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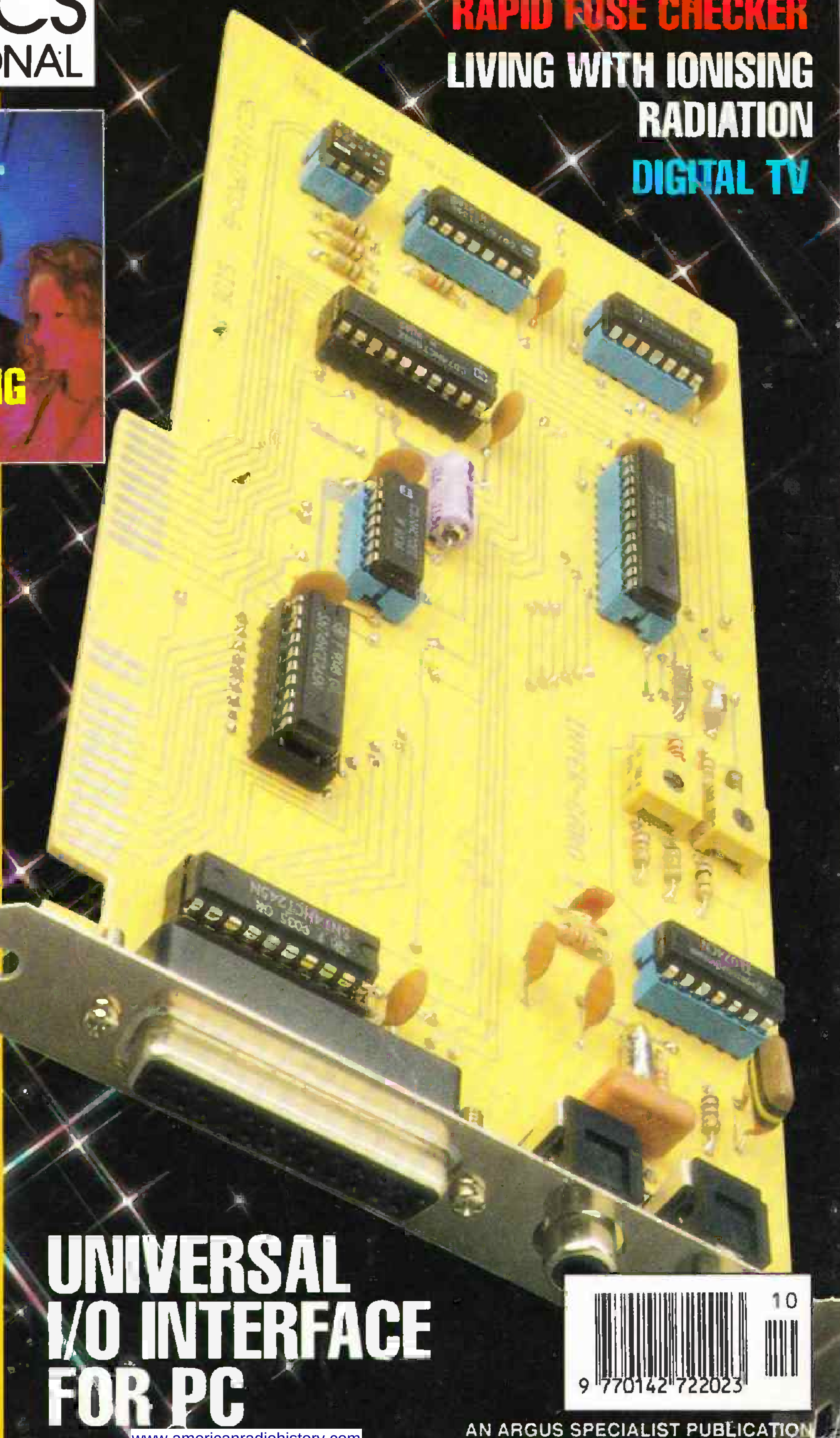

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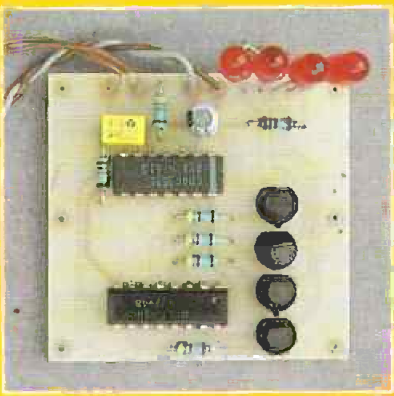

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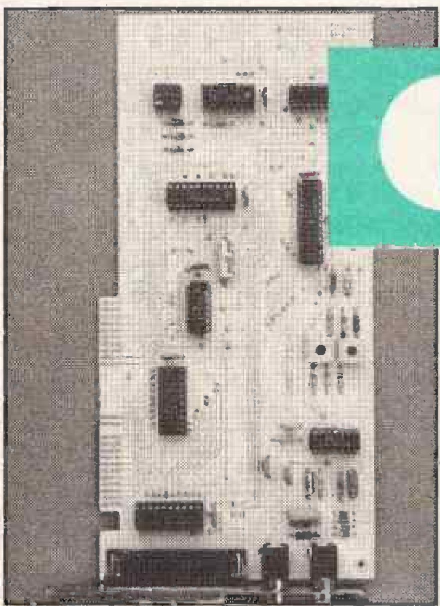

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Features & Projects

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Editorial

by Paul Freeman

What is the difference between a TV and a computing system? The differences should be easy to describe. This may have been the case in the past but nowadays the definition must vary according to the job the computer can perform. This software driven machine can calculate, present data, text and graphics on screen and provide synthetic and sampled audio. Most people might describe television as a box of moving pictures with sound.

Very soon the differences will not be easy to describe because computers are now and will be using more animated high resolution 'pictures' coupled with sound and TVs are adopting larger memory storage for display of data (teletext) and picture-on-picture information for seeing 'whats on the other side'. Solid state recording of data is also a possibility.

The Multi-Media package

Promotions, PR and Ad-people have in the past used slide and overhead projectors and sound reinforcement to add to the effectiveness of their campaign. Now Multimedia systems are replacing those old tools. Like a travelling salesman with suitcase in hand, the technology can 'do-it-all' for them. TV, audio and computer technology have combined to produce their requirements. Although not new, (Who remembers Advanced Interactive Video?) the older technology suffered from bulky packages. Now, with laptops and CD ROMs the media boys are mobile thanks to the two technologies merging. So your TV of the future could well be a computer producing sound vision and data.

OPEN CHANNEL

It's not often I get fan mail. but I did get one letter recently from a very reverend gentlemen from Port Elizabeth in South Africa. He refers to my comments in June's Open Channel, when I discussed a new dog coller which emits an ultra sonic signal whenever the dog barks. Then he goes on to describe Port Elizabeth as a city with a 700,000 strong human population and seemingly almost as many dogs. Apparently, each month in Port Elizabeth some 4,500 people are bitten by dogs. Indeed, in the course of his work, he himself has been bitten many times.

As an avid electronics enthusiast he built a project which is, in essence, an ultrasonic dog repeller - printed originally in a rival electronics magazine to ETI. He says it works well but is expensive. A cheapo design would he feels, be very popular.

It's an interesting thought. Most people in the UK now have access to such dog repellers and it's estimated that many of them are saved the trauma of dog bites with their use. It's also interesting to consider that use of an effective dog repeller renders useless the very fact why some people have dogs in the first place - to deter people from entering the property where the dog is kept. With an effective dog repeller, anyone: postman, policeman, burgler, vicar,tinker, taylor and so on, can gain acess without trouble from the dog.

I suppose it depends on what kind of state you live in - democratic state, soap box state, soap opera state, police state - as to how dog repellers are viewed. It's probably not beyond the credibility of most ETI readers to learn that in South Africa, dog repellers have been banned by the police.

Perhaps some of our new readers could design a simple but effective dog repeller (shotguns are not acceptable!) in a sort of competition, over the next few months. Accent on novellty and portability please - maybe built-in to a human dog coller (which means the gentleman concerned has the perfect cover when questioned by the police why dogs avoid him). Send proto-types to me via the editor. I'll try them out on my dog to decide the best.

TV Times

Considerable rethinking has to be done by the Independent Television Commision (ITC), the body charged with the reponsibility of governing the Independent Television network. This is because the ITV companies around the regions are finding it increaswingly difficult to maintain profitable operation, given the restrictive controls forced upon them recently. Theoretically, ITV companies cannot merge and even cannot hold a large part of one another's shareholdings.

Yet television is becoming more of an open market. Under Governmentally imposed regulations ITV companies will see their market shares reduce, and they cannot do much to restrengthen their positions. Even worse, in just over a year's time, foreign television companies will be able to buy into our ITV market, even though those foreign governments will not allow our companies to do the same with theirs.

Something has to give. Recently, Yorkshire Television and Tyne Tees Television were allowed to merge - in a deal agreed by the ITC to be a very special case. If this is a one-off special case (and no further mergers allowed) then trouble is just around the corner. ITV companies in a supposedly free market are not free at all to do what is best for their business. Laws will have to be changed.

If this isn't a one-off then rules are going to be bent in finely tuned ways as the ITV companies' lawyers can dream up. If more than just a couple of loopholes are found in current legislation, then the whole thing is going to look like something of a mockery.

Trouble At Paddy Rise

Following on from my comments last month about the wonders of technology; filing my column in true roving reporter mode - from the far flung corners of the globe in computerised fax format, I've hit upon a snag. If you didn't catch ETI last month, I'll give you a rapid update: I'm on an extended working holiday, taking family and friends caravan, computer fax, deaf dog and fortunately pen and paper around the country and beyond for the summer or until the money runs out.

Things were fine while I was able to pitch the caravan on sites with an electric hook-up. Here there is power enough to switch on the caravan reading lamps, heat the water, chill the wine, shower the dog and most importantly boot up the computer to allow me to process a few words. Things were even better when the odd phone point could be located within reach of the computer. Then I could download all I'd written since the previous tumultuous meeting of Faraday's dream, Bell's nightmare and Babbage's joke.

But problems arose as the caravan headed evermore westward, mains electricity and telephone points became evermore scarce. Finally, around the time this column began to emit a glimmer of formulation in my mind, the twain began never to meet at all - if you follow my gist. Here on the western shores of Ireland, overlooking the Atlantic it's darn nigh impossible to get a caravan site with electricity at all, let alone find one with hook-up points. As for telephones, the locals would never allow those new fangled gadgets anywhere near the peat bogs in case the countryside becomes spoilt by progress.

So here I am relying on the original communications method complete with writer's cramp. So this month's column is by pen, paper and post. It is I supose a delicate reminder that technology only goes as far as we let it and we can stop it any time we want.

Keith Brindley

ETI NEWS

NATIONAL SUCCESS FOR NAVAL COLLEGE

The need to provide music for church services on board Royal Naval ships has inspired a Naval Engineer Officer, Sub Lieutenant Jeff Crofts (22) from Bristol, to design and build the MIDI Accompanist, gaining him the top award in the Young Electronic Designer Awards (YEDA) competition.

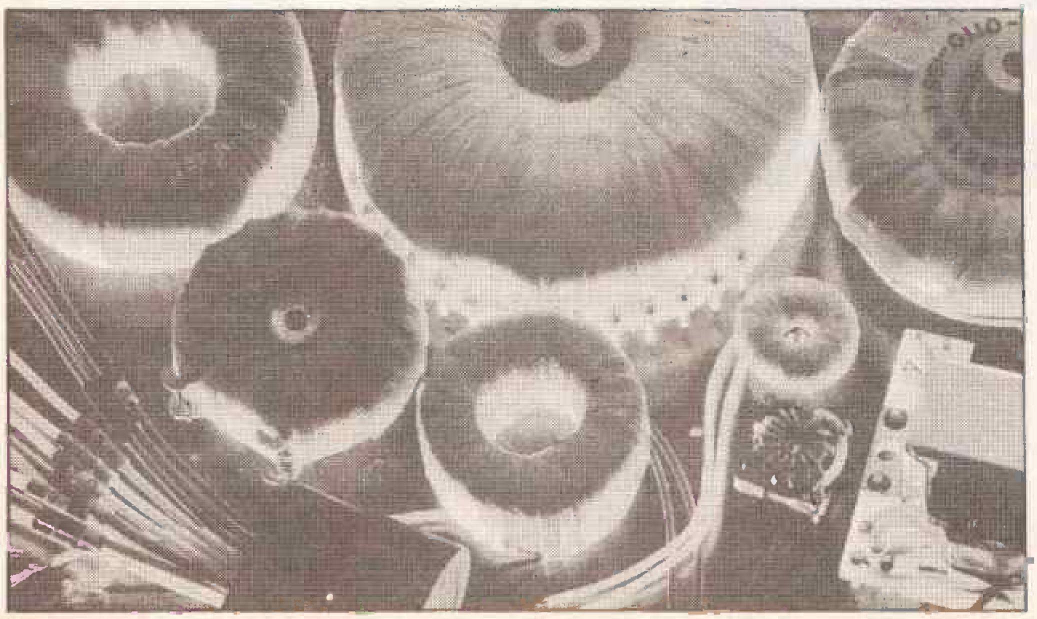
The MIDI Accompanist relies on the MIDI (Musical Instrument Digital Interface) connection found on the back of most modern electronic keyboards. The MIDI Accompanist is a sequencer, as it is a dedicated unit that gives instructions on the MIDI Interface concerning the sequence of previously stored notes that are to be produced by the keyboard.

The MIDI Accompanist reads the music from cartridges that must be recorded and encoded, but allows the user flexibility in controlling how they are played back. The user can control the speed and can transpose the music while it is playing. Playback can also start with an optional introductional phrase.

The data is held on a 64K byte PROM, which represents some 12000 notes in up to 200 sequences. The Accompanist is expandable to hold 4 such PROMs. The music is originally played on a keyboard and recorded on a PC using a commercial sequencer program. The music is edited then stored as MIDI files. These files are heavily compressed by a specially written PASCAL program, to produce a proprietary file format. Information is added concerning how the music sequences should be replayed, and the complete cartridge is programmed.

Sub Lieutenant Crofts designed the instrument whilst studying at the Royal Naval Engineering College (RNEC), Plymouth. For the second year running an RNEC entry has won the YEDA top award.

TOROIDS FOR THE MOST EXTREME ENVIRONMENTS



Wound-component specialist, Gardners of Christchurch offers a toroid transformer design and manufacturing facility which produces high-performance coils for the most extreme operating environments.

Aerospace, military and transport represent typical areas of application for toroids which must endure severe ambient conditions, these include the outer limits of 'G' forces, temperature swings, vibration and humidity.

Recent applications for specialised toroids include one for high G force aerospace instrumentation which required the use of an aluminium reinforced resin bonding technique.

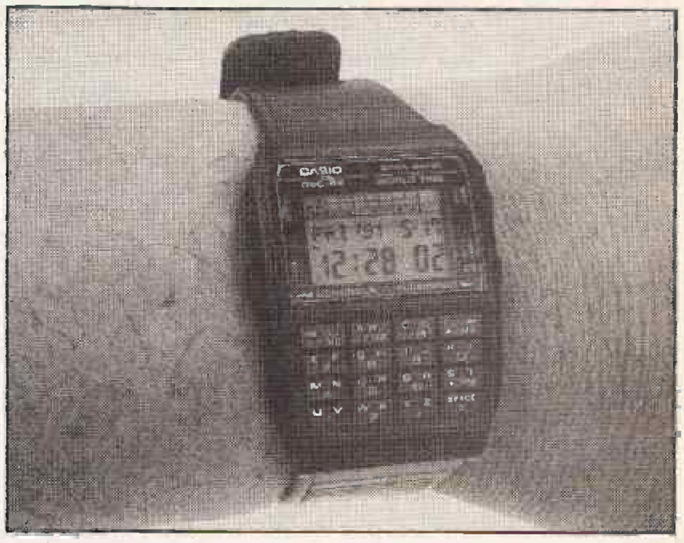
Further information contact Gardners Limited Tel: (0202) 482284.

50 PAGE MEMORY-CALCULATOR-WATCH

In what should be called the ultimate in function watches, the new multifunction LCD watch from Maplin is an extremely well-specified digital watch which couples renowned Casio quality with a host of useful features. The normal timekeeping display shows the day of the week, date, year and the time in hours, minutes and seconds. A 'chronometer' function automatically compensates for leap-years and months of differing length. A 24-hour stopwatch works to a resolution of 1/100 second.

In addition to a switchable daily alarm and an hourly bleeper, there is a countdown alarm. Also featured is an extremely useful 8-digit 4-function calculator with a watch face keypad. This keypad is also used to enter data into the 50-page telephone and scheduling memories. Each telephone memo 'page' cam comprise 8 letters and 12 numbers, while the scheduling facility will allow 5 letters per page. To prevent unauthorised people from gaining access to any information stored in the watch, a 'private' password function has been incorporated. Further security devices include a battery power fade display. Certainly a unit to watch out for.

The data bank watch costs £31.95 (including VAT) from Maplin Electronics.



REMAND HEARINGS BY TV LINK

The Home Office is now using two videoconferencing systems supplied by PictureTel Corporation. The Model 400 is a complete videoconferencing system on wheels and can be rolled to any location. Once connected to a power point and a telephone socket, it is ready to use.

The video calls are dialled like an ordinary telephone call, and cost around £15 for one hour.

Videoconferencing has already been used to give evidence in the UK civil court, in May 1992, and in a criminal trial, in 1991. The General Council of the Bar and the Law Society are both regular users of PictureTel videoconferencing equipment. Videoconferencing is already used for court hearings in the US.

PictureTel Corporation is headquartered in Danvers, Mass., USA, and established its European headquarters in the UK in May 1991. The company has been selling equipment in Europe since 1988. In 1991 PictureTel's turnover was $78Million

FIRST RADAR WITH PORTABLE DISPLAYS

Using conventional telephone lines, a new portable navigation system will provide harbours with the facilities of conventional radar systems at a fraction of the usual cost. Marine pilots will now be able to view raw images transmitted from shore based radar stations independent of the ships own systems.

Entitled Pilotwatch, the system is designed and manufactured by DB Electronics of Merseyside for Gloucester Harbour Trustees, and will be in use during the construction of the second River Severn Bridge. The system will provide a full harbour radar picture of the area upstream and downstream of the new road bridge which crosses the Severn Estuary over the English Stones. Comprising eight portable displays and two radar stations, one on the English shore and one on the Welsh shore, remote controlled via telephone lines from a central operations room, Pilotwatch is the first fully integrated system for a harbour of any size.

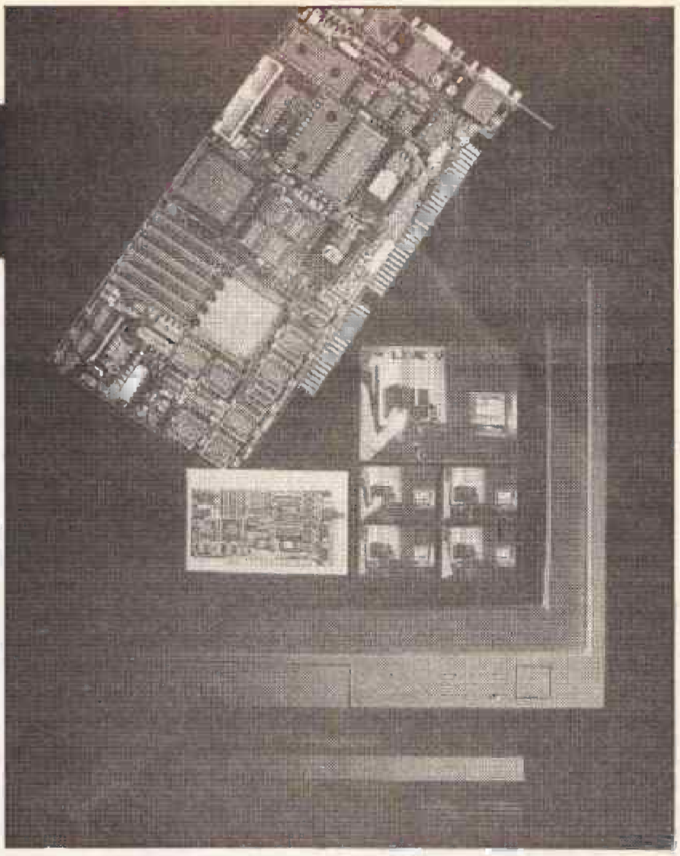
Pilots navigating the Severn will carry the portable receiver on board in its own briefcase and receive real time pictures broadcast over a VHF voice channel from the shore based radar stations enabling pilots to see construction activity on the far side of the bridge site long before they reach it - improving navigational safety particularly during poor visibility.

The Harbour Controller, in the operations centre receives a raw radar image transmitted over telephone lines without loss of integrity. Able to verify continuously the position of construction traffic, buoys, changing sandbanks, anchored vessels and uncontrolled inshore traffic the Controller is not dependent on what the ships are saying, he will see for himself. This also allows Controllers to assess accurate arrival times of visiting vessels.

DE Electronics developed Pilotwatch from its data compression image transfer technique which communicates real time images without loss of integrity. Capable of high resolution and positioning accuracy it transmits an eight colour image. All vessels in the VTS area share the same images from the same shore based antennae: Radar pictures can be broadcast from any number of radar stations, over a standard VHF channel to any number of portable receivers regardless of their position, direction or speed, something which no microwave based system can do.

It differs from conventional radar systems in that it does not use expensive microwave links. Instead, it severs the connection between transceiver and display and communicates the analogue "A scan" output from the IF amplifier. The encoding system uses a four dimensional, data compression algorithm to transmit the raw radar image to the original radar display.

PLUG-IN PC MULTIMEDIA BOARD MERGES VGA AND LIVE VIDEO



Arcom has released a powerful new multimedia adapter board for PCs which allows colour video and VGA signals to be combined into a single display. Integrating text/graphics and live/still video windows provides the means to reduce hardware costs and improve user interface ergonomics in a wide variety of professional computer system applications including process control, security, image processing, positioning and automation. Designated PCVideo, the PCbus plug-in is priced at £740.

The combined VGA/video display is very easy to control, providing a flexible building block for system designers. A camera, VCR or TV video source - in PAL, NTSC or SECAM format - may be software-selected from the board's three inputs. Video windows can be selectively displayed, scaled from full screen down to 1/64 size, and positioned in the VGA graphics/text display by either colour keying to the VGA signal, or by defining X-Y coordinates. One live video window may be displayed, plus an unlimited number of captured - or frame-grabbed - stills. Still images may be accessed by the host PC CPU, enabling designers of vision recognition systems to employ image processing techniques. Still images may also be saved to disk, or loaded from disk to a window,for applications where archiving and recall is required. A library of C routines is provided with the board to facilitate software development.

The design of PCVideo is based around Chips & Technologies' 82C9001 device for image capture and display, plus a Philips chipset to decode/matrix the composite video. Three quarters of a megabyte of video RAM is provided onboard to support the full colour operation. Memory accessing can be selected to operate in either linear or page modes, enabling designers to optimise the system's performance depending on which particular 80XXX-family CPU is resident in the host PC.

PCVideo is a half-size board with a 16-bit interface, and plugs into any standard PCATbus expansion slot. The only additional connections required, apart from the three video inputs, are the VGA signal input and output, and a Feature connector in order to Genlock the two displays.

In addition to the dual display function, Arcom has included a number of useful hardware facilities on PCVideo to simplify installation, configuration and maintenance. An advanced offset addressing scheme reduces the number of bytes required for PCVideo to just four, making it easy to install in the PC's limited free I/O space. Hex dials are provided to set this address, in preference to DIL switches. Monitor LEDs assist system integrators with system commissioning and diagnostics; one indicates the board has been selected, another that live video is present.

Further details contact:
Alan Timmins at
Arcom Control Systems Ltd,
Tel: (0223) 411200

SIEMENS, IBM AND TOSHIBA TO DEVELOP NEW SEMICONDUCTORS

Three of the world's leading semiconductor companies - Siemens AG, IBM Corp., and Toshiba Corp. - have announced an alliance that will result in advanced semiconductor devices for the end of this decade and into the next century.

The three companies will cooperate in development of a 256-million-bit dynamic random access memory (DRAM) and its process. This sophisticated submicron technology will be a basis for production of future generations of highly dense chips.

For customers, this agreement should accelerate availability of memory chips with 16 times more capacity than are available today, as well as other advanced computer components, such as microprocessors and chips for telecommunications.

Siemens and Toshiba will also conduct project-related activities at their own facilities. The development team will focus on the process technology for fabricating features only 0.25 microns wide - 400 times narrower than a human hair. (One micron is one millionth of a metre).

At the peak of the development phase, more than 200 researchers from the three companies will support the effort.

By teaming up, the three firms aim to speed up the multiyear development process and be first with quarter-micron technology in their products.

"The agreement enables the earliest availability of latest chip know-how for systems applications," stated Karlheinz Kaske, president and Chief Executive Officer, Siemens. "It contributes to future applications in telecommunications and industrial fields far beyond the turn of the century, and assures our customers of our engagement in microelectronics."

DRAMs are fingernail-size silicon devices that store electronic data in products ranging from mainframe computers to home appliances. The 256Mb DRAM, using quarter-micron technology, will be able to hold the entire works of William Shakespeare and Johann Wolfgang Goethe, as well as the Manyoshu, the Kokinshu, and the Tail of Genji. There would be still enough bits left to store a typical edition of the International Herald Tribune. The 256Mb chip will follow the 64Mb DRAM, now under development by several companies, and today's 16Mb chip, which IBM was first to introduce into a product earlier this year.

The DRAM development process is a technology driver. The knowledge and expertise gained in developing a new generation of memory chip can be applied to other, more sophisticated semiconductor devices, such as microprocessors and other logic devices.

The three-way alliance announced today is an outgrowth of separate, longstanding relationships among the companies. Siemens and IBM currently work together in 16Mb DRAM manufacturing and 64Mb DRAM development. Recently, IBM and Toshiba signed a flash memory technology agreement. Siemens and Toshiba have been collaborating in various semiconductor areas, including 1Mb DRAMs, standard cells, and gate arrays.

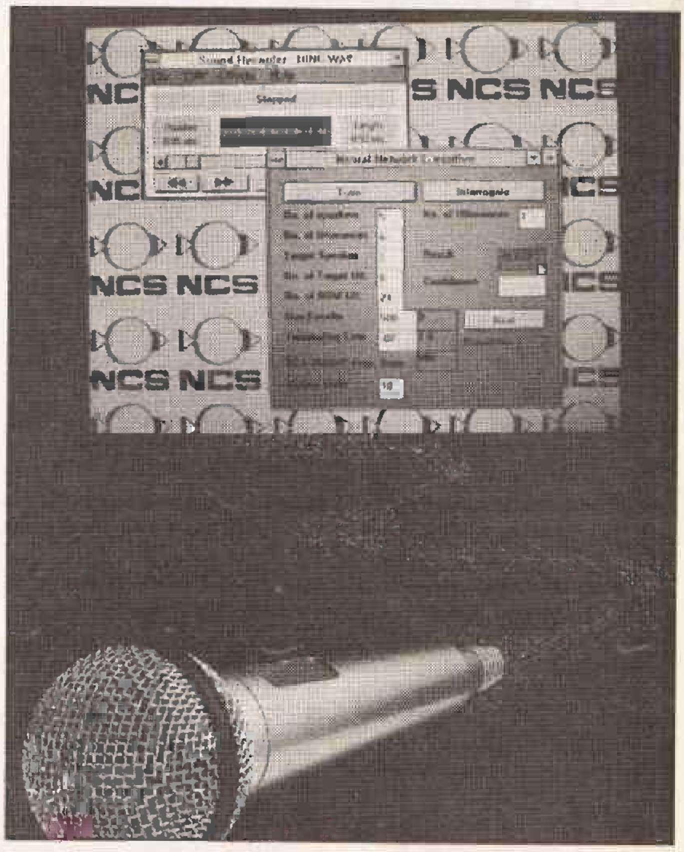
PATTERN RECOGNITION TECHNOLOGY ACHEIVED BY NEURAL NETWORKS

One of the first applications of Neural Computer Sciences' powerful new PC-based neural network package called NeuralDesk, is likely to result in the widespread availability of intelligent, fully-automatic, signal recognition systems. The application is by Domain Dynamics, who have used the package to automate the recognition of data from the output of its signal processing technique, TESPAR (Time-Encoded Signal Processing And Recognition). Currently available in the form of two circuit boards, TESPAR is capable of being converted to a single piece of silicon - opening up a host of applications such as recognition of individual voices or signatures for security purposes, or machinery health monitoring.

TESPAR provides an efficient means of capturing and storing a single elemental 'signature' of acoustic activity, which then provides a reference for recognising patterns. The technology solves long-standing problems in pattern recognition and has recently been licensed by numerous major corporations.

The circuitry is processor-based and digitizes sample data, for example a person speaking, into special codes which represent the waveform. The code system creates a new digital language for describing and comprehending acoustic information. It outputs these numerical codes as matrices. From these samples, a single statistically-relevant reference or archetype-matrix is generated, regardless of the length of data analysed. Up to now, comparing this reference to new data in order to recognise patterns has involved the use of statistical correlation techniques. The reference data provided by TESPAR is extremely compact, a couple of hundred bytes, it is ideal for use in embedded and real-time systems, and Domain Dynamics has been searching for a means of automating the matching process. Neural Computer Sciences' neural network provides the solution in an efficient way.

The neural network provides a means of automatically comparing new data with the reference matrix and quickly distinguishes between the input which, although slightly different to the reference, is an acceptable match, and data which varies slightly. As the circuitry required to embed a neural network is quite modest, Domain Dynamics expects to be able to produce a single-chip neural network plus TESPAR solution within one-two years. Very high volume applications such as ultra-smart cards for biometrics recognition including signature indentification, and smart locks, are just two potential end applications of this combination of technologies.



Domain Dynamics is now working with NCS to develop neural network-based matching systems which are geared for simple real-world use. For example, one likely product for condition monitoring is based on a 'traffic light' principle. This would use the neural network to drive three LEDs which provide a continual status indication of machinery health. The neural network is trained using recorded data of the machinery, and could be programmed to light a green, yellow or red LED depending on how far data deviated from the norm. This could be used to protect expensive or safety-critical machinery such as turbines for power generation or aircraft engines.

For further details please contact:

Nick Hallwood,
Neural Computer Sciences,
Tel: 0703 667775

LIVING WITH LASERS

Lasers can be used to correct shortsightedness, remove birthmarks, drill teeth, make holograms and eavesdrop on other people's conversations. 'Living With Lasers'an exhibition that looks at the widespread use of laser technology in daily life, opened on 15 July, at the Science Museum. It is the second in the 'Science Box' series of rapid response exhibitions on contemporary science, sponsored by Nuclear Electric plc.

Professor David Phillips, Head of Chemistry at Imperial College, who opened the exhibition said "When the first laser was built in 1960 it was termed a 'solution in search of a problem'. Since then lasers have found and solved an incredibly diverse range of scientific problems and continue to spawn new areas of research. This exhibition highlights just some of these remarkable and still evolving advances".

Street theatre-style performances and drama workshops where children become a laser beam are among the "Living With Lasers" special events that have taken place over the summer. Holography lasers in medicine and whether or not Star Trek's matter transporters will come true are just some of the lecture topics that will be explored.

The 'Living With Lasers' exhibition explains why laser light is different from ordinary light. It also covers applications of laser technology in Communications, Medicine and dentistry, at home, at the office or in the shops.

The exhibition also has a laser light display and a specially commissioned hologram.

Special drama events for "Living With Lasers" have been developed by the Science Museum in conjunction with Floating Point Science Theatre (FPST). Street-theatre style performances provide a light-hearted introduction to the applications of lasers using mime. Visitors find out through audience participation how a laser decodes a bar-code. Children's drama workshops explore how light is generated; how laser light is absorbed by tattoos and port wine birthmark stains; and what makes laser light different from ordinary light. Members of FPST are all qualified scientists or engineers as well as mime/physical performers. They specialise in combining science and art to create exciting and fun events.

Living with Lasers is on until 30th September 1992 at the Science Museum in Exhibition Road, London

ETI NEWS

...Stateside...

Experimental neural microchip

An experimental neural microchip that can process 100,000 patterns/second, independent of the size of the patterns, has been announced by Bill Communications Research Corp.

Development of the custom chip took four years. The company previously had published scholarly papers about the experiment but went public with the details of the chip after making certain performance improvements.

The chip uses 992 synaptic connections (496 bidirectional connections) among 32 on-chip neurons. The synapse array consumes the bulk of the silicon real estate.

Each synapse digitally stores 5-bit weights ranging from -15 to +15. To speed processing over methods that convert analogue inputs into digital ones, Bellcore's approach enforces the effect of the synaptic weights by multiplying the analogue voltage inputs by each weight and outputting the result as analogue current.

Unlike previous versions of the experimental microchip, the new version can be cascaded to literally any network size. The 128-pin device's expandability derives from its having half its pins dedicated for data paths that can lead to adjacent chips in a cascade.

