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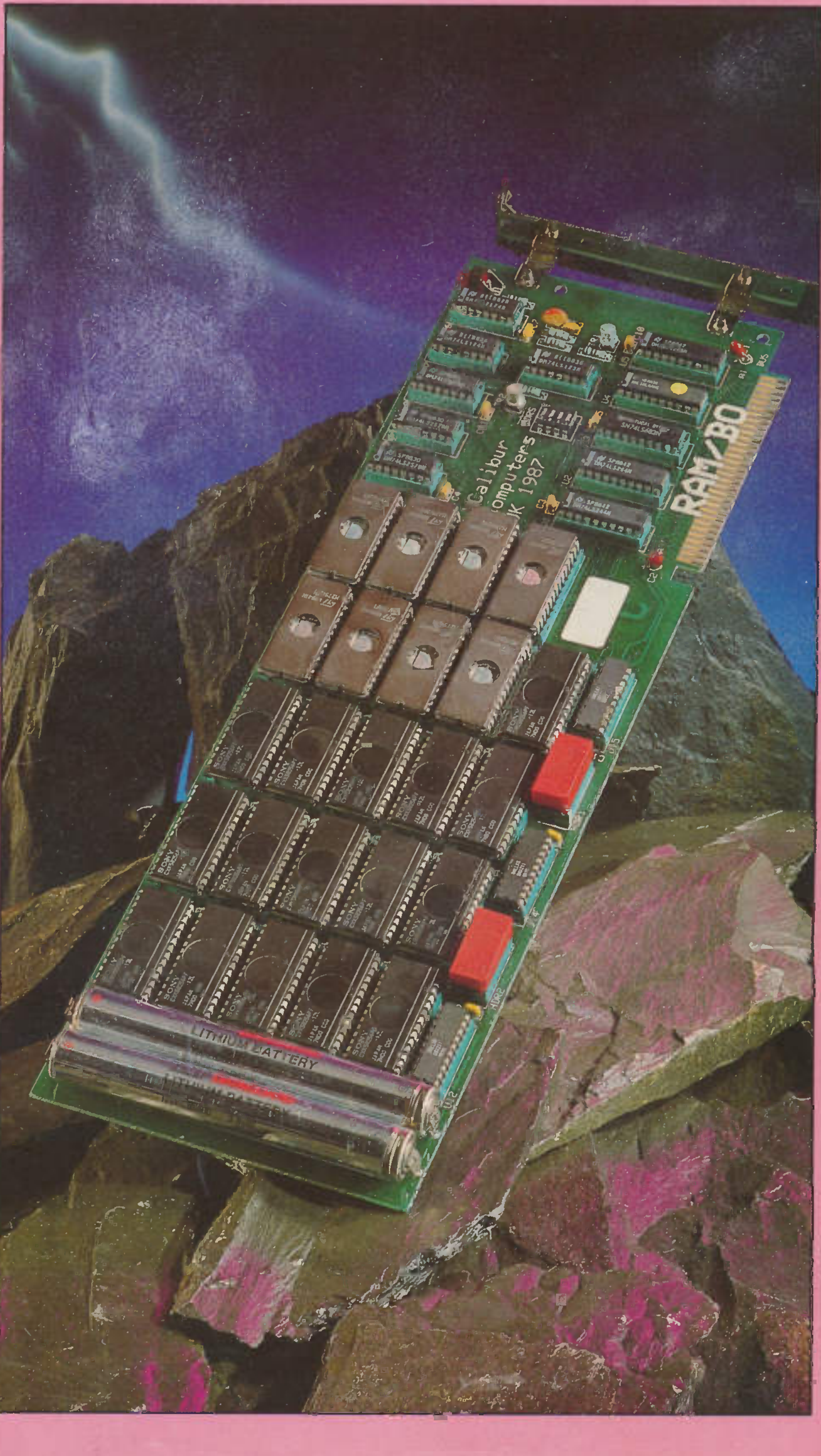
Visually displaying frequencies across the audio spectrum

BASIC ELECTRONICS
Understanding the essentials of feedback and amplification

CELLULAR RADIO
Capturing communications technology for the people



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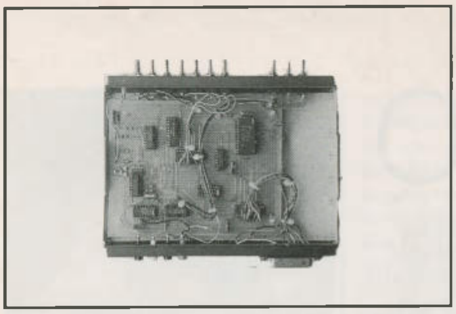

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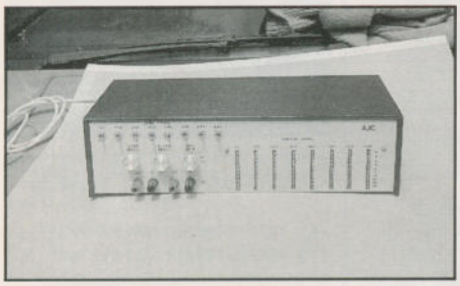

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NEXT MONTH

Whatever the weather you'll certainly warm to our very neat desk thermometer using led bargraph strip displays in °C and °F. Far-sighted as ever, we're bringing you part one of our Tele-Scope test gear project: an interface to turn a tv into an oscilloscope. We'll be examining, too, the technology behind radio pagers. Also on view will be more about the Scope Expander and AF Octave Measurer, as well as our regular top line features, including a Home-Base report from the twice-annual eyeful in America, the Consumer Electronics Show. From across the globe we bring you features and projects to show you how to enjoy electronics to the full.

★ DISPLAY YOUR FORESIGHT TOO:

★ FULFIL YOUR VISIONS WITH OUR EYE-CATCHING SEPTEMBER 1990 ISSUE

★ ON SALE FROM FRIDAY AUGUST 3RD

PRACTICAL ELECTRONICS

VOL 26 NO 8 AUGUST 1990

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PE TAKES TECHNOLOGY FURTHER - BE PART OF IT!

NEWS

SPEEDY RAM/BO

Hot on the heels of Chiptech's recently introduced CH-RomBo, the company has introduced a new high-speed disk emulator card called CH-Ram/Bo.

CH-Ram/Bo is a memory board in a standard expansion card format that will emulate a fast hard disk in any PC-compatible system. It is aimed at applications where magnetic media may prove unreliable because of harsh environments, such as dust or vibration etc, or where the non-volatile nature of eprom storage offers particular advantages.

The board can be populated with up to 768K of sram, in which case it functions as Drive C. The sram contents are backed up with dual battery supplies, ensuring total data integrity. The board can even be moved from one system to another and still retain data, and indeed can be used as the boot drive.

An alternative mode for the system allows it to be partially populated with eprom as well as sram. In this case, up to 512K bytes of each can be used, and the ram array functions as Drive C, and the eproms as Drive D.

A utilities disk is provided which helps the user to format the available ram area on the card as a hard disk. It is then a simple matter to copy over the required files into CH-Ram/Bo. If the eprom mode is used, further utilities enable files to be prepared for transfer to a suitable eprom programmer, and the eproms then installed in the card for use. The eprom utilities include the facility to 'freeze' the contents of the ram disk for use in the eprom area, thus making them read-only.

It's this interesting new product which is featured this month our front cover. Many thanks to Chiptech for their very helpful cooperation in supplying the beautiful photograph.

For further details about CH-Ram/Bo contact **Alan Turner at Chiptech Ltd,** Alban Park, Hatfield Road, St Albans, Herts, AL7 0JJ. Tel : 0727 40476.

STAG ERASER

A new eraser system for uv erasable eprom devices and microcomputers has just been introduced by Stag Microsystems.

Efficient eraser systems are required by most users of this type of device, as it is common practice to erase new devices before programming to ensure data integrity, as well as when contents need to be changed.

Known as the SE series, the new low profile eraser design features a drawer system with removable trays to take devices with 0.3 or 0.6 inch lead pitch. These can be easily loaded directly from the industry-standard anti-static tubes. A small clip system retains devices and allows them to be returned into tubes after erasure.

For further information contact **Paul Norrington, Stag Systems,** Martinfield, Welwyn Garden City, Herts, AL7 1JT. Tel : 0707-332148.

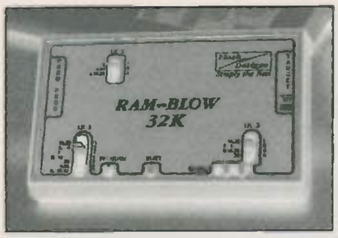
CATALOGUE DATABASE

Our browse through recently received literature

Bytronics' catalogue is an ideal browse for those who are involved in educational electronics. They say that their products have been specifically **designed to meet the needs of educational and training** establishments. Amongst the products are included those for teaching process and industrial control technology, interfacing to the BBC+ and to the IBM PC or its clones. Another unit is described as a sequencer, which allows the development of open or closed loop control programs in either a high or low level computer language or in PLC (programmable logic control) Ladder Logic. As well as a sorter unit there are **several varieties of control application board,** for example, a traffic control simulator and a shape recognition unit. Z80 microcomputer trainers are included as well. **Bytronic Associates,** 27b Coleshill Road, Sutton Coldfield, West Midlands, B75 7AX. Tel : 021 378 0613.

Heinemann's Computing and Newtech 1990 catalogue has a large selection of **books relating to technology in general.** The books are described in short detail, complete with prices and ISBN codes. Publication dates are also quoted, an important factor to know when choosing books of this nature since technology changes so fast. The catalogue includes books not only from the Heinemann Newnes Informatics series, but also Computer Weekly publications. Many of the titles are new, having been published been April and June this year. **Heinemann Professional Publishing,** Halley Court, Jordan Hill, Oxford, OX2 8EJ. Tel : 0865 311366.

Polanka Video's catalogue was collected recently from their premises near us. I had been looking for a local source of professional reel-to-reel tapes for my Revox and a kind member of staff called in on Polanka for me. They have an **enormous selection of recording tapes for many purposes.** They do video cassettes in both half-inch and 8mm, and 1 inch and U-matic three-quarter inch video tape is available as well. Audio cassettes are stocked, along with many varieties of reeled tapes in different widths. **Floppy disks are on sale too.** All brands are from the top manufacturers. A delivery service is offered so you don't need to live locally to benefit from this company. **Polanka Video Ltd,** 316 Uxbridge Road, Shepherds Bush, London W12 7LJ. Tel 081-740 6166.



FLASHY PROMMING

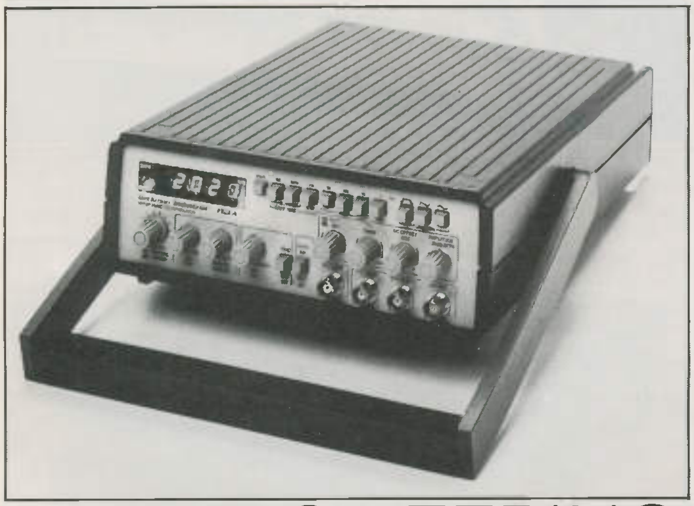
Flash designs are now offering a combined package deal of a PC card based eprom programmer, the Stag Stratos, plus their own emulator, the Ram-Blow 32K.

The emulator connects directly to the Stratos via the 28 pin zif socket, while the Ram-Blow's second cable connects to the target systems eprom socket. Users can now directly down-load code through the Stratos into the Ram-Blow's memory and begin emulation as soon as the down-load is complete. Typical down-load times are in the order of a few seconds. Ram-Blow's reset output keeps the target system reset while code is being down loaded. Ram-Blow can also be plugged into the user's sram or eeprom socket to enable a memory map to be up/down loaded and changed, thereby aiding the development of the user's program without having to recompile the source code.

For 16/32 bit applications multiple Ram-Blows can be programmed via a Gang-Set prom programmer to give instant 16/32 bit emulation.

The complete package of Stag Stratos and Ram-Blow 32K sells for £399 plus vat, which, say Flash, represents a new price breakthrough.

For more information contact **Flash Designs**, St Andrews House, PO Box 167, Crawley, West Sussex, RH11 9YE. Tel : 0293 543641.



CLEAN SWEEPING

The new 2MHz multirange sweep-function generator from Beckman provides five signal formats: sine, triangular, square, ttl and cmos pulses, and with either linear or logarithmic sweep, plus internal or external modulation. The FG3A is suitable for a wide range of analogue and digital applications.

In addition, the built-in five-digit frequency counter eliminates the need for external frequency measurement and is also available as a general 10MHz counter with 25mV sensitivity. Further flexibility is provided by a duty cycle control, a voltage controlled frequency option, output polarity inversion, dc offset voltage and an attenuator to provide low level signals.

Seven frequency ranges span 0.2Hz to 2.0MHz, the duty cycle control provides a continuously variable 1:1 to 10:1 ratio, and the vcf feature provides a 1000:1 frequency ratio for a 0 to 10V input.

The generator is housed in a stylish case, featuring a cushion grip carrying handle/tilt stand, rear cord wrap and recessed areas in the top cover for convenient stacking of multiple units.

For more information contact **Beckman Industrial Ltd**, Astec Building, High Street, Wollaston, Stourbridge, West Midlands, DY8 4PG. Tel : 0384 442394.

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!

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 information accuracy, so check details with the organisers before setting out.

July 14-22. British Amateur Electronics Club (BAEC) exhibition. The Shelter, on the Esplanade, Penarth, South Glamorgan. This is a "hands-on" opportunity to find out more about the BAEC, don't miss it!

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

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

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

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

LOW COST DVM

Autona have a new low cost digital volt meter which should appeal to those who practice electronics either as amateurs or professionals.

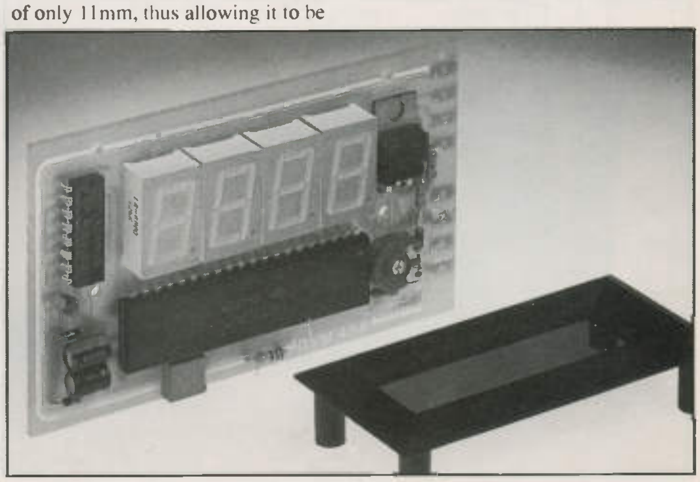
Known as the DVM 456, the meter features a 0.56 inch high efficiency display which, together with the red filter fitted in the moulded bezel supplied with the unit, provides a display which is readable under high ambient light conditions. No more switching off the lights in order to take meter readings!

The module has an overall depth of only 11mm, thus allowing it to be incorporated into the most compact of equipments.

There is a built-in stabiliser which simplifies installation into a wide range of equipment, since the module operates from an unregulated supply of 7V to 12V.

The dvm is available in a standard form with a basic sensitivity of +- 1.999V. The price of the unit in single quantities is £19.95 plus vat.

For further information contact J. Leith, **Autona Ltd**, 51 Poppy Road, Princes Risborough, Bucks, HP17 9DB. Tel : 08444 5740.



NEWS

AMBISONICS

Nimbus Records, the leading British recording and cd manufacturing company, has signed an agreement with the British Technology Group securing the rights to ambisonic technology.

The new licence granted to Nimbus covers all ambisonic patents granted or applied worldwide, with the exception of those for microphones.

Ambisonics, the British surround-sound system, was developed in the 1970's, when it was considered to be ahead of its time, and was supported by BTG. Now that other systems are becoming the subject of increasing interest, ambisonics has re-emerged as the one which most successfully captures and reproduces sound naturally, as it is heard by the human ear.

Signing the contract on behalf of BTG, Business Development Director, Peter Tanner said: "We are delighted. Nimbus has been using the ambisonic technique in recording since the 1970s and as its recordings are distributed worldwide, it is certainly the most appropriate company to develop and promote the system."

Company Secretary Stuart Garman, signing for Nimbus agreed. "At Nimbus we pioneered the use of ambisonics and have been using the system consistently for almost twenty years. We believe that ambisonics will form the basis of home entertainment systems in the future and are delighted to be behind the marketing of this outstanding British invention."

For further information contact Anthony Miall, London Press Office, **Nimbus Records Ltd**, 6 Battersea Rise, London SW11 1ED. Tel: 071-738 2396.

AIRCLEANER

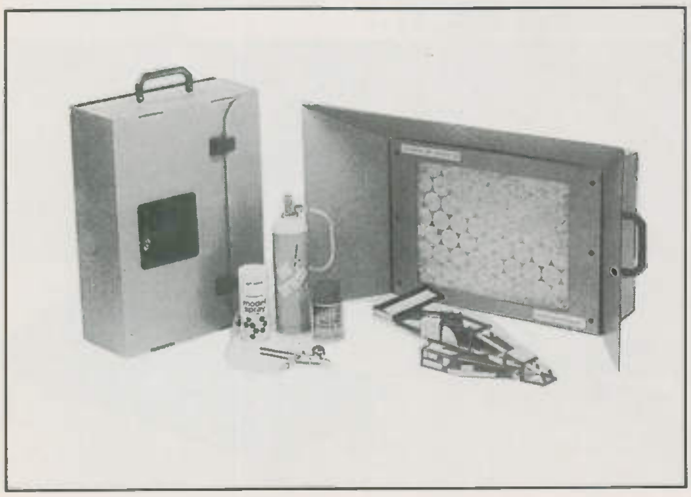
Many hobbyists from various disciplines will know the problems created by fumes, dust and other air contaminants produced when pursuing their hobbies. Spray work in particular can fill the air around the user with noxious or toxic particles which should not be inhaled. Graphic Air Systems have introduced a new portable aircleaner and spray trap that could help to clean up your workshop environment.

The aircleaner displaces, filters and absorbs airborne fumes, overspray particles and dust. It features a four stage filter and quiet(ish) fan, a collapsible spray shield and a three metre cable complete with mains plug. It is all contained within a carrying case measuring 17 x 12 x 5.5 inches, constructed from metallic grey corrugated plastic. With the spray shield attached there is a spray/fume catchment area of 25 x 15.5 inches. Space is also available in the carry-case for paints, brushes, airbrushes, hoses etc. The price is £69.95 including vat and delivery.

Having been sent a unit to examine, I feel obliged to comment that it did not appear suitable for use on an electronics workbench to extract solder fumes. It was too big to fit among the clutter of test equipment and electronic prototypes. I was unable to test it for paint spray extraction, though it was obviously capable of extracting cigar smoke. There is also doubt in my mind as to how robust the extractor will prove if used in a busy workshop, inevitably being subjected to harsh treatment. Perhaps a more robust plastic case would have been more appropriate since the present one reminds me inevitably of the corrugated cardboard products fashionable in the 1960s.

The unit is also priced at about twice the cost that I would have expected to pay for a fan and a box on their own, but I have to admit that I do not know how expensive the special filtration substance might be. However, the extractor is interestingly thought out, including the ingenious use of Velcro for the hood attachment.

For further information contact Doug Taylor, **Graphic Air Systems**, 8 Cold Bath Road, Harrogate, North Yorks, HG2 0NA. Tel : 0423 522836.



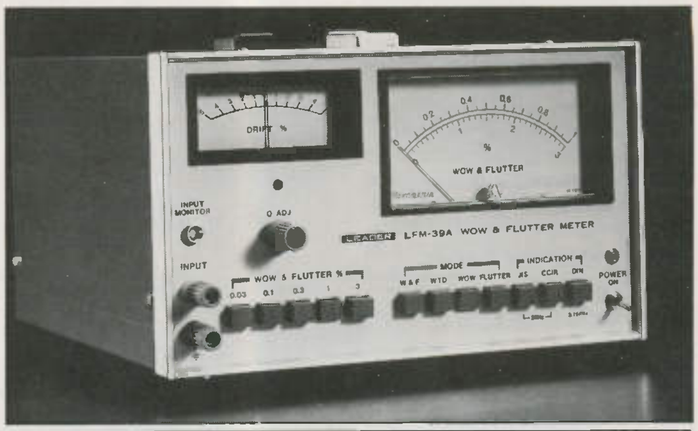
WOW CHECK

Thurlby-Thandar are conscious that despite the enormous improvements in motor speed control, some recording and playback equipments can still suffer from wow and flutter. To meet the need for checking such unsporting problems, the company have brought out a new instrument for measuring not only wow and flutter, but also drift characteristics.

The meter incorporates two large displays which indicate wow and flutter over five ranges, plus frequency drift. The measuring frequencies of 3kHz and 3.15kHz are provided to meet JIS, CCIR and DIN standards.

Applications include audio and video servicing plus the test and repair of products such as video cassette recorders, tape recorders and disc players.

For further information contact **Tony Starling**, **Thurlby-Thandar Ltd**, Glebe Road, Huntingdon, Cambs, PE18 7DX. Tel : 0480 412451.



NICAM RECEIVER

At under £200, a British company has produced a high quality NICAM stereo receiver. Sachs Nicam (GB) Ltd say that their AD9000 digital stereo receiver is simply connected to a hifi system, hifi stereo video, or stereo-equipped tv. Once the tv aerial has been plugged in, the user (assuming he's within range of a suitable transmitter!) immediately has clean, superb high fidelity sound for many tv programmes. The quality of the sound has been described as 'comparable to compact disc'.

NICAM digital stereo (near instantaneous companded audio multiplex) is transmitted on a separate 6.552MHz sub-carrier. It is modulated using QFSK techniques (quadrature phase shift keying). The audio is digitally sampled at 14 bits, then compressed digitally to 10 bits for transmission. After being received, it is expanded back to the original 14-bit format.

Stereo listening on tv is still in its infancy in the UK, whereas in Europe viewers have had stereo broadcasts for some time. This has proved to be of real advantage, since British engineers have been able to evaluate all systems. This has resulted in the higher quality NICAM system, which is now being adopted in many other countries.

NICAM is particularly noticeable when heard with a feature film, where the sound experience may be compared with that of a cinema.

At the recommended retail price of £199.95, the AD9000 receiver offers stereo tv listening at a fraction of the cost of other systems.

For full information contact **Sachs Nicam (GB) Ltd**, Suite 4, Belmont Lodge, London Road, Stanmore, Middx, HA7 4NG. Tel : 081-420 6311.

NEWS

ROYAL TELE OPENING

May 9th saw the official opening of the IBA's uplink station for the UK Direct Broadcast Satellite (DBS) service. The ceremony was performed by HRH The Duke of Kent, accompanied by the Lord Lieutenant of Hampshire.

The IBA's uplink station at Chilworth near Southampton became fully operational on March 1st in readiness for BSB's five channel satellite service for the UK. BSB programmes began on March 25th for cable viewers and on April 29th for direct domestic reception.

Not only is the IBA responsible for the safe delivery of the five programme signals to the BSB satellite, 22,500 miles out in space, it also carries out the picture, sound and data processing to produce the Multiplexed Analogue Components (MAC) signal format for onward transmission to the home.

The MAC system itself was developed by IBA engineers in the early 1980s and has since become a European standard for satellite broadcasting. MAC offers clearer, sharper pictures, multichannel digital sound and data. It also allows for progressive and compatible evolution to wide-screen and high definition pictures.

NICAM VCR

Toshiba's first NICAM stereo vcr has recently been launched in the UK. Retailing at around £449, the V610B is the first of four new vcrs coming into the Toshiba range for 1990/91.

The new vcr includes NICAM digital stereo hifi sound reproduction, a simul-cast system for combined radio and tv recording, VHS index and intro scan search system, digital tape remaining, 21-pin scart and picture quality enhancer switch. Also incorporated are direct access digital on-screen programming (OSP).

Toshiba's marketing manager (vision), Mike Brown, says "It's a real beauty. The combination of NICAM and hifi recording is breathtaking."

Ask your local Toshiba stockist for more information on this interesting new vcr.

EQUALLY RELAXED

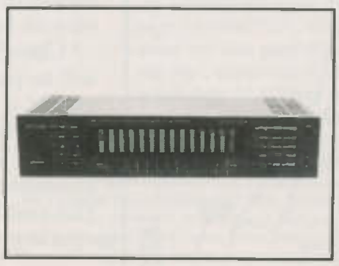
Your greater convenience and comfort have been given further attention by Maplin. They have introduced a new piece of equipment which will enable you to relax in your favourite chair with complete control over the sound from your hifi. The unit is a top quality Computer Graphic Equaliser with spectrum analyser and four memories. It comes complete with an infrared remote control unit which duplicates all the major functions of your hifi.

With a microphone (not included in the kit), it is possible to check and compensate for the particular acoustics of your room, thanks to the internal 'pink noise' generator.

Each of the 26 switches on the front panel of the equaliser has an led operational light. The display can show left channel, right channel or combined setting. The system allows the user to see the current equalisation setting or the level of sound analysed into each of the equaliser's 12 bands.

The unit costs £199.95, including vat. For mail order there is a low carriage and handling charge.

For your equal opportunity to relax in auditory comfort, contact any of the **Maplin nationwide shops**, or their head office at PO Box 3, Rayleigh, Essex, SS6 8LR. Tel : 0702 554161.



CHIP COUNT

TLE202X EXCALIBUR OPAMPS

Texas Instruments has recently introduced the industry's highest performance low-power, precision bipolar opamps, the TLE202X family.

Designed using TI's innovative Excalibur technology, the TLE202X devices are the first of a range of products to offer highest levels of ac performance, improved dc precision and lower power consumption.

Using Excalibur's high speed vertical pnps, low power opamps have been designed with significantly improved slew rates and bandwidths, of 0.9V/µs and 2.8MHz respectively. The figure shows how the TLE202X family compares against other low power products from TI. In all cases the bandwidth is higher even though the supply current is less. An improved slew rate specification enables the device to be used at higher frequencies without any degradation in outputs swing. These improved ac specifications combined with microamp supply current (200uA per amp) make the device particularly suitable in portable or battery powered applications requiring good ac performance.

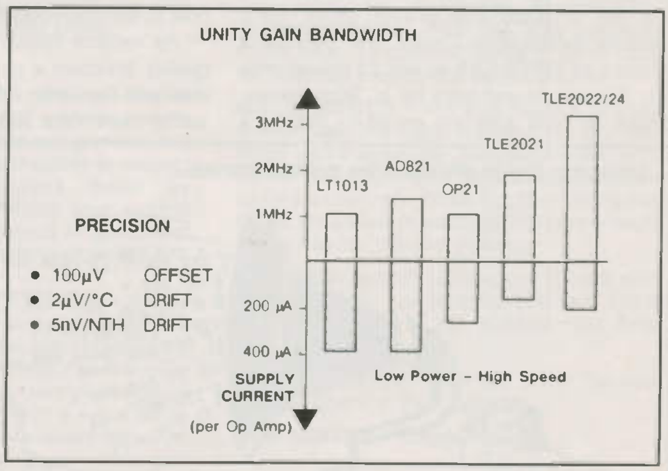
A further advantage of these devices is their excellent precision and high stability. Patent-pending bias circuitry combined with the Excalibur process has produced input offset voltages with a stability of 0.005µV/month - typically 100 times less than other products on the market. It would at this rate take 16 years for the offset to drift by just 1µV!

Circuit recalibration due to performance drift with time is no longer necessary. This high stability combined with an absolute input offset voltage of 100µV and typical open loop gain of 6.5 million mean these devices are well suited to instrumentation applications. The TLE202X family are ideal as an interface to sensors such as strain guages, phototransistors and thermocouples.

With a common-mode input range that includes the negative rail, the family are suitable for single or dual supply applications over a 4V to 40V operating range. The devices are available in single, dual and quad options.

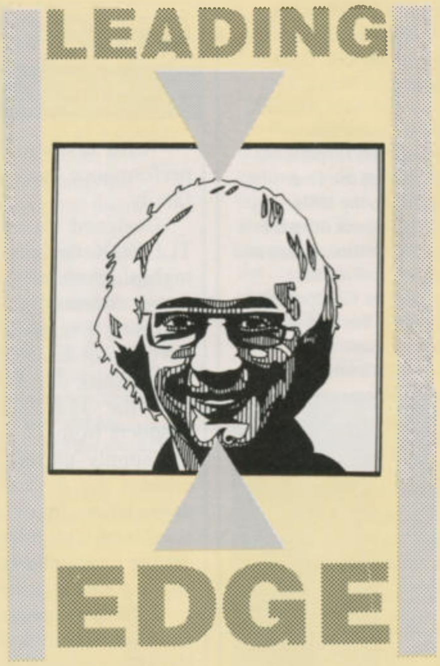
TI's Excalibur technology has been specifically developed to design opamps that satisfy the two important criteria of speed and precision. Excalibur is a complementary bipolar (CB) technology. This means the performance of the normally slow pnps has been improved to levels close to npns. This also enables opamps with improved ac performance to be developed without sacrificing other key opamp parameters such as supply current.

The TLE202X family is the first to benefit from the process features found in Excalibur. Future designs, such as a new family of bifets, will gain from some of the other new structures.



MANUFACTURER'S ADDRESS

Texas Instruments Ltd, Manton Lane, Bedford, MK41 7PA. Tel 0234 270111.



JET LINE GRIPING

BY BARRY FOX
Winner of the UK Technology Award

The quality of user-friendliness is not aided by with-holding essential data.

I recently wrote a story for the Guardian newspaper about a problem I had encountered with a laser printer, and was heartened to hear that others had hit similar snags.

Hewlett-Packard has led the revolution in laser printing, with the Laser Jet range. LJ sales now run at a million a year now. In its publicity material HP describes itself as "an international manufacturer recognised for excellence in quality and support".

Last year I wondered about this as I faced a LaserJet II which printed £ pound signs as either a blank space or # hash. Nowhere in the instruction manual was there any explanation of the root problem. (The dollar sign is the international currency standard in 7 bit ascii code and the pound sign needs an eighth bit, so you need a software fix to fool the printer into producing a pound sign (code 187) from a seven bit symbol).

I asked HP UK whether there was such a fix. After two months, four letters and numerous phone calls I finally got a brush-off Hewlett-Packard's printer product manager:. "It's up to the software vendors; if your word processing package doesn't produce pound signs with a LaserJet there is nothing we can do".

This turned out to be complete nonsense. Purely by chance (several users were discussing the problem and HP UK's lack of interest over a dinner when one piped up with the solution) I discovered that HP publishes a memory resident program called HPTRANS. It dates back to 1986 and plays the vital conversion trick to produce pound signs.

I told HP UK about their own program and asked what the company was now going to do about offering it to owners of LJ printers who still cannot get a pound sign onto paper. After a month or so more's nagging Hewlett Packard finally came up with an answer which will bring joy to pound-free printer zones. HP's Customer Information Centre will provide a free copy of HPTRANS to any LJ owner who reads this article and asks for it. Who knows, perhaps HP will now get round to putting a note in the instruction manual...

As modem speeds increase, telephone line quality becomes a governing factor for email, data and facsimile corruption. Analogue links suffer more than digital links. Mercury now offers an alternative telephone network to British Telecom, and the Mercury system uses optical fibre and is digital. But I found that Mercury connections were more likely to corrupt faxes. Odd, because Mercury claims 80% customer satisfaction and looked blank when I complained of buzz on speech calls which corrupted data.

It took a year of dogged persistence, and finally help from Oftel, to squeeze out an explanation. Mercury had been stalling because to admit to my problem meant opening a can of worms.

The key is that small businesses and home users must still rely on a BT line to route calls into the Mercury network. The hybrid service is called Mercury 2300. And initially BT provided only analogue links for the vital connections into and out of Mercury, while Mercury failed to provide extra amplification. The signal is travelling further and thus loses strength. So speech is weak and any bad contact along the analogue route may pick up mains hum at 50Hz, like a faulty hifi cable.

BT and Mercury finally agreed a policy on digital interconnection in mid 1989. Wherever BT has a digital exchange, calls are now routed out into Mercury by digital link. This has helped, but some calls still leave the Mercury network and go back into BT by analogue line. Mercury hopes that by now all calls into and out of BT's digital exchanges will be all-digital. But there is still an analogue bridge where BT's exchange is analogue. Speech level on a 2300 connection is thus still likely to be lower and data more likely to corrupt. The real problem has been that Mercury played every trick in the book to avoid coming clean on this. Sufferers were led to believe they were unique, and victims of some inexplicable gremlin fault. Now we know differently.

