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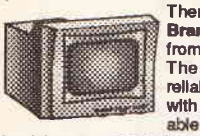
MONITORS

MONOCHROME MONITORS

THIS MONTH'S SPECIAL!



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

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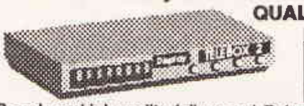

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EDITORIAL

It's not the custom of an ETI editor to provide an editorial in you favourite magazine as most editorials end up with the usual gripe about the state of the world and all its ills. Not here, our policy is to look towards the future, observe the changes taking place, report on them and move with the times. That being the case, ETI sees a development in its history.

We launch a centre-colour section to highlight and depict three dimensional cut away drawings when required. Also due to popular demand, we launch an audio supplement within these pages. The supplement will contain the latest news, your views, features and projects all within the audio spectrum.

ETI will continue the tradition of 'How it works' but now it will be extended to the world of commercial electrical and electronic equipment.

And finally, but most importantly, we welcome your views on what you like reading in ETI. Any current and perhaps, controversial views within the technology forum will be published to encourage interest and debate. Afterall, increased openess through communication will always help to produce a better world to live in.

Paul Freeman Editor

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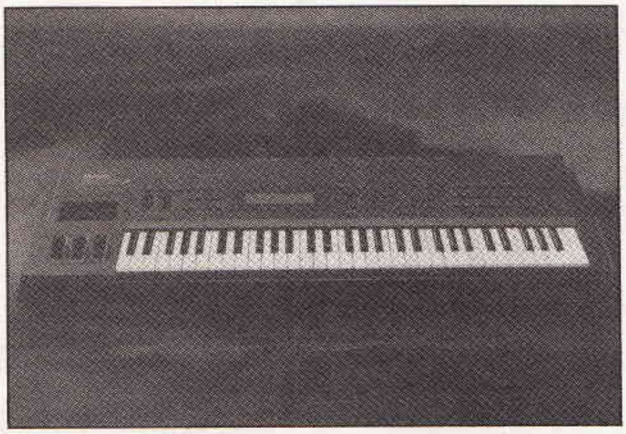
REGULARS



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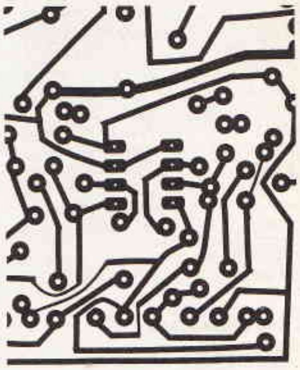

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ETI
ELECTRONICS TODAY INTERNATIONAL

FEATURES/PROJECTS

BLUEPRINT

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

This month's Blueprint addresses the problem of a digital exposure meter for making photographic prints.

Dear Blueprint,

Many years ago, back in the dim and distant days of my youth, I built an analogue enlarger time/exposure meter, using a design from a photographic magazine. The design (shown in Fig. 1) combines paper speed setting, light level measurement, and exposure time setting in a bridge circuit arranged so that adjustment of the timer-setting potiometer to balance the bridge automatically provides the correct exposure time. The light passing through the negative is averaged by a piece of sanded perspex before being detected by the light dependent resistor.

Unfortunately, this simple but elegant circuit lacks the sophistication of the digital enlarger-timer designed by Ian Coughlan (ETI February 87) and is difficult to set properly in darkroom lighting. Ian Coughlan's design overcomes the problem of seeing the setting in the dark, but does not incorporate the light-level measurement function. I have tried, so far without success, to devise a means to transfer the analogue information from my present circuit into the programmable counters of Ian Coughlan's circuit.

Leaving aside the issue of light level measurement, I prefer to use a log potentiometer to enter the timing information, because exposures (stops) follow a logarithmic law.

I would also like to know how to incorporate a centre-reading bargraph display instead of a moving-coil meter, in my light measurement bridge, so that I can see it in the dark. It must only illuminate while a measurement is taking place, to avoid fogging colour print papers.

I have not succeeded in my attempts — please can you help.

Tony Keyworth, Birmingham.

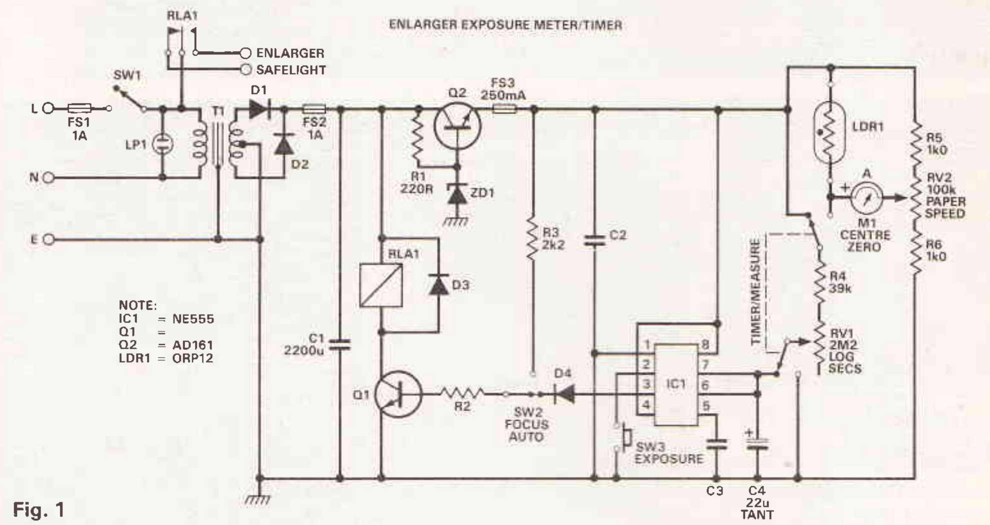


Fig. 1

I cannot answer this question by giving a precise design, because they don't pay me enough, and anyway there is not enough information about the scaling of the controls on the measurement bridge to enable me to integrate this into a fully-designed digital circuit. Accordingly, I have indicated some methods by which one might attempt to solve the problem, and I have the reader to fill in the details.

One possible scheme is shown in Fig. 2. Here, a solar cell is used to measure the light output rather than a photoresistive cell, in order to provide an output voltage proportional to the incident light. An ordinary solar cell may be usefull for this purpose, but Electromail (RS Components) stock a cell intended for this type of application (part no. 691-995). Unfortunately this cell is rather expensive, so it is best to try an ordinary cell available from Maplin first.

The solar cell feeds into an op-amp circuit called a current-to-voltage transducer. The gain of the circuit is adjustable in order to calibrate the unit, and a high-quality op-amp is used to prevent offsets from imparing the accuracy at low light levels. The voltage output from this circuit is fed to an analogue to digital converter, shown in this diagram as a 10-bit device. For most of the range, 8 bits would be good enough, but at low levels of incident light 10 bits may be required. More information about photographic printing would be required to decide this point for certain.

The output from the analogue to digital converter is fed into an eprom, programmed with the appropriate curve of timing against incident light level. It is programmed not in binary but in 2 digit bcd, in order to provide the information necessary to load into the bcd down-counters in the digital enlarger-timer design. I leave the reader to calculate the required eprom contents based on information about the response of photographic papers.

Connected to the other four address lines of the eprom is a hex-switch to select various scales for different types of paper. Again, I do not know how many sorts of paper might be used, but if sixteen different settings is inadequate, then a larger eprom and an extra switch could be used. Even if only two more address lines were employed, the number of possible settings would rise to 64, which ought to take account of any eventuality.

If cost or spectral response rules out a solar cell, the circuit of Fig. 3 shows how a light-dependent resistor (LDR) can be used to provide the input to the op-amp. In this circuit, a constant voltage is applied to the cell so that the current flowing is inversely proportional to resistance of the cell.

Fig. 4 shows another approach to the problem, assuming that the response of photographic paper to instant light obeys a logarithmic law. In this circuit, a log amp is used as feedback around an op-amp, to provide an antilog response. This might avoid the need for an eprom with different curves programmed in it, but considerable design work would be required to make this work. The idea is included here for interest only.

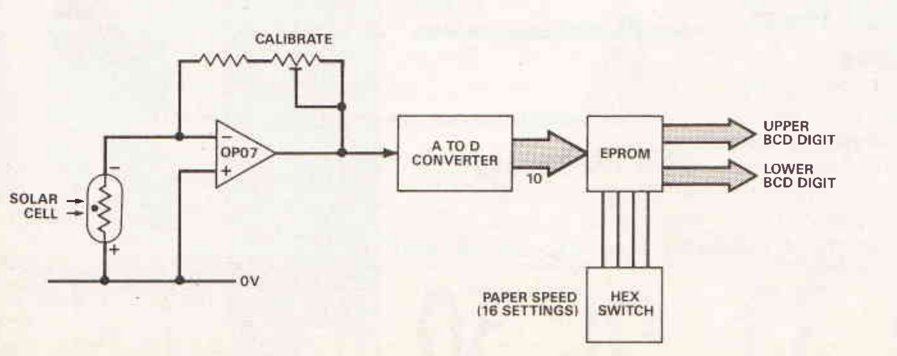


Fig. 2

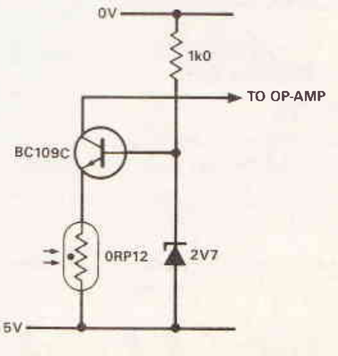


Fig. 3

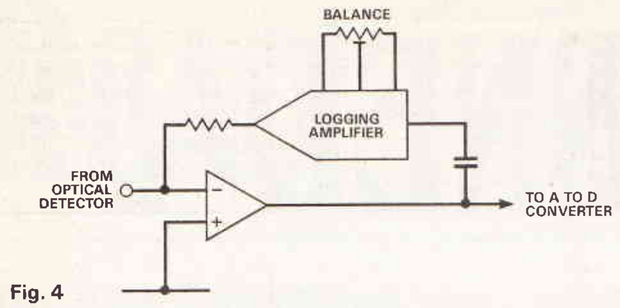


Fig. 4

Bargraph

It occurs to me that the most serious defect of your original circuit, if it is accurate enough for your needs, is probably the difficulty of adjusting it under darkroom conditions. The addition of a bargraph display as you request would go a long way towards solving that problem, and might give your old timer a new lease of life.

The circuit of a centre-zero bargraph display using the LM3914 is shown in Fig. 5. The LM3914 contains ten comparators with one input connected to the signal and the other to a voltage divider chain, whose ends are on the terminals marked R_{LO} and R_{HI}. In this design the signal input is taken from the paper speed adjustment, while the two ends of the resistor chain are fed from a bipolar voltage centred on the voltage at the junction of the photosensitive resistor and the time setting resistor.

IC1A buffers the voltage at this potential divider point, to provide a low-impedance reference point for the inverting and non-inverting buffers IC1b and IC1c. These buffer a variable reference voltage, which is then buffered and fed to the top of the resistor chain in the LM3914, and inverted and fed to the low end of the resistor chain. Thus, if the signal voltage and the voltage on the LDR are the same, five LEDs should be on and five off.

The LM 3914 has built in current regulators which control the LED current to approximately ten times the reference voltage (1.25V if REF ADJ is grounded). This sets the LED current to approximately 4.5mA, plenty to see in a darkroom.

The LEDs are powered from a 3.5V supply to minimise the dissipation of the LM3914, and the regulator is also used to switch off the LEDs when not required. A spring-loaded push-button switch is shown used for this purpose. When the switch is pressed, the voltage regulator provides 3.5V output. When the switch is released, the regulator output is reduced to approximately 1.25V, which is insufficient to illuminate a LED.

There is one further point to note: the local decoupling must be electrically close to IC2, and the 0V connections of IC2 must be low resistance, or else it is likely to oscillate.

Finally, a worthwhile improvement might be to replace the zener and transistor voltage regulator with an LM317 on a heatsink.

Andrew Armstrong

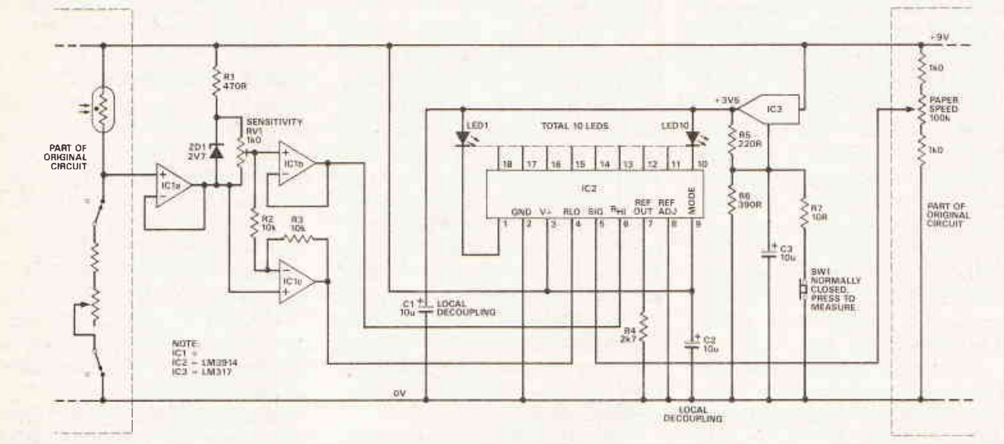


Fig. 5

OPEN CHANNEL

It seems our North American cousins are finally starting to get their act together regarding high definition television (HDTV) systems. Initially, Japanese enthusiasm for the far eastern *HiVision* HDTV system all but steamrolled the Yanks into a system which European television manufacturers and broadcasters spurned long ago.

Eventually, around the middle of last year, America woke up to two facts. One, if the Japanese designed and developed HiVision system was used in the States, resultant television receivers would all be Japanese or, at very least, produced in the USA under agreement with Japanese companies. Two, HiVision is not backwards-compatible — every existing television receiver in the country is made obsolete by its adoption.

These, of course, are the very reasons why Europe rejected HiVision in the first place; choosing instead the IBA-designed multiplexed analogue component (MAC) system. MAC, or one of its variants (would you believe HDMAC) allows problems of non-compatibility to be resolved easily (fairly simple adaptors can be used to interface old-standard television receivers with new-standard received signals) while maintaining broad control of design, development, manufacture and sales of European (that is, non-Japanese) television receivers.

Better than this, though, choosing and using MAC allows European television to evolve in a controlled manner; in discrete stages as the market requires. The first stage is reached with use of DMAC and D2MAC signals transmitted from direct broadcast satellites — such as those used in the new British Satellite Broadcasting service. When the first stage higher quality transmission possibilities have been explored, and when the time is judged right, HDMAC will be introduced in the second stage. The advantages of such a discrete adoption of higher quality television are simply that customers will not be forced into buying a new receiver straightaway and, in the end, we can be assured of having the best system. The disadvantages, of course, is that customers will have to wait for many years before European HDTV is available.

To be fair, America was taken along on the crest of the Japanese wave only insofar as customers were led to believe they would have HDTV receivers rapidly. In the end, USA television manufacturers have decided on a number of HDTV possibilities. Frontrunners are the *advanced television* (ADTV) also known as *advanced compatible television* (ACTV), and *super NTSC* systems, of which it looks as though ATV will be adopted.