The learning method is termed a relaxation technique because inputs to the internal neural network stimulate it to a higher energy level before allowing it to relax into its lowest energy state. The lowest energy state defines the output of a standard engineering I/0 function. The learning method then detects the error in that output state (compared with the known correct output) and adjust its internal synaptic weights until each input is relaxed into the desired output. After all of the I/O pairs have been learned, the neural network can be inserted into working systems.

The new chip uses feedback connections for speedier detection of errors during the learning phase and for quick retrieval of static patterns after learning.

Bellcore plans eventually to integrate the silicon into its existing telephone-switching systems with custom 'glue' microchips. It cited several telecom applications for the chip, including network management, operations, telephone-call routing, cellular-phone frequency assignment, data compression and voice recognition.

E-beam prober guides

E-beam probers have now become important for reaching within the depths of complex semi-conductor devices. The ATE Division of Schlumberger Technologies hopes to make probers even more essential with the release of an advanced version, the SDS 5000HX. Among other features, the HX is one of the first probers to offer automated failure analysis.

The rationale behind the HX is the denser and finer geometries, faster operating frequencies and shrinking signal levels found in new IC generations. To deal with those, the HX is equipped with better signal-to-noise ratios for small-signal measurements, sub-micron probing capability and wide-measurement bandwidth (up to 4GHz).

The improved S/N ratios stem mainly from a patented acquisition technique called dual-gate acquisition. The technique cuts correlated noise and boosts acquisition speed by holding down the averaging needed to obtain an optimal signal. A small-signal mode provides further improvement when working with memory and other low-voltage waveforms.

To achieve an 80nm probe size, the IDS 5000HX's designers modified the electron-optical column and changed the design of the unit's detector and collimator. By adding a selectable acquisition mode, customizable for specific IC technology, the designers slashed acquisition times by up to a factor of 10. Enhancing the detector and acquisition software also improved speed, as well as the HX's waveform accuracy.

IDA software also determines the best place to place a probe, speeding diagnostics even further. The result is that users need only modest skill and little knowledge of a chip's design.

Virtual reality

Virtual reality is now attracting the attention of major electronics companies seeking to tap the technology's potential for future products as well as research applications. Virtual laboratories would make it possible not only to simulate a design or condition but also to interact with it and control the simulation while it is running.

At IBM's T.J.Watson Research Centre, six researchers are exploring scientific uses for virtual reality. The general theme of the work is the creation of a virtual laboratory.

In the past, problems that resisted algorithmic solutions required physical models to test possible solutions. But high-speed computers have allowed simulations to serve as precursors to actual models.

Now, a new breed of specialised input and output devices - from helmet-mounted displays to electronic body suits are available.

Virtual reality could allow scientists to bring their native perceptual abilities to bear on a problem instead of just applying their intellects.

Real-time interactive simulations could greatly simplify the running of interative solutions. For instance, researchers could tune parameters on-line as a simulation runs to control the streamline solutions.

IBM hopes to realise its idea of computational 'steering' to solve problems more intuitively and more easily than in a conventional laboratory. "When you enter a virtual laboratory, the first thing you might do is attach an electronic version of test probes to the simulation running there in order to interact with the current experiment," said Larry Koved, IBM researcher.

Another goal of the virtual laboratory is to allow researchers to interact within a simulation. "When people work on these types of problems, they tend to work together in groups. But they may be in different locations - or looking at the same information in a different fashion," Koved said.

Car design is one discipline in which engineers must resolve ergonometric and electrical issues; for example, dashboard knobs must not only activate the correct functions, but they must also be within a driver's reach. Virtual reality could simplify the resolution of such divergent problems. "Each engineer could give the other a tour of their results even if they are in different geographical locations," Koved said.

Ultimately, some applications - such as database visualisation - may become more important than their physical correlates. "In some cases, the simulation itself will become the object of the collaboration, and since its only representation is in the medium, you will have to bring multiple people into it to explain it to them," Koved said.

Koved's group has constructed several demonstrations of its virtual laboratory concept. The latest is a three-dimensional system called Rubber Rocks, that represents each participant's perspective on separate computer screens. Participants deflect spontaneously appearing rocks away from themselves and toward the other players before the rocks explode.

It takes seven IBM RS/6000 workstations to run Rubber Rocks with two players (more participants require additional RS/6000s to render the graphic representation). One RS/6000 simulates bouncing rubber rocks, two manage communications, another reads electronic glove and head-tracking gear, and the last recognizes spoken commands.

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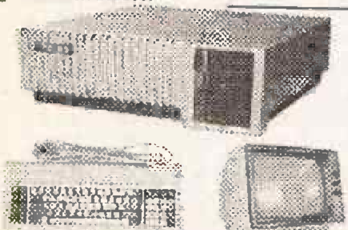

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Optional FITTED extras: 256K RAM £15; 640K RAM £39. 12" CGA colour monitor with card £89. 2nd 5-1/4" 720K floppy (or 360K if preferred) £29.95. 20 mbyte hard drive £99. **£99** (E)

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5¼" from £22.95 - 3½" from £21.95!

Massive purchases of standard 5¼" and 3½" 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 standard voltages and are of standard size. All are **IBM-PC compatible** (if 3½" supported).

3.5" **Panasonic** JU364 720K*	£21.95(B)
3.5" **Mitsubishi** MF353C-L. 1.4 Meg. Laptops only*	£29.95(B)
3.5" **Mitsubishi** MF353C-D. 1.4 Meg. Non laptop*	£29.95(B)
5.25" **Teac** FD-55(36). 360K half height.	£22.95(B)
5.25" **Teac** FD-55(72). 720K half height.	£24.95(B)

* **Data cable included in price.**

Shugart 800/801 SS refurbished & tested	£175.00(E)
Shugart 851 double sided refurbished & tested	£275.00(E)
Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW	£250.00(E)

Dual 8" drives with 2 mbyte capacity housed in a smart case with built in power supply! Ideal as exterior drives! **£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........................**£299(E)**

THE *AMAZING* TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!

TV SOUND & VIDEO TUNER!

The **TELEBOX** consists of an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by manufacturers such as MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD and many more. The composite **video output will** also plug directly into most video recorders, **allowing reception** of TV channels not normally receivable on most television receivers (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television or video channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Composite and RGB video outputs are located on the rear panel for direct connection to most makes of monitor. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

Telebox ST	for composite video input monitors	£32.95
Telebox STL	as ST but with integral speaker	£36.50
Telebox MB	as ST with Multiband tuner VHF-UHF-Cable. & hyperband For overseas PAL versions state 5.5 or 6mhz sound specification.	£69.95
Telebox RGB	for analogue RGB monitors (15khz)	£69.95

Shipping code on all Teleboxes is (B)

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

No Break Uninterruptable PSU's

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

POWER SUPPLIES

Power One SPL200-5200P 200 watt (250 w peak). Semi open frame giving +5v 35a. -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims 13" x 5" x 2.5". Fully guaranteed RFE. **£85.00 (B)**

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

Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4". New **£22.95(B)**

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

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

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

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

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

BBC Model B APM Board

WIN £100 CASH!

£100 CASH FOR THE MOST NOVEL DEMONSTRATABLE APPLICATION!

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

Only £29.95 or 2 for £53 (B)

SPECIAL INTEREST

Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator	£6500
Calcomp 1036 large drum 3 pen plotter	£ 650
Thurlby LA 160B logic analyser	£ 375
1.5kw 115v 60hz power source	£ 950
Anton Piller 400 Hz 3 phase frequency converter 75Kw	POA
Newton Derby 400 Hz 70 Kw converter	POA
ADDS 2020 VDU terminals - brand new	£ 225
Sekonic SD 150H 18 channel Hybrid recorder	£2000
HP 7580A A1 8 pen high speed drum plotter	£1850
Kenwood DA-3501 CD tester, laser pickup simulator	£ 350

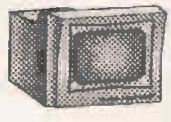
BRAND NEW PRINTERS

Microline 183. NLQ 17x17 dot matrix. Full width.	£139 (D)
Hyundai HDP-920. NLQ 24x18 dot matrix full width.	£149 (D)
Qume LetterPro 20 daisy. Qume QS-3 Interface.	£39.95 (D)
Centronics 152-2 9 x 7 dot matrix. Full width.	£149 (D)
Centronics 159-4 9 x 7 dot matrix.Serial. 9-1/2" width	£ 99 (D)

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)

COLOUR MONITORS

HI-DEFINITION COLOUR MONITORS

SAVE £59 - ONLY £100 WHEN BOUGHT WITH THE 386 ABOVE!

14" Philips Model CM8873 VGA multisync all the way up to 34Khz with 640 x 480 resolution. This one has everything! Two switches enable you to select CGA, EGA or VGA and digital/analog. Unusual for a professional monitor, sound is also provided, with a volume control. There is also a special "Text" switch for word processing, spreadsheets and the like. Compatible with virtually all computers including IBM PC's, Amiga, Atari, BBC, Archimedes etc. Good used condition (possible minor screen burns) 90 day guarantee. 15" x 14" x 12". Only...£159(E)

KME 12" high definition colour monitors. Nice tight 0.28" dot pitch for superb clarity and modern two tone plastic styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". Also functions as quality TV with our RGB Telebox. Excellent used condition with 90 day guarantee. In nice two tone beige and brown case. Only ....£149 (E)

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 12" 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. The front cosmetic bezel has been removed for contractual reasons. Only........ **£79** (E)

20", 22" and 26" AV SPECIALS

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

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

CALL FOR PRICING ON NTSC VERSIONS!

Superb Quality 6 foot 40u 19" Rack Cabinets

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

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

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

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

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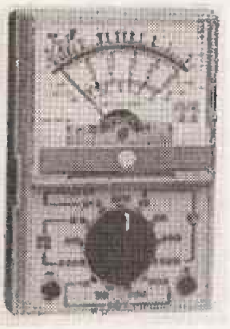
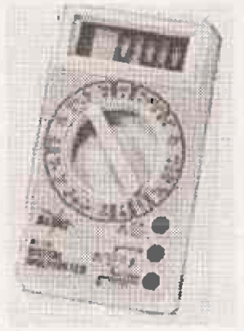
TEST AND MEASUREMENT





HC213 ANALOGUE METER
12 ranges, diaode protection, mirrored scale, 2mm leads. Pocket sized, supplied with battery and instructions.
Dim. 90 x 60 x 30mm £5.96

HM103S ANALOGUE METER
19 ranges (inc 10A dc), fuse and diode protection, battery test, shock resisitant tilted case, mirrored scale, supplied with battery, leads and instructions.
Dim. 154 x 77 x 43mm £11.47

HC2020S ANALOGUE METER
20 ranges (inc 10A dc), fuse and diode protection, transistor and diode testing, polarity reverse switch, high impact shock resistant case. Supplied with battery, leads, stand and instructions.
Dim. 1500 x 102 x 45mm £18.45

MX190 DIGITAL METER
19 ranges, 3.5 digit 12mm LCD, signal injector, diode test, fuse protection, auto polarity and zero, supplied with battery, leads and instruction manual.
Dim. 126 x 70 x 24mm £14.73

M2315B DIGITAL METER
17 ranges (inc 10A dc), 3.5 digit 12mm LCD, diode test, buzzer, auto polarity and zero, over-range and low battery indication, supplied with battery, leads and instructions.
Dim. 130 x 72 x 33mm £23.40

TL34 DIGITAL METER
33 ranges (inc 20A ac/dc) PTC and fuse protection, 5 capacitance ranges, transistor test, 3.5 digit large 24mm display. Heavy duty case with titl stand. Supplied with battery, leads and instructions.
Dim. 191 x 88 x 36mm £5.96

PCB EQUIPMENT

UV Exposure Unit	£67.38
Plasticx Developing Tray	£1.35
Photo Resist • Aerosol spray (100ml)	£3.90
Ferric Chloride Crystals (0.5kg)	£2.45
Tin Plating Powder (90g)	£8.35
Etch Resist Pen	£0.72
PCB Polishing Block	£1.84

STRIPBOARD 0.1 PITCH

64mm x 25mm	£0.27
64mm x 95mm	£0.90
64mm x 127mm	£1.20
64mm x 431mm	£3.22
95mm x 127mm	£1.50
95mm x 95mm	£1.10
95mm x 431mm	£4.80
100mm x 160mm	£1.60
119mm x 454mm	£6.30

BREADBOARD

~~81mm x 60mm~~	~~£2.86~~
175mm x 42mm	£3.50
175mm x 67mm	£5.20
203mm x 75mm includes mounting plate&posts	£6.88

COPPER BOARD (G.Fibre)

100mm x 160mm	£0.84
110mm x 220mm	£1.24

PHOTO RESIST BOARD (G. Fibre)

3 x 4"	£0.86
4 x 6"	£1.62
4 x 8"	£2.09
6 x 6"	£2.41

PHOTO RESIST BOARD (Paper)

3 x 4"	£0.67
4 x 6"	£1.24
4 x 8"	£1.58
8 x 10"	£4.63

ELECTROLYTICAL RADIAL CAPACITORS

uF	16V	25V	63V	100V
0.47	–	–	£0.05	£0.07
1.0	–	–	£0.05	£0.06
2.2	–	–	£0.05	£0.06
4.7	–	–	£0.05	£0.08
10	£0.05	£0.05	£0.06	–
22	£0.05	£0.05	£0.09	–
47	£0.06	£0.06	£0.11	–
100	£0.06	£0.09	£0.11	–
220	£0.09	£0.12	£0.31	–
470	£0.15	£0.19	£0.57	–
1000	£0.22	£0.29	–	–
2200	£0.37	£0.57	–	–
4700	–	£1.11	–	–

ELECTROLYTICAL AXIAL CAPACITORS

uF	16V	25V	63V	100V
0.47	–	–	–	£0.15
1.0	–	–	£0.10	£0.10
2.2	–	–	£0.10	£0.10
4.7	–	£0.09	£0.10	£0.10
10	–	£0.12	£0.12	£0.12
22	–	£0.09	£0.13	£0.17
47	£0.10	£0.11	£0.16	£0.20
100	£0.10	£0.13	£0.11	–
220	£0.09	£0.12	£0.21	–
470	£0.21	£0.20	£0.69	–
1000	£0.33	£0.40	£1.05	–
2200	£0.52	£0.64	–	–
4700	£0.90	–	–	–

RESISTORS

0.25W 5% CF E12 Series	£0.60/100
0.5W 5% CF E12 Series	£0.95/100
0.25W 1% MF E12 Series	£1.72/100
POTSA Log or Lin 470R – 1MO 25mm dia 0.25 shaft	£0.40
PRESETS Enclosed Horz or Vert 100R – 1MO 0.015W	£0.15
PRESETS Skeleton Horz or Vert 100R – 1MO 0.1W	£0.11

OPTO DEVICES

5mm Red LED	£0.09
5mm Green LED	£0.10
5mm Yellow LED	£0.10
5mm Orange LED	£0.10
3mm Red LED	£0.08
3mm Green LED	£0.12
3mm Yellow LED	£0.13
3mm Orange LED	£0.13
5mm FLashing Red	£0.50
5mm Flashing Green	£0.54
5mm Bi Colour	£0.36
5mm Tri Colour	£0.48
5mm Plastic Bezel	£0.04
5mm Plastic Bezel	£0.05
0.3" 7-Segment Display Red common anode	£1.14
common cathode	£1.14

VELLMAN KITS

Stockists of the full range of Vellman Kits. **NEW** 1992-93 catalogue now available send SAE for your copy (A3).

TRIACS

Z0105DA	£0.42
TIC206D	£0.65
TIC226D	£0.73
BTA08-600B	£0.84
TIC236	£0.96
DIAC	£0.20

SWITCHES

Miniature Toggle Switches 3amp 250v 6.4mm ø mounting

SPST Toggle	£0.58
SPDT Toggle	£0.64
SPDT CO Toggle	£0.62
DPDT Toggle	£0.68
DPDT CO Toggle	£0.76
DPDT CO Toggle (biased)	£1.20
DPDT CO Toggle (biased 1 way)	£1.20
DPDT mini slide	£0.15

ROTARY SWITCHES

1 POLE 12 WAY	£0.78
2 POLE 6 WAY	£0.78
3 POLE 4 WAY	£0.78
4 POLE 3 WAY	£0.78
Key Switch SPST	£2.70
Push to make	£0.25
Push to break	£0.24
Latching Push Sqr	£0.58
PCB Tact x 6mm	£0.25

RF CONNECTORS

BNC Solder Plug	£0.85
BNC Crimp Plug	£0.68
BNC Solder Skt	£1.06
BNC Chassis Skt	£0.78
PL259 5.2mm	£0.58
PL259 11mm	£0.58
RND UHF socket	£0.63
SQR UHF socket	£0.40
F Plug RG58	£0.27
F Plug RG6	£0.27
N Plug RG8	£1.64
N Socket RG8	£1.30
BNC Crimp Pliers	£15.50

BRIDGE RECTIFIERS

W005 1.5A 50V	£0.19
W02 1.5A 200V	£0.20
W10 1.5A 1000V	£0.24
BR32 3.0A 200V	£0.36
BR62 6.0A 200V	£0.64
1004 10.0A 400V	£1.39

D CONNECTORS

SOLDER BUCKET TERMINALS

	Plug	Socket
9 Pin	£0.29	£0.30
15 Pin	£0.39	£0.39
15 Pin H.D	£0.81	£0.90
23 Pin	£0.40	£0.49
25 Pin	£0.48	£0.50
9 Way plastic cover		£0.30
15 Way plastic cover		£0.39
23 Way plastic cover		£0.36
25 Way plastic cover		£0.36

LINEAR ICs

TL061	£0.35
TL062	£0.42
TL064	£0.46
TL071CP	£0.32
TL072CP	£0.34
TL074CN	£0.48
TL081	£0.33
TL082CP	£0.34
TL084CN	£0.46
TBA 120S	£0.77
LM301A	£0.25
CA311E	£0.28
CA324	£0.23
LM348N	£0.31
LF351N	£0.36
LM358N	£0.27
LM377	£2.57
LM380N	£1.12
LM381	£2.70
LM386	£0.48
LM387	£1.60
LM392N	£0.79
LM393N	£0.28
LM394	£3.98
CA555	£0.22
NE531	£1.56
NE5534	£0.66
NE556N	£0.36
NE567N	£0.36
UA733	£0.64
CA741CE	£0.18
CA747CE	£0.39
CA3130E	£0.98
LM748CN	£0.31
TBA810S	£0.68
TBA820M	£0.39
LM1458	£0.26
ULN2004	£0.48
TDA2030	£1.35
CA3046	£0.37
CA308	£0.72
CA1310	£0.98
CA3140	£0.56
CA3240	£1.22
LM3900	£0.72
LM3914	£2.70
LM3915	£2.70
MC4558	£0.36
NE5532	£0.80
ICL7621	£1.70
ICM7555	£0.43
ICM7556	£0.96
ZN414Z	£1.04
ZN425E	£4.68
ZN426E	£2.61
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ZN428E	£6.12
ZN435E	£5.31
ZN448E	£7.92
MC3340	£1.60

REG'S

78L05	£0.24
78L12	£0.24
78L15	£0.24
79L05	£0.28
79L12	£0.28
79L15	£0.28
7805	£0.28
7812	£0.28
7815	£0.28
7905	£0.38
7912	£0.38
7915	£0.38
LM317T	£0.44
LM723	£0.29
L200CV	£1.24
LM323K	£2.70
LM338K	£5.52

74LS SERIES

74LS00	£0.14
74LS01	£0.14
74LS03	£0.14
74LS04	£0.14
74LS05	£0.14
74LS06	£0.14
74LS07	£0.14
74LS08	£0.14
74LS09	£0.14
74LS10	£0.14
74LS107	£0.23
74LS109	£0.21
74LS11	£0.17
74LS112	£0.21
74LS113	£0.21
74LS114	£0.21
74LS12	£0.14
74LS122	£0.31
74LS123	£0.31
74LS125	£0.21
74LS126	£0.21
74LS13	£0.14
74LS132	£0.21
74LS133	£0.18
74LS136	£0.16
74LS138	£0.24
74LS139	£0.25
74LS14	£0.18
74LS145	£0.56
74LS147	£1.26
74LS148	£0.70
74LS15	£0.14
74LS151	£0.25
74LS153	£0.25
74LS154	£0.70
74LS155	£0.25
74LS156	£0.25
74LS157	£0.25
74LS158	£0.25
74LS160	£0.32
74LS161	£0.32
74LS162	£0.32
74LS163	£0.32
74LS164	£0.26
74LS165	£0.48
74LS179	£0.30
74LS173	£0.24
74LS174	£0.24
74LS175	£0.24
74LS190	£0.25
74LS191	£0.24
74LS192	£0.24
74LS193	£0.24
74LS195	£0.24
74LS196	£0.24
74LS197	£0.24
74LS20	£0.16
74LS21	£0.14
74LS22	£0.14
74LS221	£0.36
74LS240	£0.32
74LS241	£0.32
74LS242	£0.32
74LS243	£0.32
74LS244	£0.32
74LS245	£0.33
74LS247	£0.32
74LS251	£0.24
74LS257	£0.24
74LS258	£0.24
74LS26	£0.14
74LS266	£0.14
74LS2	£0.14
74LS273	£0.32
74LS279	£0.25
74LS30	£0.14
74LS32	£0.14
74LS365	£0.21
74LS367	£0.21
74LS368	£0.21
74LS37	£0.14
74LS373	£0.32
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74LS375	£0.34
74LS377	£0.32
74LS378	£0.62
74LS38	£0.14
74LS390	£0.25
74LS393	£0.24
74LS395	£0.26
74LS399	£0.62
74LS40	£0.14
74LS42	£0.25
74LS47	£0.42
74LS51	£0.14
74LS670	£0.69
74LS73	£0.17
74LS74	£0.19
74LS75	£0.19
74LS76	£0.25
74LS83	£0.31
74LS85	£0.35
74LS86	£0.20
74LS90	£0.23
74LS92	£0.35
74LS93	£0.25

DIL SOCKETS

8 Pin	£0.07
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18 Pin	£0.15
20 Pin	£0.16
24 Pin	£0.19
28 Pin	£0.22
40 Pin	£0.25

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IN4004	£0.07
IN4005	£0.07
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IN4007	£0.08
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IN5401	£0.09
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BA158	£0.10
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4015	£0.31
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4017	£0.25
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4031	£0.70
4033	£0.56
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4502	£0.38
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4572	£0.25
4584	£0.24
4585	£0.32
4724	£0.70
40106	£0.31
40109	£0.50
40163	£0.46
40174	£0.34
40175	£0.36
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2N2218A	£0.28
2N2219A	£0.25
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2N2646	£0.80
2N2904A	£0.25
2N2905A	£0.23
2N2907	£0.20
2N2926	£0.16
2N3053	£0.27
2N3054	£0.90
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2N3440	£0.50
2N3702	£0.09
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2N3771	£1.44
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2N3773	£1.79
2N3819	£0.40
2N382	£0.58
2N3904	£0.10
2N3905	£0.10
2N3906	£0.10
2N4036	£0.31
2N5296	£0.57
2N5321	£0.57
2N6107	£0.60
AC126	£0.30
AC127	£0.30
AC128	£0.28
AC187	£0.37
AC188	£0.37
ACY17	£3.84
AC149	£1.67
AC161	£0.92
AC162	£0.92
BC107	£0.14
BC107B	£0.15
BC108	£0.12
BC108A	£0.14
BC109	£0.14
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BC116	£0.41
BC118	£0.41
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BC134	£0.36
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BC142	£0.31
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BC149	£0.12
BC154	£0.36
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BD244A	£0.53
BD246	£0.60
BD441	£0.41
BD442	£0.41
BD534	£0.47
BD535	£0.48
BD536	£0.65
BD646	£0.52
BD648	£0.52
BD650	£0.53
BD707	£0.42
BD807	£0.80
BDX32	£1.78
BDX33C	£0.46
BDX34C	£0.50
BDX53C	£0.47
BDX54C	£0.50
BF180	£0.31
BF182	£0.31
BF185	£0.31
BF194	£0.19
BF195	£0.19
BF244	£0.35
BF257	£0.33
BF259	£0.33
BF337	£0.36
BF355	£0.38
BF423	£0.13
BF45	£0.19
BF459	£0.29
BF469	£0.36
BFX29	£0.29
BFX84	£0.31
BFX85	£0.31
BFY50	£0.29
BFY51	£0.26
BFY52	£0.28
BSW66	£1.35
BU126	£1.32
BU205	£1.41
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TIC106D	£0.40
TIC116D	£0.66
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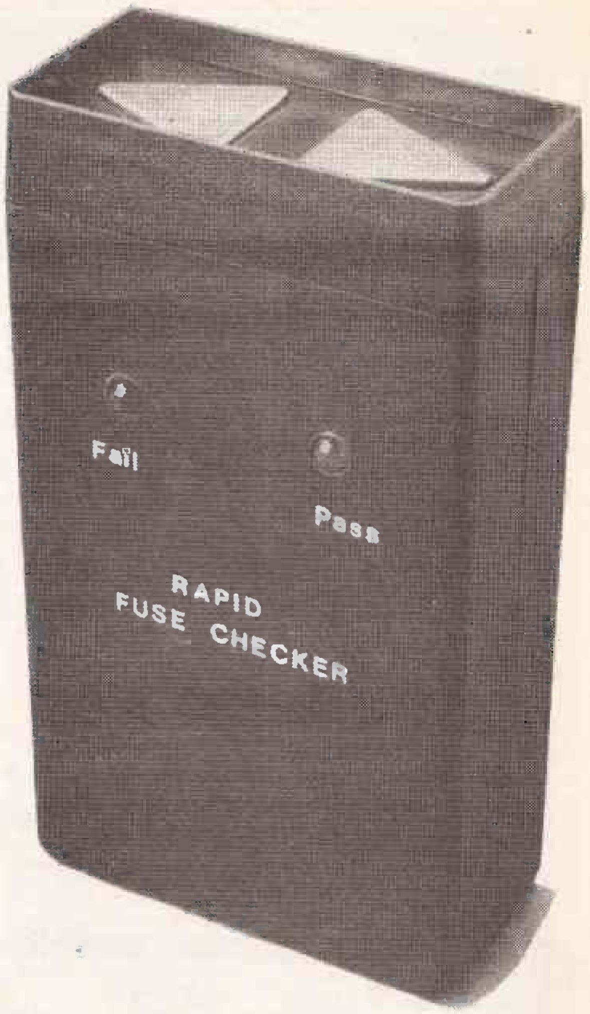
When an appliance, or an electronics project, fails to work the fuse is often the first component for investigation since its main function is to fail in preference to other, more expensive components. Many of the smaller fuses encountered in electronic equipment are glass types which may easily be checked visually.

Or can they? The higher current rated ones certainly can in most instances, but fuses rated at 250mA or less have a very fine wire which can be very difficult to see, even under ideal viewing conditions.

When a ceramic cartridge fuse is suspected to be faulty a visual check will normally reveal nothing conclusive, so the trusty old multimeter is then used to chase the fuse around the bench until a conclusive result is obtained. Unfortunately, the multimeter will produce the same results for a defective fuse as it does when you fail to get a good contact with the test probes! The results can be inconclusive, and the testing is certainly time consuming; an alternative piece of dedicated test equipment is thus very desirable.

The unit described in this article is both inexpensive and simple to use. The results obtained by using the Rapid Fuse Checker are virtually 100% conclusive as a visual indication is given for both good and defective fuses.



Design Criterea

A cursory glance at the circuit diagram for the Rapid Fuse Checker will reveal that no ICs are used in the construction of the unit! Perhaps not surprisingly, the device could have been designed around a single IC and a handful of passive components. The decision to use discrete devices in this application was not taken lightly as it offers significant advantages over any design using op-amps, or general purpose ICs.

Rapid Fuse Checker

By Mark Daniels

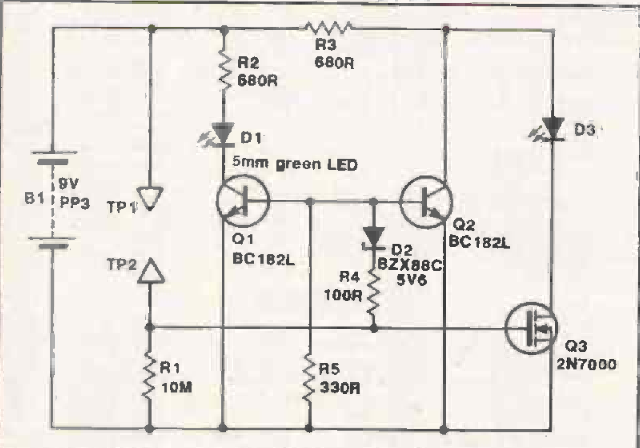


Fig.1 Circuit diagram of Rapid Fuse checker

The observant reader will already have noticed the complete absence of any on/off switch in the design; this is no accident as the device has been designed to use only minimal

HOW IT WORKS

The complete circuit diagram for the Rapid Fuse Checker is given in Figure 1. As noted above, the circuit is based around three discrete transistors, Q1 to Q3. The MOSFET, Q3 is operated in common source mode, rather akin to the common emitter mode of its more familiar bipolar cousin, providing current and voltage gain. Being an insulated gate device, the MOSFET requires only a voltage on its gate terminal to turn it on; the gate draws no current (well, very little anyway) as it is isolated from the drain and source terminals by an extremely thin insulating oxide layer.

Resistor, R1 serves to protect the gate from static discharges (the same kind that can damage CMOS ICs), as the gate is connected to the outside world via a touch pad. For the MOSFET to conduct between its drain and source terminals its gate terminal needs to be taken to a positive voltage, greater than its threshold voltage, which for the 2N7000 is around 3 volts. A human body may make the connection between the gate and positive rail, as the current requirement is very low, approximately 300nA through R1, and the extra resistance interposed will make little difference.

With Q3 turned on a current may flow through the red LED, D3 and its current limitting resistor, R3 to ground causing the LED to light. The difference that the resistance of human flesh makes becomes significant when applied to the circuitry around the bipolar transistors, due to their inherent lower sensitivity.

The bipolar devices are operated in common emitter mode, so

PROJECT

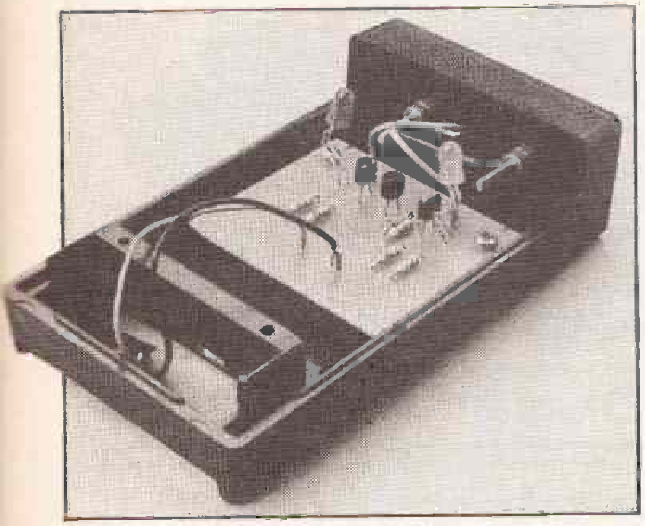
current when in standby mode, thus obviating the need for any switch.

Checking the op-amp data tables in any catalogue will reveal that even the lowest power MOSFET op-amps require around 1mA supply current, even under quiescent conditions. When it is taken into consideration that the capacity of an alkaline PP3 battery is only 550mA hr (zinc carbon types are even less!) a continuous drain as high as 1mA becomes very significant, draining the battery in just three weeks.

Construction

All components are assembled on a small singlesided glassfibre printed circuit board. The copper foil pattern and corresponding component overlay are shown in Figure 2.

To simplify later assembly and testing fit four solder pins where the leads connect to the board and solder them in place. Then fit all the resistors, which should be fitted close to the board. The two bipolar transistors, Q1 and Q2 should be fitted next.



The MOSFET may now be fitted with great care as it requires some very careful handling. MOSFETS are static sensitive and MUST be kept in their protective packaging until ready for insertion into the board. It is suggested that the MOSFETs pins be pushed into a small piece of conductive foam, of the type static sensitive ICs sometimes come packaged in, before fitting it to the board. The foam may then be ripped away after ALL connections to the device have been soldered and it is ascertained that R1 has been fitted in its correct position. With R1 connected across its gate and source terminals the MOSFET is adequately protected and no longer requires special handling.

Fit the two LEDs to the board, ensuring correct positioning and orientation. For the recommended case the tops of the LEDs should stand about 22mm above the PCB surface, so that when fitted in the case they may locate into appropriately drilled holes in the top side of the enclosure.

The battery connector may now be fitted and connected to a 9 volt battery for initial testing of the completed PCB Neither LED should glow until a connection is made across the two remaining PCB pins. If a suitable meter is available the current consumption of the device may be checked to ensure that it is no greater than a few microamps, anything greater will cause rapid depletion of the battery.

