "the most expensive failure in scientific history". Frankly, this is nonsense. When working at the very limit of modern technology, it would be over-optimistic to expect perfection at the first attempt - and the Hubble telescope is something entirely new.

REMEDIES

We must look round for a remedy, and there are several alternatives. A "repair crew" could be sent up to see what can be done, though admittedly this does not seem to be practicable before about 1993. It may be possible to adapt the ground equipment to compensate for the errors in the mirrors. As a last resort, there is the idea of bringing the telescope back to the ground, repairing it and re-launching it. Which, if any, of these options will be taken up remains to be seen.

Yet even if nothing can be done to correct the fault, the telescope must not be dismissed as a failure. Optically, it should still at least equal any telescope on the surface of the Earth; more importantly, it can carry out

THE AUGUST SKY

August is not the best time of the year for stargazing, even though the nights are becoming longer. This month the Moon is full on August 6, and in a way this is a pity, as it will interfere with the start of the Perseid meteor shower. The Perseids can always be relied upon to provide a good display, and they reach their maximum on August 12, by which time the Moon will have vanished from the evening sky; but during the first week or so it is undeniable that they will be largely drowned by the brilliant moonlight. The Perseid shower ends around August 17, the Moon is new three days later.

Of the planets, Mercury and Jupiter are to all intents and purposes out of view, but Venus continues to be a splendid object in the east before dawn - though the phase is now well over 80 per cent, and no telescope will show anything definite upon the brilliant gibbous disk. Mars is also in the morning sky, south of the Pleiades or Seven Sisters in Taurus; it has become brighter than any star visible from Britain apart from Sirius, though it will not be at its best until the latter part of November. Saturn is low in the south, in Sagittarius (the Archer), but by the end of August it will have disappeared by midnight.

There will be a partial eclipse of the Moon on August 6, but it will not be visible from Britain. In fact, from our islands there are no more eclipses this year.

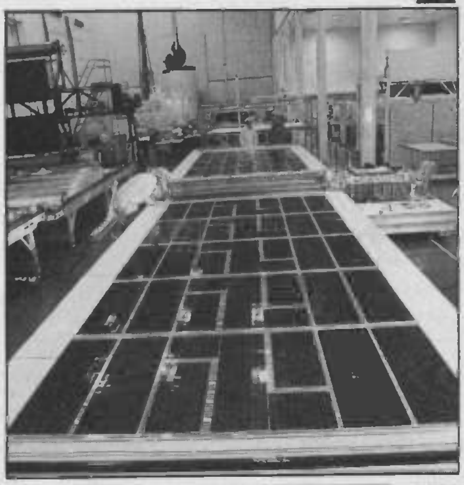
The night sky is still dominated by the "Summer Triangle" of Vega, Deneb and Altair. The star-clouds in Sagittarius are visible in the south-west (remember that Saturn lies in this area, and is much brighter than any of the adjacent stars), while the Square of Pegasus is coming into view in the east. Altair, in Aquila, is distinguished by having a fainter star to either side of it. During August we may well see a naked-eye comet, Levy's, in this area; it may even have a detectable tail, and according to calculations the magnitude may rise to as much as three – but after the disappointment of Austin's Comet earlier this year, I hesitate to make any predictions!

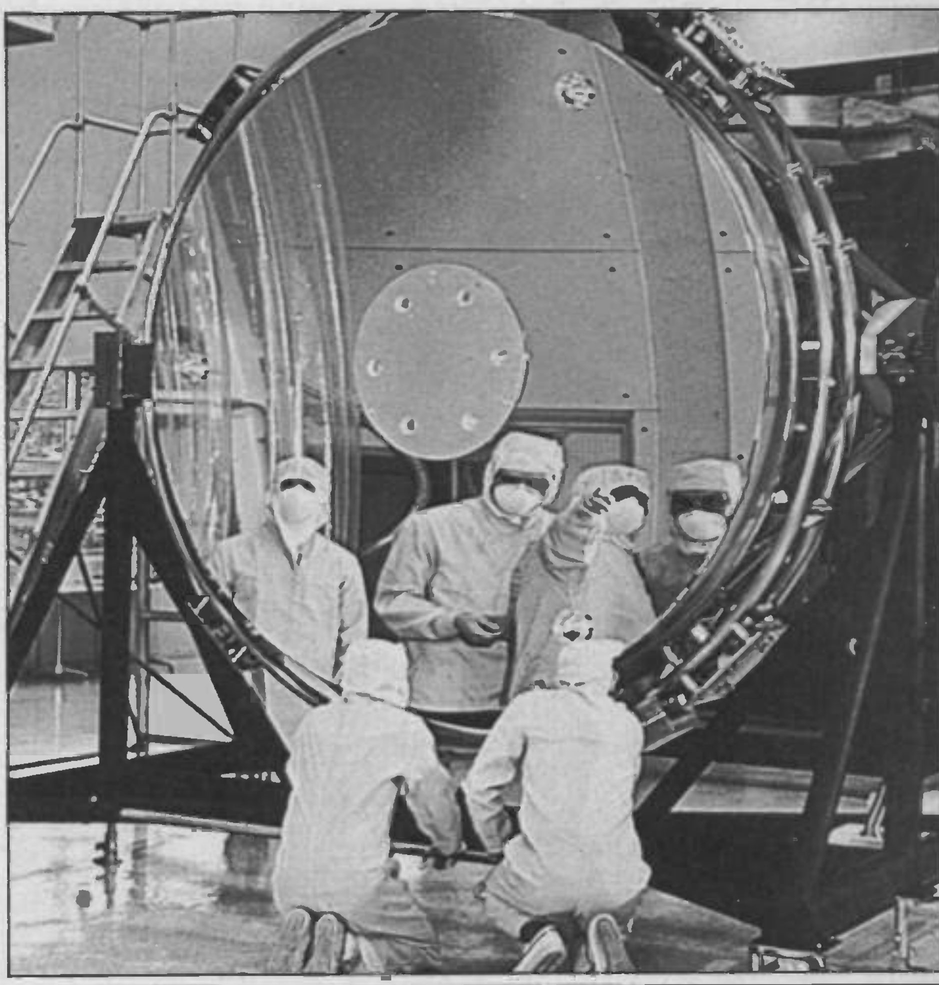
researches in the ultra-violet region of the electromagnetic spectrum, which no ground-based telescope can do, at some wavelengths, because of the screening effects of the Earth's air. So it has been well worth building, despite the expense; even if it does not come up to all its expectations, it has shown the way for future instruments.

NASA has had a bad period: not only the Hubble fault, but also the temporary grounding of all the Shuttles. Let us hope that things can soon be put right, and that the space programme will be in full operation again before the end of the year.

Pictures show the HST's mirror and solar panels during manufacture. They were kindly supplied by NASA.

PE





This month we present a varied selection of devices and circuits with many useful and interesting applications. But first we include the modules and a system we did not have space for last month. Fig. 1 shows the component layout for the transistor amplifier Module 10.

MORE MODULES

11 Loudspeaker amplifier

This is the emitter follower amplifier of Fig.22 last month, but with different component values to give it lower output impedance. The collector current is 20mA and the loudspeaker is coupled to the emitter voltage by a large-value capacitor. This provides an output suitable for a small room with moderately low background noise. (Fig.2).

Parts required: R1 56k; R2 330 ohm; C1 100n polyester; C2 470µ electrolytic; TR1 ZTX300 npn transistor; LS1 loudspeaker 8-ohm (or crystal earphone); stripboard 63mm x 25mm (Vero 15354).

