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# ELECTRONICS

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COMPETITION

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## Project SMD

Chip techniques

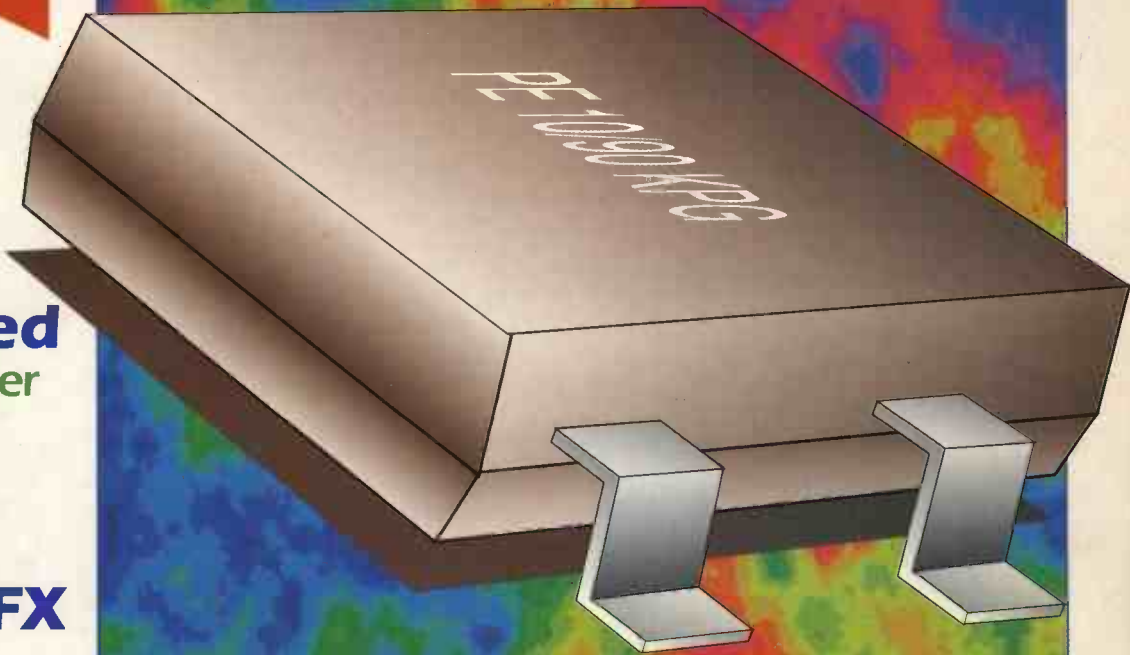
**Just released**  
Philips Scopemeter

**AM Stereo**  
The new wave

**DIY Sound FX**  
Build a sampler

**How it works**  
IR Detectors

**Fuzzy Logic**  
It's everywhere



## Take the Sensible Route!

**B**oardMaker is a powerful software tool which provides a convenient and fast method of designing printed circuit boards. Engineers worldwide have discovered that it provides an unparalleled price performance advantage over other PC-based and dedicated design systems by integrating sophisticated graphical editors and CAM outputs at an affordable price.

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In the new version V2.40, full consideration has been given to allow designers to continue using their existing schematic capture package as a front end to BoardMaker. Even powerful facilities such as Top Down Modification, Component renumber and Back Annotation have been accommodated to provide overall design integrity between your schematic package and BoardMaker. Equally, powerful features are included to ensure that users who do not have schematic capture software can still take full advantage of BoardMaker's net capabilities.

**BoardMaker V2.40 is a remarkable £295.00 (ex. carriage & VAT) and includes 3 months FREE software updates and full telephone technical support.**

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BoardRouter is a new integrated gridless autoroute module which overcomes the limitations normally associated with autorouting. **YOU** specify the track width, via size and design rules for individual nets, BoardRouter then routes the board based on these settings in the same way you would route it yourself manually.

This ability allows you to autoroute mixed technology designs (SMD, analogue, digital, power switching etc) in **ONE PASS** while respecting **ALL** design rules.

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You can freely pre-route any tracks manually using BoardMaker prior to autorouting. Whilst autorouting you can pan and zoom to inspect the routes placed, interrupt it, manually modify the layout and resume autorouting.

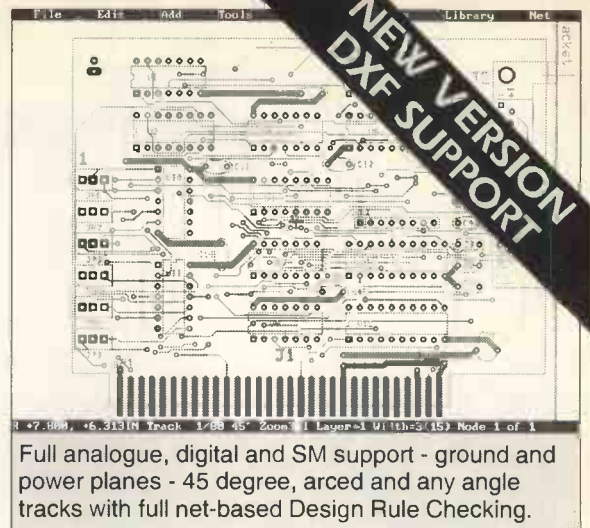
**BoardRouter is priced at £295.00, which includes 3 months FREE software updates and full telephone technical support. BoardMaker and BoardRouter can be bought together for only £495.00. (ex. carriage & VAT)**



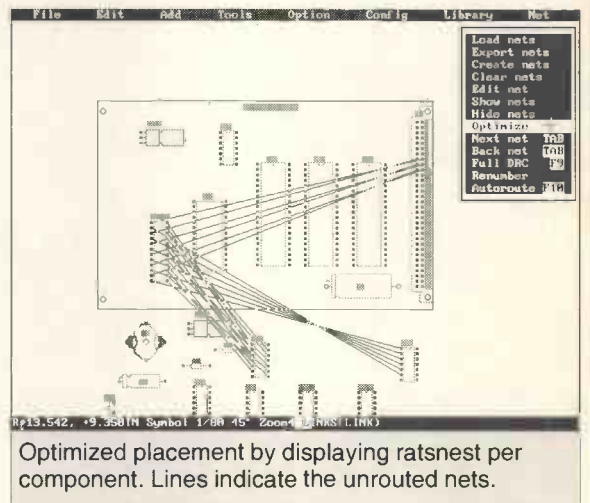
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- Full SMD support

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## This month...

Surface mount devices are smaller, cooler and easier to fit (for robots) than conventional chip designs, so the boards that use them can be cheaper to make. The techniques needed to work with them are not beyond amateur hands, though, and this issue features a background article on the technology and applications, plus the opportunity to build a useful signal tracer which uses a midget SMD circuit board.

You'll still need a soldering iron, however, so turn to page 53 and win yourself one of ten high quality soldering stations manufactured by Ungar, which are on offer in this month's competition.

AM radio is generally regarded as rather old-fashioned compared with FM, which offers full stereo capabilities. Now AM does as well... This should mean a new lease of life for those aging wavebands, which will be useful with the intense competition for airspace that proliferating communications demands have brought.

A modern alternative to the overcrowded airwaves could be provided by Cable TV. It's common in the USA, but the cost of plumbing in British homes with the required land lines has so far deterred UK investors. Once the cabling exists it will provide a wide band two-way optical fibre capability with all sorts of uses. But, as Barry Fox reveals, this won't happen overnight.

Kenn Garroch, Editor

## Next month...

### Canon's ION camera

The new wave in digital photography

### Scanners

What are they for? How do they work?

### How It Works

The humble transistor radio

### Build It

An automatic rain gauge

**Out on October 3**

## Build It

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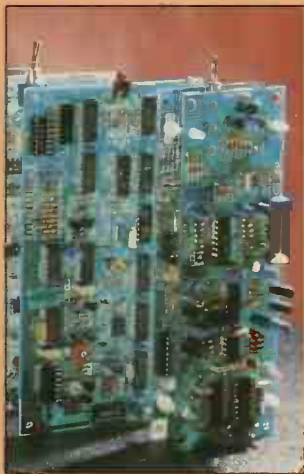
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# Wavelengths

*If you have any comments, suggestions, subjects you think should be aired, write to PE*

I need your help. Recently I acquired a 1960's Livingston Burge electronic organ which I hoped to convert into a three manual "state of the art" classical instrument. I wrote to Doug Simmons, the Marketing Director of Maplin Electronics, who informed me that Maplin no longer supply components for organ constructors. He wished me luck and referred me to Alan Douglas's books for further information.

Sadly, Mr. Simmons was really no help at all because I need to find a source of large components, such as keyboards and swell pedals, as well as ICs for tone generation and voicing. Also, I need to obtain information to enable me to use these components to construct a church-type instrument. In addition, Alan Douglas's books where written before IC technology became commonplace.

Mr. Simmons was of the opinion that the advent of chip electronic organs from Japan means that it is no longer viable for his customers to build their own instruments. Of course, the organs to which he alludes are not church organs with three 61 note manuals and a 32-note pedal board. They are bristling with effects that no classical organist would ever use and they do not have the correct sort of stops.

Can you help me to locate suitable sources of supply and information?

Frederick J Trowman MA, Mus M MCIJ

Birmingham

*I'm afraid I can find no sources for the items you want. Perhaps our readers can be of help?*

## Simple Thanks

Thank you for your innovative and interesting article "Who Said The Valve Was Dead?" (PE Sept 91) – the keynote here is simplicity and elegance combined.

I am, however, bemused by the explanation for Cascode Amplification outlined in your subsection. I feel that it would be easier for the neophyte to understand if the identifiers Q1 and Q2 were transposed in the diagram (Fig. 2b). I suggest that the circuit analysis would then be "Spot on". The design would then "currently generate" considerable interest! Perhaps you may have too much on your "plate"!

J Daen-Smith  
Somerset

## Address Please

Until recently a firm was advertised in your magazine and now that I need its address it is not there anymore. The firm used to be called Electronics Design Associates but may have changed its name to Electronize Design. Could you possibly help with the address?

Also, could we see more small constructional projects in the magazine? There used to be five or six in one issue at one time although this is going back a bit.

Adrian M N Hoare  
Newcastle Upon Tyne

*I'm afraid I can't trace the firm in question, perhaps they could write in? On the projects front, we aim to please – this month sees a nice short SMD project. We'll try to get more in in future.*

## Transparent Australians

As an owner of "Easy PC" it was with great interest that I read your article regarding this software in the December 1990 issue of PE. Once again a mystical transparentiser spray is used. Well, to cut a long story short no one here seems to know what I'm talking about and I've tried various different hair sprays, to no avail. Newsagents and art suppliers are

unable to shed any light either. Could you please advise me of brand name and/or manufacturer of this elusive spray?

John Punter  
Victoria  
Australia

*It is called Iso Draught Transparentiser and can be obtained from:*

*Cannon & Wrinn  
68 High St.*

*Chislehurst  
Kent*

*Tel UK 001144 81 467 0935*

*This company supplies the stuff to a number of retailers and may be able to put you onto an Australian source.*

## Practical Techniques

In your September 91 Techniques section I was pleased to see a design for a fluorescent light dimmer switch. I have been looking for one of these for a while now and would certainly like to make one. Do you supply or have any intention of supplying kits for the projects in the Techniques section?

R Banstead  
Surrey

*Unfortunately the Techniques section is mainly aimed at producing circuit ideas rather than complete solutions. If you want a working version you will have to design the circuit board and make it yourself.*

## More Neural Nets

I read Douglas Clarkson's feature on neural networks with interest. Are you going to be following this interesting subject up with further coverage? I hear that the technology is becoming popular in fuzzy logic systems and I'm sure other readers, like myself, would be interested in knowing more about this topic.

Alan Smith  
Brighton  
East Sussex

*PE is hoping to do something along these lines in the near future.* ■

# Innovations

*This month features a new stereo system, an alternative way of programming VCRs and the recovery of the Olympus satellite.*

## Wide Stereo

"This is a journey into sound" was the phrase that ushered in the age of stereo Hi-Fi. The concept of having two loudspeakers giving a sound image similar to a live concert revolutionised the audio industry.

A new type of speaker system from Canon is being touted as a breakthrough in sound and design technology. Instead of the conventional system where the stereo effect is created in an area between the speakers, the new Canon S-50 uses an acoustic mirror to produce images over a much broader listening area.

Instead of using a collection of drivers for bass, mid and treble, each with its crossover circuitry and different positioning, the S-50 uses one full range driver which is directed at an acoustic mirror. The sound is directed into the room giving stereo to the left, right and centre. By controlling the quality and increasing the quantity of the "early



The Canon S-50s.

reflections" from the listening walls of the room a wide image stereo sound is produced.

The new technology has led to a rather startling new design shape for a loudspeaker system. Built from zinc diecastings and ABS plastics, the black dome houses the speaker with

the acoustic mirror placed underneath.

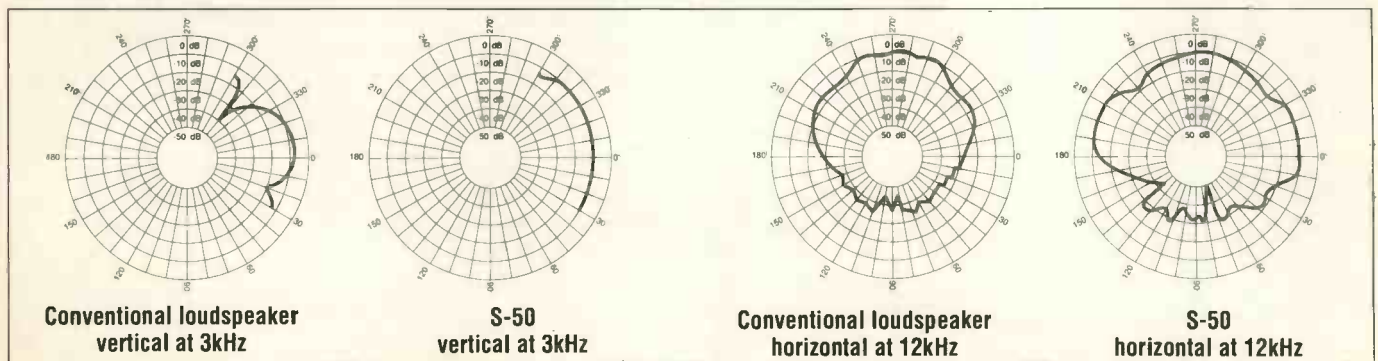
The idea of Wide Image Stereo was thought up by Hiro Negishi, Head of Canon Research Europe and developed by a team of British acoustic engineers at the Institute of Sound and Vibration Research at Southampton University. The S-50 is

said to be the first Canon product to be both designed and manufactured outside of Japan.

Needing no special amplification requirements, the S-50s will work with any standard Hi-Fi and cost around £349.95 (including VAT) a pair.

## A Box Of Words

Canon's other recent launch is the Wordtank Multilingual Intelligent Dictionary. Aimed mainly at the international traveller, this pocket sized language translator features slots for two additional languages besides the built in English. This allows words and phrases to be translated to and from English to either or both of the other languages currently slotted in. Each of the cards has 60 to 70,000 words and the built in system has 100,000 words of English plus a 50,000 entry thesaurus, 600,000 synonyms, 8,000 verb conjugations and a spell checker. The latter has a wild card system that will





Wordtank VCR and International Dictionary.

fill in missing letters or words where required.

Full language cards are available for French, German, Italian, Spanish with an additional card supplying useful phrases in English, German, French, Spanish, Italian, Dutch, Finnish, Swedish, Danish and Norwegian.

As well as being a translator, the Wordtank can also be used as a personal organiser. This provides a telephone and address book, a memo pad, a calendar (from 1901 to 2099), a scheduler and a calculator. The recommended retail price is £199.95 (inc VAT) with each card costing an additional £44.95.

### Helpful Video Star

For years, ever since they became popular, people have had trouble programming VCRs. According to Ferguson, a large manufacturer of VCRs, 73% of UK households have them and 28% of all adults have trouble when trying to set up recording times –

apparently 35% of female users have trouble as do 50% of those over 45 (source: Ferguson Consumer Electronics Market Report 1991). The main problems encountered were that programming was too complex and inflexible, too many were features available, remote control units were too complicated, there were too many buttons and they were too small and last, but not least, nobody liked to read the instruction manuals.

To combat this, Ferguson has launched a new simpler remote control to go with its latest range of Videostar video cassette recorders. The old, "complicated" handset still comes as standard but for a little extra, the "Frequent Use" controller is available. With only nine large, widely spaced, buttons, it aims to make using the VCR as easy as possible.

In addition to simplifying the handset, Ferguson has introduced "Instant Help Programming" which

pops up a number of pages of text on the screen to solve any problems. This is said to be the most comprehensive programming help system currently available.

For anyone who finds programming their VCR difficult even when provided with a simple handset and online help, the new Startext system should be the final solution. Using teletext programme schedules, the user is guided through selecting a program by on-screen prompts. The system then copies down the start and end times of the program so that it can start recording when necessary.

Unfortunately, schedules are not always as fixed as they might be and programmes occasionally overrun. To cope with this, Startext scans information transmitted along with the TV program known as program delivery control or PDC. This tells it what program is on and whether recording should start.

The system will be on



The "frequent use" handset replaces its more complex counterpart.

air in December on Channel 4 and will be supported by the Ferguson Videostar FV54LX which will also feature teletext subtitle recording in colour – during dialogue, different speakers are signified by changing the colour of the text.

## Olympus Revived

On 1st August 1991, ESA announced that it had regained full control of the Olympus experimental satellite. Contact was lost 64 days previously on 29th May with the satellite only having been in operation for about two years. The space agency declared that it would have the satellite fully operational by the beginning of September.

The recovery of a satellite in such a bad condition is a first, as far as the agency is aware. After the spacecraft had entered a tumbling mode and ended up rolling about on one axis, the solar cells were facing away from the sun and the power supply system could not maintain the battery charge. This caused a complete failure of the thermal control system resulting in internal temperatures falling to between  $-50^{\circ}\text{C}$  and  $-60^{\circ}\text{C}$ . Because of this the fuel, oxidiser and batteries were frozen. In addition, at the time the problem occurred, thruster firings caused the satellite to deviate from its assigned orbit and it was found to be drifting at  $5^{\circ}$  a day eastwards, rapidly moving out of range of the Fucino, Italy, its tracking station.

On the 3rd June 1991 the Olympus Mission Recovery Team (MRT) was set up and given the task of recovering the lost satellite by any means



The Ferguson Videostar FV54LX 4 head dual azimuth long play VCR with Startext.

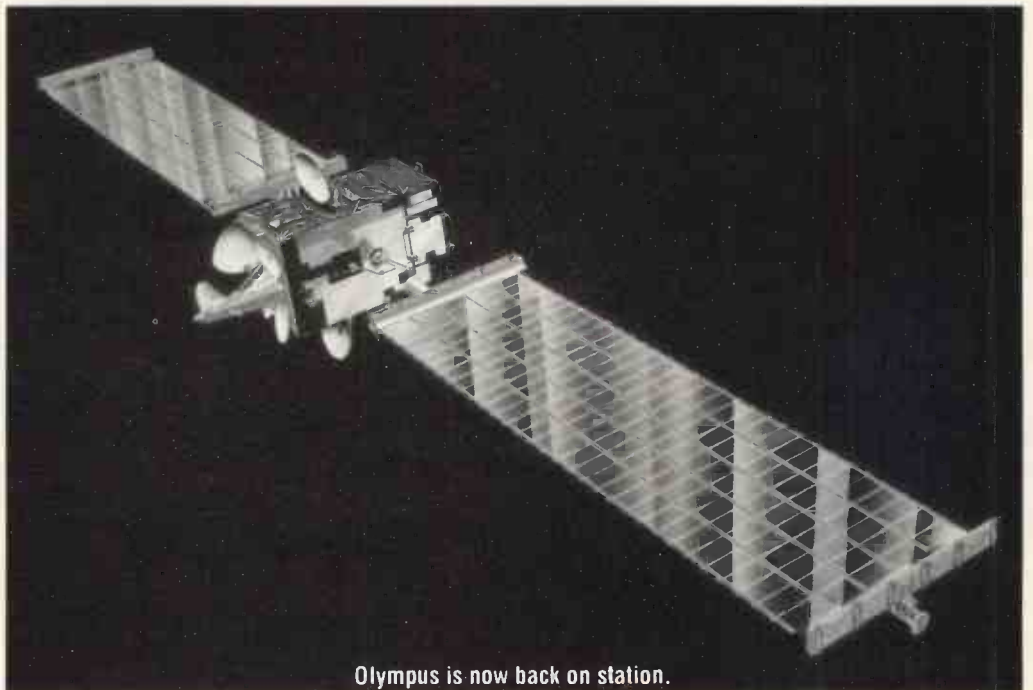
available. Additional support was provided by US and French space agencies, NASA and CNES.

Using the tracking stations in Perth Australia, Goldstone in California, Kourou in French Guiana and Villafranca in Spain, thousands of instructions were beamed at the ailing satellite in an attempt to re-establish contact. On the 19th June, the spacecraft accepted and

executed a series of commands for the first time since the end of May. In the mean time, the angle of the sun on the solar panels had improved to the stage where enough power was available for limited operations. At this point, all non-essential subsystems were shut down and attempts were made to rotate the solar panel array more towards the sun.

On 1st July a fully

regulated power supply of 50V was achieved and continuous telemetry established. Before this only intermittent contact was possible due to the tumbling motion. By the next day, the nickel hydrogen battery had been recharged and by the 8th, the nickel cadmium battery was up to capacity. By September it should be back to its assigned orbital position ( $19^{\circ}$  West) and fully functional. ■



Olympus is now back on station.



# Philips Crosses A DMM With A Scope

*With the launch of the Scopemeter, Philips has produced one of the most comprehensive test instruments around. Kenn Garroch puts it through its paces.*

The first noticeable thing about the new Philips Scopemeter is its rugged feel, especially in its bright yellow holster. There are not many scopes that will withstand a 1 meter drop onto concrete, indeed, this is probably the only one that will.

The Scopemeter range consists of three models, the basic one of which, the 93, combines a dual trace 50MHz digital storage oscilloscope with a sophisticated digital multimeter. The next model, the 95, adds features such as waveform memories, average, max and min readings with the top of the range, the 97, sporting such goodies as a sine, square wave generator, 10 setup memories and mathematical signal processing.

Although the Scopemeter is aimed at the maintenance sector of the electronics market, its high specification, ruggedness and relatively low price should make it appealing to many other users. It is easy to use, easy to transport and looks as though it should be pretty reliable although only time will tell.

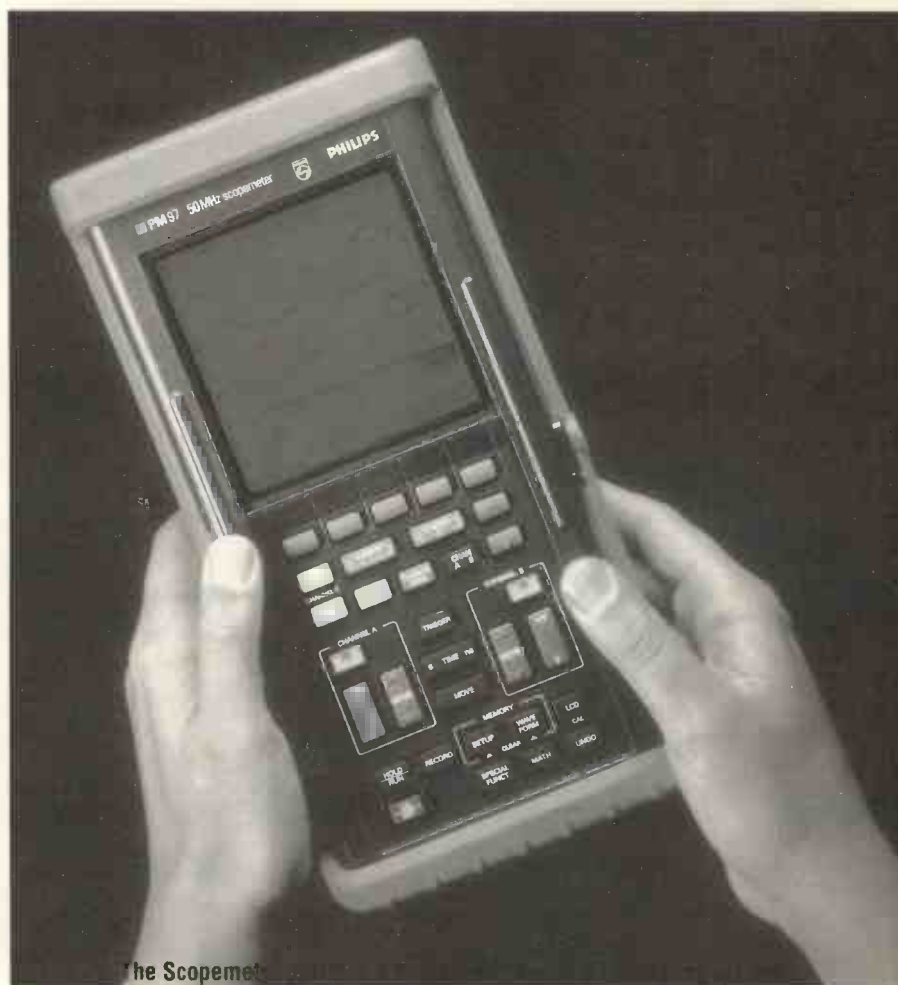
## Pressing Buttons

All of the functions of the Scopemeter are controlled from the keypad. To display a multimeter reading, the METER button is pressed. This immediately supplies the values of the DC and AC (RMS) voltages at the channel A input. The set of five "soft keys" along the top of the keypad allow further functions to be selected. In METER operation these allow the display to be devoted to AC voltage, DC voltage, DC milli-volts, diode test and ohms. Pressing any of these gives the value in large friendly

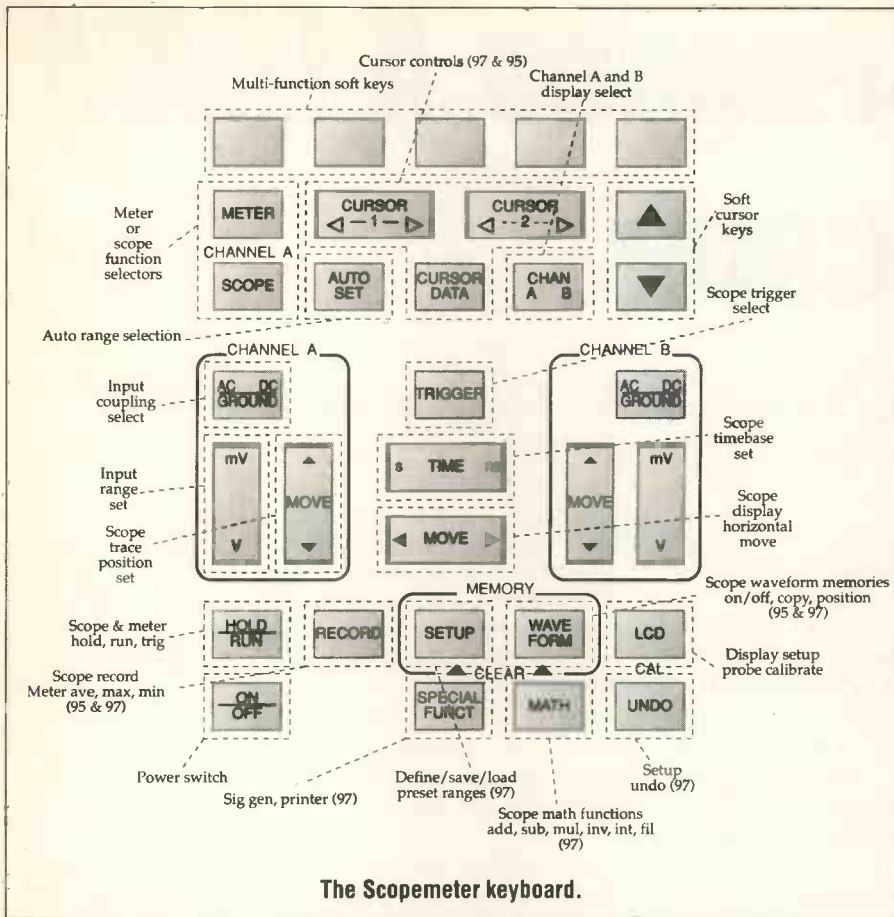
characters along with a small display of the incoming waveform. The latter is useful in that it gives some idea of what the signal being read actually is. This can be turned on and off via the display modes menu which is now available on one of the soft keys.

The pop-up menu system allows the user to either select from a number of additional functions, or turn options on and off. One inconsistency here is that when selecting a "one from many"

option, the menu disappears when the enter button is pressed. On the other hand, when turning options on or off, the menu remains after the enter key has been pressed allowing a number of options to be selected. To get out of the menu another key must be hit sometimes activating another function. The solution is to press the same key that brought up the menu – this didn't seem to be mentioned anywhere in the otherwise informative manuals.



The Scopemeter



In general, the multimeter section is just like any other high quality digital multimeter with the exception of the waveform display and extra large figures. Unlike other DMMs, however, pressing the SCOPE key turns the meter into a digital storage oscilloscope. This is a dual trace, 50MHz instrument with most of the functions found on much more expensive devices.

To make the system as easy to use as possible, Philips has included an Auto-set button. Usually, when connecting up to a circuit, a lot of fiddling with the timebase and

range controls ensues, especially if the the circuit is unknown. Pressing Auto-set causes the computer inside the Scopemeter to examine the signal and chose the most appropriate ranges for display. This puts up some sort of meaningful display on the screen although it might not always be what is wanted. The advantage is that it gives the user somewhere to start refining the display for the desired measurements and observations.

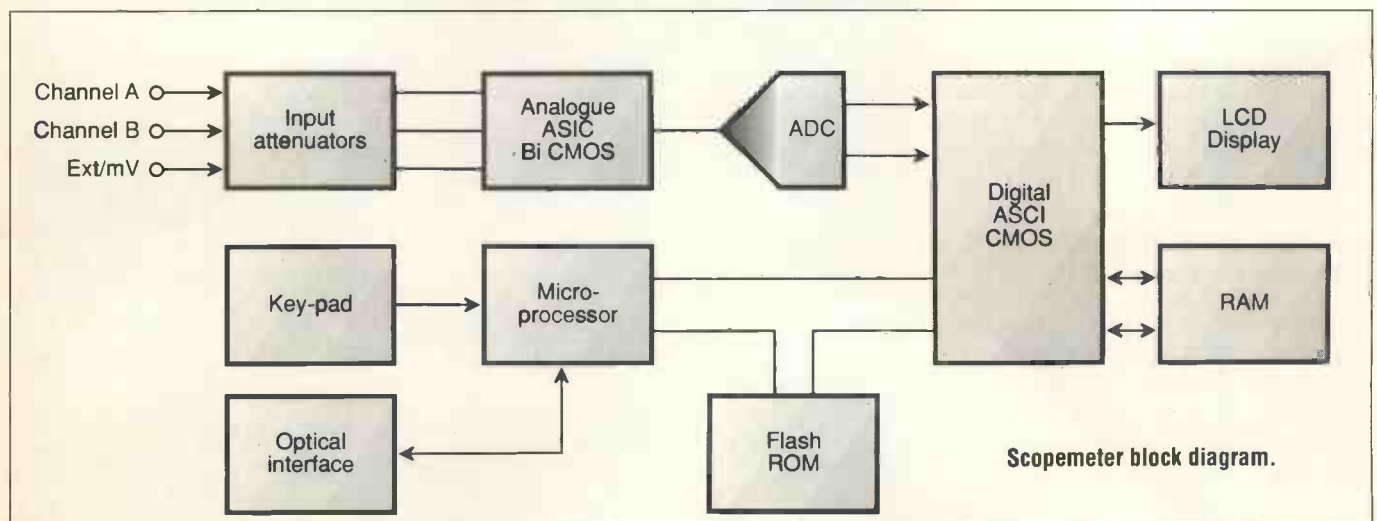
The basic Scopemeter model, the 93, allows two traces to be displayed from the two input

sockets. These are easily manouvered around the screen with the vertical and horizontal move keys. Repeatedly pressing these moves the trace slowly and holding them down causes it to accelerate. On pressing the SCOPE key, the soft keys allow either single or recurrent traces, the first being controlled by the HOLD/RUN key, free run with internal or signal triggering, and a display that fills one screen width or a double width that can be scrolled across. The trigger at 50% option forces the scope to move the trigger level to about halfway up the incoming signal to ensure some sort of trigger. Pressing the trigger key allows more sophisticated operation of this with either +ve or -ve slope, trigger level set with the soft cursor keys, trigger delay, N-cycle, events, and trigger source.