Placing a finger tip across the two remaining PCB pins should cause the red LED to light brightly, the green one remaining firmly off (unless the LEDs have been swapped over, in which case the green one will light). To light the green LED short the pins together with a piece of wire or similarly conductive material, the red LED should NOT illuminate this time.

Once everything is working OK assemble the board and touch pads to the case, allowing a small gap between the touch pads so that most fuses may easily be accomodated. Label the case up and put the unit into service.

Fault Finding

For those who are unfortunate enough to have completed assembly and not obtained positive test results it is unlikely that much is wrong. Check first that all components are in the correct positions and that the polarity of D1 is correct. The orientation of the transistors is fairly obvious and unlikely to cause problems.

The LEDs, however, are another matter entirely as the encapsulation gives little indication as to polarity, but if you look through the semi-transparent plastic the cathode may usually be identified as the larger chunk of metal. If you are uncertain, reverse the connections to the LEDs anyway, it almost certainly will do no harm and may even solve the problem.

The MOSFET may be a completely different ball game, however, and if any risks were taken with it during construction the chances are that they did not pay off, the only solution then is CAREFUL replacement of the device with a new one.

In Use

Operation of the completed Rapid Fuse Checker could not be simpler; simply hold the fuse to be tested by its end caps and place it across the test pads of the unit. A green light for go, put the fuse back in circuit, or a red light for nogo, place the fuse in the bin! The red light indicates that the fuse has been successfully tested, in so far as the connections made with its endcaps were good.

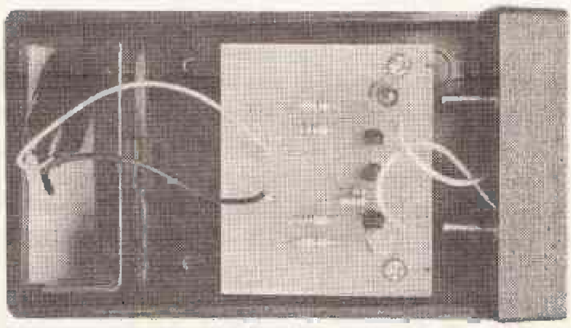
If the fuse is too large to fit across the test pads (see photograph) an alternative method of testing is to use the "Red Light Method", touch one of the touch pads with one hand and holding the fuse in the other hand by one terminal touch its other terminal to the second test pad. With this method the red LED lights for a good fuse, neither for a blown one.

require only a small base voltage of approximately 0.65 volts to turn them on; however, the voltage is not applied to their bases directly, but via a zener diode, D2 which does not become conductive until the voltage across it exceeds 5.6 volts.

R5 is the load resistor for the zener diode and ensures that the zener has to pass a current of approximately 2mA to conduct: thus the bipolar transistor cannot be turned on by a current which is limitted by the resistance of a human body. Q2 shorts the anode of D3 to 0 volts, thus ensuring that even though the MOSFET will be conductive the LED has no voltage across it and therefore does not illuminate. At the same time Q1 supplies current to the other LED, D1 causing it to light.

It should be obvious that only one or other of the LEDs may be lit at any one time, depending on the resistance across the test pads. Note that something has to be connected for any indication to be possible, and that neither LED will light with the test pads open circuit.

Some care is necessary when using this method as a ruptured fuse may still be sufficiently conductive (due to metal sprayed by the arc onto the inner walls of the cartridge) to light the red LED, in which case a supplementary test with the trusty old multimeter may be in order.



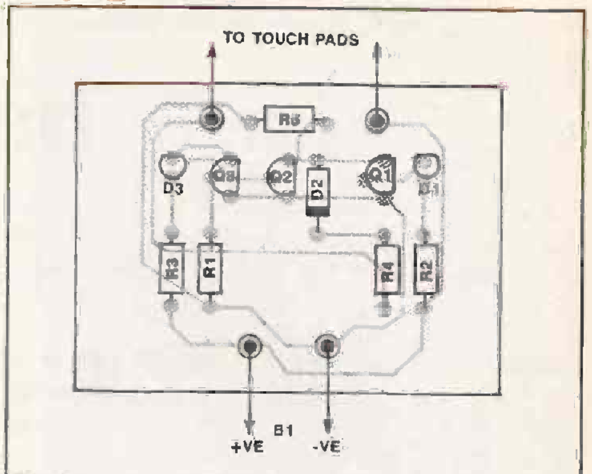


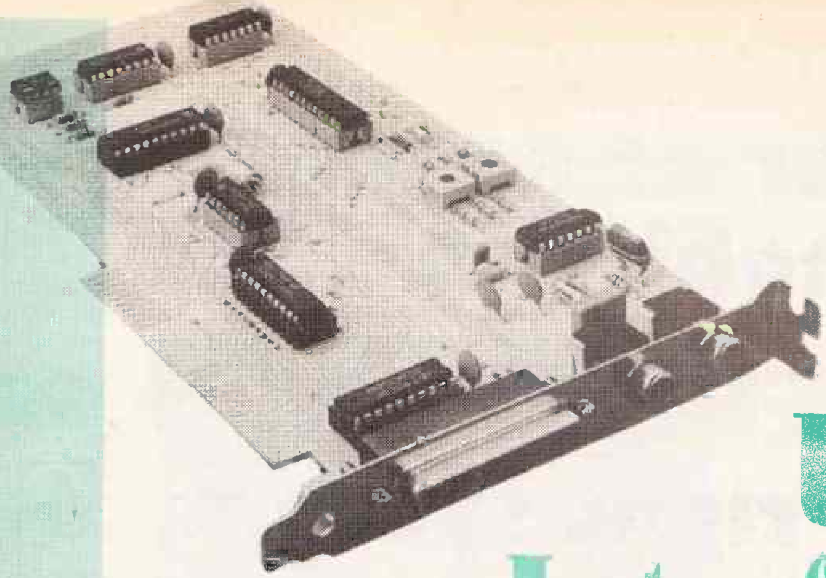
Fig.2 Component Overlay

PART LIST

RESISTORS (All 0.25W 5% Carbon Film)
R1 10M
R2 680
R3 680
R4 100
R5 330

SEMICONDUCTORS
D1 5mm Green LED
D2 BZX88C.5V6
D3 5mm Red LED
Q1 BC182L
Q2 BC182L
Q3 2N7000

MISCELLANEOUS
B1 PP3 9 volt Battery
Triangular Touch Pads (2 off)
PCB Pins (4 off)
PP3 Battery Clip
Handheld Plastic Case
6BA Nuts and Solder Tags For Touch Pads Screws and Spacers for Mounting PCB Printed Circuit Board



Universal Interface Card for the PC

'Intercard 1'

PROJECT

1

Size	8 bit half card + card end plate
Memory Location	In I/O map, region $300-$31F (prototype board)
Memory Required	4 consecutive addresses, allowing 8 possible starting addresses, i.e. $300, $304, $308, $30C, $310, $314, $318, and $31C
Busses	8 bit Data bus, 8 bit Address bus + Read/Write and enable signals
Digital I/O	Two 8 bit bi-directioal ports + Read/Write
Analogue Input	600 ohm nom. impedence, 320mV rms Filtered: 10Hz - 7KHz
Analogue Output	Low Impedance, 2.6V rms Filtered: 10Hz - 7KHz
Sample Rate	At least 14KHz, to satisfy Nyquist rate
Other	It would be nice to have available a +5V supply for testing of small digital circuits or driving opto couplers/isolators

Fig.1 Specification of IBM PC Interface Card

Design & Development by Neil Johnson

Ever since my first humble beginnings in the world of computing on a ZX81 (and proud to own up to it !) I've always wanted to be able to connect a computer to the 'real world'. Although I never succeeded with the ZX81, I did design and build a simple interface board for my next computer, a VIC20. I also began to get into assembler programming as the only alternative was BASIC, which was too slow for my tastes. After several other add-ons, I didn't progress much further until I began my engineering degree at Surrey University. During the first term I treated myself to a PC-AT clone, with a 286 under the bonnet. Coupled with a harddisk and VGA screen I had a fairly powerful system. Now my dreams could be realised!

My eyes aglow I opened up the lid of my new machine and, after the initial excitement at seeing the shiny new motherboard, felt slightly dismayed at the lack of user-friendly hardware connections. Oh sure there were the customary printer and serial ports, but to actually get to the bones of the system, namely the system busses, a special plug-in board would have to be fitted. After flipping through several PC magazines I soon reached the conclusion that to buy such a board would cost the equivalent of eating for a term. But hang on a minute, I'm studying for a degree in electronics engineering, surely I should be able to design and build a simple interface card for a PC ? After all, it was only a double sided edge connector in there.

So, with pint in one hand and mighty pen in the other, I set about laying down the basic requirements of such a board. After several months at this, interspersed with lectures, studying, exams, parties, exams and more parties, I finally had some sort of specification. This was further refined until the final specification was drawn up, outlined in Figure 1. Just a few comments. The starting addresses (base addresses) have a $ symbol in front of them to signify that these are hexadecimal (base 16) numbers. The analogue input and output levels have been specified to be compatible with most audio mixers that have effect send/return loops. Hence another feature of this board is that it can enable the computer to be used as a digital effects unit in a home recording system. Although an upper frequency limit of 7kHz has been specified, mainly because of the highest rate my PC could sample, it is very easy to raise or lower this, more details later. By the way, the Nyquist rate is twice that of the highest frequency component of the sampled signal. This should then provide enough information to be able to successfully reconstruct the original signal. The output of the converter is similarly filtered to remove any nasty aliasing and other noise that will undoubtedly be present.

The Design

The block diagram of the InterCard (short for INTERface CARD) is shown in Figure 2. The most important block is the Logic & Convertor since this is where all the address decoding and PC bus interfacing will take place. The analogue signals connect to the Analogue Output Amplifier, which includes some sort of filtering, and the Analogue Input Amplifier, which also includes filter circuitry. The whole board derives its power from the PC bus via the Supply Decouple block, which includes several capacitors to decouple the supply rails.

The most important decision to make in this project was about the type of convertor to use. Since I have been happy with the results of successive approximation convertors for several years, this was obviously the type to use (also being the most common they also tend to be the cheapest).

After hunting through numerous catalogues, I eventually arrived at two possible candidates. The first was the old favourite Ferranti ZN series of convertors which I have used in past projects. The second was a really nifty device, an AD7569, made by Analogue Devices and available from Verospeed. This device has a built in track and hold circuit, 8 bit analogue to digital converter, 8 bit digital to analogue converter, output buffer and a smattering of control logic, complete with 3 state data bus. A phone call to Analogue Devices and a data sheet was sent to me through the post. I must admit here and now that this was the most meaningful data sheet for a converter I had ever read. For one thing it actually told you the highest frequency sine wave this widget could successfully sample, in this case 200kHz quite ample for sampling audio. As you've probably gathered by now, Analogue Devices won hands down. Not only does this one chip save the bother, and expense, of buying separate devices to do the track/hold, A-to-D and D-to-A, but also reduces the component count, board space and power consumption. Now on with the rest of the circuitry. To start with, the digital side of things. Firstly the address lines must be decoded to tell the InterCard when to wake up and do something. With reference to Figure 3, IC1 is an 8 bit magnitude comparator whose output, pin 19, only goes LOW when the P inputs are the same as the Q inputs. In this case the P inputs are connected to the address bus and the Q inputs are hardware selected, including SW1, to specify a particular block of I/O memory. Also at this stage the Address Enable line (connection A11) is examined, as this will be LOW when a processor address is present on the address bus. The Input/Output Read (IOR\) and Input/ Output Write (IOW\) lines and buffered by IC6b and IC6c, with IC6d ANDing both of them to enable IC1 only if an Input/Output operation is being performed.

The output of IC1 is then used to enable IC2 and IC5a. IC2 is an octal bus transceiver with 3 state outputs, making it an ideal data bus buffer. The direction of data flow is determined by the state of the DIR input (pin 1) connected to the IOR\ line. Thus the internal data bus is connected to the PC's data bus only when the InterCard is being accessed, otherwise there will occur a situation, known as a 'bus contention', when two outputs try to drive one signal line. This can cause problems if one output is low and the other is high, the result being a short circuit.

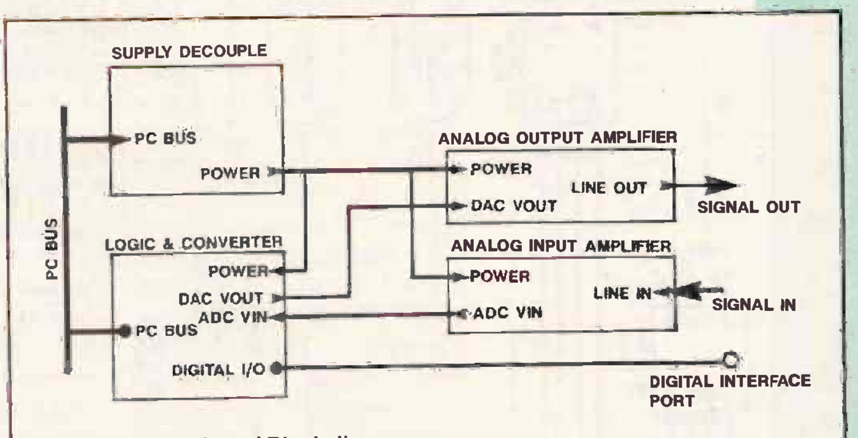
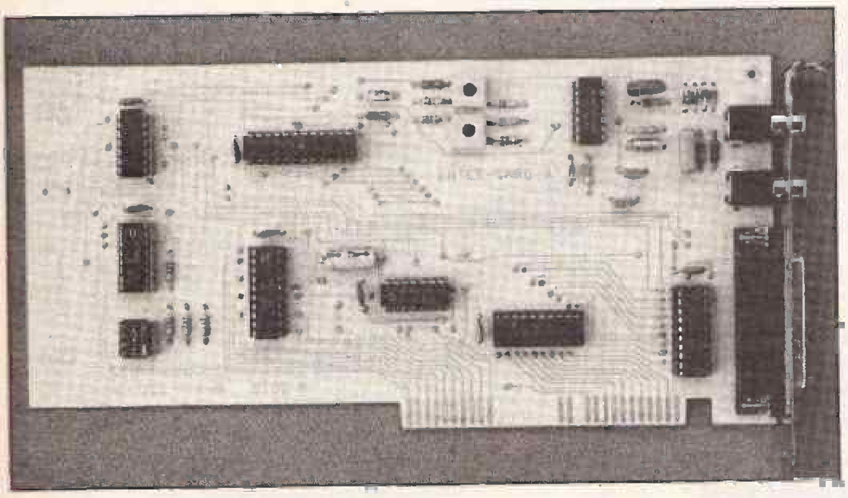


Fig.2 PC Interface board Block diagram



IC5a is a 2-to-4 line decoder which converts the lowest two address signals into four enable signals. The first and second enables are used solely for the converter, the first one for accessing the converter data bus and the second enable to start the A-to-D conversion process. The other two enable lines are used by the external 8 bit interface port as I/O block enables IO2\, for port A, and IO3\, for port B, buffered by IC7a and IC7b. IC7c and IC3 connect the external 8 bit port connector to the data bus. The direction control for IC3, another octal bus transceiver, is derived from the IOR\ signal, but this time is enabled by NORing the two digital port enable signals via IC7c. Hence IC3 is only activated when one of the two external 8 bit ports is being accessed. The digital ports are connected to the outside world via SK1, a 25 way female D-connector. Figure 4 shows the pinout of the digital connector. Now we move on to the digital side of the converter.

When the converter is enabled, by taking its Chip Select line low (pin 16), the convertor's internal data bus can be read from or written to. If the RD\ line is taken low, the data from the A-to-D converter is made available, while if the WR\ line is taken low, data is transferred into the D-to-A converter. To start the A-to-D conversion the Start input (pin 18) must be taken HIGH. This is accomplished by NORing the IOW\ line and the second enable signal, performed by

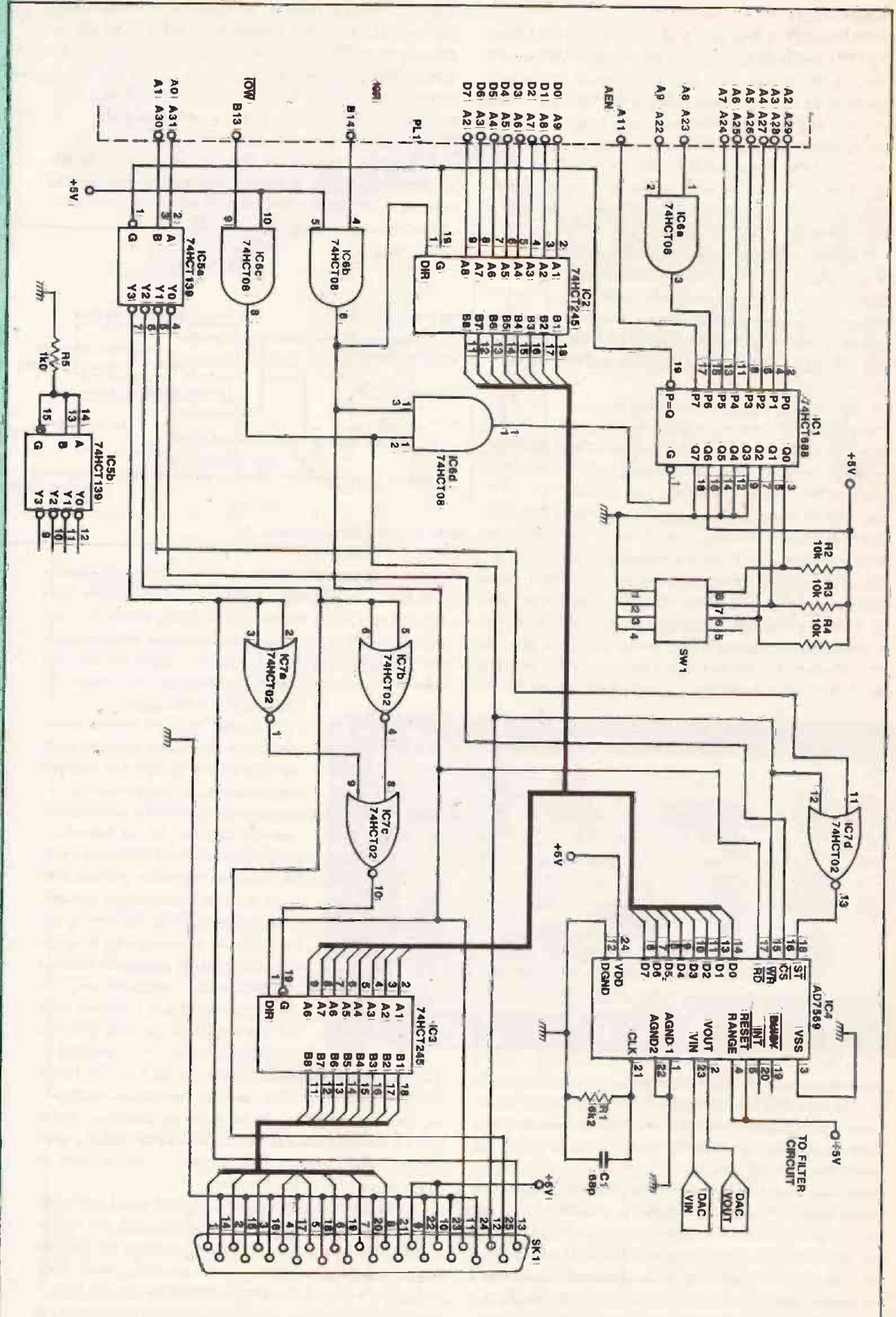


Fig.3 PC Interface board Logic and Converter

IC7d. Once the converter has been started, it will take 8 clock cycles to complete the conversion. The clock can either be externally supplied or the internal clock generator can be used. In this circuit the internal clock is used. The frequency is determined by R1 and C1, which in this case is approximately 5MHz (the conversion time being around 2µs). The Range input is held high to select the 0-2.5 volt range for both the A-to-D and D-to-A convertors. The device can also operate in bipolar mode, i.e. 2.5 to +2.5 V, but the data is converted to 2's complement, which tends to complicate matters and also means that the board cannot be used with most programs that can use D-to-A boards (but then I know of a Windows program that expects the data to be in 2's complement form, so it just goes to show that you can't always win). To recap, the interface to the PC bus has been designed as has the external 8 bit digital port. Also the digital side of the converter chip has been covered. Another important aspect, especially since this circuit uses both digital and analogue circuitry, is supply decoupling (Figure 5). All of the logic chips use a standard +5V supply, obtained from the PC Bus, and each one has their own decoupling capacitor connected close to their supply connections. These 100n ceramic capacitors help reduce noise getting into or out of the logic chips, especially when one or more outputs change state causing glitches on the supply rails. In general 100n per chip is a safe overhead to work to, although some designers use 10n per chip or 100n per five chips. The only problem then is that the inductance of the circuit board tracks must also be taken into account. The +12V and -12V supplies for the analogue circuitry are also decoupled, by C10 and C11, to help reduce noise from the supply rails affecting the analogue signal. The large electrolytic capacitor, C9, provides major smoothing of the local +5 V. supply, helping reduce the effects of the inductance of the PC bus.

The first analogue circuit block is the input buffer/filter (Figure 6). Assuming this board is to be used for audio signals, the input comes from J1, a PCB mounting phono socket. I chose to use phono sockets for three reasons. One, there are very few moving parts to break. Two, the physical connection between plug and socket is nice and strong, and three, there are plenty of wiping contacts to help maintain a good signal path. The signal enters the first active stage based around IC8d configured as an inverting op-amp circuit with a maximum gain of around 2.4, tailing off to 0 at high frequencies. The upper 3db point is set by the value of C12, whose value is derived from the equation :

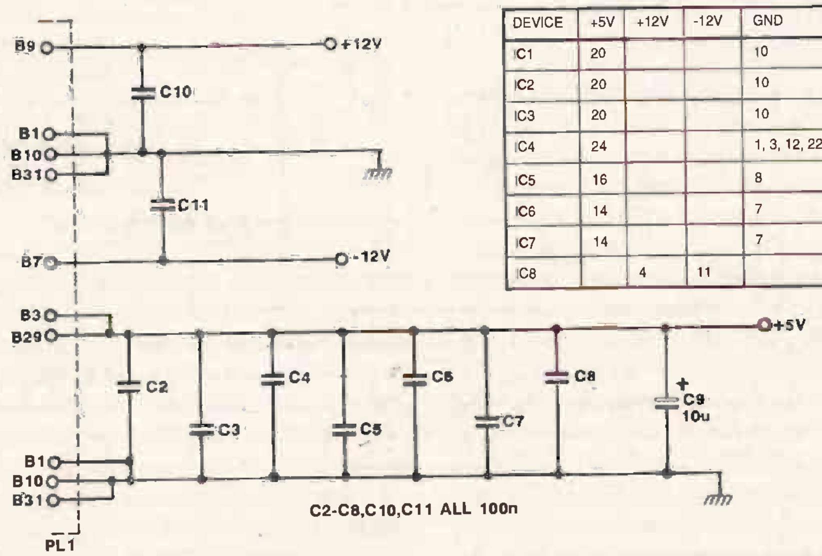
$$f = \frac{1}{2\pi R7C12} \qquad \text{where } \pi = 3.1415$$

Thus to change the 3db point to, say, 10kHz the value of C12 would need to be changed to around 10n. The filtered audio signal then passes through a signal clipper, based on R8 and diodes D1 to D4. Any voltage greater than +/- 1.2 volts (= 2 diode drops) will either turn on D1,D2 or turn on D3,D4, conducting surplus current to ground. In ideal circumstances this stage would not be needed, but since the converter chip costs just over ten pounds, a few pence spent here is worth it for the added safety. Finally the filtered and clipped signal is fed to a level shifter based around IC8a. C13 and R9 couple the AC signal to the non-inverting input of IC8a together with a constant DC offset via RV1 and R10. The gain of this stage can be finely adjusted by RV2 within the range 1.0 to 1.1 (see later for setting up details). The amplified, level shifted signal is finally fed to the analogue input of the converter chip, IC4.

The last circuit block to design is the analogue output buffer/filter (Figure 7). Ideally the output of the converter would like to see a pure 2k0 resistor, 2k2 being the nearest preferred value. The signal is then buffered by IC8b before being fed to the filter. C14 removes the constant DC offset, introduced at the input, and together with R15 sets the lower 3dB point of this amplifier at around 10Hz. IC8c amplifies the signal by about 1.4 times at low frequencies tailing off to 0 at high frequencies. Again the

Pin	Function
1	Data 7 (MSB)
2	Data 6
3	Data 5
4	Data 4
5	Data 3
6	Data 2
7	Data 1
8	Data 0 (LSB)
9, 10	+5V
11	Read (active LOW)
12	Write (active LOW)
13	Port B select (active LOW)
1424	GND
25	Port A select (active LOW)

Fig.4 Digital Port Connections



DEVICE	+5V	+12V	-12V	GND	DECOUPLE CAPS
IC1	20			10	C2
IC2	20			10	C3
IC3	20			10	C4
IC4	24			1, 3, 12, 22	C5
IC5	16			8	C6
IC6	14			7	C7
IC7	14			7	C8
IC8		4	11		C10,C11

Fig.5 Supply Decouple

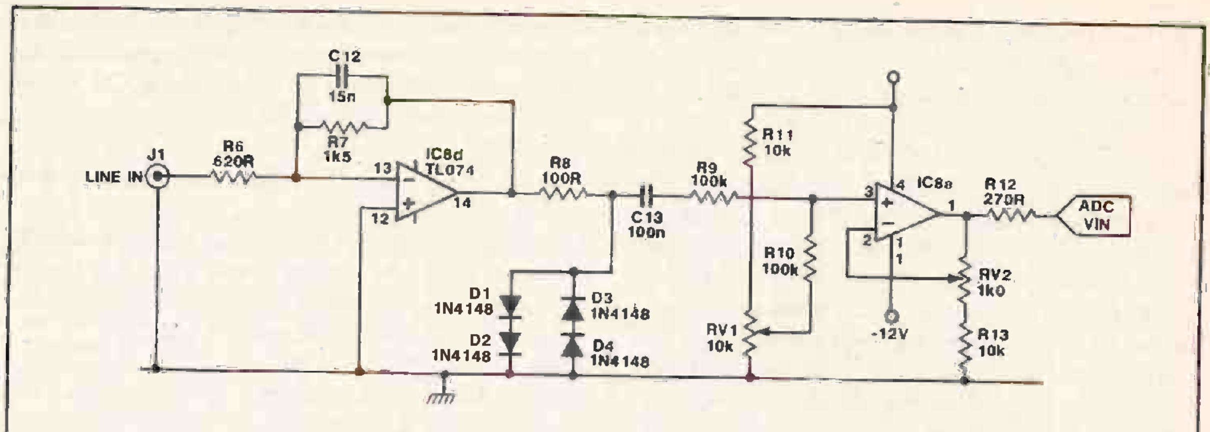


Fig.6 Analogue input amplifier

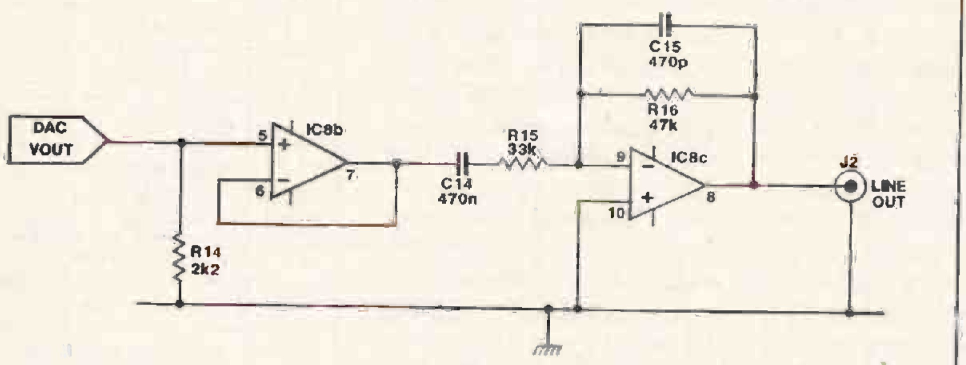


Fig.7 Analogue output amplifier

upper 3db point is determined by R16 and C15 and can be changed as explained above. The audio signal is sent back out to the real world through phono socket J2. Sometimes, when I'm wearing my designers hat, I feel envious of the constructor simply because when the inevitable circuit board is needed all the constructor has to do is order one from the supplier, whereas the designer has to start from scratch, going through several stages of prototyping, from the ubiquitous breadboard to wirewrap boards and, sometimes, several versions of the PCB before the finished product is ready. Anyway, enough of my rantings and back to the project. Now where was I ?.... Oh yes, construction.

Construction

Assuming you have a nice clean predrilled PCB in front of you and a full set of components, you should be ready to start. First of all spend a few minutes giving the PCB a good visual inspection to make sure there are no broken or, horror of horrors, shorted tracks. Spending a few minutes now could save hours later. Once you're happy that everything seems to be OK you can start populating the board with components as shown in Figure 8. Begin by soldering in all of the through board links, needed since this is NOT a throughplated PCB. You can either use the proper links for this task (available from Maplin) or use the legs of resistors from previous projects, which could be a bit cheaper since there are 102 of them to fit. Once this is done check again for any solder blobs that could be shorting tracks. With a project of this type, which will eventually be plugged into a piece of expensive equipment, being careful is a must unless you want to see your PC die a strange death (as mine nearly did once).

Proceed as usual by starting with all of the resistors and diodes followed by the capacitors. There are no wire links on this PCB one thing I just can't stand, especially on a double sided board. Again check for any solder blobs across adjacent tracks and remove them now! Continue with the IC sockets, presets, phono sockets and D-connector. For better mechanical strength, glue the phono sockets to the PCB with Araldite (or any other epoxy resin based glue) and allow to set. The DIL switch, SW1, can be fitted into its socket, but don't insert any of the ICs yet. The card edge plate needs two holes drilled into it to accomodate the two phono sockets. Refer to Figure 9 for the drilling details. Once the plate is ready it can be bolted to the PCB with the D-connector mounting bracket. Then give the board a final thorough inspection before going any further. Correcting any faults at this stage can save a lot of worry. Now it's time to enter the innards of your beloved PC.

With the PC turned off, carefully open up the case using whatever method as necessary (my PC has a lid like a car

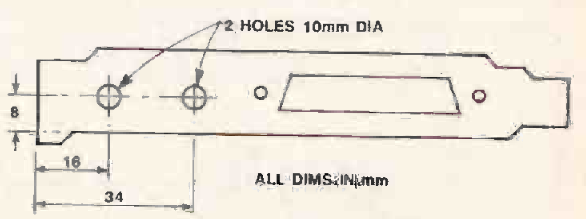


Fig.9 Card end plate drilling details

bonnet, released by two side catches). Ideally this card will be used in an 8 bit slot, although it will fit into a 16 bit slot. Remove the dummy plate for your chosen slot, being careful not to drop the screw into your PC. Making sure that you've earthed yourself, firmly but gently insert the InterCard into a slot. Once it is pushed home, check for any visible signs of problems, e.g. motherboard components fouling the PCB, and if possible correct them. Take a deep breath and turn on your PC. If everything is OK it should boot up as normal. If not, turn off IMMEDIATELY and carefully exam your board. Assuming you have no problems carefully remove the

PROJECT

Top	Mid	Bottom	Base Address
1	1	1	$300
0	1	1	$304
1	0	1	$308
0	0	1	$30C
1	1	0	$310
0	1	0	$314
1	0	0	$318
0	0	0	$31C

Fig.10 DIL Switch Settings

InterCard, insert IC1 and repeat the process of fitting the card in the PC and turning on the power. Continue this procedure for IC2, IC3, IC5, IC6, IC7 and IC8 in that order. This may seem to be a long winded method, but at least if anything goes wrong you will know where the problem is, namely with the last chip you inserted. Notice that I didn't mention IC4. That's because there is some setting up to be done before this chip is inserted.

Setting Up

With the card in your PC and powered up, carefully connect an oscilloscope to pin 23 of the IC socket of IC4 and adjust RV2 fully anticlockwise to set the gain of the level shifter to 1.0. Now slowly adjust RV1 until exactly 1.25 volts is present. The next stage involves a signal generator connected to the input. If you do not have a signal generator, leaving RV2 in its anti-clockwise position should be OK. However if you do have a signal generator apply a 1kHz sinewave, at about 1.5V RMS, to the input and adjust RV2

Offset	Data
0	AtoD/DtoA Converter Data
1	AtoD Converter 'Start Conversion'
2	External 8 Bit Port A
3	External 8 Bit Port B

Figure 11 : Address Offset Table

until the amplitude of the signal on the 'scope screen is exactly 1.25 volts peak-to-peak. You may have to adjust RV1 again to restore the 1.25V DC shift. Once the settings have been completed, turn off the PC, remove the PCB and insert IC4. Finally, there is the DIL switch to set. You can ignore the bottom switch as it is not used in this design. The top three switches determine whereabouts in the I/O map the board can be found. The actual base addresses are shown in Figure 10. In theory, you should be able to fit up to seven more interface cards like this, if you should wish to and you have enough slots. Choose the base address you want your card to be found at and set the appropriate switches. Re-insert the InterCard into your PC, fix the card edge plate to the case with its screw and refit the lid. You should now have a fully working InterCard.