12 Microphone

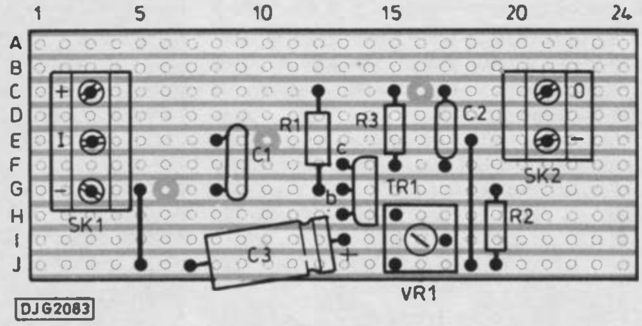
Use a ready-made crystal microphone, with the leads stripped so that they can be inserted into the sockets of Module 10. To save expense you may use what is usually catalogued as a 'crystal microphone insert'.

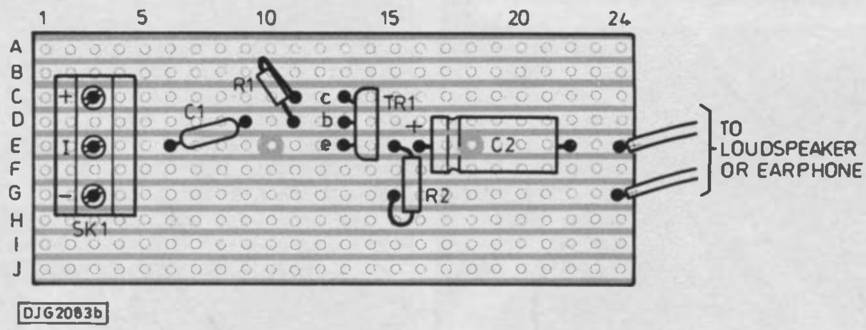
ANOTHER SYSTEM

Intercom

Fig. 3 shows a one-way intercom system, complete with a call buzzer. You need a battery

Fig 1. (right). Component layout for Module 10.
Fig 2. (below). Component layout for Module 11.





BASIC ELECTRONICS

By Owen Bishop

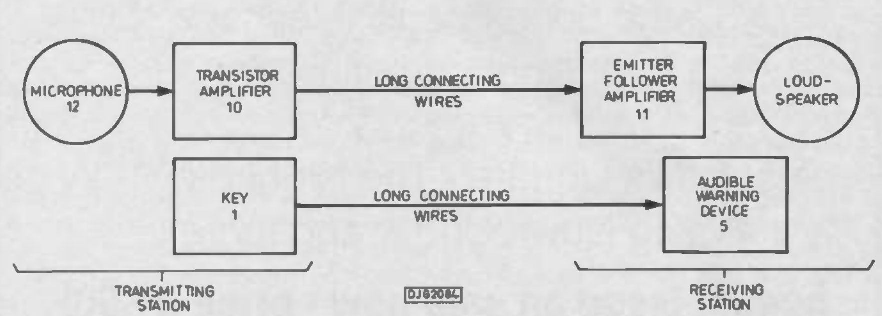
Part 9 - Assorted devices and circuits

Phototransistors, thyristors and jfets are important variations on the transistor theme. We look at theory and investigate some of their actions.

at each end.

The 0V line is shared by the audio circuit and the call circuit, so only three wires are required between the transmitting and receiving stations. Experiment with this system, substituting other types of amplifier for the specified modules. Can you convert this into a 2-way system? You will need two microphones and two loudspeakers but it makes sense to use the same amplifiers for both stations. You will need to design a switching system to allow each station to be put into 'send' or 'receive' mode.

Fig 3. System diagram of a one-way intercom.

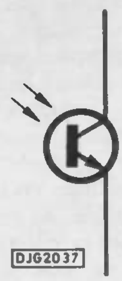


PHOTOTRANSISTOR

A phototransistor is essentially an ordinary bipolar junction transistor enclosed in a translucent package. Some of them, such as the TIL32, are encapsulated in clear resin. The package is moulded to focus the light on to the transistor. Others, such as the BPX25 and the TIL81, have a metal case with a glass or plastic lens at one end to concentrate light on to the transistor inside. It is instructive to examine a phototransistor of this type with a hand lens. You can see the tiny silicon chip bearing the transistor and the gold leads joining the chip to the external leads. Looking at this reminds us how small the actual transistor is compared with the package which contains it. We can realise how it is possible for several hundred, or even several thousand, transistors to be fabricated on the chip of an integrated circuit.

Fig.4 shows a phototransistor in symbolic form with collector and emitter terminals but no base terminal. A base terminal is not essential since, as with the photodiode, the action of the phototransistor depends on the minority carriers generated when light falls on it. The more intense the light, the more carriers. The collector-base junction is reverse-biased (see Part 4, April 1990) and so

Fig 4. Symbol for a phototransistor



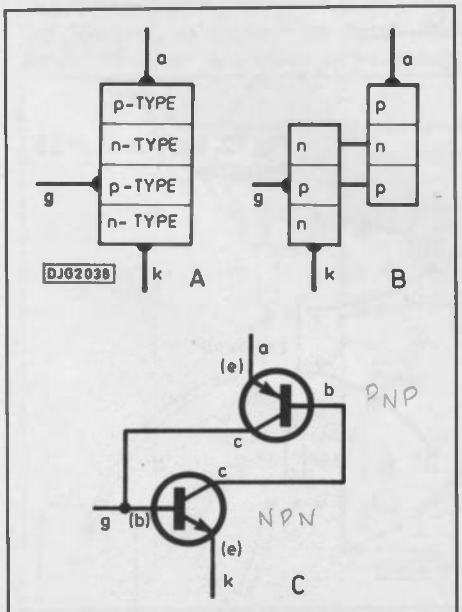
a small leakage current flows from the collector region to the base. Transistor action occurs, as described in an earlier part of this series, but this time it involves minority carriers. As a result the small base-collector leakage current leads to a very much larger collector-emitter leakage current. In effect, we have a photodiode with built-in amplification. This is why a phototransistor is considerably more sensitive than a photodiode.

Although an external connection to the base is not essential, and is not provided in many types of phototransistor, the switching time of the device can be reduced by providing a base current. If the *photo*transistor has a base terminal, its symbol is the same as that for an ordinary transistor, with the addition of the two arrows shown in Fig.4.

THYRISTOR

This is a 4-layer device, consisting of alternate layers of p-type and n-type semiconductor material (Fig.5a). It is easier to understand its action if we split it down the middle as in Fig.5b. Then it appears as two interconnected transistors, one npn and the other pnp, as in Fig.5c. In use, the emitter of the pnp transistor (known as the *anode* of the thyristor) is made positive to the emitter of the npn transistor (known as the *cathode* of the thyristor). Since neither transistor is receiving base current, no current flows through the device.

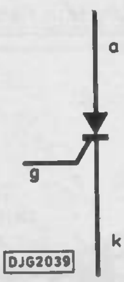
Fig 5. Thyristor (a) structure, (b) shown as two transistors, (c) transistor connections.



If the base of npn transistor (known as the *gate* of the thyristor) is now made slightly positive, the transistor is turned partly on and collector current begins to flow through it. This current flowing *into* the collector of the npn transistor results in current flowing *out* of the base of the pnp transistor. This turns the pnp transistor on too. Now current flows out through the collector of the pnp transistor, and supplies base current to the npn transistor. The increased current turns the npn transistor more fully on and this in turn draws more current from the pnp transistor, turning it more fully on. In a matter of microseconds, both transistors are fully on and current flows freely from the anode to the cathode of the device. At this point it is no longer necessary to supply an external base current to the npn transistor. In other words, it requires only a brief positive pulse, applied to the gate, to put the thryistor into its fully conducting state.

