THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY
FEBRUARY 1992 £1.60

ETI
ELECTRONICS TODAY INTERNATIONAL

BOOTSTRAPPING
A circuit idea reconsidered

COMETS
Relics of the Universe

INTUITIVE ELECTRONICS
A different angle on learning

AUDIO MIXING DESKS
The Digital approach

MAINS SWITCHED TIMER

02
9 770142 722016

AN ARGUS SPECIALIST PUBLICATION

FREE ISSUES

A subscription to your favourite magazine is the best way of making sure you never miss an issue.

And from now until 28th February 1992 you can get extra copies ABSOLUTELY FREE, by taking advantage of our special subscription offer. With a monthly title for example, this means you get 14 issues for the usual price of 12.

Order your subscription today using the coupon below and you will receive the best in reading entertainment right into the 1990's. This offer is also open to subscribers wishing to extend/renew their current subscriptions.

Standard subscription rates ▶ ▶ ▶

Monthly titles (14 for the price of 12)	UK	Europe	Middle East	Far East	Rest of World
Archimedes World	£35.40	£45.70	£46.30	£49.30	£51.30
Aeromodeller	£23.40	£28.20	£28.40	£30.20	£28.70
Citizens' Band	£19.20	£23.40	£23.70	£25.70	£24,90
Clocks	£28.80	£35.60	£38.65	£37.40	£37,40
ETI	£19.20	£24.10	£24.40	£26.80	£25.85
Film Monthly	£18.80	£22.60	£22.90	£25.10	£24.25
Ham Radio Today	£19.20	£24.00	£24.35	£26,70	£25.75
Military Modelling	£21.00	£28.30	£28.80	£32.30	£30.90
Model Boats	£19.80	£26.20	£26.60	£29.65	£28.40
Model Railways	£19.80	£24.65	£25.00	£27.60	£26.60
Photography	£23.40	£30.50	£30.75	£33.45	£31.25
Popular Crafts	£19.20	£24.80	£25.80	£27.90	£26.80
Radio Control Model Cars	£19.20	£24.45	£24.30	£27.30	£26.30
RCM&E	£19.20	£29.40	£30.10	£35.00	£33.10
Radio Modeller	£19.20	£25.30	£25.70	£28.65	£27.50
Scale Models International	£18.00	£22.60	£22.80	£24.55	£23.10
Steam Classic	£19.80	£26.40	£26.80	£30.00	£28.70
Video Today	£19.20	£24.75	£25.10	£27.80	£26.70
Woodworker	£21.00	£29.50	£30.00	£34.00	£32.50

Alternate monthly titles (8 for the price of 6)	UK	Europe	Middle East	Far East	Rest of World
Radio Control Boat Modeller	£9.60	£12.35	£12.50	£13.90	£13.30
Radio Scale Aircraft	£13.50	£16.65	£16.80	£17.95	£17.00
Practical Wargamer	£11.70	£14.80	£14.90	£16.10	£15.10
Model Engineers' Workshop	£15.00	£18.90	£19.20	£21.10	£20.30

Fortnightly title (26 for the price of 24)	UK	Europe	Middle East	Far East	Rest of World
Model Engineer	£33.60	£44.80	£45.55	£21.10	£48.80

Quarterley Title (6 for the price of 4) — negative	UK	Europe	Middle East	Far East	Rest of World
Silent Flight	£10.00	£12.05	£12.20	£13.20	£12.80

Please commence my subscription to .... with the .... issue.

I enclose my cheque/money order for £............................ made payable to ARGUS SPECIALIST PUBLICATIONS

or debit my access/Barclaycard number [ ] Card expiry date ....

Signature... Name ....

Address ....

.... Postcode ....

UK subscribers may pay for their subscription using Direct Debit — for futher information telephone: 0442 876661 during office hours.

Please return this coupon with your remittance to:

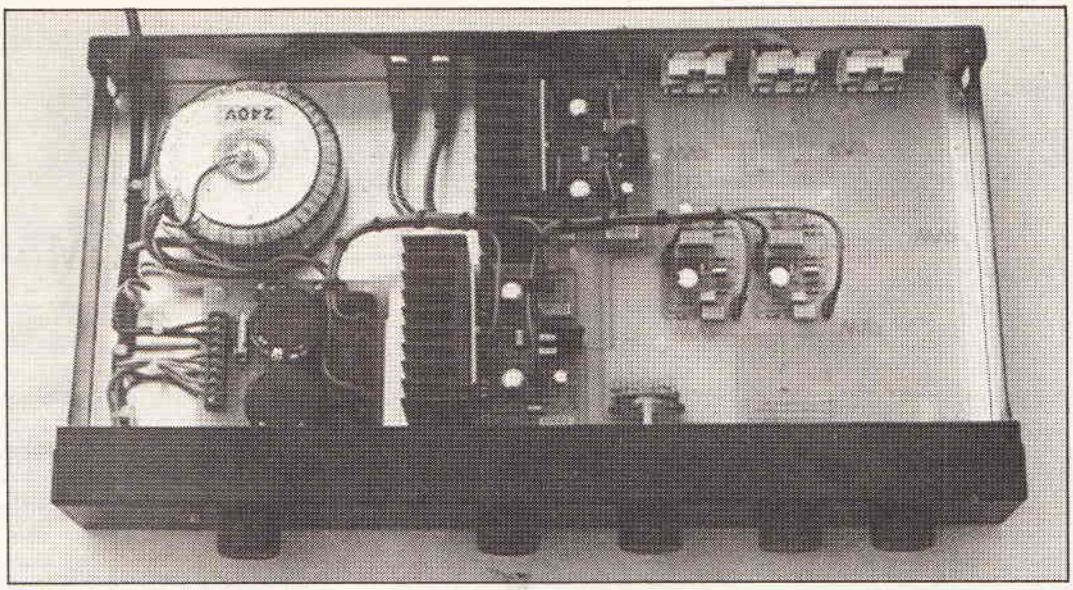
Select Subscriptions Ltd. (ETI/16) 5 River prk Estate, Billet Lane, BERKHAMSTED, Herts. HP4 1HL, UNITED KINGDOM

Contents

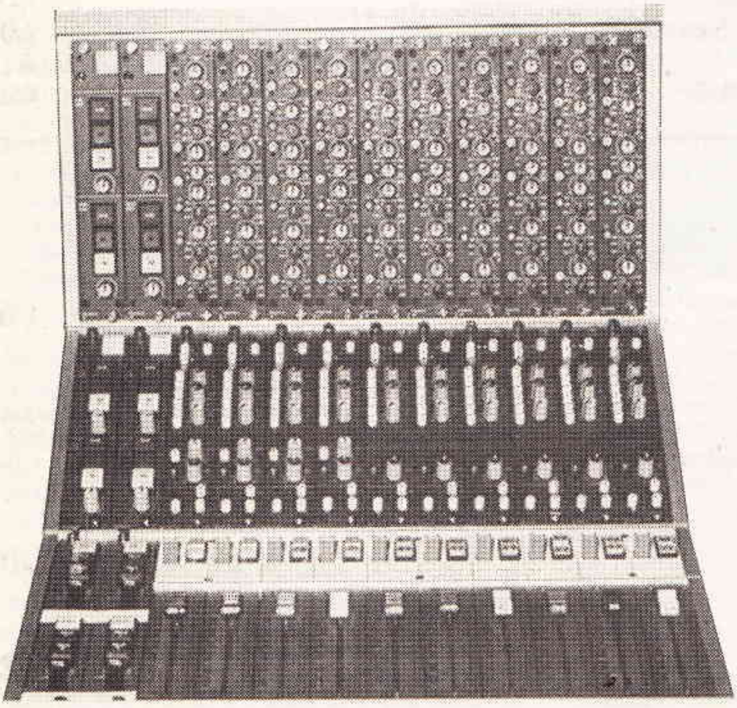
FEBRUARY '92 VOLUME 21 No 2

Regulars

Features & Projects



The Acousdix Bridge Amplifier Page 51



Introduction to Audio Mixers Page 16

Mains Switched Timer
Page 32

Editorial

By Paul Freeman

Spreading the word

A new series called Intuitive electronics by Mike Barwise starts this month. In his introduction, he makes several points about the clear divisions existing between the theoreticians whose distilled knowledge seems to be disseminated between a small number of individuals 'in-the-know' with hardly any notion of the practicalities of the subject compared to those that handle and develop circuits by a certain feeling.

It is true that in delving into a specific research area one has to create new terminology to explain new phenomena. The danger is that it can alienate the outside world who feel increasingly shut out, fearing the consequences. It's no wonder the public envisage research workers as mad eccentric professors. The tendency for the scientific community to push themselves further and further into ever tighter corners and risk isolation should be strongly resisted. Isolation could spell political suicide resulting in funds dwindling even further as politicians no longer understand the point of financing something that seems completely irrelevent to them.

Scientists have to publicly and loudly make their case in simple terms to take the will of the people with them. The lack of scientific news agencies and news dissemination makes the point clearly. The infrastructure does not exist to spread the good but simple word. Such agencies should be sponsored or financed by government money because pure research does not contain a profit motive and traditionally has not been commercially backed. If it is financed from industry then the public would also like to know about the original ideas as well as the final product.

OPEN CHANNEL

Our Government has recently licensed quite a number of operators to deliver television channels via multi-point video distribution services (MVDS), in a national trial. In case you haven't been avidly following my column over the months, I'll explain what MVDS is. In essence, it's a system whereby high-frequency (microwave) links are used to carry several television channels on a point-to-point type basis, between a central transmitter and outlying receiving dishes. I use the expression dishes here with reservations, though, because the normal image of a dish is usually thought of in satellite terms — that is, a 60 cm or so whopper, stuck on the side of a house. MVDS dishes, or at least those planned here, are much smaller — only 15 cm — and so can easily mount on a small chimney stack. Manufacturer, Marconi, describes these dishes as something like 'old-fashioned car headlamps' in appearance which, I've got to admit, doesn't fill me with much of a desire to have one.

MVDS has been discussed in one form or another for a while now, and previously it looked as though the frequency to be chosen was to be much higher than that in this trial (12GHz). But as I've argued in the past a higher frequency, although more elegant and allowing more channels to be transmitted, isn't necessarily the best choice. At say, 30GHz, equipment is not easily available and is expensive anyway. A frequency of 12GHz, on the other hand, allows existing and cheap satellite receiver equipment to be adapted. In fact, not only does it mean satellite equipment can be used, but it can be used for the dual purpose of receiving both MDVS and satellite transmissions. So you don't need an extra box of tricks on top of your telly to receive from both sources. Great!

However, there is a slight element of doubt in all this. It's as yet unproven that using the same frequency range isn't going to cause interference with existing satellite services. Hence the trial.

Quite naturally, MVDS is not seen as a supplement to services like cable, but more of a direct competitor. Because MVDS links are going to be substantially cheaper than a cable network it can only be expected that it will become very popular in areas where cost of cabling is too high. Indeed, MVDS may make the idea of cable unnecessary altogether.

I'll be reporting further in later issues of ETI.

In The Picture

Avid photographers will probably already know about two advances in photo-to-television technology. First, which is not so much of an advance, more an adaption and coming together of previously disparate technologies, is a fairly straightforward camera stand. An integral video camera and slide holder are held in a convenient unit which allows slides to be easily photographed by the video camera. A simple video output links the camera to a videocassette recorder and, hey presto, you've recorded your photographs to videocassette for later display on your television.

There's nothing particularly new in the idea except that in the unit I'm considering (the Tamron Photovix) you can videorecord slides and negatives. It also allows a selected part of your image to be enlarged by upto three times. Both are nice features which will interest many users, I'm sure.

Primarily a unit like this is aimed at amateur photographers who just want to fit together selected photographs onto videotape to present on their TV screen. It's a nice idea and I'm sure it will become very popular with photo-amateurs. However, it could have uses in some electronic publishing systems, too. It has limitations of course — it's a fairly' low definition system (well, video cameras are low definition, aren't they?), and a video grabber system is needed by the computer. But it's a start and people who require such low definition images (newspapers, estate agents, collectors wanting a record catalogue and so on) will be overjoyed by the Photovix' ease-of-use and possibilities.

Electronic publishing users and professional photographers who need higher definition, on the other hand, will be even more pleased to hear about an application of compact disc which has been developed by Kodak and Philips. Resultant Kodak's Photo CD promises to be extremely popular and important in both areas.

Using CDs containing up to 100 high-definition photographs in digital format, photo CDs can be played in new CD players which are dual standard — they can play conventional audio CDs as well as photo CDs. Players are expected to be around the same price as current mid-range audio CD players, and will connect to a television for photographic replay, and amplifier for audio replay.

After developing your film in the usual way, you simply send the negative or slide to a photofinisher, who scans the image and records it onto disc. You don't need to fill a whole disc in one go, as discs can be returned to the photofinishers as often as you need, until the disc is full with its 100 images.

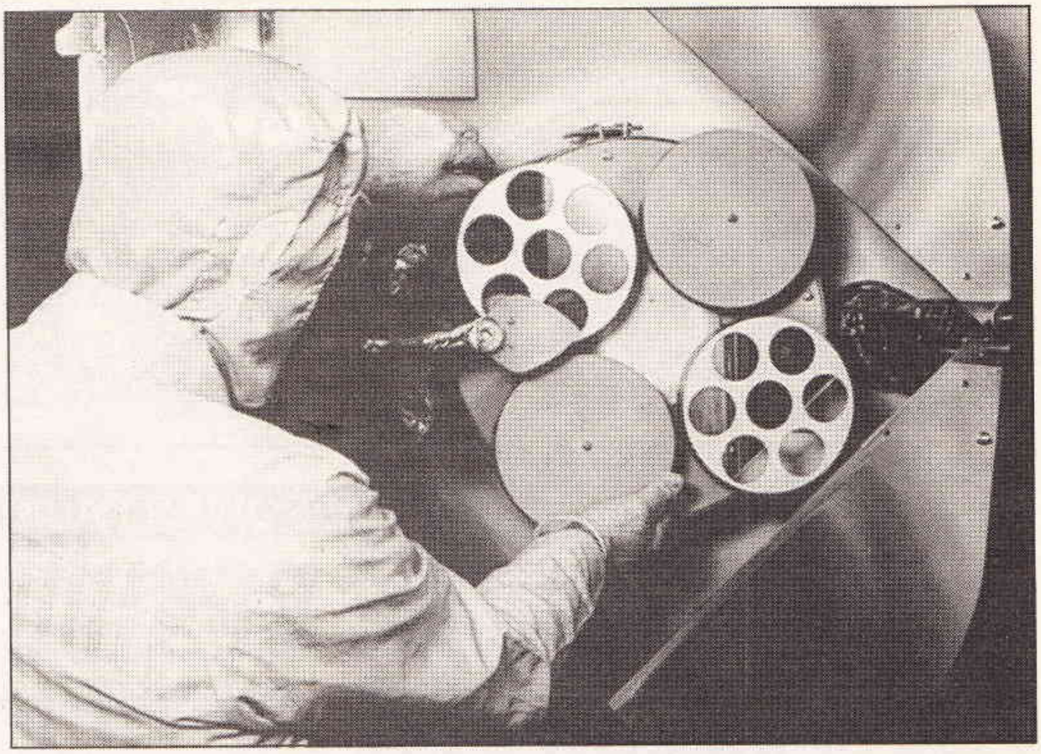
But, if some of you are awake, you'll be wondering how (without use of a video grabber system; complete with its inherent low definition) is this of any use to electronic publishing. Well, photo CDs will be playable on CD-ROM XA drives, too. So the digital image can be output directly as a TIFF file, say, into your favourite page layout software, at a high definition (around twice that of high definition television!).

Photo CD players are expected to be launched around the middle of the year, and will have features such as random access viewing (I presume this means you can key in the number of the photograph you want to look at), zooming, panning, cropping and so on.

Keith Brindley

ETI NEWS

ION BEAM SPUTTERING AVAILABLE COMMERCIALLY



Omitec Electro-Optics is the first UK company to offer ion beam sputtering technology on a commercial basis.

Electro-Optics' new technology is used for manufacturing extremely low loss laser mirrors, specialised thin films for fibre optic and sensor applications or as a subcontract development facility.

Comments Derek Read, Operations Director for Omitec:

"Using our ion beam deposition techniques, we can produce very low loss high damage threshold laser mirrors as used in aviation ring laser gyros. R.L.G.s require laser mirror performance serveral orders of magnitude greater than that produced by conventional thin film deposition techniques."

For this kind of highly specialised coating, ion beam technology is the only known process to satisfactorily achieve the following requirements: low losses (less than 80 parts per million), extremely stable optical characteristics independent of temperature and environmental conditions.

The optical and mechanical properties of thin films are determined by a number of factors including the electrochemical nature of the material, its atomic or molecular structure, the properties and condition of the surface onto which they are deposited and the method of deposition.

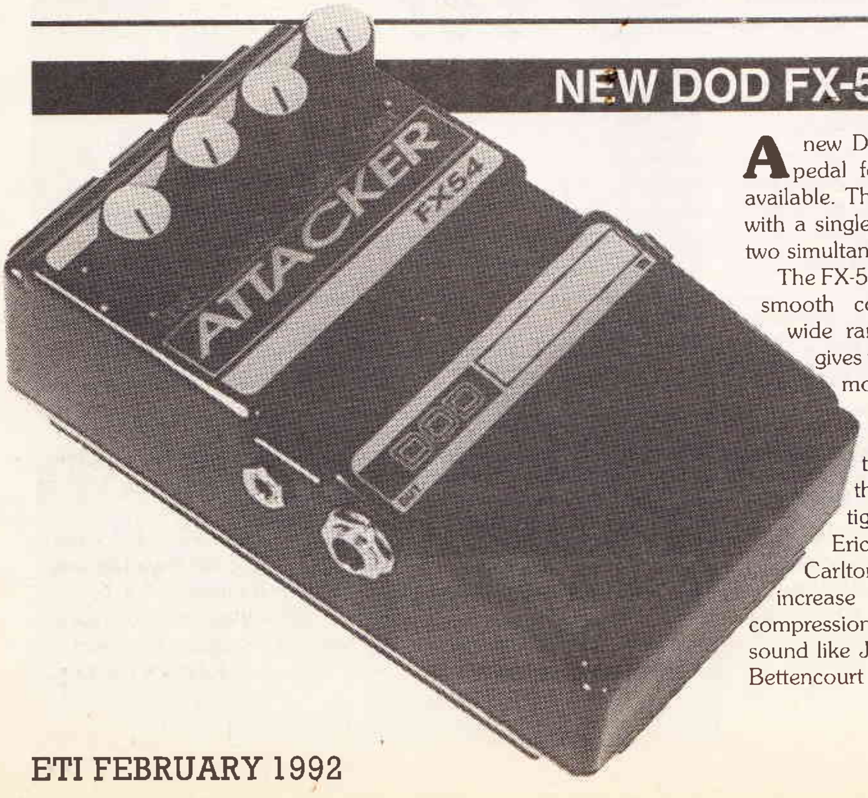
In conventional thermal evaporation, the film structure is dependent on the energy of the molecules depositing onto the growing film which is related to substrate temperature and the evaporation temperature of the material.

Within the last decade alternative methods have been developed to increase this energy by orders of magnitude. Of these, ion beam sputter deposition and ion assisted deposition techniques have been targeted by Omitec as the emerging technology for the next generation of thin films.

Ion beam deposition is a materials based technology which imparts kinetic energy to growing films to produce materials of highly ordered structure which are virtually defect-free. With ion assisted techniques, the energy is applied directly to the growing film and with ion beam sputter deposition the energy is applied to the target material itself. Omitec uses the latter technique to produce its low loss, high damage threshold laser mirrors.

Ring laser gyros are just one application of ion beam deposition, other applications include: ultra stable thin films, tribological coatings, supermodulus coatings, durable protective layers and abrasion resistant coating.

NEW DOD FX-54 ATTACKER PEDAL



A new DOD FX-54 Attacker pedal for guitarists is now available. This device is the first with a single-switch pedal giving two simultaneous effects.

The FX-54 Attacker combines smooth compression with a wide range distortion. This gives the guitarist an enormous variety of sounds to choose from. By lowering the distortion and increasing the compression, a tight bluesy sound like Eric Clapton or Larry Carlton can be achieved. Or increase the distortion and compression, a wide searing solo sound like Joe Satriani or Nuno Bettencourt appears. The compressor adds the sustain needed to simulate the feedback control found in tube amplifiers. Combined with the distortion, almost any modern or classic electric guitar tone can be had.

The pedal's controls consist of: a distortion control for varying the amount of internal gain, a tone control for simple equalization, a compression control for adjusting the amount of signal to compression ratio, and a level control which sets the amount of effect signal. Retail price is £69.

For more information contact John Hornby Skewes & Co Ltd, Tel: 0532 865381

RECORDED VOICE COULD BE QUEEN VICTORIA

A fragile Graphophone recording, which could include the voice of Queen Victoria, is currently being examined by the Science Museum and the National Sound Archive.

Circumstantial evidence indicates that this recording is the one that was made by Sydney Morse at Balmoral Castle in 1888. It is know that on this occasion Queen Victoria was prevailed upon to utter a few words into a Graphophone. If the voice is that of Queen Victoria it will be the only known recording of her voice in existence.

The sounds are very scratchy and only a few words can be made out with any certainty. Approximately 40 words are apparent on the recording but only "Greetings . . . the answer must be . . . I have never forgotten . . ." can be distinguished.

The Graphophone cylinder is a rare example of an early wax-coated cardboard record of the type which competed for a time with the Edison solid wax Phonograph cylinders. Sydney Morse's son, Esmond, presented the cylinder to the Science Museum in 1929. The author Paul Tritton became aware of the cylinder's possible Royal connections while researching his book on the British audio engineer, Henry Edmunds.

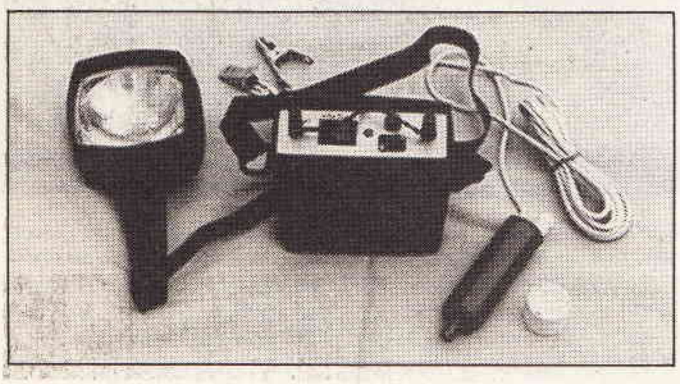
Early attempts to discern evidence of voices on the recording using microscopy techniques were inconclusive. Recently the cylinder was played on the National Sound Archive's electric phonograph which, in order to hear the recording, had to be modified by the Science Museum's workshops.

The exercise has demonstrated the progress made in audio technology in recent years. Perhaps one day further advances in enhancement will help give a positive identification but for the moment ,despite circumstantial evidence, it is a case of 'not proven'.

A special display, now on at the Science Museum includes the original Graphophone cylinder, the National Sound Archive's electric phonograph on which the cylinder was played, and a replica of the Bell-Tainter Graphophone.

Facilities are available for visitors to listen to copies of the recording at the National Sound Archive, 29 Exhibition Road, London SW7. For an appointment please telephone: 071 589 6603.

LVM PORTABLE POWER PACK



One of the most useful pieces of general purpose equipment to pass through our hands is the LV Motors Portable Power Pack. It solves all sorts of problems where a long lasting, powerful electricity supply is wanted in an akward place, or with long life portability indoors and out in the field . It can be connected to a flat car battery and left for a couple of hours, after which time it will put enough in to get the car going. You could certainly not do this with ordinary over the counter cells.

The LVM Portable Power Pack is switchable between 12v and 6v DC, has a capacity of 8 amp hours, recharges in 3 to 4 hours from the mains, the car battery, any other 12v source with over 1,000 recharges and weighs 1.8kg. It costs £72.00 incl VAT

Contact LV Motors Ltd, Tel: 0462 896095

WALL MOUNTED CONTROL

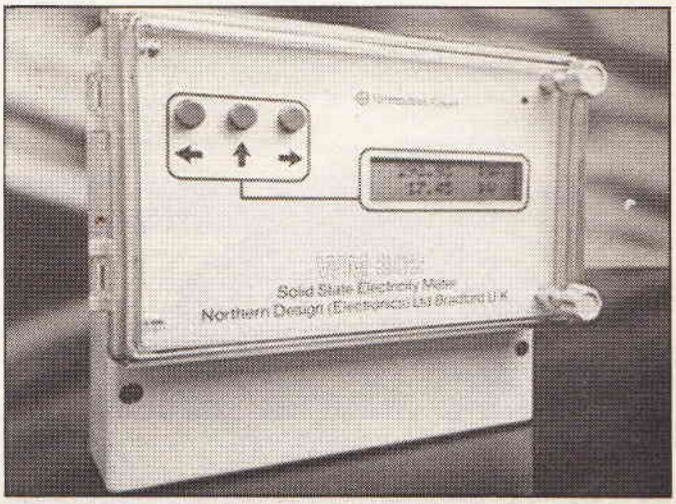
WM 302 is a new wall mounting solid state electricity meter with RS 232 Communications that is designed and manufactured by Northern Design in the UK. Ideal as a kw/kwh, single or dual tariff and Import/Export meter this latest unit also operates in a maximum demand mode for load shedding and control. All readings are shown on a two line liquid crystal display of 16 characters per line with a wide viewing angle.

Wall mounted, the WM 302 is suitable for 3 and 4 wire 3 phase unbalanced loads as well as single phase. Unaffected by input waveform distortion the accuracy is better than 1%. Complying with all current safety standards this new product from Northern Design is housed in an environmentally protected case to IP54. Current sense is via internal ring or external split core, ring or clamp-on CTs at 5A RMS per phase. Standard outputs are volt free pulse and optical data.

Useful options include 1 Amp input current or other, 4 to 20mA output, balanced loads and RS 232 Communicatons.

Prices of the WM302 (exc. VAT) start at £249.00.

For further information please contact Fred Hutchinson of Quiswood Ltd on (0756) 799737.



CIRCUIT AND APPLICATION CENTRE AT SOUTHAMPTON

Philips Semiconductors has opened an Integrated Circuit & Application centre at Southampton, the first of its kind to be established within the company. It was formally opened by Kevin Kennedy, Chairman and Managing Director, Philips Electronics (UK), on Tuesday 22 October 1991.

The centre employs some 360 staff, the majority of whom are graduate engineers or equivalent. It represents an investment by Philips of some £6.8M and is one of the largest single concentrations of electronic engineering expertise in the UK.

The centre combines on one site the design, marketing and logistics operations for microchips used in all types of consumer electronics equipment — television sets, VCRs, compact disc players etc. It also looks at how new developments in chip technology will enhance and improve the performance of such equipment.

Senior executives from leading UK based customers of Philips Semiconductors were invited to attend the opening ceremony, and to tour the centre, where a number of technical presentations were made. Also invited were senior managers of Philips who had been involved in the past with either the Integrated Circuit or Application laboratories.

ANALOGUE AND DIGITAL SCOPE

Offering the best of both worlds, the Tektronix 2210/02 digital oscilloscope is available from Carston for £1250.

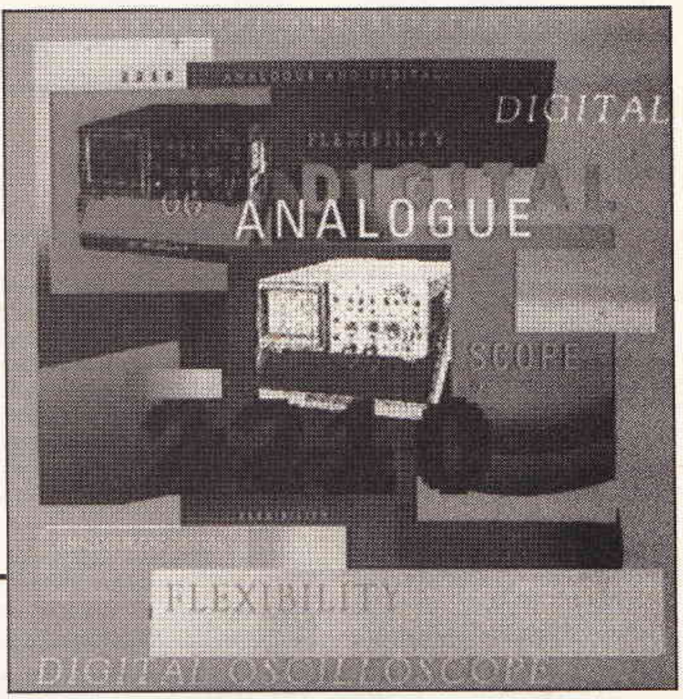
Combining digital sampling with familiar full bandwidth analogue operation, the two channel unit samples at 20 megasamples per second, with 8-bit vertical resolution and 4k record length per channel. In non-storage mode the instrument offers a 50MHz bandwidth — or 2MHz useful storage bandwidth for single shot or repetitive signals.

The 4k record length provides the time resolution for viewed waveforms. The 2210/02 displays all 4k points on screen, and so the waveforms look conventional analogue displays. One screen of information can be saved in a reference memory for later evaluation or waveform comparison.

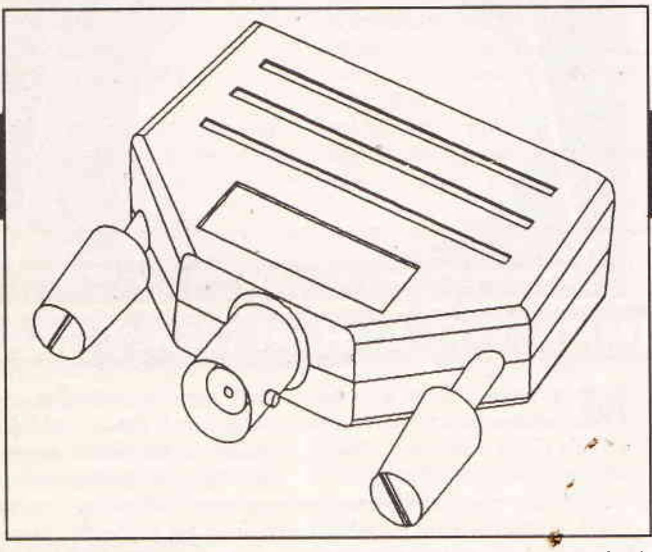
Display modes on the 2210/02 are record, roll, and triggered roll. Trigger modes include peak to peak automatic, normal, TV field, and single sweep.

The fully portable 2210/02 is supplied with two P6103 voltage probes. Supplied ex-rental, all units are fully tested to the manufacturer's specification before delivery.

For further information contact Graham Harris, Carston Electronics Limited. Tel: 081-977 0078.



ADC-10 ANALOGUE TO DIGITAL CONVERTER



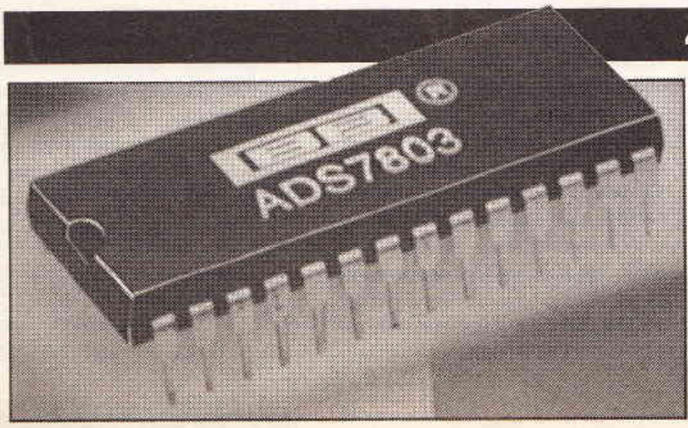
The Pico ADC-10 is a self contained analogue to digital converter for use with IBM PCs and compatibles. It is connected to the printer port and required no extra power. Input is through a standard BNC connector. The ADC-10 has many uses, firstly using the integrated software package it can in many situations replace both an oscilloscope and a digital voltmeter. Additionally the ADC-10 can perform any functions that are only currently available on an expensive digital storage oscillscopes such as saving waveforms to disk, or sending them to a printer. It is particularly suitable for displaying very low frequency trends (such as a battery discharge) which cannot be displayed on an oscilloscope due to the limitations of a CRT.

The main market is expected to be with electronic enthusiasts and educational establishments who tend to use the ADC-10 with the supplied software. In addition to this ADC-10s are being put to a wide range of uses in industry where users are customising the software, or writing their own. Typical examples of its use are in monitoring temperature, pressure and strain gauges. Many commercial sensors have 0-5V outputs so can be plugged straight into the ADC-10, this is particularly useful for remote monitoring of sensors, since the ADC-10s small size makes it ideal for use with portable computers. Another popular application is digital voice recording.

The ADC-10 sells for £49, including the software and instruction manual.

For further information contact Pico Technology Ltd, Tel: 0954 211880.

4-CHANNEL 12-BIT A TO D



New from Burr-Brown is a 4-channel monolithic sampling 12-bit analogue to digital converter (ADS7803), designed for applications which require low-power, wide input bandwidth, and exceptional dynamic performance.

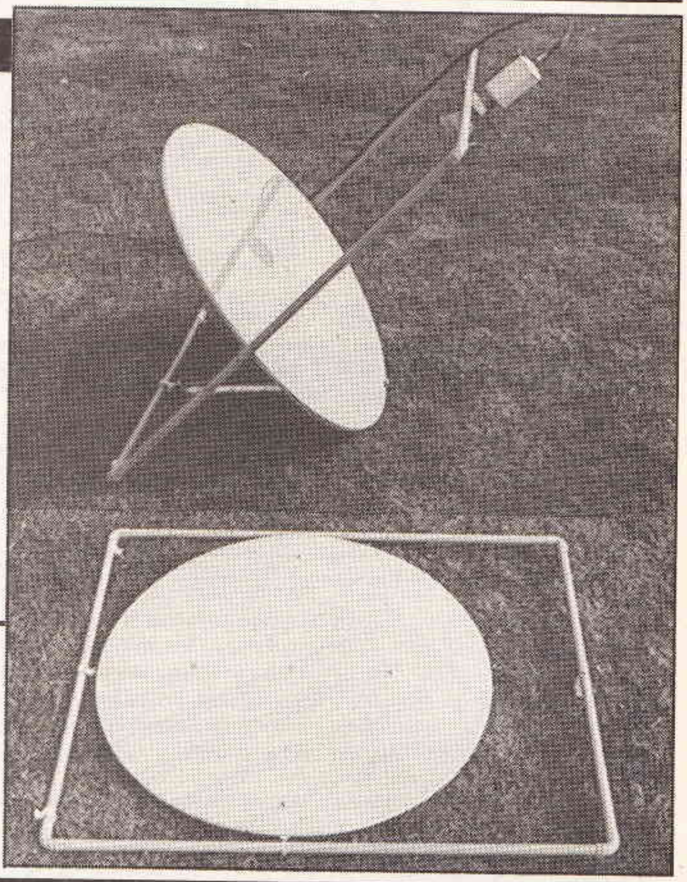
The ADS7803 works from a single 5V supply,consumes only 10mW, and a low-power standby mode consuming just 50μW, makes it ideal for portable applications. With a fast maximum conversion time, including acquisition and multiplexer settling, of 8.5μsec, the device is fully microprocessor controllable via an on-chip special function register. This allows it to be placed in lowpower mode between conversions.

Maximum channel-to-channel mismatch is ±0.25LSB, and dynamic characteristics are tested and guaranteed at input frequencies to 50kHz. Typical specifications include a signal to noise ratio of 70dB, and total harmonic distortion of −75dB. Channel separation at 500Hz is typically 92dB.

Applications will include circuitry requiring wide input bandwidth, low power, excellent dynamic performance and multiple channels, such as in general purpose spectrum analysers and mobile data acquisition systems.

Conversion results are available in two bytes through an 8-bit tri-state output bus. The two bytes can be read in either order, allowing the use of the ADS7803 in both big and little-endian systems. Output latches are provided, giving two alternative data-availability schemes: in transparent mode, the high data byte can be read as soon as it is available; in latched mode, data can be read only when the conversion is complete, but stays valid until the end of the succeeding conversion cycle.

PORTABLE TV ANTENNA



Portasat is a lightweight, portable antenna which enables the owners of caravans, mobile homes and pleasure craft to continue to receive satellite TV programmes from Astra, ECS II and all higher power satellites, whilst on holiday. Deployed on a balcony or patio, Portasat also offers an alternative to occasional viewers who are unable or unwilling to have a permanent, wall-mounted antenna installation.

The antenna consists of a flat, 1cm thick, circular zone plate of 60cm diameter which is mounted within a rectangular, tubular frame. Erection requires no specialist knowledge or tools. With the assembly lying flat on the ground, one edge of the frame can be raised; the antenna then pivots within the frame and can be secured at the correct angle for signal reception by a support strut. The assembly is then pointed in the direction of the satellite and any final adjustment made by a screw on the strut.

The total assembly weighs less than 4kg and folds away flat to a size of 75 × 62 × 2cm.

4MBYTE FLASH MEMORY CARD

Mitsubishi Electric has announced the launch of its 4Mbyte Flash memory card. The card will be generally available early 1992 in 68 pin JEIDA Standard format although Mitsubishi has the technology to produce custom versions to any pinout requirement.

According to the latest In-Stat survey into the fast developing memory card marketplace, the company was responsible for more than 41% of worldwide memory card sales in 1990.

The 4Mbyte Flash Memory card is made up of Flash EEPROMs, housed in TSOP, the packaging technology pioneered by Mitsubishi, providing high speed, non-volatile memory capabilities, for low power consumption applications.

Typical applications include replacements for floppy disk systems and to hold systems and applications software in palm top, notebook, laptop and other small computers, providing savings of weight and space, with greater resilience, increased ruggedness and higher reliability. Flash memory card technology is reckoned to be a big contender to eventually replace floppy and hard disk storage techniques. The ability of Flash devices to hold their memory content after power has been switched off also makes the cards suitable for use in industrial equipment.

Mitsubishi has also announced paper-thin packaging (PTP), the 0.5mm thick IC packaging technology which will make it possible to retain its leadership and manufacture cards with even higher memory capacities. DRAM cards of up to 96Mbytes, for example, will be available based on the technology using 16Mbit DRAMs.

For further information, contact Mitsubishi Electric UK Ltd, Ltd, Telephone:0707-276 100.

New approach to welding flexible substrates

A new approach to forming metal contacts in electronic circuits could result from a novel elastic substrate. Using a new method, gold films have been welded together under normal room conditions by pressing them together with small applied loads.

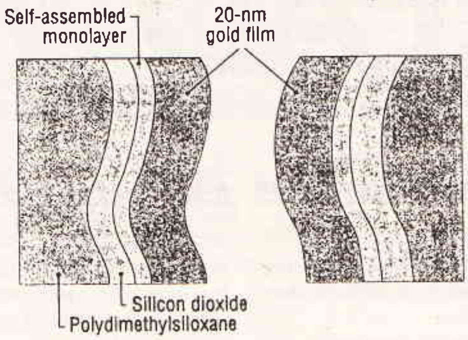
With current technology, extreme physical conditions of one kind or another are required for bonding metals; soldering and welding require high temperatures while room-temperature welding requires extremely high pressures.

The key ingredient in the new process is a material called polydimethylsiloxane (PDMS), which can be formed into thin elastic membranes. When exposed to oxygen at high temperatures, PDMS forms a silicon dioxide layer suitable for electrical isolation. Metals do not adhere very well to the silicon dioxide layer, requiring the application of an exotic process called 'self-assembled monolayers' developed at Harvard University's chemistry department.

Chemists have found that certain complex organic compounds can 'self-assemble' into complex structures on the molecular level with a wide range of useful chemical and physical properties. A self-assembled structure is able to form a strong bond between the silicon dioxide and a thin gold layer vacuum-evaporated on top. The resulting composite material is so flexible that the gold layer 'flows' around surface impurities that normally prevent metal bonding, allowing two gold/PDMS films to weld together on contact. The composite material, developed by Dow Corning of Midland, Michigan, could be the basis for novel electronics devices.

FLEXIBLE-SUBSTRATE WELDING APPROACH

It allows metal welding at room temperature



New notebook computer

Using a conventional notebook computer in the office is often uncomfortable and confining because the keyboard cannot be separated from the monitor. With a new computer, the screen and keyboard interface through a cable, as on a desktop. Normally, the two halves are joined together and the cable is kept hidden. In the new version, they can be separated, allowing users to spread out their work area. The keyboard can also be completely removed and attached to another CPU if a user wants to use the same keybaord for all computing activities.

Lunar Design Inc., of Palo Alto, designed the computer housing for Trigem Corp., cf Santa Clara. The housing, made of thermoplastic polyester and polypropylene components, is both strong and lightweight. The only metal part is an aluminium shield for the CPU electronics. Plastic clutches and latches hold the screen firmly and keep it from falling over when it is used while going over bumps. The 386-SX-based computer runs continuously for three hours on a rechargeable battery.

Electronic drawing pad

Children can draw directly on to a TV screen using an electronic drawing pad that hooks up to any colour television. The pad also connects to a VCR, so images can be animated and recorded. The micro-processor is similar to those used in adult-sized graphics programmes, but without being capable of storing designs. The wire-grid input pad is also similar to conventional graphics-input pads.

Called the Video Painter, it has a 12-colour pallete and five drawing tools, including a pencil and crayon. A library of over 50 colour objects includes vehicles, dragons, people, and animals, as well as three background scenes which can be animated. There are also six pre-programmed patterns, and outlines can be filled in with one touch, either with a pattern or a colour. The system permits artists to copy pictures as well as move and zoom in on them. There is also a tangram puzzle, where shapes are rearranged to create objects.

Source: V-Tech, Wheeling, Illinois.

Rechargeable battery system

New laws may force US manufacturers of products such as cordless shavers with rechargeable batteries to redesign their products. The laws come into effect in 1993 in some states, and require all built-in, rechargeable batteries to be easily removable so consumers can recycle the batteries.

Batteries are often soldered into rechargeable products, so meeting legal requirements will require some complete product redesigns. Manufacturers will also have to consider that consumers may replace rechargeable batteries with non-rechargeable ones.

A recently introduced rechargeable-battery system, called IntelliLink, from Gates Energy Products, Gainesville, Florida, allows manufacturers to design removable, rechargeable batteries into their products.

IntelliLink uses special batteries that have a dimple in the cap on the positive terminal. The positive connector has two contacts, a centre contact point and an outer contact ring that mate with the battery. The outer ring allows the battery to be recharged when the device is plugged into an electrical outlet. When a non-rechargeable battery is used, its flat terminal touches only the centre point and not the outer ring, so the charging circuit is bypassed and only the battery is discharged. If a conventional rechargeable battery is used, it also will only discharge and must still be recharged externally.

New insulation for aircraft cables

In a recent investigation it was found that fibreglass batting that surrounds wire bundle cables on airplanes was breaking down from hot engine air and vibrations. Without the batting, the electrical system experienced short circuits and sensor malfunctions. To eliminate the problems, it was decided to change to an insulating wrap made of silicon foam laminated with silicon-coated fibreglass. The new insulation was chosen because it is flameproof, fire retardant, virtually non-toxic, and light weight. In addition, it resists compression set and maintains integrity throughout vibration testing.

