THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

FEBRUARY 1991 £1.60

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ELECTRONICS TODAY INTERNATIONAL

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An electricity course for beginners

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Build for your listening pleasure

HDTV
The American Way

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Extracting the energy from waste

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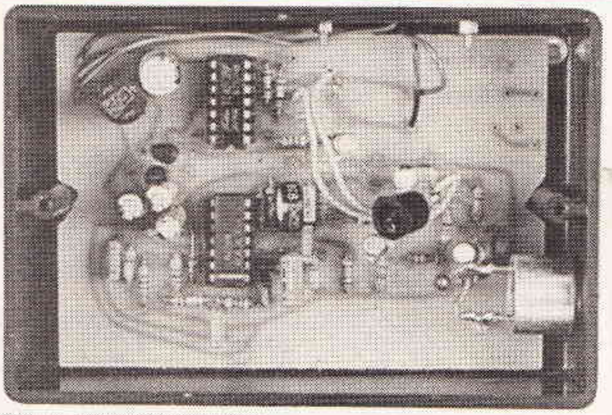
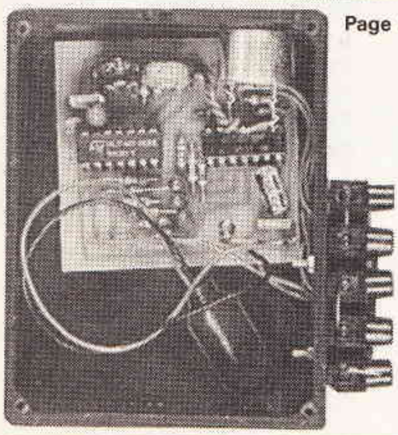
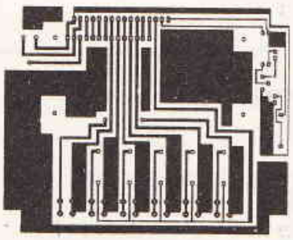




Page 21

REGULARS



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.

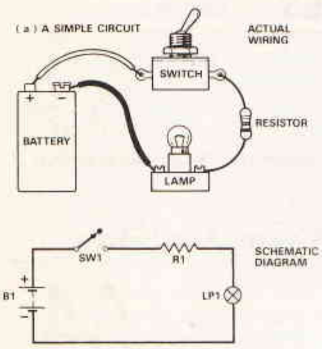
AN ARGUS SPECIALIST PUBLICATION
Argus House, Boundary Way,
Hemel Hempstead HP2 7ST
Tel: (0442) 66551 Fax: (0442) 66998

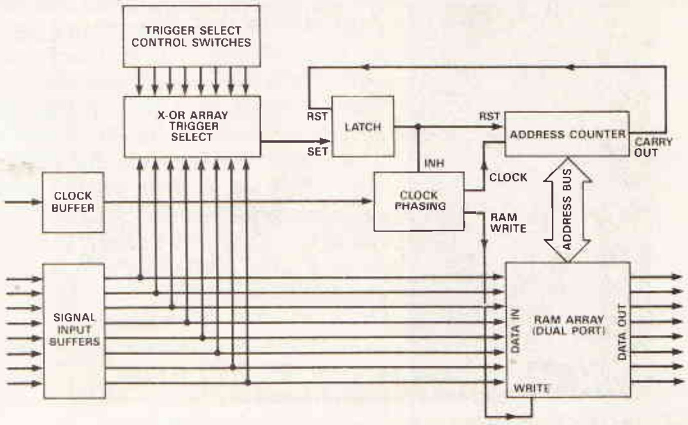
Published by Argus Specialist Publications, Argus House, Boundary Way, Hemel Hempstead HP2 7ST. Tel: (0442) 66551. UK newstrade distribution by SM Distribution Ltd., 6 Leigham Court Road, London SW16 2PG. Tel: 01-677 8111. Overseas and non-newstrade sales by Magazine Sales Department, Argus House, Boundary 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. Typesetting and origination by Project 3 Filmsetters, Whitstable. Printed by Acorn Web Offset Ltd, Bradford, W Yorks.

ETI ELECTRONICS TODAY INTERNATIONAL

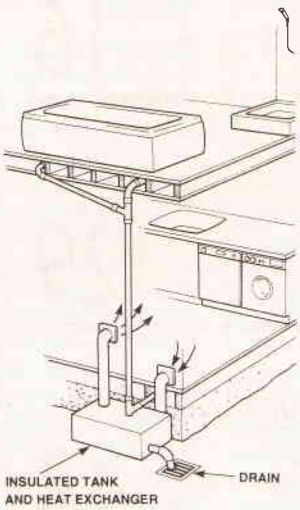
FEATURES/PROJECTS

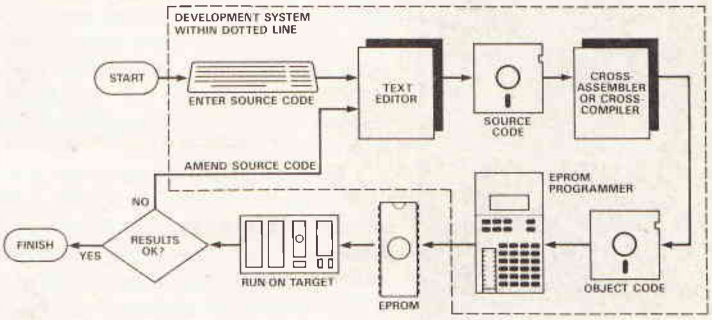
VOLUME 20 No 2



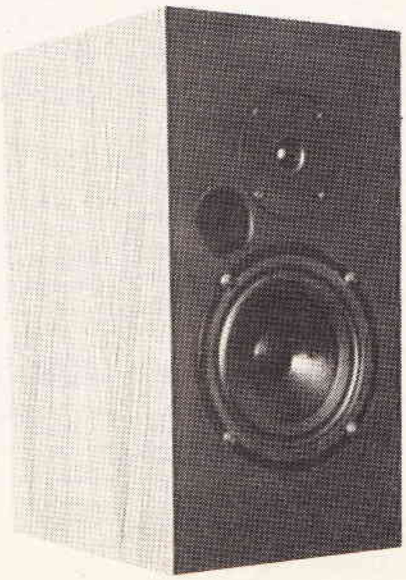


Page 34





Page 50



Page 57

BLUEPRINT

Blueprint is a column intended to provide suggested answers to readers' electronics design problems. Designs are only carried out for items to be published, and will not be prototyped by the columnist. Circuits published in Blueprint are believed to work, but may need minor alteration by the reader after prototyping. Individual correspondence will not be entered into, save as necessary to prepare items for publication.

First of all this month, some continuity. There was a lot of interest in the howlround problem a few months ago. One reader wrote to say that he had built the frequency shifter, and that it worked after a component value had been changed.

He further said that there was a 5Hz sinewave output from the circuit, and that a bandpass filter on the output should cure this. There should be no 5Hz output on a perfectly adjusted shifter, so, assuming that the unit has been properly adjusted, there must be a minor flaw in the design. Should time allow, or if the reader lends me his model, I will attempt to test a prototype and find out where I went wrong, and pass on the information. Meanwhile, I believe the reader intends to write a project using a development of this design, and including an output filter.

Fig. 1

In Practice

As a result of talking to various soundcrew personnel, I have learned a little more about the practical side of howlround reduction. As stated in the readers letter section, a microphone with a really flat frequency response gives a very noticeable improvement over '£15 special' microphones.

Something else which helps considerably is to use a graphic equaliser, set by means of a pink noise generator and a very good quality flat response reference microphone coupled with a spectrum analyser. Maplin sell a complete unit, equaliser, spectrum analyser, and auto calibration all in one, which I have observed making a dramatic improvement by automatically notching out the room's worst resonance. The one I saw suffered from a slight hum, but no doubt small improvements to power supply or internal wiring would cure that. I am awfully tempted . . . Of course, a fully professional system would use three times as many frequency bands, and would probably use a separate spectrum analyser, but it would be very expensive.

I have also learned that a delay line can, despite my original doubts, improve the feedback situation slightly in some circumstances. The received wisdom is that, because a frequency shifter is not suitable for a singer, a very short delay can slightly reduce the tendency to feedback, and much less obtrusively than a frequency shift. It will not cure a major problem, but if a slight improvement is enough then its worth a try. And, Bucket brigade lines tend to be noisy, so the preferred answer is to use a 16 bit digital delay.

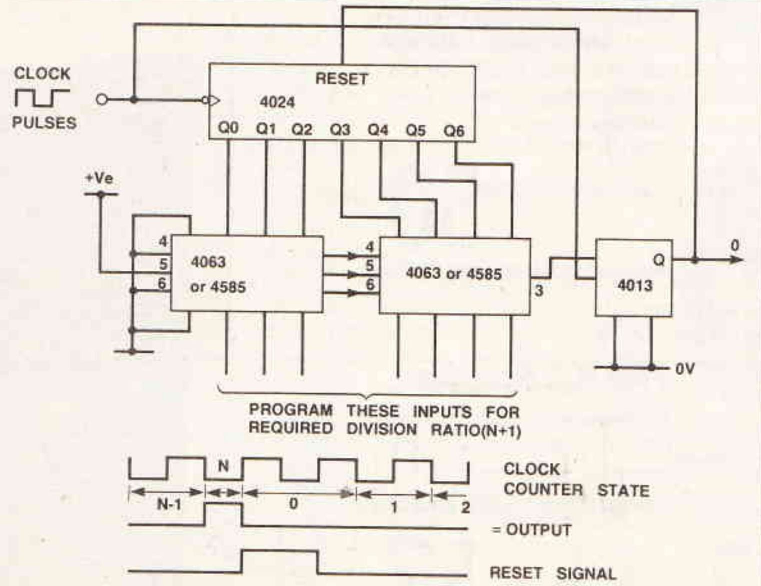


Fig. 2

Timers

This month's readers question is about timing circuits. M Rogers of Stoke on Trent wants to make a novelty clock, and needs to pulse the electromechanical system at 1 pulse per 32.7272 seconds. He would like to achieve an overall accuracy of 10 seconds per week. He goes on to say that the techniques of generating arbitrary time intervals would interest many readers. My sentiments exactly.

Arbitrary time/frequency generation is possible using RC timing elements, and selecting component values and using presets to obtain the exact period required. This principle can be extended using counters after the oscillator to extend the time period beyond that available from convenient values of resistors and capacitors. Of course, the precise R and C values can be chosen to make use of divide by 2^n stages, so that clever design of digital circuitry is not required. It is impractical to make RC timed circuitry to the accuracy requested,so we can confine our consideration to circuits timed by crystals or other fixed frequency sources (eg the mains, standard frequency transmissions from Rugby). The general type of system we are looking at is shown in Fig 1.

There are four obvious approaches to the problem. The first is to choose a suitable frequency range for a crystal, say 1MHz, then choose the nearest power of two to divide close to the required frequency (0.030555623Hz in this case), then work back from this to determine the exact crystal frequency required. Crystals of a specific frequency can be ordered from several sources, and this approach may be justified In some circumstances (a long production run). It does leave something to be desired as a one off technique, though.

The next obvious technique is to use a combination of divide by 2^n stages and binary rate multipliers to generate the frequency.

The third approach would be to calculate a convenient integer division value within the required tolerance or the range over which crystal oscillator frequencies can be adjusted by the use of external capacitance and remain stable. A figure of 0.05% variation is reasonable for most crystal oscillators, and as the specified tolerance is 0.0165%, the figure of 0.05% is the one to use.

The function of dividing by an arbitrary integer

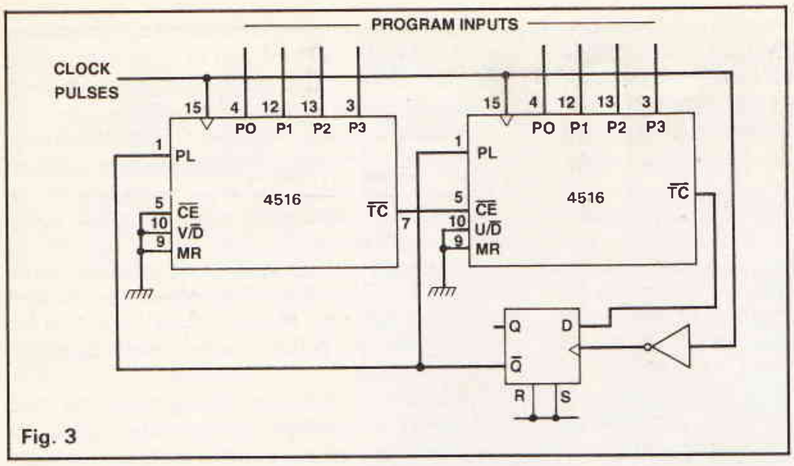


Fig. 3

make the 100kHz crystal oscillator (Figure 4) work reliably at the correct frequency rather than oscillating at a frequency set by the stray capacitance of the crystal, the impedance of C3 should approximately equal that of R2 at the required frequency. R1 is a bias resistor, while C1and C2 set the load capacitance for the crystal (normally specified at 30p). Varying Cl adjusts the frequency to calibrate the circuit.

may be accomplished in more than one way. The obvious method is to use a binary up counter, and a binary comparator to detect when the required number is reached, and then reset the counter to zero. If this is done synchronously, then the number to recognise is the one before the desired division ratio, because zero is included in the counting sequence. Asynchronous reset demands that the required division ratio is recognised, because the final number only occurs momentarily, until the reset to zero has propagated through the system.

Asynchronous counting is vulnerable to false resetting because of spurious intermediate count states, and is harder to debug using an oscilloscope or logic analyser, so I tend to eschew such questionable techniques. An example of a synchronous divider is shown in Figure 2. Note that the terminal count is only maintained for half a clock cycle, while the zero state is maintained for one and a half cycles.

Other means of integer division include the use of parallel loaded counters. If down counters are used then the number one below the division ratio is programmed into the parallel inputs synchronously on the next clock pulse after the zero count is reached. An example of this type of divider is shown in Figure 3.

The fourth obvious technique is to use a microprocessor to generate the required output pulses. The economical approach is to write a program loop having only one path, and count all the clock pulses in the entire loop. It should be possible to devise a loop of the correct duration to the nearest whole clock pulse in the required time period greater accuracy than the crystal will achieve in practice.

Other programming techniques are possible, including the use of multiple and various timer/counter division periods. If you try this, do not forget to include the time required for the processor to service the timer/counter interrupt, and make sure that this time is not variable! A fifth, less obvious approach, would be to use a dual modulus divider. This is gratuitously complicated and mainly appropriate to frequency synthesisers for communications use.

Engineering Philosophy

To provide a complete design example I shall use the BRM (binary rate multiplier) technique. This may or may not be the best approach — one cannot always tell before doing the design. For a one off design I would choose whatever type of design used the ICs I had to hand, while for a production run I would do draft designs for each plausible approach and use the cheapest.

To start with we need an oscillator, so I have chosen the 4060 oscillator divider for this function. If a 100kHz crystal is used, this must be divided by 3272720 to give one cycle per 32.7272 seconds. To

Binary rate multipliers are sometimes overlooked as a means of frequency division, and this is a shame because they can be surprisingly useful. They multiply an input frequency by a binary fraction — meaning halves, quarters, eighths, for as many bits as are used. People normally think of binary numbers as integers, but here we are using the digits after the 'binary point' which is to binary as a decimal point is to base ten.

The scheme to be used here is to divide by the largest multiple of 2 below 3272720, which turns out

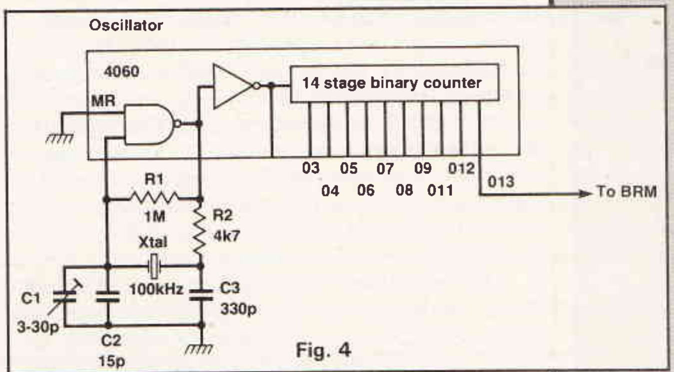


Fig. 4

to be 2^{21} (2097152). The remaining division can be achieved by multiplying by 0.640798. This is carried out by using a pair of 4 bit BRMs programmed to provide 164 pulses out for every 256 pulses in. This is 0.640625, as near as 8 binary places can be to the ideal number, and is within a reasonable tolerance.

The logic in a binary rate multiplier is arranged to even out the pulse spacing as much as possible, but 164/256 does not lend itself to perfectly even spacing. In order to minimise the output timing jitter, some of the total binary division required is positioned after the BRM to divide the timing jitter as well as the frequency. The initial oscillator/divider divides by 2^{14}, and the 4024 after the BRMs divides by a further 2^7, giving a total of 2^{21} as required.

The BRMs and final divider are shown in Figure 5. The output from the 4024 should be fed to whatever pulse shaping circuit, such as a monostable, is suitable to drive the electromechanical system. If a 555 is used in monostable mode, it will not need an extra output drive circuit because of its high current output.

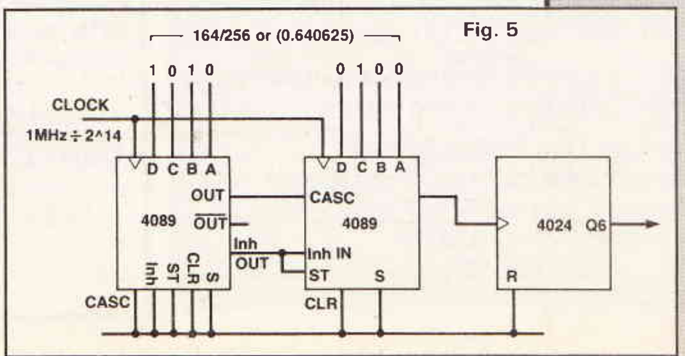


Fig. 5

OPEN CHANNEL

Exactly what is the world coming to? The entertainments world, that is! City bankers muscling in on television stations, home and away. The stations themselves muscling in on each other. And, in an offbeat though as you'll see connected way, Japanese electronics manufacturers muscling in on Hollywood. What's it all about?

Let me explain. In Europe and in the UK, financial institutions are beginning to realise the attraction of owning part stakes in television stations. La Cinq for instance, the French station, is in difficulties and several UK banks looked at it with a view to purchasing a small stake — less the 10% — allowing a say in the station's running.

Similarly, independent television stations in the UK are up for grabs now, as Governmental plans to re-allocate franchises are followed. It is not the fact existing franchises are being re-allocated which is of interest, it is the fact franchises will be sold more-or-less to the highest bidder in a most unusual auction where concern must be expressed.

Bids are basically blind. Bidders have but one chance to offer what they think will secure purchase of a required franchise. Consequently bidders have no idea at all what to bid in real terms. It will be difficult, to gauge what other bidders could offer, so bids could be higher than they would be under an open auction.

One thing, and one thing alone, about the re-franchising auction maintains a hope for fairness and future services. It is simply that part of the bid must be to show how station quality will be maintained, improved, or perhaps trimmed. As you'd expect, quality is difficult to define, being largely subjective. It is up to the Independent Television Commission, which is to re-allocate franchises between bidders, to define bid quality. Thus a financially lower bid, deemed of higher quality than a higher bid in monetary terms, could secure a franchise.

Bids for all franchises must be made by April. At this time it's not possible to say who is expected to bid, but we can make a few educated guesses. First, all existing franchise-holders will automatically bid for re-allocation of their own franchises. However, new regulations allow franchise-holders to bid for other franchises simultaneously — never allowed before — so large and financially secure existing franchise-holders like Central are expected to go for other franchises, too. It is not possible for franchise-holders to own a franchise for a bordering station, however. It's likely that large franchise-holders are only allowed to bid for small franchises along with their own.

Second, existing franchise-holders may join forces in consortia, which aim purely to maintain control over existing franchises. So, companies like Tyne Tees and Yorkshire could join together with the direct aim of maintaining a status quo.

Third, consortia may be formed between existing franchise-holders with the aim of bidding for other franchises. Greater financial securities of such consortia make this an attractive proposition.

A fourth scenario exists, in which franchises may be allocated to outsiders, ousting existing holders. These outsiders could be banks, communications providers, entertainments organisations, or more likely mixtures of all three.

Companies like Virgin are likely to be interested. People like the big RMs (Royal Majesties; Robert Maxwell and Rupert Murdoch) are bound to be interested. Indeed, if these don't express interests it will be surprising.

But, most important, foreign bidders are expected. These may be in the form of banks, simply wishing to buy small stakes in franchises, putting up the money required to finance bids. After all, if our banks can go for stations like La Cinq, why can't their banks go for ours? Bids may, be from stations abroad.

And finally, bids may be from national, international, or global entertainments organisations — film production companies, Japanese electronics manufacturers, and so on. We've already seen how organisations like Sony have realised the importance of film production companies in Hollywood. Television stations are only a couple of steps removed.

One aspect of all this bidding for franchises, which must be of highest importance for the bidders, is expected earnings of franchises. Independent television stations make profits basically through sales of air-time in the form of advertisements. Normally fairly healthy profits are made through such sales (nearly £2 billion in 1989!), and over recent years profits have gone up somewhat more than inflation. Until last year, that is. Somewhat mystically, profits have started deteriorating (a fall of more than 6% over 1989's profits was expected for 1990, at the time of writing) and this serves to make franchises less attractive.

Now I may be a cynic, but even the most die-hard of believers must admit such a downturn of profits the year before re-franchisement auctioning looks just a contrived. Contrived or not, it is bound to deter potential new contenders for franchises, leaving the bidding clear for existing franchise-holders.

Couple this with the Government's delays in defining bidding procedures (revealed this January) and you have a massive deterrent against outside bidders. Until potential bidders know what to do they can't bid; and until they bid, they can't effectively run a television station.

So the Government's own delays and an advertising recession, contrived or otherwise, look set to help the existing franchise-holders maintain the status quo, exactly the opposite of Government intentions.

ETI NEWS

YEDA

British business faces ever growing international competition. If we are to succeed it is vital that today's young people will have the required technical and commercial skills. Over the last five years the Young Electronic Designer Award (YEDA) scheme has made an impressive contribution to doing just this, by encouraging young people to combine their technical skills creatively with an appreciation of the commercial demands of the marketplace.

The Young Electronic Designer Award scheme is organised by the YEDA Trust (a registered charity) and is open to students at secondary schools, polytechnics and universities throughout the UK and is built around an annual competition for three age categories: Junior (under 15); Intermediate (15-17 years inclusive) and Senior (18-25 years inclusive).

The future of YEDA is dependent upon sponsorhip from commercial organisations which visibly aim to put something back into the community, provide incentives for tomorrow's workforce, play a positive role in reducing skills shortages and increase their corporate profile in educational and business circles.

The challenge is for students to produce an original electronic device of their own and has a useful application in everyday life.

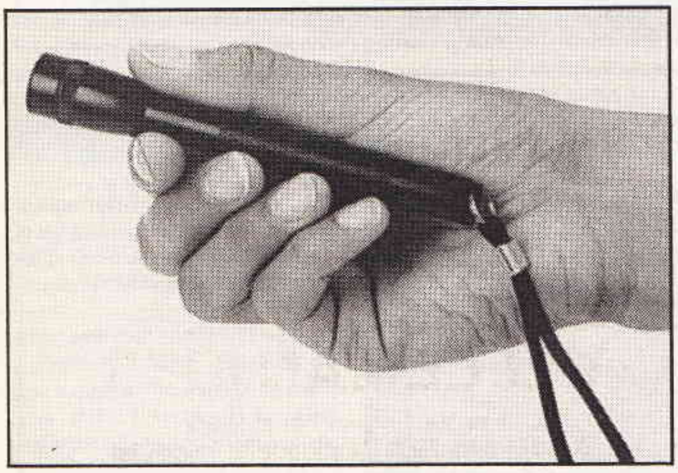
A prestigious trophy and valuable cash prizes are presented to the winners in each category and in the senior age group there are the prospects of course sponsorship and a job in electronics.

There are cash prizes of £2,500 for schools or colleges whose students have produced the most commercially and environmentally viable project. Every finalist also receives a certificate and wins a personal prize, as do their teachers.

Eighteen projects (six from each category) are chosen from a series of regional judging events to appear in the national final held annually in London. The awards are made at a presentation dinner attended by finalists, their tutors and parents, representatives from the world of commerce, industry and education. The 1991 final is to take place at the Science Museum on 3 April, followed by a public exhibition on 4 and 5 April.

Further information contact: The Yeda Trust, 24 London Road, Horsham, West Sussex RH12 1AY, Tel: 0403 211048.

NEW LIGHT FROM MAPLIN



The new Miniature Moisture Proof Torch from Maplin is made from an amazingly light and superstrong alloy usually used in aircraft construction. The rugged pocket-sized torch in diecast alloy has a knurled body and is finished in gloss black paint.

The Maplin Torch uses two AAA type batteries (not included) to power a miniature high-intensity 'krypton' bulb. This bulb provides incredible light power (the unit comes complete with a spare bulb). The beam can be focused by adjusting the lamp holder which includes a chromed reflector and plastic lens cover.

The construction incorporates 'O' ring rubber seals to ensure that the torch is splash proof and immersion proof for a few seconds. The all-weather mini torch costs £3.95.

SKY PHONE

Racal Avionics has announced the certification of its aeronautical satellite voice and data system called SATFONE.

SATFONE, is said to provide the air traveller with a quality of voice communications he or she is familiar with in the home or the office.

SATFONE is a single full duplex, digital voice/data channel of 21,000 bit/s capacity. Signals are relayed between the aircraft and the ground telecommunications network via the INMARSAT geostationary satellite constellation.

Racal has already received orders from SATFONE installations in a variety of aircraft types, including the Gulfstream III and IV, L-1011, A310-300, Boeing 707 and Boeing 747.

HDTV EQUIPMENT ORDERS

Orders for video delay lines and filters, specifically designed for HDTV applications, are flowing in for a Nuneaton-based manufacturer, BAL (UK) Ltd. The company specialises in video components and equipment for television studio applications and has taken some £25,000 worth of orders in the last two months from major companies in Germany, Japan and the USA.

The HDF Series video filters have 0.2dB frequencies from 22MHz to 30MHz, while the transition rates and group delay ripple specifications have been designed based upon the various proposed templates emanating from engineers developing advanced High Definition Television systems at research centres around the world.

BAL's business development director Derek Newport says: "We are delighted with the impact these new products are making in the market place. Some people may be under the impression that equipment for HDTV applications is still at prototype stage. Certainly, HDTV is in its infancy, but this upsurge in orders for filters and delay lines seems to be a clear indication that HDTV systems are now entering production, and confirms BAL's aim to become a major player in this field from the outset."

Further information, contact BAL (UK) Ltd, Tel: (0203) 375827.

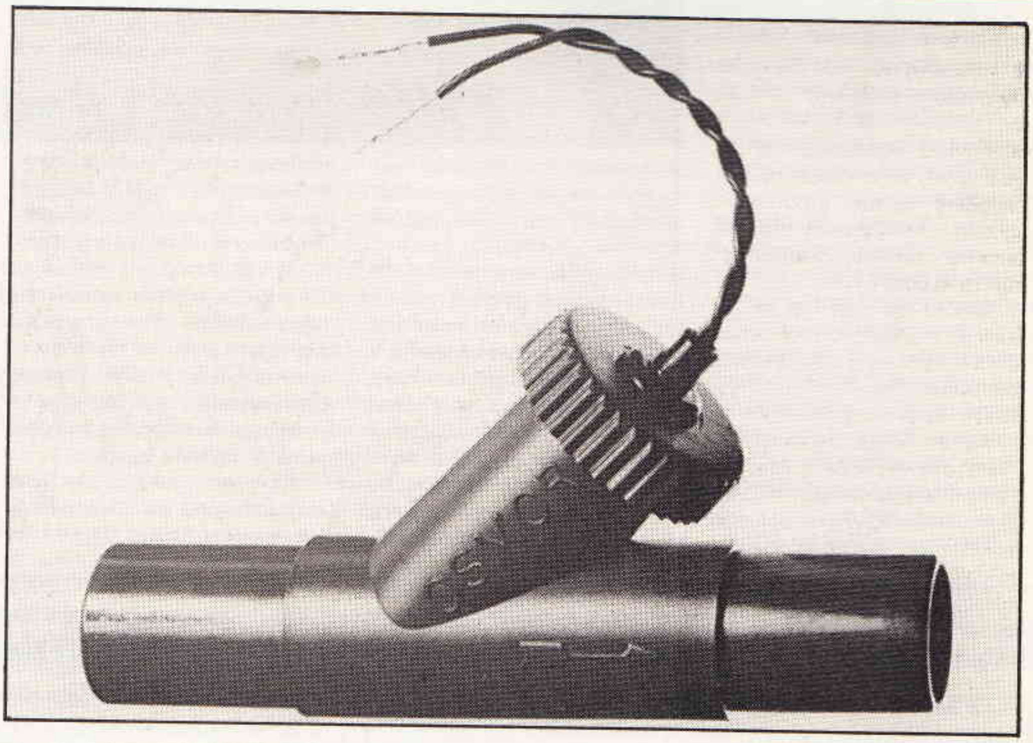
FLOWSWITCH

Osmor Technologies Ltd, have gained Water Research Centre approval for their two Flowswitches PG15 and PS22.

Recommended for use with push-fit couplings in cold water installations, they can be mounted vertically or horizontally, and can be supplied with normally open or normally closed contacts. Made in Kemetal, an acetal resin resistant to a wide range of chemicals, they are not only suitable for use in water systems, but many other applications as well; an interesting one currently being exploited is for use in an air extraction scheme for spray-booths in car workshops.

Priced at £10.75 for the PG15 (15mm fitting) and £11.25 for the PS22 (22mm fitting), there are generous discounts for quantity orders.

Contact: Osmor Technologies Ltd, Tel: 081-688 5148.



PROGRAMMABLE FUNCTION GENERATOR

Thurlby-Thandar have expanded their large range of function generators by launching an advanced programmable model the TG1304.

The TG1304 is based around an analogue voltage controlled main generator with a frequency range of 10mHz to 13MHz. Advanced microprocessor management of the generator and output circuitry has provided an extremely versatile instrument with a wealth of sophisticated features including crystal locked frequency stabilisation to 0.01% accuracy.

The TG1304 is priced at £1,295.00 in the UK. The company believes this places the new generator into a unique market position with a price similar to lower specification analogue controlled instruments and with features in advance of many programmable generators costing considerably more.

The main generator output of the TG1304 can produce sine, triangle and square waveforms of up to 20V pk-pk EMF from a 50R source impedance, as well as unipolar pulse waveforms. Symmetry and DC offset are fully variable.

A second independent generator, which operates at frequencies from 5 mHz to 50 kHz, can provide sine, triangle and square waveforms from a 600R auxiliary output. This generator can be used as a source for amplitude and frequency modulation of the main generator. The two generators can also be summed to produce two tone signals such as are used for telephone dialling.

Full sweep capabilities (internal or external, linear or logarithmic) are provided. Parameters may be set and displayed in a wide choice of units such as frequency, period, up-time plus down-time, volts pk-pk, dBm, etc. All major parameters may be entered directly from the keypad, or stepped up or down using auto-repeating keys or a continuously rotating knob.

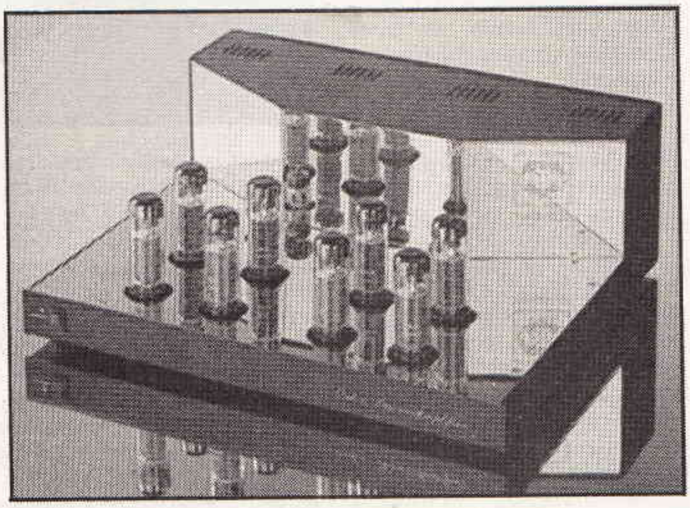
Waveform versatility is further enhanced by triggering and gating using external or internal signals. With "burst mode" control and fully variable start/stop phase these functions can be used to produce a very wide range of waveforms such as haversines, variable transition time pulses, sine-edged (band limited) pulses, square waves with adjustable overshoot, counted tone bursts and gated variable frequency tone bursts.

All functions of the TG1304 are fully programmable both from the keyboard and from the GPIB (IEEE-488) interface. A backlit 48-character alphanumeric display provides full status information and prompts for setting up the instrument. Non-volatile memory holds all of the current set-up information and enables the storing and recalling of up to 50 complete settings of the instrument.

The compact case has a small footprint for bench use and is half rack width 3U height for rack mounted use.