Once a thyristor is conducting, it continues to conduct for as long as its anode is positive of its cathode. If the supply is removed, conduction stops and it then requires a pulse at the gate to start it again. Because of its transistor nature, the thyristor conducts only from anode to cathode and not in the reverse

Fig 6. Symbol for a thyristor.



direction. In this respect it is like a diode. Its symbol (Fig.6) emphasises this fact, being the same as the diode symbol with the addition of the gate terminal.

Thyristors have many switching applications. For example, in a photographic flash-gun, a thyristor is used to turn on a large

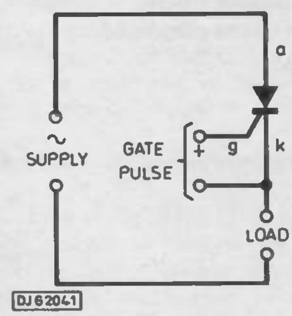
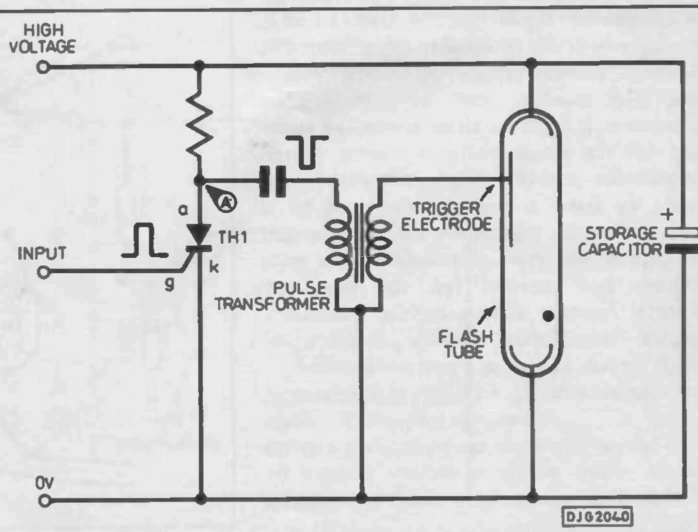


Fig 8. Simple thyristor power-control circuit.

discharge current very rapidly. In Fig.7, a low-voltage pulse applied to the gate turns on the thyristor. The sudden rush of current through thyristor produces a negative-going pulse at A. This pulse is passed through the coupling capacitor to the primary coil. A pulse of several kilovolts is induced in the secondary coil, triggering the flash-tube to discharge.

A frequent application of the thyristor is in power control (Fig.8). The circuit is powered by alternating current. A triggering pulse is applied to the gate at a given point in the positive half-cycle. This turns the thyristor on. Current flows through the thyristor for the *remainder of the positive half-cycle*, but ceases when the voltage becomes zero. By suitable circuitry (which we do not have space to describe here), it is possible to provide a pulse during each positive half-cycle. By adjusting the timing so that pulses occur earlier or later in the half-cycle, we control the length of time for which the thyristor is conducting (Fig.9). This controls the amount of power supplied to the load. A circuit of this type can be used to control the brightness of a lamp or the speed of a motor. The main disadvantage of this technique is that the thyristor conducts during the positive half-cycle only. This means that no more than half the power is available from the supply. More complex circuits using two thyristors can be used to give greater power or a related device, known as a *bi-directional thyristor* or *triac* can be used.

Fig 7. Part of a flash-gun circuit.



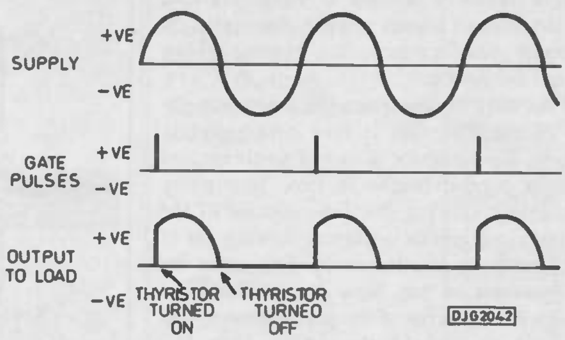


Fig 9. The rectifying and power-control action of the circuit of Fig 8.

JFET

This acronym stands for *junction field-effect transistor*. We have already met field effect transistors (fets) in an earlier issue. Then we described mosfets, which rely for their action on the field produced around an insulated electrode, known as the gate. The jfets act in a similar way, but rely on the effect of a reverse-biased *on junction*.

An *n*-channel jfet consists of a bar of n-type material (Fig.10). The bar is heavily doped, so there are plenty of majority carriers (electrons). This means that the bar has low resistance, typically less than 200 ohms. One end of the bar has a terminal known as the *source* (the source of electrons entering the bar) and the other end is known as the *drain* (through which electrons drain away to the positive supply rail). The gate consists of a region of p-type material surrounding the bar (though shown to one side of it in Fig.10, for simplicity). As in a pn diode, a depletion region forms on either side of the pn junction. Since the p-type material is more heavily doped than the n-type region, the depletion region lies more in the bar than in the gate. If this pn junction is reverse-biased (the p-type made negative of the n-type), the depletion region becomes wider. The bigger the reverse voltage, the wider the region. The effect of this is to vary the width of the bar available for the conduction of electrons from source to drain. The transistor behaves as a variable resistor, the resistance of which is controlled by the gate potential.

The high degree of insulation provided by the depletion region means that currents flowing into or out of the gate are measured in picoamps, and can be ignored. In other words, jfets, like mosfets, have very high input impedance. It is the variation in *voltage* at the gate, not the amount of gate current, which controls the current through the transistor. In short, we have a *current* controlled by a *voltage*. For this reason, we can not measure the gain of this type of transistor as a ratio between two currents (eg, the base and collector currents as in a bipolar transistor). Instead, we define another measure of amplification, known as *transconductance*:

$$\text{Transconductance, } g_m = \frac{\text{Change in drain current}}{\text{Change in gate-source voltage}}$$

When we measure resistance, we express this in ohms, which is *voltage divided by current*. This tells us how much a conductor

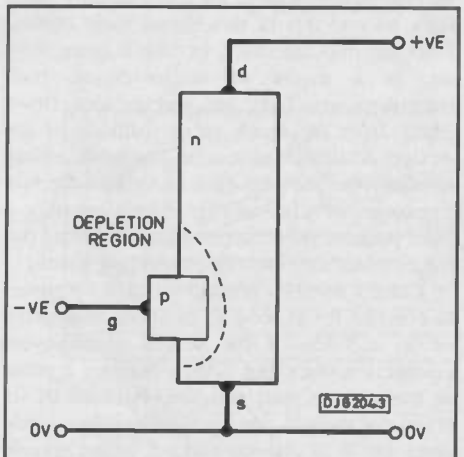


Fig 10. Junction field effect transistor.

resists the passage of current. With the fet we are measuring conductance, or how much the conductor *allows* the current to flow. It therefore makes sense to have a unit which is *current divided by voltage*. The name for the unit of conductance is the *mho* (*ohm* spelt backwards!), though an alternative name, the *siemens* is usually preferred. In the case of fets, the mho or siemens are too large for convenience, so transconductance is usually expressed in millimho or millisiemens (mS).

Let us look at a jfet in action as an amplifier (Fig.11). As with the bipolar junction transistor (the 'ordinary' transistor), jfet amplifiers may be built in various ways. The one described here is the *common-source* amplifier, which corresponds to the *common-emitter* amplifier of the bipolar junction transistor. The gate is connected to the 0V rail by the gate resistor Rg. This has a high value to give the amplifier high input impedance (1M). Since the current flowing through Rg is virtually nil, there is no appreciable voltage drop across this resistor, and the gate potential is 0V. When current flows through the transistor, there is a voltage drop across the other two resistors Rg and Rd. Thus the source terminal is at a positive voltage or, to put it the other way round, the gate is negative with respect to the source. This is the condition necessary for operation of the transistor, as shown in Fig.10.