Remarkably, ATV appears conceptually similar to MAC in that it is a homegrown system designed to keep HiVision out of the American market, and allows a staged and compatible adoption of HDTV. Technically, on the other hand, ATV is nothing like MAC. Interestingly, four companies have recently formed the Advanced Television Research Consortium — a development consortium for ATV with aims of getting first stage receivers on the market within three to four years, and second stage HDTV versions within ten years or so.

Even more interesting are the companies in the consortium. First is the David Sarnoff Research Centre (which designed ATV in the first place). Second is NBC, the American network broadcasting company. But third and fourth are RCA (Thomson) and Philips. Thomson and Philips are, of course, European companies, directly involved with production of European MAC-based HDTV systems.

Open Sesame

Even as ATV is being defined, though, proponents of a totally different concept in television systems are calling for a rethink now, before commitment to any one system closes the door to any other developments. Massachusetts Institute of Technology professor, Bill Schreiber, thinks that television systems should not be defined by standards of transmission methods (PAL, NTSC, DMAC, ATV and so on) but should be completely open. A straightforward analogy with computer systems and the way they are moving towards open systems interconnection (OSI) shows definite parallels. With OSI, which is currently being defined by the various standards organisations and bodies worldwide, any computer will be able to communicate with any other computer, regardless of computer type. In the case of the television systems, an open systems receiver would be able to receive and display signals of any transmission method. All parameters of transmitted signals: aspect ratio, horizontal line number, field rate and so on, would thus be irrelevant.

Schreiber proposes a bus-based computer-controlled television receiver, capable of displaying any signal transmitted to it. In theory, this receiver is perfectly possible and any number of existing bus-based computer architectures could be immediately adopted for use. One that springs to mind is the recently developed *VXIbus* instrumentation bus, used for modern automatic test equipment systems.

In practice, of course, such a receiver is initially very expensive. The high production numbers involved, however, would lead to significant size and price reductions. You only need to think of size and price reductions encountered over the last ten years with microprocessor-based computers to see what difference high production numbers can mean. Arguably, open systems television receivers could be available for around the same price as a reasonable quality computer. That's still considerably more than current television receivers, though no more than HiVision HDTV television receivers are expected to be.

Where an open systems receiver could score, on the other hand, is in its adaptability to interface with the variety of inputs for which current receivers require extra circuitry: videocassette recorders, satellite transmissions, home video games, PCs and so on. Further, an open systems television receiver is virtually future-proof: whatever transmission method is developed in years to come can be displayed.

Whether Schreiber's open systems television receiver proposal is accepted or not, we must surely give it some serious thought. Although ignoring it now gives a cheaper, and perhaps quicker, route to HDTV, the more long-term advantages of it cannot be swept aside as a mere inconvenience.

PCN Licencees

There are three licensees for new personal communications networks (PCNs) in the UK, formed by three consortia:

- British Aerospace; British Aerospace, Pacific Telesis, Millicom, Matra, Sony.
- Unitel; STC, US West, Thorn EMI, Deutsche Bundepost.
- Mercury; Mercury, Motorola, Telephonica.

PCNs are seen, by the Government as least, as the way forward in telephone and mobile communications. Eric Forth, Minister for Trade and Industry, has said that they will change the face of the mobile comms and the way we use the telephone. Millions of users are expected by the end of the century. Services are expected to be cheap and will be based around inexpensive, lightweight portable phones of around the same size as recently launched CT2 mobile telephones or maybe smaller. PCN telephones have advantages over CT2 versions in that calls can be in-coming and a line-of-sight contact range with a base station will be necessary.

Dawn Of Realisation

Dawn on 6 May will bring near-disruption to the nation's telephone service. A while ago (ETI September 89) this column brought you news of the impending numbering change to occur to all of London's telephones. The existing code (01) is to be abandoned in favour of two separate codes (071 for inner London, 081 for outer London), effectively doubling the number of telephones which can be allocated to subscribers within London as a whole.

Back in September last year I joked about the change — simply noting that Birmingham (with a code 021) would become the nation's first city, while London would slip to seventh and eighth in the list. However, it's time to get serious, with the change only a few weeks away from this month's publication date.

Few subscribers in this country, let alone the rest of the world, have yet to understand the implications of the numbering change. First, there may be two telephones within the overall London area with the same number. If you dial the wrong code you will get the wrong number. Obvious? Wait and see how many wrong numbers will be clocked up — and paid for — by unsuspecting subscribers.

Next, if you know the number but not the code, you can ring up directory enquiries. Mercury recently began charging 50p for this service, and you can bet your bottom dollar (or your bottom 50p, anyway) that British Telecom will follow suit, if it hasn't already done so by the time you read this.

But wait, the best is yet to come. All telephones and related equipment such as facsimiles, modems, branch exchanges and switchboards with automatic dial-out facilities will require re-programming with the new codes. Even printed stationery such as headed paper, invoices, and so on will require changing. Not so obvious are the changes required to company signs, vehicles and emergency numbers posted in lifts and the like.

Are you prepared? Is your company?

Keith Brindley

READ\WRITE

ETI LETTERS

Baffling Equations

I have been a regular reader of ETI since the September 1975 issue and have had many hours reading and constructing from them.

Recently the articles that have most coincided with my current projects have been those on loudspeaker design. I would be very grateful however if you could clarify something for me.

In the article Reflex Action (July 1989) equation 5 for finding the port length, no matter how I work it, if you substitute the values for Vb and fb found by equation 1 and 3, the values for the KEF B110 and the given pipe diameter, I do not arrive at the given 7.9 inches but 7.56 inches.

Moving on to Micromonitor Loud Speakers, August 1989, this invites me to plug previously arrived at values into the same port equation and arrive at an answer of 4.1 inches. If I do plug in these values I arrive at 4.26 inches. Is my mathematics suspect, or am I missing something? I realise that these are small differences, but annoying for being unexplainable.

One of the best points about these articles is that they explain how to deduce the required parameters from any drive unit, and these deductions are still valid for the article on Infinite Baffle Loudspeakers, January 1990. However, the article describes a method of modifying drive unit parameters given that you know cone mass, M_c, and surround compliance, C_m. Is there any method of deducing these to enable drive units of unknown pedigree to be used?

Please forgive the delay in posing the first question, but I decided that what I needed was a program on my computer to work the equations in a question and answer fashion, print out the answers in tabular form, and then allow parameters and/or drive units to be changed for comparison purposes. Then my computer died. This is being word processed on my new computer, but it is taking a devil of a long time to find my way around all its options.

Yours faithfully

B. B. Fuller
Ashford, Kent

Jeff Maucauley replies: I will take your last enquiry first, namely how to determine the compliance and moving mass of a raw driver. In order to do this you will need to measure the effective radiating area of the driver. Simply measure the diameter of the driver in metres, add to this the width of the surround (one side only) we'll call this area S_d

Now measure the free air resonant frequency (f_s) as detailed in the articles. Take the driver and mount it into an unstuffed box of known volume (v_b) in cubic metres. Measure the new resonant frequency (f_c). With this information the value of the compliance of the speaker, C_{ms} can be calculated from the equation

$$C_{ms} = V_b / \left[S_d^2 7.14 \times 10^{-6} \left(\frac{1.15 f_c^2}{f_s^2} \right) \right]$$

The answer is in N/m. From this it is a simple matter to find the moving mass M_d in kilos from the expression

$$M_d = \frac{1}{C_{ms}(2\pi f_s)^2} - 315a^3$$

Where a is the radius of the moving piston. You can now use the equations as presented in the article on IBs to modify the response.

Turning to your enquiry on reflex port lengths. Here the discrepancy is mine. The proper way to determine the length of the port to tune to a known frequency f_b is to first calculate the length and then adjust it by measurement to optimum. For practical purposes the equation gives a good enough answer but it must be realised that the optimum volume calculated does not include the volume of the vent or driver chassis etc. As a result the actual lengths are not exactly in agreement with the calculated values. What happened was that the actual lengths and calculated lengths got muddled!

Briefly the way to measure f_b is as follows. Build the cabinet and fix the driver in, and the vent. The latter should be slightly longer, say as inch than suggested by the calculation. Set up your measuring equipment as you would to measure f_c. Temporarily block off the vent and measure f_c. Unblock the vent and sweep your signal generator up from 10Hz. You will discover two peaks in the response, lets call the lower one f_l and the higher one f_h

$$F_b = \sqrt{(f_l^2 + f_h^2 - f_c^2)}$$

Having thus determined f_b which should be slightly low the exact value can be obtained by trimming the port length and remeasuring it. Normally an error of ±5% is not audible on program so the calculated length is usually adequate.

Earth Current Signals Underground

I have been interested to read the current series in ETI by George Pickworth about earth return communications.

For several years now, the South Wales Cave Rescue Organisation has used earth return field telephones to provide underground-to-surface communications during cave rescue incidents in South Wales. Many of the caves here contain literally miles of passages. The longest is Ogof Ffynnon Ddu with over 30 miles of surveyed passages on several levels and going in all directions: a true 3D maze.

Our telephone system comprises hand held units powered by 9V PP3 batteries and the range is *several miles* over single core cable. Each set can be clipped on to the line anywhere and can then talk to all other stations. The electronics is very simple and cheap. The audio quality is excellent. This is a well tested stable design with PCB masks available.

Yours sincerely

Stuart France
Warden
South Wales Cave Rescue Organisation

Atmospheric electrometer required

Here is an idea for a project: I was fascinated by an article in another magazine, about electrostatic activity in the earth's atmosphere.

The author used an atmospheric electrometer to produce a host of data, showing how the electrostatic potential in the atmosphere varied as a result of thunderstorm activity and other meteorological events. I've read elsewhere how the electrostatic potential varies as a result of solar events, as well.

Apparently, the author used a valve circuit with a 2GΩ input impedance, and switched sensitivity to read signals from 25mV to 350V. He described the antenna as a well-insulated 20m wire. The output went to a pen plotter.

A more practical silicon version of the circuit might be an interesting design exercise, and sounds like it could be a really interesting and unusual project.

So how about it?

Yours faithfully

Steve Thackery
Felixtowe, Suffolk

Well, that sounds quite a challenge! If you come up with any solutions, send them in to us.

A smashing idea for a project

Would you please publish a Project to stop me backing my car into anyone foolish enough to be behind me.

Seriously, in these days of small parking places it would be a great help to have a sensor in the back bumper that sounded off or flashed a light to warn the driver that she or he is a foot or so away from the next car/wall/traffic warden.

Obliged
HELP

Any offers?

The latest from Cardigan Island

Thank you very much for your help and the publishing of our project in your magazine, it has certainly created a lot of interest.

We have been given a die-cast aluminium case sealed to IP65 from West Hyde Developments to install the amplifier in and hopefully some waterproof connectors are being dispatched to us.

The whole package has undergone trials and has been shut down over winter. Shortly, sea conditions permitting, we shall turn on the equipment in earnest as the Shearwaters start returning to our coast in late February. We shall certainly keep you informed of events.

Yours sincerely,

Rod Penrose
Dyfed Wildlife Trust
Cardigan, Dyfed

It's good to hear that things are going well for the Shearwater project — we hope to hear more news of its progress soon.

NEWS

KEEPING IN TOUCH

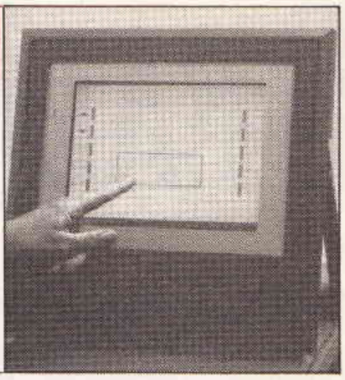
Very soon you might be able to book all your requirements on a flight just by the use of your finger on a screen.

Touch Screen Technologies of Hampshire has developed the interactive screen to fulfil a variety of applications. One of these might be at an airport where an enquiry about availability and price of tickets, class, seat position and hotel booking could be made. A parallel access facility such as this would cut down waiting time greatly.

TST also suggest using the screens in cars for control of most of your in-car facilities.

Touch screens allow switching areas to have re-definable legends and sizes in accordance with the menu selected.

For further information call Touch Screen Technologies Ltd, on 0703 629545.



MOTORWAYS TO BECOME AIRWAYS?

Could flying cars be the answer to the problem of motorway jams? In the US, former professor of aeronautical engineering Paul Moller has developed a vertical take-off flying car, to take electronic highways through the air.

The car is the Moller International M400, which has been designed to drive on a road, take off vertically, and fly at 9,100 metres at 640 km per hour (400 miles per hour). The first M400 is currently being completed, before flight testing takes place.

The car is driven by eight rotary internal combustion engines. These compact and light weight engines each produce 112kW, but weigh only 31kg.

Flying cars will require some extensive air traffic control. Moller envisages that microwave beams or satellite references will provide guides through the skies, rather like electronic roads. Computers on board each car will ensure that safe speeds and distances from other cars are maintained.

But of course, there's nothing new in the idea of a flying car. Chitty Chitty Bang Bang took to the skies years ago.

BRITISH TELECOM TESTS OPTICAL PIPELINES

British Telecom has completed installation of the optical fibre 'pipelines' for trials of their advanced optical fibre network for the 21st century.

The fibre will provide combined voice and entertainment services — television, high-fidelity stereo radio, telephone calls, information technology and other interactive services — to private and commercial customers in Bishop's Stortford, Hertfordshire.

The trial will test the technical feasibility of advanced concepts developed at British Telecom's research laboratories, and is provided in collaboration with BICC Cables, Fulcrum Communications and GEC Plessy Telecommunications.

During its two-year run, the trial will provide British Telecom and Britain's industry with data for planning advanced commercial communications for the next century. It will also enable British Telecom to compare the different technologies which may be used for future services.

For more information, contact British Telecom. Tel: 01 356 5366.

POWERFUL POCKET PHONE

No longer will designer suits be pulled out of shape by that essential yuppie accessory, the cellular telephone.

Until now, mobile telephones have been either relatively light without the power to last through a working day, or powerful but too heavy to carry comfortably in a pocket.

But now cellular telephones manufacturer NEC has developed a balance, with a phone that has a battery life of around 18 hours but weighs little more than that other yuppie essential — a full wallet.

The NEC P3 offers 80 minutes talktime and 18 hours standby. With an optional fast charger kit, the P3 can be recharged in about one and a half hours.

The telephone is equipped with a range of 'user-friendly' features, including a 99 number address book, a clock with timer and alarm, and a flip up aerial.

Because the P3 is very small and light, it will also serve as a handset when connected via a cord to a car base station.

For more information, contact Mark Davis. Tel: 01 631 5414.

SMART IDEA

Mitsubishi has released a new smart card — the width and height of a credit card — capable of storing up to 2 Mbytes of data in static RAM. A dynamic RAM version is also available.

The SRAM memory cards are robust and protected against static. They provide reliable, removable data storage, and can be used in industrial and office computers, as well as for information transfer systems. Each card measures 85.6mm × 54mm × 3.4mm, using very small outline packaging (VSOP) technology.

Features include buffer ICs for improved data protection and a lithium cell for battery backup when the cards are removed from the host system. The card can also be write-protected to behave as a read-only device.

The card is interfaced to the host computer using buffer and card detection circuitry, which disable data transfer when the card is removed.

Contact Mitsubishi Electric UK Ltd. Tel: 07072-76100.