NEW AUDIO KITS

Velleman Kits, of Belgium, have introduced 19 new kits to their 1990/91 line up taking their total number of high quality kits to in excess of 100, including audio, automotive, lighting control, communication, security, computer control and industrial control kits.



Two of the new kits for the audio enthusiast and professional are a very high quality Digitally Controlled Pre-Amp and the Stereo Valve Amplifier.

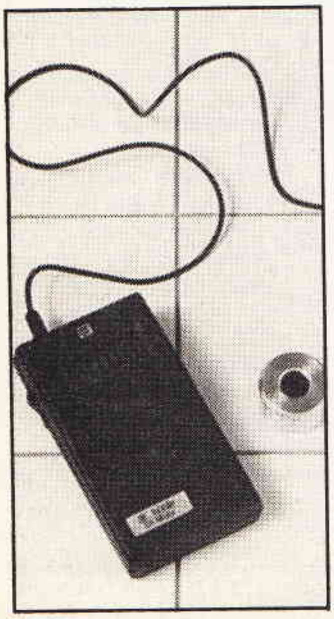
As its name suggests the Digitally Controlled Pre-Amplifier is controlled totally by digital electronics and contains no potentiometers. All functions such as volume, tone controls, balance and input selection can be operated through push buttons and LED displays. The advantage is that everything can be operated via a separate remote control. Also a switched power outlet has been provided, which allows you to switch the rest of your audio system on and off via the remote control. On top of all this ease of operation you can make use of a priority setting of your own programming, which can be invoked at all times and which becomes the default setting upon power up.

Most of us cannot afford a high power, high quality amplifier with valves. This kit changes that, so that now everybody can enjoy the sublime "valve sound". The sound of valves could not be surpassed up till now, neither by transistors of FET's. While developing the amplifier, special attention was given to the housing. Indeed, the valves form an integral part so that your eyes also have something to enjoy. All components, including valves and ultra-linear output transformers (toroidal core) are supplied with the kit.

Technical data . . .
Output Power — 2 × 200W MP, 2 × 95 WRMS in class AB, 2 × 15W in class A
Output impedence — 4 or 8R.
Harmonic Distortion — 0.8%
S/N ratio — 102dB (A weighted)

A colour catalogue covering the full range of kits contact — ESR Electronic Components, Tel (091) 251 4363.

UV-C METER



This new UV-C Meter allows direct, accurate measurement of absolute UV-C radiation intensities for the first time.

The sensor head contains a photo-cell filtered to produce maximum sensitivity in the wavelength region 200-280nm.

Applications include:
Monitoring the output of all types of UV lamps.
Calculation of the transmission factors of glass, plastics and liquids.
Measurement of direct and reflected light from UV lamp installations for determination of safe working practices according to the Health and Safety Executive.

The unit is available from Uvalight Technology Ltd, Tel: 021-643 2463/2472.

VIDEOCRYPT FOR SUB TV

Against worldwide competition Thomson Consumer Electronics has been selected by BBC Subcription Television Ltd to provide VideoCrypt access control technology for its encrypted subscription television service, scheduled for launch in September 1991.

The new service, named BBC Select, will be transmitted during the unused night-time hours of both BBC television networks. Initially, the service will offer a range of up to 15 'niche' television services for special interest groups. The programmes be divided into four broad subject categories:

Professional, Business and Training (doctors, laywers, teachers); Leisure (music, gold, sailing); Community (Irish and Asian); Education (languages, management and information technology).

The programmes will largely be produced by outside companies and the service financed by a combination of subscription income, advertising and sponsorship.

The VideoCrypt decoder, coupled with a News Datacom smart card, is said to provide secure encryption against piracy. Recognising that most subscribers are likely to record their selection for viewing later, a special feature of the decoder will be an automatic VCR switching capability.

The VideoCrypt decoders will be designed by Thomson Consumer Electronics and manufactured by its Ferguson Ltd subsidiary at Gosport Hants.

NEWSPAPERS ON COMPACT DISC

The Times and The Sunday Times are to be the first UK national newspapers to market the text of a full year's issues of both titles on a single compact disc.

The new disc, known as THOR, runs on a personal computer equipped with a compact disc player. Information can be located quickly with one or more subject words and will be of particular benefit to researchers, academics, journalists, lawyers, advertising agencies, librarians and the general public.

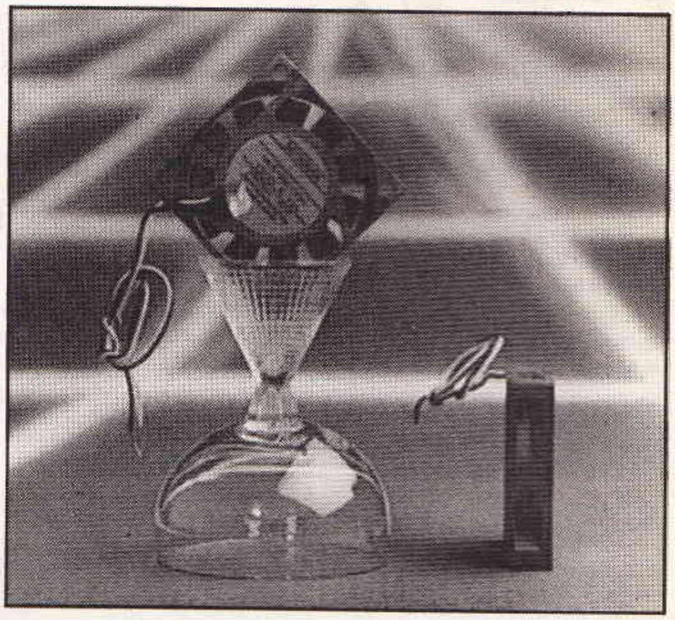
The first disc will be available in January 1991, and will hold The Times and The Sunday Times for the whole of 1990. Every three months after that, subscribers will automatically receive an update disc containing all issues of The Times and The Sunday Times for the calendar year to date. Also during 1991, material for the years 1985-1989 will become available as a comprehensive archive is built from The Times and Sunday Times.

The CD-ROM technology used by THOR provides a storage capability of the equivalent of 250,000 A4 pages of dense text, on a single, compact disc. Powerful search facilities within the THOR software, specially developed by The Open University, guide the user to specific stories and features, within either a full year or a given year date span, cross-referencing with other subjects when necessary.

Articles are arranged in familiar sections such as Home and Foreign News, Business, Sport, Obituaries and Letters. Users may search the entire database, or may focus on a single section. THOR displays the full text from features and articles on the computer screen and can then be either printed off on paper or transferred to a separate 'Cuttings File' on disc for later use.

THOR has been developed by The Times Network Systems Limited in association with Times Newspapers and The Open University.

A NEW FAN



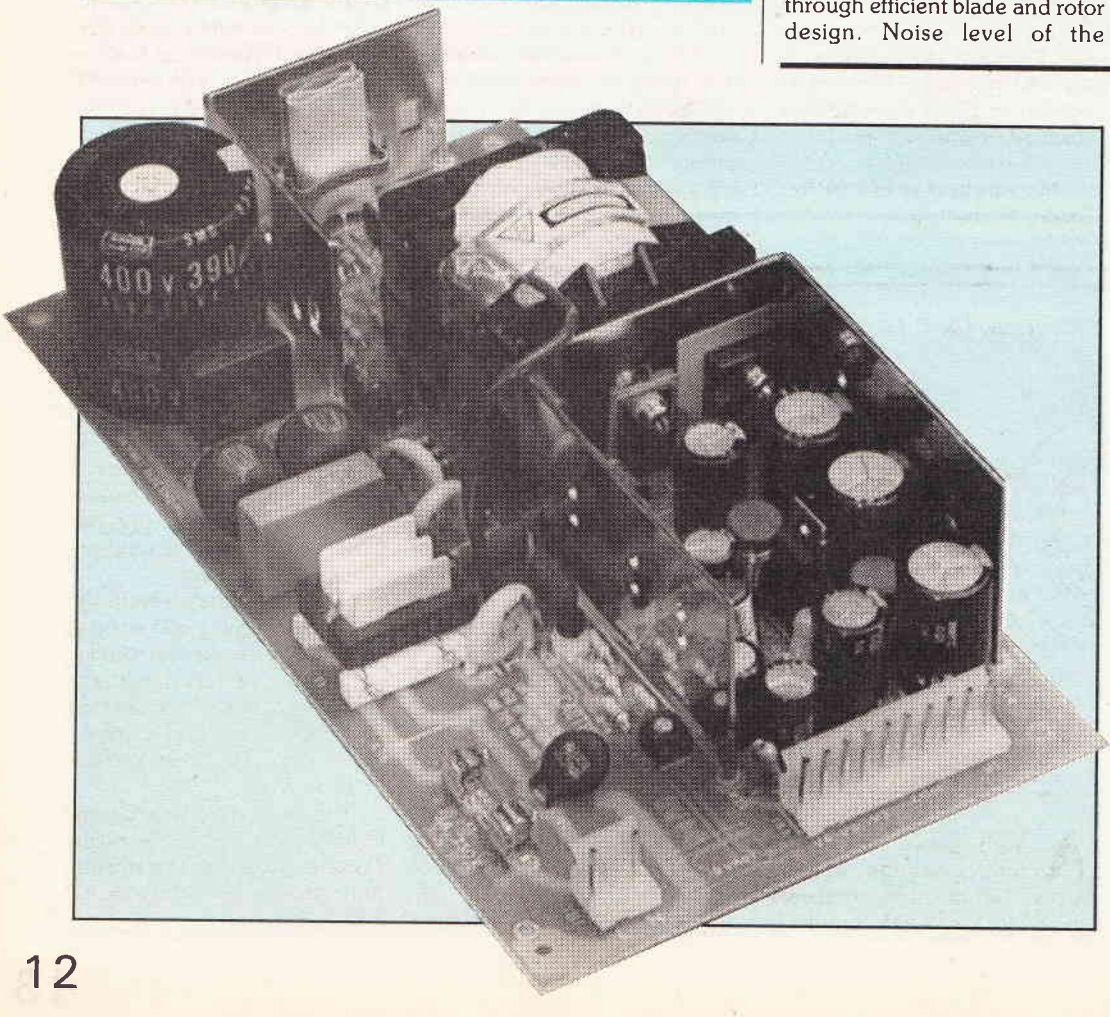
If space is a problem to fit a box fan, Mitsubishi Electric UK Ltd has launched an axial flow fan. The design measures 60mm square by 15mm thick and is said to be ideal in power supply and computer applications, or any piece of electronics equipment that needs cooling.

The sleeve bearing fan operates from 12V DC supplies and is said to achieve similar air performances to thicker models through efficient blade and rotor design. Noise level of the operating fan is a low 30dB(A), typical, and 33dB(A), maximum.

Sleeve bearing fans have in the past been accepted for applications despite having a shorter life compared to ball bearing designs but providing a clear cost advantage. Now Mitsubishi has improved sleeve designs to match the expected life of equivalent ball bearing designs.

Further information contact: Mitsubishi Electric UK Ltd, Tel: 0707 276100.

SWITCH MODE POWER



Skynet Electronic has launched a new range of 85W open frame, switched mode power supplies for portable computer systems, peripherals, robotics and instrumentation. With a wide universal input of 96 to 260V AC, over a frequency range of 47 to 440Hz, the SNP-318 series provides up to four outputs with a maximum of 85W continuous power over a 2.7kHz bandwidth.

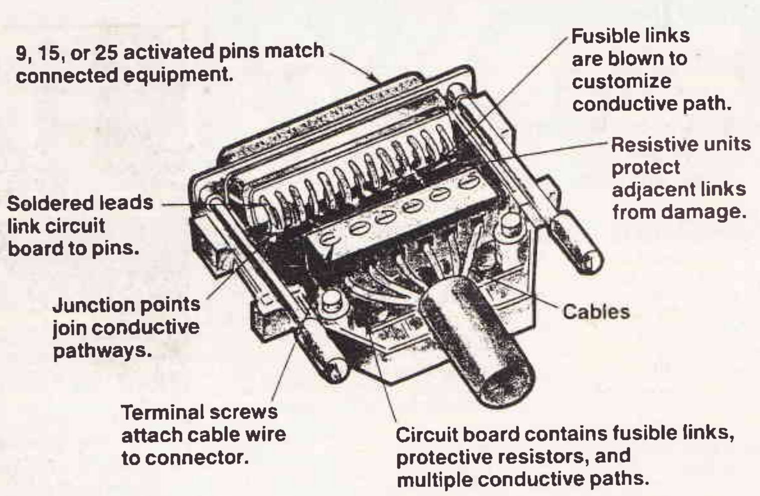
Pulse width modulation, PWM, and high speed MOSFET design, provide an efficiency of 80% or more, with low minimum load requirements. Input line filtering and thermal protection is provided.

Additional specifications include: a switching frequency of more than 30kHz, foldback overload protection at 150% of full load; and crowbar overvoltage trip points of 6.2V +0.4V or rated output plus 2V.

For more information contact Skynet Electronic Co Ltd, Tel: 0256-810 810.

ETI NEWS stateside

Special connector for cables



To couple serial communication cables through D-type connectors requires soldering pins to attach cable ends. A quicker approach uses a special connector with screw-on terminals. The connector attaches to a circuit board composed of resistors and fuses, which permits multiple current paths. Shorting out the appropriate fuses provides a path matching the pin count of the manufacturer's device.

Called the CableMate 'D' connector it supports 25, 15, and 9 pin connectors and is the same size as standard devices. It requires no soldering and protects from electrical noise. Possible equipment combinations include Modicon, Allen-Bradley, Texas Instruments, General Electric, Nematron, and IBM PC/AT.

Manufacturer is PC Industries Inc., Knoxville, Tennessee.

Third wire eliminated

A new inductive proximity switch can provide either positive or negative switching, and is either normally open or closed. A new circuit within a universal DC proximity sensor provides three-wire performance using only two wires. The circuit allows the proximity switch to maintain a low voltage drop while on and low leakage current when off.

Call the Quadronorm proximity switch, it simplifies proximity sensor wiring and reduces parts inventory by 75 per cent. Switches are available in four threaded, tubular configurations with 8, 12, 18, and 30 mm diameters. Non-shielded versions have plastic bodies and a pre-wired cable. Sensing ranges are up to 10 mm for shielded models and up to 15 mm for the non-shielded design.

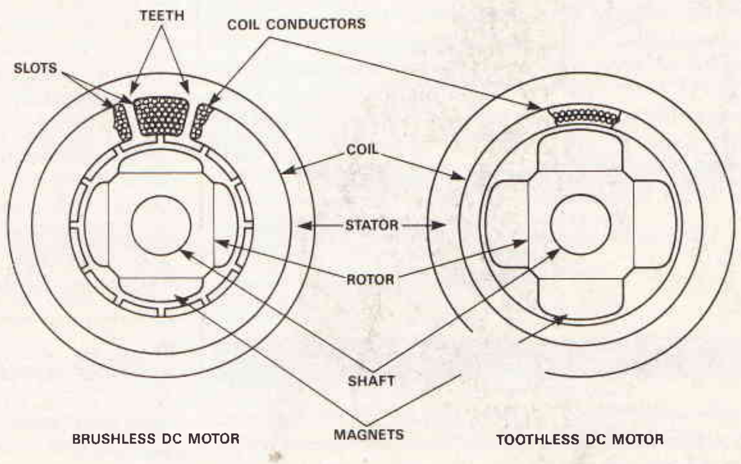
Manufacturer is Efector Inc., Exton, Pennsylvania.

Stingrays detect electric fields

An isolation amplifier that gives out a low-level non–distorted signal is allowing research workers to study the ability of stingrays to detect electric fields. It has been used at the Washington University School of Medicine in a machine that simulates the electric fields produced by female stingrays. In the ray, an electrochemical voltage exists between the mucus membranes in its mouth and surface membranes around its gills. The distribution of the gill membranes produces a complex multi-pole field that varies in intensity as the ray opens and closes its mouth.

In operation, the isolation amplifier called AD210 eliminates signal distortion by galvanically isolating the signal from the power supply. It also interrupts ground loops and leakage paths and rejects common-mode voltage signals. The device features 2500V isolation, ±25 ppm/°C gain drift, and 120dB common-mode rejection.

Manufacturer of the AD210 is Analog Devices of Norwood, Massachusetts.



Toothless brushless dc motor

A high-speed laboratory micro-centrifuge uses a special DC motor to accelerate smoothly to 13300 rpm in 8 seconds and to stop in 10 seconds without exceeding noise levels of 60dB. In a conventional DC motor, the rotor seeks preferred positions of minimum reluctance across from the teeth in the armature. This produces slot ripple in the output torque and makes precise positioning and speed control difficult. In addition, the effect is worse in brushless DC motors because of flux leakage which opposes current reversal in the windings during commutation.

Removing armature teeth also eliminates cogging and reduces leakage flux. A patented winding process and rare-earth magnets have made it possible to make this a toothless, brushless DC motor. Motor sizes range from subfractional to 2 hp.

The motor is made by Electric Indicator Co. Inc. of Norwalk, Connecticut, and used in a centrifuge made by International Equipment Co.

READ\WRITE

ETI LETTERS

Last Word on Audioparts

I am delighted to see the interest which my letter to your September issue has raised.

John Linsley Hood is unhappy that my letter implied that his amplifier was not as good as it could have or should have been. Any amplifier can be improved by better parts, but whether it should be improved obviously depends on the effect of improvements on the overall cost. If the cost is placed to high, many people will not build it. Getting the balance right between components and circuit design is the skill which determines whether the amplifier will meet the quality the customer aspires to at a price he can afford. There are many people who want to improve on an already good design (who would want to start from a bad design?) and are prepared to spend extra on achieving that goal. This is why the Virtuoso preamp and power amp were produced in both standard and upgraded versions.

I am complemented by his remark that the 'sound quality' of any audio design is the outcome of the skill of ... the individual designer. I have taken my SONIC LINK DM20 amplifier to many of the best specialist hi-fi shops to persuade them to sell it, yet it is still very rarely that I have heard any comparably priced amplifier with 'sound quality' equal to my own designs. I would not agree that any one designers products should show any family resemblence. I have recently completed the design of an upgraded version of the DM20 amplifier to sell at twice the retail price of the standard model. Wow! Does this sound different! If a designer's products all sound the same, then I would suggest that the designer is not adventurous or resourceful enough to seek out the improvements in sound quality that are there to be gained; unless this is done for purely commercial reasons to keep existing customers happy.

The only rational way that sound quality can be measured is by a listening experience. Despite the many different types of music that people enjoy (or not), the different aspect of performance that they judge important, and other factors there is a very broad consensus of agreement on matters of sound quality. If this were not the case, selling hi-fi equipment would be impossible. Mr Linsley Hood's suggestions that 'one would need to do a series of fairly careful instrumental measurements to make sure that it was not worsened by the change' after making a component change really made me laugh. Imagine a situation at a restaurant where someone is asked by the waiter if he enjoyed the food and gets out a selection of test tubes, places samples of the food therin, looks at the colour of his litmus paper and decides from that whether he enjoyed the food. Sounds like an idea for TV comedy sketches to me.

Finally, I would challenge any reader of ETI who is interested in achieving high quality sound to try out high quality components and cables in their equipment and judge the results for themselves. Changing components can be as rewarding as building from scratch, and the joy gained from hearing a greater insight into a musical performance is one which is well worth the effort.

Graham Nalty
Audiokits, Derby.

Shifty Design

I have built the frequency shifter circuit from Blueprint and have got it working. One of the problems with this design is the 5Hz component in the output. You show a band-pass filter in the input. This will not be able to suppress the 5Hz (sine wave type) frequency present in the output.

I would recommend a band-pass filter at the output of the unit. The adjustments of the pre-sets are not difficult to make. An osilloscope helps with this.

I have drawn out stripboard layouts for the circuits and have made a prototype. Would you be interested in a full project write-up?

Peter Kunzler,
Surbiton, Surrey

We certainly are interested in the project. Judging from the feedback we have had from readers on the subject of howlround, it will be most welcome. As most ETI readers will know, all projects are constructed and presented on printed circuit board and not stripboard.

Oscilloscope Safety

Whilst reading Simon Russell's article 'Repairing Oscilloscopes' (ETI Dec.), I could hardly fail to notice his continual attempts to impress upon the reader the dangers of working on high tension circuitry. This is of course sound advice, considering even a modest current can dispatch the hardiest of individuals if 'taken the wrong way'. I was therefore horrified to see that half way into his article, Mr Russell recommends that the vertical deflection control may be checked 'with a finger on the Y input'. Even in the most trustworthy of instruments, there is always the danger that a chance fault or component breakdown may render the inputs at line voltage and this danger can only be increased in the case of antiquated and clearly faulty equipment. As a first year medical student who is often involved in physiological experiments, may I strongly recommend to all readers that nobody should connect themselves or any other living material to the input of any mains driven equipment, unless this connection is made through an optical isolation amplifier.

G. Bullingham,
Harleston, Norfolk.

Natural Sounds

It must be fifteen years now I have been reading your magazine. The articles and projects on audio subjects have been excellent. However, they have usually been biased towards the indoor use of equipment.

Outdoor use is becoming more common, particularly in the recording of wildlife sounds, from insects to elephants. An interest by your magazine in, microphones, analogue, and R-Dat recoders, windshields, reflectors and power packs would be greatly appreciated.

Peter Maskens,
Hornchurch, Essex.

Thank you for your comments. We will see what we can do for you. It would be nice for somebody experienced in outside broadcast and recording to offer handy tips on the subject. The offer is there.—Ed.

Toko Coils

Some people have had difficulty in getting the Toko Coils for the four-track cassette recorder project. The author has a supply — more on this next month.

THE *ORIGINAL* SURPLUS WONDERLAND!

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!

Zenith ZVM-1240-EA brand new & boxed 12" amber flat screen with optional swivel and tilt base. Sunflex filter with dark tint. Standard TTL PC compatible. 18 mhz bandwidth. Very attractive "state of the art" tapered grey case. Standard 9 pin D plug (supplied) on 1 metre cord and mains cord terminated with IEC connector. 240 volts complete with operations manual. Free swivel/tilt base. An absolute gift at: £59 (D) **10/£500** (G).

Wang green screen 12" chassis monitor with composite video input. Adjustable for tilt. Requires 12 vdc. Brand new and boxed in perfect condition. **Only £39 each or 2 for £75** (F)

Motorola M1000-100 5" black & white compact chassis measuring only 11.6H x 12W x 22D. Ideal for CCTV or computer applications. Accepts standard composite or individual H & V syncs. Needs 12vdc at only 0.8a. Some units may have minor screen blemishes. Fully tested with 30 day guarantee and full data. **£29.00(C)**

Fully cased as above in attractive moulded desk standing swivel. Dim 12 x 14.5 x 26cm. **£39.00(C)**

JVC 751 ultra compact chassis monitor for 12vdc 0.7a. Dim 11 x 14 x 18cm. Simple DIY data included to convert to composite video input. Full data. **BRAND NEW** £65.00(B)

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)

HI-DEFINITION COLOUR MONITORS

Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubishi 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)

SCOOP! 14" Colour Multisync/Multifunction

Never before has such a deal been struck to bring you this ***quality*** Japanese manufactured ***multisync, multifunction*** professional grade monitor at an unheard of low price!! The **Electrohome ECM1311** with its host of inputs will connect to most computer systems including: IBM PC/XT/AT/PS2 (CGA, EGA, PGA, VGA modes) Atari, Archimedes (both modes), Commodore, BBC and many more. Many other features include: RGB analog & TTL inputs, separate horizontal, vertical, composite and sync on green inputs; auto 15 to 36khz operation; 0.31mm tube dot pitch; tinted non glare etched screen & 30 mhz bandwidth makes this item an absolute snip!! ***Current makers list price over £900 !*** Each supplied with data, fully tested in used good condition with full 90 day RTB guarantee. Quantity discounts available. Will also function as quality TV with our RGB Telebox.

Only £175 (E)

V22 1200 BAUD MODEMS

We got a tremendous buy on further stocks of this popular **Master Systems 2/12** microprocessor controlled V22 full duplex 1200 baud modem - we can now bring them to you at ***half last advertised price!*** 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)**

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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)

MAINS SUPPRESSORS & FILTERS

Roxburgh SDC 021 2 amp mains RFI filter. Has an extra wide frequency range of 150 khz to 30 mhz. Can type, solder lug connection. Quality manufactured to BS 613 standards. Dims 1-1/2"D x 1-3/4"H.......... **£3.95 or 3 for £10** (A) **10 for £28** (B)

Roxburgh SDA 013/25. Similar to above rated at 1-1/2 amps. Dims 1-1/2"D x 1-3/4"H.... **£2.95 or 3 for £8.50** (A) **10 for £25**(B)

Suppression Devices SD5 A10. Extra compact general purpose suppressor. Plastic moulded case with single bolt fixing and snap connectors. Rated at 230 vac 5 amps. Dims 1-3/4"L x 1-1/8"W x 5/8"H.......... **£3.95 or 3 for £10** (A) **10 for £28** (B)

Belling-Lee type L2127 3 amp mains RFI filters. Has a built in mains cable (English coding), and a three pin miniature non-reversible socket and a mating plug, to go to the equipment. Ideal for those who are bugged by RF interference. Very compact. Dims 3-1/8" x 2.5" x 1.5".................. **£3.95 each or 3 for £10** (A)

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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)

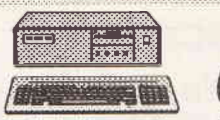
NICKEL CADMIUM

Quality 12v 4ah cell pack. Originally made for the Technicololor video company. Contains 10 GE top quality D nicad cells in a smart robust case with a DC output connector. Ideal for portable equipment. Brand new. £19.95(B)

Ex-equipment NICAD cells by GE. Removed from equipment and in good, used condition: D size 4ah **4 for £5**(B)
F size 7ah **6 for £8**(B)

SPECIAL INTEREST

Tektronix 1751 Waveform/Vector monitor	£2750
Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
DEC VAX11/750 inc. 2 Meg Ram DZ and full documentation, in brand new condition	£3900
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
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**	£ 790
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



Fantastic PC-XT Col/Mono Compat !

Fantastic deal for an entry machine or cheap enough to buy as a backup. Brand new and boxed colour (CGA) or mono (MGA) **switchable** PC-XT compatible, complete with MS-DOS 3.3 and GW Basic & manuals. 8088-2 16 bit CPU with socket for 8087 co-processor. 512K of RAM easily expandable on mother board to 640K. Clock with battery backup. Serial & parallel ports & one 5.25" DS 360K floppy disk. Two half height bays on the front plus one inside. Disk controller, power lead and ribbon cable are ready installed waiting for a second floppy. Option for an internal 20mb hard drive ready installed, complete with installed drive card and ready to go. CGA/MGA card, switchable at rear. Small footprint, dims. only 13.5"W x 15"D x 4.25"H.

Choose your own configuration !

XT1 System	Computer & keyboard	£269 + (E)
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XT5 System	XT1 + 14" multisync VGA mon.add	£150* + (E)

*Prices applicable when ordered with PC system.
See MONITOR section for full description of the monitors.

POWER SUPPLIES

All PSUs 220-240vac input and are BRAND NEW unless stated. Many types ranging from 3v to 10kv always in stock.

Power One SPL130. 130 watts. Link selectable for 12v (4A) or 24 v (2A). 5v @ 20A. ± 12v @ 1.5A. Switch mode. **£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". **£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 **£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)**

Farnell G24/5S. As above but 24v @ 5a. **£65.00(C)**

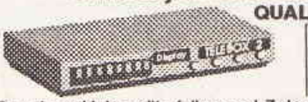
COOLING FANS

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)
4 inch	AC 110/240v 1½" thick.	£10.95(B)
4 inch	AC 1½" thick	£ 9.95(B)
10 inch	AC round. 3½ thick. Rotron 110v	£10.95(B)
10 inch	As above but 230 volts	£24.95(B)
62 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..........£29.95(B)
Telebox STL as ST but with integral speaker.............£34.95(B)
Telebox RGB for analogue RGB monitors..................£65.95(B)

RGB Telebox also suitable for IBM multisyinc 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 cpl 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!

159-4 Serial up to 9.5" paper, fan fold tractor..............**£ 99.00**(E)
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152-2 parallel up to 14.5" paper, tractor or s/sheet.....**£149.00**(E)

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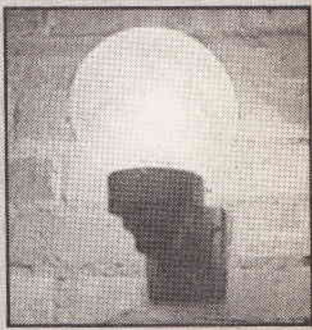


The first in a series of articles examining the basics of electricity by Paul Coxwell.

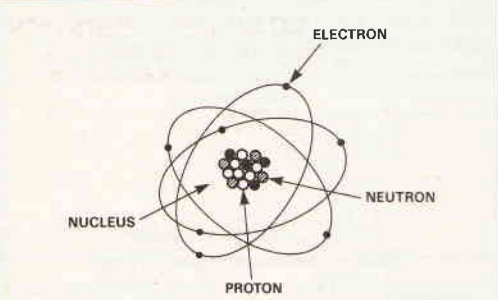


Fig. 1 The structure of the atom.

The name 'electricity' is derived from the Greek word for amber, which is 'elektron'. The Greeks discovered that by rubbing a piece of amber it could be made to attract small objects — an experiment which has been repeated countless times since.

The explanation lies in the way in which matter is constructed. All materials are made of atoms; these atoms consist of a nucleus around which a number of electrons orbit (Figure 1). Each electron carries a negative electric charge. The nucleus contains one or more protons, each of which carries a positive electric charge. There may also be some neutrons in the nucleus, but as they are electrically neutral they will play no further part in our discussion.

In a normal atom, the number of electrons orbiting the nucleus is equal to the number of protons within that nucleus. The sum of the positive charges is therefore equal to the sum of the negative charges and the atom is electrically balanced, and carries no overall charge. If two different materials are rubbed together, the friction generates heat, which can cause the atoms in one material to give up electrons to the atoms in the other material. When an atom loses one or more electrons, it becomes positively charged, because there are more protons than electrons. Similarly, when an atom gains electrons, it becomes negatively charged, since there are more electrons than protons. A fundamental principle is that a surplus of electrons represents a negative charge, and a deficiency of electrons represents a positive charge.

The action of rubbing two dissimilar materials together therefore leaves one material with a positive charge and the other with a negative charge. Which material gives up electrons depends upon the types of material involved.

The second important principle is that like charges repel one another and unlike charges attract. If two bodies are charged and suspended in close proximity, this effect can be observed (Figure 2). If one body carries a positive charge and the other a negative charge, they will be attracted to each other. If both bodies carry a charge of the same polarity, either positive or negative, they will repel each other. The presence of positive and negative charges on a material is called static electricity.

When two bodies carrying opposite charges are brought into contact, electrons will move from the negatively charged material to the positively charged material in an attempt to balance out the difference in charge (Figure 3). This movement of electrons is a flow of electric current. If the two materials started with equal but opposite charges, then they will both be left electrically neutral. It is not necessary for one body to be positive and the other negative, however — all that is necessary is for there to be a difference in charge between the two objects. If the two objects started with different negative charges, they would finish with equal negative charges, electrons flowing from the more negative material to the less negative material until the charges are balanced.

Conductors And Insulators

Most materials can be loosely categorized as a conductor or an insulator. Within each atom of a material, there exists a mutual attraction between the positively charged nucleus and the negatively charged electrons orbiting around it. The electrons in different materials orbit at varying distances from the nucleus, and the further away an electron is from the nucleus, the less the force of attraction. Electrons in the outer orbits of an atom are therefore attracted much less than those in inner orbits.