The transistor itself acts to conduct a given current for a given input voltage, Vin. In the

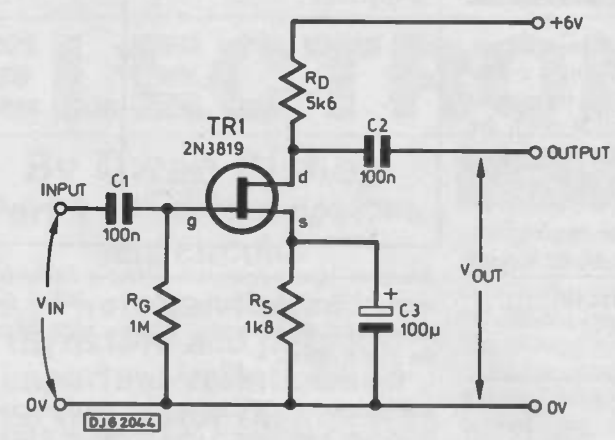


Fig 11. JFET Common source amplifier (Investigation 1).

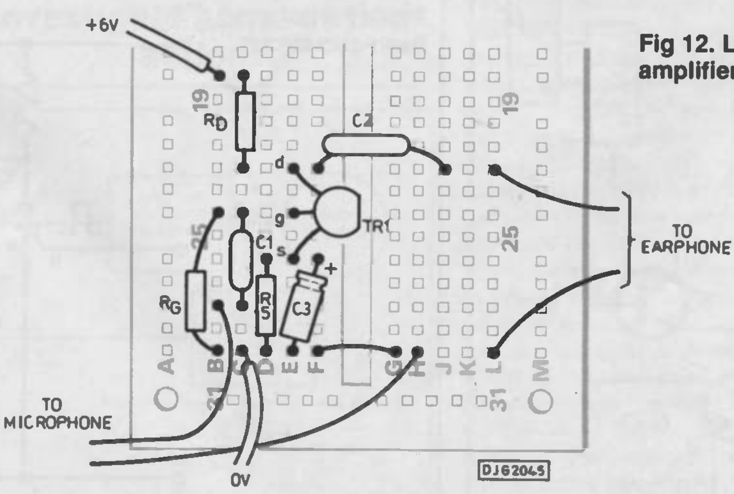


Fig 12. Layout of JFET amplifier.

circuit of Fig.11 the current for a given through a resistor Rg and a voltage develops across it. As explained in a previous issue, we are using the resistor to turn a current into a voltage. This is Vout. Thus the amplifier *circuit* as a whole is a voltage amplifier. To see how the jfet operates in practice, try this investigation.

Investigation 1 - a common-source jfet amplifier

Connect the circuit of Fig.11 as shown in Fig.12. Connect a microphone insert to the input side and a crystal earphone to the output. Preferably, the earphone should be on a long lead, so that it can be in a separate room. Try speaking into the microphone.

How does this amplifier compare in performance with the common-emitter amplifier you tried in a previous part ? What is the function of C3 ? (Hint: try the amplifier with and without this capacitor) What is the name given to this capacitor ?

Investigation 2 - jfets and electric charge

The breadboard layout (Fig.13) is similar to that of Fig.12, except that C1, C2 and Rg are omitted. This allows the gate voltage to 'float'. Vout is measured with a voltmeter connected between the 0V rail and the drain terminal of the transistor. A small metal plate (eg, a square of aluminium kitchen foil) is connected to the gate terminal. Hang the plate over the edge of workbench.

Take a strip of plastic and rub it with a woollen cloth. You can use the same strips of polythene and acetate sheet as you used in Part 1 of this series. Rubbing charges the strip. Bring a charge polythene strip near the metal plate. What happens to Vout? Repeat, using an acetate strip. What happens now ? What can you deduce about the nature of the charge on the polythene strip and on the acetate strip ?

Try the effect of charging other types of plastic by rubbing them on fabrics of various kinds.

Try touching the metal plate with your finger. What happens? Try this again while you are touching an earthed conductor. Walk around the room on a nylon carpet, wearing plastic-soled or rubber-soled shoes; touch the plate again. What happens ?

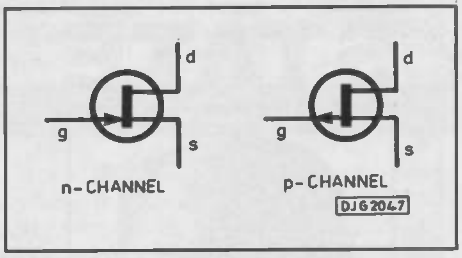


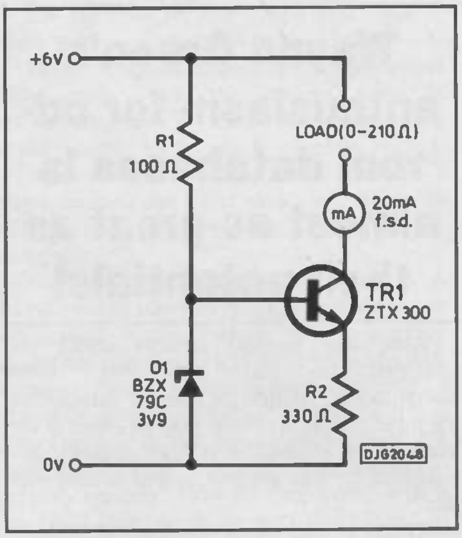
Fig 14. JFET symbols.

The type of jfet used in the investigations is an *n-channel jfet*. Less frequently we use *p-channel jfets*, in which the bar is p-type material, the gate is n-type and conduction is by holes (Fig.14).

CONSTANT CURRENT SOURCE

A useful circuit element is one that generates a constant current, independently of the load and the supply voltage (within limits). Such a circuit is shown in Fig.15. This one makes use of one of the properties of the bipolar junction transistor. When we investigated the action of the transistor in a recent issue, we found that, for a given base current, the collector current remains more-or-less constant over a wide range of collector-emitter voltages. Even if you do not need to use a constant current source, studying how it works is an easy way of revising certain aspects of electronic circuits.

Fig 15. Constant current source.



Investigation 3 - a constant current source

Set up the circuit of Fig.15, as in Fig.16. A 100-ohm resistor is used as the load, Rl. Measure the current through the load. Now increase the load to 150-ohm, 180-ohm, 220-ohm, and 330-ohm. Record the current through each load. Reduce the load to 68-ohm, 47-ohm, and 27-ohm. Measure the current through each load.

With 27-ohm as the load, reduce the supply voltage to 4.5V by tapping the battery holder so as to use only three of the four cells. This reduces the supply voltage by 25%. Is the current through the load also reduced by 25%?

The zener diode holds the base of TR1 at a steady voltage. What is the voltage across R1? What is the voltage drop (Vbe) between the base and emitter of the transistor? Calculate the current through R2. The maximum permissible value of the load resistor is that for which the voltage drop across it is equal to the drop across R1. If it was greater, the collector-base junction would be reverse-biased and the transistor would not work. Calculate the maximum load resistance.

To be continued next month, when we shall look at Unijunctions, more reference sources and power supplies, and discuss the investigations.