## Making Connections

The channel to be displayed is selected with the CHAN A B button and allows either channel, both, add and subtract A and B and A vertically plus B horizontally. All scopemeters have their input connections at the top. These comprise two BNCs, an earth and an  $\Omega$ , mV and diode test input – this is also used for the signal generator output on the 97. All inputs are protected and there is no exposed metal – the BNC connectors are actually made of plastic with the ground connection being internal.

All models are supplied with a complete set of leads for all three channels. These include pointed, **Continued on page 12**



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## B Realistic PRO-35.

100 channels. Covers: 68-88, 108-136.975 (AM), 137-174, 406-512 MHz. Two-second scan delay, lockout and search function. Priority channel, backlit LCD display. Memory backup. BNC aerial jack, belt clip, earphone jack. Complete with rechargeable ni-cad battery pack and AC adapter/charger. 20-9136 ..... £179.95

## C Realistic PRO-41

10 channels. Covers: 68-88, 137-174, 406-512 MHz. LCD channel display, review key to display frequencies. Manual and scan modes. Three-second scan delay, keyboard lock switch. Memory backup. Requires 5 "AA" batteries. 20-9301 ..... £99.95

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Continued from page 10.

clip-ons and banana plugs. One problem is that they don't all seem to fit inside the pouch provided, especially the extra probes for the  $\Omega$ , mV and diode test.

## Backlit LCD

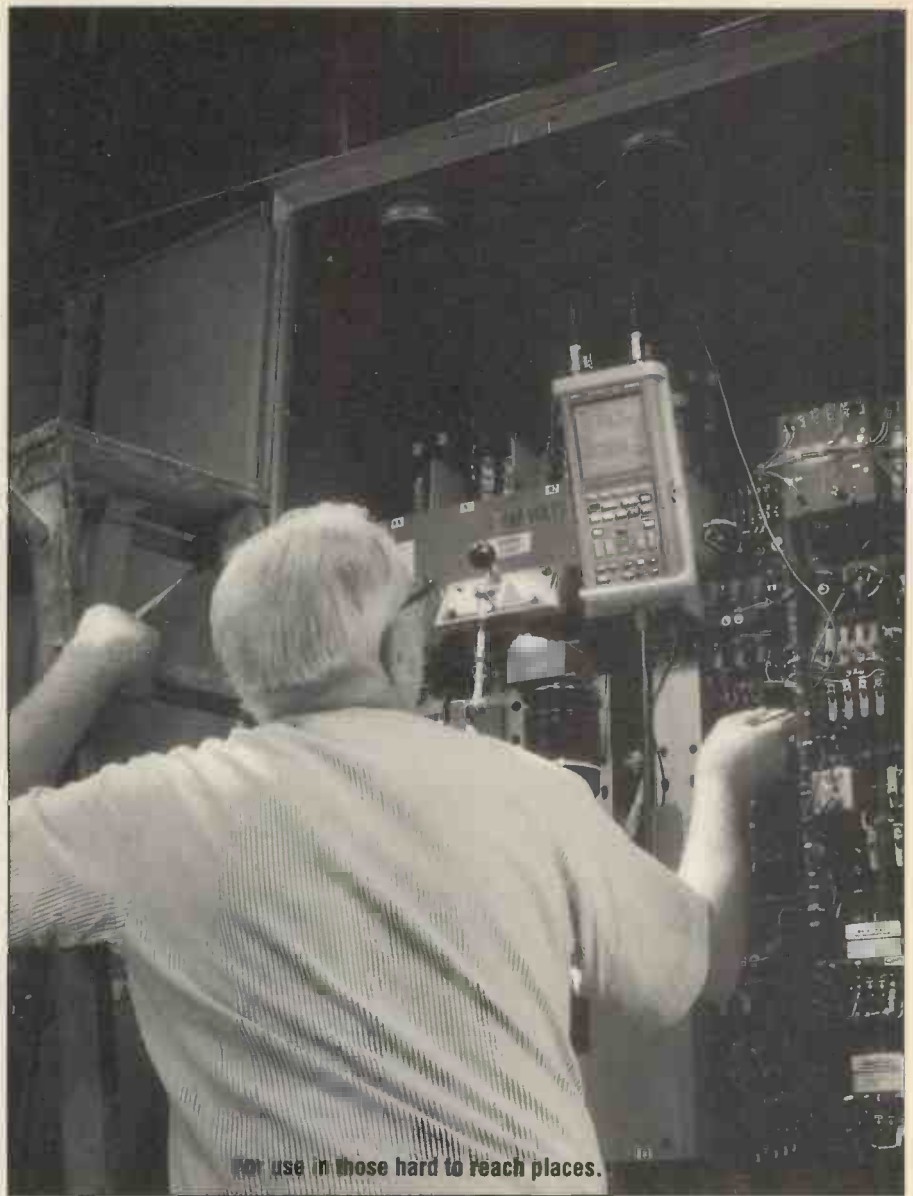
Models 93 and 95 come with reflective background LCD displays and give a reasonably clear view of what is going on. The 97 has an electroluminescent backlight and a non-reflective LCD. This works well in sunlight but the backlight is necessary for all other occasions.

When switching the scopemeter on, the default soft key setup is for the LCD mode. This is mainly to allow the backlight of the 97 to be switched on. However, it also gives access to display controls for contrast, dot size (1 to 3), display invert, grid selection and probe calibration. For DC, the latter is automatic and for AC, the small screwdrivers supplied allow the user to adjust the probe for the perfect square wave – on the 97, the squarewave is internally generated so calibration requires no other signal sources.

Since everything has to be shown on the one display, there are times when information overlaps. Sometimes this is taken care of by the system moving things around. Other times, especially for the intermittent error messages, they are just plonked right on top of everything else. There also appeared to be a few bugs in the way some of the indications are made – the HOLD overlapped with the NOTRIG indicator at times. The review model was pre-release so perhaps these small problems will be corrected.

## Keeping The Costs Down

To keep the price of the Scopemeter at a reasonable level, a high level of circuit integration is used. Apart from the 80C196 microprocessor, the RAM and ROM, most of the digital circuitry is concentrated in ASICs (Application Specific Integrated Circuit). The main system comprises over 11,000 gates and 1k bytes of fast RAM all fabricated in CMOS to give low power. On the analogue side, another ASIC is used control the timebase, trigger, display and aquisition control logic.



For use in those hard to reach places.

## Measuring Up

The way in which measurements are taken on the oscilloscope varies from model to model. On the 93, the grid or graticule must be used in conjunction with the Human Optical Sensor (EYE). On the 95 and 97 automatic cursors are provided.

These allow data to be extracted from a waveform quickly, easily and continuously. By selecting any five from the 11 options provided on the menu, information about the waveform can be displayed alongside the trace. Options available include dV, dt, RMS, MEAN, frequency, rise time and phase. Where the Scopemeter is taking the measurements from can also be displayed as crosses on the waveform. In addition, there are horizontal and vertical cursors that appear on the display which can be moved around with the cursor keys. This automatic information system takes all of the hard work out of using the oscilloscope as a measurement device.

## What's In Store?

The Scopemeter models 95 and 97 have provision to store up to eight

Scopemeter 93  
The basic scope and multimeter £725

Scopemeter 95  
Adds cursors, record and glitch detection to the basic model £899

Scopemeter 97  
Adds waveforms, setup memories, backlit LCD, printer interface and maths functions. £1095

All prices exclude VAT

## Scopemeter main features

Model  
93 95 97

### Digital Storage Oscilloscope (DSO)

- Bandwidth: 50MHz
- Dual channel
- Sample rate: 25MS/s
- Glitch capture: 40ns
- 8 waveform memories
- Single pushbutton autoset
- Cursor measurements
- Mathematical processing
- 10 setup memories



### Digital multimeter (DMM)

- DC and AC (true RMS) measurements
- Resistance measurements
- Continuity test
- Diode test
- Simultaneous display of waveform and meter results
- Selectable dBm, dBV, dBW readings
- Continuous recording of max, average, min and actual readings



### Other features

- Sine, square wave generator
- 84 x 84 mm LCD screen
- Electroluminescent backlighting
- Protective holster
- Autonomy under battery operation typically 4 hours
- Weight 1.8kg including holster
- Sealed case



waveforms and recall them back to the display for later comparison and examination. On the 97 this is enhanced by the maths functions which allow signals to be modified, stored and re-displayed almost instantaneously. For example, it is possible to display the channel A input and feed it to the filter function. The output of this goes into a memory which can also be displayed allowing both A and its filtered counterpart to be seen – useful for noisy signals. Memories can also be used as sources for the maths functions allowing very sophisticated processing of the inputs.

## Setting Up

Other memory functions on the 97 allow up to ten setups to be stored. When taking a reading from a signal, the settings of the range buttons, cursors and so on can be stored in a setup memory. On the 97 these can also be stored alongside the waveform memories allowing snapshots to be taken repeatedly from a number of signal sources without having to fiddle with the range functions every time. Also on the 97 are a set of special functions. These include a built in signal generator and printer driver.

All Scopemeters have an optical

RS232 interface. Normally this is used for recalibration or reprogramming – useful should upgrades be needed. However, the 97 also uses this to drive a printer or a PC. Screen dumps can be sent to the printer or computer either once or at specific intervals providing a signal logging system. The source for the image can be from the screen, any of the memories, or from a specific channel.

An alternative way to record data is to use the trace roll option which automatically occurs with the timebase greater than 5 seconds.

## The Flexible Solution

The Scopemeter provides a highly flexible measurement tool that is both portable and rugged. The bottom of the range model doesn't provide very many functions but would do all of the work needed by a test engineer. The flip out stand allows it to either be propped up for easy viewing, or hooked onto a convenient bracket when taking measurements in those hard to get at places. Unfortunately, the stand doesn't appear to be very sturdy and looks as though any rough treatment would break it – the design of the rest of the instrument gives it a pretty solid feel so it will probably be given some pretty "solid" treatment and the stand may not be able to take it.

The top of the range model should find applications in areas other than maintenance where electrical signals need to be measured, logged and analysed. Its maths functions, memories, setups and signal generator make it more than a match for other similar priced scopes plus it has a built in meter as well.

The idea of combining a meter and a scope into one tough package is a good one and should gain the Philips Scopemeters a good following, not just among service engineers. ■

For more information contact:  
Philips Test & Measurement  
Colonial Way  
Watford  
Herts  
WD2 4TT  
0923 240511

# Breathing Life Into The Medium Wave

*The rise of FM stereo has seen a decline in the fortunes of AM. Could the setting up of stereo stations on the Medium Wave give it a new lease of life? Ian Poolé reports.*

The major growth area in sound broadcasting undoubtedly lies with FM stations. They provide high quality signals free from interference and most transmissions are now in stereo. However, that old favourite of the 1950s and 60s, Medium Wave (AM), although something of a backwater in broadcasting terms could have a brighter future if trials of stereo AM being carried out in the UK are a success.

## Fitting In

The choice of a system for AM Stereo is not as easy as it may seem at first sight. The first problem is that the new system must be compatible with existing receivers. There are literally millions of these in use in the UK so this is a vital consideration.

In a similar vein the new system must comply with international standards. For example the bandwidth must be no greater than the existing AM transmissions otherwise it will cause interference to stations on adjacent channels. This is even more important if the transmission is likely to cross any international boundaries. This problem increases noticeably at night when the signal can be received over much greater distances.

Finally, the introduction of a new system now must not preclude any advances likely to be made in years to come. This is obviously difficult to predict, but vitally important. It would be no use if a small improvement now prevented a much bigger improvement taking place in a few years time because the new standards could not be

incorporated for some reason.

As a result of all of these constraints it is hardly surprising that any system which is being considered undergoes extensive trials.

## Stereo On AM

A number of different systems have been devised for AM Stereo and some of them have actually entered service. With the US FCC (Federal Communications Commission) allowing market forces to determine the best system, Motorola's C-QUAM seems to have come out on top.

C-QUAM stands for Compatible QUadrature Amplitude Modulation and, essentially, it is a system in which the main Left plus Right (L + R) signals are transmitted normally by amplitude modulating the carrier with a type of quadrature

modulation. By having the stereo information placed in quadrature or 90 degrees out of phase with the main transmission, both can be placed on the same carrier.

The advantage of C-QUAM is that the main L + R signal is the equivalent to mono and is transmitted and received in the normal way. Stereo receivers simply decode the two signals L + R and L - R and then add and subtract one from the other to give the left and right channels.

## Theory Into Practice

In order to see how C-QUAM works it is best to look at how an ordinary AM quadrature system would work. Here, the two audio channels are placed onto the same radio frequency carrier, but one is shifted by 90 degrees.

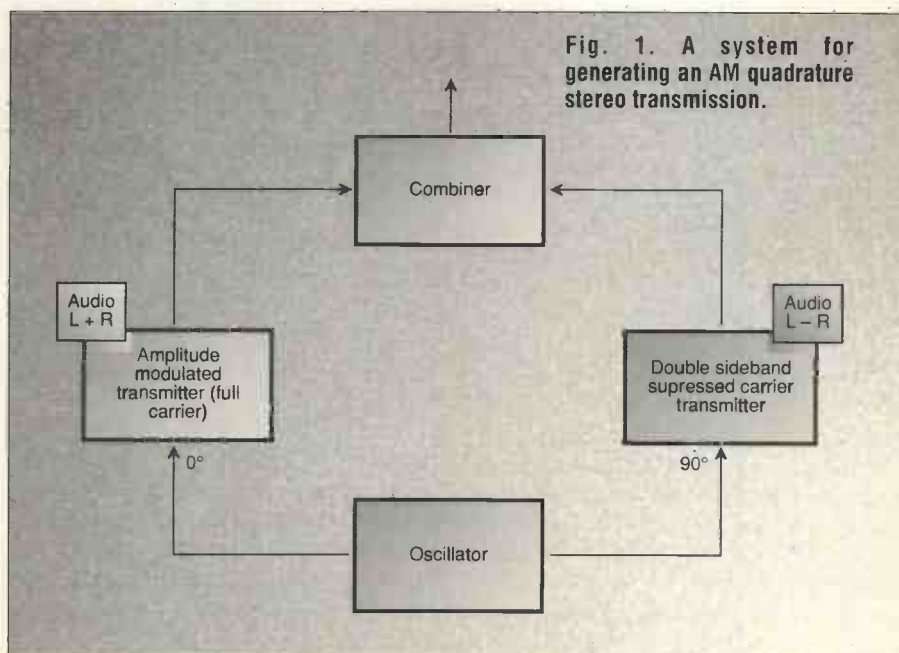


Fig. 1. A system for generating an AM quadrature stereo transmission.

This can be achieved quite simply as shown in Fig. 1. A standard AM transmitter is used in the normal way and transmits the L + R signal. To obtain the quadrature sidebands which carry the L - R signal a second transmitter is used. This transmits only two sidebands and has no carrier since that provided by the first transmitter is all that is needed. In order to obtain the quadrature phasing between the two sets of sidebands a phase change of 90 degrees is added to the master oscillator signal for the second transmitter. Finally the two transmitter signals are combined to give the full quadrature AM signal.

In order to demodulate an AM quadrature signal, the method shown in Fig. 2 is used. The RF enters the demodulator and is fed straight into two balanced demodulators or product detectors. Essentially these circuits are mixers and they are able to detect the audio on the carrier. However they are also phase sensitive and by adjusting the phase of a reference oscillator it is possible to extract either one channel or the other.

The simple AM-AM stereo signal has the advantage of being relatively straightforward. Unfortunately, it does not fulfil one of the major requirements of any new system because it is not compatible with existing receivers. The reason for this is that standard systems only see the amplitude

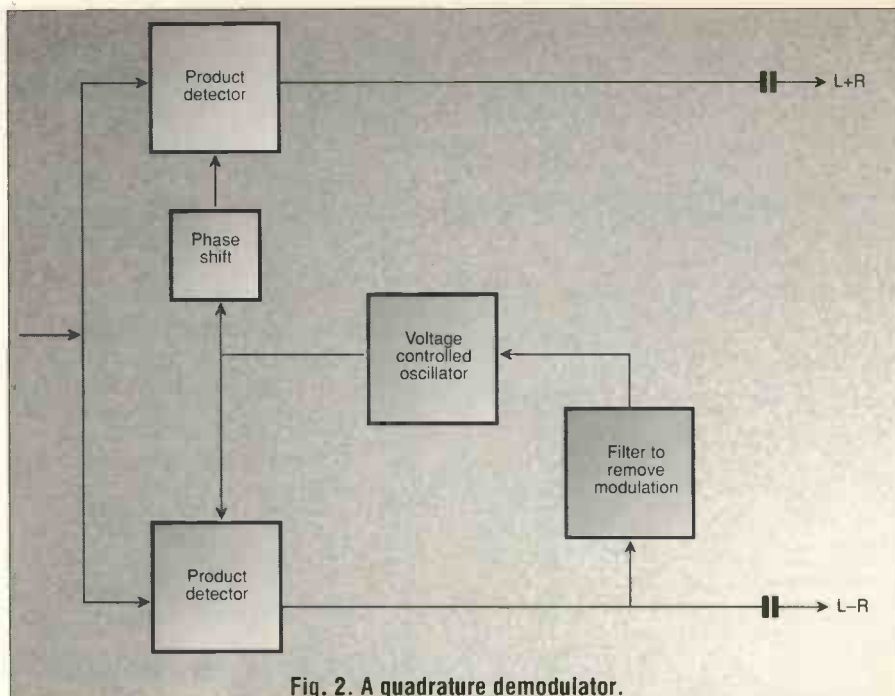


Fig. 2. A quadrature demodulator.

information and ignore any of the phase differences resulting in high levels of distortion.

When the left and right stereo channels are the same there is no distortion, as the L - R data is zero - the signal is the equivalent to standard AM. Unfortunately, the situation is very different when there is only a Left or Right signal present. In this case there are both the L + R and L - R signals and both transmitters are contributing equally to the overall signal which appears like the waveform shown in Fig. 3. When received on a

standard receiver this will be very distorted and quite unacceptable. Although these are both extreme cases, the real situation falls somewhere between them and there will almost always be a fairly high level of distortion.

### Compatible Modulation

In order to overcome distortion problems and make the signal compatible with existing receivers a cunning solution is used. Instead of using the two transmitters a standard transmitter is used with a

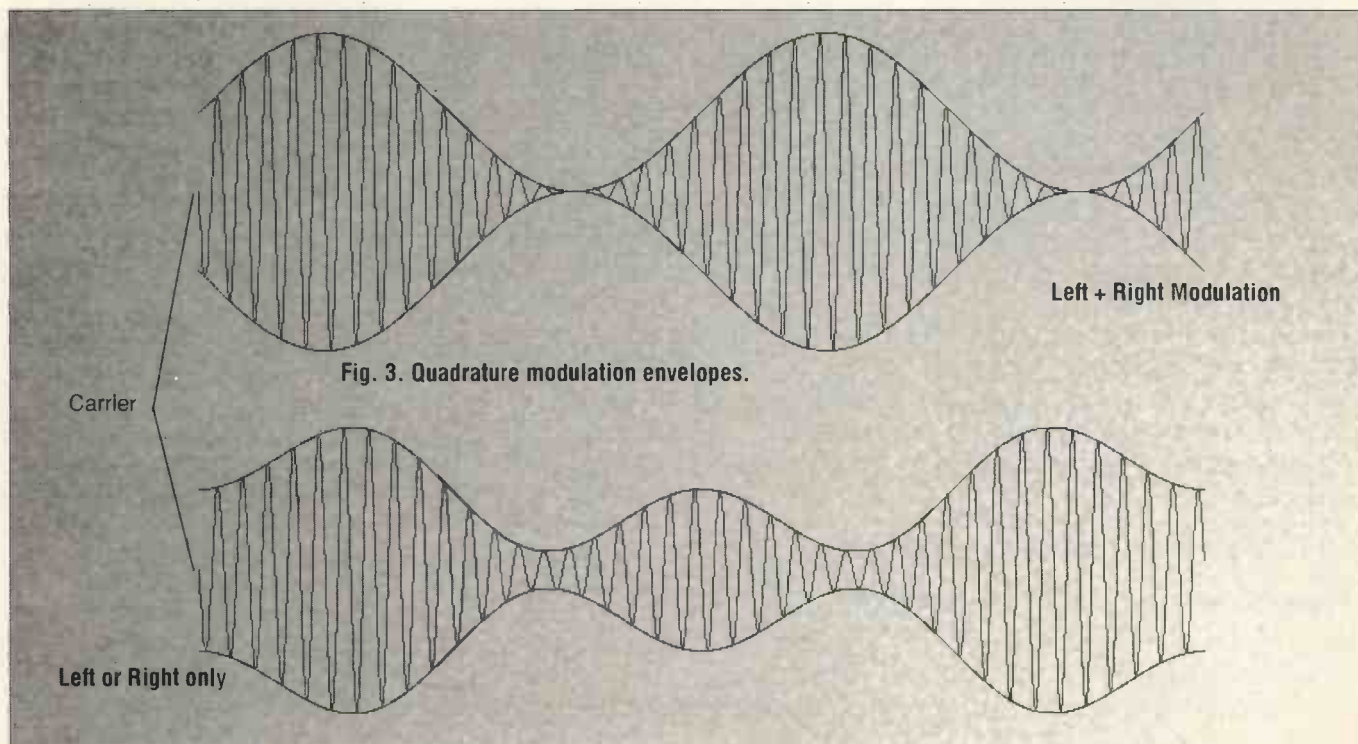
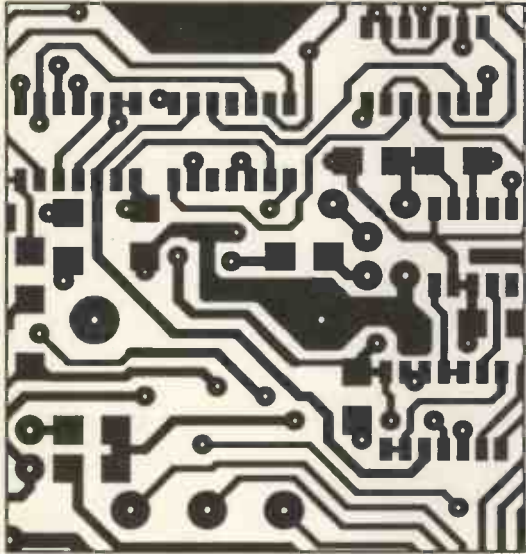


Fig. 3. Quadrature modulation envelopes.

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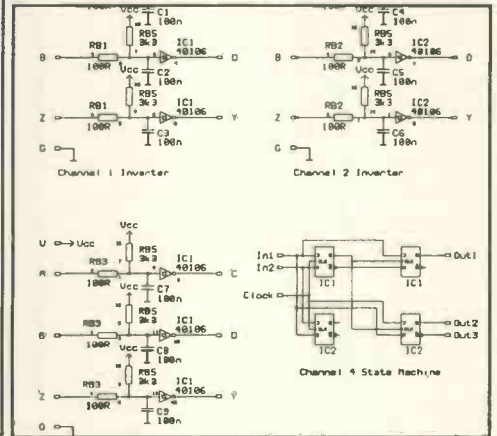
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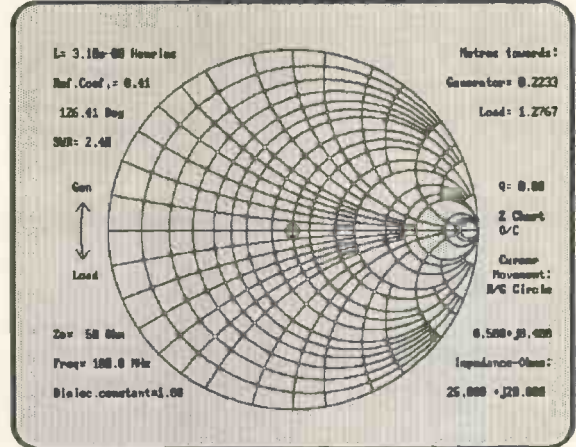
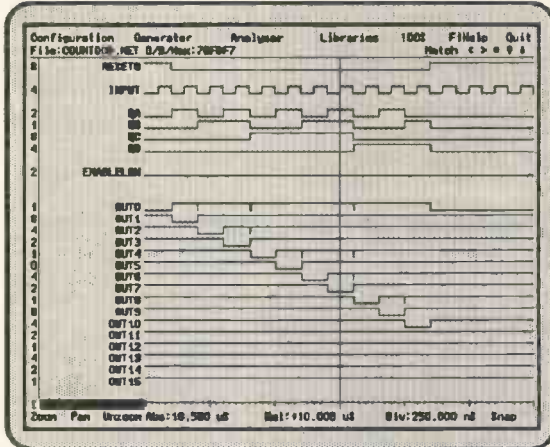


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## Modulation

There are a number of different ways in which audio (or for that matter any signal carrying information) can be used to modulate an RF carrier or signal. The first and most obvious is to use the audio signal to change the amplitude of the carrier to give amplitude modulation (AM). When viewed on an oscilloscope the overall waveform would appear something like that shown in Fig. A. However if the signal was viewed on a spectrum analyser where frequency is displayed along the X axis and amplitude along the Y axis then a number of different signals would be seen to make up the signal. Firstly, the main carrier would be present, and then on either side there would be two further sets of signals. For example, if the modulating signal was a pure sine wave of 1kHz then these two further signals would appear 1 kHz either side of the main carrier as shown in Fig. B. Obviously if the modulating waveform was a complex speech of music waveform consisting of a whole variety of frequencies then the sidebands would consist of all these frequencies. It can also be seen that they would be the mirror image of one another. Another important fact to note is that the amplitude of the carrier remains constant.

An alternative way of modulating a signal is to keep the amplitude constant but vary the frequency to give frequency modulation (FM). Again sidebands are produced but this time the picture is a little more complicated as the sidebands are located at multiples of the modulating frequency away from the carrier as shown in Fig. C. It is also worth noting that even though the overall amplitude of the signal remains constant, the amplitude of the carrier will vary. The reason for this is simply that sidebands containing a definite amount of power are generated by the action of modulating the signal. In order that the amplitude of the whole signal remains constant the level of the carrier must fall when modulation is applied.

A third type of modulation is known as phase modulation. In many respects it is very similar to frequency modulation, and basically the same

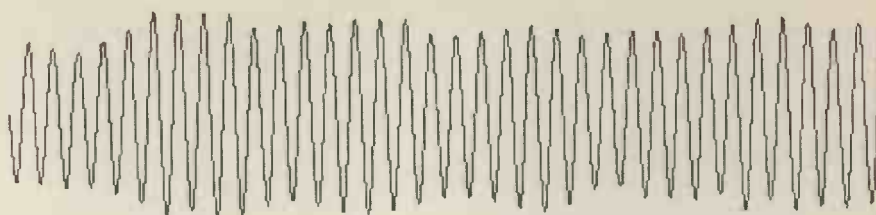


Fig. A AM signal.

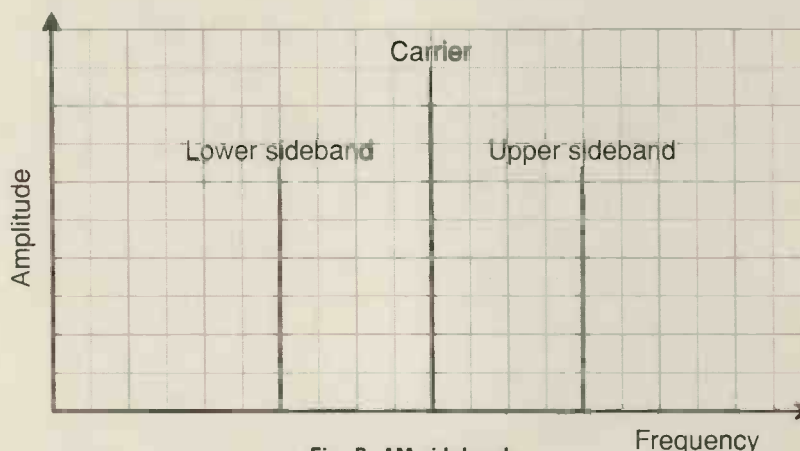


Fig. B. AM sidebands.

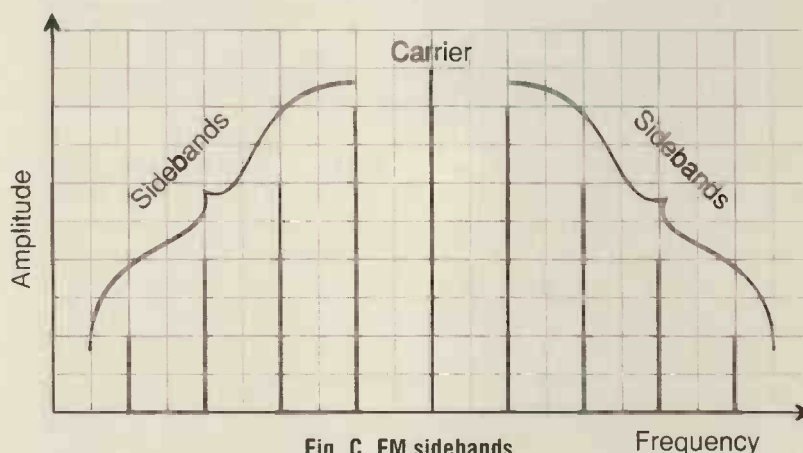


Fig. C. FM sidebands.

methods of modulation and demodulation are used. As the name implies, the actual phase of the signal is varied. However in doing this the frequency of the signal has to be changed instantaneously to accommodate the phase change. In fact by taking a frequency modulation system and differentiating (using the rate of change of frequency) the modulating signal phase modulation is achieved. Then at the receiving end the

signal has to be integrated (the opposite to differentiation) to regenerate the original modulating signal. In view of the similarities between phase and frequency modulation the sidebands which are produced by the two systems are broadly the same. A single modulating tone will produce sets of sidebands extending out from the carrier.

few minor modifications.