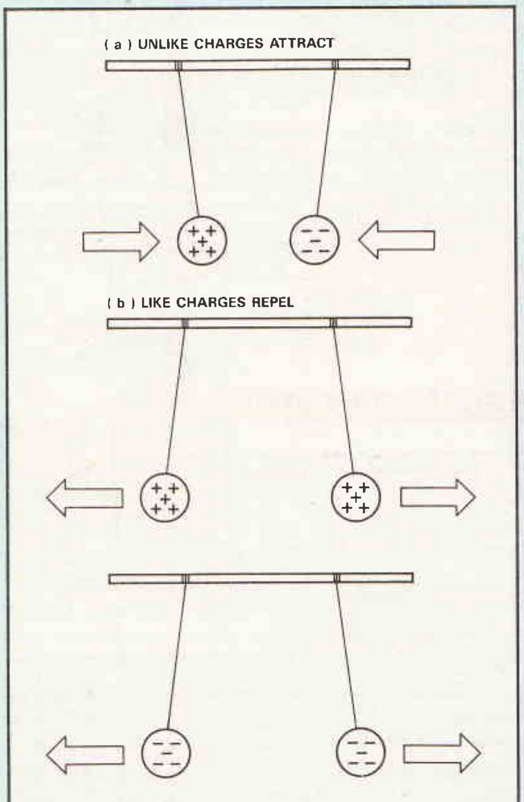
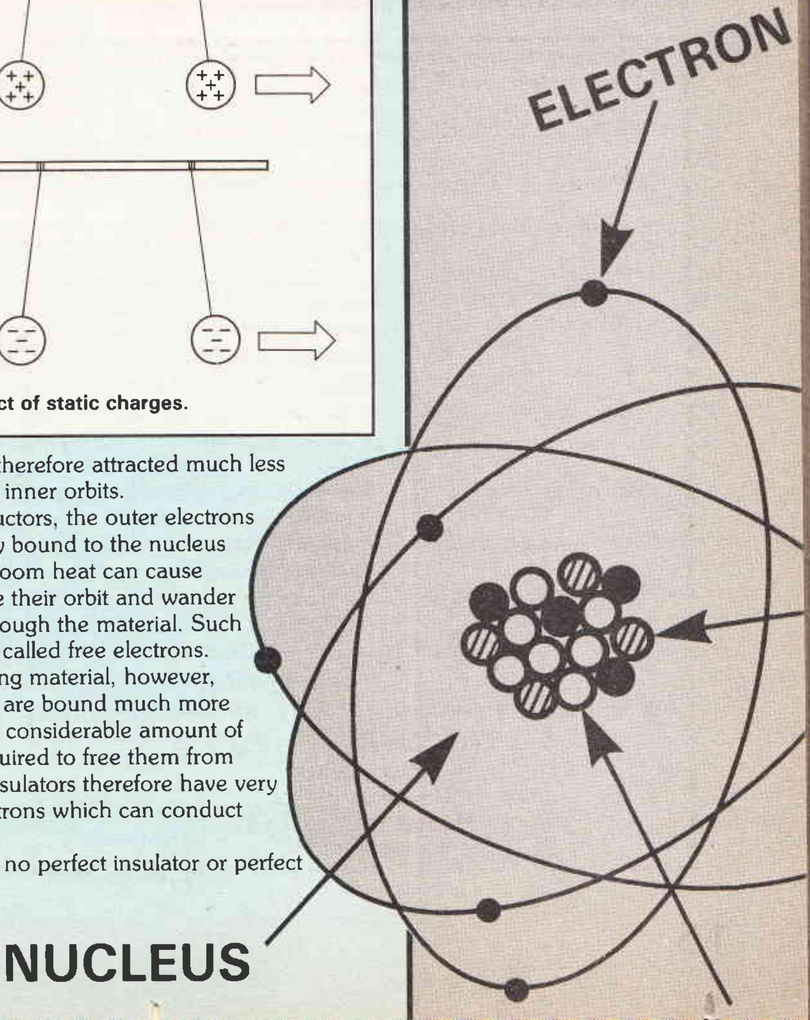


Fig. 2 Effect of static charges.

In conductors, the outer electrons are so loosely bound to the nucleus that normal room heat can cause them to leave their orbit and wander randomly through the material. Such electrons are called free electrons. In an insulating material, however, the electrons are bound much more tightly, and a considerable amount of energy is required to free them from their orbit. Insulators therefore have very few free electrons which can conduct electricity.

There is no perfect insulator or perfect



conductor. The more tightly bound a material's electrons are, the more energy, or charge, is required to cause a current to flow. Good conductors include silver, copper, aluminium, zinc, iron and all other metals. Some good insulators are glass, dry air, rubber, and ceramics. Cables may be made by using copper conductors surrounded by rubber insulation — the rubber confines the electricity to the copper wires.

Maintaining A Flow Of Current

The momentary flow of current caused by two charged objects discharging cannot be put to much practical use. To cause a current to flow continuously through a wire it is necessary to maintain a difference in charge, or potential difference, between its two ends.

In a regular cell, chemical action is used to produce this potential difference (Figure 4). The chemicals inside the cell take electrons from the positive electrode and deposit them on the negative electrode. If a wire is connected across the two poles of the cell, electrons flow from the negative pole, through the wire, and into the positive pole.

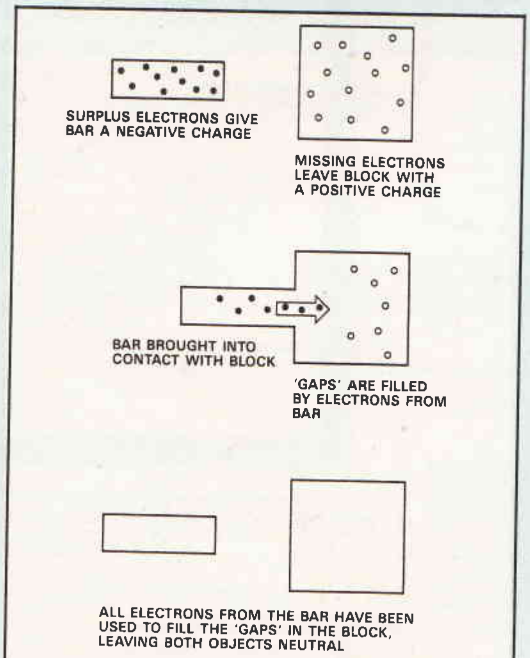


Fig. 3 Static discharge.

The force supplied by the chemicals in moving electrons inside the cell to generate a potential difference is called electro-motive force, or EMF. Both EMF and potential difference are measured in units called Volts, abbreviated to V in common notation. (The symbol E is often used for EMF). The higher the voltage, the greater is the force generating a potential difference. A voltage is an EMF when no current flows and a potential difference when it is.

The actual quantity of an electric charge is measured in coulombs, one coulomb representing the charge of billions of electrons. It is the rate at which charge flows that is more commonly referred to. This rate of flow is measured in Amperes (abbreviated A, and often colloquially called amps). A current of one ampere represents one Coulomb of electrons passing a given point on a conductor in one second. When written in calculations, current flow is symbolized by I (the symbol C is already used for other purposes).

There are two fundamental requirements for a current to flow: there must be a source of EMF and there must be a complete loop, or circuit, for the current to flow. An electric switch simply breaks the conductor to prevent current flowing through the whole loop.

Resistance

There is a relationship between voltage and current, for if a greater EMF is applied to the ends of a piece of wire, a greater current will flow from the potential difference now placed across it. The factor which determines how much current will flow for a given potential difference is called resistance.

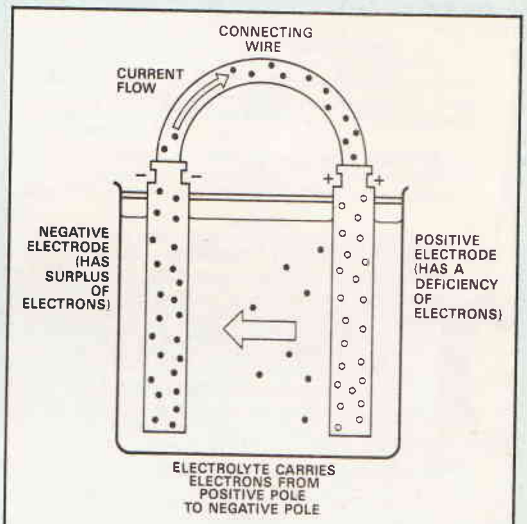


Fig. 4 Chemical action in a cell.

The fewer free electrons a material possesses, the more it resists the flow of an electric current. Good conductors, like copper, therefore have a low resistance and good insulators, like rubber, have a very high resistance. The length of the material directly affects its resistance: if the length of a piece of wire is halved, so is its resistance. The cross-sectional area has an inverse effect upon resistance: increasing the area decreases the resistance. Temperature also has an effect, although not usually as great as the other factors. Most metals show an increase in resistance when heated, but few materials will decrease resistance as temperature increases up to a point.

$$\text{CURRENT} = \frac{\text{VOLTAGE}}{\text{RESISTANCE}} \qquad \text{RESISTANCE} = \frac{\text{VOLTAGE}}{\text{CURRENT}}$$

$$\text{VOLTAGE} = \text{CURRENT} \times \text{RESISTANCE}$$

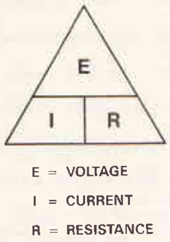
Example:
If supplied e.m.f. is 12V and resistance is 6Ω, then

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} = \frac{12\text{V}}{6\Omega} \; \underline{\underline{2\text{A}}}$$

Fig. 5 Relationship between voltage, current and resistance.

The symbol used to represent resistance is R and the unit of measurement is the Ohm, written as the Greek letter omega (Ω). For a given value of voltage, as resistance is increased, the current decreases. This is because the potential difference has to work harder against the increased resistance.

There is a definite link between voltage, current, and resistance. Current flowing in a circuit is directly proportional to the applied voltage and inversely proportional to the resistance of the circuit. The units of measurement are such that a current of 1A will flow through a circuit with a resistance of 1Ω (now abbreviated to 1R when dealing with electronic circuits) when a potential difference of 1V is applied. This relationship (shown mathematically in Figure 5) is known as Ohm's Law. It will be seen that the



$E = I \times R$

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

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

Fig. 6 The Ohms Law Triangle.

SYMBOL	MEANING	MULTIPLICATION
M	MEGA	1,000,000
k	KILO	1,000
m	MILLI	0.001
u	MICRO	0.000001
n	NANO	0.000000001
p	PICO	0.000000000001

EXAMPLES:
1,000V = 1kV
1,000kV = 1MV
1V = 1,000mV
1mV = 1,000uV
0.5mA = 500uA

Fig. 7 Prefixes used for electrical measurements.

equation may be written three ways, allowing any one quantity to be calculated if the other two are known.

Ohm's Law is one of the most important electrical laws to memorize and understand, for it is used extensively. The equation is often illustrated in the form of a triangle (Figure 6). By covering the unknown value, the two remaining symbols show the formula needed to calculate it. The three equations are shown in the diagram.

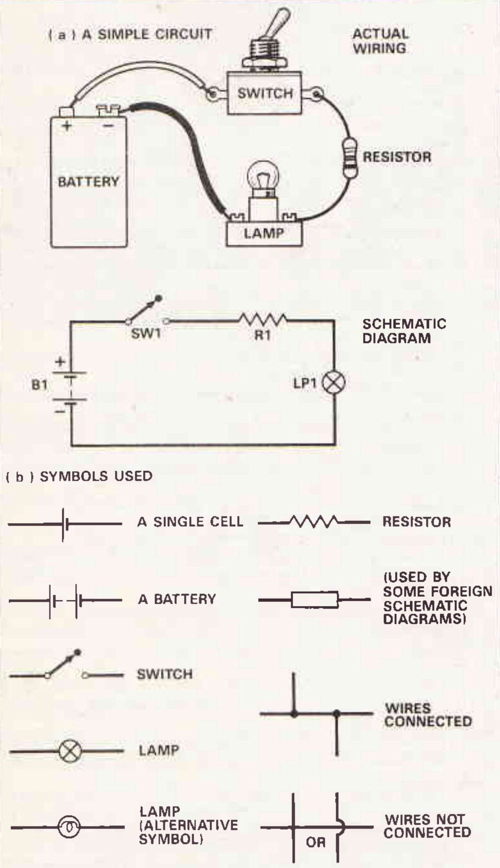


Fig. 9 Schematic diagrams.

Electrical Measurements

It is now a good time to look at the units of measurement used in a little more detail.

When dealing with electronic circuits, it is very often not convenient to use whole units of measurement (amperes, volts, and ohms), for the values may be many thousands or thousandths of the whole unit. Standard prefixes are used to indicate such small or large values (Figure 7).

The prefixes shown may be applied to any unit, although some combinations are hardly ever used (voltages are seldom measured in megavolts and resistances are seldom measured in micro-ohms, for example). It will be seen that from one prefix to the next there is usually a difference of 1,000. A voltage of 1kV is equal to 1,000V, and a current of 1mA is equal to 1,000μA, for instance. There are other prefixes to represent even larger and smaller numbers, but the table shows the most common ones. The ability to convert between units of measurement is a very valuable asset, and a mathematical mind is useful when dealing with many electrical calculations.

Using the Ohm's Law formula, a common trick to use is substituting current and resistance values. The equation expects voltage to be measured in volts, current to be measured in amperes (so that a current of 25mA should be expressed as 0.025A), and so on. It quite often happens that one is dealing with values of current in the milliampere range and values of resistance in the kilo-ohm range. By simple mathematics, these values can be used together (as proven in Figure 8). Similarly, microamperes and megohms can be used together, because each represents a multiplication factor of 1,000,000. Great care must be taken however, when using this technique.

Schematic Diagrams

The schematic, or circuit, diagram is used as a graphical representation of a circuit. Standard symbols are employed to show each type of component, and parts are generally numbered for reference in any accompanying text (see Figure 9).

The schematic does not necessarily show the exact layout of a circuit; it is only intended to show how the parts are connected together (an example of how the actual layout may differ is shown in Figure 10).

ADJUSTMENT OF VALUES IN CALCULATIONS

$E = I \times R$

If $I = 50mA$ and $R = 2k\Omega$, then

$E = I \times R = 0.05A \times 2{,}000\Omega = \underline{100V}$

By using mA and kΩ

$E = I \times R = 50mA \times 2k\Omega = \underline{100V}$

By using uA and MΩ

$E = I \times R = 50{,}000uA \times 0.002M\Omega = \underline{100V}$

Fig. 8 Adjustment of values in calculations.

It is essential to be able to read a schematic diagram to do any sort of electrical or electronic work, and the symbols used will be introduced in this series as each type of part is encountered. One very important point to note is the way in which junctions and crossings are shown. It is not possible to draw anything but the simplest circuit without having to cross a line over another. Most printed diagrams show a small dot where a wire is connected to another, and a four-way joint is usually drawn staggered to avoid confusion. Notice the two different ways of showing crossing wires.

Note that the symbol for resistance is used to indicate a component called a resistor, a fixed amount of resistance inserted intentionally into the circuit. Although all wires have a certain amount of resistance, it is usually so low as to be of no consequence.

Next month we examine the link between electricity and magnetism.

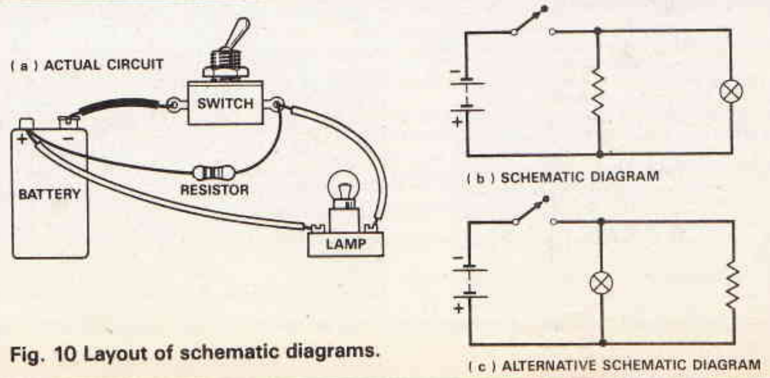


Fig. 10 Layout of schematic diagrams.

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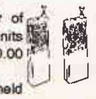

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ULTRASONIC WIRELESS ALARM SYSTEM. Two units, one a sensor which plugs into a 13A socket in the area you wish to protect. The other, a central alarm unit plugs into any other socket elsewere in the building. When the sensor is triggered (by body movement etc) the alarm sounds. Adjustable sensitivity. Price per pair £20.00 ref 20P34. Additional sensors (max 5 per alarm unit) £11.00 ref 11P6.
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PROJECT

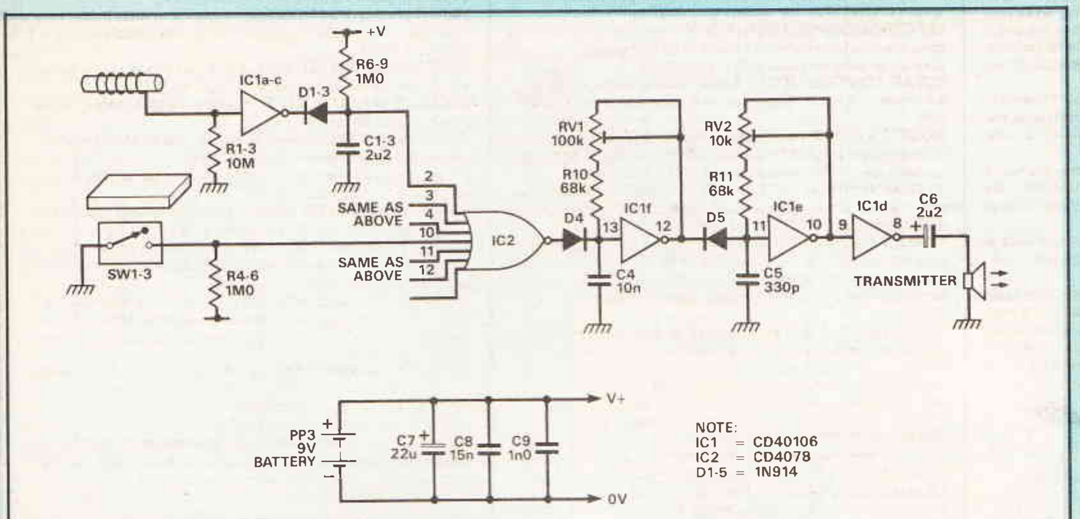


Fig.1 Circuit diagram of Transmitter

Edward Barrow shows you how to construct this simple but effective alarm.

ANTI-THEFT ALARM

Before you skip over this project summing it up hastily as just another alarm project just lend me your ears for the length of the introduction. This system differs from other mainstream varieties by two virtues. Firstly the sensors detect the movement of specific treasured pieces of equipment to another house (ie burglary). The sensors are small and unobtrusive. Secondly there is no physical link between these sensors and the actual bit that makes all the noise. So the law breaker cannot turn off the alarm by putting his foot through the sensor or transmitting circuit after the alarm is triggered. Also the siren can be placed well out of harms way at another end of the room thus preventing your alarm unit meeting a similar fate with the other foot of the intruder.

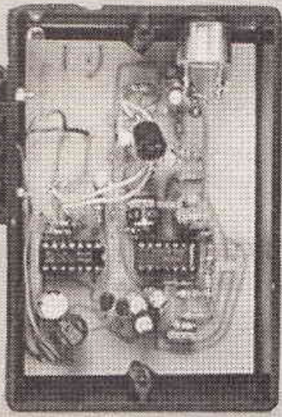
Even the transmitting device is small in size and so can be powered from a single PP3 battery. Also because of the detachable nature of the sensor the transmitter can be effectively hidden out of view. Even if the burglar finds the transmitter he will usually take one of two actions besides resorting to physical violence. Firstly he might cut the sensor wires, this action would trigger the alarm. Or secondly he might look to disable the transmitter by turning off the power which needs lots of time as there is no power switch. Two types of sensors are catered for within a single transmitter board. The first detects if a particular piece of equipment unplugged from the mains or if the power cord is cut, this is particularly good for midi hi-fis. The second detects if a particular piece of equipment is physically moved but it is not actually physically in contact with it. This is more useful for TVs and videos.

Transmitter theory

In this section it is best to treat each of the sensors separately and also the transmitter and receiver sections respectively. In trying to follow the circuit's operation it is best to glance at the schematic diagram shown in Figure 3. The first of the sensors uses the principal that a wire carrying a mains supply will act as an aerial and so transmit a certain amount of 50Hz signal. To pick this signal up a coil made of a series of turns of a fine copper wire wound around the mains lead in question is sufficient. The returned signal is the familiar 50Hz mains hum that audio buffs spend hours trying to minimise, here it is sufficient to drive a CMOS gate. The output of this gate will now be a 50Hz square wave. If the mains voltage is switched off in the mains lead, then this signal received by the gate will disappear and so give us warning of any tampering.

The second sensor is quite simple in concept and relies on a magnet-reedswitch combination to sense the displacement of your precious video. A small magnet, placed on the bottom of your video provides the required field to close a pair of reed contacts mounted inconspicuously close by. If an intruder decides to forcefully evict your video then the partnership described above breaks down and the change in state of the reed switch relays the information to the transmitter circuit.

These sensors are linked to the main alarm by two ultrasonic transducers. These are analogous to a speaker and a microphone but they operate outside the audible part of the spectrum, around about 40kHz. To generate signals in this circuit we used



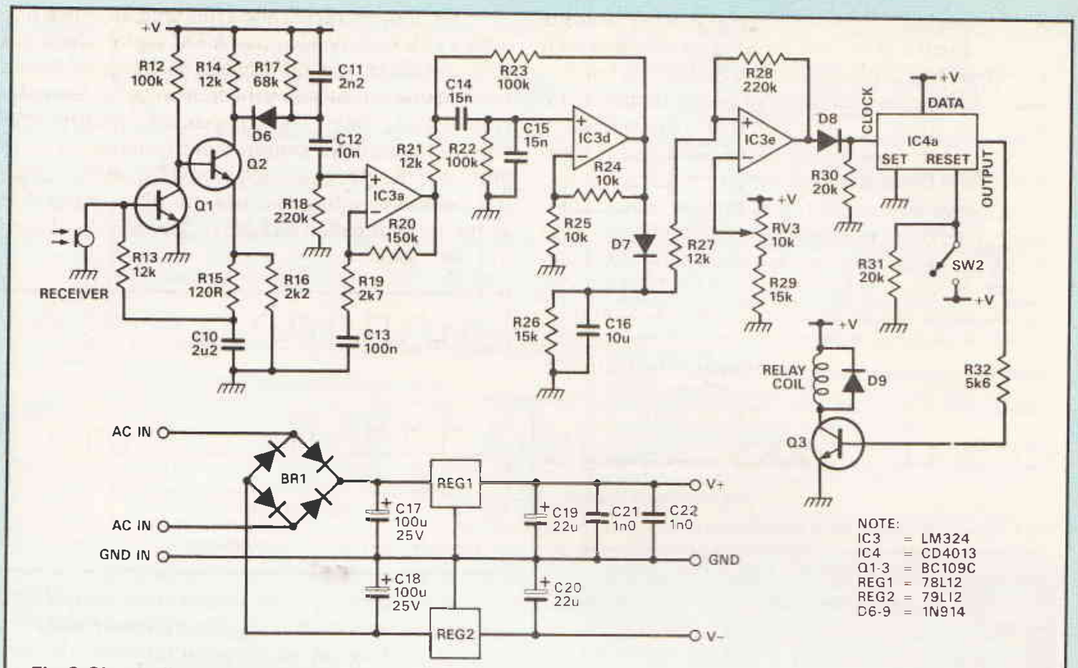


Fig.2 Circuit diagram of Receiver and power supply

inverting schmitt triggers. These devices act as normal CMOS inverter gates but they have one major difference, the input levels required to switch the output are different when the input is rising. Here it is about 5.8 volts and different again when falling, about 4.5 volts. It is this hysteresis that allows them to be used as oscillators. All that is needed is some feedback provided by a resistor and some delay provided by a capacitor. Its operation is shown in Figure 4. The frequency of the output can be easily derived and is given by the equation; $f_{out} = 2/RC$.

There is one problem in using just a pure tone to trigger the main alarm, that is other spurious sources might give similar tones and so trigger the alarm. To reduce the possibility of this occuring, the output tone is modulated with a secondary tone of about 100Hz (see Figure 5). It is the presence of this secondary tone that is used to trigger the alarm.

The transmitter board was designed to draw small currents so it could be driven from a single PP3 volt battery. This would last about five months. One solution to the problem of flat batteries is to use a mains driven power source, eg a small one used for Walkmans and portable stereos, and have a battery as a backup if this is unplugged. Two simple modifications are given in Figure 8

Receiver

Moving over to the receiver part of the project, the almost non-existent signal is amplified and then rectified to remove the 40kHz. This operation is tailored to leave the 100Hz secondary tone intact. Before any further amplification, the signal is decoupled to remove any DC elements and then it is rectified to give a usable DC signal. This DC signal needs to be changed to a binary one as an alarm is a binary device, on or off. The natural choice for the job is a comparator but this needs some form of memory to prevent the alarm being switched off by the burglar putting his foot through the transmitter or to stop a signal being transmitted, thus stopping the alarm. A D-type flip/flop with its data input held high and its clock input connected to the comparator stays in the positive latched state once triggered and can only be reset by using the clear direct pin. A simple transistor switch buffers the output of the. flip/flop and in turn energises the coil of a relay. A simplified timing diagram shows the theoretical stages to produce this binary decision (Figure 6).

The particulars of the type and wiring of the sounder has been left to your ingenuity as only you know your particular needs. An on board power supply has been included to provide the circuit with the +12V-0-12V regulated DC supply needed and only needs a 12V twin secondary winding transformer to complete it.

Three of each type. of sensor is catered for on each transmitter, so to get a single output from all six of them they need to be gated. Here we use an 8 input NOR gate so if one of the sensors is triggered then its

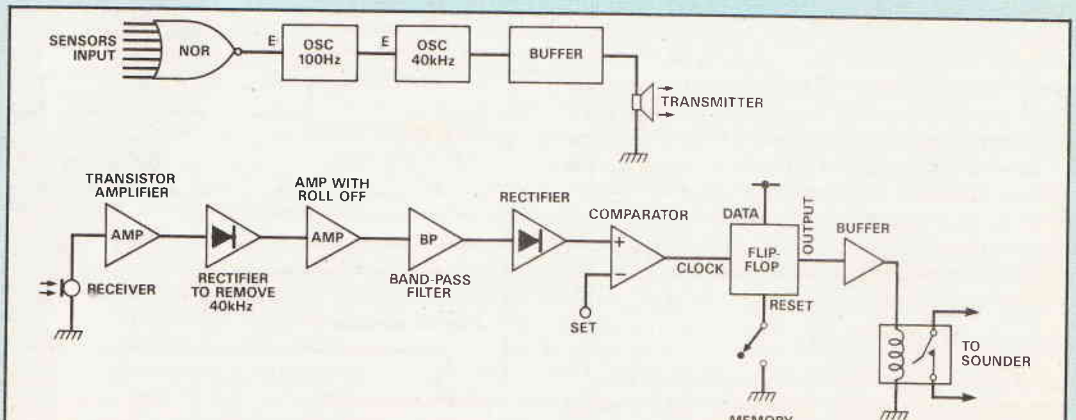


Fig.3 Block diagram of Transmitter/Receiver

output goes low. The chain of events that follows starts with a schmitt trigger configured as an oscillator with an output frequency of 100Hz. A diode is used to switch this oscillator depending on the output of the NOR gate, low is on, and high is off. This operation is quite simple if the output of the NOR gate is high, the diode is forward biased and so conducts, holding the oscillator's input high. This stops any oscillation. When the NOR's output is low, the diode is reverse biased and leaves the oscillator to do its oscillating. The net link in the chain uses a similar technique to modulate the 40kHz carrier with the 100Hz tone. A diode is used to switch on and off the carrier's oscillator, which is again a simple schmitt trigger oscillator.

HOW IT WORKS

A suitable aerial can be made out of fine enamelled wire of about 20 turns around the mains lead in question. A small load resistor is required to make the difference sizeable between mains flowing or not. A value of 10M is about right. The high impedance nature of CMOS gates means that if this resistor is left out the gate will still pick up stray mains signals and so think life is hunky dory when it is not as mains is not flowing in the lead. The output of this gate should be a clean 50Hz square wave and after rectification and further buffering this provides the necessary digital signal to go to the next stage.

The operation of the reedswitch type sensor needs little explaining. When the magnet and the switch are in close contact then the switch contacts close making a circuit. No frills are necessary to convert this to a digital signal, just a pull up resistor to +V to tie the input high if the circuit is broken. Mounting the switch and practical operation is dealt with in the 'In Use' section.

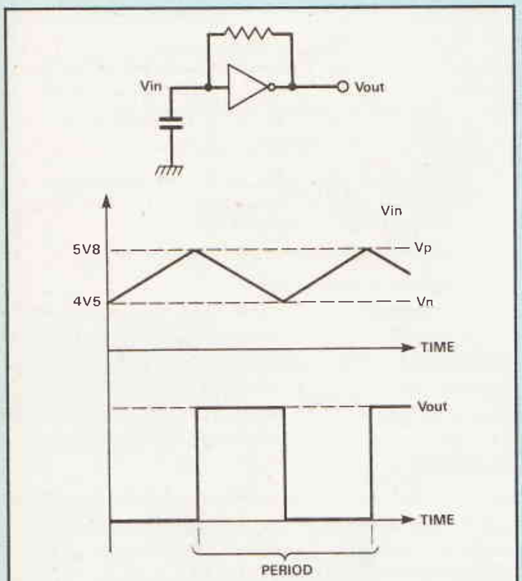


Fig.4 Oscillator waveforms

Assuming there is some 40kHz signal modulated with a 100Hz signal in the air, then this is picked up by the receiver. Two common emitter amplifiers in series provide enough signal gain. A diode-capacitor combination provide the first rectification. The load resistor R17 must be carefully chosen so the low pass filter action removes the 40kHz carrier but leaves the 100Hz signal intact. In this case the low pass frequency chosen is about 400Hz. Further amplification by IC4a is configured to give a high pass action with maximum gain of 50 at 100Hz, and brings his remnant signal to well above noise levels. In order to reduce the probability of accidental triggering, a bandpass filter is used to remove any stray tones and is set to a resonant frequency of 100Hz.

Yet another rectification this time an active one with a little gain finally gives a DC signal which has sufficient discrimination between back ground signals and the one produced by the transmitter to leave the conditioning field. A comparator extracts this informaton from the output signal giving a yes or no answer to the 'Are you being burgled' question. Once this comparator has said yes, the D-type flip/flop stores the information and can only be reset by closing the reset switch.

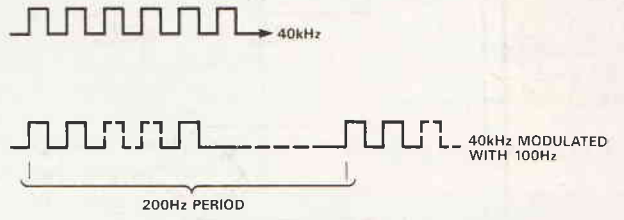


Fig.5 Pulsed 40kHz waveform

To make this unit have independent capability, a relay has been built in which can handle sufficient current to drive an extremely loud air horn. The output of the flip/flop has not been used to switch the relay coil directly as it would sink too much current. Instead a transistor switch does the dirty work providing the necessary current gain. The reverse biased diode is there for a reason, it stops your transistor from being destroyed. When the transistor switches off the relay coil this self same coil tries to keep the current flowing through it by using its collapsing magnetic field to create very high reverse voltage across the coil. This leads to semiconductor breakdown and hence the reverse diode is there to conduct this charge.

Testing

As always, firstly check power is being received by the IC sockets before committing them to their sockets. This is the case for both boards. The reader will need access to an oscilloscope as testing the 40kHz oscillator as it can not be done by listening tests with headphones for obvious reasons. If you are prepared to be trusting about the 40kHz oscillator or rely on an AC meter, then the rest of this project can be tested by audio means and with the aid of a meter. In the case of the transmitter board, we get the circuit in oscillating mode by leaving all the sensors unconnected. Now the first oscillater IC1f, should be giving a output square wave of 100Hz. This should be modulating the second oscillator IC1e, which has

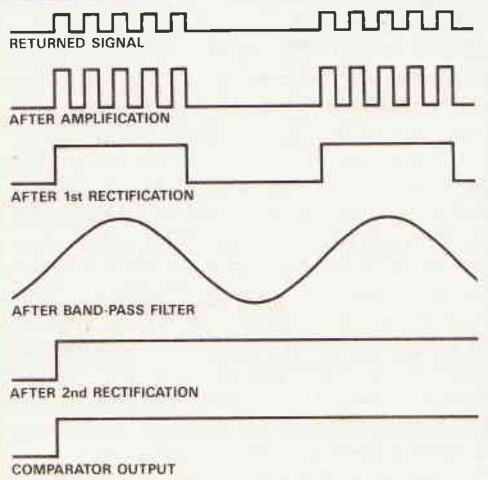
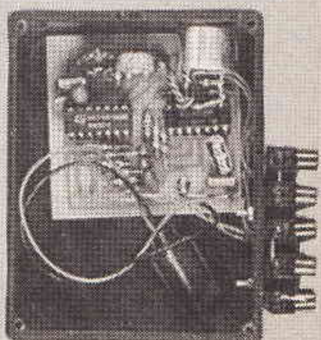


Fig.6 Timing diagrams



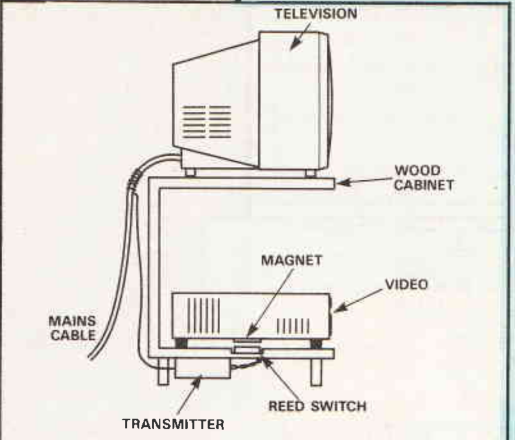


Fig.7 Transmitter in position with electrical appliance

an output frequency of 40kHz. More is said about checking the frequency of this in the 'Setting Up' section.

To test the reciever, the transmitter board should be left transmitting. It is best not to point the transducers together as this is an unrealistic situation. So on the test bench, point the two transducers directly away from each other. The collector of Q2, if viewed on an oscilloscope on high gain, should be some periodic patches of green fuzz (the modulated 40kHz signal), and a large DC offset. On the other side of D6, most of the green fuzz should have gone leaving the periodic waveform. The output of IC3a should show the amplified form of the input. There is no cause to panic if your periodic wave is not in a recognisable format as the signal sent out by the transmitter.