FOOLPROOF CAMCORDER FROM SONY

An 'autolock' panel makes the feature-packed Sony CCDF380 camcorder foolproof. The panel covers the less-used facilities and puts the camcorder in to automatic mode. With few buttons to worry about, the CCDF380 can be used for point-and-shoot filming.

Essential controls are still accessible, including an 8 times power zoom with macro and date or time insertion. A display in the viewfinder keeps the user informed of status and function. The linear time counter can be displayed through the playback TV.

When more control is required, the auto-lock cover is slid back, and manual over-ride is available. Shutter speeds can be varied up to 1/4000 of a second, and a versatile digital superimposer is provided. This offers a choice of 8 colours with reverse and scrolling facility, allowing the user to be as creative as he or she wants to be!

MODEMS IN MINIATURE

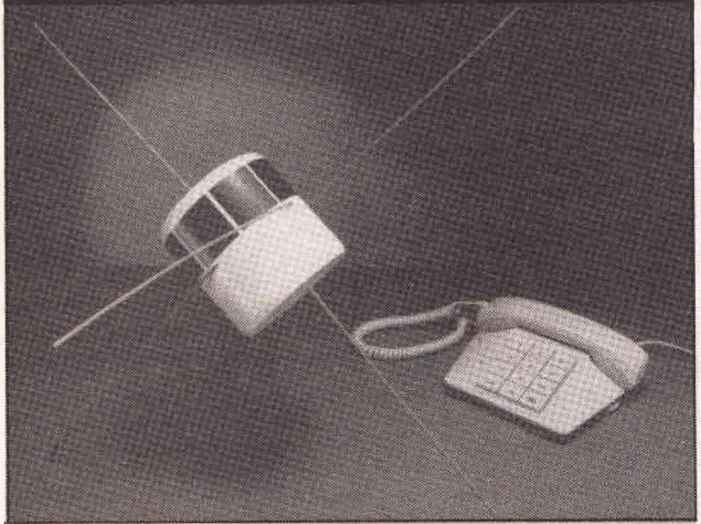
Today's laptop computers are nearly as small as the average modem. Now a Stockport-based company called Peartree Dram has produced a miniature modem, ideal for use with laptop computers.

The Voyager MV 213 Micromodem measures only 94mm by 60mm by 20mm, and allows digital data to be transferred over telephone lines by using the handset of existing telephones. The modem is adjustable to any handset in the world. There is no longer any need to dismantle hotel telephones when you are away from the office on business!

The modem supports a range of international standards, and offers full duplex communication with a baud rate of 1200. It is powered by a 9V battery pack.

For more information, contact Tim Clarkson. Tel: 061 406 6604

LOW COST SATELLITE



The concept of a very low cost spacecraft is to be investigated by the technical consultancy, Smith Associates, in a study for the Ministry of Defence.

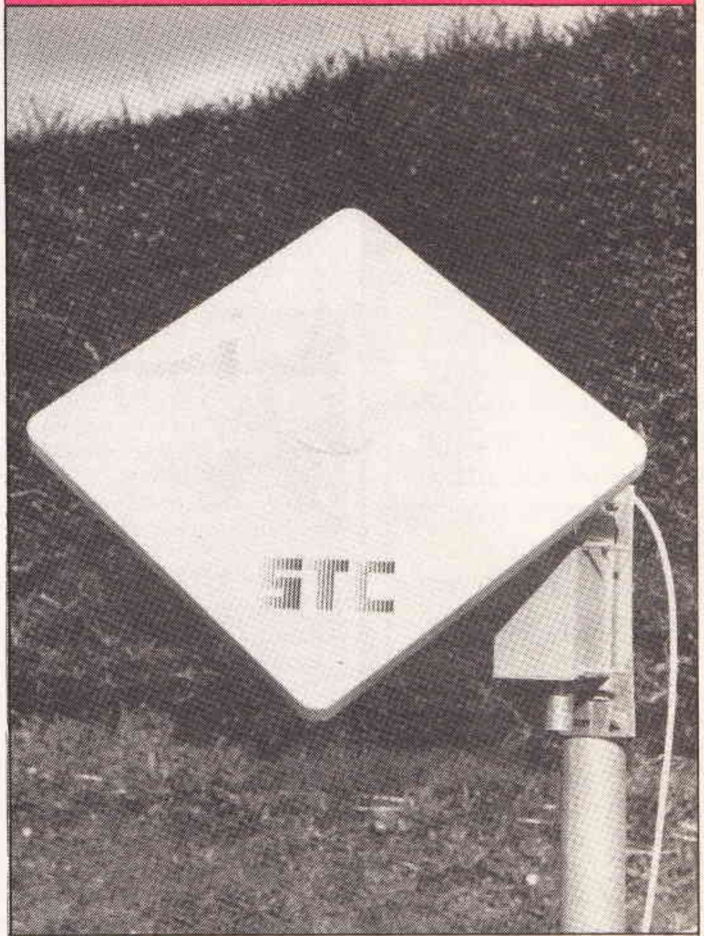
The study will provide details on the spacecraft's design and applications, enabling a working demonstration to be built so that the MoD can make an evaluation of the feasibility of project. Smith Associates hope to use an Ariane launch in 1991 for the demonstration.

The Smith Associates design gains its cost and weight advantage because, unlike other light satellites, it has no means of generating power. Intended for short duration tactical missions of less than a year, all power will be derived from non-rechargable batteries. The removal of power generation apparatus allows easier construction and more efficient thermal management.

Smith Associates will also investigate the use of carbon fibre reinforced thermoplastic instead of metals to save weight.

For more information, contact Smith Associates. Tel: 0483 505565.

SQUARE DEAL FOR STC



STC have won a major order for 50,000 'squarials' from British Satellite Broadcasting.

The squarial is the flat, square aerial specified by British Satellite Broadcasting (BSB) for reception of its new satellite television service.

STC were the only European company to satisfy BSB's requirements, and have won the order by producing a squarial which is smaller than any comparable product available elsewhere in the world. The STC squarial measures 38cm × 38cm × 2cm, and gives very high quality reception of test TV signals from BSB's transmitter in space.

STC made extensive use of computer-aided design when developing the squarial. The squarial uses phased-array technology (an array of small aerials all working together) derived from military applications for radar and communication antennae.

For more information contact STC Tel: 01 788 7272.

TALKING TRANSLATOR

Portable translators have been around for a while, but the translated word is normally shown on a written display, giving no information of correct intonation or pronunciation.

Now the hi-tech mail order company, Innovations, have announced a *speaking* translator.

Interpreter is a portable five language translator that speaks a language translation — intonated and correctly pronounced. Interpreter uses British technology to store over 13,000 phrases in each of five languages — English, French, Spanish, German and Italian.

A word is typed in on a standard 'qwerty' keyboard, and Interpreter creates a selection of phrases around that word. When the required language button is pushed Interpreter will immediately translate, speaking and displaying the phrase in the chosen language. Earphones are provided so that users can learn privately.

Interpreter can instantly provide emergency phrases, and when there is less hurry, can be used as a teacher, speaking random words to learn. Interpreter is available in male or female voices!

COMPUTER BUGS

Chip designers are beginning to meet the limits of their ability to impose complex circuit patterns on tiny bits of silicon. As an alternative to this 'top-down' approach, they are beginning to explore a 'bottom-up' technique, where the electronic circuit is built up molecule-by-molecule, with the required structure and connectivity.

A new study by Frost & Sullivan looks at the prospects for creating, manufacturing and marketing circuits from proteins, applying the technology of bioengineering to chip production.

The ultimate bioelectronics fantasy would have genetically engineered cells producing microscopic protein computers. However, despite its theoretical limitation, conventional technology is advancing so fast that 'biochips' will be hard-pressed to overtake it in the foreseeable future.

It is more likely that biocomputers will come in for applications where silicon is less successful, such as in neural networks and artificial intelligence.

Currently, bioelectronics is being successfully used in biosensors. This exploits a protein's ability to generate a signal in the presence of certain substances. Conventional transducers are used to produce an electrical signal measurable by standard instruments.

EUROPEAN PATENTS

Marc Masson explains how to save the time and cost of patenting in several countries by bringing out a European Patent, valid in thirteen countries.

A national patent (for example, a British patent) is valid only in the country in which it was filed. And filing a patent in several countries is costly, time consuming and requires fluency in the language of each country.

One Patent For Thirteen Countries

Fortunately, there is a simpler route — the European Patent. The European patent requires only one application, and is valid in thirteen member countries. These countries are:

Austria
Belgium
France
Greece
Italy
Liechtenstein
Luxembourg
Netherlands
Spain
Sweden
Switzerland
UK
West Germany

The European patent is the result of successful international co-operation, and is as easy to obtain as a national patent. The following is taken from a brochure published by the European Patent Office:

> *Patents encourage and stimulate innovation, as they provide a fair reward for the inventor and at the same time, a unique and original source of technical information.*
>
> *From its beginning in 1978, the European Patent Office (EPO) has been the central body for obtaining patent protection in up to 13 European countries through a single grant procedure. European patents have become a key for industry and commerce, since they provide a solid basis for business decisions on investment and licensing.*
>
> *Half of the EPO's 3100 international staff are examiners with university degrees in science or technology. They work at the forefront of technology, undertaking patent search, examination and opposition procedures.*

All the information about European patent applications is stored at the European Patent Office. To help them cope with the vast quantities of data involved, they store it on compact disks, each capable of holding more than a Gbyte of information.

Saving Time And Money

The cost of a European patent is higher than that of a national patent, but as a result of extensive work by politicians, it is now lower than ever before. It works out at less than the cost of bringing out separate patents in three or more different countries.

It is no more time-consuming or difficult to apply for a European patent than for a national patent. It will obviously save you a lot of time and trouble to apply for a European patent than for several national patents.

Also, your patent application need be in only one language: English, German or French, whichever is easiest for you to use. Providing you are fluent in just one of these languages, there should be no language difficulties.

However, as for a national patent, you should still seek the advice of a solicitor. Patenting, whether on a national or European scale, still requires legal skills.

How To Apply

If you want to apply for a European patent, you will have to go through the stages outlined below. The procedure is no more difficult than applying for a national patent in most countries:

The stages are:

- Filing of the patent application
  Examination of the application
  Search
  Publication of the application and search report
- Substantive examination (grant of patent or refusal of application)

- Opposition proceedings (if an opposition occurs)

In many countries, including Britain, you can apply for a European patent by going through your national patent office first. Otherwise, you can apply directly to the European Patent Office at:

Erhardstrasse 27
D-8000 Munich 2
010 49 89 2399-0

There are also branch offices at Den Haag (The Hague) and Berlin:

Patentlaan 2
NL-2280 HV Rijswiik (ZH)
010 31 70 340-2040

Gitschiner Str 103
D-10000 Berlin 61
010 49 30 25901-0

CABLE TELEVISION
Part 2

Following last months explanation of cable television, Jim Slater explores financial and political issues, and suggests that the future lies in optical fibre.

Technical stargazing is always difficult, and the wide variation in the penetration of cabled distribution systems in different countries makes any predictions of future developments even more difficult than usual. There are two conventional responses when media-aware people are asked what the future of cable holds. Some envisage a future where radio, television, and interactive services are brought into every house in the same way as electricity or water. Others look at the capability of a single satellite to serve tens or hundreds of millions of people with a wide range of services and say that the lower cost per head of providing satellite services must win out in the end, and that satellites will therefore replace cable.

The cognoscenti shake their heads and say that satellites can never provide the interactive services that the future will demand, but they often fail to recognise that even a humble copper-wire telephone line can provide virtually all the two-way capabilities anyone is likely to need for home or small-business use. Even the electronic keys which permit viewers to watch scrambled programmes can be sent over air in the form of coded teletext-like signals addressed to individual receivers, so that we certainly do not require a cable to provide the advantages of pay-television.

A Cabled Future For Europe?

History shows that what happens in the United States in the field of radio and television often happens in Europe a few years later (although recently this has become less true, with some developments, like the take up of teletext and the home video-recorder, growing faster in Europe and Japan than in the USA). In America, the cable operators have been using distribution satellites to keep cable customers happy by providing them with a wide range of programmes from satellite sources. This close link between cable and satellite is already being repeated in Europe. Cable operators who have been restricted for years to relaying only the basic national programmes plus one or two others can now offer a much wider choice of viewing by putting satellite receiving dishes at their head ends, giving the cabled services a competitive edge over the off-air services.

In Belgium, where over 80% of all television homes are now cabled, the way forward can be clearly seen. Cable operators there have the technical potential to introduce more and more new services at a financial cost which is attractive to both operator and subscriber. These may involve specialised pay-television channels, interactive services, or even telecommunications services. The main problems facing the cable services providers are political and regulatory, since any technical difficulties are usually soluble, and the cost of supplying viewers with new services is generally realistic.

The strong existing cable base in many countries in western Europe could provide an exciting future for cabled distribution systems. Cross-border links present no technical problems, and it is relatively inexpensive to provide viewers with an extremely wide range of programmes from different countries. Since the cabled viewer does not need to buy any extra equipment he may well be prepared to pay extra for a wider choice of viewing. This money will then be available for reinvestment in programme making, which is really the seed corn of the whole television business. Even more importantly, the ability to watch programmes from other European neighbours may have a leavening effect on the closer harmonisation of the countries of Europe, so that for the first time Europeans really will come to consider themselves as members of one great community.

Once 80% of a country is covered by cable services it is usually relatively simple to increase this coverage by extending existing networks, although a law of diminishing returns exists, and the economics of laying cable to every isolated hamlet may make it impracticable to serve all potential viewers in this way. A satellite can provide nearer to 100% coverage of scattered populations than a cable or terrestrial transmitter network, but with a capital cost of around a hundred million pounds for a high-power satellite, this is no economical way to achieve coverage of the final 5% of a population which is already mostly served by cable or off-air services.

UK Cable — Hard Times Ahead?

Much depends upon the coverage requirements placed upon the broadcasters by the government, and although many countries would consider a coverage of 95% of the population to be adequate, the United Kingdom government requires broadcasters to serve 'as many people as may from time to time be practicable'. Thus although terrestrial television transmitters currently cover about 99.5% of the UK population, the job of building relay stations to serve the remaining population continues, even though this has long been a strictly uneconomic undertaking. With such a background, where public-service broadcasting traditions provide almost everyone with a choice of four off-air programme channels for the cost of the receiving licence it is perhaps not surprising that cable has found it hard to compete, especially since the government's treatment of capital expenditure on cable services for tax purposes has proved far from generous. Under a million homes out of a total of over twenty million in the UK are passed by cable systems, and although it is difficult to obtain accurate figures for penetration (homes connected as a percentage of homes passed), it is thought to be about 17% (although some of the newer systems can claim over 20%).