The L + R audio is used to amplitude modulate the radio frequency signal in the usual way. Then extra circuitry is used which takes the ordinary quadrature signal and extracts the phase information from it. This is used to phase modulate the master oscillator at the transmitter to give a signal which is compatible with

existing receivers and is almost an AM - AM quadrature signal but not quite.

## In The Receiver

In order to make C-QUAM an attractive proposition for receiver manufacturers as well as the transmitter operators, Motorola produces an IC to demodulate C-

QUAM signals easily and cheaply. The method it uses involves two stages. The first converts the received signal from C-QUAM into pure quadrature modulation. This is then demodulated to give the separate channels.

A block diagram of the system is shown in Fig. 4. Here, the gain modulator stage supported by the comparator and the envelope

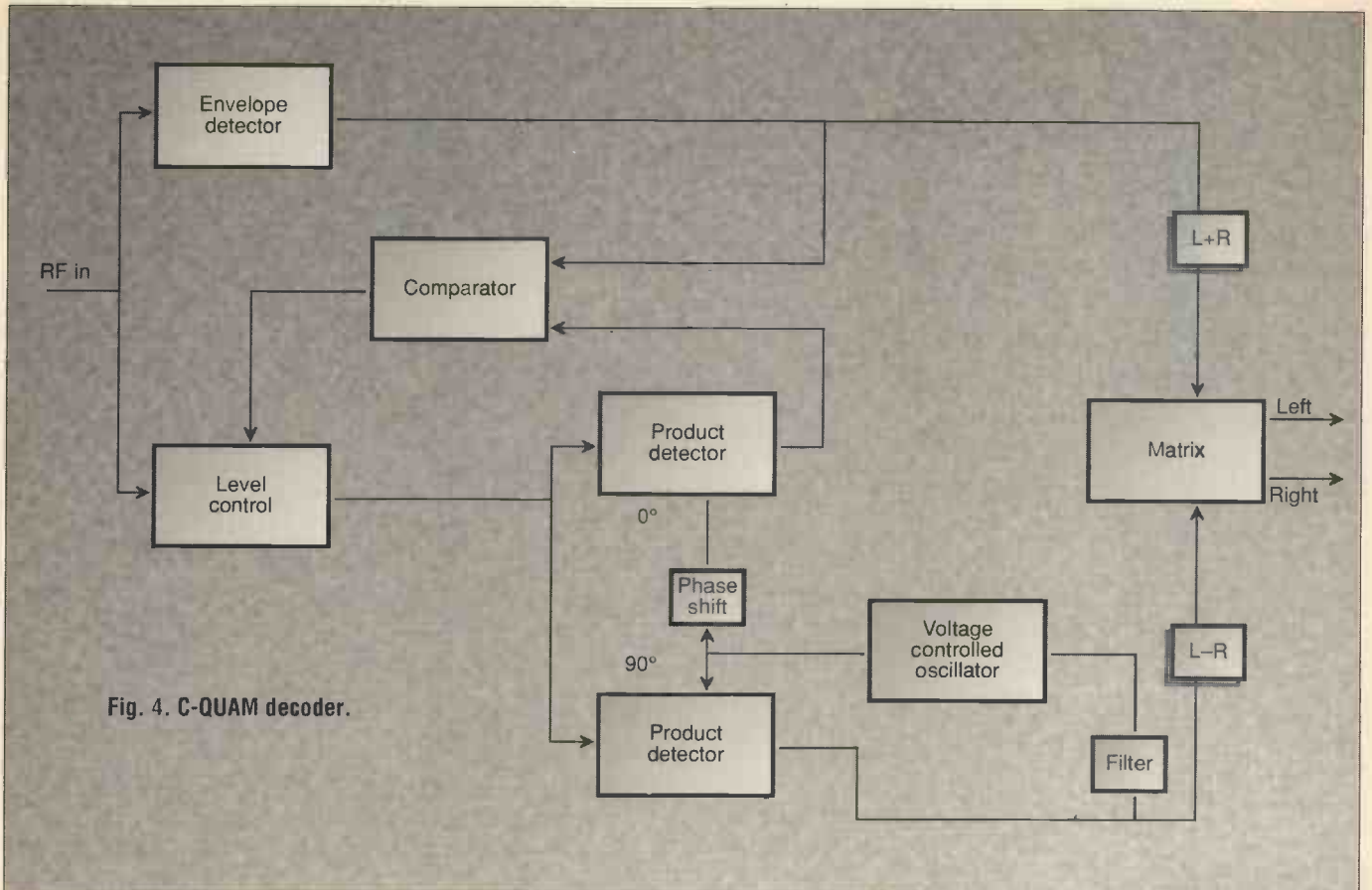


Fig. 4. C-QUAM decoder.

detector perform the conversion to quadrature modulation and the two synchronous detectors and the VCO demodulate the audio (actually only the L - R signal).

The signal enters the demodulator and the amplitude modulation is detected to retrieve the L + R signal. This signal is also used to feed into a comparator. The other signal entering the comparator comes from the quadrature modulation detector. This signal would be the L + R signal if pure quadrature modulation was used. However, there is a difference between the two. This appears at the output of the comparator and is used to alter or modulate the signal level and pure quadrature modulation is regenerated. As a result the L - R signal can be extracted as shown.

Having extracted the L + R and L - R information the two signals are added and subtracted to give the Left and Right channels.

### Is It Worth It?

There are a number of reasons why C-QUAM has come out as the dominant system for the transmission of AM stereo. Firstly it

is compatible with existing receivers and no degradation of sound quality should be noticed when it is being transmitted. Although other systems give good compatibility some of them do give a noticeable increase in the level of distortion when mono receivers are used.

Another advantage is associated with the level of background noise on a signal. Transmissions on the Medium Wave band occupy a relatively narrow bandwidth since AM gives the best noise performance under these conditions. The background noise level on an FM signal actually increases when modulation is applied which affects some of the competitive systems using a combination of AM and FM or phase modulation (PM). It is found that when there is a period of heavy modulation, the noise level increases quite noticeably.

Other sources of distortion are due to the signal reaching the receiver over a number of different paths or the receiver being poorly tuned. By using a system of transmission having the same type of modulation on both channels these sources of distortion become less noticeable. Accordingly C-

### The Origins Of C-QUAM

- 1922 .. British Broadcasting Company is formed and starts broadcasting with the station 2LO
- 1935 .. E.H.Armstrong demonstrates the viability of wideband FM for high quality transmissions.
- 1954 .. BBC decides to start wideband FM transmissions for a new high quality service.
- 1973 .. Independent Local Radio starts broadcasting with the opening of Capital Radio and L.B.C. in London. The new service is available on Medium Wave as well as VHF FM.
- 1975 .. Motorola starts work on its C-QUAM system.
- 1975 .. National AM Stereophonic Radio Committee (NAMSRC) formed in the U.S.A. to evaluate AM stereo systems.
- 1982 .. Motorola C-QUAM production hardware available.
- 1990 .. Over 800 stations world wide are using C-QUAM. Just under 700 are in the U.S.A., and the remaining stations are in countries which include Australia, Canada, Spain and Brazil.
- 1990 .. C-QUAM trials start in the U.K. with transmissions on Radio Orwell.

QUAM, which is a modified form of an AM-AM system, provides a better signal than one which uses two types of modulation (for example AM-FM or AM-PM).

A big advantage is that C-QUAM can be added to an existing transmitter with the minimum amount of modification. This saves the broadcasting company a colossal amount of money over other systems which could involve the installation of a second transmitter.

## AM Stereo Takes Off

C-QUAM has firmly established itself in the USA as the leading method for transmitting AM stereo. The system is also widespread in Canada and Australia, as well as being used to a lesser extent in many other countries including China, Brazil, Venezuela, and South Africa.

In terms of the listening public,

the majority of receivers designed for C-QUAM are aimed at the car market. Even so, manufacturers of portable radios are also introducing new sets with stereo included. In fact it should not be too long before it is possible to see the larger portable radios with FM and AM stereo in those countries where C-QUAM is on the air.

UK trials took place on Radio Orwell in 1990 and were quite successful. As a result, the Radio Communications Agency of the Department of Trade and Industry who have to authorise the use of C-QUAM are keen to see further tests. These would be both in the laboratory as well as in the field, and they will help to establish the implications of the use of C-QUAM for future planning.

It may seem that the UK Government is being rather slow but the situation in Britain is not as simple as in countries like the USA. Checks have to be made to see if

AM stereo can be introduced without any adverse effects on other transmissions which may or may not carry stereo. In addition to this the proximity to the rest of Europe means that it has to be shown to be acceptable across the Channel.

## For the Future

AM stereo opens up a whole new lease of life for AM transmissions. Until now they have been steadily losing ground to the higher quality transmissions on VHF. This has been made obvious by the number of commercial radio stations which have been running different programs on VHF and Medium Wave. Often these Medium Wave transmissions carry chat shows or news programs which don't require the same quality as music. However, the introduction of AM stereo could breath new life into the Medium Wave. ■

# Dry Joints

## PE Chronos July 1991

Fig. 1

R25 (1k5) at pin 9 of IC4 not labelled  
R26 (820) at pin 11 of IC4 not labelled

R29 (680) from pin 3 of IC4 to R31 was mistakenly labelled R28 and given the wrong value of 180.

C15 was labelled 18k it should have been 1 $\mu$ 0.

IC2 (741C) was completely unlabelled.

IC3 (LM319N) type No. was omitted.

## PE Chronos August 1991

R28, R37, R38 (all 360 $\Omega$ ) omitted from the parts list.

The author feels that the suppliers of IC1 (ELH0032CG) should be mentioned as it is difficult to locate. It can be obtained from Microelectronics Technology, Unit 2, Gt Haseley Trading Estate, Gt Haseley, Oxfordshire OX9 7PF.

Thanks to Tony Smith.

## Talking To The Skies July

Alex Pathan of Sheffield City Polytechnic wrote in to point out that: on page 11 in the shaded grey

area, it must have been obvious to all that the velocity required to get an object into orbit is called the orbital velocity of that particular altitude, the 17000mph quoted is approximately the minimum orbital velocity and this converts to approximately 7599m/s not 3075 m/s. The 3075 m/s is the orbital velocity at geosynchronous altitude.

The escape velocity at any orbital altitude is  $\sqrt{2}$  times the local circular velocity. This makes the escape velocity from the earth's surface to be about 11km/s. Of course all this does not account for energy losses due to atmospheric drag or losses due to the particular trajectory profile flown.

As for ground control manoeuvring the satellite to overcome "gravitic"(?) irregularities, at the 290km altitude level, help!

Worse follows, it is then stated that moving the satellites further away although increasing their speed causes them to be overhead for longer periods. Nothing could be further from the truth.

$V = \sqrt{GM/r}$  where V is the circular satellite velocity at radius r from the centre of any planet of mass M and G is the Universal Gravitational Constant.

As you can see fortunately the velocity required to orbit any mass at increasing distances from the centre of any planet actually drops sharply.

A fairly casual sentence follows giving the impression that as altitude is increased eventually a point is reached when the satellite appears stationary. It must be emphasised that this is only possible if the satellites orbital inclination is zero i.e. the orbital plane is within the plane containing the earth's "equator", you can see that if this is interpreted as the "geographical equator" gravitational anomalies cause perturbations dependent on longitude.

The comment that even before the rocket takes off it is travelling at 1667 km/h is only correct in the direction west to east at an equatorial launch site. At any other location  $\lambda$  the velocity would be 1667  $\cos \lambda$  km/h but still west to east hence the roll program and pitch program for the launch vehicle to generate the required orbital inclination.

At Cape Canaveral 28.5°N approximately, this velocity becomes 1464 km/h, a dramatic reduction.

$$\begin{aligned} \text{On page 12:} \\ F &= GM_1M_2/d^2 \\ g &= GM/R \end{aligned}$$

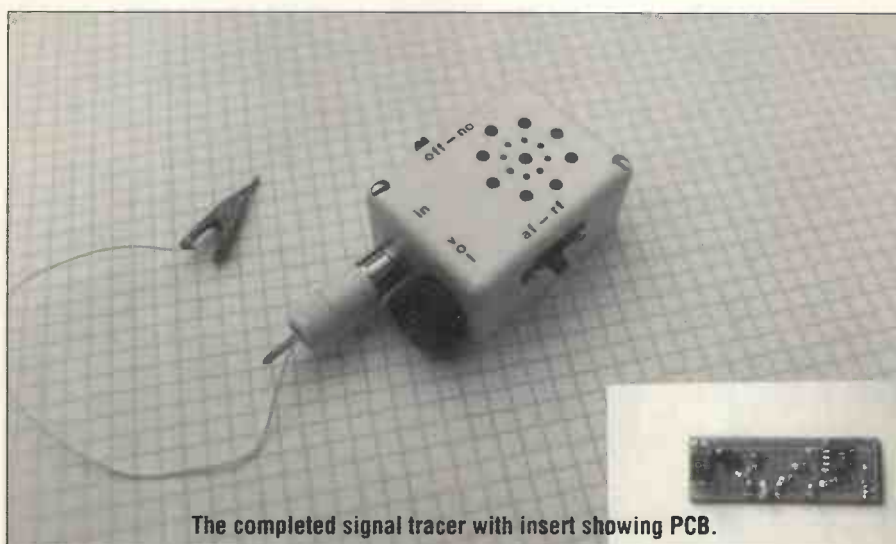
# A Surface Mount Signal Tracer

*Bill Mooney describes how ultra miniature components can be used to construct a super small circuit test device.*

When designing, servicing or just dabbling with electronic circuits, a tracer is a handy gadget to have around. Its built in detector for amplitude modulated (Radio Frequency) RF signals will allow you to trace signals back through the various stages of the circuit and its use of surface mount components introduces this interesting technology.

The circuit is based on the MC34119, a clever little device originally designed for speakers, power amplification and other telephone applications. It draws only 2.7mA quiescent current and will work with a supply as low as 2V. In the signals tracer it will deliver 100mW into an 8Ω speaker using a 3V supply provided by a couple of 1.5V N cells. The chip also has a useful chip-disable (muting) input where a high on pin 1 reduces the standby current to 65μA. Although this is not used in the signal tracer, it may be of interest to those who compulsively scribble circuit diagrams on the back of beer maps and envelopes. The circuit diagram of the tracer is shown in Fig. 1.

The gain of the circuit is determined by a pair of resistors R2 and R3 connected to the inverting input in classical manner. The capacitor C3 provides bass cut and the maximum gain is 48dB at 1kHz but falls off above this due to internal compensation. A lower gain would give a wider frequency response but in this case the small speaker compensates somewhat for the fall off and the tracer needs to be as sensitive as possible. The resistor R3 is a little outside the design range of for this IC and a



The completed signal tracer with insert showing PCB.

small offset current must be injected into the negative input to balance the outputs. The 10MΩ resistor, R1, provides this current. Since there is no output capacitor even a small DC difference across the loudspeaker (pins 5 and 8) will result in a heavy increase in quiescent current. For example just 100mV difference between pins 5 and 8 will result in some 12mA extra drain.

To achieve the high input impedance required in such an instrument the system is operated in the less stable non-inverting mode. A value of 100kΩ is adequate and will have minimal effect on any circuit under investigation. The sensitivity control consists of] a 100k potentiometer and audio signals are applied directly to this. For radio frequency work a Schottky diode detector, D1, is switched into the circuit. The resistors R4 and R5 provide a current loop for the diode. A 100pF input capacitor, C5, allows only RF to reach the detector. C6 removes

residual RF allowing audio to be picked off through C7. The BAR18 Schottky diode is packaged in an SOT23 surface mount package. It has a very low turn on voltage, starting to conduct well below 100mV but specified as 0.4V at 1mA. A very low junction capacitance allows it to work up to UHF and it will withstand 70V piv. This is a respectable replacement for the germanium device usually employed in this application. If working in high voltage environments such as valve equipment, the working voltage of C5 should be increased to account for the increased strain.

The circuit is fabricated on a thin (1mm double sided PCB measuring 3.8cm by 1.25cm. This is small enough to make a very compact probe using button cell batteries.. However, a more practical approach is to use the N cells which should give a couple of months intermittent operation. The PCB foil pattern in shown in Fig. 2 and the

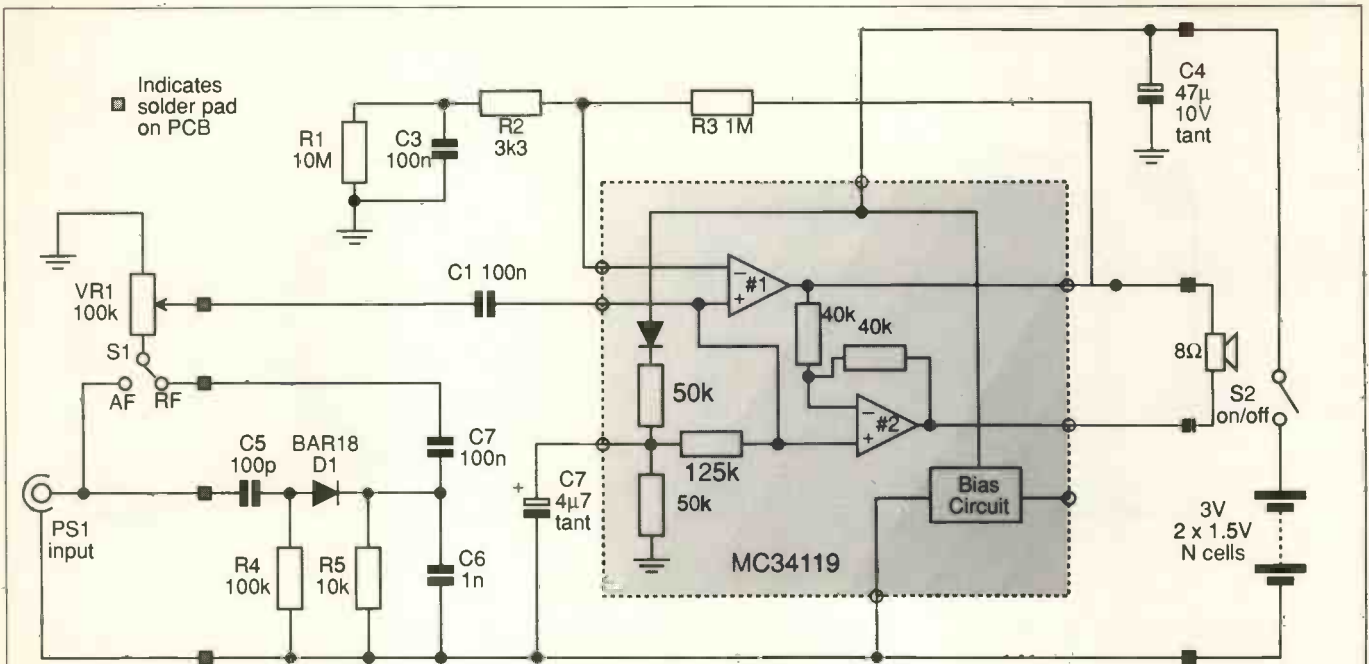


Fig. 1. The main circuit diagram.

component overlay in Fig. 3. The PCB is produced in the conventional manner using UV sensitive spray coating, developing and ferric chloride etching.

When putting the surface mount devices onto the board it is better to start with the larger devices such as the tantalum capacitors. Use the minimum amount of solder and apply the iron for sufficient time to allow it to flow nicely and wet both surfaces. The IC pins can easily be bridged with solder so take care – a solder wick or sucker can be used to remove any excess.

The tantalum capacitors are marked with a band at the positive end. The ceramic chip caps are not marked and should be kept under wraps until required. Pin 1 on the IC is indicated by a flat along one

edge. Sometimes a dot is used to indicate pin 1 of SOIC ICs.

The position of the PCB and the various pieces of hardware can be seen in Fig., 4. Mark the battery holes first by making sure that the PCB will slot in as shown underneath S1. Leave a small gap running between the battery holder and the box for the wires running from the solder tags. The pins on the switches, phono socket and sensitivity control all need to be cur back with a side cutters. A length of about 1.5mm should be sufficient. See that the phono socket terminal is clear of the battery connector and likewise the three connections to VR1. Mark the long pin of VR1 before trimming, this is the wiper. The potentiometer specified in a P16 "knob pot" having the resistive



Fig. 2. The PCB (full size).

element in the knob and thus leaving plenty of room inside the project box. Thin 30awg Kynar wire is ideal for all interconnections with a twisted pair for the loudspeaker connections. The battery holders should be wired in series before finally bolting them into place. The M2 countersunk bolts for the battery holder should be cut to length and filed level with the nuts otherwise the cells will not fit into

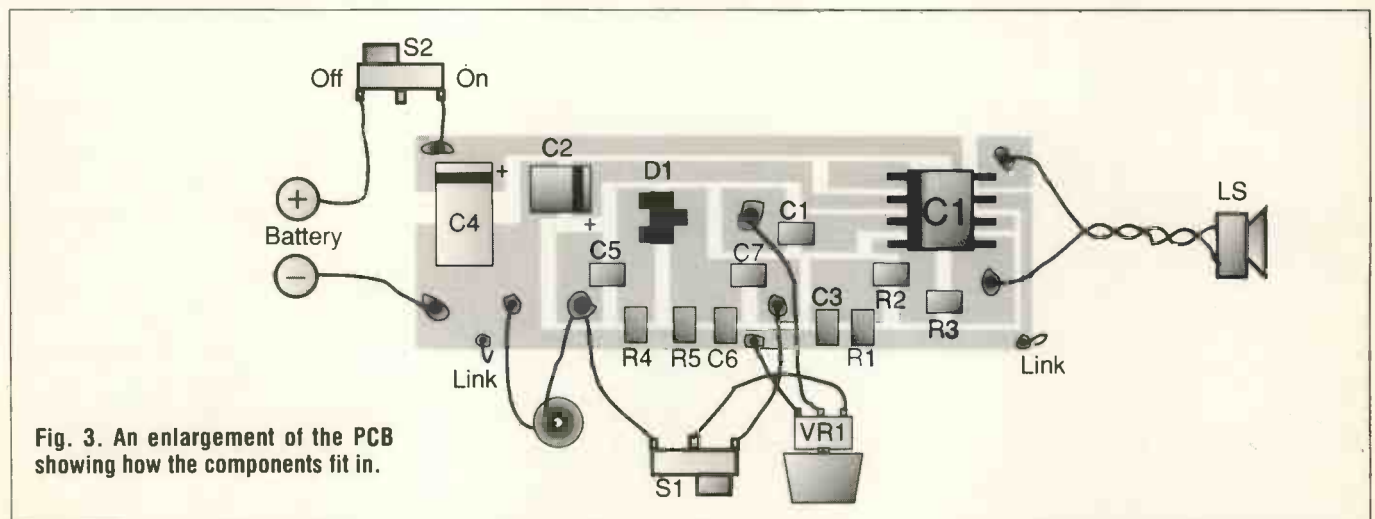


Fig. 3. An enlargement of the PCB showing how the components fit in.

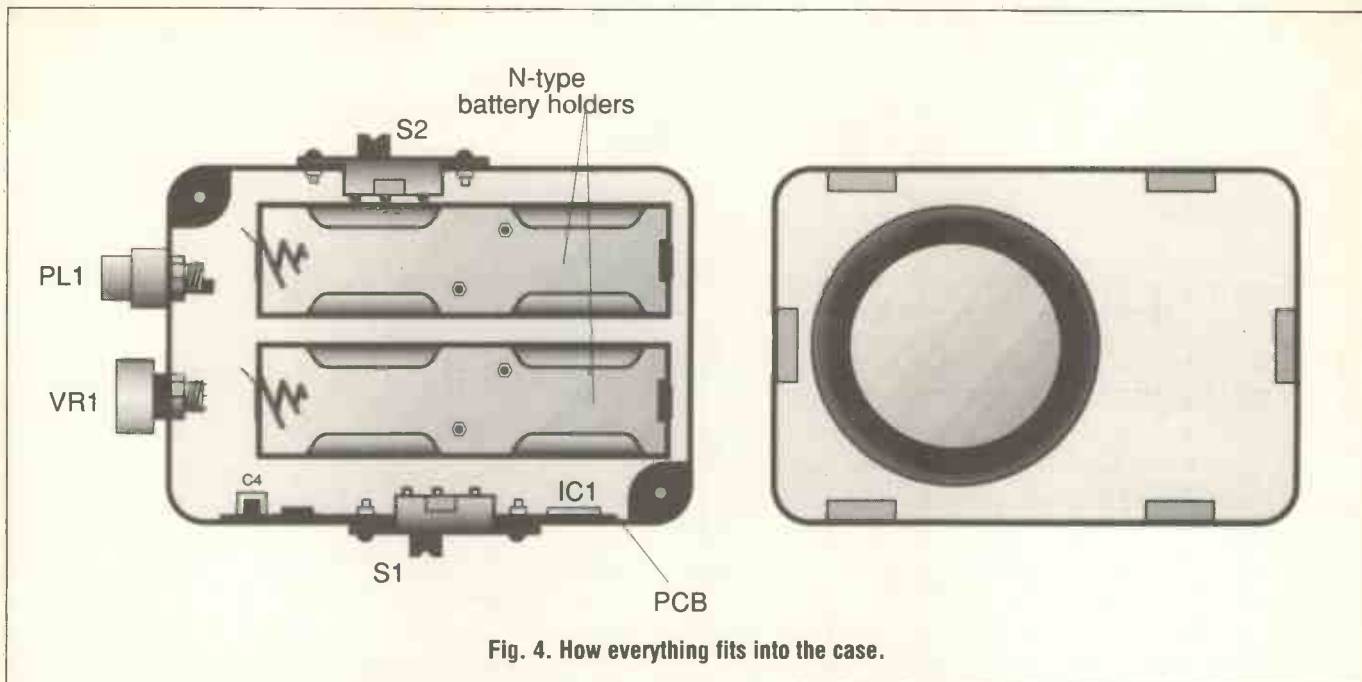


Fig. 4. How everything fits into the case.

the holder correctly. The M2 round head bolts for the switches also need to be trimmed to length. The 'U' shaped channels for the two switches to drop into can be made with a sharp scalpel and filed square as the plastic is easily worked. The switch mounting plates remain on the outside of the box leaving more room inside and allowing the batteries to be replaced easily.

Solder some lengths of connecting wire to the PCB and slide it into place. Now trim the leads to the shortest length which will allow the board to be slid out slightly to make measurements. Take care with the Kynar wire as it will not take too much flexing and is liable to break at solder joints. The links between the rear of the board and the ground track

provides screening. Input wires should be kept away from output wires for maximum stability. A dab of blue-tack will hold the PCB in place.

The next step is to check everything very carefully. Are the batteries wired correctly? and the tantalum capacitors the right way around? Are there any solder bridges? If all looks well apply power but monitor the drain current with the sensitivity control set to minimum. The unit should draw 2.7mA ideally but up to 5mA is acceptable. The difference is due to a slight imbalance of the output amplifiers which could be trimmed by setting R1 to actually achieve 2.7mA. Check the audio function first by poking around inside a radio receiver or applying a 1kHz signal to the input.

A simple input probe can be made up from an inch or so of 18swg wire soldered to the centre of a phono plug and fired to a point. A few inches of flexible wire soldered to the phono plug screen with a small crocodile clip at the end provides a ground connection. ■

## Components

### Resistors

0805 chip resistor 2%

R1	10M
R2	3k3
R3	1M
R4	100k
R5	10k
VR1	100k P16 type knob pot

### Capacitors

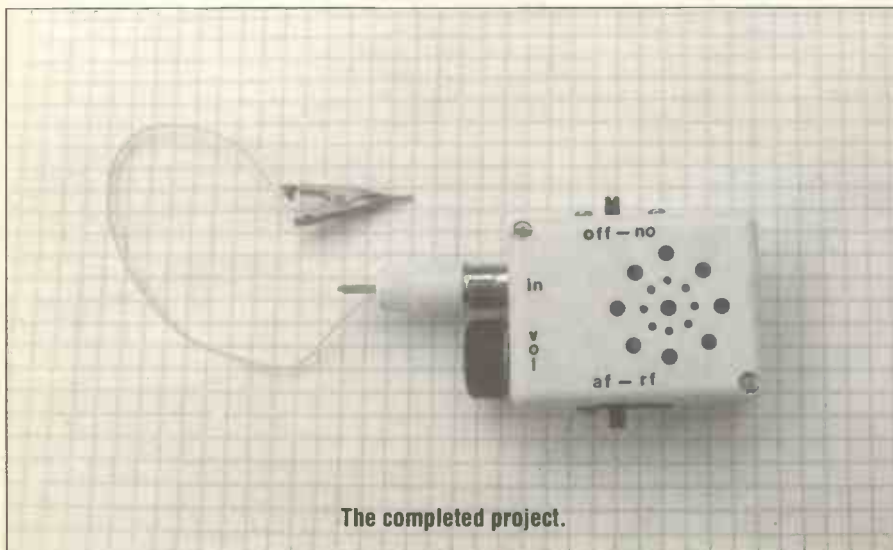
C1, C3, C7	100nF 0805 chip capacitor X7R
C2	4.7µF 16V tantalum
C4	47µF 10V tantalum
C5	100pF 0805 chip capacitor COG
C6	1nF 0805 chip capacitor COG

### Semiconductors

D1	BAR18 Schottky diode SOT23 package
IC1	MC34119 SO8 package

### Hardware

S1, S2	miniature slide switch
Sk1	phono socket
2 x flat based N type battery holder	
Project box type BIA 50x37x24mm	
small mountable white plastic box	
8Ω miniature dynamic loudspeaker	
CS29B type	



The completed project.

# The Old And The New

*Superfast analogue to digital conversion, credit card sized memory, a single chip disk controller and a source for old chips are all featured this month.*

**F**loppy disk controllers for PCs normally require nine or more chips in their implementation. The new FDC37C75 Paddle Chip from Standard Microsystems cuts this down to three. All of the functions of an IBM PC compatible disk drive controller are included on the 68 pin device giving 100% compatibility. Fabricated in CMOS for low power, the chip features a digital data separator, IDE interface, on-chip address decoder, single crystal oscillator circuitry, software and hardware power down/reset capability, game port decode logic and a 1.8432MHz clock signal for direct drive of external I/O products.

Its low power consumption and high level of integration make it ideal for use in portable laptop computers

Contact Standard Microsystems, 35 Marcus Boulevard, Hauppauge, New York, USA, for more information.

## Memory Credits

Designed for use as low power, external memory upgrades for portable computers, the MT12DC136 and MT24DC236 from Micro Technology conform to the 88 pin memory card JEDEC standard. The "12" is available in 1Mb x 36 or 2Mb x 18 and the "24" in 2Mb x 36 or 4Mb x 18. The 88 pin cards can be used with 16, 18, 32 or 36 bit systems and have buffered input signals for compatibility, individual memory bank selection for low power consumption, parity to correct data errors and stainless steel panels to provide better protection and heat dissipation.

The integrated circuit RAM card is about the same size as a credit card and has low power DRAMs (Dynamic Random Access Memory) surface-mounted on both sides of its ultra-thin printed circuit board.

Contact: Micro Technology, 2805 East Columbia Road, Boise Idaho, USA.