The fibreglass lamination adds durability and the foam can easily be bonded to other fabrics or substrates. This COHRlastic silicon foam, from the CHR Division of Furon Co., New Haven, Connecticut, can also be used for gasketing and sealing because it resists chemicals and moisture penetration. The foam is available in thicknesses ranging from 0.062 to 0.5 in.

READ\WRITE

ETI LETTERS

UV Go-ahead Through Paper On Draught

I was interested in the various letters in the ETI December addition relating to PCB production at home.

As a freelance designer in electronics, I make PCBs quite often for prototyping work. The artwork is produced on PC using Boardmaker II software, and printed out via a Mannesman Tally 905 laser' printer in HP emulation mode.

For a long time I used to produce the artwork on paper and have a local printer make a diapositive copy for about £2. This gives a fully transparent acetate copy with very dense black image. However, as it involved a 20 mile drive each way, I experimented with various options to produce my own transparancies. Acetate was the first option, but I was unable to obtain a dense enough printout from the laser printer and large areas were not evenly black. I then switched to draughting paper, which contrary to Mr Silvester's analytical laboratory's findings, is in fact UV transparant. The laser printer gives very good and even reproduction on it and the end result is both sharp and consistent. The same should apply to pen & ink drawings, although I gave up that method long ago. A good dot matrix printer will also yield usable results with a new ribbon. The software allows for reversed printing, so the image side is in direct contact with the unexposed PCB. The exposure time for the RS photoresist boards is 2 minutes. A critical factor not mentioned is the temperature of the sodium hydroxide developer which should be around 25°C. Too cold, and the board doesn't clear properly, too hot and the whole coating may come off.

The drafting paper is RS part number 561-448 (A4 — other sizes available up to A0). I have to date made very many boards with consistent results and saved a lot of time and fuel in the process!

Gerry Taylor,
High Humbleton,
Northumberland.

Mr Taylor sent in a laser printed example of a PCB design on draughting film and it is indeed a very good reproduction. We also tried it out on photoresist board with UV light exposure and had no problem in getting a board out of it. Thank you for your very helpful suggestions Mr Taylor, no doubt others will benefit — Ed.

The Window — An Open And Shut Case?

The Blueprint article by Andrew Armstrong in the November issue of ETI addressed the problem of remotely sensing whether each of a number of windows were open or closed, using a single cable to connect the windows in a chain.

The published solution used a reed switch at each window to switch the output of a tone generator onto the common supply line. The frequency of each tone generator was different from the others and a detector for each was built into the base unit to drive the display.

The alternative solution proposed here, whilst returning to reed switches, has the advantages of a much reduced component count in the remote circuits. Furthermore all of them are identical and need no setting up.

The system operates by sensing the state of the switches in sequence. The base unit supplies a pulse train to the chain of remote circuits, each of which routes the first pulse it receives to its switch. All subsequent pulses are sent to the next circuit in the chain (see figures 1&2).

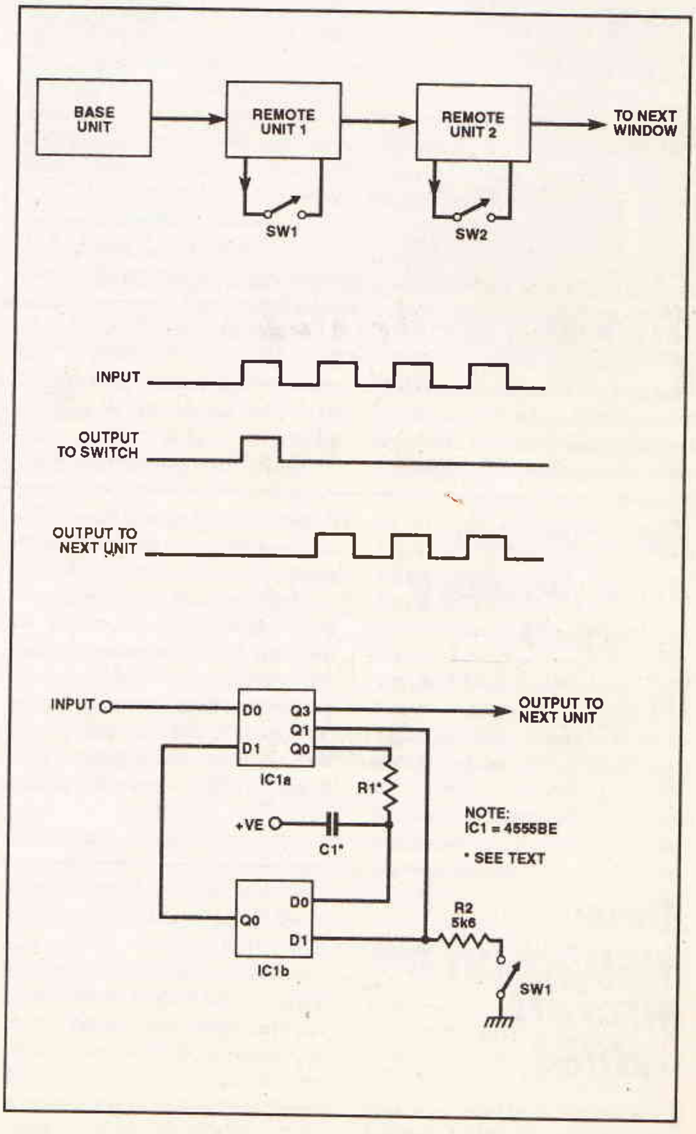
In this way, the first pulse goes to SW1, the second to SW2 and so on. The state of each switch is read by monitioring (in the base unit) the current in the power line to the chain.

A circuit for the base unit is not shown here, but the monitor output could be fed to a serial in/parallel out shift register, clocked by the pulsetrain and displayed as required.

Each remote circuit can be implemented using only one IC and very few other components as shown in Figure 3. A dual 2 line to 4 line decoder is cross coupled to provide the required switching and latching functions. The network R1-C1 is needed to remove glitches and ensure the correct state after powering up. The time constant should be a small fraction of the pulse period.

Nigel Smith,
Weston-Super-Mare

Andrew Armstrong replies:
Well done for thinking it out Mr Smith. It looks like a very sensible idea. If you can provide more details, maybe ETI will run it as an article.



R U 4 FX 2?

At last a project that has fired and held my interest for four months. I refer to the excellent series about the Nightfighter light show units by Mike Meechan.

As a regular reader of ETI since 1973, I have felt 'left out' in the last few years as the content of your magazine has changed. Where have the humourists gone? There are no cartoons or articles that poke fun at the institutions (Anyone remember Adzap?). There has been a decline in analogue circuits bands/disco/PA uses. Now is the time to redress the balance, so how about the following:

1,2/3,and 1/3 Octave equaliser with balanced/non balanced inputs.

Real time analysers for these with internal pink noise and Mic/Line inputs 2,3,4 way 6,12 and 18dB/octave crossovers, in fixed, switched range and fully variable crossover frequencies.

Digital delay lines that can be linked for stereo effects with 1 second delay.

Music/voice sample and hold with 10 second sample time.

Stereo Amplifiers 100, 200, 300watt. All into 4R. With MOSFETs,open and short circuit protected, Anti thump, over temperature and DC protection. Optional fan cooling switched by heatsink temp.

Mixing desks and disco mixers with all the usual facilities (the list was too long to print — Ed).

So after all that, less of the Brainwave monitors, computer controlled didgeridoos etc and more of the above.

Finally if someone could write a simple article on the operation of 2,3,4 and 5 way Parametric and graphic equalisers, I would be grateful.

D A Howard,
Brixton, London.

Your comments are welcomed. Would you believe we intend to feature a project on mixing desks very soon. Most of the items you suggest have appeared in ETI over the years in some form or other, including the excellent 'Business Bass Amplifier'. The heyday for audio effects modules seems to have been in the early eighties, before the Japanese had a grip on the market with the 'all-in one' FX box. The price factor and lack of any further ideas is probably the reason for scarcity in this field unless of course, you the reader, knows otherwise. — Ed.

The Plot Thickens

Further to recent correspondance about PCB plotting, my own experiences may be useful. We have the 'Pads' Professional System with an HP 7475A (A3) plotter. This will give prints for photographic use, but for 'kitchen sink chemistry' one-off's, the standard films are not dark enough. Contact with Ardale computer supplies (051 639 7878) produced fast results and samples with the usual disclaimer. The medium supplied was either translucent paper or Vellum. Both are equally good. The pen was a Staedtler (757PL- GS) with cross groove nib and dense black ink (747). Excellent results are obtained but the plotted speed must be under 20cm/sec - I use 5cm/sec. A 2 line program in DOS is required to slow the system down from its default level of 38cm/sec.

A processing time of 3 minutes on Farnell copper board gives excellent results.

Ed Dinning,
Durham

Solution CROSSWORD No. 1

S	A	B	L	E		A	M	M	E	T	E	R		M
T		A		R		R				U		E		E
R		B	A	N	D	G	A	P		N	I	F	T	Y
O		O		I		A		O		N		E		A
B	O	O	L	E	A	N	A	L	G	E	B	R	A	
E						D		E		L		E		F
	C	A	L	V	A	D	O	S		N	O	N	C	E
O		T		A		I		P		E		C		T
H	O	T	E	L		A	F	L	U	T	T	E	R	
M		E		V		G		I						V
	I	N	T	E	G	R	A	T	E	D	D	T	O	A
N		D		L		A		T		U		E		L
U	S	A	G	E		M	A	I	L	N	A	N		L
L		N		S				N		K		O		E
L		T	E	S	T	I	N	G		A	R	R	A	Y

Across: 1 Sable. 4 Ammeter. 8 Band-gap. 10 Nifty. 11 Boolean algebra. 13 Calvados. 16 Nonce. 18 Hotel. 19 A-flutter. 21 Integrated D-to-A. 25 Usage. 26 Mailman. 27 Testing. 28 Array.

Down: 1 Strobe. 2 Baboo. 3 Ernie. 4 Argand diagram. 5 Tunnel-net. 6 Reference. 7 Maya. 9 Pole-splitting. 12 FET. 14 Attendant. 15 Valve-less. 17 Ohm. 20 Valley. 22 Dumka. 23 Tenor. 24 Null.

ETI ELECTRONICS TODAY INTERNATIONAL 1991 PROJECT INDEX

20 YEAR PROJECT INDEX COMING SOON

ETI ELECTRONICS TODAY INTERNATIONAL

1991 FEATURES INDEX

20 YEAR PROJECT INDEX COMING SOON

2

Introduction to Audi

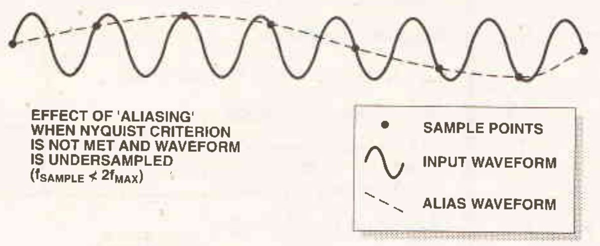


Fig.1 Effect of undersampling

Mike Meechan looks at he computerised and ligital aspects to mixing.

Last month, we looked at the basic elements which comprise an average mixing console. This month, we'll delve into the aspects of the console which lend themselves readily to digital or computer control.

Should one ask a person not intimately involved with the music industry what their initial impression of a mixer is, a likely response might be that it looks very complicated because of all the controls. Ask an engineer and he might say that initial impressions are deceiving and it is basically a series of simple controls replicated many times. (This isn't quite true as I have struggled for some time to get a test tone out of a mixer with which I was completely unacquainted!) It is in this region that some kind of automation might be most useful. We shall consider a large desk with perhaps 64 inputs and 48 group outputs.

Assignable Desks

Each of the 64 inputs will have an associated gain control, EQ system, Aux Mix system, Group Routing system etc. We have only two hands with which to make adjustments of the various controls, so at best he/she can alter only two controls simultaneously. In order that the desk size is kept as compact as possible, all of the controls by necessity must be made small and positioned close to one another, thus increasing the risk of operational error and reducing the relative ease with which a particular function can be quickly located. If only one or two control settings can be altered simultaneously, this makes the 3000 or so other controls on the desk somewhat redundant.

It is this philosophy which forms the basis for the design of a so-called assignable desk. In a sound desk of this sort, we have one set of controls which can be assigned at a particular time to any one channel (by pressing a CHANNEL ASSIGN button adjacent to the relevant fader) and a set of channel faders, one per channel, which set the channel level. What we do to operate the desk is to set the operating parameters of each channel using this one set of controls. These controls will consist of all those normally found on an input channel (gain, EQ, routing, pan etc). We assign these control settings to each channel in turn, gradually working along the console channel by channel until each is set. The setting for each channel will normally be stored in battery backed-up RAM so that the channel configurations are memorised even when desk power is removed. In this way, the settings of one particular channel can be altered without affecting other channel control settings. This approach means that quite significant economies can be made in the number of pots, switches and indicators which are fitted to the desk, with consequent reduction on the complexity and cost. The drawback is that now we no longer have any visual feedback of the control settings for a particular channel because there are now only one set of control knobs whose setting may no longer bear any

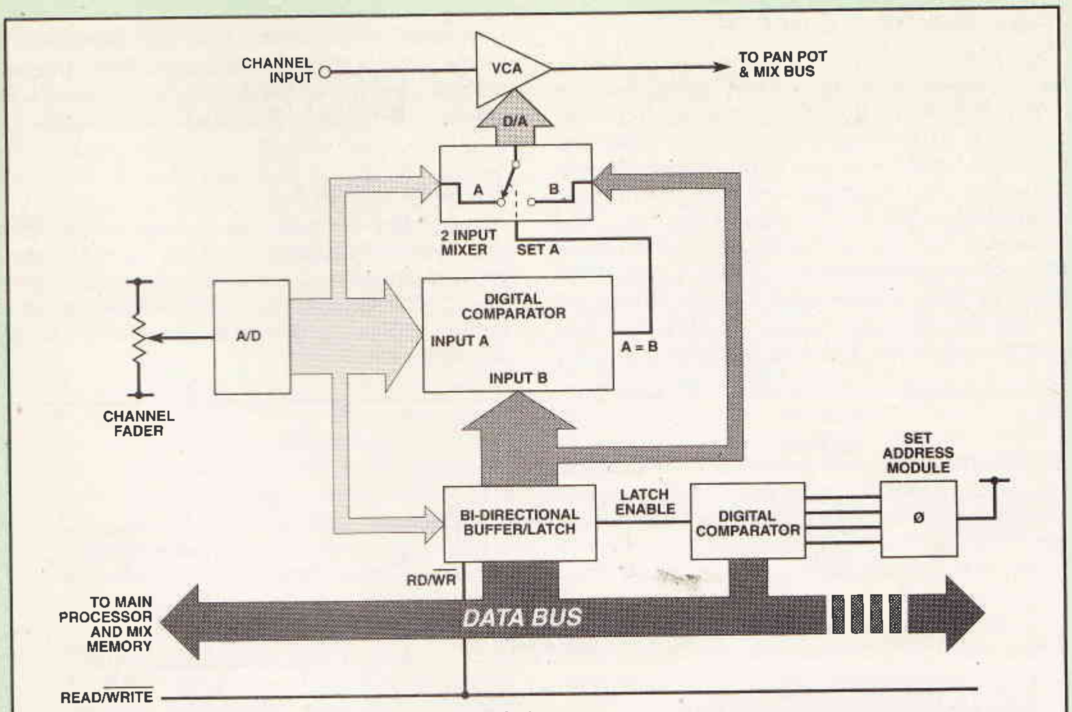


Fig.2 Fader automation using non-motorised fader

o Mixers

relation to those present, as each of the controls must now take the form of a shaft encoder. This problem is circumvented by the inclusion on each channel of LED displays which show the relevant control settings. An update function allows any control setting to be changed and the new value to be stored in the system memory.

An assignable desk is thus an analogue desk under digital control. Figure 1 shows a typical assignable desk. The desk control surface contains no audio circuitry, all control signals being derived from switches, faders, pots etc which are then sent to a rack mounted crate of audio control circuitry. The faders are also assignable, there being one fader per source and there is one set of controls on the desk, these altering all of the normal control parameters such as gain, tonal content and so on.

The controls on the desk surface are uniquely identifiable through a system of addressing, the same being true of the channel cards and mixer board. When a fader is assigned a channel, a software link between the two addresses is made and subsequent fader movements after assignation control a VCA in the audio crate. There are separate control and data busses carrying information between the desk and the audio crate. The memory can be used to store convenient or preferred set-ups.

The second application of computers as related to mixing is in what is known as computer-assisted mixing.

Computer-Assisted Mixing

This is different from the previous example in that we actually do use a proper sound desk in the conventional sense whilst coupling it to a computer, using this digital addition to take the drudgery out of some of the more boring tasks which have to be undertaken and using the computer's speed and memory retention facilities wherever these can be applied to improve performance.

There are four main areas in which a computer can be put to good use in the environment of studios and mixing consoles. These are:

Secretarial
Tape Machine Control
Total Recall
Assisted Mixing

We shall look at each in turn.

Secretarial

This is more or less what the title suggests. The computer is used to store lists of what is recorded on each track, for example snares on track 1, hi-hat on 2, bass

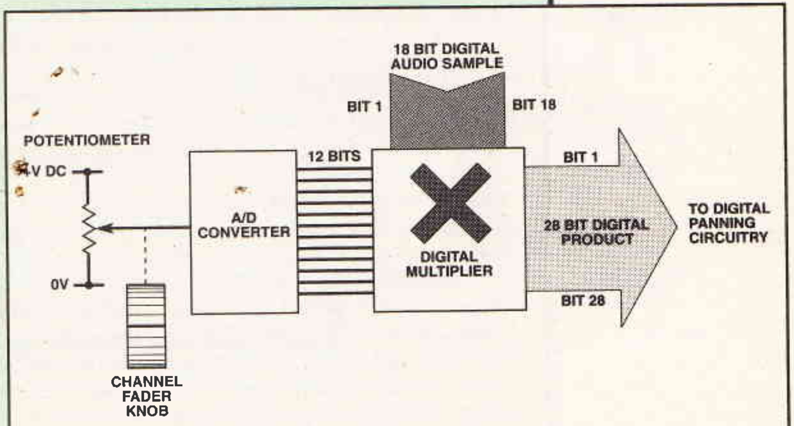


Fig.3 Typical Fader system in a digital desk

on 3 etc etc. The system is word processor orientated so that lists of titles, cue-points, retakes etc can be stored and edited, altered, deleted and supplemented at any time and virtually any information which otherwise would have been on pieces of paper can now be stored on floppy disk.

Information such as titles and timings of musical pieces, cues and track-lists (which may already be important for auto-locate functions) can also be stored.

Tape Machine Control

This is obviously of great use in a multi-track recording situation where, as discussed in Part 1, it is unlikely during the Recording part of the process that more than one or two tracks will be 'laid' at any one session and yet all 8, 16 or 32 tracks must be recorded exactly time coincident with one another and in exact synchrony. The ubiquitous SMPTE (Society of Motion Picture and Television Engineers) Timecode is recorded on one track of the multitrack and the computer can then control all aspects of tape transport control to an accuracy of within one frame of the timecode. This allows tape drop-ins and dropouts of great precision.

orientation may or may not bear any resemblance to its electrical effect in a circuit, they must also incorporate some means of easy and quick discernment of their actual setting. Again, LED's are the usual choice.

Digital Desks

A truly digital desk is one where, apart perhaps from the Mic Inputs, all signal control, routing and manipulation is done in the digital domain. One must ask the question, "Why go to the trouble of having a digital desk at all?" when many analogue desks perform admirably well.

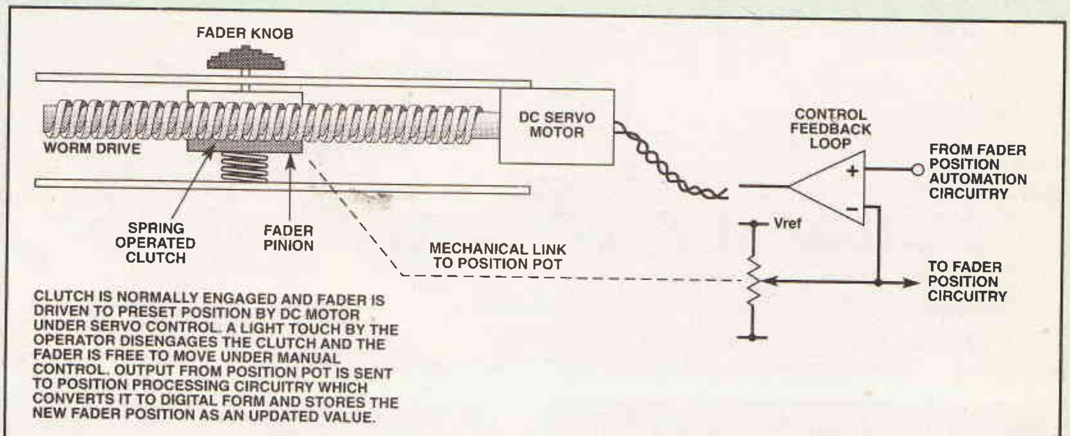


Fig.4 Typical fader automation system

Total Recall

No, not a sci-fi movie or even a hint of Arnold Schwarzenegger! The computer scans all of the controls (pots, switches et al) and remembers the settings. These can then be displayed on a VDU and individual control settings more readily scrutinised although the desk must be reset manually.

Assisted Mixing

Here, the computer remembers any movement of the fader during track starts by scanning the fader at the start position. It notes down the changes and can then make adjustments. TRIM on replay then adjusts the fader relative to an absolute value and so it mimics the first mix. One notable disadvantage is that the fader position does not reflect the gain through the system. (Other systems use different approaches, either motorised, servo-controlled faders which give control from machine to operator when manually touched or moved or a system where any fader movement is interpretated as relative to the previous setting although the fader may be in the same physical position).

Consequently, at any time and for each control there must be some sort of indication of the setting of a particular control since the physical setting of it does not necessarily reflect its electrical effect. This indication normally takes the form of LED's which show information normally available by inspection of its physical setting, ie a bargraph arrangement of LED's which may show gain.

Although the desk is in essence still an analogue desk because all the signals present in the console remain in the analogue domain and are processed and manipulated and mixed in this domain, no analogue signals pass through any of the controls. The outputs from the controls will be DC control voltages or pulses used to clock up/down counters, and will be pots or shaft encoders respectively. DC voltages will be used to control VCA's and related devices. Since these controls too can now have no pointer since their physical

To justify the extra cost and complexity of going digital, the desk must have a performance, in terms of noise, distortion, crosstalk and ease of use, better by an order of magnitude than its analogue counterpart. The original question still remains unanswered.

To understand the answer, most readers will have to look no further than the corner of their own living rooms. Yes, the gleaming, usually black, always-more-expensive-than-we-ever-imagined, domestic hi-fi stack. the present-day proliferation of high fidelity formats such as R-DAT, compact disc and the like means that the paying public — upon whose custom the record companies and artists depend for survival — is much more critically aware of noise and distortion and all of the other factors which spoil or impair their listening enjoyment. Gone are the halycon days when record company executives could rest smugly on their laurels, content in the knowledge that noisy recording or other sonic imperfections are unlikely to be noticed by Mr or Mrs Average on whose Fidelity Radiogram MkII the recordings were likely to be played. Since this age of the digit has heralded the need for previously unheard of quiet between tracks, there is now a tireless and impossible quest for aural perfection as manufacturers of sound equipment strive to out-do one another in terms of facilities and performance!

Digital desks give the designer and engineer much greater scope to improve noise, crosstalk and distortion performance while making it more operationally friendly. Allowing electronics to do the tedious and repetitive tasks frees the mixing engineer to allow his or her creativity full rein. Mixes need not be ruined by one careless mistake. They can be stored real-time or snap-shot, allowing the engineer to endlessly experiment, without losing the inspiration of the original. Pause to consider the vast number of 'different' remixes available of any chart song. . . .

If we can digress briefly and explain about Analogue/Digital conversion (and its complement), the wonders of digital desks will become more readily apparent.

Analogue to Digital Conversion

Sampling Frequency

The frequency response of the ear is readily accepted to extend from 20Hz to 20kHz, although most peoples' hearing starts to roll off above about 15kHz (especially in those people of more mature years). With reference to the Nyquist's criterion, we must sample the audio signal at more than twice the highest frequency present if any aliasing problems are to be avoided. For audio extending to 20kHz, this means a sampling frequency of more than 40kHz. The two sampling frequencies used in digital audio are 44.1 kHz and 48kHz.

The former is used for compact discs and also in digital recording systems where the audio will be recorded on video tape, making use of an adaptor such as the Sony F1 which formats the audio in such a way that it is compatible with the process used to store video information on magnetic tape. The 44.1 kHz is mathematically locked to this concept and relates to the way in which the audio is inserted into the active lines of a television picture. We shall avoid digressing further and accept that there will be 3 samples per line for 588 lines of a 25Hz (PAL UK) picture.

48kHz is the standard used by professionals since it readily lends itself to both the EBU (European Broadcasting Union) standard for the 32kHz used in VHF FM transmitter chains (a 3:2 ratio) and for PAL UK recording (using the system outlined above). 1920 samples per picture can be fitted. The ratios are also correct for recording using the NTSC 60Hz standard.

Bits and Pieces

Now that we have chosen a sampling frequency, how many bits resolution do we want? Really, it depends upon what dynamic range is necessary at a given point in the signal path.

It is easily shown that dynamic range equates to:

$$(6 \times n)\text{dB}$$

where n is the number of bits per sample. The multiplicand is 6 since there is a 6dB increase in range for a twofold increase in the number of bits. Therefore a 12-bit digital signal will have a 72dB dynamic range. This is an over-simplification since we have assumed a perfectly noise-free signal, which, even in the digital domain, is a practical impossibility. It is accepted that the weighted signal/noise ratio of a digital signal is:

$$(6 \times n) - 11 \text{ dB}$$

We can now consider all of the above in the context of a digital sound desk. A microphone input may need to have an effective sensitivity down to −120dBu or thereabouts. This equates to 22-bit resolution, which is far beyond the capabilities of any analogue to digital converters on the market. Instead of direct conversion of the analogue Mic signal, it is amplified and this higher level signal is then converted to a 16-bit digital sample. 22-bit accuracy is maintained by incorporating a 3-bit range code into the sample, this effectively compressing the signal to 13 bits with the three range bits indicating in what one of eight possible ranges the sample lies in. This is similar in many ways to the digital companding used in systems such as NICAM.

As previously noted, all of the facilities available on an analogue desk should be available on the digital counterpart. These facilities must include EQ, Routing, Fading, Gain Control, Special FX and Mixing. We shall deal with each in turn.

EQ

This is performed using digital filters. Even a very brief discussion on the workings of digital filters would involve a multi-part article on its own, and besides, it is beyond the scope of an article such as this to tread such deep water. In any event, there are numerous good books available on the subject, packed to the covers with complicated maths and analysis, and interested readers may wish to delve more deeply into the subject. As far as this introduction is concerned, it is sufficient to say that transversal or finite impulse

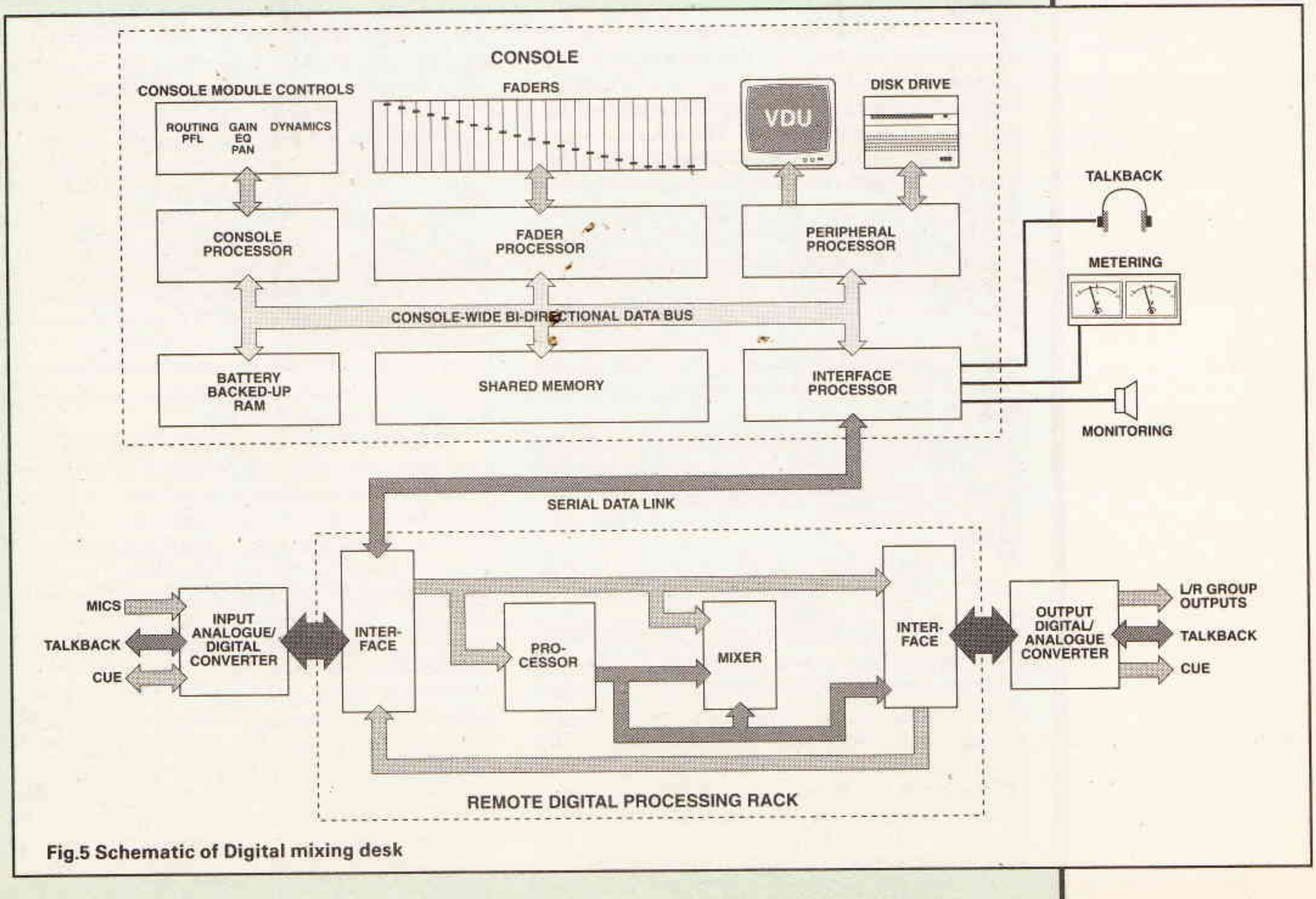


Fig.5 Schematic of Digital mixing desk

reponse filters are normally employed for the task, since these are more inherently stable than infinite impulse response types, and, as with their analogue cousins, various filter responses can be achieved by cascading different sections, different sections in this context meaning adders, multipliers and delays. The diagrams show a very simple digital filter function.

Routing

This is achieved using Time Division Multiplexing techniques wherein samples are allocated unique timeslots for source and destination, and so a change in the ordering of the bitstream of these timeslots effects a change of routing for a given sample. This is a more satisfactory and reliable method of routing than in an analogue desk, where the multitude of switches and connectors are prone to wear and consequent noisy operation.

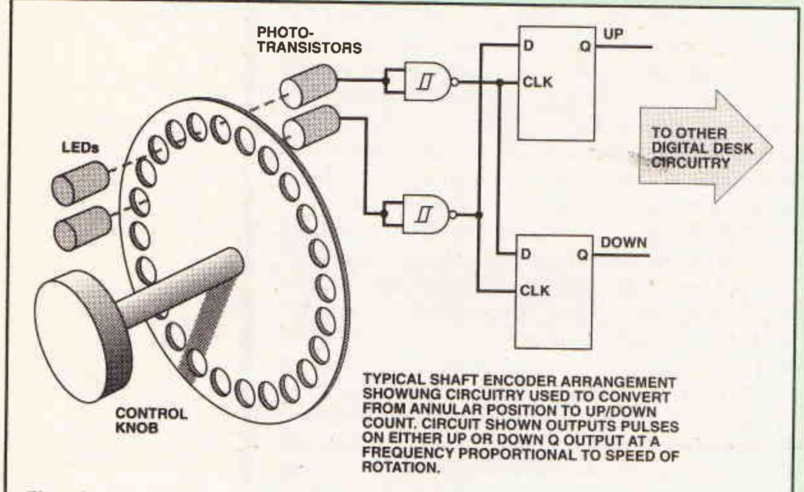


Fig.6 Shaft encoder

Fading

Fading is achieved using multiplication techniques. We shall assume for all instances that it is a multiplication process and consider that for co-efficients of less than one that the process is still multiplication and not division, as is the usual convention. The fader output is a DC voltage proportional to its relative position. This analogue voltage is converted to digital form and the resultant number used to multiply the digital audio sample. For a unity output from the fader, the audio sample value will remain unchanged after passing through the multiplier.

Gain Control

This is identical in all respects to fading, with the ouput from the gain control knob being converted to digital form and used to multiply the sample.

Special FX

This may encompass effects such as reverbration, delay, pitch-changing etc. In delay, the samples are simply written into fast memory, and read out of this memory when needed.

Mixing

This is simply the binary addition of samples and is similar in many respect to the way that sources are mixed in an analogue desk.

The major problem in a digital sound desk is not in the implementation of any of the above functions (most of which can be done with relative ease) but in completing the processing task in the very short time available. If we consider gain control where a typical 16 bit audio sample is to be operated on (multiplied) by a 12 bit gain setting sample number, k. This multiplication of 12 bits by 16 bits renders a 28 bit product. The mixing bus must therefore be capable of handling 28 bit numbers. It must also do all of the processing required in one period of the sampling frequency, ie 1/48,000th second and we must also consider that there may be 30 or 40 different operations to contend with at any one time on a typical input channel. This is further complicated by the number of input and output channels present in the console, all of which are contending with one another for the processor's attention. It should be easy to see that any processor must perform millions of complex calculations every second that the console is in use. This is beyond the capabilities of almost all processors and so a dedicated maths co-processor is allocated the task of number-crunching while another processor does the house-keeping.

Finally, no article on mixers would be complete without the mention of MIDI or Musical Instrument Digital Interface. This is a Yamaha-proprietary asynchronous serial data interface protocol, similar in some aspects to RS 232 but operating at 19,200 baud and using different methods of handshaking etc. As far as mixers are concerned, it is used on some, via an interface connection, to control all of the desk automation facilities which will normally include Channel Mute, Fader Level and Group Routing. Control is instigated from a central sequencer which may also control a tape machine with a MIDI interface card and musical instruments such as synthesisers.

Doing It Yourself

There are numerous occasions now where some form of audio mixer would come in handy, be it for creating a soundtrack/commentary for video recorded material using a camcorder, for house parties or for aspiring bedroom mixing engineers/musicians. There are a wealth of units available, but now that we have discussed in simple terms some of the ins and out of mixers, I would hope that some of our readership will attempt the challenge of designing one from scratch.

The apparent complexity of a desk is minimised if we try to keep uppermost in our minds that any console, no matter how large or small, is simply a collection and vast repetition of small, inter-connected analogue circuits (I think that I can rightly assume that no-one is likely to attempt to construct a digital desk!)

Once the basics of an input channel module are understood, for example, it becomes much easier to analyse, understand and even design other modules such as monitor, group and master, since these modules will also use many of the circuits and concepts already apparent in the unit already scrutinised. Again, as we mentioned earlier, there may exist more elegant or higher performance techniques of circuit design to implement a given function, but the overall philosophy remains the same, any radical deviations from the norm usually involving expensive custom-designed IC's or cunning circuits which themselves are probably the subject of patent protection.

Whatever the circuit, it should perform well, operate reliably, preferably use a minimum of mechanical or electro-mechanical components, and use a minimum of expensive or difficult to get hold of hardware. If this sounds reminiscent of normally-employed good electronic design practise, well it is although it takes on new significance if we remember especially that any extra cost incurred in the implementaion of one function will be replicated many times over when the console is considered as a whole.

It is very tempting to think, "Ah, using such-and-such a switch or component or whatever gets me out of a jam, looks better, performs better or whatever . . .", when another approach, although more difficult in terms of time, slightly less expensive etc may suffice. This is a very difficult temptation not to succumb to, especially since the said item may only add perhaps £1.00 or so to the cost of that particular circuit. Multiplied, as we said, perhaps some 50 or 100 times, this small increase in cost becomes slightly more significant, and again, this is for just one circuit. A similar scenario may be re-enacted 100 times in the design of a whole desk. The ideal design is always a compromise between what is best for the job, what can I accept, what do I really want and most importantly, what can I afford. A bit like everyday life really. . . . . It is also similar in many aspects to hi-fi, sports, photographic or any hobby equipment where even a slight increase in performance in terms of durability, reliability etc usually brings a twofold increase in cost.

The idea of a 'noise budget' is also worth some contemplation as using 0.01% resistors, for example to create a front-end noise performance which far exceeds that of the remainder of the desk (because it uses devices such as the 741 as Mix Amps) is obviously somewhat wasteful of effort and resources and very bad practise. If this sounds elementary, my dear Watson, it is intriguing to ponder why, some years ago, one commercial manufacturer produced a mixer excellent in all aspects but for the fact that it used said low performance devices in critical parts of the circuitry.

With the present abundance of readily obtainable, inexpensive, custom audio IC's, careful consideration must be given to whether or not the designer uses these in his/her design. Time and effort spent designing circuits using discrete components can be saved in enormous quantities if a no-nonsense, custom IC is used in place, perhaps with the added bonus of performance equal to or surpassing that of the discrete approach. If this sounds contradictory to what was said not three paragraphs back, it is because we as amateur designers have the freedom to design purely for performance, with little or need for commercial viability. Indeed, the author suffered a similar quandry when the recent introduction of just such an IC rendered his burning-the-candle-at-both-ends-discrete-component-job obsolete since it needed just a handle of ancillary parts and out-performed it to boot. Audio circuit design is fascinating in that nothing is ever cut and dried and whereas with the design of digital circuits, it is invariably possible to dispense with the breadboarding stage, analogue circuitry has endless scope for tweaking and experimentation which can sometimes realise a design which is very close to text book specification.

Any serious investigation of audio mixer design would, of necessity involve much complicated mathematics and analysis. It is obviously beyond the scope of an article such as this to delve as deeply into the subject, and in any case, if this were not so, any text would serve merely to scratch the surface since there exist in print many good and lengthy volumes on this subject. IC manufacturers' Data Sheets also provide an invaluable source of information and inspiration and no design work should be undertaken before the contents of these have been thoroughly digested. I hope that this series of articles has served to whet the appetites of budding audiophiles and perhaps will inspire some of our readers to experiment and pursue his/her own designs to completion.

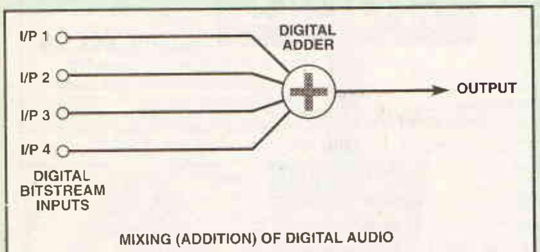


Fig.8 Digital implementation of mixer functions

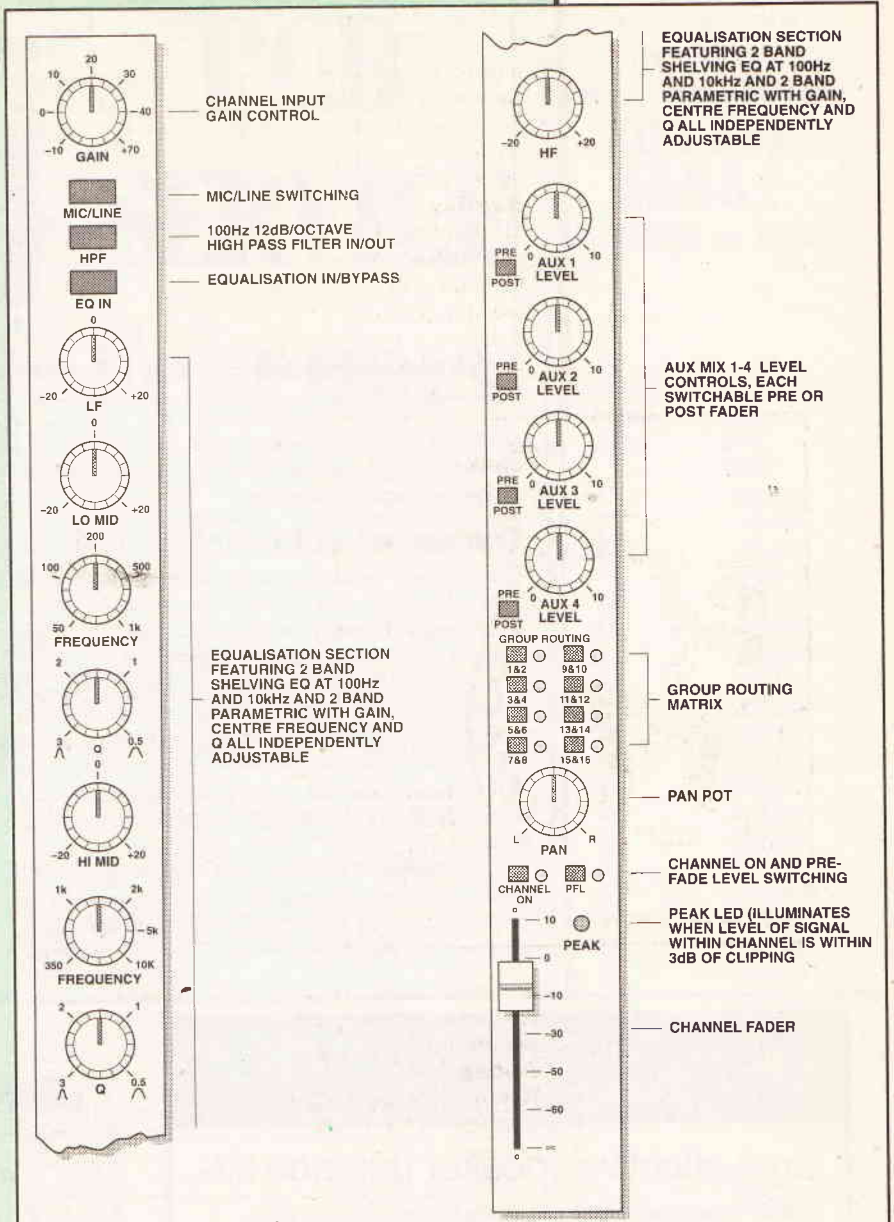


Fig.7 Typical input module

A method which I have found to be of great use is firstly to study mixer manufacturers' information sheets which detail the facilities available on a given console within their range and then to devise circuitry for the functions which are of interest. This is better than having a circuit and then trying to fit it to a function. I used this philosophy to great effect when designing the Nightfighter (ETI September '91) There is immense satisfaction to be had from pursuing a concept through circuit design, prototyping and development to fruition.

I mentioned in Part 1 that there would be a listing of the different kind of mixing consoles available, their functions and the use to which they are normally put. We shall conclude the series with that list.