Next month I'll move on to the software aspect of this project, with a few example programs in both BASIC and C, and conclude with some ideas for future developments.

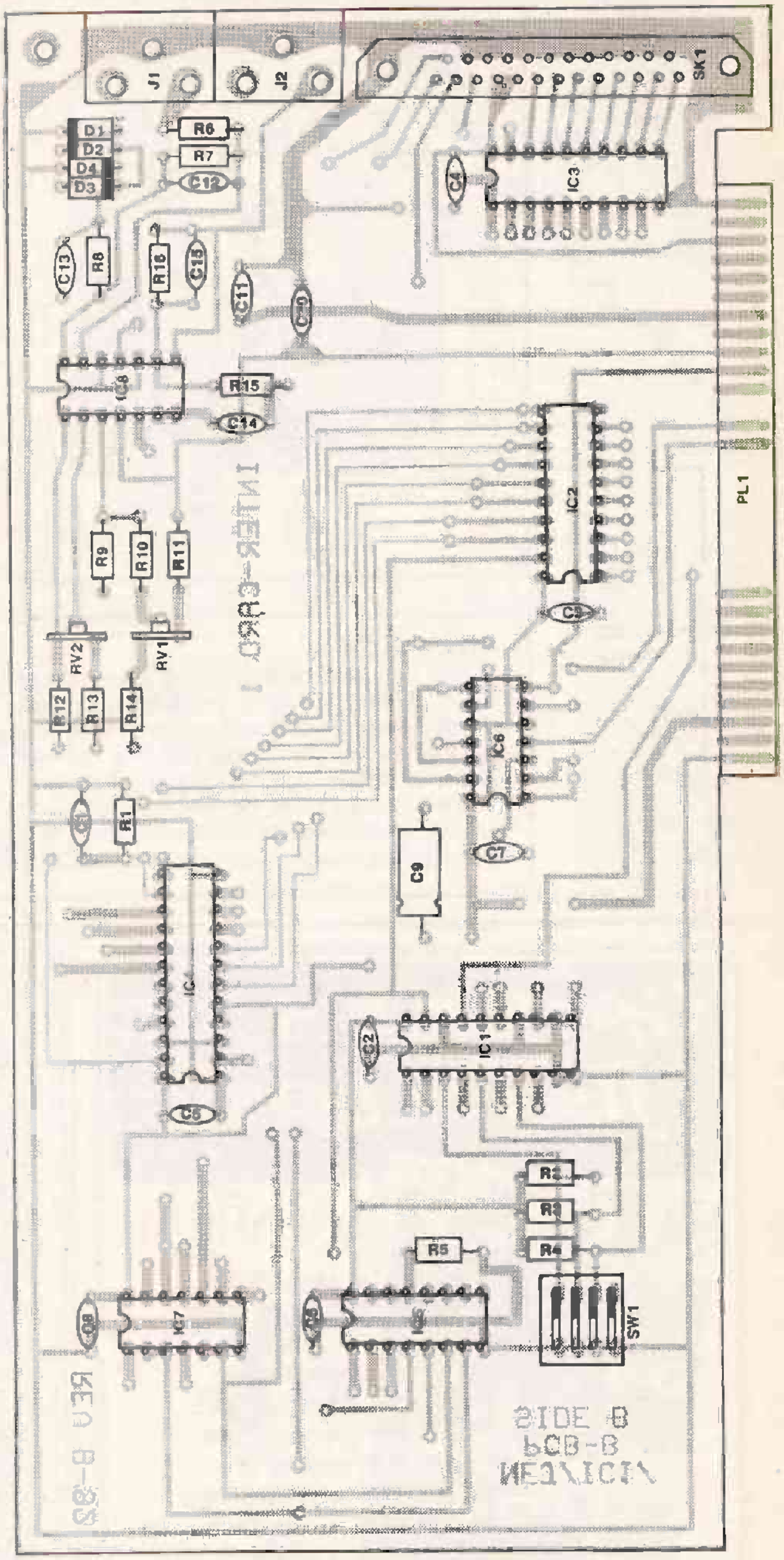


Fig.8 Component overlay

Language	Time to complete execution
Assembler	3 seconds
C	3 seconds
Pascal	12 seconds

Figure 12 : Program Timings

PART LIST

RESISTORS (+/5% or better, 0.5W)	
R1	6k2
R2,R3,R4,R11,R13	10k
R5	1k0
R6	620R
R7	1k5
R8	100R
R9,R10	100k
R12	270R
R14	2k2
R15	33k
R16	47k
RV1	10k 3/8" horiz. cermet
RV2	1k0 3/8" horiz. cermet

CAPACITORS	
C1	68p polystyrene
C2,3,4,5,6,7,8 10,11,13	100n ceramic
C9	10u 16V axial electrolytic
C12	15n polyester
C14	470n polyester
C15	470p polystyrene

SEMICONDUCTORS	
IC1	74HCT688
IC2,3	74HCT245
IC4	AD7569
IC5	74HCT139
IC6	74HCT08
IC7	74HCT02
IC8	TL074
D1,2,3,4	1N4148

MISCELLANEOUS	
SK1	25 way female Dconnector r/angle PCB mounting
SW1	4 pole DIL switch
J1,J2	phono socket PCB mounting card edge plate, PCB, DIL sockets 1 x 8 PIN, 3 x 14 PIN, 1 x 16 PIN, 3 x 20 PIN, 1 x 24 PIN (0.3" width), solder, through board links (optional).

BUYLINES

There should be no difficulty in obtaining most of the components for this project. The AD7569 is available from Verospeed (0703644555) order code 25362385E, as are all of the HCT chips, the TL074, the phono sockets (order code 22757732H) and a ready punched card end plate (order code 42759693J). Their catalogue is recommended and is free. The right angled PCB mounting Dconnector is available from Maplin (order code FG27E). The rest of the components can also be purchased from most suppliers. The PCB is available from the usual sources.

If you want a copy of a disk with the C source code and executable programs, as well as a few other programs for this card, send a cheque or postal order for 5.00 to : Neil Johnson, 2 Chapel Field, Dixter Road, Northiam, East Sussex, TN31 6PQ. At the moment I can supply 51/4" and 31/2" disks in both normal and high density (please specify what you want) but after July 1993 I'll only be able to supply 51/4" high density (1.2MB) disks.

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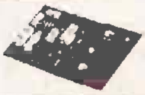

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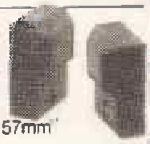

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Coping with Radiation

by Douglas Clarkson

The brief history of Radioactivity in the modern age is strewn with painful reminders that man is in many ways only a babe in arms when it comes to the safe and responsible use of key powers of Nature. This brief outline of radiation and the sequences of events and discoveries which have shaped the present day appreciation of ionising radiation tries to put in perspective aspects with relate to scientific, military, economic and environmental viewpoints. It is quite natural, that the middle two of these seldom find sympathy with the environmental factors. Scientists, also, in the main are too busy discovering to be going about ensuring that their discoveries are used to best effect.

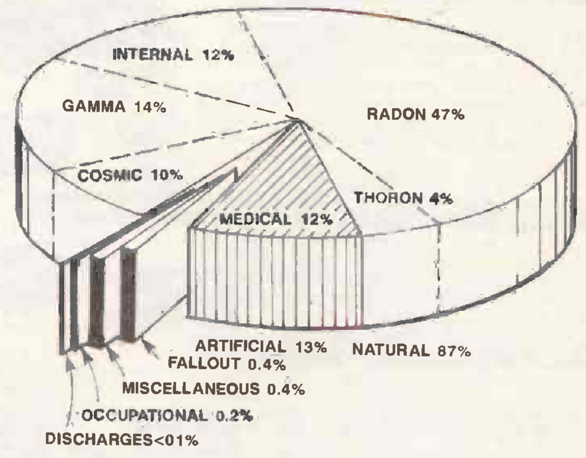


Fig.1 The annual average exposures to radiation of members of the UK population assuming a total exposure of 2.5mSv.

About Ionising Radiation

The anxiety about ionising radiation stems from its effect on living systems on all living organisms in the plant and animal kingdom and of course including man himself. Ionising radiation's risk relates to its effect principally on cell nuclei whereby cells can be destroyed and/or their DNA structure degraded with the risk of forming 'rogue' cancerous cells.

By no means are all of the questions about radiation induced damage are known. It is considered in the case of X-rays and gamma rays that the chain of events begins when the high energy photon ejects an electron from a target atom creating in the process an ion/electron pair. The electron is thought to attach itself to a neighbouring molecule forming a free radical which can attack biologically important target molecules in its vicinity, resulting in chemical change due to the breaking of chemical bonds. The translation of the bond damage to biologic effect can take years or decades to manifest as symptoms.

The so called 'Target Theory' of radiobiology is very much built on this 'targeting' of sensitive sites within the tissue being irradiated.

The effects of ionising radiation upon delicate living systems such as homo sapiens are complex in the extreme and this has tended to confuse the public in their appreciation of radiation. The world has known about X-rays and radiation for about 100 years and for at least the first half of this interlude has had grossly insufficient understanding to weigh up risks and dangers.

X-rays and Gamma Rays

While photons of light of several electron volts energy are not energetic enough to produce ionisation of matter along their path when they interact with matter, when energies increase to around 50,000 eV (50 keV) then they have sufficient energies to produce this effect. These are so called soft X-rays. At higher and higher energies these photons (gamma rays) become more and more able to produce ionising effects and so induce damage to living systems.

Particle Radiation

Gamma rays can be considered to be 'massless'. There is a broad range of charged particles with mass which because of their high energies can induce ionisation effects in matter. Alpha particles which are positively charged Helium nuclei is one example and high energy electrons, beta radiation , is another. Often contamination by materials emitting these particles is more dangerous since the contaminants tend to be taken up within the tissues of the body itself, eg in the bones and specific internal organs.

Units of Radiation: Assessment of Risk

The public is more and more seeking simple answers about exposure to ionising radiation. This section tries to present in a simple way concepts relating to exposure.

The units of radiation are expressed as described previously in terms of absorbed dose and dose equivalent. The unit of absorbed dose the Gray (abbreviation Gy) relates to a

TYPE OF RADIATION	WEIGHTING FACTOR
Photons, all energies	1
Electrons, muons, all energies	1
Neutrons <10keV	5
Neutrons 10keV-100keV	10
Neutrons 100keV-2MeV	20
Neutrons 2MeV-20MeV	10
Neutrons >20MeV	5
Protons >20MeV	5
Alpha particles,heavy nuclei	20

Table 1: Radiation weighting factors associated with types of radiation.

RADIATION

deposition of 1 Joule of energy due to ionising radiation in a kilogram of tissue. This unit, however, does not introduce the concept of the relative risk of the radiation. Table 1 indicates the so called radiation weighting factors used to 'weight' incident energy deposited to perceived risk.

The corresponding dose equivalent is expressed in Sieverts (abbreviation Sv). These are the new standard units used by the radiation community. They relate to the old units of rad and rem.

The values below shows the equivalence of the two systems of units for reference.

1 rad = 100 ergs per gram of tissue

1 rad = $100\infty 10^7 \infty 10^3$ J/kg = 0.01 Gy

100 rad = 1 Gy

100 rem = 1 Sievert

Many doses are in fact defined in milli Sieverts (mSv).

The type of tissue irradiated is an important factor in determining risks. Table 2 indicates a simplified description of the relative risk weighting factors of the human body. Where an individual is irradiated by radiation of some type, the radiation has first to be weighted by its radiation weighting factor and then the exposure of the various compartments of the body has to be assessed as outlined in Table 2. The sum of the total weighted exposures is expressed as the effective dose equivalent. This is used as an indication of relative risk of fatal malignancy and can be derived for individuals experiencing a broad range of types of radiation exposure.

RISK WEIGHTING FACTORS	
TISSUE OR ORGAN	FACTOR
Testees or overies	0.25
Breast	0.15
Red Bone Marrow	0.12
Lun g	0.12
Liver	0.06
Thyroid	0.03
Bone surfaces	0.3
Remainder	0.24
Whole body total	1.00

Table 2: Table of risk weighting factors of tissue and organs within the human body with regard to fatal malignancy

Estimations of Annual Exposure to Radiation

It is important to obtain a perspective in the way in which the exposure of the public at large is described and how local conditions in the environment can change this. Figure 1 shows the annual average exposures to radiation of members of the UK population assuming a total exposure of 2.5mSv of which 13% comes from artificial sources. Shown in this way, the menace to society is very much natural causes.

Figures compiled for the US population indicate an exposure of about 1.9mSv with a very much higher artificial component of about 45% largely introduced by medical exposures.

What these averaged figures do not indicate is the relatively high variation in background radiation from location to location. There is considerable variability in the natural background of the soil or rock. While the normal background in the USA is in the region of 0.27 to 1.3mSv per year, local conditions can increase this to significantly higher levels.

On the Atlantic Coast of Brazil about 200 miles north of Rio de Janeiro, the coastal resort of Guarapari boasts exposure levels as high as 15mSv in its main street. Levels on the beaches are even higher. There are other natural 'hot spots' in countries including India, France and Switzerland.

There has been increasing interest in recent years in preventing exposure to high revels of Radon gas. In the UK the average dose attributable to Radon is estimated to be about 1.0mSv though values can be significantly higher in areas either built on granite or where houses are built of granite. In the USA Radon gas is considered to cause the deaths of between 5000 to 20000 individuals within the global total of 136,000 fatal lung cancers each year.

Natural radioactivity within the body is largely attributable to Potassium 40. About 15,000,000 such atoms disintegrate within the average individual every hour releasing high energy beta rays and some gamma rays. In the same time interval approximately 7000 Uranium atoms will disintegrate in the body, releasing alpha particles.

Around 200,000 gamma rays from the soil and building materials will also pass through an individual each hour.

Table 3 shows how the mean annual dose due to cosmic rays in mSv varies with altitude. Regular aircraft passengers are bound to receive on increased radiation dose.

HEIGHT ABOVE SEA LEVEL	MEAN DOSE IN mSv/yr
Zero	0.2-0.4
1500m	0.4-0.6
3000m	0.8-1.2
12000m	28
36-600km	70-150
Interplanetary space	180250
Van Allen radiation belt	<15000

Table 3: Details of mean dose exposure due to Cosmic Rays for various heights above sea level. Interplanetary space travel does have its hidden drawbacks.

Medical Exposure

While natural exposure cannot in many instances be avoided, there are other types of exposure which are avoidable. Table 4 lists the typical doses associated with routine X-ray diagnoses.

The truth of the matter is with regard to Medical Exposures that values for individuals will vary widely over those individuals who receive no X-rays and those who have a relatively large number of X-ray examinations.

The medical profession argue that the increased risk of X-ray exposure is more than compensated for by the benefit to the patient of the examination. In the majority of cases this

EXAMINATION	DOSE PER EXPOSURE(mSv)
AP lumber spine	0.9 per film
AP chest	0.02 per film
PA skull	0.06 per film
Lateral Abdomen	0.5 per film
Lateral Pelvis	1.1 per film
Barium meal	3.8 mean per examination
Barium Enema	7.7 mean per examination
CAT scan	20 typical abdomen

Table 4: Typical radiation doses for a range of X-ray exposures.

will be the case but there is certainly room to improve procedures to minimise exposure to the patient.

Looking more closely at this problem area, even a 'standard' X-ray eg of the chest can be undertaken with a wide range of administered doses. Where films of low sensitivity are used, additional exposure is required to produce the required clarity of pictures. One simple method of reducing exposure is to use rare earth 'screens' to enhance the developed image on the photographic plate.

The increasing availability of CAT scanners which produce images of 'slices' through the body is tending to increase the dose of X-rays which patients receive. This will no doubt lead towards moves for dose reduction based on improved technology of tubes and sensor arrays.

Public awareness of radiation exposure may in time prompt patients to ask of radiographers what dose of radiation they are likely to receive as a result of X-ray examinations. Where these are within bounds of normality then the patient would probably allow them to proceed. Where they are clearly unreasonably high, then the patient may be unwilling to undergo the exposure.

Estimations of Relative Risk

Based on data from the survivors of the Japanese atomic devices, a fatal risk estimate has been devised which seeks to relate exposure to risk of fatal cancer risk. There is a problem of determining if the risk of radiation exposure is proportional, non linear or has some threshold effect as shown in Figure 2. At present a simple proportional model is assumed. For low dose rates the risk calculated to 40 years is calculated to be 1 in 70 per Sv. Thus an additional exposure of 1mSv will carry the risk of 1in70 ∞ 1in1000 produces 1.4 in 100,000 of a fatal cancer.

For hereditary disease, a risk factor of 1 in 50 per Sv is considered to apply.

These figures apply over the whole population. The influence of genetic resilience or weakness with respect to doses of ionising radiation which could give some people more or less tolerance of ionising radiation is difficult to quantify.

Risks Elsewhere

In estimating risks elsewhere, Table 5 shows a summary of relative risk values within other industries.

This would seem to show that radiation workers are not greatly disadvantaged in terms of risk of developing cancers when compared with risks generally in other industries. What is not shown is the risk of hereditary disease being carried on to other generations. This must always be viewed with considerable caution.

OCCUPATION	RISK OF DEATH PER YEAR
Sea fishing	200 x 10
Coal Mining	14 x 10
Construction	10 x 10
Metal Manufacture	6 x 10
Radiation workers (1.1mSv/yr average)	3.7 x 10
Textiles	3.6 x 10
Timber,furniture	1.0 x 10
Clothing and footware	0.3 x 10

Table 5: Table of relative annual risks of death in UK occupations, including potential cancers due to occupation exposure of radiation workers

Early Days

Wilhelm Röentgen discovered X-rays on the 8th of November 1895 as he was passing current through a Crook's tube. A screen of Barium platinocyanide glowed at the opposite end of his laboratory in the dark when the tube was activated. He gradually determined the amazing new properties of X-rays such as their ability to pass through various substances and not others. Perhaps one of the most memorable early photographs taken was that of his wife's hand. His results were widely published in late December and workers all over the world began to repeat his experiments. This was indeed the beginning of man's 'unnatural' exposure to ionising radiation.

Clinicians were quick to appreciate the application of X-rays to medical investigations and they quickly became used in a large number of centres. The novelty of X-rays led to their use in many areas which by today's standards would be considered reckless and irresponsible. They were widely used as treatment, for example, of baldness and infertility.

Today's extreme caution with regard to minimising the dose of radiation was totally unknown. Even in the first year of X-rays, there were consistent reports of 'effects'. The significance of these were not appreciated until years later. The outbreak of World War I shelved reservations about the hazards of X-rays and at the same time led to a very large increase in their use. It was not until 1924 that international agreement was achieved on units of measurement of ionising radiation. The unit of the Röentgen, R, was established as that amount of radiation which would produce a given number of charged ions in a specific volume of air. It was quite common in the early days of X-rays for machines to be calibrated in terms of erythema dose, the dose at which reddening of the skin would develop. Patients 'used' as radiation markers in this way must have received dangerous doses of radiation.

Enter Radioactivity

The news of the discovery of X-rays led more or less directly to the discovery of Radioactivity emissions of radiation from atoms. Henri Becquerel was looking for emissions of X-rays from a range of substances when in February 1896 he discovered that a photographic plate had been exposed by rays from a Uranium salt. This area of work was taken up by Marie Curie for her doctoral dissertation leading to the discovery of Radium in December 1898.

Radium was again given widespread publicity it was almost immediately heralded with all sorts of 'magical' properties and with an almost total level of ignorance of its properties began to be used for medical and also consumer applications. This was the point in time where science was widely regarded as the saviour of mankind its discoveries would herald a brighter and healthier future for all.

It was not until more extensive deposits were discovered in North America around 1910, however, that the use of Radium became widespread. In the medical world, Radium was used for a broad range of conditions, although not exclusively to cancer related treatment. In the consumer marketplace the use of Radium laced products creams, spa waters, bracelets and so on, persisted at least until the 1930's. It was not until man made radio-isotopes became available in the 1940's that the use of Radium declined. With the availability of a wide range of more suitable radio-isotopes, Radium became more of an historical curiosity.

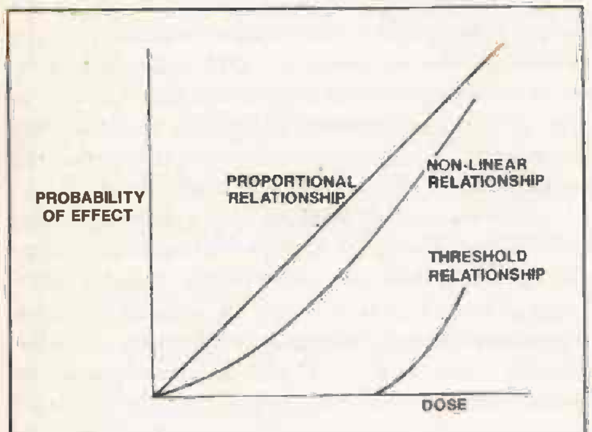


Fig.2 Models of proportional, non linear or a threshold effect of risks due to radiation dose.

Assessing Risks

Thus up till the time of the second world war, the main sources of manmade ionising radiation were from exposures to X-rays and from Radium. One group of workers who were chronically exposed to Radium, however, were those individuals who painted dials of instruments with a 'Radium cocktail' which would glow in the dark. It was the deaths of numerous 'dial painters' in the USA which focused both public and scientific attention on the problem and which led, though painfully slowly, to the setting of maximum uptake levels of Radium. This intake value was initially set in 1941 in the USA at 0.1 μCurie where:

1 Curie = $3.7 \infty 10^{10}$ disintegrations per second.

Enter Fission and Fusion

Until the development of the atom bomb, nothing new had been introduced in the field of radioactivity to alter the slow but natural decay of natural atoms to natural decay products. Radium had been extracted as a natural but highly radioactive element. With the development of projects such as the Manhattan Project and the construction of a number of nuclear reactors where a range of radioisotopes could be fabricated. New highly radioactive and toxic elements such as Plutonium were being created within nuclear reactors by bombarding Uranium with neutrons. So, when the uncontrolled chain reaction was unleashed, a wide range of completely new radioactive compounds could be released into the environment. The intense blast of gamma radiation at the instant of detonation was also an unknown quantity.

The initial momentum for introducing radiation standards for occupational exposure during the war came from a need to protect a large and diverse workforce. Instead of a few thousand workers world wide being involved, the Manhattan Project was to involve hundreds of thousands of workers in a range of chemical and industrial production lines. The end point of the project the creation of an intense glowing fireball out of which would fall a host of radioactive elements was not considered as the real risk. Even after the devastation of Hiroshima and Nagasaki the aspect of radiation fallout was not given high prominence. The way was left for time to write its own catalogue of human suffering instead. This is an area of science which is still yielding up secrets.

Working with Plutonium

In many respects the foundation of modern radiation protection services were established during the Manhattan Project where very large teams of workers had to be monitored and leaks of radiation identified and dealt with. There is an aura of 'safe working practices' now spread over the Manhattan Project which may or may not be well placed.

There is considerable amazement still felt by British Scientists in the way in which work was undertaken on the bomb project by their American colleagues. One tragic but revealing incident took place in a classroom where the principle of fusion was being demonstrated by moving two half spheres of Plutonium together on a mechanism driven by a screwdriver. The demonstrator was showing that as the two spheres were moved closer, the radiation given off by the Plutonium increased. At one point the screwdriver slipped and the spheres suddenly jerked closer together. A blue light radiated from the spheres and the demonstrator instinctively separated them with his hands to prevent an uncontrolled chain reaction taking place. A major nuclear accident had been averted though the demonstrator received a fatal dose of radiation and died in extreme agony a short time later.

British scientists indicate that such a 'demonstration' should never have been allowed in the first place. Critical masses of fission material should never be allowed into any such environment. The Manhattan Project was also undertaken under the conditions of utmost secrecy.

The Manhattan Project certainly led to significant advances in quantifying radiation. While the Röentgen unit had obvious relevance for X-ray and gamma radiation, the British Physicist Herbert Parker working on the project developed units of radiation which could be related to exposure of a broader range of radiation sources. The rad was developed as a measure of energy of radiation deposited in one gram of human tissue. The biological effectiveness of radiation varies considerably with the type of radiation. A revised unit, the Rem, was devised as an indication of the relative effect of radiation on the individual. A dose of 10Rads of gamma radiation was set equivalent to 10Rems of biologically weighted radiation though one Rad of Alpha radiation was then set equivalent to 10Rems indicating that it was potentially more dangerous. This is because the Alpha radiation has more significance for causing cell damage etc. Details of modern units of radiation (the Gray and the Sievert) are given in an earlier section.

'Brighter than a Thousand Suns'

In the final stages of the Manhattan Project, the question of fallout became more and more pressing as predictions of the amount of radiation released were made. This was the first time, also, that the Military would have to consider (or not consider) the general public in their equations.

The best scenario was to detonate the bomb when weather conditions were favourable, the wind was in the correct direction and it wasn't raining. In any case on Presidential orders the first device code named Trinity was detonated on July 16th 1945 in time for the first day of the Potsdam Conference attended by Stalin whose spies probably observed its bright flash in the desert.

Fortunately most of the fallout fell in isolated areas where the main victims were grazing animals. At this stage all operations were undertaken at a very high security level the public had absolutely no idea what was taking place.

When the first bomb was dropped on Hiroshima, the device was described simply on the basis of its massive explosive power. Any reference to possible radiation danger was omitted. It was only in time that the full horror would be revealed. This was also the point in time at which the world was informed of the Manhattan Project and the existence of a new power in the world.

Enter the Atomic Age

If the nuclear industry had had a somewhat secretive childhood, it certainly experienced a more open period of adolescence and maturity. In the immediate post war age, nuclear energy was hailed as a bringer of all good things the energy crisis could be overcome once and for all. It is now known that there were strategic goals to be achieved in the West's nuclear arms programme which would require fission materials such as Plutonium to be produced as the by-product of a civilian nuclear power initiative. Perhaps there was an unwritten agenda to implement nuclear power stations to underpin any future requirement for bomb making products. In any event, it was the British who opened the World's first commercial nuclear reactor at Calder Hall in 1956.

Thus nuclear installations began to pass from purely military control to civilian control and the numbers of people working in such installations grew significantly. There were very good reasons for extracting large reserves of uranium wherever they could be discovered. Extensive prospecting was encouraged in the USA in the early 50's and numerous deposits were identified and mined. It is quite obvious that at a time when national priorities were focused by the Cold War, the working conditions of Uranium miners were a scandal. After drilling holes in rock to place explosive charges, the miners would return to a smoke filled mine and help extract the ore. Water was drunk from underground springs and food was rapidly contaminated in the dusty conditions. While elsewhere the radiation hazards of such mine workings were clearly identified, the Authorities were quite happy to exploit the health of the miners as long as supplies of Uranium were forthcoming. There was extensive data on file from Uranium mines in Europe relating to hazards of working in such environments.

The Unfolding Scenario

The sheer scale of resources plowed into atomic and nuclear research military and civilian has been stupendous. One of the reasons for the collapse of the Soviet Empire was its over commitment to developing nuclear weapons. The world seems to be drawing back from a superpower confrontation though the risk has not been removed.

Recent disclosures about the Soviet nuclear arms project have been most revealing. Based in Myak in the Urals, the equivalent of the USA's Manhattan project succeeded in contaminating extensive areas of the countryside through reckless waste disposal. One waste store exploded in the 1950's, sending contamination over a widespread area. Today large parts of this area are still highly contaminated and childhood cancers abound.

The Three Mile Island incident, although not as serious as the Chernobyl incident, was a a hair's breadth from developing into something more devastating. Although there was plenty of 'high tech' at Three Mile Island, it was almost impossible for anyone to understand what was happening once dozens of alarms started to compete for attention. At Chernobyl, it is claimed the design of the reactor was intrinsically unsafe and that poor supervision and working practices prevailed.

What has been demonstrated is that the there has been a gradual reduction in the 'safe' levels of radiation exposure since World War II. During this time, radiation workers, military personnel and members of the public have been exposed to levels of radiation high enough to significantly increase the chances of developing fatal cancers and also carrying forward genetic damage to future generations.

With the benefit of hindsight, things could have been undertaken differently. In terms of what can be undertaken now to reduce exposures, there are two strategies which spring to mind. One is to reduce the incidence to Radon exposure in dwelling homes and the other is to reduce the exposure to medical X-rays. Clearly this does require strategic planning. It could have been appropriate to have included minimum levels of radiation exposure for standard X-ray procedures in the recently announced Patient's Charter in the UK. The other is to consider the long term role of the nuclear power industry and decide if it should be retained and if so what policy changes for its existence require to adopted.

Conclusion

Assessment of the effects of radiation on man needs a healthy sense of perspective. There are clearly identified ways of both measuring radiation doses and predicting the potential risk that it may or may not present. Risk factors may well be modified as greater understanding is developed.

There have always been two facets of radiation, one black and one white. There needs to be a better understanding of the basic nature of radiation and how it can influence health so that individuals can be sufficiently educated about this important subject and make their own informed judgements.

Further Reading:

Living with radiation, National Radiological protection Board, 1991, ISBN 0 85951 320 3, available in UK through HMSO bookshops.

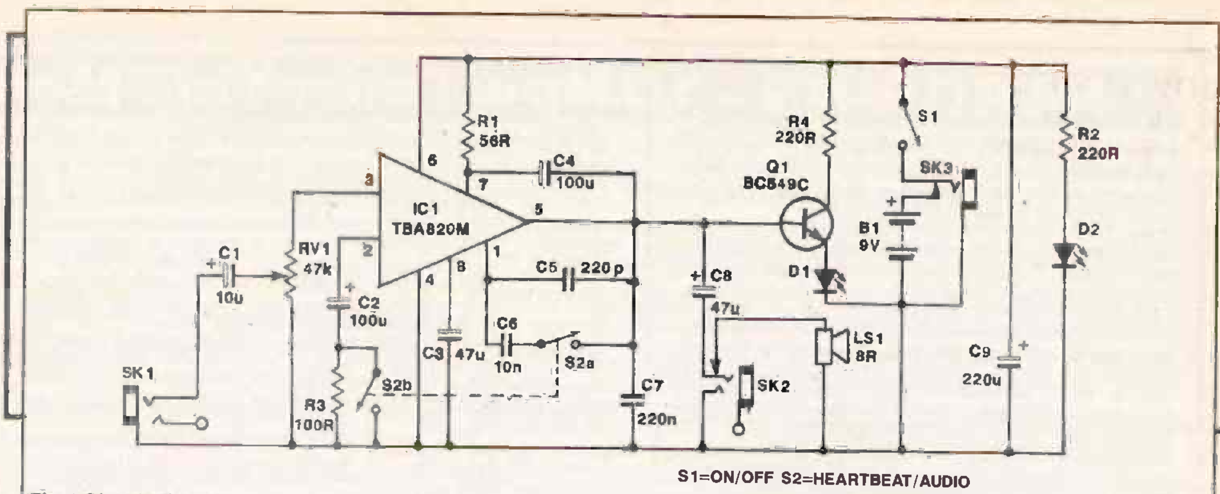
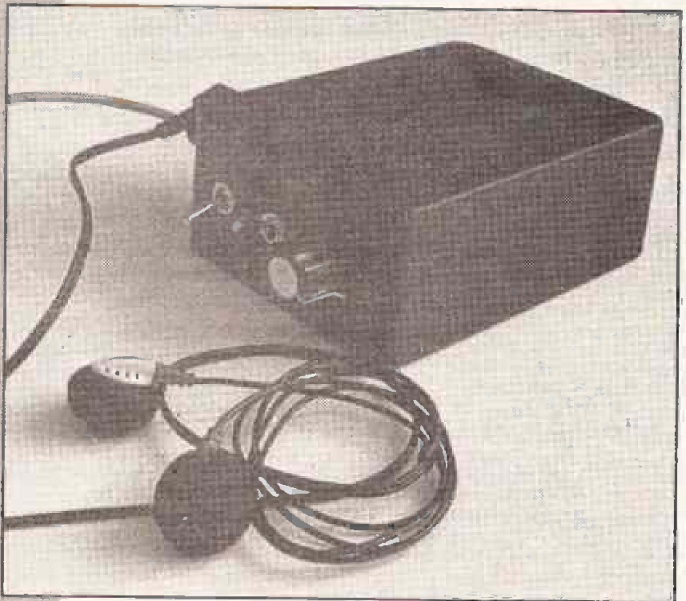


Fig.1 Circuit diagram

Heartbeat /Audio Listener



A sensitive amplifier to listen to your heartbeat by Shabaz Yousaf.

This heartbeat listener project also doubles as an audio amplifier, so will find plenty of uses on the workbench. When switched to HEARTBEAT mode, the circuit will amplify the low-frequency heartbeats to a level suitable for medium impedance headphones (for example, Walkman-type headphones or earphones). The louder heartbeats - for instance after jogging - will also trigger an LED which will pulse in sympathy.