## Flash In The Can

Two new "flash" analogue to digital convertors (ADC) from National Semiconductor feature 20 million samples per second to 8-bit resolution. The ADC0881 operates on a +5V supply whereas the ADC0882 uses a split  $\pm 5V$ . Generally aimed at the video market, the ADCs can also be used in other areas where high speed conversions are required, such as medical imaging, radar and high-speed data links.

Since the chips use flash conversion with a comparator for each of the 255 levels, no sample and hold hardware is required. The 255 resistor divider network splits the incoming voltage in levels that can be sensed by the comparators whose outputs are coded to give an

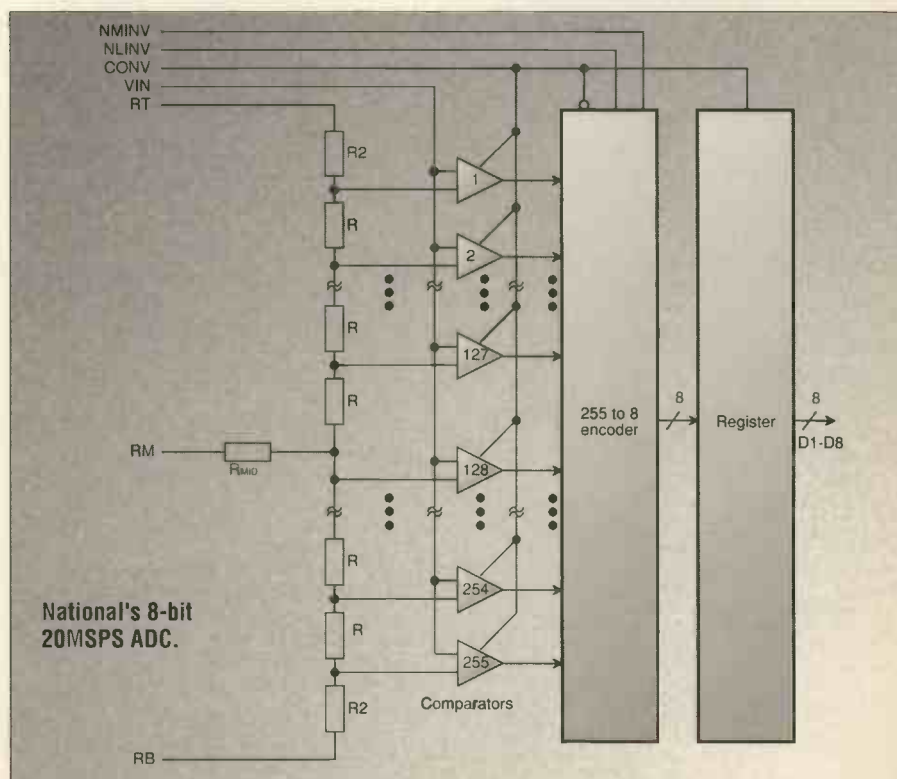
8-bit output which is TTL compatible.

For more information contact National semiconductor, c/o Lorenz Minderer GmbH, Att. Mrs Humbert, Raiffeisenstraße 10, D-8016 Feldkirchen, Germany.

## Dated Chips

Anyone needing to get hold of obsolete integrated circuits could do worse than contact Versa Dis. Now supporting the product range of Lansdale Semiconductor, the company is able to obtain products once made by Motorola, Harris, AMD, Intel, Signetics (Philips), Raytheon and Fairchild (National Semiconductor). All chips are made from the original masks and production tooling equipment guaranteeing complete compatibility with the original ICs.

For more information, contact Versa Dis, 17 Thame Park Road, Thame Oxfordshire, OX9 3XD. ■







# It's A Fuzzy Old World

*Ian Burley looks into the fuzzy logic consumer revolution currently taking place in Japan. Everything from camcorders to rice cookers is having the new technology applied.*

A mini-revolution is happening in Japanese consumer electronics. It hasn't yet impacted in a big way on Western consumers, but the signs are there and more than the odd eye-brow is now being raised by the two words "fuzzy logic" emblazoned on new electronics goods in high street stores.

So far the few products to reach western shores featuring fuzzy logic have been restricted to certain video camcorders. It's a different story in Japan where you can buy fuzzy logic washing machines, vacuum cleaners, air conditioners, toasters, microwave ovens, televisions and more. The technology isn't restricted to consumer electronics either; it controls a Japanese underground train service, the latest generation of "smart" elevators, engine management systems, active ride suspensions for cars and even nuclear power plant control systems.



The Fisher FVC-990 camcorder employs Fuzzy Logic.

## Humble Beginnings

Fuzzy logic was the brainchild of Professor Lofti Zadeh 25 years ago at the University of California in Berkeley. The ideas weren't taken seriously and ended up being neglected in the West. But later, fuzzy logic was seized by the

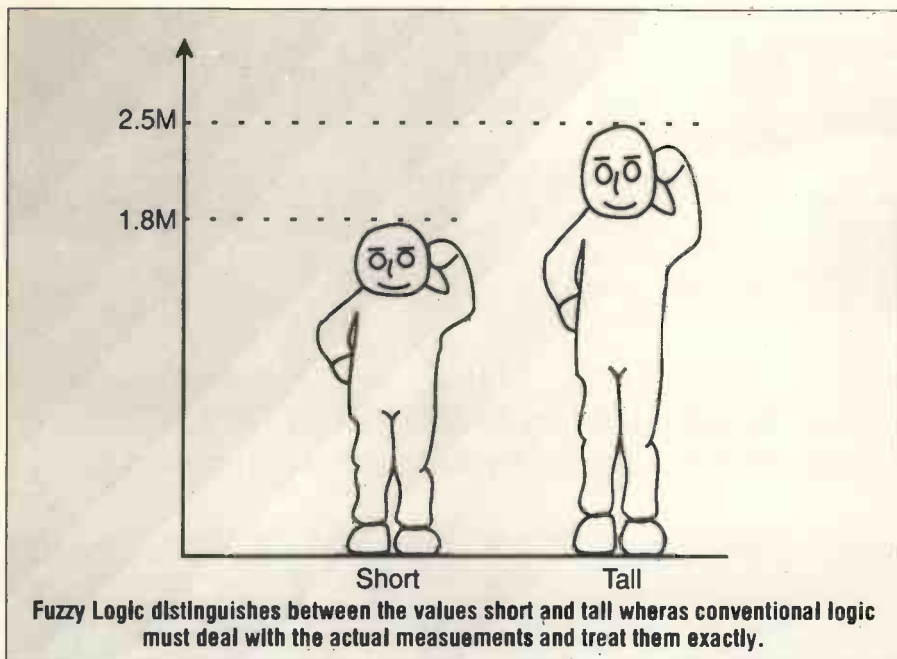
Japanese and successfully applied to markets which are threatening to be huge.

Zadeh reasoned that conventional mathematical or Boolean logic was all very well, but human responses were inadequately served by it in many every day situations. Pure logic describes certainties and accuracy. Something is right or wrong, it's yes or no, one or zero, on or off.

Boolean logic is great for orthodox computing, based on the binary system, but try and apply it to questions like how tall is somebody? How hot is something? How dusty is this floor? We might say a six footer is tall, but somebody of that height won't be much use to a professional basketball team. At the other end of the scale, a five footer might be a relative giant to some pigmy tribes. A plate of food served at 60 degrees centigrade might be too hot to eat but it might also be too cold to cook. A floor might be dust-free,



A Kerosene fan heater employing Fuzzy Logic.



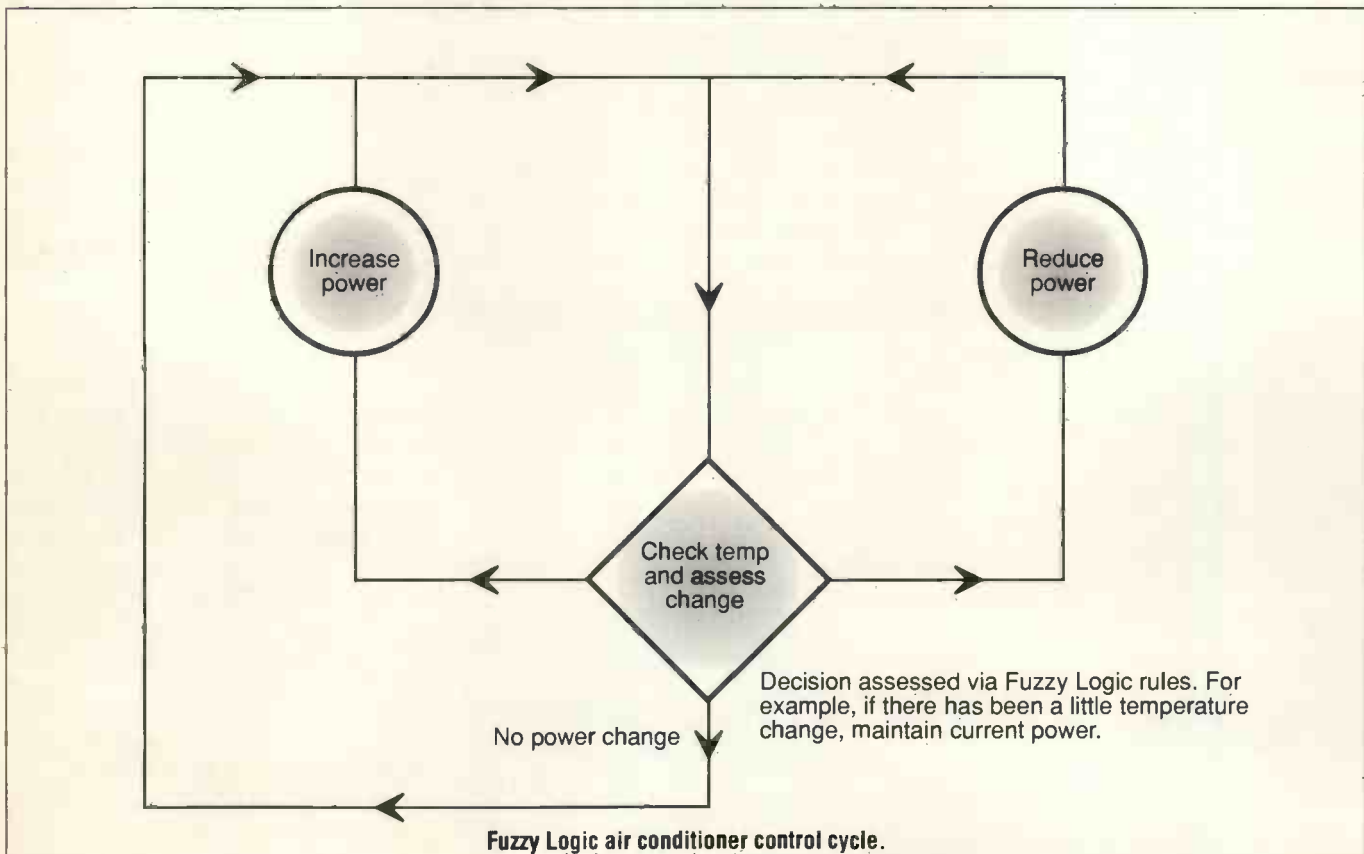
sort of slightly dusty, rather dusty or positively thick with the stuff. These are just a few examples of the kinds of reasoning Lofti Zadeh hoped fuzzy logic would be able to tackle successfully.

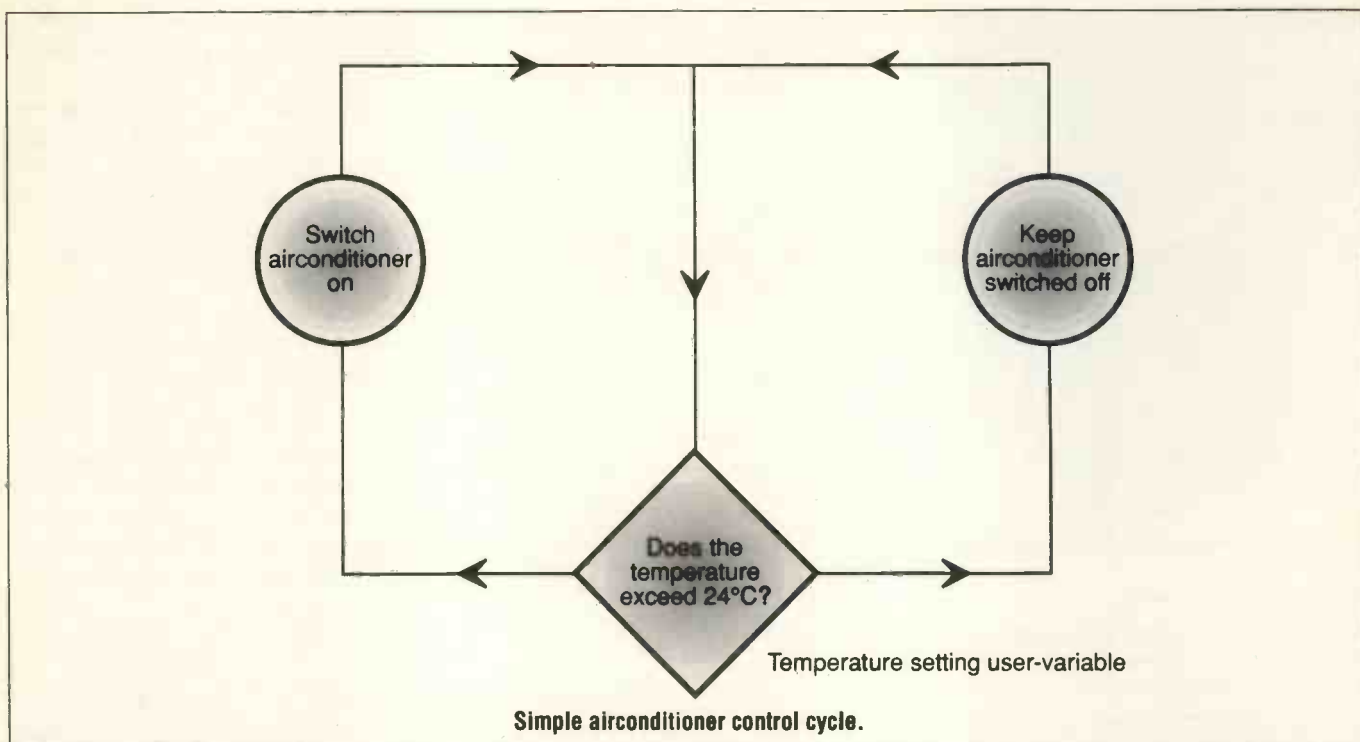
One of the first practical applications of fuzzy logic was in the process control of a Danish cement works where the technique was used in controlling kilns. Since then there has been little obvious evidence that fuzzy logic has been taken seriously outside Japan.

Four years ago the northern Japanese city of Sendai completed its underground train system. This dispensed with human drivers, who were replaced by a predictive fuzzy logic control system developed by Hitachi's Dr. Seiji Yasunobo. Automatic trains are nothing new, but if you've ridden a few you will have noticed they can be a bit jerky. The Sendai trains are claimed to have an impressive ride as the fuzzy logic system is designed to apply brakes and acceleration very

smoothly. In effect the system asks itself questions like "if we're going a bit too fast, apply the brakes a wee bit." The platform is never over-shot and there is consistency in the train's operation because there aren't any inexperienced or rough drivers.

Seiji Yasunobo is now a senior member of the Laboratory of International Fuzzy Engineering (LIFE). This was set up with \$50 million of funding from Japan's powerful Ministry of International Trade and Industry (MITI). Today the market is estimated to be worth \$500 million and is rising rapidly. About 50 of Japan's biggest electronics firms make up the LIFE organisation. For consumer products, fuzzy logic has been applied as an antidote to what might be described as technophobia. Fuzzy logic uses sensors that adjust appliance functions automatically. The basic reasoning is that users shouldn't be faced with a daunting control panel of buttons, switches and dials and forced to use manual control. There is a saying among Japanese fuzzy logic developers which simply describes the technology with the statement "all you need is to press one button."





## Human Applications

Theoretically, any appliance or device which can be electronically controlled is a candidate to be fitted with fuzzy logic. At present, simple every day microprocessors are used and fuzzy logic software is designed for specific applications. However, AT&T's Bell Labs has demonstrated the reality of dedicated fuzzy logic processor chips and there is much talk of marrying fuzzy logic with neural network computing in an effort to mimic human brain responses. Prospects for a fuzzy future are very exciting, but here's what the Japanese are enjoying right now:

Matsushita, better known for its Panasonic and Technics brand names has several house-hold



A Neuro-Fuzzy Logic vacuum Cleaner from Matsushita.

appliances which employ fuzzy logic. For example, there is the Aisaigo Day Fuzzy washing machine. Aisaigo literally translates into "beloved wife". The washing machine features no less than 600 washing cycles. The fuzzy controller relies on a battery of sensors to determine which one to choose. These check the size and weight of the wash load, how dirty the clothes are and what type of detergent is being used. It even takes into account what type of fabrics are being washed. All the user, or Aisaigo, needs to do is press one button and off it goes.

Matsushita's Canister 7 vacuum cleaner senses what type of floor surface it is cleaning, carpet or smooth surface, and coupled with a dust quantity sensor, suction power is varied accordingly. Often the cleaner decides that it can work at low power which saves energy and is a lot less noisy.

Also from Matsushita are fuzzy logic rice cookers, hi-tech kerosene fan heaters (which even detect the movements of people in a room) and microwave ovens.

Matsushita is already improving its fuzzy logic technology by replacing ordinary microcomputer with special processors tied into a simple neural network. These improved devices can handle more sensors and make more complex decisions. Buyers are already faced with the choice of first and second

generation fuzzy logic appliances from the company.

Mitsubishi's fuzzy logic air conditioners differ from conventional models by doing away with a simple thermostat. Internal, external air temperature and humidity are constantly evaluated and applied to a set of 50 fuzzy logic rules. Cooling power is varied progressively instead of being simply switched on or off by a thermostat. Mitsubishi not only claims users will enjoy better climate control but power savings of up to 25% can be expected.

Sony uses fuzzy logic to recognise hand-writing and calligraphy in its keyboardless portable or "palmtop" PTC 500 personal computer. This is an ideal application for the Japanese due to the nature of their writing. However, it has been reported that the system is sometimes prone to errors, especially when dealing with the rather more ambiguous Western alphabet. Sony has no plans to export the computer although that doesn't necessarily mean it won't develop a better version for the Western market in the future.

The most common fuzzy logic application is in camera auto-focus systems. Sanyo, Fisher, Ricoh and Olympus video camcorders use such systems to make focussing more reliable. An example is that once set, the subject in focus will remain in focus even if it moves



Matsushita's Neuro-Fuzzy Washing Machine.

about on the screen. Conventional systems would lose the subject if it strayed beyond a certain sensor boundary, usually in the middle of the screen. The idea is interesting, though it has to be said that camcorder reviewers have been unanimous in their opinion that it doesn't actually work that well.

Some camcorders also use fuzzy logic for setting recording colour balance. The system measures the ambient colour temperature and adjusts the camera's colour recording settings according to a series of pre-set rules. If it's a bit blue, the fuzzy logic program will warm the picture up a bit and vice versa, so to speak. Panasonic uses fuzzy logic in its latest hand-held camcorders which are so light they are very prone to camera-shake. A so-called digital image stabilisation system detects when the recorded image is suffering from shake and effectively restricts the region being recorded and with a bit of image processing masks the shaking effects. The premium is a loss of resolution, but some say it is visually quite effective.

## Sharp Cooking

Sharp caused quite a stir recently by unveiling its fuzzy-logic microwave oven. The unit incorporates a food processor and the systems relies on three sensors. An absolute humidity sensor checks the moisture content of vapours from the food being cooked. A weight sensor evaluates its mass. An optical sensor estimates the volume of food and its condition. This sensor also works in conjunction with the food-processor

section's chopping, stirring or kneading function.

The recipe for mashed potatoes using its RE-F1 microwave oven is: Cube the potatoes, place into the processing bowl, press 1 on the keypad to select "potato" and press the "fuzzy-cook" button. The user is then prompted to add certain ingredients and off device goes. The potatoes are stirred and mashed while cooking takes place – there's no need to remove it every now and then and manually mash. The system senses the texture of the mash and varies how vigorously it mashes. Sharp boldly claims the system can even detect different potato varieties and adapt accordingly. The Sharp RE-F1 can also make sauces, gravies, puddings and bread.

Fuzzy logic toasters sense the size of bread slices, the type of bread and its density and grill for a suitable time period for what should be perfect toast.

The Japanese are also designing fuzzy logic televisions. These will turn the sound up if ambient noise rises and change the brightness if the sun comes out or you turn the lights down. There's even talk of a viewer sensor; if you move to a different part of the room, the TV might decide to adjust the volume.

On a larger scale, Toshiba has developed a fuzzy-logic controller

for its latest elevators. The system attempts to keep the waiting time for a lift to arrive at a minimum. It's so impressive that rival electronics giant NEC installed the system in its new Tokyo headquarters. You never need to wait more than 30 seconds for the lift there, even though the building is 43 storeys tall.

Omron, a big Japanese robot manufacturer reckons 20% of its product line will be fuzzy logic controlled by 1994. Dai Dan, a Japanese firm which is developing an intelligent building system, saw its share price surge on the Tokyo stock market after it announced fuzzy logic would be employed. That's how seriously the technology is taken in Japan.

It will be only a matter of time before fuzzy logic will be incorporated into electric razors, cars, home automation, hifi, lawn mowers, telephones – you name it.

One cruel commentator wondered if fuzzy logic was just a marketing ploy to regenerate Japanese consumer interest in mundane appliances. Some fuzzy logic applications certainly seem more successful than others and there are plenty of reports that fuzzy is certainly a fad. In the long term it looks certain to stay and we should soon get to enjoy the benefits of fuzzy logic on this side of the world as well. ■



Hand-held camcorders remove camera shake with fuzzy logic.

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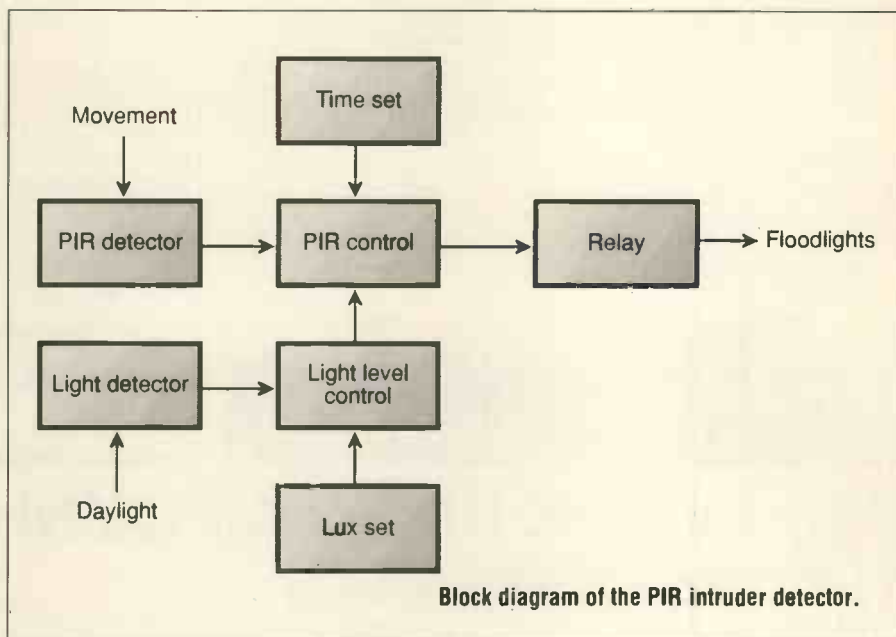
## IR Intruder Detector

Alan Benning pulls apart an infra-red movement detector to see what's inside. Illustrations by Derek Gooding.

One of the most common and effective security systems available is the Passive Infra Red Detector. This is a simple unit which senses a heat source within its vicinity and triggers a relay.

The system exposed on the opposite page has four main sections, the power supply, infra-red detector, light sensor and relay. The first is a simple unit comprising mains transformer and associated circuitry to produce a stabilised 12V supply. This is then connected through to the main PCB on which are mounted the light and infra-red detectors plus their controllers. The light sensor is a simple light dependent resistor which is used in conjunction with a detector to sense when the ambient light level has fallen below an amount set by the lux control – this decides when night has fallen and activates the infra-red detector circuitry. The aim of this system is to disable any alarms that occur during the day.

When activated, the passive infra-red detector (PIR) circuit will

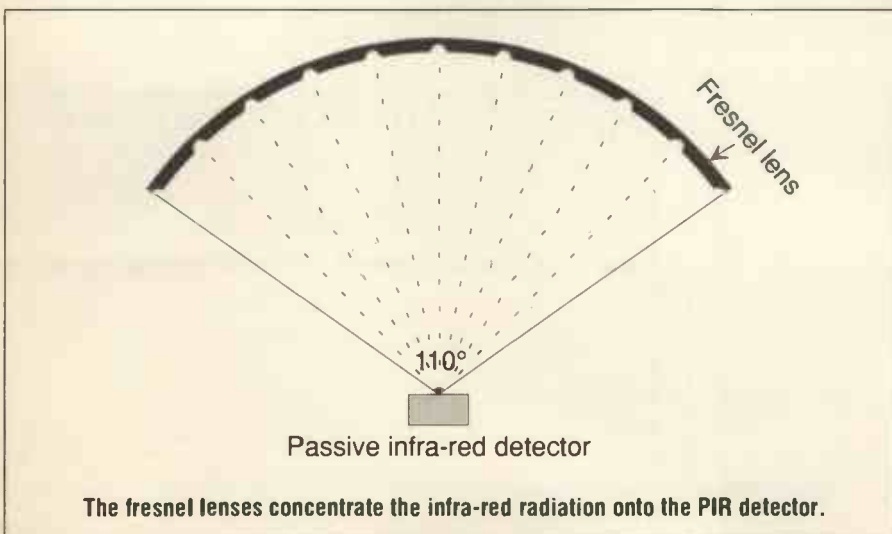


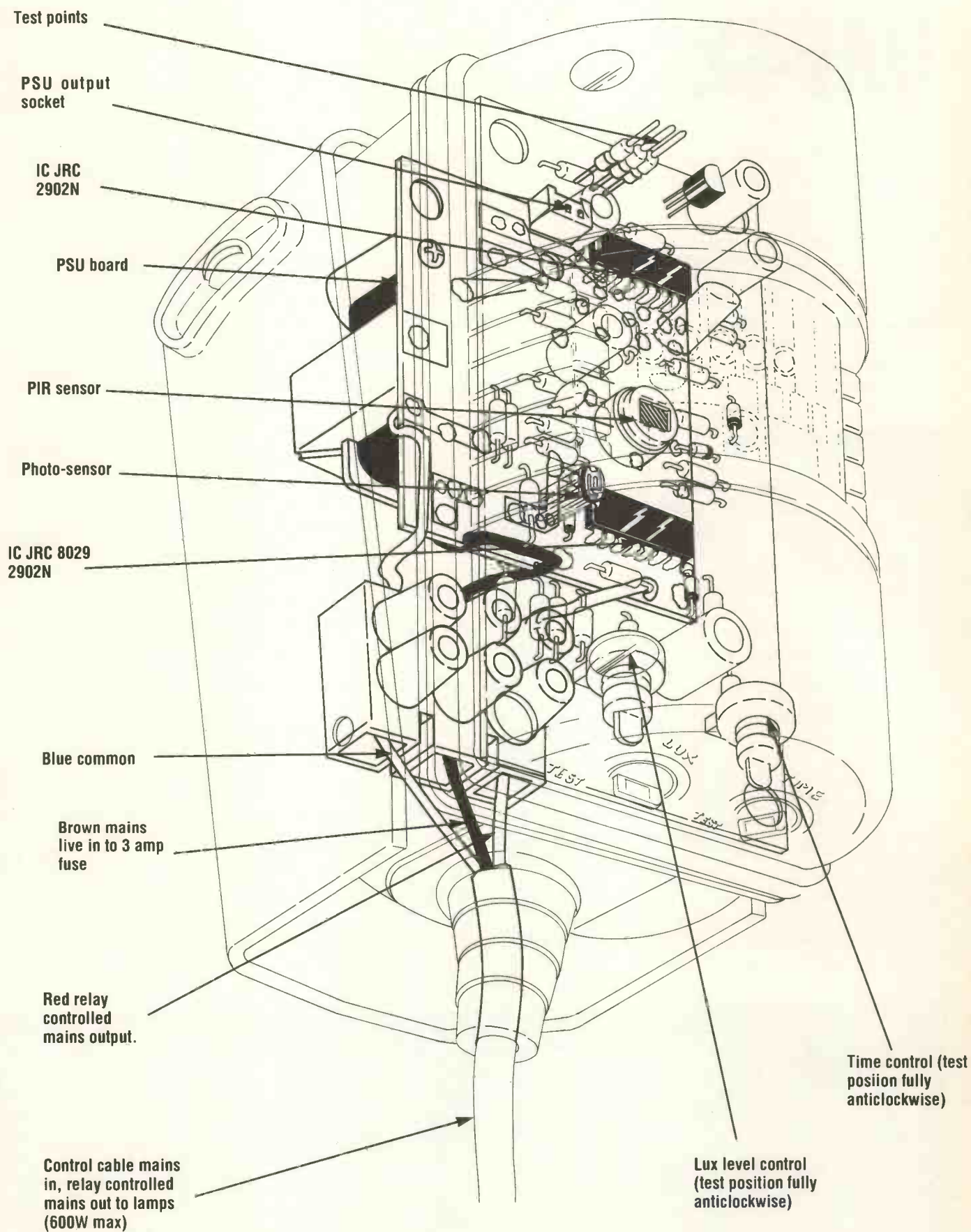
react to any change of temperature in the area under surveillance. The transformer driving section is then activated, turning on any external lighting in the circuit. A timing circuit is also triggered which keeps the relay activated for a time set by the Time control – in the example

system this can be from 5 seconds to 10 minutes.

The input to the PIR comes via a set of fresnel lenses. These are arrayed in two rows, the lower one of 9 and the upper of 10. This arrangement allows infra-red radiation to be picked up from two zones or distances from the detector and increases the sensitivity by concentrating the heat generated by any bodies in the field of view. Because the PIR has a flat sensor surface, it will only normally react to head on irradiation. The fresnel lenses are arranged in a semicircular pattern to give a field of view of about 110° and a range of about 12m. This give a total coverage area of approximately 10m x 10m.

In the system shown, the relay is able to drive up to 600W of power. This could be six 100W bulbs or any other combinations up to the maximum allowed power. ■





# Universal Active Filter

## UAF42

The UAF42 contains all of the op-amps, matched resistors and precision capacitors needed for a state variable filter pole-pair. It offers time continuous filters which are free from the switching noise and aliasing problems encountered with switched capacitor filters. The state-variable topology also provides low sensitivity to external component values, and simultaneous low-pass, band-pass and high-pass outputs.

### Software Solution

Designing and testing a filter is a long complicated process which Burr Brown's free filter design program, FILTER42 for the PC aims to circumvent. It produces designs for Butterworth, Chebyshev, Inverse Chebyshev, Bessel and tuned circuit filters.

A filter designed with the program is made up from a number of UAF42s, each of which can be set up in one of six formats (PP1 to PP6). All of the necessary components are specified by the program along with the various layouts.