POINTS ARISING

Part 3 March 90

Several words were omitted from the first paragraph on page 26. This is how it should have read:

When a steady current (ie direct current) flows through one coil it generates a magnetic field in the core. But, since the current is constant, the magnetic field is constant and has no effect on the other coil. If an alternating current is passed through the one coil, this produces an alternating magnetic field. PE

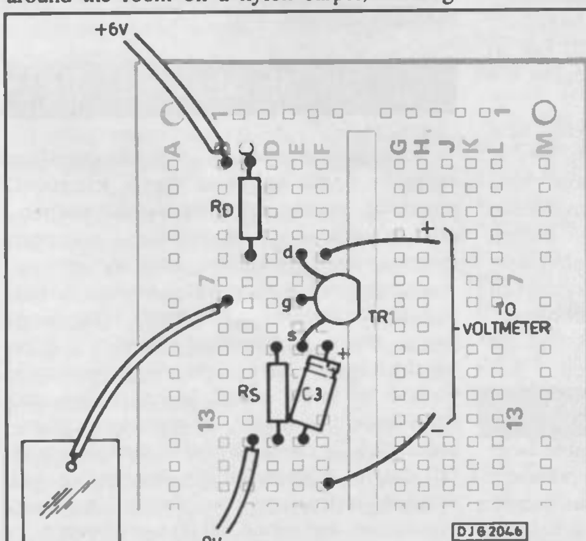
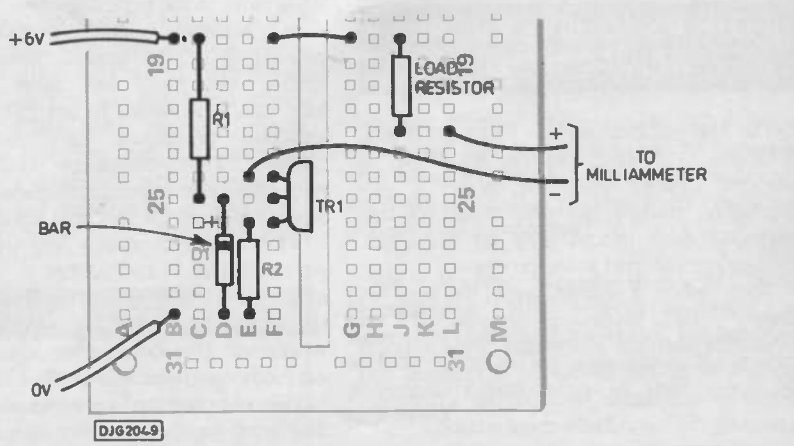


Fig 13 (left). Layout for Investigation 2.

Fig 16 (below). Layout of circuit in Fig. 15.



HOME DATA SYSTEMS

Wayne Green's enthusiasm for cd-rom databases is almost as great as their potentials!

With the costs of health care escalating, the health industry is looking for possible economies. In this vein (pardon), there is a trend toward educating doctors to be specialists and repair people rather than being information processors.

In the past, doctors were trained to memorise vast quantities of information as a way to help them with the diagnosis of medical problems. With information becoming easier to access via computers, and increasing computer portability, there is a lessening need for doctors to have to depend on their memories.

In the last few years we've seen more and more home medical guides being published, but these have several drawbacks...not the least of which is their expense. Depressingly few people are willing to invest in these books as a safety precaution for their families.

Then there's the difficulty of finding what you need in these books if you don't already know what's wrong. The diagnostic process is often too complicated for this approach to be helpful. I suppose we can add to the mix a low level of literacy in lower income groups and an inability to cope with what is often rather technical language.

We do have some information systems developing which are better geared to this kind of application...such as the cd-rom. We're able to cram an enormous amount of information on a compact disc these days. One friend of mine has just put out a cd-rom full of Macintosh software with 719 megabytes of data. That's over 350,000 pages of data, all nicely cross-indexed in depth.

A medical text in fairly plain language, complete with a good index which would allow us to search for symptom combinations and which could even include an interactive diagnostic program to be downloaded into ram, is now practical.

The first use of such a new product would be for medical offices, hospitals and clinics, where it would help lower diagnostic costs. But as cd-rom reader prices drop, this will even become practical for households.

THE PSYCHOLOGICAL COMPONENT

The medical industry has had a great deal of trouble in dealing with the mind and its profound control over the body. It has reluctantly, grudgingly, come to accept that the mind does indeed play an important, possibly critical, part in the process.

Thus, when a doctor wants to treat an illness, it's becoming recognised as imperative that the associated psychological component of the illness be diagnosed and treated at the same time as the symptoms caused by the mind-body combination.

Alas, our medical schools aren't yet equipped to deal with this added complication, so though doctors realise that the mind and its problems may be either at the heart of an illness, or at least substantially contributory, they are unequipped to deal with this.

This is an area where computer technology in the form of intelligent systems is beginning to develop. Artificial Intelligence (AI) has, so far, been more hope and hype than reality, but it's a move in the right direction.

As scientists make progress with their unwinding of the genetic genome, they're finding out more and more about how inherited weaknesses in our DNA molecular structure predispose us toward certain illnesses. This information would obviously help give a computerised diagnostic system an edge in looking for potential health problems.

How can a computer help us to find the psychological component which has contributed to triggering an illness – perhaps taking the easy path provided by a genetic weakness? This information is available from our subconscious minds, but it's cleverly hidden and protected by our conscious minds. The work for the computer then is to help us get this critical confidential information past the conscious mind, which acts like a censor. It turns out this is an ideal application for a computer.

By attaching a sensor to a finger to read changes in moisture and pulse rate, it's possible to set up an effective lie detector system which will help a computer deal directly with the subconscious mind. When we're anxious about something, even subconsciously, our palms sweat. This was originally designed to give our ancestors better traction for climbing trees when things got tense. This automatic mechanism still works and can easily be measured with a differential ohmmeter circuit connected to a computer.

We've had psychiatrist-imitating computer programs (such as Eliza) for over twenty years, so all we need to do is adapt them to this application and we'll have a quick and dependable psychological diagnostic system.

By using a computer to chase down the traumas which have contributed to an illness, there's much less anxiety over the reaction of a doctor to things which a person might consciously want to hide. Less embarrassment. This makes the discovery of the underlying psychological factors precipitating an illness much easier to uncover. Indeed, experiments in taking patient histories via computers were pioneered in the UK and found to be substantially less stressful than questions from a nurse or doctor. This resulted in more honest answers.

By combining the data base made possible by cd-roms and an interactive diagnostic program, we'll have a powerful tool for families to use at home to help prevent illness or speed their recovery.

When the underlying psychological component of an illness - or even what seems like an accident - are uncovered, it is possible to greatly speed the recovery. And this holds true even for bruises, burns, and cuts, which can often heal in a fraction of the time normally required.

HOME REPAIRS

Some people invest in an almost unending series of books on home repair. Electrical, plumbing, heating, refrigerators, dishwashers, air conditioners, thermostats, security systems, lawn care, tree pruning, roofing, leaks, windows, wallpapering, kitchen design, bathroom fixtures, furniture refinishing, patios, pools, gardens, etc. Wouldn't it be worthwhile to have everything you ever wanted to know about home repairs and enhancement available, all thoroughly cross-indexed? This can be available, complete with full colour, high definition illustrations and detailed instructions on design, building, installation, and repair...all on one cd-rom.

You want to know what's available in intercom systems and how to install them? It's there. Maybe you'd like a couple loudspeakers on your porch or patio. No problem.

CALL THE LAWYER?

No, look up your legal question on a Home Legal Advice cd-rom. For the price of one hour at your lawyer's office...or even on the phone...you can have the answers to a hundred thousand legal questions all at hand and easy to find.