The device has a small built-in loudspeaker which is useful when using it as an audio amplifier, but really headphones will be needed when listening to heartbeats. The actual heartbeat sensor is a piezo-electric transducer which has the advantage of a relatively high output, which means that the amplifier gain does not have to be excessive.

The Circuit

Figure 1 shows the complete circuit diagrams. The audio amplifier is based around the integrated circuit IC1. This is the TBA820M - possibly the oldest audio amp IC widely available nowadays, and is connected in its standard configuration. The output drives the loudspeaker and LED.

Power for the circuit is obtained from a PP3 9V battery or from an external source connected to SK3, which is a 3.5mm jack socket. If you have one of the popular battery eliminators, then this can be used. The current used by the circuit is about 10mA, but this figure can rise to several hundred milliamps at peaks in the audio level and also depends on the load connected to the headphone socket.

Construction

The circuit I constructed on a single sided fibreglass PCB designed for a perfect fit in the recommended case. Start by soldering the smaller components, such as the resistors and capacitors. Orientate the IC and 'minicon' connectors the correct way round, as shown on the component overlay in Figure 2. Finally, trim the battery clip leads to approximately 60mm and solder it on to the PCB - the red lead is positive.

The next stage is to prepare the 'minicon' sockets by crimping leads to them. If you do not have the correct tools for the job, a small pair of pliers will have to suffice. The leads can be trimmed and the ends soldered to the controls, LEDs, sockets and loudspeaker, as detailed in Figure 3.

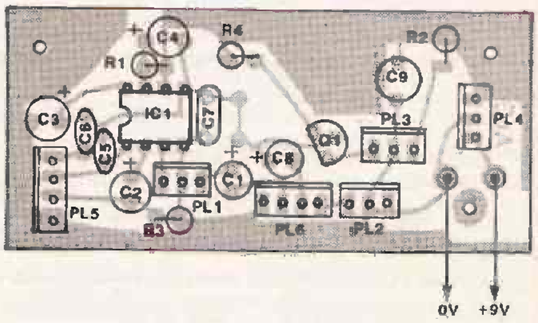


Fig.2 Component overlay

If you are using the recommended case then the hole drilling dimensions are indicated in Figure 4. If a whole range of drill bits to suit each switch or socket are not to hand, then it may be worthwhile purchasing a reaming tool, which can be used to widen a pilot hole to the required diameter. A pattern of holes will be needed for the loudspeaker. The

HOW IT WORKS

IC1 is arranged with a conventional amplifier with switch SW2 in the AUDIO position. When changed to heartbeat, the resistor in the GAIN lead (pin 2) is short-circuited for higher gain. At the same time capacitor C6 is paralleled with C5 to alter the frequency compensation characteristics of IC1. This has the effect of cutting high frequencies, and increasing the gain of lower frequencies. The output is taken from pin 5 via a conventional DC blocking capacitor to the loudspeaker. The LED is directly driven by a transistor configured for current gain. It was found that directly using the voltage at the output pin 5 to drive the transistor base was adequate, and no blocking capacitors and gain control were required.

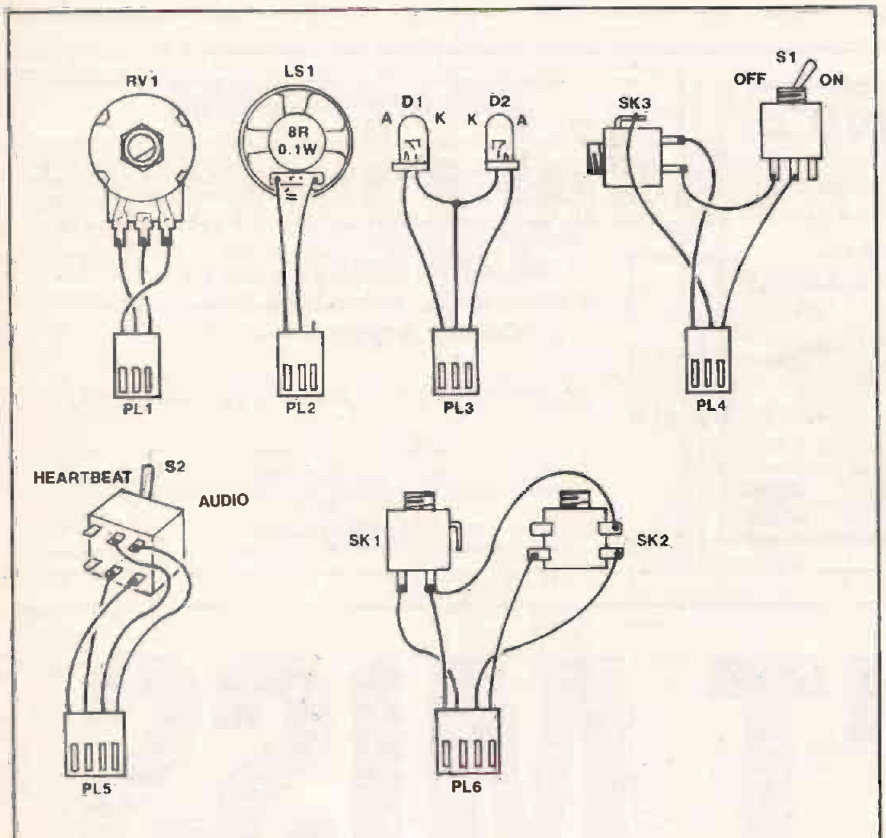


Fig.3 Interconnection diagram

recommended case is quite small and there is only enough room for a 1.6" loudspeaker but if you are using a larger case, a more substantial loudspeaker can be used to great effect.

The switches and sockets are screwed into place, but the LEDs and loudspeaker will have to be glued with an impact adhesive such as UHU. The PCB can now be plugged in and slotted into position.

For the piezoelectric sensor, a Tandy piezo element was used because this has a plastic rim which is useful for holding the microphone against the heart with. The element is supplied with two wires already soldered to it. These are removed, and a length of screened lead is soldered instead, Soldering to the element must be done with the minimum of heat to prevent any damage to the piezo-electric crystal. The end of the lead is terminated with a 3.5mm mono jack plug. For a professional look, the back of the piezo element can optionally be covered with a small piece of acrylic trimmed to shape with a Stanley knife and file. A small hole is required in the centre of the acrylic, to keep the inside at the same air pressure. A cheap source of acrylic is the clear part of a cassette cover. Yes! You can finally put Kylie Minogue's hits to good use! Chuck away the cassette and keep the cover!

Once trimmed, the plastic can be sprayed with paint. Coat the plastic rim of the piezo element with glue, taking care not to let any drip onto the actual element. Glue the surfaces together. The final result should be professional looking.

Testing

Plug the heartbeat sensor and a pair of headphones into the relevant sockets, and switch on. Provided a battery or power supply is connected, the power 'on' LED should be lit. Ensure the HEARTBEAT/AUDIO switch is in the AUDIO position, and speak into the heartbeat sensor. You should hear your own voice through the headphones. If not, adjust the volume control RV1. Now, flick the switch to the HEARTBEAT Position. Holding the microphone by the rim, press it against your heart firmly while keeping the air hole clear. The sensitivity of the piezo sensor means that it can be used effectively even through a shirt. If you can't find your heartbeats, it may help to jog on the spot for a minute to get some stronger pulses. This should also trigger the LED D1.

For constant heartbeat monitoring on the move, the sensor can be held in place with dressmakers elastic band (about 1.5" wide, used around the hip with dresses) with the two ends sewn together to form an elastic hoop which goes around the chest. The heartbeat listener could be clipped to the waist by adding a belt clip to the casing, from an old radio, for example.

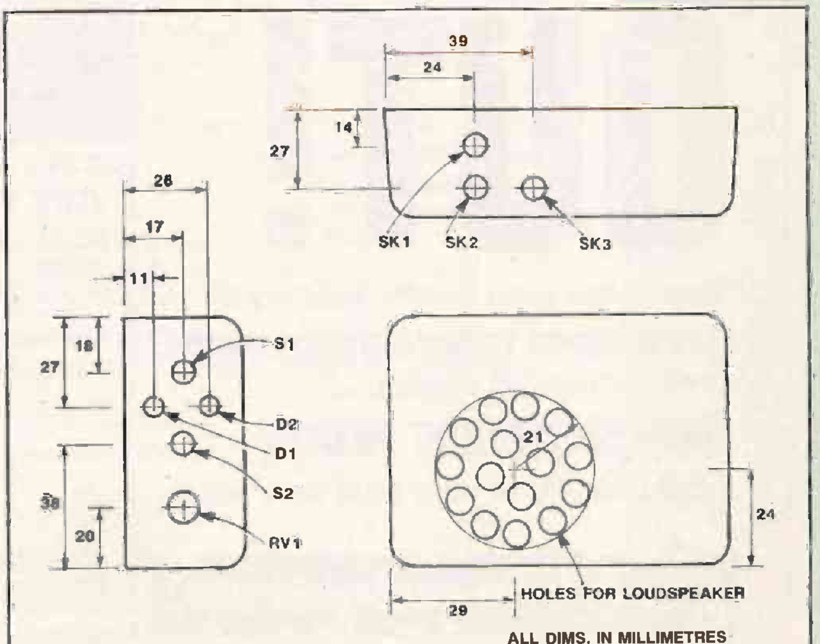


Fig.4 Dimensions for drilling case

PARTS LIST

RESISTORS (all 1/4 watt)		C6	10n Ceramic	SK1	3.5mm stereo jack
R1	56R	C7	220n multilayer	SK2	3.5mm mono jack with 2 break contacts
R2,4	220R	C9	220µ/16V	SK3	3.5mm jack with 1 beak contact
R3	100R			SW1	SPDT toggle
RV1	47k log pot	**SEMICONDUCTORS**		SW2	DPDT toggle
		IC1	TBA820M	LS1	8R 1.6" miniature speaker
CAPACITORS		Q1	BC549C	PL1-4	3way minicon plg and socket
C1	10µ/16V	D1,2	RED LED	PL5,6	4way minicon plug and socket
C2,4	100µ/16V				
C3,8	47µ/16V	**MISCELLANEOUS**			
C5	220p	BATT1	PP3 9V battery		

case, mono jack plug, piezo element, stereo headphones, impact adhesive, piece of plastic (cassette cover), foam

BUYLINES

All components are commonly available. Maplin sell the 'minicon' connectors, as do many other retailers. The piezo element is available from Tandy, part no. 273-091. The case was purchased from Electrovalue, code B505.

Reader Survey

It's survey time again and your chance to win one of 20 prizes supplied by Maplin Electronics and ETI

Although some of the questions here may not seem to relate directly to the magazine, please complete the whole questionnaire. Your answers not only help us to steer the editorial content of the magazine in the direction you want but they also help us to build up an overall profile of readers to present to advertisers who require such data to select suitable magazines for their products.

No names and addresses will be disclosed to any third party and all information will be treated in the strictest confidence.

As an incentive for your hard work, all entries received by 10th October will be entered in the draw for the 20 prizes given by Maplin Electronics and ETI.

1. If you could make one improvement to ETI, what would it be!

....

....

2. Please indicate what you think of the following aspects of ETI's coverage:

	Poor	Average	Good	Excellent
Product News	☐ 001	☐ 002	☐ 003	☐ 004
Industry Technology News	☐ 005	☐ 006	☐ 007	☐ 008
Advanced Projects	☐ 009	☐ 010	☐ 011	☐ 012
Basic Projects	☐ 013	☐ 014	☐ 015	☐ 016
General Features	☐ 017	☐ 018	☐ 019	☐ 020
Tutorial Features	☐ 021	☐ 022	☐ 023	☐ 024
Product Reviews	☐ 025	☐ 026	☐ 027	☐ 028

3. Would you like to see a greater or lesser proportion of ETI devoted to the following:

	Less	The same	More
Beginners' Projects	☐ 029	☐ 030	☐ 031
Advanced Projects	☐ 032	☐ 033	☐ 034
Computer Projects	☐ 035	☐ 036	☐ 037
Audio Projects	☐ 038	☐ 039	☐ 040
Music Projects	☐ 041	☐ 042	☐ 043
Radio Projects	☐ 044	☐ 045	☐ 046
Home Improvement Projects	☐ 047	☐ 048	☐ 049
Bio-electronics/Health Projects	☐ 050	☐ 051	☐ 052
Test Equipment Projects	☐ 053	☐ 054	☐ 055
Security/alarm Projects	☐ 056	☐ 057	☐ 058
Car Electronics Projects	☐ 059	☐ 060	☐ 061
Robotics Projects	☐ 062	☐ 063	☐ 064
Photographics	☐ 065	☐ 066	☐ 067
Novelty/Gimmick Projects	☐ 068	☐ 069	☐ 070
Basic Elementary Theory	☐ 071	☐ 072	☐ 073
Advanced Electronic Theory	☐ 074	☐ 075	☐ 076
General Science/Technology	☐ 077	☐ 078	☐ 079
News	☐ 080	☐ 081	☐ 082
Product Reviews	☐ 083	☐ 084	☐ 085
Letters	☐ 086	☐ 087	☐ 088
Open Channel/etc	☐ 089	☐ 090	☐ 091
Design/Circuit ideas	☐ 092	☐ 093	☐ 094
Competitions	☐ 095	☐ 096	☐ 097
Others (please specify)	☐ 098	☐ 099	☐ 100

4. Indicate which of the following equipment you use:

	Own	Don't own but regularly use
Home Computer	☐ 101	☐ 102
Professional Computer	☐ 103	☐ 104
Hi-fi	☐ 105	☐ 106
Electronic Musical Instrument	☐ 107	☐ 108
MIDI Equipment	☐ 109	☐ 110
PA/Recording equipment	☐ 111	☐ 112
Photographic/Darkroom Equipment	☐ 113	☐ 114
Ham Radio/CB	☐ 115	☐ 116
Satellite TV	☐ 117	☐ 118
Video Camera	☐ 119	☐ 120
Security/Alarm System	☐ 121	☐ 122
Oscilloscope	☐ 123	☐ 124
Multimeter	☐ 125	☐ 126
Other test gear	☐ 127	☐ 128

5. Do you buy ETI for:

Projects only	Features only	Both
☐ 501	☐ 502	☐ 503

6. Do you read any of the following magazines:

	Never	Occasionally	Regularly
Practical Electronics	☐ 129	☐ 130	☐ 131
Everyday Electronics	☐ 132	☐ 133	☐ 134
Elektor Electronics	☐ 135	☐ 136	☐ 137
Maplin Magazines	☐ 138	☐ 139	☐ 140
Electronics & Wireless World	☐ 141	☐ 142	☐ 143
Music Technology	☐ 144	☐ 145	☐ 146
Home & Studio Recording	☐ 147	☐ 148	☐ 149
Hi-fi News & Record Review	☐ 150	☐ 151	☐ 152
New Scientist	☐ 153	☐ 154	☐ 155
Scientific American	☐ 156	☐ 157	☐ 158
Practical Wireless	☐ 159	☐ 160	☐ 161
Ham Radio Today	☐ 162	☐ 163	☐ 164
Electronics Product News/ Electronics Equipment News/New Electronics/ Electronic Product Review	☐ 165	☐ 166	☐ 167

7. If read, please indicate what you think of the following magazines

	Not as good as ETI	As good as ETI	Better than ETI
Practical Electronics	☐ 168	☐ 169	☐ 170
Elektor electronics	☐ 171	☐ 172	☐ 173
Everyday Electronics	☐ 174	☐ 175	☐ 176
Maplin Magazine	☐ 177	☐ 178	☐ 179

8. Which of the following do you buy and how frequently?

	Never	Sometimes	Regularly
Electronic Components	☐ 180	☐ 181	☐ 182
Complete Electronic Kits	☐ 183	☐ 184	☐ 185
ETI PCBs	☐ 186	☐ 187	☐ 188
Stripboard/Wirewrap Etc	☐ 189	☐ 190	☐ 191
Cases/Case Materials	☐ 192	☐ 193	☐ 194
Tools	☐ 195	☐ 196	☐ 197
PCB making Equipment/Materials	☐ 198	☐ 199	☐ 200
Pre-programmed ROMs	☐ 201	☐ 202	☐ 203
Computer Software	☐ 204	☐ 205	☐ 206

Floppy Disks	□ 207	□ 208	□ 209
Electronic Books	□ 210	□ 211	□ 212
Data Books	□ 213	□ 214	□ 215
Second Hand Equipment	□ 216	□ 217	□ 218

9. Please indicate what you think of the services offered:

	Poor	**Average**	**Good**
PCB Service	□ 219	□ 220	□ 221
Photocopy Service	□ 223	□ 224	□ 225
Foil Patterns	□ 227	□ 228	□ 229
Buylines	□ 231	□ 232	□ 233
Subscriptions	□ 235	□ 236	□ 237
Back numbers	□ 239	□ 240	□ 241

10. Have you used:

	Yes	**No**
Our PCB service	□ 243	□ 244
Photocopy service	□ 245	□ 246

11. If you own or regularly use a computer, please indicate which it is:

Spectrum □ 247
BBC Micro/Master/Electron □ 248
Commodore 64/128 □ 249
Amstrad CPC □ 250
Amstrad PCW □ 251
IBM PC Compatible □ 252
Atari ST □ 253
Amiga □ 254
Archimedes □ 255
Cortex □ 256
Apple Mac □ 257
Other (please specify) □ 258

....

12. How many ETI projects have you built in the past 12 months?

None □ 259
1-3 □ 260
4-6 □ 261
7-12 □ 262
More than 12 □ 263

13. Do you find ETI projects

	Yes	**No**
Reliable	□ 264	□ 265
Easy to build	□ 266	□ 267
Useful	□ 268	□ 269
Instructive	□ 270	□ 271
Technically understandable	□ 272	□ 273
Work first time	□ 274	□ 275

14. Do you modify ETI project designs?

Not At All □ 276
A Few Mods □ 277
Many Mods □ 278

15. Do you prefer to build ETI projects from complete kits when they are available?

Yes□ 279 No□ 280

16. Do you make your own PCBs?

Never □ 281
Sometimes □ 282
Always □ 283

17. Have you used our cover PCB to construct a project?

Once□ 284 Sometimes□ 285
Always□ 286 Never □ 287

18. What type of projects would you like to see using our cover PCB?

....
....
....

19. Do you primarily build electronics projects

To save money on commercial goods □ 288
As a satisfying pastime □ 289
As an instuctional exercise □ 290

20. As far as electronics design and construction is concerned, do you consider yourself:

Novice □ 291
Proficient □ 292
Accomplished □ 293
Expert □ 294

21. Estimate the value of your electronics test gear and construction equipment as new:

Under £25 □ 295
£25-£100 □ 296
£101-200 □ 297
£201-£500 □ 298
£501-£1000 □ 299
£1000-£2000 □ 300
£2000-£4000 □ 301
over £4000 □ 302

22. How much do you estimate you have spent on equipment and components during the past 12 months?

Nothing □ 303
Under £25 □ 304
£25-£50 □ 305
£51-100 □ 306
£101-£200 □ 307
£201-£500 □ 308
£501-£1000 □ 309
over £1000 □ 310

23. Are you responsible for recommending/specifying electronic equipment in your job?

Yes□ 311 No□ 312

24. How long do you keep your copies of ETI for:

Less than one month □ 313
One month □ 314
Three months □ 315
Six months □ 316
A year or more □ 317

25. If kept, how often do you refer back to issues of ETI?

Once a week or more □ 318
About once a month □ 319
Once every three months □ 320
Less often □ 321
Never □ 322

26. How long do you spend reading your copy of ETI?

Over 2 hours □ 323
1½-2 hours □ 324
1-1½ hours □ 325
½-1hour □ 326
Less than ½ hour □ 327

27. How long have you been an ETI reader?

Less than three months □ 323
3-6 months □ 324
7-12 months □ 325
1-2 years □ 326
2-5 years □ 327
Over 5 years □ 328

28. How often do you buy ETI?

Occasional issues □ 329
Most issues □ 330
Every issue □ 331

29. How much of ETI do you read?

Read only some articles □ 332

Read most articles ☐ 333
Read all articles ☐ 334

30. With regard to the advertisers in ETI do you?
Read or look through most or nearly all the ads ☐ 335
Read or look through some of the ads ☐ 336
Just read or look through the occasional ad ☐ 337
Very rarely/never look at the ads ☐ 338

31. Thinking specifically about the advertising content, would you please rate the two main types of advertisement:

	Display	Classifieds
Very useful	☐ 339	☐ 340
Useful	☐ 341	☐ 342
Not very useful	☐ 343	☐ 344

32. Which of the following would you most like to see featured with the magazine? (one box only).
Cover mounted gifts ☐ 345
Additional supplements ☐ 346
Competitions ☐ 347
Money saving offers ☐ 348
Other (please specify) 349

33. Does anyone else read your copy of ETI?
No only myself ☐ 350
One or two other people ☐ 351
Three or four other people ☐ 352
More than four other people ☐ 353

34. If your copy of ETI is read by other people, please give details of their age and sex:

	Person 1	Person 2	Person 3
Age:			
9-14 yrs	☐ 354	☐ 355	☐ 356
15-24 yrs	☐ 357	☐ 358	☐ 359
25-34 yrs	☐ 360	☐ 361	☐ 362
35-44 yrs	☐ 363	☐ 364	☐ 365
45-54 yrs	☐ 366	☐ 367	☐ 368
55-64 yrs	☐ 369	☐ 370	☐ 371
Over 64 yrs	☐ 372	☐ 373	☐ 374
Sex:			
Male	☐ 375	☐ 376	☐ 377
Female	☐ 378	☐ 379	☐ 380

35. Are you aware of the scheduled publication date of ETI?
Yes☐ 381 No☐ 382

36. If the answer to the last question is YES, do you normally attempt to purchase the magazine on that day?
Yes☐ 383 No☐ 384

37. How do you normally obtain your copy?
Chance purchase ☐ 385
Newsagent shop collection ☐ 386
Newsagent home delivery ☐ 387
Subscription ☐ 388
Passed on copy ☐ 389

38. If you are a subscriber, on which date did you receive this issue?

☐ ☐ /☐ ☐ /☐ ☐

39. If you are a subscriber, how long have you subscribed to this magazine?
1-6 months ☐ 390
7-12 months ☐ 391
1-2 years ☐ 392
3-5 years ☐ 393
6-10 years ☐ 394
Over 10 years ☐ 395

40. If you do not obtain your copy by subscription, is it due to one of the following:
Subscription too expensive ☐ 396
Not every issue required ☐ 397
Not aware subscription service available ☐ 398

41. Are you aware that to subscribe to this magazine in the UK costs the same as purchasing it in a shop?
Yes☐ 399 No☐ 400

42. Would you like to receive further details on taking a subscription?
Yes☐ 401 No☐ 402

43. If you do not subscribe, from which type of newsagent do you most often obtain your copy?
High Street Shop ☐ 403
Estate shop ☐ 404
Corner shop ☐ 405
Other (please specify) ☐ 406

44. Please tick any hobby/interests you may have besides Electronics:

Model Railways: ☐ 408
Model Engineering: ☐ 409
Model Cars: ☐ 410
Model Boats: ☐ 411
Model Aircraft: ☐ 412
Steam Locomotives: ☐ 413
Radio/CB: ☐ 414
Computers: ☐ 415
Fish keeping: ☐ 416
Woodworking: ☐ 417
Handcrafts: ☐ 418

45. Please tick the box which represents the annual total of your gross income:
Under £6,500 ☐ 419
£6,501-£8,000 ☐ 420
£8,001-£10,000 ☐ 421
£10,001-£12,500 ☐ 422
£12,501-£15,000 ☐ 423
£15,001-£19,000 ☐ 424
£19,001-£25,000 ☐ 425
Over £25,000 ☐ 426

46. What is your age?
Under 15 yrs ☐ 427
15-18 yrs ☐ 428
19-21 yrs ☐ 429
22-24 yrs ☐ 430
25-34 yrs ☐ 431
35-44 yrs ☐ 432
45-54 yrs ☐ 433
55-64 yrs ☐ 434
Over 64 yrs ☐ 435

47. Which of the following newspapers do you read?
The Times ☐ 436
The Daily Telegraph ☐ 437
The Financial Times ☐ 438
The Guardian ☐ 439
The Independent ☐ 440
The Daily Express ☐ 441
The Daily Mail ☐ 442
The Daily Mirror ☐ 443
The Sun ☐ 444
Today ☐ 445
None of the above ☐ 446

48. Which of the following Sunday newspapers do you read?
The Sunday Times ☐ 447
The Observer ☐ 448
The Sunday Telegraph ☐ 449
The Sunday Express ☐ 450
The Mail on Sunday ☐ 451
The Sunday Mirror ☐ 452
The People ☐ 453

The News of The World ☐ 454
News on Sunday ☐ 455
Today ☐ 456
None of the above ☐ 457

49. What is your marital status?
Married ☐ 458
Single ☐ 459
Divorced ☐ 460

50. Sex:
Male☐ 461 Female☐ 462

51. Are you a member of a book club?
Yes☐ 463 No☐ 464

52. Are you a member of a record club?
Yes☐ 465 No☐ 466

53. Are you:
In full time employment ☐ 467
In part time employment ☐ 468
Not employed at present ☐ 469
Retired ☐ 470
Student – full-time ☐ 471
Student – part-time ☐ 472

54. If in full-time employment, please state your occupation:
....

55. If a student what subjects do you study?
....
....
....

56. If you have children, please indicate their age given in the ranges:

	First	Second	Third	Fourth
Age 1-3 yrs	☐ 473	☐ 474	☐ 475	☐ 476
4-8 yrs	☐ 477	☐ 478	☐ 479	☐ 480
9-12 yrs	☐ 481	☐ 482	☐ 483	☐ 484
13-16 yrs	☐ 485	☐ 486	☐ 487	☐ 488
Over 16 yrs	☐ 489	☐ 490	☐ 491	☐ 492
Male	☐ 493	☐ 494	☐ 495	☐ 496
Female	☐ 497	☐ 498	☐ 499	☐ 500

Thank you for completing the ETI readers' survey. To qualify for entry in the free draw for one of 20 prizes from Maplin Electronics and ETI you must fill in your name and address below, pull out the centre pages, fold as shown and post to arrive not later than 10th October 1992

Name ....
Address ....
....
.... Postcode ....

To post, fold on the dotted line A. Fold again at B and C and tuck B into the flap formed by C.

A

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2

C **B**

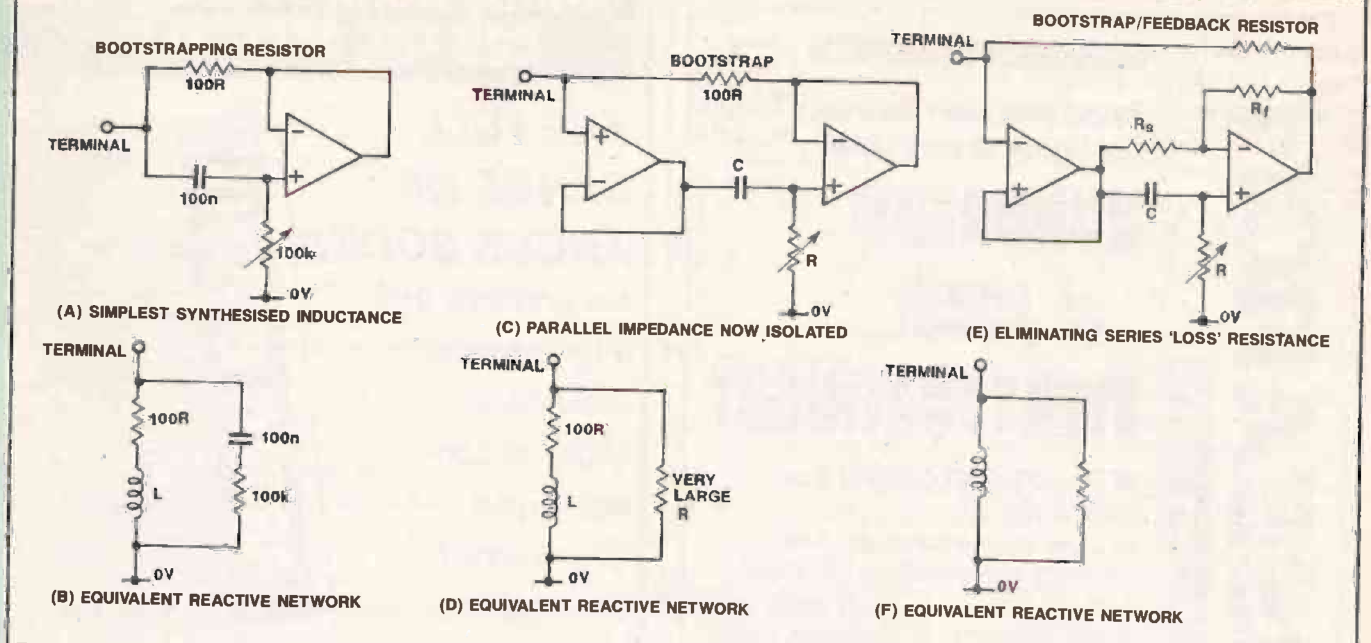


Fig.1 Synthesising the reactive properties of an inductor using 'bootstrapping techniques'

AutoMate Anniversary Mixer

7

PROJECT

This month, Mike Meechan looks at everything that you've ever wanted to know about EQ but were afraid to ask.

Continuing from last month, in this chapter of our slowly unfolding tale of the pursuit of audio excellence within the AutoMate mixing console, we shall expand our examination of 'sound' equalisation. In this section, our finale or pièce de resistance will be an examination of the comprehensive equalisation circuitry of this console.

I mentioned last month, albeit briefly, the subjective versus scientific/objective argument. Both the topic of EQ and that of its predecessor, the op-amp in any high quality audio pathway, are hotly disputed subjects within such a sphere of argument and discussion.

I should perhaps say that EQ is probably one of the only subjects within the realm of audio engineering where I am more partial to the 'subjective' cause. Not especially from the point of not wishing to include such circuits for fear of derision etc but that which says if it sounds good, do it and be damned. It is a difficult viewpoint to rationalise and put on paper but I shall try anyway.'

For absolute accuracy in sound reproduction, the replay should sound identical to the original recording. Superficially this means a concert performed in the Carnegie Hall, should sound as it was when recorded at this venue when one replays it on a record deck, CD player or whatever in one's typical 20' x 12' suburban living room.

Is this then a true and accurate rendition of what it sounded like when first performed in the concert hall? To my mind, it is not. For it to sound like that, it would be necessary for it to be replayed in a room of similar dimensions and acoustic treatments.

It also implies absolutely perfect recording and reproducing apparatus and correct positioning of microphones etc. This is the prevailing situation when the source material is completely naturally produced, ie from acoustic instruments with no artificial electronic means of sound reinforcement before it reaches the ears of the attending concert-goers.

Accurate Recording - Synthesis or Analysis

Once the factor of sound reinforcement is introduced, (a typical rock concert) the errors are compounded by a very large order of magnitude. The audience will hear instrument sounds which, although perhaps not heavily processed or enhanced in anyway will have passed through an electronic reproduction/reinforcement system. Even if the amplifiers were completely perfect, the sound would inevitably be coloured in some manner by the loudspeakers. The extreme might be in a concert group choosing to use valve amps with the 'wick' turned up, so to speak. They will then produce the overdriven, soft-clipped second and other low order harmonic distortion products associated with this type of amplifier - the type so beloved by the rock fraternity. In this instance, we would then be trying to simulate a distorted sound, no matter how pleasing to the ear this might be. Any recording of this would, in the interests of accuracy, be trying to simulate this 'processing', no matter how subtly it might have been applied.

Returning to the interests of absolute accuracy, should the recorded musical piece sound like it is being replayed in the Carnegie Hall (which is artificial and a travesty of the accuracy requirement since the room is NOT the Carnegie Hall) or should it sound like a bunch of musicians crammed into one's living room?

If all of this sounds a little oblique and removed from the subject of equalisation, we should remember what I said last month about modern-day recording techniques. The final stereo master isn't an accurate representation of what the artist sounded like in the studio but one of how the sound engineer/producer wished or hoped that it should sound. There must always be some trade-off between accuracy and 'pleasantness', for want of a better word. This relates to EQ in the manner in which it must also sound natural and musical. Having designed a filter network, it's of little consolation to point to reams of transfer functions, pages of beautifully executed equations and sheets of smoothly-drawn curves when the finished product sounds rough or discordant or unnatural but theory suggests otherwise. Some compromise and much subjective testing is necessary.

Equalisation by Empirical Means

Some very poor examples of EQ networks abound in equipment and textbooks alike. These include so-called 'shelving' equalisers which do not have a true shelving characteristic in operation, circuits with component values badly chosen so that turnover frequency wanders with the setting of the boost/cut control, or chosen so that the control has little effect for much of the angular rotation about the 'flat' position but all at the extremes of control setting. The list goes on.

The AutoMate equalisation stages were designed with much thought given to subjective effects and particularly to the effect upon typical programme material, be that material of an instumental or vocal nature.