Multitrack Consoles

We have looked at these extensively, but for completeness, we shall say that these are used in the creation of multi-track recording, with some of the cleverer desks able, through the use of Channel Flip buttons which bypass the Group Routing Matrix, to be used directly as stereo consoles. Consoles are extremely flexible, with many of the Tape Returns and Monitor Inputs able to be used as Mix Inputs during mixdown. This is done using Subgroup switching. Stereo desks are also

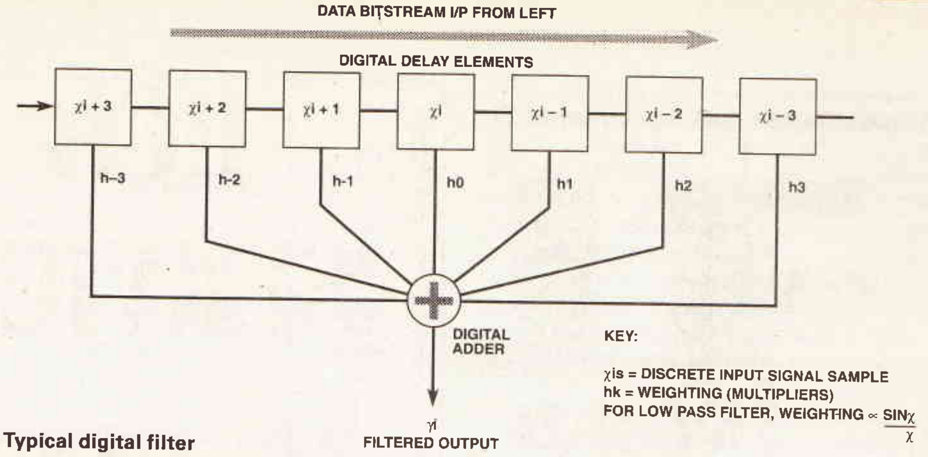


Fig.9 Typical digital filter

produced in similar formats and may be used for stereo drama productions or for the recording/broadcasting in stereo of a concert.

Transmission Consoles

This type will be used in radio stations and may be either self-operated or used in a Control Room/Studio environment. The self-operated desk is similar in many respects to the disco mixer with which many of you will be acquainted, the presenter (or DJ) using the console himself, adjusting levels and doing the programme presentation. There may be studio operators assisting him by cueing and starting records, tapes and jingle cartridges or these may be remotely-started by him/her using remote-start buttons on the desk control surface.

The second type is more prevalent within professional broadcasting organisations, the presenter or presenters seated in a sound-proofed, miked studio adjacent to the control room. The control room houses the console and all other studio equipment and the desk operator deals with all technical aspects of the programme, adjusting levels, starting record decks etc to cue, switching mikes on, dealing with any outside contributors like phone-in guests, outside sources such as reporters, and newsroom feeds. The desk will be well-equipped with outside source selection panels, cue and clean-feed mix facilities, talkback facilities and studio monitoring facilities (which control studio and cubicle loudspeaker feeds and cut or dim these when a microphone is live, thus preventing howlround).

Live Music Mixers

These will be used extensively by bands and musicians. Again, they are similar in many aspects to a multitrack or stereo desk, with Pan, EQ, etc all available although the desk will be similar, too, in many ways to the transmission desk in that it will have extensive monitor and cue mix facilities for the origination of foldback and stage monitor mixes.

ELECTRONICS TODAY INTERNATIONAL

PCB SERVICE February

TELEPHONE ORDERS may be made on (0442) 66551 ACCESS or VISA

Price code	Price (inc. VAT)
C	£1.80
D	£2.50
E	£3.25
F	£4.00
G	£4.75
H	£5.50
J	£6.62
K	£7.20
L	£8.80
M	£10.60
N	£13.10
O	£15.80
P	£17.90
Q	£21.80
R	£23.90
S	£25.90
T	£29.00
U	£32.20
V	£35.80
W	£37.90
X	£40.70

E9202-1 Timer — Counter Driver (double sided) .... F
E9202-2 Timer — Time Base (double sided) .... F
E9202-3 Timer — Power Supply C

PCBs for the remaining projects are available from the companies listes in Buylines.

Use the form or a photocopy for your order. Please fill our all parts of the form. Make sure you use the board reference numbers. This not only identifies the board but also tells you when the project was published. The first two numbers are the year, the next two are the month.

Terms are strictly payment with order. We cannot accept official orders but we can supply a proforma invoice if required. Such orders will not be processed until payment is received.

E9103-3	SSB Radio Receiver	G
E9103-4	Active Loudspeaker board	H
E9104-1	Testmeter Volts	E
E9104-2	Active Direct Injection Box	F
E9104-3	EPROM Eraser	F
E9104-4	Digital Tachometer	F
E9104-5	Radio Calibrator	F
E9105-1	Modulator Laser (2 boards)	H
E9105-2	Thyristor Tester	F
E9105-3	Frequency Plotter	K
E9106-1	Laser Receiver	F
E9106-2	Temperature Controller — Power Supply	G
E9107-1	Tempe.ature Controller — Main Board	K
E9107-2	Temperature Controller — Probe PCB	F
E9107-3	The Foot Tapper — Volume Control (double sided)	J
E9107-4	The Consort Loadspeaker	H
E9108-1	Pulsed Width Train Controller	E
E9108-2	Model Speed Controller — Main Board	F
E9108-3	Model Speed Controller — Power Supply	F
E9109-1	Geiger Counter	E
E9109-2	Hemisync Waveform Generator Board	G
E9109-3	Hemisync Pulse Generator Board	F
E9109-4	Hemisync Power Supply Board	C
E9109-5	Nighfighter Main Processor Board	O
E9110-1	Freeze Alarm	E
E9110-2	Document Saver	E
E9110-3	Proto-type Designer	J
E9110-4	Nightfighter — Sound to Light (double sided)	L
E9110-5	Nightfighter — Ramp Generator Board	F
E9110-6	Nightfighter — Cyclic Crossfade (double sided)	M
E9110-7	Nightfighter — Strobe Board (double sided)	J
E9110-8	Nightfighter — 8 Channel Triac Board	N
E9111-1	Digital Code Lock	L
E9111-2	Switched Mode Power Supply	E
E9111-3	Nightfighter Mode Selection (double sided)	J
E9111-4	Nightfighter — Display Board (double sided)	M
E9111-5	Nightfighter — Bass Beat Trigger (double sided)	L
E9111-6	Nightfighter — Sequence Select (double sided)	H
E9111-7	Nightfighter — Master Controller PSU	K
E9111-8	Nightfighter — Output Switch (double sided)	M
E9112-1	Nightfighter Sensor Switch Master Control (double sided)	L
E9112-2	Nightfighter Sensor Switch Channel Control (double sided)	L
E9112-3	Nightfighter Sensor Switch Sound Trigger	H
E9112-4	Nightfighter Connector Board	F
E9112-5	Nightfighter Sensor Switch PSU	K
E9112-6	Nightfighter 8-Channel Input Interface (double sided)	P
E9112-7	Power On and Overload Regulator	P
E9201-1	Laboratory Power Suppy	F
E9201-2	Test Card Generator Board	M
E9201-3	LED Star (double sided)	L
E9201-4	Enlarger Timer Main PCB (double sided)	N
E9201-5	Enlarger Timer Selector Board (double sided)	K
E9201-6	Enlarger Timer Switch PCB	E

TO: ETI PCB SERVICE, READERS' SERVICES, ARGUS HOUSE, BOUNDARY WAY, HEMEL HEMPSTEAD HP2 7ST

Please supply:

Quantity	Ref. no.	Price Code	Price	Total Price

Post and packing £0.75

Total enclosed £

Please send my PCBs to: (BLOCK CAPITALS PLEASE)

Name ....

Address ....

....

.... **Postcode** ....

CHEQUES SHOULD BE MADE PAYABLE TO ASP Ltd.

Comet Halley on 10 March 1986 (photo reproduced by kind permission of Royal Observatory, Edinburgh)

COMETS

The nature of comets by Douglas Clarkson.

For a variety of reasons comets have always caused humanity to speculate about their origin and what they may portend. While most of the phenomena of astronomy fit nicely into known and measurable cycles, and some comets take on the characteristic of an 'old faithful', other comets of the so called 'wild' type can enter the solar system in a totally unpredictable way. This greatly upset the ancients who preferred to be able to predict the appearance of any skyward phenomenon.

The word comet comes from the Greek 'kometes' meaning 'hairy one', derived presumably from the tail observed with such visitors. In the clear and unpolluted skies of the ancient world, comet gazing with the naked eye would have been easier than in today's modern world where there is so much light pollution.

Within the world of science, comets have always had their great enthusiasts who have observed new comets and proposed theories for their origin and lifecycles. It is only recently that aspects of their research have been seen to be directly relevant to the development of life on earth. One theory suggests that the greater part of the water on planet earth originated from vast numbers of comets which collided with the earth since its formation. There are also revolutionary theories that comets over long life cycles round the sun and in deep space can synthesise complex organic molecules which are important building blocks in the evolution of carbon based life forms. There are even theories that comets can distribute self replication organisms such as bacteria and viruses between star systems.

Newtonian mechanics

While aspects of these ideas will be considered later, comets can be relatively well understood on the basis of objects subject to Newtonian mechanics. The dominant influence on comets while in the solar system is the gravitational attraction of the sun. Figure 1 shows the different types of orbit which comets can occupy while either 'passing through' or lodging within the solar system. While the planets occupy elliptical orbits which are usually close to circular, comets can travel along elliptical (short and long period), parabolic and hyperbolic orbits.

Kepler reviewed the extensive and highly accurate observational data of Tycho Brahe in order to formulate his three laws relating to planetary motion. The first of these was that planets move in an ellipse with the sun at one focus. His second law indicated that a straight line connecting the planet with the sun (the radius vector of the planet) sweeps through equal areas in equal intervals of time. In figure 2 the various sectors C1-C2, C3-C4 and C5-C6 which are of equal areas are swept out in equal times. This implies that objects in elliptical orbit travel more rapidly when they are closer to the sun. The law also applies to comets in elliptical motion round the sun.

His third law states that the squares of the periods in which the planets describe their orbits are proportional to the cube of their mean distance from the sun. This third law can be simply shown for an object in a circular orbit.

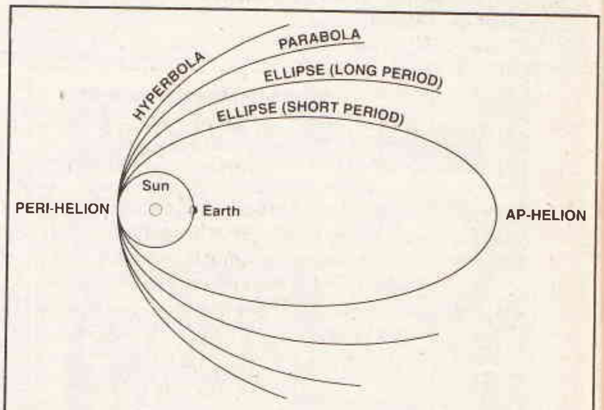


Fig.1 Possible orbits of comets round the sun.

The gravitational force acting on the planet or comet of mass m at radius R from the sun mass M is:

$$\frac{GmM}{R^2}$$

where G is the gravitational constant.

This in turn is equal to the centripetal force experienced by the planet/comet in its orbit:

$$\frac{mV^2}{R}$$

Equating these two forces:

$$\frac{GmM}{R^2} = \frac{mV^2}{R}$$

Since the period T, of the planet is given by

$$T = \frac{2\pi R}{V}$$

$$T^2 = \text{const} \times R^3$$

Thus for T=1 year and R=1 AU for earth, the period of rotating objects in the solar system is:

$$T = R^{1.5}$$

Table 1 indicates how the value of T changes with value of R in AU.

It is possible, based on simple consideration of

Comets

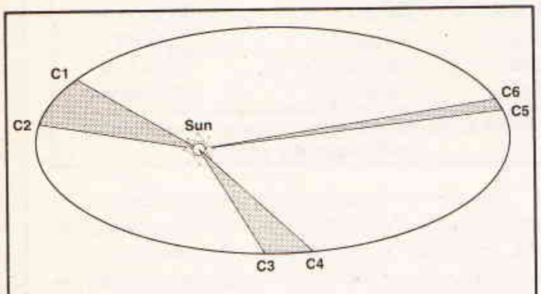


Fig.2 Equal areas C1-C2, C3-C4 and C5-C6 are swept out in equal times for masses in elliptical orbit round the sun.

energy, to determine whether a comet will be bound within the solar system or be able to escape from it. The energy per unit mass can be described as:

$$0.5\ V^2 \text{ (kinetic energy)} - \frac{GM}{r}$$

where V is the velocity of the comet, M the mass of the sun and r the distance of the comet from the sun. If this value is greater than zero the comet is unbound and its path is a hyperbola. If it is zero then its path is a parabola. If its value is negative, the comet is bound and it moves around the sun in an ellipse. If therefore a comet interacts with the gravitational fields of planets it can gain or lose 'energy', resulting in modification of orbits accordingly.

Value R (AU)		Value T (earth years)
1		1
2		2.83
3		5.2
4		8
8		22.6
10	(Jupiter Orbit)	31.6
12		41.6
15		58.1
20	(Uranus orbit)	89.4
25		125
30	(Neptune orbit)	164
40	(Pluto orbit)	253
50		353.6
60		464.8
70		585.7
80		715.5
90		853.8
100		1000

Table 1: Values of radius of orbit (AU) and computer value of orbital period.

Comet Trajectories

Modern computers can readily calculate the orbit of a comet from a set of observational data. The problem is significantly complicated by perturbations arising from interaction from the major planets of the solar system. Some interactions will act to speed them up or slow them down in their cycles or even perturb their path significantly. While comets such as Halley's may have cycles of the order of 76 years, perturbation during each cycle require to be determined before the exact appearance of the comet can be predicted.

Figure 3 shows the interaction between Brook's comet and Jupiter in 1886 which changed its period or revolution from 29 to 7 years. There is in fact a 'Jupiter set' of comets which have been perturbed by Jupiter so that they occupy orbits around the sun within its orbit. (Jupiter's mass is approximately 300 times that of the earth.)

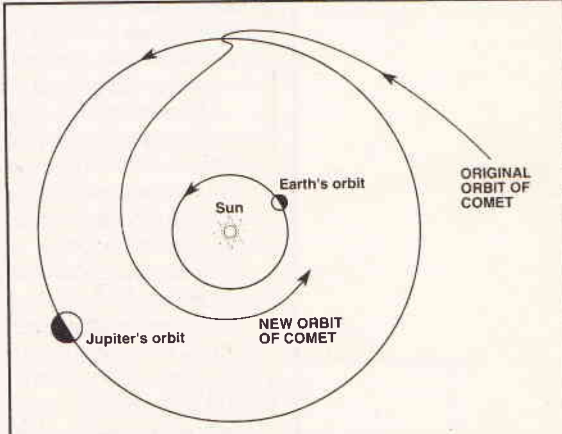


Fig.3 Diagram showing how the orbit of a comet can be perturbed by Jupiter.

In the description of elliptical orbit comets, the value of the perihelion gives the 'closest' distance from the sun, the aphelion being the 'furthest' distance from the sun. Table 2 below gives values of a range of a selection of 'famous' periodic comets to give an indication of their general characteristics.

Name	first seen	period (yrs)	perihelion (AU)	aphelion (AU)
Halley	240 BC	76.09	0.59	35.33
Lexel	1770	5.6	0.67	5.65
Encke	1786	3.3	0.34	4.09
Flaugergues	1811	3094	1.04	423.66
Pons-Winnecke	1819	6.34	1.25	5.61
Great Comet	1843	512.57	0.006	128.09
Donati	1858	1950	0.58	311.55
Tebbut	1861	409.11	0.82	109.4
Cruls	1882	758.37	0.008	166.32
Humason	1962	3000	2.133	406.91
Ikeya-Seki	1965	879.88	0.008	183.64
Bennet	1970	1680	0.54	281.86

Note: AU = 1 astronomical unit = distance of earth from sun (Pluto is approximately 50 AU from the sun.)

Table 2: Details of some 'famous' comets.

The periodic comets which pass close to the sun and suffer sublimation of their materials, are of necessity transient phenomena in the life cycle of the solar system.

Origin and Distribution of Comets

As to number of comets in the vicinity of the solar system, ie within several hundred AU, values of between 100,000 to 150,000 have been postulated though the number may be several millions. Comets not only occupy the zone of volume as far as the outer planets of the solar system but also extend far out to where the sun appears only as a faint star in the crowded firmament.

Comets only become visible when the heat from the sun sublimates particles from their surface. This usually happens at a distance of 3 AU. Thus comets in orbit round the sun which do not venture closer than this value corresponding to between the orbit of Mars (1.5 AU) and Jupiter (5.2 AU) cannot at present be detected. Their distribution is unknown.

It has been suggested that a vast reservoir of comets exist in the region of the solar system which, owing to perturbations, either pass through relatively unscathed or are 'captured' by planetary interactions. The so called Oort-Opik cloud is believed to be a vast reservoir of ancient comets which have remained outside the orbit of the main planets of the solar system.

This cloud margin is considered to extend out as far as 50,000 AU or 1000 times greater than the known extent of the solar system. Little is known about these comets in terms of distribution and trajectories. When comets from this region are perturbed and fall towards the sun, they are as it were messengers from the time of the birth of the solar system.

Perhaps there is some intuitive awareness that comets do play an intriguing role in cosmic cycles and that this accounts for their aura of mystery. As to what the perturbing effects could be which gives rise to the inward flight of such material towards the centre of the solar system possible agents are passing stars or clouds of gas and dust. Comets could in fact be the left-over material from the evolution of the solar system.

In terms of distances in the solar system, it is useful to describe this in terms of light years. One AU is approximately 9 light 'minutes' (time taken for light to travel from the sun to earth). The distance to 50,000 AU is approximately 0.8 light years. The distance to the nearest star Alpha Centauri is 4.3 light years. The perturbing material in this region is highly unlikely to be observed directly and so probably will remain a mystery.

What must be obvious from the orbit and period data is that comets in orbit in this external region of the solar system must have exceedingly long orbital periods. An object orbiting at 10,000 AU will have an approximate period of a million years and one at 50,000 at the probably extremity of the Oort-Opik cloud of 11 million years.

Influence of Comets on Planetary Bodies

The effect of comets on the major planets of the solar system is an issue of scientific debate. Data from the Dynamics Explorer 1 satellite indicated that each year as many as 10,000,000 mini comets weighing as much as 100 tons vapourise in the earth's atmosphere each year. (A comet of 10 tonnes mass assuming a density of 300kg/m^3 has a diameter of about 4 metres.) This rate of collision would produce in a period of 10,000 years an approximate increase in the world's ocean depth 25mm. Moreover, in an assumed lifetime of 4.5 billion years of the earth, this mechanism could account for all the water in the world's oceans. Thus water, the life giving element on planet earth, could have an altogether cosmic origin.

The planets Neptune and Uranus are thought to have extensive amounts of ice/water due to the cometary impact theory over a prolonged time scale.

High flying aircraft such as the U-2 have been able to detect so called Brownlee particles in the upper atmosphere which are thought to be produced by comets which graze the upper atmosphere and melt 'gracefully', releasing their burden of embedded dust particles in the process.

Comet tails are known to contain a range of solid particles as frozen material sublimes as a result of solar radiation incident on its surface. Where, for example, the earth passes through the path of such cometary debris, this can lead to significant meteor activity. Table 3 outlines the major meteor showers associated with previous comet transits in the vicinity of the earth.

Shower name	Average date of maximum	associated comet
Lyrid	April 22	1861 I(Thatcher)
Draconid	October 9	Giacobini-Zinner
Perseid	August 12	Swift-Tuttle
Leonid	November 17	Temple-Tuttle
Geminid	December 14	3200 Phaeton

Table 3: Terrestrial meteor showers associated with cometary tails.

The activity of a particular shower depends on an extensive number of parameters and may vary considerably from year to year. Also meteor showers associated with a comet are likely to be brightest during the first encounter.

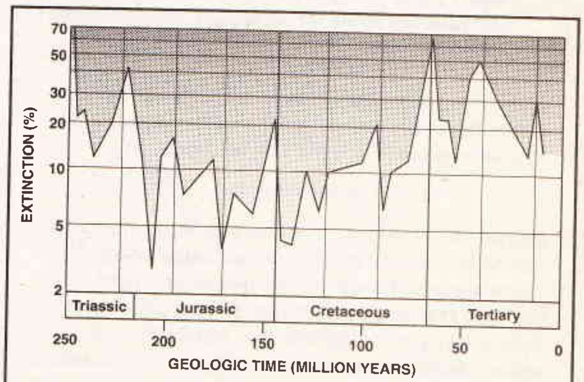


Fig.4 Diagram showing rates of repetition of biological extinctions.

Interest has centred recently on the mini planet Chiron which occupies an orbit between Saturn and Uranus. It is considered that this object, with an icy nucleus of some 350 kilometers, could in fact be a giant comet. Calculations show that several thousand years hence its orbit could be perturbed by Saturn so that it could fall towards the sun as a spectacular comet.

Figure 4 shows an estimation of the frequency of extinction of biological species. A cycle of 26 million years appears to be evident. Is this due to perturbations in the cloud of comets in the solar system? Fortunately we do not appear to be close to a 'natural' biological extinction.

Famous Comets

Halley's comet is certainly the best known comet in the solar system. Being first observed in 240 BC by the Chinese, it has been a faithful companion in its orbit which is shown in Figure 5, extending out between the orbit of Neptune and Pluto. In its orbit, Halley's comet moves in a direction about the sun, that is counter to the motion of the planets. The photo at the start of the article shows a picture taken during the 1986 transit.

Halley had observed the bright comet of 1680 while in Paris and also the appearance of what was to be Halley's comet in 1682. These observations were to trigger a keen interest in comets for the rest of his life.

When in 1684 Halley ventured to Cambridge to seek out the wisdom of Sir Isac Newton in an attempt to predict the nature of the gravitational force exerted by the sun on bodies in its orbit, Newton indicated that he had solved the problem some 17 years previously but had not bothered to tell anyone of his discovery of the inverse square law of gravity. It was in many ways the enthusiasm and the ability of Halley to find sufficient funds which led to the publication of Newton's Principia by the Royal Society in 1687. Thus celestial comets in many ways led to the Newtonian Model of the universe gaining acceptance and heralding the mechanistic era of Newtonian Science.

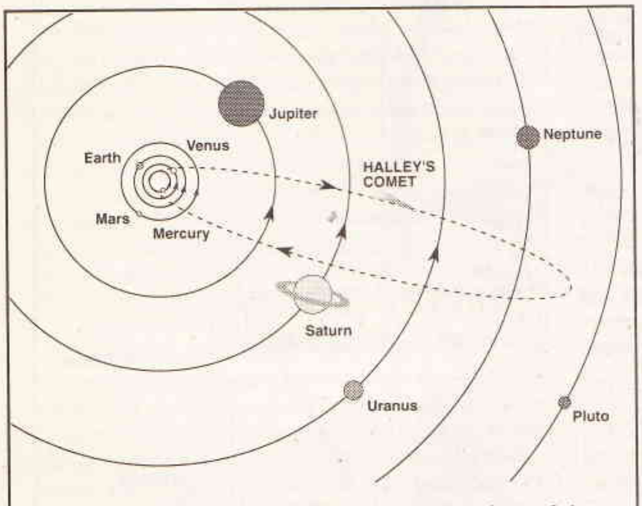


Fig.5 Projected orbit of Halley's comet on the plane of the earth's orbit around the sun.

In 1986 the European Space Agency (ESA) successfully undertook a close encounter mission using the Giotti satellite with Halley's comet. The soviet VEGA spacecraft also sent back valuable information. Figure 6 shows how the Giotti spacecraft fly past took the satellite across the so called 'bow wave' of material sent out by the solar wind from the comet. The distance of closest approach was of the order of 500 km.

The Giotti mission was so called after the painter Giotti di Bondone who around 1303 painted the Adoration of the Magi, showing a comet over Bethlehem. He probably was influenced by an appearance of Halley's comet in 1301.

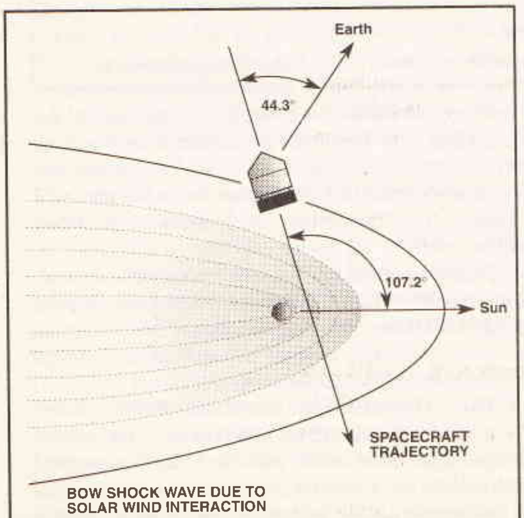


Fig.6 Diagram of Giotti's close encounter with Halley's comet.

Figure 7 shows details of Giotti flight path and how it nearly intersected with Halley's comet. Thus the comet was winging its way out of the solar system and the two were closing with their combined velocities, rather like two express trains travelling in opposite directions.

The surface of the comet consisted mainly of a black inactive crust. Vapour was seen to stream from two volcanic-like vents on the comet surface and from a number of smaller fissures. This was presumably water vapour sublimating from its core. The comet was 'peanut' shaped approximately fifteen by eight kilometres long and appeared to be tumbling in space with a period of either 2.2 days or 7.3 days.

Instruments on board Giotti were able also to analyse the chemical compounds present in the emerging tail. Water vapour accounted for over 80% of the emission, with additional contribution from carbon monoxide (10%), carbon dioxide (5%), methane (1%) and ammonia 1%.

The Giotto mission, taking place amid the acclaim of the Voyager missions to the outer realms of the solar system, was perhaps not fully appreciated at the time. Not to have attempted such a mission would have left a considerable gap in the knowledge and understanding of the solar system — a gap that would not have been filled until around the year 2061.

In many ways the Giotti spacecraft, shown in Figure 8, was a revolutionary space vehicle. In the final brief encounter with the comet lasting a few minutes, the spacecraft had to compute and navigate its own trajectory since the return time for ground control signals was around 17 minutes. In the 'close encounter' the comet and Giotti were moving in opposite orbital directions.

One novel experiment on board Giotti was a piezo-electric dust particle counter which consisted of a PVDF piezo-electric film which registered a voltage 'pulse' when impacted by minute dust particles. This experiment was able to count not only the number of impacts per second but also the distribution of signal values which in turn was a function of the impact energies of the dust particles. Thus it provided a valuable running commentary on the nature of dust particles thrown off in the advancing bow wave of the comet.

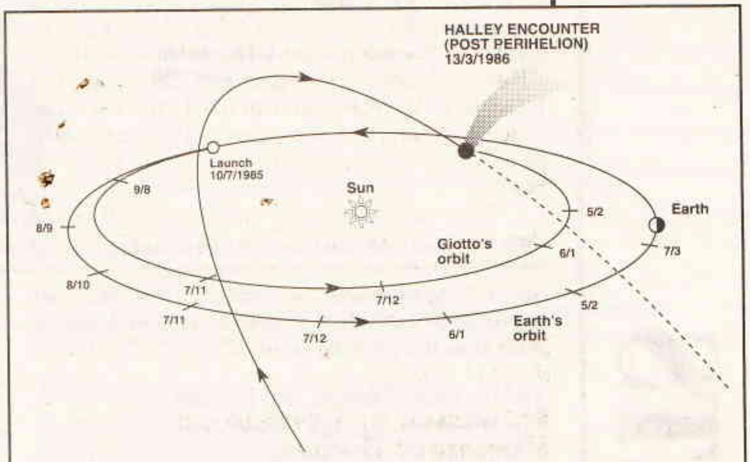


Fig.7 Diagram of orbit paths of Giotti and Halley's comet within the solar system.

It is planned to use the Giotti craft to intercept the

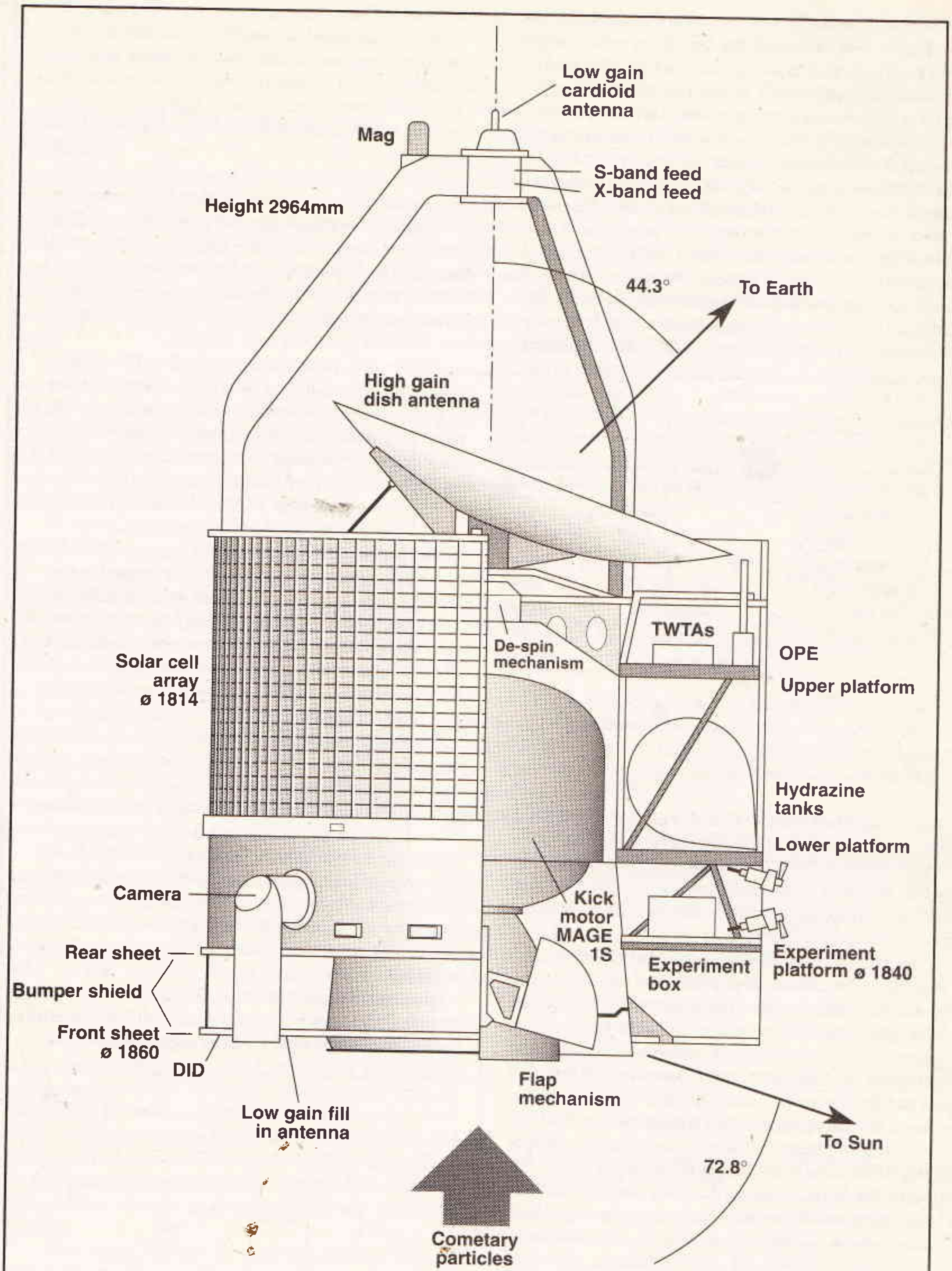


Fig.8 Diagram of Giotti spacecraft showing propulsion system, antenna and scientific experiments.

comet Grigg-Skjellerup on 10th July 1992. The craft has already been sent into an orbit that will enable a close encounter to take place.

Tails and Head of Comets

The nucleus of comets which may typically be no more than 10 to 100 km in size, cannot be observed from earth. In fact the Giotti mission determined in the case of Halley's comet that the surface of the nucleus was as black as soot and therefore would reflect very little light. It is only the 'head and tail' of a comet that can be observed, as previously indicated this usually begins to be observed at a distance of about 3 AU from the sun. The head or 'coma' of the comet is that part immediately in front of the nucleus while the tail is that part which streams out behind it. Different mechanisms are thought to give rise to the light given off by the coma and the tail.

Figure 10 shows the simplified interaction of the solar radiation in driving back gas and dust driven off from the comet. It should be stated there are still aspects of the complex interaction between the solar influences and the comet which are poorly understood.

Frozen gases which 'sublime' escape into the vacuum of space and in the process freed dust particles are driven out into space. In the case of Halley's comet, the visible bow wave extends out a distance of about 30,000km from the nucleus.

The brightness of the tail of the comet is determined by a range of factors. The major ones include the closeness of the comet to the sun, the closeness of the comet to the earth and the volume and nature of the material cascaded by the process of solar heating into the coma and tail.

So called 'Sungrazer' comets produce highly visible tails as they approach the sun. The great comet of 1843 approached the sun as close as 0.006AU — about half a million miles which is less than a solar diameter. Such comets, daring to venture so close to the sun must be a short lived phenomenon. They could only survive a few such close transits.

Halley's comet which has been seen to make 28 returns since it was first observed in 240 BC by the Ancient Chinese, is known to have a 'conditioned' outer surface which acts to 'insulate' the core of the comet from the sun's activity. 'Wild' comets, which have not experienced a close solar transit are more susceptible to losing aggregated material and therefore tend to produce more luminous tails. These newcomers, therefore, put on a better show for us.

'Wild' comets which have lodged in deep space for long periods of time (perhaps billions of years) are understood to consist of amorphous ice formed by the consolidation of tiny grains or snowflakes. Such structures are exposed to cosmic ray energies and stellar light. Laboratory experiments have shown that when such structures are heated from low (deep space) temperatures to those experienced within 2 to 3 AU from the sun (about 150°) stored energy in the ice structure was suddenly released. This would in the vacuum conditions of space cause a sudden blow off of material from the comet's tail.

Separate experiments have also shown that damage to ice crystal structures caused by simulated cosmic ray radiation can be released when ice is warmed from 20 Kelvin to about 30 Kelvin. Thus this release of energy would presumably take place at distances greater from the sun than 3 AU when the tail usually becomes visible. It is thought, that the Kohoutek comet of 1973 which brightened at unusually great distance from the sun was one of these 'primordial' comets.

Under exceptional conditions, comet tails can be observed over vast distances. The great comet of 1843 was estimated to have a tail 300,000,000 km long. Light produced in the tails of comets can essentially be produced from the reflection of light from dust particles and from fluorescence of ionised atoms and molecules. The process of light scattering from particles is relatively straightforward. Some of the dust particles, however, are exceedingly small like cigarette smoke particles. Some are indeed too small to reflect light.

In the process of fluorescence, photons of light are absorbed by discrete ions, atoms or molecules in the tail of the comet and radiate in turn photons of lower energy. While the origin of the light is essentially straightforward, the direction of the tail of the comet is subject to a range of complex factors. Previously comet tails were described as types I, II or III where type I was the most straight and type III showed the most 'bending'. This classification was initially introduced by the Russian scientist Bredikhin in 1903. This model of classification is gradually passing out of use as additional modes of comet tail formation and evolution are being discovered.

Solid dust particles which are initially travelling outwards from the comet are bombarded by photons of light which in time transfer their momentum to the particles and reverse their direction, sweeping them behind the comet.

The tail of ions given off by the comet appears to line up with the direction of the Solar Wind — a stream of positive ions sent out by the sun at speeds of 400 km/second. The sun and its associated solar wind is responsible for establishing a magnetic field throughout the solar system. The interaction between this field and the solar wind particles tends to bend round the ions of the comet into the direction of the solar wind particles.

The sun is itself rotating with a period of 26.9 days. This causes a rotation in the trails of solar wind particles sent out into the solar system and it also causes the rotation of magnetic field vectors in the solar system. When the tail of a comet passes through such a boundary, a discontinuity will be visible in the comet tail.

Thus comets are useful 'windsocks' for determining the path of the solar wind and detecting magnetic field boundaries in the solar system. While these large magnetic sectors change slowly in time over months, changes can also take place in the tails of comets due to extreme changes in the activity of the Solar Wind.

The coma of the comet is that area opposite from its tail. It is an area where clouds of material blown off from the comet interact and become dissociated, releasing light energy in the process. The paths of ions are then swept round the nucleus and into the cometary tail. Dust particles released into and around the coma area will also reflect light.

If the ultraviolet spectrum of the coma is observed, this is usually observed to extend out considerable distances from the comet — as much as 10,000,000km. This effect is produced by ionisation of Hydrogen which being a very light atom escapes from the comet with greater velocity and forms its larger interaction cloud. Usually visible comas vary in size between 100,000 and 1,000,000km.

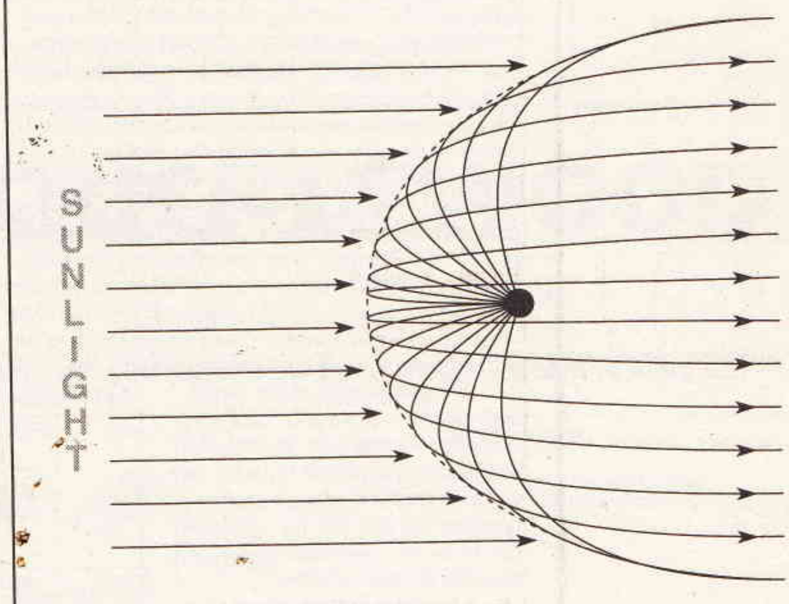


Fig.10 Classical concept of generation of comet's coma and tail.

Conclusion

The recent encounter with Halley's comet has provided valuable new insights into the realm of comets. There are many points about them which still remain a mystery. Perhaps the greatest of these is their origin and distribution within the solar system and indeed other star systems.

Also, the role of comets as catalysts in the evolution of carbon based life in the solar system is a subject of considerable but tantalising debate. There is no doubt that the 'chemical soup' of a deep space comet is fundamentally different from that of the earth's primordial oceans. If the earth's oceans originated from comet bombardment, then the old adage all life began in the sea needs a subtle re-interpretation.

Bootstrapping

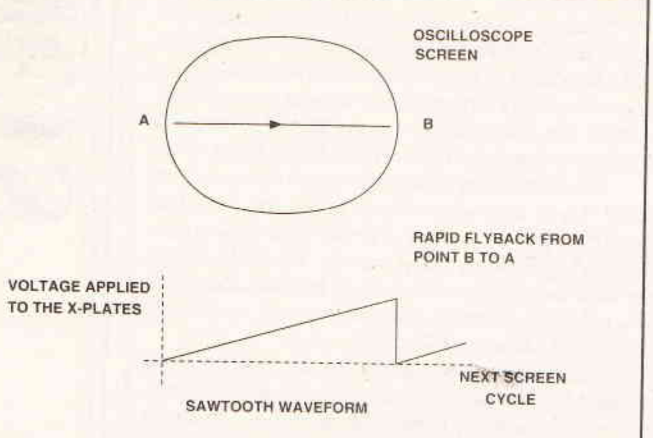


Fig.1 CRT sawtooth timebase

S. D. Waddington recalls an old but simple technique.

An undergraduate friend recently asked me to examine a rather archaic cathode ray oscilloscope which had belonged to her Grandfather and had remained confined to a cupboard since his death; wishing to restore it to working order, she sought my opinion.

Removing the case revealed over four decades of dust — indeed the cathode ray tube might have been a cast off from one of Kaufmann's elm experiments. Close inspection, revealed that the fault lay within the timebase circuitry — everything else appeared, rather surprisingly, to be completely operational.

After locating the precise defect, it was quickly realised that many of the components required to resurect the oscilloscope were now obsolete. The instrument represented a piece of scientific history and was too marvellous to dispose of; presented with the challenge I decided to attempt to replace the faulty circuit with a contemporary equivalent.

The problem then, to design and calibrate a variable timebase oscillator suitable for driving the x-plates of the cathode ray tube. At first such an exercise appears trivial, however the fact that the timebase has to be of a sawtooth formation prompts further reflection.

The characteristic shape of a sawtooth waveform is responsible for the horizontal movement of the electron beam in all forms of cathode ray tube utilizing a raster technique. In a cathode ray oscilloscope, the waveform generates a uniform sweep from left to right followed by a rapid flyback, as depicted in Figure 1. The test waveform to be displayed is fed via necessary shunts or amplifiers to the y-plates and thus the two fields form the resultant waveform on the screen.

Clearly, a wander through the semiconductor section of any electronics catalogue, provides a whole array of customised integrated circuits suitable for the chore. An impoverished student though, I am reluctant to part with money and besides rudimentary intuition told me that there ought to be a simpler method involving the use of a RC combination or such like.

Browsing through my limited assortment of text books, provided little explanation of how a sawtooth waveform might be generated. A telephone call to an elder compatriot however, revealed a very neat and simple solution to my dilemma — the use of a bootstrap; a rather capricious but highly appropriate term used to describe a technique used in a variety of applications, in which a capacitor — the bootstrap capacitor — is used to provide one- hundred percent positive feedback for sinusoidal currents across an amplifier stage of unity gain or less.

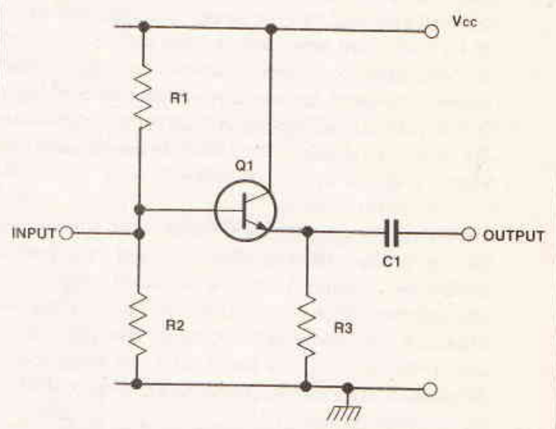


Fig.2 Standard emitter-follower circuit

Academic definition aside; suppose an emitter-follower circuit is required with a high AC input impedance. A normal unmodified circuit such as that shown in Figure 2, has a rather low input impedance because of the shunting effect of the bias resistors, R1 and R2. The circuit presented in Figure 3 overcomes this problem, a bootstrap capacitor with a value large enough to act as an almost short circuit at the lowest frequency required is connected from the output node to the bottom end of the additional bias resistor R3. This provides positive feedback, but because the gain of the emitter-follower is less than unity, the circuit will not oscillate. The R3 — C 1 combination will however, act as a much higher impedance to AC signals. As one end of R3 changes in voltage, the opposing end moves by

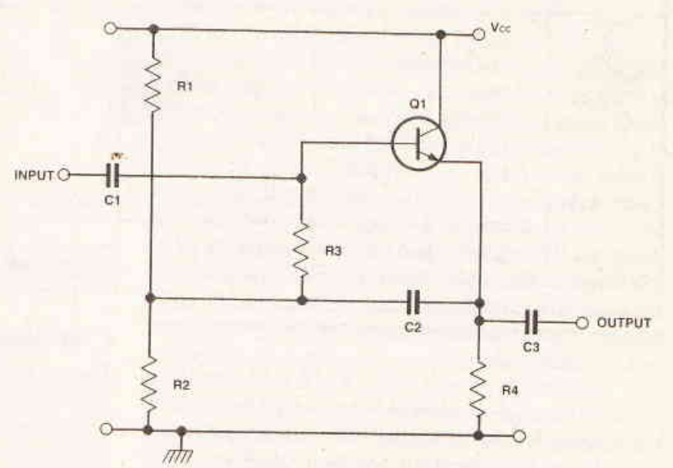


Fig.3 Bootstrapping an Emitter-follower

DESIGN

an almost identical amount in the same direction. The effective AC signal across R3 is thus very small and it appears, quite neatly, as if R3 is pulling itself up by its own bootstraps.