The output of the bandpass filter (IC3d), should consist of a similar waveform and after rectification by D7 this should settle to an almost DC signal. Again do not be alarmed (no pun intended) if it is not a stable DC signal. Check the comparator is working by adjusting RV3 across its range so that its output is forced to switch. This also tests the D type flip/flop as on the positive edge of this transition the output (0) should change to the high state and so energise the relay. This is reset. by the switch SW2. One problem which I encountered when building the prototype was with the orientation of the diodes, so be warned!

In Use

As with other alarms, the over-riding concern is inconspicuousness The greatest thought must be given to the positioning of the sensors and transmitter. The method I used for concealing the reed switches was to drill a recess in which they were mounted flush to the wood face of the cabinet. The connecting wires were run similarly through the wood base to the transmitter positioned under the base of the cabinet (see Figure 7).

If fine copper wire is used to pick up a mains signal then the coil and link wire can be easily concealed. It is best to put the sensor coil high up the mains cable so that if the burglar cuts the mains cable in question and lives, then you are certain of the alarm working. The connecting wires were terminated into a block. This means if that particular sensor input was not being used then it could be easily shorted out with a link wire. Note this must be done if an input is not being used so as to tie the gate to an off state.

The receiver needs access to the mains to drive its power supply but its positioning is not to crucial as it will be well away from the scene of the crime. It is important to have both ultrasonic transducers facing each other and in large rooms with not to many objects blocking its line of vision. There is a limit to the range of the transducers so don' t try the impossible like separating the two with bricks and mortar or placing the receiver 4 miles down the road. Try many different positions with the transmitter on and look for maximum signal strength in the same manner as you did when adjusting the 40kHz oscillator.

The choice of switches for the receiver has been left up to your discretion. The more safety conscious of you might want to use key switches as power and reset switches so only you have the power to switch off the alarm. In my prototype an ordinary toggle switch and a push switch was used as the power and reset switch respectively. If the alarm is going to be a permanent fixture then it might be an idea to hard wire the mains to it. Please note that the unit was not designed to cope with mains failures. This causes two effects. Firstly, it triggers the transmitting circuit owing to a lack of mains voltage in the leads being monitored. Secondly the receiver will not function as it is mains powered. This can be overcome by using a battery back-up but the problem remains that you will be woken up at the whim of the electricity boards. But rationally speaking, it is rare that you will be burgled at the same time as a mains failure takes place.

Construction

The logical approach applies here as with all circuits. IC sockets were used on the proto-type and are as always recommended. Take the usual precautions when handling the three CMOS chips. Solder the link wires and small components like resistors and diodes first. Secondly the IC sockets and presets and finally the regulators and capacitors.

The size of the transmitter is important so try to use the smallest box that it would fit in. Remember that the ultrasonic transducers both need free access to open air, so help their cause by either drilling a series of grill holes or one single large one and mounting the transducer firmly next to it.

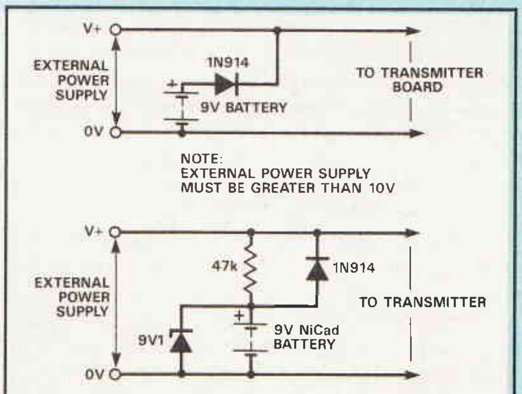


Fig.8 Power supply options

When selecting a sounder, bare in mind that if it requires a modest amount of current, it may be driven from the unregulated DC power supply of the receiver board.

Setting Up

Before connecting up the sensors to the transmitter board the presets need to be adjusted. Firstly arrange for a similar set-up to that given in the 'Testing' section. The first task is to adjust the 100Hz oscillator. This is done so the modulation frequency closely matches the resonant frequency of the bandpass as it is easier to change the former as opposed to the latter. If an oscilloscope is being used then adjust RV1 so the output of IC3b is maximum or if a meter is being used then adjust so the output of the rectifier built around D7 is maximum.

Secondly the 40kHz oscillator has to be set. This is done in a similar way to the previous one. RV2 is adjusted while monitoring the output of the rectifier built around D6 with a meter. The important difference is that the object is to achieve a minimum DC voltage as D6 is reverse biased.

The only other preset that requires tweaking is RV3 this requires the transmitter and the receiver to be placed in their most likely future position, so it is best to consult the 'In Use' section first. Now adjust RV3 so the output of IC3b goes high. Turn off the power on the transmitter and make sure the comparator returns to the negative state.

BUYLINES

The ultrasonic transducers used in this circuit have no specific code letters or numbers but similar types are widely available from mainstream distribution like Maplin. Also, purpose built reed switches and magnets for alarms encapsulated in plastic and surface mounted can be bought from Maplin. The relay was equivalent to Fujitsu FBR611 or Omron G2R117PV and was bought from Rapid Electronics. Other components should present no problems.

PARTS LIST

TRANSMITTER

RESISTORS (all ¼W 5%)

R1,2,3	10M
R4,5,6,7,8,9	1M
R10	680k
R11	68k
RV1	100k
RV2	10k

CAPACITORS

C1,2,3,6	2u2 tantalum
C4	10n polyester
C5	330p
C7	22u elect
C8	15n polyester
C9	1n disc

SEMICONDUCTORS

IC1	CD40106
IC2	CD4078
D1,2,3,4,5	1N914

MISCELLANEOUS

PP3 Battery Connector
Ultrasonic transmitter

RECEIVER

RESISTORS

R12	100k
R13,14,21,27	12k
R15	120R
R16	2k2
R17	68k
R18,28	220k
R19	2k7
R20	150k
R22,23	100k
R24,25	10k
R26,29	15k
R30,31	20k
R32	5k6
RV3	10k

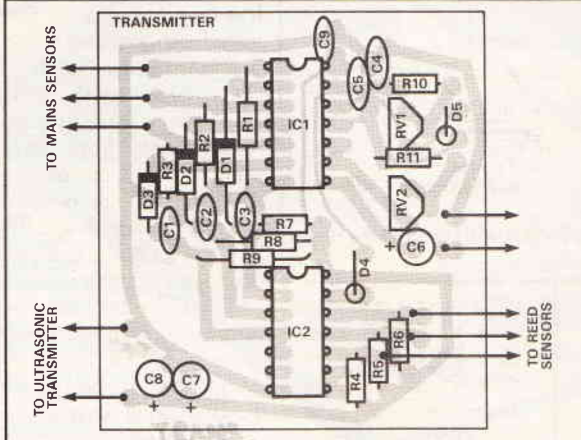


Fig.9 Component overlay of transmitter

CAPACITORS

C10	2u2 tant
C11	2n2 polyester
C12	10n
C13	100n
C14,15	15n
C16	10u
C17,18	100u/25V
C19,20	22u elect
C21,22	1n disc

SEMICONDUCTORS

IC3	LM324
IC4	CD4013
Q1,2,3	BC109C
REG1	78L12
REG2	79L12
D6,7,8,9	1N914
BR1	W08 Bridge Rectifier

MISCELLANEOUS

SW4	Power switch
SW5	Reset switch
Ultrasonic Receiver	
TR1	12-0-12V 0.5A transformer

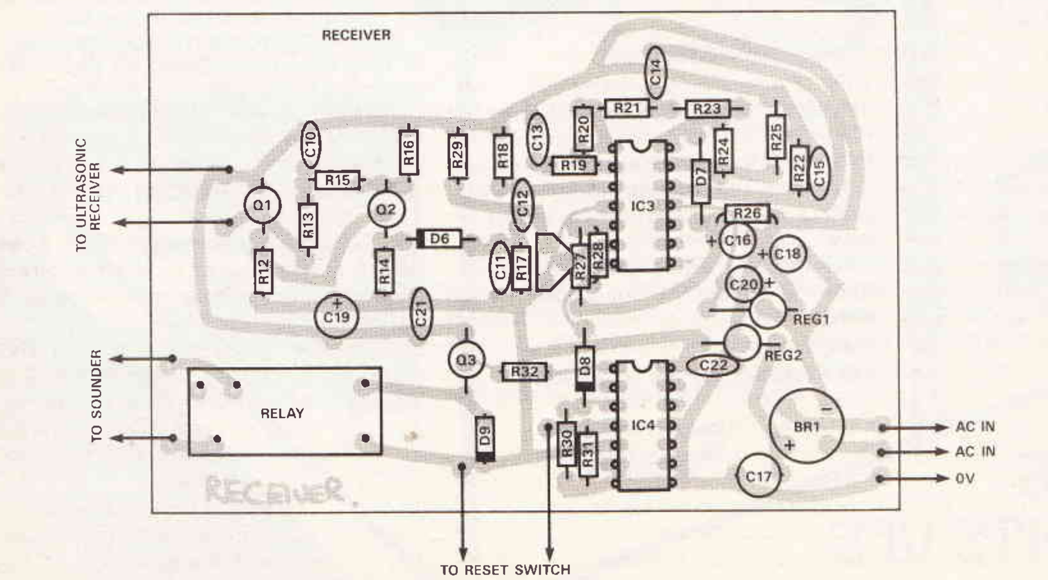


Fig.10 Component Overlay of Receiver

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The components are of excellent quality, in packs originally intended to sell at £1 each. To make sure you get a good variety, the 20-pack parcel will have no more than two of any one pack, the 100 pack parcel will have at most five of any one pack. Packs supplied as they come – our choice.

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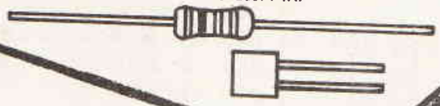

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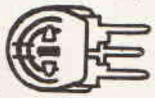

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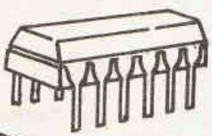


TANTALUM CAPACITORS

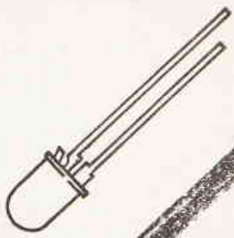
A nice range of tants in values up to 47μF. Lots of useful caps, and we're not mean with the most expensive ones. A fine selection.

PARCEL 4A: 100 TANTS for £6.80 + VAT
PARCEL 4B: 500 TANTS for £29! + VAT

LEDs

All shapes, sizes and colours of LEDs. Round ones in various sizes, rectangular ones, red, green, amber and yellow ones, clear and tinted lenses, all sorts.

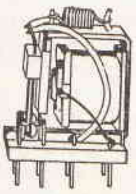
PARCEL 7A: 100 LEDs for £5.90 + VAT
PARCEL 7B: 500 LEDs for £24.90 + VAT



RELAYS

All kinds of relays: plug-in, PCB mounting, low voltage (down to 3V coils), miniature, reeds, heavy duty contacts, signal contacts, you name it. A fantastic selection. You'll be back for more!

PARCEL 16A: 50 RELAYS for £12 + VAT
PARCEL 16B: 200 RELAYS for £38 + VAT



TRANSISTORS

A mix of general purpose silicon transistors, mostly bipolar NPN and PNP, with a few FETs and unijunctions thrown in (when available) to spice the mixture. The contents vary from month to month – at the moment there are BC212s, BC213s, BC548s, BC238Bs, MTJ210s, and so on. Next month – who knows? All top quality components.

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An exciting selection of capacitors. There are ceramics for decoupling and general use, Polystyrenes for high performance circuits, dipped and moulded polyesters in values from a few nF up to 2.2μF (very expensive!), tants and aluminium electrolytics – just about any capacitor you'll ever need. Don't miss this one!

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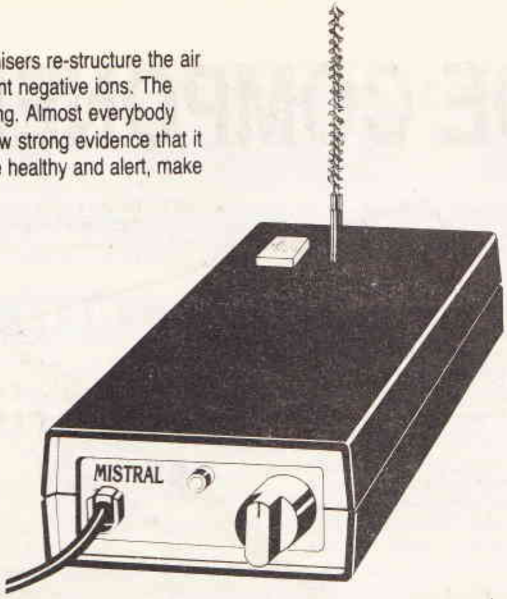
By means of points raised to a very high voltage, ionisers re-structure the air you breathe, turning ordinary air molecules into potent negative ions. The effects of breathing in these ions can be quite startling. Almost everybody reports that it makes them feel good, and there is now strong evidence that it can also improve your concentration, make you more healthy and alert, make you sleep better, and even raise your IQ.

THE MISTRAL AIR IONISER ▷



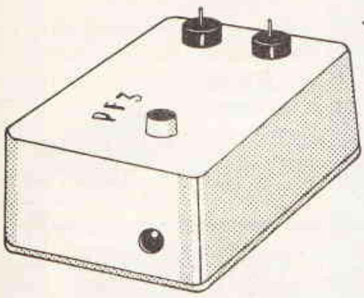
The ultimate air ioniser. The Mistral has variable ion drive, built-in ion counter and enough power to drive five multi-point emitters with ease. Its nine main drive stages, five secondary drives and four booster stages give an immense 15 billion ions per minute output – enough to fill the largest room in a matter of seconds.

The parts set contains everything you need to build the Mistral: components, PCB, case, emitter and full instructions. If you're keen to increase the output still further, there's an optional eight-point internal emitter set to give extra ionising capability, and an almost silent piezo-electric ion fan to drive the ions away from the emitter and into the room.

MISTRAL IONISER PARTS SET **£32.66** ☐

INTERNAL EMITTER PARTS SET (optional) **£3.22** ☐

ION FAN (optional) **£11.27** ☐



◁ PROPHET PF3

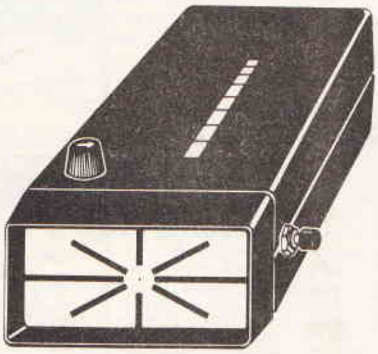
The Prophet performs its own special miracle on the dashboard of your car. First reports are most impressive: driving becomes a positive pleasure, easier to stay alert on long motorway journeys, a child cured of travel sickness. The ion effect is not to be underestimated. Don't forget the experiments either: there's the smoke trick, triffids, the living emitter, and more. The Prophet can be used anywhere with a supply of 9V to 12V DC, so don't restrict it to the car alone!

PROPHET PF3 PARTS SET **£21.39** ☐

THE Q-ION ▷

Check out the ion levels around your house. The Q-Ion will measure the output of any ioniser, test the air to see where the ions are concentrating, help you set up fans and position your ioniser for best effect, and generally tell you anything you want to know about ion levels in the air. The readout is in the form of a bar graph which moves up and down as the Q-Ion sniffs the air in different parts of the room. Readings up to 10^{10} ions per second, positive or negative.

Q-ION COMPLETE PARTS SET **£21.16** ☐



IONISER EXPERIMENTS

* The Vanishing Smoke Trick

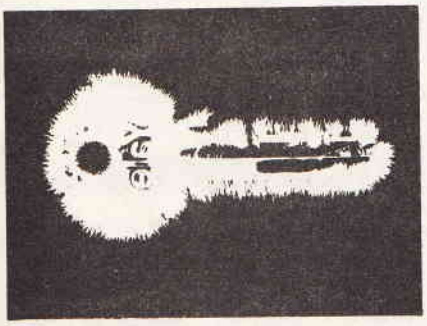
Light up a cigarette and gently puff smoke into a glass jar until the air inside is a thick, grey smog. Carefully invert the jar over the ioniser so that the emitter is inside. Within seconds the smoke will vanish! This is one of the best demonstrations of an ioniser's air cleaning action and with a large jar the effect is quite dramatic.

* Triffids

Connect a length of wire from the ioniser emitter to the soil in the pot of a houseplant. One with sharp, pointy leaves is best. Hold your hand close to the plant and the leaves will reach out to touch you! In the dark you may see a faint blue glow around the leaf tips – this works better with some plants than with others, so try several different types. The plants don't object to this treatment at all, by the way, and often seem to thrive on it.

* The Electric Handshake

Wear rubber soled shoes. Touch the ioniser emitter for a few seconds until your body is thoroughly charged up. When your hair stands on end, that's just about enough. Then give everyone you meet a jolly electric handshake. Just think, you could lose all your friends in a single evening! (A meaner trick still is to charge up a glass of water or a pint of beer. Even your family won't speak to you after that!)



◁ KIRLIAN CAMERA

Bioplasmic fields, auras, or just plain corona discharge? No matter how you explain them, the effects are strange and spectacular. Can you really photograph the missing portion of a torn leaf? Can you really see energy radiating from your finger tips? Most researchers would answer 'yes' to both questions.

Our Kirlian photography set contains everything you need to turn the Mistral into a Kirlian camera, your bedroom or spare room into a darkroom, and to expose, develop and print Kirlian photographs (photographs made with high voltage electricity instead of light). The set includes exposure bed, safelight bulb, developing and fixing chemicals, trays, imaging paper and full instructions. A Mistral ioniser parts set is also required.

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Tech-Tips

Electronic Watering Meter

There is a need for a small simple electronic watering meter for the visually handicapped. There are about one million people in the UK with some sight deficiency. As a large proportion of these are elderly they may also be 'hard of hearing' and have a reduced sense of touch.

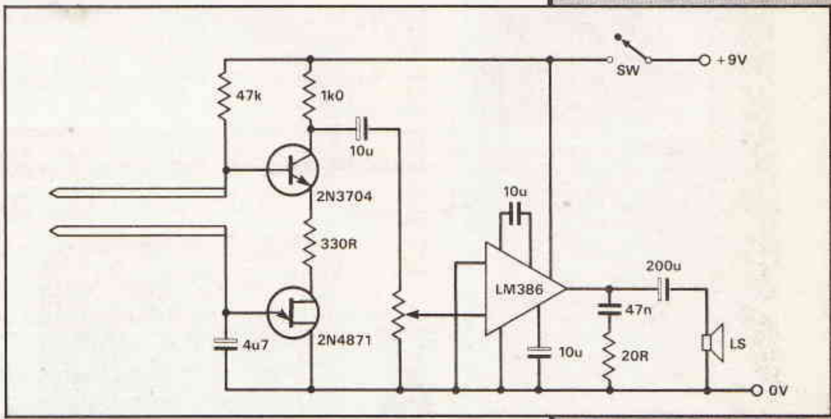
A watering meter can be made to measure the dampness of the soil in a plant pot or in gardens giving audible indication of soil state. Reduction in hearing in the elderly tends to occur over 3000Hz and below 300Hz which would exclude a pulse system and favour a tone system sine or square wave.

I examined a commercial piece of equipment which was based on a pulse system and found the clicks were inaudible as was the output from the transducter, a piezo electric crystal.

This design overcomes these problems by using an LM386 325mW power amplifier and 45mm Loudspeaker. The sound generator consists of a ramp function unit which uses a resistor and the soil as the resistive part of the charging element and a 4μ7 capacitor to provide the capacitive element. A unijunction 2N4871 provides the discharge element and a transistor 2N3704 buffer completes the active components in the design in Figure 1.

The circuit was built on vero board — a good enough system for a one off although a PCB would be more robust. The box used for the prototype was the size of a hearing aid although any Project Box would do just as well. The size of this would depend on the loudspeaker used. The lower size is governed by getting the speaker and PP9 battery in. The upper size by how convenient it is to hold in the hand. The ON/OFF switch is a microswitch in the original but a push-to-make would do just as well, as the unit should only be on when a reading is being taken.

P.D.Somerville,
West Sussex.



3

REMOTE CONTR

We present the final part in our electrical house manager. Kevin Browne describes the receiver and testing proceedure.

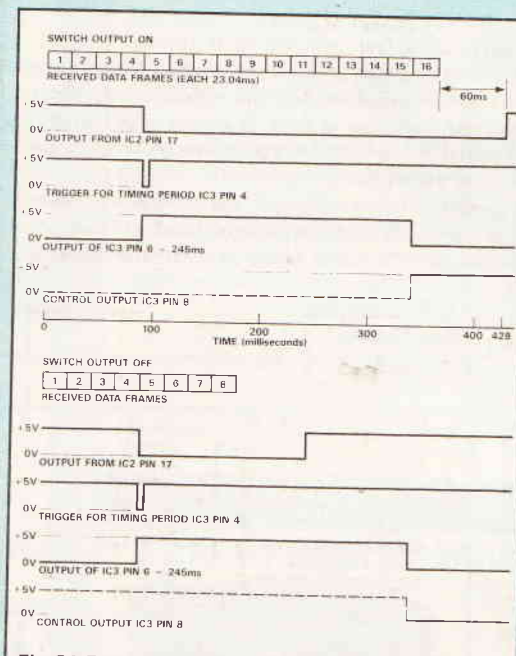


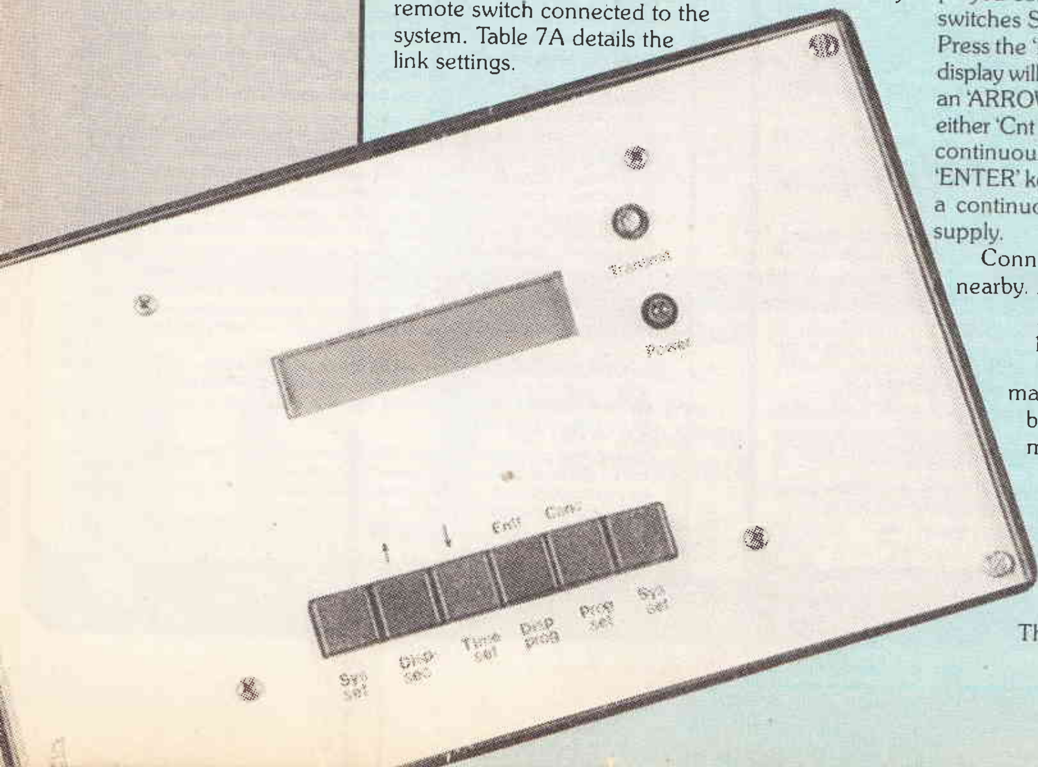
Fig.21 Remote Switch Unit — Timing Details

Assembling the PCB is fairly straightforward — though carefully check the orientation of the isolating transformer T2 (see Figure 17). As with the transmitter PCB, it is advisable for safety reasons to insulate the leads of capacitors C1 and C2 with sleeving and manufacture a plastic cover for the fuse. I again used sockets for all the IC's.

Complete the wiring of the remote switch unit as shown in Figure 23. The wiring to the plug and socket must be 240V rated.

Setting The Links And Switches

There are 4 links, LK9-LK12, the setting of which determines the security code of the system. This code (in the range 0 to 15) is set to the SAME value for every remote switch connected to the system. Table 7A details the link settings.



The eight DIL switches SW1-SW8 are used to identify the individual remote switching units. Each unit on a system should have a unique setting, unless it is required for two remote units to respond to the same control commands. Switch settings should be in the range 0 to 99 (see table 7B).

Remote Switch Unit Testing

First, carefully check the PCB for short circuits and bad soldering, paying particular attention to the 240V side of the circuit. Temporarily secure the PCB in the box. Connect up the power, REMEMBER that parts of the PCB are at 240V so great care should be taken. Push the toggle switch in the ON direction, the relay should operate and the LED light. Then flick the switch in the OFF direction. The relay should release and the LED extinguish.

To set up a remote switching unit it is necessary to connect it to the mains supply. It is VERY STRONGLY advised to temporarily mount the PCB in its box, and cover the live section of the circuit with an insulating material to prevent fingers from inadvertently touching a mains connection.

Adjustment of the remote switch unit is easy. I have built into the timeswitch software, a 'Set Up' program. To access this program, proceed as follows: Connect the timeswitch control unit to the mains supply, the '(C) 1990..' message should be displayed on the LCD display. Press the 'ENTER' key, and the display will change to 'Secure code 00'. Using either of the two 'ARROW' keys, change the secure code to correspond to the settings chosen for the links LK9 to LK12 in the remote switching unit. Press the 'ENTER' key again, and the display will then change to show the time and date. At this point press both 'SYSTEM SET' keys together, to enter the set up mode. 'SET UP MODE' should then be displayed.

Once the timeswitch control unit is in the set up mode press the 'ENTER' key. The display will show 'Output No? 00'. Change the output number, using either of the 'ARROW' keys, until the number displayed corresponds to settings selected by the DIL switches SW1 to SW8 in the remote switching unit. Press the 'ENTER' key to confirm this selection. The display will change to 'Select Cnt Tone'. By again using an 'ARROW' key the display can be changed to show either 'Cnt Tone', 'Cnt Code' or 'XON/OFF'. Select the continuous tone (Cnt Tone) mode, and press the 'ENTER' key. The control unit will now superimpose a continuous 180 kHz carrier tone on the mains supply.

Connect up the remote switch unit to the mains nearby. Attach a digital meter or a 'scope to the junction of capacitor C3 and C4. With a plastic trimming tool, carefully adjust the core of the transformer T2 until the maximum carrier tone is detected. This will be somewhere in the region of 8mV on a meter, or 0.5V peak to peak on a 'scope.

Once you are satisfied with the adjustment of T2, press the 'CANCEL' key on the control unit. The display will revert to 'SET UP MODE'.

Press the 'ENTER' key twice, to get the display back to 'Select Cnt Tone'. This time, however, select the continuous

OL TIMESWITCH

PROJECT

code option (Cnt Code). The control unit will now send a continuous stream of control codes to the remote switch unit. Monitor pin 17 of IC2. It should be low. If this is not the case, the setting of the DIL switches and links LK9 to LK12 may not agree with the setting input into the control unit software.

When this test proves satisfactory, cancel the test with the 'CANCEL' key. Then select the third test, transmit ON and OFF (XON/OFF) on the control unit. This time the control unit sends alternate 'ON' and 'OFF' control signals to the remote switch unit.

The Initial Power Up.
When power is first connected to the timeswitch unit, it performs various self checks. If these checks are satisfactory the display shows a continuously scrolling copyright message. It is only at this point in the program that entry can be made to the calibrate mode (by pressing both SYSTEM SET keys together). Assuming that calibration of the system has been completed successfully as described earlier in the text, there should be no further need to enter the calibrate mode.

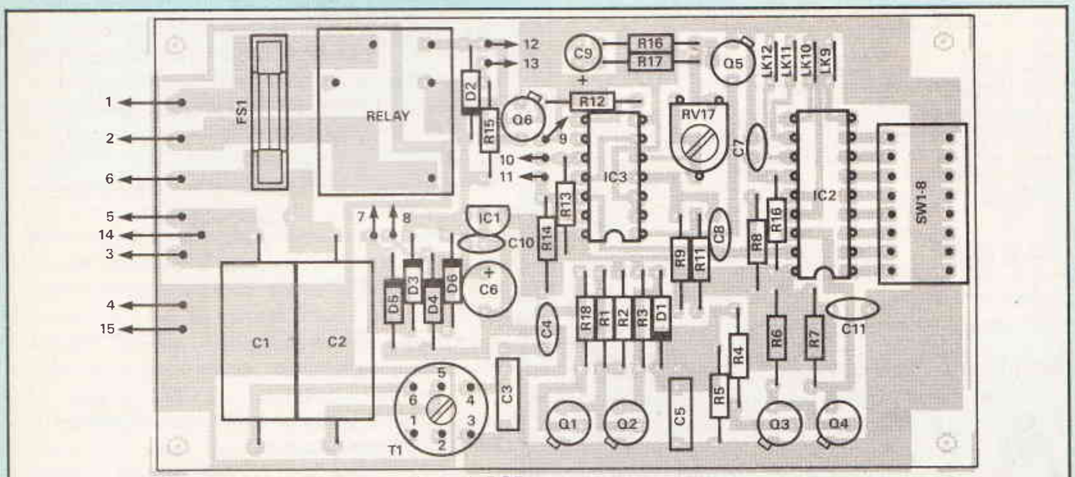


Fig. 22 Component overlay for Remote Switch PCB

By careful adjustment of the variable resistor VR17, the relay can be made to operate and release at approximately 15 second intervals. This adjustment requires a bit of patience, as at least 30 seconds have to elapse between each adjustment.

This now completes the set up of the remote switch. Cancel the test on the control unit, by pressing the 'CANCEL' key. Finally leave the set up mode and return to the normal time display, again by pressing the 'CANCEL' key.

Final Assembly

Assemble the PCB and transformer in a suitable box. The plug and socket can either be mounted on the front and back of the box with small nuts and bolts, or alternatively, fitted to the ends of short trailing leads.

Setting Up The Timeswitch

Key functions.
Programming the various functions of the timeswitch is done via the six control keys. Each key has a number of different functions, depending upon the menu shown on the display module. The basic key functions are as follows:

The 'SYSTEM SET' keys. These keys are used together, to enter the system calibration or remote switch set up mode.

The 'ARROW' keys. These keys are used to step through the various options shown on the display module. When setting the time, the keys increase or decrease the displayed time, one count at a time. If a key is held pressed for more than 2 seconds the displayed time is rapidly advanced or retarded until the key is released. The 'ENTER' key is used to confirm a selection. The 'DELETE' key is used to cancel a selection.

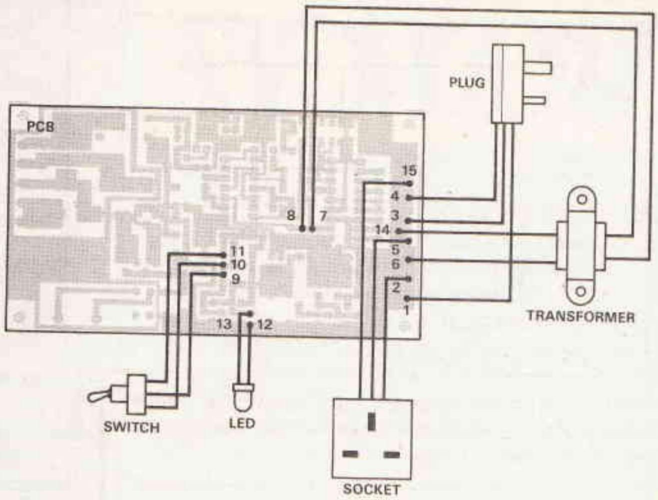
If any key (other than the SYSTEM SET keys) is pressed when the copyright message is showing, the display will change to show current time. Initially this time is set to 00:00 Monday 1st January 1990.

It is probably a good idea at this stage to fit the standby battery. This will preserve the time, and any programs you may enter, if the power is accidentally disconnected.

Setting the Time and Date.
To set the system time and date, first press the TIME SET (DOWN ARROW) key to enter the time setting mode. The display will change to the hours and minutes, with the hours shown between two arrow symbols. These arrows indicate the part of the display which is being edited at the moment i.e. the hours. Press either of the ARROW keys to change the hours display to the current time. Note that holding an ARROW key pressed for more than 2 seconds will cause the display to advance rapidly.

When the correct hours is shown in the display, press the ENTER key. This will confirm the hours setting, and move the indicating arrows on the display to the minutes display. Set the minutes to the correct time, again using the ARROW keys. Press the ENTER key.

Carry on setting the DAY, DATE, MONTH and YEAR in the same way, using the ARROW keys to select the choice and the ENTER key to confirm the choice. After the year has been set, and the ENTER key pressed, the display will revert to the normal time display. Note that it is possible to set a non existent date, (30th February). The system will automatically correct this at midnight — making the next day the 1st of March.