With such a low baseline it is difficult to see how cable television in the UK can ever make the breakthrough needed to become the main means of television distribution. The promise of three more television channels from a high powered satellite, which can be received on cheap domestic equipment by the end of 1989, will make life even more difficult for the cable operator, although he will be compelled to carry the extra channels. The root of the problem is financial. Although broadcasters would deny that there has been any subsidy of the building of the transmitter network, half the cost has come from BBC licence fees and the other half has come from the profits of the commercial television companies, so that the viewer has paid directly or indirectly, almost without realising it, for the construction of the transmitter network. For environmental reasons it is not generally permitted to hang distribution cables from poles in the UK, so all new cables have to be embedded in the ground. The cost of these ground operations is high; costs between four hundred and

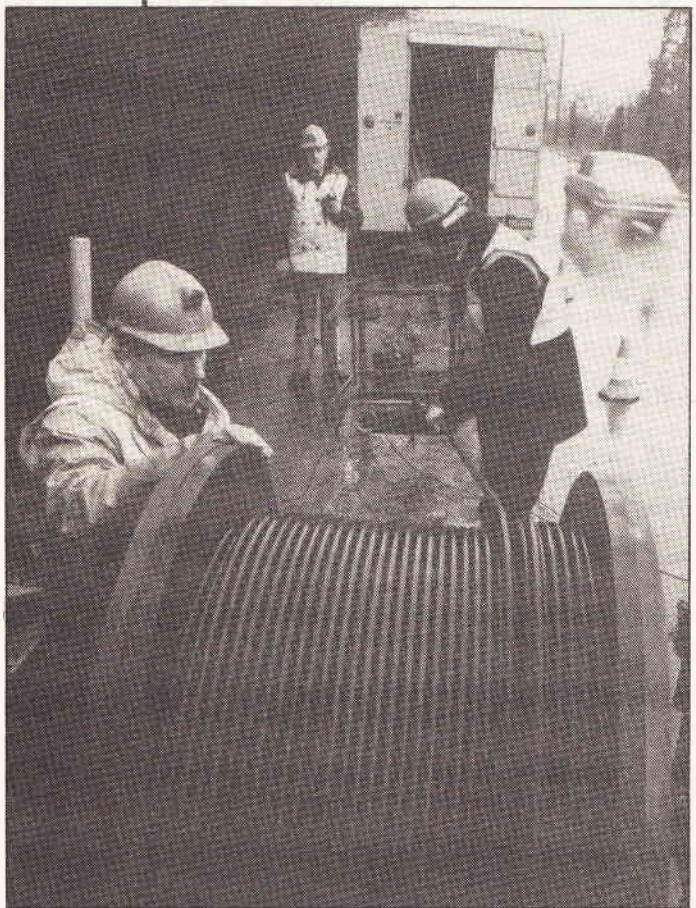


Photo courtesy of British Telecom

seven hundred pounds have been quoted for each additional home connected, depending upon the location. It is therefore no surprise that new companies have found some difficulties in raising the necessary capital. Would-be investors must ask how long it will take to make a worthwhile profit on such a huge investment. When they are told that it may be as long as seven years, many people decide to entrust their savings to a less risky venture. Fortunately, though, there are those who believe that cable has a future, and in areas where the latest technologies and the widest choice of programme and interactive services are provided, the viewers seem to appreciate the new services, and would perhaps pay more for. Many of these 'new' cable distribution services are in fact extensions and refurbishments of the old cable services operated by the Rediffusion company, which kept faith with cable for over thirty years even though off-air broadcasting services seemed to be given all the breaks. Much of the new money invested in cable television systems is coming from the USA, where investors know that cable can be a good investment, although it may take a long time for the first rewards to come in.

Optical Fibre — One Man's View Of The Future

In the short term, then, life looks difficult for the cabled distribution systems in the UK, with other technologies seeming to have the upper hand, but as in all crystal ball gazing much depends upon the person staring deep into the mists of the crystal. The scenario that follows can be no more than one man's view, but this particular viewer believes that cabled systems in the UK may have a great future in the longer term.

It is 1990, UK viewers have four terrestrial programme services, half a dozen Astra satellite services, and the promises of five more if they are prepared to buy a second satellite receiver. The broadcasters are beginning to replace their twenty year old terrestrial transmitters with new, more efficient ones that will last another twenty years. This will cost tens of millions of pounds, and will maintain the status quo until well into the twenty-first century. Against this background cabled distribution systems can expand only slowly, but new satellite services will continue to appear, and will prove popular since they can be received on existing equipment.

Now let us jump forward twenty years. The broadcasters will need to replace their transmitters again, this time at a cost of perhaps hundreds of millions of pounds, unless inflation really can be persuaded to stand still. In order to buy new equipment, the broadcasters will have to discuss where the money is coming from, and it will not be surprising if by that time some satellite operator can provide nationwide multi-channel television coverage for a fraction of the cost of renewing the terrestrial network. Although there are some worries that a satellite service will not be as secure in times of national emergency as a network of terrestrial transmitters would be, the financial arguments win the day. Plans are drawn up for the national services (BBC1, BBC2, and Channel Four, say) to be immediately transferred to satellite. The replacements for today's ITV companies protest that they provide regional broadcasting, and that satellite beams are too large and all-embracing to make their form of broadcasting viable from satellites. However by the time twenty years have passed, the technology will have advanced enough for broadcasting satellites to carry much larger, and therefore more directional aerials. It will be possible to have a satellite footprint that covers just Yorkshire, or just Scotland, so satellite broadcasting could replace all out current terrestrial broadcast output.

Satellite transmitters still cost a great deal of money, however, and at about the time that this major national investment will be required, the national telecommunications operator (whether British Telecom or some other body yet to be created) may have just completed replacing copper wire telephone cables throughout the land by fibre-optic cables. This will have taken several years, but now nearly every house has a small-fibre optic cable instead of the previous telephone wires. The programme will have been entirely self-financing, because BT has been able to sell the old copper cables at a price considerably higher than the cost of the replacement fibre-optic equipment. The fibre-optic equipment has itself become much cheaper since opto-electronic components have become available in integrated circuit chip form. BT has had to plan the replacement programme carefully over a number of years, because it has so much copper available in its ducts that to put it all on the market at once would lower the price of copper in the world's commodities markets. Once the project is complete, with over 95% of homes having a fibre-optic cable input, BT can suggest to the government that it be allowed to carry all existing broadcast services on its fibre optic network, so as to reach virtually every home in the kingdom. Because it has already paid for the capital costs of the work of installing this huge fibre-optic network, and made a profit out of the deal, it can offer to carry the television services free of charge, knowing that it will be able to reap its profits from the multiplicity of new services that the optic-cable network will be able to carry in the future. The government is unable to resist such a wonderful financial deal, adds a few more 'musts' to its 'must-carry' regulations in order to show that it is still in charge, and gives the go-ahead.

Thus in one mighty leap cable has overtaken both terrestrial and satellite broadcasting for home use, since who will buy satellite receiving equipment when all the programmes are already coming into the houses by cable? Only the needs of the portable user will not be satisfied by the cable, and by that time there will be sufficient satellite services available for the viewer (with his brief-case portable satellite receiver and built-in flat-plate aerial) to have access to a wide range of other programmes, including the twenty-four hour international news programmes, and world-wide paging services.

Although most of the present-day cable operators do not yet appear to have recognised the possibility of such a scenario, British Telecom certainly has, and has published details of its plans for the provision of a national multi-purpose fibre-optics grid. This complex cable network would provide for interactive services, high-quality television pictures, data transfer services, videotex services, and even picture-phone services.

During the latter years of the twentieth century higher definition television (HDTV) pictures, which can be shown with excellent quality on large screens of perhaps a metre diagonal, will become available on videodisc and perhaps from special wide-band satellite transmission systems. If cabled distribution systems are to keep up with this new technology, they will have to make provision for the increased bandwidths that such services will require. Whether HDTV finally comes in the form currently proposed by the Japanese, requiring a bandwidth of over 20MHz, or in one of the enhanced Multiplexed Analogue Components formats requiring around 16MHz preferred by most European countries, cable operators will need to ensure that they have the capacity and flexibility to deal with the increased bandwidths that will certainly be required. Only by planning well in advance can operators be sure that their systems will prove adequate, and it is notable that one of the claims for the BT fibre-optic system is that it will be able to deliver HDTV to the home.

Photo courtesy of British Telecom

Although the picture painted above shows a rosy future for cabled distribution systems, observant readers will have noticed that it is BT (or some other nationwide operator) which ends up in total control of the nationwide network. This situation, though familiar in many countries where the PTT runs everything, is totally at odds with what most cable operators would want. There is, however, no good reason why local operators should not be allowed to provide their own competing services whilst using the network that BT has laid down, and it is to be hoped that a suitable legislative and control framework can be worked out to permit us to have the best of both worlds.

We end on an optimistic note, therefore, with thoughts of a nationwide fibre-optic system that provides all the services that we could possibly need, including a feature which only cable can provide, a really local service of radio and television programmes and information that can be used to bind together the communities in which we live — true community broadcasting. The only slight cloud on the horizon of our cabled landscape is the fact that the horizon is still some distance away; cable in the UK has a great future, but the future may be a long time coming!

Jim Slater's book Cable Television Technology is published by Ellis Horwood. ISBN 0-7458-0108-0.

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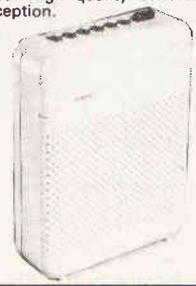

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ELEMENTS OF RADIO

Part 3

In the final part of this series, John Linsley Hood describes some more advanced receiver designs, as used in many modern systems.

In principle, with modern components, you can push the performance of a superhet radio system as high as you want, in terms of bandwidth, stability of timed frequency, and signal-to-noise ratio. It depends on your needs, and the cost and complexity which can be justified in the design.

However, for the amateur, the existence of so many radio applications 'goodies' allows plenty of scope for low cost DIY experiments. Very convenient components are the quartz crystal filter and the modern, cheaper alternative, the ceramic 'ladder' or *SAW* filter, used for the provision of adjacent channel selectivity. Both are used in fixed frequency IF stages, typically at 455kHz, though other frequencies up to many MHz are also available.

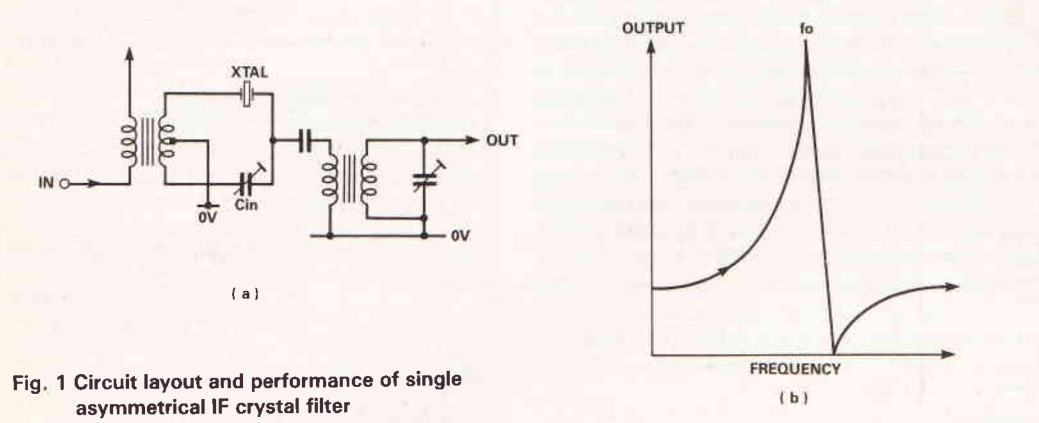


Fig. 1 Circuit layout and performance of single asymmetrical IF crystal filter

Filters For IF Stages

● Quartz Crystal Filters

The earliest techniques used to obtain high selectivity in superhet radios were based on the extremely high electromechanical Q values offered by the quartz crystal resonator. When this crystal is used in the circuit of Fig. 1a, its very sharp resonance peak gives a tuning response of the kind shown in Fig. 1b.

This was fine for isolating a single CW signal in the crowded amateur bands. The only modulation of the carrier was caused by switching on and off the morse key of the sender, and the interrupted carrier could be converted into an audible chirp by 'heterodyning' the IF output with the output from a local oscillator tuned to near the IF frequency — the Beat Frequency Oscillator, or BFO. Fig. 2 shows the circuit layout.

However, for a modulated carrier carrying speech, the very narrow pass-bandwidth of a single crystal filter set-up would make speech unintelligibly 'boomy'. You can get round this problem by using a *band pass* crystal filter. This uses a pair of quartz crystals, with a separation in their resonant frequencies approximately equal to the bandwidth required, arranged as shown in Fig. 3a. This gives the kind of frequency response shown in Fig. 3b which is very good, but is a bit costly to put together.

● Ceramic SAW Filters

These devices (also called *ladder filters* because of the shape of the electrode pattern used) make use of the

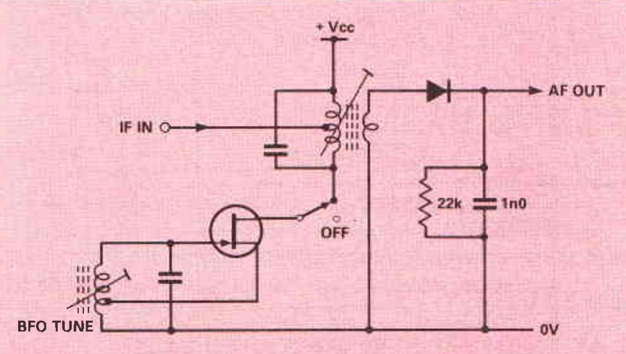


Fig. 2 Simple IF beat frequency oscillator (BFO) using FET

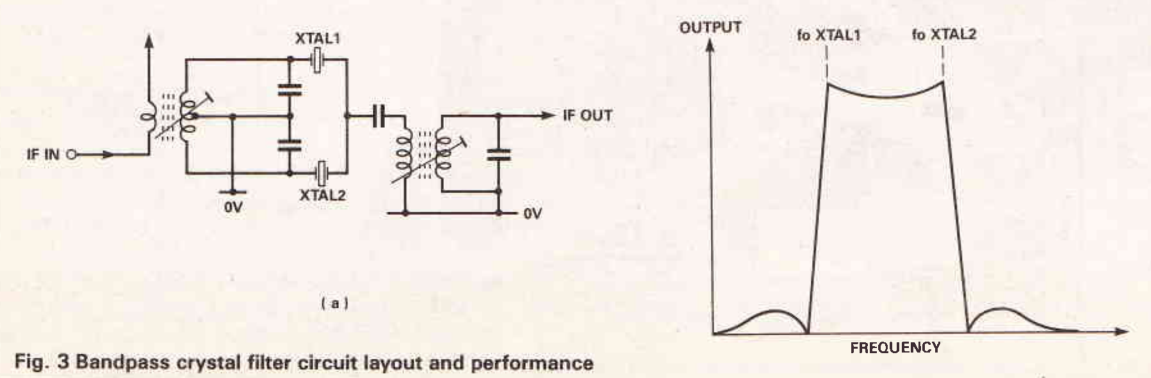


Fig. 3 Bandpass crystal filter circuit layout and performance

piezo-electric properties of materials such as Barium Titanate. Thin strips of single crystal quartz may also be used in some of the more up-market versions of these devices.

Their operation is based on the physical effect of an electrical signal applied between a group of interlaced parallel metallised strips, as shown in Fig. 4. If the electro-mechanical wavelength of an applied oscillatory voltage has an appropriate relationship to the spacing between the metal electrodes, a surface ripple will be propagated along the strip of material.