I was correct in trusting my initial conjecture, a basic sawtooth generator consists simply of a capacitor which is charged by means of an input load resistor and then discharged by a periodic step voltage. As the capacitor is charged, the voltage across it increases exponentially. Correspondingly, the voltage across the input load decreases. The output is approximately linear, provided that only a small portion of the charging signal characteristic is utilized. Consequently a square wave input is introduced to discharge the capacitor periodically. Such a signal is generated with ease using a simple astable multivibrator.

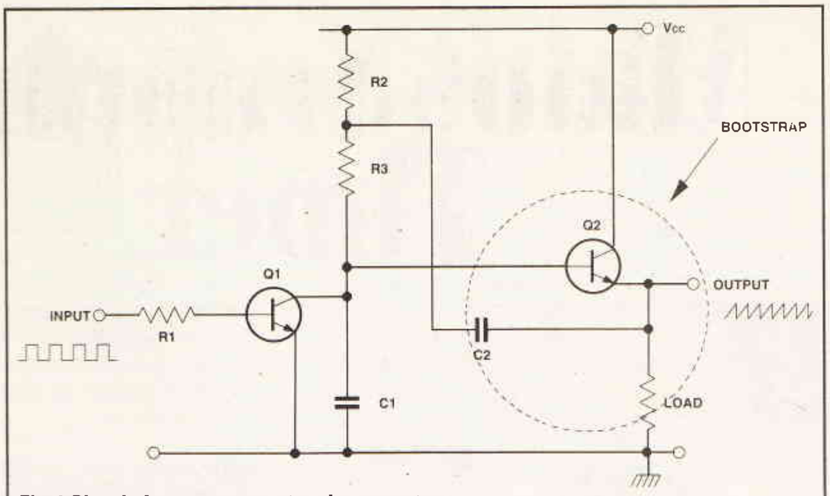


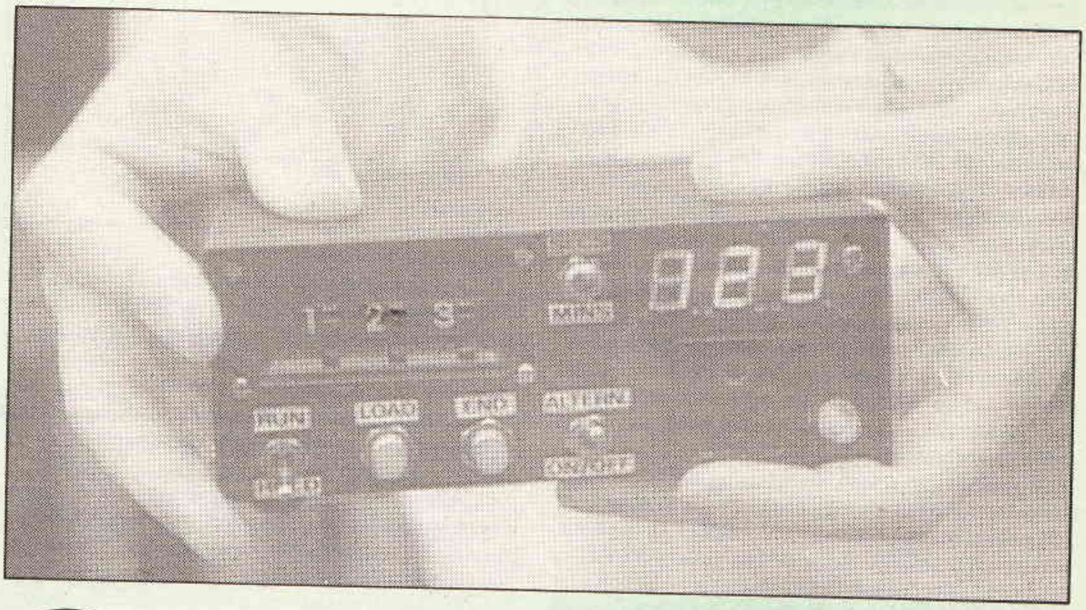
Fig.4 Simple bootstrap sawtooth generator

A simple sawtooth generator employing a bootstrap is shown in Figure 4. The output is derived from an emitter-follower capacitively coupled via the bootstrap capacitor C2 to the input load resistor R2. As the output voltage rises, the voltage at the node between R2 and R1 also rises; the voltage across R2 and hence the charging current is therefore maintained substantially constant, consequently a near linear sawtooth waveform is produced.

Astute readers may by now bemoan the fact that it has taken several paragraphs to realise a relatively primitive circuit which with hindsight, I should have produced readily. This fact apart, by discussing bootstrapping, a brief but interesting excursion has been made into an area of electronics which many text books neglect, contributing no real explanation of function or purpose.

After the addition of a linearing network, appropriate amplifier and calibration, a variable version of the simple sawtooth generator was implemented in the cathode ray oscilloscope with a high degree of success and I understand that a thrilled student is using it as standard piece of her laboratory kit. A full commissioning has been arranged in the student bar!

Mains Switched Timer



A handy mains control by David Ponting.

Sooner or later all of us who are involved in this hobby of electronics, will want to make printed circuit boards by the 'photographic' method; and those of us who have already tried will soon tell the rest that getting the correct exposure for the pre-sensitized circuit board is an absolute must.

I have been making printed circuit boards by this technique for many years now and during that time I have looked for an accurate timer which had certain features I needed; and I have searched in vain.

What I wanted was a small device which could be set to count down very accurately and repeatably a given number of seconds, preset in advance; I wanted it to turn on a mains socket when the timing countdown started, and turn it off at the end of the preset period, and I wanted the alternative of not turning the socket on until *after* the preset time had elapsed; I wanted a 'hold' function so that the timer could be stopped in mid countdown, with the socket on or off, as desired; and I wanted a reset button which could bring the countdown to an end while the timing period was in progress.

Nothing on the market met the above requirements: I could buy egg-timers, whose accuracy was very doubtful; I could buy photographic clocks, which had some of the features I wanted, but not all. And in any case, they were expensive.

So, the alternative was to make a timer. (And incidentally, this timer not only serves to time the exposure of printed circuit boards, but is equally invaluable in the darkroom where it will accurately and repeatedly time the exposure of photographic enlarging paper. So if your interests are under the red light in the darkroom, or even boiling an egg to an accuracy of 0.1%, then this project is also for you!)

It is possible to obtain some pretty esoteric integrated circuits that will perform many of the functions I wanted to build into this circuit, but, like most of you reading this article, rarely do I have access to anything

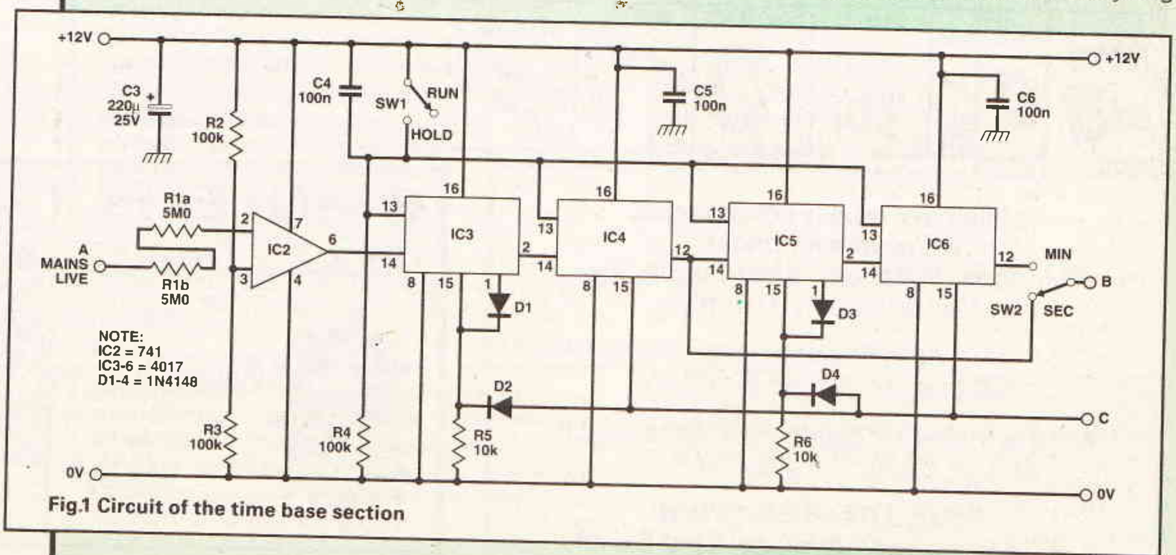


Fig.1 Circuit of the time base section

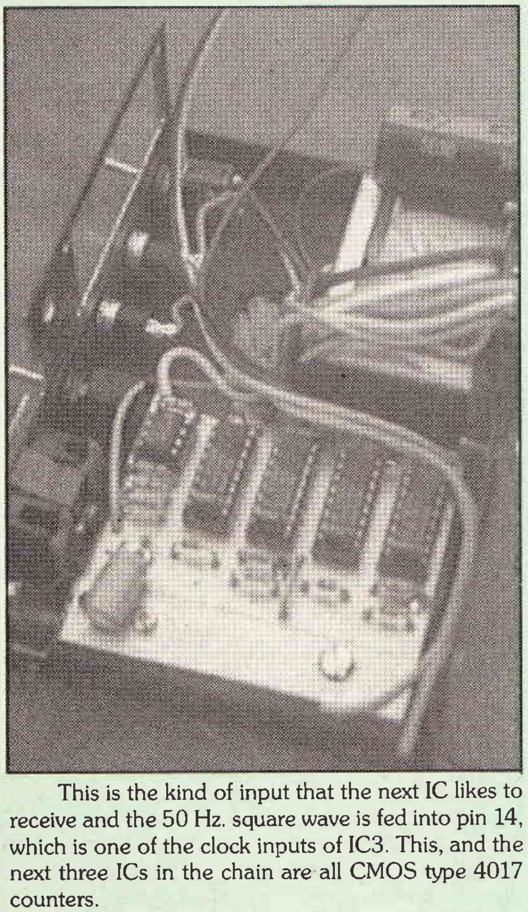
other than standard, off-the-shelf components. So I wanted to use only those which were easily available to everybody. In consequence, with 13 integrated circuits in this project it may seem a little over designed. However, all the components are standard, off-the-shelf, and inexpensive. So don't let the component count put you off.

The Time Base Circuit

Since this timer was going to switch a mains socket on and off, it seemed obvious that the circuit should be mains (rather than battery) driven. In consequence I decided that the time base pulses to drive the clock should be derived from the mains frequency of 50Hz. by dividing this down until a one second pulse was achieved.

Time Base Circuit

Be careful! Each of two principal circuit boards has live mains applied to it, in this case to point A. Resistors R1a and R1b (use two of 5M each rather than one of 10M since the voltage limit of a single resistor is exceeded by the 240 volt mains) ensure that the current flow is strictly limited into the inverting input of IC2, a standard 741 operational amplifier. The non-inverting input is held at 6 volts by the voltage divider R2 and R3. Used in this way the 741 is just a voltage comparator and, as the sinusoidal input from the mains passes through the 6 volt level on each wave, the output switches sharply between about 2 volts and 11 volts, providing a precise square wave at pin 6.



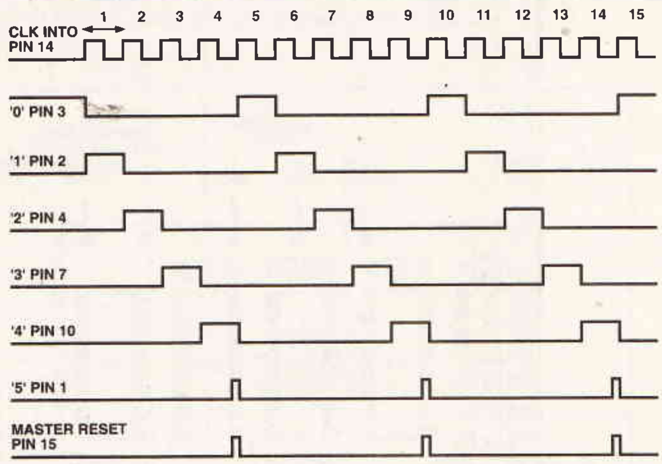
This is the kind of input that the next IC likes to receive and the 50 Hz. square wave is fed into pin 14, which is one of the clock inputs of IC3. This, and the next three ICs in the chain are all CMOS type 4017 counters.

In general, as each pulse is counted, one of ten pins on the 4017 goes high. The no-pulse-counted, or 'zero' pin is 3. This is high before any clock pulses are counted; and, while it is high, all the other nine 'number' pins are low. As soon as the counter detects the rising edge of the first square wave, the 'zero' pin 3 goes low and the 'one' (which is pin 2) goes high.

Don't forget that one clock pulse includes both the high, and the adjacent low section of the square wave, and the next clock pulse does not start until the next rising edge. When that happens, the 'one' pin 2, goes low and the 'two' pin 4, goes high. And so on.

But in our Time Base Circuit, diode DI effectively joins pin 1, which is number 'five' in the count, with pin 15, which has the special function of re-setting to low all the counter outputs except 'zero' pin 3, which re-sets high. Pin 15 is normally held low by resistor R5. From the timing diagram, it is possible to see that after the fourth wave is counted, 'five' pin 1, goes high very briefly, taking reset pin 15 high as well; this resets to low all counters (including 'five' pin 1 — this is the reason why this pulse is so short), with the exception of the 'zero' pin 3, which re-sets high during the fifth wave; and the cycle repeats itself.

In other words, (by which I mean that if you find my poor explanation totally meaningless, don't worry



1. COUNTER ADVANCES ON EVERY RISING EDGE OF THE CLOCK, PROVIDED PIN 13 IS LOW

2. WHEN PIN 13 GOES HIGH ('HOLD'), THE COUNT STOPS EXACTLY WHERE IT IS UNTIL PIN 13 GOES LOW AGAIN, WHEN THE COUNT CONTINUES FROM WHERE IT WAS.

Fig.2 Timing diagrams

about it), although 50 clock pulses are going into the counter IC3 every second, the output from 'one' pin 2, provides only one pulse for every five going in, i.e. ten every second; and the original frequency has been divided by five.

Consequently the frequency into the clock input, pin 14, of IC4 is 10Hz. This IC is also a type 4017 but now used in a different way. None of the 'zero' to 'nine' pins is connected to the reset pin 15, and the output is taken from pin 12. This is the IC's 'carry-out' pin. If, for example, you were going to add up thirteen separate pulses, the answer would be: three units, carry forward one 'ten'. And that function is exactly what 'carry-out' pin 12 provides: one pulse out for every ten counted.

So, with the frequency into IC4 being ten pulses per second, the frequency out of pin 12 is one pulse per second, ie very accurate pulses of one second duration.

All we need now is a down counter which can be set to start at the time required in seconds, feed this counter with our one second pulses, arrange for the counter to stop when it reaches zero, and we are well on the way to achieving our design goal.

However, when I was working on the design, and having got as far as this in my thinking, it occurred to me that the addition of only two more 4017 counters and a single-pole/double-throw switch would allow minutes to be counted as well as seconds. So IC5 merely repeats the functions of IC3, except that it now divides by six the 60 pulses per minute coming out of IC4, out-putting 10 per minute to IC6, which divides them by ten, to produce its output of one pulse per minute. And you now have two timers for almost the price of one. The first will count down in seconds, and the second will count down in minutes. Now the function of switch SW2 should be obvious: with the switch in position S, pulses one second long are fed to the rest of the circuit; when this switch is in position M, pulses which are one minute long go forward.

The only other components I have not yet explained in the Time Base Circuit are the de-coupling capacitors C5 and C6 (which are there to take switching spikes out of the power supplied to these four ICs), the diodes D2 and D4, and those components around the commoned pins 13 on each of the counters.

In general, when pin 15 on a 4017 is taken high, all the counters on the chip are 'zeroed' and held that way as long as pin 15 is kept high. In our circuit, pins 15 on IC4 and IC6 will follow whatever value the control input C has. The same pins 15 on IC3 and IC5 are normally kept low by resistors R5 and R6, but will always go high via diodes D2 and D4 when input C goes high (as well as being switched by the other diodes D1 and D3).

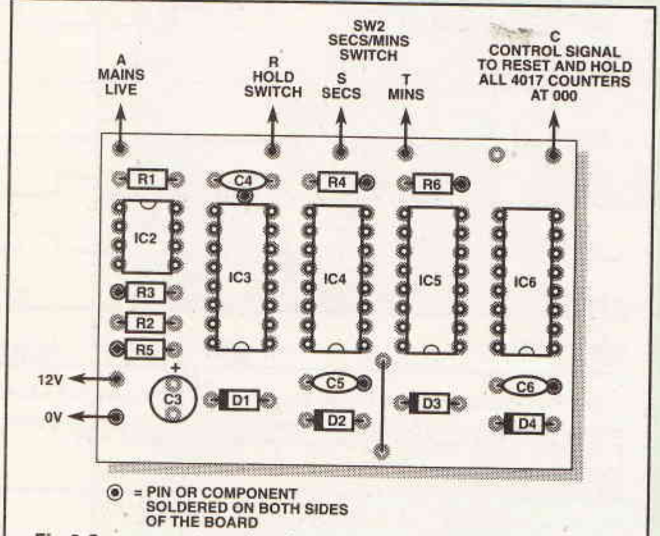


Fig.3 Component overlay for time base diagrams

Consequently we want to arrange the logic driving input C so that it is taken and held high at the end of each timed interval and then, whenever a new timing period is required, all the counters start from zero. So, logic in the rest of the circuit is used to take point C high (that is pins 15 on IC4 and IC6 directly, and on IC3 and IC5 via diodes D2 and D4) so that the clock stops at the end of the timed interval and is always ready to start from zero when the next timing period is started.

Pin 13 on the 4017 is an alternative clock input allowing the 4017 to count pulses starting with the falling edge of each wave. This pin can also be used (as it is here) as a clock-enable control when the 4017 will only count clock pulses into pin 14 if pin 13 is held low. In this circuit, 'low' is the 'normal' state of all pins 13 via resistor R4, switch SW1 being open. When SW1 is closed, each pin 13 is taken and held high, causing all the counters to stop exactly where they were in their count. Releasing SW1 allows the counters to continue their count from exactly the position they were in when SW1 was closed. The capacitor C4, is there to take some of the 'bounce' out of the operation of this switch, so that spurious pulses are not counted. This is the 'Hold' function.

The printed circuit board for the Time base Circuit and the positions of its components are shown in Figure 3.

The three printed circuits illustrated in this article are all designed to be made on double sided board. Making full, double-etched boards with through connections is really quite difficult and so the three in this project use the second side of each board only as an earth plane. Points showing where pins must be used to join the earth plane to the etched side are indicated in each diagram. Where links are to be fitted, dotted lines are drawn and care must be taken to see that these links are not shorted to the earth plane.

On the Time Base printed circuit board, there are two positions where pins (just short pieces of wire such as those trimmed from resistors and capacitors when they are fitted into the boards) are soldered to both sides: one is where the ground supply joins the board and the other is at the 'top' end of IC3, earthing pin 8. The components R3, R4, R5, R6, C5 and C6 have one of their leads soldered to both sides of the PCB. There is one wire link, allowing pin 16 of IC5 to be connected to the positive supply.

The rest of the circuit, shown as Figure 4, drives the counters and displays. It may seem rather complicated but it really is not. If you are like me and tend to be put off when you see a project where the resistors are beginning to be numbered in the forties, do not despair. Most of the resistors are grouped either in three lots of seven and simply current-limit each individual LED segment of the displays, or in three lots of four, serving the purpose of holding low until otherwise switched, the various sections of the thumbwheel switches.

The central part of this circuit is built around three CMOS integrated circuits, type 4510. The 4510 is a counter which will count up or down. It has a binary coded decimal (BCD) number input and a similarly coded number output which increments up or decrements down (depending on which direction the IC has been set to count) on each pulse sent into the clock input, pin 15.

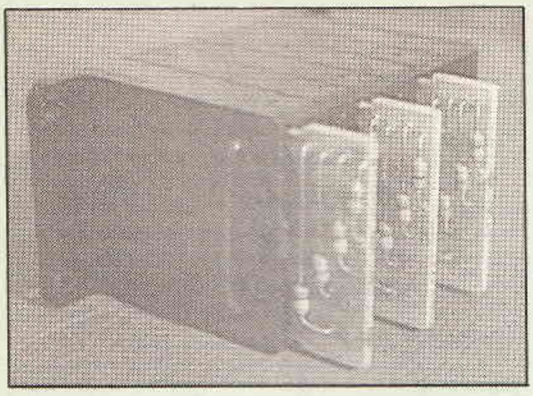
BCD thumbwheel switches are special switches which have either ten positions with numbers 0 to 9, or sixteen positions with numbers 0 to 9 and A,B,C,D,E, and F, showing individually on the front face of the switch and depending on its position. Any particular number or letter can be reached by rotating the switch to the digit desired.

For the purposes of this circuit, only ten position BCD thumbwheel switches should be used. Each switch has five contacts, usually labelled '8', '4', '2', '1', and C. All the digits from 0 to 9 can be represented using only 4 binary digits.

The following table gives the codes.

Number	'8'	'4'	'2'	'1'
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

For a thumbwheel switch to output these codes, the C, or Common on the switch is connected high (to the 12 volt rail in this circuit). Now, for example, with the switch in the number 5 position, contact '4' is connected to 12 volts, as is contact '1'. So, whenever there is a 1 in the right columns of the above table, that contact is switched to the 12 volt supply. Unfortunately where the table shows a 0, that contact is just an open circuit. So each of the four contacts '8', '4', '2', and '1' on every switch has to be held low using four resistors. I had enough room on the contact boards of each of the three thumbwheel switches to mount four, 1/8 watt, 100k resistors there. (See photograph).



The four-digit binary codes produced by each thumbwheel switch are fed into pins 4, 12, 13 and 3 on the corresponding 4510 counter IC. Be very careful that these pins are each wired to the correct '8', '4', '2', '1' contact on each thumbwheel switch.

When the coded input number is loaded into the counter (see later) the same coded numeral is output from the 4510 at pins 2, 14, 11 and 6. This number can only be revealed when its BCD is decoded into a seven-segment code by a special IC: in this case the 4543. This IC will not only decode the four binary digits into a seven-segment code to light up the correct form of the numeral on the display, but has enough current capa-

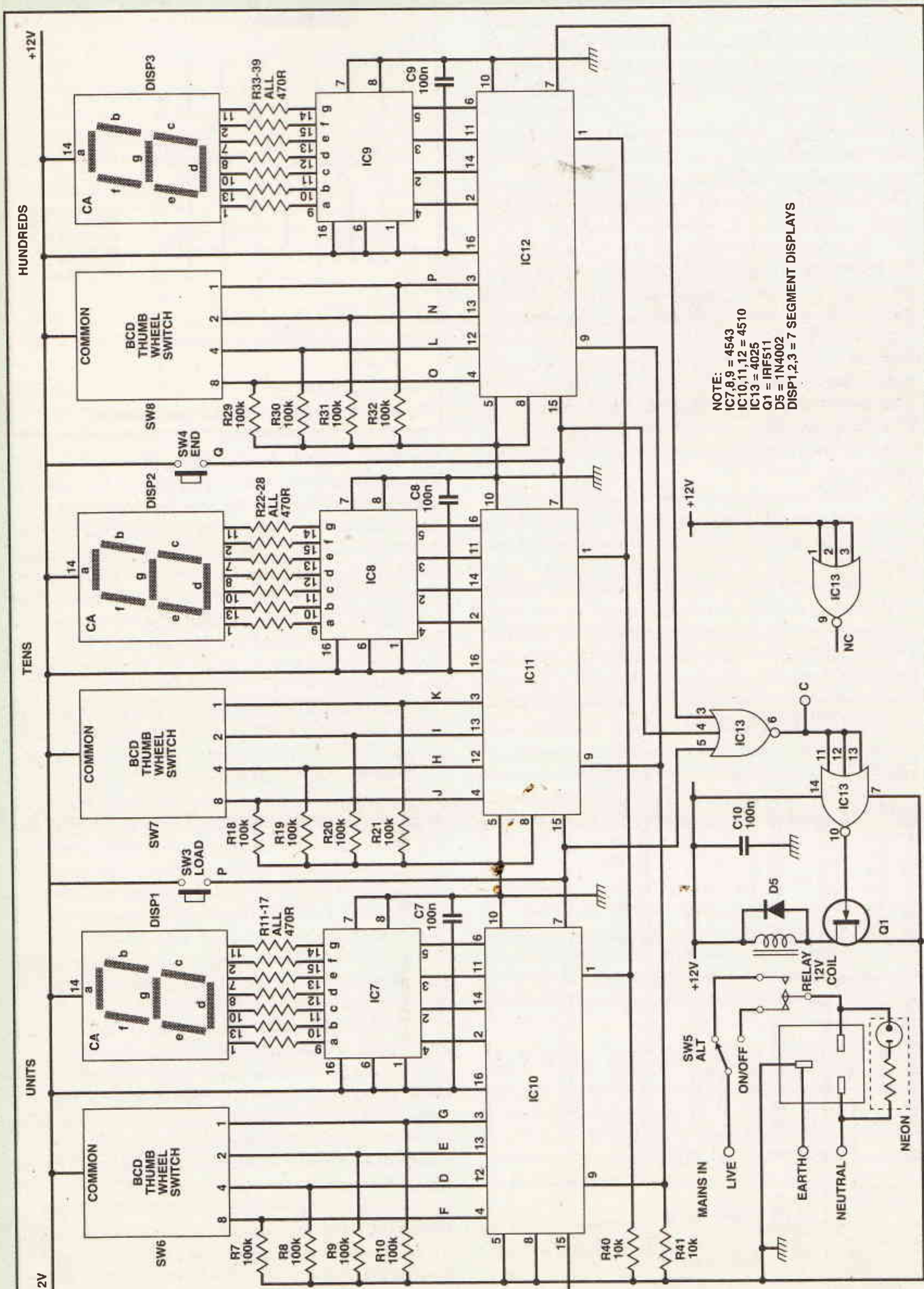


Fig.4 Counter and display circuit

bility to drive this seven-segment display directly. With appropriate wiring the same IC will drive common cathode as well as common anode displays. The circuit diagram shows the correct wiring for use with the common anode displays I used. Not all seven-segment displays have the same pin outs as one another, so do check the pin outs on the ones you have chosen to use before wiring-in the current-limiting resistors.

Incidentally, do not make the mistake I did and try to build this device in a box too small. I just happened to have a box 3 1/2 x 5 x 1 7/8 inches (see the various photographs) but with my clumsy fingers and quite a lot of fairly large components, this was really too small, the construction producing considerable anguish and sucking of teeth before it was finished. Nevertheless, it is a good plan not to include the current limiting resistors (R11 to R17, R22 to R28, and R33 to R39) on the printed circuit board itself, but use them instead as the way of connecting the board to the individual seven-segment displays.

See Figure 5 for an enlargement of the interconnections from a 4543 drive/decoder IC to the seven segment display I used. Note that pins 14 and 15 on the 4543 have to be reversed if the straight run of each segment, a, b, c, d, e, f, g, is to be achieved.

So, when any digit from 0 to 9 is set up on each of the thumbwheel switches, its BCD code will appear at pins 4, 12, 13, 3 on the associated 4510 IC and this number can be loaded into the counter by briefly taking pin 1 high. In this circuit, all the pins 1 are usually held low by resistor R40, but pressing the LOAD switch, SW3, will take them all high, loading each thumbwheel digit into the corresponding counter. The IC will then reproduce this same digit on pins 2, 14, 11 and 6. Thence it will appear on the seven segment display via the 4543.

Pin 10 determines whether the 4510 counts up or down, and when it is held low, as here, it only counts down. Pin 5 is a count-enable control, which must also be kept low.

When the first pulse enters a counter through the clock pin 15, its output is decremented by one. With each succeeding pulse, the display will show one less. When it reaches zero, the next display will be 9, but before that happens and while displaying 0, a 'borrow-one' pulse (high to low to high) will appear at pin 7. This allows the three 4510 counters to be cascaded using the pin 7 output of one as the clock input of the next. With two, three or more of these counters cascaded, you can set up any number on the thumbwheel switches, load that number into the counters and thence the displays. When the clock is set going it will count down from that number all the way to zero; and unfortunately continue on through 999, 998, 997.. etc., if you do not stop the clock at 000... That is one of the reasons for IC13.

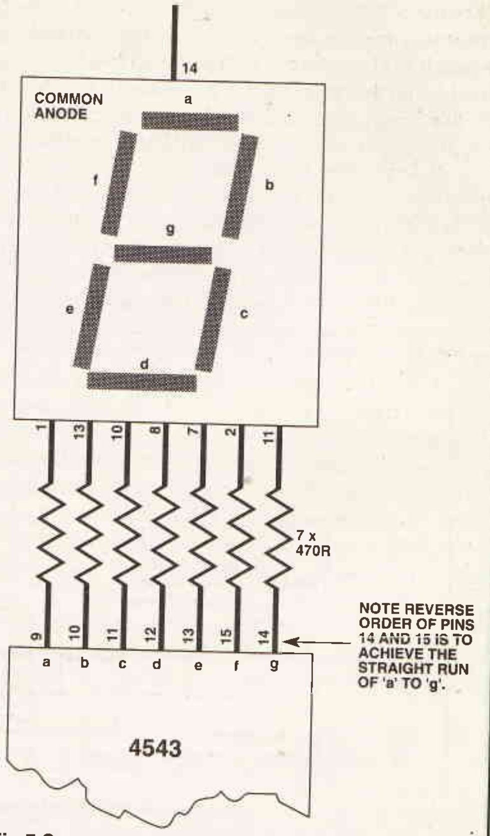


Fig.5 Seven segment display connections

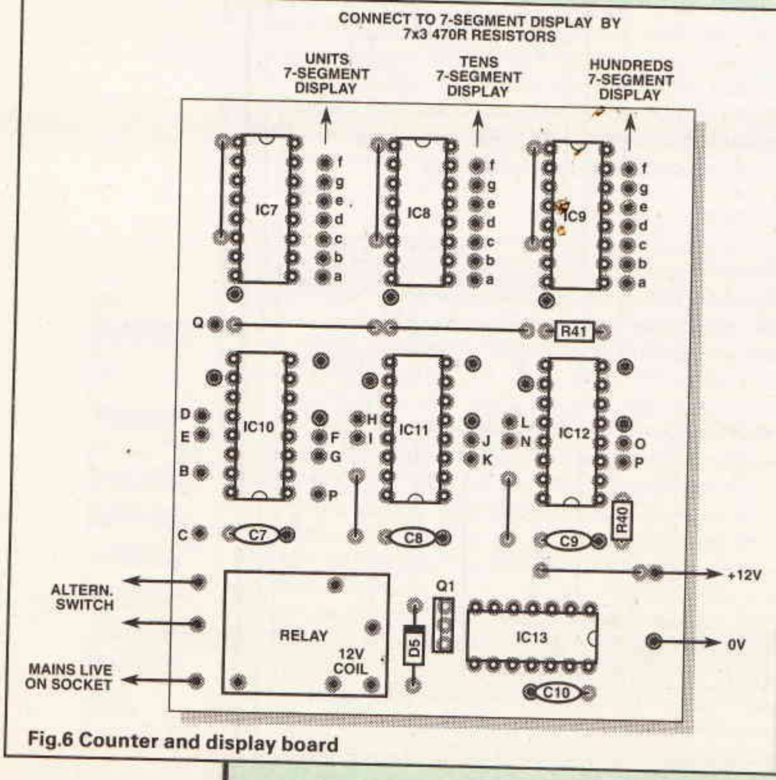


Fig.6 Counter and display board

When the 'hundreds' counter reaches 0, the output from pin 7 on IC12 goes low, and stays low while the number being displayed is 0. Some time later, the 'tens' counter, IC 11, counts down to 0, when the output from its pin 7 also goes low and stays there while displaying 0. At this time only the 'units' display has any figure other than zero and this counter continues to count backwards to 0 when its pin 7 goes low. Now for the first time all three inputs into pins 3, 4, and 5 of the first NOR gate of IC13 are simultaneously low and so its output at pin 6 goes high. This is the 'C' connection on the Time Base circuit which takes all the 4017 master reset pins 15 high, thus zeroing and holding at zero the three counters, IC3, 4, 5 and 6.

With IC13 pin 6 high, all the inputs into the second NOR gate (here used just as an inverter) are high, so its output is low. Hence, in this state, field effect transistor, Q1 is off and so is the relay. Depending on the position of the ALTERNATIVE switch SW5, power is, or is not, supplied to the mains socket, indicated by the neon being lit or not. The diode across the coil of the relay is to short-circuit any potentially dangerous voltage (damaging that is for the FET, Q1) which will be back induced in its coil when the relay is switched off.

IC13 has a third, triple-input NOR gate which is unused in this project. To stop it 'floating' and switching randomly (a state which can produce the strangest of spurious outcomes in the other two gates) the input pins 1, 2 and 8 should all be tied low or high via either voltage rail as convenient. Only when the displays are showing 000 will the relay be off. For all other displays the relay will be on and the timer will be counting down towards 000, unless the HOLD switch has been operated, when the timer will 'freeze', but leave the relay on. At this time, power to the socket can be turned off or on as required using the ALTERNATIVE switch.

If you wish to bring a timing sequence to an end, without waiting for the timer to reach 000, then the END button SW4 can be pressed. This is connected to all pins 9 on the 4510 ICs, and to resistor R41, which normally holds these pins low. But when SW4 is pressed, all the pins 9 are taken high, zeroing the 4510 counters. Simultaneously, point C will go high, zeroing the 4017 counters.

Figure 6 shows the printed circuit board and the layout of the components for the Counter and Display Circuit.

On this PCB, there are 13 places where pins need to be used to join etched tracks on one side to the earth plane on the other. There is one each for the joined pins 7 and 8 on IC7, IC8 and IC9, three for pins 5, 8 and 10 on each of IC10, IC11 and IC12, and one at the point where the 0 volt lead is connected to the board. In addition, the components C7, C8, C9, C10 and Q1 must have one of their leads soldered to both sides of the board. There are eight links; one joining pins 1 and 6 on each 4543, two joining the pins 9 on the 4510 ICs, one joining pin 15 on IC11 to pin 5 on IC13, one joining pin 15 on IC12 to pin 4 on IC13, and one joining all the power supply pins 16 on the 4510s to the 12 volt supply.

The Power Supply.

The power supply used in this project is absolutely standard in design and needs little explanation.

The incoming mains is connected to the primary of the transformer, T1. The LIVE side of the mains is also connected to the common contact on the ALTERNATIVE switch and to point A on the Time Base PCB. In your design of this project you may feel that it would be safer to mount resistors R1a and R1b directly on the mains transformer where they can probably be well insulated, rather than have a LIVE connection straight onto the Time Base PCB. Either way, BE CAREFUL.'

You may think it safer and simpler to produce the 50Hz. square wave directly from the transformer's secondary. This is certainly safer but will give very poor time-keeping. As the ICs switch the displays of the various digits, enough spikes appear on the secondary supply at the transformer to make clock pulses generated in this way highly unreliable.

The NEUTRAL side of the mains is not only connected to the primary of the transformer but also to the Neon and the neutral terminal of the Mains Socket.

The 14 volt AC output from the transformer (you can probably get away with using a 12.6 volt transformer if it will supply at least 1 amp) is bridge-rectified and then smoothed by C1 to about 16 1/2 volts DC. This is connected to a volt regulator IC, type 7812, which will supply a constant 12 volts at up to 1 amp. This design does not require as much as 1 amp but it is surprising how much current the displays consume, so reckon that you will need at least 1/2 amp to run the project and that means that the voltage regulator IC1 will get quite hot and needs a heatsink. The printed circuit design that I have shown uses the copper on the ground plane of the double-sided board to provide the necessary heatsinking.

Capacitor C2 is there to make certain that high frequency oscillations which can occur when using this type of voltage regulator are decoupled to earth. If the power supply board in your design is a long way from the other boards (more than 6 inches, say) then the Counter and Display Board should also have a reservoir capacitor of about 220 microfarads connected between the supply voltage at its entry point and earth. A similar capacitor is already included on the Time Base PCB.

There are no pins or links needed on the power supply PCB, but the middle pin of IC1 and one lead of C2 can be soldered to both sides of the board. IC1 does not need to be insulated from the earth plane of this board because its tab is connected to the middle pin anyway.

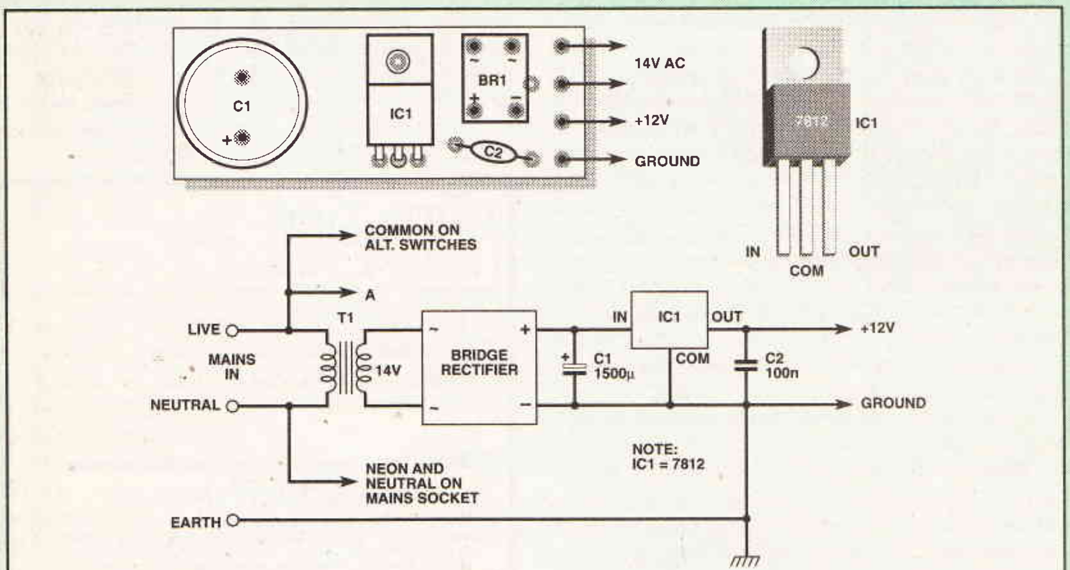


Fig.7 Power supply circuitry

Building And Setting Up

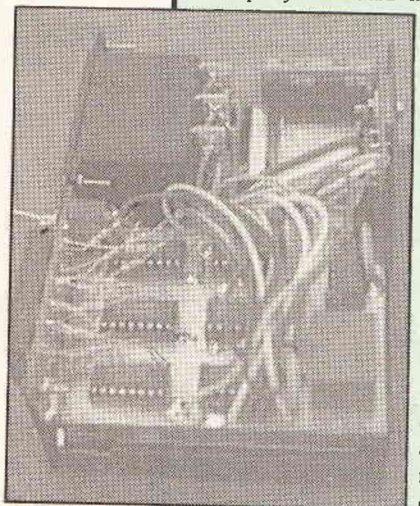
Building this project should present few difficulties and no setting up is required.

It is good technique to check out the power supply before connecting it to the other circuit boards. Make sure that the output is a clean, ripple-free 12 volts, and then connect the supply to the two other PCBs. At this stage none of the chips should be plugged into its socket. First check that each IC socket is receiving the 12 volt supply at the appropriate pin, (pin 7 for the 741, pin 14 for the 4025 and pin 16 for the rest) and check that all the other pins which should be 'high' are, and those which should be 'low' are.

When those tests are completed, fit the integrated circuits.

All the text books point out the dire warning that CMOS devices expire maliciously and silently unless they are handled with great care. My own experience is that CMOS chips seem rather more difficult to destroy now than they did some years ago when there were no internal protection circuits to discharge the static charges that build up on the user's body. However, these ICs should be treated with respect and not taken out of their protective sleeves or conducting foam plastic until they are to be plugged in and used; and try not to over-handle their pins.

Check first the Time Base PCB. If you have an oscilloscope you should find that pulses of exactly one second duration are reaching the S position of switch SW2 and if your oscilloscope has two channels, check that the signal at the M position of SW2 changes from high to low and then low to high every 30 counts of the one-second pulses reaching S.



Now make the inter-board and display connections.

Because the circuit boards do most of the work of wiring up, the biggest potential error is in misconnecting the BCD coded inputs and outputs to and from the 4510 ICs. One misplaced connection can produce such strange figures on the displays that it is difficult to trace errors. So in carrying out this wiring up it is better not to copy what you have done with the previous 4510 but to work out the connections afresh for each of these counters.

Once all the inter-connections are complete, take your courage in both hands and plug in to the mains. If the earlier checks have been carried out there should be few problems. There are no setting up procedures, nor potentiometers to adjust.

When first switched on the displays should register 000 and therefore the relay should be off. The mains socket may be on or off (check the neon), depending on the position of the ALTERNATIVE switch, SW5. Set the thumbwheel switches to some convenient three digit number, say 123, and press the LOAD button, SW3. You should hear the relay close and the displays should now show 123. The timer will start counting down towards zero if the HOLD switch, SW1, is in its open position. If the timer is not counting down, operate the HOLD switch when timing should begin. Pressing SW4 should bring the timing sequence to a premature conclusion, and you should hear the relay drop out when the display shows 000. Alternatively, allowing the timer to count all the way down to 000, should produce the same result: the relay will drop out, and the display will hold at 000.

Some Final thoughts

This timer is particularly suitable for darkroom work where, during enlarging, the experienced photographer will often use the same exposure time for each negative, varying the iris to achieve correct exposure. With the enlarger plugged into the timer's mains socket, simply pressing LOAD each time a print is to be made will repeatedly turn the enlarger on for the number of seconds set. But changing the time period as required is just as easy.

Using a double pole double throw ALTERNATIVE switch and a second changeover set of relay contacts would enable the timer to turn on the enlarger light (and the safe-light off) while timing out, and turn the enlarger off and the safe-light on at the end of each timed period.

One other relatively minor modification that my photographic friends have suggested to me as a useful feature for them is the possibility of the timer being set up to time periods to one tenth of a second.

Making this change is rather simple. Just take the time base output from pin 2 on IC3 as the input into the Counter and Display Circuit at point B, and the third digit of the display will now represent tenths of a second. Now by lighting the LED decimal point between the second and third digits (simply connect the appropriate pin on the display to earth via a 470R resistor), the timer can be set to display and time any period up to 99.9 seconds.