No.	USE	
1	240V AC LIVE	FROM MAINS SUPPLY (PLUG)
2	240V AC LIVE	TO APPLIANCE (SOCKET)
3	240V AC NEUTRAL	FROM MAINS SUPPLY (PLUG)
4	240V AC EARTH	FROM MAINS SUPPLY (PLUG)
5	240V AC NEUTRAL	TO APPLIANCE (SOCKET)
6	240V AC LIVE	TO TRANSFORMER
7	12V AC SUPPLY	FROM TRANSFORMER
8	12V AC SUPPLY	FROM TRANSFORMER
9	SWITCH COMMON	
10	SWITCH OFF	
11	SWITCH ON	
12	LED −VE	
13	LED +VE	
14	240V AC NEUTRAL	TO TRANSFORMER
15	240V AC EARTH	TO APPLIANCE (SOCKET)

Fig. 23 Remote Switch Unit Wiring

IC Number	+5V PIN	OV PIN
2	8	1
3	8	1
4	14	7
5	11	29
6	28	14
7	24	12
8	20	10
9	14	7

Table 6 IC Voltage Supplies

Displaying the Seconds.

To change the display mode from the normal time and date display to hours, minutes and seconds, press the DISPLAY SECONDS (UP ARROW) key. To syncronize the seconds press both SYSTEM SET keys together. The seconds count will be zeroed to the nearest minute. To return to the normal display mode, again press the DISPLAY SECONDS (UP ARROW) key.

Programming a Switching Operation.

There are two different types of switching program to choose from. There are fixed programs, which will turn an output ON and then OFF at a fixed time. There is also the option of random programming, where you define a period of time and the system automatically switches the chosen output ON and OFF a number of times at random intervals, between the times you have selected.

Programming Fixed Programs.

From the normal display time mode, press the PROGRAM SET (CANCEL) key to enter the program mode. The display will show 'Output number?' Select the number of the remote switching unit that you wish to control using the ARROW keys, in the same way as before. Again use the ENTER key to confirm your choice. Next, set the 'switch on' time, and the 'switch off' time, confirming your choice with the ENTER key. Then, again using the ARROW keys, select the day(s) when switching is to take place. The choice is between any single day, everyday, weekdays (i.e. Monday to Friday) or weekend (i.e. Saturday and Sunday). Again confirm your choice with the ENTER key.

The display will then show either 'fixed period' or 'Random period'. Select 'fixed period ' using the ARROW keys, and confirm the choice with the ENTER key. Finally, the display will show either 'once only' or 'repeat'. If you require the switching to take place every week at the same time, select 'repeat'. Selecting 'once only' will cause the program to cancel itself automatically after execution. The final press of the ENTER key will return the display to the normal time display mode. A switching operation has now been programmed.

Randon Switching Operations.

Setting a random switching program is very similar to setting a fixed program. The 'ON from', 'UNTIL' times are set to define the period in which you wish random switching to take place. The maximum period you can set is 23 hours 59 minutes i.e. all day. When you reach the selection point 'Fixed Period' or 'Random Period', select 'Random Period'. Confirm this choice, and the display will then show 'Number of periods?' This is the number of complete ON/OFF periods to be switched within the times you have specified earlier. Up to 15 periods can be generated from one program.

When setting the start and stop times for a random program you must allow a minimum of 10 minutes for each random period. (If the number of random periods is set to 5, the time interval between start and stop times must be a minimum of 5 × 10 minutes — 50 minutes). If the time interval is set to less than this, an error will occur when the program execution is attempted. This program will then be automatically deleted from the memory.

	LINK Number			
	12	11	10	9
VALUE	8	4	2	1

Note: 0 – LINK fitted
1 – LINK fitted
Example – Security Code = 10 = 8+2
∴ Fit LINKS 11 and 9 miss out LINKS 12 and 10

Table 7a Security Code value

	Switch Number							
	8	7	6	5	4	3	2	1
VALUE	Note 2	64	32	16	8	4	2	1

Note 1: 0= Switch operated
1= Switch normal
Note 2: Switch 8 always operated
Example: Switching unit Number 23 = 16 + 4 + 2 + 1
∴ Operate switches 8,7,6,4 leave switches 5,3,2,1 normal.

Table 7b Switching unit number

Displaying The Switching Programs

To display the switching programs, press the DISPLAY PROGRAM (ENTER) key to enter the display program mode. The display will then show 'Show All Data?' The ARROW keys can be used to change this option. The three choices are:

- Show All Date. This will display all the switching programs.
- Show One Day. This will display only programs for one selected day.
- Show One Output. This will display programs for one selected output number.

Select the desired option, and press the enter key. Choose the specified day or output if required, again using the ARROW keys. Confirm with the ENTER key.

The first program in the memory is now found and displayed. using the ARROW keys, the display can be scrolled left or right to read the various parameters of the program. To select the next program, press the ENTER key. Once the last program has been displayed, the display will revert to the normal display.

Delete A Program

To delete a program, first display the program to be deleted, as explained above. Press the CANCEL key, the display will then show 'ENT to Delete'. Press the ENTER key to delete the program, or press the CANCEL key again to revert to the display a program mode.

System Errors

If the software program detects an error whilst executing a program, the display will show an error message instead of the normal time display. The timeswitch will still continue to function normally, however the program which caused the error will either be ignored or deleted automatically.

There are four error displays. The first two, 'Transmit Queue Full' and 'Job Queue Full', occur when more than 16 switching operations are requested to be performed in any one minute. The first 16 operations are processed normally, any remainder are ignored.

The third error is 'Memory Full'. This can occur either when you attempt to insert more than 255 programs in the system, or during a random program operation, when the total number of programs stored would exceed 255.

The final error display, 'Short Period', occurs during random program operation, when the time interval between the start and stop times is insufficient to allow the specified number of switching periods to be executed. (i.e. 10 minutes must be allowed for each random period). If this error occurs, the program which caused the error is automatically deleted from the memory.

Once an error has occurred, the display will continue to show the error until the ENTER key is pressed. The display will then revert to the normal time display mode.

Power Failure

If mains power failure occurs, the timeswitch is no longer able to control the remote switching units. However by using the standby battery the current time and all the stored programs are preserved in the memory. The current states of all the remote switches at the instant of power failure is also stored in the memory. This record is updated whenever a switching operation should have been performed.

Once the power is restored, the control unit waits for 30 seconds, then checks through its memory for any remote switch unit which should be in the ON state. It then sends out a series of control signals, to set each remote switch to its correct state. This operation can take up to 50 seconds, after which the timeswitch resumes normal operation.

Alternative System Configuration

It is possible to replace the mains transmission link with either a directly wired connection or another transmission system, such as ultrasonic or radio. Figure 24 shows how this may be done.

The unused outputs from IC8 may be wired as shown in Figure 25. This will allow direct control of up to 7 switching relays. The operation of these relays is controlled by outputs 0 to 6 in the software program. (See table 8.)

Reference

The following reference material has been used in the preparation of this project:
Date sheets — EPSOM EA-D LCD displays. EPSOM (UK) Ltd. Tel: 01 902 8892.
Data sheets — UM3750 encoder/decoder. Maplin Electronics. Tel: 0702 554161.
Z80 — Machine Language Programming Made Simple For Programming. your Sinclair. Melbourne House Publishers.

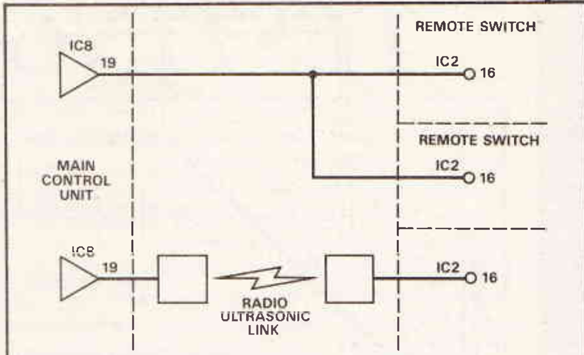


Fig. 24 Alternative Systems

A free copy of the Hex dump program is available for constructors by sending an SAE to ETI.

PARTS LIST

REMOTE SWITCH PCB

RESISTORS (all ¼W 5%)

R1,10	100k
R2,3,7	10k
R4,6	47k
R5	15k
R8,9,11,12	4k7
R13,14,15	1k
R16	20k
R17	56k
R18	22k
RV17	100k (horizontal min preset)

CAPACITORS

C1,2	220n 250V AC working (2 off) (Maplin JR35Q)
C3	47n polyester
C4,8,10,11	100n disc ceramic
C5	10n disc ceramic
C6	220µ/25V elect
C7	1n disc ceramic
C9	10µ/25V elect

SEMICONDUCTORS

D1	1N914
D2,3,4,5,6	1N4001
Q1,2,3,4,5,6	BC108
IC1	78L05 100mA regulator +5V
IC2	UM3750 Encoder/Decoder (Maplin UK77J)
IC3	74LS74 dual D type flip flop
LED	5mm Red

MISCELLANEOUS

T1	Transformer sub-miniature 6 volt 100mA
T2	Transformer coil (Maplin FT55K7)
F/S	250mA 20mm fuse
IC sockets	1×8 way 1×14 way
SW1-SW8	8 way DIL switch
SW9	SPDT non locking, centre off.
RELAY	10A miniture mains relay (Maplin Y×97F)
LED Clip	
Fuse Clips (2 off)	
BOX	ABS2005 146×76×46mm (Maplin LH61R)

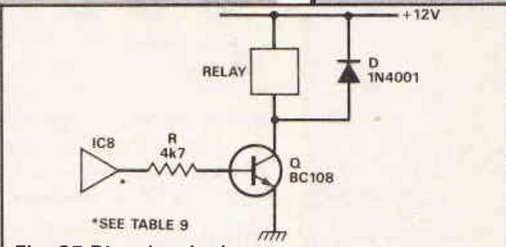


Fig. 25 Directly wired output

Output Number	IC8 Output PIN
0	16
1	15
2	12
3	9
4	6
5	5
6	2

Table 8 IC8 Outputs

BUYLINES

A programmed EPROM is available from the author price £10 including postage and packing. Send to Beldon Cottage, 23 Burton Royd Lane, Kirkburton, Huddersfield, HD8 0TU.

TESTING TESTING

This month Mike Barwise looks at displaying digital signals

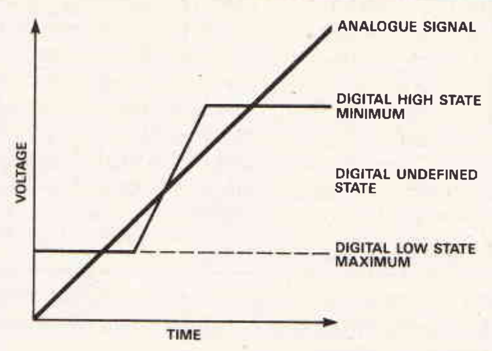


Fig. 1 Analogue and digital signal comparison.

When we looked at voltage measurement of analogue signals, we saw that there were two types of values to be measured: constant (DC measurements) and time-varying (AC) signals, and that different approaches and equipment are used for each. Let us look at these in turn in the context of digital signals, to see how the techniques and equipment compare.

Constant analogue signals can exhibit any value between a defined maximum and a defined minimum: the range of intermediate absolute values is infinite. A meter with high resolution is thus required, typically with a resolution of at least 1%. Constant digital signals exhibit two (or at most, three) ranges of values where the range is the important factor and the absolute value within that range is relatively unimportant. This is shown in Figure 1. The significant choices in digital testing are: HIGH, LOW, UNDEFINED. A beneficial consequence of this is that voltage readings may be made with much lower resolution in digital systems than in analogue. Static (DC) logic

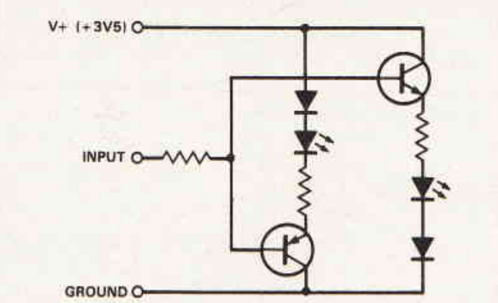


Fig. 2 Three state logic indicator (TTL).

signals can be monitored using equipment as crude as a little lamp: on = high, off = low. A slightly more sophisticated version is given in Figure 2. This circuit provides a full logic indication for TTL: valid HIGH, valid LOW and UNDEFINED (or TRI-STATE OFF). It actually consists of two indicators. The first uses an NPN transistor in common collector mode (collector to V+) as a switch providing current to an LED. As the emitter is offset from GND by the combined V_f of the LED and the rectifier diode (total about 2.4V), the NPN transistor will only conduct significantly when its base is raised to about +3V with respect to GND (V_{fLED} + V_{fDIODE} + V_{beNPN}), which indicates a thoroughly acceptable TTL logic HIGH. The second indicator consists of a PNP transistor, also in common collector mode (collector to GND). This transistor conducts when its base is more NEGATIVE when V+ by the same amount (about 3V). The logic LOW threshold indicated will thus depend on the supply voltage, and for a valid TTL LOW, V+ should be in the region of 3.5V to accomplish a logic LOW indication of about 0.5V. This is accomplished by a suitable supply voltage regulator, which should be an adjustable one (set on test), as V_{fLED} varies quite a lot with batch and LED current. There is of course, a range of voltages between +0.5V and +3V (undefined logic state for TTL) where neither transistor is in significant conduction, and this is indicated by both LEDs off. As both transistors are never on at the same time, they can share a common input resistor.

This is fine for static logic levels, but most real-world, interesting signals are time-varying, both in analogue and in digital systems. In the analogue context, the oscilloscope is used to display a waveform (graph of voltage vs. time) and the display is locked on the screen by triggering the 'scope trace at **a critical voltage threshold** which is guaranteed to occur only occasionally in the waveform.

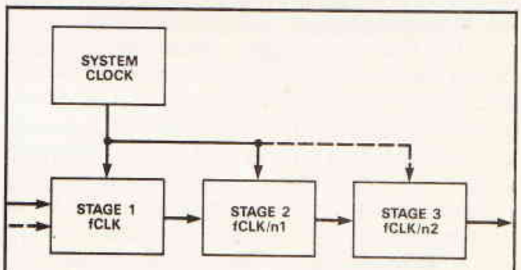


Fig. 3 Typical sequential logic system.

This approach cannot possibly work for us when displaying digital signals, as ALL LEGAL SIGNALS SWING BETWEEN THE SAME VOLTAGES. There will thus be no unique voltage level in the signal which can be used as a trigger threshold in the familiar (analogue) sense. To lock a digital signal on the 'scope screen, we have to find some other approach. The most obvious theoretical starting point is that in dynamic digital systems, events tend to happen in sequential cascade: a signal somewhere near the start of the circuit initiates another event, which initiates the next, and so on through the system (Figure 3). If we could find the first event and use it as the 'scope trigger, we could lock onto an image of what follows. This is perfectly true, but (as usual) in the real world, things are not always quite so simple.

A basic assumption in the majority of sequential logic systems is that the fastest signals are at the input end. Clocked elements generally perform as divider stages which reduce signal rate, so outputs tend to be slower than inputs. In a repetitive system such as a simple counter chip (counts 0 to 15 and back to 0) it is therefore possible to trigger the 'scope from the slowest signal in the system, e.g. the ripple carry or overflow output of the chip, and display the input or other signals which occur on the following system cycle.

Unfortunately, this approach breaks down when the system under test has a random or very long sequence, which is a very common situation, particularly when microprocessor systems are being investigated. Under these conditions, the event you wish to observe may be so long after the available trigger signal (derived from a single output of the circuit) that it does not occur during the 'scope sweep time. We have to look for a technique which will allow for this. The basic approach is to trigger the system

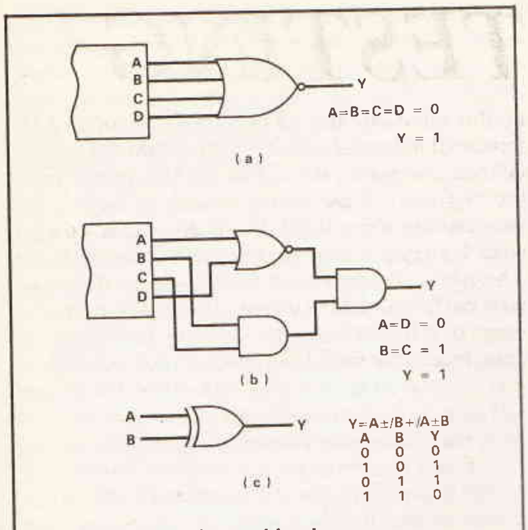


Fig. 4 Various logic combinations.

from a set of simultaneous inputs which only coincide occasionally.

The ordinary analogue 'scope is not suitable for this, because, whereas the analogue measurement system triggers on single vertical axis events (voltages) which are as near as possible in time to the events of interest, the digital requirement is for triggers derived from multiple co-incident horizontal axis events (pulse positions). This requires a lot more signal inputs and an entirely different set of control circuits from those in the conventional 'scope, and is why the wealthy among us spend lots of loot on Logic Analysers. What would be nice, is some kind of add-on to the ordinary 'scope, which would turn it into a logic analyser at lower cost. Let's investigate how to do this.

The logic analyser takes advantage of the low resolution required of the vertical (voltage) information in digital systems, by storing the information in digital memory as single set or unset bits. This has two implications: firstly, one-off events and non-repetitive signals (which are much more common in digital systems than in analogue) can be trapped and stored permanently for display whenever you like, and secondly, very long sequences can be trapped and displayed screen-by-screen at a large scale which might otherwise be beyond the resolution of the 'scope screen.

The simplicity of the logic analyser input channel (a fast digital buffer) and the cheapness of wide digital memory allow a very large number of channels to be incorporated in one instrument. 32 or 64 channels is quite common now. I'm sure that an analogue 'scope with more than two channels would come in useful, but the complexity of the channel electronics has always effectively prohibited it, though there are a few very expensive analogue 'scopes with three or four channels.

The large number of input channels of the logic analyser allows us to implement our ideal method of locking onto wanted events. Let us continue to investigate our simple (4 bit) counter chip for the moment. It would be nice to display a 'scope trace starting from, shall we say, the all-zeros state of the counter. The trigger event would then correspond to the logical AND of four LOW signals at the counter outputs (0000b). A four input positive logic OR gate would be the best device to pick off this trigger (Figure 4a). Now let's say we wanted to trigger our 'scope when the counter outputs stood at 6. The required combination would be the logical AND of 0110b, which would require quite a different gating circuit (Figure 4b). For every different TRIGGER WORD we would require a totally different logic circuit. Obviously, although our principle is good, we need a more versatile implementation than simple INVERT/AND gating. The device which comes to our aid is the exclusive or gate (XOR) (Figure 4c). The truth table shows that the output is 1 when the inputs are different and 0 when they are the same. Our signal is applied to one input, and the other is used for control. It will be obvious, particularly in very wide (eg 32 bit) input sets, that not all signals will be wanted to control the trigger. We therefore need, in addition to recognition of HIGH and LOW, a DON'T CARE, which allows a given input to be ignored for the purposes of the trigger. Left to itself, the control input of the XOR gate can only be taken HIGH or LOW. If it is taken HIGH, the gate output will be HIGH when the signal input is LOW, and if the control input is taken LOW, the gate output will be HIGH when the signal input is HIGH. Now comes the clever bit! If we connect the control input of the gate to its own signal input, they will be at the same logic level at all times, and the gate output will always be low. This condition implies negative logic, so we reverse the definitions of the other two alternatives, resulting in:
control LOW, signal LOW, output LOW.
control HIGH, signal HIGH, output LOW.
and accomplish our AND combination in negative logic (using an OR gate) as shown in Figure 5. A three-position switch on the control input to each XOR gate allows any signal line to contribute to the trigger when HIGH or LOW, or not to contribute at all.

This little gadget alone (with suitable signal buffering) will allow us to display two digital traces on our 'scope in real time (while the test is in progress), starting at a point defined by the trigger word, which can be as wide as we like. However, two traces do not give us very much of the information available. Our next task is to see how we can display more than this. It is not going to be possible in real time, as the 'scope is only capable of looking at its own two traces in this mode, but if we capture the information in a RAM chip, we can then look at many more traces, one after the other. This leads to a dissociation of the capture and display phases of the measurrement task, which is typical of logic analysers. The capture phase is outlined in Figure 6. The trigger logic releases a disable in the clock feed to a binary counter which supplies

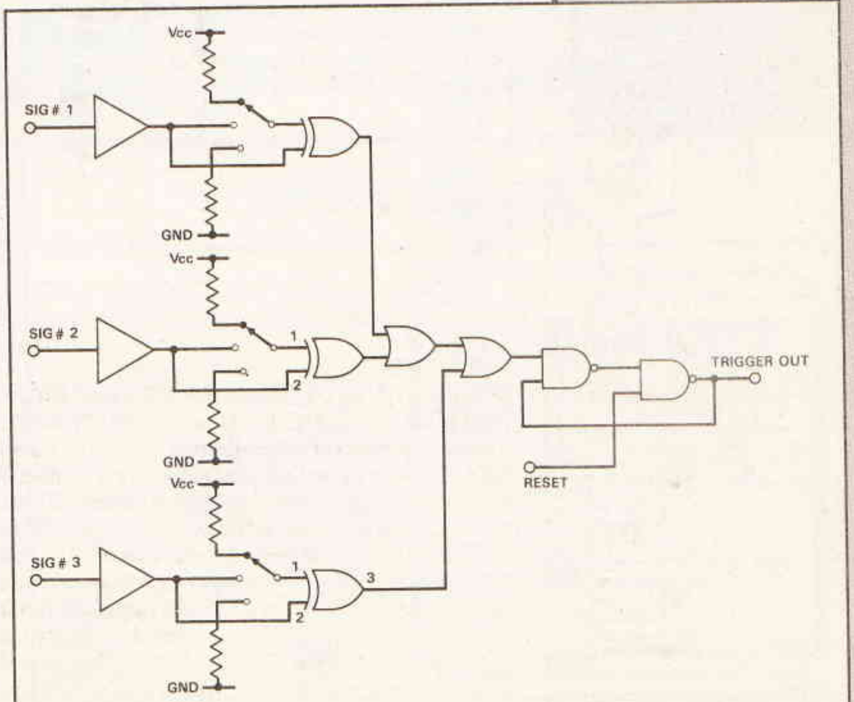


Fig. 5 Trigger selector (3 inputs shown).

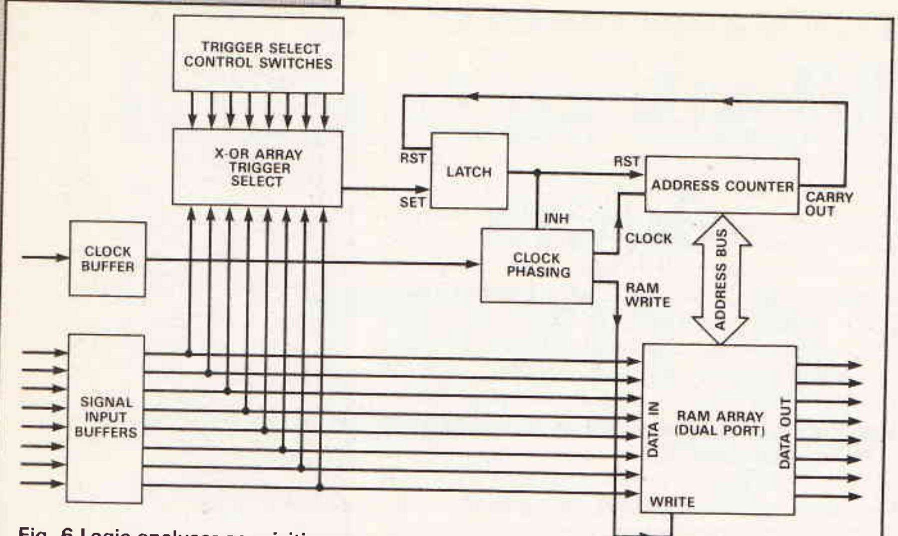


Fig. 6 Logic analyser acquisition system.

sequential addresses to a RAM chip. The logic levels appearing at the chip data inputs are latched into the chip by the clock signal (derived from, say, a master clock which drives the circuit under test), and the same clock then advances the counter so that the next RAM location is available for the next store operation. When the counter overflows, the carry out operation disables the clock feed, thus stopping the system with the RAM full of data. This is a very simple system, and is common to all digitisers.

The display phase of the operation is a little more complicated, and depends on the display device in use. If the captured data were sent to a microcomputer, the digital information would be read into a port, and software graphics commands used to draw traces on the screen. The 'scope needs a different approach. The basis of it is the method by which the single electron gun displays two traces on the screen. In the simple ALTERNATE mode, a multiplexer in the 'scope signal path displays a trace of channel 1 signal followed by a trace of channel 2 signal, and so on alternatively. A combination of the time taken for the phosphor to fade and human persistance of vision gives the impression of two simultaneous continuous traces. The traces can be positioned differentially in the vertical axis by means of an offset voltage added to each by the 'scope electronics as it is displayed. Now, there is no reason why this system should not be used for more than two traces, particularly as our required signal voltage resolution (trace height) is so low. What we need is a signal multiplexer, an offset voltage generator and some way of combining the signal and the offset. We also need some way of regenerating our signals from the RAM data, and some way of scaling the signals and offsets to create a convenient display. This is surprisingly simple, as shown in Figure 7. We allow the RAM address counter to run continuously, so that the RAM presents all our channels of date as serial bit streams on its data outputs. The RAM address counter overflow (ripple carry) enables the channel multiplexer counter to advance, and the same counter drives a DAC which generates the vertical channel offset. The DAC data increment (hard wired by leaving LSBs undriven) is fixed, but a potentiometer (gain control) across the output defines the total "picture height". A potentiometer across the data output buffer from the multiplexer controls the individual trace height. The 'scope is triggered during "playback" by the RAM address counter ripple carry, which effectively synchronises the start of each trace to the start of data.

There are many additional features which can be built in to the system. Examples are:

(a) pre-trigger mode, where the data acquisition runs continuously until trigger, when it continues for a specified number of samples and then stops. This allows the events which preceded the trigger to be displayed, but an additional RAM bit is required, to store a state change at the trigger point. The output from this is used as an extra display channel, so that the trigger point is shown on screen;

(b) clock qualifiers. We have assumed to date that data are stored on every clock after the trigger event. Sometimes, we are only interested in storing data on selected clocks. For example, if you are trapping bus activity in a microprocessor system, it is sufficient to capture the addresses of the op code fetches: it is assumed that the data fetches will follow them automatically, and the op code fetch addresses only occur once every few cycles (e.g. 6502, op code fetch averages about one cycle in three). Data volume will be reduced by this. The technique is to use a similar XOR array to the trigger system, to gate the clock, whereas the trigger mechanism is a sequential or latched condition, the clock qualifier is a combinatorial one. Great care is required in selecting suitable signals to serve as clock qualifiers, but it is a very powerful data compression technique.

These are just two examples of the way you can build more and more sophistication into your logic analysis add-on, but the basic instrument will serve for most purposes quite well enough. The major limiting factor in design will be the speed of the memory you can afford. A good quality logic analyser should have a maximum clock rate in the region of at least 50MHz, and a 20MHz machine is pretty slow by modern standards. Dynamic memory is really out, due to lower reliability and refresh overhead, so expensive static memory is the only real option. For a 50MHz capture system (20ns cycle), you would need at least 10ns memory, which effectively means ECL. For the 20MHz system (50ns cycle), 35ns memory would be required, which just allows use of the very fastest CMOS memory currently available. You will also see that some pretty nifty control logic will be needed, given the very small windows we have available, so a real system would need quite a bit of careful planning and experiment. It has been done, though, and I see no reason why the advanced amateur should not have a go. You could almost certainly beat the current average price tag of about £400+ for 20MHz and £1500+ for 50MHz.

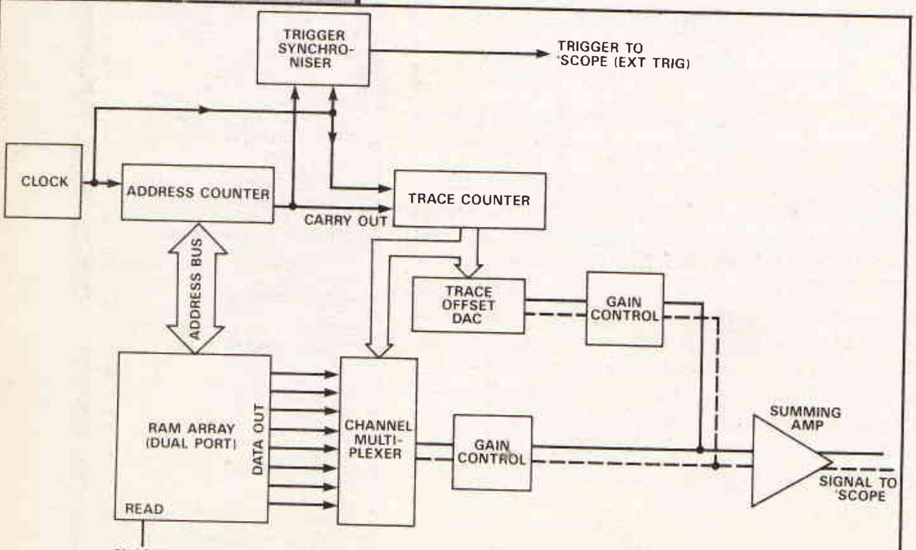


Fig. 7 Logic analyser trace generator for analogue 'scope.

Paul Freeman takes a sideways look at extracting energy from waste

WASTE

The idea of taking energy from waste suggests there is a fundamental fault in our manufacturing and industrial base. For it causes us to state the obvious; the waste should not be there in the first place. Leaving essential packaging aside, for nobody wants to receive damaged goods, the vast majority of operational processes create unwanted products. But to demand that this should not happen is not easy. The laws of physics state that no such machine or useful energy convertor can boast of being 100% efficient, meaning you never get as much out as you put in. We can try to minimise the waste by making our machines as efficient as we possibly can, thereby cutting the cost of consumed energy and reducing the waste that nobody wants.

Daily waste products have increased dramatically over the last thirty years for a variety of reasons and is fast becoming a big problem. Products have been manufacturered without any regard to the effect that the excess waste packaging has on the environment which has given us the problems arising today.

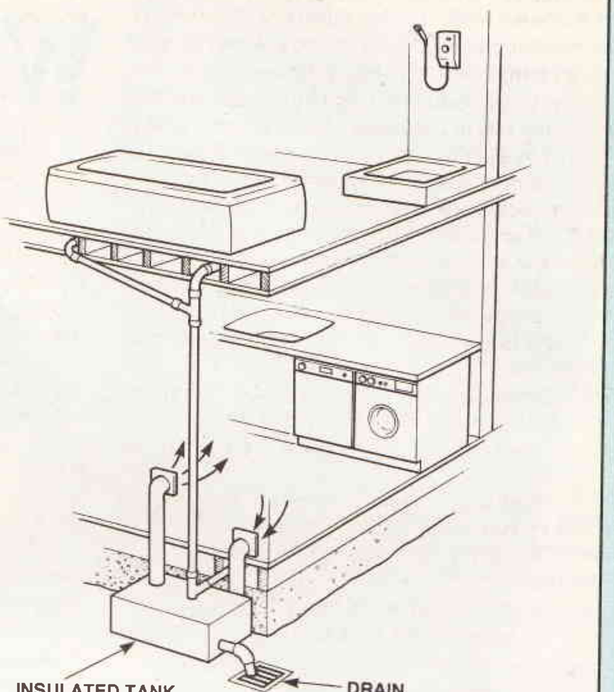


Fig. 1 Collecting hot water waste from baths, showers, washing machines and dish washers for removal of the heat before it goes down the drain

Consumer pressure resulting from media awareness has forced manufacturers to bow to consumer demand. Conservation is now treated as a resource and not so much of a saving particularly by the utility companies like electricity, gas and water.

Bio-technology could answer many of our problems in the future. With the demand for paper ever increasing, which all ultimately ends up as waste, wood farms might supply the short term answer until the demand on the wood industry levels out. This growth sustainable industry could greatly benefit from current research into what type of quick-growing trees are available and to where these farms could be placed to make optimum use of the suns energy and water available.

So what are the real practical alternatives and what can we do at home to make use of the energy in discarded waste apart from recycling bottles for the community.

Liquid Waste

Just consider how much hot or warm water we quite casually discard down the drain without a thought of the usefulness it could be to us. 1kg of water will release 4200Joules of energy when it drops by 1 Celcius. That is equivalent to a single bar electric fire being run for just over 4 seconds.. You probably remember that from your school Physics lesson, but something that perhaps is not commonly known is that water holds far more energy than most other substances for every kilogramme and every degree.

It needs a lot of energy to bring it to the boil! In fact, water is a most peculiar substance. According to other similar chemical substances, it shoud be a gas at room temperature. Thank goodness it isn't.

One way to extract the heat from water and thus deprive the rats in the sewer of a nice warm bath is to store it in a central site at ground level (Figure 1). All hot water wastes from baths showers, sinks washing machines and dishwashers, could be fed into the tank. If space is at a premium it could be an idea to build the storage tanks around the bath if space permits with control electronics to discharge the water at room temperature down the drain. If the tank is within the house, heat can be extracted naturally through the use of cooling fins or if heat is to be removed more quickly, a heat exchanger could be installed. The natural place for an insulated tank with heat exchanger is at ground level so all hot outlets can be gravity fed.