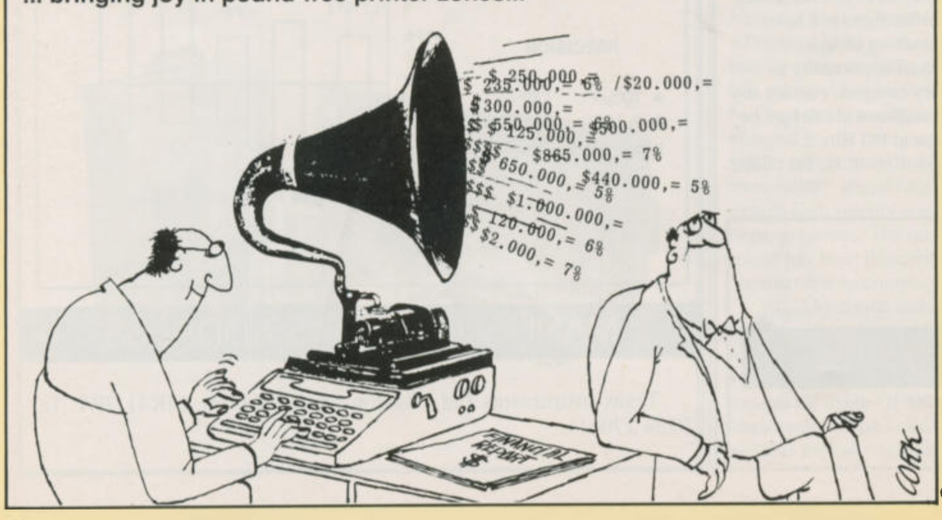
And now I have a fresh mystery on my hands. My fax machine will now happily make long distance fax transmissions via the BT network, but when the same machine is used on the same line and to the same destination, but via the Mercury network, it often fails. The call connects but the fax machines at opposite ends of the line refuse to handshake; and this despite the fact that I am on a digital BT exchange which should be interfacing digitally with Mercury's network.

Mercury's fault centre has a computer which can analyse the quality of a fax transmission. It checked mine and pronounced my fax machine faulty and in need of adjustment. But what adjustment, and why should my machine work perfectly on BT's network but be judged faculty by Mercury ?

I have put in my questions to Mercury and will be pushing for an answer on this one too, even if it takes another year and again needs pressure from Oftel to resolve.

Has anyone else been suffering line problems with Mercury ? If so, let me know. This could be another can of worms. If so, let's open it with evidence. PE

... bringing joy in pound-free printer zones...



The level of anyone's addiction to electronics can be judged by the quantity of test gear stacked up in their workshop. Actually, my wife would say that *stacked* and *workshop* are the wrong terms: *cluttering* and *entire household* are those she considers to be more appropriate.

I have to admit that there a few people who have not yet learned to appreciate the beauty of gleaming grey, silver and black boxes intertwined with an enchanting array of colourful cables. The vast majority of us, though, know that a man's wealth can be assessed by the number of occupied 13 amp sockets that line the walls. Works of art, silver salvers, expensive cars, number-crunching bank statements - who need's them? Give me the satisfaction of a single pcb monitored by a multitude of test equipment, all displaying messages of comfort: "Yes, it works!" Oh, those smoothly squiggling scope lines, those delightful decimalised digital readouts, and the victoriously waving meter needles. That's where my wealth and health of mind are stored.

Yes, I'm preaching to the converted, aren't I? You too would prefer microchips to blue-chips, soldering irons to gold pens, a pcb board to work on rather than a company board to sit on. Wouldn't you?

Of course you would. And that's why I know you'll be delighted by this month's set of test gear projects. They're all going to help you get even more pleasure out of your chosen way of life.

PRACTICAL ELECTRONICS

TESTING ADDICTS

Take my *Scope Expander* for starters. However much your workshop's already draining the national grid and keeping Powergen on overtime, you quite likely haven't yet built yourself a unit that simultaneously multiplies your scope's screen lines, stores your sampled digits, and allows you to analysis your logic in a leisurely fashion. If you have, then congratulations, you're definitely "one of us".

You know, I've been meaning to cram this type of unit onto my overstuffed test bench for years. But as with many things in life, you don't necessarily get down to them until after you wish that you'd already done so! Well, here's your chance to jump ahead of yourself.

Latent audio fanatics, prick up thine ears too, to Joe Chamberlain's *AF Octave Measurer*. There's a resurgence of interest in building audio equipment (or did it never go away?). There may a lot of ready-made audiomation around that's readily accessible without burning large holes in your pockets, but is it really giving you the quality you want? Check out some of it's aspects with Joe's equipment. Perhaps the results may enable you to make a few corrections. If you're designing your own audio gear, you could benefit even more from this *AF O-M*.

And maybe you're one of the breed of experimenters who love to have as many means of probing into the inner secrets of circuits as they can. Here's another one dedicatees! Glowing lights that shift along as you tap into those analogue levels with Stephen Bailey's voltage probe.

Should there conceivably be any hint of spare space in your workshop, one or more of these three test circuits could very well fill the gap. And while you're rediscovering long lost coffee mugs in an attempt to make sure there is space enough, throw out a bit of household rubbish as well to make room for more test gear I've got lined-up. You might get rid of the bed for a start: if you're truly addicted to electronics you probably never sleep in it anyway.

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ISSN 0032-6372

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(See page 4)

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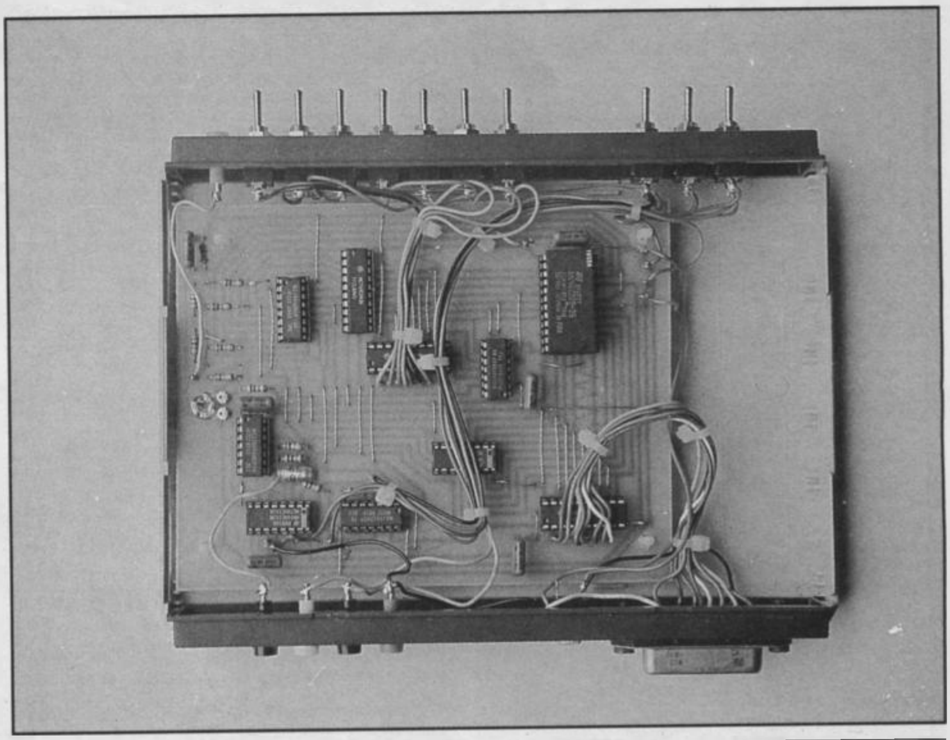
This really interesting piece of test equipment will add greater versatility to your oscilloscope, and to your ability to analyse digital circuits. The unit comprises an 8-line digital sampler, a 16K data store and a multiplexed trace multiplier, plus automatic start/stop facilities and sync selection. Eight separate digital lines can be fed to the unit, be sampled and stored in the memory, and then be viewed simultaneously on a single or multiple beam scope as an eight-line display. The entire 16K memory contents can be examined as static displays, each showing the data stored in blocks of 128 bits. All blocks are readily accessible via panel switches.



INCREASING TRACES

The basic idea behind the increasing of the number of traces seen on the scope's screen is very simple. It's based on the staircase waveform principle. Photo 2 shows part of the stepped waveform produced by the unit and displayed on my scope. At each step of the staircase the scope trace moves up the screen by an amount related to the voltage step. By selecting a suitable scope time-base frequency, the movement of the trace across the screen can be timed so that the duration of each step is longer than the trace crossing time. Using a synchronisation signal which coincides with the start of each step, the screen will give the appearance of having several trace lines across it.

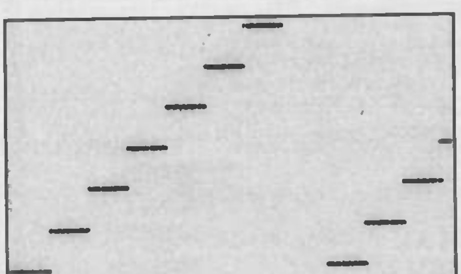
SCOPE EXPANDER

John Becker describes a new piece of test equipment which gives a scope more traces, records digital data and doubles-up as a logic analyser. And it doesn't need a computer!

In theory, providing the time-base and sync timings are correctly set, a staircase waveform consisting of any desired number of steps can cause the screen to show the same number of traces, apparently all occurring simultaneously. Each of these seemingly independent traces can additionally be modulated by separate signals, each them being displayed on their allocated screen lines. This is the principle upon which many dual trace scopes operate, with a single trace being chopped up and down the screen while the signal data is routed according to which aspect of the step is being displayed. In this design the modulation is digital and no provision for analogue signals has been made.

Visually, there is a limit to the number of traces that can be displayed on the screen while still being easily distinguished by the eye. The screen on my main scope measures 3.3 inches high and 4.1 inches wide, and although I have persuaded it to show 16 traces simultaneously, the modulation height of each step was just a bit too small to be of practical use. Eight or nine traces was found to be a more realistic quantity. Consequently, I have designed this unit to allow eight traces to be screened by a single beam scope. There is enough space left on the screen for a ninth trace to be displayed, showing the data on channel two from a dual beam scope. It seems likely that the third channel from a triple beam scope could also be displayed at the same time, making ten traces in all.

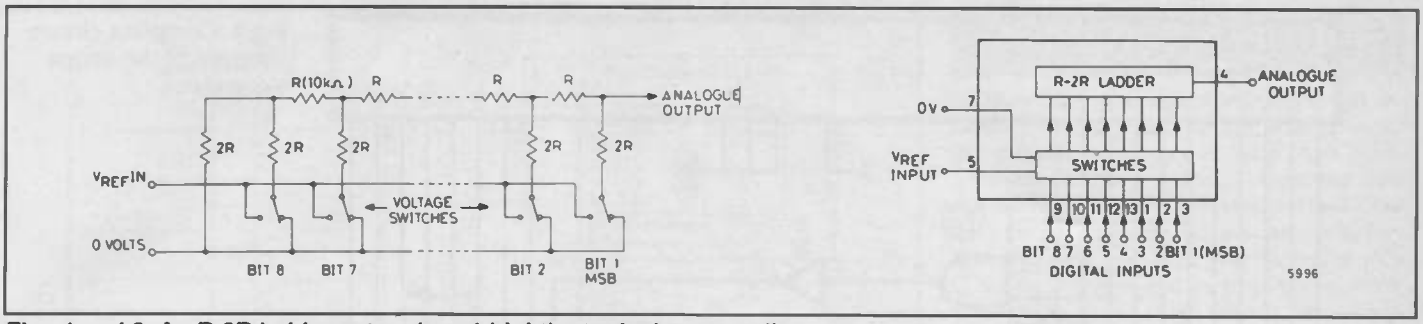
Photo 2. Basic staircase waveform.



STAIRCASE GENERATOR

There are several ways in which a staircase waveform can be generated. The two most obvious ones are to use a diode pump circuit driven by a constant frequency, or to use some form of digital to analogue converter. For this circuit I have chosen the d-to-a technique making use of a counter chip which plays an integral part in another aspect of the circuit. The precision of each step is not so accurate as would be obtained by using a dedicated d-a chip, but in this application true precision is not vital. The reduced precision is caused by the tolerances of the resistors used which are specified as the familiar 5% type. Resistor tolerances of 2% or 1% will produce a greater precision, but their use really is not necessary here. In dedicated d-a chips the resistors are trimmed by laser techniques ensuring very tight accuracies of the final analogue output.

The d-a converter here uses the R-2R resistor chain principle, in which each output of a counter is coupled via its own resistor to another chain of resistors connected as a series of potential dividers. Figs.1 and 2 show the principle as illustrated in the Ferranti d-a converter databook. Each resistor in the main part of the chain is of equal value, R. Each counter output resistor is then made twice the value of R, that is, 2R. I won't prove the formula here, but the result is that at the final junction in the chain the voltage will be related linearly to which counter outputs are high or low. By stepping the counter through sequentially, the tapped voltage will appear as evenly stepped voltages, rising as the count



Figs 1 and 2. An R-2R ladder network and (right) a typical system diagram.

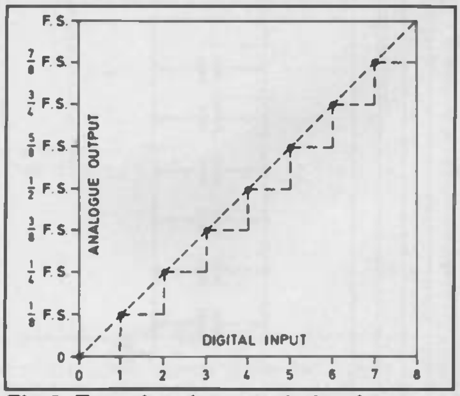


Fig 3. Transfer characteristic of an ideal 3-bit DAC.

increases, and then jumping back to the lowest level as the counter resets to zero. Fig.3 shows Ferranti's 8-step example.

The counter used is IC2, as seen in Fig.4. It is a 14-stage counter and is driven by a clock whose source will be discussed later. We are interested in producing a waveform consisting of eight steps and so we need to use only three consecutive counter outputs, numbers 6 to 8 (pins 2, 4 and 13, respectively). The first five outputs are concerned with the memory control and trace modulation aspects and the step changing must only take place following the internal routines associated with the modulation routing.

The chain of resistors consists of R4, R5 and R7. R4 is connected to the positive rail which supplies the basic reference level. The counter output resistors are R3, R6 and R8, and the stepped waveform is tapped from the junction of R7 and R8. It is to this junction that the scope probe is connected, via SK1. If you set the scope time-base to a suitably low speed you will clearly see the steps, which are about 0.5V high.

CLOCK AND SYNC

In order that the steps are seen on the screen as eight separate traces, the scope must be synchronised correctly and its time-base set according to the unit's basic clock speed. The clock is generated by the oscillator formed around IC1a and IC1b. The frequency is controlled by the values of C1 and R1, and is round about 40kHz. The exact speed is not critical, providing it's somewhere in this region. At this clock speed, the scope time-base needs to be set somewhere between 0.2ms and 20µs for the illusion of eight traces to be seen. The time-base setting can be chosen according to how many data bits you wish to see horizontally on each trace.

The sync pulse is taken from the fourth output of IC2, via SK4. If you are using a single beam scope the sync signal is taken to the scope's external sync input, with the scope's sync controls set accordingly. With a dual beam scope the sync pulse can be taken to the scope's external sync input or to the second input channel, again setting the scope's sync controls to suit.

TRACE MODULATION

Since we have eight traces, we can monitor eight external digital signals. However, because the traces only appear to be individual lines and are in reality one single line, we have to multiplex the external signals, routing them each in turn to the scope probe via a simple level mixer.

This is where IC3 is used. It's a 74HC251 8-input data selector and its logic diagram is shown in Fig.5. The signal data, coming either via the input gate IC10 or from the memory store IC7, is routed to IC3's signal inputs, pins 1-4 and 12-15. The chip's non-inverting output is at pin 5, to which any of the input lines can be switched, according to the status of the 3-bit code applied to its control inputs at pins 9-11. From pin 5, the selected signal goes via R10, VR1, and R9 to be added to the stepped waveform voltage level. (Note that R10 is erroneously marked as R11 in Fig.4.)

The signal voltage level is set by VR1 so that the stepped waveform is modulated to clearly show the signal on its screen line. VR1 is adjusted so that the maximum modulation swing leaves a visible gap between its peak and the lowest level of the line above it. Typically, a swing of about 20mV is about right. There's nothing tricky about setting this level and it is done simply while watching the screen.

The signal line routing must, of course, coincide with the respective screen line and so the routing code is taken from the same outputs of IC2 which generate the stepped waveform. The signal routing has been designed so that the least significant bit (lsb) of an input digital signal is displayed on the lowest trace, and the most significant bit (msb) on the highest.

MEMORY

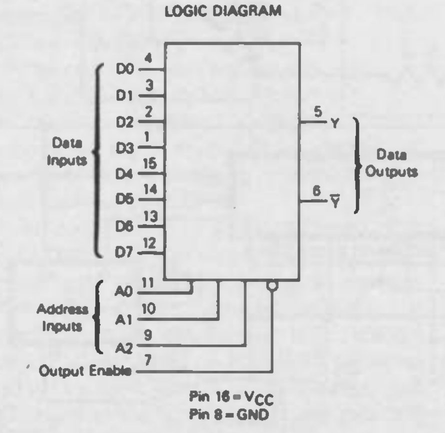
The basic display clock speed has to be fairly fast so that the illusion of eight traces is seen. Because of this, the circuit will only allow input signals to be meaningfully viewed in real time across a limited input frequency. This is one reason why the unit has been designed with a built-in memory store. First, the eight inputs are sampled simultaneously at a rate set by an external clock (such as that which generates the input signals, for example) and stored in the memory, IC7. At the end of the sample, the circuit then switches over to its internal clock and the contents of the memory are routed to the output probe.

The memory is a 16K device, allowing 2048 8-bit samples to be stored. The address at which the samples are stored is controlled by the counter IC2.

Although 2048 samples can be taken, we cannot possibly have them all displayed

Fig 5. 74HC 251 logic details.

LOGIC DIAGRAM



FUNCTION TABLE

Inputs				Outputs	
A2	A1	A0	Output Enable	Y	$\overline{Y}$
X	X	X	H	Z	Z
L	L	L	L	D0	$\overline{D0}$
L	L	H	L	D1	$\overline{D1}$
L	H	L	L	D2	$\overline{D2}$
L	H	H	L	D3	$\overline{D3}$
H	L	L	L	D4	$\overline{D4}$
H	L	H	L	D5	$\overline{D5}$
H	H	L	L	D6	$\overline{D6}$
H	H	H	L	D7	$\overline{D7}$

Z = high-impedance state
D0, D1. . .D7 = the level of the respective D input

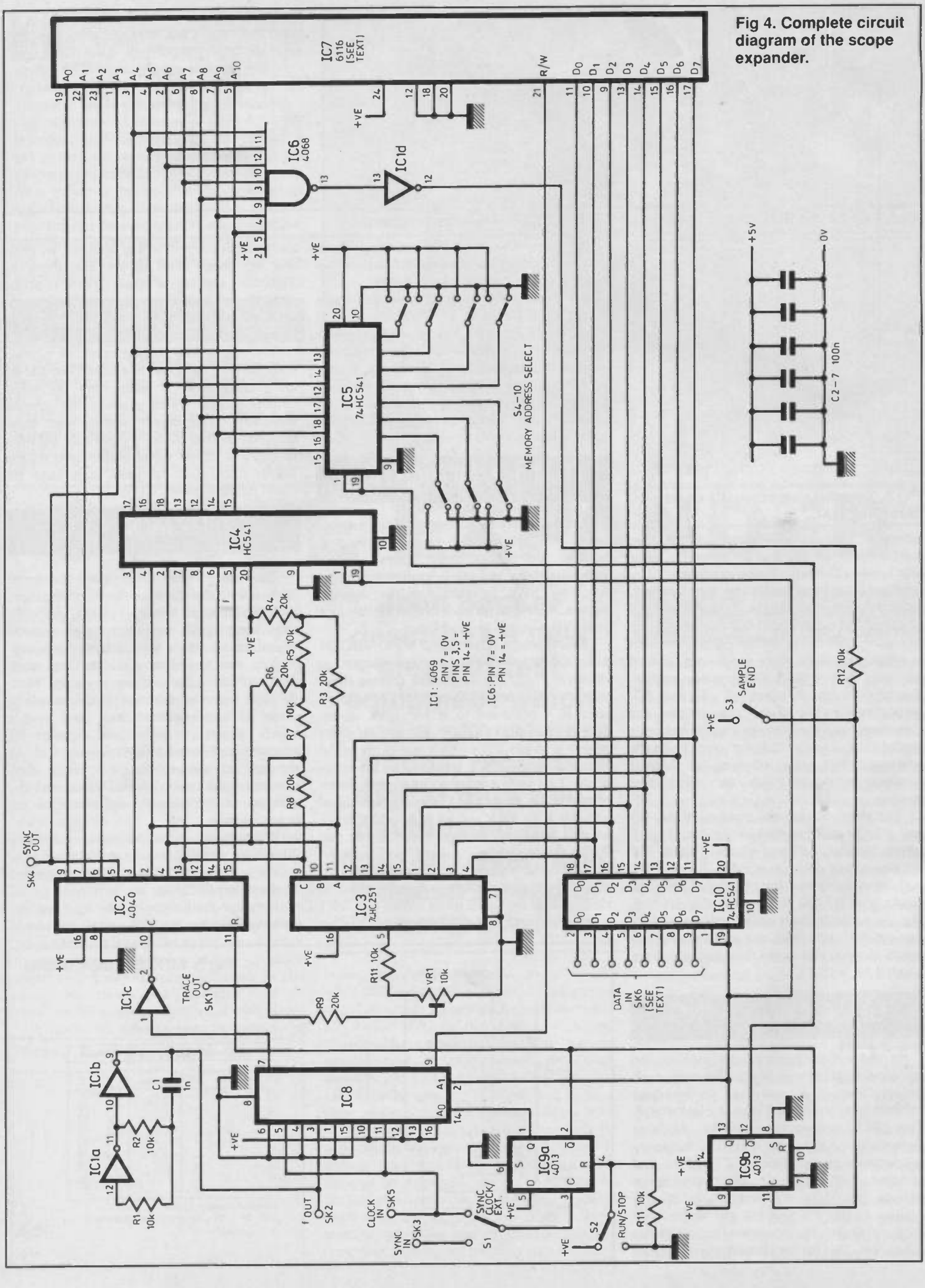
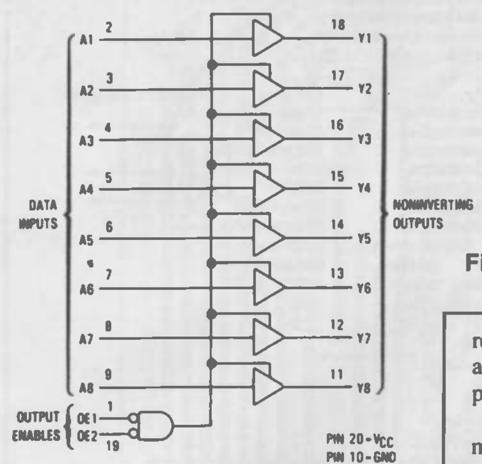


Fig 4. Complete circuit diagram of the scope expander.

LOGIC DIAGRAM



FUNCTION TABLE

Inputs			Output
OE1	OE2	A	Y
L	L	L	
L	L	H	
H	X	X	Z
X	H	X	Z

Z = high impedance
X = don't care

Fig 6. 74HC541 logic details.

across a scope screen at the same time. The screen simply is not big enough, nor is anyone's eyesight good enough to distinguish the individual bits. What we can do, though, is fill the memory with data, and then selectively view its contents as smaller blocks.

With any scope screen, the eye should be able to see the detail of at least 16 bits displayed horizontally, and this is the block length chosen. Therefore, on screen you can view eight lines each containing 16 bits, 128 bits in all. The choice of which block you view is made by selection of the memory address lines as determined by S4-S10.

In the sampling (recording) mode, all the address lines from the counter IC2 are routed to the memory, the first four directly, and the remainder via the gate IC4. At this time S4-S10 are isolated from the memory by another gate, IC5. Once the sampling is complete, gate IC4 closes, and gate IC5 opens. Memory address lines A0 to A3 are then still under counter control from IC2, but A4 to A10 are under switch control. By switching any combination of S4-S10 high or low, so the relevant address block within IC7 will be selected and multiplexed out to the scope probe. In this way you can look at all 2048 bytes of memory data as individual blocks of 16 bytes.

IC4 and IC5 are 74HC541 octal tri-state non-inverting buffers for which the logic diagram is shown in Fig.6.

AUTOMATION

There are several housekeeping functions which need to be performed in order to make the sampler of practical convenience. We need to allow for external synchronisation, detection of when the memory is full, automatic selection of internal and external clocks, automatic opening and closing of the address gates, and the switching between record and playback. We additionally need to avoid conflict between the input and memory-playback signals.

The latter is controlled by the nature of the memory itself and by IC10, which is a gate identical to those used for IC4 and IC5. When recording the input signals, IC10 is opened and the signals pass through to the memory data pins. When in record (write) mode, the memory's data lines are set as inputs, and therefore do not affect the incoming data logic. In playback (read) mode, IC10 is switched off and its outputs go into a high impedance state, shutting off the input signals. At the same time the memory's data lines are activated and their data are sent to the multiplexer IC3.

SIGNAL SYNC

I have designed in a choice of whether the start of each sampling period is controlled by the external clock signal, or from a separate external sync pulse generator. This allows for the start of each sampling period to be initiated automatically to suit your needs. S1 selects the sync mode.

The sync signal controls the start of the sequence by triggering the flip-flop IC9a. Any positive-going 5V logic signal will trigger it.

To initiate the sequence, the reset switch S2 (labelled as Run/Stop in the wiring diagram - Fig.10 next month) is first switched on to take IC9a's reset input high. This sets IC9a's pins 1 and 2 low and high respectively. The latter resets the counter IC2, and also resets the sequence-end controller IC9b so that its pins 13 and 12 are low and high respectively.

IC9a and IC9b also control the gate IC8, which is a dual 4-input data selector whose logic diagram is shown in Fig.7. (Figs.5-7 are reproduced from the Motorola databook covering the high speed cmos series of chips.)

The combination of IC9a pin 1 and IC9b pin 13 both being low sets IC8 so that logic 1 appears at its pin 9, thus setting the memory into read mode. Simultaneously, IC8 pin 7 is forced low so, via the inverter IC1c, holding high the clock input of IC2. IC9b's outputs now hold gate IC4 open to the counter, gate IC10 open to the input signal, and gate IC5 closed to S4-S10.

SEQUENCE STARTING

When S2 is switched off, IC9a will be clocked by the arrival of the first positive-going signal received on its clock input pin 3. This sets its pins 1 and 2 high and low respectively, so taking the reset level off from both the counter and sequence-end controller. Simultaneously, the code now applied to gate IC8 pins 2 and 14 causes the external clock signal to be routed to the counter, and also to the memory's read/write pin.

As you will see, the counter and the read/write pin are triggered by opposing phases of the same signal. When IC10 pin 10 goes low, the counter steps on by one place, while the memory at that moment is held in read mode. When IC10 pin 10 goes high, the counter ignores this change, but the memory is now set into write mode, and so the data from IC10 is written into the memory at the address set by IC10.

AUTOMATIC ENDING

The sequence of counter-step followed by memory-write continues until one of two things happens, one them manual and the other automatic, at which point the sequence is stopped. The automatic sequence-end condition is governed by the status of the NAND gate IC6. This is set to detect for when all seven address lines via IC4 are high.

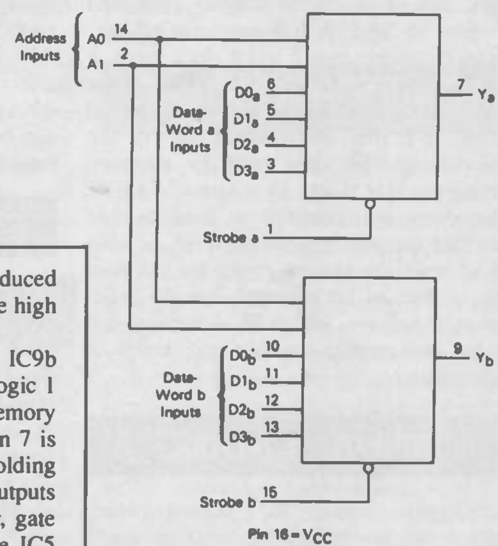
Fig 7. 74HC153 logic details.

FUNCTION TABLE

Inputs			Output
A1	A0	Strobe	Y
X	X	H	L
L	L	L	D0
L	H	L	D1
H	L	L	D2
H	H	L	D3

D0, D1, D2, and D3 = the level of the respective Data Input

LOGIC DIAGRAM



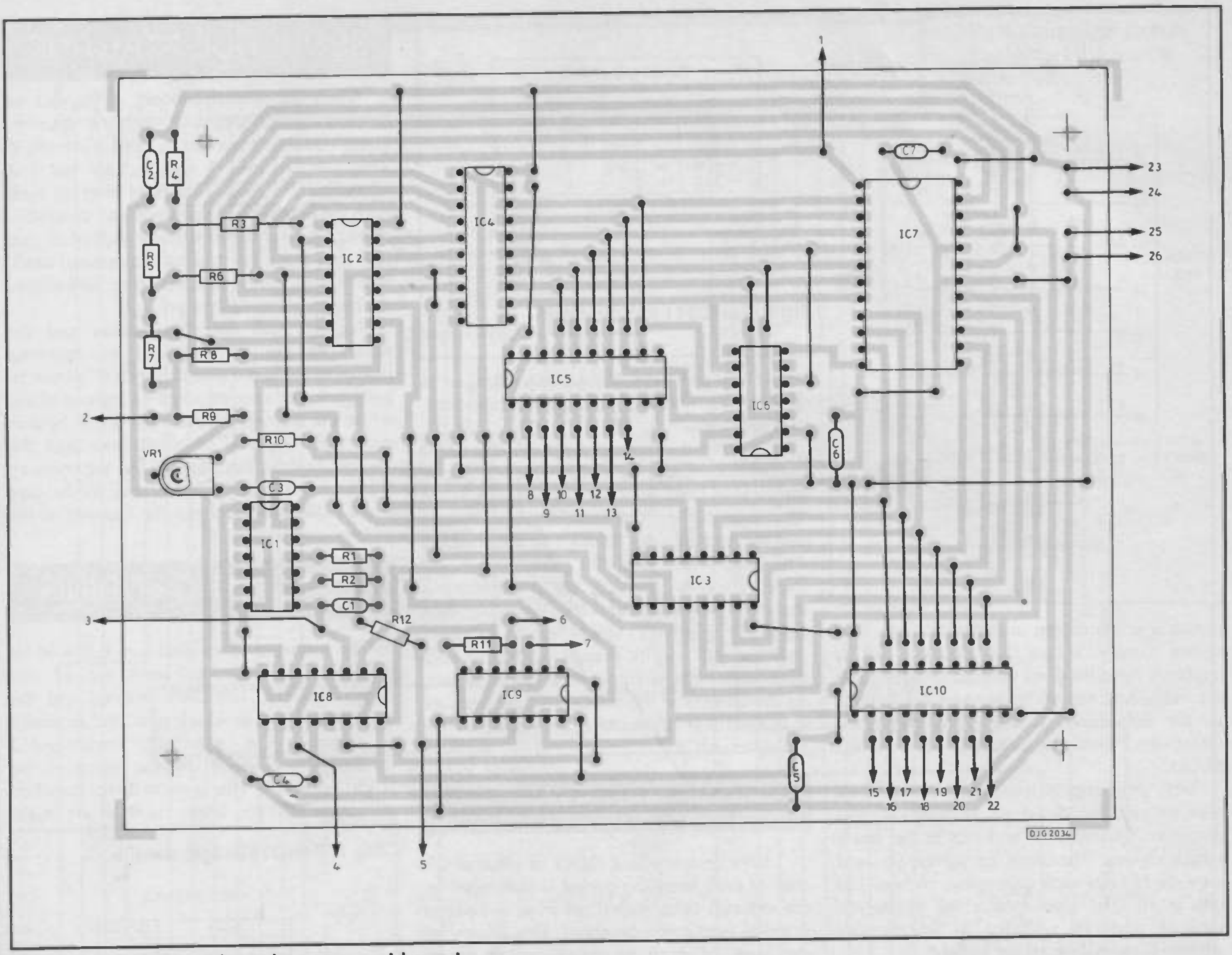


Fig 8. Printed circuit board component layout.

(Observant readers will spot that this occurs 16 steps earlier than a 'full' memory condition.) At this point in the count, IC6's output goes low, is inverted by IC1d, and triggers the clock input of IC9b. This sets IC9b's pins 13 and 12 high and low respectively.

Immediately, IC10 closes to the input signals, IC4 closes to the counter lines, and IC5 opens to S4-S10. IC8 now sees another code on its control pins 2 and 4. As a result, it holds the memory in read mode, and puts the counter under control from the internal oscillator. It is from this moment that you can start viewing the data held in memory, selecting the byte blocks by means of S4-S10. The memory will continue to hold its data until either the power is switched off, or S2 is used to reset the system ready for the next batch of data to be recorded. (In the latter instance, the data is still held in memory but will be over-written by the next batch of sampled data.)

MANUAL ENDING

Obviously, when the signals being recorded are controlled by a high speed external clock, the completion of the recording will occur in only fractions of a second. If, however, you want to record data that is associated with a slow external clock, then you may not wish to wait until the NAND gate has detected the end-of-sequence count condition. So that you can terminate the sequence early in this sort of situation, S3 has been included. By switching S3 on, a high level is applied to the clock input of IC9b, so simulating the end-of-sequence pulse from IC6. R12 prevents S3 from adversely affecting IC6's output. S3 must be switched off again before the next recording sequence can be started (a push-make switch could be used instead of the toggle switch shown).