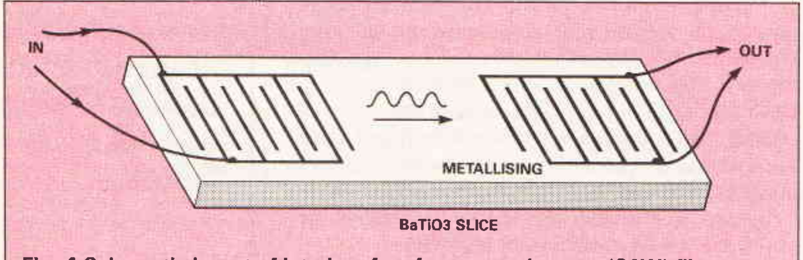


Fig. 4 Schematic layout of interior of surface acoustic wave (SAW) filter

This ripple will then be converted back into an electrical signal when it reaches a similar group of inter-digitated electrodes at the other end of the strip.

By choosing the width and spacing of the metallised electrode strips, the operating frequency and bandpass characteristics of the filter can be determined quite precisely. However, unlike the quartz filters, which are basically high impedance devices, ceramic SAW filters usually require a fairly low source and load impedance, typically 330 ohms.

The kind of frequency pass-bands obtainable are shown in Fig. 5. The diode switching circuit shown in Fig. 6 can be used to offer a choice between two or more filters in the IF circuit, giving a range of possible bandwidths for different signal or reception conditions.

However, as explained in the first part of this series, a very narrow pass-band is not wholly advantageous, since increased selectivity cuts the audio bandwidth, and may make the signal less intelligible. It will also increase the demands of the stability of the receiver tuning.

Frequency Stable Oscillator Systems

The stability of tuning of a superhet is principally determined by the stability of the frequency of the local oscillator. This problem is more acute in up-market communications receivers, where very high values of first IF frequency are used to push the second-channel frequency way above the Rx input pass band, since this also requires the local oscillator to operate at a very high frequency.

There are two major techniques used to get round this problem; the drift-cancelling loop, such as the Barlow-Wadley system (used in the Yaesu FRG7 communications Rx), and the frequency synthesiser technique.

The last method is becoming increasingly widely used in multi-band radio receivers, due to the fall in cost of large-scale integrated functional blocks, required for frequency division and its numerical control.

• The Barlow-Wadley Loop

The basic scheme is shown in Fig. 7. It is based on the fact that a quartz crystal oscillator can be designed to be extremely stable in frequency, so that even the frequencies of its harmonics will be adequately stable. The incoming signal is heterodyned (mixed) with the output of a relatively unstable LC oscillator. The

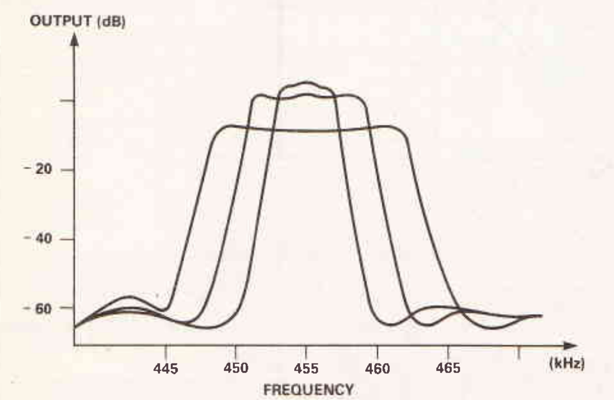


Fig. 5 Typical pass-band characteristics of various types of SAW filter

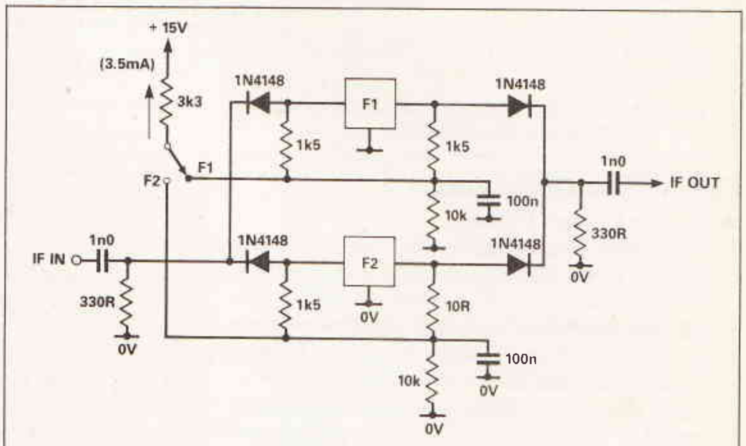


Fig. 6 Technique for switching between two or more ceramic filters

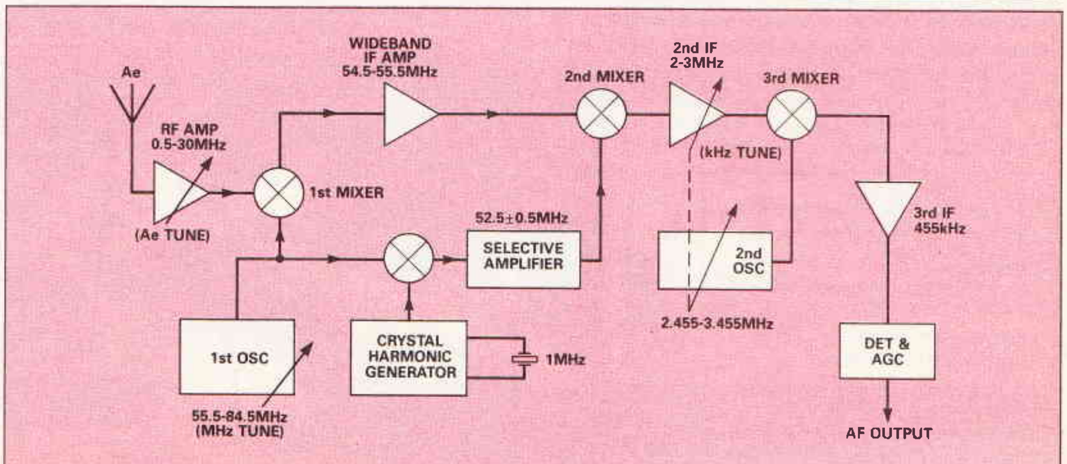


Fig. 7 The Barlow-Wadlet loop, as used in the Yaesu FRG7 Communication Rx

resultant IF is amplified, and its output is then remixed with a third signal which is the combination of the original oscillator plus a harmonic of the crystal frequency. The drift due to the instability of the LC oscillator will then cancel out.

As shown in Fig. 7, an incoming signal is amplified by a tuned RF stage, which has a built in low-pass filter to cut out all signals above 30MHz. This signal is then mixed with the output of a reasonably (but not entirely) stable LC oscillator, oscillator 1, to give an IF somewhere in the region 54.5 to 55.5MHz, which is then amplified by a fairly wide-band first IF amplifier stage.

The output of oscillator 1 is then also mixed with the harmonics of a 1MHz quartz crystal oscillator, and passed through a frequency selective amplifier which has a 52-53MHz pass-band. Of the input mix of frequencies that within the range 52-53MHz is then combined with the first IF output to give a second IF of 2-3MHz. If there is a drift in the frequency in oscillator 1, then there will be an identical drift in the

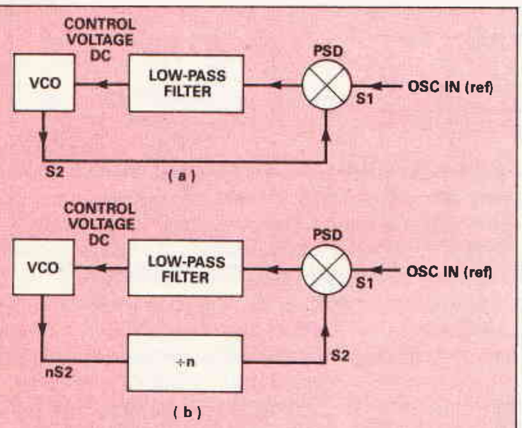


Fig. 8 Frequency multiplying phase-locked loop

52-53MHz signal fed to the second mixer and this drift will then be cancelled in its output to the second IF stage.

The second IF is actually the tuned 'RF' stage of a conventional 2-3MHz superhet receiver. It is ganged to a lower frequency tuned LC oscillator, oscillator 2, to provide a 455kHz third IF for final amplification and selectivity. Although oscillator 2 is not absolutely frequency stable, it is adequate compared with the 55.5-84.5MHz. oscillator 1, and for most practical applications the system is drift-free.

● Frequency Synthesisers

Frequency Synthesisers employ a circuit called a *phase-locked loop*, shown in Fig. 8a, which is built from a phase sensitive detector (PSD). A PSD is a kind of mixer, which gives a voltage output related to the relative phase angle between two input signals, S1 and S2, which are at the same frequency.

If this DC output voltage is then fed to a voltage controlled oscillator (through a low-pass filter to remove unwanted RF components) it can force the VCO into precise phase synchronisation with the incoming signal S1. Depending on the characteristics of the loop and its filter stage, it can also force the VCO into frequency synchronisation with S1 when it was not initially running at the same frequency.

As an interesting spin-off, if a frequency divider stage is inserted in the loop between the VCO and the PSD, the VCO can be forced into frequency and phase synchronism with some multiple of the input frequency, giving a very reproducible frequency multiplier stage. This is shown in Fig. 8b.

This idea can be developed into the circuit shown in Fig. 9, where both the reference frequency and the VCO have frequency divider stages inserted between them and the PSD. If *m* and *n* can be specified over a wide enough range, the VCO, can, in principle, be give almost any desired output frequency which has the same stability as the reference input, which could be a highly stable quartz crystal oscillator.

This layout is the basic frequency synthesiser scheme. With modern systems of the kind shown in Fig. 10, a small dedicated microprocessor converts the desired tuning frequency, entered at a digital key pad, into the values of *m* and *n* which will make the VCO run at that frequency.

The construction of a wide frequency coverage superhet receiver can then be greatly simplified, to the kind of layout shown in Fig. 11. The first IF is high enough to avoid second channel interference, and the second oscillator is a crystal-controlled fixed-frequency circuit to reduce the signal frequency back to, say, 455kHz for amplification and pass-bandwidth selection by the use of ceramic filters.

To avoid the need to tune the pre-mixer RF stage, in parallel with the signal frequency selected by the synthesised oscillator the RF input is normally routed through one or other of a group of diode-switched LC filter networks, with the actual input filter in use being selected by a voltage output from the same microprocessor IC which controls the synthesised oscillator. The circuit is shown in Fig. 12.

The only problem is that there may be, within the

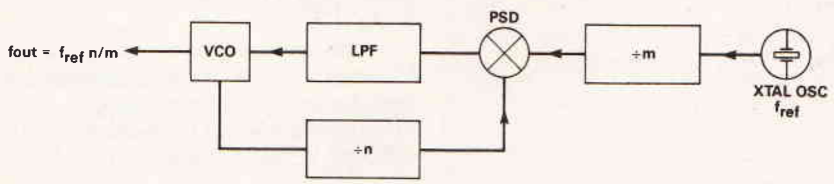


Fig. 9 Basic layout of crystal controlled frequency synthesiser

chosen filter pass-band, a sufficiently strong unwanted signal to drive the RF or mixer stage into a non-linear part of its characteristics. This can cause *cross-modulation* where the modulation on the unwanted

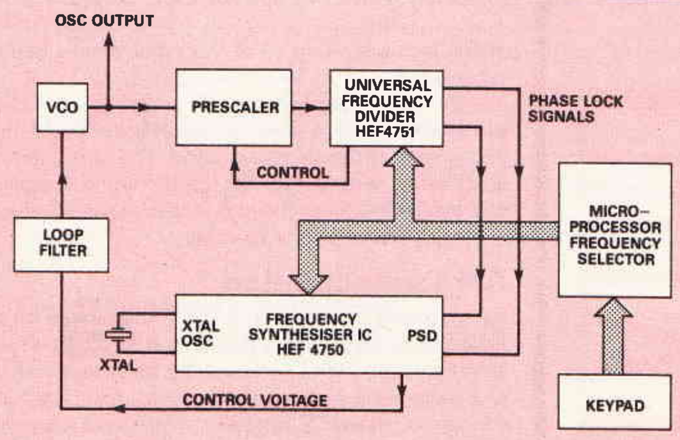


Fig. 10 Microprocessor controlled frequency synthesiser

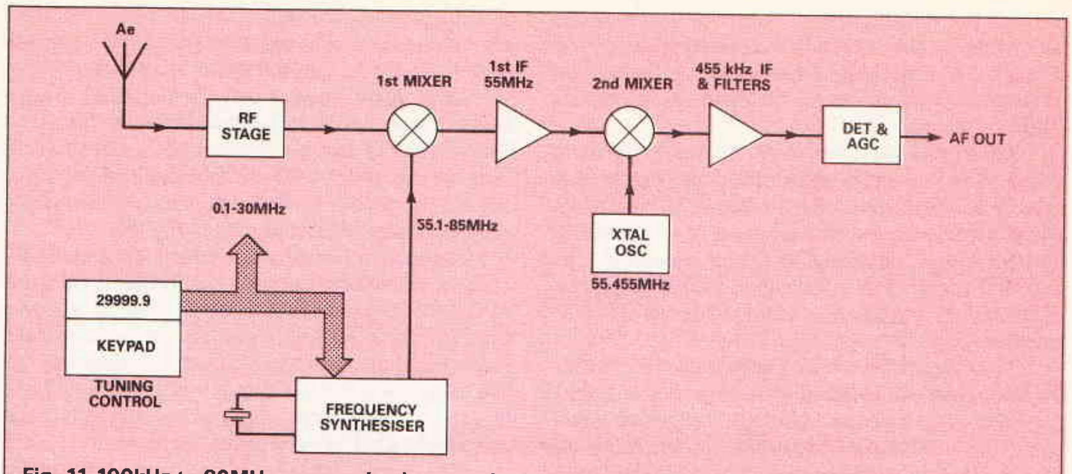


Fig. 11 100kHz to 30MHz communications receiver using synthesised oscillator

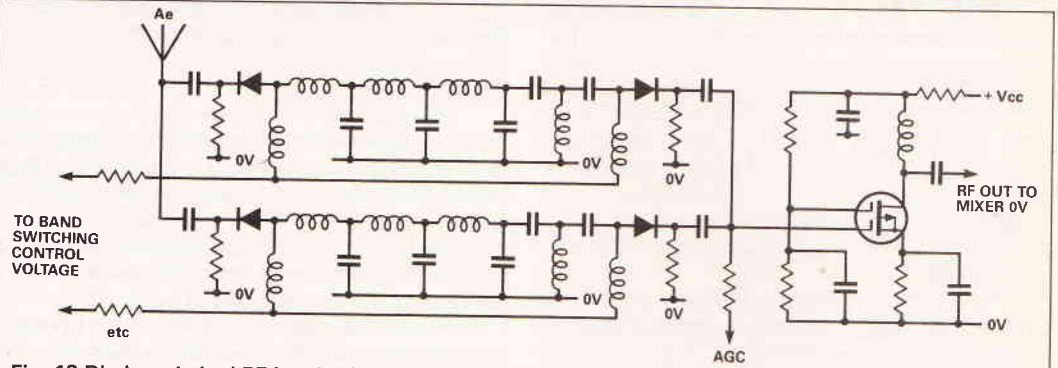


Fig. 12 Diode switched RF band selection system using LC filters

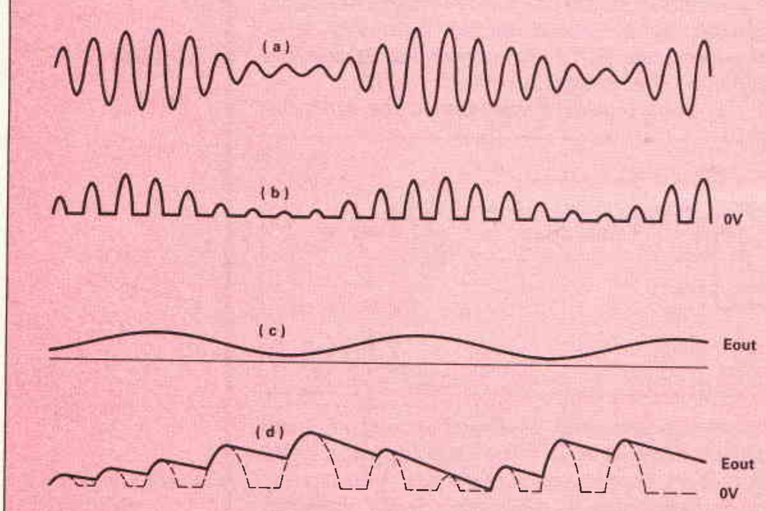


Fig. 13 Demodulation of RF signal using rectifier circuit

modulated carrier into a useful AF signal is to pass it through a rectifier circuit of the kind shown in Fig. 14, which will, ideally, give the kind of output shown in Fig. 13b. However, before this can be used, the RF component must be removed by some low-pass filter circuit, to give the electrical 'average' output shown in Fig. 13c.