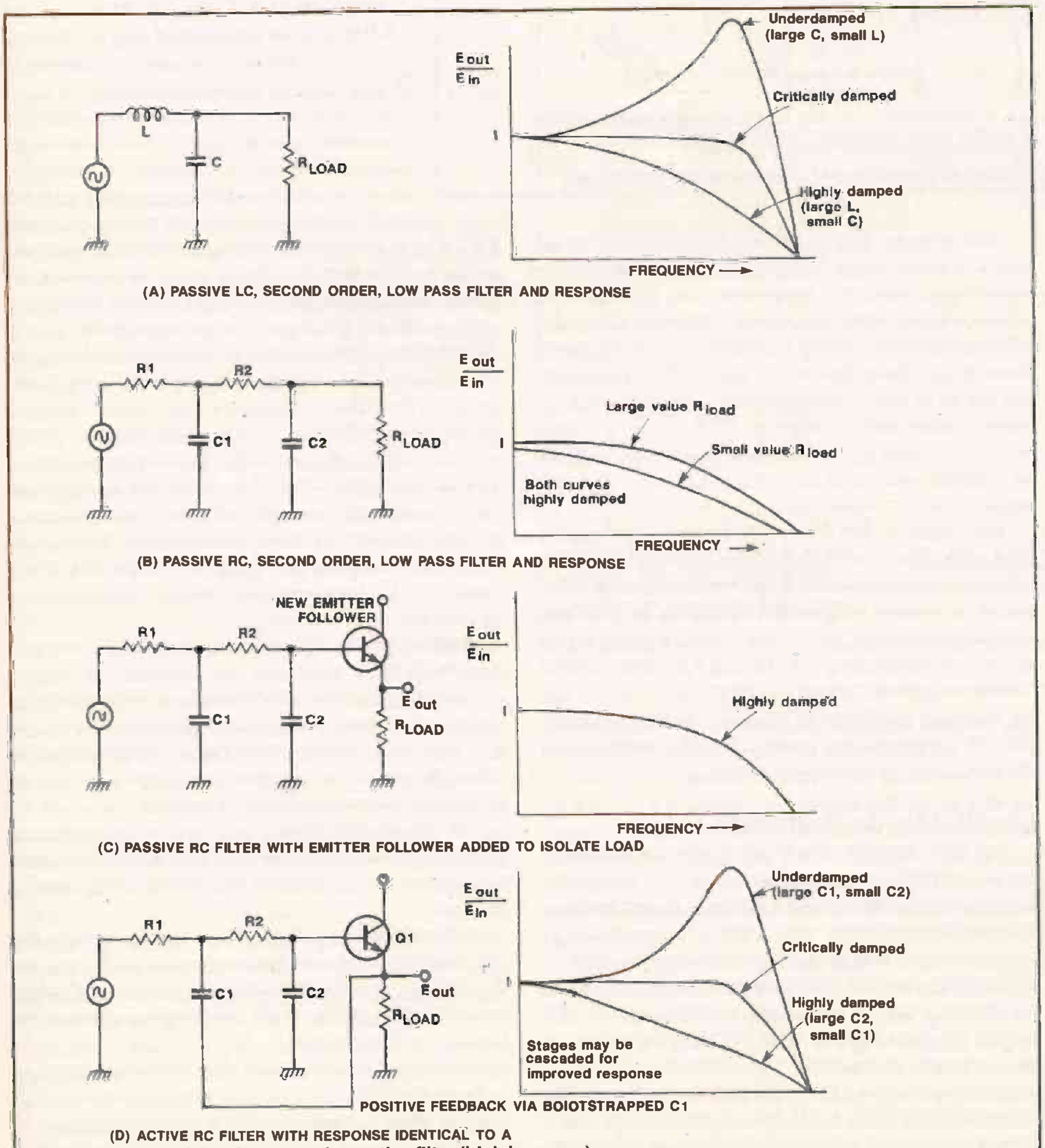
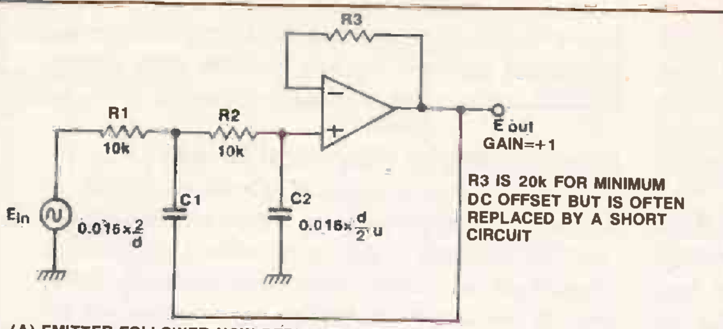
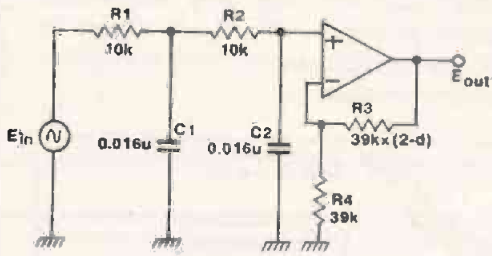


Fig.2 Evolution and development of an active filter (high low pass)



(A) EMITTER FOLLOWER NOW REPLACED BY OP-AMP -CLASSIC UNITY-GAIN SALLEN & KEY LOW PASS FILTER



(B) GAIN IS INTRODUCED VIA R3 AND R4 AND Rs AND Cs ARE NOW EQUAL. THIS IS THE EQUAL COMPONENT VALUE SALLEN-KEY (OR VOLTAGE-CONTROLLED VOLTAGE SOURCE)

Fig.3 Evolution and development of an active filter (continued)

With all of the afore-mentioned firmly in mind, we can now look at the various types of filters and equalisers to be found within a console. Some notion and appreciation of what is required and of some of the problems or advantages which the use of the op-amp will cause or cure in this area of ciruit design should have been gained. Most importantly, any applied equalisation should sound natural with great care taken to ensure that its application is in fact to create a given effect, or to either remove unwanted sounds from the signal or to add that which is lacking. It should rarely be used as an effect or 'toy' in its own right.

Last month, we had a very brief look at simple, passive filter networks and closed Part 6 by mentioning one method of simulating inductance by devious electronic means. Realising an inductor by electronic means can be performed using a device called a gyrator although as such, it is of little use to us as student designers of the tunable variety. This is because the network dynamic impedance changes with changing frequency ie different Q values as frequency is altered. The GIC (or General Impedance Converter), happily, is not the only way of synthesising inductances.

Grabbed by the Bootstraps

One of the simplest - and for this reason, one of the most popular - is the 'bootstrap', so-called because of the way that bootstrapping is used to create inductance. Bootstrapping as a circuit design technique works whether the source voltage is steady-state or alternating. This is because any phase or difference in potential creates a potential difference across the resistor which, in turn, causes a current to flow. By making this bootstrapping action frequency dependent, we can synthesise an inductor. See Figure 1a. It has one shortcoming - nothing's perfect, to paraphrase Joe E. Brown in 'Some Like It Hot'. At HF there is a parallel impedance between the terminal and ground. Buffering this chain from the terminal can, however, effect a cure.

The synthesised inductor now looks like the network in Figure lb with the bootstrap resistor now manifested as a loss resistor in series with the inductor. Effectively, this produces behaviour which is akin to that encountered when winding resistance 'impedes' upon a circuit's ideal electrical characteristics. A finite R_s causes the inductor to have a lower Q than at first might have been expected from a theoretical example. The parallel RC network is a High Pass Filter. Figure 1c shows the effect of buffering this network, with the RC components now replaced by the high impedance which the buffer input presents to the network.

This configuration of components now begins to look more like a typical filter circuit. Figure 2 and 3 show the complete evolution of a low pass type.

Genesis of an Active Filter

Now that we have learned how to synthesise inductive properties, let us look at a real example. At this juncture, it should be noted that an active filter realisation of a passive inductive network is rarely expected to replace it on a one for one basis. Rather, the overall mathematical or transfer response is considered and the active filter section used to simulate or synthesise its passive counterpart. Last month, mention was made of the many response curves possible with this type of circuit. Not only can we control the product of the inductor (or its active counterpart) and the capacitor but also the RATIO of one to the other. If the capacitor is made very large in value and the inductor very small, the load resistor RL will not load the L_C network very much and the network behaves as a series resonant circuit on the verge of oscillation. At some frequencies at or near resonance, the circuit will exhibit gain or peaking and will yield an underdamped response. Balancing the ratio of all three components gives a flatter response with no peaking or gain and is known as the critically-damped curve. Unbalancing again, but with the bias this time toward large L and small C means that R_L dominates and a droopy, highly or overdamped response is created.

Setting the damping by altering the L-C ratio determines only the SHAPE of the response curve and the filter performance near f_{cutoff} and that this frequency is set solely by the product of the two components. Cascading two sections to give higher order filter networks also gives faster roll-off (as we might expect) but with very high damping because the two resistors cause the network to be lossy.

Damping is so bad, in fact, as to make the network almost unusable in most instances. Bolstering this lack-lustre performance can be achieved by injecting energy into the network.

Adding an emitter follower eliminates any output loading effects since the follower has unity gain, high Z_{in}, and low Z_{out}. With this circuit, gain and damping are now independent of R although the overall damping performance still leaves a lot to be desired.

Further improvements occur if we connect the capacitor to the output of the emitter follower rather than to ground. In this way there is positive feedback or bootstrapping from output back to the middle of the RC filter. This feedback improves the response and allows a reduction in damping to the point where we can then achieve any acceptable response that we might wish for. This is analogous to controlling the response in the totally passive section by altering the inductor-capacitor ratio. The feedback method delivers energy to the network only near the cut-off frequency - this localised feedback is caused by the reactance of the feedback capacitor being too high to affect LF and by V_{out} being too small to be worth feeding back at HF. Consequently, the feedback does what it is supposed to do ONLY where it is supposed to do it ie near f_{cutoff}

Changing the ratio of the two capacitors changes the damping whilst the RC product sets f_{cutoff} Damping of a second-order filter is defined as being a measure or index of its tendency towards oscillation. For example, practical damping values range from 2 to 0, with zero damping being the value for an oscillator, 1.414 being a critical value which gives maximum flatness without overshoot and a damping value of 2 being that yielded when two identical and isolated RC networks are cascaded. Highly damped filters combine to produce a smooth response with good overshootand transient properties - important in high quality audio applications - whilst slightly damped ones combine to produce a filter response which is lumpy but with sharp rejection characteristics.

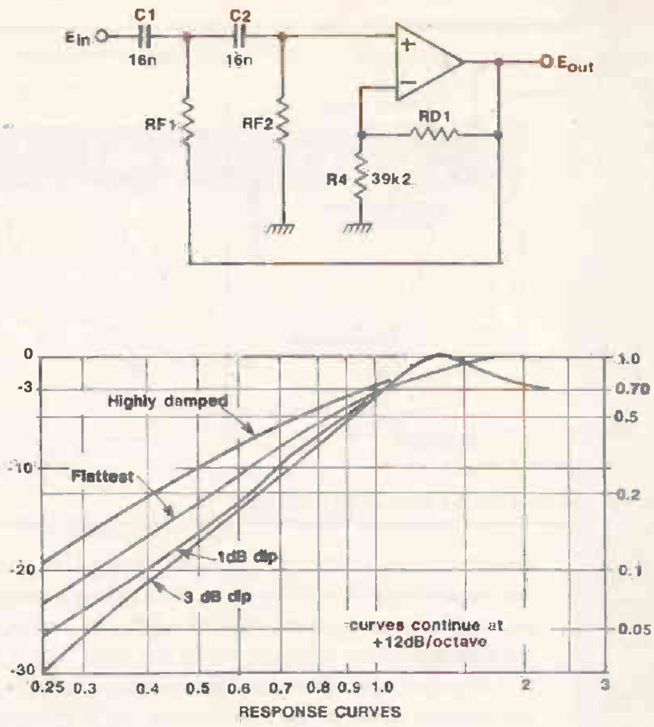
Hooked on Classics

It is only very slightly removed from the classic equal component Sallen and Key filter which just happens to be the easiest-to-design and easiest-to-use single op-amp filter you can possibly obtain. This is particularly true if one has to tune it over a frequency range or alter or trim its damping. Replacing the simple emitter-follower with an op-amp yields this classic filter. The Sallen and Key is a simple circuit to explain.

We have two cascaded RC sections driving an op-amp which unloads the circuit from any output and feeds back just the right amount of signal near the cut-off frequency to bolster response. In this way, the desired damping and shape can be achieved. Low pass and high pass transfer functions can be exchanged by swapping the positions of the resistors and capacitors. Despite the attractions of such a simple circuit, the unity-gain Sallen and Key is not without its failings. Damping and frequency cannot be independently adjusted and variation of the filter break frequency requires that we alter two different-value resistors simultaneously. A further, less obvious limitation is that low pass and high pass realisations cannot be achieved by the simple interchange of resistive and capacitive elements since upper components are always in a 1:1 ratio whereas the lower ones are in a 4/d ratio. The break frequency of the circuit is set by the PRODUCT of the resistors and capacitors while the damping is controlled so by the RATIO of the capacitors, values of which are not easy to calculate.

Altering this basic configuration yields a more civilised and refined version, a circuit known as the Voltage Controlled Voltage Source (VCVS) or the equal-component-value Sallen and Key filter. At a magic gain value 3-d, resistor values are identical, capacitor values are identical and consequently the circuit can be easily tuned. Equal value components throughout mean that we can switch easily between low and high pass types if so required and by using only a simple switching arrangement. Damping is adjusted by setting the gain which is always moderately positive. Gain affects ONLY damping, which is rather nice from our point of view, but it must be less than 3 or the circuit becomes an oscillator. This is because the damping at this value becomes negative. The ratio of the two resistors on the inverting input sets the gain and damping and as the absolute value of these is non-critical; they are normally set such that the parallel resistance equals the resistance seen from the non-inverting input to ground.

The unity-gain and the equal-value-component versions of the Sallen and Key are definitely the most workable. The gain of the latter type is normally fixed at 6dB although values can be manipulated to yield other values. We are already aware that damping determines filter shape. For this filter, there are seven shape options - best delay, compromise, flattest amplitude, slight dips, ldB dips, 2dB dips and 3dB dips. They are sometimes better known as Bessel,



RESPONSE	RF1,2	RD1	GAIN EOUT/EIN	GAIN (dB)	Damping
Highly damped	12k7	10k5	1.3	2.3	1.732
Compromise	11k3	16k9	1.4	3.0	1.564
Flattest amp	10k	22k6	1.6	4.1	1.414
Slight dips	9k3	30k9	1.8	5.2	1.216
1-decibel dip	8k66	37k4	2.0	6.0	1.045
2-decibel dip	8k45	43k2	2.1	6.4	0.895
3 decibel dip	8k45	48k7	2.2	6.8	0.767

RESISTOR SCALING TABLE FOR EQUAL COMPONENT HPF SALLEN-KEY 12dB/OCTAVE (SELECT RESISTORS FOR DESIRED RESPONSE). VALUES SHOWN FOR 1kHz f_{cutoff} TO CHANGE FREQUENCY, SCALE CAPACITORS SUITABLY-DOUBLING CAPACITANCE HALVES FREQUENCY AND VICE VERSA.

Fig.4 Achieving desired in-band and out-of-band responses for Sallen-Key second order high pass filter

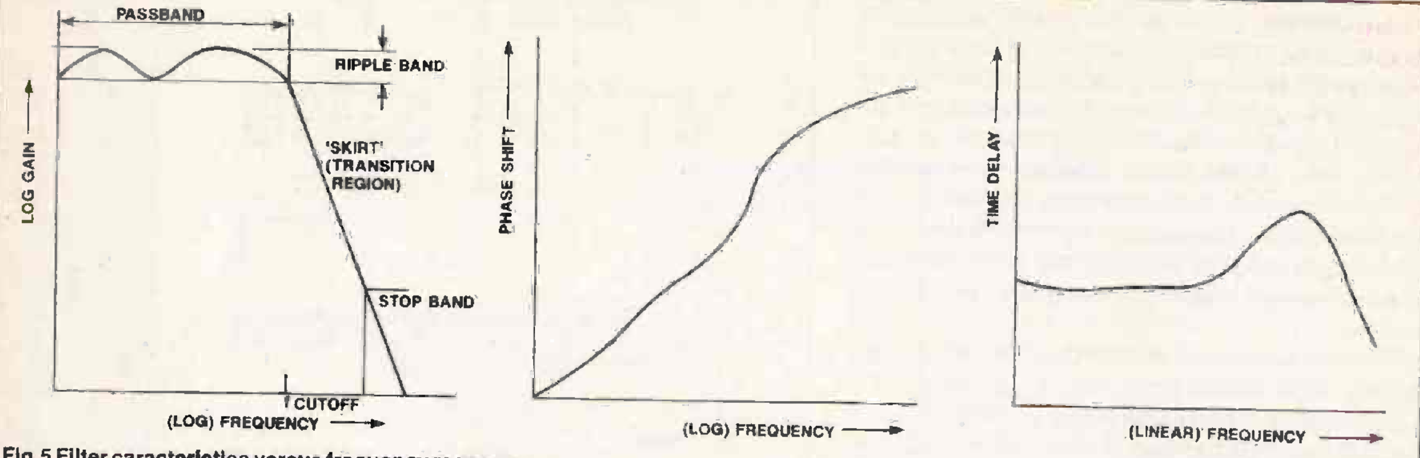


Fig.5 Filter caracteristics versus frequency response

Butterworth and Chebyshev types. See Figure 4. In essence, we trade sharper cut-off outside the frequency range of interest for worse transient response inside. As it transpires, the flattest response is the one which also gives 4dB of gain.

Of course, aside from amplitude response, other important features of a filter are the the steepness of the skirts or the uniformity of time delay versus frequency. Up until now, we have concerned ourselves primarily with effects in the frequency domain and specifically what happens in the passband, the transition region -skirt - and the stopband. The other factor of great importance in the frequency domain is the phase shift of V_{out} relative to V_{in}. Phase is important because a signal entirely within the passband of a filter will emerge with its waveform distorted if the time delay of different frequencies in going through the filter is not constant. Constant time delay corresponds to a phase shift increasing linearly with frequency. See Figure 5.

Filters can also be described in terms of their time domain properties; rise time, overshoot, ringing, and settling times and good performance in this domain is of particular importance where the input waveform is step or pulse-like in nature. Overshoot and ringing are both self-explanatory terms for some of the undesirable properties of filters. See Figure 6.

As it transpires, filter design can be optimised for maximum flatness of passband response at the expense of a slow transition from passband to stopband. Alternatively, by allowing some ripple in the passband characteristic, the transition from passband to stopband can be steepened considerably. As already mentioned, a third criterion that may be important is the ability of the filter to pass signals within the passband without distortion of the waveform caused by phase-shifts. There exist different filter designs to optimise each of these characteristics or combinations of them. Rational filter design begins with a set of requirements on passband flatness, attenuation at some frequency outside the passband and whatever else matters.

For audio work, rate of attenuation is an important consideration. To understand this point, we should designate all of the aforementioned circuits as 'filters' rather than as 'tone controls'. In normal applications, they will be employed to have effect at either the LF or HF end of the audio spectrum and will typically be second or third order filters, that is with rates of attenuation of 12 or 18dB per octave. Pyschoacoustic reserach has shown that rates of attenuation in excess of 6dB/octave lead to some degree of colouration in the in-band audio signal. As the rate of attenuation increases, so the degree of colouration worsens also. This is of less significance at the extreme ends of the audible spectrum - where they are most likely to be used -but some degree of restraint must still be exercised. This is because fast rates of out-of-band attenuation cause severe modifications to the transient response of the in-band audio signal - ringing type time-related components are introduced. Again, Figure 6 shows these filter-inherent transient problems. In the turnover area of the filter, the relationship between instrument fundamentals and their harmonics is of paramount importance. Any temporal disturbances in this area will be perceived as unnatural-sounding, especially if the fundamental is attenuated with respect to the harmonic (or vice-versa). Although the Butterworth type, with its maximally-flat response, has in fact been employed within the AutoMate, it is not quite as attractive as it might first have appeared since we are always accepting some variation in passband response. A filter characterised by a flat amplitude response may have large phase shifts and attendant overshoot problems, as already discussed. Conversely, the Bessel type's constancy of time delay is achieved at the expense of an amplitude response which has an even lazier roll-off rate than the Butterworth.

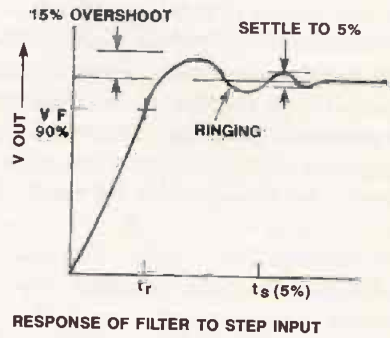


Fig.6 Transient response of a low pass filter

Another worthwhile approach to the problem of realising a filter with a uniform time delay is to use an all-pass filter (also known as a delay equaliser) which have constant amplitude response with frequency. See Figure 7. Phase shifts can thus be tailored to individual requirements and this approach can yield a design which vastly improves upon the time delay constancy of ANY filter. (More of the importance of this type of filter a little later). Compromise is the order of the day and the Butterworth-type is the true compromise filter with audibly-acceptable performance in both the frequency and time-domains. Figure 8 shows the basic Sallen and Key modified to become a multiple feedback type with a bandpass response.

A simple one or possibly two op-amp type filter such as this is a good basis for a design of filter to be used at the extremes of the frequency range. Having said this, one should mention that with a single op-amp type of filter, component spread problems, sensitivity problems or restrictions to available gain as Q rises beyond a certain value are all problems which can present themselves to the unwary. Figure 9 shows the effects of component spread.

True high performance, tunable filtering demands a more complicated circuit with three or possibly four op-amps. In most normal filter applications, a need for this type seldom arises since all that is usually required of the circuit is a filtering action which is fixed at one particular frequency or can be manually tuned.

Next month we move onto more complex filter sections. These types lend themselves more readily to inclusion within a mixing console.

To be continued...

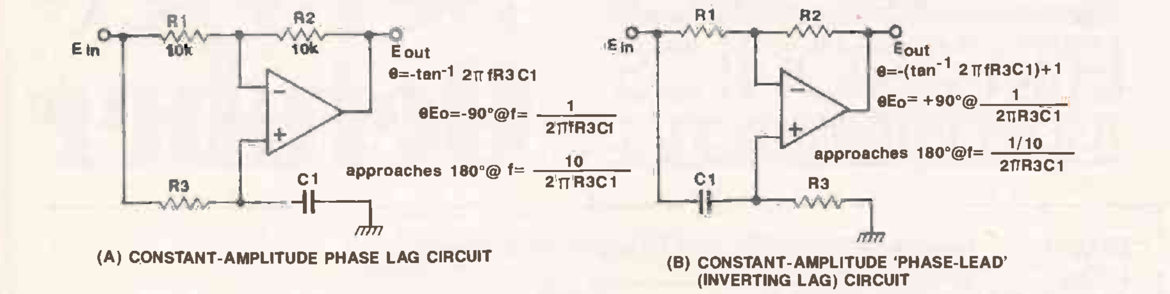


Fig.7 Delay equaliser (constant all pass phase shifting filter)

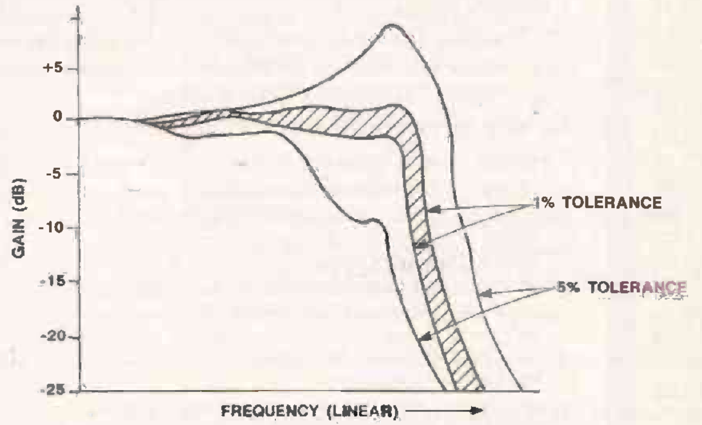


Fig.9 Effect of component tolerance on active filter performance)

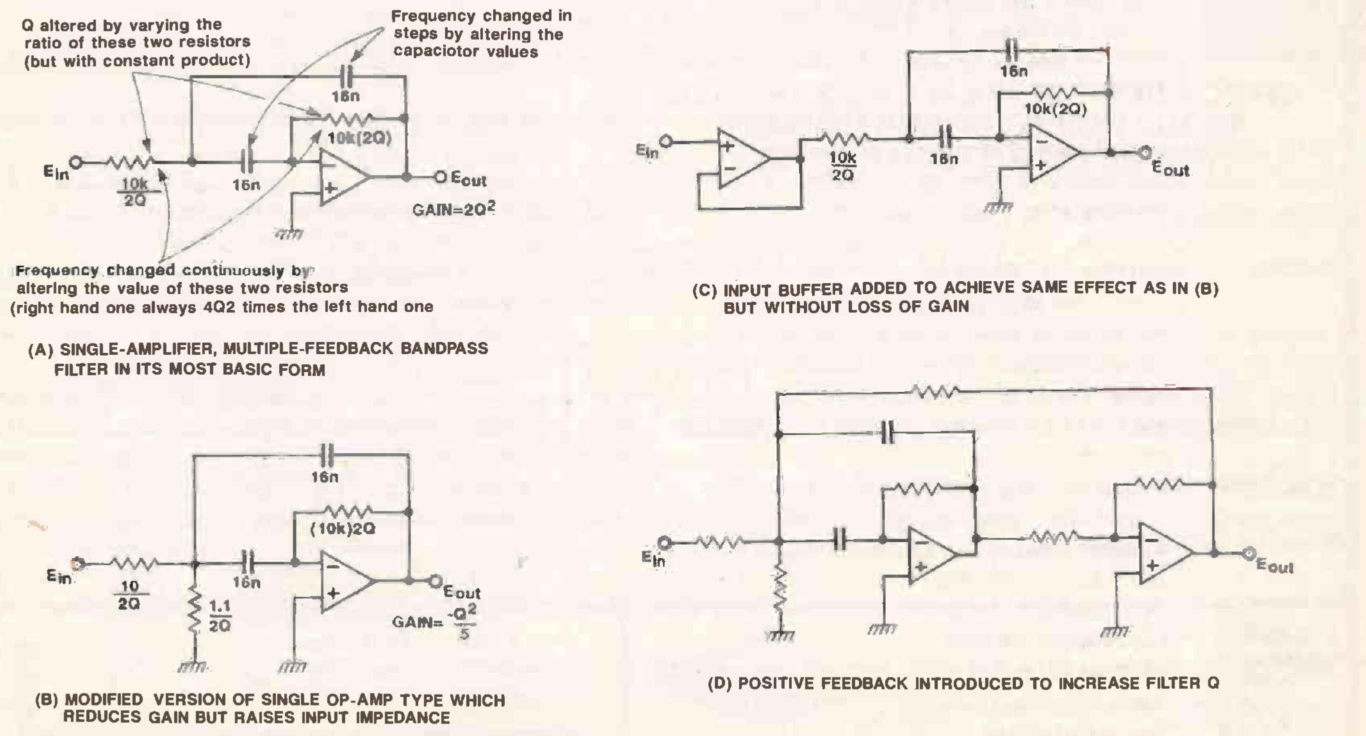


Fig.8 Bandpass filter development using a single op-amp (multiple-feedback filter)

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E9203-2	MIDI Switcher - Power Suply	E
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E9206-3	Xenon flash trigger Flash Board	F
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E9207-6	AutoMate Precision 17V power supply	J
E9207-FC	Surround Sound Decoder	F
E9208-1	Dynamic Noise Limiter	F
E9208-2	Touch Controlled Intercom (2 boards)	H
E9208-3	MIDI Keyboard	K
E9208-FC	Battery charger	F
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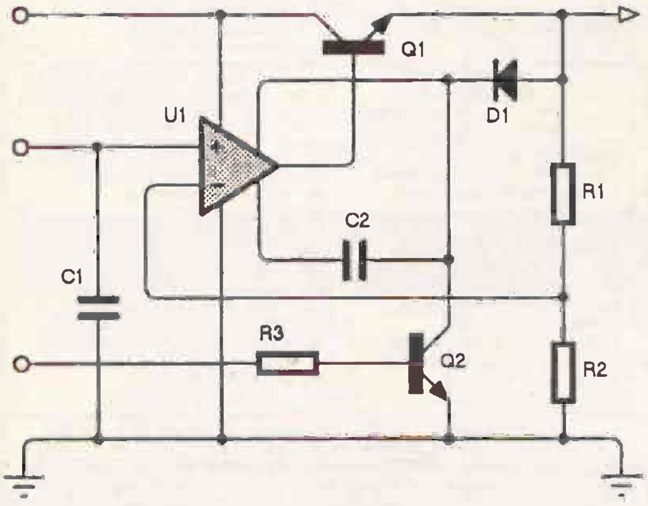

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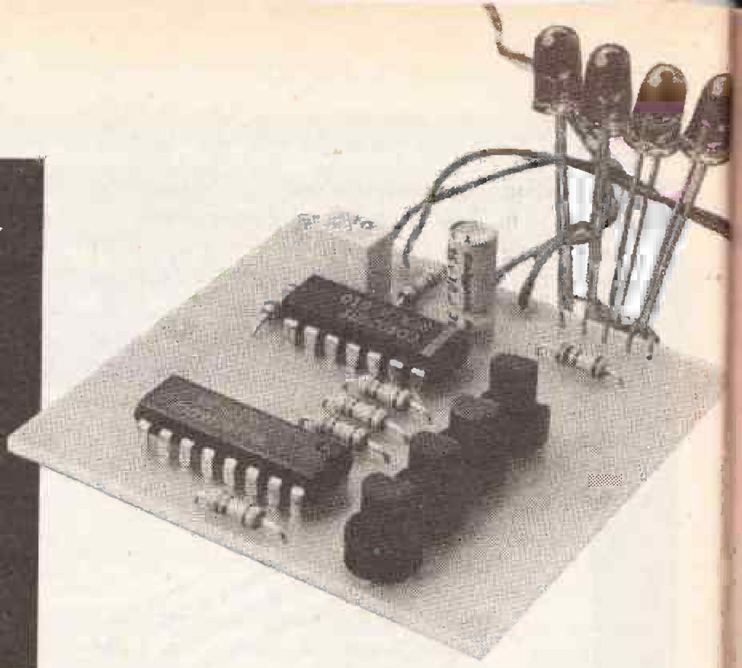
Flashy Wizard's Hat

ETI Cover PCB Project



Andrew Armstrong constructs a party hat to shine above the rest.

This is a novelty project which sequences four chains of LEDs round a hat. Its primary use is to excite comment at the sort of parties to which respectable constructors are not supposed to be invited. The project was initially designed as a one-off for a fancy dress party, and was inspired partly by my wish to experiment with the decorative potential of LEDs. It proved a success, and has been popular with friends who borrow it regularly.

The chimney at the top is purely an engineering addition. Lifelong study of electronic engineering has consistently indicated that electronic components cease to run if the smoke is let out of them. Once this smoke mixes with the air, you cannot extract it and reinsert it into the components, which, lacking their working fluid, never function again. A chimney is provided just in case the smoke is driven out by some overload or breakdown.

On a more pedestrian level, the chimney houses the potentiometer which is used to adjust the clock rate of the sequencer.

PCB Construction And Testing

Assembly of the PCB should present no problems. The ICs should be inserted last, using anti-static precautions. As a temporary measure to enable testing, four LEDs should be connected to the output, and the preset potentiometer should be connected, though it will need to be disconnected again to route the wire through the chimney. A power supply or battery in the range 4V to 6V should be connected to the power terminals of the PCB. Take great care to connect the supply the right way round, because the PCB does not incorporate any protection.

As soon as the power supply is connected the LEDs should sequence, with one LED on at a time. If this does not happen, check that the LEDs are connected the right way round, then look for unsoldered connections and for tracks shorted by solder blobs. This is a simple circuit, and the possibilities for malfunction are limited, so it should soon be working.