SIGNAL INPUT RATES

There is no limit to the slowest speed at which data can be sampled. The external clock frequency can be as slow as you like. The maximum sampling rate when using the chip types specified is probably in the region of 2MHz, as dictated by the rate at which the counter IC2 can count. If the counter is clocked at a rate faster than about 2MHz, it simply won't be able to keep pace with the clock. Remember that there is a finite time at which the data within the counter can ripple through all 14 stages. If you need to sample at a higher rate, then substituting a high speed cmos counter type 74HC4040 will increase the maximum clock rate to at least 4MHz, and possibly higher. The other 74HC chips in the circuit will happily cope with the same speeds as a 74HC counter, and the memory should also be content with the same rate. None of the remaining chips in the circuit should be unhappy with a 4MHz sampling clock speed.

MEMORY CHOICE

In my own unit I used an MK48T020B-20 lithium battery-backed memory for IC7. This gave the added advantage that the data remained stored in memory even after the power was switched off, though the benefit is probably only marginal. In most instances, a normal volatile static random access memory (sram) will prove satisfactory, such as the 6116 for example. Several manufacturers produce it, each giving their own prefix and suffix codes to the number. Other srams are probably also suitable, but check that their 16K size is arranged as 2048 words by 8 bits and that they have the same pin configurations.

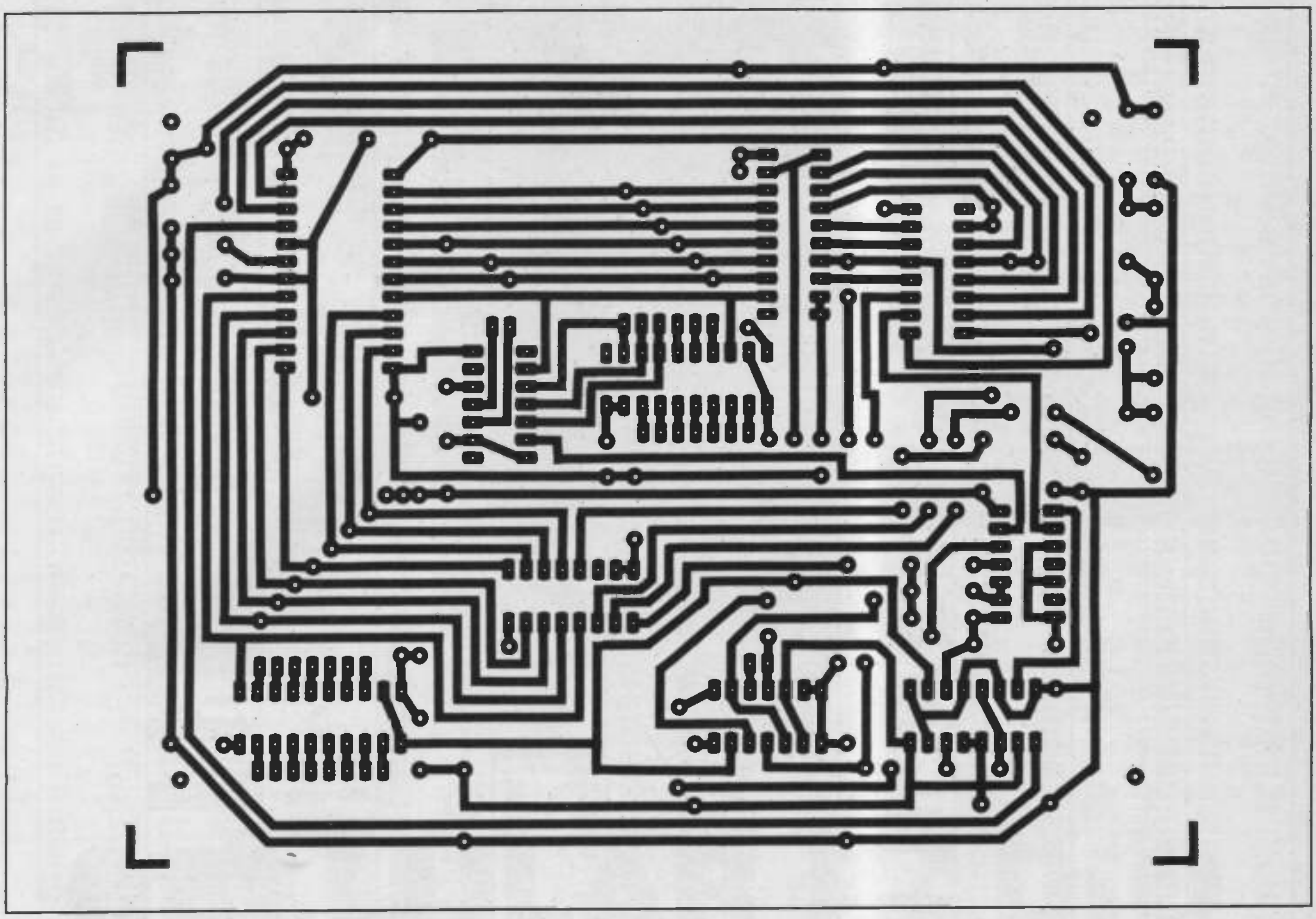


Fig 9. Printed circuit board track layout.

COMPONENTS

RESISTORS
R1, R2, R5, R7, R10-R12 10k (7 off)
R3, R4, R6, R8, R9 20k (5 off)
VR1 10k skeleton preset
All 0.25W 5% carbon or better

CAPACITORS
C1 1n polystyrene
C2-C7 100n polyester (6 off)

SEMICONDUCTORS
IC1 4069
IC2 4040
IC3 74HC251
IC4, IC5, IC10 74HC541 (3 off)
IC6 4068
IC7 6116 type memory (see text)
IC8 74HC153
IC9 4013

SOCKETS
SK1-SK5 2mm single (5 off)
SK6 data connector - (see text)
SK7 3.5mm jack socket
14-pin dil (3 off), 16-pin dil (3 off), 20-pin dil (3 off), 24-pin dil

MISCELLANEOUS
S1-S10 spst min toggle (10 off), printed circuit board, pcb supports (4 off), box to suit (approx 210 x 150 x 40mm).

POWER SUPPLY

The unit has been designed to be run from a 5V dc source. This level must not be exceeded and it's preferable that the supply should be stabilised. The power can come from any normal 5V power supply, of which many examples have been published in PE over recent years. However, since you are obviously interested in experimental electronics, I am sure that you probably already have a suitable psu in your workshop. The current drawn by the circuit is approximately 180mA maximum when recording, and about 30mA on replay. These figures were measured using the lithium backed sram referred to above. Other memory types may draw different currents. (Without the sram in place the current drawn is less than 2mA.)

DATA SOCKETS

For my own convenience I used a D-type computer socket as SK6 on the prototype and it is this which is shown in the wiring diagram. There is no need to stick to this type of socket and any means of connection to your source signals can be chosen to suit your needs. You may even find it more convenient to simply connect wires to the input pins of IC10, allowing you to hard-wire the unit to whatever circuit you are checking. Remember to always discharge static electricity from yourself before making connections to the wires, and don't allow signals greater than 5V, or less than 0V, to be fed into the unit. This applies to all inputs of the circuit, not just those to IC10.

Also to suit my other workshop equipment, 2mm single sockets were used for the other five signal inputs and outputs. For the psu input a 3.5mm jack socket was used. Naturally, you may substitute other types of socket to suit your workshop.

CONSTRUCTION

The pcb track and component layouts are shown in Figs.8 and 9. It is preferable to use ic sockets for all of the ics. The wire links can be made from strands of connecting wire, with or without the plastic sheathing. Alternatively, do as I do, use 24 swg tinned copper wire cut to length, and then shaped using thin-nosed pliers. It can be bought in rolls from several advertisers and is always a useful product to have in the workshop. Avoid the enamelled types for this application since the enamel usually needs to be scraped off before soldering - a tedious task!

Next month I'll show the control wiring diagram and tell you about the testing and use. PE

CELLULAR RADIO

Mike Sanders looks at the principles behind the radio phone system introduced essentially for public and PSTN communications.

Cellular radio is an outgrowth of mobile radio. It is a means of using a limited number of channels, in the already crowded radio spectrum, over again. This is achieved by splitting the coverage area into cells, using different transmission frequencies for the neighbouring cells and then re-using the first set of frequencies for cells further away.

Mobile radio started as a trial in 1959 in South Lancashire. Using vhf radio and two base stations, the Post Office manually patched the 55 channels. These channels were spaced 50 kHz apart. In 1965 the London Radiophone Service started an automatic dialling became available in 1981 with Radiophone System 4. The channels are spaced at 12.5 kHz in the vhf band and over 10,000 people used the service.

Supply could never keep up with demand and in 1979 the World Radio Conference provided 1000 channels at 25 kHz spacing in a band near 900 MHz. Of these, 400 are reserved for a pan-European cellular network and the remaining 600 divided equally in the UK between the two licensed operators Racal Vodafone, and Telecom Securicor Cellular Radio (TSCR) trading under Cellnet.

Both operators are licensed for 25 years and were required to begin service at 31 March 1985 and cover 90% of the population by 1990. The operators cannot sell their services directly but must offer them through licensed retailers of telecommunications equipment such as Granada, Aircall and Motorola.

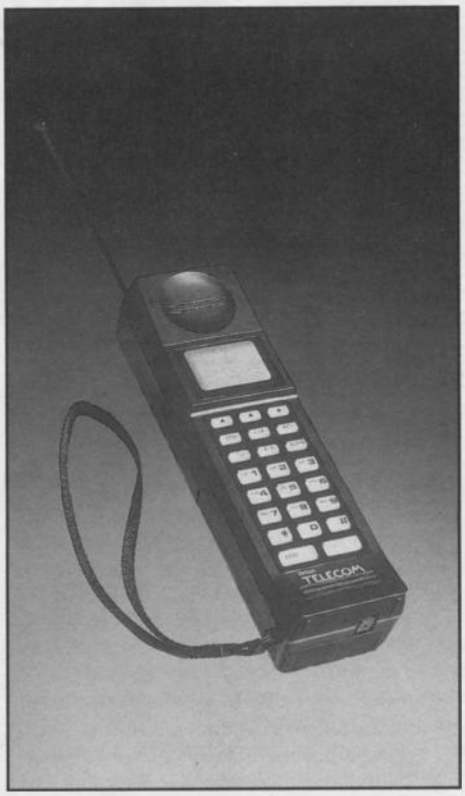
The network can provide the following features:

a) last number redial
b) call waiting indicator
c) call diversion
d) itemised bills
e) conference calls
f) abbreviated dialling
g) alarm call
h) voice store and forward (mailbox)

AMPS AND TACS

Cellular radio was proposed by Bell Laboratories of the USA after the second World War but the computer technology did not exist to make it work. It was not until 1978 that Bell developed the Advanced Mobile Phone System (AMPS) and Ameritech marketed the system in Chicago, signing on 8000 customers.

The system used in the UK is called the Total Access Communication System (TACS) and is based on AMPS. The parameters are compared in Fig.1 and some of these will be explained later. A pair of frequencies separated by 45 MHz are chosen and the higher frequency is used for base to mobile transmission. The lower frequency in the mobile to base direction for TACS operation.



Our thanks to British Telecom for kindly supplying this photograph of their "Ivory" cellular phone.

THE TACS SYSTEM

The area to be covered is divided into smaller areas called cells which are hexagonal in shape. These shapes are then grouped together into clusters of 4, 7, 12 or 21, as in Fig.2, which are the most common clusters since they can fit alongside other similar clusters.

Cells in rural areas can be large, 20 to 30 miles across, using transmitter powers of around 100W. Urban cells on the other hand can be small, about a mile, with transmitter powers of 25W and less.

Larger cells can be divided into smaller ones when traffic grows and the size of cells will depend on the type of aerial and height, power transmitted and location of aerial. Urban base stations can be found in such places as the corner of public car parks.

If there are a small number of cells in each cluster, a large number of channels can be allocated per cell and therefore the traffic per cell is higher. However the distance between cells which use the same channels reduces, which increases the interference and a 7-cell cluster is a suitable compromise between traffic capacity and interference.

Fig 1. Comparison of TACS and AMPS.

Feature	AMPS	TACS
Maximum channels	666	1000
Spacing	30kHz	25kHz
Base transmit	870-890MHz	935-960MHz
Mobile transmit	825-845MHz	890-915MHz
Speech frequency deviation	12KHz	9.5kHz
Signalling rate	10kbit/s	8kbit/s

NETWORKING, SCANNING AND REGISTRATION.

Base stations are connected to Mobile Switching Centres (MSC) which are equipped with sufficient computer power to perform all the functions of cellular radio. The MSC is also connected to other MSCs and to the public telephone network to give access not only mobile to mobile but mobile to fixed telephone.

The links from the base station to MSC and MSC to the public network are permanent, (Fig.3), unlike mobile to base station links which are reallocated as the need arises.

The MSCs keep a record of the whereabouts of each mobile. This is called registration and when a mobile moves out of a base station, the MSC commands other base stations to take power level measurements. The mobile is then handed off to the nearest base station. A break of only 400ms is encountered.

These are the general networking aspects and scanning and registration will be dealt with in greater detail.

Each of the two networks operating within TACS reserves 21 channels for control. The rest of the 279 channels may be used for speech or control as required. Mobiles are programmed with the Dedicated Control Channels (DCC) of both networks and an indicator to designate one of them as the primary network.

When a mobile telephone is switched on, it scans the DCCs of its primary network looking for channels with the strongest and second strongest signals. If it fails, it scans the DCCs of the secondary network. All this usually takes 5 to 10 seconds but could take as long as 17 seconds.

The mobile then registers its location. There are two kinds of registration: forced and periodic. With forced registration, the mobile registers its location each time it crosses a boundary whereas with periodic registration, the mobile keeps a record of the previous four traffic areas and updates this record.

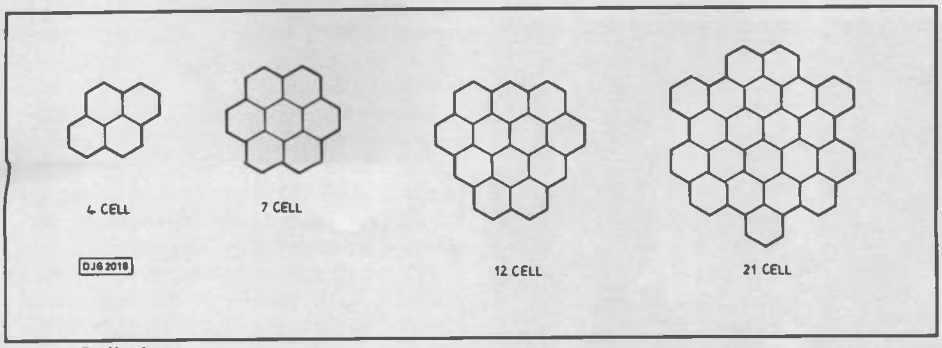


Fig 2. Cell clusters.

SPEECH, CONTROL AND SIGNALLING CHANNELS

Speech is carried by frequency modulation (fm) using a peak signal deviation of 9.5 kHz. Preceding mobile radio systems used a peak deviation of only 5 kHz on a 25 kHz spacing to limit adjacent channel interference. In cellular radio, adjacent channel interference is avoided by carefully planning the cell repeat pattern, ie allocation of channels in neighbouring calls.

A greater problem in cellular radio is co-channel interference, ie interfering signals on the same channel, and this wider frequency deviation assists the rejection of these interfering signals.

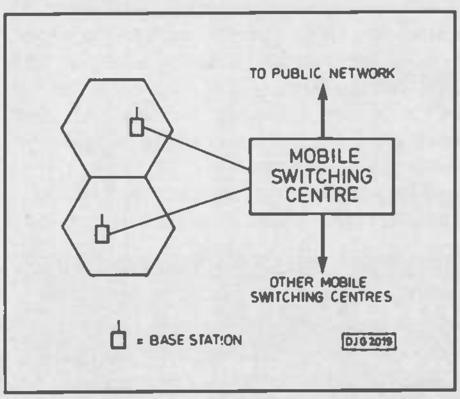
There could be as many as three different types of control channel: the dedicated control channel already discussed, paging channels and access channels. All the functions could be carried on one type of control channel but the three different types of control allow for growth and expansion of the network.

Paging channels are used to inform mobiles of incoming calls, provide channel numbers of access channels and identity of traffic areas. Access channels are used to reply to paging calls, set up outgoing calls and register the mobile's location.

In order to set up a call or hand off a mobile to another base station, signalling is required. The signalling rate is 8 Kbit/s but is Manchester coded to a rate of 16 Kbit/s so that the clock may be extracted at the receiver. Signalling is achieved by frequency shift keying (fsk) the radio carrier with a carrier deviation of 6.4 kHz.

Since there is plenty of interference on radio channels, three methods of error correction are employed:

Fig 3. Cell linking.



1) sufficient redundancy is built into the message; this is called forward error correction (FEC);

2) the message is repeated several times;

3) a majority decision is taken on the repeated message, eg if the message is repeated five times and the first digit is received four times as a one and once as a zero, it is quite likely a one.

The message to be transmitted is encoded into a block together with a parity word, using BCH (Bose-Chaudhuri-Hocquenghem) coding.

In the base station to mobile direction, the signalling information is repeated five times and the speech message eleven times. In the mobile to base station direction both signalling and speech are repeated five times.

When a message is received, a majority decision is made on the blocks by comparing the bits. Most of the errors are corrected in this way. The parity word then corrects one more error if it exists and detects the existence of more errors. If they exist the message is rejected.

Mobiles lock onto a message by bit synchronisation and with word synchronisation to indicate the start of an information frame. Also, a mobile must indicate to a base station whether or not it is free to receive calls. It does this quite simply by transmitting an 8 kHz tone when free instead of transmitting whole information frames.

SUPERVISION, HAND-OFF AND POWER CONTROL

In order to enable the audio path, a supervisory audio tone (SAT) is required. Three different frequencies around 6 kHz are used and these are distributed around the cells to reduce co-channel interference. Therefore a cell in an adjacent cluster and using the same radio channel will use a different SAT. The base station instructs the mobile which SAT is being used while the call is being initiated. The SAT is then transmitted by the base station and looped back by the mobile for the duration of the call.

During a call, the base station constantly checks the level of the signal. If this falls below a threshold, the base station informs the MSC which instructs the neighbouring base stations to measure the mobile's signal strength. The MSC scans the results and chooses the best cell to transfer the mobile to. The MSC allocates a speech channel and instructs the original base station to order the mobile to this channel. The user experiences a period of silence lasting up to 400ms while the mobile tunes in the new channel.

Just as the signal can get too weak when a mobile moves away from a base station, the signal can get too strong if a mobile moves close to a base station. These high signal levels from the mobile can cause intermodulation in the receivers of the base station and therefore interference to other users. For this reason the mobile signal levels are monitored and if they exceed the threshold, the mobiles are instructed to reduce their levels. The mobile acknowledges the instruction and selects a suitable power level.

CALL SET UP

When a call to a mobile is being set up, the MSC checks the mobile's location from the registration files and pages the mobile via the base stations in that area. The mobile tunes to the allocated channel and checks the received SAT. The mobile phone then alerts the user and transmits an 8 kHz signal back to the base station. When the user takes the call, the signal is discontinued and the speech channels are enabled.

To originate a call, the mobile user dials the number or sends it directly from the short code memory. The mobile then tries to access the network by scanning the access channels and choosing the channel with the strongest or second strongest signal to receive overhead messages on access procedures.

The mobile monitors the busy-idle bit stream from the base station and if it is idle the mobile transmits its message. The mobile then checks that the bit stream changes to busy at the correct moment in its transmission. If this does not occur, the mobile abandons the message, waits a random period of time and tries again. In this manner, the difficulty of several mobiles trying to access the network at the same moment is overcome.

When the mobile has transmitted its message, it waits on the access channel for a message from the base station. If it is merely registering, the reply is a confirmation and the mobile returns to idle. If the mobile is setting up a speech path, it gets a channel number and SAT. The mobile then tunes to the allocated channel and the user can hear the ringing tone.

When a mobile user has finished his call, the mobile transmits a burst of 8 kHz for 1.8 seconds to the base station and then begins the channel scanning mode. Similarly if the call had been originated on the inland telephone network and the originator terminates the call, the mobile acknowledges with an 8 kHz burst and begins the channel scanning mode.

If, during a call, the user wishes to take advantage of any of the special facilities, like calling up a third party for a conference call, he punches in the relevant code and presses the send key. The mobile sends 8 kHz of signalling for 0.4 seconds and the base station replies by asking for the message. When the mobile has sent the message, the user returns to his conversation, while the message is being processed.

SCANDINAVIAN NMT

The world's first international cellular radio network was the Scandinavian Nordic Mobile Telephone System (NMT 450) which started service in 1981 and was developed by Denmark, Finland, Norway and Sweden.

User growth has been rapid, from 45,000 to 100,000 in Sweden alone and overall there are around 350,000 mobile cellular phone users from a combined population base of only 22 million. The band around 450 MHz was good for rural communication since the range is better than that for the 900 MHz band but soon became congested for use in the cities of Oslo, Helsinki, Copenhagen and Stockholm.

To alleviate the shortage a band around 900 MHz was introduced (NMT 900). Since it is harder to operate at 900 MHz because of Rayleigh scattering and so on, the NMT 900 is fitted with a receiver diversity system and companders giving a compression ratio of 2:1.

The mobile transmits in the 890-915 MHz range and receives in the 935-960 MHz range. This accommodates 1000 channels with a 25 kHz separation. The system can also double the number of channels for city use by reducing the channel spacing to 12.5 kHz.

Automatic call queuing is a facility available on most modern telephone exchanges and although not possible on the NMT 450, it is available on the NMT 900.

The NMT 450 has already been implemented in other countries such as Austria, Belgium, China, Spain, Netherlands, Oman, Malaysia, Indonesia, Thailand, Turkey and Saudi Arabia.

PAN EUROPEAN CELLULAR RADIO NETWORK

Network providers appreciate that in the 1990s mobile systems would operate in the 935-960 MHz range for base station transmission and 890-915 MHz for mobile transmission. Accordingly the lower 15 MHz of each band was reserved for planned systems and the upper 10 MHz for a pan European system.

In May 1987 France, Italy, the Federal Republic of Germany and the UK signed an agreement to provide digital cellular radio by 1991 in the four countries. The eleven other countries within CEPT (Committee for European Post and Telecommunications) also agreed to the standards laid down by the GSM (Groupe Speciale Mobile).

The number of users at the year 2000 is expected to be 10 million and the standards to be defined are:

1) user to mobile
2) mobile to base station
3) base station to switching centre
4) switching centre to switching centre
5) switching centre to public network

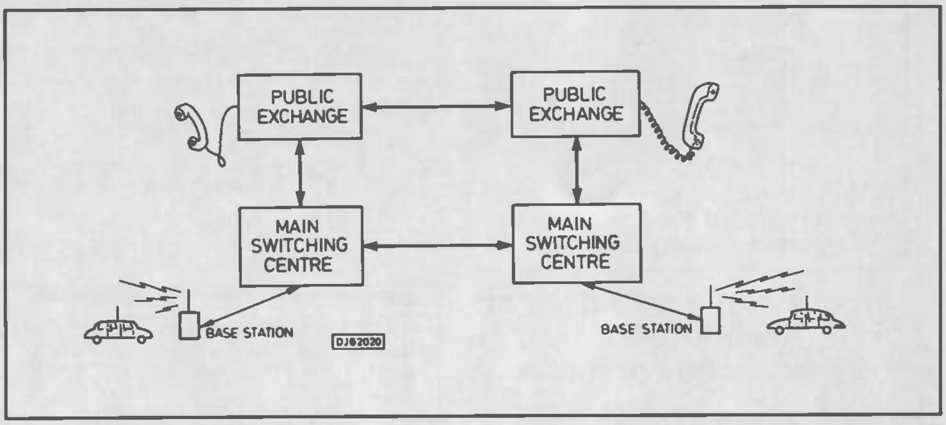


Fig 4. Mobile and fixed networks.

Fig.4 shows the relationship between the mobile and fixed networks.

First generation systems like TACS are analogue since the voice is carried as a continuously varying waveform whereas second generation systems will carry digital signals. The first generation systems also assigned a speech channel for the duration of the call whereas digital systems will be by tdma (time division multiple access). That is, each user is assigned a time not only when actually transmitting (time division) and multiple access means that several users can access the system at the same time.

Two types of tdma were tested: a wideband tdma occupying 4.5 MHz and transmitting 63 channels and a narrow band tdma occupying 250 kHz and transmitting 10 channels. The narrow band version has been opted for.

Another advantage of tdm transmission is that the transmit and receive paths are on different time slots, reducing interference, therefore the bulky duplex filter used on the analogue version is no longer required.

Digital transmission of analogue signals is wasteful on bandwidth and this is a strain on the already overcrowded radio spectrum. Pulse code modulation (pcm) requires that the sampling rate be at least twice the highest frequency.

Therefore if speech is transmitted in a 4 kHz bandwidth, the minimum sampling rate must be 8 kHz. Each sample is then encoded by eight bits, therefore the total bit rate per speech channel is:

8 kHz x 8 bits = 64 kbit/s

An obvious method of reducing the bit rate is to reduce the encoding digits from eight bits to say four bits. Of course the quality suffers but in some applications this may give sufficient intelligence to the speech.

Other methods are by sub-band coding and linear predictive coding (lpc). Predictive encoding uses an electronic model of the human vocal cords to predict the sounds. In sub-band coding the analogue band is divided into smaller bands and the energy in each band is encoded. At the receiver the message is decoded and the original speech reconstructed.

In addition to speech, data transmission will also be possible at 300, 1200, 2400, 4800 and 9600 bit/s. The following facilities will be available:

1) voice store and forward
2) videotex
3) telefax
4) facsimile
5) call diversion
6) call barred
7) alarm calls
8) three party calls
9) speech encoding
10) call queuing
11) identity of caller
12) access restricted to selected groups
13) information on call charges

A pan European cellular mobile network will be one of the most exciting and challenging developments expected by a mobile society since one will be able to roam across Europe taking one's own telephone along.

GLOSSARY

AMPS	Advanced Mobile Phone System
BCH	Bose Chaudhuri Hocquengham
CEPT	Committee of European Posts and Telecommunications
DCC	Dedicated Control Channel
FEC	Forward Error Correction
FSK	Frequency Shift Keying
GSM	Groupe Speciale Mobile
LPC	Linear Predictive Coding
MSC	Mobile Switching Centre
NMT	Nordic Mobile Telephone
PCM	Pulse Code Modulation
SAT	Supervisory Audio Tone
TACS	Total Access Communications System
TDMA	Time Division Multiple Access
TSCR	Telecom Securicor Cellular Radio

PE

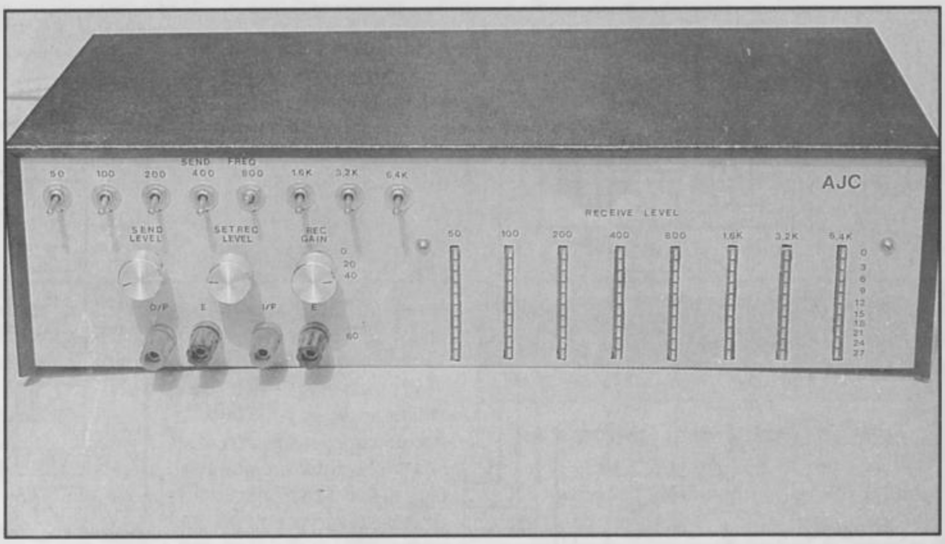
Next month Mike Sanders takes a look at Radio Paging.

AF OCTAVE MEASURING

Joe Chamberlain reveals how you can call your own tune with this audio frequency reading design.

The audio frequency (af) octave measuring system described here was developed to meet a specific demand for a measuring system which would allow rapid assessment of the balance of a line-terminating circuit which incorporated a number of variable components. The initial objective was to produce a display which would give a rapid and continuous visual response to circuit adjustments. The design was subsequently modified to make it of more general use.

This article describes how the particular system was chosen and compares possible alternatives. The details of the specific design are then discussed and two options for the construction of a working model are offered. As the specific detail of the design may not suit everyone's requirements methods of modifying the system are indicated where relevant and a number of possible options and additions to the basic design are proposed.



OPERATIONAL SPEED

One of the basic problems with any af measuring system is that the measuring device must operate sufficiently slowly for the signal detection circuits to acquire enough information to determine the circuit condition at specific frequencies. If, for example, you want to measure the amplitude of a signal having a frequency of 10Hz then you must wait at least one full cycle of that signal, in this case 100milliseconds. This is the absolute minimum time and in practice, as several cycles may be required to obtain a steady reading, this time may triple or quadruple. The delay obviously becomes less as the frequency of the measured signal increases but any common detector circuits must be designed to cater for the lowest frequency to be measured.

For many applications the frequency sweep measuring method is ideal since every frequency in a given band is measured, usually by increasing frequency with time and displaying the resultant output on an oscilloscope either as an ac wave envelope or by detecting the ac signal to display only the peak voltage. Particularly for the home constructor, the sweep system has two major problems. Firstly, provision of suitable frequency markers and/or frequency scale, and secondly the generation of the correct (usually logarithmic) sweep waveform to drive the oscillator. A third but lesser difficulty is covering the desired number of octaves in a single sweep while retaining the desired resolution. Having said all this the main advantage of the continuous sweep is all frequencies within a specified band are examined so that, for example, if a filter is being examined the sweep system is ideal, although even here care has to be taken to sweep the filter sufficiently slowly to produce an accurate display. Too fast a sweep will distort both the apparent frequency and amplitude of a rapidly changing filter response.

For the specific function for which the octave generator was designed there were no sharp peaks or notches in the response and so a detailed frequency scan was not necessary. Many tone control circuits, equalising filters and, in the author's case, balancing circuits have only a gradual change of attenuation or gain with frequency and are thus suitable for octave frequency measurement. The system is also very useful for making rapid comparisons of the performance of two or more nominally similar circuits. The initial design was produced to observe the effect of multiple variables on the balance of a line hybrid circuit for a modem. In this case the variables were adjusted to achieve minimum output from the hybrid over the widest possible frequency range. The great advantage of this measuring system over a sweep system is that the whole frequency spectrum of interest can be observed at the same time, and the effect of parameter changes are seen as the adjustments are made, instead of having to wait for a few seconds to observe the effect of a change. Although this may at first sight appear to be of little advantage, in practice it allows much faster and more accurate settings to be achieved.

SPLIT SYSTEM

The measuring system can be considered as two separate parts, the transmit section shown in Fig.1 and the receive section shown in Fig.2. When we come to consider the practical construction it will be seen that some parts of the transmitter and receiver are combined onto common circuit boards but this is solely for ease of construction and to reduce the number of separate boards required. The general method of interconnecting the boards is shown in Fig.3.

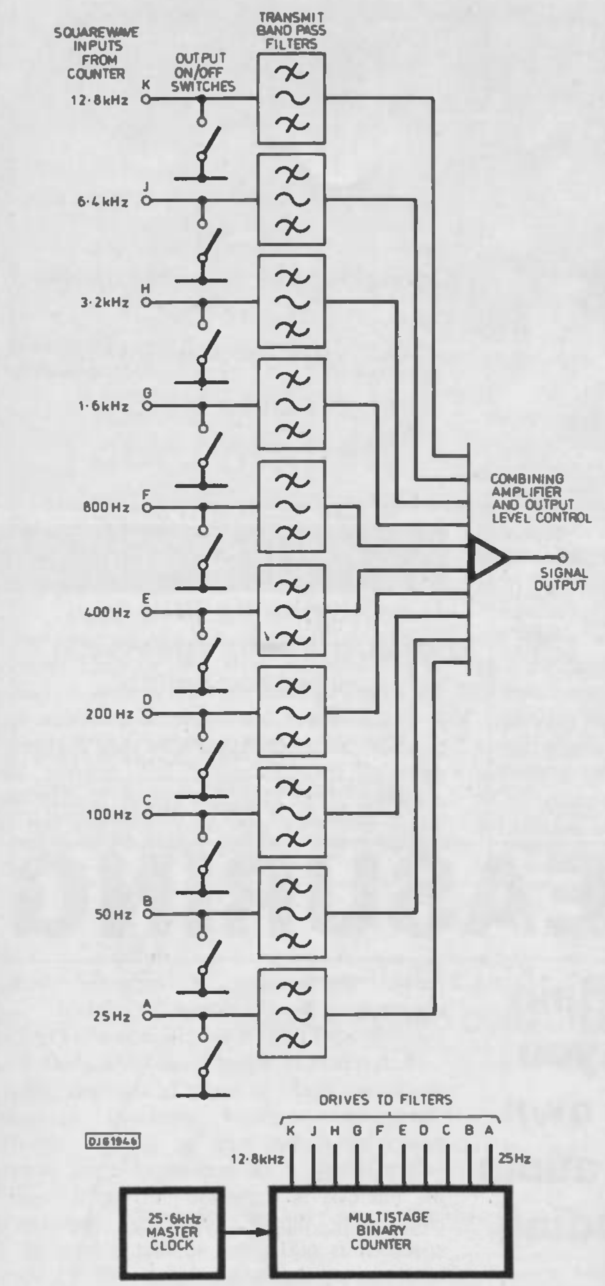
References to signal levels throughout this article are made in terms of decibels (dBs). These units (strictly speaking) represent power ratios but may be used to specify voltage levels if the impedance at the points of interest is constant. In most audio engineering applications the impedance specified is 600 ohms so that a level of 1 milliwatt represents a voltage of 0.775 volts rms in a 600 ohm resistive load. Even where the impedance at the measurement point is not 600 ohms voltages may be expressed as dBs provided that it is remembered that only the voltage ratio (and not the power ratio) is of significance.