This works well at low modulation frequencies. However, higher audio frequencies where the impedance of the parallel capacitor, C, is beginning to be comparable with R, the demodulated waveform will begin to distort, as shown in Fig. 13d. A *full-wave*

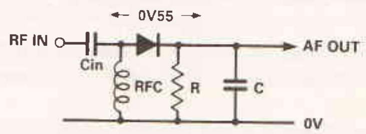


Fig. 14 Simple diode demodulator

signal is imposed on all of the other signals being received.

A more sharply tuned RF stage lessens the probability of such a powerful signal occurring in the chosen part of the input pass-band. The only answer is to try to ensure that the input/output transfer characteristic of all of the gain stages are as linear as is compatible with their function.

AM Demodulation

An incoming RF signal amplitude modulated by a lower frequency sinewave produces a waveform of the kind shown in Fig. 13a. Since the fundamental RF carrier frequency is well above the human hearing, such a modulated RF signal range on even the lowest practicable carrier frequency would be inaudible.

The conventional method of converting such a

rectifier circuit, which doubles the RF frequency of the rectified output, allows a lower value of shunt capacitance to be used, and lowers the distortion introduced by the demodulation process.

A further problem of the simple diode rectifier system is that received RF signals which are less than the 0.55V forward conduction voltage of, say, a typical silicon diode will simply not cause it to conduct at all. However this may not be much of a practical difficulty in a normal superhet where, in the absence of any other signal, even mixer noise may be amplified to more than 0.55V peak-peak.

With smaller input signals, this turn-on threshold effect can be avoided by ensuring that a forward voltage is applied to the diode(s) as shown in Fig. 15a. An alternative arrangement is to use emitter-follower or source-follower circuits as shown in Figs 15b and

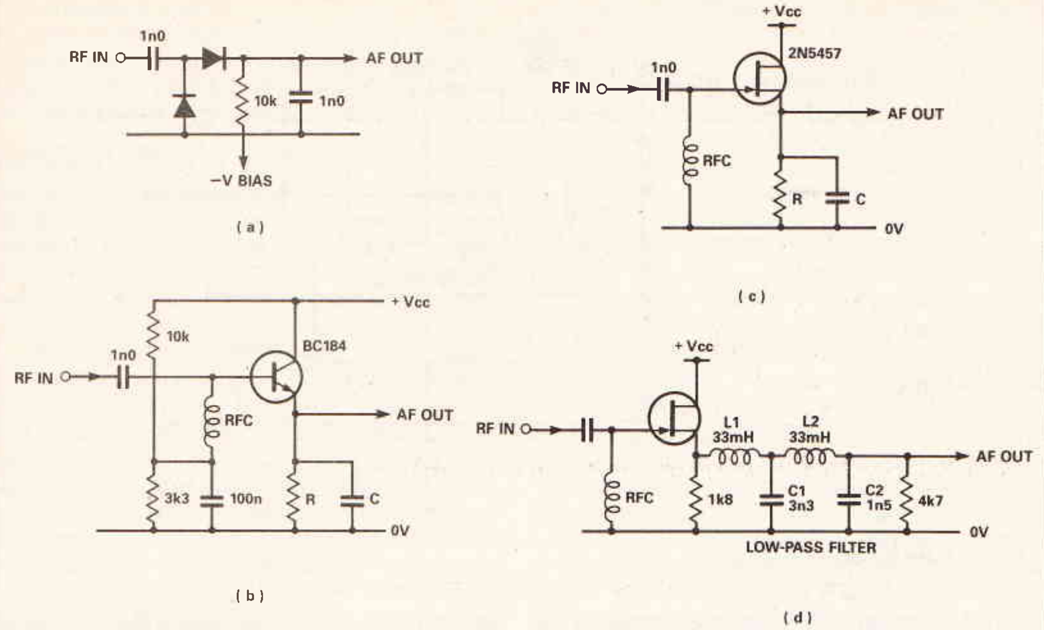


Fig. 15 AM Demodulator systems

15c. In valve days, this used to be called an *infinite impedance detector* since it didn't lead to the same loading (and Q spoiling effects) on the preceding tuned circuit which the simple diode would cause.

If the transistors in Figures 15b and 15c are biased so that they are just conducting, a positive input voltage will increase the current flow through the device, and increase the emitter or source potential, whereas a negative input voltage swing will tend to cut the device off. Once again, the emitter/source RF bypass capacitor must not cause too long an RC time constant value or the recovered AM signal will be somewhat distorted.

A better answer is to use a steep cut RF rejection filter, of the type shown in Fig. 15d, to separate the RF and AF components.

FM Demodulation

The basic structure of a normal FM receiver is not very different from that of an equivalent VHF AM radio, except that it has a wider IF bandwidth to accommodate the +/−75kHz deviation of the carrier, and oscillator stability is not usually a problem because of the wide receiver bandwidth. However the conversion of a frequency modulated RF signal into an audio output is less simple than in any AM system, since the carrier amplitude is now constant, and only its frequency will vary.

A simple and crude answer is merely to tune the signal so that it sits on the side of the receive response curve, as shown in Fig. 16, but since the slope of the curve is far from linear, the audio output will be pretty badly distorted.

A better answer is to exploit the phase shift in the voltage developed across a tuned circuit in relation to the RF input current, as the applied input frequency moves above or below the resonant frequency of the circuit. This characteristic is used in all three of the common FM demodulator circuits, the *ratio detector*, the Foster-Seeley, and the IC gate coincidence system, shown in Figs. 17, 18 and 19.

This last circuit is now almost exclusively employed in all contemporary 'hi-fi' FM tuner systems, and can, with care, give a recovered distortion figure of as low as 0.2%. However, the final linearity of all phase-related demodulator systems depends on the accurate phase coherence of all the tuned circuits which precede the demodulator, since if the phase of the incoming signal is shifted, the demodulator cannot distinguish between this and a waveform related frequency shift.

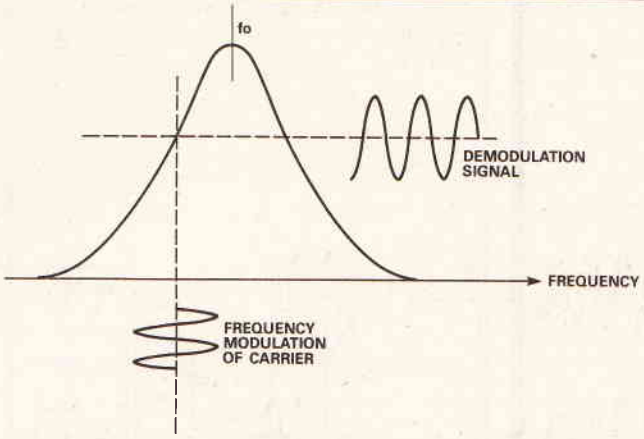


Fig. 16 Slope demodulation of an FM signal

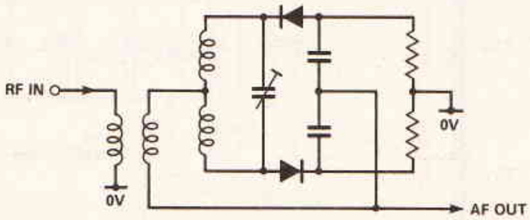


Fig. 17 Ratio detector

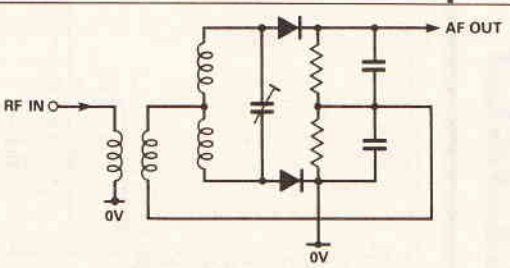


Fig. 18 Foster-Seeley or phase detector

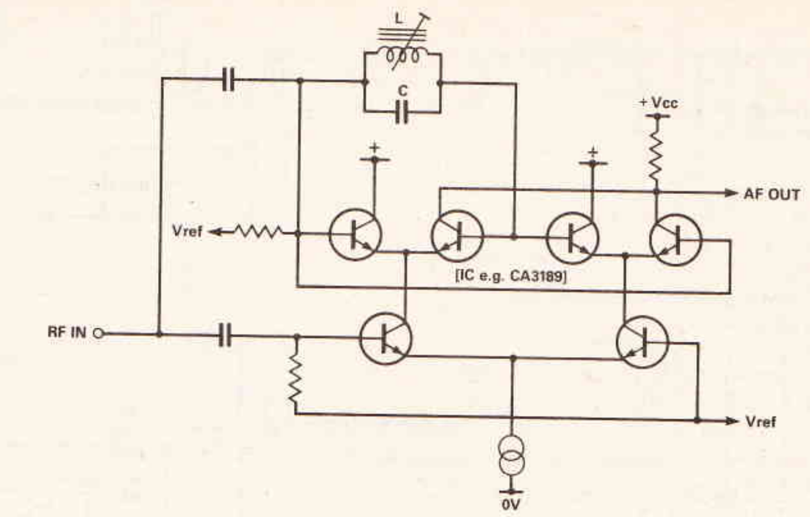


Fig. 19 Gate Coincidence detector

A nicer answer to this difficulty is to return to the phase-locked loop circuit shown in Fig. 8a, which I used in my own PLL FM receiver, (described in ETI in March and April 1987). The incoming FM RP is fed into a phase sensitive detector, and the loop output is used to control the frequency of a VCO which is frequency locked to the incoming signal. The AF output from the loop (the filtered frequency control

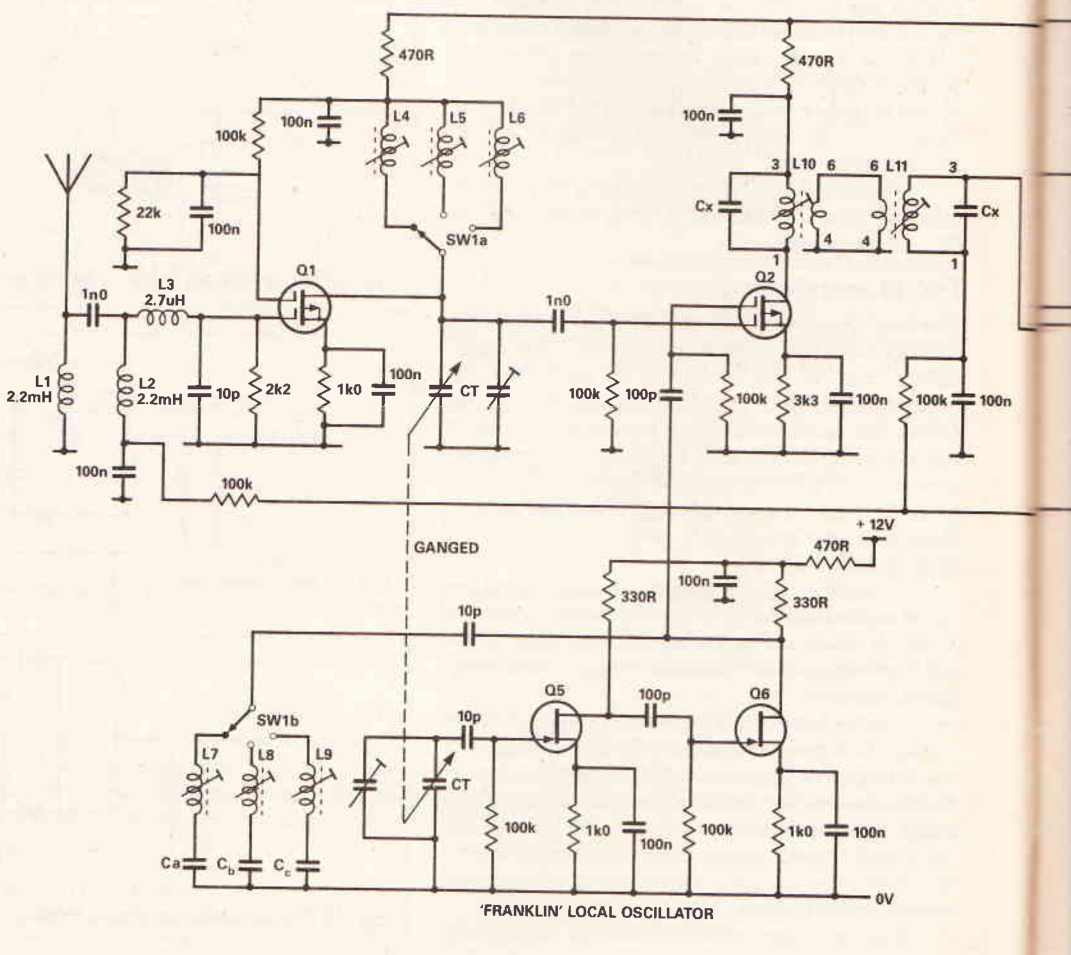


Fig. 20 Sensitive 455kHz Superhet covering 100kHz to 30MHz with suitable RF oscillator coils.

RADIO

voltage fed to the VCO) will then be as linear as the VCO characteristics allow.

With careful design of the VCO you can get an output linearity as high as 0.05%, without the need to use carefully chosen (and expensive) RF stages and filter modules in the preceding circuitry.

Single IC Radio Systems

Most of the cost of making a simple AM/FM radio is the labour needed to put the necessary components together. In order to reduce the component count and the consequent labour costs, a number of manufacturers have made special purpose ICs which perform all the necessary circuit functions.

With the exception of the Ferranti ZN414, nearly all these ICs – such as the TEA5570 (described by Paul Chappell in ETI November 1989) or the TDA1072A — employ superhet circuits. The necessary oscillator, RF/IF gain and demodulator/AGC stages are on the chip, so that with the addition of some external tuning and decoupling components, the IC will make a complete radio set. The loudspeaker driver stages can also be provided by a single IC, such as the TDA1013A. Some, like the NS AM/FM LM1868, even have an audio power amplifier in the package.