Hat Construction

The hat was made from reasonably firm cardboard covered with black cloth. There are three cardboard sections: the brim, the sides and the crown. The sides were fashioned from a strip of card about six inches wide by eighteen inches long, wrapped around the head of the destined wearer and overlapped until it fitted comfortably above his ears! This was then marked for size and an overlap of about 1 inch glued. The inner edge of the brim, cut from a flat piece of card, was determined using the glued side-piece as a template but this cylinder must be 'tried' onto the wearer and held in shape by

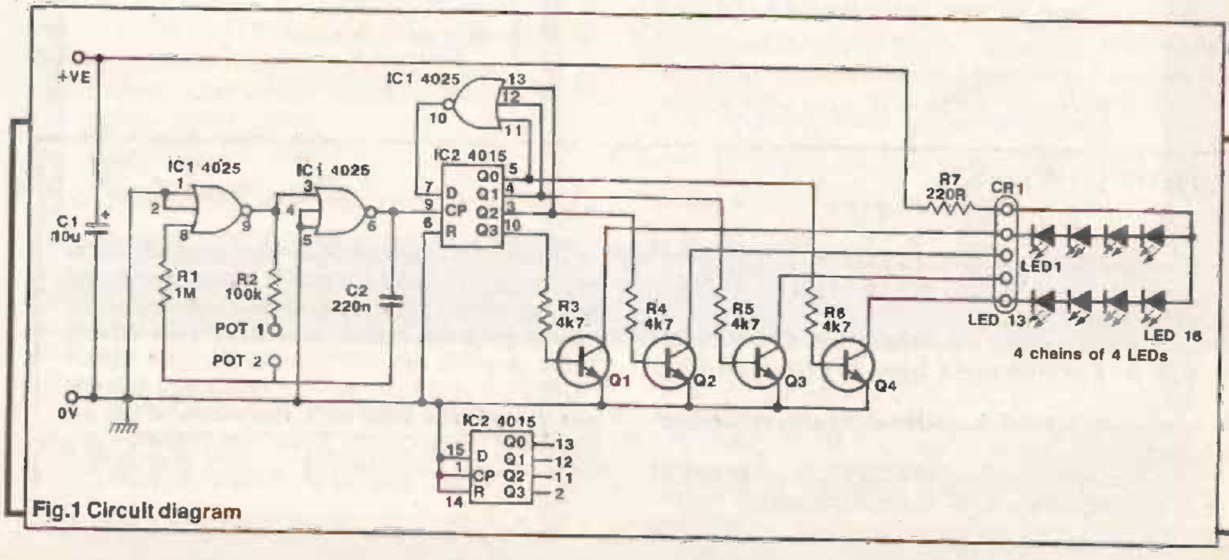


Fig.1 Circuit diagram

PROJECT

hand while somebody draws around it firstly to make certain that the fit to the head is still accurate after gluing, and secondly because the wearer's head is unlikely to be perfectly cylindrical! Our heads are usually deeper front-to-back than they are from side-to-side, and so the 'sides' must either hold, or be held into, the right shape while the inner edge of the brim is being drawn. It is a good idea to make an initial template on a piece of stout paper, cut it and try it for fit, and if necessary try again before drawing and cutting the card.

The width of the brim itself is, of course, a matter of taste. Ours is about 1.5 inches.

The crown was cut from a circular section, and overlapped until it formed a cone of the right size to fit within the glued side-cylinder.

Before any of these sections were attached together, they were covered with black cloth. The cloth we used is a fairly thick jersey (slightly stretchy) fabric, stretched lightly over the card sections inside and out, and sewn into place with black button thread (which wears better than machine thread). The fabric on the inside of the sidepiece and the crownpiece was also tacked down with a craft adhesive, to keep it taut. Use this method sparingly so that the glue does not soak into the fabric and mark it.

The sections of the hat were then sewn firmly together, taking the needle through the cloth of both sections being fastened. the brim and side sections need a 'seam' inside and out. The crown section, which doesn't take any strain, may only need a 'seam' outside. My fabric consultant actually made a narrow roll of fabric and placed it over the join to neaten it a little, so there is a row of stitches on each side of this piping. This stitching has survived a good many years of use without collapse.

The chimney is simply a small cylinder of the same fabric-covered card, sewn into a hole cut out of the crownpiece.

The shape and style of the hat is, of course, a matter of personal preference. Those of you not versed in fabric technology may wish to consult someone who is. My wife was responsible for the shell construction of the hat, although she looks perplexed when she inspects it now.

You might prefer to fix and finish the sections using some method other than fabric-covering and needlework, but the cloth imparts a nice gloss, and also turned out to be helpful for fixing the batteries and wiring inside the hat.

Final Assembly

The first thing to fit into the hat is the LEDs. There are four rows in this design, and the placing was done simply by starting each row on roughly opposite sides of the hat and then measuring the 'drop' of each row with a short ruler and the offset roughly by eye. I found that if I got one 'slope' as I wanted it, and then located the other LEDs on that level, opposite and at 90° to the first one, it came out looking right. As to colour: the spiral arrangement is uphill/clockwise, so I arranged LEDs of the same colour uphill/anticlockwise where a red LED is in the bottom of one row, it is second from the bottom in the next row, and so on. All the LEDs of one colour are wired to light up together. The four colours used are red, green, orange and yellow. A later addition was one blue LED in place of one of the orange ones just as a talking point.

I made the holes for the LEDs with a small drill then and there. You might like to mark the spots with a piece of chalk or something similarly non-permanent if you are not certain of your placement. All the LEDs are mounted in led mounting clips. These little collars, held down by a dob of glue, are essential to stabilise the fabric and stop it from fraying (and

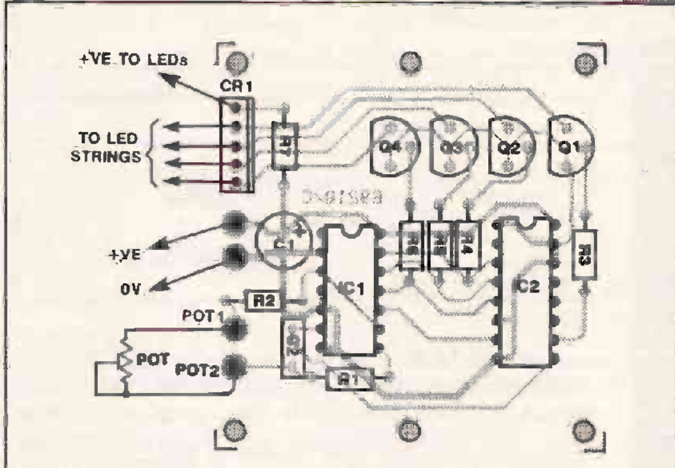


Fig.2 Component Overlay

to neaten the hole). When drilling, try and make the hole in the outer fabric as neat (and small) as possible, as it will give a bit. The LEDs are then inserted from inside the shell.

The next job is to wire up the LEDs, as neatly as possible, running the wires round together in the track of the LEDs, leaving space clear to mount the rest of the works. Then connect the sets of LEDs to the PCB, fit the preset pot in the top of the chimney, and wire that to the PCB, then test the assembly so far by applying 12 volts to the power connections of the PCB. You can either use a lab power supply, or the batteries destined for permanent use. When everything works, a charging socket and a switch should be connected to the power connections of the PCB as shown in the circuit diagram. Connections for the batteries should now be avail-

HOW IT WORKS

This circuit in Figure 1 uses a shift register to generate the moving sequence. Two parts of IC1, the three input NOR gate, are connected in a standard CMOS clock circuit. Clock pulses from this clock the shift register, whose first three outputs are fed to the third part of the NOR gate.

When there is a logic 1 in any of the first three stages of the shift register, a 1 is not needed at the serial input. When the first three stages contain logic 0, a 1 is fed to the first stage at the next clock pulse. At the same time, a 1 in the last stage would be dropped off the end of the register.

The current drive from the output of CMOS gates is insufficient to drive LEDs, so transistors are used to provide adequate drive. The LED current is set by one current limiting resistor, R7, because only one chain is on at a time.

The inputs to the second shift register are connected to 0V. It would be possible, on an expanded PCB layout, to cascade the second shift register by feeding its D input from the Q3 output of the first part. This would generate an 8way sequence, but would need a gate with seven inputs to generate the serial input signal for the first register. Either an 8 way NOR gate would be used, with one input grounded, or diode logic could be added to the present circuit. In either case, an eight way adaptation of this design would require a new PCB layout, or a Veroboard layout.

able, with positive going to the switch and negative to the charging socket. No more connections to the PCB should be required. Finally check all the wires going to the PCB, because a wire hanging on by one strand, will be difficult to replace later, then sew the PCB to the hat using the three holds down each side to pass the thread through. You may have to drill these holes out to a couple of millimetres, and angle them, to allow a needle to pass through at a suitable angle to 'catch' the cloth lining of the hat.

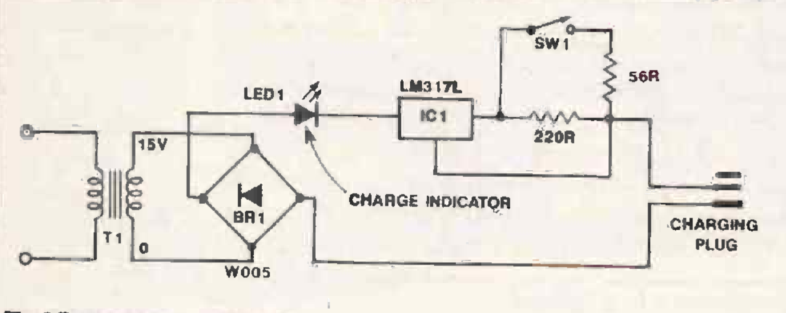


Fig.3 Battery charging circuit

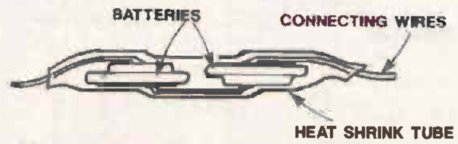
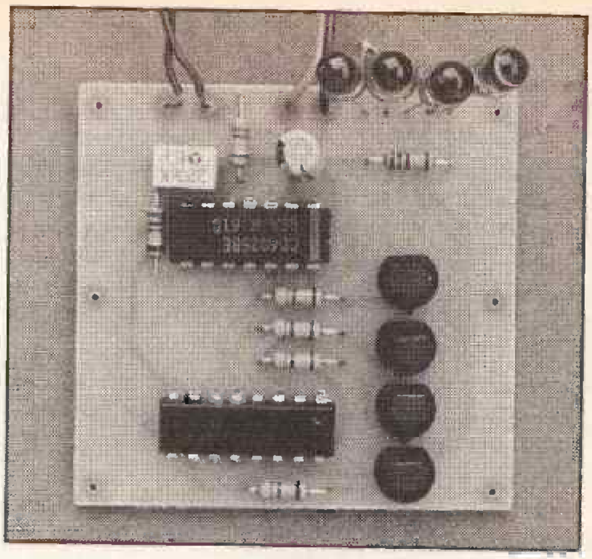


Fig.4 Battery detail

The final job is to fit the batteries. Any 12 volt power source will do the job, but it is recommended that you use nickel cadmium button batteries. We have mounted these in pairs, each pair held together by a piece of heatshrink sleeving. The batteries were mounted flat, as shown in Figure 4, rather than as a stack, to allow easier fitting and better balance. The pairs of batteries were mounted at equal intervals round the interior of the hat, as low down as possible without contacting the wearer's head, to keep the centre of gravity low. They were held in place with doublesided adhesive pads.

Charging

The Nickel-Cadmium batteries chosen for this project have a capacity of 170mAhours. They should be charged at 17mA for 12 hours to charge them up from flat, then they should run the LEDs for approximately 8 hours. As long as they are at least partly charged, nickel cadmium batteries do not deteriorate rapidly in storage, but they may lose charge at



a rate of up to 30% per month, so must be recharged periodically.

To avoid the need to remember this, it may be useful to leave them on trickle charge permanently. A suitable charger circuit with a switch for slow trickle charge or normal overnight charge is shown in Figure 3. This very simple circuit may conveniently be built on a piece of Vero board.

PARTS LIST

RESISTORS

R1	1M
R2	100k
R3,4,5,6	4k7
R7	220R
RV1	470k

CAPACITORS

C1	10µ/16V
C2	220n

SEMICONDUCTORS

Q1,2,3,4	BC182
LED1,2,3,4	0.2" RED
LED5,6,7,8	0.2" GREEN
LED9,10,11,12	0.2" YELLOW
LED13,14,15,16	0.2" AMBER

Optionally a blue LED may be used but note that the viewing angle is limited.

IC1	4025
IC2	4015

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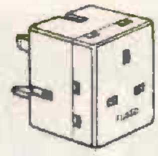

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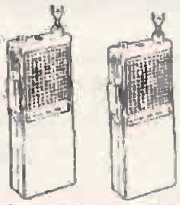

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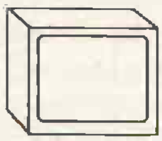

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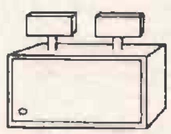

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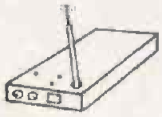

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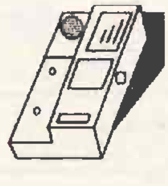

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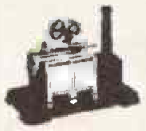

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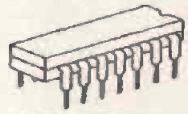

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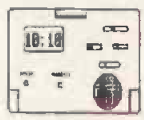

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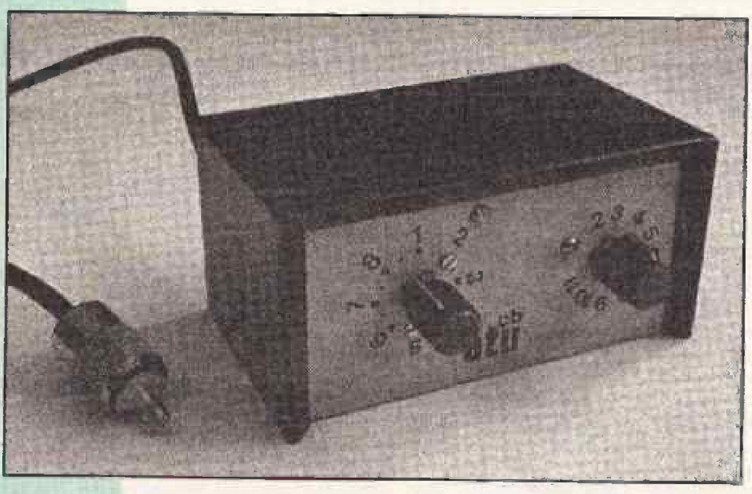
Aerial Tuner Unit



Shabaz Yuosaf describes how to get the best possible reception from your radio.

An Aerial Tuning Unit (or ATU for short) is a very useful device for getting the best results with a badly matched antenna. For example, an aerial will not give good results if used on the CB bands and viçe-versa, but with an ATU placed between the aerial and receiver (or transmitter), quite decent results are achieved.

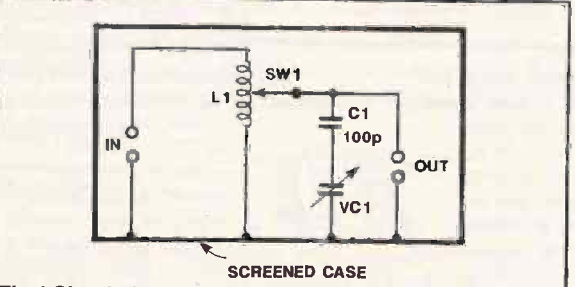


Fig.1 Circuit diagram

The ATU described here is very simple to construct, and costs far less than a commercial unit. It can be used throughout a wide part of the radio spectrum (SW to FM and beyond) but was originally designed for use with a CB.

The Circuit

Figure 1 shows the circuit diagram. It is built inside a metal case, which acts as a screen. Inductor L1 is an air coil, wound around a 1" former. The inductor has to be variable, so it is tapped at various points with thin wire, and these are connected to switch SW1 which is a 1-pole 11-way rotary switch. This gives 11 taps along the inductor. The recommended variable capacitor CV1 is a dual gang 365p per section type, but only one gang is used here. The exact capacitance does not matter, so any variable capacitor suitable for AM radios can be used. Indeed, an old AM reciever can be a very useful source for such a variable capacitor. The entire circuit is assembled in a smart vinyl-covered aluminium box which certainly won't look out of place among your other equipment.

Construction

Coil construction is the trickiest part of the assembly, and for this a former of about 1" diameter will be required. A suitable former can be made by using the tube in which solder is often supplied. The top is cut off, leaving a tube about 2" long. Two small holes are drilled at each-end of the tube, and these serve to secure the ends of the coil, see Figure 2. The coil is constructed from 18 gauge enamelled wire, wound round the former 19 times. The tappings are made by scraping the enamel on the winding and soldering a short length of insulated wire to it. The tappings must be made on windings 0, 1, 2, 3, 4, 6, 8, 10, 13, 16, 19. Now, following the wiring diagram shown in Figure 3, these tappings are soldered to the switch SW1.

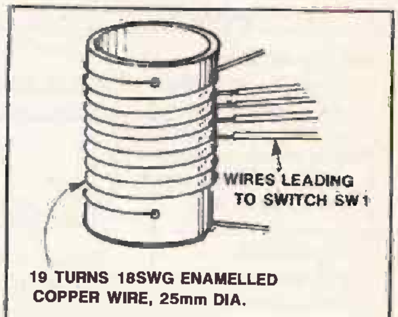


Fig.2 Construction of coil

Holes are now drilled in the case to accomodate the components.

The switch and variable capacitor are mounted on the front of the case, and the chassis socket at the rear. Another hole at the rear will be needed for the CO-AX input cable. A strain relief or rubber grommet will be needed to prevent the cable from rubbing against the metal. The photograph shows the positioning of all the components. The braid from the cable is connected to the case with a nut and bolt.

The end of the cable is terminated with a connector, depending on the equipment the ATU is to be used with. If it is for CB use, this means a PL259 plug. If you have never assembled this type of plug, you might find the photograph helpful. Finally, the lid is fitted and screwed on.

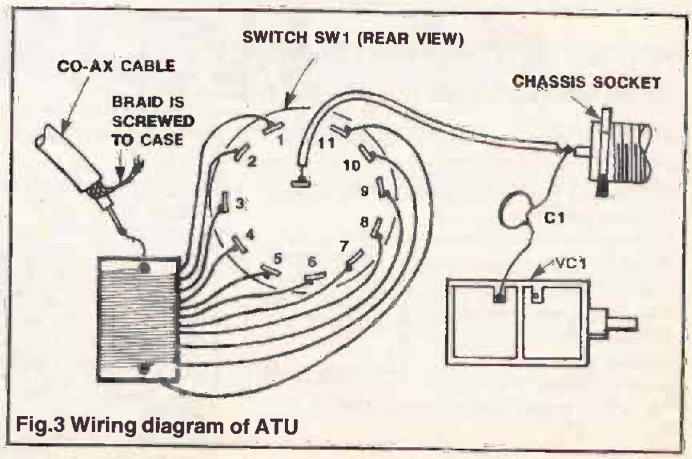


Fig.3 Wiring diagram of ATU

Testing

Before connecting the ATU up to your equipment, check the input and output connectors with a multimeter set to ohms. The resistance between ground and input, and ground and output should be infinity. If all is well, connect up the ATU. The ATU is tuned for maximum signal strength measured, say, on an S-meter.

BUYLINES

The variable capacitor was purchased from Cirkit, cat.no. 06-05250. The switch is a fairly common device, and was bought from Tandy. The case was obtained from Maplin, order no. LFO2C.

PARTS LIST

CAPACITORS
C1 100p
VC1 365p dual gang

MISCELLANEOUS
L1 19 turns of 18swg enamelled copper wire around 25mm diameter former
SW1 1 pole 11 way
Coaxial cable, coaxial UHF chassis socket

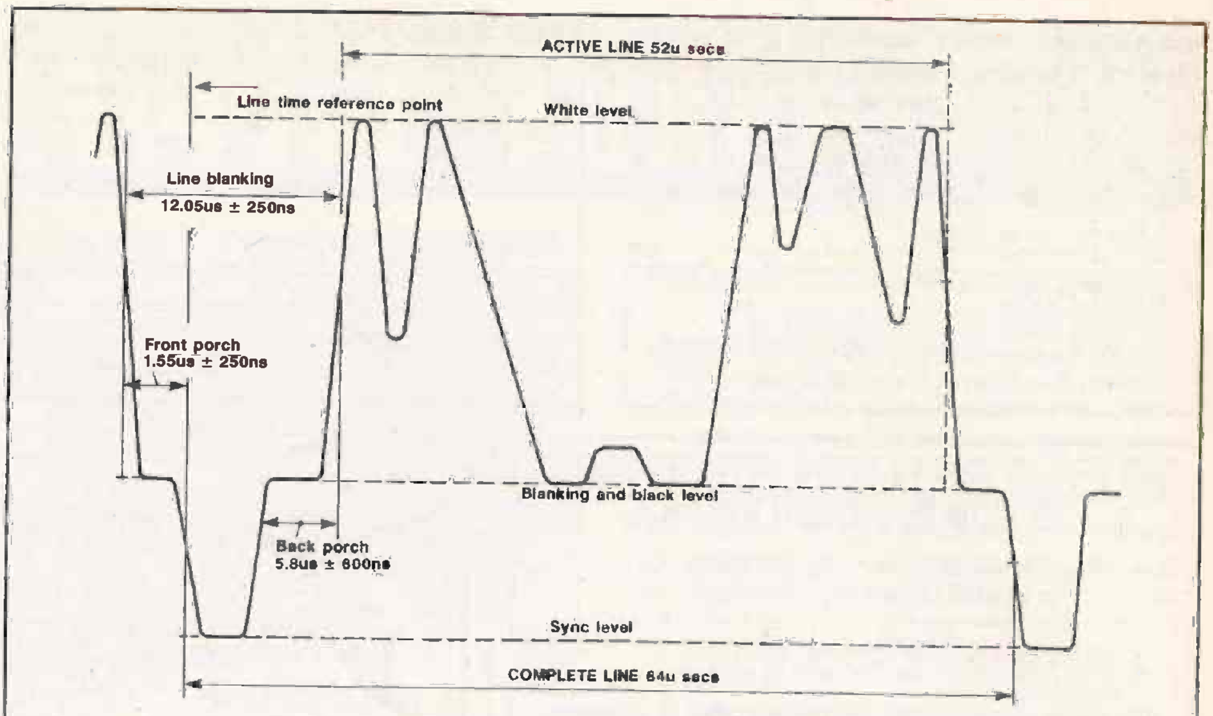


Figure 21 A single TV hue showing the total and the active line periods

5 Digital Television

More of the latest ideas in television from James Archer

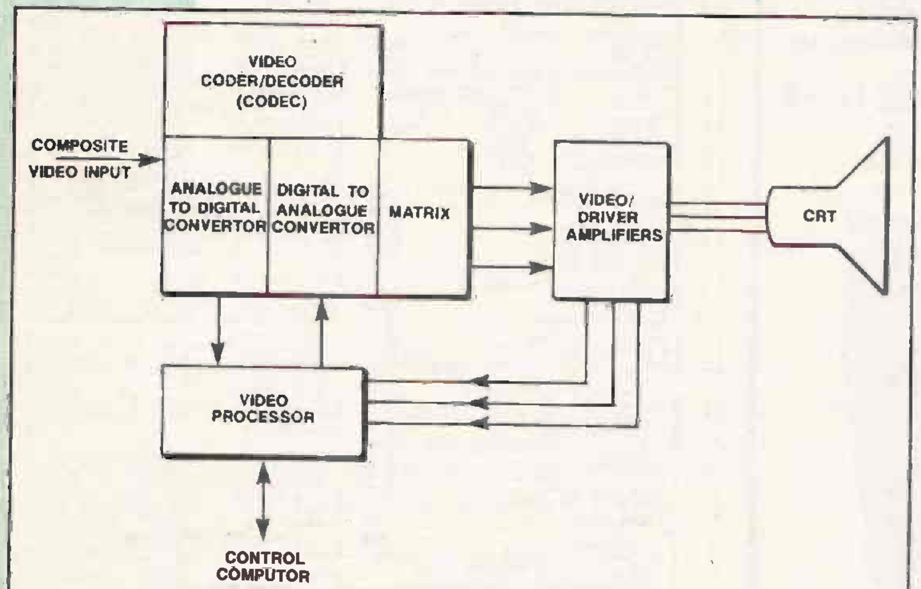


Fig.22 Block diagram of the digital video signal processmg system used in the ITT chipset.

So much for the advantages of Digital TV, now let's see what can be done practically, and which bits of the television receiver we can sensibly digitise. You will remember from the first part of this series that the Nyquist theorem states that the sampling frequency for a signal must be twice its bandwidth if we are to avoid problems. We also saw that we need 8 bits per sample for satisfactory video resolution. As I said earlier, with the present digital technology it's not feasible to convert the signals to digital form at IF, around 40MHz. Although it is possible for present-day monolithic analogue digital convertors with 8 bit resolution to digitise signals at these frequencies there seems little chance of their being produced at domestic equipment prices for a few years yet. Semiconductor manufacturers who are experts in the fabrication of such state of the art devices generally say that it is far more difficult to add one bit of resolution linearity to an analogue to digital converter than it is to double the amount of memory that can be stored on a chip. It is generally expected, therefore, that the video A/D converter will be placed after the video demodulator. This means that the video analogue-digital convertor will have to deal with a signal of less than 6MHz bandwidth, and since a typical receiver video demodulator will provide 1-2 volts of signal at its output, there should be plenty of signal to drive the ADC.

When we come to deal with sound in the receiver the frequency-modulated audio intercarrier sound signal is at 6MHz for UK receivers. The audio signal has a very wide dynamic range, however, and we have seen from our compact disc players and NICAM transmissions that high-fidelity sound processing requires around 14 bits per sample, although acceptable sound can be achieved with 10 bits and a companding process such as is used in the NICAM system. Digitisation before demodulation of the analogue FM sound with adequate resolution would therefore prove difficult, and it is far more practicable to place the audio AD convertor after the sound modulator. Remember that this ITT chip set came onto the market several years before NICAM transmissions began, and so the design was intended to deal with the standard analogue FM sound channel, or two channels in countries where dual channel FM stereo is used; the NICAM signals have their own special decoder chips in today's receivers.

The third section of the receiver that we can usefully digitise is the deflection control and synchronisation circuitry, so let's have a look at the circuit requirements. First let us look at the order of timing accuracy that we are likely to need for the circuits that deflect the electron beam. If we make the reasonable assumption that the smallest horizontal displacement that we can recogrise on a 26 inch diagonal television screen is about 1/10 of a millimetre, this would correspond to 10 nanoseconds.

Just to show you that I haven't made the figure up, lets do the maths.

A typical so-called 26 inch (diagonal) screen might have a visible line length of just under 21 inches, say 520mm for the purposes of our example.

The active line time, that is the time during which the scanning spot is carrying picture information, is 52 microseconds.

Therefore the total deflection in 52µsecs i.e. 52,000 nanoseconds is 520 mm. Thus a deflection of 520 mm corresponds to 52,000 nsecs, and the minimum displacement of 0.1mm corresponds to a time of 10nsecs.

Since we have to cope with 5200 elements (i.e. a 520mm screen width with each element 0.1mm long) across the screen, we need to deal with 13 bits per sample since 13 bits implies 2 to the power of 13 samples = 8192, which can comfortably cope with 5200 elements. Notice that 12 bits per sample would not be enough, since this would only give 2^{12} (= 4096) samples, which would not be sufficient.

Video Processor

The A-D and D-A conversion of video signals is carried out on one chip, the video codec, or coder/decoder. The analogue digital decoder is of a type that uses 2^n comparators in parallel, where n is the number of bits.

As can be seen from the diagram, the signal to be digitised is applied to one input of all the comparators, and the other input of each of the comparators is fed with a carefully defined fraction of the reference voltage. Somewhere down the chain of comparators one of the comparators will have a signal applied to its input that is the same as the fraction of the applied reference voltage on its other input, and this will cause its output to go 'high'. This signal will then be fed to logic circuits which will provide an appropriate digital number as the output.

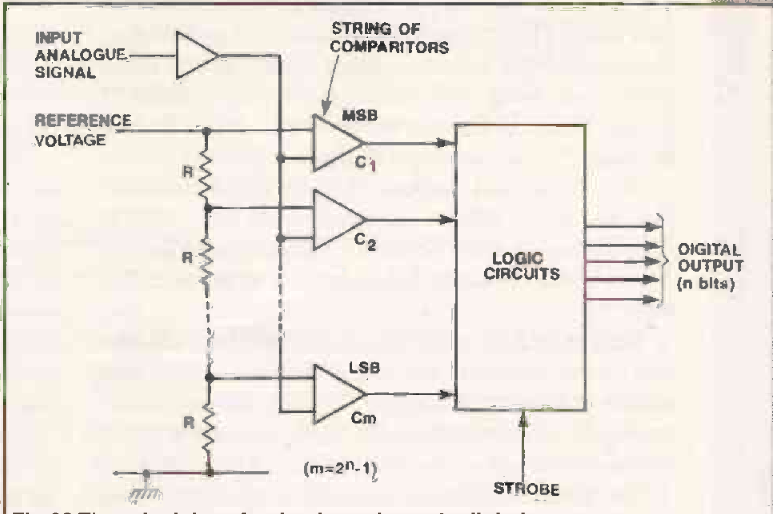


Fig.23 The principles of a simple analogue to digital convertor.

The engineering of such devices is complex, since to convert to an eight bit resolution signal it is necessary to use (2^{8-1}) i.e. 255 comparators. Multiple comparators contain large numbers of circuit elements, and this number doubles as the number of bits per sample increases by one; this sort of design therefore makes it important to reduce the number

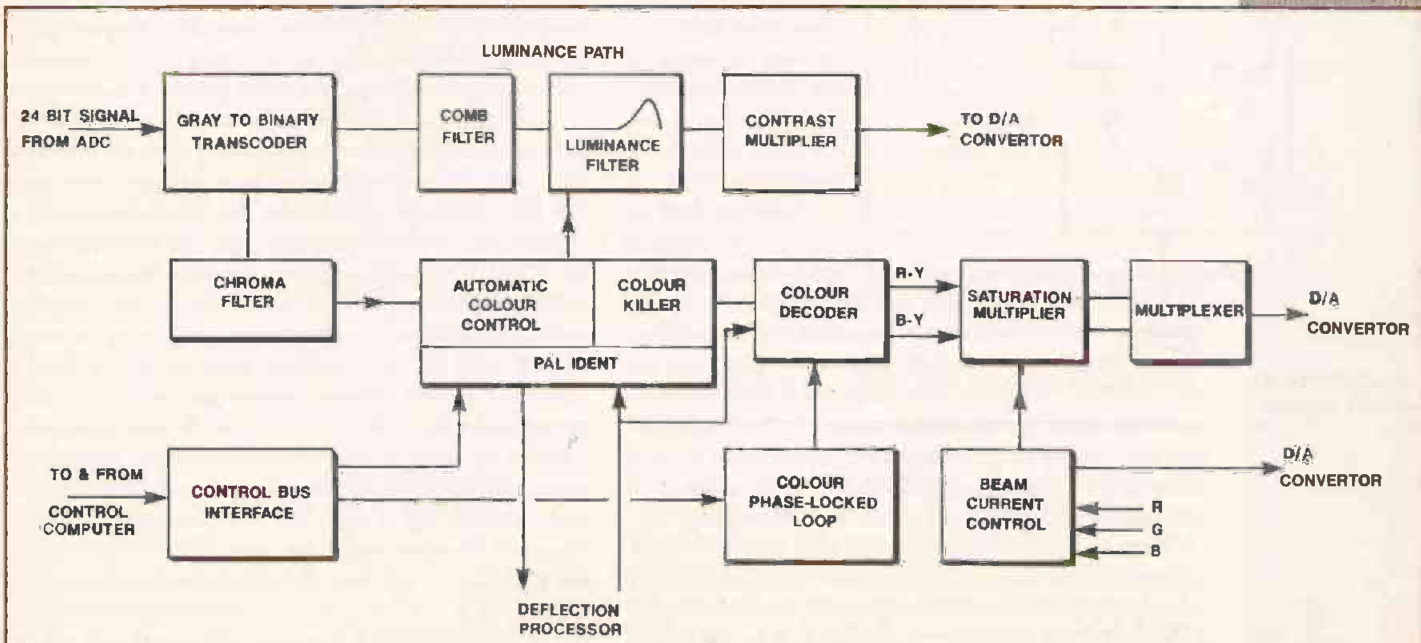


Fig.24 Video processor IC block diagram

Binary System	Grey Code Variant
0000	0000
0001	0001
0010	0011
0011	0010
0100	0110
0101	0111
0110	1010
0111	0100
1000	1100
1001	1101
1010	1111
1011	1110
1100	1010
1101	1011
1110	1001
1111	1000

Fig.25

of bits used, and so the number of comparators, and for this reason the ITT chip 'cheats', using only 7 bits of resolution but appearing to give 8 bits.

This is achieved by biasing the reference voltage of the A-D converter during alternate horizontal sweeps by a voltage corresponding to half the least significant bit. This technique converts a luminance value that is in the middle of two 7-bit steps into the lower value during one sweep and into the higher value during the next. The idea is that your eye will then average the two, and the effect will be that the picture appears to have been resolved with 8 bits per sample.

The comparators in the A-D convertor have their output in the form of a Gray code.From the table you will see that the Gray code has the property that only one of the four digits ever changes each time instead of one or more if normal binary coding were being used. This reduces the possibility of voltage spikes giving rise to false data, and is thus an advantage for video analogue-to-digital conversion.