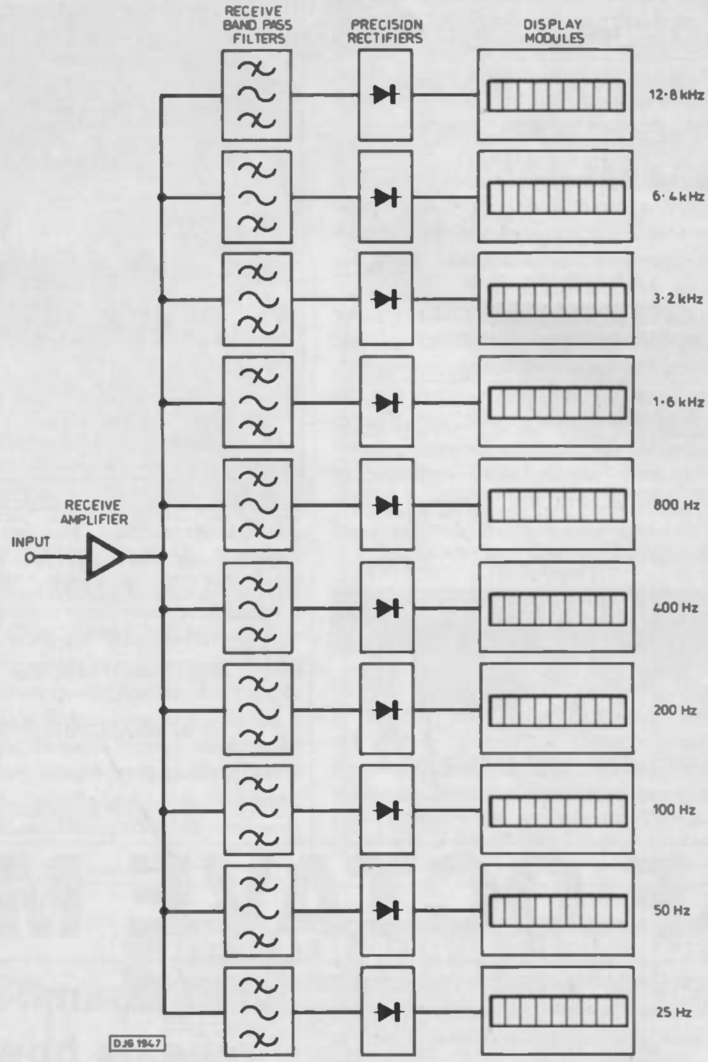
$$\text{The voltage ratio in dB} = 20 \log \times \frac{\text{Voltage 2}}{\text{Voltage 1}}$$

Therefore if voltage 1 = 0.775 V and voltage 2 = 7.75 V the logarithm of the ratio V2/V1 is 1 and the dB ratio is +20dB. The same thing happens if you calculate V1/V2 except that the ratio becomes -20dB.

THE BASIC SYSTEM - TRANSMITTER

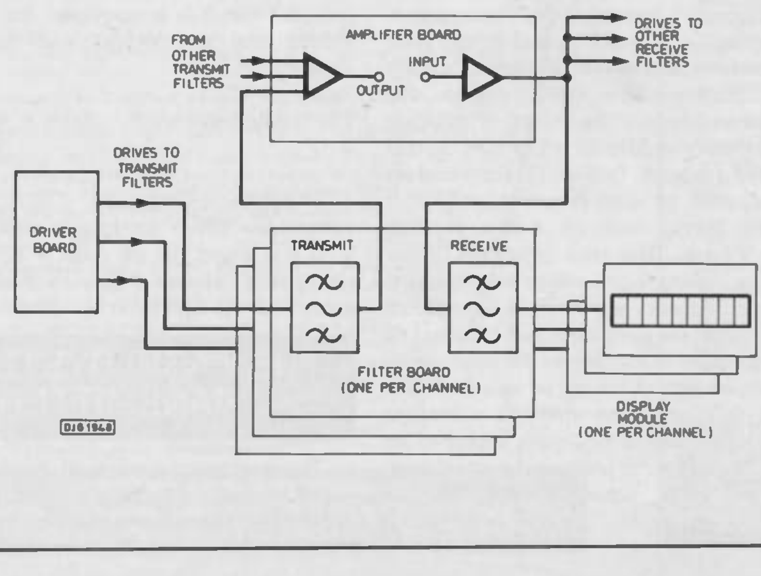
The transmitter consists of a square wave signal generator feeding a multistage binary divider the various outputs from which have





Above: Figs 1 and 2. Block diagrams of transmitter and receiver.

Below: Fig 3. Interconnection of circuit boards.



their fundamental components selected by band pass filters. The response of the filters determines the harmonic content of the output signal. The outputs from the filters are combined by a unity gain virtual earth input amplifier and fed via level adjustment circuits to the transmitter output.

At first sight there is no objection to substituting separate free running sine wave oscillators for the band pass filters and square wave generator. However, if this were done from time to time the outputs from all oscillators would add in peak voltage to produce a signal which might overload the circuit under test and would certainly overload the transmitter output circuit. By deriving the signals from a coherent, harmonically related source the output signals add to produce an output having a much lower peak amplitude that that of the sum of the individual signals. When the transmitter has been constructed it is instructive to turn on the individual channels one at a time starting with the lowest frequency and observe the resultant change in output signal waveform.

The performance of the transmit bandpass filter determines the purity of the transmitted sine wave signal. When the square wave signal is applied to the filter input, virtually all the odd harmonics of the fundamental

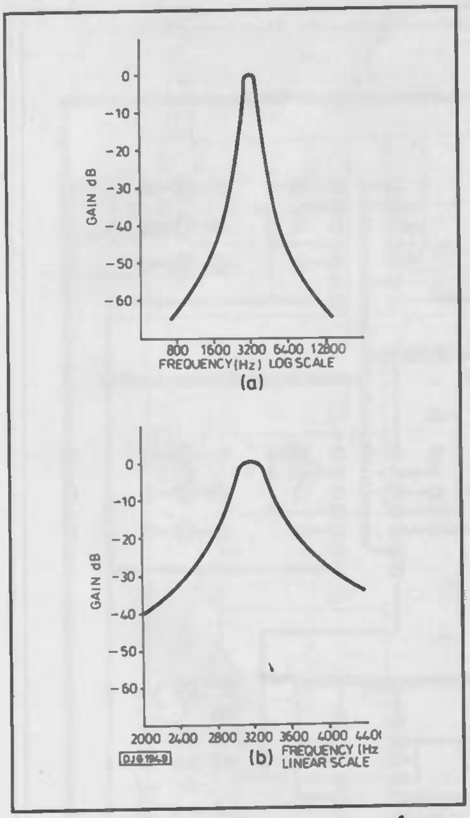


Fig 4. Gain/frequency response of 3200Hz band pass filter.

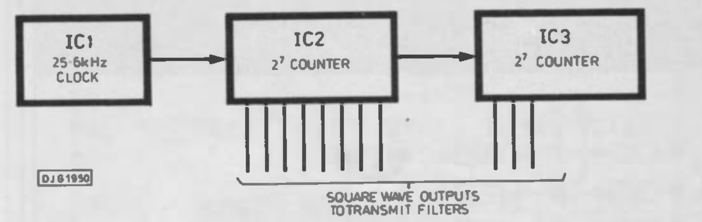


Fig 5. Analogue filter driver schematic.

frequency are present at equal amplitude. The graphs shown in Figs. 4a, 4b indicate the performance of the filter when constructed from components having an accuracy of better than 1%. From this it can be seen that no harmonics are present at a level greater than -47dB below the fundamental. Because the original square wave signal contains very little 2nd harmonic the actual harmonic content of the output is significantly better than this. Although in practice the filter may be constructed with components having a lesser degree of accuracy the effect on the filter outside the pass band is minimal. A slight increase in loss at the centre frequency (one or two dB) may be observed which can be compensated for during the alignment of the measuring set and will in effect worsen the whole stop band performance by the same amount.

The main change to the original design was to incorporate 2-stage filtration of the transmit and receive signals. As the initial requirement was to achieve a flat response over the whole frequency band harmonic suppression of 20 or 30 dB was quite adequate. In making the equipment of more general use it was thought best to cater for a slope across the band of the maximum measuring range (30dB). The increase in circuit complication and cost is minimal and the result is a much more flexible design.

ANALOGUE FILTER DRIVE CIRCUIT

Let us now look at the system design in detail starting with the Driver Board for use with the analogue filters. A functional diagram of the board is shown in Fig.5 and the circuit diagram in Fig.6. The signal source is a 25.6kHz square wave generator built around a CD4047 programmable multivibrator (IC1). In this instance the circuit is used as a free running multivibrator. The circuit has a frequency stability of better than 1% which is adequate for this application. The exact frequency is set by VR2 in conjunction with R1 and C1. The output is taken from pin 10 of the CD4047 to the clock input of a 7-stage binary counter, IC2. All seven outputs from this counter are used to drive the corresponding analogue band pass filters. Output 7 of the counter is also used to drive the clock input of a second counter, IC3, which also drives filters.

The various signal outputs from the counters are reduced to half their original amplitude by resistive attenuators. Because it is desirable to be able to switch off any one or more of the outputs for testing purposes this attenuator forms a convenient point to connect output on/off switches. The switches operate by shorting the output signal to the 0V line. The switches themselves are mounted on the front panel of the instrument.

The printed circuit board track and component layouts are shown in Figs. 7 and 8.

ANALOGUE FILTERS AND DISPLAY MODULE

The basic circuit of the analogue filter is shown in Fig.9. The design is the standard Sallen and Key configuration which I have found to be very good natured, exhibiting no signs of instability, and producing a filter which can be trimmed in the same way as an LC circuit to adjust precisely the centre frequency. This trimming is achieved by adjustment of VR2. The adjustment can compensate for component variations of up to 5% without significantly affecting the Q factor but, as has already been said, the loss in the pass band may increase. In my own model a typical pass band loss of 1.2dB was measured when the filters were constructed with components having a tolerance of +2%.

The transmit and receive filters are identical in configuration and each consists of two of the filter blocks shown in Fig.9. The first section of the transmit filter, however, has its series input resistor reduced in value by 5k to compensate for the source impedance presented by the generator output attenuators. It should be noted that the low end of the output attenuator is taken to the zero volt rail

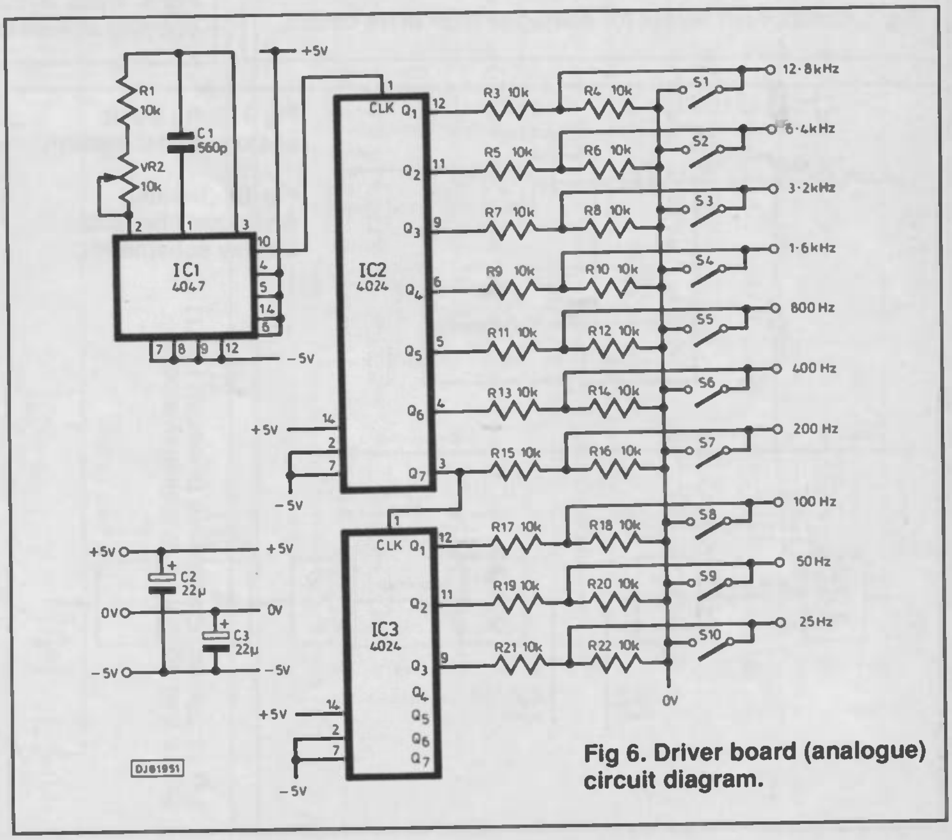


Fig 6. Driver board (analogue) circuit diagram.

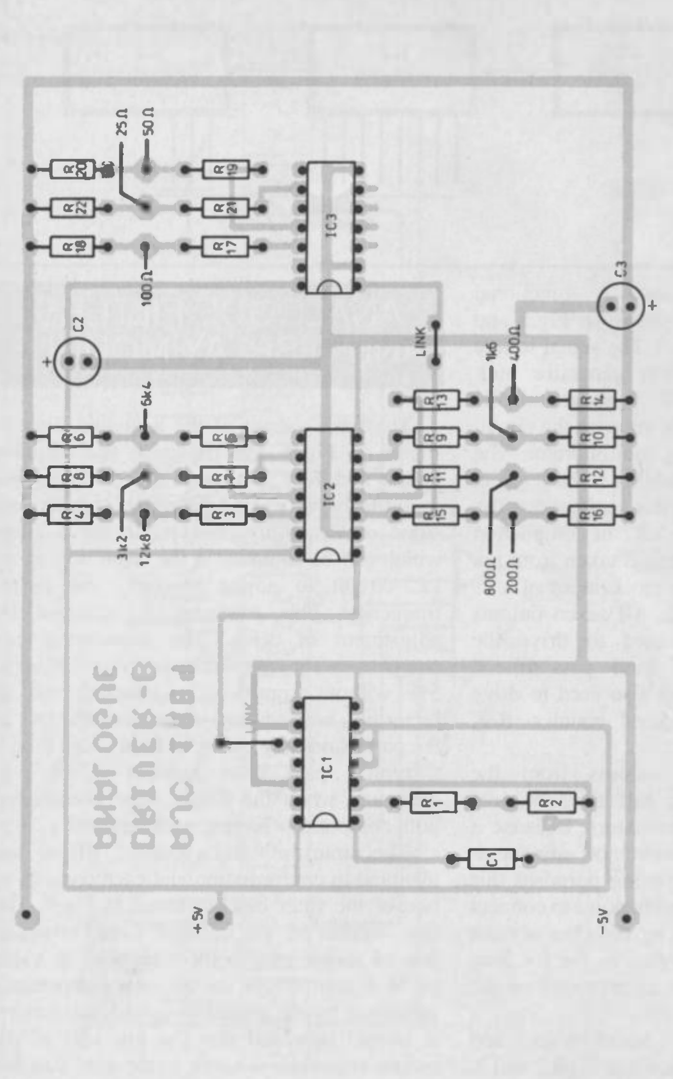


Fig 7. Component layout for analogue filter drive circuit.

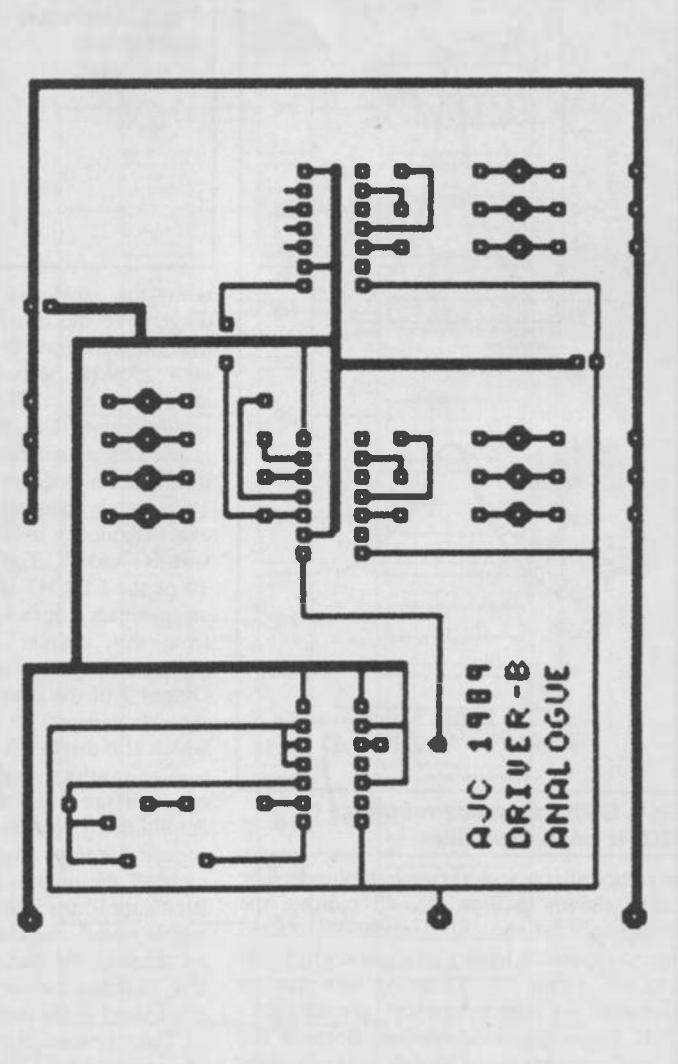


Fig 8. Track layout for analogue filter drive circuit. When copying ensure that ic pin spacing is exactly 0.1 inch.

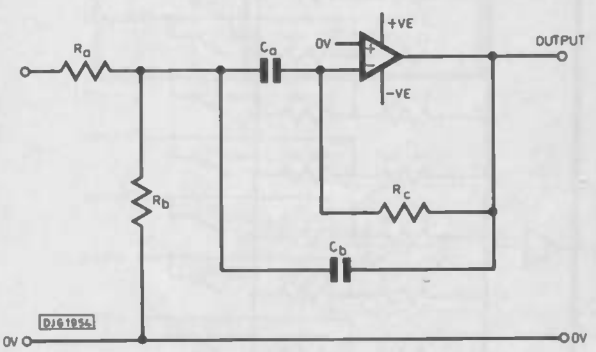
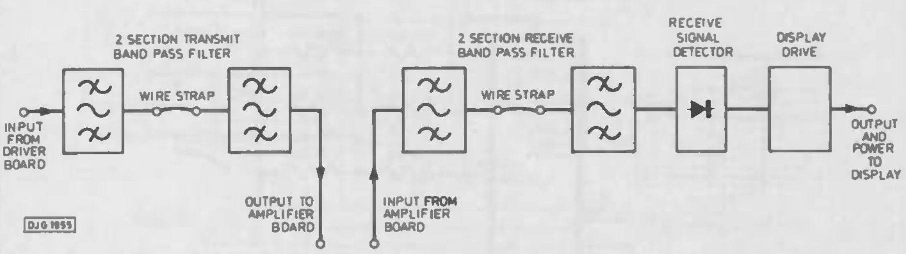


Fig 9. (left). Basic analogue filter section.

Fig 10. (Below). Analogue filter and display schematic.



COMPONENTS ANALOGUE DRIVER

RESISTORS

R1, R3-R22	10k (21 off)

All 0.25W 5% carbon or better

CAPACITORS

C1	560p 5% polypropylene or polystyrene
C2, C3	22µ 25V electrolytic

SEMICONDUCTORS

IC1	4047
IC2, IC3	4024 (2 off)

POTENTIOMETER

VR2	10k preset

SWITCHES

S1-S	10 spst (10 off)

MISCELLANEOUS

14 pin dil ic sockets (3 off), pcb.

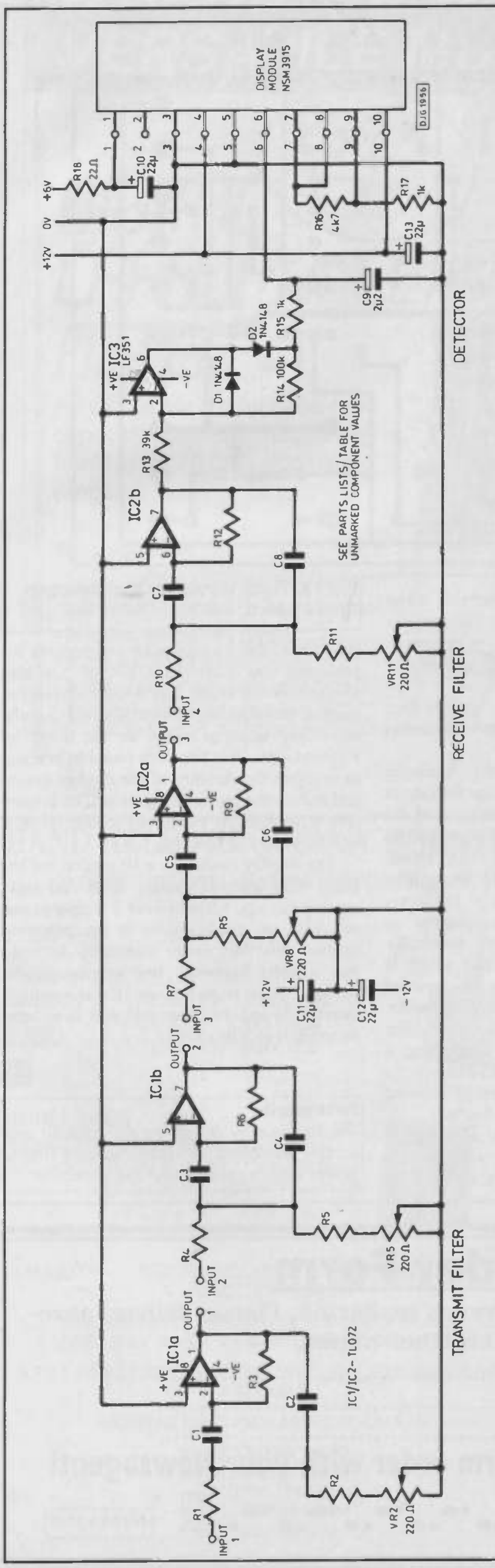
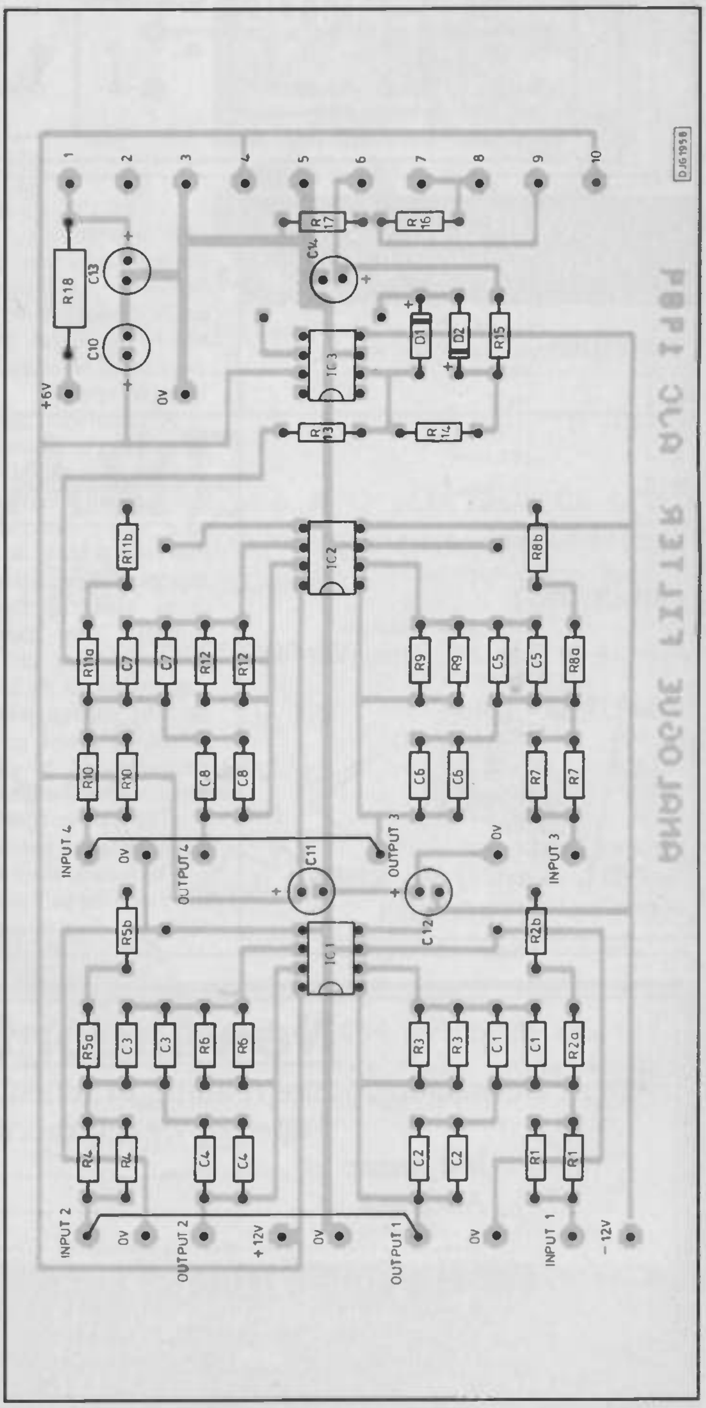


Fig 11. Analogue filter and display module
Fig 12. (Below) Component layout for Fig. 11.

ANALOGUE FILTER - FREQUENCY DEPENDENT COMPONENTS

Freq	R1	R4,R7 R10	R2,R5 R8,R11	R3,R6 R9,R12	C1-C8
25Hz	88k6	93k6	470	187k	680n
50Hz	91k5	96k5	360	193k	330n
100Hz	67k3	72k3	270	145k	220n
200Hz	74k6	79k6	300	159k	100n
400Hz	79k7	84k7	330	169k	47n
800Hz	85k4	90k4	330	181k	22n
1.6kHz	94k5	99k5	390	199k	10n
2.3kHz	101k	106k	390	212k	4n7
6.4kHz	70k4	75k4	270	151k	3n3
12.8kHz	51k8	56k8	220	113k	2n2



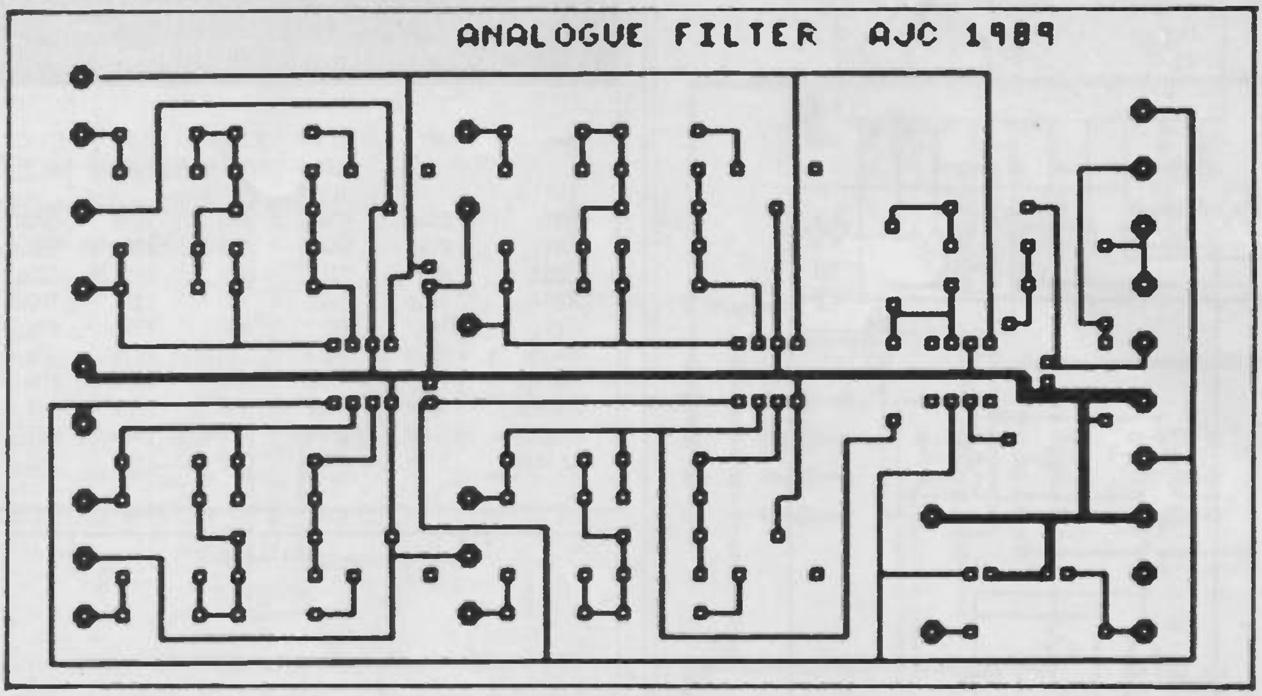


Fig 13. Track layout for the analogue filters board.

COMPONENTS ANALOGUE FILTER

RESISTORS

R13	39k
R14	100k
R15,R17	1k (2 off)
R16	4k7
R18	22ohms

All 0.25W 5% carbon or better

CAPACITORS

C9	2.2µ 12V tantalum
C10-C13	22µ 25V electrolytic (4 off)

SEMICONDUCTORS

D1,D2	IN4148 (2 off)
IC1,IC2	TL072
IC3	LF351

MISCELLANEOUS

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to ensure that a signal symmetrical about earth is presented to the filters. This ensures that very little second harmonic is present in the filter input. From Fig.4 it can be seen that the degree of 2nd harmonic reduction is 47dB and for all higher harmonics is greater than this figure, ensuring a high degree of output waveform purity.

A functional diagram of the Analogue Filter Bond is shown in Fig.10, and the circuit diagram is in Fig.11. The two sections of the transmit and receive filters are connected by wire straps external to the circuit board. Provision is made on the board for each of the frequency determining elements of the filters to be made up from two components in parallel. The capacitors are nominally standard values and if a capacitor which is slightly low on the nominal value is chosen it may be padded with a trimming capacitor connected across it. Any "difficult" resistor values should be made up by selecting a suitable combination of standard values.

(The resistor combinations can be selected using the tables published in PE Jan 90.)

The receive filter is connected on the board to a precision half wave rectifier which in turn feeds the display module via a simple low pass filter. The various other components for powering and biasing the display are also mounted on the board. The display is powered from a rectified by unsmoothed 6V supply, smoothing being provided on the board by R18 and C10. This has been found in practice to improve the stability of the display device and reduce the power dissipation. The display chip otherwise has a tendency to shut down if all leds are on for too long.

The display module is a 10 section led bar graph with integral display drive and level sensing circuits. I have found it simple to use and with the modification to the powering method described above reasonably accurate and reliable. There are two versions of the device, one model has linear voltage increments and the other, which is used here, increments in 3dB steps.

PE

Next month:
We continue by describing the transmit and receive amplifiers, switched capacitor filters, power supply, construction and alignment.

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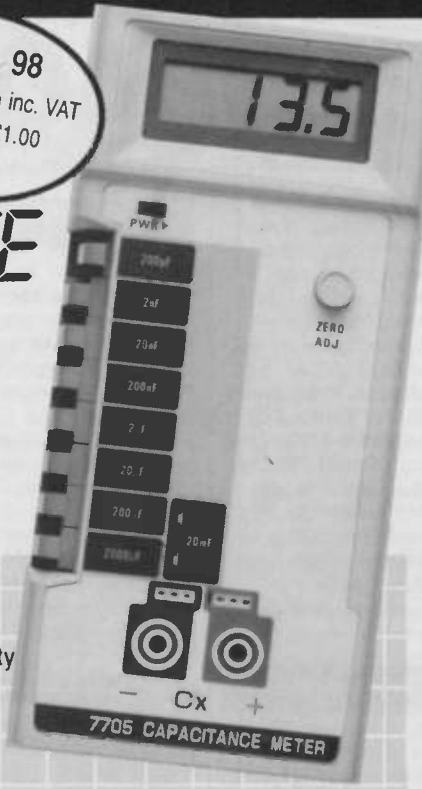

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ranges	res.	accuracy
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2nF	1.0pF	+ (0.5% + 1 digit)
20nF	10pF	+ (0.5% + 1 digit)
200nF	100pF	+ (0.5% + 1 digit)
2µF	1.0nF	+ (0.5% + 1 digit)
20µF	10nF	+ (0.5% + 1 digit)
200µF	100nF	+ (0.5% + 1 digit)
2000µF	1µF	≠ (1.0% + 1 digit)
20,000µF	10µF	+ (2.0% + 1 digit)

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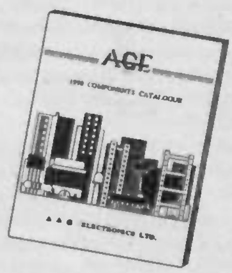

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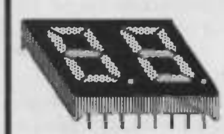

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TRACK FEEDBACK

LIKE MOTHER, LIKE DAUGHTER

Dear Mr Becker,

Thank you for sending us the competition prizes - "*Robot Builder's Bonanza*" and "*Remote Control Handbook*". They look very interesting.