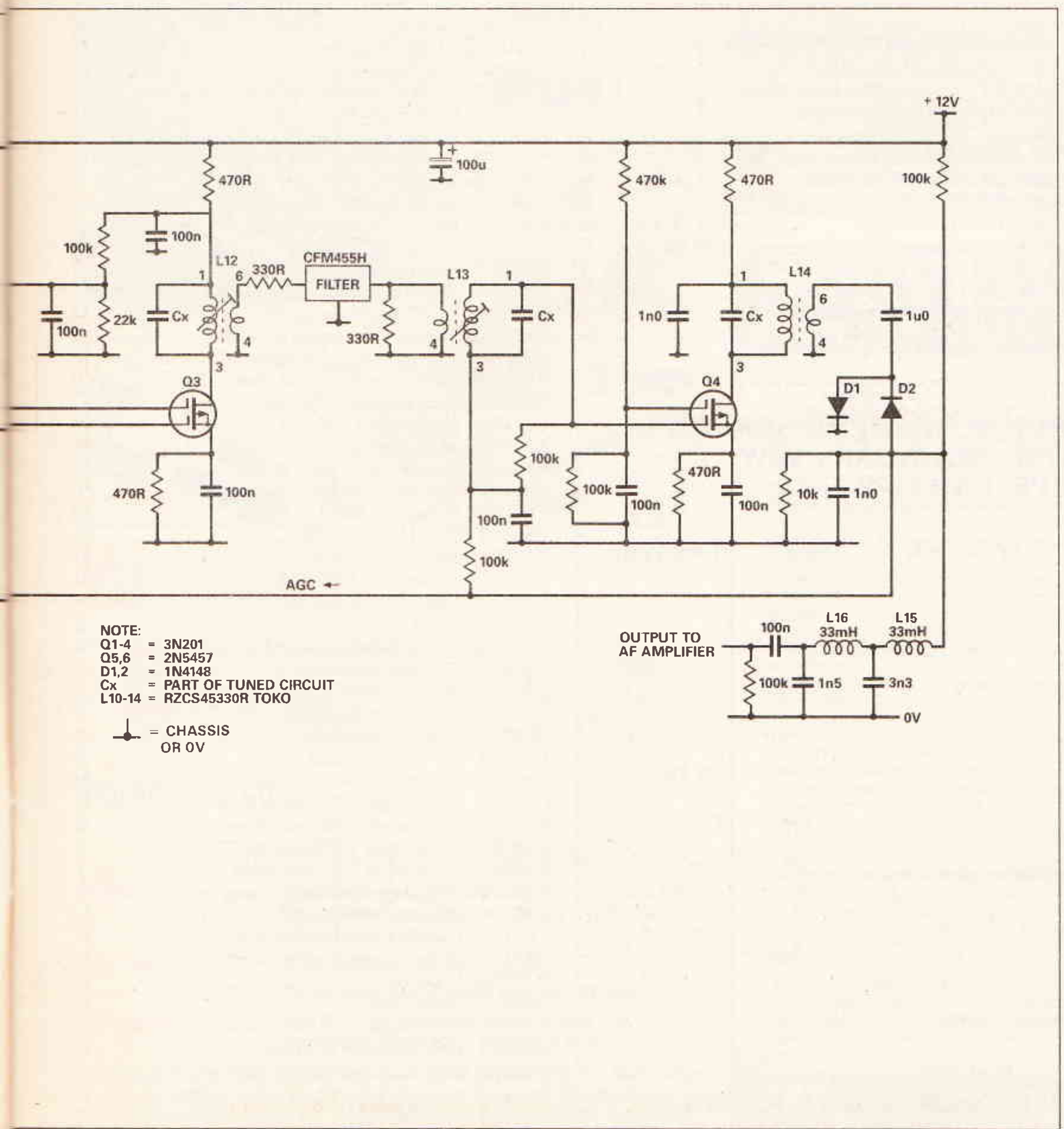
While these ICs offer a simple route to radio construction, they don't, I think, offer nearly as much scope for individual experiments or performance improvement as circuits built up from separate bits — provided that you know how to do it.

A DIY multi-waveband

To round off this series Fig. 20 shows a fairly simple single conversion superhet, with a 6kHz pass-band IF ceramic filter and an untuned RF stage, which includes some of the circuits described above. The tuning range is controlled by the aerial and oscillator coils (L4/L5/L6 and L7/L8/L9), switched by S1a/S1b. Many of these ranges can be chosen.

Each of the oscillator coils requires a 'padding' capacitor, (Ca/Cb/Cc) to help keep the aerial and oscillator coils in tune over the chosen frequency range. The proper value for these capacitors will depend on the coils chosen, varying from 220p for the long wave (120-300kHz) band to 0.01μ for the 10-30MHz band.

Since it uses only a 455kHz IF, the second-channel rejection on higher frequency short-wave bands will not be very good. However, the sensitivity and signal-to-noise ratio is good enough to receive almost any usable incoming signal. The tuning capacitor is an airspaced 330p dual gang unit, with trimmers caps. All the components needed can be obtained from *Cirkit*, or *Bonex* (102, Churchfield Road, Acton, London) if your local shop cannot help.



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E8904-3	Intelligent Plotter Main Board	O
E8904-4	Kinetotie Tie Board	N
E8904-5	Kinetotie Control Board	E
E8905-1	Guitar Tuner	H
E8905-2	Camera Trigger Ultrasonics (2 boards)	F
E8905-3	Bench Power Supply (2 boards)	H
E8906-1	PC edge connector	F
E8906-2	MIDI converter CPU	N
E8906-3	MIDI converter keyboard	N
E8906-4	MIDI converter control	M
E8906-5	AF signal generator	G
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E8907-2	Priority Quiz Switch	E
E8907-3	Camera Trigger Infra-reds (2 boards)	G
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E9001-2	Wavemaker FG	L
E9001-3	Motorcycle Intercom	F
E9001-4	Low Voltage Alarm	C
E9002-1	EPROM Emulator	N
E9002-2	Superscope Mother Board	M
E9002-3	Superscope CRT Driver Board	K
E9002-4	Superscope Timebase Board	K
E9003-1	Superscope Y1 input board	J
E9003-2	Superscope Y2 input board	J
E9003-3	Superscope switch generator	E
E9003-4	Business power amp board	L
E9003-5	Business power supply board	J
E9003-6	Business pre-amplifier board	L
E9003-7	Water hole	G
E9003-8	Super Siren	D
E9003-9	Val's badge	F
E9004-1	Bass Amplifier DC Protection	F
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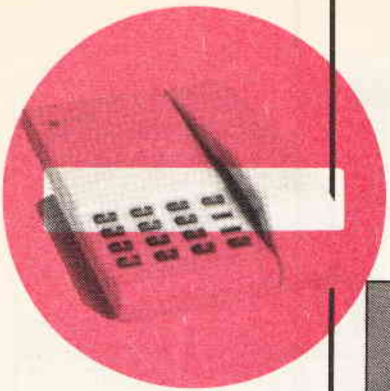
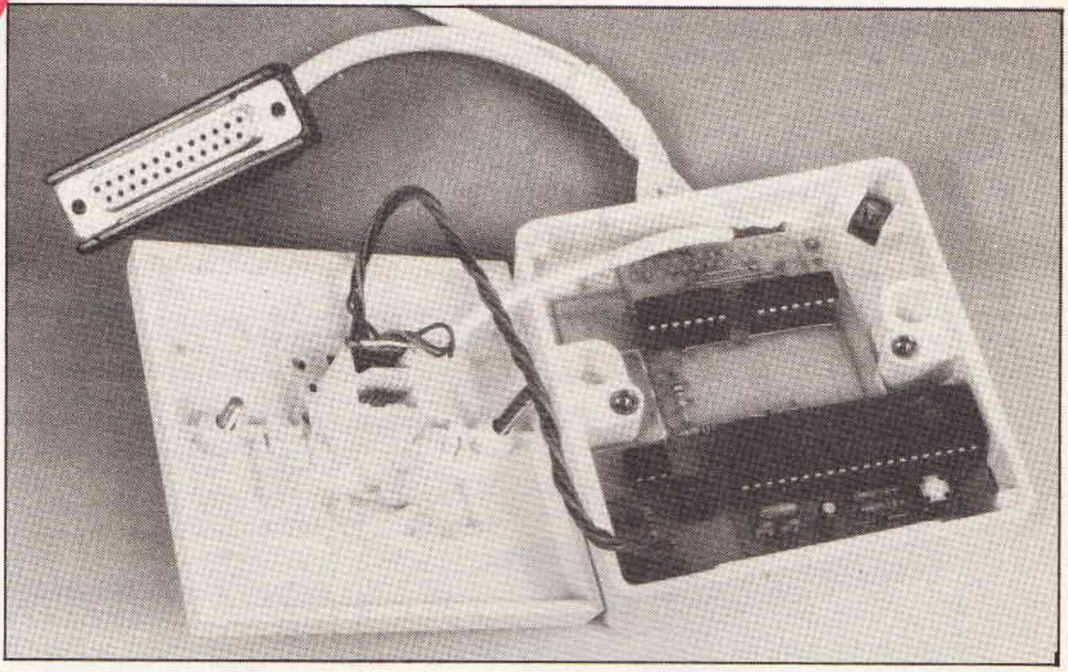


PHONE LOCK AND CALL LOGGER



In March, we asked why phones aren't protected by PIN numbers. Now Kevin Kirk has come up with a circuit which does just this - and logs outgoing calls too!

PROJECT

Anyone who has had a large telephone bill (which probably includes almost every reader) will wonder how the bill could be so high when the phone is only used occasionally. The mystery may be partially solved if there is a teenager in the house or if the telephone in question is in a company, where a certain pimply youth has more than a passing knowledge of Willing Wanda's 0898 phone-in.

The phone bill maybe the real reason why this country has such a high rate of heart attack victims. So that a low cost call logger unit that stops unauthorised calls and logs all others, may save the NHS a fortune!

Design Philosophy

The original idea was a simple telephone combination lock, which required you to dial a code before you could make any calls. Originally it was thought that a pure logic circuit could be used, but the design became too complex.

It emerged that the unit needed some sort of processor. With some form of intelligence it became much easier to add call logging and screening of certain types of calls.

To prevent unauthorised users knowing that the call logger unit is there, it must be hidden (I would get suspicious if I saw a load of lights start flashing on a large box as soon as I lifted the phone off the hook). There is no better place to hide the unit than in the bottom of the pattress box, behind British Telecom socket. This means that the unit has to be small, so there is not enough room for the standard combination of micro, eprom, ram, I/O and so on. Instead a single chip microncontroller was used, which had all these functions in one 40 pin chip.

The next consideration was for network safety. This means that the unit must be capable of getting British Approval Board for Telecommunications (BABT) approval. To this end Opto isolators which have been BABT tested and have been approved on equipment are used. Careful attention was also paid to the creepage and clearance distances of the components on the non-BT side to those on the BT line.

The call logger must be transparent to the operation of the telephone and the network. In particular, it should not effect the ring nor add to the REN. For this reason the unit is not powered from the BT line but from a separate 5V power supply, and the components on the BT side are kept to the minimum required for correct operation.

On the operation side, there is a choice of either monitoring the line as a whole or just an individual extension. This design allows either — it can be fitted into the pattress box to monitor an individual telephone, or in series with the master socket to monitor all use of the line.

The password should be simple to change without the use of keys (which would rather defeat the object of the unit) so a hidden push button approach is used with the password being sent from the telephone, rather than a set of BCD switches.

The unit will (depending on the first digit of the password) allow the following calls:

Password 1st digit	Calls allowed without password
1 (or NULL)	All calls
2, 3 or 4	All calls except 0898
5, 6 or 7	Local calls only
8, 9 or 0	None

So a password of say 5678 would allow a user to make a local call only. Note that NULL is the default value on switch on.

The unit should be capable of logging the number dialled and the duration of the call on a standard printer, using a standard printer cable for a PC. It should also be capable of keeping a record of attempts at unauthorised calls, so Wanda's potential clients would have their misdeeds recorded for all time without the satisfaction of actually getting through. At the end of certain lines the following messages could appear:

Aborted — Call terminated by user before it was through

Not Allowed — User did not use Password so call not allowed

International — To call attention to all International Calls

Expensive — To call attention to all expensive calls

So a typical line could look like this:

0442 66551 10:24:38 expensive

The time is in the international HH:MM:SS format with colons as delimitters.

For some users this arrangement may not be convenient as it would tie up a printer completely (although a printer buffer may be used for storage if a printer is not always available, with a print dump once a day or even once a week). It may also not be the best solution in a business or home with several extensions that need to be monitored individually.

In these cases a serial port was envisaged in conjunction with the parallel printer port. The serial port could be multiplexed into any computer along with inputs from other loggers.

The serial port needs to carry minimum overhead, which means sending its information in the minimum time so the multiplexor is not tied up for long. A synchronous system was chosen, which uses a separate clock line to clock out individual bits. This not only removes the need for start stop and parity bits but can also work at a higher speed decided by the processor. This is particularly relevant as many processor-based 'soft' universal asynschronous receiver transmitters (uarts) spend most of the processor time marking time between sending bits instead of getting on with serious processing. We have to be careful in this design because although the processor used is ideal for this task, it is a fairly dumb and bug filled unit. While it was processing a serial stream it would either have to stop calls going out or would miss calls.

A simple ready line from the host or multiplexor will signal the readiness to receive.

The information sent must also be kept to a minimum, so there should be no messages and no delimitters between hours and minutes, and minutes and seconds. There must be one delimitter between the number called and the duration of the call. This is followed by a sumcheck consisting of the lower 8 bits of the sum of all digits except the delimitter. A typical serial stream will look like this (in Hex):
30 34 34 32 36 36 35 35 31 38 31 30 32 34 33 38 **3E**
The highlighted digit is the sumcheck.