Although I think this design meets all the requirements I had for my purposes, I suppose the major disadvantage of a timer set up in this way is that it does not decode and display time in the way we normally expect, in minutes and seconds. Specialist chips are available to do this but they are not easily obtainable and they are expensive. So, in consideration of my intention to make this project with off-the-shelf components, I decided that the difficulty of calculating, for example, that $4\frac{1}{2}$ minutes was 270 seconds, was not too high a price to pay for construction simplicity and component availability. I hope you agree.

PARTS LIST

RESISTORS	
R1a, R1b	5M
R2-4,7-10,18-21,29-32	100k
R5,6,40,41	10k
R11-17,22-28,33-39	470R
CAPACITORS	
C1	1500µ 25v Elect.
C2,4-10	100n
C3	220µ 25v Elect.
SEMICONDUCTORS	
IC1	7812 volt reg.
IC2	741 op. amp.
IC3-6	4017 CMOS
IC7-9	4543 CMOS
IC10-12	4510 CMOS
Q1	IRF 511 Power FET.
D1,2,3,4	1N4148 signal diodes
D5	1N4002 power diode
BRIDGE RECTIFIER	
40 PIV 1 amp	
MISCELLANEOUS	
SWITCHES	
SW1,2	SPDT lever switches
SW3,4	press-button N.O.
SW5	SPDT lever 240V 6amp
SW6,7,8	10 position BCD thumbwheel
IC Sockets	one at 8-pin
	one at 14-pin
	ten at 16-pin
T1	240v PRI 14v SEC 1/2a
7-Segment Displays	three common anode
Relay	12V coil C/O contacts switching 240V 6A
Standard Mains	
Socket	Three-pin
Neon	240v, integral resistor
Case and Hardware, etc.	

Thevenin And Delta Star Transforms

Easy circuit reduction by P Stephenson.

ANALYSIS

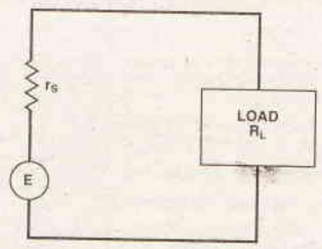


Fig.1 Thevenin objective

Voltage drops and currents in complex networks can usually be found by applying Ohm's and Khirchoff's laws. College students spend many an absorbing hour using these two basic tools to unravel circuit diagrams which, as the course progresses, become more and more formidable. By the time the dreaded exams loom, over-enthusiastic lecturers may be presenting diagrams which could easily be mistaken for the work of Picasso during his middle period.

Ohms law is indispensable but relying two heavily on Kirchoff alone can often lead to time consuming, and sometimes even unnecessary, work. There are several other analytical tools which can cut down the work and, more importantly, lead to a better understanding of circuit behaviour. Thevenin's Transform and the Star/Delta Transform are two of the most useful examples of such additional tools.

Thevenin's Transform

Some circuits are easier to analyse and understand if they can be redrawn in a way which temporarily eliminates an awkward component in order to arrive at an itnermediate solution. A powerful circuit dodge, known as a 'Thevenin Transform', employs this two-stage approach.

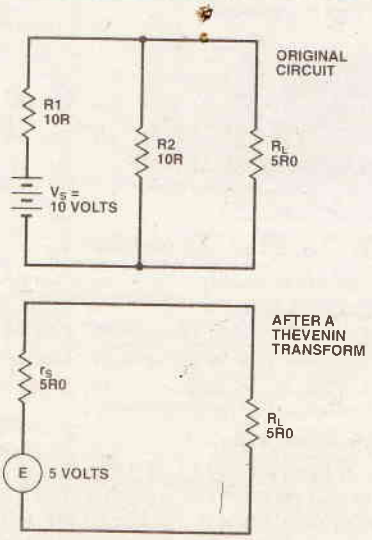


Fig.2 Example transform

The object is to reduce a circuit, however complex, to the three element form shown in Figure 1. The three elements resulting from a Thevenin transform are referred to as:

a) The equivalent source emf, E.
b) The equivalent source resistance, r_S.
c) The load, R_L.

The instructions for performing a Thevenin transform, when expressed in the rigid language favoured by academics, can be a trifle off-putting. It is easier to understand with the aid of an example, such as the one shown in Figure 2a, and 2b. If the load is deemed to be the 5R resistor in Figure 2a then Figure 2b is the transformed version. Three steps are involved:

Step 1. Identify the load terminals and consider the load removed. The voltage across the open-circuited terminals is the equivalent EMF source, E.

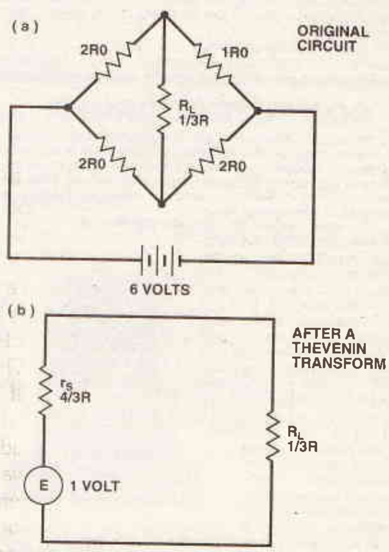


Fig.3 Unbalanced bridge

Step 2. The equivalent source resistance, r_S, is now the total resistance measured across the load terminals if the original voltage source is replaced by a short circuit.

Step 3. Redraw the circuit using only the two new elements and restore the load back to its terminals.

After the transform, the load resistance will be unware that it now rests in a different circuit because the current through it and the voltage across it will be the same as before. That the process is valid — and also time saving — is shown by calculating the load voltage and current in both circuits.

Using the original circuit shown in Figure 2a:
Total resistance, $R_T = R_1 + (R_2 R_L)/(R_2 + R_L) = 13.33$ ohms

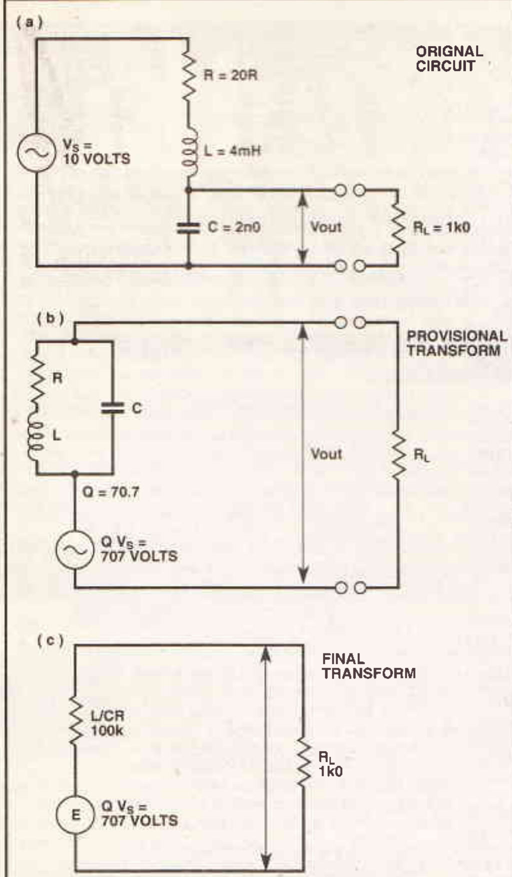


Fig.4 Series resonant circuit

Total current = V_S / R_T = 10/13.33 = 0.75 amps.
Voltage drop across R_1 = 0.75 × 10 = 7.5 volts.
Volts across load = 10 − 7.5 = 2.5 volts.
Current through load = 2.5 volts/5 ohms = 0.5 amps.

Using The Transform In Figure 5

Total resistance = $r_S + R_L$ = 10 ohms, so current in load = 5 volts/10 ohms = 0.5 amp.
Volts across load = 2.5 volts/5 ohms = 0.5 amps.

Both results agree but there is no doubt that method 2, using the Thevenin transform is simpler and quicker. It may be argued that, although method 1 is the longer way round, much more information about the circuit is gained. For example, it has found the total resistance, the total current, the voltage across R_1 as well as the current and voltage across the load. This is, of course undeniable but this is the very point of Thevenin! It can be used to find the conditions across one particular component of interest without the drudgery of first extracting information which may be unwanted anyway. The resistor values in the example were, of course, biased in favour of the Thevenin method but the advantages would be equally evident whatever values are chosen. It should be emphasised that the particular resistor defined as the 'load' remains a personal choice — it need not be the 'outside' one!

Thevenin Solution Of Bridge Network

Figure 3 shows a bridge with resistor values which throws it off-balance. Only when such a bridge is balanced will the current through R_L be zero. In this case however, some current will flow. The problem is — how much current? The solution requires a certain amount of juggling with Khirchoff and simultaneous equations. As shown in Figure 3b, Thevenin again, can help. By applying the same three steps, the equivalent EMF is 1 volt and the equivalent source resistance is $\frac{4}{3}$ ohms. When the $\frac{1}{3}$ ohm load is restored, the total resistance is 2 ohms so the current through R½ amp.

Resonant Circuit Example

To emphasise that Thevenin can be used equaly well in A/D networks, Figure 4a is showing a series circuit consisting of an inductance, L, having resistance R in series with a capacitance, C. When the circuit is resonant, a voltage is developed across the capacitor equal to Q times the supply voltage — where Q is the circuit magnification factor. Unfortunately, this voltage is little more than hot air — it is there until it is asked to do some work! As soon as it senses a load across its terminals, the voltage could plunge downwards, and become a mere shadow of its former glory.

Although calculating the on-load voltage is not difficult it can involve a nauseating orgy of j notation. However, if only the load voltage is required, much of the tedium can be avoided by employing the Thevenin transformed version, shown in Figure 4b. Using the same three steps used in the first example, the equivalent EMF is QVs and the equivalent source impedance turns out to be a PARALLEL resonant circuit which is a pure resistance of value L/CR (called the 'dynamic impedance'), Z_D.

When the load is now connected, the voltage across it can easily be found because, as Figure 4c shows, it is the output from a simple voltage divider. The following calculations, based on Figure 3 show the conditions before and after the load is connected.

Open-circuited output:

$$Q = 1/R \sqrt{L/C} = 70.7$$

Output voltage = Q × Vs = 707 volts

Output with load connected:

Thevenin equivalent EMF E = 707 volts.
Thevenin equivalent source impedance = L/CR = 100k
Output voltage is therefore about $\frac{1}{100}$th of 707 = 7.07 volts.

Anyone doubting the power of a Thevenin transform should try calculating this output voltage on load without it! Apart from finding the on-load output voltage, it is usually more important to determine the lowest load resistance permissable if the high open-circuit voltage is to be maintained. To ensure this, the load should be at least ten times higher than the equivalent source resistance. As Figure 4c shows, this would require a load of at least 1 Megohm.

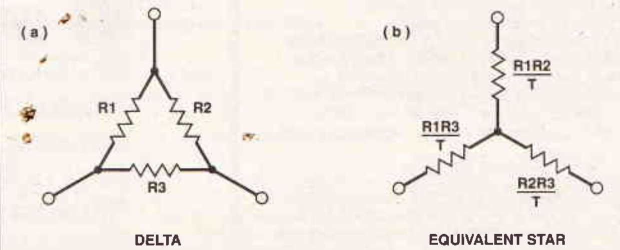


Fig.5 Delta to star transfer rules

The Delta Star Transform

Figure 5a shows a three-terminal 'delta' network, so-called because it resembles the Greek letter of that name. This network can be quite difficult to crack when it forms part of a larger network. The delta-star transform is a useful dodge for changing to the equivalent 'star' form as shown in Figure 5b.

Rules for converting

- First add up the value of all three resistors in the delta form and call this T.
- The equivalent 'star' resistor is then the product of the two adjacent delta resistors divided by T.

Figure 6 shows a worked example of such a trans-

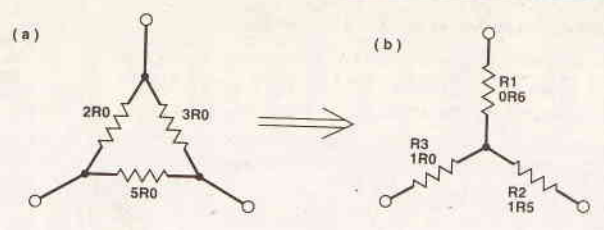


Fig.6 Example figures

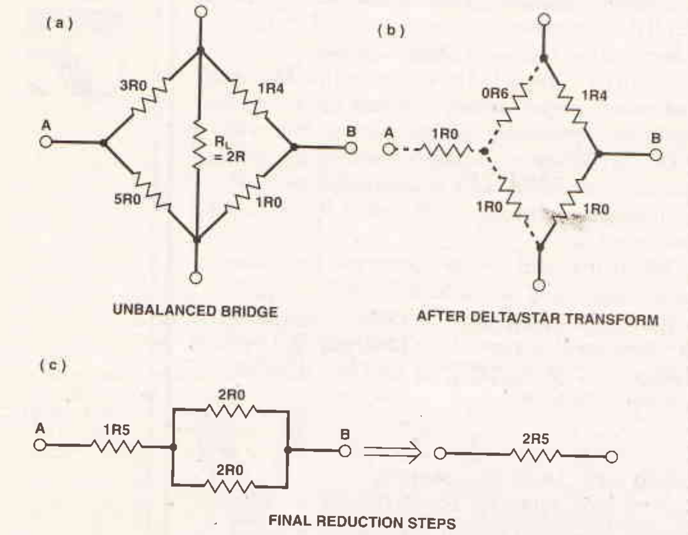


Fig.7 Unbalanced bridge example

form. The value of T in the delta form is 2+3+5=10. So, applying the rule to find the equivalent star form:
$R_1 = (2\times3)/10 = 0.6$ ohm
$R_2 = (3\times5)/10 = 1.5$ ohm
$R_3 = (2\times5)/10 = 1.0$ ohm

Now, if a sealed 'black box' contained one of these forms with its three terminals brought out, it would be impossible to tell by any external testing methods, whether the black box contained a delta or the equivalent star form!

Using Delta/Star in bridge networks

Figure 7 shows an unbalanced bridge network and the problem is to find the total resistance across the terminals A and B. At first sight, this may seem like a straightforward exercise involving parallel and series resistors. But, after a few abortive attempts it is soon realised that the awkward resistor in the middle is a serious obstacle. The difficulty vanishes if one of the deltas is converted to the equivalent star form. Either of them can be taken but a glance at the example reveals that the left hand delta has the easier figures — the value of T works out to a nice round value of ten. Figure 7b shows the star equivalent of the left hand delta, drawn in dotted lines for emphasis. By applying the rules given above, the star values work out to:
$R_1 = (3\times5)/10 = 1.5$ ohms.
$R_2 = (5\times2)/10 = 1.0$ ohm
$R_3 = (3\times2)/10 = 0.6$ ohm

The resultant network is now free of that awkward resistor which was in the middle. Figure 7c shows the final steps — which, hopefully require no explanation — leading to the 2.5 ohm result.

Surplus always wanted for cash! THE *ORIGINAL* SURPLUS WONDERLAND! Surplus always wanted for cash!

BBC Model B APM Board

WIN £100 CASH!

£100 CASH FOR THE MOST NOVEL DEMONSTRATABLE APPLICATION!

BBC Model B type computer on a board. A major purchase allows us to offer you the **PROFESSIONAL** version of the BBC computer at a parts only price. Used as a front end graphics system on large networked systems the architecture of the BBC board has so many similarities to the regular BBC model B that we are sure that with a bit of experimentation and ingenuity many useful applications will be found for this board!! It is supplied complete with a connector panel which brings all the I/O to 'D' and BNC type connectors - all you have to do is provide +5 and ± 12 v DC. The APM consists of a single PCB with most major ic's socketed. The ic's are too numerous to list but include a 6502, RAM and an SAA5050 teletext chip. Three 27128 EPROMS contain the custom operating system on which we have no data, On application of DC power the system boots and provides diagnostic information on the video output. On board DIP switches and jumpers select the ECONET address and enable the four extra EPROM sockets for user software. Appx. dims: main board 13" x 10". I/O board 14" x 3". Supplied tested with circuit diagram, data and competition entry form.

Only £29.95 or 2 for £53 (B)

MONITORS

MONOCHROME MONITORS

THIS MONTH'S SPECIAL!

There has never been a deal like this one! **Brand spanking new & boxed** monitors from NEC, normally selling at about £140! These are over-engineered for ultra reliability. 9" green screen composite input with etched non-glare screen plus switchable high/low impedance input and output for daisy-chaining. 3 front controls and 6 at rear. Standard BNC sockets. Beautiful high contrast screen and attractive case with carrying ledge. Perfect as a main or backup monitor and for quantity users! **£39.95 each** (D) **or 5 for £185**(G)

CALL FOR DISCOUNTS ON HIGHER QUANTITIES!

COLOUR MONITORS

Decca 16" 80 budget range colour monitor. Features a PIL tube, beautiful teak style case and guaranteed 80 column resolution, features usually seen only on colour monitors costing 3 times our price! Ready to connect to most computers or video outputs. 75Ω composite input with integral audio amp & speaker. Fully tested surplus, sold in little or hardly used condition with 90 day full RTB guarantee. Ideal for use with video recorder or our Telebox ST, and other audio visual uses. £99(E) 3/£275(G)

20", 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools,Shops,Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

CALL FOR PRICING ON NTSC VERSIONS!

HI-DEFINITION COLOUR MONITORS

Brand new 12" mutlinput high definition colour monitors by Microvitek. Nice tight 0.31" dot pitch for superb clarity and modern metal black box styling. Operates from any 15.625 khz sync RGB video source, with either individual H & V syncs such as CGA IBM PC's or RGB analog with composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 14" x 12" square. Free data sheet including connection information. Will also function as quality TV with our RGB Telebox.

Only £145 (E)

Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubushi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case.Full 90 day guarantee. **Only £129** (E)

NEC CGA IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. A terrific purchase enables us to pass these on at only.... **£79** (E)

V22 1200 BAUD MODEMS

Master Systems 2/12 microprocessor controlled V22 full duplex 1200 baud modem. Fully **BT approved** unit, provides standard V22 high speed data comm, which at 120 cps, can save your phone bill and connect time by a staggering 75%! Ultra slim 45 mm high. Full featured with LED status indicators and remote error diagnostics. Sync or Async use; speech or data switching; built in 240v mains supply and 2 wire connection to BT. Units are in used but good condition. Fully tested prior despatch, with data and a full 90 day guarantee. What more can you ask for - and at this price!! **ONLY £69** (D)

IBM KEYBOARD DEALS

A replacement or backup keyboard, switchable for IBM PC, PC-XT or PC-AT. LED's for Caps,Scroll & Num Locks. Standard 84 keyboard layout. Made by NCR for the English & US markets. Absolutely standard. Brand new & boxed with manual and key template for user slogans on the function keys. Attractive beige,grey and cream finish, with the usual retractable legs underneath. A generous length of curly cord, terminating in the standard 5 pin DIN plug. A beautiful clean piece of manufacturers surplus. What a deal! **£39** (B) **5/£175** (D)

Brand new and boxed 84 key PC/XT type keyboards in standard IBM grey with very attractive mottled finish and "clicky" solid feel keys. 10 function keys on side. English layout and £ sign. Green LEDs for Caps, Scroll & Num locks. **£29.95** (B) **5/£135** (D)

CALL FOR DISCOUNTS ON HIGHER QUANTITIES!

FLOPPY DISK DRIVES BARGAINS GALORE !

NEW 5¼ inch from £29.95!

Massive purchases of standard 5¼" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested,aligned and shipped to you with a 90 day guarantee and operate from +5 & +12vdc, are of standard size and accept the standard 34 way connector.

TANDON TM100-2A IBM compatible DS	**£39.95**(C)
CANON,TEC etc.DS half height.State 40 or 80T	**£79.00**(C)
TEAC FD-55-F.40-80 DS half height. **BRAND NEW**	**£79.00**(C)

Specials!

TEAC FD-55 half height series in your choice of 40 track double sided 360k or 80 track double sided 720k. Ex-equipment fully tested in excellent condition with 90 day warranty. Order TE-36 for 360k **£29.95**(C) or TE-72 for 720k **£39.95**(C)

CHOOSE YOUR 8 INCH!

Shugart 800/801 SS refurbished & tested	**£150.00**(E)
Shugart 851 double sided refurbished & tested	**£225.00**(E)
Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW	**£250.00**(E)

SPECIAL OFFERS!!

Dual 8" drives with 2 megabyte capacity housed in a smart case with built in power supply! Ideal as exterior drives! **Only £499.00** (F)

End of line purchase scoop! Brand new **NEC D2246** 8" 85 megabyte of hard disk storage! Full CPU control and industry standard SMD interface. Ultra hi speed transfer and access time leaves the good old ST506 interface standing. In mint condition and comes complete with manual. Only........................**£399**(E)

AFFORDABLE 10 Mb WINCHESTERS

A fantastic deal - 10mb (formatted) Winchester for £39.95! **Tandon TM502** full height ST506 interface. Use it as a second hard drive on your present driver card or as a starter into Winchester land - see the driver card listed below. In excellent used condition, guaranteed for 90 days......................**£39.95**(C)

Hard disk driver card, complete with cables ready to plug into your PC or compatible. Supports two Winchesters......**£29.95**(A)

No Break Uninterruptable PSU's

Brand new and boxed 230 volts uninterruptable power supplies from **Densei**. Model MUK 0565-AUAF is 0.5 kva and MUD 1085-AHBH is 1 kva. Both have sealed lead acid batteries. MUK are internal, MUD has them in a matching case. Times from interrupt are 5 and 15 minutes respectively. Complete with full operation manuals............**MUK......£249** (F) **MUD......£525** (G)

RECHARGEABLE BATTERIES

LEAD ACID

Maintenance free sealed long life. Type A300.

12 volts	12 volts 3 amp/hours	£13.95(A)
6 volts	6 volts3 amp/hours	£ 9.95(A)
12 volts	Centre tapped 1.8 amp hours. RFE.	£ 5.95(A)
12 volts	12 volts 38 amp hours.7-1/2"L x6"S.RFE	**£35.00**(B)

EXTRA HI-CAPACITY NICKEL CADMIUM

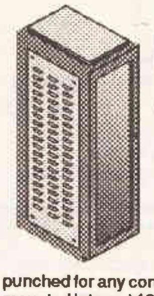
Super high capacity **Chloride Alcad** 12 volts refillable type XL1.5. Electrolyte is readily available Potassium Hydroxide. In banks of 10 cells per 8"H x 24"L x 5.5"D wooden case. Each cell measures 8"H x 1.75"L x 4"D. Can be easily separated. Ideal for all standby power applications. Ex MoD, like new..**£49.95** (E)

SPECIAL INTEREST

Newton Derby frequency changer 3 phase 50hz to 3 phase 400hz. 15 kva output. As new.	£2900
Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator	£6500
Calcomp 1036 large drum 3 pen plotter	£ 650
Thurlby LA 160B logic analyser	£ 375
1.5kw 115v 60hz power source	£ 950
Tektronix R140 NTSC TV test signal standard.	£ 875
Sony KTX 1000 Videotex system - **brand new**	£ 650
ADDS 2020 VDU terminals - **brand new**	£ 225
Sekonic SD 150H 18 channel Hybrid recorder	£2000
Trend 1-9-1 Data transmission test set	£ 525
Kenwood DA-3501 CD tester, laser pickup simulator	£ 350

Superb Quality 6 foot 40u 19" Rack Cabinets

Massive Reductions Virtually New, Ultra Smart! *Less Than Half Price!*



Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels or stand singly. Overall dimensions are 77-1/2"H x 32-1/2"D x 22"W. Order as:

Rack 1 Complete with removable side panels......**£275.00** (G)
Rack 2 Less side panels.....................................**£145.00** (G)

POWER SUPPLIES

Power One SPL200-5200P 200 watt (250 w peak).Semi open frame giving +5v 35a, -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims13" x 5" x 2.5". Fully guaranteed RFE. **£85.00** (B)

Power One SPL130. 130 watts. Selectable for 12v (4A) or 24 v (2A). 5v @ 20A.± 12v @ 1.5A. Switch mode. New. **£59.95**(B)

Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4".New **£19.95**(B)

Greendale 19AB0E 60 watts switch mode.+5v @ 6a,±12v @ 1a,+15v @ 1a. RFE and fully tested.11 x 20 x5.5cms. **£24.95**(C)

Conver AC130. 130 watt hi-grade VDE spec.Switch mode.+5v @ 15a,-5v @ 1a,±12v @ 6a.27 x 12.5 x 6.5cms.New. **£49.95**(C)

Boshert 13090.Switch mode.Ideal for drives & system. +5v@ 6a, +12v @ 2.5a, -12v @ 0.5a, -5v @ 0.5a. **£29.95**(B)

Farnell G6/40A. Switch mode. 5v @ 40a.Encased **£95.00**(C)

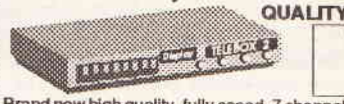
COOLING FANS

Please specify 110 or 240 volts for AC fans.

3 inch	AC. 1½" thick	£ 8.50(B)
3½ inch	AC ETRI slimline.Only 1" thick.	£ 9.95(B)
3½ inch	AC 230 v 8 watts. Only 3/4" thick	£12.95(A)
4 inch	AC 110/240v 1½" thick.	£10.95(B)
4 inch	AC round. 3½ thick. Rotron 110v	£10.95(B)
10 inch	As above but 230 volts	£24.95(B)
60 mm	DC 1" thick.No.812 for 6/12v.814 24v.	£15.95(A)
80 mm	DC 5 v. Papst 8105G 4w. 38mm. RFE.	£19.95(A)
92 mm	DC 12v. 18 mm thick.	£14.95(A)
4 inch	DC 12v. 12w 1½" thick	£12.50(B)
4 inch	DC 24v 8w. 1" thick.	£14.50(B)

THE *AMAZING* TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER!

Brand new high quality, fully cased, 7 channel UHF PAL TV tuner system. Unit simply connects to your TV aerial socket and colour video monitor turning same into a fabulous colour TV. Dont worry if your monitor does'nt have sound, the TELEBOX even has an integral audio amp for driving a speaker plus an auxiliary output for Headphones or Hi Fi system etc. Many other features: LED Status indicator, Smart moulded case, Mains powered, Built to BS safety specs. Many other uses for TV sound or video etc. Supplied BRAND NEW with full 1 year guarantee.

Telebox ST for composite video input monitors.........**£32.95**(B)
Telebox STL as ST but with integral speaker............**£36.50**(B)
Telebox RGB for analogue RGB monitors..................**£68.95**(B)

RGB Telebox also suitable for IBM multisync monitors with RGB analog and composite sync. Overseas versions VHF & UHF call. SECAM / NTSC not available.

BRAND NEW PRINTERS

TEC Starwriter Model FP1500-25 daisywheel printer renowned for its reliability. Diablo type print mechanism gives superb registration and quality. On board microprocessor gives full Diablo/Qume command capability. Serial RS-232C with full handshake. Bidirectional 25 cps, switchable 10 or 12 pitch, 136 cpi in Pica, 163 in Elite. Friction or tractor feed. Full ASCII including £ sign. Font and ribbon Diablo compatible..........**£199**(E)

DED DPG21 miniature ball point pen printer plotter mechanism with full 40 characters per line. Complete with data sheet which includes circuit diagrams for simple driver electronics......**£49**(B)

Centronics 150 series. Always known for their reliabilty in continuous use - real workhorses in any environment. Fast 150 cps with 4 fonts and choice of interfaces at a fantastic price!

150-4 Serial up to 9.5" paper, fan fold tractor.................**£99.00**(E)
150-4 Serial up to 9.5" paper, tractor, roll or s/sheet.....**£129.00**(E)
152-2 parallel up to 14.5" paper, tractor or s/sheet.....**£149.00**(E)

CALL FOR THE MANY OTHERS IN STOCK.

VISIT OUR SHOP FOR BARGAINS

LARGE QUANTITIES OF OSCILLOSCOPES AND TEST GEAR ALWAYS AVAILABLE - CALL NOW!

DISPLAY -ELECTRONICS-

MAIL ORDER & OFFICES
Open Mon-Fri 9.00-5.30
Dept ET, 32 Biggin Way,
Upper Norwood,
London SE19 3XF.

LONDON SHOP
100's of bargains!
Open Mon-Sat 9-5.30
215 Whitehorse Lane,
South Norwood,
London, SE25.

DISTEL © The Original
Free dial-up database!
1000's of items+info On Line
V21, V22 & V22 bis
081-679-1888

ALL ENQUIRIES
081-679-4414
Fax- 081-679-1927
Telex- 894502

VISA

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. PO orders from Government,Universities,Schools & Local Authorities welcome-minimum account order £25. Carriage charges (A)=£2.00. (B)=£5.50. (C)=£8.50. (D)=£11.50. (E)=£14.00 (F)=£18.00 (G)=Call . All goods supplied subject to our standard Conditions of Sale and unless otherwise stated guaranteed for 90 days. All guarantees on a return to base basis.We reserve the right to change prices & specifications without prior notice. Orders accepted subject to stock. Quotations willingly given for higher quantities than those stated. Bulk surplus always required for cash.

AMSTRAD PORTABLE PC'S FROM £149 (PPC1512SD). £179 (PPC1512DD). £179 (PPC1640SD). £209 (PPC1640DD). MODEMS £30 EXTRA.NO MANUALS OR PSU.

HIGH POWER CAR SPEAKERS. Stereo pair output 100w each. 4ohm impedance and consisting of 6 1/2" woofer 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00 Order ref 30P7R.
2KV 500 WATT TRANSFORMERS Suitable for high voltage experiments or as a spare for a microwave oven etc. 250v AC input. £10.00 ref 10P93R
MICROWAVE CONTROL PANEL Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. £6.00 ref 6P18R
FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29R
12V SOLAR CELL. 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42R

PASSIVE INFRA-RED MOTION SENSOR. Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual overide facility. Complete with wall brackets, bulb holders etc. Brand new and guaranteed. £25.00 ref 25P24R. Pack of two PAR38 bulbs for above unit £12.00 ref 12P43R

VIDEO SENDER UNIT Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel). 12v DC op. £15.00 ref 15P39R Suitable mains adaptor £5.00 ref 5P191R
FM TRANSMITTER housed in a standard working 13A adapter (bug is mains driven). £26.00 ref 26P2R
MINATURE RADIO TRANSCEIVERS A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases. £30.00 ref 30P12R

FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42AR
12 BAND COMMUNICATIONS RECEIVER. 9 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead NOW ONLY £19.00!! REF 19P14R.

WHISPER 2000 LISTENING AID. Enables you to hear sounds that would otherwise be inaudible! Complete with headphones. Cased. £5.00 ref 5P179R.
CAR STEREO AND FM RADIO Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. £25.00 ref 25P21R.
LOW COST WALIKIE TALKIES. Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R

7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power amp! 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14R.
NICAD BATTERIES. Brand new top quality. 4 x AA's £4.00 ref 4P44R. 2 x C's £4.00 ref 4P73R, 4 x D's £9.00 ref 9P12R, 1 x PP3 £6.00 ref 6P35R
TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. Latest edition £20.00 ref 20P32R.
CABLE TIES. 142mm x 3.2mm white nylon pack of 100 £3.00 ref 3P104R. Bumper pack of 1,000 ties £14.00 ref 14P6R

1992 CATALOGUE AVAILABLE NOW
IF YOU DO NOT HAVE A COPY PLEASE REQUEST ONE WHEN ORDERING OR SEND US A 6"X9" SAE FOR A FREE COPY.

GEIGER COUNTER KIT. Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1R
FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158R
FM BUG Built and tested superior 9v operation £14.00 ref 14P3R
COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.
SINCLAIR C5 MOTORS 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £20.00 ref 20P22R.
As above but with fitted 4 to 1 inline reduction box (800rpm) and toothed nylon belt drive cog £40.00 ref 40P8R.
SINCLAIR C5 WHEELS 13" or 16" dia including treaded tyre and inner tube. Wheels are black, spoked one piece poly carbonate. 13" wheel £6.00 ref 6P20R, 16" wheel £6.00 ref 6P21R.
ELECTRONIC SPEED CONTROL KIT for c5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref 17P3R.
SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R.

12 VOLT BRUSHLESS FAN 4 1/2" square brand new ideal for boat, car, caravan etc. £5.00 ref 5P206.
ACORN DATA RECORDER ALF503 Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43R
VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 10 tapes £20.00 ref 20P20R.
PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10R. MAINS POWER SUPPLY KIT £20.00 REF 20P33R READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4R.
6V 10AH LEAD ACID sealed battery by yuasha ex equipment but in excellent condition now only 2 for £10.00 ref 10P95R.
12 TO 220V INVERTER KIT As supplied it will handle up to about 15w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.

VERO EASI WIRE PROTOTYPING SYSTEM Ideal for designing projects on etc. Complete with tools, wire and reusable board. Our price £6.00 ref 6P33R.
MICROWAVE TURNTABLE MOTORS. Ideal for window displays etc. £5.00 ref 5P165R.
STC SWITCHED MODE POWER SUPPLY 220v or 110v input giving 5v at 2A, +24v at 0.25A, +12v at 0.15A and +90v at 0.4A £6.00 ref 6P59R
HIGH RESOLUTION 12" AMBER MONITOR 12v 1.5A Hercules compatible (TTL input) new and cased £22.00 ref 22P2R
VGA PAPER WHITE MONO monitors new and cased 240v AC. £59.00 ref 59P4R
25 WATT STEREO AMPLIFIERc. STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69R (Circuit dia included).
LINEAR POWER SUPPLY Brand new 220v input +5 at 3A, +12 at 1A, -12 at 1A. Short circuit protected. £12.00 ref 12P21R.
MINI RADIO MODULE Only 2" square with ferrite aerial and tuner. Superhet. Req's PP3 battery. £1.00 ref BD716R.
BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R
FRESNEL MAGNIFYING LENS 83 x 52mm £1.00 ref BD827R.
ALARM TRANSMITTERS. No data avaliable but nicely made complex transmitters 9v operation. £4.00 each ref 4P81R.
UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36R.

COLOUR MONITORS
AMSTRAD CTM644
RGB INPUT
£75.00 REF A75P1

RESISTOR PACK. 10 x 50 values (500 resistors) all 1/4 watt 2% metal film. £5.00 ref 5P170R.
CAPACITOR PACK 1. 100 assorted non electrolytic capacitors £2.00 ref 2P286R.
CAPACITOR PACK 2. 40 assorted electrolytic capacitors £2.00 ref 2P287R.
QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R.
LED PACK. 50 red leds, 50 green leds and 50 yellow leds all 5mm £8.00 ref 8P52R
FERRARI TESTAROSSA. A true 2 channel radio controlled car with forward, reverse, 2 gears plus turbo. Working headlights. £22.00 ref 22P6R.

MIRACOM WS4000 MODEMS
V21/23
AT COMAND SET
AUTODIAL/AUTOANSWER
FULL SOFTWARE CONTROL
TONE AND PULSE DIALLING
£29

PIR LIGHT SWITCH Replaces a standard light switch in seconds light operates when anybody comes within detection range (4m) and stays on for an adjustable time (15 secs to 15 mins). Complete with daylight sensor. Unit also functions as a dimmer switch! 200 watt max. Not suitable for flourescents. £14.00 ref 14P10R
CUSTOMER RETURNED 2 channel full function radio controlled cars only £8.00 ref 8P200R
WINDUP SOLAR POWERED RADIO! FM/AM radio takes rechargeable batteries complete with hand charger and solar panel 14P200R
240 WATT RMS AMP KIT Stereo 30-0-30 psu required £40.00 ref 40P200R
300 WATT RMS MONO AMP KIT £55.00 Psu required ref 55P200
ALARM PIR SENSORS Standard 12v alarm type sensor will interface to most alarm panels. £16.00 ref 16P200
ALARM PANELS 2 zone cased keypad entry, entry exit time delay etc. £18.00 ref 18P200
MODEMS FOR THREE POUNDS!! Fully cased UK modems designed for dial up system (PSTN) no data or info but only £3.00 ref 3P145R
TELEPHONE HANDSETS Bargain pack of 10 brand new handsets with mic and speaker only £3.00 ref 3P146R
BARGAIN STRIPPERS Computer keyboards. Loads of switches and components excellent value at £1.00 ref CD40R
PC POWER SUPPLIES These units are new but need attention complete with case, fan IEC input plug disc drive and mother board fly leads. Our price is £5.00 (less than the fan alone would cost!) ref 5P208R

HIGH VOLTAGE CAPACITORS A pack of 20 500PF 10KV capacitors ideal for ionizers TV repairs and high voltage experiments etc. Price is £2.00 ref 2P378R
DATA RECORDERS Customer returned mains battery units built in mic ideal for Computer or general purpose audio use. Price is £4.00 ref 4P100R
SPECTRUM JOYSTICK INTERFACE Plugs into 48K Spectrum to provide a standard Atari type joystick port. Our price £4.00 ref 4P101R
ATARI JOYSTICKS Ok for use with the above interface, our price £4.00 ref 4P102R
BENCH POWER SUPPLIES Superbly made fully cased (metal) giving 12v at 2A plus a 6V supply. Fused and short circuit protected. For sale at less than the cost of the case! Our price is £4.00 ref 4P103R
SPEAKER WIRE Brown twin core insulated cable 100 feet for £2.00 REF 2P79R
MAINS FANS Brand new 5" x 3" complete with mounting plate quite powerfull and quite. Our price £1.00 ref CD41R
DISC DRIVES Customer returned units mixed capacities (up to 1.44M) We have not sorted these so you just get the next one on the shelf. Price is only £7.00 ref 7P1R (worth it even as a stripper)
HEX KEYBOARDS Brand new units approx 5" x 3" only £1.00 each ref CD42R
PROJECT BOX 51/2" x 31/2" x 1" black ABS with screw on lid. £1.00 ref CD43R
SCART TO SCART LEADS Bargain price leads at 2 for £3.00 ref 3P147R
SCART TO D TYPE LEADS Standard Scart on one end, Hi density D type on the other. Pack of ten leads only £7.00 ref 7P2R
OZONE FRIENDLY LATEX 250ml bottle of liquid rubber sets in 2 hours. Ideal for mounting PCB's fixing wires etc. £2.00 each ref 2P379R
QUICK SHOTS Standard Atari compatible hand controller (same as joysticks) our price is 2 for £2.00 ref 2P380R
VIEWDATA SYSTEMS Brand new units made by TANDATA complete with 1200/75 built in modem infra red remote controlled qwerty keyboard BT approved Prestel compatible, Centronics printer port RGB colour and composite output (works with ordinary television) complete with power supply and fully cased. Our price is only £20.00 ref 20P1R
3 INCH DISCS Ideal for Amstrad PCW and Spectrum +3 machines pack of 10 discs is £12.00 ref 12P1R
AC STEPDOWN CONVERTOR Cased units that convert 240v to 110v 3" x 2" with mains input lead and 2 pin American output socket (suitable for resistive loads only) our price £2.00 ref 2P381R
SPECTRUM +3 LIGHT GUN PACK complete with software and instructions £8.00 ref 8P58R
CURLY CABLE Extends from 8" to 6 feet! D connector on one end, spade connectors on the other ideal for joysticks etc (6 core) £1.00 each ref CD44R
COMPUTER JOYSTICK BARGAIN Pack of 2 joysticks only £2.00 ref 2P382R
MINI MONO AMPLIFIER PACK 4 amplifiers for £2.00! 3 watt units 9-12v operation ideal for experiments etc £2.00 ref 2P383R
BUGGING TAPE RECORDER Small hand held cassette recorders that only operate when there is sound then turn off 6 seconds after so you could leave it in a room all day and just record any thing that was said. Price is £20.00 ref 20P3R
IEC MAINS LEADS Complete with 13A plug our price is only £3.00 for TWO! ref 3P148R
COMPUTER SOFTWARE BARGAIN 10 cassettes with games for commodore 64, Spectrum etc. Our bargain price one pound! ref CD44R
NEW SOLAR ENERGY KIT Contains 8 solar cells, motor, tools, fan etc plus educational booklet. Ideal for the budding enthusiast! Price is £12.00 ref 12P2R
FUSE PACK NO 1 Fifty fuses 1 1/4" long (glass) quick blow 10 popular values £2.00 ref 2P384R
FUSE PACK NO 2 Fifty fuses 20mm long (glass) quick blow 10 popular values £2.00 ref 2P385R
POTENTIOMETER PACK NO 1 30 pots for £3.00! ideal for projects etc. Ref CD45R

286 AT PC
286 MOTHER BOARD WITH 640K RAM FULL SIZE METAL CASE, TECHNICAL MANUAL, KEYBOARD AND POWER SUPPLY £139 REF 139P1 (no i/o cards or drives included)

35MM CAMERAS Customer returned units with built in flash and 28mm lens 2 for £8.00 ref 8P200
STEAM ENGINE Standard Mamod 1332 engine complete with boiler piston etc £30 ref 30P200

TALKING CLOCK LCD display, alarm, battery operated. Clock will announce the time at the push of a button and when the alarm is due. The alarm is switchable from voice to a cock crowing! £14.00 ref 14P200.R
HANDHELD TONE DIALLERS Small units that are designed to hold over the mouth piece of a telephone to send MF dialling tones. Ideal for the remote control of answer machines. £5.00 ref 5P209R
COMMODORE 64 MICRODRIVE SYSTEM Complete cased brand new drives with disc and software 10 times faster than tape machines works with any Commodore 64 setup. The orginal price for these was £49.00 but we can offer them to you at only £25.00! Ref 25P1R
USED SCART PLUGS Packof 10 plugs suitable for making up leads only £5.00 ref 5P209R
C CELL SOLAR CHARGER Same style as our 4 x AA charger but holds 2 C cells. Fully cased with flip top lid. Our price £6.00 Ref 6P79R

BULL ELECTRICAL
250 PORTLAND ROAD HOVE SUSSEX
BN3 5QT TELEPHONE 0273 203500
MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £2.50 POST PLUS VAT.
PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY
NEXT DAY DELIVERY £8.00
FAX 0273 23077
VISA

SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

Instrumentation & Test Gear Basics

Ray Marston presents the second part of his new 'test gear' mini-series.

November's opening part of this mini-series began by introducing the reader to modern instrumentation and test gear terminology, and ended by looking at basic types of 'generator' circuit. This month's episode picks up from where we left off.

'Indicator' Accuracy

The next major category of test gear is the 'indicator', which usually consists of some type of analogue or digital meter. Before looking at the various types of indicator, mention must be made of the system of specifying the accuracy of meters.

The accuracy of analogue meters (i.e. moving coil types, etc) is specified by the statement that the actual meter reading is 'accurate to within ± 'x % of the FSD value of the meter'. By convention, this statement is usually abbreviated to the simple but rather ambiguous statement that the meter has an 'accuracy of 'x' %', the remaining qualifying parts of the full statement being accepted (by practical engineers) as implicity and self explanatory. Thus, if a meter has a specified 'accuracy' of 3% (a typical value) and has a FSD (full scale deflection) value of 10V, as shown in Figure 1, it is implied that the meter has a true input in the range 9.7 to 10.3 volts when it reads 10V, and in the range 0.7 to 1.3 volts when it reads 1V. Note in the latter example that meter errors may be as high as 30%.