Small businesses will find that such a resource will save them an incredible amount on questions on contracts, licences, and so on. A cd-rom can have hundreds of legal forms all ready to be used. Wills, apartment rentals, leases, home buying details, traffic violations, etc.

BOOKS

Wouldn't you like to have an in-depth index to every book published, complete with a thorough cross-index so you can find what you're interested in? It could even have reviews reprinted from magazines and newspapers to help you decide which book you want. The front covers could be shown in full colour...plus even some commentary or a sales pitch by the author in his or her own voice.

The cd-rom could also have an interactive program built in for maintaining your own library. You'd unload this program into your hard disk drive and keep your own cross-indexed library data there.

MAGAZINES

There are thousands of special interest publications, but how can you find the ones you'd like to read? Only a few ever make it to the newsstands, so many great magazines are difficult to find out about. A cd-rom index to magazines and newsletters would let you look for those which may be of particular interest to you. I subscribe to five skin diving magazines, but I'll bet there are a dozen more around the world which I might enjoy if I knew about them.

In the music field there are publications devoted to calliope, bluegrass, theatre organ, and other music special interests. Most of these are nicely done, but very obscure.

You wouldn't believe how many specialised travel publications there are. I get over a dozen, but there are hundreds more.

If you're a Macintosh fanatic (like my wife, Sherry), then you'll want to know about the dozens of Mac publications. if you're going to get into home computing or desktop publishing, you're going to need all the information you can get.

Would you believe there are over 500 magazines and newsletters devoted to amateur radio? Packet, moonbounce, amateur tv, weather satellites, ham radio satellites, radio teletype, you name it and there's a publication somewhere...or, more likely, three.

MUSIC

How about a cd-rom index to every available phonograh record? Well, cds these days, now that lps are blowing away. This would enable you to find out what's available by any composer, performer or group. You might want to find hammered dulcimer, steel drum, or carousel band organ music.

I have such a cd-rom already available which lists over 45,000 cds and has in-depth reviews of several thousand of them which have been printed in my publications over the last five years. It also provides a summary of over one million reader evaluations of many other cds. There are many full colour cd covers and even sound samples with full digital audio sound quality.

PET TOPICS

How about one for pet lovers? This would provide pet owners with information on selecting, buying, feeding, training, grooming, health maintenance, etc. It could include reprints of important articles from pet magazines...thousands of them, all indexed. It would tell how to photograph pets, how to show them, and what to watch for healthwise.

How about a cd-rom for home electronics? This could cover the various types of telephones...how to select, buy, install and repair them. VCRs, hi-fi systems, radios, vacuum cleaners, fax machines, perhaps a video camera for your door, etc. How do Nicads work and how often should they be charged?

How about car repair and maintenance? A cd-rom could take you through just about any emergency. It could show you how every model car is designed and what generally fails first with them. Would you like to install a cd player in your car? Which models will fit? How can you do the installation yourself and save hundreds of pounds? How about car security systems? How do they work? Which are best? How much do they cost? How do you install them? Which tyres work best on which cars? Everything you ever wanted to know about your car, right there waiting for you...in detail.

You're into skin diving? Then you'll want to know how experts rate various diving vacation spots around the world. You'll want to know the details on the latest diving computers, watches, fins, snorkels, masks, regulators, wet suits, etc. You'll want to read reviews from a dozen diving magazines on new products and on dive locations. You'll want to see full colour, high definition pictures of fish.

MOVEABLE FEASTS

Maybe you're into movies. How about a cd-rom index to every current and old movie, complete with reprints of reviews? You'd want good still shots from them, pictures of the stars and supporting actors. You'd want their bios too, all indexed. This would help you find the best movies for video rental and not waste your time on B-movies.

For people who have an interest in more than tv dinners, a cooking cd-rom could provide tens of thousands of recipes, complete cooking courses for breads, pastries, salads, curries, desserts and so on. It could cover how to grow and prepare herbs...and when to use them. Do you know how to make baklava? Bialys? Spring rolls? What kitchen accessories should you get...and why? Where can you get the ingredients? How about mail order suppliers of speciality food products?

ENCYCLOPAEDIC

Once we start getting cd-rom players into the home, we're going to have a whole new industry supplying encyclopaedic information on almost any subject. In a few years I believe this is going to be a big industry...in case you're looking for an industry where you can get in early.

It shouldn't be long before most home cd players are beefed up to handle the fast, frequent searching required for cd-rom use, so the better cd players will also play cd-roms. This might add 20% to the cost of the player.

On the other hand, if digital tape ever gets going, it could replace cd-roms for data handling applications. One two-hour dat can hold two to three times as much information as a cd....and it has the benefit of being able to be updated. Cd-roms are optical devices, so one needs to buy a new cd-rom disc in order to get an update. And there are very few data bases which don't require frequent updates. We'll see how that develops.

Dats could be updated via satellites, fibre optics or just plain swapping of the cassettes. Cd-roms, which cost about 50p to make, may do better as throw-away items when replaced...like old phone books.

ON-LINE DATABASES?

Sure, we'll probably see some of this information available to computers over the telephone, but the slowness and cost of on-line systems as compared to home use will limit their sales. Remember, as soon as computers came down in price we saw on-line computing services blow away.

Ten years from now, when you enviously see lots of new millionaires, don't say I didn't warn you. I've called the turn early on cellular telephones, microcomputers, and the compact disc. Many of those who followed my advice are filthy rich today. The down-sides to being rich are vastly overrated. PE

Dr. Wayne Green lives in New Hampshire, USA, where he runs a successful publishing company. His hobbies include scuba diving and skiing. He is also passionately interested in the future of education .

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INDUSTRY

NOTEBOOK

GREENHOUSE ELECTRONICS

By Tom Ivall

Electronics has two opposing ecological aspects, one adding to pollution, the other capable of monitoring its reduction. Both have to co-exist, but the latter must prevail.

By coincidence, the United Nations' scientific panel on global warming reported its findings on the greenhouse effect in the very same week that the International Radio Consultative Committee's plenary assembly failed to agree on a world standard for high-definition television.

Apart from the UN link there seems no obvious connection between enhanced atmospheric carbon dioxide and hdtv. The second appears trivial compared with the serious implications to mankind of the first. Yet in fact hdtv does epitomise the human activities which are adding more parts per million every year to the natural level of CO_2 in the atmosphere. It is a new technology which sooner or later will become a new contributor to industrial production.

Initially, compatible broadcasting systems like Eureka 95 (see February and March 1989 issues) will not result in any immediate increase in tv set manufacturing. That's the point of adopting an 'evolutionary' compatible system. But obviously the whole purpose of the development is for viewers eventually to be able to enjoy the higher definition picture on new sets capable of displaying them.

The commercial motivation behind hdtv, justifying the r&d expenditure and manufacturing investment, is the boost it's likely to give to the television sector of the consumer electronics industry. In the past we have had shots in the arm from new transmission standards, colour, larger screens, teletext, remote controls, vcrs and, most recently, digital stereo sound. Arriving this year will be 16:9 wide-screen sets. Initially these will work on existing transmission standards, but they are also a practical step on the way towards hdtv reception and display.

At the time of writing the French industry minister has just announced a £2 billion collaboration between Philips and Thomson on hdtv development. The two firms have not yet confirmed it. But if they do get together it will make good sense. First of all Philips and Thomson have been major contributors to the development of the Eureka 95 system. Secondly, their alliance would form a stronger defence of the European consumer electronics industry against the undoubted willingness of the Japanese to manufacture hdtv sets for a European transmission standard.