On starting the program up, the response, type, order, frequency and bandwidth of the filter can be specified. Outputs are then available in the form of a graph of the response - both phase and frequency - and the necessary component values. Fig. 1 shows the setups for a band-pass filter of Bessel form with an order of 4, a centre frequency of 2kHz and a

bandwidth of 100Hz. Fig. 2 shows the graphical output and Fig. 3 the component values. Fig. 4 shows how the design should be laid out using two PP1 circuits.

As parameters are entered into the program it checks to see that they are valid and information on each parameter is also given to help the less experienced user. ■

### Filter types

#### Bessel

- +Best step response, very little overshoot or rippling.
- Slower initial rate of attenuation beyond the pass-band than Butterworth.

#### Butterworth

- +Maximally flat magnitude response in the pass-band. Good all-around performance. Pulse response better than Chebyshev. Rate of attenuation better than Bessel.
- Some overshoot and ringing in step response.

#### Chebyshev

- +Better attenuation beyond the pass-band than Butterworth.
- Ripple in pass-band. Considerably more ringing in step response than Butterworth.

#### Inverse Chebyshev

- +Flat magnitude response in pass-band with steep rate of attenuation in the transition band
- Ripple is stop-band. Some overshoot and ringing in step response.

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 USA

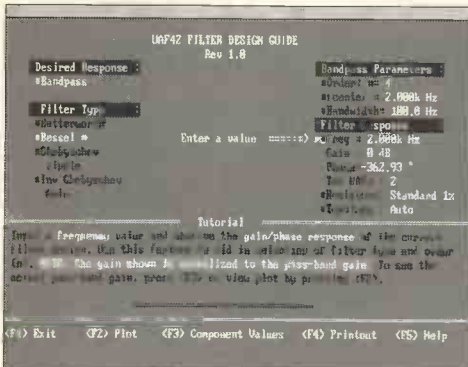
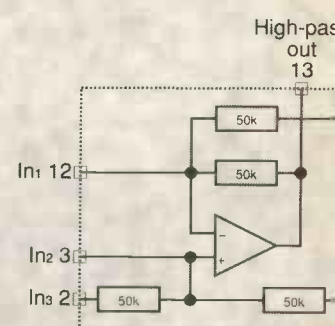
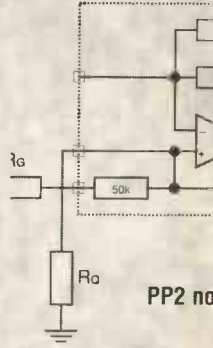
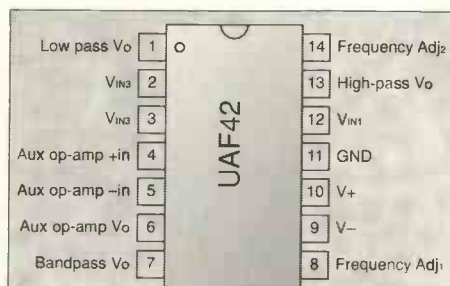


Fig. 1. FILTER42 setup screen.

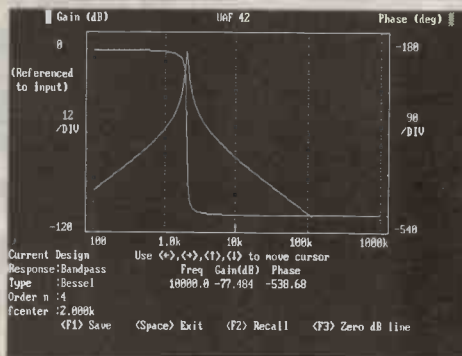


Fig. 2. Frequency and phase plot.

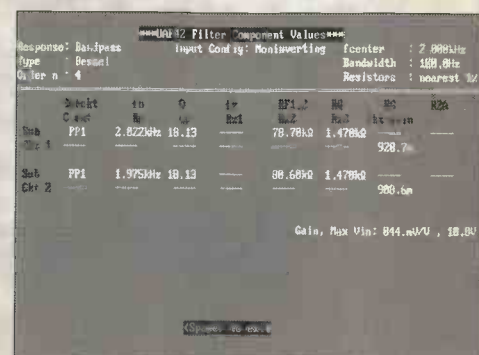


Fig. 3. Components for the circuit.



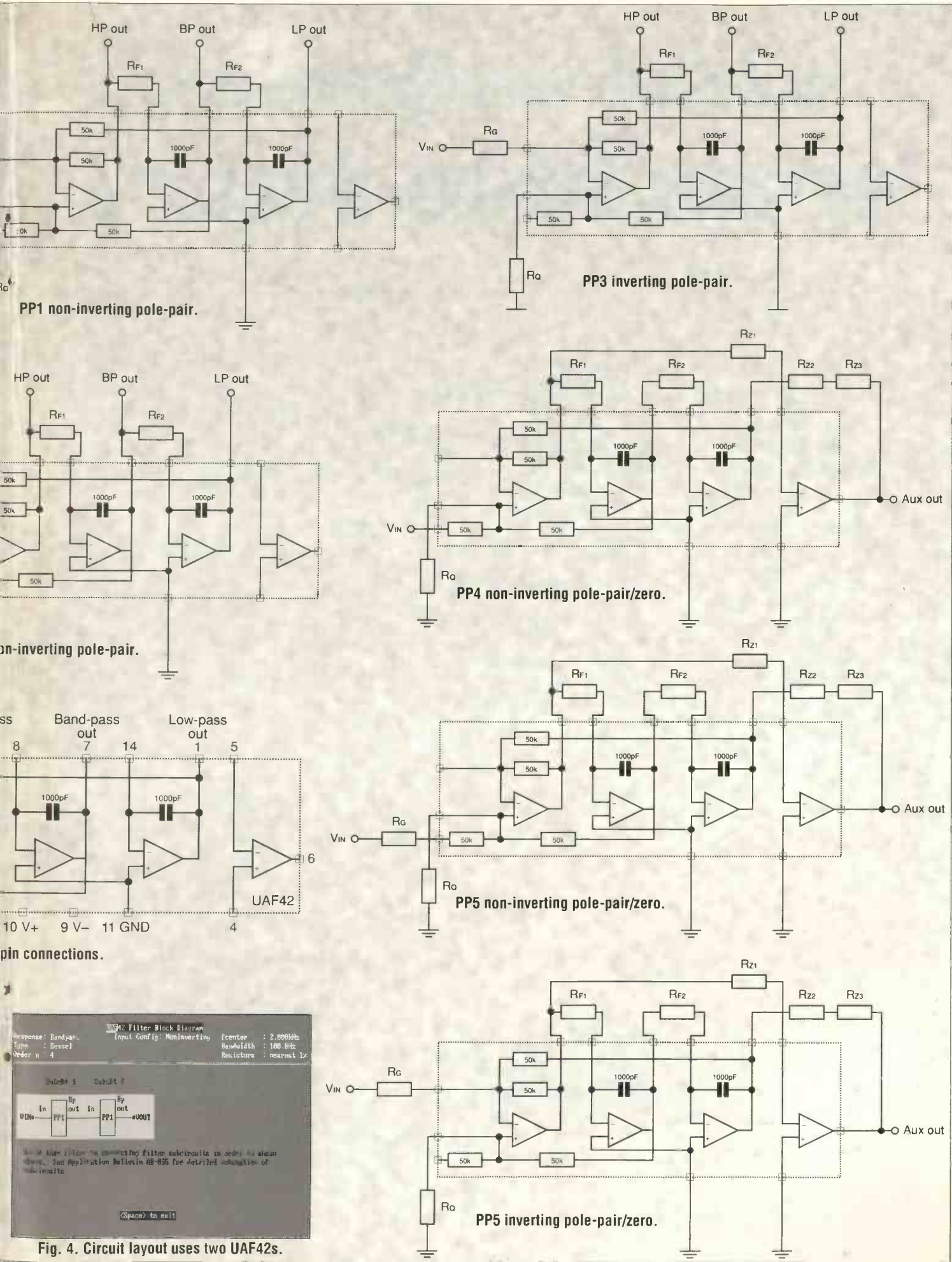


Fig. 4. Circuit layout uses two UAF42s.

# Practical Components: Surface Mount Devices

*Ian Poole explains the ins and outs of surface mount technology, how they are made, used and how to hand-solder them.*

Surface mount technology (SMT) and the associated surface mount devices (SMDs) have been available for a number of years. They have revolutionised the automated production of electronic equipment and opening up any modern domestic equipment will reveal quite a number of them.

## The Need

Surface mount technology came about through the need to make the mass production of electronic equipment easier to automate. Conventional components were difficult to use because the leads had to be inserted through holes in the boards. This required a high degree of precision and, sometimes, a little manual intervention.

The solution was to design components without leads, or in the case of ICs, more convenient leads. With the new technology resistors and capacitors could be reduced in size as could ICs and the fact that holes were not needed in the board reduced production costs.

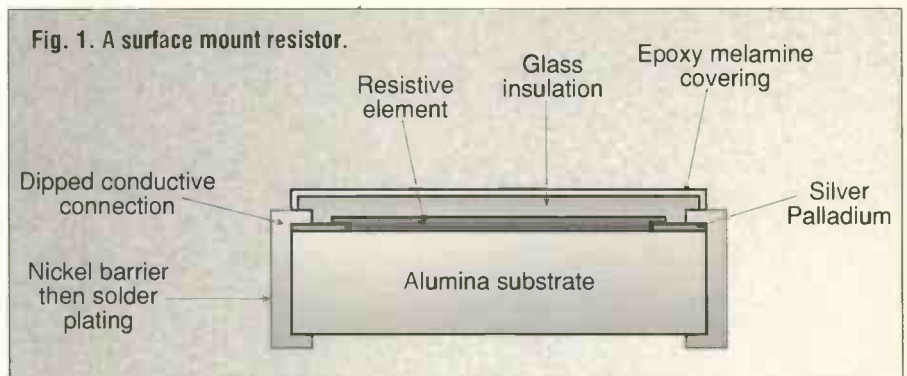


Fig. 1. A surface mount resistor.

## Automatic Assembly

Components are put onto the boards using "pick and place" machines. As the name implies these systems pick up the components and then place them onto the board in the correct place and orientation. In order to do this the machine has to be programmed with a new program needed for each different type of board. Fortunately, if the board has been designed using a computer aided design system then it is often possible to use the same data to generate the pick and place program.

To simplify the handling of SMDs, small components such as resistors and capacitors come packaged in large tape reels of several thousand items. Other components, like integrated circuits, come in tubes designed to be loaded directly onto the machine.

To keep the components in place before they are soldered, a small spot of glue is dotted onto the board at the desired position. Alternatively, solder paste can be applied to all the pads and used to hold the components in place before it is melted.

## Soldering

There are a number of ways in which boards with SMDs can be soldered. The most widely used is known as flow or wave soldering. Over one side of a large container a flow of molten solder is allowed to run. Boards which are to be soldered are mounted onto a conveyor line and moved over the solder waterfall so that the underside of the board touches the solder.

Whilst flow soldering is popular for conventional components as well as surface mount, it does have

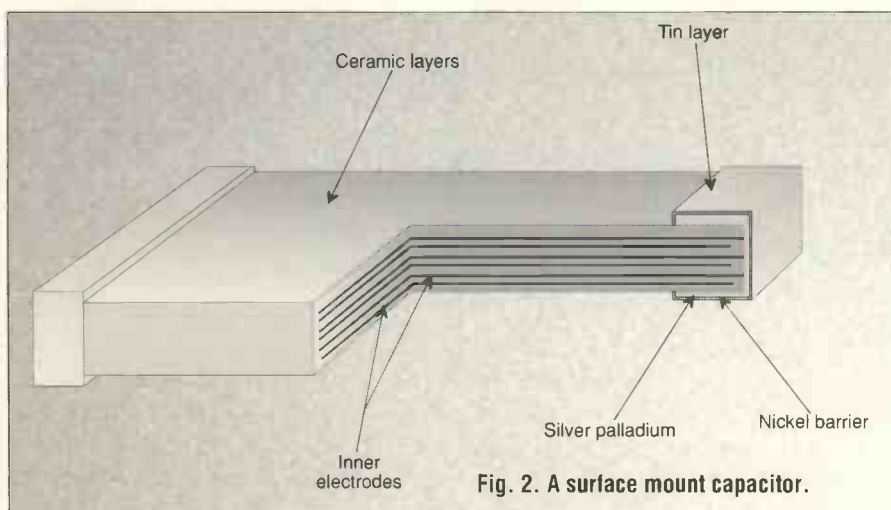


Fig. 2. A surface mount capacitor.

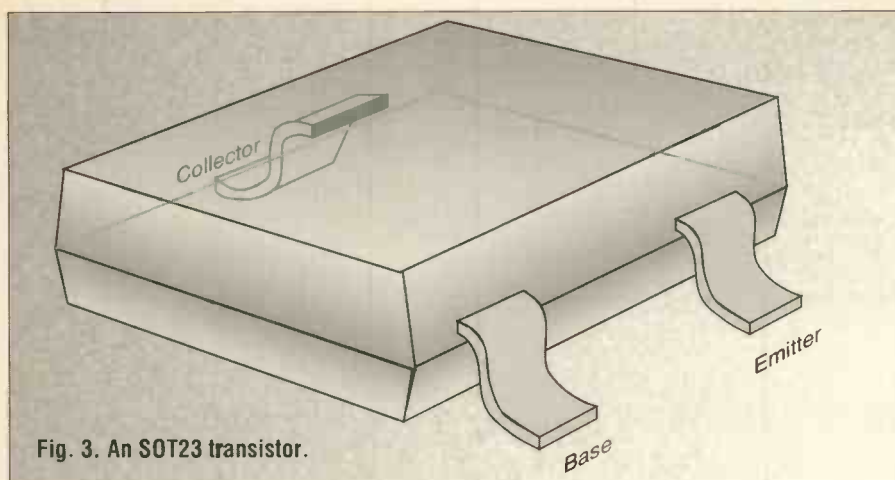


Fig. 3. An SOT23 transistor.

some disadvantages. It gives a large thermal shock to the components as they meet the solder and large components can shield or shadow other components preventing them from being soldered properly. To overcome this vapour phase solder has been devised. Loaded boards using solder paste are lowered into a container in which there is a boiling liquid. As the board temperature rises, the solder melts – the change in temperature is gradual enough to reduce thermal shock. Unfortunately, this method is not ideal as it is difficult to maintain a constant temperature over the whole board.

A third method now finding more favour is called infra-red reflow. Boards loaded with solder pasted components are passed through a series of infra-red heaters. These steadily raise the temperature of the board until the solder melts. The temperature can be controlled exactly and the rise is more gradual. It seems to be the ideal method for soldering SMDs.

## Hand Assembly

Whilst surface mount technology was initially devised for mass production, there is no reason why the devices cannot be soldered by hand. However, there are a few skills and tricks of the trade which have to be learned.

When building up a board the

components should be placed in position and then held in place whilst they are soldered. This prevents the surface tension of the solder from causing the component to stand on end when the first joint is made – an effect known as tombstoning (for obvious reasons).

Care should be taken not to hold the iron on the joint for too long, especially on ceramic capacitors. The reason for this is that the metallisation at the end of the component can be destroyed by keeping the solder molten in the joint for too long. Other components are less susceptible to damage, but as the components have no leads care should be taken to prevent thermal damage.

Another less obvious but equally important point to watch results from the lack of markings on the components. Capacitors in particular have no markings on them. Accordingly when circuits are being built up it is necessary to keep the components in their packs until they are to be used.

## Components

It is possible to obtain virtually all types of component in SMT packages these days. Resistors are available in two main sizes. One is called the 0805 and the other is the 1206. The 0805 size is almost standard within industry and it measures 2.0mm long x 1.25mm

wide and 0.5mm high and it can dissipate 0.1W. The 1206 is slightly larger at 3.2mm x 1.6mm x 0.6mm and it can dissipate 0.125W. Other sizes are available and the new 0603 devices which are even smaller than the 0805. Essentially the resistors are thick film devices held on an alumina substrate (Fig. 1).

Capacitors come in a variety of different types. The most widely used is the ceramic chip capacitor, which comes in a similar size to the resistors. They are made by putting a metallic layer onto a ceramic material with a number of layers being built up to give the required capacitance. The whole chip is then fired to give the basic capacitor and a further stage puts a contact onto each end. This is done by applying the metal and then firing the capacitor again to give a permanent connection. A basic capacitor is shown in Fig. 2.

Other capacitors, such as electrolytic, are also available and in the same way that the size of conventional electrolytics varies considerably, so do their SMT counterparts. Accordingly there is no real standard for them both in size and style of outline.

A number of different package styles for transistors are available, one of which is the almost universal SOT 23 shown in Fig. 3. Most are for the smaller dissipation transistors but even so there are a few SMT transistors which are able to dissipate a couple of watts.

For integrated circuits there are a couple of basic formations used for the leads. The first is called the gull wing and is currently the most popular. From Fig. 4 it can be seen how the name was derived. This type of lead is a lot easier to hand solder than the other types. An alternative is the J lead (Fig. 5.). It has the advantage that it takes up less board space, but the connections are not as easy to make, and the soldering process has to be exactly right if a minimum number of poor joints are to be made. ■

Fig.4. Gull wing package.



Fig.4. J lead package.



# Dealing With Very High Frequencies

Anthony Smith explains how prescaling can be used to examine very high frequencies in his universal counter timer project.

One of the tricks used in the Chronos to enable a chip with a maximum input frequency of 10MHz to read frequencies above 100MHz is prescaling. This is just a matter of dividing the frequency of the signal by the appropriate amount – preferably a factor of ten so that the scale just requires a movement in the decimal point.

The Chronos VHF input, channel C, is shown in block diagram form in Fig. 1. As with the other two channels, a protection circuit guards against high amplitude inputs. The VHF signal ( $F_{in}$ ) is fed to the amplifier which increases the sensitivity of the channel and brings the signal within the range of the prescaler. The prescaler itself is simply a specialised divider which reduces the input frequency by a factor of 100 such that the signal fed to the 7226A is a digital waveform of frequency  $F_{in}/100$ .

Fig. 2 shows the schematic diagram for channel C. The first, and, perhaps, most obvious impression is that it is simpler than channels A and B. There are no attenuators, no filters and no

trigger level controls. These are rather difficult and expensive to implement at high frequencies above 10MHz to 100MHz. In addition, most of the extra circuitry on the other channels helps with time measurements and are unnecessary with channel C where frequency is the only consideration.

The main thing to note about channel C is that it cannot tolerate mains overload.

## The Amplifier

The SL560C is an inexpensive, high frequency amplifier in an 8-pin DIL package. It has three high performance transistors configured to provide a common emitter gain stage followed by two emitter followers. The primary advantage of this device lies in its transistors which have a typical transition frequency of 1GHz. The theoretical gain however, was found to be significantly less than this. Nevertheless, the amplifier is essential to provide adequate sensitivity for the channel and provides ample gain up to 200MHz or more.

## Prescaling

A division factor of 100 is required to bring the prescaler within the range of the ICM7226A. The SP8629 (IC58) is a specialised device with the ability to extend UCT ranges up to 100MHz and 1.5GHz. It is an ECL (Emitter Coupled Logic) divider with a TTL compatible output. However, because of its high input sensitivity, the device can easily be configured to work in an analogue fashion and detect sinusoidal inputs as well as rectangular waveforms.

The prescaler features two complementary inputs and for the single input mode of operation employed in channel C, it is necessary to decouple the unused input, pin 6, with a resistor (R142) and capacitor (C80) to ground. The additional resistor results in a loss of input sensitivity but is necessary to prevent spurious oscillations under no-signal conditions.

This problem is unlikely to arise with the circuit of channel C but if oscillation problems arise, the value of R142 from 33k to 100k should remedy the problem.

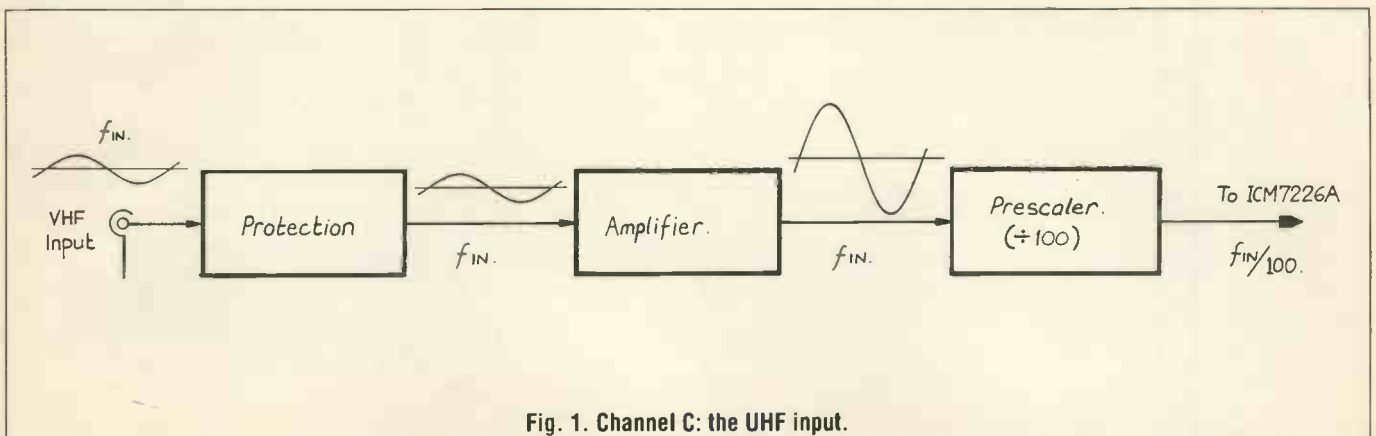


Fig. 1. Channel C: the UHF input.

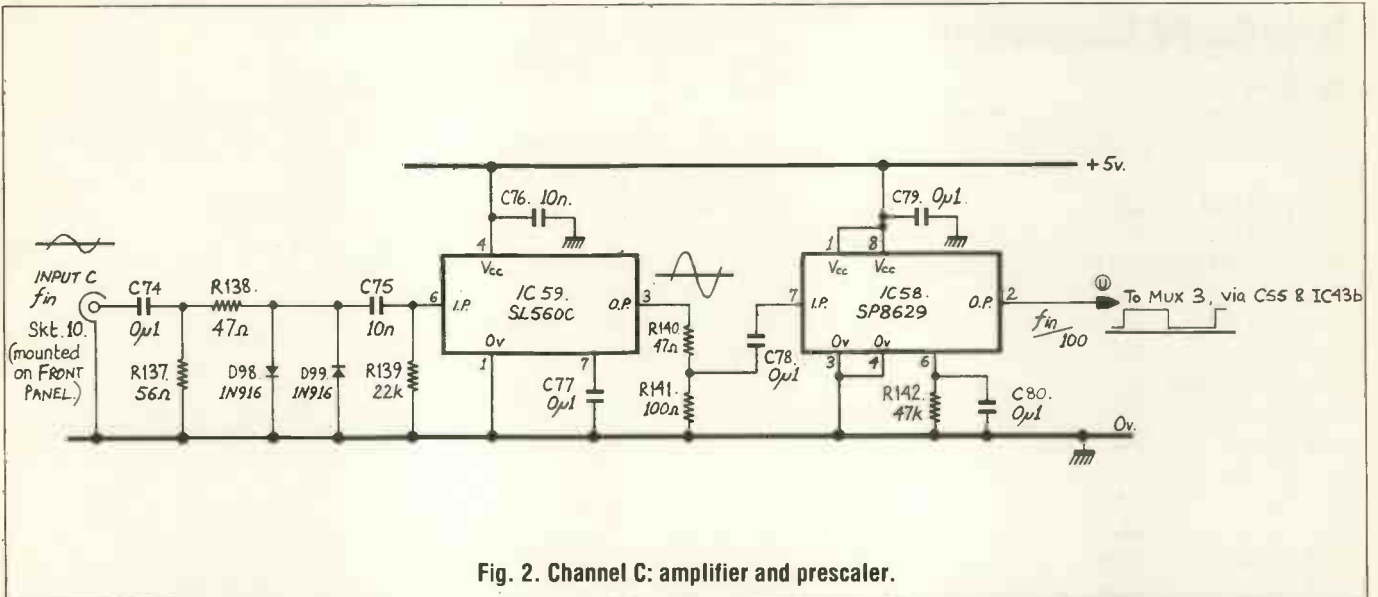


Fig. 2. Channel C: amplifier and prescaler.

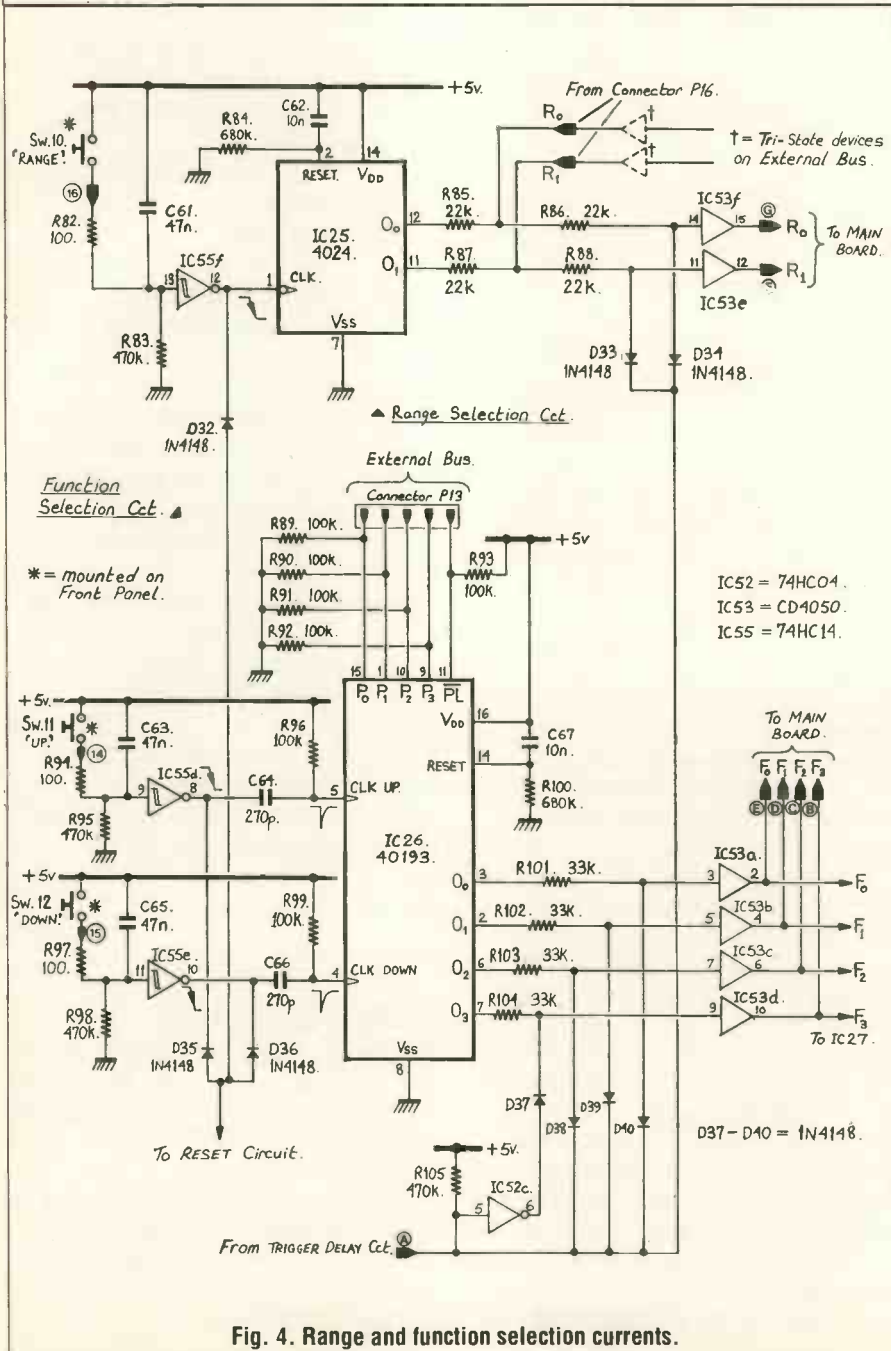


Fig. 4. Range and function selection currents.

### Prescaling Problems

The output of IC58 on pin 2 is fed to the ICM7226A via MUX 3, C55 and IC43b. The waveform itself is a digital signal of frequency  $F_{in}/100$ . Obviously, dividing the input frequency by 100 has an adverse effect on measurement resolution. The answer is to choose a long gate time – say range 3 or 4 – to boost the resolution.

### Constructing Channel C

Located at the edge of the display board, the channel C circuitry will not be touched until the rest of the board is constructed.

Locating the channel on the display board has several advantages. It avoids the need for a separate board, it sites the channel input very near to the front panel socket and, because the circuit is built on a complete ground plane, it ensures that the channel is well screened when sandwiched between the ground plane and the front panel.

### Chronos Architecture

The interrelations between the various digital sections of the UCT are shown in Fig. 3. The central block is, of course, the ICM 7226A located on the main board. The remaining digital elements are shared between the main and display boards.

Most of the blocks can be grouped into one of three categorie.