I have been buying PE regularly since Issue 1. I was 14 then. Now my fourteen year old daughter is also showing an interest in electronics and has chosen to take 'technology' in GCSE. This makes the prize books particularly appropriate and welcome.

Best wishes to all at PE.

Elizabeth Hanson, Bracknell, Berks.

I was especially pleased to see that two ladies were amongst the winners in our April 90 competition, and I am further interested to know that you are in fact mother and daughter. Electronics does indeed transcend both gender and generation. Good luck to you both. Ed.

OVERSEAS OPPORTUNITIES

Dear Sir,

I have recently returned from spending two years working as a technical teacher with the UK charity VSO (Voluntary Service Overseas) in Nigeria, West Africa.

I thought other readers might like to hear about the opportunities VSO offers practically-minded people to live and work overseas: every year the charity receives 50 requests from men and women to help teach the new Introductory Technology (Introtech) course in Nigerian schools.

Introtech aims to teach basic technology in secondary schools - it is similar to the Craft, Design and Technology (CDT) course in the UK. Practical projects include the making of toys, jewellery, electrical torches and musical instruments from a range of materials. Through these, students learn about materials, design, technical drawing and measuring, and so build up a basic technical knowledge.

Given the broad nature of the subject, VSO is looking for people from a wide range of backgrounds - diy, carpentry, technical drawing, metalwork, ceramics and vehicle maintenance.

VSO volunteers need a qualification, ranging from City and Guilds part three to degree, and at least two years' work experience. VSO jobs are for a minimum of two years and volunteers are paid at local rates. Volunteers also need quite demanding personal qualities like enthusiasm, adaptability, initiative and a good sense of humour to teach in what is often a very challenging environment. It is a job equally suitable for men and women.

If readers would like to know more, they are invited to contact me.

Richard Mitchell, Recruitment Unit, VSO, 317 Putney Bridge Road, London SW15 2PN. Tel : 081 780 2266.

Here's a really worthwhile opportunity. I worked in Nigeria for a while and found the country to be fascinating and the people interesting to work with. Do follow up this invitation. Ed.

INVENTION

Dear Ed,

Twenty two years ago I invented the Pye TVT self-assembly machine which uses magazines full of components to completely assemble printed circuit boards. What used to take hours now takes seconds and all the firms have to employ are magazine fillers.

Can you tell me if I was the first to think of automation in the electronics industry? Perhaps it may mean a mention in the *Guinness Book of Records*. My foreman, Don Law, used to call me Leonardo Devinchi of the ballpoint pen. At the same time I also invented automatic test equipment to do away with test engineers. The invention was given to the test equipment manager, but I do not know what happened to it.

TVT won the Queen's Award to Industry three years running, I believe, on my machine. A pity they did not even give me a mention, in fact they were so successful they were taken over by an American Company.

Robert Hill, Loanhead, Midlothian, Scotland.

I don't know who might be said to be the inventor of automation in electronics. It seems probable that automation is something that simply 'evolved', no doubt simultaneously among many manufacturers. And, I suspect that, unlike the days of Hertz, Maxwell, Baird, et al, these days true inventors are less likely to be plentiful, since many 'inventions' are the result of team work.

Perhaps readers may care to comment? Ed.

HOBBY TRAIN

Dear Mr Becker,

After reading your Editorial in PE April 90, my first reaction was a phone call of support and agreement. However, as the result would have been being arrested for using language unfit for public consumption, I thought I'd better just send you a copy of an editorial in another magazine.

Thanks for the multimeter which I won in your Nov 89 competition. There's just one problem with it: I can't find anything in the instructions on how to make coffee with it!

David Thompson, Callander, Perthshire.

The editorial to which David Thompson refers was published in the Jan 73 issue of Model Railway Constructor. *The editor was lamenting the tone of an article in the* Sunday Times Colour Magazine *of Nov 19, 1972, which, apparently, had been critical of those who enjoyed the hobby of model railways.*

It seems likely that any age will produce those who are critical of hobbies. To be charitable, perhaps I should feel sorry for those who have never been willing or able to enjoy the pleasures of doing things for their own sake, and for non-commercial reasons.

I can't directly answer your coffee-meter problem, but I can suggest that you might try using the meter to test the strength of alternatively-made coffee, measuring the resistance between the meter probes immersed on either side of the mug! Ed

GATE ILLOGIC

Dear Ed,

Let me add my voice to the thunderous cries of protest regarding the London Underground automatic entry-exit gates.

Every since I became trapped in the automatic doors of a train at Shepherds Bush a couple of years back, I've seldom used the Tube. Normally I drive the car into London, timing the journey to avoid the depths of rush hour mayhem. However, I wanted to visit an exhibition, and unwilling to face the hassle of parking problems around Earls Court I took the train.

At Victoria, I came through the ordinary ticket check point on the main line platform, and headed for the Underground. Seeing an auto entry gate I fed my magnetic-strip ticket into the slot, and passed through ok, only then to spot I was heading for the wrong tube line. The gates surrounding me were all one-way types, and I couldn't retreat through them. Then I saw an open gate a few yards away, and went back to the main concourse, to the auto gates leading to the line I wanted. Feeding the mag-ticket into a gate slot, I was refused entry - "*seek assistance*", or words to that effect, it said in glowing red letters. Technology on the blink, I thought, and tried the next gate. Same effect. And at the next! "I can't get in"! I complained irately to a nearby ticket inspector, who wearily passed me through an ordinary entry.

At Early Court exit auto gate I was behind a man whose ticket had just traversed the slot. Expecting he'd immediately be passed through, in my inexperience I fed in my ticket, just as the machine was visually rejecting his! But my ticket was already in the system, and he got through because it opened the gates for him, only to immediately reclose. Feeding my ticket in again, the machine then rejected me! Already irate from the Victoria trouble, my patience vanished completely. To Hell with idiosyncratic technology, I complained to the world at large, and forcibly prised my way through the heavily resistant gates. It was so difficult to get through I then fully understood the concern of those who question the safety of auto gates in emergency situations.

I've not checked with London Transport how their electronic ticket coding works, but I suspect that you can only enter if you haven't already done so, and only leave if you haven't departed! As far as the two sets of artificial unintelligent machinery were concerned, in both respects I was apparently trying to do the illogical! There's nothing illogical about my feelings towards non-user friendly auto gates....

Jim Kelly, Petts Wood, Kent

I, too, have had similar problems. Ed.

POINTS ARISING

Circuit Breaker (June 90)

In Fig 3., C1 at top right should be C12, and D4 polarity should be reversed.

Eprom Poly-Programmer (June 90)

Figs. 13 and 14 are incorrectly shown as mirror images of the tracks. The pcb image should be reversed, or alternatively the components may be directly soldered on the track side.

bookmark

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

Test Equipment Construction. R.A. Penfold. Babani. £2.95. BP248. ISBN 0-85934-193-3.
Here's a book to delight all electronics constructors. In it, Robert Penfold presents a selection of simple and inexpensive pieces of test equipment that you can build for yourself. They have been designed to fill some of the gaps not covered by oscilloscopes and standard multimeters, and cover the checking of both linear and digital circuits. Stripboard layouts are provided for all the designs, together with wiring diagrams where appropriate, plus notes on their construction and use. Robert comments that while the designs should prove useful for the more experienced readers, they are not beyond the capabilities of newcomers to the hobby. Apart from providing the constructor with a useful range of test gear, building these projects should also be an interesting and rewarding exercise in its own right. There are three lengthy chapters, individually covering audio test gear, meters, and probing. The constructional projects include an AF generator, a test bench amplifier, an audio millivoltmeter, high resistance voltmeter, transistor tester, capacitance meter, AF frequency meter, analogue probe, cmos probe, and a ttl probe. Over 100 pages of good value subject matter.

More Advanced Test Equipment Construction. R.A. Penfold. Babani. £3.50. BP249. ISBN 0-85934-194-1.
This is a companion book to the above BP248, carrying on from where it left off, describing some slightly more advanced projects for readers who have a certain amount of experience at project construction. Unlike BP248, the book is not primarily aimed at beginners and near beginners at electronic project construction. A certain amount of practical experience and knowledge of electronics theory is assumed. However, you do not need to be an expert at electronics in order to build and use the designs included. Anyone with a moderate amount of electronics experience should be able to tackle these projects. Someone who has gained some experience by building and using projects from BP248 should be able to successfully undertake and use the designs featured. The designs include: digital voltmeter, digital capacitance meter, digital transistor tester, digital heatsink thermometer, bench power supply, dynamic transistor tester, AF digital frequency meter, digital resistance meter, digital current tracer, crystal calibrator, pulse generator. Well done, Robert, you've written another very useful book.

More Advanced Uses of the Multimeter. R.A. Penfold. Babani. £2.95. BP265. ISBN 0-85934-210-7.
The book is primarily intended as a follow-up to BP239, *Getting the Most from Your Multimeter*, (available through the PE Book Service). It should also be of great value to anyone who already understands the basics of voltage testing and simple component testing. Although you need a certain amount of technical knowledge in order to fully exploit the information in this book, you do not need a really in-depth knowledge of electronics. The first chapter looks at simple component testing procedures, including numerous varieties of transistors, integrated circuits, scrs, leds and lcds. The second chapter is titled *Extending Your Multimeter* and covers some useful but simple and inexpensive add-ons that extend the capabilities of a multimeter. These include ac and dc booster amplifiers, memory circuits, a current tracer add-on, an active RF probe and a high resistance probe. A multimeter is probably the most important piece of test gear you should own, and you owe it to yourself to know fully how to use it, and to extend its capabilities. This book will help you in both objectives.

How to Use Oscilloscopes and Other Test Equipment. R.A. Penfold. Babani. £3.50. BP267. ISBN 0-85934-212-3.
Next to a multimeter, the oscilloscope is the second most important piece of test equipment you should know how to use. Experienced constructors will know that scopes are not difficult to master, but those uninitiated may find the prospect a trifle daunting. Robert Penfold helps dispel the fears of the inexperienced and in this book he explains the basic function of a scope, giving a detailed explanation of all the standard controls, and providing advice on buying a scope. A separate chapter deals with using a scope for fault finding on linear and logic circuits. Plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators. The basics of component testing are also covered. This is a very worthwhile book to have in your workshop.

Digital Audio Projects. R.A. Penfold. Babani. £2.95. BP245. ISBN 0-85934-190-9.
The sophistication, availability and decreasing price of digital ics has made them increasingly suitable for applications relating to audio circuits. This book illustrates some of the simple yet very useful circuits you can build to improve your audio signal control capabilities. The first section of the book takes a look at the basic principles involved in converting an audio signal into digital form, and then converting it back to an analogue signal again. It also deals with some practical aspects that have to be borne in mind when considering digital audio projects. The second section contains some useful and extremely interesting, practical circuits for constructors to build and experiment with. By current standards the projects are not highly complex, but they are probably beyond the scope of complete beginners and are more suitable for someone with a moderate amount of experience in electronic projects building. Among the circuits included are an a-d converter, digital delay line, compander, echo circuit, and an oscilloscope store.

More Advanced MIDI Projects. R.A. Penfold. Babani. £2.95. BP247. ISBN 0-85934-192-5.
Anyone remotely familiar with the complexities of MIDI based instruments will probably appreciate that the building of such equipment is beyond the capabilities of most constructors. For example, many of the sophisticated integrated circuits are specially produced for particular equipment manufacturers and are not available for retail sale. Additionally, the high volume production of MIDI equipment enables costs to kept well below the levels that would result for a constructor who attempted to buy the components on a one-off basis. Nonetheless, there are several areas, as this book shows, in which the amateur constructor can benefit from building MIDI-associated equipment and accessories. The projects fall into two main categories; those that are designed to overcome a deficiency in an item of equipment in the system, and those that are designed to enhance the performance of the system or make it easier to use. The circuits presented in the book include a MIDI indicator, a THRU box, a merge unit, a code generator, a pedal, a programmer, a channeliser and an analyser. The projects are generally more complex than those featured in the *MIDI Projects book* BP182 (available through the PE Book Service), although a few simple units have been included as well. While most of the projects are not suitable for beginners, they should be well within the capabilities of someone who has a reasonable amount of experience in electronics construction. The circuits should also provide some useful electronic building blocks for use in readers' own designs.

An Introduction to Amateur Radio. I.D. Poole. Babani. £3.50. BP257. ISBN 0-85934-202-6.
Over the last few months PE has been taking a look at various aspects of radio and we shortly be publishing a series of articles on amateur radio by the author of this book, Ian Poole. (Regular readers will also be aware that Ian periodically keeps us informed about the histories of notable personalities famous for their contributions to electronic advancement.) In this book Ian reveals his enthusiasm for the subject of amateur radio (his call sign, incidentally, is G3YWX) and presents us with a great deal of information to help us appreciate the subject as well. He shows that it is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century. It encompasses a wide variety of subjects from the historical to the latest technology, and from operating to construction. There is little doubt that there is, as Ian says, some aspect of the hobby to interest almost anybody. It can also probably be argued that the health of the electronics industry in general may be partly dependent upon those who have learned the fascination of electronics through becoming involved in amateur radio. In his book Ian gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. The book is also an essential reference volume which can be used time and again. The topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials, etc. You'll also find some useful add-on circuits as well, plus some valuable system block diagrams and data charts. Nice one Ian!

PUBLISHER'S ADDRESS

Bernard Babani (Publishing) Ltd, The Grampians, Shepherds Bush Road, London W6 7NF.

BASIC ELECTRONICS

Owen Bishop Part 8 - Amplification.

Here is the good news – we have negative feedback! Being positive isn't so cool.

Before we get down to this month's topic, there is a little more to be said on a subject that was raised at the very end of last month's article. In connection with the *System of the Month* we introducted the idea of *feedback*.

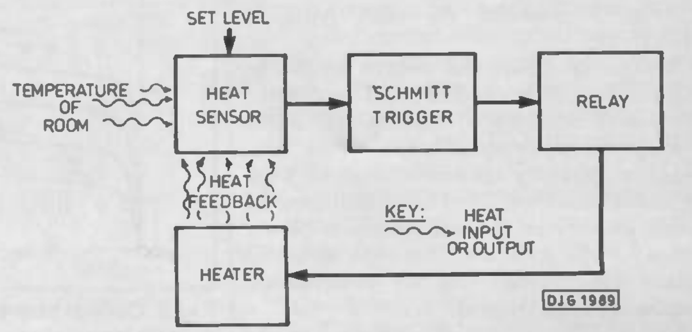


Fig 1. Feedback in a thermostat system.

FEEDBACK

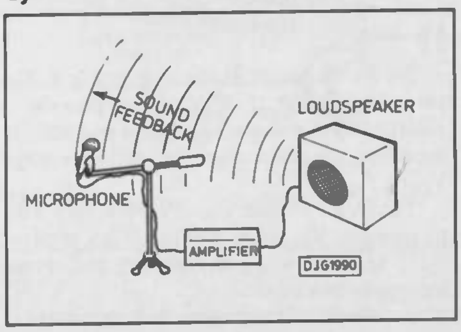
Most systems or parts of systems, electronic or otherwise, have an input and an output. If we take part of the output and feed it back as part of the input, we have *feedback*. To make this clear, let us take some examples.

The example quoted last month was the thermostat system. Its function is to keep the temperature of a room or enclosure constant. The input of the system is the temperature of the room, as detected by the sensor (Fig. 1). The output is the heat coming from the heater. We arrange that part of this heat is fed back to the sensor. The heat becomes part of the input. The other part of the input is the setting of the variable resistor which adjusts the temperature at which the sensor responds. Assume that the level has been set and the system is left to regulate itself.

When the temperature becomes too high, the sensor detects this fact and the heater is switched off. When the temperature becomes too low, the heater is switched on. In this way the temperature is kept constant - or at least held within a small range. Note that the circuit is designed so that excessive heat turns the heater off and insufficient heat turns the heater on. The feedback produces an effect that *opposes* any change in the system. This kind of feedback is called *negative feedback*. Negative feedback leads to stability, so we shall expect to see several examples of this in the amplifier circuits.

As a non-electronic example, consider a person driving a car along a straight road. The input is the view of the road ahead, as seen by the driver's eyes. The output is the direction of travel of the car in relation to the road. Any slight irregularity in the road surface or a cross-wind causes the car to deviate from its straight path. This information is fed back to the driver who is watching the road. The driver reacts to correct any deviation, turning the steering wheel one way or another until the car is back on its path again. The feedback is used to oppose deviations from the straight path. It is negative feedback and gives stability.

Fig 2. Feedback in a public address system.



We go back to electronics with the next example, which is sometimes met with in public address systems (Fig. 2). The input is sound, detected by the microphone. The output is sound from the loudspeaker. If the microphone and loudspeaker are badly positioned and the amplifier is turned up too much, part of the output is fed back to the input - that is to say, the microphone picks up part of the sound from the loudspeaker. A faint sound picked up in this way becomes amplified and appears at the loudspeaker as a louder sound. The sound reaching the speaker is thus increased, then amplified and the output goes up even more. Soon a loud whistling noise is heard, which continues indefinitely. Note that only a *part* of the output is being fed back to the input. Most of the output passes into the surrounding area and annoys the audience. In this example, the input is amplified and *reinforces* the output. We call this *positive feedback*. Positive feedback leads to instability and is usually to be avoided.

Another example of positive feedback is thermal runaway, described last month. The small leakage current, results in a larger collector current, which causes heating, which increases the leakage current, which results in an even larger collector current, which causes more heating..... until the transistor burns out. Again, this is something to be avoided. However, positive feedback has its uses if kept under control, as we shall see in later articles on oscillators and radio receivers.

AMPLIFICATION

To amplify something is to make it larger. Ideally, an electronic amplifier takes a small input signal and produces an output signal which is exactly like the input signal in every way, *except* that it is larger. But no circuits are perfect and the output signal is likely to differ from the input signal in one or more other ways. We say it is *distorted*. Amplifier design is directed toward minimising all types of

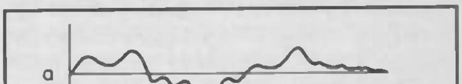


Fig 3. Types of distortion: (a) original waveform, (b) amplified without distortion, (c) clipped, (d) severely clipped, (e) uneven frequency response (low frequencies less amplified), (f) crossover distortion, (g) noisy signal.

distortion, but it is impossible to get rid of them altogether.

Fig. 3 illustrates the main types of distortion:

Clipping: the peaks and troughs are not as high or deep as they should be. In the extreme they may be flattened because the output voltage can not swing as far as it should.

Uneven frequency responses: notes of some frequencies are amplified more than those of other frequencies. In cheap systems the lower (bass) frequencies are often less amplified than the higher (treble) frequencies, producing a 'thin' sound.

Crossover distortion: the output stays briefly at zero every time the waveform changes from positive to negative or from negative to positive.

Noise: an unwanted signal is added to the waveform. In the figure, the noise is an irregular signal, heard as a hissing or crackling sound. Noise may also be a regular unwanted signal, such as a mains hum.

OUTPUT CHARACTERISTICS

Fig. 4 shows a circuit for measuring the output characteristics of an npn bipolar junction transistor - an 'ordinary' transistor. You could try this measurement for yourself if you have the necessary meters and a 10V or 12V power supply. The circuit has two independent power sources. A 3V battery supplies the base current I_B, using a potential divider to vary the voltage and hence I_B, measured by M1. A 10V power pack (or 12V battery) with VR2 allows the collector-emitter voltage V_{CE} to be varied in the range 0-10V dc. This is measured by M3. The collector current I_C is measured by M2.

First of all V_{CE} is set to zero. Then VR1 is adjusted until I_B is 20μA. V_{CE} is increased in steps from 0V to 10V, and I_C is read at each step. Thus we have values of the collector current corresponding to a given base current over a range of collector voltages. The result is the lower curve on Fig. 5, and is known as an *output characteristic*. The measurements are repeated for a number of different base currents giving the family of curves shown in the figure.

The curves show us two important things (when V_{CE} is greater than about 1V):

* *I_C does not depend on V_{CE}*. For all practical purposes the curves are almost horizontal. The action of the transistor is not affected by variations in its power supply.

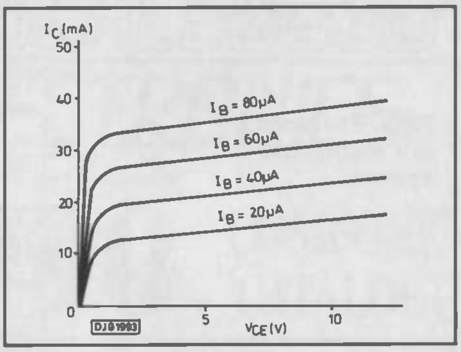


Fig 5. Output characteristics of an NPN silicon transistor.

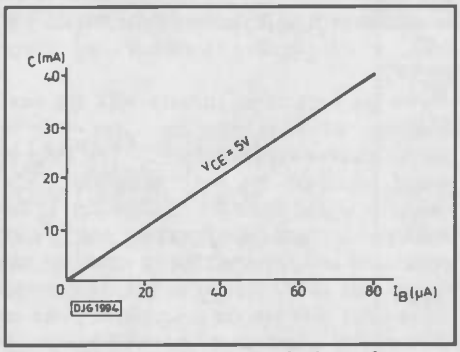


Fig 6. Transfer characteristics of an NPN silicon transistor.

* *Equal increases of I_B give equal increases of I_C*. Current amplification is linear.

The second point is made clearer if we plot a graph relating I_B to I_C for a fixed value of V_{CE} (Fig. 6). The axis for I_B is marked in microamps, while that for I_C is marked in milliamps. This is known as the *transfer characteristic* of the transistor. As I_B increases, I_C increases at a steady rate (i.e. the relationship is linear).

The slope or gradient of the line represents the *direct-current gain* of the transistor. Taking the example of the transistor on which Fig. 5 is based, increasing I_B from 0μA to 80μA, increases I_C from 0mA to 40mA. The current gain is 40mA/80μA = 4000μA/80μA = 500. In general:

current gain, $h_{FE} = I_C/I_B$

The value found above is rather high for most transistors. The ZTX300 transistor used in our investigations typically has a current gain of 150. Different transistors *of the same type* may have widely different gains, depending on variations inherent in manufacturing.

The direct-current gain f_{FE} calculated above is a *static* parameter; it is measured under constant (dc) conditions. Another way of expressing gain is by h_{fe} (small 'fe') the *forward current gain, or small-signal current gain*. This is the gain when an alternating signal is applied to the transistor. It is a *dynamic* parameter. Theoretically the two gains mean different things but, in practice, their values are almost equal.

COMMON EMITTER CONNECTION

There are various ways of connecting a transistor into a circuit. One of these is the *common emitter connection* (Fig. 7). There are two sides to the circuit, the input side and the output side. The input is to the base, the output is taken from the collector, and the emitter is *common to both sides* of the circuit.

The description in the previous section shows that the transistor is essentially a *current amplifier*. When we amplify a signal we are usually more concerned with amplifying a *voltage*. This is the reason for the resistors in Fig. 7. R_B determines the value of I_B for a given input voltage. R_C determines how much V_{OUT} varies for given variations in I_C. Since I_C depends on I_B and the gain h_{FE}, the voltage amplification of this amplifier depends on the values of R_B, R_C and h_{FE}. The values of R_B and R_C may vary with temperature, so temperature affects the amount of amplification. The value of h_{FE} varies from one transistor to another. As a result of these variations, circuits built with different transistors of the same type have different voltage gains.

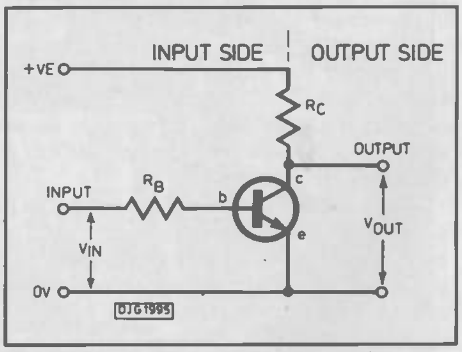


Fig 7. Common emitter connection.

Investigation 1 - voltage gain of a common-emitter amplifier

You need: battery box (6V)
R1 1k
R2 3k3
VR1 10k potentiometer
(Module 3)
testmeter

Set up the circuit of Fig 8, as in Fig 9. The potential divider (VR1) is to provide a variable input voltage V_{IN}. Use a testmeter to measture this, and also the output voltage V_{OUT}.

Turn VR1 so that V_{IN}=0V. Now turn VR1 to increase V_{IN} from 0V to 1V in steps of 0.1V. Measure V_{OUT} at each step and record the results in a table:

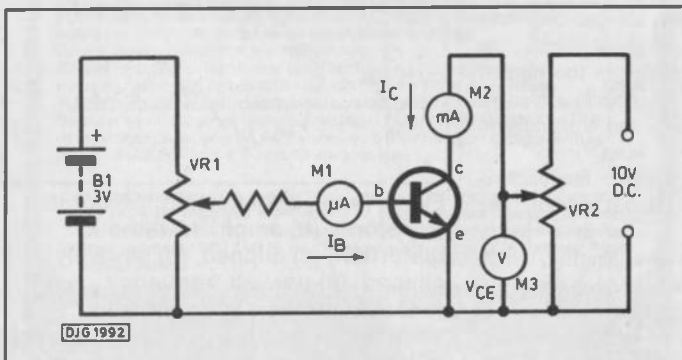


Fig 4. Measuring the output characteristics of a transistor.

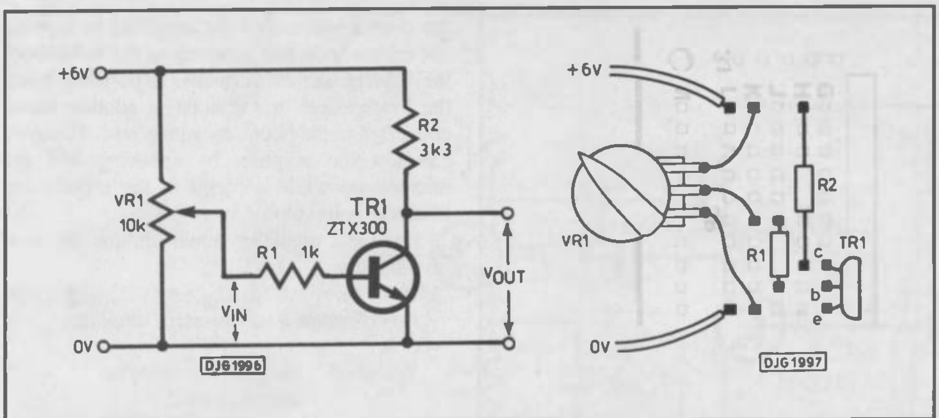


Fig 8 and Fig 9. Circuit and breadboard layout for Investigation 1.

V_{IN} 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
V_{OUT}

Plot a graph of these results. Part of the curve shows a steep fall, where V_{OUT} is falling most rapidly. Taking this part of the curve, find the change in V_{OUT} corresponding to a given change in V_{IN}. Calculate the *voltage gain* of the amplifier. Remember that this depends on the value of R1, R2 and the direct current gain of the transistor used.

BIASING

One of the problems of using an amplifier such as that described above is that its output is constant if V_{IN} is negative or less than 0.6V positive. Often the signal voltage is a small one such as the output from a microphone so as not to be as big as 0.6V. Moreover, it may alternate above *and below* 0V. Such a signal has no effect if applied directly to the amplifier of Fig. 7.

In Fig. 10 we see one solution to the difficulty. The source of the signal is a crystal microphone which produces an alternating signal of a few hundred millivolts in amplitude. Since it alternates above and below 0V the *average* signal from the microphone is 0V. The microphone is coupled to the common-emitter amplifier by a capacitor. As explained in part 3, capacitors block low-frequency signals and pass high-frequency signals. The audio signals from the microphone have a high enough frequency to be passed through the capacitor. Blocking of low-frequency signals includes blocking zero frequency - i.e. direct current levels. In other words the *average* voltage on one side of the capacitor may be 0V, but the average voltage on the other side can be anything we choose. So why not choose a voltage that supplies a steady base current to the capacitor without saturating it?

There are three main ways of providing a steady base current, or *biasng* the transistor, as it is usually called. Fig. 8 shows the simplest method, a single resistor providing the current. For satisfactory action, we should aim at a collector current of 1mA. If the gain of the transistor is 200, the base current should be 50µA. The emitter current is almost the same as I_C. A 1mA current through a resistor of 1k, produces a voltage drop of 1V. The emitter is at 1V, so the base of the transistor is at 1.6V (due to 0.6V forward voltage drop). The voltage drop across the bias resistor is 6-1.6 = 4.4V. To obtain a base current of 50µA we need a bias resistor of 4.4/0.000005 = 880000. This is close enough to the standard value of 820k.

While we are calculating resistors, let us work out a suitable value for the collector resistor. The ideal output voltage of the amplifier is half the supply voltage. This allows the output to swing up and down by the maximum amount without being clipped (see Fig. 3c and Fig. 3d). If the supply is 6V, the voltage across the resistor is to be 3V, and we have already said that the current is to be 1mA. So the value of R_c should be 3/0.001 = 3k. The nearest standard values, 2k7 or 3k3, will probably be good enough.

With no signal a steady bias current flows, a steady collector current flows, and the output voltage is steady about half-way between 0V and the supply voltage. When the microphone picks up sound, a small alternating voltage is generated. This passes across the capacitor. A small and varying signal current is added to or subtracted from the base current. The total base current fluctuates a little in sympathy with the audio signal. The collector current fluctuates similarly, causing a fluctuating voltage across the collector resistor. This is the output signal voltage of the amplifier. If necessary, this can be fed to another capacitor, coupling the output of this amplifier to the input of another amplifier for further amplification.

Questions

1. Calculate the bias and collector resistor values for an amplifier operating on 6V when the gain of the transistor is 100.
2. Calculate the bias and collector resistor values for an amplifier working on 9V when the gain of the transistor is 180.

In both questions suggest suitable values from the E12 range (see Part 1).

IMPROVED BIASING

Biasing with a single resistor is simple, but has considerable drawbacks. The most important aim in designing the circuit is to fix the average collector current. We choose a value that gives a suitable swing of voltage, and which gives a linear relationship between I_B and I_C. A current of about 1mA is suitable in most instances. To decide on what the base current should be, we have to *assume* the value of the gain of the transistor. Since the gain of a given type of transistor may have a tolerance of +50%, our calculation gives only an approximation to the required value of the base current and of the bias resistor.

We could, of course, measure the gain of the individual transistor that we intend to use and work out the value of the bias resistor accordingly. But this approach is unsuited to the design of mass-produced circuits, or to the designs that are to be published in magazines such as this. And this approach is only partly satisfactory because gain varies according to temperature and so may change in different environments. Also, the base-emitter voltage (the voltage of the in-built cell) varies according to temperature and this affects the base current. We need circuits that do not depend on the exact value of the gain of the transistor or on the temperature at which it is operating. In other words, we need a circuit that has *stability*.

The circuit in Fig.11 is an attempt to improve circuit stability. Assuming that the 'no-signal' output voltage of the circuit is half that of the supply (to allow free voltage swing in either direction), the drop across R_B is 3V-0.6V = 2.4V. To obtain a base current of 50µA, as previously specified, needs a resistor of 2.4/0.000005 = 480000, say 470k. Having fixed the bias resistor and thus fixed the base current, see what happens if the gain of the transistor is larger than assumed:

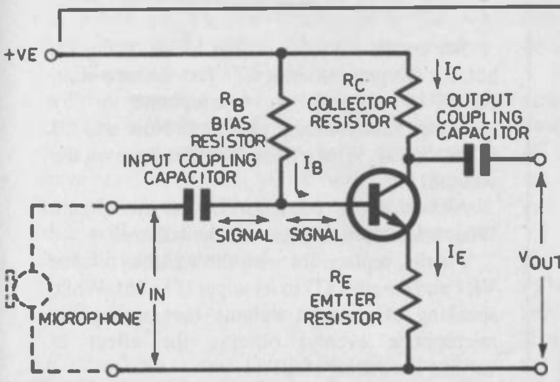


Fig 10. Common emitter amplifier with bias resistor.

Gain larger	I_c larger	Voltage across R_C larger	Voltage at A lower	Voltage across R_B smaller	I_B smaller	I_c smaller

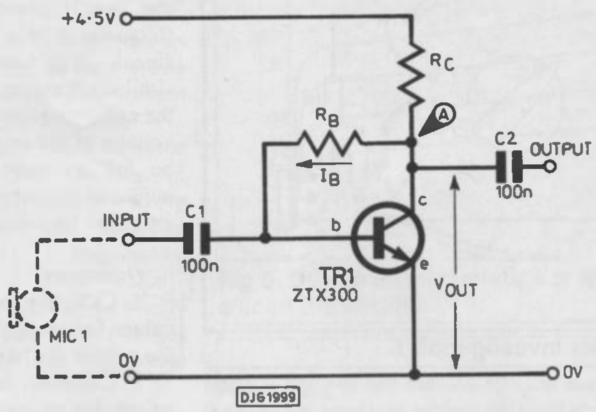


Fig 11. Common emitter amplifier with biasing by collector resistor. Circuit for Investigation 2.