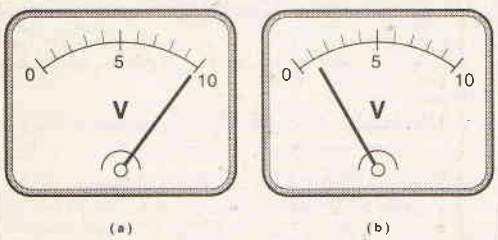


Fig 1. This 10V meter has a basic 'accuracy' (see text) within 3% of FSD; its readings are accurate to within (a) 3% at 10V, and (b) 30% at 1V.

Digital meters usually give three or more digits of readout, as shown in Figure 2. A simple 3-digit type can give a maximum reading of 999. Most general-purpose digital voltmeters (DVMs) can give a maximum reading of 1999, and are known as 3½-digit DVMs; high-precision types can give a maximum reading of 19999 and are known as 4½-digit DVMs. Their precision is fully specified by the statement that their reading is 'accurate to within 'x' percent of the actual reading, ± 'x' digits'. By convention, this statement can be abbreviated to a simple statement that the meter has an 'accuracy of 'x' percent, ± 'x' digits'. Thus, if a 3½-digit 19.99 volt meter has an 'accuracy' of 0.5% ±2 digits (a typical value), as shown in Figure 3, it is implied that its readings are accurate to within 0.7% at 10V, and to 2.5% at 1V0.

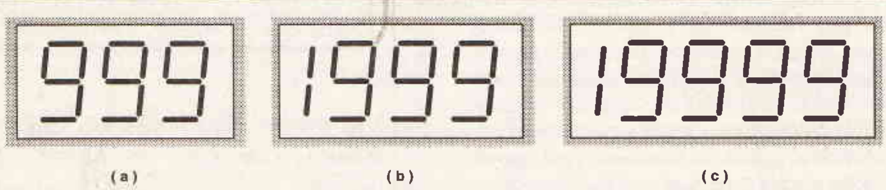


Fig 2. Full-scale readings on digital meters with (a) 3-digits, (b) 3½digits, and (c) 4½-digits.

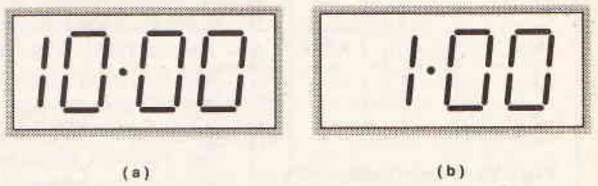


Fig 3. This 3½-digit meter has a full scale sensitivity of 19.99V and a basic 'accuracy' (see test) within 0.5% ±2 'digits'; its readings are accurate to within (a) 0.7% at 10V, and (b) 2.5% at 1V0.

Indicator Types

The following 'Indiator' types of test gear are in common use:

ANALOGUE METERS. These are designed to give a visual representation of a monitored parameter value by moving a pointer or a dot or bar of light a proportionate distance across a graduated scale. Figure 4 shows examples of a 7 volt reading given on 10 volt meters using (a) moving pointer and (b and C) ten-LED bar-graph and dot-graph 'moving light' diplays.

The reader should note that analogue meters have two major advantages over digital types. The first is that they give clear indications of measurement variations (digital displays present a confused jumble of numbers under this condition), making them uniquely well suited to applications such as 'peak point' and 'null point' indicating. The second great advantage is that they can be inscribed with both linear and non-linear scales, enabling, for example, a single meter to read both linear and dB voltage values.

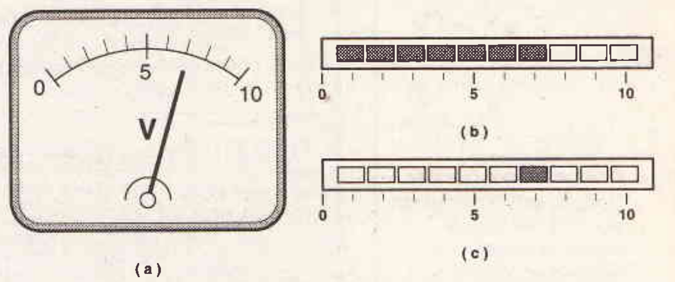


Fig 4. Representations of 7V readings on 10V meters of the following types; (a) moving pointer, (b) 10-LED bar-graph, (c) 10-LED dot-graph.

In instrumentation and test gear applications, the most widely used type of analogue meter is the 'moving coil' type. These are actually current-indicating meters in which the test current flows through a coil and causes the meter's pointer to deflect by a proportional amount. The coil has a finite resistance, and the performance of the meter can thus be depicted by presenting it as shown in Figure 5; in this instance the meter has an FSD sensitivity of 100µA and an internal resistance of 1000R, and

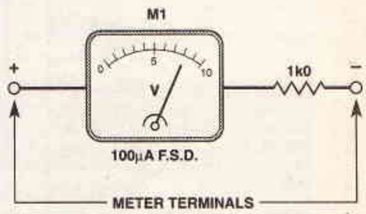


Fig 5. Representation of a moving coil meter with a FSD sensitivity of 100µA and 1000R internal resistance.

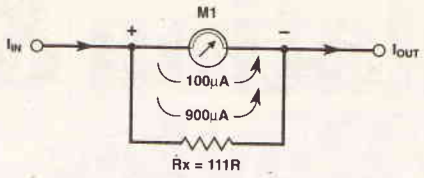


Fig 6. External shunt (R_x) used to convert the above meter to read 1mA FSD.

thus has 100mV generated across its terminals at FSD.

The sensitivity of the Figure 5 meter can be effectively reduced (so that it needs a greater current to give a FSD reading) by shunting the meter's terminals with a suitable resistor (Rx), as shown in Figure 6. Alternatively, the meter can be made to act as a DC voltage indicator by wiring it in series with 'multiplier' resistor Rx, as shown in the '10V FSD' meter circuit of Figure 7; here, the 100µA meter has, by definition, a basic sensitivity of 10kΩ/V, so Rm (which equals the sum of Rx and the meter's internal resistance) needs a value of 100k. The meter can be made to indicate AC current values by feeding them to the meter via a bridge rectifier; Figure 8 shows how the meter can be made to indicate AC voltage values by feeding them to the meter via a multiplier resistor (Rx) and a bridge rectifier.

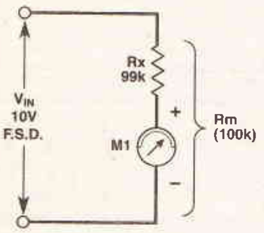


Fig 7. Series multiplier resistor R_x used to convert the 100µA meter to read 10V FSD.

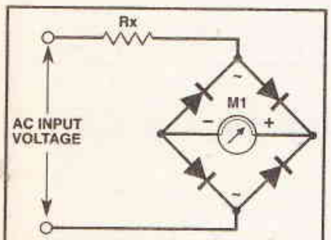


Fig 8. Multiplier resistor and bridge rectifier used to convert the 100µA meter to an AC voltmeter.

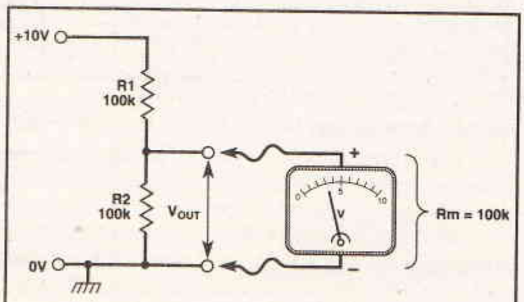


Fig 9. This voltage divider gives an unloaded output of 5V, but this simple test meter gives an output reading of 3.3 volts, due to its loading effect.

ANALOGUE MULTIMETERS. These consist of a good-quality moving coil meter with a wide span of switch-selected AC and DC voltage and current ranges, plus a battery-powered addition that enables the meter to indicate a wide range of resistance values. When using a simple multimeter, always consider its effect on the circuit under test; Figure 9 illustrates this point. Here, the R_1-R_2 divider gives an unloaded output of 5V, but when the meter is connected across the output its 100k Rm value shunts R_2 and reduces its effective value to 50k, thus reducing the output voltage to the 3.3V value indicated by the meter.

ELECTRONIC ANALOGUE MULTIMETERS. These united a normal moving coil meter with an electronic buffer/amplifier and a high-impedance input attenuator, as shown in Figure 10, to greatly increase the meter's effective sensitivity and input impedance, etc. Such meters may typically have an input impedance of 10MΩ and a maximum AC or DC FSD sensitivity of 1mV.

DIGITAL VOLTMETERS (DVMs). These are usually 3½ or 4½-digit instruments with a LED or LCD readout and a FSD sensitivity of 199.9mV (or 199.99mV) and an input impedance of 100 Megohms; they are readily available in 'module' form, and need a nominal supply voltage of 5V (LED types) or 9V (LCD types). They can easily be made to read various FSD values of AC or DC voltage or current, or resistance, etc., by connecting the inputs to the meter via simple 'conversion' circuitry.

DIGITAL MULTIMETERS. These combine a DVM module and a variety of switch-selected 'conversion' circuits, to make a highly versatile and accurate battery-powered general-purpose test meter that can outperform the ordinary analogue multimeter in many respects.

DIGITAL FREQUENCY METERS. These are 6 to 8-digit instruments that give a direct readout of input frequency or period, with crystal precision.

OSCILLOSCOPES. These are complex instruments that enable waveforms, etc.,to be displayed in real-time form on a cathode ray tube's (CRT's) flat TV-like screen, which is fitted with a calibrated graph-like graticule. The CRT is fitted with an electron gun that enables a sharp spot of light to be generated on the screen; this spot can be moved up and down the screen (on the 'Y' axis) by signals applied to a pair of 'Y' plates, or left and right across the screen (on the 'X' axis) by signals applied to a pair of 'X' plates. The spot intensity can be varied via signals applied to a 'Z' grid, thus giving 'Z' axis control.

Figure 11 shows, in simplified block diagram form, the basic elements of an oscilloscope (or 'scope, as it is usually called). The external test signal that is to be displayed is fed to the 'scope's high-impedance (typically 10 Megohm) input attenuator and passed on to the CRT's 'Y' plates via a wideband amplifier and a push-pull driver. Part of the amplified signal is tapped off to activate a 'trigger' generator, which synchronously fires a 'time base' generator that feeds a linear sawtooth waveform to the CRT's 'X' plates via a push-pull driver; the time base generator also activates a 'bright-up' generator that gives 'Z' axis control of spot intensity. These elements act together to draw or 'trace' a graphic display of the input waveform, with the 'Y' axis tracing the vertical movements on a volts-per-centimetre basis, and the 'X' axis tracing the horizontal left-to-right movements on a microseconds-per-centimetre basis.

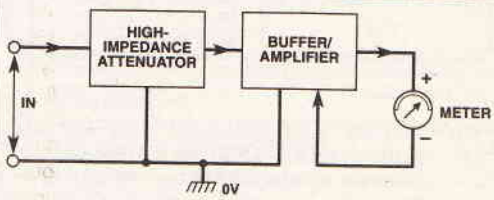


Fig 10. Block diagram of an electronic analogue multimeter.

In practice, the sensitivity of most simple modern 'scopes can be varied, in calibrated steps, from about 5mV/cm to 5V/cm in the 'Y' axis, with a bandwidth extending from DC to 20MHz, and from 0.5µs/cm to 0.5s/cm on the 'X' axis. Some 'scopes have bandwidths that extend to 100MHz or more, and others have multi-trace facilities that enable waveforms from two or three different parts of a circuit to be displayed simultaneously.

'Composite' Test Gear Types

The following 'Composite' types of test gear are in common use:

L-C-R BRIDGES. These combine a passive 'bridge' network and an energising generator and a balance indicator, to form a stand-alone test set that can be used to measure values of inductance (L), capacitance (C), and resistance (R). Figure 12 shows the basic elements of a resistance-measuring 'Wheatstone' bridge unit; the actual bridge (R1-R2-R3-Rx) is energised by a low-frequency (typically 50 to 1000Hz) oscillator, and the bridge's output signal is monitored via a null-indicating logarithmically-scaled meter.

The bridge's action is such that its output is zero when the ratio of R_1/R_2 equals that of R_3/R_x, and under this condition the bridge is said to be 'nulled' or 'balanced'. Thus, at balance, the R_x value equals that of R_x multiplied by the ratio R_3/R_1. In practice, variable resistor R_2 is fitted with a calibrated scale, and the value of R_3 can be varied in switch-selected decades, to give a 'decade value multiplier' action; the R_x value is found by simply adjusting R_2 and R_3 until the bridge is balanced, and then reading off the R_2 value and multiplying it by the R_3 factor. The bridge can be adapted to measure values of inductance or capacitance by replacing parts of the Wheatstone bridge with reactive, rather than resistive, elements.

DISTORTION-FACTOR METERS. These instruments enable the inherent distortion of a sine wave signal to be accurately measured in terms of total harmonic distortion (THD), and are used in checking the linearity performance of audio amplifiers, etc. They consist of an ultra-low-distortion sinewave generator, a high-performance twin-T (or similar) adjustable notch or 'rejector' filter, and an electronic millivoltmeter that gives a reading of true RMS values, all interconnected as shown in Figure 13. Here, the sinewave generator is first set to the desired test frequency (usually 1kHz) and its output is fed to the input of the test amplifier; the output of the amplifier is connected to the input of the notch filter. The output level of the amplifier is then set to some convenient reference value (e.g., 1V), which is read on the built-in meter with SW_1 set to position '1'; SW_1 is next set to position '2' to monitor the output of the notch filter, which is then tuned about the 1kHz test frequency to give the minimum possible meter reading. Under this condition the notch filter totally rejects the fundamental 1kHz test signal, and only its harmonics reach the RMS reading meter, which thus gives an accurate reading of THD (e.g., a reading of 1mV corresponds to 0.1% of the filter input signal, and thus represents a THD value of 0.1%).

Electrical 'Standards' Types

Every professional electronics laboratory should hold a selection of electrical 'standards', which can be used to check the fundamental accuracy of other types of test and measuring gear. These are high-quality, high-accuracy units that (ideally) carry a certificate of calibration, which is periodically checked against national or international standards. All 'standards' should be held in a thermally regulated environment. Standards are in common use for the checking and measurement of the following parameters: ATTENUATION, CAPACITANCE, FREQUENCY, INDUCTANCE, RESISTANCE, and VOLTAGE. The attenuation standard usually takes the form of a switched, precision, attenuator box. Capacitance, inductance, and resistance standards can take the form of individual components, or switch-selected components in 'boxes'. Frequency standards may take the form of a thermally stabilized crystal oscillator, or a special radio receiver that is tuned to a dedicated 'reference standard' broadcast station. Voltage reference may take the form of a 'standard' cell, or a modern precision voltage-reference IC circuit.

Basic Test Gear Circuit Elements

Virtually all practical instrumentation and test gear circuits are made up one or more of the following basic types of circuit element, which will be described in detail in future parts of this series.

ATTENUATORS and FILTERS; these passive networks are used to correctly condition or adjust the amplitude or quality of signals reaching the inputs of indicating instruments, or coming from the outputs of generators.

BRIDGES; these passive networks come into balance only under sharply defined conditions of impedance matching, and can be used in a variety of test gear applications for measuring parameters such as resistance, inductance, or impedance, or as the basis of precision sinewave generators and THD meters.

ANALOGUE and DIGITAL METERS; these can be used as the basis of a whole range of single- and multi-range 'indicator' instruments, to give accurate readings of all types of voltages and currents, as well as frequency, resistance, and other parameters.

WAVEFORM GENERATORS; these form the basis of many types of test gear; a vast range of waveform types can be directly generated or synthesised.

Finally, POWER SUPPLY circuits have almost universal application; they can be used to provide simple 'rough' voltages or ones that are precision regulated to provide a specific voltage, almost irrespective of output loading conditions.

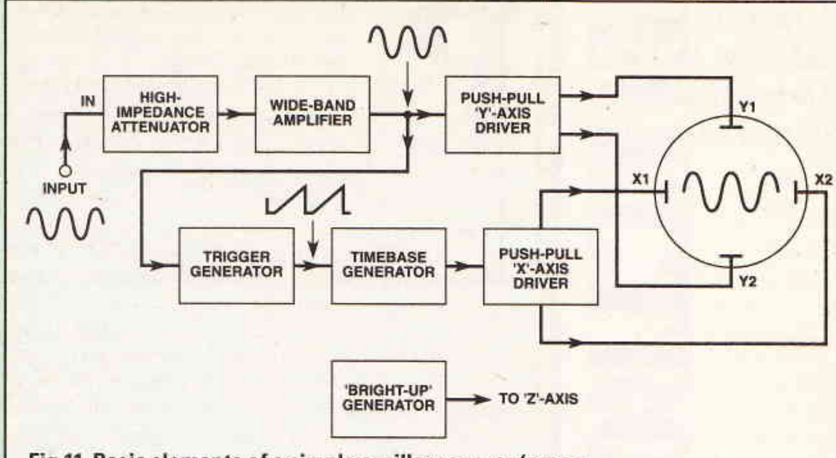


Fig 11. Basic elements of a simple oscilloscope, or 'scope.

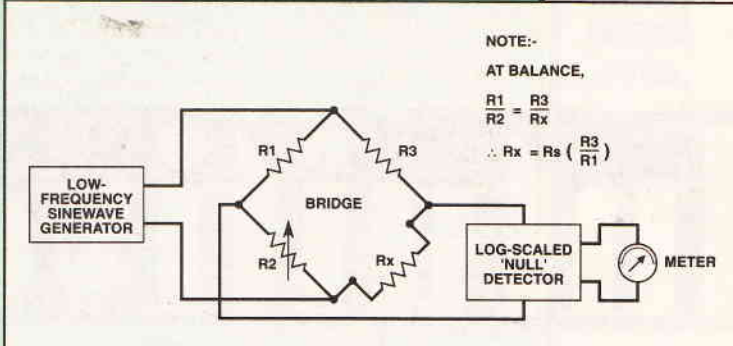


Fig 12. Basic elements of a resistance-measuring Wheatstone bridge unit.

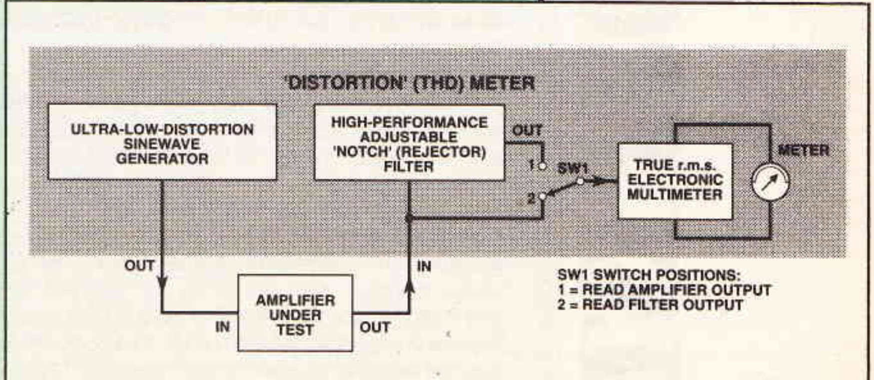


Fig 13. Basic elements of a 'Total Harmonic Distortion' (THD) meter.

Mike Barwise is back with a sideways look at the first principles of electricity and electronics.

Intuitive Electr[o]

Electronics: The Broader Picture

Practically all elementary introductions to electronics start on day (or page) one with the concept of the electron. Neat little diagrams of atoms like solar systems in miniature soon alternate with descriptions of mechanisms and phenomena such as energy bands and holes, which cannot be observed first-hand, and must be taken on faith in the authority of the tutor or writer.

It is almost always overlooked that most of the fundamental concepts in electronics have reasonably usable analogies in everyday mechanisms with which most of us are familiar. These mechanisms may operate with or on media other than the movement of electrons in wires (water, gas, mechanics etc.), but their various processes can in many cases be described quite accurately, using a small collection of very similar equations which operate equally in many branches of physics.

This series is an attempt to break out of the confines of electronics in isolation by showing how it fits into physics as a whole. We will discuss some of the similarities between practical electronic phenomena and their mechanical counterparts, and demonstrate how different types of system can be described in the same basic mathematical terms. Before we dive in, it is probably instructive to look at some historical background, and attempt to answer the questions: what is PHYSICS anyway, and how did its current fragmentation come about? What follows is necessarily a brief resume of an enormous and fascinating subject. I would strongly recommend the interested reader to follow up the references at the end of this month's text.

Most of us tend to view the totality of Science as including three separate subjects: Chemistry, Biology and Physics. Physics in turn is seen as a set of isolated sub-spheres: Motion, Heat, Light, Waves, Electricity and so on. These divisions have been drummed into us by the education establishment for longer than anyone can remember, inculcating a viewpoint which denies the interconnectedness of the amazingly complex real world. I am reminded of the remark by eminent psychophysiologist Robert Ornstein that, in spite of overwhelming evidence of their essential interaction in the living organism, Psychology and Physiology are dissociated by the medical profession, solely because they tend to be studied in two different buildings on the university campus[1].

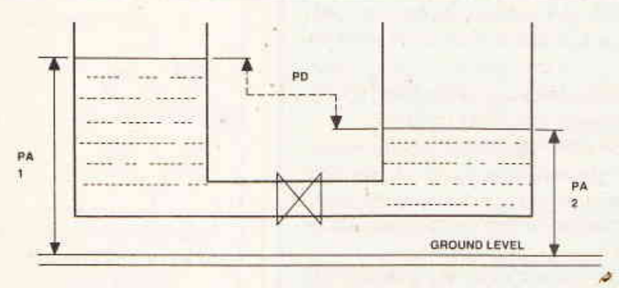


Fig. 1 Absolute and differential pressure.

Breaking The Law?

When comparing systems, I tend to consciously avoid the use of any expression such as 'obey the same physical laws', because I believe that this approach is counter-productive. The idea of breaking a Physical Law is difficult to dissociate from the concept of robbing a bank or mugging someone.

In reality, there is no such thing as a physical law. All we have is a constantly shifting ground of best guesses, each of which seems to predict the behaviour of some natural phenomenon more or less reliably within the limits of our observational capacity.

Not so long ago, the Earth was considered not only flat, but to be at the centre of the whole Universe. Very recently, it was believed that a clever enzyme called Swivelase was responsible for the untwisting of the DNA double helix in preparation for cell division. Right now, in Nucleonics, we have Fermions and Bosons, which can be sub-divided into Leptons, Quarks, Photons and Gluons, which can be further sub-divided ad nauseam, and these are not even realities you might pick up with a pair of (very small) tweezers, but probabilities that the reality might be there at a given instant. There is even a revolting object called a Glueball which is postulated under certain conditions. To me, it is reminiscent of those horrid wet blotting paper missiles we used to flick round the classroom as bored schoolboys. The point of all this is that our models of the world depend entirely upon our observations at a given time, which in turn depend on our preconceptions. Even our innate senses are highly selective, and sensory perception depends mainly on previous experience[7]. When we make observations beyond the resolution of our unaided senses, our instruments are entirely the produce of existing expectations concerning the things we wish to observe.

Just considering the nucleonics example, a whole area of superpowered theoretical physics and computing expertise is now solely concerned with mapping the interactions of this multiplicity of theoretical ping-pong balls, which may, or may not, even be there[2]. It has however been perfectly possible to develop quite sophisticated electronic (and other) components and systems without recourse to such theories for a very long time, and I have a suspicion that Occam's Razor might be brought to bear on the problem with advantage.

Narrow Specialisation

Occam's Razor can be summed up as the principle that the simplest of several alternative explanations of any phenomenon is the most likely to be right.

In the 16th century, it was possible, with diligence, to study the totality of knowledge of the civilised world. To a great extent, the position remained unaltered until the start of the Industrial Revolution. This milieu tended to breed individuals with radically differing out-

ELECTRONIC

looks on the same body of information. The resulting diversity of postulates allowed a healthy atmosphere of debate in most areas of knowledge.

In our time, we have split our knowledge into such narrow specialisms that it needs quite a large development team to make even small advances. An indication of this is the proliferation of scientific publications: a nominally exponential growth in the number of specialist journals from less than half a dozen around the year 1700 to well in excess of 100,000 today. Equally, it has been observed that the average journal doubles in thickness every decade[4], which suggests, not so much that discovery is accelerating, but that more and more is being written about less and less.

In spite of all this prolific paperwork, modern mainstream science only very rarely has more than one or two alternative explanations of any phenomenon in view at any time, so it is practically impossible to apply Occam's Razor. This is due, to a great extent, from the technological bandwagon syndrome. Communications are now so good, that, at any given time, there is one main sphere of interest which occupies the majority of the brainpower available. There is a tendency to rapidly form a consensus of opinion, and then reject

ronics

conflicting input, even from within the group (a basic attribute of human behaviour). This can even result in the heretic being expelled from the field, or having their funding cut!

An interesting sidelight on these changes is the language of scientific papers over the last few centuries[3]. Until the late 19th century, papers were written in the everyday language of generally educated people (mostly Latin until about 1670) and phenomena were described by analogy with familiar objects which were mostly observable without special equipment. Since about 1880, the language has gradually, but at an accelerating rate, become more turgid and specialised, and the descriptions increasingly mathematical, until modern scientific papers are almost unreadable by ordinary mortals. This has more or less kept pace with the division of science into ever narrower specialisms as the volume of knowledge has increased.

It would be superficially convincing to suggest that the problem of communication of technical information results from (a) the number of modern specialisms, and (b) the upsurge of commercial science, which demands an element of secrecy. However, I think a more valid reason is *the invisible nature* of most of the phenomena which bear on our current technology. A machine with visible moving parts tends to become more familiar than a system which performs in secret. Even if the observers are not wholly informed, they can make assumptions about the working of the visible machine by application of common sense, whereas the 'black box' has to be explained by an 'Expert' for even a marginal understanding to be obtained.

A system consisting of several black boxes thus has to be explained by *several* experts talking different technical languages. The result can often be apparent conflict of information. A beautiful example of this came to light during World War II. At the time the V2 rocket sites were starting to be visible in aerial photographs, the allied rocketry development team apparently disregarded the information, on the grounds that the only possible rockets were solid fuelled, and the rocket— shaped things in the photos were too big to get off the ground if they were solid fuelled. Their calculations were perfect. The only error was the assumption that there was no other kind of rocket motor[6].

Most people now use a huge array of increasingly complex technologies (about which they know practically nothing) to perform everyday tasks. The user's need for basic operational skills, and the narrowness of the specialisms which engender the product, have lead to a two-tier information system: a light-hearted superficial treatment for the ordinary reader, and the almost impenetrable jargonesque of the inner circle of the informed. Between these two extremes, there is virtually no information available.

The upshot of this essentially cultural divide (in our terms) is the development of two schools in electronics. The first is that of the Technically Trained, who know exactly how to use a resistor, but haven't a clue how it works, and the second, the Scientifically Educated, who know exactly how a resistor functions, but couldn't use one to save their lives.

The purpose of this series, then, is to bridge the gap between these two standpoints: to explain the secret workings of electronics in terms of visible parallels, and, thereby, banish the mystique. It must be remembered that most of the following descriptions are compromises. Many analogies will work in part, and many phenomena and mechanisms will require different analogies for different detail.

Making A Start

There is one basic premise that has to be taken on trust for our version of science to work at all. This is the concept of ENERGY, and the principle that *energy is neither created nor destroyed* by any process, but is simply converted from one form to another. There have been many attempts to demonstrate this principle experimentally, all of which have more or less worked, within the fairly crude limits of experimental error.

As to what energy is anyway, that is the $64000 question for physicists, but we don't really care. The ordinary notion of 'having lots of energy today' is really quite close in our terms. It means, more or less, that you have *the capacity to do lots of work*. Energy, therefore, is, roughly, the capacity to do 'work' or to change things.

For our purposes, we consider the existence of two types of energy: the energy transferred during work, which we call *kinetic energy* (from the Greek for "movement"), and the energy stored in something as a result of work, but not yet being used (*potential energy*). The mechanism of transactions (interactions between 'things') consists of the interchange of energy by conversion between kinetic and potential forms or vice versa.

The normal textbook example is the raising of a weight against the force of gravity[5], which imparts to it some potential energy. This is then converted back into kinetic energy when the weight falls. Although this is perfectly true, and will have to be used later in our discussion, it is not perfectly obvious.

A clearer first insight is obtained by considering petrol. Dead plants and animals are exposed to heat and pressure for millions of years, absorbing in the process an enormous amount of kinetic energy (the remains get hot and squashed). The energy of this heat and pressure is converted into the potential energy of chemical changes in the material. Thereafter, petrol will sit around quite innocently for ages with no visible energy exchange *until you light that match*. In setting the petrol on fire, you are reversing the process, by converting chemical potential energy into kinetic energy (the emission of light and heat, and the force which throws you across the room), but unless you do, the potential energy in a given volume of petrol does not 'leak away': it cannot be lost except in a transaction with something else (in this case with the oxygen in air).

If that is not enough for you, the concept is brought home in a very familiar way by the common school report comment: "shows great potential", which implies "hasn't used any of it yet", in other words, *kinetic energy is the energy of change* and *potential energy is the energy of stasis.*

In most transactions, the energy is converted in more than one way simultaneously. Assuming you only want one type of conversion, you then describe the system as having losses. A filament lamp, for example, converts less than 10% of the electrical energy supplied into light. The remainder is converted to heat, which is not useful in a lamp. The heat therefore represents a loss to us, although the total energy of the heat and the light coming out still equals the total electrical energy going in. This concept of losses will be very important later on in our discussion.

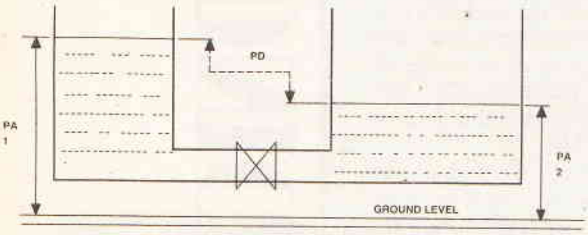


Fig. 2 Potential difference maintained with unequal tank dimensions.

In At The Deep End

Water is a very good analogy for the basics of electrical energy. If you can ignore electricity's lack of 'wetness', they have many features in common at a fundamental level. Both water and electricity are *incompressible*, so a very simple water system (Figure 1) can be used to explain some of the basic terms in electronics.

The water in each tank has potential energy proportional to the height of the water surface above ground, which we call the head or water pressure. The valve is closed for now, so the water is not going anywhere, but there is a difference in potential energy or POTENTIAL DIFFERENCE between the two lots of water in the two tanks because their water levels are different. The absolute height above the ground of the two tanks does not affect the potential difference between them, which is purely a function of the difference in their water levels. In the same way, an electrical potential difference can exist between any two points at any absolute potentials with respect to ground. The difference in depth of the water is what determines the pressure difference, which is measured in N/m^2 or pounds per square inch (depending how ancient you are) for water and in VOLTS for electricity.

As the potential difference is due solely to the difference in water levels, it is possible to produce the same potential difference using almost any two different volumes of water (or to alter the potential difference without changing the relative or absolute volumes of water), simply by changing the dimensions of the tanks (Figure 2). The volume of water is an absolute quantity of matter: a finite number of molecules. In the same way, an electrical CHARGE is a finite number of electrons, a quantity of electricity. The charge of water is measured in litres or gallons, and the electrical charge is measured in COULOMBS.

Now let's open the valve. Immediately there will be a flow of water between the two tanks. This will continue until the level in the tanks has equalised. Everyone whose drains have ever blocked knows to their cost that water finds its own level. This flow of water can be measured in litres per second, and directly equates to the electric CURRENT (a flow rate of electrons), which we quote in Coulombs per second (Amperes). The flow rate depends on the difference in pressure in the two tanks. Each tankful is trying to flow towards the other tank under the influence of an *absolute pressure*, and they are pushing in opposite directions. The net flow depends on the sum of the two pressures, one of which is negative with respect to the other.

Down To Earth

We have so far considered relative pressures as existing between two *variables*: the water levels in the two tanks. Each in reality exhibits an absolute pressure, and it is the difference between these absolutes which we have so far discussed. This absolute is the difference between one variable and something which never changes (a reference). In terms of water, absolute pressure (head) is measured with respect to sea level. This works because sea level is defined to be the same everywhere, making it an acceptable reference. Why is this?

When we opened the valve between our two tanks, we saw that the difference in water levels disappeared quickly as water flowed from one tank to the other. The time taken for the levels to equalise depends on the rate of flow in the connecting pope. As we will discuss in detail later, the flow rate depends on the size of the pipe: the bigger the pipe, the quicker the levels will equalise. Supposing the pipe is infinitely large, any difference in level will be equalised instantly, so there will *never* be any difference in level. This is the scenario which describes the condition within a single tank: all point in the tank are connected to each other by 'infinitely large pipes', so there can never be a difference in level between any point in the tank and any other. The sea amounts to a gigantic 'tank', so the same applies.

For electrical purposes GROUND is the absolute reference point, for the same reason: it is at about the same electrical level (potential) anywhere on the planet. The earth's surface is considered to offer no impediment to the motion of electric currents (just like the infinitely large pipe offered no impediment to the flow of water), so the whole surface must remain at the same potential.

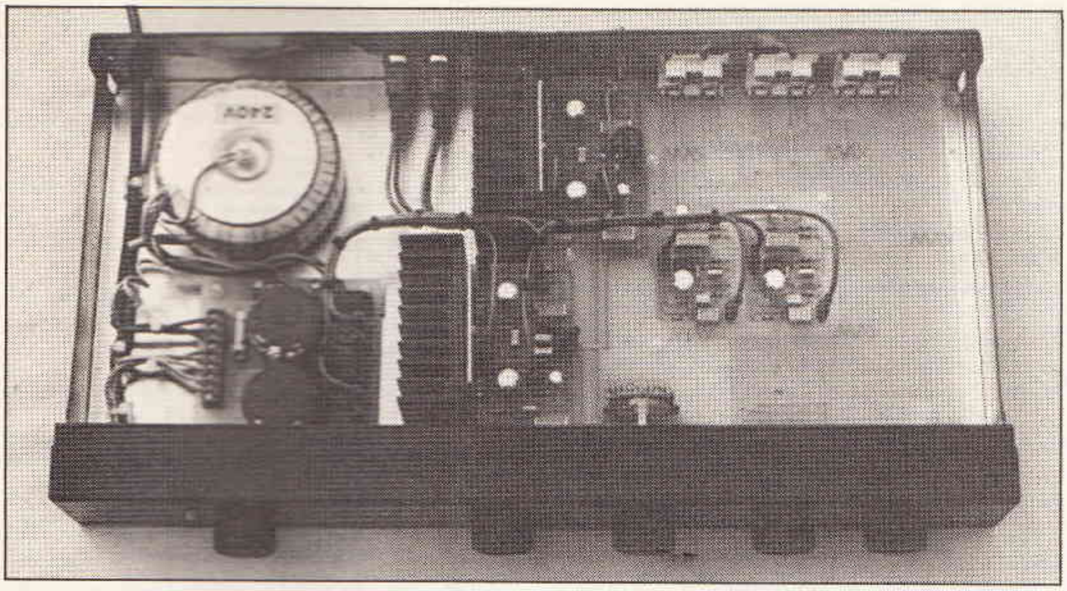
We have now defined the most basic attributes of electrical energy in very simple terms:

Potential Difference or relative pressure, measured in Volts;
Ground, an arbitrary reference potential with respect to any other, which is the same everywhere, quoted as 0 Volts.
Charge or absolute volume, measured in Coulombs;
Current or flow rate, measured in Coulombs per second or Amperes.

Next month, we will start to investigate the relationships between them.

References

1. Ornstein Robert & Sobel, The Healing Brain, Macmillan 1988, ISBN 0 333 4511 4.
2. Pendelbooth Greg, All the World's a Lattice, New Scientist No. 1750, 5 Jan. 1991.
3. Jennings Humphrey, Pandaemonium, Deutsch 1985, ISBN 0 233, 97808 9.
4. Ziman John, The Force of Knowledge, Cambridge 1976, ISBN 0 521 20649 9.
5. Bolton W., Patterns in Physics, 2nd Ed., McGraw Hill 1986, ISBN 0 07 084961 7.
6. Jones R. V., Most Secret War, Coronet Books 1979, ISBN 0 340 24169 1.
7. Neisser U., The Processes of Vision, in: The Nature of Human Consciousnes, Ornstein R. (Ed.), W.H. Freeman 1973, ISBN 0 670 50480 7.



PROJECT

The Acousdix Bridge Amplifier

A 20 watt integrated amplifier by John Dix.

Although amplifiers can be made with nominally the same performance specification, there appears to the human ear to be subtle differences between them, which are extremely difficult to associate with scientific measurement. Various reasons for this have been offered and the point has often been made that the majority of studies and measurements are based on continuous sine wave considerations, whereas speech and music consist of complex waveform components including transients. Certainly, any amplifier design must be founded on a good understanding of the basic scientific/electronic principles involved and once achieved, judicious changes can then be made on the basis of listening tests.

Thus, if the starting point of a design is to be based on standard recognised performance specifications, how important are they to the listening pleasure? Harmonic distortion can be reduced to levels in modern amplifier designs but the subjective effect of spurious harmonic content depends on the order of the harmonics. Higher order harmonics are more objectionable than lower order, even harmonics and in some instances a change in harmonic structure simply changes the character of the sound of an instrument slightly, even perhaps to make the overall subjective effect more attractive to the listener. On this basis, the writer feels that a reasonable approach is to aim to keep total harmonic distortion below 0.1% over a range of listening levels up to about 20W RMS. In particular, the characteristic,less than 0.01% at 25W RMS and only exceeded by lower, listening levels, is very much to be avoided. This is usually symptomatic of a large amount of negative feedback being present under the high loop gain conditions at high signal levels. This is significantly reduced at low imput signal levels where the output devices present some non-linearity and a reduction in gain in the Class AB and Class B area of operation. It has also been claimed that over application of negative feedback can have a delaterious effect on the transient response. Transients are an important feature of speech and music, and good transient response must therefore be the aim in a good amplifier design.

Initial approach to the design

What now emerges is a requirement for a good transient response and a reasonably low figure for the total harmonic distortion, without the application of excessive amounts of negative feedback. With a well balanced push-pull amplifier design even order harmonic distortion is minimised and this reduces the need for large amounts of negative feedback. Transient response is dependent on a good high frequency response, particularly in the output devices and some amplifier designers/manufacturers make a point of obtaining a special, probably expensive, supply of well matched devices with the correct frequency response. For the impecunious constructor an alternative approach has to be adopted. To achieve well balanced devices and avoid selection and/or special bias adjustments, there is no need to search further than the nearest list of integrated circuit power amplifiers. Good matching and good thermal coupling between devices are all part of the integrated circuit manufacturing process. The total harmonic distortion curves plotted against output power have to be studied to select a type that does not exhibit incredibly low distortion

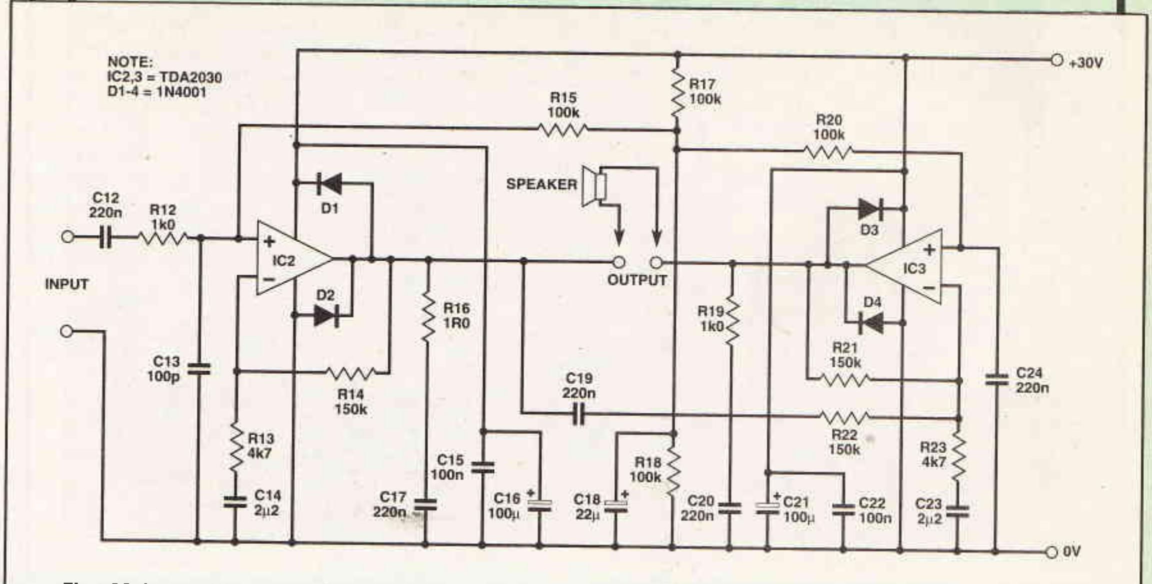


Fig.1 Main amplifier circuit

How it Works

It can be seen from the circuit diagrams for the main and preamplifiers (Figures 1 and 2) that the circuitry is based on the standard operational amplifier configuration shown below.

The amplifier of gain A has a differentially coupled input stage such that the output voltage v_o is A times the difference between the two input voltages. Thus

$$V_o = A\left(V_i - \frac{V_o R_1}{R_1+R_2}\right)$$

Rearranging

$$\frac{V_o}{V_i} = \frac{1}{\frac{1}{A} + \frac{R_1}{R_1 + R_2}}$$

and when A is very large, $\frac{1}{A}$ is negligible
and

$$\frac{V_o}{V_i} \simeq 1 + \frac{R_2}{R_2}$$

dependent solely on the ratio of two resistors.

Inserting a capacitor in series with R1 has the effect of increasing the negative feedback applied to the inverting input as the frequency decreases (because the reactance increases with decreasing frequency) until at DC a 100% feedback is applied. This helps to stabilise the DC operating conditions of the circuit. The point at which the amplifier gain starts to decrease is when the reactance of the capacitor becomes comparable with R_1.

A capacitor in series with R_2 reduces the negative feedback as the frequency decreases and this is used in the preamplifier for the low frequency RIAA equalisation. A further resistor connected across the resistor capacitor combination removes the bass boost at very low frequencies and determines the absolute value of maximum gain in this region. The high frequency RIAA equalisation in the preamplifier is determined by a simple RC low pass filter section at the output (R_9 and C_7 in preamplifier circuit Figure.2). The main amplifier is based on two operational amplifier type circuits connected in a bridge

Amplifier 1 has a gain of $1+R_2/R_1$ and amplifier 2 has a gain of $-R_1/R_2 = -1$ because the input signal is applied to the inverting input. The output voltage across the loudspeaker is $V_{o1}+V_{o2} = 2V_{o1}$, because of the unity gain of amplifier 2. Thus the gain of the amplifier as a whole is $2(1+R_2/R_1)$. As the output voltage of the bridge connected amplifier is twice that of a single amplifier then the bridged output power (proportional to the square of the output voltage) will theoretically be four times that of a single amplifier.

Of course, this power will not be achieved completely in practice if either the amplifier voltage and current ratings or the power supply capability cannot support the required output power.