## Main Board Components

### Resistors

all 5%, 0.25W unless otherwise stated.  
 R43, R69, R76, R81 (if used)  
 560k  
 R44, R49, R78 10k  
 R45, R50, R71 4k7  
 R46, R52, R54, R55, R74, R152, R153  
 100k  
 R47, R48 (1%) 1k  
 R51, R53 220  
 R56, R57 (0.6W) 47  
 R58 (1%) 3k9  
 R59 (1%) 5k1  
 R60 (1%) 18k  
 R61, R77 1M  
 R62 68k  
 R63, R136 390k  
 R64, R72 470k  
 R66, R67 2k4  
 R68 (see text) 3k3 or 6k8  
 R70 33k  
 R73 220k  
 R75, R80 (if used) 680k  
 R79 (if used) 10M  
 R143 22  
 R144, R145, R146, R147 20  
 R148, R149, R150, R151 8k2  
 VR3 Dual gang 100k lin 20% or better

### Capacitors

C31 1 $\mu$  10V Tant  
 C32, C33, C38, C39, C56 100p 5%  
 axial polystyrene  
 C34, C37, C47 47n 5% polyester  
 layer  
 C35, C36, C51 2 $\mu$ 2 10V Tant  
 C40, C44 1n ceramic mylar  
 C41 120p 2% min ceramic  
 C42 150p 2% min ceramic  
 C43 100p 2% min ceramic  
 C45, C48, C49, C54, C60 (if used), C88,  
 C89, C90, C91 100p min ceramic  
 C46 390p axial polystyrene  
 C50 33p or 100p min ceramic (see  
 text)  
 C52 68n polyester layer  
 C53 680p axial polystyrene

C55 10n min ceramic  
 C57 33p 2% min ceramic (see text)  
 C58 22p 2% min ceramic (see text)  
 C59 56p 2% min ceramic (see text)  
 C81 100 $\mu$  16V radial elect  
 C82 3300 $\mu$  25V axial elect  
 C84, C85, C86, C87 100 $\mu$  25V rad elec  
 C92 100 $\mu$  10V min radial elec  
 VC4 5-65p Mullard "beehive" trimmer  
 808 series (see text)

### Semiconductors

IC9 74HC221  
 IC10 74HC74  
 IC11 74HC157  
 IC12 74HC76  
 IC13 74HC151  
 IC14, IC15, IC16, IC17 74HC251  
 IC18 74HC4046 or 4046B (see text)  
 IC19, IC21, IC22 74HC390  
 IC20 DIL 10MHz  
 xtal controlled oscillator (see text)  
 IC23, IC29 4052B  
 IC24 ICM7226A  
 IC28, IC30, IC31 4051B  
 IC33 7805C  
 IC34 4066B  
 IC35, IC40, IC43, IC46 74HC14  
 IC36 74HCU04  
 IC37 74HC86  
 IC38, IC42, IC44, IC48 74HC08  
 IC39, IC47 74HC32  
 IC41 74HC4050  
 IC45 74HC02  
 D11, D12, D15 to D21 inclusive, D23 to  
 D27 inclusive, D30, D96, D971N4148  
 D13, D14 Min red LEDs  
 D28, D29 1N916  
 D80, D81, D82 OA47  
 BR1, BR2 W005 bridge  
 rectifier

### Switches

S6 SPDT lever operation  
 S7 DPDT lever operation  
 S8, S9 SPST illuminated latching  
 pushbutton

### Miscellaneous

XTAL1 (if used) 10MHz quartz crystal  
 SK5, SK6, SK7 50 $\Omega$  BNC round  
 chassis socket  
 0.1in PCB connectors  
 P1, P2 17 way  
 P3 12 way  
 P4 10 way  
 P5, P6, P9, P11 2 way  
 P7 3 way  
 P8, P10 5 way  
 489 x 0.8mm through board track links  
 20 x PCB terminals  
 20mm fuses  
 F2 1A anti-surge  
 F3, F4 250mA antisurge  
 F5 50mA quick blow  
 8 x fuseclips  
 Heatsink 17 $^{\circ}$ C/W twisted vane type,  
 22x19x19mm mounted with IC33  
 IC sockets (low profile) 16 x 14-pin, 18  
 x 16 pin, 1 x 40 pin  
 6BA screws, nuts, lock washers, earth  
 tags (see text)  
 Potentiometer knob

### Mains power components

Sk 11 3 pin chassis socket 1.5A @  
 250V RMS  
 F1 20mm fuse, 250 antisurge  
 panel mounting 20mm holder for F1  
 S18 power on/off switch, square,  
 latching pushbutton 1.5A @ 250V RMS  
 T1 9V mains transformer rating 9VA  
 T2 12V-0-12V mains transformer rating  
 6VA  
 V1 250V RMS VDR (voltage dependent  
 resistor), mains transient supressor,  
 working voltage 250V RMS  
 Instrument case, Contil Classic II  
 (CL2CHL)  
 Hookup wire, earth wire, earth tags,  
 insulating cable, sleeving, co-axial  
 cable, spiral cable wrap, adhesive cable  
 clips, nuts and screws as per text.

Circuitry used to select the desired range or function, circuits which implement a particular mode of operation and circuits required to interconnect the various elements of the system as a whole.

## Display Board Circuits

The function selector circuit is operated by two pushbuttons and directs the blocks of the UCT to implement the desired measurement mode.

Depending on the particular function selected, it is necessary to route the input control and timing signals to and from various points within the system. This is achieved using multiplexers (MUX) which are electronic switches operated by a control signal.

MUXs 2, 3, 4, 7, 8 and 9 are all controlled by the function selection circuit. Note that this is also required to illuminate one of the 16 LEDs which indicates the choice of measurement and selects one of the five units LEDs appropriate for the

measurement being made.

## Range Selection

The range selection circuit is mainly responsible for routing the correct digital driver (D1 to D4) to the range input of the 7226A via MUX 6b.

The range chosen is indicated on one of the four range LEDs and, for certain functions, the range will also have a bearing on the external decimal point selected.

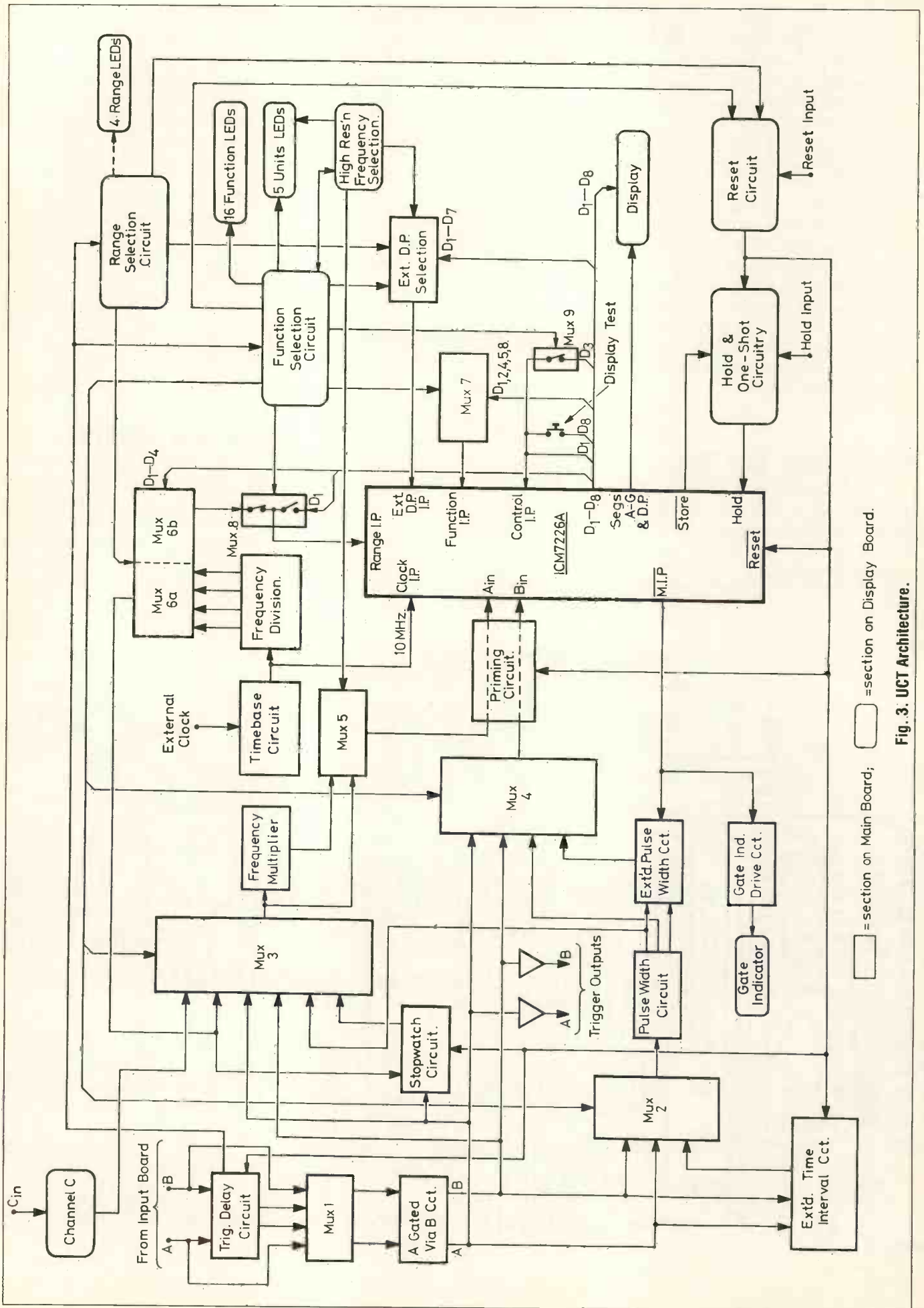


Fig. 3. UCT Architecture.

When the high resolution frequency mode is selected, MUX 5 is directed to route the output from the frequency multiplier to input A of the 7226A. The multiplier itself (located on the main board) is a phase locked loop which increases the input frequency by a factor of 100.

When selected, high resolution frequency is indicated in units of Hz and also requires a change in the decimal point position. Note, also, that because the high resolution mode is only relevant to modes one and two, there is a link to the function selection circuit which prevents the frequency multiplier affecting other functions.

### Reset, Hold, One Shot

The Chronos can be reset either by pushbutton or external signal. In either case, the reset logic sends a signal to various parts of the system. In particular the reset input

of the 7226A and to the priming circuit.

Note that the reset circuit is also linked to the range and function selection circuits so that a change of range or function will reset the system ready for a new measurement.

Like reset, hold is activated either by pushbutton or external signal. The one-shot section is closely linked to the hold circuit – both can be overridden by activating reset.

### Main Board Sections

After being processed by the input conditioning circuits, the signals from inputs A and B are fed to the trigger delay circuit on the main board. MUX 1 determines whether the signals are passed directly, or whether they are cleaned up first by the trigger delay section.

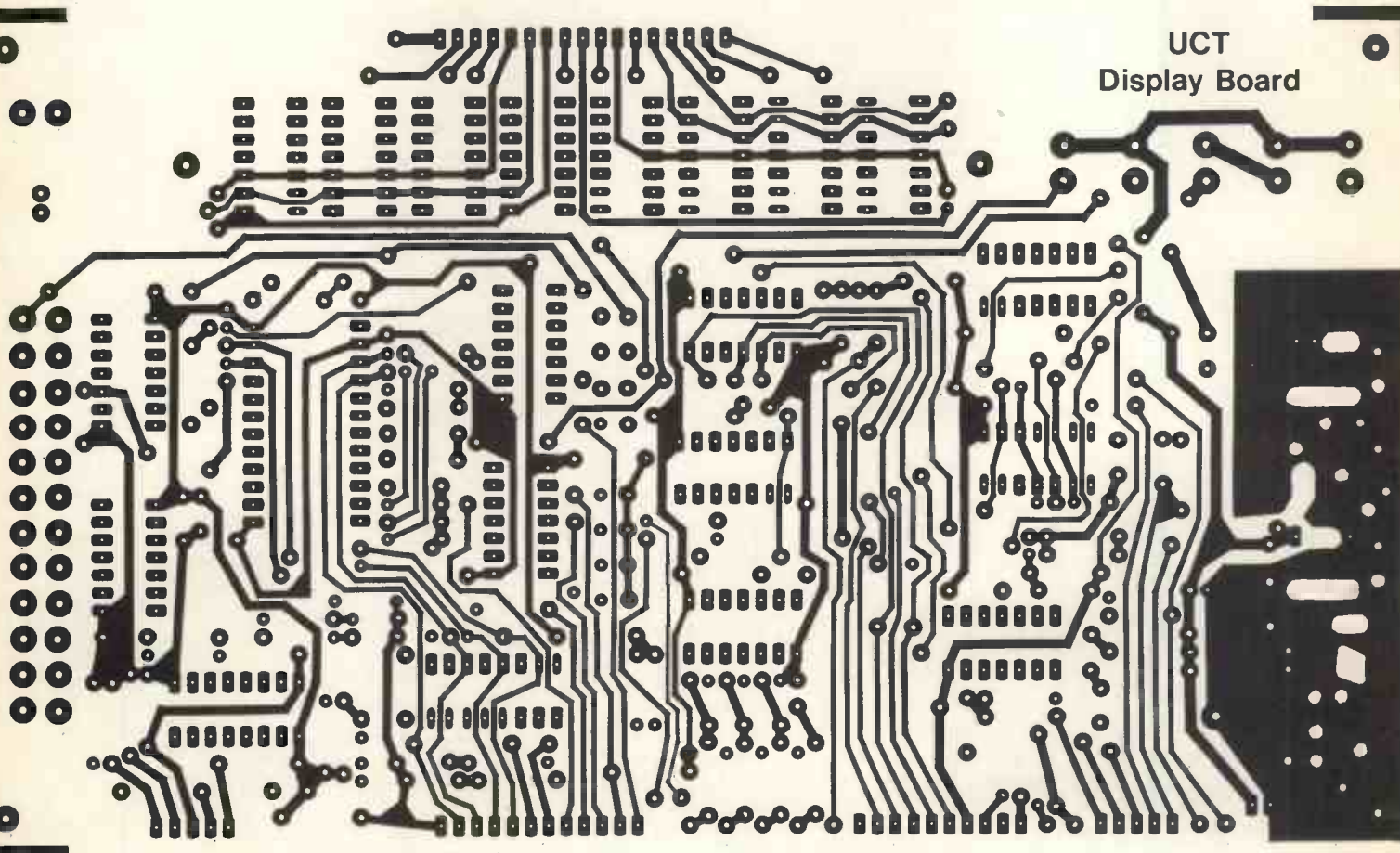
From MUX 1, the signals are fed to the "A gated via B" circuit when brought into operation, this circuit

allows the signal from channel A to be controlled directly by the signal at channel B.

The outputs from the A via B section are fed to various circuits on the main board and processed in different ways depending on the function selected. The outputs are also buffered and made available at the trigger outputs so that the digital forms of the Chronos' input signals can be viewed on an oscilloscope. This allows visual determination of the way in which the signals are processed and affected by input circuits, the trigger delay section and the A gated by B circuit.

### Range and Function

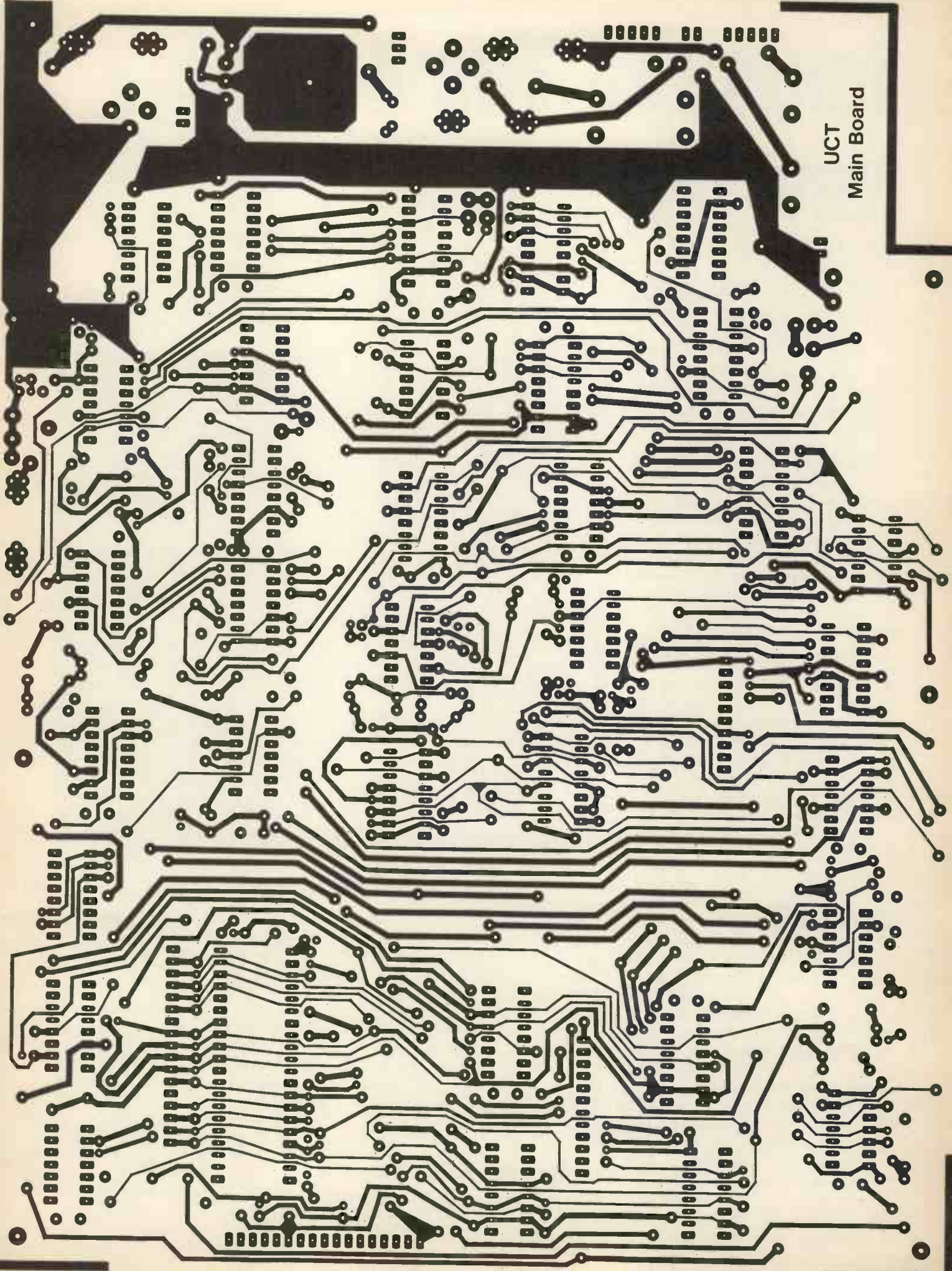
Fig. 4 illustrates the circuits used to select a particular range and function. At the heart of the circuit is IC25 a CMOS 7-stage binary counter. The function selector operates in a similar way. ■



UCT Display board first side.



UCT  
Main Board



UCT Main board bottom side.

# Taking To The Air In New York City

*David Jardine (G0FDV) discovers that Amateur Radio is big in the US, especially in New York where contacts from over 10 states can be made.*

It's the rush hour in New York City. Millions of commuters are leaving their offices in Mid-town and Down-town Manhattan – the "island" borough area that most people refer to when they talk of New York. Coming into the city is K2VKA. He is approaching the Lincoln Tunnel under the mighty Hudson River... and who is directing him in? None other than G0FDV. There are dozens of Hams on the air in the NYC region particularly in the rush hour – but imagine their surprise when they hear a man with a Hertfordshire accent guiding a native New Yorker into his city. We were using the very popular 2 metre band, I was static in Broadway and he was mobile, inside one of those "huge gas guzzling monsters" heading to meet me from New Jersey, via the New Jersey Turnpike. We were about to have a discussion on the finer points of Ham Radio Stateside.

## Central USA

I quite like New York City in some ways, it is a centre of commerce and culture for the USA and the rest of the world. You could spend literally weeks, seeing all there is to see, and doing all there is to do. As a Radio Ham it's even more interesting because you're in repeater-rich country, and if you use 70cms and 2 metres you have a choice of over 25 repeaters with which to transmit your signal through. I should add that many repeaters are strategically placed adjacent to or on top of some of the very tall skyscrapers in the city thus optimising the chance of solid



QSO's throughout the day and night. Seven of these repeaters are in the Manhattan area alone.

The beauty of New York for the radio ham is that you can walk all over with a pocket handheld transceiver and be given first class directions and information about the city by the helpful local radio amateurs. I recommend say, a dual band handie with a fair amount of RF power and powerful nicads to last you a few hours. You will have some absolutely memorable QSO's I guarantee.

## Getting Licenced

Here's some advice about obtaining your reciprocal licence which I thoroughly recommend you act on

if you're planning a visit.

Write to:

Federal Communications Commission, (FCC) PO Box 1020, Gettysburg, PA 17326, USA

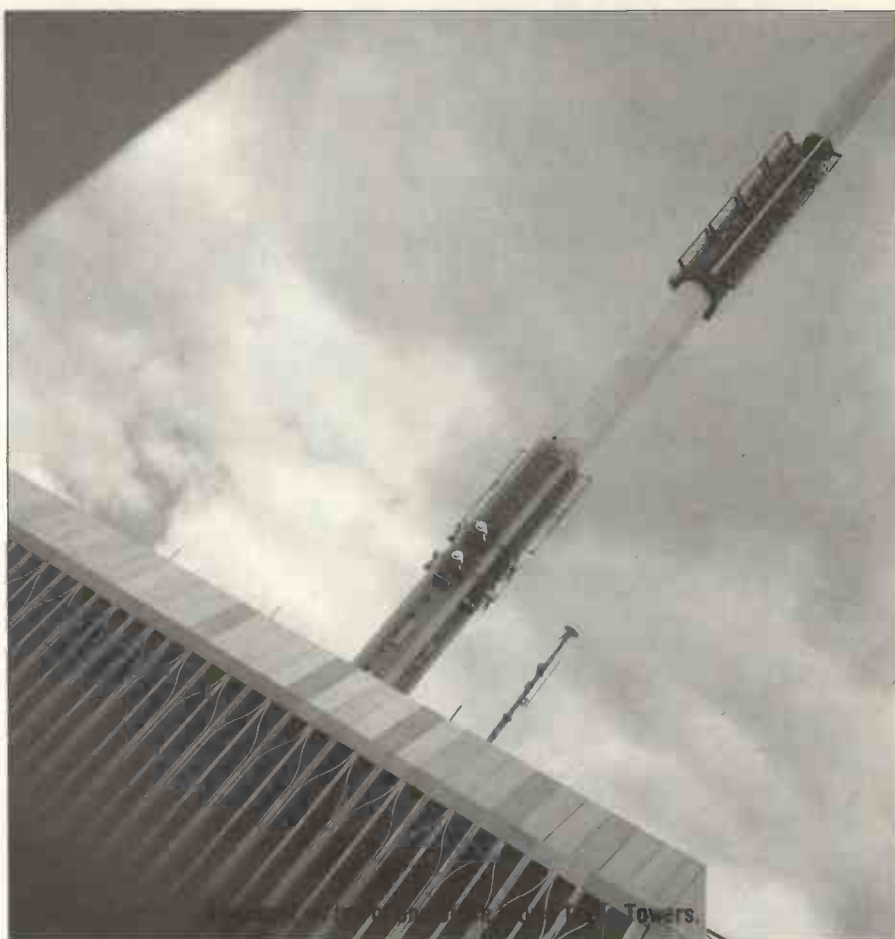
Can I also recommend a trip to the top of the Empire State Building? (Some 1200 ft above sea level). Take your dual band handie to the top, and just listen or put out a CQ. You'll be amazed especially if you give your location (in as strong an English accent as possible, of course). Signals on every repeater channel will probably come rolling in on 70cms and 2m – you can do this on the ground, but on the Empire State you'll hear them from many adjacent states such as: Pennsylvania Connecticut Washington New York (State) West

Virginia Massachusetts plus, Ohio, Maine, New Hampshire, Vermont, Canada and further while still in a lift.

In New York State there are an astounding 28,000 licensed Radio Amateurs, (the state, not the city I stress), and this is second only to California with an astounding 62,000 – approx 14% of the total US figure of almost half a million. So in the US Ham Radio is big business, when you compare it with a UK figure of 50,000. Because of this the main Japanese importers such as Yaesu, Trio and Kenwood have their own offices and warehousing facilities in the USA, which can facilitate after sales service and advice.

### Day Tripper

I mentioned briefly a trip around the New York City area and harbour (take your handheld VHF/UHF transceiver) on the famous Circle Line boat trip. Few realise the city is almost completely surrounded by water, being virtually on the Atlantic Coast. Its pollution problems are more confined to the major office areas in and between Mid-Town and Downtown Manhattan. The air on the boat trip and on the top of the Empire State seemed very fresh and clear, not at all what I'd expected. I did this trip on a beautiful sunny day recently, and I thoroughly recommend it to potential visitors. It all starts from Pier 83 adjacent to the famous moored World War Two battleship "Intrepid", which is now a fascinating floating US



Navy Museum. With this cruise there's 35 miles of sightseeing – and no tired feet or noisy traffic – you can always work Maritime Mobile (ask the Captain first, however). This is a cruise to remember, relax on spacious decks or in a glass covered salon as the scenery comes to you. Hundreds of famous sites are brought to life by the expert commentators who entertain you with facts, lore and humorous trivia. See it all in three

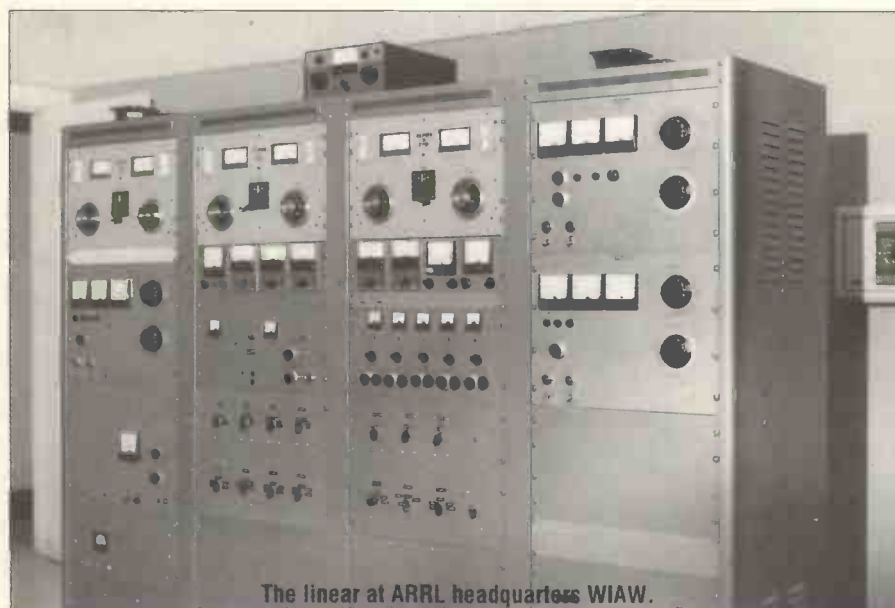
breeze filled hours – sights of important events in history and where the latest skyscraper is going up (or coming down), to change the most famous skyline in the world.

One final point. Just about a half day's drive by car or coach is the ARRL Amateur Radio Relay League, America's equivalent of the RSGB. They are a most helpful group and willing to show visitors around their set-up in Newington, Connecticut. The writer visited their offices and spent a most memorable day seeing the W1AW Memorial Station, as well as the amazing Antenna Farm – including beams for the 40 metre band. They have continuous transmissions around the world from their very powerful Amateur Transmitter, in both CW and Phone (SSB).

Should any reader decide to visit New York or the USA, and wish to visit any of the various Ham Clubs and the ARRL HQ, just write direct to:

ARRL Newington, Connecticut, CT 06111, USA

You'll find them most helpful, especially if you say you're from England. ■



The linear at ARRL headquarters W1AW.

# SURVEILLANCE EQUIPMENT

**PROFESSIONAL  
QUALITY KITS**

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all of our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

- UTX Ultra-miniature Room Transmitter. Smallest room transmitter kit in the world! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range.....£16.45
- MTX Micro-miniature Room Transmitter. Best-selling micro-miniature room transmitter. Just 17mm x 17mm including mic. 3-12V operation. 1000m range.....£13.45
- STX High Performance Room Transmitter. High performance transmitter with a buffered output stage for greater stability and range. 22mm x 22mm including mic. 6-12V operation, 1500m range.....£15.45
- VT500 High-Power Room Transmitter. Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range.....£16.45
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- QTX180 Crystal Controlled Room Transmitter. Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catalogue). Size 20mm x 67mm. 9V operation. 1000m range.....£40.95
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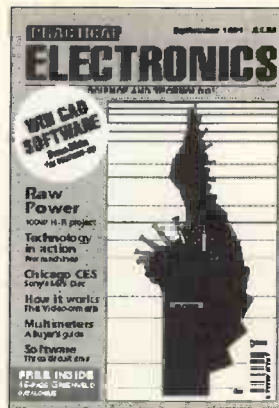
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# Samfex, A Digital Sound Sampling System

*John Becker's mini-sampler allows recording and playback of sound bites from two to 90 seconds in length.*

Sound samplers have been around for a number of years. However, they are generally complicated and require sophisticated programming. The Samfex is a simple unit that can be used as a stand-alone sound effects record and playback module, as well as in conjunction with a computer. The latter facility readily allows speech synthesis experiments to be carried out, but can equally well be used for much simpler purposes. For example, the computer can be used to add echo to the sampler's recording, or to reverse the recording so that it plays backwards.

Using a 32kbyte memory and a variable rate sampling clock, recordings of between two and 90 seconds can be stored. Either an EEPROM (Electrically Erasable Programmable Read Only Memory) or an SRAM (Static Random Access Memory) may be used interchangeably as the memory device, the former retaining recorded data even after power has been switched off.

## Logical Sound

The block diagram for the complete sampler is shown in Fig. 1. The functions marked with an asterisk can be omitted if the computer interface is not required.

Fig. 2 shows the circuit diagram for the signal input, data conversion and storage functions. Although a microphone is shown as the signal input source, the signal could equally well be brought in from other sources, such as a cassette recorder or Hi-Fi.

IC7a and its surrounding circuitry form a simple input stage

for which VR2 can set the gain to between  $\times 1$  and  $\times 100$ . From IC7a, the signal is taken to the analogue-to-digital converter (ADC) IC5. Between them, R3 and R4 set the voltage reference range to suit the maximum likely output swing from IC7a. IC5 is a high speed ADC which converts the analogue signal into an equivalent 6-bit digital binary code in response to each positive-going clock pulse received on its pin 7. The code is stored within the ADC and is only presented to the output lines when the chip's pins 5 and 6 are high and low respectively. Via IC2, pin 5 is under control of the master clock signal, the positive phase of which opens the ADC outputs at the same time that it sets the memory into read mode. Pin 6 is controlled by S3a which is used to switch between internal (INT) and

computer (CPU) control modes. The six output lines from IC5 are connected to the common bus connecting to the memory IC4, the digital-to-analogue converter (DAC) IC6 and to the computer's data port.