Cooling water down from a bath from say 60 Celcuis to 10 Celcius could extract about 42MJ of energy. This is the equivalent of the 1kw fire on for 700 minutes.

A heat exchanger could be the basis for a warm air ducting system in the house, taking in the cooler air and returning warm.

Another serious consideration in these days of changable climatic conditions is whether the water is discharged into the sewer anyway. In the summer months when the garden is dry, the cooled water could drain out through a divertor valve under gravity or pumped into leaky ground pipes to water your prize plants (Figure 2). Control electronics would detect a preset water temperature from a thermal probe and open a valve to discharge the water into the sewer or on to the garden. (Here is a nice little practical electronics project for readers to put together for publication in ETI).

Solid Wastes

For years now domestic household waste has been dumped in Land-fill sites and covered over when it's full without any regard for collective problems that arise as a result of mass indiscriminate dumping. The problem of 'leeching' is a very serious one if the site was not lined in the first place. Rainfall washes through the site and deposits toxic chemicals into underground water channels that eventually build up concentrations in our drinking water.

Organic waste products produce gas on these tips. The mixture of methane and carbon dioxide eventually finds its way up to the top and escapes. A few landfill sites once finished have had this resource tapped to power local machinery either on the site or close to. This controlled method of drilling into the rubbish to release and use the gas is by far the safest thing to do, otherwise if left, methane has been known to build up just below the surface providing a real risk of explosion, particularly if houses have been built on old sites.

Some new dumping sites have been prepared by lining the hole with plastic sheet. This prevents leeching and ensures that the eventual gas supply, once tapped can only come out of the bored hole.

Mixed solid wastes are more of a problem and becomes an expensive exercise when a substantial investment has to be made in sorting machinery. Whilst this cannot be avoided, it can at least be reduced by pre-sorting our rubbish at source. This is not common practice in Britain as yet but the time may be coming when commercial, environmental and even legal pressures will require us to do so. We might start by returning to incentive schemes. Large scale producers of waste like hotels or industry could gain a reduction in their business rate if they adopt such a policy. They could also benefit from lower energy bills after a payback period on bought treatment plants to recycle waste and /or Combined Heat and Power units. CHP not only provides much needed heat and electricity but can also benefit from exported electricity to the National Grid sold on the open market (See ETI May 90). Incentives should also apply to the individual like guaranteed cash return for collected glass bottles.

Sadly, Britain lags behind many countries in the recycling stakes. Holland has three bins for collecting glass, metal and the rest of the rubbish. The effort

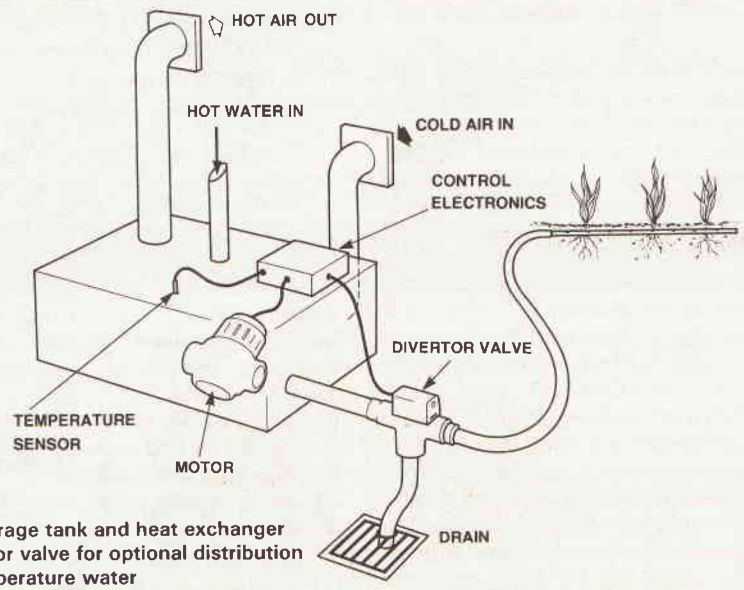


Fig. 2 Lagged storage tank and heat exchanger with divertor valve for optional distribution of low temperature water

D ENERGY

involved in taking your sorted rubbish to specialised skips is too much to bear for a lot of Britains so it might make sense to sort right at the point of disposal. Future Utility rooms in modern houses might have a hi-tech disposal unit that ends up with three or more shutes for waste materials, bagged and ready for collection. For those with a really lazy disposition, a single chute, for all waste could be available with electronic sorting.

Rubbish treatment is a complex and at present somewhat expensive operation to sort completely mixed rubbish into its component parts IF the vast majority of household rubbish has already been sorted and then collected, the cost of reprocessing could be reduced. Reprocessed bio-fuels are created at some plants by pelleting the burnable waste and bagging it. The heat or calorific value of pelleted waste is only about half that of coal and so would require a greater storage volume. Burning the recycled fuel in a more efficient manner will go some way to compensate for this difference. Sulphurous emissions are also below 10% of the emissions from coal.

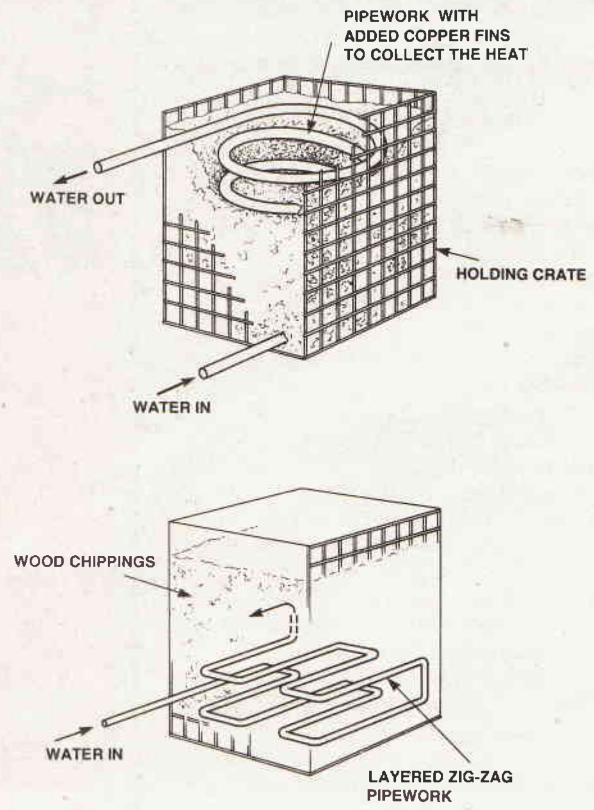


Fig.3 Experimental woodchip pile providing hot water

Incineration of household waste is a contentious issue. Whilst providing heat for nearby housing estates and generating electric power is an arguement for conservation and recycling energy, it still can produce plenty of airborn pollutants if not dealt with in the proper way. There have been many complaints over smells, and sooty smuts landing everywhere resulting from low temperature burning. Even more worrying are the toxic gases that are colourless and odourless. Again these can be dealt with if incinerated a higher temperatures.

So much for conflagration of waste, but what about less violent methods of treating rubbish?

Biological activity has very often been neglected in the part it can play to reclaim some of the sun's energy. Getting rid of garden refuse is now considered to be a weekend chore in todays urban garden, with miriads of journeys to take the garden clippings to the dump. Your friendly dustman will not take such things. So in view of the all-embracing tiny garden, where having a bonfire can be antisocial and dangerous, an alternative might be to shred up the twigs, branches, leaves and household organic waste for quick composting to redistribute back on the land. This is the natural way to put back energy into the soil. Another alternative, if there is a big pile of waste chippings from lopped branches is to make use of the liberated heat generated inside. Useful heat can be extracted from generated inside from the moist pile of chippings by embedding a copper water pipe in the form of a coil or layered zig-zagging throughout the body of the heap (Figure 3). The greater the metallic surface area the water can pass through using as long a pipe as posible with heat conducting fins, the hotter will be the outcoming water. When all the heat energy has been extracted, the pile can be composted and fresh waste can be added.

Another area that might be considered is the use of chemical enhancement of bio-degredation, extracting the heat at a faster rate and producing a valuable by-product called wood alcohol or methylated spirits. There is a huge potential market for methanol as it has been shown that a car engine can run on this, the most simple of alcohols. A point to bear in mind here is firstly the expense of the chemical used might defeat the object of the exercise and an excess of any reactive compound be it organic or otherwise might produce unwanted pollution.

During the war and for many years after, another collecting system was in operation. The Rag-and-Bone man would principally give you a small financial return for unwanted garments or rags. The recycled rags were used mainly for the manufacture of good quality paper when combined with wood pulp. This trading died in the late sixties as we entered the throw-away age. The fact remains in the 90s, old clothes just go to the scrap heap. If you are a caligrapher and handy with quil or ink pen you might have tried to make your own paper or parchment from rags.

Gaseous Waste

Domestically speaking, loosing a lot of hot air is indeed a problem unless arguements prevail in the household. The retention of warm air in the house has been greatly discussed over the years by the usage of insulation and it we will not delve into it further.

The principal source of hot gas waste is from gas-fire boilers and real grate fires. Great efforts have been made over the years by boiler manufacturers to improve the efficiency of such machines and it is true to say the waste heat output has been vastly reduced. But the real test is whether you consider the heat output could be reduced. Could the output benefit from a heat exchanger to lower the temperature of output flue gases without impeding the flow of burnt gases from the boiler? The same goes for open fires, the chimney lining and brick acts as a storage radiator throughout the use of the fire. Heat is slowly lost to the chimney cavity and out the top. Could a heat exchanger be used in the chimney breast to remove the waste heat by warming cool air from the room on one side and passing it out on the other? A difference in temperature and therefore pressure is required to get air to move in the first place.The greater the differences, the greater the movement of air will be.

Space has not permitted us to go further but the ideas presented here are intended as a guide to stimulate further thought and by taking a sideways look at the problem may cause technology to leap ahead by three paces instead of the developmental one.

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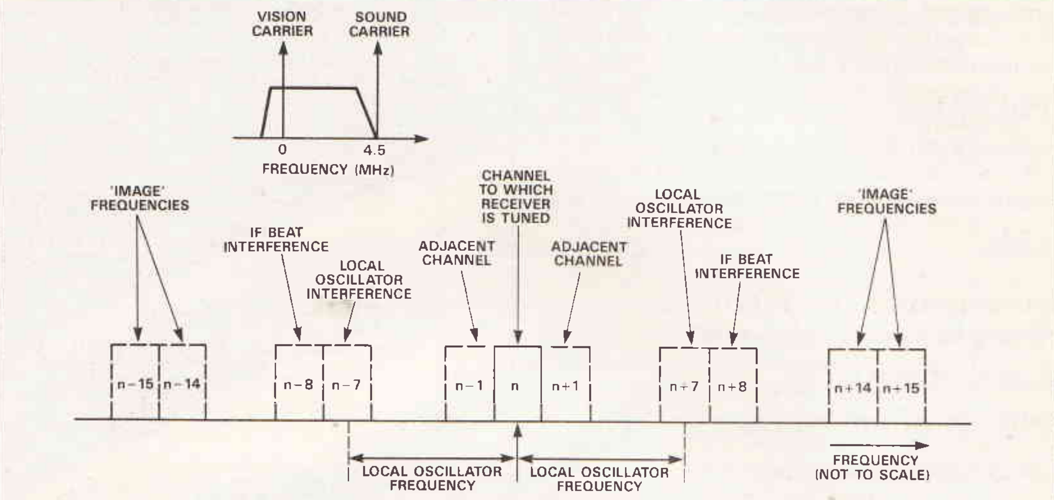


Fig. 1 The 'Taboo' channels which cannot normally provide extra services for either NTSC or ATV

James Archer reports on the American approach to High Definition TV

Large numbers of viewers in the United States of America already have a choice of twenty to thirty different television programme channels available to them, from cable distribution systems and off-air receivers. For this reason there has not been the commercial pressure towards direct-to-home satellite broadcasting introduced in other parts of the world.

With the large number of channels already available it is no surprise there is currently no real demand for direct to home satellite broadcasting in the USA. This is surprising as US viewers were the first in the world to install 'backyard' dishes to eavesdrop on the output of distribution satellites carrying programming intended for cable operators. The satellite route to HDTV therefore seems an unlikely way of bringing improved quality television pictures to the USA, and it is not surprising the emphasis in the USA has been different. This, has led the Americans to seek ways of providing higher quality and widescreen pictures over their existing terrestrial networks, both off-air and cabled. Rather than use the terms HDTV or EDTV, American broadcasters prefer the more generic term ATV,Advanced Television, and this has been defined as a collective term embracing IDTV (Improved Definition TV), EDTV (Enhanced Definition TV) and HDTV.

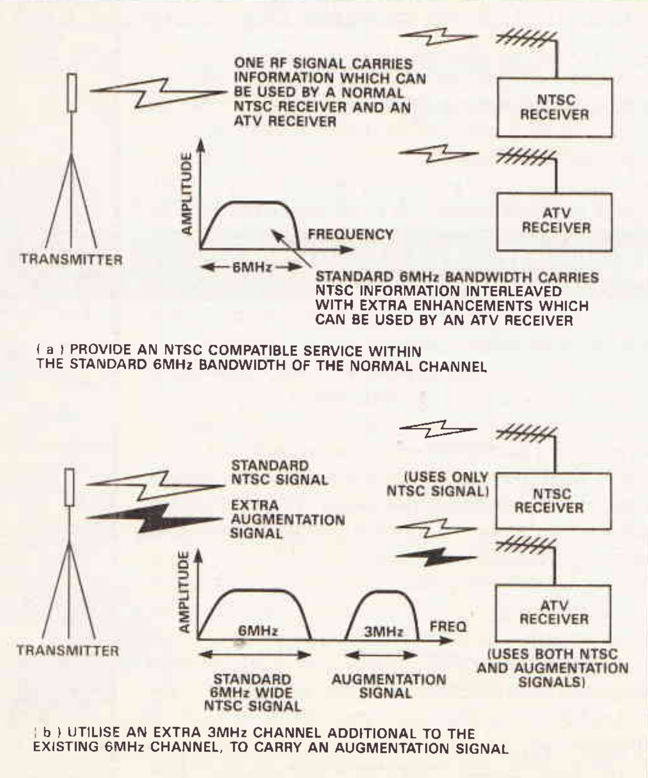


Fig. 2 The four main Spectrum usage options for ATV

In 1983 the Advanced Television Systems Committee (ATSC) was formed from manufacturers, broadcasters, cable and satellite operators, and the film industry, with the aim of coordinating and developing voluntary national standards for Advanced Television Systems. The work of this group has covered both studio production and transmission.

The major American requirement is to provide enhanced and higher definition pictures in a way that is as completely compatible with existing receivers.

All television broadcasting in the USA is regulated by the Federal Communications Commission (FCC), and in 1987 they formed an Advisory Committee regarding an Advanced Television Service (ACATS).

The FCC said it must be compatible with existing NTSC standard receivers, or must provide for the existing standard transmissions to be duplicated on another channel.Existing viewers must be able to continue to watch and no existing sets should be made obsolete. The FCC also said that any additional spectrum, required for Advanced Television services must be found in the existing VHF and UHF television broadcast bands. This could prove difficult to implement in many areas without interference being caused to existing transmissions.

Studies are continuing to see how spectrum usage might be improved by rearranging some existing allocations, and whether new TVs with improved selectivity and better interference rejection capabilities would make it possible to use previously avoided channels owing to interference.

A TV transmitter network generally consists of a large number of different transmitting stations situated around the country, and since the amount of radio-frequency spectrum that is allocated to television broadcasting is invariably restricted, several transmitters in different locations have to share the same channels. If transmitters are far enough apart then channel sharing is possible without interference, but in practice the distance is not great enough sometimes giving rise to 'co-channel interference'. Unfortunately, domestic receivers are built with economy in mind, rather than to the highest possible technical standards, and it is found that certain channels can cause interference if used within a certain distance of another transmitter.

Overcoming The Taboos

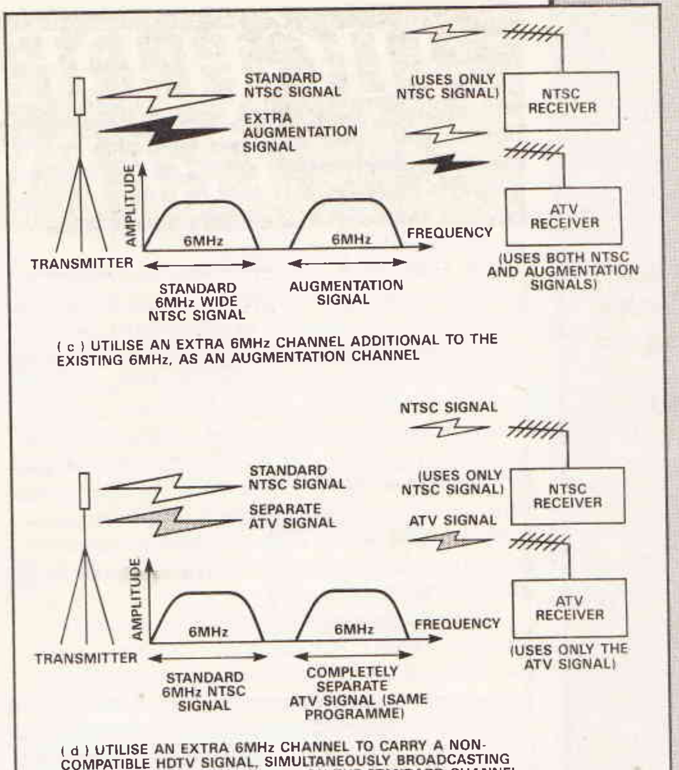
The FCC has had an improved performance experimental TV specially built. This receiver has high selectivity, carefully designed filter circuitry throughout, and special precautions have been taken to reduce the local oscillator radiation. The results suggest that if future receivers are built in this way all the taboo channels might be usable for ATV, but could take a considerable number of years to phase out older poor quality receivers.

The spectrum usage options for ATV

The rule for ATV spectrum usage, laid down by the FCC was that no system would be allowed to use more than an extra 6MHz of bandwidth on top of the 6MHz already used by normal NTSC signals. Four alternative methods by which ATV might be introuced were suggested by the FCC:

- Provide an NTSC compatible ATV service within the standard 6MHz of the normal 6MHz channel. This might sound impossible, getting 'something for nothing' but it must be remembered that the NTSC system does have a great deal of redundancy in it, and there are techniques which could be perfectly practicable.
- Utilise an extra 3MHz channel additional to the existing 6MHz channel, to carry an augmentation signal.
- Utilise an extra 6MHz channel additional to the existing 6MHz channel, as an augmentation signal.
- Utilise an extra 6MHz channel to carry a non-compatible ATV signal, simultaneously broadcasting the same programmes in NTSC on the standard 6MHz channel.

There are various other features to be considered if the three possible systems using augmentation channels are used. The simplest form of augmentation channel might be one where the additional spectrum is provided next to the normal spectrum allocation of that television station. This might not always be possible, if the optimum use of the spectrum is to be made, and even if they are, it is likely much of the present broadcast spectrum will need to be reorganised and reallocated first. It may be necessary to augment UHF television stations using other frequencies in the UHF band, and to use VHF augmentation channels for VHF stations. It could involve more complexity for both transmitters and receivers if the augmentation channel had to be in a different band from the main channel, say VHF augmentation with a UHF station. This is by no means impossible, and is one scenerio being considered.



(c) UTILISE AN EXTRA 6MHz CHANNEL ADDITIONAL TO THE EXISTING 6MHz, AS AN AUGMENTATION CHANNEL

(d) UTILISE AN EXTRA 6MHz CHANNEL TO CARRY A NON-COMPATIBLE HDTV SIGNAL, SIMULTANEOUSLY BROADCASTING THE SAME PROGRAMME IN NTSC ON THE STANDARD CHANNEL

Fig. 2 (continued)

The FCC invited comments on its initial decisions and many organisations have submitted many different proposals.

Standardisation in America

The insistance of compatibility from the FCC means the USA will take a very different path towards higher quality television systems than either the Japanese or the Europeans.

Although it goes without saying that in Europe standardisation is considered to be a good thing, and although only partially achieved, there are real differences in attitudes to standardisation in the USA.Having a single standard for television broadcasting in the United States, can have many advantages, including the provision of more programming for viewers and lower priced sets but there are also potential disadvantages. It is felt that the choice of a statutory inflexible standard might reduce consumer choice, and might prevent or delay the introduction of improved technology in the future. The FCC has for some years now tended to shy away from any standardisation processes for new radio and television services, its aim being the admirably democratic and capitalistic one of 'letting the market decide' which new systems would be successful. This idea seemed to reach its peak with the introduction of no fewer than five different technical systems for the introduction of stereophonic sound to medium wave radio channels. The FCC adamantly refused to come down in favour of just one standard, with the result that at least three systems were marketed. Being incompatible with one another, a driver moving from one State to another would need to have access to different decoders. So it is not surprising that stereo on medium wave has not been established.

In the case of ATV, the FCC has encouraged manufacturers and broadcasters to participate in the work of the advisory committee which it set up to consider ATV policy issues, and voluntary standards bodies such as the American National Standards Institute (ANSI), the Advanced Television Systems

Committee (ATSC), and the Electronics Industry Association (EIA) have all been asked for their views. From this it seems the FCC may eventually be prepared to endorse a mandatory or at least a recommended ATV standard, although by no means certain. They wish to preserve flexibility in the standards setting process, and in particular it wishes to ensure that even if a standard is finally recommended, methods of introducing further improvements should be considered.

In 1988 the FCC said that it felt that it might be too early to adopt ATV transmission standards, and asked those in the industry to consider the pros and cons of adopting one standard, and the best timing for such action. A suggestion was made that it might be better not to set firm standards, but to encourage compatibility amongst ATV systems and perhaps just to provide regulations limiting the amount and type of interference that any new ATV standard could cause to any other transmission. In this scenario the market would be left to decide how to cope with several standards, perhaps in the hope that a de-facto standard might emerge.

Another suggestion, considered by the FCC from the Massachusetts Institute of Technology was for the industry to adopt so-called 'open architecture' receivers where the additional cost of providing dual standard TV might well be quite small. If this development were to prove technically and economically practicable, it might be preferable to setting standards.

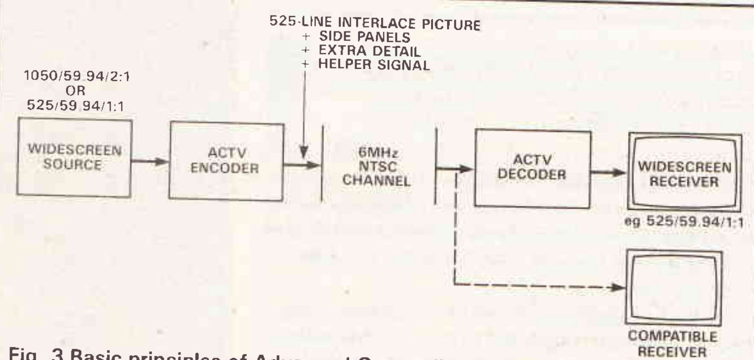


Fig. 3 Basic principles of Advanced Compatible Television

The field for the introduction of ATV in America is therefore wide open, with most of the possible systems in with at least a chance of succeeding. More than twenty different systems have been submitted to the FCC for consideration, some fairly similar to each other, and we shall examine a number of these. Before embarking on a tour of the various ATV systems, it is worth mentioning that the first HDTV system to gain any sort of a foothold in the USA was the Japanese 1125/60 system, which, thanks to a great deal of lobbying by a few manufacturers and a couple of broadcasters, was actually accepted as the approved HDTV standard by the Advanced Television Systems Committee. The Society of Motion Picture and Television Engineers (SMPTE) also favoured this system for HDTV production,and published a studio standard SMPTE-240M, which has since been updated. During the latter half of 1989 the SMPTE began further work to try to reach an agreed studio standard for the USA.They stressed that they would be looking at a wide range of different systems, including a proposal by the National Broadcasting Company (NBC), giving 1050 lines (i.e. 2 × 525 lines) and a field rate of 59.94Hz, which is likely to prove much more compatible with NTSC than the 1125/60 system. Incredible as it now seems, in the mid-1980s it even appeared the Americans would be supporting the Japanese 1125/60 System in the CCIR deliberations as to the world standard for HDTV. All this changed when US industry woke up to the fact that adopting a Japanese HDTV system might have disastrous long term effects on the US equipment suppliers. Several powerful manufacturers made their disagreement known, and this led to the work which was to result in the eventual FCC rulings on ATV. The Japanese manufacturers have not entirely given up hope of getting the 1125/60 system into the USA, however, and a number of manufacturers of production equipment for HDTV have formed an organisation, 'The HDTV 1125/60 Group', whose primary purpose is to enhance programme production opportunities by actively supporting and promoting the 1125/60 system as the production standard for programme origination and exchange between HDTV broadcasters. There are currently a number of facilities houses in the USA which use the 1125/60 standard for high-quality productions. In addition to these uses of the 1125/60 system, the Japanese have made several different proposals as to how various narrow-band forms of MUSE could be used to satisfy the FCC criteria, so they have obviously not yet given up the struggle.

At present, it is difficult to make predictions about either the technical aspects or the timing for the introduction of advanced television in the United States, but it seems certain that some form or forms of ATV will be transmitted within the next few years. The Advanced Television Test Centre (ATTC) has been set up in Virginia, and its engineers made a start at the beginning of 1990 testing some of the 23 systems that have so far been proposed. Several different types of test will be carried out on each system, where possible:

- Measurements and objective tests to assess the detailed characteristics of system.
- Tests to determine the amount of interference to other users caused by the particular system.
- Radio propagation tests.
- Tests over terrestrial and cable TV paths.
- Subjective tests to determine how viewers perceive the quality of the pictures, and whether problems of compatibility are noticed.

Proposed American ATV systems

We will first of all give brief technical details of some of the many systems and ideas for ATV which have been proposed, although not all have actually been submitted to the FCC, and then try to make some comparisons, and to draw some conclusions.

Advanced Compatible Television

Towards the end of 1987 a team of engineers at the David Sarnoff Research Centre, a contract research organisation, with the cooperation of RCA, NBC, GE, Thomson and others, proposed what is claimed to be a fully compatible system which can provide High Definition Television and which can transmit its signals using only a standard 6MHz wide NTSC channel. To understand how engineers can manage to squeeze a quart into the pint pot of the 6MHz wide channel, it is useful to remember that in the NTSC system, colour was added to the black and white signals without using any more bandwidth, using a frequency interleaving technique. Effectively, the ACTV system, and several of the other proposed systems, manage to squeeze even more information into the basic channel, and this extra information can be used to improve the quality of the transmitted pictures.

Once the initial headline-grabbing hype of 'HDTV in a 6MHz channel' was overcome, and fuller details of the system became available, it became apparent that ACTV is actually an evolutionary family

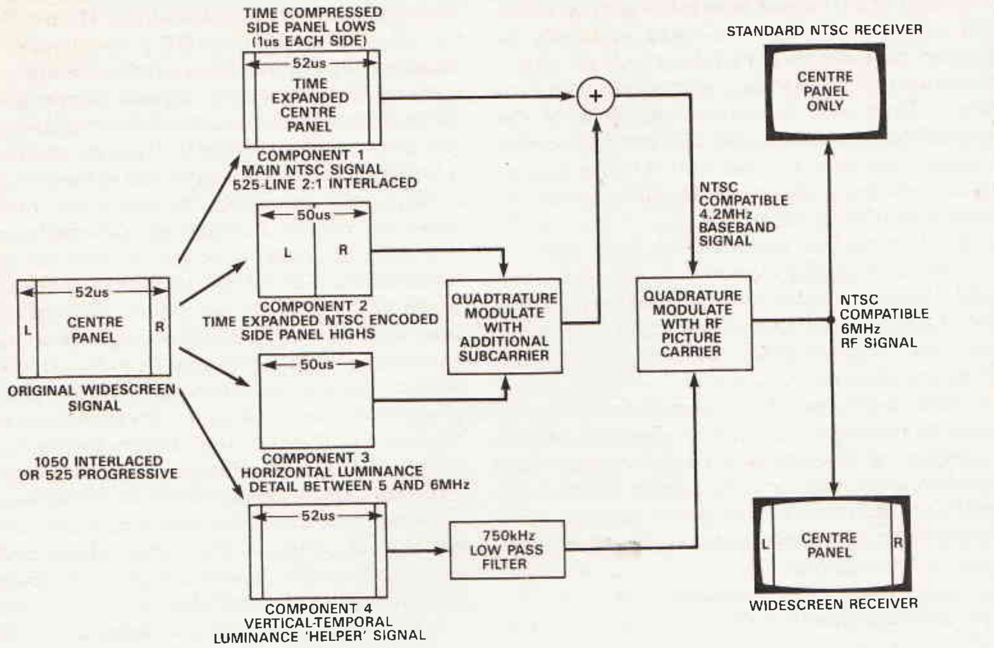


Fig. 4 Coding system used for ACTV-I (single channel NTSC) — compatible enhanced television system

of three systems, and that only the first two of the steps towards HDTV can actually be introduced within the constraints of a standard 6MHz channel.

All the ACTV signals can be viewed on existing receivers as well as ACTV receivers, so the basic compatibility of the system is very good.

ACTV-I NTSC compatible EDTV

The so-called 'introductory system', ACTV-I, is not in fact the simplest possible system, as we shall see later, but its signals can be sent along a normal 6MHz bandwidth TV channel. ACTV-I cannot provide full HDTV quality, and is more correctly described as an EDTV system, but it can take a wide aspect ratio 1050 line interlaced picture or a 525-line sequentially scanned picture as its source, and provide both higher quality widescreen pictures for viewers equipped with new receivers, and normal 525/60 interlaced pictures for viewers with standard NTSC receivers. Figure 4 shows the basic operating principles of ACTV-I.

A 1050-line 59.94Hz interlaced picture is recommended as the ideal source signal for ACTV, but to use this signal for ACTV-I purposes it must first be converted to a 525-line progressively scanned image, since this type of signal is the best type to process for transmission over the normal 525/59.94/2:1 transmission network, and it also allows various processing algorithms to be used to derive a signal which contains information about the vertical temporal detail in the pictures. The first process in ACTV-I, as can be seen from Figure 4, is to split the widescreen high-definition picture into four different components. The first component, the main signal, is a signal with the same aspect ratio and bandwidth as a standard NTSC signal; the other three components contain extra information which can be used to provide the viewer with a wider aspect ratio picture and better resolution, when used with the main signal. The extra three components are carried along with the main signal channel on sub-channels, in a similar way to which the colour information modulates a subcarrier. This is added to the black and white signals to provide compatible NTSC colour pictures. Figure 5 shows how this is done, and indicates the positions in the spectrum of various additional signals.

Obtaining Component 1 — The Main NTSC signal

The 525-line progressively scanned source picture, with its widescreen aspect ratio of 16:9 (an improvement on the initially submitted 5:3), is horizontally scanned in the normal line-time period of 52μs. Since the widescreen picture has been scanned in the same time that is normally taken to scan a 4:3 picture, the horizontal bandwidth and the amount of detail available on a horizontal line is increased. The source picture is converted to a standard 525 line YIQ (i.e component format) interlaced signal, which forms the basis of the first component.

The YIQ signals are filtered to limit the bandwidth of the luminance information in this first component to 5MHz, and the colour-difference information to 600kHz, which are actually slightly better than the resolutions available on standard NTSC pictures. The high-frequency information above 5MHz, in practice a band from stretching from 5-6MHz, is separated out, and, as we shall see later, is used to form component three of the ACTV system.

To actually form component one, the first step is to select the central 4:3 part of the original widescreen picture; this is done, line by line, and then the central part of each line is expanded until it takes up 50μs almost the full 52μs active line time utilised by an NTSC receiver. A signal expanded in the time domain will require less bandwidth, and so will comfortably fit into the normal NTSC bandwidths for transmission. The remaining two microseconds of the 52μs line time are used to carry some of the information that was previously carried in the 'side-panels' of the 16:9 picture. these were discarded to form the 4:3 picture. Since this information is carried only for 1us at the start and finish of each line, and since most conventional TV displays overscan, a standard NTSC receiver should display only a standard 4:3 picture; the extra information at the edges of the picture will be ignored.

In the case of a widescreen receiver, this will have circuitry which can take the information in the one microsecond wide strips and expand it to display the side panels along with the 4:3 picture. The amount of information which can be squeezed into the time-compressed 1μs strips is however limited; compressing the side panels by a factor of six results in the maximum frequencies that can be carried within the standard bandwidth NTSC channels being about 700kHz for luminance and 83kHz for chrominance. Because of this, it is not possible to carry all the information about the side panels in the 1μs strips, so the side panel information has to be separated into two frequency bands, known as the 'lows' and the 'highs'. Only the low frequency information about the side panels can be carried in the 1us strips, but these frequencies carry the direct current component of the television picture and most of the energy of the signal.

The 4:3 aspect ratio picture and the low-frequency parts of the compressed side panels can now be NTSC encoded, after filtering, and the result fits into the normal luminance and chrominance regions of the NTSC spectrum.