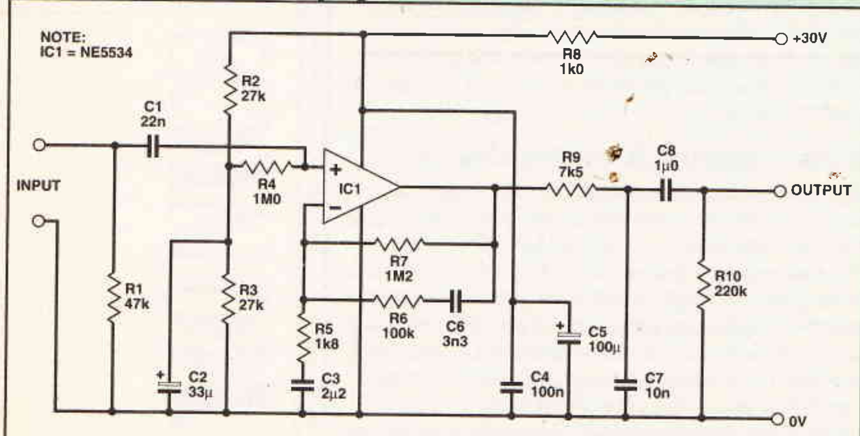


Fig.2 Pre-amplifier circuit

figures at full power only to increase substantially at the lower levels. Finally, the frequency response has to be considered to ensure a good transient response. Unfortunately a good high frequency response tends to be associated with the lower power members of the integrated circuit power amplifier family and considerations have to be given to ways of increasing their power output. One quite effective way is to use two amplifiers in a bridge connection.

Detailed Design

The first step then is to select the power amplifier integrated circuit. Looking through the various options, one that stands out in terms of availability is the TDA 2030. It is a well established design, bandwidth (up to 140kHz claimed), convenient voltage rating, power output and cost. This has a nominal power output capability of around 10 watts, which theoretically can be increased by a factor of 4 by bridge connection (see How it works). The next step concerns the type of component in the signal and negative feedback paths and there is agreement among many designers that electrolytic capacitors should, where possible, be avoided. Such a consideration governs the choice of resistor values when readily available non-electrolytic capacitors have maximum values in the region of 2µ2. A typical example relates to the values of R13 and C14 in the

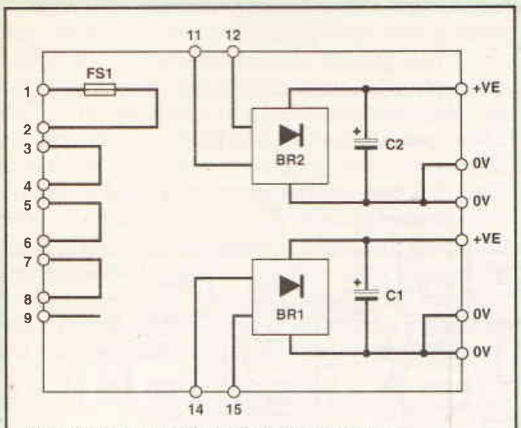


Fig.3 Power supply unit arrangement

main amplifier circuit (Figure 1) where these components represent part of the negative feedback network from the inverting input down to the common line. The reactance of C14 increases as frequency decreases thereby increasing the negative feedback and decreasing the amplifier gain. It is important to ensure that over the required operating frequency range the amplifier gain is constant and at the design value. Thus if 15Hz is the lowest frequency to be handled by the amplifier, then a value of 4k7 for R13 will give a −3dB point at this frequency. Similarly R5 in the preamplifier (Figure 2) is chosen at 1k8 to give a −3dB point of 40Hz as part of the RIAA recommended pick-up playback response. As shown in the How it works section, the rest of the low frequency equalisation is also based on a capacitor in series with one of the feedback resistors (R6 and C6 in the preamplifier circuit diagram, Figure 2). A further design consideration is the desirability quoted by many designers that the gain of the main amplifier should be such that high signal level sources such as tuners, tape recorders, and compact disc players can be fed directly to its input terminals. The value of R14 (150k in Figure 1) was chosen so that a power output of 20W RMS into an 8R loudspeaker load could be achieved with not more than 250mV input signal level.

It is also claimed that improved sound is obtained if there is no overall phase inversion from any input of the complete amplifier to the output and it can be seen from the circuit diagram that all inputs are connected to non-inverting input terminals in the amplifier. Another consideration is the thermal stability of the semiconductor devices and any effect this may have on the sound. Efficient heat sinking is important if for no other reason than to minimise the chance of thermal runaway occurring and presenting undesirable levels of DC across the loudspeaker terminals. Efficient heatsinks are provided for each amplifier in this design and the devices are clamped directly to them. To do this pin 3 has to be connected to 0V of a single ended +30V supply and to ensure that the device output pins 4 are at mid-supply the non-inverting inputs are connected by 100k resistors (R15 and R20) to the potential divider R17, R18 (Figure 1). A further advantage of the bridge amplifier connection gives a direct connection to the loudspeaker load and yet adopting a single-ended supply. A standard twin secondary mains transformer is used to feed each amplifier from an independent bridge rectifier, reservoir capacitor DC source (BR1, BR2, C1 and C2 on PSU, PCB in

PROJECT

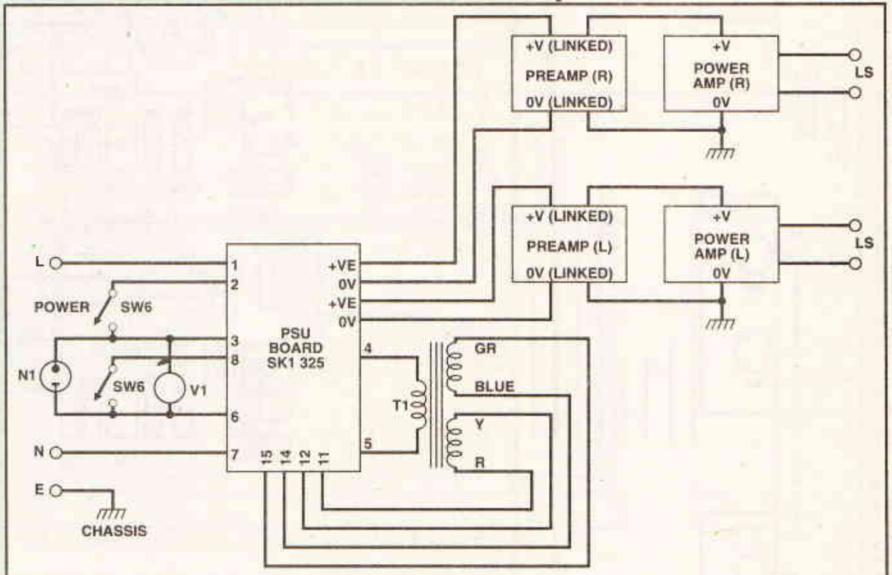


Fig.5 Mains,DC supply and loudspeaker wiring

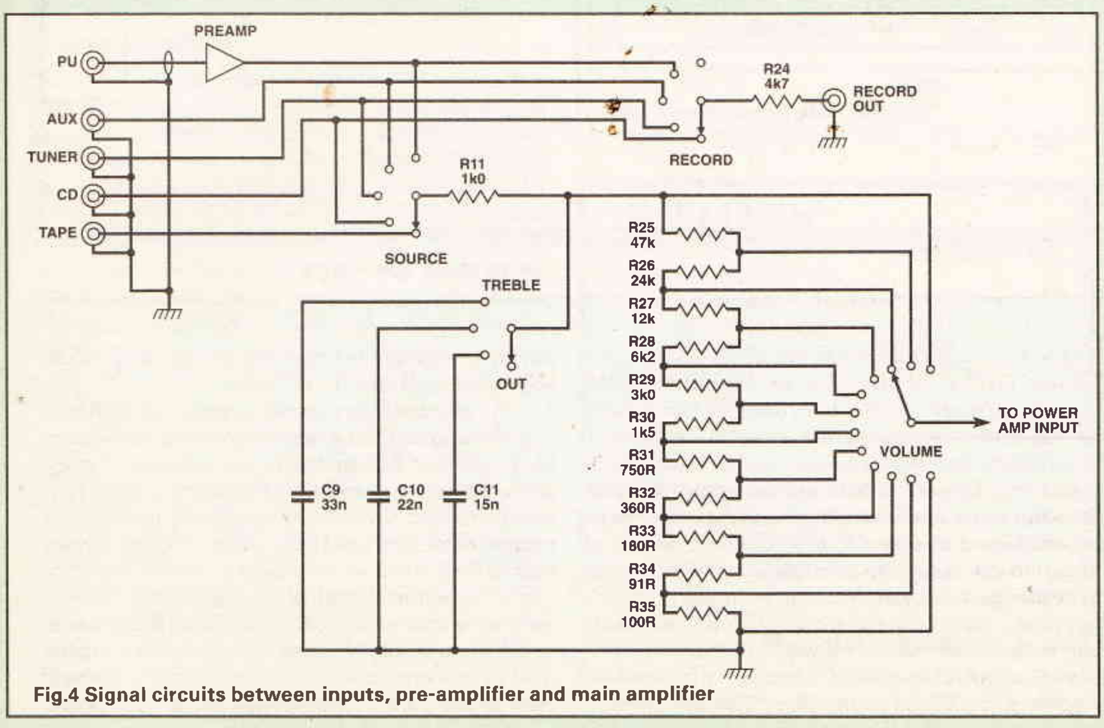


Fig.4 Signal circuits between inputs, pre-amplifier and main amplifier

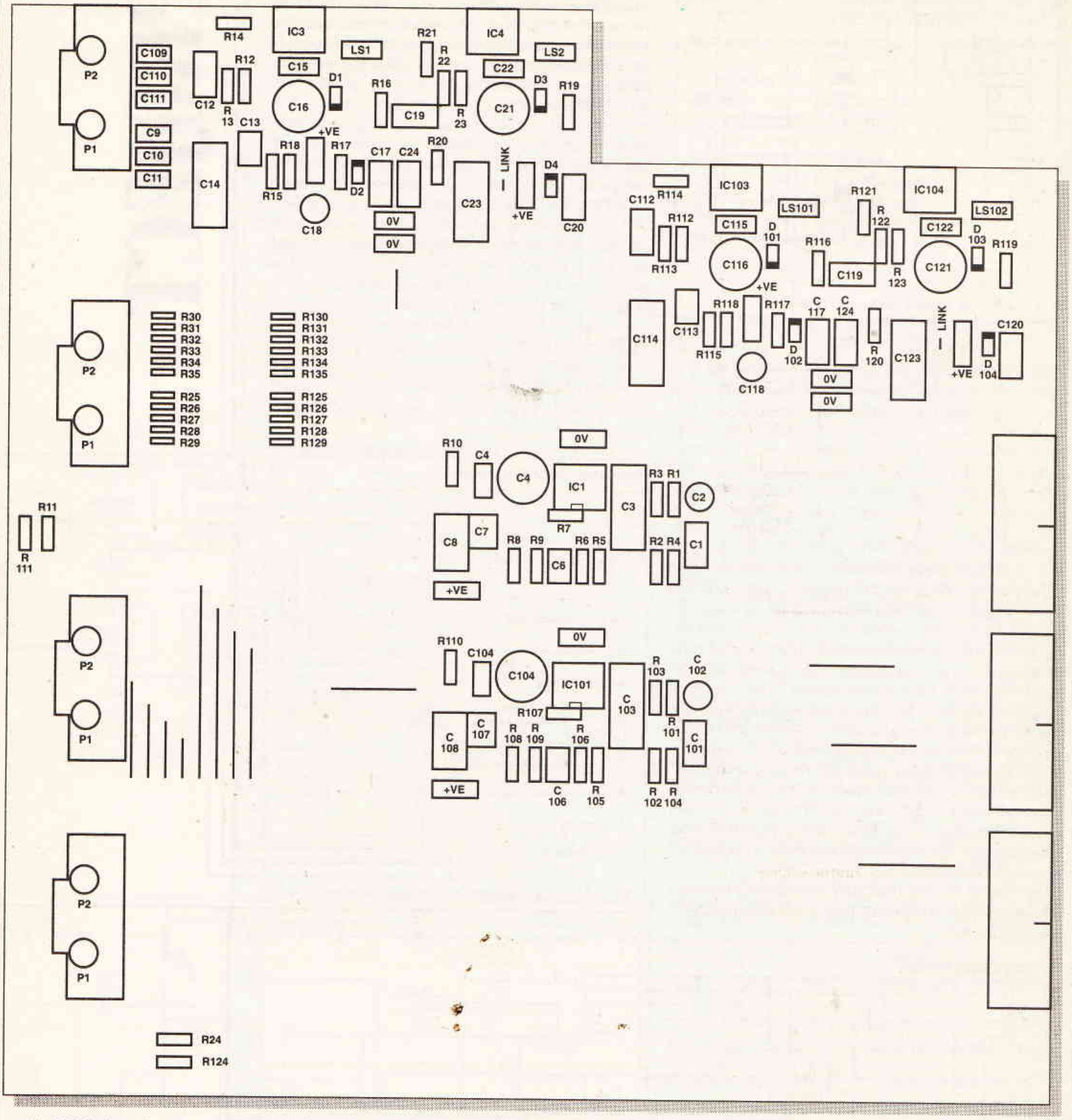


Fig.6 Main board overlay

Figure3). Finally, the differential drive to the loudspeaker provided by the bridge connection means that there is increased isolation from unwanted waveforms present on the supply lines. These waveforms can arise from supply interference effects or what is even more interesting, interaction between the output transistor current swing waveforms and the spurious reactive elements in the power supply components. Absence of these effects results in an audible improvement in amplifier performance.

The Complete Circuit

Having indicated the salient features of the main and preamplifiers the interconnection diagram between the input signals, preamplifier and main amplifier is shown in Figure 4.

A tape record-out facility is provided such that any of the signal sources, excluding tape playback, can be recorded whilst listening to the same source or any of the others. A simple treble-cut filter, resistor R11, and capacitors C9 ,C10, and C11, is provided to reduce noise and distortion from a lower fidelity source.

The volume control is a ganged switch with 12 positions and resistors R25 to R35 giving 6dB changes in volume over a 60dB range from full output to zero. This type of control was chosen after careful listening tests in comparison with a standard ganged potentiometer. The balance of the potentiometer was far from satisfactory at low listening levels and at more realistic levels improved imaging, stability, and clarity was obtained from the stepped control. To keep costs within a budget design, the number of steps selected corresponded to readily available switches and, whilst an early prototype had an ancilliary switch to provide an intermediate 3dB step, it was never used in the final design. The mains, DC supply and loudspeaker connections are shown in Figure 5. Note each channel is earthed to the chassis via the heat sinks and the 0V connection on the power amplifier IC tabs. This eliminates the possibility of internal earth loops and results in a very low hum level for the completed amplifier. It

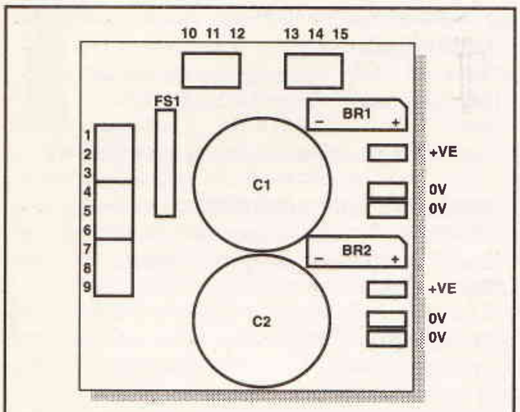


Fig.7 Power supply board component overlay

can be seen from the photograph in Figure 6 of the amplifier with the cover removed, that the mains input, transformer, and power supply wiring can be arranged very neatly at one end of the case with the remaining wiring forming a harness assembly spaced well above the board. The vertical wiring from board to harness keeps power amplifier distortion to a minimum by reducing the coupling between the high current output pulses in the supply wiring and the sensitive input loops in the printed circuit layout. As a result of our considerations what is available to the constructor is an integrated amplifier requiring no setting-up but with a standard of construction and performance normally associated with equipment built to exacting professional standards.

Construction

The input sockets, selector switches, volume control switches, preamplifiers and main amplifiers are all mounted on the main printed circuit board the component overlay of which is shown in Figure 6. The power supply board is mounted separately in the case and a component overlay is shown in Figure 7. The location of the major components and boards in the finished case is shown in Figure 8. The mains wiring with power switch, neon indicator and spike suppressor can be assembled using Figures 3,5,6 and 8 whilst the remaining wiring uses the harness and spade and receptacle connectors on the circuit boards and the loudspeaker terminals.

Detailed board construction starts with installation of all the wire links and low profile components finishing up with the switches and input sockets. The printed circuit boards are held by self adhesive plastic stand-off pillars and the power amplifier integrated circuit tabs are fastened to the already installed heat sinks using the instructions supplied with the component packs. Case assembly is straightforward, taking care to ensure that all joints meet neatly before tightening the self-tapping screws. It is important not to overtighten these assembly screws.

Testing and Use

Having double checked component installation and ensured that there are no solder bridges between printed circuit conductors it remains to plug in the various signal sources and a pair of loudspeakers. If a test meter is available, then the circuit can be checked for short circuits and if all is well, the mains supply can be switched on. The DC supply across the reservoir capacitors should be in the region of 30V with no signals applied and the constructor should then be greeted by high quality sound as the volume control is advanced from zero. Prototype amplifiers have been built and demonstrated to a wide sample of listeners working through a wide variety of loudspeakers. The clarity of sound has been appreciated by the listeners and extremely good results are obtained from the author's own design of loudspeaker, the QWL.

Specification

Each amplifier driven, power output equals 25W RMS for a 20msec tone burst at 1kHz.
Amplifier distortion better than 0.1% at a power output of 20Wrms.
Amplifier power bandwidth 20Hz-50kHz.
Main amplifier input sensitivity 250mV for 20W output.
Pickup sensitivity 6.2mV for 20W output.

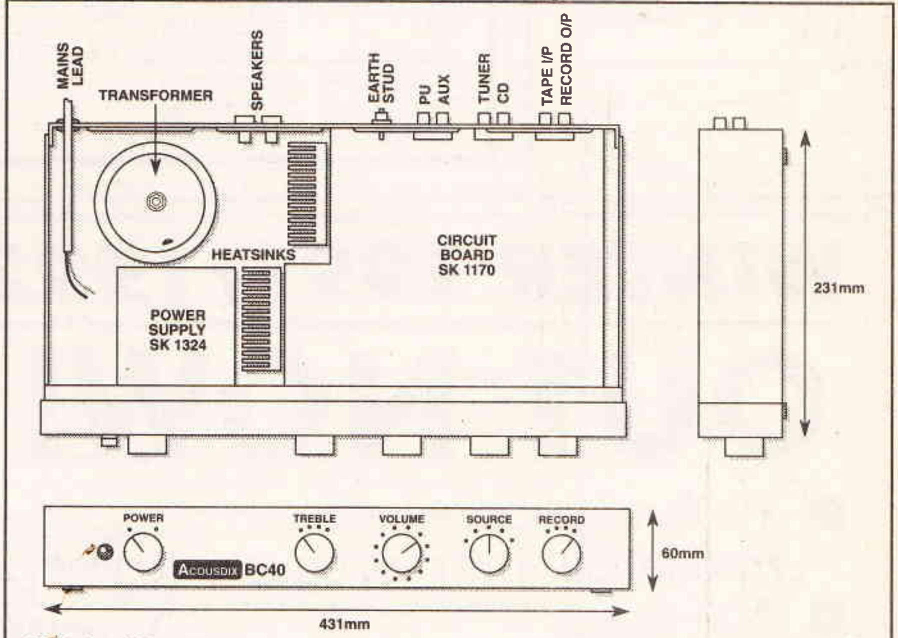


Fig.8 Amplifier plan and elevation

BUYLINES

The Acousdix BC40 Bridge Connected Amplifier can be obtained in complete or partial kit form from:

Martech Systems (Weymouth) Ltd.
Unit A2/3
Marabout Industrial Estate
Dorchester
DT1 1YA

The complete kit consisting of all the items specified in the parts list costs: .... £163.63 (inc. VAT and P & P)

The following partial kits are also available:

Pack A (Items 1 to 38) (Components Pack) £27.85
Pack R (Items 39 to 45) (Amplifier PCB Pack) £41.95
Pack C (Items 40 to 54) (PSU Pack) £38.43
Pack D (Items 55 and 56) (Case Pack) £41.95
Pack E (Items 57 to 63) (Ancilliaries Pack) £32.55

All the above prices are inclusive of VAT and Post and Packing within the UK.

PARTS LIST

RESISTORS (All .25W Metal Film)

R1,25,101,125	47k
R2,102,103	27k
R4,104	1M
R5,105	1k8
R6,15,17,18,20,106, 115,117,118,120	100k
R7,107	1M2
R8,11,12,108,111,112	1k
R9,109	7k5
R10,110	220k
R13,23,24,113,123,124	4k7
R14,21,22,114,121,122	150k
R16,19,116,119	1R
R26,126	24k
R27,127	12k
R28,128	6k2
R29,129	3k
R30,130	1k5
R31,131	750R
R32,132	360R
R33,133	180R
R34,134	91R
R35,135	100R

CAPACITORS

C1,111	22n Polyester 10%
C2,18,102,118	22u 50V Electrolytic
C3,14,23,103,114,123	2u2 Polyester 10%
C5,15,22,105,115,122	100n 63V Ceramic
C4,16,21,104,116,121	100u 50V Electrolytic
C6,106	3n3 Polycarb 10%
C7,107	10n Polycarb 5%
C8,108	1u Polyester 10%
C9,109	33n Polycarb 5%
C11,111	15n Polycarb 5%
C12,17,19,20,24,112, 117,119,120,124	220n Polyester 10%
C10,110	22n Polycarb 5%
C13,113	100p Polycarb 10%

SEMICONDUCTORS

IC1,101	NE5534A
IC3,4,103,104	TDA2030
D1-4,101-104	1N4001

MISCELLANEOUS

SW1-3	Switch PCB Rotary 2p 5W
SW4	Switch PCB Rotary 2p 12W
SW5	Wafer 1P 12W

Terminals PCB Mount; Socket 8-pin DIL; Heatsinks; Amplifier PCB

POWER SUPPLY UNIT PCB COMPONENTS

PSU PCB; Screw Terminals; Transformer 80VA 22V; Fuseholder; Fuse 3.15A 240V; 4700μF Cap; Bridge Rectifier; Transient Suppressor; Neon.

CASE ASSEMBLY

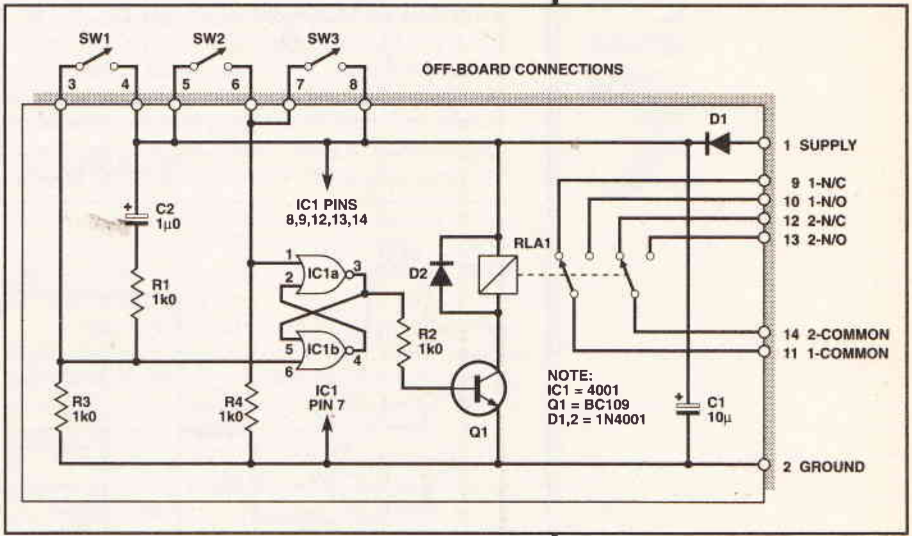
Case; Pack of Screws.

ANCILLIARIES

Wiring Harness; Input Connectors; LS Connectors; PCB supports; Earth Terminal; Rear Plate; Knobs.

Tech Tips

Model Railway Track Section Controller



I was recently asked by a railway modeller friend if I could design a simple circuit that would operate as an automatic track section controller. The circuit here is my solution to this problem.

A section of track has an 'Entrance' and an 'Exit'. A signal placed at the 'Entrance' tells the driver if he can or cannot enter the section. Also, the signalman has the option of manually blocking a section so that, for instance, track maintenance can safely take place.

The circuit to implement this design has therefore two functions to perform: to count trains as they enter and leave the track section and to provide a manual control of the section.

Firstly, the counting. Since the maximum allowable number of trains in the section is one, only one bit is all that is required to count with. A bistable is made from two NOR gates (IC1a,b) connected as shown. When a train passes the signal, placed at the 'Entrance', the track detector SW2, next to the signal, senses the train and sets the bistable. This de-activates RLA1. The track signal, connected to one set of contacts of RLA1, will change to 'Danger': the other set used for track isolation. This stops any further trains entering this section. Only when the train leaves the section, triggering SW1 placed at the 'Exit', will the bistable be reset, RLA1 activated, the signal set to 'Clear' and allow another train to enter the section.

The manual control for the signalman is simply effected by permanently setting the bistable via SW3, located in the 'Signalbox' connected to a 'Signal Lever'. D1 and C1 form a simple power supply for IC1 enabling this circuit to run from either a 12V DC or 16V AC supply.

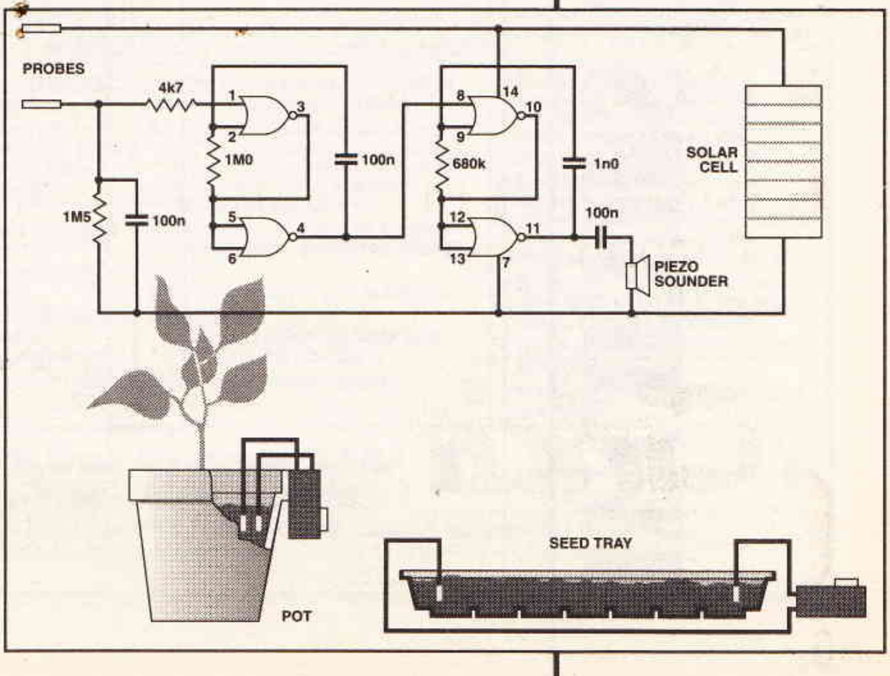
The whole circuit can be built on stripboard or purpose-made PCB. The two track sensors, SW1 and SW2, are reed switches placed under the track and SW3 is a microswitch operated by a signal lever. We found that some loco's permanent magnets were suitably located to trigger the sensors while on others small magnets had to be fixed on the under-side of the loco's.

Several of these circuits can be connected in series to provide section control of a longer length of track. Provided that all the circuits operate from the same supply, SW1 of the first circuit can be the SW2 of the second circuit and the SW1 of the second circuit can be the SW2 of the third circuit and so on.

Neil Johnson,
Northiam, Sussex.

Once again we present some circuit ideas from the reader postbag.

Dry Soil Alarm



Here is a solar powered dry soil alarm. It might particularly be useful for the blind as well as the sighted. The circuitry is based around a standard CMOS 4001 chip and taking a very small amount of current. A very low frequency oscillator pulses and triggers an audible oscillator, the output transducer being a piezo sounder. If required, I have a supply of solar panels available (see classified ads in this issue).

R Keyes,
Newport, Gwent.

Multi-level bit computer

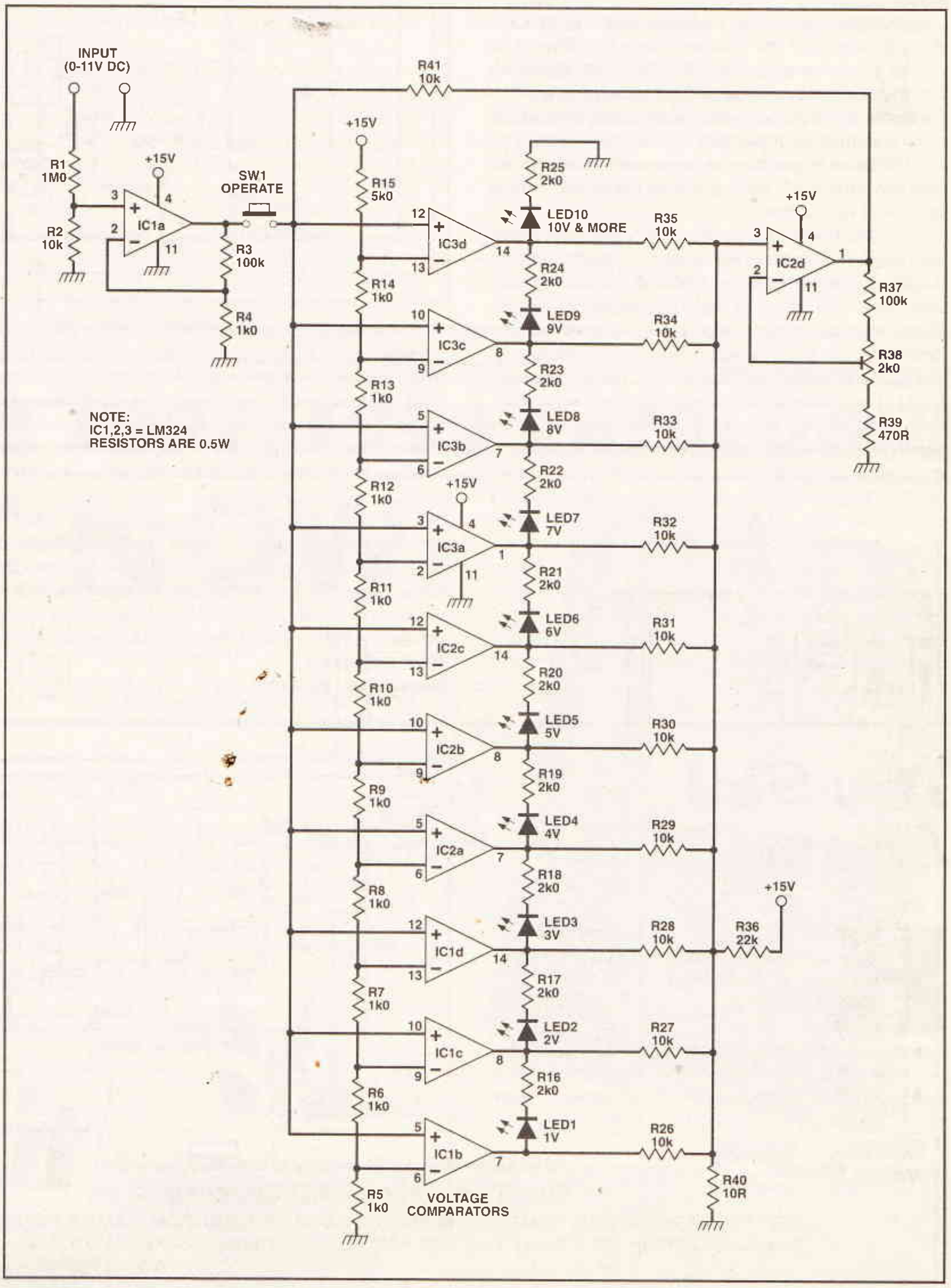
In the future, when computers change from binary bits to multilevel bits, the circuit presented here can be used as a memory cell with faster operational amplifiers. The number nine is carried by one multilevel bit and four binary bits will be required for the same work. Is this an analogue computer? No. This is a digital one (memory output is Pin 1 of IC2d. For the present time we can use the circuit as voltmeter with memory (10 volts range).

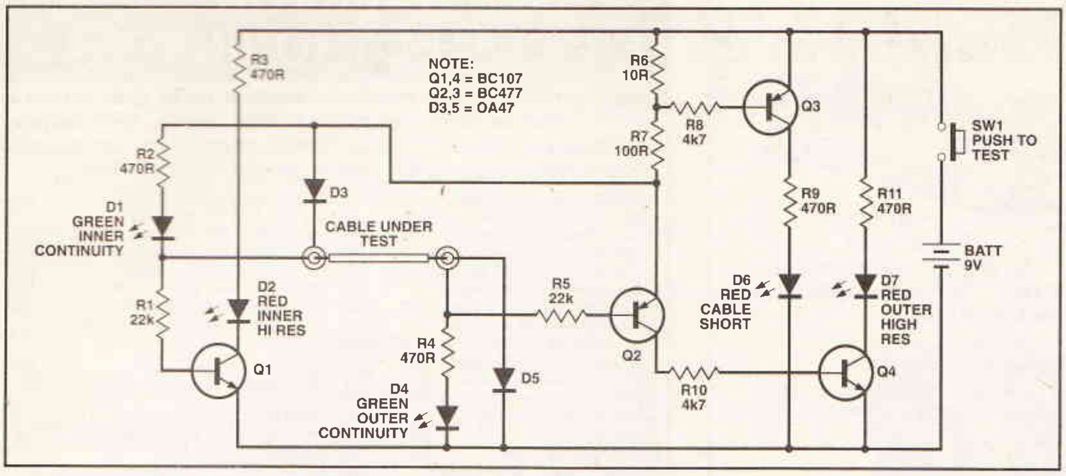
The voltage to be measured is applied to the input and across the voltage divider R1 and R2 and is fed to IC1a, an LM 324 operational amplifier. The same voltage applied to the input is presented to the output of the operational amplifier IC1a and is applied to the voltage comparators by SW1. When the voltage at the positive input of each comparator is greater than the reference voltage at the negative input, the respective output turns on for high level. The LED connected between high level and low level output is energised.

The resistor R40 contains the sum of the currents coming from the high level outputs and respective resistors (R26 to R35) and the current comes from +15V by R36. The resulting voltage of R40 is applied to IC2d. The output voltage of IC2d is 1V for each high level output of the comparators more 0,5V approximately due R36. This output is fedback to the comparators by resistor R41. In this way the voltage measured is memorized.

Adjust R38 for stable memorization. When LED 8 is on, turn off SW1 and LED 8 must stay on. When LED 1 is on, it indicates an input between 1 volt and 2 volts and so on.

Renato L.M. de Azevedo,
Sao Paulo, Brazil.





Coaxial Cable Tester

This is a useful device to have to hand wherever coaxial cables are in use. The tester gives a visual indication of continuity for both inner and outer conductors, indicates a short between the two, and also signals poor conductivity for either.

When the test button is pressed, current flows through R6 and R7, D3, cable outer conductor, R4 and D4. D4 illuminates to show 'OUTER CONTINUITY'. At the same time, current also flows through R6 and R7, R2 and D1, cable inner conductor, and D5. D1 illuminates to show 'INNER CONTINUITY'.

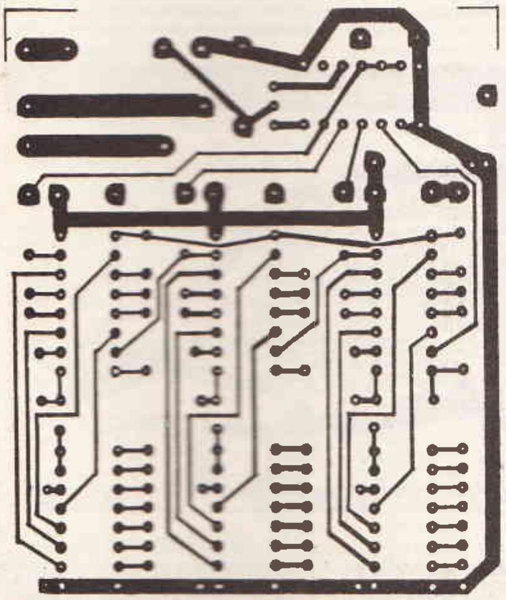
If the inner and outer conductors are shorted, the current flows through R6 and R7, D3, from outer to inner of the shorted cable, and D5. The LEDs D1 and D4, and resistors R2 and R4 are effectively bypassesd. However, the current flow increases from a normal total value of around 10mA to about 80mA. The voltage drop across R6 turns Q3 on, and thus the 'CABLE SHORT' indicator is on.

Transistors Q1 and Q2 monitor the voltage drop across the cable inner and outer respectively, together with the associated diodes D3 and D5. If the resistance of either conductor is greater than about 20R, the appropriate indicator will illuminate.

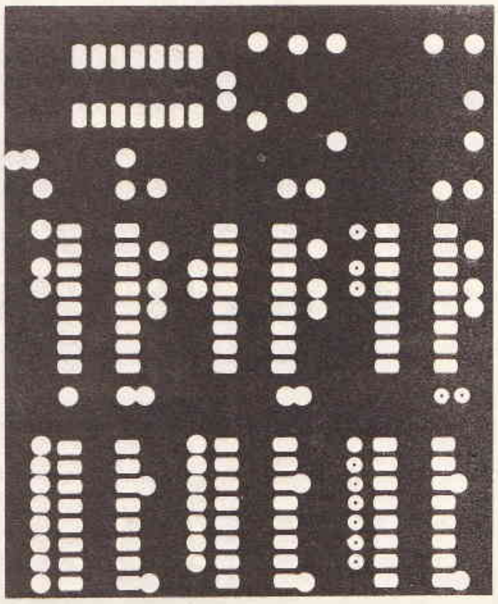
Diodes D3 and D5 must be germanium, not silicon, for their lower forward drop. Remember, if using a conductive housing for the tester, insulate the coaxial connectors or use isolated types.

S Roberts,
Bude, Cornwall.

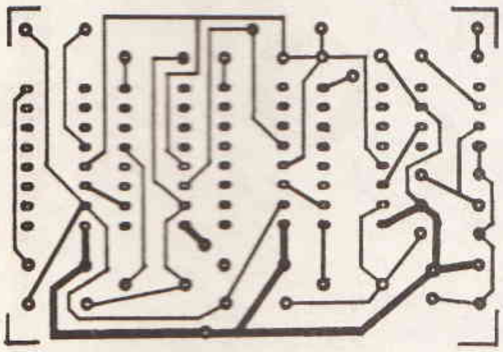
PCB Foils



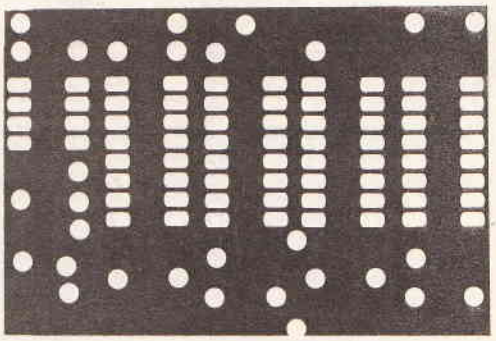
Mains Switched Timer
Counter/Driver solder side



Counter/Driver Topside ground plane



Mains Switched Timer
Time Base solder side



Time Base top side ground plane

Mains Switched Timer
Power Supply

ETI

ELECTRONICS TODAY INTERNATIONAL

CLASSIFIED

Rebecca Daborn
0442 66551 Ext 313

Send your requirements to:
ETI Classified Department, ASP, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST.

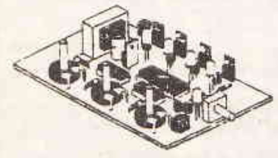
Lineage: 60p per word (+VAT) (minimum 15 words)
Semi display: (minimum 2.5cms)
£15.00 per single column centimetre (+VAT) **per insertion**
Electromart £24.00 per Insertion (+VAT)

Ring for information on series bookings/discounts.
All advertisements in this section must be prepaid.
Advertisements are accepted subject to the terms and conditions printed on the advertisement rate card (available on request).

KITS

TK FOR KITS

DISCO SEQUENCER



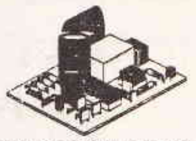
Four channels (up to 1kw each) to drive Rope lights. Pin-spots etc. (Resistive/Inductive loads) with 30 different eye-catching sequences. Variable speed and sequence change frequency AND built in audio input. Ideal for mobile or permanent desplays. Complete KIT (less box)

XK141 **26.95**

Don't forget our other value for money DISCO KITS

DL8000	8-channel 80 programme sequencer	46.95
DL3000	3-channel sound to light	21.95
XK124	High power strobe with audio input	17.95
XK139	4-channel sequencer	14.50

SINGLE CHANNEL INFRA RED REMOTE CONTROL



A simple yet highly versatile Infra Red remote control kit with a multitude of uses in the home or car. Operates from 9-15V dc or 240V ac and switches a 3A relay on and off alternately each time the transmitter is operated at ranges up to 20ft (6m). Responds only to the transmitter frequency. Great for lights, TV, alarm controls.

XK134 **11.95**

Suitable transmitter complete with box (9V PP3 battery required)

XK135 **5.95**

For more channels use our popular MK12/MK18 IR transmitter receivers

MK9	4-way keyboard	3.35
MK10	16-way keyboard	9.75
MK12	16 Channel Receiver	21.95
MK18	IR Transmitter	9.75

SEND 50p and SAE for our latest CATALOGUE which includes details on more exciting kits such as Progammable Lock, Voice Record/Play back, Touch Dimmers, Temperature Controller and components

SUPERSENSITIVE MICROBUG

Only 45x25x15mm including built-in mic. 88-100 MHz (standard FM radio). Range approx. 300m depending on terrain. Powered by 9V PP3 (7mA). Ideal for surveillance, baby alarms etc **XK128** **7.25**

ORDERING INFORMATION. Prices INCLUDE VAT but please add 1.25 P&P (UK). Overseas Customers divide total order by 1.175 then add P&P: Europe 3.50, elsewhere 10. Send PO/cheque/VISA /MASTERCARD No. with order. GIRO NO. 529314002. Local Authority and education orders welcome. Office Hours: Mon-Fri 9.30am - 5pm. Shop Hours: Tues - Thurs 10am - 5pm, Sat 10am - 1pm.

ORDERS: 081 - 567 8910 24 HOURS

TK ELECTRONICS **13 BOSTON ROAD, LONDON W7 3SJ**

NEW VHF MICROTRANSMITTER KIT tuneable 80-135MHz, 500 metre range sensitive electet microphone, high quality PCB, SPECIAL OFFER complete kit ONLY £5.95 assembled and ready to use £9.95 post free. Access/ Visa order telephone 021-411 1821. Cheques/POs to: Quantek Electronics Ltd, Kits Dept (ETI), 3 Houndley Road, West Heath, Birmingham B31 3AL. Tel: 0214 599647. For details on this and other kits.

CONSORT SPEAKER KIT as July '91 E.T.I. £188 inclusive. All parts available separately. Memex Electronics Ltd. 1 Icknield Close, Ickleford, Hitchen, Herts SG5 3TD.

KITS. VHF/FM Microtransmitter, 15x25mm, £5.95, built £9.95. "Stinger" Shocker, uses PP3!, £12.99, built £19.99. Loads of plans, kits, units, surveillance, protection. Sae list. Cheque/PO: Ace(ti), 53 Woodland Way, Burntwood, Staffs WS7 8UP. Tel: 0543 676477 (24 hrs).