If the gain is larger than assumed, the base current is smaller than assumed. This is a negative feedback effect which *opposes* the increase in collector current due to the excessive gain. The same effect operates if the gain is larger due to changes in temperature. The same effect works in reverse if the gain is less than assumed. Biasing the transistor as in Fig.11 is one step toward circuit stability.

Investigation 2 - An improved amplifier

You need: battery box (6V)
R_B bias resistor (see below)
R_C collector resistor (see below)
C1, C2 100n polyester (2 off)
TR1 ZTX300 npn transitor
MIC1 crystal microphone insert
LS1 loudspeaker 8-ohm, or crystal earphone

This investigation is a practical exercise in designing a stabilised common-emitter amplifier. To give different figures, the amplifier will be operated on 4.5V. Obtain this by connecting the battery box as shown in Fig.12.

The collector current is to be 1mA. The output voltage when there is no signal is to be half-way between the supply voltage (4.5V) and 0V (Why?). Calculate the value of the collector resistor.

Assume that the gain of the transistor is 150. What should the base current be? What will be the voltage drop across R_B? Calculate a suitable value for R_B.

Make up the circuit using resistors of the value you have calculated. Connect the power. Measure the output voltage (at the collector), and check that it is correct or reasonably near to the correct value. Test the amplifier by tapping the microphone and listening to the noise from the loudspeaker or earphone. If possible, place the loudspeaker or earphone in another room, connected to the circuit by a long lead. Then you can test the amplifer by speaking into the microphone while a friend in the other room listens to your voice.

Keep the amplifier made up, for the next investigation.

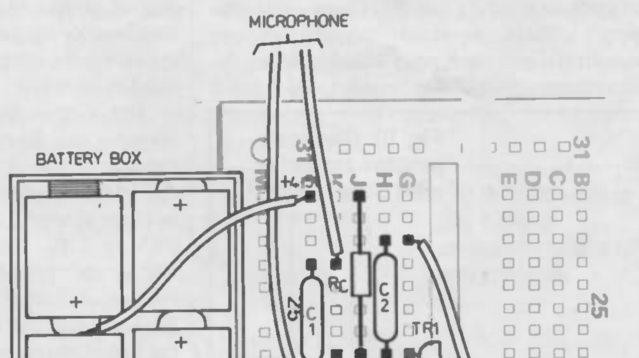


Fig 12. Breadboard layout for Investigation 2.

Investigation 3 - a two-stage amplifier

You need: the amplifier made in Investigation 2
components to make a second amplifier of the same kind

Fig.13 shows the two amplifiers coupled together by a capacitor. Assemble the second amplifier and join it to the first amplifier. Test the complete two-stage amplifier as before. How does its performance compare with the single-transistor amplifier? Place the loudspeaker close to the microphone. What happens next? Hint: see Fig.2.

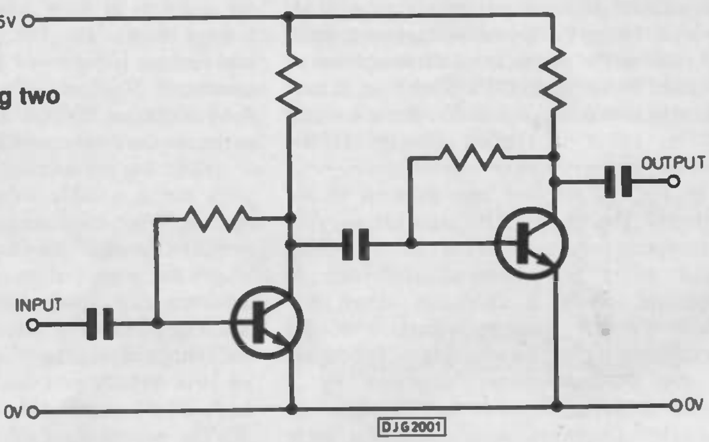


Fig 13. Coupling two amplifiers for Investigation 3.

Investigation 4 - more stabilisation

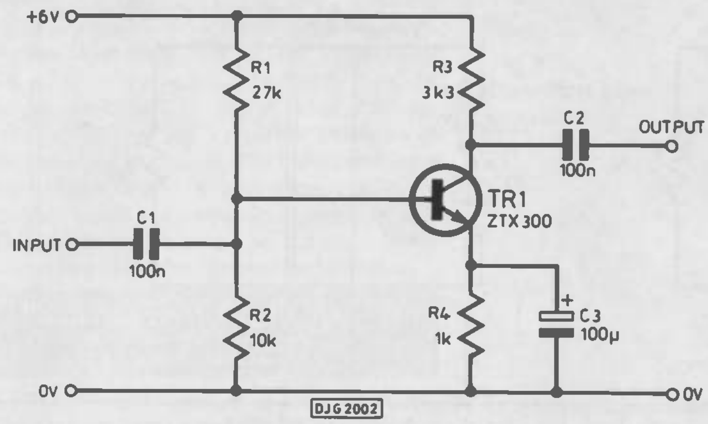
You need: battery box (6V)
R1 27k
R2 10k
R3 3k3
R4 1k
VR1 1k potentiometer
C1, C2 100n (2 off)
C3 100µ 16V electrolytic

Set up the amplifier of Fig.14, as in Fig.15, but, for the present, omit C3. Test the amplifier, either by tapping the microphone or by speaking. Can you hear anything? Now add C3 to the circuit. What effect does this have on the volume?

Now add the capacitor C3 to the circuit. What effect does this have on the volume?

Finally, replace R4 with the variable resistor VR1 and connect C3 to its wiper (Fig.16). While speaking at constant volume (or tapping the microphone evenly) observe the effect of varying the setting of VR1.

Discussion of this investigation follows below.



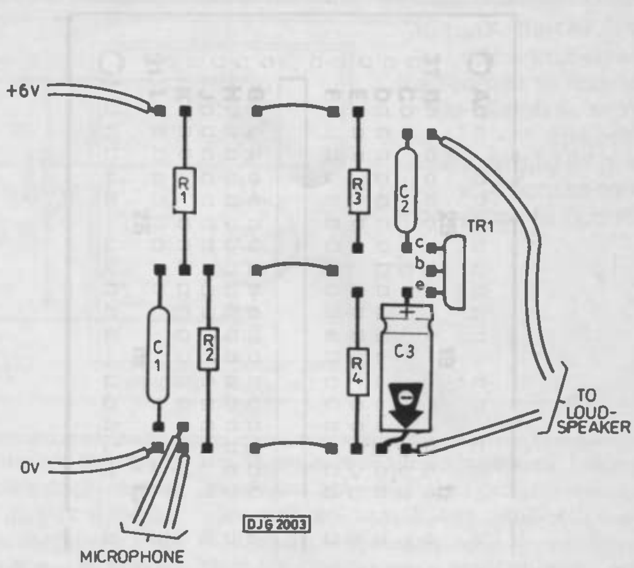
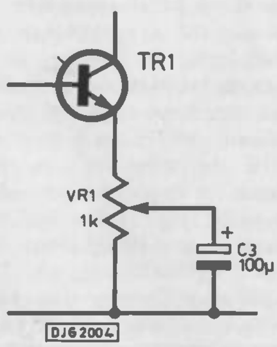


Fig 14. Circuit for Investigation 4, and its breadboard layout (Fig 15).
Fig 16. (Below). Modifying Fig 14.



IMPROVING STABILISATION

The amplifier studied in Investigation 4 illustrates another technique for producing stability. The base current is provided by a potential divider (R1 and R2). This fixes the base potential at almost exactly 1.6V. The forward voltage drop across the base-emitter junction is 0.6V, as usual, so the emitter potential must be 1.6 - 0.6 = 1V. The emitter resistor R4 has a resistance of 1k, so the current flowing through it must be 1/1000 = 1mA. Since emitter and collector currents are always virtually equal, the collector current must be 1mA too. This is the current for which we have been aiming in the amplifiers described earlier. The difference is that we have been able to fix this collector current *without any mention of transistor gain*.

In this circuit, the 'no signal' collector current is 1mA whatever transistor is used. For the same reason, changes of temperature have no effect either. All we now have to do is to calculate the value for the collector resistor that will put the 'no signal' output level at half the supply voltage.

R - V/I - 3/0.001 = 3k

A 3k resistor is best, though 3k3 will do.

The other feature of this amplifier is the large-value capacitor C3. Let us see what happens in the circuit if this capacitor is not there. If the input signal swings positive, I_B increases. This makes I_C and I_E increase. If I_E increases, the voltage across R4 increases. The emitter potential increases, *reducing* the base-emitter voltage and thus tends to *cancel out* the effect of the positive increase in the input signal. We have large negative feedback. Its effect could be strong enough to cancel out the input signal altogether. In that event there would be no output signal. This effect is apparent in Investigation 4. Without C3 in the circuit the output volume is dramatically reduced.

Now put C3 back into the circuit.

As we have already seen, a capacitor passes high-frequency signals (which in this case includes all frequencies in the audio range). Thus the would-be audio-frequency variations in voltage across R4 are passed through C3 to the 0V line. We say that C3 is a *by-pass* capacitor. The result is that the voltage across R4 remains steady and there is no feedback. Of course, C3 has no effect on voltage variations across the collector capacitor so the output of the amplifier is at full volume. This may be a good thing but, if the amplitude of the input signal is already fairly high, the output signal may try to swing higher than the supply voltage or lower than 0V. It can not actually swing outside this range so the effect is to clip the output waveform as shown in Fig.3d. Such distortion is avoided by reducing the gain, as described in the next paragraph.

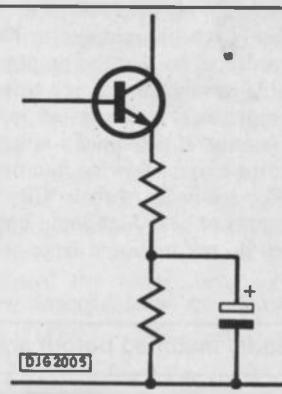
Feedback gives good stability but reduces output volume. We need to be able to adjust the amount of feedback by feeding back only a part of the voltage variations across R3. This is done by modifying the circuit as in Fig.16. The voltage variations across the 'lower' part of VR1 are bypassed, but those across the 'upper' part are not. We vary the amount of feedback by setting VR1. At the same time as we are adjusting the stability of the amplifier we are also using VR1 to adjust the gain. We can set the gain at any desired level, as long as it is less than the gain of the transistor. This means that we can set gain to be as high as possible without introducing distortion such as clipping. When we have decided what the gain is to be we can replace VR1 with two fixed resistors, as in Fig.17.

The overall gain of the amplifier is reduced by this arrangement but is has the advantages that:

* gain is fixed at a level we choose
* gain does not depend on the gain of individual transistor
* gain is independent of temperature
* gain is the same for all frequencies, so reducing distortion

The amplifier is much improved at the loss of some of its gain. But we can compensate for this loss by coupling several amplifiers together.

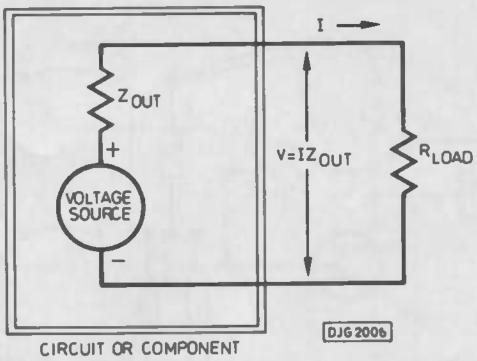
Fig 17. Fixing gain in the circuit of Fig 14.

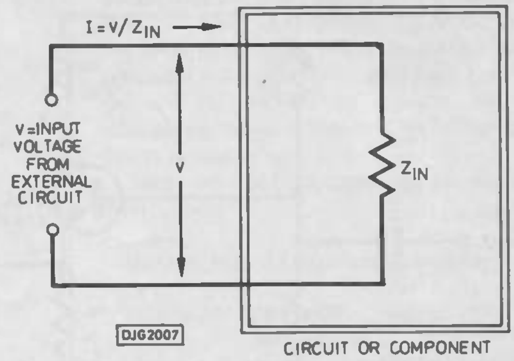


IMPEDANCE

Impedance is the extent to which a circuit or part of a circuit opposes the flow of a current. Impedance is measured in ohms. It sounds as if impedance is similar to resistance - so what is the difference? Resistance is *part* of impedance, but there are other factors that affect impedance. If a circuit contains a capacitor, the flow of low-frequency currents is opposed. If a circuit contains an inductor, the flow of high-frequency currents is

Fig 18 (left). Output impedance of a circuit or component (circuit details not shown).
Fig 19 (right). Input impedance of a circuit or component.





opposed. Impedance is the sum of the effects due to resistance, capacitance and inductance. Since the latter two depend on frequency, impedance is often frequency-dependent. In many circuits there is no or little effect of capacitance or inductance, in which case impedance is due to the resistance of the circuit only. The symbol for impedance is Z, and it is expressed in ohms.

There are two types of impedance that are particularly important – *output impedance* Z_{OUT} and *input impedance* Z_{IN}. In this discussion 'circuit' can also be taken to mean a single component, such as a microphone, a lamp, a cell or a loudspeaker. The output impedance of a circuit is represented in Fig.18 by a resistor. Somewhere in the circuit is a voltage source. Current has to flow through the impedance resistor (it is shown as a resistor, but might include capacitors and/or inductors as well). If the output impedance is high and the load takes a lot of current, there is an appreciable voltage drop (the equation $V=IZ_{OUT}$ is equivalent to the better-known V=IR) across the impedance. The result is that the voltage appearing at the output of the circuit is much lower than that of the voltage source. Ideally we like circuits to have low output impedance, so that the output voltage is only a little less than the source voltage.

Input impedance is illustrated in Fig.19, also by a resistor. If we apply a voltage V to the circuit, the current flowing into the circuit is $I = V/Z_{IN}$ (compare with I=V/R). Ideally we like circuits to have high input impedance so that they do not require a large current to drive them.

Now let us see what happens when the output of one circuit or device is joined to the input of another circuit or device. Fig.20 shows a medium impedance output connected to a low impedance input. An example of this would be connecting a microphone directly to a loudspeaker. The output impedance of the microphone might be about 600 ohms. The input impedance of the loudspeaker might be 8 ohms. Suppose that the voltage being produced by the microphone at a given instant is 50mV produced by the microphone, only 0.7mV appears across the loudspeaker coil. The remaining 49.3mV is lost, appearing as it does across the output impedance of the microphone itself. No wonder an intercom as simple as this does not work!

You get the same effect if you use a 6V dry battery to power a 6V car headlamp. The dry battery has an appreciable output impedance. The car headlamp has very low input impedance (it requires a lot of current to light it). When the two are connected the voltage at the battery terminals drops markedly. The result is a very dim light. To power a car headlight we need a battery with very low output impedance, such as the lead-acid 'accumulator' cell used in the car.

To make a better connection between a microphone and a loudspeaker we use an amplifier. It is not just that the amplifier increases the voltage swing. Indeed, as we shall see later, some amplifiers have a voltage gain of only 1. The main point is that the input of the amplifier can have *high* impedance. An amplifier input could typically have Z_{IN}=10k (Fig.21). The total resistance of the circuit is now 10600 ohms. The current becomes 0.05/60000 = 4.7μA. The voltage across the amplifier input now becomes V = IZ = 4.7μA x 10600 = 47mV. Only 3mV is lost in the microphone. This is a great improvement. Having successfully transferred the signal to the amplifier, we need next to transfer it to the loudspeaker. If the output impedance of the amplifier is low this transfer can be made successfully.

From the above it is clear that, for audio applications at least, an amplifier should have a high input impedance and a low output impedance. The requirement for low output impedance can be relaxed a little if it is to be followed by a second amplifier with high input impedance, but the general principle remains. The common emitter amplifier fills these requirements fairly well. The input impedance is the resistance due to the biasing resistors and the input resistance of the

Fig 21. Well matched output and input impedance.

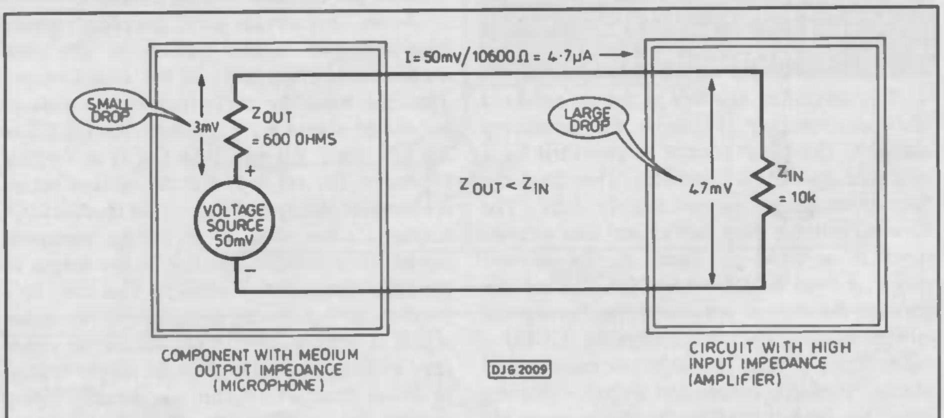
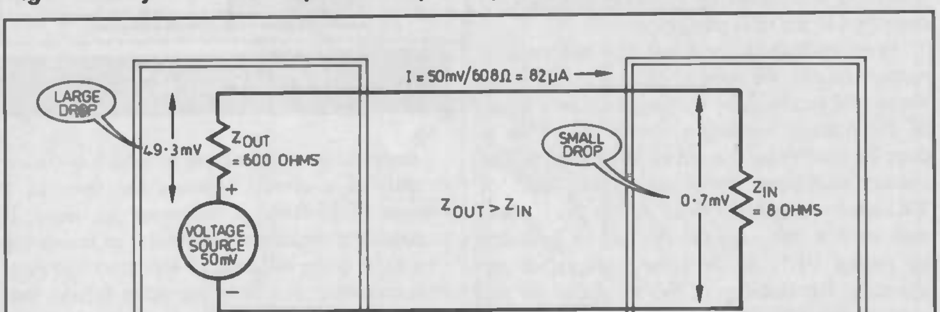


Fig 20. Badly matched output and input impedance.



transistor, all in parallel. The transistor input resistance is high and can be ignored. So the input impedance is high and can be ignored. So the input impedance of the amplifier of Fig.14 is 7k3, which is reasonably high. Its output impedance is the resistance of the collector resistor and the output resistance of the transistor in parallel. The transistor output resistance is almost infinite, so we can ignore it. This leaves the output impedance as 3k3. This is not particularly low, but suitable for connecting to another stage of amplification.

EMITTER FOLLOWER AMPLIFIER

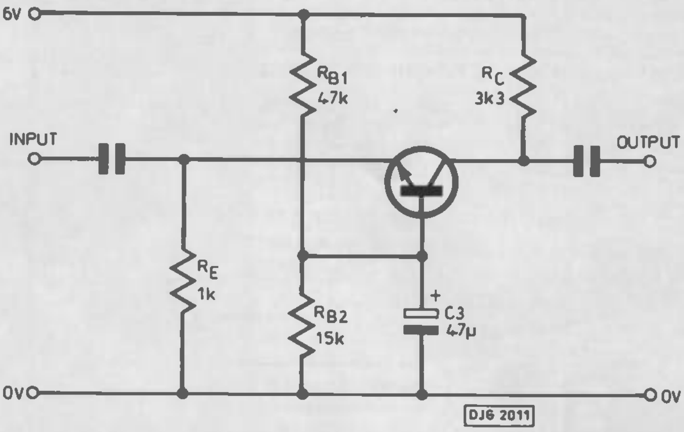
The successful processing of audio signals depends very much on *impedance matching*, that is, ensuring that the signal from one section of the circuit is transferred to the next section without undue loss. An amplifier which is often used in impedance matching is the *emitter follower* amplifier of Fig.22. This is sometimes called a *common collector* amplifier, because input goes to the base, output comes from the emitter and the collector is common to both sides of the circuit. You could set up this amplifier on a breadboard and examine its action.

This is best done by using a variable 10k resistor as in Fig.8, to supply a series of voltages between 0V and 6V direct to the base of the transistor. To measure the corresponding output voltages, connect a voltmeter to the emitter.

As the base voltage varies according to the input signal, the emitter voltage varies by the same amount, except that it is always 0.6V less. Thus this amplifier has a voltage gain of 1. The input impedance is the resistance of the transistor in parallel with the bias resistor. The resistance of the transistor is h_{fe} x R_E. Assuming h_{fe} = 150, then the input resistance of the transistor is 150 x 3000 = 450k. In parallel with 430k of the bias resistor, the input impedance is 220k. This is a very high input impedance. If the amplifier output is connected to another circuit the input impedance of this circuit must be taken in parallel with R_E, in the equation above. This results in a lower input impedance for the combined circuits. The reduction in impedance is not significant if the input of the following circuit is reasonably high.

The output impedance is R_B/h_{fe}. In using this equation we do not take R_B on its own, but take the resistance of R_B in parallel to the circuit connected on the input side. If, for example, this amplifier is being fed from the amplifier of Fig.14, with output impedance 3k3, we have 3k3 in parallel with 430k, giving approximately 3k9. If gain is 150 then Z_{OUT} for the combined circuit is 3k3/150 = 22 ohms. Thus the emitter follower amplifier has very high input impedance and very low output impedance, which is why it is used so frequently for impedance matching.

Fig 23. Common base amplifier.



COMMON-BASE CONNECTION

This is the third of the three ways of connecting a transistor (Fig.23). In this example, there are two biasing resistors (R_{B1} and R_{B2}) working in the same way as in Fig.14. A bypass capacitor C3 holds the base potential steady. The signal is applied to the emitter and the output is taken from the collector. A common-base amplifier has a *low* input impedance and its output impedance can be low too. It is no use for impedance matching but important applications, one of which will be described next month. In the meantime, try breadboarding this amplifier and testing it. This is best done by using a variable 10k resistor as in Fig.8, to supply a series of voltages between 0V and 6V direct to the emitter of the transistor. To measure the corresponding output voltages, connect a voltmeter to the collector.

MODULE OF THE MONTH

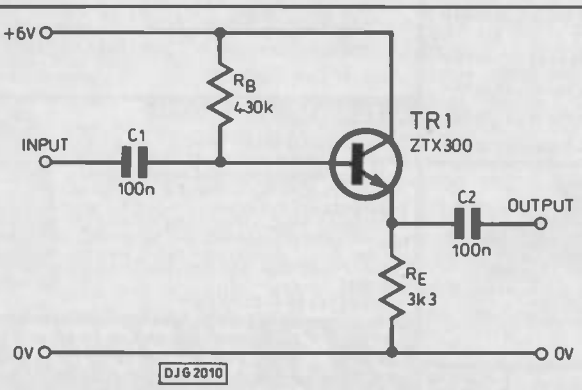
10 Transistor amplifier

This is the amplifier shown in Fig.14, with a variable resistor, as in Fig.16, to allow gain to be varied. You may wish to make two modules of this sort to give increased amplification, though connecting it to the emitter-follower loudspeaker module (Module 11) is usually adequate.

Input (eg Module 12) is connected between terminal 'I' and the 0V rail. Output comes from 'O'. (*Modules 11 and 12 will be shown next month. Ed.*)

Parts required: R1 27k; R2 10k; R3 3k3; R4 1k; C1, C2 100n (2 off) polyester; C3 100u electrolytic; TR1 ZTX300; SKT1 3-way PC socket; SKT2 2-way PC socket; stripboard 63mm x 25mm (Vero 15354).

Fig 22. Emitter follower amplifier.



DISCUSSION

Investigation 1: V_{OUT} is high (6V) until V_{IN} becomes 0.6V or more. This is because the in-built cell has not been overcome. From 0.6V upward the transistor begins to conduct. Collector current gradually increases and V_{OUT} falls, reaching zero when V_{IN} is a little over 0.7V. In the second run the fall of V_{OUT} is more clearly shown. With one transistor we tested the voltage gain *of the amplifier* was about 40. Yours could be considerably less or more than this, depending on the gain of the transistor you are using.

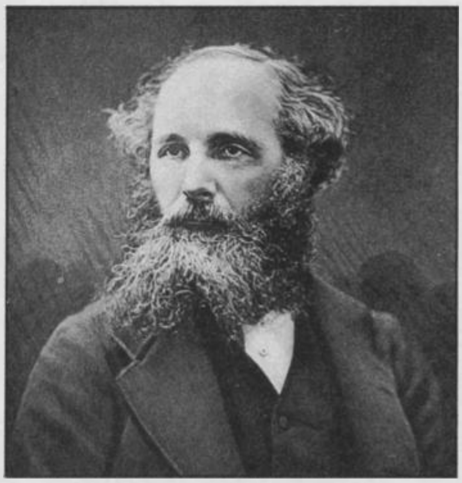
Investigation 2: This allows the output voltage to swing as far as possible up and down without clipping. R_C = V/I = 2.25/0.001 = 2250 ohms. A standard 2200 ohm resistor will do very well. If the gain is 150 the bias current is I_C/150 = 1/150 = 0.0067mA. The voltage drop across the bias resistor is 2.25-0.6 = 1.65 volts. R_B = V/I = 1.65/0.0000067 = 246k. A resistor of 220k is suitable.

Investigation 3: Amplification is more than that of the single-stage amplifier of Investigation 2. If the loudspeaker is close to the microphone, you get positive feedback, as in Fig.2. Whistling sounds come from the loudspeaker. Do not be surprised if you hear music or voices issuing from the earpiece or loudspeaker! If you live close to a powerful transmitter (as we do), radio signals are picked up on the wires of this circuit, and their audio content is greatly amplified. You may hear several stations at once.

Investigation 4: Adding C3 restores the amplification. By varying VR1 you vary the amplification. PE

JAMES CLERK MAXWELL

Ian Poole looks at a great man remembered for his equations.



Maxwell was probably the greatest scientist of the 19th Century. Yet his name is not as well known as people like Ohm, Volta, and Ampere, and less is commonly known about him than some of the people who hit the headlines like Alexander Graham Bell and Edison. But Maxwell's work and discoveries have undoubtedly had more impact on the whole field of science than any of these people. It was Maxwell who proved mathematically the presence of electromagnetic radiation, and his equations were used as the basis of research into wireless as well as being used as the foundation for many of today's advanced theories. Apart from his equations about field theory, Maxwell applied himself to a wide variety of topics during his career and he made significant contributions to these subjects as well.

CHILDHOOD

James Clerk Maxwell was born on June 13th 1831 in Edinburgh. He was an only child born late in life to his parents who were delighted at the birth of their son.

The family were well off as his father was a lawyer. Shortly after Maxwell's birth the family inherited a large estate at Glenlair. As a result the family moved there and Maxwell's father changed the family name from Clerk to Maxwell.

At Glenlair Maxwell lived a happy life, but this was not to last for long because his mother died when he was just eight years old. This brought about many changes in the life of the young Maxwell. His father decided that the best way for his son to be educated was to employ a tutor. Unfortunately, this was not a success as the man they employed did not live up to their expectations, and Maxwell soon became backwards in his learning.

EDUCATION

Seeing the poor performance of his son, his father decided to send the young boy to Edinburgh Academy. This was most certainly the turning point in Maxwell's education. Here he blossomed. His teachers noted that he had a very inquiring mind, very good reasoning powers and a tremendous memory. As a result he soon became one of the best students at the Academy, and proved the fact by publishing a paper on geometry when he was just 14 years old.

Maxwell continued his rapid progress, and entered Edinburgh University in 1847 when he was only 16 years old. Here he published two further papers whilst continuing his studies, which were mainly directed towards science and mathematics.

From Edinburgh Maxwell moved to Cambridge in 1850. Here his full potential soon began to be realised. His tutors recognised that he was a student of exceptional quality having a natural flair for any subject related to science. In addition to this he was stimulated by meeting with other students, some of whom were to make their marks in scientific history.

Maxwell's studies continued so well that in 1854 he was offered a fellowship at Trinity College. However, he was unable to accept this. His father, to whom he had grown very close after the death of his mother, was ill and his health was deteriorating. Maxwell returned to Scotland and was able to be near to his father. It was not long, though, before his father died. Maxwell was devastated at the loss of his only remaining parent and remained in Scotland rather than return to Cambridge. It was here that he took up his first academic post when he became the professor of physics at Marischal College in Aberdeen.

A MOVE

In 1860, the two colleges in Aberdeen were merged to form the new Aberdeen University. In this reorganisation several people lost their jobs, and Maxwell found that he was one of them. He then applied for another post within the University but was turned down. So it was that Maxwell had to look further afield and he was soon offered a job at Kings College London as the professor of natural sciences.

From here Maxwell never looked back. He threw himself into his work and as a result he started to make a speedy progress. He published several papers on his work into electromagnetic wave theory, each one developing the theory a little further. These papers were also the first publications to contain his world-famous equations.

Another advantage of life in London was that he was more able to meet with other leading scientists of the time. In fact he often met with Faraday, and this obviously helped him in his research.

However, Maxwell did not content himself with just one area of research. He also spent a considerable amount of time looking into subjects as varied as the viscosity of gasses and the velocity of light.

Even though Maxwell was making tremendous progress in his research, the call of his native Scotland began to grow stronger and in 1865 he returned to live on the family estate at Glenlair in semi-retirement. Despite this he still kept in touch with the academic world and the latest scientific developments. He also became an external examiner for Cambridge University and he made frequent trips to London.

He also kept up his research into electromagnetic theory, developing it and refining it further. This work took him many years to complete. But, before he completed it, he was tempted back to England by the offer of the directorship of the Cavendish Laboratory in Cambridge. He started there in 1871 and in this position Maxwell had to design a new laboratory and set up a new department.

MAJOR CONTRIBUTIONS

Whilst he was doing all of this, Maxwell still continued his work on electromagnetic theory. It was published in 1873 under the title "*A Treatise on Electricity and Magnetism*". This work summed up the bulk of Maxwell's work on the subject and it was so successful that it was used as a standard work for many years afterwards.

Sadly, in the spring of 1879, he became ill. His doctors were unable to treat his condition and in the June of that year he returned to Scotland. There he died on November 5th 1879 at the age of 48. His burial was quiet, being attended by his family and a few friends.

Had Maxwell lived for longer his work may well have brought new revelations. As it was, many new discoveries he might have made had to wait for many years for some other talented research scientist to reveal. Even so he had made many major contributions to many areas of research. Apart from electromagnetic theory, he had undertaken a significant amount of research into topics as varied as the kinetic theory of gasses and colour photography. He even presented a paper on the structure of Saturn's rings which even in the light today's knowledge proved to be remarkably accurate.

During his life Maxwell received few honours. But today his life and work is remembered by the fact that his name has been given to the unit of magnetic flux. PE

Photograph by courtesy of The Institution of Electrical Engineers

SPACE WATCH

BY DR PATRICK MOORE CBE

Although a Dutchman has directly examined spacial objects in close-up at home, sophisticated orbiting equipment is usually considered more appropriate.

There is no reliable report that anyone has ever been killed by a falling meteorite, but on April 6 a half-kilogram meteorite fell through the roof of a house in Glanerbrug, Holland - luckily when the owners were out. Apparently it was a chondrite, and is assumed to be part of a larger object which broke up during its headlong descent through the atmosphere.

There is sad news about the Japanese lunar satellite Hagomoro. Its transmitter has failed, and all contact with it has been lost. However, Hagomoro has at least shown that the Japanese are now capable of sending probes to the Moon.

As we all know, the Hubble Space Telescope has been successfully launched. There have been some minor problems, but these seem to be being solved, and the first results are most encouraging. It now seems that unless any unforeseen hitch occurs, the HST will do all that its makers have hoped of it.

CLOSER QUASARS?

For some time now a few astronomers, notably Dr. Halton Arp (formerly of Mount Wilson, now working in Munich) have been claiming that our distance-measures beyond the Galaxy are wrong, and that quasars, usually assumed to be very remote and super-luminous, may be fairly local to our Galaxy. Arp's latest results indicate that the most famous of all quasars, 3C-273, is aligned with a cloud of neutral hydrogen in the Virgo cluster of galaxies, 'only' about 60,000,000 light-years away; in Arp's view, 3C-273 is an actual member of the cluster. Not many astronomers agree with him - but if he is right, then we are due for a revolution in thought which will be almost as great as that of almost seventy years ago, when Edwin Hubble first showed that the galaxies are outer systems rather than mere members of the Milky Way.

ROSAT

The latest scientific satellite, Rosat, is one of the most important for many years. It is a German vehicle, but there is strong British participation, as we have been responsible for Rosat's Wide Field Camera, developed by the Leicester team led by Professor Ken Pounds in collaboration with the University of Birmingham.

Rosat is designed to study radiations in the X-ray and EUV (Extreme Ulta-violet) part of the electromagnetic spectrum - that is to say, between 6 and 200 Angstroms. This is one of the regions which needs careful study, all of which has to be carried out from above the atmosphere; the EUV region, in particular, is imperfectly known. The British camera is an instrument which views an area five degrees in diameter, and will image each source within the field of view with an accuracy of one minute of arc. It is hoped that it will discover several thousand new EUV sources. Identifications will be carried out by comparing the positions of the sources with images of the sky taken by Schmidt

THE JULY SKY

Midsummer has passed by, though the Earth is at aphelion - its greatest distance from the Sun - early this month; the date of aphelion is July 4, when the distance from the Sun will be 152,000,000 kilometres. Remember that the Earth's path is not very different from a circle; those of some of the other planets, notably Pluto, Mars and Mercury, are more eccentric.