In order to ensure that the join between the side panels and the normal 4:3 picture will not be visible on 5:3 displays, the transmitted centre panel information is actually made to overlap the side panels, so that a very narrow strip covering the area where the join takes place is actually transmitted twice. This extra information can be used by the decoder in the receiver to provide a smooth transition between the edges and the main picture, so no hard edge is visible.

which will be described in the next section, without causing interference to the main NTSC signal.

Component three — extra horizontal detail

The scanning of the 16:9 picture in 52μs means that more horizontal resolution would be available than for a standard NTSC signal. The first two components have only transmitted luminance information up to 5MHz, so in order to allow the widescreen receiver to make use of the potentially greater resolution it is necessary to find a method of carrying information about the luminance detail contained in the band of frequencies between about 5MHz and 6.1MHz. After selecting the information within this band by appropriate filtering, the extra luminance detail for the whole of the 52μs widescreen line is time compressed by the small amount necessary to squeeze it into the 50μs which is used to carry the centre panel of the picture. This reduction gives better resolution in the side panels as modulation here causes undesirable effects. The result is an extra 1MHz of horizontal resolution can be obtained over the whole image. Component three contains very little low frequency information and is therefore a low energy signal, so that it can be compressed in amplitude and quadrature modulated

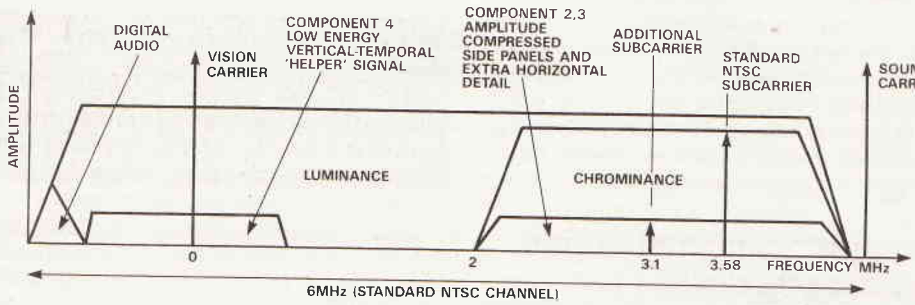


Fig. 5 The RF Spectrum occupied by the various components of an ACTV-I system

An incidental advantage of the filtering process that takes place with ACTV pictures is that ordinary NTSC receivers actually show an improvement in the picture quality; the cross-colour and cross-luminance effects are reduced, and some increase in resolution is also claimed.

Component 2 — the high frequency parts of the side panels.

If the displayed side panels were to contain only the low-frequency information transmitted so far, there would be a noticeable resolution difference between the centre and the edges, so some method has to be found of transmitting the side panel 'highs'. The luminance frequencies between 700kHz and 5MHz corresponding to the side panels and the chrominance frequencies from 83kHz to 600kHz are filtered, and the chrominance is quadrature modulated onto the luminance signal at 3.58MHz. The side panels take up about 6μs at each end of the 16:9 widescreen picture and are then expanded in time to fill the part of the active line that is used by the centre panel, about 50us long. The time expansion causes the bandwidth requirement for these side-panel highs to be reduced to about 1MHz. It was found by experiment that if component two was expanded to fill the whole of the 52μs line period, as might seem the obvious thing to do, the resolution of the edge panels was reduced. Figure 4 shows how component two is made up. Because component two is a low energy signal it can be compressed in amplitude and quadrature modulated onto a new subcarrier, together with component three, onto a separate subcarrier at 3.1MHz, together with the component two signals. Figure 5 shows the effect of this, which is to include a low-amplitude sub-band containing the information about components two and three within the spectrum of the main signal. The subcarrier frequency of 3.1MHz is an odd multiple of half the line rate and was chosen so that the energy from the signals relating to components two and three interleaves into gaps in the spectrum of the main signal, and the subcarrier is made to invert its phase on alternate lines. All this ensures the extra information can be carried along with the main signal without having any effect on normal NTSC receivers. Effectively the extra subcarrier is hidden in a small portion of the spectrum normally given over to colour signals, but instead this region is dedicated to carrying the high resolution luminance detail. This technique was first developed by Dr. Fukinuki of Hitachi Research Laboratories, and this hidden region is sometimes called the 'Fukinuki hole'.

Component four — the vertical temporal helper signal

It was explained earlier that one source standard for the ACTV system uses a 525-line continuously scanned display, and we saw this must be reduced to a 525-line interlaced display if the pictures are to be sent along a standard 6MHz bandwidth radio frequency channel. It is then possible to include line doubling circuitry to convert the incoming interlaced signals into a progressively-scanned display. Invariably this gives less than perfect results on some moving parts of the image, and so component four has been introduced to provide a so-called 'helper' signal to transmit extra vertical-temporal information which a suitable receiver can use to increase the amount of vertical detail present, especially in moving images. For this system to work perfectly the helper signal would enable the receiver to restore the vertical detail in moving parts of the picture that was lost in the original conversion to an interlaced display. In practice the algorithm that the receiver will use to reconstruct the image is known, and it is therefore possible to work out at the source when certain parts of the moving picture will displayed erroneously by the receiver. The fourth component, the helper signal, can be used to transmit an error signal which carries enough detail to enable the receiver to correct the display. The helper signal could also be used to send control signals to switch in appropriate motion adaptive processing circuitry at the receiver.

Since the helper signal consists only of error signals, the information sent will be small, so a relatively narrow bandwidth signal can be used. The helper signal currently used as Component four is restricted in frequency to 750kHz, and is transmitted in phase quadrature with the main vision carrier.

The Composite Signal — A Summary

The ACTV system relies on carrying extra components, in addition to the normal luminance and chrominance signals, within a standard NTSC signal. If this happens in a compatible way, the extra signals must be invisible to the viewer with an NTSC receiver. In addition, the extra components must be readily extractable from the total signal by an ACTV receiver. Figure 5 has been demonstrated to work well, but there are many possible detailed modifications which could be made to alter the balance between the above requirements. In particular, the helper signal could take different forms, and it may even be possible to add several more such signals for future use. There is even room to accommodate an additional digital audio signal, shown in Figure 5.

Demonstrations have shown that the requirement for the extra components to be invisible on a normal NTSC receiver is generally well met. We saw earlier that the compressed side panels will be hidden by the normal receiver overscan, so component one provides no difficulties. Components two and three are quadrature modulated onto a carefully selected subcarrier whose frequency and phase alternation have been chosen for minimum visibility.

Component four, the helper signal, has been arranged so it quadrature modulates the vision carrier, and the inevitable pattern is spatially correlated with the main vision signal. On older NTSC receivers the helper signal is difficult to perceive because of the way it is placed spatially with respect to the vision signals, and in modern receivers using synchronous radio frequency detectors the helper signal can actually be removed before it reaches the display.

The American approach to HDTV will continue next month

ETI

1990 FEATURES INDEX

INDEX

THE ETI SBC 09

Mike Bedford continues with his micro-controller board

FIRMWARE 2

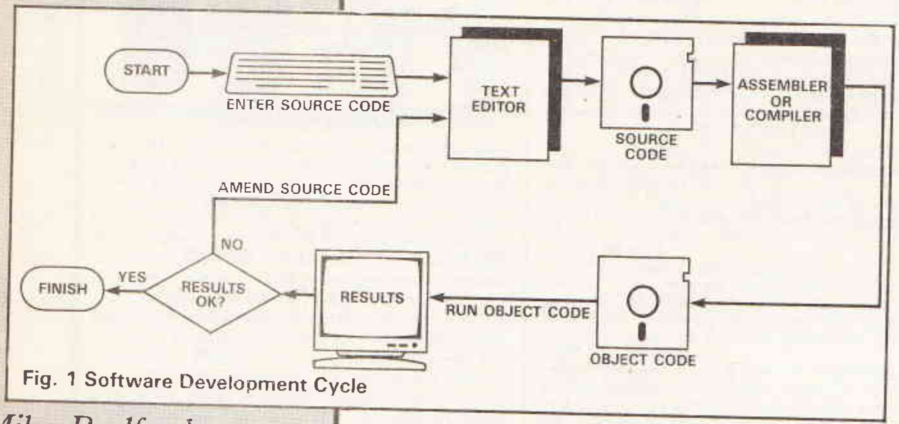


Fig. 1 Software Development Cycle

Last month we published hardware details of the SBC-09, a Motorola 6809 based control board. This month we intend to guide the reader in the method of developing firmware for this control computer. In particular we shall take a look at the architecture and instruction set of the 6809 microprocessor, which is necessary for assembler programming. We shall also describe the 6821 PIA from a programming point of view. It is assumed the reader of this article already has some programming experience (even BASIC) but perhaps knows nothing of firmware development. The article will be most readily understood by those with some assembler experience (of any processor) but with perseverence it is thought that this is not an absolute prerequisite. Reference 1 is recommended for those who find this tough going and would like instruction in 6809 assembler programming starting with the basics.

Firm Development

Before complicating things by getting into the realm of firmware, let's have a quick reminder of the steps involved in software development in general. Figure 1 shows the development cycle for programming in assembler or a compiled language and will be familiar to those who have programmed any computer in just about anything other than BASIC which is a special case, being an interpretted language (usually). Actually many of the modern generation of compilers and assemblers (eg Turbo Pascal for the PC) tend to camoflague this process, presenting an integrated environment for editing, compiling (or assembling) and running the program but, this is what actually happens.

Turning now to firmware development for a control board, the type of development cycle described above is just not possible since the target system (ie the one on which the program will run) will be a minimal design capable of only what is necessary for its control application and this won't include the ability to run editors and assemblers. The implication is that the firmware must be developed on a separate system which is normally referred to as the development system. The simplest development cycle is illustrated as Figure 2. You'll notice the assembler/compiler box is now labelled cross-assembler/cross-compiler. If the development system happens to be based around the same processor as the target board then a straight assembler or compiler would be used. In the general case it will be the cross-equivalent, this being the name given to an assembler or compiler which runs on one processor but generates code for another. The snag with the development cycle in Figure 2 is that it requires an EPROM to be erased and reprogrammed for each itteration. This is slow and frequent unplugging and plugging of the EPROM into the target will result in un-reliability due to socket wear.

At the expense of some extra hardware, these problems can be overcome by adopting the alternative firmware development cycle illustrated in Figure 3. In actual fact a further quantum leap in convenience is achieved by use of a processor emulator instead of an EPROM emulator. This eases software debugging by allowing break points to be set, memory to be examined and/or modified and registers to be examined to mention just a few features. Since these cost many thousands of pounds, it will remain a dream for nearly all home enthusiasts and we shall therefore say nothing more about it. The EPROM emulator shown in Figure 3, is more affordable. This is an expansion board which attaches to the development system where it appears like ordinary memory, so the object code can be written to it. Once this loading has taken place, the target system, into which a pod from the emulator is plugged, 'sees' this same data as if it were in an EPROM plugged into the target. The need for EPROM erasing and blowing is now obviated during development and the code only goes into a real EPROM once all the bugs have been ironed out.

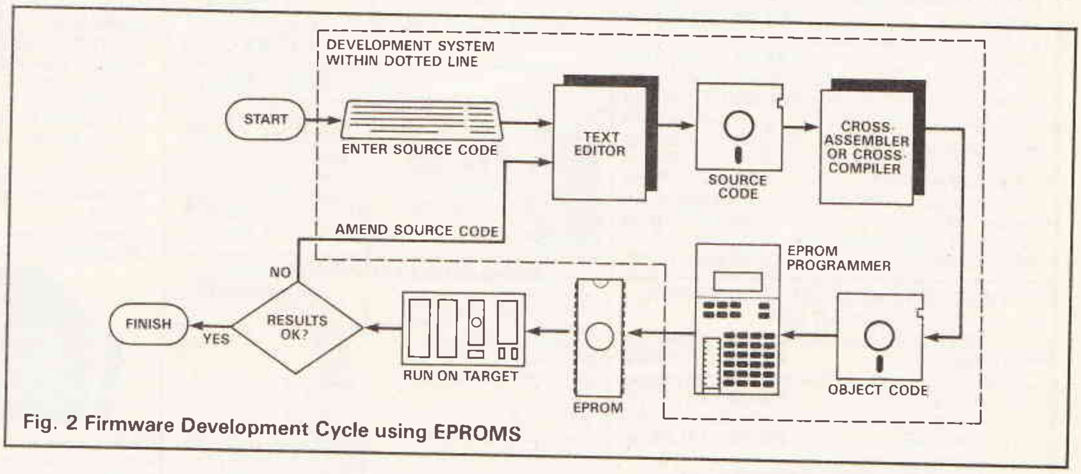


Fig. 2 Firmware Development Cycle using EPROMS

The PC As A Development System

Although other machines could probably be used, depending on the availability of suitable cross-assemblers, it is the intention here to give some advice for those wishing to use an IBM PC, PC/AT or compatible as the development system. This decision was made on grounds of software availability, increasing use of PCs amongst electronics enthusiasts plus the fact that this is what the author uses!

The first software tool required is a screen text editor. The only editor which comes with MS-DOS as part of the system is EDLIN. This is basic, to say the least, being only a line editor and is very tedious for anything other than perhaps editing the odd 5 line .BAT file. Most readers will have invested in a word processor for their PC. This will undoubtedly present a full screen display but will, unfortunately, have a nasty habit of adding a whole manner of headers and embedded control characters into the text of the resultant file.

What is needed is usually referred to as a text editor and produces an output file containing only what the user typed in — an essential if it is to be read by an assembler or compiler.

Although full commercial text editors are available, I would be inclined to recommend one of the numerous shareware products available at a much lower price. A couple of basic PC text editors I have already used are ED and EDIT (a couple of very original names!). More comprehensive offerings listed in the shareware catalogues include EDWIN, QEDIT and NYEDIT.

Turning now to 6809 cross assemblers and compilers, C and PASCAL compilers are only available commercially at a not insignificant price. A cross-assembler, is available as public domain software and is therefore expected to be the preferred language for most users. Various cross-compilers are available from Grey Matter at 4, Prigg Meadow, Ashburton, Devon TQ 13 7DF — Tel: (0364)53499. The public domain assembler is on a disk of Motorola cross-assemblers (which also includes the rest of the 6800 family, the 6502 and the RCA 1802/1805) and is available from most of the numerous public domain/shareware suppliers. For those who don't already use shareware, the supplier used by the author is S.M.S. at 19, Carshalton Road, Camberley, Surrey — Tel: (0276) 681864.

The two hardware tools required are an EPROM programmer and an EPROM emulator unless you have a limitless supply of blank EPROMs, an EPROM eraser is also required. The December 1989 issue of ETI contained a review of EPROM programmers for the PC. To summarise the findings, the Sunshine Electronics EW-901BN was recommended as a good buy for the home user at £89 + VAT. It is available from Chipboards Ltd., 65, High Street, Bagshot, Surrey GU19 5AH — Tel: (0276)51441. EPROM emulators for the PC are an extremely rare breed and there is almost certainly nothing available commercially at a price to interest the amateur. This being so, next month's ETI will feature a constructional article on a PC EPROM emulator capable of emulating all 27-series devices up to the 27512. The following month we will describe the construction of a safe EPROM Eraser with electronic timer.

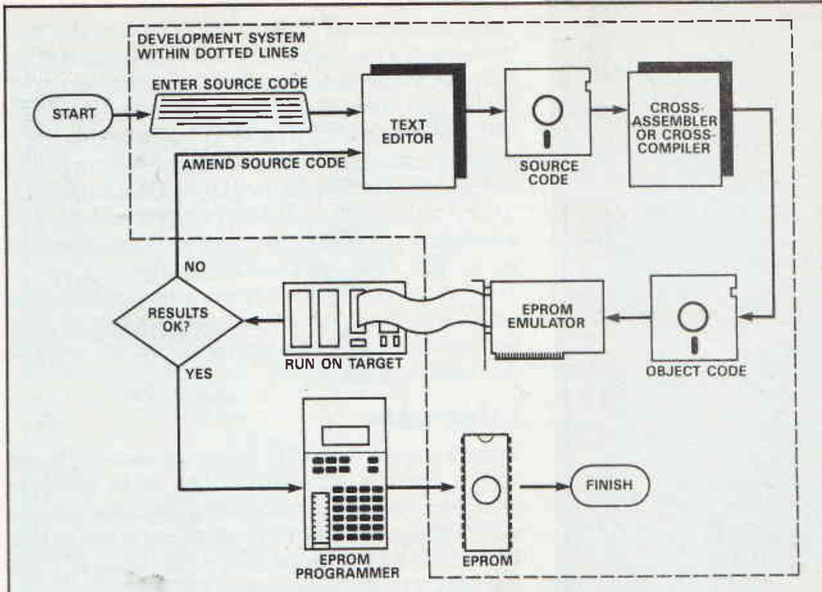


Fig. 3 Firmware Development Cycle using an Emulator

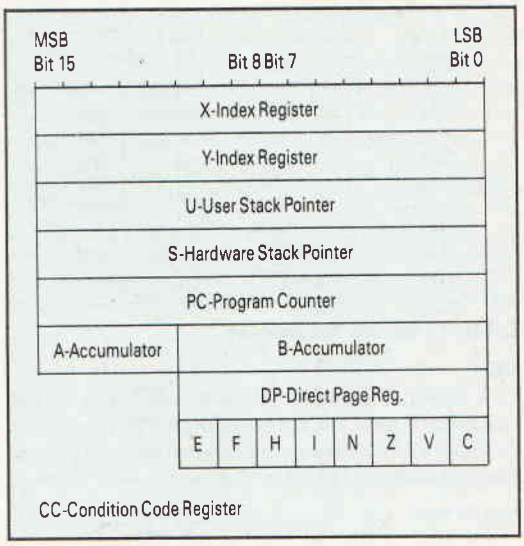


Table 1

6809 Architecture

Table 1 shows the 6809's internal registers. These are described briefly in this section.

Table 1 : 6809 Registers

Index Registers — X, Y
These 16 bit registers are used in indexed addressing to point to memory.

Stack Pointers — U,S
These 16 bit registers are used to manipulate the user and hardware stacks respectively by use of push and pull instructions. The hardware stack is used automatically by the hardware during interrupts and subroutine calls. Either stack may be used for user data. Both these registers may also be used as general purpose index registers.

Program Counter — PC
This 16 bit register is automatically updated by the processor to point to the next instruction to be executed.

Accumulators — A,B,D
A and B are 8-bit accumulators which in certain cases may be considered to be a single 16-bit accumulator called D. A is the most significant byte and B the least significant byte of D. These registers are used in arithmetic instructions and for data manipulation.

Direct Page Register — DP
This 8 bit register is used in the direct addressing mode which is used because of its efficiency in terms of both speed and memory usage. In this addressing mode, only the least significant byte of the address of the data is given in the instruction, the most significant byte having already been loaded into the DP register. Clearly this is only effective if a number of addresses within the same 256 byte block are to be accessed.

Condition Code Register — CC

This register consists of 8 processor status flags. The C bit indicates that a previous instruction resulted in a Carry from an accumulator. The V bit indicates that a previous instruction resulted in an oVerflow from an

accumulator. The Z bit indicates that a previous instruction resulted in Zero. The N bit indicates that the result of a previous instruction was Negative. If the I bit is set, the processor will not recognise interrupts on the $\overline{IRQ}$ pin. This bit is automatically set by $\overline{RES}$, $\overline{NMI}$, SWI, $\overline{FIRQ}$ and $\overline{IRQ}$. The H bit indicates that the result of a previous instruction was a Half carry. This is a carry from bit 3 and is used by the DAA instruction. If the F bit is set, the processor will not recognise an interrupt on the $\overline{FIRQ}$ pin. This bit is automatically set by $\overline{RES}$, $\overline{NMI}$, SWI and $\overline{FIRQ}$.
The E flag is used by the RTI instruction to determine whether the Entire set of registers was stacked on entry to interrupt (ie $\overline{IRQ}$) or whether just the PC and CC was stacked ($\overline{FIRQ}$).

Interrupts

Table 2 shows the 6809 interrupt vectors. These vectors are the addresses of the code which is executed when the corresponding condition occurs. It is the responsibility of the programmer to ensure that each of these locations contains a valid address. Each interrupt is briefly described in this section.

Vector Address		Vector Description
MS Byte	LS Byte	
FFFE	FFFF	RES
FFFC	FFFD	NMI
FFFA	FFFB	SWI
FFF8	FFF9	IRQ
FFF6	FFF7	FIRQ
FFF4	FFF5	SW12
FFF2	FFF3	SW13
FFF0	FFF1	Unused

Table 2: Vector Addresses

RES
This vector is executed when the $\overline{RES}$ pin on the processor is held low for more than 1 bus cycle. On the SBC-09 this happens at power on and accordingly this vector should point to the initialisation code.

NMI
This vector is executed when the $\overline{NMI}$ pin on the processor (Non-Maskable Interrupt) undergoes a negative transition. This level of interrupt is not used on the SBC-09.

FIRQ
This vector is executed when the $\overline{FIRQ}$ pin on the processor (Fast Interrupt Request) is held low so long as it is not masked by the CC register. This level of interrupt is not used on the SBC-09.

IRQ
This vector is executed when the $\overline{IRQ}$ pin on the processor (Interrupt Request) is held low so long as it is not masked by the CC register. On entry to the interrupt routine, all registers are stacked and further $\overline{IRQ}$s are prevented by setting the I bit in the CC register. IRQ will be re-enabled on exit from the interrupt routine due to the un-stacking of the CC register and it would be unwise to un-mask it implicitly within the routine. This interrupt may be generated by the 6821 on the SBC-09.

SWI, SWI2, SW13
These vectors are executed as a result of the three software interrupt instructions SWI, SWI2 and SWI3 and may be considered as analagous to subroutines. All registers are stacked and SWI (but not SWI2 or SWI3) mask IRQ and FIRQ. Clearly the masked IRQ will be un-masked (so long as it was in this state before execution of SWI) on exit from the interrupt routine due to unstacking the CC register.

Addressing Modes

The 6809 has a number of addressing modes which may be used with its instruction set.

Whereas some instructions only allow a single addressing mode, the availability of a comprehensive range of addressing modes provides flexibility in many of the instructions.

Each of the addressing modes are described in this section.

Implied Addressing
In this addressing mode, the operand is inherent in the instruction. For example the instruction ASK (Add B to X) can only operate on these registers.

Immediate Addressing
This addressing mode allows a constant value given in the instruction (actually it is stored immediately following the Op-code) to be used as the operand. Eg. LDA # $80 causes the value hexadecimal 80 to be loaded into A.

Extended Addressing
Here the operand is the address of the data to be used in the instruction. Although a numeric value can be used it is more common to use a previously defined label which will be substituted by the assembler. Eg. LDA FRED causes the data at address FRED (a label previously defined) to be loaded into A.

Extended Indirect
This is similar to extended addressing but has a further level of indirection. In other words the operand is the address of the address of the data. Eg. LDA (FRED) will cause the data at the address at address FRED to be loaded into A.

Direct Addressing
This is similar to extended addressing except for the fact that only the least significant byte of the address of the data is given, the most significant byte having previously been loaded into the DP register. This addressing mode is used as it executes more quickly and the instruction takes up one less byte. There are various types of assembler syntax for this mode. Eg. in LDA >L1, the ">" forces the assembler to direct addressing. Giving only a 1 byte address obviously forces direct addressing and use of the SETDP assembler directive will cause syntax which would otherwise result in extended addressing to generate a direct addressing instruction if the address given is within range of the DP register.

Register Addressing
Here the instruction acts on one or more registers. Eg. TFR A,B transfers the contents of accumulator A to accumulator B.

Indexed Addressing
This addressing mode uses an index register (usually X or Y) to generate the address of the data. In its most basic form, the index register contains the address of the data. Eg. LDA, X causes the data at the address in X to be loaded into A. The second category of indexed addressing uses a constant offset. Eg. LDA 2,Y causes the data at the address generated by adding 2 to the contents of Y to be loaded into A. The third category uses an accumulator as an offset. Eg. LDA A,X causes the data at the address generated by adding A to X to be loaded into A. The final category allows the index register to be post incremented or pre-decremented. Eg. LDA ,X+ has the same effect as LDA ,X except that the index register X is incremented after the load. LDA ,-Y causes the index register Y yo be decremented before the load. Double increments or decrements may also be used. Eg LDA,Y++.

Index Indirect Addressing
This addressing mode is the same as indexed addressing but has a further level of indirection. Eg LDD (,X + +) causes the data at the address pointed to be X to be loaded into D following which X is incremented by 2.

Relative Addressing
This addressing mode is used in branch instructions and is so called because it causes a branch to an address generated as an offset from the current PC address. Eg. BRA FRED causes a branch to the label FRED. Actually the assembler will have calculated the offset from the current address and used this as the operand.

Program Counter Relative
Here the PC is used as a pointer register with a constant offset. This provides a means of writing position independant code. Eg. LDA FRED,PCR causes the data at the address obtained by adding the contents of the PC to FRED to be loaded into A. Program Counter Relative Indirect is also available.

Instruction Set

A full definition of the instruction set would list each instruction showing the op-codes and number of clock cycles for each addressing mode available as well as giving a formal definition and showing which condition codes are affected. This would take up a lot of paper and as such we are going to abreviate this somewhat. We will tabulate all the instructions in categories, describing their action, indicating the addressing modes available and showing the condition codes affected. At the end we will then explain a few of the more tricky ones. For those readers who really do need to know the additional information, a programming card or data book should be obtained from Motorola (or other 6809 manufacturers) but these don't come cheap.

Table 3 is the instruction set summary and this needs some explanation as a number of abbreviations have been used to save space.

Addressing Modes Available	I	Implied or Register
	D	Direct
	E	Extended
	#	Immediate
	X	Indexed, Indexed Indirect, PC Relative and Indexed Indirect
	R	Relative
Definition	A,B,D,S,U,X,Y, PC,CC	Registers
	M	Memory
	EA	Effective Address
	+	Arithmetic Add
	−	Arithmetic Subtract
	*	Arithmetic Multiply
	V	Logic OR
	⊕	Logic Exclusive OR
	Λ	Logic AND
	$\overline{X}$	Complement of X
	:	Concatenation
	→	Transfer into
Condition Codes Affected	.	Not Affected
	*	Set or Cleared According to Result
	0	Cleared
	1	Set
	U	Undefined
	C	CC Affected as Direct Result
	E	Same as "C" if CC is specified

Mnemonic	Description	Addressing Modes (IDE#XR)	Definition	Condition Codes (HNZVC)
ABX	Add B to X	I	B + X→X	.....
ADCA	Add to Accumulator with Carry	DE#X	A + M + C→A	*****
ADCB		DE#X	B + M + C→B	*****
ADDA	Add to Accumulator	DE#X	A + M→A	*****
ADDB		DE#X	B + M→B	*****
ADDD		DE#X	D + (M:M + 1)→D	.****
ANDA	AND with Register	DE#X	A ∧ M→A	.**0.
ANDB		DE#X	B ∧ M→B	.**0.
ANDCC		#	CC ∧ M→CC	CCCCC
ASL	Arithmetic Shift Left	DE X	M	U****
ASLA		I	A	U****
ASLB		I	B	U****
ASR	Arithmetic Shift Right	DE X	M	U**.*
ASRA		I	A	U**.*
ASRB		I	B	U**.*
(L)BCC	Branch Carry Clear	R	Branch if C = 0	.....
(L)BCS	Branch Carry Set	R	Branch if C = 1	.....
(L)BEQ	Branch Equal	R	Branch if Z = 1	.....
(L)BGE	Branch Greater or Equal	R	Branch if N⊕V = 0	.....
(L)BGT	Branch Greater	R	Branch if Z ∨ (N⊕V) = 0	.....
(L)BHI	Branch Higher	R	Branch if C ∨ Z = 0	.....
(L)BHS	Branch Higher or Same	R	Branch if C = 0	.....
BITA	Bit Test Memory with Accumulator	DE#X	M ∧ A	.**0.
BITB		DE#X	M ∧ B	.**0.
(L)BLE	Branch Less Than or Equal	R	Branch if Z ∨ (N⊕V) = 1	.....
(L)BLO	Branch Lower	R	Branch if C = 1	.....
(L)BLS	Branch Lower or Same	R	Branch if C ∨ Z = 1	.....
(L)BLT	Branch Less Than	R	Branch if N⊕V = 1	.....
(L)BMI	Branch Minus	R	Branch if N = 1	.....
(L)BNE	Branch not Equal	R	Branch if Z = 0	.....
(L)BPL	Branch Plus	R	Branch N = 0	.....
(L)BRA	Branch Always	R	Branch Always	.....
(L)BRN	Branch Never	R	Branch Never	.....
(L)BSR	Branch to Subroutine	R	Branch to Subroutine	.....
(L)BVC	Branch Overflow Clear	R	Branch if V = 0	.....
(L)BVS	Branch Overflow Set	R	Branch if V = 1	.....
CLR	Clear	DE X	0→M	.0100
CLRA		I	0→A	.0100
CLRB		I	0→B	.0100
CMPA	Compare Memory from Accumulator	DE#X	A-M	U****
CMPB		DE#X	B-M	U****
CMPD		DE#X	D-(M:M + 1)	.****
CMPS		DE#X	S-(M:M + 1)	.****
CMPU		DE#X	U-(M:M + 1)	.****
CMPX		DE#X	X-(M:M + 1)	.****
CMPY		DE#X	Y-(M:M + 1)	.****
COM	Complement	DE X	$\overline{M}$→M	.**01
COMA		I	$\overline{A}$→A	.**01
COMB		I	$\overline{B}$→B	.**01
CWAI	Clear CC and Wait for Interrupt	#	CC ∧ M→CC then wait for interrupt	CCCCC
DAA	Decimal Adjust A	I	Decimal Adjust A	.**U*
DEC	Decrement	DE X	M-1→M	.***.
DECA		I	A-1→A	.***.
DECB		I	B-1→B	.***.
EORA	Exclusive OR Accumulator	DE#X	A⊕M→A	.**0.
EORB		DE#X	B⊕M→B	.**0.
EXG	Exchange Registers R1,R2	I	R1↔R2	EEEEE
INC	Increment	DE X	M + 1→M	.***.
INCA		I	A + 1→A	.***.
INCB		I	B + 1→B	.***.
JMP	Jump	DE X	EA→PC	.....
JSR	Jump to Subroutine	DE X	Jump to Subroutine	.....

And finally, a word of explanation about a few of the less obvious instructions:

Branches
In Table 3, the mnemonic for each branch instruction had (L) in front of it. To take (L)BEQ as an example, this signified two instructions, namely BEQ and

Mnemonic	Description	Addressing Modes IDE#XR	Definition	Condition Codes HNZVC
LDA LDB LDD LDS LDU LDX LDY	Load Register	DE#X DE#X DE#X DE#X DE#X DE#X DE#X	M→A M→B (M:M+1)→D (M:M+1)→S (M:M+1)→U (M:M+1)→X (M:M+1)→Y	.**0. .**0. .**0. .**0. .**0. .**0. .**0.
LEAS LEAU LEAX LEAY	Load Effective Address	X X X X	EA→S EA→U EA→X EA→Y	....*.. ..*..
LSL LSLA LSLB	Logical Shift Left	DE X I I	M A B	.**** .**** .****
LSR LSRA LSRB	Logical Shift Right	DE X I I	M A B	.0*.* .0*.* .0*.*
MUL	Multiply	I	A*B→D	..*.M
NEG NEGA NEGB	Negate	DE X I I	$\overline{M}$+1→M $\overline{A}$+1→A $\overline{B}$+1→B	U**** U**** U****
NOP	No Operation	I	No Operation	.....
ORA ORB ORCC	OR with Register	DE#X DE#X \#	A v M→A B v M→B CC v M→CC	.**0. .**0. CCCCC
PSHS PSHU	Push onto Stack	I I	Push onto S Push onto U	....
PULS PULU	Pull off Stack	I I	Pull from S Pull from U	....
ROL ROLA ROLB	Rotate Left	DE X I I	M A B	.**** .**** .****

Mnemonic	Description	Addressing Modes IDE#XR	Definition	Condition Codes HNZVC
ROR RORA RORB	Rotate Right	DE X I I	M A B	.**.* .**.* .**.*
RTI	Return from Interrupt	I	Return from Interrupt	EEEEE
RTS	Return from Subroutine	I	Return from Subroutine	.....
SBCA SBCB	Subtract from Accumulator with Borrow	DE#X DE#X	A-M-C→A B-M-C→B	U**** U****
SEX	Sign Extend	I	Sign ext B→A	.**..
STA STB STD STS STU STX STY	Store Accumulator	DE X DE X DE X DE X DE X DE X DE X	A→M B→M D→(M:M+1) S→(M:M+1) U→(M:M+1) X→(M:M+1) Y→(M:M+1)	.**0* .**0* .**0* .**0* .**0* .**0* .**0*
SUBA SUBB SUBD	Subtract from Accumulator	DE#X DE#X DE#X	A-M→A B-M→B D-(M:M+1)→D	U**** U**** .****
SWI SWI1 SWI2	Software Interrupt	I I I	Software Interrupt	....
SYNC	Synchronise	I	Syncronise to Interrupt	.....
TFR	Transfer Registers R1, R2	I	R1→R2	EEEEE
TST TSTA TSTB	Test	DE X I I	Test M Test A Test B	.**0* .**0* .**0*

LBEQ, BEQ meaning Branch Equal and LBEQ meaning Long Branch Equal. The short branch instructions have just a single byte argument representing the relative branch address and is therefore only able to operate within the range 128 bytes backwards to 127 bytes forward. If the required branch is outside this range, a long branch must be used. This has a 2 byte argument and has a range of anywhere within the 64K address map.