Once it has been digitised, then, the first block of the video-processor changes the signals from Gray code to normal binary, and then the signal is passed through filtering circuits which extract the luminance and chrominance signals.

Since one of the major reasons for going digital in the receiver was to do away with adjustable coils and capacitors used in analogue models, digital filtering techniques have been used, which comprise delay, adder, and multiplication circuitry which can output signals of the correct shape.

The luminance filter has a variable frequency response that allows the response to be artificially peaked, increasing the amplitude of the high-frequency content of the luminance signals, especially on any 'edges' within the picture, providing a subjectively sharper picture.

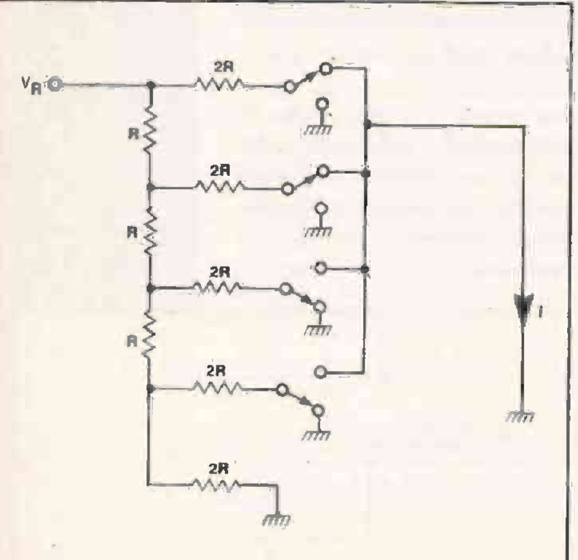


Fig.26 Principles of a digital to analogue convertor

The contrast multiplier box then sets the amplitude of the luminance signal and its level is clipped, to prevent overloads, before being fed back to the DAC part of the video codec chip.

Now lets look at the chroma circuitry on the block diagram. The first step is that the amplitude of the chroma is controlled by the automatic colour-control circuitry, which keeps the amplitude of the reference burst at a pre-set level. Remember that the amplitude of the burst controls the saturation of a PAL signal, so this will ensure constant saturation independent of any variations that take place in the filters. Absence of the burst on monochrome signals will actuate the colour-filter.

The colour data is then fed to the decoder, which gives colour difference outputs. As you know, the PAL sub-carrier is amplitude modulated with the BY and R-Y signals, known as U and V when appropriately weighted, and using phase-synchronous demodulation of the subcarrier, phase errors lead to reduced saturation. In the digital receiver such problems are eliminated by phase-locking the sampling clock to the colour reference burst which is sent by the transmitter at the start of each line.

It is interesting to note here that we don't need the usual PAL glass delay line, since the necessary delay can be obtained by passing signals in and out of blocks of Random Access Memory on an integrated circuit chip; this is a very good example of the sort of advantages that digital techniques can bring to receiver designers.

We obtain phase lock by comparing the signal with the R-Y signal of the burst, and the relative phase difference between the burst and the sampling clock is used to adjust a Voltage Controlled Oscillator (VCO) in the colour decoder.

The Y, B-Y and R-Y signals are routed back to the D-A converters on the video codec, which are of the R-2R ladder network type, shown in Figure 26.

The digital signal, four bits in the case of the simple circuit shown in our diagram, is used to set the four switches, one for each bit, to the appropriate state, either off or on. The reference voltage shown comes from a constant voltage source, and the switches steer the current to earth via the appropriate number of resistors. The DAC is effectively a multiplier, producing as its output a current which is the product of the reference voltage and the digital number which has been applied to the switches.

Once back in analogue form the signals are separated into R,G,B signals which drive the ordinary video-amps whose outputs feed the tube guns.

Notice that R,G,B, signals are fed back to the video processor chip, which monitors the beam currents and automatically adjusts to pre-set levels. The black and peak white reference levels are also controlled by the video processor, which sends out test signals during the frame flyback period and then adjusts the gain and bias of the video amplifiers.

In receivers which have the 'picture in picture'(PIP) capability, the small images are usually produced quite independently of the main picture, since the different size of the images makes it impossible to show the pictures with normal timings, the small size of the picture meaning that the active line and field times of the small picture are much shorter than those of the normal image. Reflecting on this, I started to think how one might achieve the PIP effect using only analogue technology, and rapidly came to the conclusion that it would be virtually impossible to obtain the necessary timing accuracy for the synchronisation signals. No doubt this is why PIP only became available on digital receivers! The PIP signals are obtained by first of all decoding the incoming composite PAL picture signal, and turning it into the Y,U, and V components, so as to avoid the horrendous problems that could occur if we tried to process the PAL colour signal with the video signal timings being so much altered, using the only synchronisation available, the 10 cycles of subcarrier reference burst at the beginning of each normal picture line. Once in YUV form the video signal to be turned into a PIP is sampled so that roughly every third picture element along a line is kept, the rest being thrown away, and two out of every three horizontal lines are also discarded. This leaves a picture with about 88 lines, every line consisting of just over 200 samples (picture elements). In terms of picture area, the PIP is about one ninth of the original, since we have kept only about one third of the horizontal picture elements and one third of the lines. If you

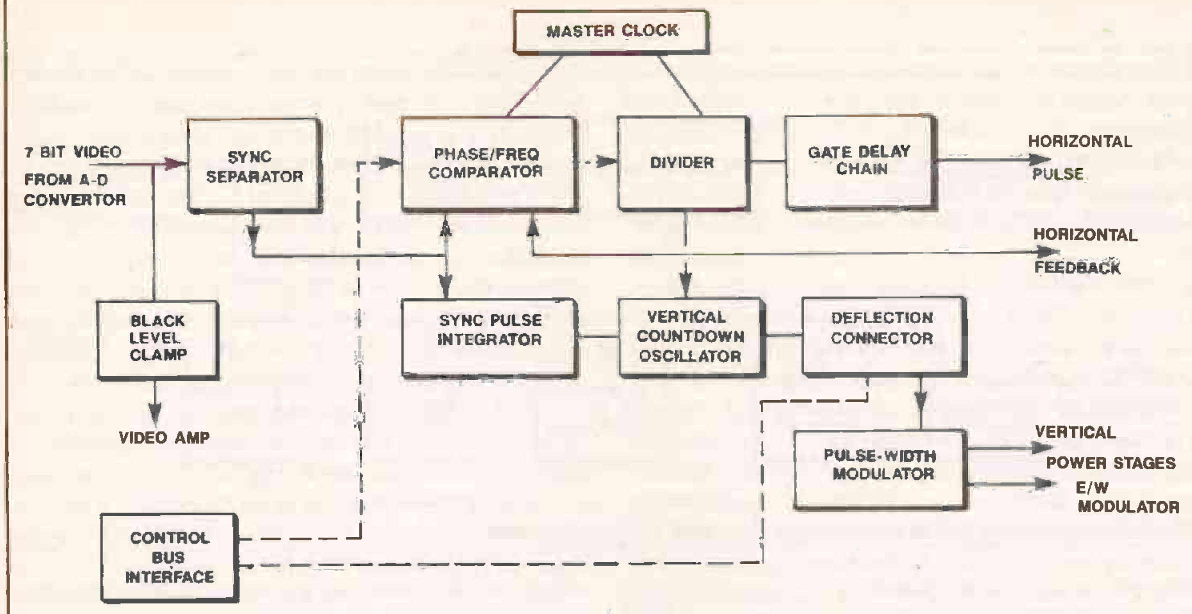


Fig.27 The deflection processor chip

have ever tried to look at a test card as a PIP you will know that it is almost impossible to see any detail; now you can see why! This reduced information picture is then quantised to only 6 bits, and the available 26 levels give 64 levels of luminance or colour. Y U and V signals are fed to the PIP memory in time division multiplex, different sampling frequencies being used for luminance and colour difference. To display the PIP the signals are read out from the memory store, converted back to analogue form and then finally re-coded into PAL before being fed in to the receiver video circuitry.

Returning to the ITT chipset, after our little digression to PIP, it is important to remember that the 7 bit output of the video A-D converter contains the line and frame synchronisation information as well as the chroma and luma data, so this same signal is also fed to the deflection processor IC

Deflection Processor Circuits

The first thing that happens to the signal is that it is fed to a black-level clamp which provides a video bias signal which keeps the black level of the video at a fixed voltage in the video amplifier; this ensures that full use is made of the whole conversion range of the video ADC.

To separate the syncs from the video a level is chosen halfway between black level and the bottom of the sync pulse. In order to increase the reliability of the sync timing, several pulses are integrated to give a timing reference for the line oscillator. Line flyback pulses are then fed back into the deflection processor and a phase comparator detects the relative phase between the horizontal flyback circuit and the line sync pulse. The output from the comparator is used to control a divider that counts down to 15,625 kHz. This can be done to the required accuracy of one-quarter of a cycle of subcarrier (about 56nS), since the system clock frequency runs at four times sub-carrier frequency, about 17.72MHz.

A 'gate-delay chain' is used to enhance the resolution by delaying the sync pulse by a variable amount. Provision is made to automatically change the time constant of the circuit so that the receiver can deal with non-standard sources such as video games or VCR's.

The line sync pulses produced by the chip are used to drive a conventional line output stage and deflection coils.

The frame, or vertical oscillator is a resettable counter, reset by each incoming frame sync pulse. It has a variable width acceptance window so that it can cope with nonstandard signals if required. When a standard signal is received it operates in its socalled 'locked-mode', which takes account of the fact that broadcast TV signals have line frequency, frame frequency and colour sub-carrier locked together in precise ratios. The deflection processor therefore derives its line and frame frequencies by dividing down from the received colour subcarrier frequency, and this makes the deflection circuits proof against interfering signals or fading. The frame syncs provided by the counter are fed to a deflection correction circuit which provides for East-West raster correction, and the output drives a pulse-width modulator circuit. The modulator outputs are then amplified by a class D amplifier before being filtered to provide sawtooth and parabolic field frequency outputs which then drive conventional o/p stages.

Audio Processor Circuits

Let's look now at the audio processor chip, which was designed from the start to deal with two-carrier stereo-sound signals of the type that has been used in West Germany for some years; NICAM decoder chips are now available for use in countries like the UK which use this improved digital sound transmission system.

The inputs to this chip, from the audio demodulator are two channels of audio and the pilot tone, which in this system is used to indicate one of three states, mono, stereo or bilingual, where left and right hand channels carry different languages. The pilot tone is usually a weakish signal of narrow bandwidth, needing high-Q filters to satisfactorily process it. This is another area where digital techniques are useful, since it proves easier to make such filters digitally, and digital filters need no tuning to the correct frequency because the resonant frequency depends only on the crystal-controlled clock.

Each of the three signals goes through its own A-D converter section after passing through a conversion filter which maximises resolution and filters out any noise.

Satisfactory digital audio needs 14 bits of resolution, and once the signals are in digital form the ALU, arithmetic logic

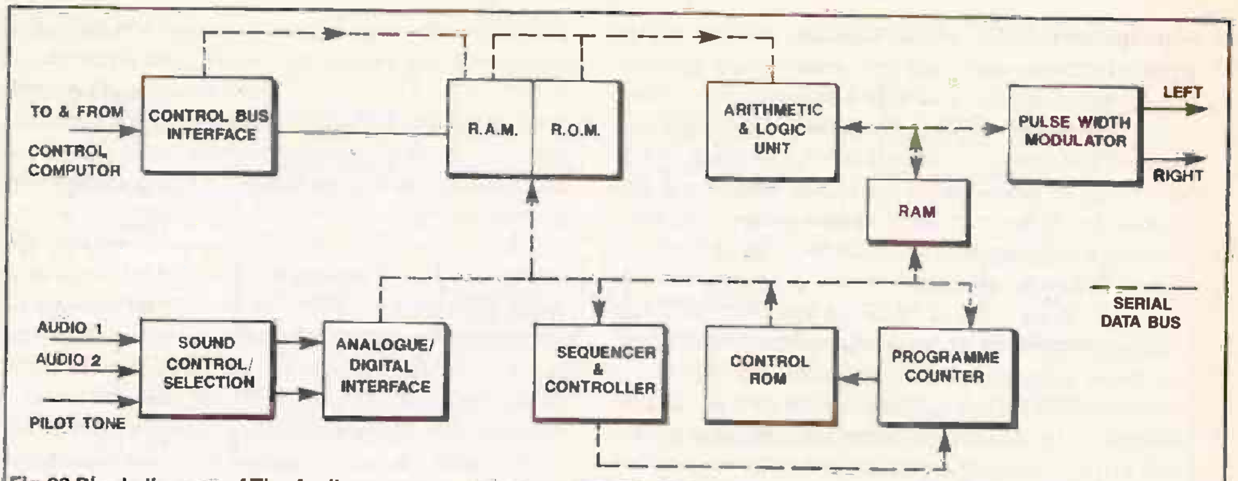


Fig.28 Block diagram of The Audio processor chip.(non -MCAM version)

unit, controls all filter coefficients so as to give any desired audio characteristics. The audio processor's serial bus allows the control computer to alter tone control characteristics or perform mono/stereo/bi-lingual switching.

The Control Computer

In order to tie together the work of all these different chips we need a computer, so the last of our chips, not surprisingly, is called the control computer, and this passes instructions between all the other digital processors. Such an approach gives great flexibility and allows a vast range of features to be included.

Any normal analogue command (increase sound, decrease brightness, alter contrast, etc.) needs first to be translated into digital numbers so that these digital signals can control the various signal-processing IC's. The control computer needs to be able to control the tuner on the receiver which it does with a phase-locked loop frequency synthesizer, and it also allows features like auto channel search and channel indication. The computer has to cope with signals received from an Infra Red receiver controlled by a remote-controlled handset.

Commands from the control computer are transferred to the other digital processors via a 3-bit digital bus, which is fairly slow, but quite adequate. As an example it takes around 100µs to transfer one byte of address information to a data store.

An important role of the computer is to carry out the regular alignment checks and adjustments of the receiver that the use of digital techniques makes possible. The central element here is a non-volatile EEPROM which is loaded with alignment data in the factory when the receiver is first lined up, and from then onwards the computer can ensure that these optimum alignment values are maintained even as the receiver circuitry ages. The receiver owner can store settings of brightness, contrast and volume, and tuning settings for his favourite stations in the EEPROM.

Digital techniques in receivers don't have to stop there. Receivers of the future will have ghost-cancellation circuits with adaptive equalisation to cope with varying degrees of 'ghostliness', and already there are several different techniques in use. These receivers measure the displacement of the ghost image by measuring the time difference between a specially inserted pulse or series of pulses and its reflection, and then automatically adjust the digital filters to provide the necessary video delay to achieve cancellation. Japanese ICs which can eliminate a small number of reasonable static reflected signals are already on the market, but European receiver manufacturers have so far considered that the improvement in picture quality that can be produced by these circuits does not yet justify their inclusion in receivers. Much work on ghost-cancellation is currently being carried out in Europe, however, as part of the wider project to generally improve and extend the working life of the PAL television system. The ghost cancellation systems being studied include 'receiver training' signals in the vertical blanking interval of the picture signal, which consist of multi-frequency 'chirp' signals, which should allow the receivers to cope actively with a wide range of varying ghost signals.

We are just beginning to have the technological capability to economically build complete digital frame stores into our receivers; this could allow all sorts of signal processing improvements to be made to our pictures, including the reduction of noise and cross-colour effects and the elimination of flicker, and there are already several receivers on the market which provide displays which refresh the screen at the rate of 100 fields per second.

Once digital transmissions actually begin, then digital receivers will really become useful. No analogue to digital convertors will be required, which will simplify the overall receiver circuitry considerably, but counteracting this will be the need for extremely high speed integrated circuits to deal directly with the incoming digital signals. Whilst it is true that these could be at data rates as high as 1000 Mbit/s if real time, uncompressed HDTV signals were to be used, it is far more likely that some of the data compression techniques now being used experimentally will reduce the data rates to much less than a tenth of the raw data rate, and ICs are now under development that will readily cope with this type of signal.

Digital television - research work in related fields

The research work and investigations to determine the best methods for transmitting digital television signals have not needed to start from scratch. Much research work into different aspects of digital communications technology has already been carried out in Europe, and the results from several existing European collaborative research projects are likely to be directly applicable to future digital transmission systems.

It is eight years since the first European collaborative research project to consider the digital coding of HDTV picture signals for transmission purposes began. The COST 206 (CO-operation europeene dans le domaine de la recherche Scientifique et Technique) project studied problems related to the subsampling and interpolation of digital picture signals, and examined the difficulties of practically implementing the circuitry required. Much was learned about the high-speed digital architectures needed for such signal processing, and this led to the successful development, in large scale integrated circuit form, of an HDTV coder/decoder. This coder-decoder equipment provided contribution-quality signals for transmission at a data rate of 560Mbit/s.

Although such high data rates can readily be used by broadcasters, there will also be the need for lower bit-rate local digital delivery systems, perhaps even to the home, via optical fibres and broadband ISDN networks. Part of the work involved in the EUREKA-95 project was to develop a system for digitally coding and distributing various types of MAC signals at bit rates of up to 140 Mbit/s.

Since 1986 a group of experts from the CMTT has been developing an algorithm to reduce the bit rate required for the distribution of television signals digitised in accordance with CCIR Recommendation 601 from 216Mbit/s to 34Mbit/s, one of the lower levels of the digital distribution hierarchy used by European PTTs. The need to reduce the bit rate from over 200Mbit/s to 34Mbit/s represents a reduction factor of about 6, and the task proved to be quite difficult. Early attempts used systematic subsampling techniques, but these introduced distortion on many different types of picture, and the later work has concentrated on coding techniques based on the Discrete Cosine Transform (DCT). Because DCT-based pictures are essentially made up of 'blocks', and early implementations of the technique for telephone videoconferencing had made the blocks obvious, there was some initial reluctance to use DCT. As further work in broadcast research laboratories showed that the techniques were not too complex for use with standard 625-line TV pictures, the CMTT group agreed that this was the path to take, and their work has shown that good results can be achieved at 34Mbit/s, although some small distortions can be noted on certain critical picture material. This 34Mbit/s system, which is currently going through the ETSI standardisation process, is primarily for use over inter-studio contribution links.

The work just described applies to standard definition 625 line television pictures, but as HDTV develops in Europe there will be similar needs to distribute the signals at far more modest bit rates than the 1Gbit/s of the source pictures. Another European project, HIVITS(HIgh quality VIdeophone and high definition Television Systems) is involved in developing hardware to implement similar coding techniques for HDTV, and one system, which was successfully demonstrated last year, used a number of subsystems working in parallel, the HDTV data being cleverly shared out amongst the various subsystems. HIVITS is a project of the RACE programme (Research & development in Advanced Communications technologies in Europe), a wide ranging European collaboration whose objective is to introduce a broadband communications network throughout Europe during the 1990s.

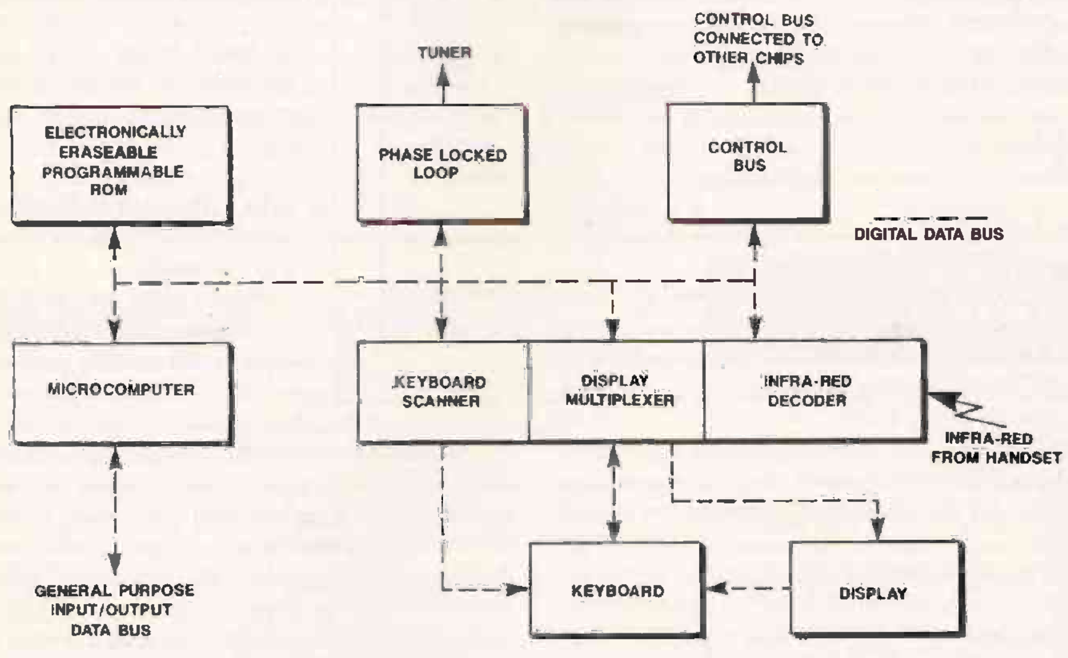


Fig.29 Block diagram of the control computer chip.

Another part of the HIVITS project is to investigate coding formats which would be appropriate to the final link in the distribution chain - the link to the home. Digital systems can provide great flexibility, and an ideal system would permit various bit rates to be supplied, in order to satisfy the need for different resolutions; although the viewer might want the best possible HDTV resolution when watching a film, he will need only a fraction of this resolution, and a minuscule amount of data, when using his videophone. The HIVITS researchers are looking at coding methods that can provide the necessary flexibility and that will allow data to be readily transcoded from one transmission channel to another, so that the same basic data could provide a domestic viewer with perfectly adequate standard TV pictures, whilst offering the local cinema the chance to use full resolution HDTV to display the film. This upwards and downwards compatibility of data and pictures is at the heart of the HIVITS work, and combinations of different coding methods are currently being investigated.

Another European project EUREKA-256, has developed digital coding techniques particularly suited to the transmission of HDTV signals via satellite. Using a DCT-based system similar to that used in the 34Mbit/s proposed ETSI standard, but using four separate 34Mbit/s modules, the transmitted bit rate was 70Mbit/s, and QPSK coding was used. An early version of the coding algorithm, which did not include motion compensation, was used to transmit World Cup matches from Italy via the Olympus satellite, using 1250/50 and 1125/60 HDTV sources on different occasions.

Later versions of the coding system, which do include motion compensation, have been used successfully for HDTV transmissions via Eutelsat and TDF-1, and the project is continuing with the aim of developing suitable digital coding for a proposed digital HDTV satellite broadcasting service at 20-22 GHz. This will more complex coding and modulation schemes.

Again planning to use digits for television, but for conventional 625 line TV rather than HDTV, is VADIS (Video Audio Digital Interactive System), a European project which is aimed at developing the enabling technology required to allow full 625 line resolution pictures to be carried at around bit rates of 5-10Mbit/s. This implies data compression by factors of 20 to 40 times compared with the 216Mbit/s of the digital source pictures. If such compression can be achieved reasonably economically, and the cost is important, then near studio quality digital pictures could be carried over telecoms networks and on terrestrial UHF channels as well as satellites, and domestic digital videorecorders providing excellent picture quality could become a reality. VADIS originally began as a project of the 150 MPEG (Moving Picture Experts Group) group, but now continues as a European Community project, EUREKA 625.

The in-built flexibility that digital systems provide means that the same stream of digits can be used to carry standard TV, HDTV, and even radio programmes, and the experience gained in all aspects of digital broadcasting from these many different European projects will act as a strong foundation for the digital transmissions that we shall be seeing in a few years time.

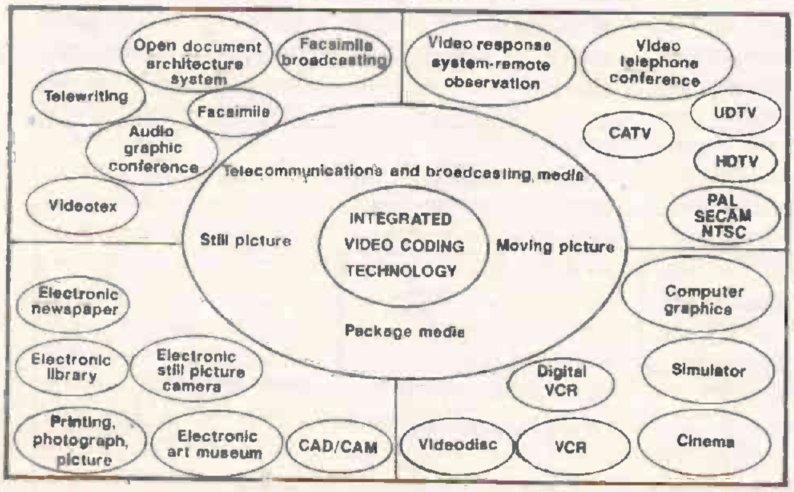


Fig.30 Media Fusion by Integrated Video Coding Technology (Courtesy MPT NEWS, Japan).

Convergence - today's 'buzz-word', tomorrow's technology?

Those working on digital television research began with fairly well-defined and focused aims, trying to develop a system that would produce television pictures of a quality better than anything previously seen. As the work has developed, however, it has become obvious that the same sort of technologies being developed for television use could have applications over a much wider field. It was soon realised that the techniques which have been developed for digital television, including digital image processing, data compression and bit-rate reduction, could also be used for processing all sorts of different audiovisual information. Computer graphics, computer games, compact disc storage of audio and video, digital still-image photography, and document scanning were readily identified as applications which could benefit from some commonality in the way in which the data representing, but deeper thought shows just how far these same technologies could lead. The current buzz-words for all this are 'convergence' and 'media fusion' - all the different technologies are converging towards a common goal and common technologies.

Libraries, art galleries, record archives of the world, unite!

The one simple truth that is starting to shine forth from all this digital research is that virtually anything that we class as 'information', no matter how broadly we base this definition, can ultimately be represented by no more than a complex stream of digits. Just think about it: books, letters, voice messages, pictures, whether from a newspaper, by Matisse , or from your own favourite computer graphics package, music from Sting to Stravinsky, photographs, videotaped programmes, teletext pages, all can be turned into digital code and stored, processed and treated like any other digital signal. At its simplest, we could regard the processing and storage of any signal of this type as merely an information handling problem - something librarians and museum curators have been familiar with for decades. Once this fairly sobering fact has been realised, it makes little sense to have completely different digital coding and storage systems for every new product that comes along, engineers effectively re-inventing the digital wheel (there's a nice thought - there just has to be a future article on that topic somewhere!) for every different project. How much more sensible if all the various new developments that are being worked on could use the same basic coding and information processing technologies, using a common family of digital chips which could be cheap and readily available because they are suitable for use across a wide range of fields, not specifically built for the latest 'Sanyitsu' wonder gadget. The advantages of common hardware are clear, but the benefits of media fusion could range much wider. In the field of 'software', different media are currently non-interchangeable. How frustrating if you are left with a complete set of Beethoven symphonies on vinyl, but you have only a CD player, or if you have 'books of the world' on microfiche, but no fiche reader! How much better things would be if software produced for one medium could be used directly on another; how useful if an image from the latest TV programme could be printed out directly for use in a colour magazine, or if a current article on education from The Times could be sent directly down the telephone to the teachers at schools throughout the country. How useful (although perhaps annoying!) if your 'voice message' could appear as a subtitle on the television programme that the person you are trying to reach is watching, wherever he may be. All these things are perfectly possible today, but the different hardware and software technologies used prevent their being used widely.

Although it will be enormously difficult to bring together the manufacturers and standards makers of the world, 'media fusion' is something that will not go away, and the pressures towards common standards for dealing with information in its widest sense are already growing. The Japanese have made a start by organising a Digital Video Committee, and Figure 30 shows how they are recommending that a single 'Integrated Video Coding Technology' should be developed as the heart of an information system based on video media.

The committee has been asked to look into how video technologies should be oriented towards the 21st Century, and how the integration of various standards concerned with video coding technologies should be achieved. Some of the world's major standardisation bodies, including the CCIR (Comite Consultatif International de Radio Communications), the CCITT (Comite Consultatif International Telegraphique et Telephonique) and the 150 are also keenly aware of the need to set standards for these convergent technologies, and although such standards are probably still some years away, the mere fact that their importance has been recognised gives us some reason to be optimistic about future developments.

The way forward

To sum up then, digital transmission really does seem to be the way forward. The advantages that it can give in terms of enhanced picture quality, reduced interference and more channels, mean that its eventual introduction is a certainty. The big problem at the moment is that the systems which we are able to demonstrate in the laboratories utilise vast amounts of computer processing power, and we cannot really foresee that our laboratory computers will be replaced by a few inexpensive chips within less than perhaps five years.

We have ranged widely in this series on digital television, moving between the fairly dense thickets of digital processing techniques and the comparatively open spaces of free-thinking looks into the digital future. There are numerous hazards ahead, and still a great deal of work to be done, especially in developing the large scale integration of image processing circuitry, so that we can have access to cheap chipsets. Continuing work on international standardisation is also vital, even though history has shown that progress in this area can be painfully slow. Whatever the problems, however long or short the timescale, there is absolutely no doubt in my mind that digital television transmission will make it in the end!

PCB Foils

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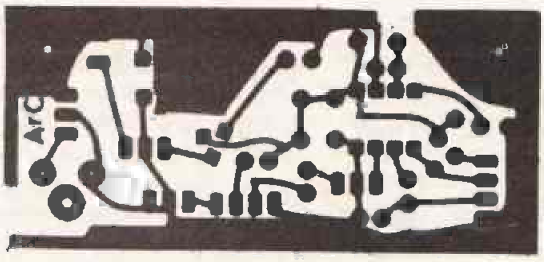

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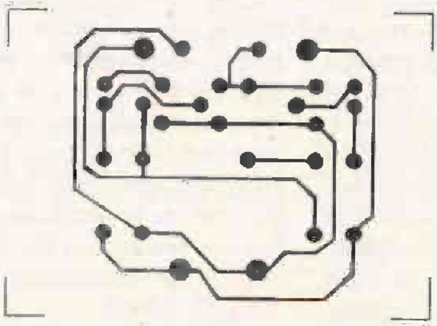

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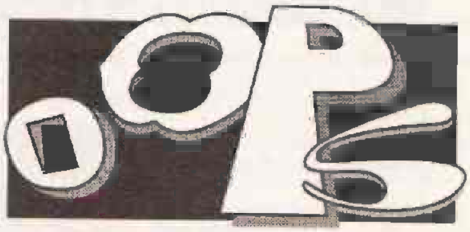
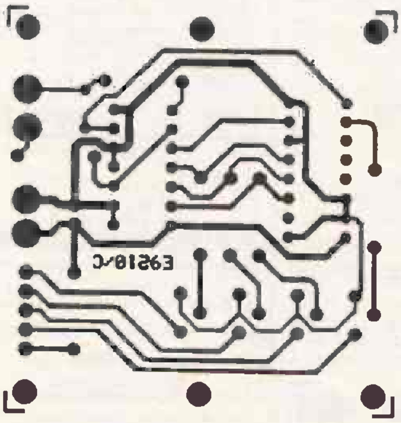


45watt Hybrid Power Amp Sept '92

C3 in Fig.2 and the parts list shows a voltage of 63V. This should be a **400µ/450V** capacitor. C4 should be **220µ/63V**.

Dynamic Noise Limiter August '92

Fig.4 R5,6,7 should be labelled 100R as in the Parts list. IC3,4 in the Parts list are for the other channel and IC5 should be a 7812 regulator. The component overlay in Fig.5 shows the foil displaced to the left by 8mm. The correct version was reproduce in the September issue. In Fig. 4 Q1 collector should not be connected to S1 and TL072 input. It should be connected to the supply line above. ie to regulator, C6 and R1. The regulator should be labelled IC5. In Fig.5, C6 should be labelled C7 and vice versa.



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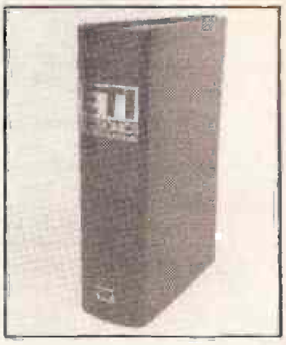

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Next Month

In the rising tide of thefts, we publish next month a favourite amongst **ETI** projects - a Car Alarm. Using the the PCB given away on the front cover, why not construct this hide-away circuit to protect your car.

If you are a games fanatic then try building our electronic die.

On the audio scene we look at an international project for measuring hi-fi audio responses. We also look at the software for the Universal I/O interface card and if you remeber 'The Hemisync' from August '91 then we have a quick-build version to see if the idea works.

All this and more in your November edition of **ETI** in the shops on **2nd October**.

The above articles are in preparation but circumstances may prevent publication

Last Month

Our September issue featured:

- Intercom for light aircraft
- 45W Hybrid Valve/Transistor Power Amp
- Alarm Protector Unit
- Window Opener
- Temperature Controller
- AutoMate Mixing desk Part 6
- Digital TV Part 4
- Why Waveguides

Back issues can be obtained from Argus Subscription Services. Address in column to left.

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