You may think I'm being unreasonable in singling out hdtv as a 'culprit' in the worsening of the greenhouse effect. In fact the manufacture and use of motor cars will be responsible for a very much greater volume of CO_2 and other gas emissions into the atmosphere. I've merely picked on hdtv because it's a modern application of electronics and one which will probably have a wide market, initially as a luxury trade. As individuals we could manage without it. Most people are still unaware of its potential existence and therefore don't feel particularly deprived without it.

When the broadcasters and set manufacturers eventually produce this new enhancement to home entertainment we shall, of course, be persuaded that we really do need it. And when the price of sets comes down, as it undoubtedly will, we shall no longer be worried by thoughts of extravagance and conspicuous consumption.

It will, however, be one more example of industrial production, commercial activity and economic growth driven forward by human craving and its satisfaction. The likely ecological disasters resulting from global warming will make the more thoughtful among us ask how much longer the industrialised countries can be allowed to continue on this path without restraint.

I've also picked on hdtv as representative of a particular class of electronic applications - as against another class which is relevant here. hdtv is an application which results in consumer products. These are simply grist to the mill of the electronics business. The shareholders of electronics companies are not fundamentally interested in the technology or social impact of new products. They are only concerned to the extent that successful new products, better mousetraps, will expand markets, keep the factories going and maintain sales and profits.

In contrast is the class of electronic applications which are very useful to us but not exploitable in a mass market. The products here are devices and systems used in science, medicine, education, industrial automation and so on. They are manufactured in small quantities by specialist firms, and nobody makes a fortune out of them. Some electronic automation systems I've seen are essentially one-off: each is designed for its particular plant and will work nowhere else.

It's in this area that electronics can be of direct help in environmental problems like the greenhouse effect. Take, for example, the monitoring of flue gases from boilers and other industrial installations. There are many physical principles by which you can measure, say, the carbon dioxide content of such gases. Some of these lend themselves to use in direct-reading instruments. One such instrument is the katharometer, another the mass spectrometer, a third the infra-red absorption analyser. All give electrical output signals which can be a/d converted, transmitted digitally and subsequently processed in computers.

Gas measuring instruments are an essential part of emission control systems. These are already being used on industrial plant to achieve more efficient burning of fossil fuels and so save energy and reduce emissions into the atmosphere. The electronic systems of motor cars would do well to include this principle rather than some of the trivial electronic gimmicks we are seeing at the moment.

With the aid of electronics the condition of the Earth's atmosphere is also being monitored from outside - by instruments carried in satellites. Most recent are five geostationary satellites strung out at roughly 70° intervals round the Earth. Some are European spacecraft (Meteosat) and others American (GOES Geostationary Operational Environmental Satellite).

As the names indicate, these satellites are partly for short-term weather forecasting and partly for longer-term environmental observations. In both types a radiometer working in the visible, infra-red and water-vapour wavelength regions measures the radiance of the Earth and its cloud cover. This instrument provides information - transmitted back to Earth as digital data which is being used to monitor both atmospheric pollution and water vapour concentration - another contributor to global warming. PE

PRACTICAL ELECTRONICS

BOOK SERVICE

Here is your Editor's choice of books he thinks will be of interest to electronics and computer enthusiasts

BEGINNERS AND EARLY STARTERS

Mini-Matrix Board Projects. R.A.Penfold. 112 pages. £2.50. Order Code BP99

Shows a selection of 20 useful and interesting circuits that can be built on a mini-matrix board of 24 holes by 10 copper strips in size - an ideal book for early experimenters.

From Atoms to Amperes. F.A.Wilson. 160 pages. £3.50. Order Code BP254.

For the absolute beginner, clearly explaining the fundamentals behind the whole subject of electricity and electronics.

Electronic Projects for Beginners. F.G.Rayer. 128 pages. £1.95. Order Code BP48

Specially for the newcomer to electronics who is looking for a book containing a wide range of easily made projects. Some circuits need no soldering and many others show actual component and wiring layouts.

Electronics Build and Learn R.A.Penfold. 128 Pages. £5,95. Order Code PC 101

Combining theory and practice, the book describes a circuit demonstrator unit that is used in subsequent chapters to introduce common electronic components and circuit concepts, complete with practical experiments.

Practical Electronic Building Blocks R.A.Penfold. There are two books - Book 1 : 128 pages. £1.95. Order Code BP117 Book 2 : 112 pages. £1.95. Order Code BP118

Book 1 is about oscillators and gives circuits for a wide range, including sine, triangle, square, sawtooth and pulse waveforms and numerous others from voltage controlled to customised ic types.
Book 2 looks at amplifiers, ranging from low level discrete and opamp types to ic power amps. A selection of mixers, filters and regulators is included.

30 Solderless Breadboard Projects R.A.Penfold. Two books each of 160 pages. Book 1 : £2.95. Order Code BP107. Book 2 : £2.25. Order Code BP113.

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Beginners Guide to Building Electronic Projects R.A.Penfold. 112 pages. £1.95. Order Code BP 227

Shows the complete beginner how to tackle the practical side of electronics and includes simple constructional projects.

SATELLITE TV

Satellite TV Installation Guide - 2nd edition John Breeds. £11.95. Order Code STV1

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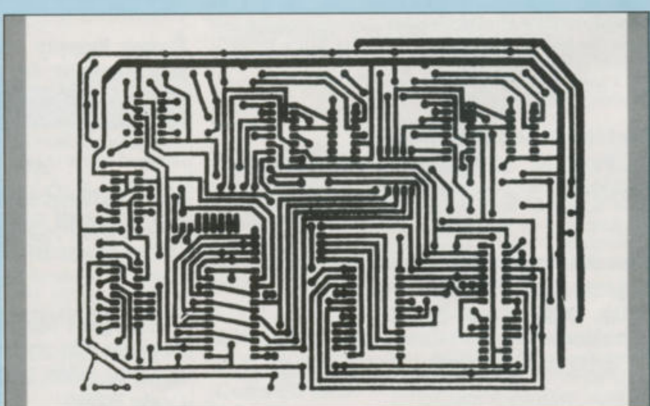

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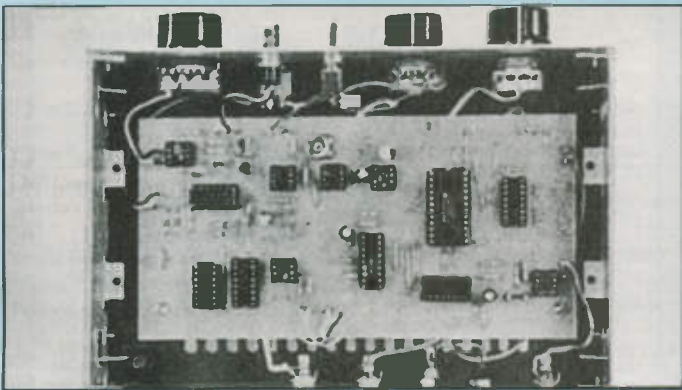

NICE AND EASY DOES IT

Building the projects published in PE is a lot easier than some of you perhaps might think. Especially when you use one of our professionally made printed circuit boards.

It's almost like painting by numbers. All the pcbs are fully drilled, and basically all you need to do is slot in the components and carefully solder them to the pcb track pads. Their places are shown in the drawings published with the project.

IDENTITIES

Component identities are usually clearly marked on them. Even if they are colour coded, like some resistors and capacitors, their values are easily worked out from component colour code charts. From time to time we publish these charts, but if you don't already have one, send a 9in x 4in stamped and self-addressed envelope to the Editorial office asking for one.