Of the planets, Mercury and Jupiter are out of view this month. Venus is a brilliant morning object, but is low down; look for it in the east before sunrise. Mars is also a morning object, but is not yet really well placed, though it reaches zero magnitude by the end of July; its apparent diameter is still below 9 seconds of arc, so that a large telescope is needed to show much on its disk. This leaves us with Saturn, which comes to opposition on July 14. Its ring system is still wide open, and in any telescope the planet is a glorious sight; look too for its large satellite Titan, which will, we hope, be encountered by the Cassini probe in the year 2002. Unfortunately Saturn, in Sagittarius, is very low down as seen from British latitudes, and for some years hence it will be best observed from the southern hemispheres.

Neptune, the outermost planet, also comes to opposition this month, on the 5th. Like Saturn, it is low down in Sagittarius; but unlike Saturn, it is much too faint to be seen with the naked eye, though binoculars will show it as a dot of light. Neptune was by-passed by the Voyager 2 probe in August 1989, and shown to be a dynamic, beautifully blue world, with a great dark spot and violent winds. We are not likely to have any new information from close range for many years; no more probes to Uranus or Neptune are planned as yet. However, it may be that the newly-launched Hubble Space Telescope will be able to show the main details on the planet's surface.

The Moon is full on July 8, at last quarter on the 15th, new on the 22nd and at first quarter on the 29th. There are no major meteor showers until the start of the Perseids, at the very end of the month.

The Summer Triangle of Vega, Deneb and Altair continues to dominate the starry scene, with the Great Bear in the north-west and Cassiopeia in the north-east; the brilliant orange Arcturus is still above the western horizon until very late in the evening, while the Square of Pegasus is starting to come into view in the east. This is the best time of the year for seeing the magnificent star-clouds in Sagittarius (the Archer) which hide our view of that mysterious region, the centre of the Galaxy. Sagittarius itself has no definite form (some people nickname it 'the Teapot') but this year it is made easy to identify because of the presence of Saturn. Sweeping round the star-clouds with binoculars is a rewarding pastime; you will see many rich star-fields, together with clusters and gaseous nebulae.

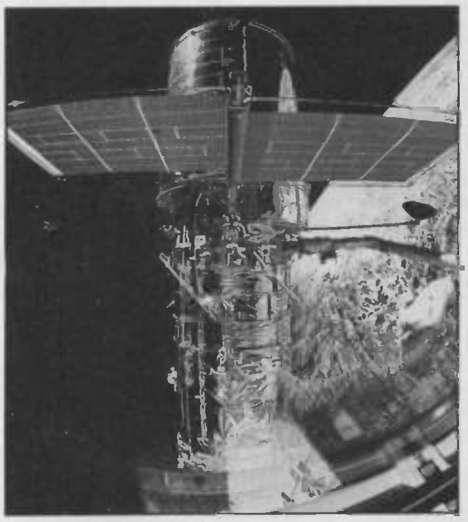
This Month's Solar Eclipse

On July 22 there will be a total eclipse of the Sun. Sadly, the track misses Britain; but this is one of the more accessible totalities, because the central track crosses Finland. Various expeditions are going there, though it is true that the Sun will be low down and the weather prospects are not really encouraging. The track, beginning in Finland, crosses along Northern Asia and ends in the Pacific Ocean, between Hawaii and the North American mainland. The eclipse begins at 00.40 GMT and ends at 05.24 GMT; the maximum duration of totality is 2 minutes 33 seconds. A total solar eclipse is without doubt the grandest sight in nature; let us hope that the Finnish parties will be untroubled by cloud!

telescopes in America and Australia. X-ray sources, too, will be identified. The positions, shapes, colours and brightness of stars and other objects lying near identified Rosar sources will provide the vital clues.

Rosat is an ambitious vehicle. It should remain operational for some time, and it ought to provide important new data.

Two of NASA's beautiful photos of the Hubble Space Telescope in orbit. The solar array panels are seen in different states of deployment. In the right hand photo the HST is backdropped by Cuba and the Bahama Islands. A large format Aerolinhof camera captured the scenes. PE



HOME-BASE

Ian Burley reveals that Sony are busy hammering nails into book coffins. Intel's DVI chip set could add another dimension to the interactive CD scene, while Mercury finds a voice for fax systems.

It's the in-thing to condemn any useful long term future for books in their present, paper based, form thanks to the advancement of digital technology. Sony added another nail to the coffin of the book with its announcement of the DD-1 Data Discman hand held cd rom player in Japan.

Portable cd rom players are already nothing new now, but these have so far simply been compact portable units for use in conjunction with PC installations. They're also restricted to standard five inch cd roms.

Sony has come up with a compact cd rom unit with an lcd text display capable of reading three inch cd rom discs. In the words of Sony's press statement: "the Data Discman is the answer for computer users who have felt confined to a desk or the use of a laptop for information." That's the first time I've heard a laptop computer being criticised for confining its user!

The DD-1 is about 7 by 4 inches in dimension - post card size, and weighs 550 grams without a battery. The monochrome screen can display 15 characters in 10 lines or display graphics in up to 256 by 200 pixels. The keyboard sits on the top cover of the disc loading mechanism. A bonus feature is that you can play standard three-inch music cds on the DD-1 and headphones are supplied. You will also be able to get a video adapter.

It's expected that DD-1 users will buy discs which feature travel guides, textbook information, dictionaries, instruction manuals, etc. Sony has already lined up 18 cd rom 'books' from 14 publishers, but these are all for the Japanese market and Sony has made it clear that we won't see the DD-1 outside of Japan until a Western publishing base has been set up. Currently the three inch cd is in common use for music publishing but cd rom's are all five inch discs so far. One three inch disc is supplied with the DD-1 and this contains a Japanese/English and English/Japanese translation dictionary and a conventional word dictionary in Japanese.

The Data Discman DD-1 will cost Y58,000 when it goes on sale in Japan at the beginning of July, that's about £250. Perhaps the humble book is not doomed just yet...

DVI A THREAT?

Last month we looked at Philips' cd-i digital interactive video cd rom system. Philips has always intended that cd-i should eventually form the basis for a multimedia system affordable enough for the home. This has proved difficult, especially as Philips decided to go for full-screen motion video after the original specifications had been laid down four years ago.

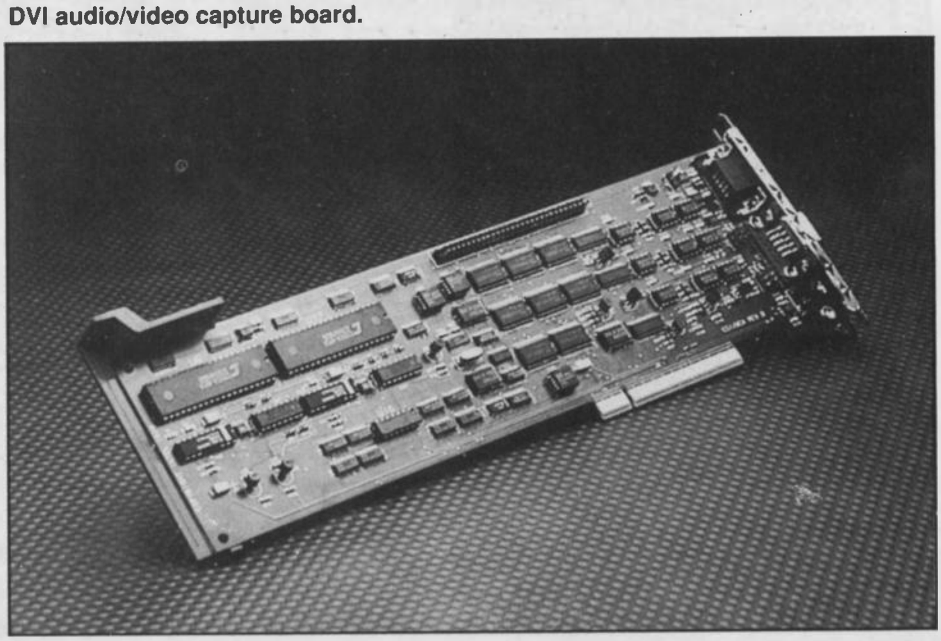
Another cd rom based interactive video system which has been developed inparallel with cd-i is dvi developed originally by a division of General Electric. In 1988, Intel took over the project and there is some support from IBM - big guns indeed. So far dvi has only been pushed in the professional market for animated presentations and interactive training or large scale information retrieval.

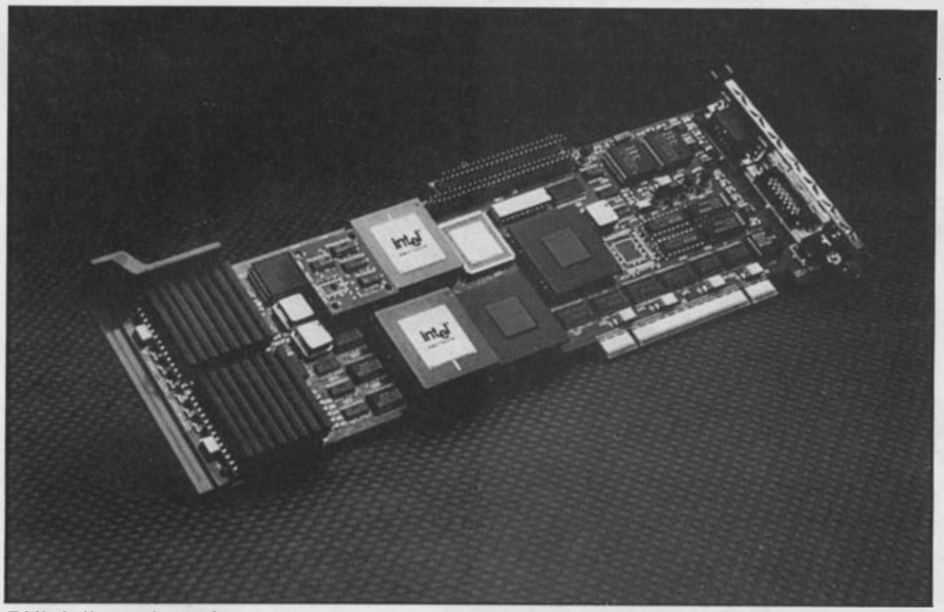
Dvi's specifications are very similar to cd-i. Like cd-i, dvi is read-compatible with 'lower' levels of cd, though dvi also encompasses other forms of data storage like hard discs. Both standards use hardware compression to fit over 72 minutes of motion video on a five inch cd rom and both enable 30-40 hours of medium quality audio to be recorded on a disc. Unfortunately neither of the systems are compatible.

While Philips is working hard to reduce hardware costs in order to produce a multi-format consumer cd-i machine, Intel has concentrated on producing add-in cards for personal computers. While this appears to rule out the consumer, professional applications using dvi have been used in experiments involving consumer use. One example is the delivery of interactive video across a domestic cable network. For example, you might find yourself using cable tv to select your next house through an interactive service based around dvi.

There is also speculation that IBM could take the Intel dvi chip set and incorporate it into a PC motherboard. This could revolutionise both home and business computer sound and graphics standards. Currently the chips cost too much for these

DVI audio/video capture board.





DVI delivery board.

applications, but economies of scale could solve that problem if there was enough incentive.

What is clear is that in a few years from now, personal computers, digital audio and video and interactive media control will finally merge into one super information technology machine which will, hopefully, be affordable to all. The only question is, whose standard will be the winner?

TALKING FAX

With more and more people working from home, the fax machine has steadily gained acceptance as a domestic appliance - especially in the USA.

Perhaps with this fact partially in mind, Mercury Communications has developed an information retrieval system which uses the fax format to deliver reasonably high quality printed text and graphics. The idea is that you use a touch-tone telephone to dial up Mercury's Faxess service and use those numeric touch-tones to communicate with an information database and select voice-prompted information categories. Once a category has been selected you dial in your fax telephone number and a few minutes later pages of information including graphics are delivered to your fax.

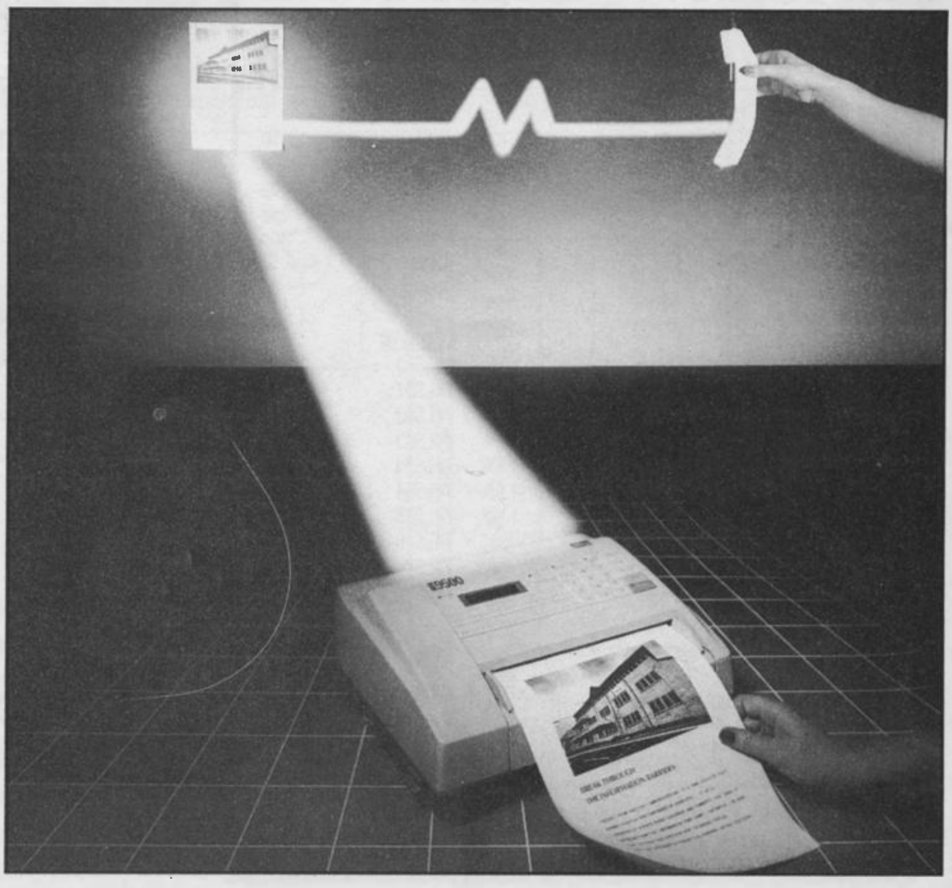
The 200 dots per inch graphics are computer generated specifically to match the fax image format precisely so there are no nasty 'saw-tooth' jagged line effects on graphics or scanning distortions - as long as the phone line isn't noisy. The resulting pages look as though they've come straight out of a medium resolution desktop publishing system. Clarity is really very good.

Faxess is intended to be the platform for subscriber orientated services. One of the advantages for an information provider built into the system is automatic market research data logging. Which pages you download and how frequently, etc. will be logged for later evaluation.

One possible application of Faxess could be as a link into a service like Autoroute, the route planning database for car drivers. Imagine a detailed and personalised map being produced for your journey via a fax machine. Indeed you might even have that fax machine in your car!

The only question mark over Faxess is who will be the information providers on the system? So far even Mercury is unable to answer that question. As a technology exercise, Faxess is impressive, but as commercial operation, we'll have to wait and see.

Faxess system from Mercury.



SUMMER CES PREVIEW

It seems just like a few short months ago that the Winter Consumer Electronics Show at Las Vegas took place. The twice yearly event moves to Chicago for its summer outing in June and we'll be there to dig out all the interesting consumer electronics innovations once again.

From the gossip which has been flying around we can expect a major announcement from Commodore regarding a cd rom multimedia machine based around the Commodore Amiga home computer chip set. Those who claim to have seen it appear very excited about the new Commodore.

The last show disappointed for its lack of high definition television exhibits. My information is that the Japanese are going to rectify that omission this time around and you can expect some news from Thomson of France with its rival hdtv system. Another interesting tv related development is in the area of local short range broadcasting. Several of these systems which enable the pictures from, say a pre-recorded video or live video camera to be transmitted to any ordinary tv set within around 100 feet, are in the process of getting FCC electrical standards approval. We will also expect to have some news about the development of a suite of home automation standards in the USA, plus the latest news on the arrival of consumer digital audio tape.

Next month's CES report in *Home Base* is going to be big, so don't miss it.

PE

VOLTAGE PROBE

Here's a simple item of workshop test gear from Stephen Bailey: a probe for analogue which also understands logic.

This analogue probe was designed to be used on low frequency signals in logic circuits but is better suited to analogue circuits. The circuit is based around the LM3914 bargraph driver chip to display the input voltage on 11 leds. The 0V comparison is done with a separate LM311 comparator.

The probe has three ranges, 0-5V, 0-10V and 0-20V and can therefore be used on ttl or cmos circuits. The circuit gets its power from the circuit under test and draws about 40mA which although high isn't normally a problem. If the circuit under test cannot supply the power needed the probe can be powered from any convenient supply with the 0V lines linked together.

SPECIFICATION

Supply voltage	5-40Vdc 4-28Vac supply is unpolarised so there is no need to check which power rail is +ve
Supply current	40mA
Input range	0-5V, 0-10V, 0-20V switchable
Input protection	+100V
Input current	1mA max.
Freq response	28kHz for full scale deflection 200kHz max visible (3 leds lit)
Supply protection	100mA fuse fitted in external fuse holder Overvoltage crow bar circuit limits input voltage to 47V dc/33V ac approx.

HOW IT WORKS

Power is obtained from the circuit under test via fuse 1, which protects against supply overvoltage as well as faults in the probe. Rectifier 1 is included to prevent accidentally reversing the power leads, and it also allows the probe to be powered from an ac source, with C1 smoothing the output.

An overvoltage crowbar circuit is formed from D12, D14, R5 and R8. If the input voltage exceeds the breakdown voltage of D12 it conducts turning on the scr TR2, shorting out the supply and blowing the fuse to prevent damage to the probe. *(Readers are cautioned that this technique should not be used if the power supply is not short-circuit protected. Ed.)* TR1, R1 and D13 form an emitter follower to supply a maximum of 22V to the circuit.

The input signal from the probe is fed through R10 which limits the input current. S1 then divides the signal with resistors R11, R12, R13 and R6. These produce an fsd of 5V, 10V or 20V depending on the setting of S1. R10 has little effect on the divider chain. The resistors are not as expected in theory (R11 ought to be 300k to halve the signal) but these values are necessary in practise to make the readings correct.

IC1 is a bargraph driver chip, LM3914. This chip buffers the input on pin 5 and feeds the signal to 10 internal comparators which compare the signal with the voltage on a resistor divider chain. The reference voltage for the divider chain is provided by an internal voltage regulator. The output voltage of the regulator is set by the ratio of R4 and R7. R4 also controls the internal current sources for the led drive transistors. The output of the comparators turn on transistor switches which light the appropriate leds. Pin 9 is the mode control pin. If pin 9 is left open circuit the chip is in dot mode (only one led lit at a time). If pin 9 is connected to +ve the chip operates in bar mode (all leds below the input voltage are lit). The LM3914 doesn't compare the input signal with 0V so IC2 is used. The input signal is fed to pin 2 and compared with the voltage on pin 3, which is about 0.4V. The output transistor switches when the input voltage is below 0.4V and lights led D1.

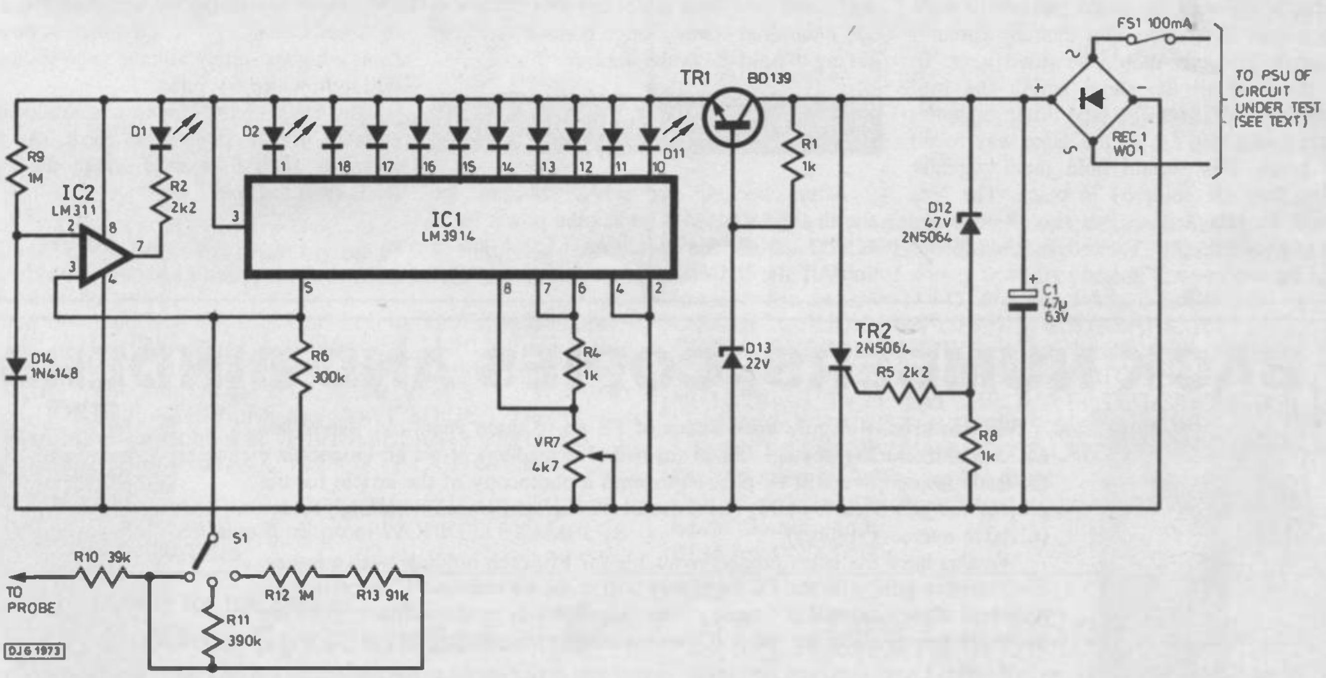


Fig 1. Circuit diagram for the voltage probe.

COMPONENTS

RESISTORS

R1, R4, R8	1k (3 off)
R2, R5	2k2 (2 off)
R6	300k
R9, R12	1M (2 off)
R10	39k
R11	390k
R13	91k
VR7	4k7 horiz preset

CAPACITOR

C1	47µ 63V mini elect.

SEMICONDUCTORS

D1-D11	Green leds (11 off)
D12	BZX61C47V zener
D13	BZX61C22V zener
D14	1N4148
TR1	BD139
TR2	2N5064 SCR
IC1	LM3914
IC2	LM311
Rec1	WO1 1A 50V Rectifier Bridge

MISCELLANEOUS

SW1	4pole 3way slide switch
FS1	100mA fuse and holder

4mm socket for probe, 4mm plug for probe, 2 min. croc clips, flex for power leads.

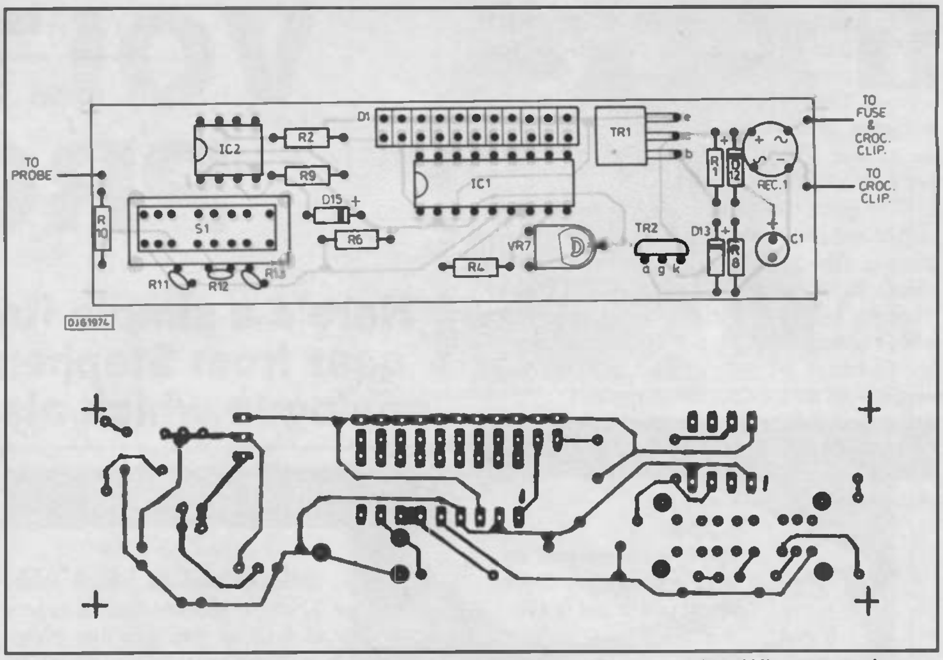


Fig 2. Components and pcb track layouts for the voltage probe. When copying pcb tracks ensure that ic pin spacing is exactly 0.1 inch.

CONSTRUCTION

The small horizontal components should be fitted first, followed by the preset and TR1. The leads of TR1 should be bent through 90° so that it fits with the metal pad on the back uppermost. IC sockets can then be fitted if required. The leds should be fitted next. To get the leds all the same height the best method is to carefully tape them together making sure they are all the same way round and level. This should hold them together whilst they are soldered in place. The leds should be mounted so that the IR tops are 17mm above the pcb. The longer leads should be in the outer row of holes.

The remaining components can now be fitted, leaving R11 to R13 till last as they are a close fit against S1. Make sure the exposed leads are toward the outer edge of the pcb so as not to short on the switch.

The probe can be constructed from a 4mm plug and 1.5 inches of 2mm diameter brass rod from a model shop. One end can be carefully filed to a blunt point, the other end is soldered to the plug. If you can get a small piece of nickel the probe can be simply plated. Connect the nickel strip to the +ve of a 1.5V battery. Connect the probe to the -ve and place both in a small container of vinegar. The circuit is left overnight, the probe is then removed, washed and cleaned with Brasso. The use of a socket to connect the probe allows a lead to be connected between the probe and the circuit under test so a signal can be monitored over long periods without having to hold the probe in place.

TESTING

After checking for solder splashes the circuit can be tested. Connect the power leads to a 5V supply and switch on. LED 1 should light. If the led doesn't light check that the supply components are fitted the right way round and that the fuse is fitted and not blown. If D12 is fitted the wrong way round it will act as a normal diode and conduct, turning on the SCR D14 blowing the fuse. Check that the rectifier is fitted the right way round.

When all is ok connect a lead between the input and +5V. With S1 in the position closest to R10 the last two leds should light. If they don't, adjust R7 until they do. Switch S1 to the center position and check that the middle led lights and, if necessary, adjust R7 slightly until it does. S1 can then be switched to the third position and the third and fourth leds should light. Continue to trim R7 until the leds light as above, the probe is then set up. The top two leds light on the 5V range with a 5V supply due to the voltage drop caused by the rectifier and TR1. If the probe is powered from a higher supply voltage only the last led will light with a 5V input.

The probe circuit can now be mounted in a suitable metal or plastic box. A small grommet should be used where the supply leads enter the box.

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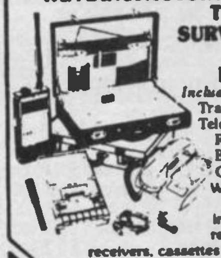

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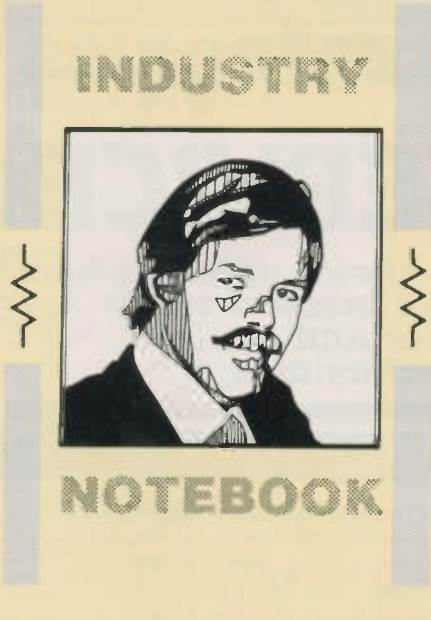
SATELLITED AND LETTER-BOXED

By Tom Ivall

Dense words breed dense minds – let us have space for discussion.



A few days ago I rang up an R&D engineer about some work he had reported in the journal *Electronics Letters*. Because of the nature of this publication the text was so condensed and the diagrams so enigmatic that I was completely baffled about some aspects. A specialist probably would not have been. However, the engineer concerned was extremely helpful and sympathetic in answering my simple-minded questions, so that, as the discussion proceeded, I gradually began to comprehend what had previously been obscure.

Then, suddenly and unexpectedly, he exclaimed "It's so nice to talk to someone who really understands what this work is all about!" Considering I was still emerging from a mental fog, this was an undeserved compliment and not quite true. But the fact was, something had happened through the opening-up in our rambling, digressive and occasionally jokey conversation. I suppose it was true communication, in the sense of sharing or having something in common, rather than just a one-way transmission of information.

Afterwards, I felt that this little experience had confirmed, once again, the great need for 'space' in language. What I mean by 'space' here is that the speech or writing should be of a nature to allow one to question, think around, analyse, expand, illustrate, qualify, criticise, rebut etc. what is being delivered. This is usually possible in friendly discussions. But in bald statements it usually isn't. How often have we worried over a piece of opaque prose in an official or technical document and felt that if only the writer could be present we could ask him or her to clarify and fully explain it!

The *Electronics Letters* report had been condensed to meet publishing requirements; within this constraint it was quite well written. But much that appears in print is badly written. This is often because the person writing is such an authority on his subject that he is allowed to do as he pleases. The publisher or editor is too overawed to question or interfere. (I'm glad this doesn't apply on PE!) But there are many other situations where the density, or lack of critical 'space', is introduced quite deliberately.

It's done by skilled operators or writers to achieve a desired effect. Politicians, evangelists, public relations consultants, advertising copywriters, campaign organisers are all in the business of persuasion. However simple, direct and personal, their messages are usually assertions, rather than propositions open to discussion. Their techniques are something like those in good poetry, where the emotions are stirred by images, sounds and allusions, and semantics are not the main consideration.

Their messages do convey meaning but don't allow the meaning to be developed or explored. The effect is to close off the subject, rather as some religious or political beliefs deal with opposing views which seek to examine them from the outside, by enclosing these opposing views within the universal but unprovable assumptions of the belief. Thus the dissenters are treated as unfortunates who need to be enlightened.

In his book *One Dimensional Man*, the political philosopher Herbert Marcuse describes this process as "the closing of the universe of discourse." He says that this kind of language produces habits of thought in which "the tension between appearance and reality, fact and factor, substance and attribute tend to disappear. The elements of autonomy, discovery, demonstration and critique recede before designation, assertion and imitation. Magical, authoritarian and ritual elements permeate speech and language... The concepts which comprehend the facts and thereby transcend the facts are losing their authentic linguistic representation. Without these mediations, language tends to express and promote the immediate identification of reason and fact, truth and established truth, essence and existence, the thing and its function."

When Marcuse talks about a thing being identified with its function he points to a condensation of thought which you often find in science and technology. For example, the concept of a physical quantity tends to become synonymous with the process of sensing or measuring it. We understand temperature as, say, something we feel, or the height of mercury in a thermometer. Although in reality temperature cannot exist without heat energy, it is a valuable entity in scientific/technological thinking because it has been isolated as a pure concept, a product of the mind alone. Similarly with voltage, current, magnetic field strength and so on. But generally we know what we mean by these concepts through the phenomena that demonstrate them or the operations we use to measure them.

Marcuse is concerned that such identification of thing with function may, through language, distort our discrimination in moral, social and political matters. In the UK, for example, students, parents and sick people are being re-designated as 'customers' - identified with the market function of 'consuming' public services.

You get this kind of identification in technical terminology when nouns are turned into verbs. When I was young 'access' was only a noun, but now the language allows us 'to access' (a memory location, say). I quite like the latest verbs 'to satellite' (transmit via a satellite) and 'to letter-box' (display a wide-screen film on a 4:3 television screen).

They are neat and useful expressions and no more objectionable than those earlier verbs derived from nouns: 'to cart', 'to ship' and 'to telephone'. But we have to be aware of the danger to analytical thought of telescoping the thing and the function into a single word.

It may be that language, as Dr Johnson said, is the dress of thought. My own experience, I must confess, is rather the reverse. I feel more like Alice when she exclaimed "How do I know what I think till I hear what I say?" The words we actually use - and this goes for other symbols as well - have the power to determine our thoughts. So, in responding to words, we have to be on our guard against those cunningly constructed phrases, like slogans or 'word bites', that eliminate the mental 'space' we need for questioning their validity. PE

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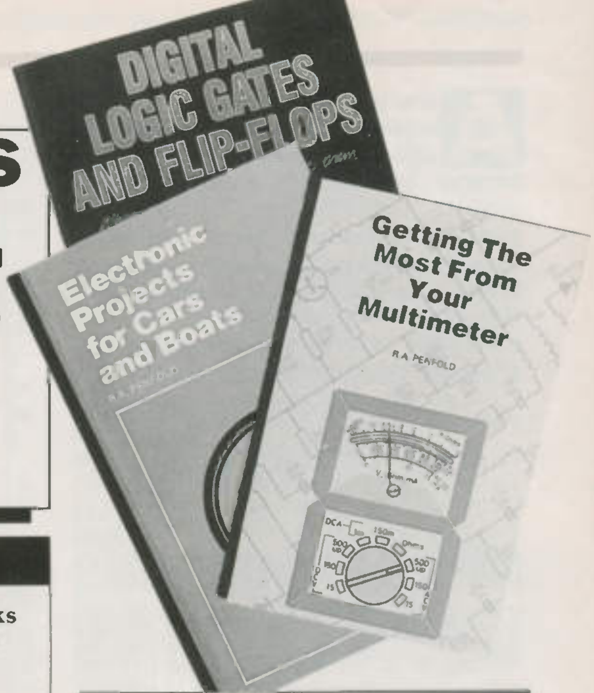

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NEW! Digital Logic Gates and Flip-Flops. Ian R. Sinclair. 192 pages. £8.95. Order Code PC 105
Intelligently looks at the basic building blocks of all digital circuits and is intended for enthusiasts, students and technicians who seek to establish a firm grasp of fundamental principles.