Load Effective Address

These instructions are some of the most difficult to understand. They work by calculating the effective address used in an indexed instruction and storing that address, rather than the data at that address, in a pointer register. They are particularly useful for modifying the values of pointer registers since most of the arithmetic instructions only work on accumulators. Eg LEAK -1,X subtracts 1 from the value in K. LEAY D,Y adds the value in D to Y.

Programming The 6821

Table 4 shows the internal registers of the 6821. It will be noted that there are 6 such registers despite the fact that the device has 2 address inputs and therefore occupies just 4 bytes in the memory map. This is explained by the fact that there are 2 registers at addresses 0 and 2, the one which can be 'seen' by the processor depending on the setting of a bit in the appropriate control registers as we shall see shortly. The addresses in Table 4 are, of course, offsets from the 6821's base address which, on the SBC-09, is $8000.

It will be evident that there are 2 groups of 3 registers which control the A port and the B port respectively and since the operation of the two ports is almost identical we shall describe the operation of just a single set of registers.

Address	Register
0	Peripheral Register A or Data Diection Register A
1	Control Register A
2	Perpheral Register B or Data Direction Register B
3	Control Register B

Table 4: 6821 Registers

The data direction register controls whether each bit of the corresponding port is an input or an output. Bit 0 (the least significant) controls PA0 (or PB0) through to bit 7 which controls PA7 (or PB7). In each case setting a 0 causes the pin to be an input whereas setting a 1 causes it to be configured as an output.

The peripheral register similarly has bits 0-7 mapped onto PA0-PA7 (or PB). In this register, for any pin configured as an output, the value written to the corresponding bit will control the signal level on the pin. For any pin configured as an input, the value read from the corresponding bit indicates the signal level on the pin. Reading this register clears any interrupt generated by that port.

The control register is rather more complex and is illustrated in Table 5.

Bit 7 (M.S.B.) ... Bit 0 (L.S.B)

IRQA1	IRQA2	CA2 Direction	CA2 Transition	CA2 Interrupt	DDRA Access	CA1 Direction	CA1 Interrupt

Table 5: 6821 Control Register Bit Designations

1RQA1 and IRQA2 are read only bits. They indicate that an active transition has taken place on CAl or CA2 respectively if configured as an input. These bits are typically used to determine the source of an interrupt and are reset once the register has been read.

CA2 Direction is used to configure CA2 as an interrupt input or an output. A 0 represents input and a 1 output.

CA2 Transition has a diferent function depending on whether CA2 is an input or an output. For an input, a 0 indicates that the active transition (ie the one which generates an interrupt) is high to low whereas a 1 represents low to high. For CA2 as an output, a 0 indicates that it is a handshake output (this is complex and we won't go into it here) whereas a 1 indicates that it is a normal output.

CA2 Interrupt has a different function depending on whether CA2 is an input or an output. For an input, a 0 disables the generating of an interrupt as a result of an active transion on CA2 (but IRQA2 is still set) whereas a 1 enables this. For CA2 as an output, the value written here controls the signal level on the pin.

DDRA Access is used to control whether the register at address 0 (address 2 for port B) is the Peripheral Register or the Data Direction Register. 0 gives the Data Dire Register, 1 gives the Peripheral Register.

CA1 Transition and CA1 Interrupt are similar to the corresponding CA2 bits but in the case of CA1, this pin can only be an input.

A Programming Example

The last five paragraphs contain concentrated information which is really for reference by those who already have some background knowledge rather than for reading through from start to finish. To bring this article to a close we will present the source of the object code given last month which was used in conjunction with the practice interface card for testing the SBC-09. Although this article is not intended as a tutorial on 6809 programming, it is anticipated the reader will gleam quite a lot by studying this listing. Please note that the syntax of the assembler used (the shareware product suggested earlier) conforms to a UNIX standard and is therefore different to Motorola's syntax. The documentation supplied on disk clarifies this. It is further suggested that the would be 6809 programmer enters the source onto a computer, cross-compiles it, blows an EPROM (or uses an EPROM emulator) and tests it on the SBC-09, firstly in an unmodified form and then attempts to make changes to it. The following alterations are suggested:

1. When counting is enabled, read the DIP switches and use their setting to control how the LEDs count. Eg. upwards, downwards, in steps of two etc.

2. Use one of the DIP switches to control the speed of counting.

3. Cause the other push button to generate an input. Use this interrupt to reset the LEDs to a known state.

4. Write a new program from scratch. Start with all LEDs off. Each time an interrupt occurs, add the value on the DIP switches to a running total, displaying the results on the LEDs.

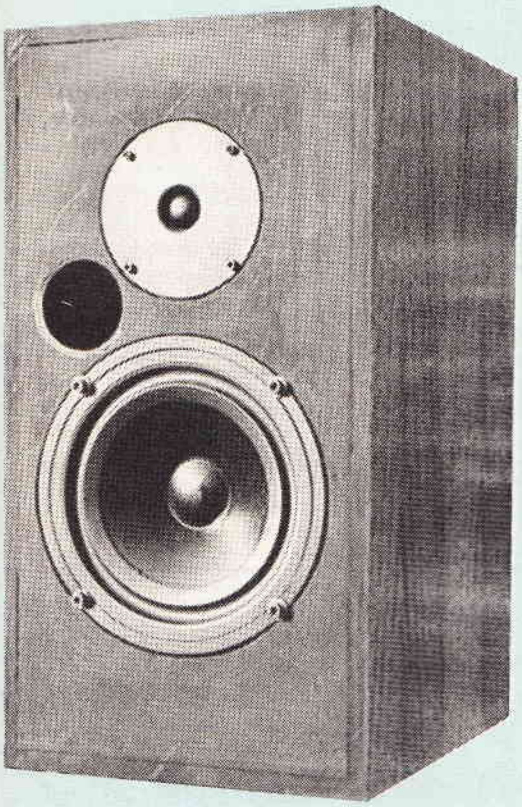
5. Design an application specific interface card and write some firmware to do something really useful. When you've got it working let us know here at ETI. It may result in your name in lights!

ETI SBC-09 control computer test program

```
.equ    IOarea,    X'8000      ;I/O area
.equ    PIA,       IOarea      ;6821 PIA
.equ    PortA,     PIA         ;Port A
.equ    DDRA,      PortA       ;Data direction register A
.equ    CRA,       PortA +1    ;Control register A
.equ    PortB,     PIA + 2     ;port B
.equ    DDRB,      PortB       ;Data direction register B
.equ    CRB,       PortB +1    ;Control register B
.equ    EPROM,     X'C000      ;Start of 27128 EPROM
.equ    RAM,       X'0000      ;Start of RAM
.equ    stack,     RAM+X'100   ;Top of stack
.equ    Running,   Stack+1     ;Counting in progress
.org    X'FFF0                 ;Vectors – end of EPROM
        .dw        Init        ;Reserved
        .dw        Init        ;SWI3 (unused)
        .dw        Init        ;SWI2 (unused)
        .dw        Init        ;FIRQ (unused)
        .dw        IRQ         ;IRQ
        .dw        Init        ;SWI1 (unused)
        .dw        Init        ;NMI (unused)
        .dw        Init        ;Reset
.org    EPROM                  Code – start of EPROM
IRQ:    TST        PortA       ;Read PortA to clear IRQ
        COM        Running     ;Complement counting flag
        RTI                    ;Return
Init:   LDS        # stack     ;Initialise stack pointer
        CLR        Running     ;Running not enabled
        CLR        CPA         ;Select DDRA instead of PortA
        CLR        DDRA        ;Set PortA to all inputs
        LDA          X'05      ;Code for PortA instead of
        STA        CPA         ;DDRA and interrupt on CA1
        CLR        CRB         ;select DDRB instead of PortB
        LDA        # X'04      ;Set PortB to
        STA        DDRB        ;all outputs
        LDA          X'04      ;code for PortB instead of
        STA        CRB         ;DDRB and no interrupts
        CIR        PortB       ;Turn all LEDs off
        ANDCC        X'EF      ;Enable interrupts
Count:  TST        Running     ;Counting flag enabled?
        BEQ        Count       ;If not loop
        INC        PortB       ;Increment the LEDs
        BSR        Delay       ;Wait a while
        BRA        Count       ;Loop back to start
Delay:  LDY        # X'2000    ;Delay loop initial value
Delay1: LEAY       -1,Y        ; Decrement
        BNE        Delay1      ;Loop if not zero
        RTS                    ;Return
```

THE K2 LOUDSPEAKER KIT

A twin driver loudspeaker kit by Mike Fox



Selecting loudspeakers for a hi-fi system can be a traumatic experience, particularly if you are in the habit of reading hi-fi magazines, which,over recent years, have regarded the loudspeaker end of a system as the least important link in the chain. The emphasis has been placed on signal retrieval at the record deck or CD player. This has led to the ridiculous situation where people are literally encouraged to spend a small fortune on record decks, tone arms, cartridges and esoteric amplifiers. Then, almost as an after thought, a pair of budget loudspeakers, are bought which in most cases, are incapable of delivering the full range of frequencies you've paid through the nose to produce. No one would disagree with the importance of the front end of a system, after all, you want to hear everything that is on the recording. Why then restrict the output by using poor loudspeakers?

This situation has resulted in many speaker manufacturers scrambling to produce ever cheaper budget products, with little money being invested in quality drive units, a pair of two-way speakers retailing for approximately £150, will contain drive units worth a total of about £5 in each cabinet. Trying to buy a decent pair of speakers to suit your system can become a nightmare, faced with the conflicting views of reviewers in each of the different hi-fi magazines, the necessarily restricted range of products stocked in local hi-fi shops and manufacturers constantly changing the model you're likely to buy, sometimes twice a year. So that you end up with a Mk 1 which before very long is valueless, because eveyone wants the Mk 3 which has just come out and is 'better' than the highly praised version you had the misfortune to buy! This 'flavour of the month' philosophy drives the hi-fi world, urging people to buy not necessarily better products, indeed, in many cases inferior articles costed down to the bone. In our view, a good loudspeaker, properly designed say in 1985, should STILL be a good loudspeaker in 1995 and beyond. All this bodes ill for the potential customer, vainly seeking a decent product at a reasonable price in a minefield of confusing advice and possibly inferior products.

The practical solution to this problem is to build your own speakers and given that you are capable of some simple woodwork and can use a soldering iron, the rest is relatively easy, especially if some thought

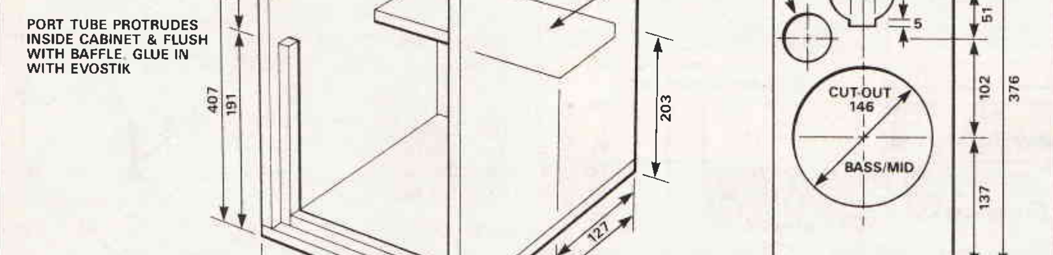


Fig. 1 Cutting dimensions for each speaker cabinet.

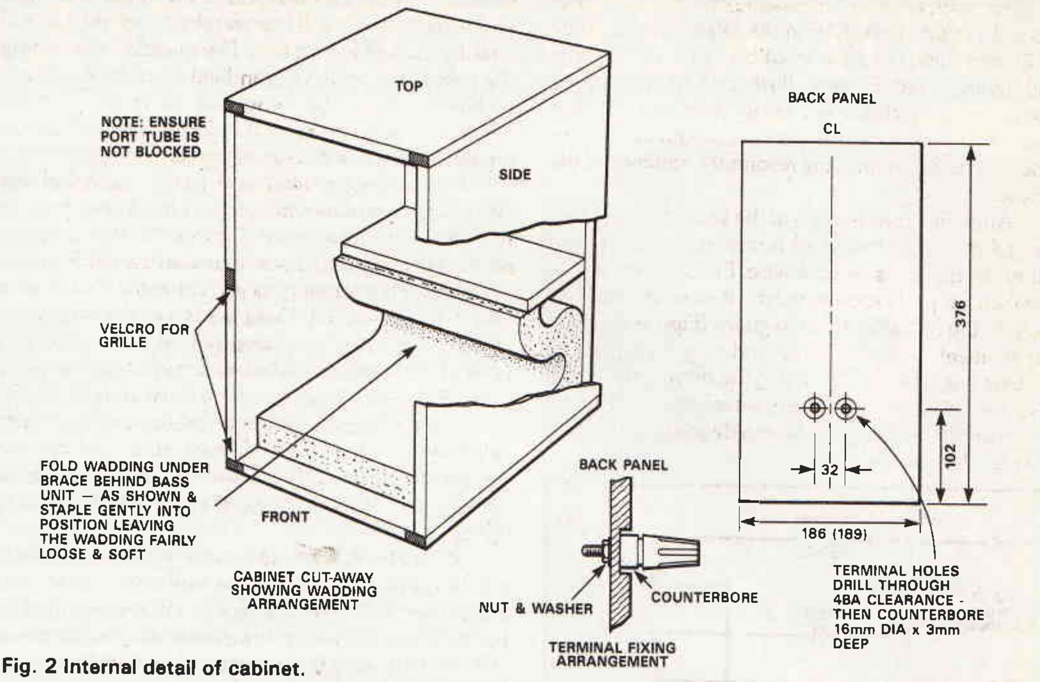


Fig. 2 Internal detail of cabinet.

has been put into the design to produce a product which is easy to make and when completed, will produce satisfyingly accurate, clean, dynamic quality sound at a fraction of the price you would pay in a hi-fi shop for an equivalent model.

The Kord K2s were designed with this in mind, having compact size, using good quality components, they will enhance any hi-fi system. The sound quality is excellent, offering open and detailed uncoloured sound, with surprisingly extended bass response for their size, tightly contolled transients and a sparkling top end performance on all types of music, from rock through to classical, the better the system, the better they'll sound! The K2's compare more than favourably with speakers costing around the £250/300 mark.

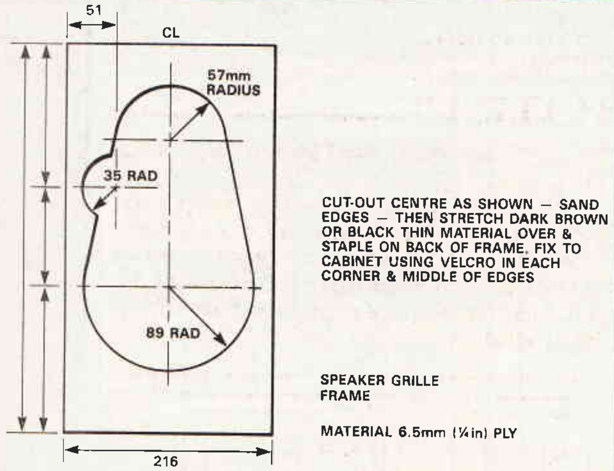


Fig. 3 Speaker Grille Frame.

Design

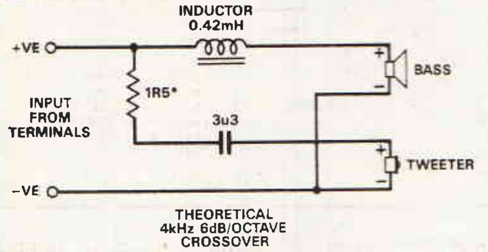
The Kord K2 is a two way compact sized reflex or ported design, which, if well designed, gives enhanced bass output with lower distortion than an equivalent sealed cabinet of the same size. Cabinet size was determined by the fact that most homes nowadays do not want massive speakers cluttering up the place. The aim was to provide a really good quality compact design which would compare with, or better, any equivalent speaker on the market, the emphasis being on quality. After many hours of testing, measurement and listening that aim has been achieved, the K2 is a loudspeaker, with a ruler flat frequency response. No more need be said. The K2 will demonstrate it's capabilities better than any words!

The design employs a very good quality 165mm. doped paper cone bass/midrange unit with a cast magnesium alloy chassis and a first class, carefully matched 19mm polyamide soft dome tweeter. With simplicity of construction in mind, it was necessary to select not only two matching drive units but also suitable roll-off characteristics to enable the use of a very simple crossover. In addition, the bass/mid 'Q' had to be suitable for reflex loading. Many units were tested and found wanting until the final selection was made. The chosen drive units proved ideal for the purpose, combining the correct roll-off, near matching sensitivity and excellent sound quality.

The crossover is a simple 6dB/octave system, set at 4kHz, employing an inductor (choke) in the low frequency section, to assist the bass/mid roll-off, with a resistor and capacitor in the tweeter section (Figure 4). The capacitor Protects the tweeter, whilst the resistor corrects for a slight imbalance in the efficiency of the two units, by attenuating the tweeter and reducing it's output by −1.4dB. Good quality air cored inductors and polyester capacitors are included in the crossover, as these have a direct bearing on ultimate sound quality. An added bonus of simple crossover networks is that, the less components used, the less any subsequent inefficiencies in the system The efficiency rating for the completed system is a high 88.6dB SPL at 1 metre/1 watt, which means a higher output per watt than less efficient designs.

The cabinet for the K2 (See Figure 1 & 2) is a straighforward box, manufactured from 15mm. MDF board, a very rigid, dense material, which obviates the need for quite a lot of internal bracing. One shelf brace is used in each cabinet (Figure 1) to give additional rigidity and help to keep cabinet vibration from adding it's own colouration to the sound output. Cabinet dimensions are 408mm H × 217mm W × 267mm D with a volume of 15.75 litres, this being the optimum size for a reflex design, based an Thiele parameters for the particular drive unit employed. Without going into unnecessary details, this volume gave by far the best results, the cabinet being tuned to 43Hz, with excellent transient response. The port tubes are made from 54mm dia. plastics tube (Tube ID 50mm) fitted into the front baffle of the cabinets and glued in with Evostik, flush with the panel, the port opening inside the box left unobstructed. Do not under any circumstances alter the length of the port tube, as this determines the resonant frequency of the cabinet.

Amplifier connections at the rear of the cabinet are good quality insulated terminals which accept either 4mm. plugs or bare wire. Finally, to give the speakers a professional finish, it was decided to provide the option of making grilles (Figure 3). They are relatively easy to make and may just prevent probing fingers from damaging the drive units, however, for the best results in use, we recommend taking the grilles off, all grilles do have a degrading effect on the high frequencies.



AS YOU CAN SEE IN THE DIAGRAM THE POSITIVE CONNECTION FROM THE INPUT IS CONNECTED TO THE INDUCTOR COIL AND THE 3u3 CAPACITOR. THE INDUCTOR GOES TO THE +VE ON THE BASS/MID UNIT AND THE CAPACITOR TO THE +VE ON THE TWEETER. THE NEGATIVE CONNECTIONS OF BOTH DRIVE UNITS GO DIRECTLY TO THE NEGATIVE INPUT

*AN OPTIONAL 2R2 7W RESISTOR CAN BE FITTED IF YOU PREFER MORE ATTENUATION ON THE TWEETER. SIMPLY DISCONNECT THE 1R5 AND INSERT 2R2 RESISTOR — THIS WILL GIVE A FURTHER −0.8dB ATTENUATION

4BA SOLDER TAGS ARE SUPPLIED TO ENABLE CONNECTIONS TO THE INPUT TERMINALS

Fig. 4 Electrical Connections.

TABLE 1 Specifications K2 Compact Loudspeaker

Frequency range	43-20,000Hz
Frequency response	70-20,000Hz
Impedance	8 ohms
Power Handling	15W-80W
Efficiency	88.6dB SPL at 1m/W
Reflex Tuning	43Hz
Crossover Frequency	3,000Hz
Bass/Mid driver	165mm pulp cone-doped
HF driver	19mm polyamide soft dome

Construction Hints

Having gone through all the glowing descriptions, they now need to be built. In general, the drawings give most of the necessary details of construction, however, a few useful pointers may be of assistance. For the cabinet, it makes good sense to get all the panels cut to size when you purchase the wood, they can cut it accurately on a circular saw,leaving nice square edges. Butt joints are recommended for making the basic open fronted boxes, this is relatively easy and provided you use plenty of glue, such as PVA to ensure good joints with no leaks, a good result will ensue. It is also a good idea to allow the panel edges to stand slightly proud, then when set, sand or surform the edges back level with the cabinet surface. Before glueing in the shelf brace, make sure that it is a good tight fit against the cabinet sides and also that it fits snugly against the back panel. Remember that the front baffle is the last panel to be fitted, having previously cut out the drive unit and reflex port holes. (Figure 1) If you decide to rebate the drive units, the easiest method is to place the unit in the cut-out and mark round it with a pencil, then set the router to the correct depth (The thickness of the speaker flange) and work to the line. It is preferable to rebate, but not vital if you don't feel up to it. The question of finishing the cabinets is up to your individual taste, if you are ambitious, it can be veneered, or much simpler, covered by a laminate such as formica and of course a painted finish is always an option.

In conclusion, after you have assembled the crossover, complete with leads for the drive units, do not leave it lying around loose in the cabinet, otherwise it will cause some unwanted rattles when the speaker is operating, fix it to either the back or side panel, then twist any loose leads together and cleat them to the sides, also, ensure that the port tube is clear of any obstruction before finally fitting the drive units. Solder the leads on to the drive units as shown in Figure 4. The tweeter is then secured by four 3mm self tapping screws and the bass/mid. unit by four 4mm self tap screws. It will be necessary to drill small pilot holes for the screws, then secure both units tightly.

All that remains is to couple it into your system via. reasonably good speaker leads, such as 13 amp cable, then switch on and listen to the sound quality. For best results we recommend using solid metal stands, with good floor contact. The tweeter should be placed at ear level when sitting down and give yourself a pat on the back for doing a good job.

PARTS LIST

Wood (M.D.F.) Cutting List For One Cabinet.

2 off 376mm × 186mm × 15mm M.D.F.	Front baffle & back panel
2 off 376mm × 267mm × 15mm M.D.F.	For side panels
2 off 267mm × 217mm × 15mm M.D.F.	For top & bottom panels
1 off 382mm × 217mm × 6.5mm Ply	For Grille frame (if required)

PARTS LIST

2 off 165mm Bas/Mid. Drive units	2 off 0.42mH. chokes
2 off 19mm H.F. Drive units	2 off 3.3u caps.
4 off Insulated terminals	2 off IR5 resistors
4 off 4BA. solder tags	2 off port tubes
8 off 4mm self tap screws	cable
8 off 3mm self tap screws	
2 off wadding	

BUYLINES

The cost of the set of parts for a pair of K2 speakers is £113 including VAT and carriage.

The woodwork is NOT included in this kit, however, if you feel unable to make cabinets, an easy to assemble flatpack cabinet kit is available at extra cost. Complete ready built cabinets may also be produced in the near future. Contact Kord for details at Kord Audio Products Ltd, 7 The Green, Nettleham, Nr Lincoln LN2 2NR. Tel: 0522 585261 or 750702.

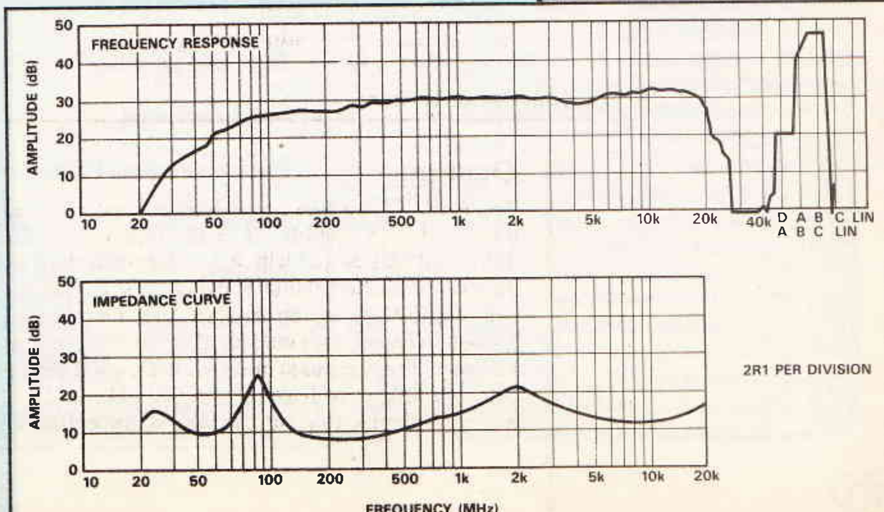


Fig. 5 Frequency Response curves.

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E9102-1 Remote Control Timeswitch — Receiver Board ...... F
E9102-2 Anti-theft Alarm (2 boards) .... H

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E9002-4	Superscope Timebase Board	K
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E9003-2	Superscope Y2 input board	J
E9003-3	Superscope switch generator	E
E9003-4	Business power amp board	L
E9003-5	Business power supply board	J
E9003-6	Business pre-amplifier board	L
E9003-7	Water hole	G
E9003-8	Super Siren	D
E9003-9	Val's badge	F
E9004-1	Bass Amplifier DC Protection	F
E9004-2	Bass Amplifier Graphic Equaliser	L
E9004-3	Bass Amplifier Micro	N
E9004-4	Quad Power Supply	O
E9005-1	Business Display	O
E9005-2	Phone Lock and Logger	F
E9006-1	Dark Room Timer	G
E9006-2	Telephone Extension Bell	C
E9006-3	Telephone External Bell	D
E9006-4	Fecko Box	G
E9006-5	Bug Spotter	E
E9007-1	Guitar Practice Amp	G
E9007-2	Digital Frequency Meter	M
E9007-3	Footstep Alarm	E
E9007-4	Transistor Tester	C
E9007-5	Decision Maker	J
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E9008-3	FM Generator	L
E9009-2	Slide Projector Controller	E
E9009-2	Ultimate Diode Tester	D
E9009-3	The Entertainer	G
E9010-1	Component Tester	F
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E9011-2	Infra-lock transmitter (2 boards)	K
E9011-3	Infra-lock receiver	H
E9011-4	Four-track cassette recorder (record/playback one channel)	F
E9011-5	Four-track cassette recorder (Bias/erase oscillator board	K
E9012-1	Infra Switch	F
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E9101-2	Remote Control — Display Board	H
E9101-3	Remote Control Timswitch — Transmit board	E
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Specification:

Model Number:	**BM41012**
Input:	115/230V, 50/60Hz
Outputs:	+5V 3.75A
	+12V 1.5A
	−12V 0.4A
Total Wattage:	65W
Price	**£14.95; 100 + 11.21**

We've also discovered a small quantity of an Astec model offered previously. Regrettably we've had to increase the price, but they still represent outstanding value for money. Enclosed in a steel case 203 × 112 × 60mm is a PCB 197 × 106mm. Input and Outputs are via pins on the PCB.

Specification:

Model Number	**AC9231**
Input	115/230V, 50/60Hz
Outputs	+12V 2.5A
	+5V 6A
	12V 0.5A (+or −)
	5V 0.5A (+or −)
Total Wattage	50W
Price	**£17.95; 100 + 13.46**

We still have good supplies of yet another Astec model. This one is partially cased, the overall size being 160 × 104 × 45mm. The PCB measures 160 × 100mm. Input and Outputs are on flying leads, all colour coded. There is also an additional IEC socket to extend mains to another unit.

Specification:

Model Number	**AA12531**
Input	115/230V, 50/60Hz
Outputs	+5V 5A
	+12V 0.15A
Total Wattage	50W
Price	**£6.95; 100 + 5.21**

Also still available: An Astec 'bare board' model. The PCB is standard Eurocard size, 160 × 100mm. Input and Outputs are on right angle PCB pins. This is a very compact model offering excellent value for money.

Specification:

Model Number	**AC8151-01**
Input	115/230V, 50/60Hz
Outputs	+5V 2.5A
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	−12V 0.1A
Total Wattage	40W
Price	**£12.95; 100 + 8.91**

Z8887 Made by STC, this 160 × 100mm PCB is attached to an aluminium chassis 165 × 102 × 65mm and has a single 5V 6A output. Supplied with connection details, we can offer these at fraction of their normal cost!
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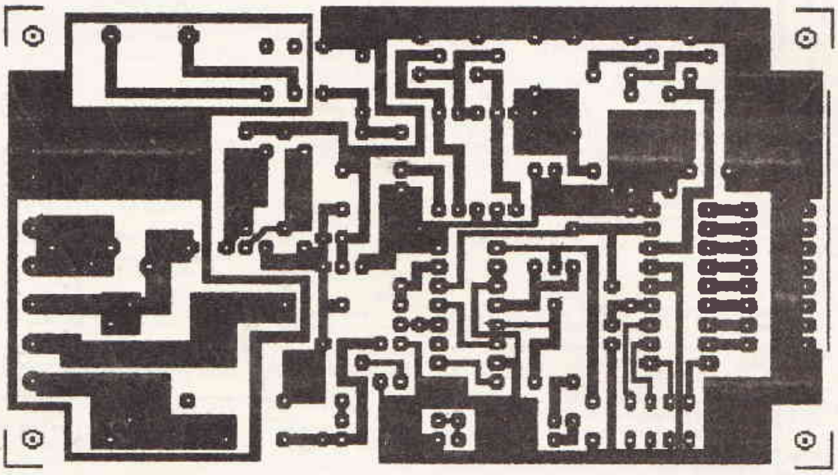
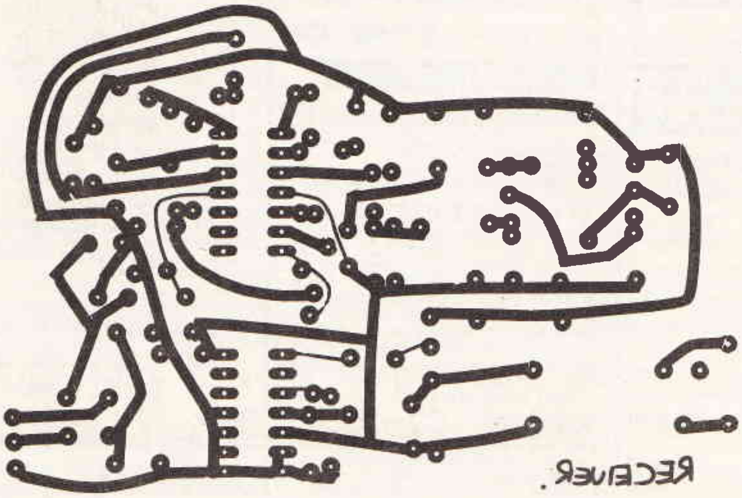
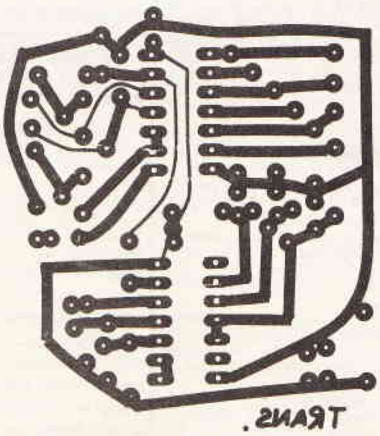


Remote Control Time switch — Receiver board



Anti-theft Alarm Receiver



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NEXT MONTH

The March issue of ETI can boast a variety of subjects to tantalise your thoughts and turn some of them into practical reality. For keen radio listeners, we present a project to make a simple SSB radio and radio calibrater.

Tripping the light fantastic, ETI enjoys a series of articles on the LASER giving you the oportunity to build one and try out on a variety of suggested applications. Also on the light theme you can construct a micro-controlled light show to amuse the family.

For audio interests, we have an article on the ins and outs of RIAA equalisation.

American developments in TV technology remains in the forfront of our HDTV series and we continue our beginners electricity course. And finally in the computing world, we present a 64K EPROM Emulator for PC comatible machines. Sounds like fun for the 90s so rush out and order a copy.

ETI appears on the first Friday in February that's the 1st.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

What did you miss in the January issue? This festive edition of the mag contained features on the technology behind aircraft landing systems,the first domestic DAT recorder from Sony and HDTV, the all American way. Projects included the second article on the remote controlled timer, a micro-controller board and a five in one device for detecting mains in cables. There were some festive Tips for Christmas and the second of two articles on Repairing Oscilloscopes.

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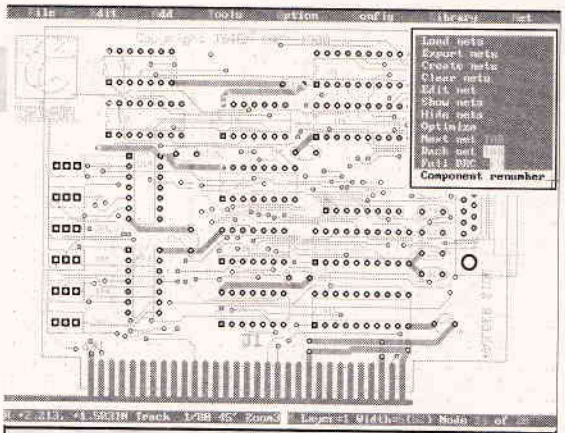

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