TOOLS

For many projects you only need a few simple tools - Soldering iron between 15W and 25W, with a bevelled tip. Damp sponge for keeping the tip clean. Good multicore solder of 18swg or 22swg grade. Fine nose pliers for wire shaping. Adjustable spanner or heavy pliers for tightening nuts. Miniature screwdriver for adjusting preset controls. Small wire cutters for trimming component leads. Drill and selection of bits for drilling holes in boxes. Strong magnifying glass for checking joins in close up. It's also preferable to have a multimeter for setting and checking voltages. There are some very good low cost ones available through many of our advertisers, but get one that is rated at a minimum of 20,000 ohms per volt. Many projects do not require you to have a meter, but if you are serious about electronics, you really should have one.

ASSEMBLING THE PCB

Authors will sometimes offer their own advice on the order of assembly, but as a general guide, it is usually easier to assemble parts in order of size. Start though with the integrated circuit sockets. Please use them where possible, they make life much easier than if you solder the ics themselves - with sockets you can just lift out an ic if you want.

Then insert and solder in order of resistors, diodes, presets, small capacitors, other capacitors, and finally transistors. Clip off the excess component leads after you have soldered them. Now use a magnifying glass, ideally one that you can hold to your eye, and take a good look at the joints, checking that they are satisfactorily soldered, and that no solder has spread between the pcb tracks and other joins. Be really thorough with visual checking since errors like this are the most likely reason for a circuit not working first time.

SOLDERING

Bring the tip of the iron into contact with the component lead and the pcb solder pad, then bring the end of the solder into contact with all three, feeding it in as it melts. Once sufficient solder has melted to fully surround the pad and the lead, remove the solder, and then the iron. Now allow the join to cool before touching it, otherwise the solder may set unsatisfactorily. If it does move, just reheat the join once more.

WIRING

Connecting the pcb to the various panel controls is the final assembly stage. Do this just as methodically, following the published wiring diagram. You can connect the wires to the pcb in one of three ways. The best is to insert terminal pins into the connecting holes on the pcb, and then solder wires direct to them. Or, pass the end of the wire through the pcb hole, soldering it on the other side. Alternatively, the wire can be carefully soldered direct to the pcb tracking. In all cases first strip the plastic covering off the wire, twist the strands together, and apply solder to them to keep them secure.

TESTING

Now you are ready to test and use the project as described by the author. Components can occasionally fail, but these days it is extremely uncommon, and if you have followed the instructions, been careful with your joins, and bought the parts from a good supplier, you will have the enormous satisfaction of having built an interesting and working unit. It really can be easy if you do it with care.

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The PE PCB Service list shows all the pcbs available through PE. Look down the list and see which title takes your fancy - there must be at least one that will interest you! You will probably already have the relevant issue of PE, but even if you don't we can still help you.

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We can usually supply copies of back issues of PE up to three years old. These are £1.75 each including postage (£2.25 for overseas readers). If we no longer have the issue needed, we will be pleased to send a photocopy of the article for the project that you want to build. These are £1.00 each per issue, including postage (£1.50 to overseas readers).

OBTAINING PARTS

Some projects are available from advertising suppliers as complete kits. Otherwise, all the components listed in the text will be available from suppliers who specialise in individual components.

Occasionally a specific part may only be available from a particular supplier, if so the source will be given in the parts list. Otherwise there should be no difficulty in buying the parts. We have many good suppliers advertising in PE so have a look through their adverts - that's why they're here! Even though a part may not be listed in the adverts, a phone call or two should find a supplier who will be pleased to help. Like us, they too are in the business of encouraging you to enjoy electronics!

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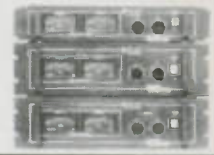

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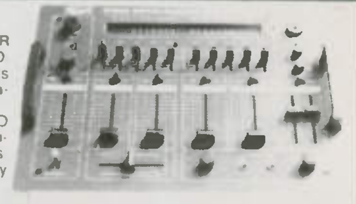

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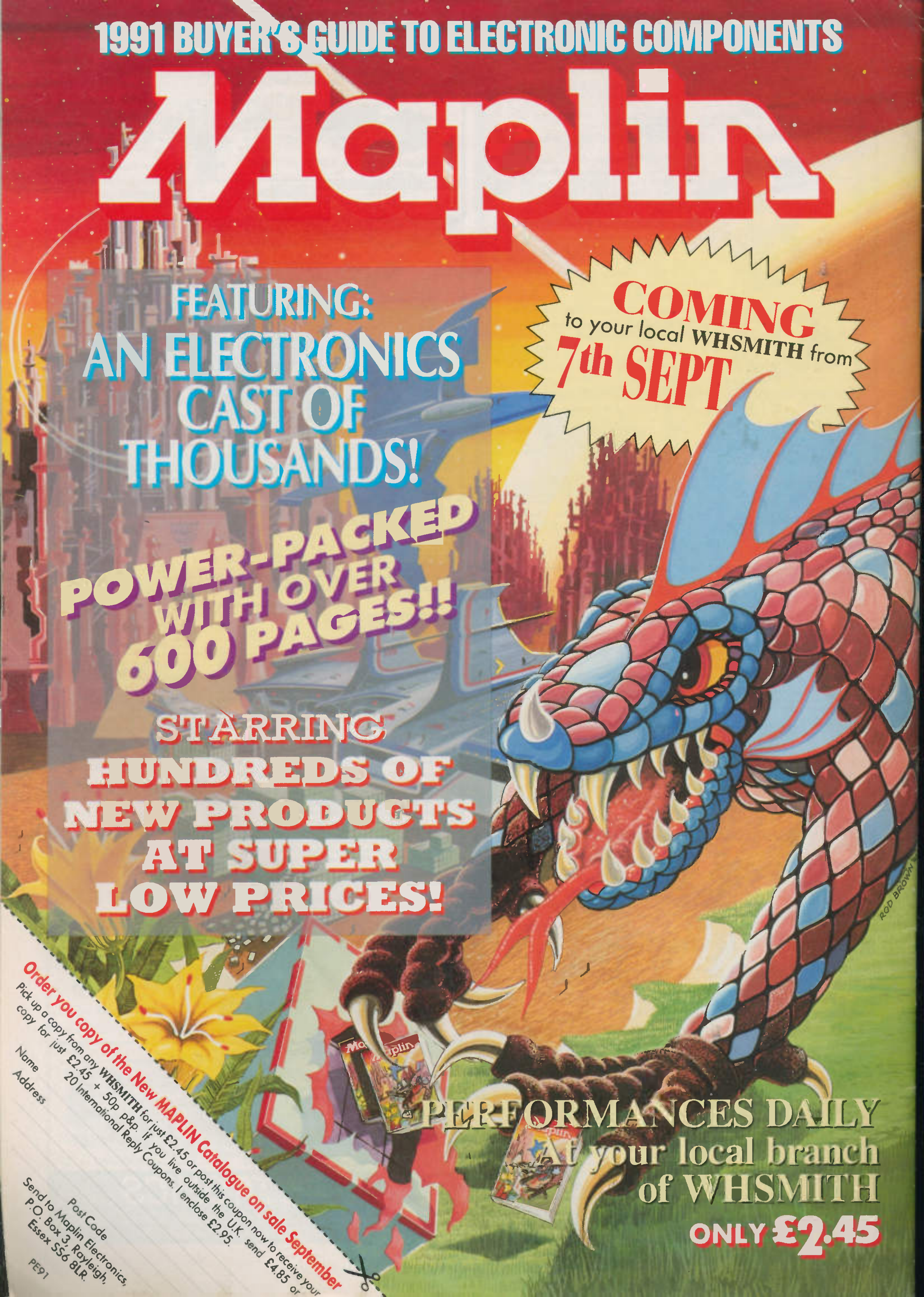
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