When the sampler is used independently, the master clock which controls the read, write and addressing functions is generated by the circuit around IC1a. C1, R1 and VR1 set the clock rate, the latter being a panel mounted control allowing for different record and playback rates to be set. With S3a switched to INT, gate IC2 is set to route input paths A0-A3 through to output paths Y0-Y3. The clock signal from IC1a pin 6 is routed via A2/Y2 to control the clocking of the ADC and the 12-bit binary counter IC3. The final output of IC3 (Q11) provides the clock signal to IC8, a

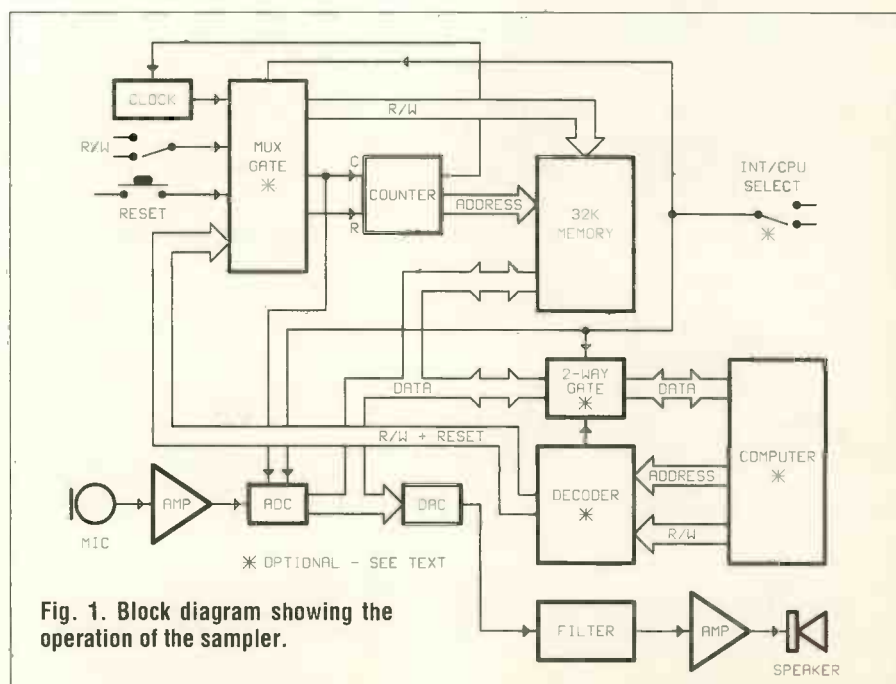
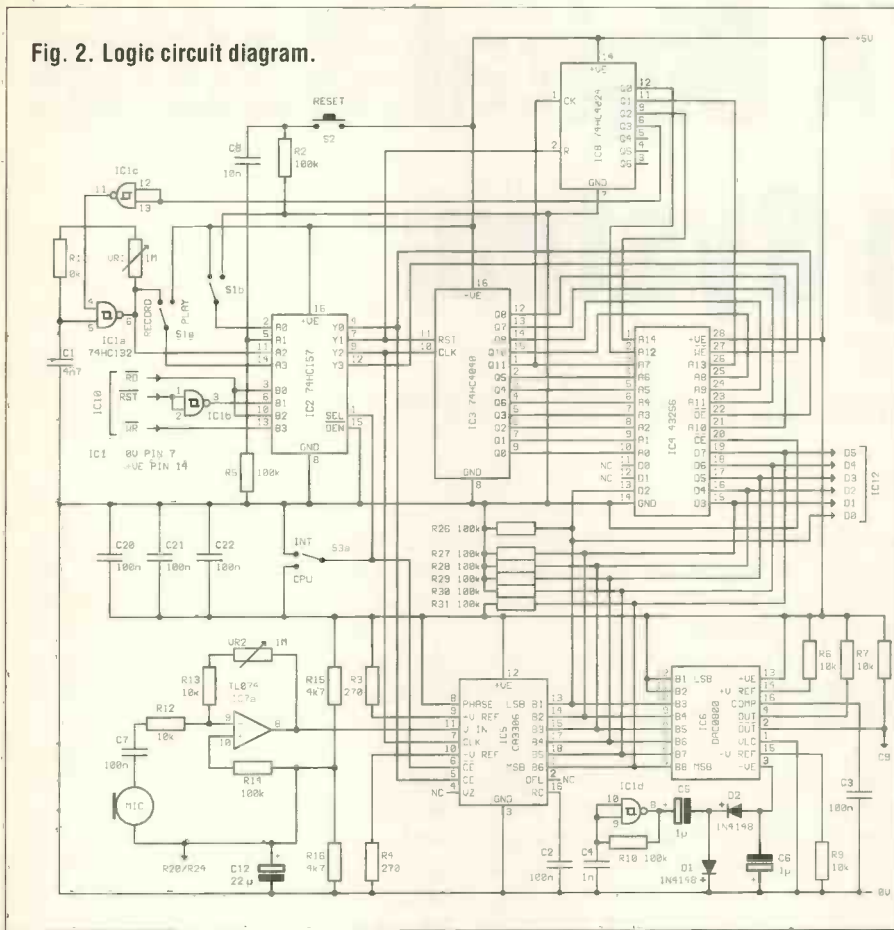


Fig. 1. Block diagram showing the operation of the sampler.

Fig. 2. Logic circuit diagram.



second binary counter of which only four outputs are used. Jointly, all outputs of IC3 and the first three outputs of IC8 provide the memory with the consecutive addresses at which data is to be stored or retrieved. IC8's fourth output, Q3, controls the switching on and off of the clock generator. When under INT mode control, the start of the counter clocking sequence is initiated by pressing S2. This generates a positive-going pulse across C8 which is routed via IC2 A1/Y1 to reset both counters. The resulting low output level from IC8 Q3 is inverted by IC1c, so setting

high IC1a pin 4 and allowing the clock generator to start oscillating. The count sequence proceeds until IC8 Q3 goes high on the 32767th clock pulse at which point IC1a pin 4 is forced low, switching off the generator.

In independent record mode, S1a switches the clock signal via IC2 A3/Y3 to pulse the read-write pin of the memory IC4. IC3 is clocked on by one place on the positive-going edge of the pulse and IC4 is set into write mode by a logic 0 clock level. S1b, via IC2 A0/Y0, controls the memory's output enable pin 22 and the ADC's chip

enable pin 5. In write mode, both are pulsed by the clock signal, whereas in read mode both are held low.

## Stepping Back

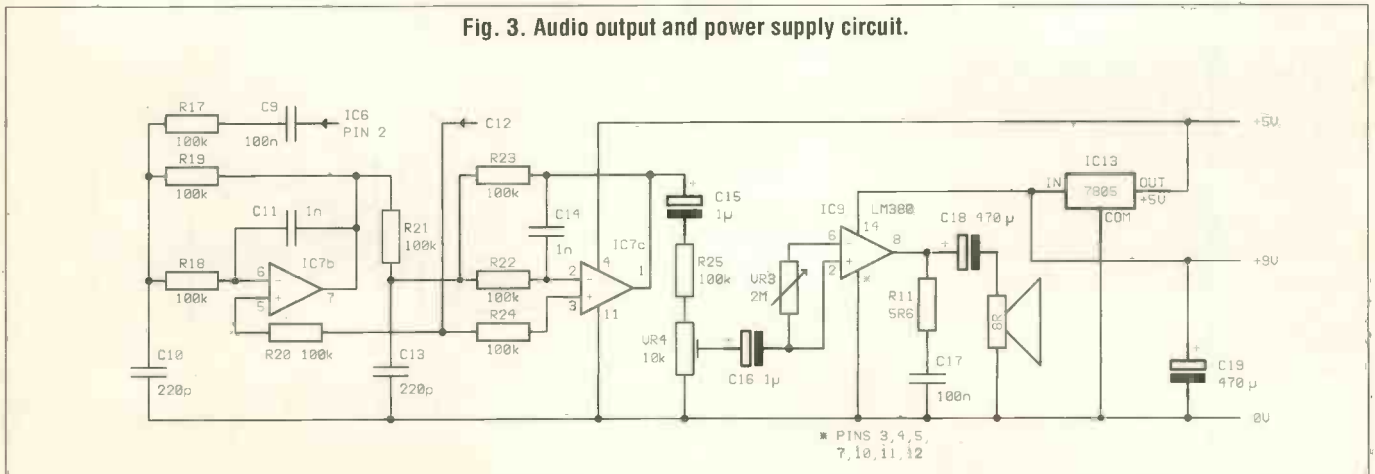
Once a sound effect or other audio signal has been recorded in IC4, it may be played back as many times as required, just by pressing the reset switch S2. The counters are clocked through the full address range and the recorded data within IC4 is put onto the common data bus to which the DAC IC6 is connected.

IC6 does not need a conversion clock pulse and the conversion of digital input data to an equivalent analogue output voltage is practically instantaneous. It does, however, need a negative bias voltage on its pin 9. This is generated by the inverter circuit around IC1d, which produces a non-critical voltage of around -3V. R6 and R9 set the current-controlled reference voltage range which determines the current produced at the differential outputs, pins 2 and 4. The outputs are loaded by R7 and R8 whose values determine the resulting voltage swing range. In this application, only the inverting output is used as the signal source feeding to the audio output circuit in Fig.3.

There are two sections to the audio output stage, a filter to smooth out the sampling waveform steps, and a power amplifier which drives a small loudspeaker.

Inherently, a sampled signal is made up of a number of discrete steps, each representing the voltage level present on the ADC's signal input at the moment its conversion process was clocked. The size of the

Fig. 3. Audio output and power supply circuit.



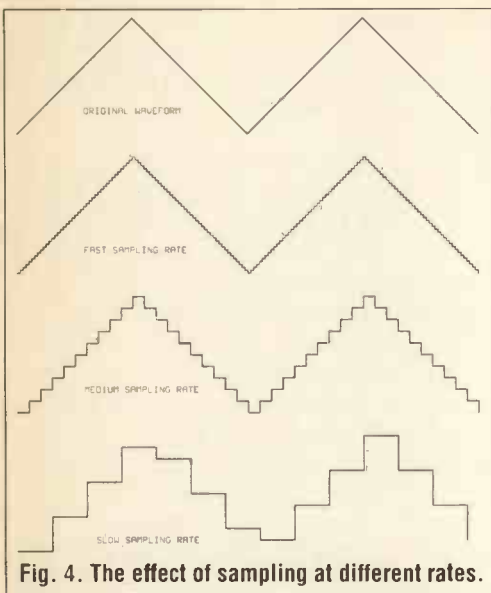


Fig. 4. The effect of sampling at different rates.

jumps in voltage between each sampled step depends on the signal frequency, its amplitude and the rate at which it was sampled. For the best audio results to be obtained with a digital sampling process, the sampling rate should be far greater than the signal frequency, and the number of bits into which the signal is coded should be as many as practical. Fig.4 shows typical examples of the results of sampling a given waveform at different rates. As may be expected from looking at the slowest rate, a lot of signal detail can be lost in the conversion, while unwanted harshness can be introduced by the steps. The detail cannot be reinstated once lost, but the harshness can be smoothed by filtering the signal. A by-product of the filtering, though, is that by setting the frequency characteristics of the filter to suit the largest, low frequency steps, higher frequency detail will be further lost in the process.

In a more sophisticated sampler, various additional processes would be included to minimise the quality loss. Such techniques include the use of pre-emphasis to enhance higher frequencies prior to digitising, anti-aliasing filters tuned to the sampling rate to reduce the effect of subharmonics caused by asynchronous signal/sampling rates, and the use of a compander to compress the signal before sampling and then re-expand it after conversion back to analogue.

With this mini-sampler, a compromise has been struck between frequency response, simplicity and maximum recording

time. Analogue processing of the reconstituted signal is limited to twin-bandpass filtering to take the edges off the sampling transients, favouring the higher sampling rates. All components in the signal path between the DAC and the output of IC7c affect the filter characteristics, though C10, C11, C13 and C14 are the principal bandwidth setters.

From IC7c the signal is routed to VR4 which presets the output level to suit the amplifier stage around IC9. The latter is a single-chip power amplifier conventionally configured to drive an 8-ohm speaker, with VR3 providing full-range volume control. It is capable of producing an output power of around one watt into eight ohms when supplied at 10V DC.

## Computer Interfacing

Placing the sampler under computer control allows the data stored in IC4 to be imported by the computer, processed and re-recorded into IC4. For this function, the computer needs to supply three control signals to be able to read from or write to six data lines. In CPU mode, S3a switches gate IC2 so that the control signals are routed along the B0-B3 to Y0-Y3 paths. Counter resetting is routed along the B1-Y1 path and requires a logic 0 level to be applied to the input of the inverter IC1b. Counter clocking and memory reading are controlled by the same negative-going signal applied jointly to paths B0/Y0 and B2/Y2. Writing to the memory requires a logic 0 level to be sent along the B3/Y3 path. Each write instruction must be preceded or followed by a read command to step the counter on to the next address.

Any data present on bus lines

D0-D5 will produce a corresponding analogue output voltage from DAC IC6. However, unless the computer sampling rate is in a similar range to the unit's original sampling rate, the DAC's output changes will not be perceived as recognisable audio signals, although there may be random sounds emitted from the speaker. To minimise the generation of random noise during periods when all devices on the unit's data bus could be in a high impedance state, including the computer data port, R26 and R31 have been included to force the binary code for decimal 32 onto the bus. This sets the DAC output to a mid voltage level when the bus is otherwise unloaded.

Some computers will be able to interface directly to the unit without additional circuitry. Those having an 8-bit parallel user port with an additional output handshake line should be suitable, such as many of the BBC and Commodore varieties. IBM-compatibles require an additional interface circuit to decode the addresses necessary for matching the unit to the CPU data bus. With this type of computer, hex address block \$0300-\$031H (decimal 768-799) is reserved for use by expansion cards, for which three or more identical sockets are usually provided. Several examples of different address decoding methods of varying complexity have been shown in recent PE issues. The circuit in Fig.5 shows another, simpler method in which the decoding is limited to the extraction of two 16-bit address code blocks.

In Fig.5, IC11 is a 3-to-8 line decoder with additional chip-select inputs. It is directly under control of CPU address lines A4-A6, A8 and A9, and via OR gate IC10a

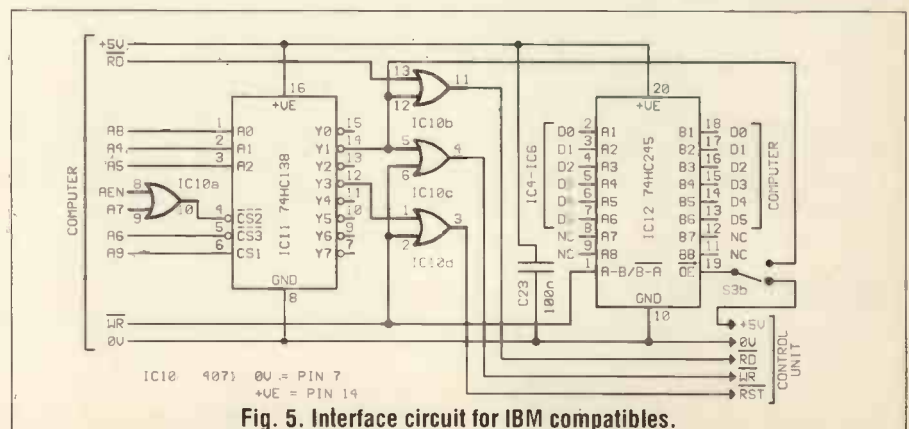


Fig. 5. Interface circuit for IBM compatibles.

```

100 REM SAMFEX EXAMPLE
110 REM SWITCH S3 TO 'INT' BEFORE
120 REM RUNNING THIS PROGRAM
130 CLEAR:CLOSE #1:CLS
140 LOCATE 10,22
150 PRINT "SET S3 TO 'CPU' ";
160 PRINT "THEN PRESS ANY KEY"
170 AS=INKEYS:IF AS="" THEN 170
180 DIM A$(128)
190 REM INPUT DATA FROM SAMPLER
200 PRINT:PRINT "INPUTTING DATA"
210 OUT 784,0:FOR A=1 TO 128:PRINT A:
220 FOR B=1 TO 255:C=INP(768) AND 63
230 A$(A)=A$(A)+CHR$(C+64)
240 NEXT:PRINT
250 STOP
260 REM ADD ECHO AND RETURN TO SAMPLER
270 PRINT "OUTPUT DATA WITH ECHO"
280 G=5:OUT 784,0
290 OUT 768,32:FOR A=1 TO 128
300 PRINT A:;FOR B=1 TO 255
310 C=ASC(MID$(A$(A),B,1))-64
320 IF A<G THEN 360
330 J=ASC(MID$(A$(A-G),B,1))-64
340 C=C+((J-32)/2):IF C<1 THEN C=1
350 IF C>63 THEN C=63
360 H=INP(768):OUT 768,C:NEXT:NEXT
370 PRINT:STOP
380 REM REVERSE ORDER BACK TO SAMPLER
390 PRINT "OUTPUT FOR BACKWARDS PLAY"
400 OUT 784,0
410 OUT 768,32:FOR A=128 TO 1 STEP-1
420 PRINT A:;FOR B=255 TO 1 STEP-1
430 C=ASC(MID$(A$(A),B,1))-64
440 H=INP(768):OUT 768,C:NEXT:NEXT
450 PRINT:STOP
    
```

Fig. 6. Example software.

indirectly under control of A7 and AEN (address enable). Calling any address between \$0300 and \$030F (decimal 768-783) causes IC11 output Y1 to go low, while calling any address between \$0310 and \$031F (decimal 784-799) causes Y3 to go low. Y1 is ORed with RD in IC10b and with WR in IC10c, controlling the unit's read and write lines. The reset line is controlled by ORing Y3 with WR in IC10d.

IC12 is included to isolate the unit's data lines from the computer bus when not actively required. It is an 8-bit bidirectional device with tri-state outputs. Pin 1 controls the data direction routing and is under the direct command of the computer's WR line, a high level setting pins A1-A8 as inputs and pins B1-B8 as outputs. A low level reverses the status of the A and B pins. Pin 19 when high puts the outputs into a high impedance state and is under control of switch S3b. Ganged with S3a, the switch holds IC12 closed while the unit is under internal sampling control. When under computer control, IC12 pin 19 is under the command of IC11 Y1.

## The Software

The Basic listing in Fig.6 shows examples of the way in which data can be input from the sampler, modified and returned. It is written

in GW-Basic but can be readily translated into other Basic dialects. Following the housekeeping commands between lines 100 and 170, the next section between lines 180 and 250 is concerned with inputting data from the unit's memory. Counters IC3 and IC8 are first reset by the command OUT 784,0 in line 210. In line 220, the command C=INP(768) AND 63 causes the data to be input in numeric form a byte at a time and ANDed with 63 to nullify the unwanted values of data lines D6 and D7. Each data input call automatically increments the unit's address counter. In line 230, data is converted to alpha characters and concatenated into 128 strings each of 255 characters in length. (The final 128 data bytes are ignored, but may be input by additional command lines if preferred.)

The routine between lines 260 and 370 shows how echo data can be added to the data now held in A\$( ) and returned to the unit's memory. In line 280, variable G holds the echo displacement factor, and OUT 784,0 resets the counters prior to data output. The looped commands in the next few lines take the equivalent value of an earlier string character, halve it and add it to the equivalent value of the principal character in the main loop. With the example shown the delay factor set by G is 1275 (255 x 5) bytes. Data bytes earlier than this displacement are left unchanged. The modified data is returned to the unit in line 360. Prior to sending each byte with the command OUT 768,C, the counter is incremented by the command H=INP(768). H is a dummy variable and serves no

other purpose. Repetitive echo effects may be enhanced by re-inputting modified data, further modifying it and returning again to the sampler.

The third section, between lines 380 and 450, sends the input data held in A\$( ) back to the sampler in reverse order. When the sampler is triggered in normal playback mode, the audio message or effect will be played backwards.

This program is not meant to be definitive, but is just to give an idea of what might be done with the sampler and a computer. Facilities, however, have not been provided to allow the computer to control the original sampling routine. The computer can only be used to modify an existing recording or, via software, create an original sound effect for outputting to the sampler. Once input to the computer and with S3 set to INT, data may be stored on disc for future use.

## Memories

The sampler can use either an SRAM or an EEPROM as its memory device. Regrettably, though, EEPROMs currently suffer from write-sluggishness and in an audio sampling situation there is a disadvantageous limit to the rate at which they can store data, although they are more than fastest enough for replay. The readily available Xicor 32K x 8-bit EEPROM type X28C256-25 has a typical write cycle time of 5ms (this is actually quite fast when compared to some other EEPROM types), although its typical read cycle time is a speedy 250ns.

In order to obtain a reasonable

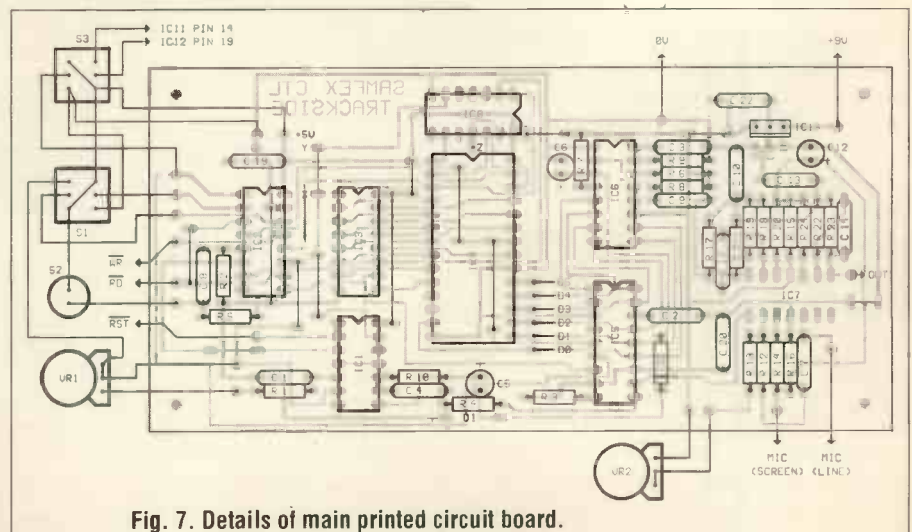


Fig. 7. Details of main printed circuit board.



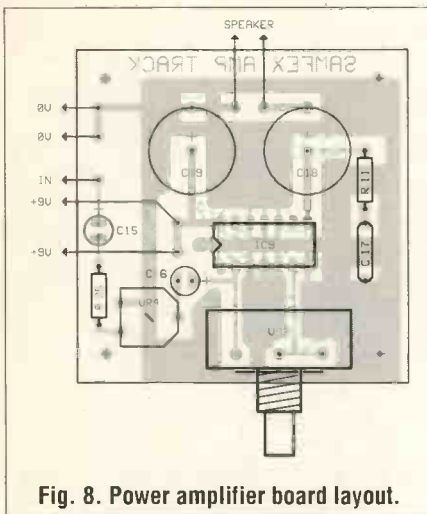


Fig. 8. Power amplifier board layout.

representation of a given waveform, the digital sampling rate should be at least three times the waveform frequency, and preferably higher. In music, although harmonics may extend into the ultrasonic range, broadly speaking the useful range for fundamental frequencies is 40Hz to 4kHz, the human voice having a maximum range of about 80Hz to 1kHz (bass to soprano). It will be apparent that using an EEPROM with write cycle time of 5ms, that the sampling rate is barely adequate to directly record even the deepest male voice.

The solution to providing the sampler with an audio signal held in non-volatile memory is to record into an SRAM, transfer the data to the computer and replace the SRAM with an EEPROM into which the data is then rewritten.

For some applications it is likely that an 8K x 8-bit EEPROM such as the X2864 will offer adequate memory storage. The X2864 is pin compatible with the X28C256 except that pins 1 and 26 of the former have no function. If preferred, the unit's sampling length may be shortened to 8K by connecting IC1c pins 12 and 13 to IC8 pin 12 instead of IC8 pin 6. The PCB design has allowed for this possibility.

## Making Up

The logic circuit requires a 5V DC power supply and this level should not be exceeded. The output amplifier stage can be powered by any DC supply between +8V and about +15V. It is suggested, though, that a +9V supply is used as the primary source, powering the output stage directly from it, but dropping it to +5V for the logic

circuit via the 7805 regulator chip IC13. The logic draws around 40mA, but the power amp can consume a fair amount more than this, depending on the output volume. Consequently, although a 9V battery could be used as the power source, a better solution is to use a 9V mains adaptor (sometimes known as a battery eliminator).

The main logic PCB and associated control wiring details are shown in Fig.7. Sockets should be used for all ICs and it is suggested that a ZIF (zero insertion force) type should be used for the memory if SRAM/EEPROM interchanging is anticipated. A fine tipped iron should be used for all soldered connections.

If a 32K memory is used, PCB points X and Y should be linked as shown. For an 8K memory, ignore point Y and link points X and Z. If the unit will not be used with a computer, S3 and IC2 may be omitted, although the following additional connections must then be made. At the IC2 position, link pin 2 to pin 4, pin 5 to pin 7, pin 9 to pin 11, pin 12 to pin 14. Link IC1b pins 1 and 2 to 0V. Link IC5 pin 6 to 0V.

The output amplifier has been put on a separate board, as shown in Fig.8. This allows readers to build and use additional copies of the amp in other situations. It is to this board that the 9V supply should first be brought, and then routed to the main control board. The amp board may be secured to the front panel by means of VR3's mounting bush.

With IC13 soldered into the main PCB, but before any of the other chips are inserted, connect the power supply and check that +5V is present at the output of IC13. If a higher voltage than this is found, check that IC13 is in the correct way round. If all is well, switch off and insert the remaining ICs. Set S1 to PLAY, S3 to INT, VR1 to minimum resistance (fastest sampling rate), VR2 to maximum gain, VR4 and VR5 to maximum volume, then switch on again. Check the output voltage of IC13. If it is significantly less than +5V the PCB should be closely examined for overlooked shorts between tracks. Check, too, that a negative voltage of around -3V is present at IC6 pin 9.

At the moment of switch on, buzzing or clicking noises should be heard from the speaker, due to the

address counters initially cycling the memory through its contents, which at this stage are purely random. This may be checked by pressing the reset switch S3 to again trigger the playback cycle. Now set S1 to RECORD, press S2 and immediately start speaking into the microphone. A faint echo of your words should be heard from the speaker while the recording cycle continues. At the end of the cycle, switch back to PLAY and again press S2, whereupon the recorded message will be heard. Experiment with different settings of the signal level and rate controls, noting in particular how recordings made at one speed can be substantially changed in pitch by playing back at different speeds.

The computer interface PCB details are shown in Fig.9. This is a double-sided board and its correct orientation in the computer expansion socket should be verified against the computer manual. To check this board, set S3 to INT, switch on the unit, then switch on the computer. If the computer fails to respond as normal, immediately switch off both units and check the boards for assembly errors. Load the software example, record a message into the sampler and then run the data input routine, lines 100-250, switching S3 to CPU when prompted. (The computer may fail to respond correctly if S3 is switched to CPU at any time other than when prompted to by the program.) When the program stops at line 250, instruct the computer to CONTINUE, whereupon the echo creation routine of lines 260 to 370 will be performed. When the program stops at line 370, switch S3 back to INT and press S2 to play back the modified message. ■

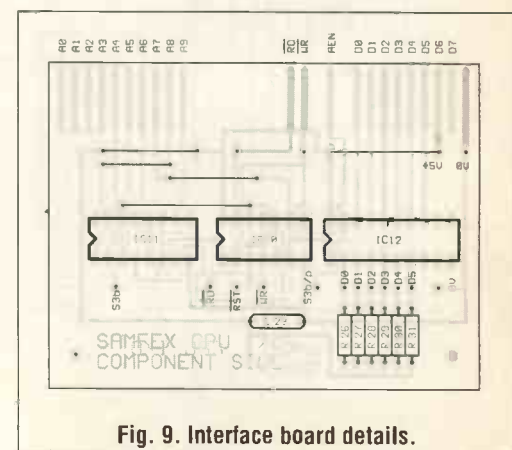
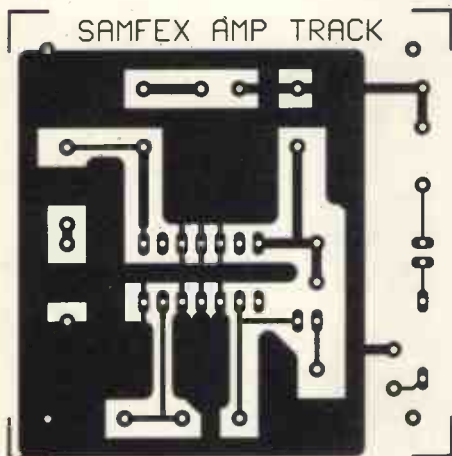
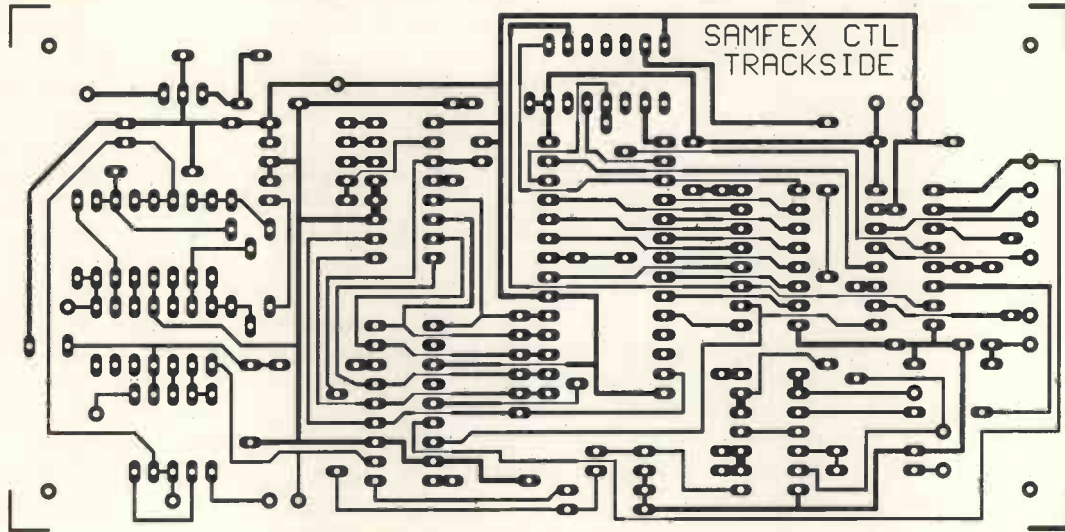
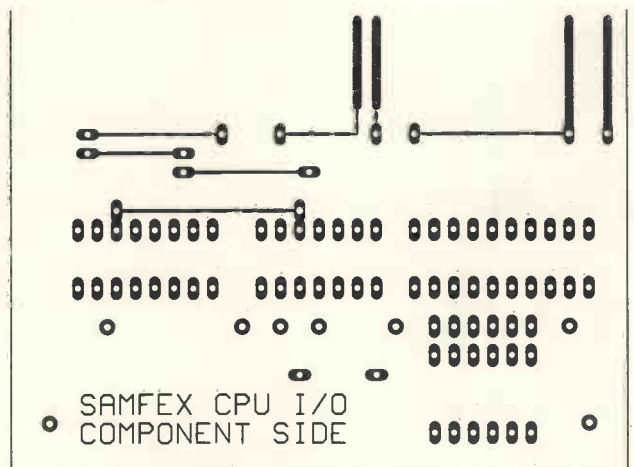
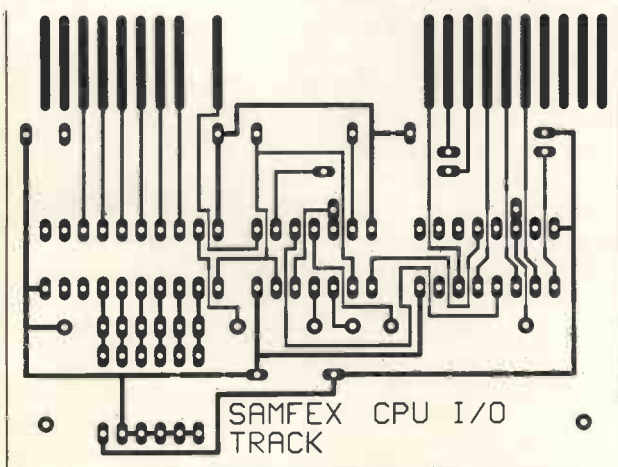


Fig. 9. Interface board details.