Introduction to 6800/6802 Microprocessor Systems
R.J.Simpson and T.J.Terrell. 238 pages. £10.95. Order Code NT9
The book covers systems hardware, programming concepts and practical experimental work that will assist in understanding the 6800/6802 microprocessor, with additional information on the 6802D5E evaluation system.

An Introduction to 68000 Assembly Language.
R.A. and J.W.Penfold. 112 pages. £2.95. Order Code BP184
Covers the fundamentals of writing programs that will vastly increase the speed of 68000 based machines such as the Commodore Amiga, Atari ST range, Apple Mackintosh, etc.

Getting the Most from Your Printer
J.W.Penfold. 96 pages. £2.95.
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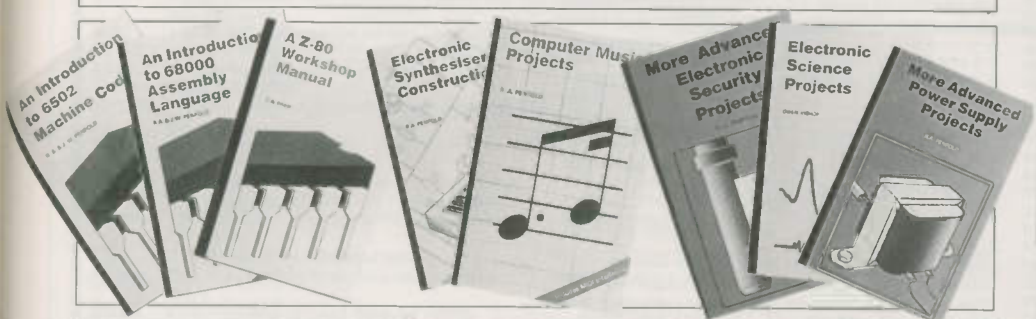
How to use the features found on most dot-matrix printers from programs and popular wordprocessors, showing examples of what must be typed to achieve a given effect.

Micro Interfacing Circuits
R.A.Penfold. Two books, each of 112 pages.
Book 1 : £2.25.Order Code BP130.
Book 2 : £2.75. Order Code BP131
Both books include practical circuits and useful background information though pcb layouts are not included. Book 1 mainly covers computer input-output techniques. Book 2 deals primarily with practical application circuits.

An Introduction to 6502 Machine Code.
R.A. and R.W. Penfold. 112 pages. £2.95. Order Code BP147
Covers the main principles of machine code programming on 6502-based machines such as the Vic-20, Oric-1/Atmos, Electron, BBC and Commodore 64. It assumes no previous knowledge of microprocessors or machine code and gives illustrative programming examples.

A Z-80 Workshop Manual.
E.A.Parr. 192 pages. £3.95.
Order Code BP112
A book for those who already know Basic but wish to explore machine code and assembly language programming on Z80 based computers.

Practical Digital Electronics Handbook
M.Tooley. 208 pages. £6.95.
Order Code PC 104
Nine constructional projects introduce digital circuits, logic gates, timers, microprocessors, memory and interface circuits - an essential book for anyone interested in digital devices.



GENERAL CONSTRUCTIONAL

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Owen Bishop. 144 pages. £2.95. Order Code BP104
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Electronic Security Devices
R.A.Penfold. 112 pages. £2.50. BP56
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R.A.Penfold. 96 pages. £2.95.
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Popular Electronic Circuits.
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DATA AND INFORMATION BOOKS

NEW! Radio and Electronics Engineer's Pocket Book - 18th Edition. Keith Brindley. 325 pages. £9.95. Order Code NT 11
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NEW! Microprocessor Pocket Book. Steve Money. 252 pages. £9.95. Order Code NT 12
Provides a wide selection of information which will be of general use to anyone involved in developing, designing or servicing, or who just wants to learn more about microprocessor systems.

NEW! Computer Engineer's Pocket Book - 2nd Edition. Michael Tooley. 224 pages. £9.95. Order Code NT 13
An invaluable compendium of facts, figures, circuits and data indispensable to designers, students, service engineers and all others interested in computer and microcomputer systems.

Op Amps
B.Dance. £7.95.
Order CodeNT2
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R.A.Penfold. 96 pages. £4.95. Order Code BP233
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Newnes Electronics Pocket Book
I.E.Parr. £9.95.
Order Code NT10
Presents all aspects of modern electronics in a readable and largely non-mathematical style, and is a good source of valuable information for enthusiasts and professional engineers alike.

Key Techniques for Circuit Design
G.C. Loveday. £6.95.
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Tackles the problems of designing circuits from scratch, introducing the concept of target specifications, the design sequence, device selection, rules of thumb, and useful equivalent circuits.

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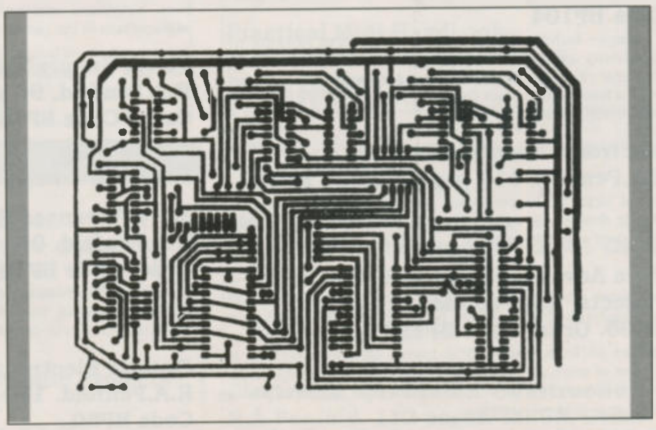

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All packs are £1 each Note the figure on the extreme left of the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

BD2	5	13A spurs provide a fused outlet to a ring main where devices such as a clock must not be switched off.
BD9	2	6V 1A mains transformers upright mounting with fixing clamps.
BD11	1	6.5-in speaker cabinet ideal for extensions, takes our speaker. Ref. BD137.
BD13	12	30 watt reed switches, it's surprising what you can make with these - burglar alarms, secret switches, relay, etc., etc.
BD22	2	25 watt loudspeaker two unit crossovers.
BD30	2	Nicad constant current chargers adapt to charge almost any nicad battery.
BD32	2	Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch.
BD42	5	13A rocker switch three tags so on/off, or change over with centre off.
BD45	1	24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day, original cost £40 each.
BD49	5	Neon valves, with series resistor, these make good night lights.
BD56	1	Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole.
BD67	1	Suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks.
BD103A	1	6V 750mA power supply, nicely cased with mains input and 6V output leads.
BD120	2	Stripper boards, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc.
BD128	10	Very fine drills for pcb boards etc. Normal cost about 80p each.
BD132	2	Plastic boxes approx 3in cube with square hole through top so ideal for interrupted beam switch.
BD134	10	Motors for model aeroplanes, spin to start so needs no switch.
BD139	6	Microphone inserts - magnetic 400 ohm also act as speakers.
BD148	4	Reed relay kits, you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets.
BD149	6	Safety cover for 13A sockets - prevent those inquisitive little fingers getting nasty shocks.
BD180	6	Neon indicators in panel mounting holders with lens.
BD193	6	5 amp 3 pin flush mounting sockets make a low cost disco panel.
BD199	1	Mains solenoid, very powerful, has 1in pull or could push if modified.
BD201	8	Keyboard switches - made for computers but have many other applications.
BD211	1	Electric clock, mains operated, put this in a box and you need never be late.
BD221	5	12V alarms, make a noise about as loud as a car horn. Slightly soiled but OK.
BD252	1	Panostat, controls output of boiling ring from simmer up boil.
BD259	50	Leads with push-on 1/4in tags - a must for hook-ups - mains connections etc.
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.
BD667	2	4.7 uf non-polarised block capacitors, pcb mounting.

There are over 1,000 items in our Bakers Dozen List. If you want a complete copy please request this when ordering.

GEIGER COUNTER KIT Includes tube, PCB and all components to make a 9V counter £34. Ref 39p1

PERSONAL STEREOS Again customer returns but complete and with stereo head phones a bargain at only £3.00 each. Our ref 3P83.

MAINS OPERATED MICROWAVE CONTROL PANEL with Touch switches. This unit has a 4 digit display with a built in clock and 2 relay outputs - one for power and 1 for pulsed power level. Could be used for all sorts of timer control applications. Only £6.00. Our ref 6P18.

EQUIPMENT WALL MOUNT Multiangle for speakers etc. £3 each ref 3P72.

SUB-MIN TOGGLE SWITCH Body size 8mm x 4mm x 7mm SBDT with chrome dolly sixing nuts. 3 for £1. Order ref BD649.

COPPER CLAD PANEL for making PCB. Size approx 12in long x 8.5in wide. Double-sided on fibreglass middle which is quite thick (about 1/16in) so this would support quite heavy components and could even form a chassis to hold a mains transformer, etc. Price £1 each. Our ref BD683.

MAINS FANS Brand new, snail type. Approx. 6" x 4" approx. 70W only £4.00. Ref. 4P58.

REAL POWER AMPLIFIER for your car, it has 150 watts output. Frequency response 20hz to 20Khz and signal to noise ratio better than 60dB. Has built in short circuit protection and adjustable input level to suit your existing car stereo, so needs no pre-amp. Works into speakers ref. 30P7 described below. A real bargain at only £57.50. Order ref: 57P1.

POWERFUL IONISER

Generates approx. 10 times more IONS than the ET1 and similar circuits. Will refresh your home, office, workroom etc. Makes you feel better and work harder - a complete mains operated kit, case included £18.00 + £2 p&p. Our ref 18P2.

REAL POWER CAR SPEAKERS. Stereo pair output 100W each. 4-Ohm impedence and consisting of 6.5in woofer, 2in mid range and 1in tweeter. Ideal to work with the amplifier described above. Price per pair £30.00. Order ref: 30P7.

STEREO CAR SPEAKERS. Not quite so powerful - 70w per channel. 3in woofer, 2in mid range and 1in tweeter. Price per pair: £28.00. Order ref: 28P1.

VIDEO TAPES These are three hour tapes of superior quality, made under licence from the famous JVC Company. Offered at only £3 each. Our ref 3P63. Or 5 for £11. Our ref 11P3. Or for the really big user 10 for £20. Our ref 20P20.

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.

12" HIGH RESOLUTION MONITOR Amber screen, beautifully cased for free standing, needs only a 12v 1.5 amp supply. Technical data is on its way but we understand these are TTL input. Brand new in makers' cartons. Price: £22.00
Order ref: 22P2.

COMPOSITE VIDEO KITS. These convert composite video into separate H sync, Vsync and video. Price £8.00. Our ref 8P39.

BUSH RADIO MIDI SPEAKERS Stereo pair. BASS reflex system, using a full range 4in driver of 4 ohms impedance. Mounted in very nicely made black fronted walnut finish cabinets. Cabinet size approx 8.5in wide, 14in high and 3.5in deep. Fitted with a good length of speaker flex and terminating with a normal audio plug. Price £5 the pair plus £1 post. Our ref 5P141.

3.5in FLOPPY DRIVES We still have two models in stock: Single sided, 80 track, by Chinon. This is in the manufacturers metal case with leads and IDC connectors. Price £40, reference 40P1. Also a double sided, 80 track, by NEC. This is uncased. Price £59.50, reference 60P2. Both are brand new. Insured delivery £3 on each or both.

YUASHA LEAD ACID BATTERIES 6V 10A. Superb Value at only £12.00 REF 12P24 or 2 for £20.00 ref 20P29. Also some 12V 1.9AH £7.00 REF 7P19.

ASTEC PSU. Mains operated switch mode, so very compact. Outputs +12v 2.5A, +5v 6A, +-5v .5A, +-12v .5A. Size: 7.5in long x 4.75in wide x 2.25in high. Cased ready for use. Brand new. Normal price £30+, our price only £13.00. Order ref 13P2.

VERY POWERFUL 12 VOLT MOTORS. 1/3rd Horsepower. Made to drive the Sinclair C5 electric car but adaptable to power a go-kart, a mower, a rail car, model railway, etc. Brand new. Price £20 + £2 postage. Our ref. 20P22.

ELECTRONIC SPEED CONTROL KIT Suitable for controlling our powerful 12v motors. Price £17.00. Ref. 17P3 (heatsink required).

SINCLAIR C5 WHEELS. Set of 4 wheels with inner tubes and tyres. 2 13" dia. front wheels and 2 6" dia. rear wheels. Brand new £24 set. Ref 24P3.

PHILIPS LASER

This is helium-neon and has a power rating of 2mW. Completely safe as long as you do not look directly into the beam when eye damage could result. Brand new, full spec. £35 plus £3 insured delivery. Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £15.

ORGAN MASTER is a three octave musical keyboard. It is beautifully made, has full size (piano size) keys, has gold plated contacts and is complete with ribbon cable and edge connector. Can be used with many computers, request information sheet. Brand new, only £15 plus £3 postage. Our ref 15P15.

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HIGH RESOLUTION MONITOR. 9in black and white, used Philips tube M24/306W. Made up in a lacquered frame and has open sides. Made for use with OPD computer but suitable for most others. Brand new. £16 plus £5 post. Our ref 16P1.

12 VOLT BRUSHLESS FAN. Japanese made. The popular square shape (4.5in x 4.5in x 1.75in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. £8 each. Our ref 8P26.

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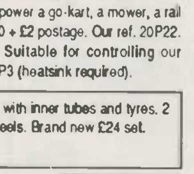
Fitted Volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or 13 for £12.00.



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JOYSTICKS for BBC, Atari, Dragon Commodore, etc. All £5.00 each. All brand new, state which required.

TELEPHONE TYPE KEYPAD. Really first class rear mounting unit. White lettering on black buttons. Has conductive rubber contacts with soft click operation. Circuit arranged in telephone type array. Requires 70mm by 55mm cutout and has a 10 IDC connector. Price £2.00. Ref. 2P251.

SUB-MIN PUSH SWITCHES Not much bigger than a plastic transistor but double pole PCB mounting. 3 for £1.00. Our ref BD688.

AA CELLS Probably the most popular of the rechargeable NICAD types. 4 for £4.00. Our ref. 4P44.

20 WATT 4 OHM SPEAKER With built in tweeter. Really well made unit which has the power and the quality for hifi 6.5in dia. Price £5.00. Our ref; 5P155 or 10 for £40.00 ref. 40P7.

MINI RADIO MODULE Only 2in square with ferrite aerial and solid dia. tuner with own knob. It is superhet and operates from a PP3 battery and would drive a crystal headphone. Price £1.00. Our ref. BD716.

BULGIN MAINS PLUG AND SOCKET The old and faithful 3 pin with screw terminals. The plug is panel mounted and the socket is cable mounted. 2 pairs for £1.00 or 4 plugs or 4 sockets for £1.00. Our ref. BD715, BD715P, or BD715S.

MICROPHONE Low cost hand held dynamic microphone with on/off switch in handle. Lead terminates in 1 3.5mm and 1.25mm plug. Only £1.00. Ref. BD711.

MOSFETS FOR POWER AMPLIFIERS AND HIGH CURRENT DEVICES 140v 100watt pair made by Hitachi. Also available in H pack Ref 2SJ99 and 2SK343 £4.00 a pair. Ref 4P51.

TIME AND TEMPERATURE LCD MODULE A 12 hour clock a Celsius and Fahrenheit thermometer a too hot alarm and a too cold alarm. Approx 50x20mm with 12.7mm digits. Requires 1AA battery and a few switches. Comes with full data and diagram. Price £9.00. Our ref. 9P5.

REMOTE TEMPERATURE PROBE FOR ABOVE. £3.00. Our ref. 3P60.

25 WATT STEREO AMPLIFIER IC STK043. With the addition of a handful of components you can build a 25 watt stereo amplifier. Supplied with a circuit diagram. £4.00 REF 4P69.

600 WATT AIR OR LIQUID MAINS HEATER Small coil heater made for heating air or liquids. Will not corrode, lasts for years. Coil size 3in x 2in mounted on a metal plate for easy fixing. 4in dia. Price £3.00. Ref. 3P78 or 4 for £10.0. Our ref. 10P76.

EX-EQUIPMENT SWITCHED MODE POWER SUPPLIES Various makes and specs but generally +-5, +-12V ideal bench supply. Only £8.00. Our ref 8P36.

ACORN DATA RECORDER Made for the Electron or BBC computer but suitable for others. Includes mains adaptor, leads and book. £12.00. Ref. 12P15.

PTFE COATED SILVER PLATED CABLE 19 strands of .45mm copper will carry up to 30A and is virtually indestructible. Available in red or black. Regular price is over £120 per reel. Our price only £20.00 for 100m reel. Ref. 20P21 or 1 of each for £35.00. Ref 35P2. Makes absolutely superb speaker cable!

NEW PIR SENSORS Infra red movement sensors will switch up to 1000w mains, UK made, 12 month manufacturers warranty, 15-20m range with a 0-10min timer, adjustable wall bracket. Only £25.00. Ref 25P16.

MAINS FANS 80mm square silent mains fans ideal for equipment cooling where space is at a premium. They give quite a good draught and use about 12 watts. £9.00 ref 9P10.

10 MEMORY PUSHBUTTON TELEPHONES These are customer returns and sold as seen. They are complete and may need slight attention. Price £6.00 Ref 6P16 or 2 for £10.00 Ref 10P77 BT approved.

MINIATURE DOT MATRIX PRINTERS. These are 24 column 5v and similar to the one sold by Radio Spares for £46.00. You can have one for £10 ref 10P92.

MYLAR CONE SPEAKERS. These 85mm square 35ohm 2 watt speakers are ideal for outside use as they are virtually waterproof. £1.00 each ref BD903.

SPECTRUM SOUND BOX Add sound to your Spectrum with this device. Just plug in. Complete with speaker, volume control and nicely boxed. A snip at only £4.00. Our ref. 4P53.

BBC JOYSTICK INTERFACE Converts a BBC joystick port to an Atari type port. Price £2.00. Our ref. 2P261.

TELEPHONE EXTENSION LEAD 5m phone extension lead with plug on one end, socket on the other. White. Price £3.00. Our ref. 3P70 or 10 leads for only £19.00! Ref. 19P2.

LCD DISPLAY 4.5in digits supplied with connection data £3.00. Ref. 3P77 or 5 for £10. Ref. 10P78.

CROSS OVER NETWORK 8 Ohm 3 way for tweeter midrange and woofer nicely cased with connections marked. Only £2.00. Our ref. 2P255 or 10 for £15.00. Ref. 15P32.

REVERSING LIGHT ALARM Fits to car reversing light and sounds when reversing. Only £2.00. Our ref. 2P248.

BASE STATION MICROPHONE Top quality uni-directional electret condenser mic 600r impedence sensitivity 16-18KHz - 68db built in chime complete with mic stand bracket. £15.00. Ref. 15P28.

MICROPHONE STAND Very heavy chromed mic stand, magnetic base 4in high. £3.00 if ordered with above mic. Our ref. 3P80.

SOLAR POWERED NICAD CHARGER 4 Nicad AA battery charger. Charges 4 batteries in 8 hours. Price £6.00. Our ref. 6P3.

MAINS SOLDERING IRON Price £3.00. Our ref. 3P65.

SOLDERING IRON STAND Price £3.00. Our ref. 3P66.

SHARP PLOTTER PRINTER New 4 colour printer originally intended for Sharp computers but may be adaptable for other machines. Complete with pens, paper etc. Price £16.00. Our ref. 16P3.

CAR IONIZER KIT Improve the air in your car, clears smoke and helps prevent fatigue. Case req. Price £12.00. Our ref. 12P8.

NEW FM BUG KIT New design with PCB embedded coil 9v operation. Priced at £5.00. Our ref. 5P158.

NEW PANEL METERS 50UA movement with three different scales that are brought nto view with a lever. Price only £3.00. Ref. 3P81.

STROBE LIGHTS Fit a standard edison screw light fitting 240V 40/min. flash rate available in yellow, green. Complete with socket. Price £10 each. Ref. 10P80 (state colour required).

EXTENSION CABLE WITH A DIFFERENCE It is flat on one side making it easy to fix and look tidy. 4 core, suitable for alarms, phones etc. Our price only £5.00 for 50m reel. Ref. 5P153.

METAL PROJECT BOX Ideal for battery charger, power supply etc. Sprayed grey size 8in x 4in x 4.5in. Louvred for ventilation. Price £3.00. Ref. 3P75.

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ADVANCED ELECTRONIC PRODUCTS LTD

P.O. BOX 10, Newton Abbott,Devon. TQ12 1JP Tel: (0626) 332091 Fax: (0626) 332381

MAIL ORDER TERMS: POSTAL ORDER OR CHEQUE WITH ORDER. PLEASE ADD 75P POST AND PACKING TO ORDER VALUE AND THEN 15% VAT. IF KIT INCLUDES MAINS TRANSFORMER THEN ADD AN ADDITIONAL £2. ACCESS & VISA HOLDERS PLEASE PHONE ORDER BEFORE 4.45 PM FOR SAME DAY DESPATCH. ALL ORDERS UNDER 750 GRMS SENT BY FIRST CLASS POST. OVERNIGHT CARRIER £9.

RESISTORS

Carbon Film 0.25W E12 or E24 series 1 p each (min quantity 10 per value), 80p per 100, £6.00 per 1000.

Special Offer

Mixed Pack, of 1000 Carbon Film resistors, 1R to 10M, 100 different values all separately packed and labeled only £5.90

Metal Film 0.25/0.5 W E96 series 10R to 1MO 4p each (min quantity 10 per value), £3.00 per 100.

Ceramic/wire wound

4W OR1-10K	35p each
7W OR33-12K	37p each
11W OR68-10K	40p each
17W 1R-10K	44p each

5% discount on 10+, 10% on 25+ 20% on 100+

Enclosed Pre-Sets

100R-10M 20% Horizontal or Vertical 24p each. 5% discount on 10+, 10% on 25+, 20% on 100+

Enclosed Pre-Sets

100R-10M 20% Horizontal or Vertical 24p each. 5% discount on 10+, 10% on 25+, 20% on 100+

20 Turr 3/4" Cermet Pots

10% tolerance 10R-2M 90p each, 5% discount on 10+, 10% on 25+, 20% on 100+

CAPACITORS

Radial Aluminium Electroylitic
20% tolerance

10/16/25/35 Volt	
4.7,10,22,33,47,100	12p
220,330,470	20p
1000	30p
2200	48p
3300	65p
4700	85p
50/63/ Volt	
0.47,1,2.2,3.3,4.7,10	12p
22,33,47	20p
100,220	30p
470	50p
1000	90p
100 Volt	
0.47,1,2.2,4.7	12p
10,22	20p
47	30p
100	50p

Ultra miniature Aluminium electrolytic radial 20% tolerance

4V	
220	18p
6.3 Volt	
22,100	18p
16 Volt	
10,22,47	18p
25 Volt	
10,22,33	18p
35 Volt	
4.7,10,22	18p
50 Volt	
0.1,0.22,0.33,0.47, 1,2.2,3.3,4.7,10	18p

CAPACITORS

Disc Ceramic 5% tolerance
150Volt values In pF

15,22,33,47,68	4p
100,150, 220,330,470	6p

10% tolerance value in pF

220,330,470,680	6p
1000,1500,2200	
3300,4700,6800	8p

+80%-20% tol. value pF

4700,10000	6p
22000,47000	9p

Tant.Bead resin dipped 20% tolerance value in uF

6.3 Volt	
10,22	15p
47	25p
10 Volt	
3.3,4.7,6.8	15p
10,15	25p
22,33,47	35p
16 Volt	
2.2,3.3,4.7,6.8	15p
10,15	25p
22,33	35p
25 Volt	
1,2.2,3.3	15p
4.7,6.8	25p
10,15	35p
35 Volt	
0.1,0.22,0.33,0.47	15p
0.68,1,2.2,3.3	20p
4.7,6.8,10	30p

CMOS

4000	17p	4106	34p
4001	17p	4160	40p
4002	17p	4161	40p
4006	37p	4162	40p
4007	17p	4163	40p
4008	37p	4174	37p
4011	17p	4175	40p
4012	17p	4194	42p
4013	25p	4501	27p
4014	37p	4502	40p
4115	37p	4503	37p
4016	28p	4504	120p
4017	37p	4506	76p
4018	37p	4508	99p
4020	37p	4510	37p
4021	37p	4511	37p
4022	37p	4512	37p
4023	17p	4513	99p
4024	35p	4514	85p
4025	17p	4515	80p
4027	34p	4516	37p
4028	37p	4517	99p
4029	37p	4518	37p
4032	56p	4519	26p
4034	95p	4520	37p
4035	44p	4521	85p
4038	65p	4522	44p
4040	37p	4526	44p
4042	37p	4527	44p
4043	37p	4528	44p
4044	37p	4529	50p
4046	47p	4530	99p
4049	27p	4531	44p
4050	27p	4532	60p
4051	37p	4534	240p
4052	37p	4536	120p
4053	37p	4538	54p
4060	37p	4539	45p
4066	29p	4541	50p
4067	99p	4543	54p
4068	17p	4544	130p
4069	17p	4547	130p
4070	17p	4549	400p
4071	17p	4551	85p
4072	17p	4553	120p
4073	17p	4554	320p
4075	17p	4555	50p
4076	37p	4556	50p
4077	17p	4557	120p
4078	17p	4558	120p
4081	17p	4559	440p
4082	17p	4560	110p
4093	27p		
4094	48p		
4097	99p		
4099	46p		

call sales for 4500 series above 4560

DIODES

1N914	5p
1N4148	4p
1N4001	3p
1N4002/3/4/5/6	4p
1N5401	7p
1N5402/4/6/8	11p

Zener Diodes

500 mW

2.4,2.7,3.3,3.9,4.7,5.1,5.6,6.2,6.8, 8.2,10,11,12,13,15,16,18,20,2 2,24,27,30,33,39,43,62,66,75,82, 91

All above voltages at 5p each

1.3W

3.3, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1, 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91.

All above voltages at 16p each

2.5W,20W & 75W versions available

Bridges

W005	23p
W02	25p
W04	30p
W06/08	35p
2A 200V	65p
2A 400V	72p
2A 600V	90p
6A 200V	78p
6A 400V	84p
6A 600V	99p

Linear I.C.s call for price

TRANSISTORS

BC107B	20p
BC108B	20p
BC109C	22p
BC184C	6p
BC212B	6p
BC239C	4p
BC307C	4p
BC548C	4p
BC558C	4p
ZTX300	17p

The above are a few examples from the 1000's of transistor types we have. We cover all ranges and types including JFET, SIPMOS, TMOS, TIP plastic & metal, FET & Darlingtons.

REGULATORS

7805	5V @ 1.5A	30p
7812	12V @ 1.5A	30p
7815	15V @ 1.5A	30p
7905	-5V @ 1.5A	30p
7912	-12V @ 1.5A	30p
7915	-15V @ 1.5A	30p

KITS KITS KITS

ALL KITS ARE SUPPLIED WITH HIGH QUALITY GLASS FIBRE SILK SCREENED PCB, FULL INSTRUCTIONS, HEATSINK, SOLDER ETC. CASE NOT SUPPLIED BUT AVAILABLE.

CONSTANT CURRENT NI-CAD CHARGER Charge your NI-Cads safely, can be left on idenfinitely without damage, batteries fully charged from flat in approx. 18 hours. Charge up to 12 batteries in series (except PP3). (with transformer) **£7.50**

FAST NI-CAD CHARGER Rapidly charge your NI-Cad racing pack from mains or 12Volts. Charger guarantees a full charge every time, making maximum use of your pack. (with transformer) **£10.00**

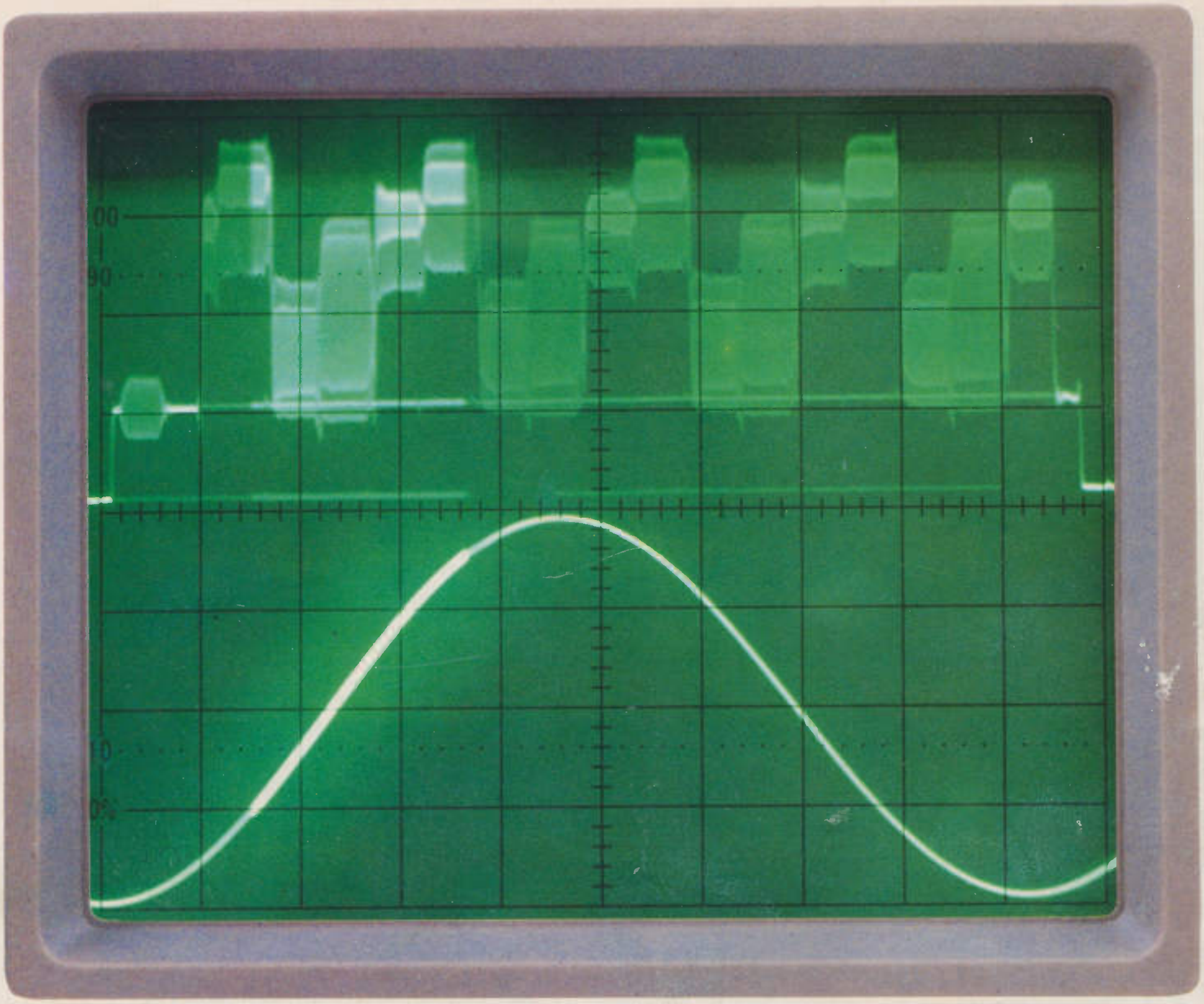
BENCH POWER SUPPLY 2.5 - 35 Volt @ 2 Amps The following spec ensures excellent value for money for this most essential of workshop equipment. Line Reg. 0.03%, Load Reg. 0.1% Ripple Rejection 70 dB, Output Res. 1.5 milliOhm, Output Noise 80uV. (with transformer) **£8.00**

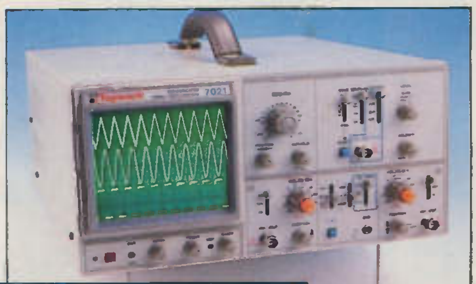
10 Amp BENCH POWER SUPPLY 5 - 33 Volt Use for powering C.B/Ham Radios, or a very high powered bench power supply. Spec as 2A version above. (with transformer) **£32.00**

FM Bug, 26 x 16 x 12mm, super sensitive 500yd range 4.5-9V supplied with miniature mic & ready wound coil. **£4.50**

Telephone Bug, powered from phone line. Spec as above. **£4.00**

HUNDREDS OF KITS AVAILABLE - SEND FOR LIST





20MHz

40MHz