NEW VALVE AMP KITS! PE Moscode amp 100W/CH DC coupled 1194. ETI Hybrid preamp, full facilities £92.99. PE Hybrid Class A headphone amp, cathode follower output £73.00. All kits are easily built and offer audibly superior performance. Prices are inclusive. Hobtek, The Cottage, 8 Bartholomews, Brighton BN1 1HG.

FOR SALE

SOLAR PANELS 100mm x 60mm 2.5V 0.2Wp £1.40. 6 for £8. 12" x 6" 12V or 6V 1.4Wp £8.50. 12"x 12" 12V 3Wp £15.00. 36" x 12" 12V 5-6Wp £23.50. Prices include U.K. P&P. Larger / mounted panels available. Orders to Bob Keyes GW4 IED. 4 Glanmor Crescent, Newport, Gwent. NP9 8AX.

Technical Information Services
76 CHURCH STREET, LARKHALL, ML9 1HE
Tel: (0698) 884585 Mon-Fri 8.30am - 5.00pm
Tel: (0698) 883334 Outwith business hours
Write now with an sae for your
FAST, FREE QUOTE AND FREE CATALOGUE
Remember, not only do we have EVERY service sheet ever produced, but we also have
THE WORLD'S LARGEST COLLECTION OF
SERVICE MANUALS
& WE ARE SOLE SUPPLIES OF VARIOUS FAULT-FINDING GUIDES, REPAIR MANUALS & TECHNICAL MANUALS
DATA REFERENCE MANUAL "... essential for the serious electrician". FREE updating and a 10% discount voucher only £5.95. Incorporates Unique Model Identification and Chassis Data

PLANS

ELECTRONIC PLANS, laser designs, solar and wind generators, high voltage teslas, surveillance devices, pyrotechnics and computer graphics tablet. 150 projects. For catalogue. SAE to Plancentre Publications, Unit 7, Old Wharf Industrial Estate, Dymock Road, Ledbury, Herefordshire, HR8 2HS.

SERVICE MANUALS

SERVICE MANUALS
Available for most equipment
TV's, Video's, Test, Audio etc
Write or phone for quote
MAURITRON (HRT),
8 CHERRY TREE ROAD,
CHINNOR, OXON OX9 4QY
TEL (0844) 51694 FAX (0844) 52554

MISCELLANEOUS

HEATHKIT UK educational products distributors — service centre. Cedar Electronics, Cedar House, 12 Isbourne Way, Broadway Road, Winchcombe, Cheltenham, Glos. Tel 0204 602402.

WANTED

Turn your surplus transistors, ICs etc, into cash. Immediate settlement. We also welcome the opportunity to quote for complete factory clearance.
Contact:
COLES HARDING & CO.
103 South Brink
Wisbech, Cambs.
NOW ESTABLISHED OVER 15 YEARS
Tel: 0945 584188
Fax Number: 0945 588844

DRAWING UTILITY

Schematic Drawing Utility
Draw your own professional circuit diagrams on the **Amstrad CPC6128** or **PCW 8256** computer with our easy to use design utility. Offers high quality printout of drawings, up to 50 inches square on a standard dot matrix printer. Comprehensive symbol library containing many commonly used ciruit symbols. Symboli library can be edited and added to. All this and more for only **£29.99** fully inclusive.
For further details send SAE to:
CADsoft Systems, 18 Ley Crescent, Tyldesley, Manchester M29 7BD

LIGHTING CONTROLLER KITS

FOR THE SERIOUS MOBILE DISCO
Switchable 3-4 Channel Controller with beatchase and speed controls
PCB — Components Kit **£21.00**
Hardware Kit **£12.00**

Multichase 4 Channel Controller with beatchase, speed and chase-select controls.
PCB — Components Kit **£26.00;** Hardware Kit **£13.00**

COMPUTER CHASE 4 CHANNEL CONTROLLER.
A controller designed to achieve very good results from many types of lighting display. Perfect for pinspots, super on screens, can even revitalize spotlamp boxes. Fast tracking autolevel audio input and choice of sound modes ensure accurate and varied interpretation of music.
PCB + Components Kit **£35.00**
Hardware Kit **£15.00**
Postage & packing £1.50 per order

LOUDSPEAKER KITS

HIGH POWERED SPEAKERS FOR PA AND DISCO USE
Ready made black vynide covered cabinets, cutout ready for fitting of wide dispersion horn and 12" 100 Watt RMS driver or 15" 200 Watt RMS driver. Kit contains all fixings, clamps, sockets, labels etc.
Magnum 100 (1×12" + 7×3" horn) **£165 pair**
SIZE 540mm×380mm×300mm
Magnum 200 (1×15" + 7×3" horn) **£235 pair**
SIZE 635mm×460mm×330mm
Carrier Delivery £12.00 pair

TEST EQUIPMENT KITS

LED DISPLAY OSCILLOSCOPE with 9×9 grid of high efficiency LED's with trigger/freerun brightness, sensitivity, Y position and timebase **£19.95**

WAVEFORM GENERATOR with sine, triangle and square wave output. Range, frequency and amplitede. **£9.95**

Postage & packing 50p

FAST FRIENDLY SERVICE ALL PRICES INCLUDE VAT

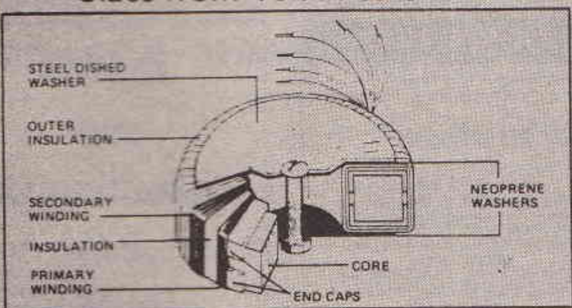
NORTECH electronic

98 SCHOOL STREET, WOLVERHAMPTON,
WEST MIDLANDS WU3 ONE · TEL: (0902) 23275

OLP TRANSFORMERS FROM JAYTEE

The UK Distributor for Standard Toroidal Transformers

* 106 types available from stock
* Sizes from 15VA to 625VA



Write or phone for free Data Pack

Jaytee Electronic Services
143 Reculver Road, Beltinge, Herne Bay, Kent CT6 6PL
Telephone: (0227) 375254

MANUFACTURERS ORIGINAL SPARES

COMPONENTS for TV · Video · Audio · Computer

WE CAN SUPPLY A VAST RANGE FOR MANY MAKES — **WRITE** (send SAE please) **OR PHONE 0452 526883 FOR A 'PRICE & AVAILABILITY' ON YOUR REQUIREMENTS.**

AMSTRAD/SINCLAIR
40010 G.Array £20.63
CPC464 Serv Manual £8.49
Spec 48K Membrane £4.50
+/128K Membrane £7.99
QL Membrane £7.95
ULA6C001E £16.77
ZX 8302 (QL) £10.75
ZX 8401 (Spec) £7.94
PHILIPS
CM8833 Serv Manual £3.80

COMMODORE
6526 CIA £11.11
8520 (Amiga) £11.22
8701 Clock Gen £6.90
901225 Char ROM £6.55
C64 User Manual £4.25
ATARI
'Basic' ROM (XE/L) £4.49
PC713V (STE-PSU) £2.94
EPSON
C78010BD031 CPU £30.24

OTHER MAKES
Sanyo/Fisher VCR Belt Kit VTC6500/VBS3500 .... £2.49
Hitachi VT11/14/33/34/63 Replacement Video Head £26.10
Toshiba St-U2/U2L Power Transformer £9.99
TBA530 £1.14 AY38912 £5.74
TBA810P £1.40 UPC1378H £2.45
TDA8170 £3.53 LM 733CN £2.27

This just a small sample of our stock — We are also holding Tools, Connectors, Aerial & Telephone Accs and much more. For our **catalogue** please send **50p** stamps/chq. MAIL ORDER ONLY. Please add 95p (UK) P&P but not VAT. All items subject to availability. Price can change without notice.

MARAPET (TB), 1 HORNBEAM MEWS, GLOUCESTER GL2 0UE

SPECIAL OFFERS

NEWMARKET TRANSFORMER LTD

UNIT 15 CRAVEN WAY INDUSTRIAL ESTATE
NEWMARKET, SUFFOLK CB8 0AP
Tel: Newmarket (0638) 662989 · Fax: (0638) 660799

TOROIDAL & LAMINATED TRANSFORMER MANUFACTURERS

Very competitive mail order service

Phone M. J. Dornan for immediate quote
Tel: 0638 662989

COURSES

Start training now for the following courses. Send for our brochure — without obligation or Telephone us on 0626 779398

ETI/10/91

Name ______________________

- ☐ Telecomms Tech C&G 271
- ☐ Radio Amateur Licence C&G
- ☐ Micro-processor
- ☐ Introduction to Television

Radio & Telecommunications Correspondence School
12 Moor View Drive, Teignmouth, Devon TQ14 9UN

A CAREER IN TECHNICAL AUTHORSHIP

There is a constant demand for technical authors thoughout industry. If you have a technical background, a qualification in technical authorship can open up the prospect of a new and rewarding career. For details of a comprehensive Open Learning Course, leading to recognised qualifications in this field, send for free information pack to:

TUTORTEX SERVICES ETI1
Freepost, Ulverston, Cumbria LA12 7BR
Tel: 0229 56333

SPECIAL OFFERS

CATALOGUE £1.00 + 25p P&P

LEDs 3mm or 5mm red or green .... 6p each yellow 11p each
High intensity red, green or yellow 5mm .... 30p each
Cable ties 1p each £5.95 per 1000 £49.50 per 10,000
Stepping motor 4 phase 12v 7.5 step 50 ohms £8.95
SAA1027 stepping motor driver chip £3.95
FM Transmitter kit good quality sound £8.60
High quality photo resist copper clad epoxy glass boards

Dimensions	single sided	double sided
3x4inches	£0.95	£1.07
4x8 inches	£2.40	£2.68
6x12 inches	£5.37	—
12x12 inches	£10.66	—

Special Offers
Computer grade capacitors with screw terminals 38000uf 20v £2.50
87000uf 10v £1.95, 68000uf 15v £2.95, 10000uf 16v £1.50
7 segment common anode led display 12mm £0.45
LM2931AT5.0 low drop out 5v regulator TO220 package £0.85
BS250 P channel mosfet £0.45, BC559 transistor £3.95 per 100
74LS05 hex invertor £10.00 per 100, used 8748 Microcontroler £3.50
TV Mains switch 4A double pole with momentry contacts for remote control pack of 10 £3.95 box of 60 £19.95
DC-DC convertor Reliability model V12P5 12v in 5v 200ma out 300v input to output Isolation with data £4.95 each or pack of 10 £39.50
Hour counter used 7 digit 240v ac 50Hz £1.45
Resistor pack 2500 resistors 1/8-2W 50 different values £8.95
QWERTY keyboard 58 keygood quality switches new £5.00
QWERTY keyboard with serial output no data (used) £5.00
Wide range of CMOS TTL 74HC 74F Linear Transistors kits rechargable batteries capacitors tools etc always in stock. Please add 95p towards P&P vat included

JPG ELECTRONICS
276-278 Chatsworth Road Chesterfield S40 2BH
Access/Visa Orders (0246) 211202 callers welcome

FOR SALE

MISCELLANEOUS ITEMS

Camera returns; 35mm Auto Flash /Wind-on, minor faults .... £6.00 ea or 2 for £10.00
Dictaphone cassette, mech/record erase playback heads, 6V solenoid, motor, hall effect switch .... £2.00 ea*
TV/Printer stands .... £3.95 ea
Bicc-Vero Easiwire construction kit .... £4.95 ea*
TTL/CMOS short circuit snooper £4.95*
Dot matrix LCD 10×2 lines .... £3.75 ea*
Dot matrix LCD 16×1 lines with Dots £4.95*
2 digit 16 segment VF display with data .... £2.95 ea*
4 digit intelligent dot matrix display £6.00*
17 segment VF display with driver board and data .... £2.99 ea*
8 digit liquid crystal display .... £1.75 ea*
4 digit LCD with 7211 driver chip .... £3.50 ea*
Digital clock display £2.50*
11 key membrane keypad .... £1.50 ea*
Keyboard 392mm×180mm/100 keys on board + LCD + 74HC05/ 80C49 easily removable £4.95
19" 3U sub rack enclosures £8.95
12V stepped motor, 48 steps per rev, 7.3° step angle .... £3.95 ea*
Stepped motor board with slotted opto+2 mercury tilt switches .... £3.95 ea*
1000 mixed ¼ watt 1% resistors .... £4.95 ea
250 electrolyic axial+radial caps £4.95 ea
100 Mixed trimmer caps popular values £4.95*
50 off MC 78M12CT Volt Regs £2.95*
20 off W02M Volt Regs £1.50*
Cable box UHF modular/video preamp/ transformer/R's + C's/leads £6.95
1000 off mixed Multilayer Ceramic Caps £7.95
Solar cell modules 0.45V 700mA .... £2.95 ea*
BBC Micro to disc drive lead £1.50*
Car Burglar alarm vibration auto entry/ exit delay .... £5.95 ea*
Single zone alarm panel auto entry/ exit delay housed in domestic light socket .... £9.95 ea

P.S.U.'s, TRANSFORMERS, COMPONENTS

P.C. P.S.U. 50 watt 115-230V input+5V 4A+12V 2.5A output with built-in fan, IEC inlet+on off .... £9.95 ea
STC P.S.U. 240V input 5V 6A output (converts to 12V 3A details available) .... £5.95 ea
240V input 5V 10A output (converts to 12V 5A no details) .... £5.95 ea
600Ω line output transformers .... £1.25 ea
240V in 0-12V 0.75A out transformer £2.75
240V in 0-28V 62VA out transformer £2.75
Transformer+PCB gives 2×7.5V 32VA with skt for 5 or 12V regulator, will power floppy drive .... £3.75 ea
Ultrasonic transducer (transmit+ receive) .... £1.50 pair
3 to 16V Piezoelectric sounders 50p*
9V DC electromechanical sounder 50p*
24V DC electromechanical sounder .50p*
2A 250V keyswitch 3 position key removable in two positions £1.50*
DIL switches PCB MT 3/4/6 way 35p*
5V SPCO SIL reed relay 40p*
5V 2PCO DIL miniature relay 60p*
12V 2PCO or 4PCO continental relay 60p*
12V 10A PCB MT (to make contact) relay 95p*
3 to 12V electro magnetic accoustic transducer with data 75p*
2.4576/8.8329/21.10 MHz crystals .... 50p ea*
Bridges 25A 200V £1.00*
2A 100V 50p*
3lb Mixed components pack £4.95
50 Mixed terminal blocks £2.95
250 off 16/22/24/40 way IC Skts £4.95*
100 off Phono plugs (red/blk/grey) £3.50*
QUANTITY DISCOUNTS AVAILABLE — PLEASE RING

ALL PRICES INCLUDE V.A.T.
*PLEASE ADD £2.00 p&p EXCEPT ITEMS MARKED * WHICH ARE 50p*
SAE FOR BULK BUYING LIST
PAYMENT WITH ORDER TO:

Dept ETI, COMPELEC, 14 Constable Road, St Ives, Huntingdon, Cambs PE17 6EQ
Tel/Fax: 0480 300819

SPECIAL OFFERS

VARIABLE VOLTAGE TRANSFORMERS

INPUT 220/240V AC 50/60
OUTPUT 0-260V

	Price	P&P
0.5KVA 2.5 amp max	**£29.00 £**	**£3.75**
		(£38.48 inc VAT)
1KVA 5 amp max	**£37.40**	**£4.25**
		(48.94 inc VAT)
2KVA 10 amp max	**£54.00**	**£5.48**
		(£69.89 inc VAT)
3KVA 15 amp max	**£71.50**	**£6.24**
		(£91.34 inc VAT)
5KVA 25 amp max		**£126.50**
		(Carriage on request)

Buy direct from the Importers. Keenest prices in the country

COMPREHENSIVE RANGE OR TRANSFORMERS-LT-ISOLATION & AUTO
(110-240V Auto transfer either cased with american socket and mains lead or open frame type. Available for immediate delivery.

ULTRA VIOLET BLACK LIGHT FLOURESCENT TUBES
4ft 40 watt **£10.44** (callers only) (£12.27 inc VAT)
2ft 20 watt **£7.44** + £1.25 p&p (£10.21 inc VAT)
13in 10 watt **£5.80** + 75 p&p (£7.70 inc VAT)
12in 8 watt **£4.80** + 75p p&p (6.52 inc VAT)
9in 6 watt **£3.96** + 50p p&p (£5.24 inc VAT)
6in 4 watt **£3.96** + 50p p&p (£5.24 inc VAT)

230V AC BALLAST KIT
For either 6in, 9in or 12in tubes **£5.50+55p** p&p (£7.11 inc VAT)
For 13in tubes **£6.00** + 75p p&p (£7.93 inc VAT)

400 WATT UV LAMP
Only **£34.00** + £2.50 p&p (£42.89 inc VAT)

175 WATT SELF BALLASTED BLACK LIGHT MERCURY BULBS
Available with BC or ES fitting. Price inc VAT & p&p £20.27

12 VOLT BILGE PUMPS

Buy direct from the importers
500 GPH 15ft head 3 amp £16.36
1750 GPH 15ft head 9 amp £26.65
PRICES INCLUDE P&P & VAT

EPROM ERASURE KIT
Build your own EPROM ERASURE for a fraction of the price of a made up unit kit of parts less case includes 12 in 8 watt 2537 Angst Tube Ballast unit, pair of bi pin leads, neon indicator, on/off switch, safety microswitch and circuit £14.00 + £2.00 p&p (£18.80 inc VAT)

SUPER HY-LIGHT STROBE KIT
Designed for Disco, Theatrical use, etc
Approx 16 joules. Adjustable speed £48.00 + £2.00 p&p (£58.75 inc VAT)
Case and reflector £22.00 + £2.00 p&p (£28.20 inc VAT)
SAE for further details including Hy-Light and Industrial Strobe Kits

"BOFFINS SPECIAL" — UNIQUE OFFER

Surplus Precision Medical Unit, internally in excellent condition. Designed primarily to eject a precise controllable amount of fluid from a medical syringe (latter not supplied). Contains the following removable components. Dual Micro Processor Boards and EPROMS Escap Precision 12V DC Motor with 300 1 Gear Box and optical encoder coupled to a precision threaded drive mechanism. Mains supply with 12 x 15V Ni-Cad AA cells back-up LCD. Digital read-out 17mm high with legends. Audible warning.
These are sold for the dismantling of the exceptional quality components. Regret no Circuits available. Ridiculously low price **£16.00 + £4.00 p&p** (£23.50 incl VAT).

WIDE RANGE OF XENON FLASHTUBES
Write/Phone your enquiries

GIANT BLOWER EXTRACTOR UNIT
Twin output centrifugal blower. 1 HP, 240V AC motor. Output approx 3800 c.f.m. Size. Lenth 100cm. Height 27cm. Depth 26cm. Fixing plate 1106 x 33cm. Price **£125** + VAT. Ex-warehouse.

TORIN CENTRIFUGAL BLOWER
230V AC 2,800 RPM 0.9 amp. 130mm diameter. impellor outlet 63 x 37mm. Overall size 195 x 160 x 150mm long. Price **£17.50 + £2.50 p&p** (£23.50 inc VAT).

SOLID STATE EHT UNIT
Input 230/240V AC. Output approx 15KV. Producing 10mm spark. Built-in 10 sec timer. Easily modified for 20 sec. 30 sec to continuous. Designed for boiler ignition. Dozens of uses in the field of physics and electronics, eg supplying neon or argon tubes etc. Price less case **£8.50** + £1.00 p&p (£11.16 inc VAT) NMS

GEARED MOTORS
71 RPM 20lb inch torque reversable 115V AC input including capacitor and transformer for 240V AC operation. Price inc VAT & p&p **£23.50.**

HEAVY DUTY MOTOR
Crouzet 115/230V AC heavy duty 1RPM motor. Anticlockwise type 82/0f5 Size 68mm. diameter x 55mm long. Shaft 6mm diameter x 20mm long. Price inc VAT & p&p **£18.86**.

RHEOSTAT
50W 2 ohm 5 amp ceramic power rheostat price inc VAT & p&p **£10.61.**

MICROSWITCH
Pye 15 amp changeover lever microswitch. Type S171. Brand new price 5 for **£7.05** inc VAT & p&p

NMS = NEW MANUF SURPLUS
R&T = RECONDITIONED AND TESTED

SERVICE TRADING CO (E.T.I.)
57 BRIDGEMAN ROAD, CHISWICK, LONDON W4 5BB
081-995 1560
ACCOUNT CUSTOMERS MIN. ORDER £10
Showroom open Monday - Friday
VISA
Ample Parking Space

E L E C T R O M A R T

LIVERPOOL

PROGRESSIVE RADIO
87/93 Dale Street Tel: 051 236 0982
051 236 0154
47 Whitechapel Tel: 051 236 5489
Liverpool 2
'THE ELECTRONICS SPECIALISTS'
Open: Tues-Sat 9.30-5.30

LIVERPOOL

ALL PARTS
TV & Video spares emporium
Phone for best price on spares
Ferg Video Heads from £10.95, Panasonic Heads from £10.95
Video Copy Kits £5.99. Amstrad Satellite Spares
All your TV & Video needs here in Liverpool
ALL PARTS, 101 Rocky Lane, Tuebrook, Liverpool 6 4BB. Tel: 051-2604825
Mon-Fri 10am-5.30pm, Sat 9am-5.30pm

THIS SPACE COULD HAVE ADVERTISED YOUR COMPANY!
FOR DETAILS OF RATES
TEL: 0442-66551

Technical & Scientific Supplies

Pulse/Function Generator, Thandar TG503. Range:- 0.005 to 5 MHz. Sine, square, triangle, double pulse, sweep function. Unused/boxed with handbook. Normally £545. Special offer £395
Communications Receiver. FRG-7. 0.5 to 30MHz. Working but frequency display faulty, hence £69
Computers HP150. Touch-screen by Hewlett Packard. As seen, to clear £80
Printers, inkjet. Hewlett Packard. HPIB Interface. As seen, to clear £65
Air-conditioned workshop. 2 metre cube container fitted bench, power, lights, rack, cupboards £850
Projector, 35mm strip. Kershaw 250. In case, tested. £45
Camera, Polaroid CU5 with CRT/Oscilloscope hood. £35
Cable. Used polyethelene covered marine cable. Multicore and mains. Strainer wire. 30p/metre
Bruel and Kjær Microphone 4138 (1/8 inch) with adaptor. Unused/boxed. Normally £1100. £500
Valves of many types available, including part-used at very cheap prices. *Please enquire.*
Desks and tables - ideal work places! Heavy grey wooden topped. Single/double pedestal. £18-£38
Filing Cabinets, 4-drawer metal, mostly green. £35 and £40

All prices exclude V.A.T. and carriage. Please check availability before ordering.
We also purchase equipment and components. Any quantity considered. Clearances welcome Lists available
P.O. Box 19, Hythe, Southampton, Hampshire. SO4 6XQ.
Tel:- (0703) 848 666. (Any Time) Fax:- (0703) 897 079

LOUDSPEAKERS

Falcon DIY SPEAKERS
Send for our FREE price list PL20.
All we ask for is a large SAE (34p stamp) or $2 bill (air) overseas, (Europe — 3 international reply coupons)
SYSTEM DESIGNS (Total Kits):
Focal, KEF Constructor, Seas, etc.
DRIVE UNITS:
FOCAL, KEF, Audax, Coles, Peerless, Seas, Slare, Elac Metal Dome, Scanspeak, etc.
Also Group/Disco Units.
CROSSOVER NETWORKS:
Active & Passive Components, Accessories, Polypropylene Caps.
AUDIO AMATEUR PUBLICATIONS BACK ISSUES:
Speaker Builder, Audio Amateur & Glass Audio & lots of books.
Full details from
FALCON ELECTRONICS
(Dept ETI) Tabor House, Mulbarton, Norfolk NR14 8JT (0508) 78272
(Proprietors: Falcon Acoustics Ltd)

To place your advertisement in the classified section phone 0442 66551

ETI

ELECTRONICS TODAY INTERNATIONAL

EDITORIAL
Editor Paul Freeman
CREATIVE
Art Editor Peter Kirby
Designer Iain Houston
Technical Illustration Jerry Fowler
Photography Manny Cefai
ADVERTISEMENT SALES
Advertisement Manager
Mark Linacre
Advertisement Sales
Michele Donovan
Advertisement Copy Control
Marie Quilter
MANAGEMENT
Managing Director
Terry Pattisson
Circulation & Promotions Manager
Debra Stupple
Production Manager
Tony Dowdeswell
Group Editor
Stuart Cooke

ISSN 0142-7229

ABC Member of the Audit Bureau of Circulation

● Subscription rates — UK: £19.20. Europe: £24.10. Middle East: £24.40. Far East: £26.80. Rest: £25.85 or US$48.00. Cheques payable to A.S.P.

Published by Argus Specialist Publications, Argus House, Boundary Way, Hemel Hempstead HP2 7ST. Tel: (0442) 66551. UK newstrade distribution by SM Distribution Ltd., 6 Leigham Court Road, London SW16 2PG. Tel: 081-677 8111. Overseas and non-newstrade sales by Magazine Sales Department, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST. Tel: (0442) 66551. Subscriptions by Select Subscriptions Ltd., 5 River Park Estate, Berkhamsted, Herts HP4 1HL. Tel: (0442) 876661. US subscriptions by Wise Owl Worldwide Publications, 4314 West 238th Street, Torrance, CA90505 USA. Tel: (213) 3756258. Typesetting and origination by Ashford Scanning, Whitstable. Printed by Wiltshire Ltd, Bristol.

AN ARGUS SPECIALIST PUBLICATION

Argus House, Boundary Way,
Hemel Hempstead HP2 7ST
Tel: (0442) 66551   Fax: (0442) 66998

NEXT MONTH

If you have problems interconnecting all your MIDI equipment like drums, synths, samplers and computers then the MIDI switcher, a project featured next month, could be the answer.

We have another surface mount project in store. This time its a Voltage controlled general purpose oscillator packed into a very tiny box.

Also originally designed for atmospheric measurements within astronomy, we present a High resolution voltmeter or Earth charge recorder.

Our features include the latest information on Digital Audio Broadcasting (DAB) the proposed future of quality radio reception, Intuitive Electronics and its investigation on the fundamental connections between charge, potential and current and finally more on Test-gear basics.

Why not order your copy now and collect it on 7th February.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

Our January edition contained:

Introduction to audio mixers
Faraday:Thinker and Experimenter
Making PCBs at home Pt 2
Lab Power Supply Pt 2
Photo Enlarger timer
Test-card generator Pt 2

A limited supply of back numbers are availble from Select, address in column to left.

ADVERTISERS' INDEX

2 x 220 watt MOSFET AMPLIFIER

A top-of-the-range performer that will satisfy the most demanding audio enthusiast. If you're looking for an amplifier to power your subwoofer, the **SPARKOMATIC** is all you'll need! Highly sophisticated MOS-FET technology dramatically extends frequency response, separate input sensitivity controls, built-in protection circuitry for overheat and short circuit with l.e.d. indication, output power 2 x 220 watt maximum and 2 x 110 watt at 0.1% THD, Bridged 440 watt mono maximum and 220 watt mono at 0.5% THD.

£164.50 plus £3.50 P&P

100 watt x 4 CLASS A AMPLIFIER FOR CARS

Delivers 4 x 100 watt into 4 woofers or with the aid of its built in active cross over delivers 200 watt of Bass via sub-woofer output and 2 x 100 watt, range into 2 speakers; thus giving you all the power you require to make even traffic jams a positive pleasure. SPECIFICATION 4 x 100W (4Ω), 2 X 200w Bridged, THD .08%, S/N RATIO: 7 90db, RESPONSE 10Hz-50KHz, LOW PASS FILTER SWITCHED 75Hz 150Hz, INPUT 4 x PHONO 100-3 Volts, INPUT x 4 HIGH LEVEL 20KΩ, SIZE 240mm x 50mm x 400mm.

£118.50 postage £4.50

75 watt x 2 CLASS A AMPLIFIER FOR CARS

Small but powerful, high efficiency amplifier, suitable for a number of hidden mounting locations. Easy connection through phono and high level input capability. SPECIFICATION 2 x 75 watts 4Ω, 1 x 150 watt Bridged, THD 0.190, S/N RATIO: 7 85 dB, RESPONSE 20Hz-30KHz. INPUTS; 2 X PHONO 100mV-3 VOLT 2 X HIGH LEVEL 2 X 20KΩ SIZE 240mm X 50mm X 140mm.

£48.50 postage £3.50

11 BAND COMPONENT GRAPHIC EQUALIZER FOR CARS

This neat unit connects between the line output of your car stereo and your power amplifiers so you are able to adjust the sound as in a studio compensating for soft furnishing and sound reflections from glass, also it has a sub-woofer output to drive a separate amplifier for that extra deep bass sound. FEATURES 2 channel inputs 4 channel outputs via phono sockets, CD input via 3.5mm jack 11 band graphic. SPECIFICATION RANGE 20Hz-60KHz THD 0.05%, S/N RATIO 85dB, EQ FREQUENCIES 60HZ, 120Hz, 250Hz, 380 Hz, 500 Hz, 750 Hz, 1 KHz, 2KHz, 4KHz, 8KHz, 16KHz (Boost cut of ±12 dB) SIZE 178mm x 25mm x 140mm.

£32.70 postage £1.80.

EMINENCE 4Ω PROFESSIONAL USA MADE IN CAR CHASSIS SPEAKERS

All units are fitted with big magnets "Nomex" Voice coils NOT ALUMINIUM. "Nomex" is very light and can stand extremely high temperatures, this mixture makes for high efficiency and long lasting quality of sound.

V6 6 ½" 200W Max	Range 50Hz-3KHz	**£34.40**
V8 8" 300W Max	Range 45Hz-3KHz	**£39.35**
V10 10" 400W Max	Range 33Hz-4KHz	**£44.45**
V12 12" 400W Max	Range 35Hz-3KHz	**£45.95**
BOSS 15" 800W Max	Range 35Hz-4KHz	**£79.90**
KING 18" 1200W Max	Range 20Hz-1KHz	P.O.A.

Postage **£3.85** per speaker.

AUDAX JBL 40-100 watt CAR TWEETERS

These state of the art advanced technology, high performance 10 mm dome tweeters are Ferrofluid coded and are active horn-loaded for high dispersion of sound with very low distortions. Ideal for tuning up your dull sounding in-car system. SPECIFICATION IMP4Ω 40 watts at 5KHz, 100 watt at 10KHz, MAGNET, SIZE 5mm x 30mm, VOICE COIL SIZE 10.5mm EIFFICIENCY 92.8 dB, 5K. SIZE 51mm x 51mm x 16.5mm. RECOMMENDED. 1st ORDER CROSSOVER, VALUE 1.5uf-2.2uf supplied. **£7.50**pair plus **90p post.**

MAIL ORDER
£1 BARGAIN PACKS
BUY 20 GET 1 FREE
Please state pack(s) required

No.	Qty.	per pack
BP015B	1	30W dome tweeter. Size 90x66mil *JAPAN made*
BP017	3	33000µF 16V d.c. electrolytic high quality computer grade *UK made*
BP019	20	20 ceramic trimmers
BP020	4	Tuning capacitors, 2 gang dielectric a.m. type
BP021	10	3 position, 8 tag slide switch 3 amp rated 125V a.c. *made in USA*
BP022	5	Push-button switches, push on push off, 2 pole changeover. PC mount *JAPAN made*
BP023	6	2 pole 2 way rotary switch
BP024	2	2 Right angle, PCB mounting rotary switch, 4 pole, 3 way rotary switch *UK made by LORLIN*
BP025	4	3 pole, 3 way miniature rotary switch with one extra position off (open frame YAXLEY type)
BP026	4	4 pole, 2 way rotary switch *UK made by LORLIN*
BP027	30	Mixed control knobs
BP029	6	Stereo rotary potentiometers
BP030	2	10k wire wound double precision potentiometers *UK made*
BP032	4	UHF varicap tuner heads, unboxed and untested *UK made by PHILIPS*
BP033	2	FM stereo decoder modules with diagram *UK made by PHILIPS*
BP033A	4	6"x⅜" High grade Ferrite rod. *UK made*
BP034	3	AM IF modules with diagram *PHILIPS UK MADE*
BP034A	2	AM-FM tuner head modules. *UK made by Mullard*
BP034B	1	Hi-Fi stereo pre-amp module inputs for CD, tuner, tape, magnetic cartridge with diagram. *UK made by MULLARD*
BP035	6	All metal co-axial aerial plugs
BP036	6	Fuse holders, panel mounting 20mm type
BP038	20	5 pin din, 180° chassis socket
BP039	6	Double phono sockets, Paxolin mounted
BP041	3	2.8m lenghts of 3 core 5 amp mains flex
BP042	2	Large VU meters *JAPAN made*
BP043	30	4V miniature bulbs, wire ended, new untested
BP044	2	Sonotone stereo crystal cartridge with 78 and LP styli *JAPAN made*
BP045A	2	Mono Cassette Record and play heads
BP046A	2	606 Mains transformers, PCB mounting. Size 42x33x35
BP047A	1	25V DC 150mA mains adaptor in black plastic case with flying input and output leads new units made for famous sound mixer manufacturer. Size 80x55x47
BP049	10	OC44 transistors. Remove paint from top and it becomes a photo-electric cell (ORP 12). *UK made by MULLARD*
BP050	30	Low signal transistors n.p.n., p.n.p. types
BP051	6	14 watt output transistors. 3 complimentary pairs in TO66 case. *(Ideal replacement for AD161 and 162s)*
BP052A	1	Tape deck pre-amp IC with record/replay switching No LM1818 with diagram
BP053	5	5 watt audio ICs. No TBA800 *(ATEZ)*
BP054	10	Motor speed control ICs, as used with most cassette and record player motors
BP055	1	Digital DVM meter I.C. *made by PLESSEY* as used by *THANDAR* with diagram
BP056	4	7 segment 0.3 LED display (red)
BP057	8	Bridge rectifiers, 1 amp, 24V
BP058	200	Assorted carbon resistors
BP059	1	Power supply PCB with 30V 4V/A transformer. MC7818CT IC & bridge rectifier: Size 4" x 2¾"
BP061	5	6.35mm Mono jack plugs
BP063	5	6.35mm stereo switched jack sockets
BP064	12	Coax chassis mount sockets
BP065	1	3mtr Euro-mains lead with chassis socket

Postage £3 per order

ROADSTAR OF SWITZERLAND. QUALITY 13cm 40 watt CAR SPEAKERS. Fitted with dual polypropylene cone and foam rubber surround. Large 70mm magnet for good bass and treble response. Supplied complete with grills, fixing screws and cable.

OFFER PRICE £11.70 pair

They weigh nearly 1.5kg. Postage £3.15 each

2 pairs for £22 POST PAID UK ONLY
UNDER ½ PRICE OFFER

AUSTIN ROVER MINI MAYFAIR. 15 watt POD SPEAKERS. Moulded in a black housing for vertical or horizontal use. Fitted with a good mains 10cm speaker.

£4.95 pair plus £3 pp or
2 pairs for £10.50 post paid UK only

BSR STEREO RECORD PLAYER DECK

Manual auto operation, 3 speed (78, 45, 33⅓), 240V opertion, unused but store soiled.

£10.50 ea P&P £3.75   2 for £18.00 P&P £3.75

RADIO AND TV COMPONENTS ACTON LTD
323 EDGWARE ROAD LONDON W2 1BN

MAIL ORDER TERMS. POSTAL ORDERS and or CHEQUES with orders. Nett monthly accounts to Schools, Colleges and P.L.C. only. ACCESS-VISA. Phone orders between 9.30-12pm please. Overseas readers write for quote on delivery.

Phone 071 723 8432 or 081 992 8430

323 Edgware Road, London W2 1BN. Closed Sun.

AMPHONIC 125+125 POWER AMPLIFIER

125 watt per channel stereo power amplifier with independent volume controls, professional 19" rack mount and silent running cooling fan for extra reliability.

Output power	125W RMS max. per channel
Output impedance	4 to 16 ohms (max power into 4 ohms)
Sensitivity	450V at 22K ohms
Protection	Electronic short-circuit and fuses
Power	220-240V a.c. 50Hz
Chassis dim.	435 x 125 x 280mm

£170 + £7.00 pp

30+30 WATT AMPLIFIER KIT

An easy to build amplifier with a good specification. All the components are mounted on the single PCB which is already punched and back-printed.

- 30W x 2 (DIN 4 ohm)
- CD/Aux, tape I, tape II, tuner and phono inputs.
- Separate treble and bass.
- Headphone jack.

Size (H.W.D.) 74 x 400 x 195mm.
Kit enclosed: case, PCB, all components, scale and knobs **£40.00** + £3.50 pp.
(Featured project in *Everyday Electronics,* April 1989 issue). Reprint Free with kit.

MULTIBAND RADIO

VHF 54-176MHz + AM CB BANDS 1-80
Listen to: AIR TRAFFIC CONTROL, AIRCRAFT, RADAR, PUBLIC UTILITIES, RADIO AMATEURS AND MANY MANY MORE
SQUELCH CONTROL
AERIAL

£17.95
POSTAGE £2.85

ROSS PUSH BUTTON RADIO

Mains and battery operated.
High quality VHF/FM,
Medium and Long Wave reception,
6 push button selected preset stations.
Fully retractable telescopic aerial
Headphone/earphone jack socket.
Size 230H x 150W x 65D
Ref. RE-5500
Brand new.
Listed price over £30.00

OFFER £15.00
+ £2.80 pp

VIDEO SENDER

With this handy unit you can transmit the output of your home video, video camera or satellite equipment over-the-air to a receiving television within a range of 100ft. Simply connect the video and audio output of your equipment into this unit and a 10-13.8V dc power supply extra **£3.75** size 122 x 70 x 21mm

£11.50 + £2 pp

VHF RADIO TRANSMITTERS

100mW mini bug. Built on a neat little fibre glass pcb with condenser mic. Fully tunable over the FM band. 9V DC **£5.75** + £0.90 pp
2 Watt transmitter kit, supplied with fibre glass pcb, all components, diagrams, ready for you to build. 12-24V DC. **£7.50** + £0.70 pp
25 Watt Transmitter kit. Fully tuneable over the FM band. Kit comprises double sided pcb diagrams and all components, including heat sink. Supply voltage 12-18V DC. **£67** + £1 pp
Transmitters listed on this page are not licensable in the UK.

SPECIAL OFFER

DTMF TONE DIALLER

Suitable for remote control of telephone answering machines, videos, appliances etc. requiring DTMF signals over telephone lines.

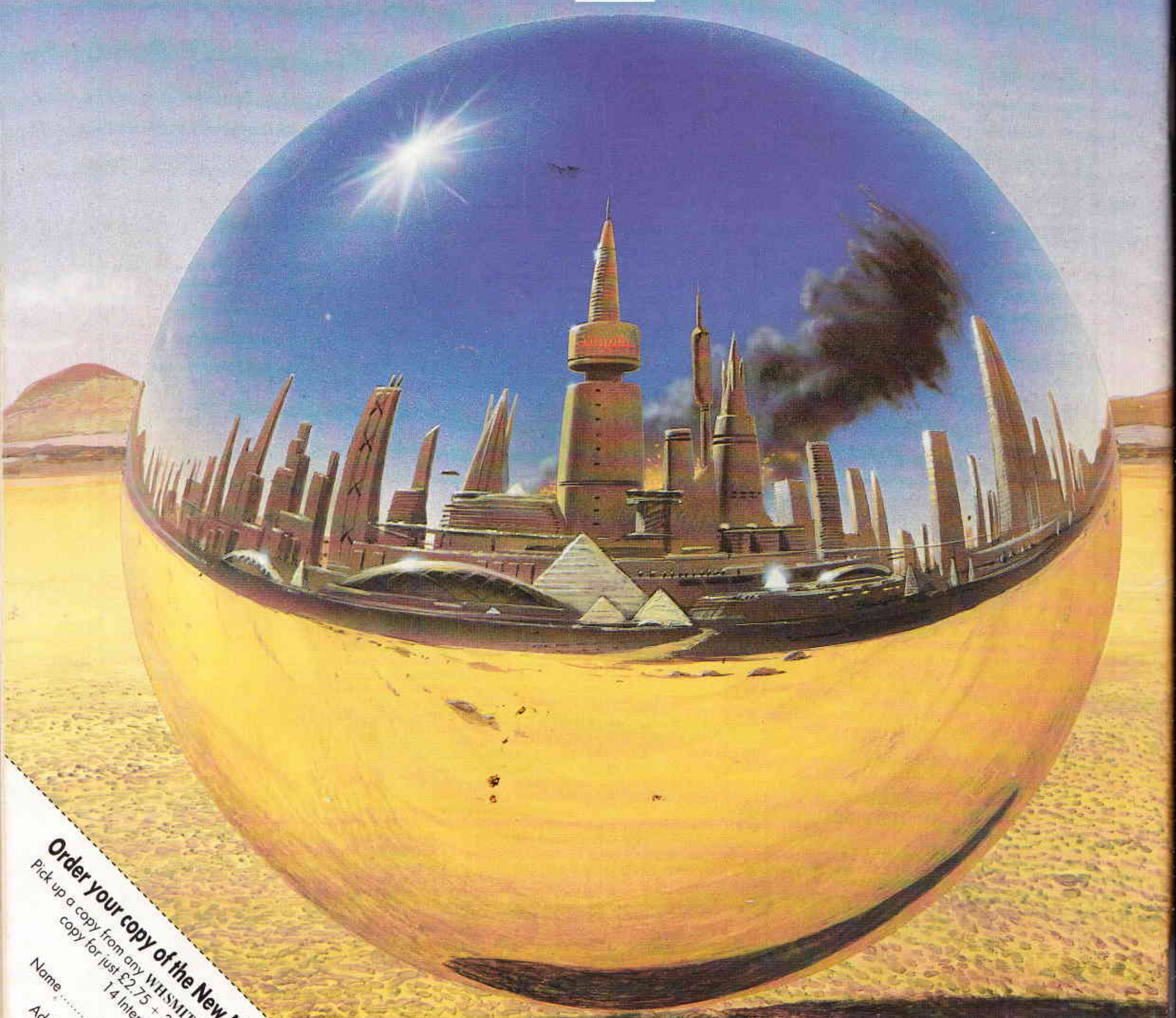
£8.95

Please add 75p p&p when ordering

Please add 2.2% to all our prices due to the increase of the VAT rate to 17.5%

1992 BUYER'S GUIDE TO ELECTRONIC COMPONENTS

Maplin



Order your copy of the New MAPLIN Catalogue on sale NOW!

Pick up a copy from any WHSMITH for just £2.75 or post this coupon now to receive your copy for just £2.75 + 20p p&p. If you live outside the U.K. send £4.85 or 14 International Reply Coupons. I enclose £2.95.

Name ....

Address ....

....

.... Post Code ....

Send to Maplin Electronics,
P.O. Box 3, Rayleigh,
Essex SS6 8LR.

ETI92

Over 600 product packed pages with more than 600 brand new products. On sale now, only £2.75

Available from all branches of WHSMITH and Maplin shops nationwide. Hundreds of new products at super low prices!