**COMPONENTS**

Resistors		EEPROM (see text)	
R1, R6-R9, R12, R13	10k	IC5	CA3306
R2, R5, R10, R14, R17-R31	100k	IC6	DAC0800
R3, R4	270R	IC7	TL074
R11	5R6	IC8	74HC4024
R15, R16	4k7	IC9	LM380
All 0.25W 5% or better		IC10	4071
Capacitors		IC11	74HC138
C1	4n7 polystyrene	IC12	74HC245
C2, C3, C7, C9, C17, C20-C22	100n polystyrene	IC13	7805
C4, C11, C14	1n polystyrene	Potentiometers	
C5, C6, C15, C16	1µ 16V electrolytic	VR1, VR2	1M lin rotary
C8	10n polyester	VR3	2M log rotary
C10, C13	220p polystyrene	VR4	10k min skeleton preset
C12	22µ 16V electrolytic	Switches	
C18, C19	470µ 25V electrolytic	S1, S3	DPDT min toggle
Semiconductors		S2	SP push-make
D1, D2	1N4148	IC Sockets	
IC1	74HC132		14-pin x 5, 16-pin x 4, 18-pin, 20-pin, 28-pin (see text)
IC2	4HC157	Miscellaneous	
IC3	74HC4040		Printed circuit boards, PCB supports x 4, knobs x 3, small 8 ohm speaker, box to suit.
IC4	43256 SRAM/X28256		





# HAPPY MEMORIES

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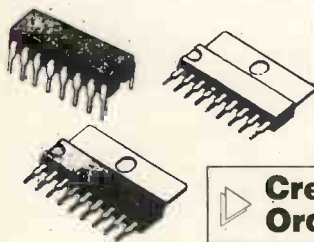
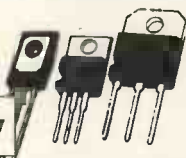
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# Techniques

Andrew Armstrong explains aerials, frequency response and solar cells.

Reader David Mugford from Hereford, writes: why do some television aerials have more structural elements than others? This might sound like a very simplistic question, but I do not know a great deal about aerials, and would appreciate an explanation.

One might regard the basic "standard" aerial as a dipole. The dipole aerial, normally a half-wavelength from end to end, receives signals arriving normal to its long dimension, but not signals arriving at its ends. Thus, in three dimensions, the reception/radiation pattern of a dipole is toroidal.

The radiation and reception pattern (the two are identical and I will refer just to the radiation pattern in this article) of a dipole is illustrated in Fig. 1. The efficiency of reception is related to the angle between the aerial and the direction of the signal, with  $e_I$  and  $e_M$  representing received signal strengths for different angles.

For reception of television and of FM radio, it is a disadvantage to receive signals in directions other than that of the transmitter. A television aerial with too broad a directional pickup would receive signals reflected off large buildings

or geographical features, as well as the direct signal. This gives rise to multiple images, commonly called ghosting. In the case of FM radio reception, distortion or loss of stereo information can result in some cases.

The most commonly used VHF and UHF directional aerial is the yagi aerial, whose typical radiation pattern is shown in Fig. 2. In this design, a reflector is placed behind the dipole element, and usually one or more directors are placed in front. The function of these elements is exactly as the name suggests: the reflector cuts reception from the rear while enhancing reception from the front. The reflector is always longer than the dipole. In some cases, instead of a single element reflector, a mesh or array of elements may be used.

The directors are always shorter than the dipole and their function is to concentrate the signal coming from straight ahead. The more directors the aerial has, the better reception it has from straight ahead, and the less from elsewhere. Television aerials with many elements can exhibit a gain, on axis, in excess of 10dB. In marginal areas this can make the difference

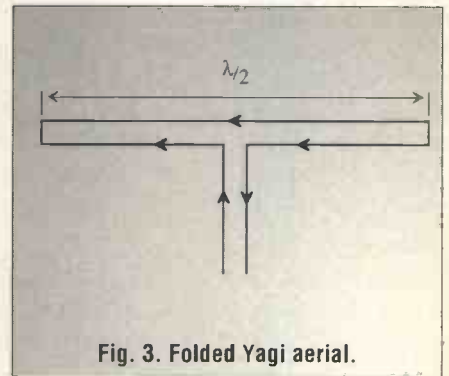


Fig. 3. Folded Yagi aerial.

between very poor and quite acceptable picture quality.

The dipole element of a yagi aerial is usually folded, as shown in Fig. 3. The addition of the extra elements affects the impedance seen at the centre point of the dipole, while folding it has the reverse effect. The aim of folding the dipole is to raise its impedance to 75 ohms to match normal coaxial cable.

A couple of peripheral points are worth mentioning: first of all, it has been found that the bandwidth of a yagi aerial is increased if the directors are not all the same length. It is for this reason that long television aerials sometimes have a tapered appearance.

Continued on page 57

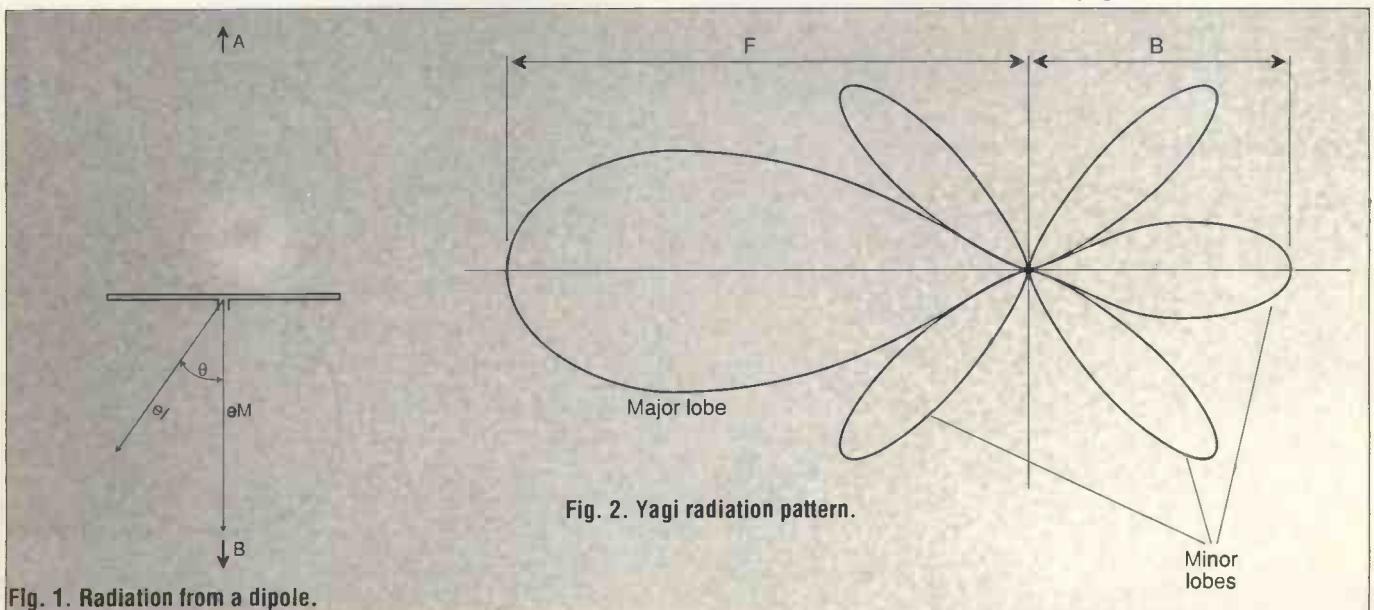


Fig. 1. Radiation from a dipole.

Fig. 2. Yagi radiation pattern.

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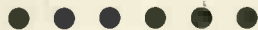
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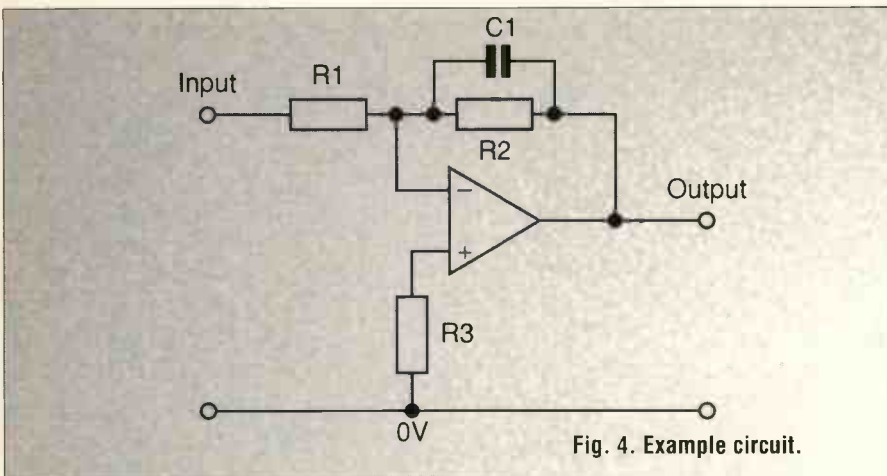
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◆ Continued from page 52.

The second point to note is that, for uhf television reception, loss in the coaxial cable is often a significant factor in determining picture quality. Poor quality, or cable which has been subjected to damp for a long period of time, may have so much loss that only stray pickup on the cable gives any reception at all. A symptom of this may be that the television reception is affected by people walking around the room despite the fact that a roof aerial is plugged in.

In less extreme cases of cable loss, an aerial preamplifier situated near the aerial may improve reception a lot, while a preamplifier situated near the tv set may make only a small improvement.

## A Frequent Response

I have had several queries over the years about how to determine the frequency response of circuits, and how to design a circuit with a specified frequency response. Taking one enquiry as an example, N Gharebeigui asks about two circuits, the first of which is shown in Fig. 1. He requests design equations and gain-phase vs frequency plots for the two circuits.

First of all, the philosophy: In engineering, it is often a good approach to ask what happens at the theoretical limits, sometimes beyond any practical limits.

Applying this to the circuit of Fig. 1, and assuming that the op-amp is perfect, we see that at the lowest possible frequency, DC, the gain is  $R_2/R_1$  because the capacitor plays no part. At a very high frequency, it is clear that the impedance of  $C_1$  must be negligible

compared with that of  $R_2$ , so that the gain will be zero.

A practical op-amp will give the expected DC gain (unless very large) to a close approximation, but is likely to have a significant offset. Part of the offset is normally caused by input bias current – which is where  $R_3$  comes in. To the extent that the bias current of each input is the same, the presence of  $R_3$  can be used to cancel any offsets arising from the bias current flowing in  $R_1$  and  $R_2$ . Assuming that  $R_2$  is driven from a source of DC low resistance, the value of  $R_3$  should be equal to that of  $R_1$  and  $R_2$  in parallel. As a reminder, the formula is:  $R_3 = R_1 \times R_2 / (R_1 + R_2)$ .

It is usually most useful to show frequency and phase response on a logarithmic graph, as shown in Fig. 2. The first point to plot is the low frequency gain, on the left hand axis. The graph is scaled so that the turnover frequency, at which the effect of  $R_2$  and  $C_1$  on the gain is the same, is at 100 units of frequency. What the units are (Hz, tens or tenths of Hz, does not

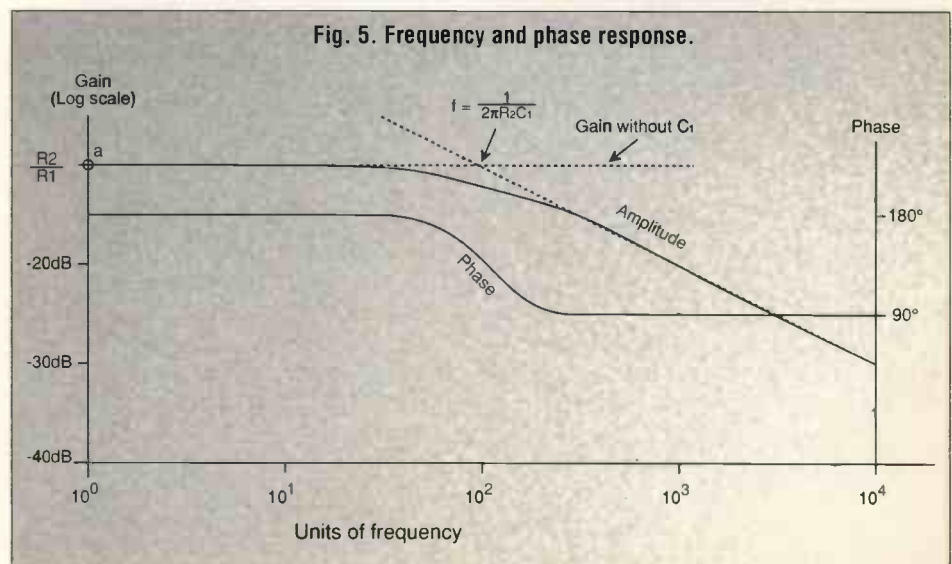
matter).

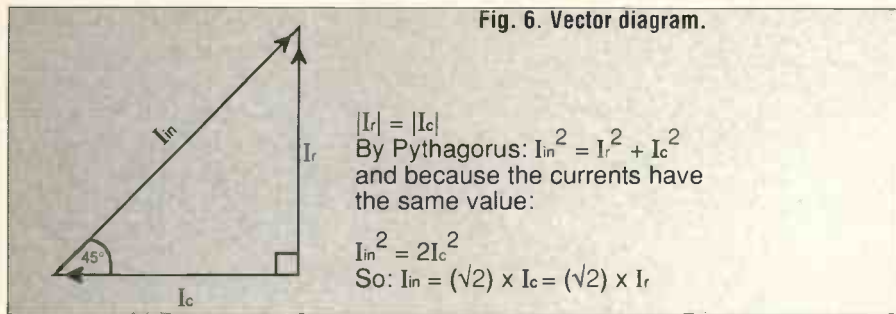
Equally, it is clear that the output is in phase with the input, but inverted. The inversion is equivalent to a  $180^\circ$  phase shift (though it is important not to confuse inversion with real phase shift) so that the starting point is at  $180^\circ$ .

At the turnover frequency the current in the resistor and the current in the capacitor are equal in magnitude, though  $90^\circ$  out of phase. The capacitive current leads the resistive current. The vector diagram of Fig. 3 illustrates this, showing that the input current (which flows in  $R_1$ , and is in phase with the input voltage) is the square root of two times either of the feedback currents. Therefore the output voltage, which is in phase with the vector sum of the feedback currents, lags the input voltage by  $45^\circ$  and is  $1/\sqrt{2}$  times the input voltage.

This allows points to be plotted at  $-3\text{dB}$  and  $135^\circ$  at the turnover frequency.

At frequencies high enough for the effect of  $R_2$  to be neglected, the output will lead the input by  $90^\circ$  (it would lag but for the inversion). The relative gain will also depend solely on  $C_1$ , so that a line can be drawn at high frequencies showing the gain as it would be if  $R_2$  were not present. Where this line comes close to the turnover frequency in Fig. 2, it is shown dotted. All that remains for the amplitude graph is to hand-draw a curve joining the lines, and passing through  $-3\text{dB}$  at the turnover frequency. This will not be perfectly accurate, but will be very close to the truth.





Similar sketched approximations can be applied to the frequency response curve, with the results shown in Fig. 2.

The formula describing this circuit is:

$$\frac{V_{out}}{V_{in}} = \frac{-Z_{feedback}}{Z_{input}}$$

$$= \frac{-R_z \times \frac{1}{j\omega C_1}}{R_z + \frac{1}{j\omega C_1}} \left( \begin{array}{l} \text{Where } \omega = 2\pi f \\ \text{and } j^2 = -1 \end{array} \right)$$

$$= \frac{-R_1}{j\omega C_1 R_1 R_2 + R_1}$$

From this we see that the gain at low frequencies, when the term containing  $\omega$  is negligible is, as common sense dictates,  $R_2/R_1$ , while at high frequencies the term containing  $j\omega$  dominates, the  $j$  indicating a  $90^\circ$  phase shift.

The reader's second question, about a slightly more complicated circuit, will be answered next month.

## Solar Power

*I use a caravan as the site office for my small business. The electricity is provided by batteries charged by a generator. I am interested in using a wind generator or a bank of solar cells to charge the batteries, but I have found few ready-made units available. Have you any advice?*

Mr R P Port of Derby

Renewable energy in any form is a subject close to my heart, but despite my personal enthusiasm I cannot say that wind and solar power is always practical or cost effective. If there is a situation where the battery lasts almost long enough, it may be possible to avoid the expense of an extra battery by supplementing the battery power

with solar cells.

Wind power has been shown to be less effective than solar in many areas of the UK, because the solar power is more consistent. Even on a dull day there is some useful light, but there can be a string of days when the wind velocity is too low to generate electricity.

At first, all solar cells used crystalline silicon, were made in small quantities, and were very costly. They were suitable only for applications such as satellites and unattended low power installations a long way from mains power. Even with the availability of such cells, unattended telecommunications relays were often powered by replaceable primary battery packs.

Pioneering work on amorphous materials a few years ago opened the door to lower cost solar cells. The manufacturing process has a lot in common with manufacture of coated aircraft windscreens, so that a well known glass technology could be adapted to mass produce large solar panels. Depositing metalisation to connect cells in series was easy, so that a 12V solar panel became a practical product.

Widely available amorphous solar cells have a conversion efficiency of approximately 7%, while crystalline cells have approximately 14%. However, development of amorphous cells is continuing, with the addition of an extra layer to absorb a different part of the spectrum.

As interest in solar power has stimulated demand, the prices of crystalline cells has been reduced, so that the cost per watt of amorphous cells is perhaps 15% lower than for crystalline cells. However, the necessary area of amorphous cells for a given power output is double that of crystalline cells for the same output.

In theory, solar radiation of 1kW per square metre is possible. In practice, clouds, atmospheric haze and so on, will reduce that even on

a sunny day. On an average day in mid summer, a panel rated at 22W peak power would provide the equivalent of four to five hours of peak power over the entire day.

For example, a one square foot 12V amorphous solar panel will typically produce 1AH per day in June (not this June!) and 0.2AH/day in December in the UK.

As each square foot costs approximately £30 the economics depend partly on the difficulty of charging the batteries. Extending the time between charges can be very useful, and if there is a period when the batteries are not used, natural degradation will be much reduced if solar panels are used to keep the batteries charged.

A new lead/acid battery can lose about 15% of its charge per month, rising to 40% per month as it ages. Temperature cycling (eg night/day temperature changes) promotes the formation of inactive sulphate crystals which reduce the capacity of the battery, and this effect is much greater if the battery is discharged when its temperature is cycled. Solar cells may therefore significantly prolong the life of batteries which are left idle for long periods.

Solar panels are occasionally advertised in the pages of electronics magazines, and have been found on sale at amateur radio rallies. They are available commercially from several companies; I choose two as examples.

Solapak of High Wycombe offer a range of crystalline solar panels ranging from the M20, costing £161+VAT and rated at 22W (14.5V, 1.38A) typical to the M55 costing £288+VAT rated at 53W. These are peak powers, and the energy output in the UK is estimated as between four and five hours of peak power equivalent in summer, and a three quarters to one hour in winter.

Solapak's telephone number is 0494 452941

A company undergoing a name change (they used to be called Chronar) offer amorphous solar panels. For example, their 1W "caravan kit", when used to charge 12V batteries, provides an average 3AH per day in June and 0.6AH per day in December. This is sold for £85+VAT, including mounting brackets, diode, and cable. Phone 0656 661211. ■

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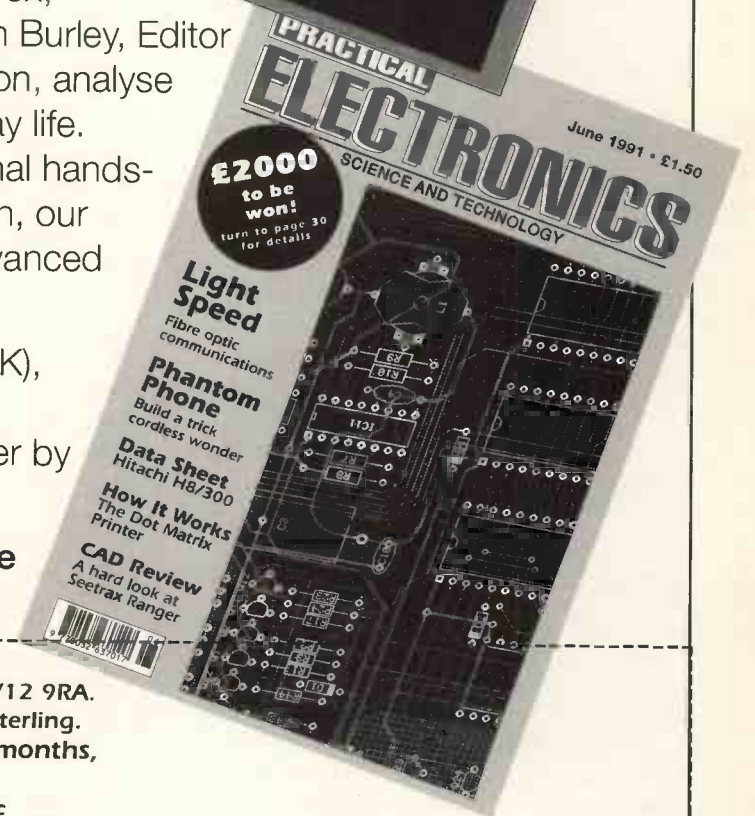
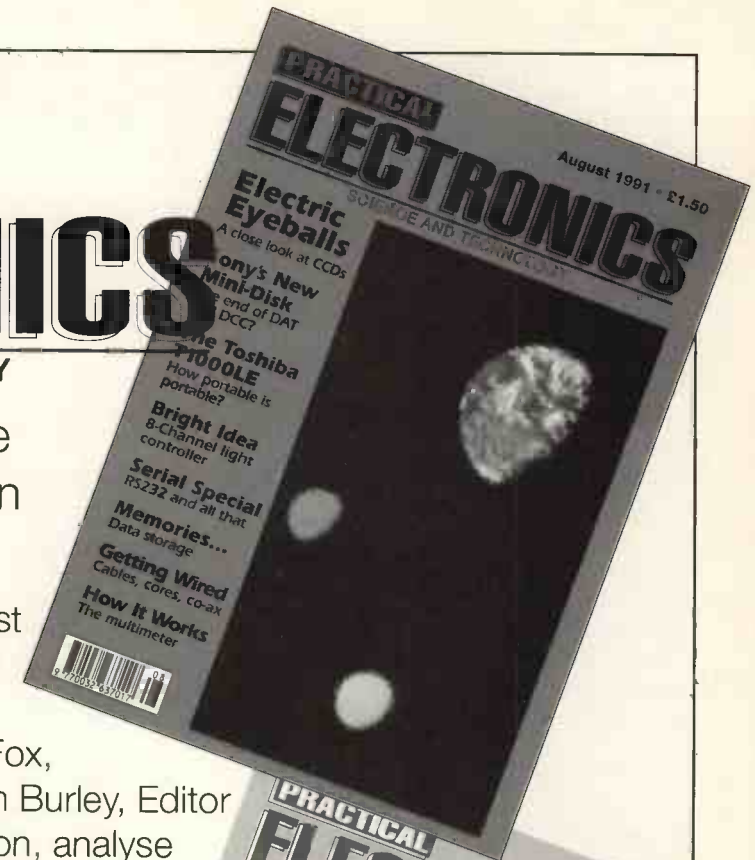
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# **PRACTICAL** **ELECTRONICS** SCIENCE AND TECHNOLOGY

*We chart the changing face of electronics with a look at the past 25 years of PE.*

## October 1966

25 years ago this month PE printed a feature all about thunderstorms. This illuminating article described the ins and outs of thunder-cells in terms of electronic circuits and put forward a number of suggestions as to why they form and why the base is always negatively charged. The most interesting argument for this was that radio-active particles were one of the root causes of electrification in a thundercell. Some of the evidence for this was that thunderstorms don't often occur at sea and almost never on the ice-packs. They are most frequent over geologically disturbed landmasses and, perhaps, where there is a greater emission of Radon gas and hence alpha particles. Has any work been done on this since?

## 1976

The new constructional aid, as it was touted in this issue, was the Wiring Pen. This device used long pin connections on IC sockets and components to wind wires around and hence connect them together. It was a reasonably good idea in its time and, as the feature pointed out, was ideal for constructors since it was quick and relatively easy. Unfortunately, as a replacement for stripboard it seems to have lost headway and it is no replacement for PCBs. The authors final comment sums the idea up, "You either like the idea of this new system or you don't." It seems that many people didn't since it is now almost never used.

## 1981

It was at about this time that people were getting worried about robots replacing workers. A feature on Robots in this issue saw them performing a number of jobs. Building Mini-Metros (yes the car is that old) and becoming a blacksmith. An interesting graph showed that Japan and West Germany were well into using as many machines as possible whereas the UK and USA, although trying hard, were still lagging behind. On the other hand, their use also appeared to follow the economic boom and growth and the general trend was (and is) up. Why should human beings belittle themselves with jobs fit only for robots?

## 1986

Barry Fox announced that digital video recorders were on the way this month five years ago. Sony was about to launch a model costing over \$100,000 – definitely not aimed at the consumer market. Nowadays it is hard to get away from digital video. Although home video recorders don't use it, it shouldn't be very long before they do. ■

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# Feedback And How To Get Rid Of It

*The latest books reviewed by Kenn Garroch include an explanation of acoustic feedback, a shortwave radio listening guide and a concise introduction to electronics.*

This short book (92 pages) is aimed at the beginner who wants to use a PA (Public Address) system. It should also appeal to anyone who wants to know more about acoustics in general and feedback in particular. Although the book is rather poorly produced, the illustrations are simple and the writing style is easy to read.

Starting off with a few definitions of the various terminology, the book moves on to discuss the basics of sound and acoustics, feedback paths, microphones, methods of reducing feedback, pop groups and some ideas that don't work. It finishes up with a project to construct a variable notch filter on stripboard – this device can be used to eliminate feedback at any frequency it might occur.

Although expensive at £3.95, the book could prove useful to anyone suffering from PA feedback problems or who has an interest in acoustics in general.

Acoustic Feedback – How To Avoid It  
Vivian Capel  
Bernard Babani (BP310)  
ISBN 0-85934-255-7  
£3.95

## On The Air

Anyone with an interest in listening to radio should find this book an indispensable reference. It lists all of the shortwave radio transmitting stations in the world with their location, frequencies, power and programming. Not content with that, it also lists the medium and longwave stations for Europe, the Middle East and North Africa,

Canadian and US Medium wave, International English broadcasts and UK FM. In short, pretty well any radio station within listening range of the UK.

Of the 266 pages, the first 10 are devoted to an introduction to shortwave listening. This includes short descriptions of how radio waves travel, what stations are likely to be available and when and the difference between short, medium and long wave. A brief guide to buying a receiver is also included as is a guide to getting the best from the rest of the book.

Anyone interested in listening to the radio as a hobby should find the book a helpful, if not vital, guide. If nothing else, browsing through the contents makes interesting reading. – want a radio station in Ljubljana? try 918kHz, could be interesting in these days of Central European disquiet.

International Radio Stations Guide (revised edition)  
Peter Shore  
Bernard Babani (BP255)  
ISBN 0-85934-200-X  
£5.95

## Electronics In Brief

So you want to know about electronics. Graham Giller's book runs through all of the basics from direct current to fibre optics in 268 pages.

Starting off with simple ideas such as current flow, voltages and their effects on various components – resistors, capacitors, inductors and filters – the first section describes the mathematical analysis of the circuits upon which the rest of the subject stands. A knowledge

of mathematics is necessary to the real understanding of all this but then, electronics is a very mathematical subject (perhaps more so than any other, including mathematics itself).

Chapter 2 examines solid state semiconductor devices with a discussion of energy bands, junction, rectifiers, LEDs, transistors and amplifiers. It also looks at the manufacture of semiconductors, thyristors, FETs and unijunctions.

Chapters on op-amps, logic, digital electronics, audio circuits, radio transmission and fibre optics follow. Sometimes these have detailed explanations, including the maths, other times only simple descriptions are given.

The biggest drawback with this book is the poor quality of the diagrams. These appear to be the hand drawn originals produced by the author. In these days of DTP and computer graphics packages, they could all have been reproduced to a very high quality with little additional effort.

To obtain the best from a book like this, additional maths reference books (and perhaps courses) are needed. Anyone with the requisite background (According to the author it is suitable for anyone with BTEC level three or A level electronics) should find no great trouble understanding the basics and in this context, perhaps it would serve as reference material.

Electronics Principles and Applications  
Graham Giller  
Sigma Press  
ISBN 1-85058-151-7  
£12.95

# British Cable

## Bites The Dust

*Whatever happened to Cable TV? Other countries have thriving systems but Britain is definitely lagging behind. Barry Fox looks at the reasons for this.*

The government's Cable Authority is now dead. Its work is now taken on by the Independent Television Commission.

In its six year life the Authority granted 137 franchises for new broadband cable stations which could, in theory, cover two thirds of the UK population – Broadband is the term used to distinguish new cable networks which can carry several dozen TV channels at the same time, from the old systems which could carry only a few channels and were used to relay off-air TV stations to towns where roof aerials were either forbidden or useless because of surrounding hills. The number of franchises actually operating is only 29 and the number of subscribers is still only around 170,000. The Cable Authority blames the recession for this lack of interest.

I found dealing with the Authority very difficult. It was only when threatened with extinction that it bothered to start communicating with the press. It was a Cable Authority lawyer who, gleefully, started warning the press and trade that anyone who shared an Astra dish aerial risked criminal prosecution because they became an unlicensed cable station. This was at a time when the Department of the Environment was trying to discourage people from erecting more than one dish aerial on house to serve separate flats.

Visiting Americans always wonder what there are so many roof aerials in the UK and why there is so little cable. They throw up their hands in horror when told the prices charged by British cable stations. "No wonder so few people have cable", one told me.

After more than a year one of



the franchisees, Cable Camden, had laid cables past 12,000 homes. But there were still only around 4,000 paying subscribers with no clear pattern of who subscribed and who didn't. Camden realised that cost was the key factor and slashed prices in an effort to break out of the doldrums.

Cable Camden subscribers pay £30 for connection plus a £25 deposit on a set-top switchbox. Then there is a charge of £10 a month for the basic package of nine channels including Sky One, Sky News, CNN, the sports channels, childrens' and music channels.

Camden lays a mix of optical fibres and copper coaxial cables. It costs around £200 in labour to dig up the roads and "pass" each home. Add another £30 per home for laying telephone wire. Then add another £100 labour for connecting the street cable into a home, around £150 for the set-top electronics, plus around £50 for any telephone connection. Adding in the cost of unconnected homes that still have to be passed brings to total to well over £1000 per home connected.

Now add to that the £3.50 or so per subscriber per month the cable companies have been paying the satellite operators for the movie channels and you see why so many cable companies are so slow to exploit their franchises and lay cable.

Significantly most of the money now going into UK cable comes from abroad, mainly North America. Investors there know that in the long run British town dwellers will grow to expect their TV and radio stations to be available by wire, on tap.

The investors also recognise that cable TV is the way to gain a foothold into Britain's telecommunications market. Until now only Mercury has been able to compete with British Telecom and the only way for Mercury to compete head on with BT has been to install its own optical fibre cables or microwave links. This is only cost effective for large offices which will make enough calls to cover Mercury's investment in the links. For small businesses and domestic subscribers Mercury must rely existing BT lines. The Mercury subscriber keys in a code which routes the call out of BT's local exchange and into the Mercury network.

Once a cable station has laid a phone line into a building along with a cable TV connection, Mercury can bypass BT altogether. When the BT/Mercury duopoly ends, others will be able to offer a competitive use of these cable station lines.

British companies will eventually regret not investing in cable TV. My experience of the Cable Authority makes me wonder how hard it tried to get this message across. ■



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