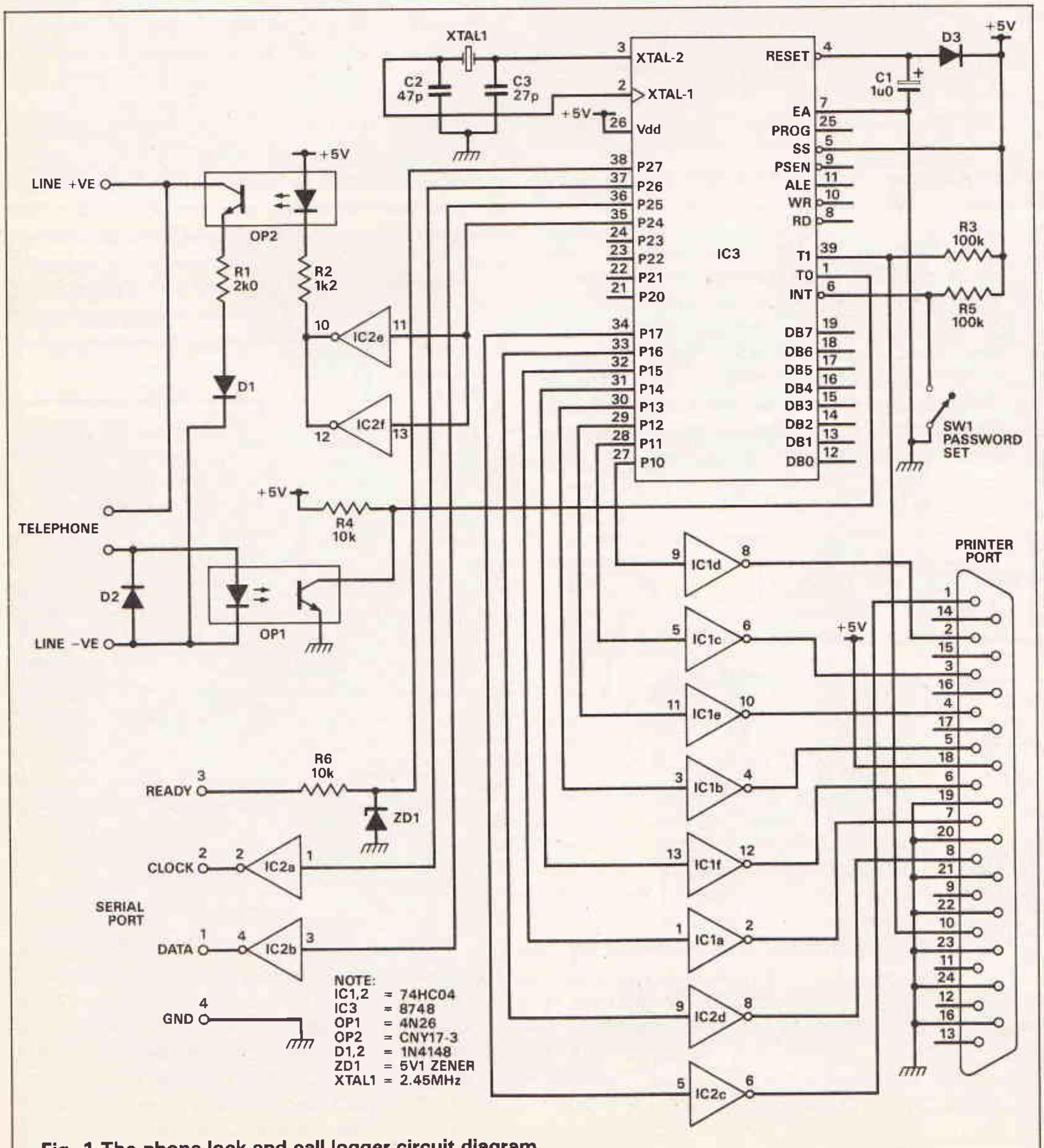
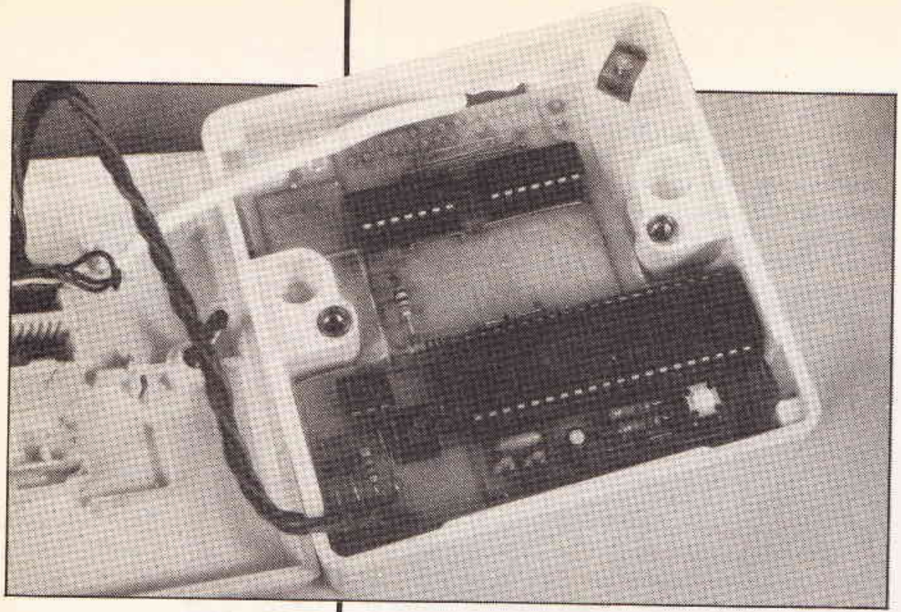


Fig. 1 The phone lock and call logger circuit diagram



Construction

The unit should pose few problems regarding the electronics. Use sockets for all of the ICs, but not for the OPTOs. The biggest problem is modifying the pattress box to allow the 25-way D-connector to stick out.

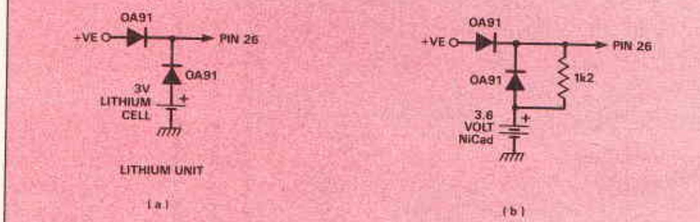


Fig. 2a Lithium cell battery backing **Fig. 2b Nicad battery backing**

If this is too difficult, use multicore cable (12 ways will do as you don't have to connect all of the earth connections) and take it out of the bottom of the box. In this way it can be chased into the wall if required. The serial cable can be very simply a five way cable (the +5 will also come in on this cable). You need not use both the parallel and serial ports at the same time.

Use a deep pattress box if you are using a standard telecom socket. On the prototype a Tenby 7301 was used, but this was made difficult by lack of depth, so the BT socket had to be modified to allow the unit to fit together. The board with the connector on was removed, and the connector was glued directly to the back of the panel. The connections were soldered onto a small piece of stripboard to which the flying connections were made.

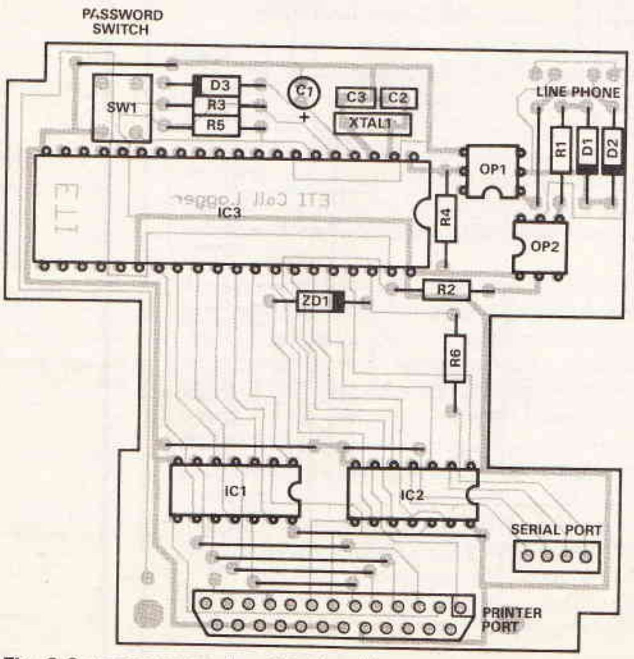


Fig. 3 Component overlay of lock and logger

Test and Use

Before putting the chips into the sockets, connect up the power and monitor pins 40 on the 8748 and 14 on the 74HCO4 sockets to ensure that 5V is there.

Take the red and white wires from the telephone input wire and, using a meter set to 50V DC or more, determine which input is positive. Connect this input to the line input closest to the opto on the PCB. Pin headers and crimped connectors should be used here, so that you do not have to solder a live BT line.

The phone can be connected in either way on the other connector again using pin headers.

Plug the chips in and connect up the printer. Switch on and the printer should print the following:

Call Logger and Telephone Lock

together with some other information, such as column headings. If it doesn't, switch off and check all the connections.

To check that the 8748 is working, connect a 'scope on frequency meter to pin 11. The output should be about 163,840Hz. If thats OK, check all other connections, polarities and so on. If everything is OK, press the password switch and within half a second start to dial in your required password. You may use any type of telephone except those using tone dialling (which won't register on the processor).

You can fit the unit into an individual socket on an extension, in which case it will monitor that extension and no other. You could put a unit on each extension if you liked, each set to a different password.

On the other hand you could wire it beyond your master socket, so that all extensions are connected to

PARTS LIST

RESISTORS (all ¼W 5%)	
R1	2k
R2	1k2
R3	100k
R4	10k
R5	100k
R6	10k
CAPACITORS	
C1	1µ min elect
C2	47p, ceramic 0.1 pitch
C3	27p, ceramic 0.1 pitch
SEMICONDUCTORS	
IC1	74HCO4
IC2	74HCO4
IC3	8748 40 pin dipole
MISCELLANEOUS	
D1	IN4148
D2	IN4148
D3	IN4148
OPTO1	4N26
OPTO2	CNY17-3
Printer	25-way D-connector Right-angled PCB mount
SW1	Omron BF32000 push-switch
XTAL1	2.45MHz
ZD1	5V1 Zener

the unit. In this case it will monitor all calls on that line.

The unit's memory is not battery backed. If you require battery backing, cut the positive track from pin 40, close to pin 26, then connect a battery onto pin 26 of the 8748. Then use either of the circuits in figure 2. Note that one is for lithium cells and the other for Nicad. Don't use the Nicad circuit for the lithium cell or it will explode. Similarly if you use the lithium unit for the NIcad it won't charge.

By feeding the serial input into a BBC master user port or PC then the calls may be time date stamped.

BUYLINES

Most of the parts are available from most stockists. The CNY17-3 can be obtained from RS Components or Farnell.

The switch is an OMRON unit B3F1000, available from Farnell (Tel: 0532 636311).

The 8748 is available pre-programmed from Kitz of PO Box 1, Cymystwyth, Dyfed, at a cost of £17.80 (plus 50p Carriage and VAT) with a full kit of parts available (excluding Pattress box and Socket) for £25.32 (plus 50p Carriage and VAT).

PROJECT

HOW IT WORKS

Much of the work is done by the software in the microcontroller IC3, so the rest of the circuit is very straight forward.

On the Telecom Side OP1 is in series with the telephone, so when the telephone is picked up then current will pass through the LED in OPTO1 and will pull TO on the 8748 low. When the telephone dials the current is made and broken. This is mirrored on the Test O input of the 8748 so it can detect, by using a fairly simple timing routine, what numbers are being dialled.

D2 passes the negative ring current.

OPTO2 draws current from the exchange. This stops the dial pulses from being detected by the exchange, but doesn't draw enough current to stop the pulses from being counted by the 8748. R1 sets the current and its value shouldn't be changed.

D1 ensures that the transistor in OPTO2 does not turn on when the ring signal comes in. If it is not there then the transistor will start to pass current. This will signal to the exchange that the phone has been picked up and it will not send any more ring signals.

A CNY17-3 was chosen as it has a good transfer ratio (over 100%), so its input current is limited to about 5mA. This is provided by two buffers in parallel. R2 may be decreased to 1k if the operation is found to be spurious

The printer port is standard with a single 8-bit output port used to provide both data output and strobe. Only 7 bits are actually required to send ASCII, so the lower 7 bits of the port provide the data and the most significant bit is the strobe.

The outputs are buffered just in case something disastrous happens. The 74HCO4 will die to save the 8748.

The serial port is also very simple. Note that it does not provide RS232 outputs. As it is synchronous, an RS232 port may not work anyway.

The ready input is protected by a current limiting resistor R6 and a Zener diode. If you want to connect an RS232 driver to it then terminate it with a 4k7 resistor from pin 3 to ground.

The password set calls up an interrupt routine. The interrupt flip flop is set on the first transition, so a contact debounce circuit is not necessary.

The power supply is outside the unit and could come from the printer (some printers have a 5 Volt output on pin 35) or from an external power source. **Don't be tempted to put a mains power unit in the same case as this unit.** The unit is not battery backed up and so if the power is removed then the password is lost.

ONE POUND BARGAIN PACKS

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

BD2	5	13A spurs provide a fused outlet to a ring main where device such as a clock must not be switched off
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BD22	2	25 watt loud speaker two unit cross-overs
BD30	2	Nicad constant current charges adapt to charge almost any nicad battery
BD32	2	Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch
BD42	5	13A rocker switch three tag so on/off, or change over with centre off
BD45	1	24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day.
BD49	5	Neon valves, with series resistors, these make good night lights
BD56	1	Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through on pole
BD67	1	Suck or blow operated pressure switch, or it can be operated by any low pressure variations such as water level in water tanks
BD103A	1	6v 750MA power supply, nicely cased with input and output leads
BD120	2	Stripper boards each contains a 400v 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers etc
BD132	2	Plastic boxes approx. 3" cube with square hole through top so ideal for interrupted beam switch
BD134	10	Motors for model aeroplanes, spin to start so needs no switch
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BD148	4	Reed relay kits you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets
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BD400	4	Books. Useful for beginners. Describes amplifiers, test equipment and kit sets
BD653	2	Miniature driver transformers. Ref LT44. 20k to 1k, centre tapped
BD548	2	3.5 volt relays, each with two pairs changeover contacts
BD667	2	4.7uf, non-polarised block capacitors, pcb mounting

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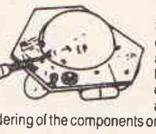

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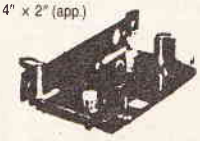

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MAINS SOLDERING IRON. Price £3. Our ref 3P65.

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

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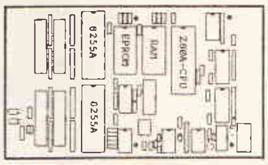

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A star feature is that no special or custom chips (ie PALs, ULAs, ASICs etc) are used — and thus there are no secrets. The Z80A is the fastest and best established of all the 8-bit microprocessors — possibly the cheapest too!

Although no serial interface is included, it is easy for a Z80A to waggle one bit up or down at the appropriate rate — the cost is a few pence worth of code in the program: why buy hardware when software will do?

Applications already identified include: Magnetic Card reader, mini printer interface, printer buffer, push button keypad, LCD alphanumeric panel interface, 40-zone security system, modem interface for auto sending of security alarms, code converter (eg IBM PC keyboard codes to regular ASCII), real time clock (with plug in module), automatic horticultural irrigation controller.

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The idea is (if you are a manufacturer) you buy just one development system and then turn out the cheap SBC-1 systems by the hundred. If you are really lazy we can write the program for you and assemble the SBC-1 cards so you can get on with manufacturing your product, leaving all your control problems to us.

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COMBINED HEAT AND POWER

CHP is fast becoming a challenge to the power industry in the search for lower costs. Helen Oughton reports on how CHP could benefit medium scale users of heat and electrical power.

A typical power station loses over 60% of the energy it produces. Combined Heat and Power (CHP) is a system of power generation which is up to three times more efficient at producing useful heat and electricity than could be generated from a conventional power station. Yet the principles behind CHP are very simple. In this feature, we find out why more and more commercial users are turning to CHP.

In a typical thermal power station, between only 33% and 38% of the energy produced by burning any type of fuel reaches the domestic or commercial customer's premises in the form of electrical power.

Thermal power stations burn fossil fuels (such as coal, oil or gas) or nuclear fuel to produce steam. The steam drives a turbine coupled to an electricity generator. A huge proportion of the energy produced in this way is never converted to electricity, as nearly 60% of the energy is lost as low-level heat in cooling towers. Around 3% more energy is lost after conversion to electricity, dissipated during transmission along power lines.

Clearly, electricity generation can be made more efficient by making use of this heat, which is otherwise simply lost to the atmosphere. But how is this to be achieved? Heat could perhaps be transferred to homes and commercial premises, but the cost of piping such heat from power stations which produce it makes this option impracticable.

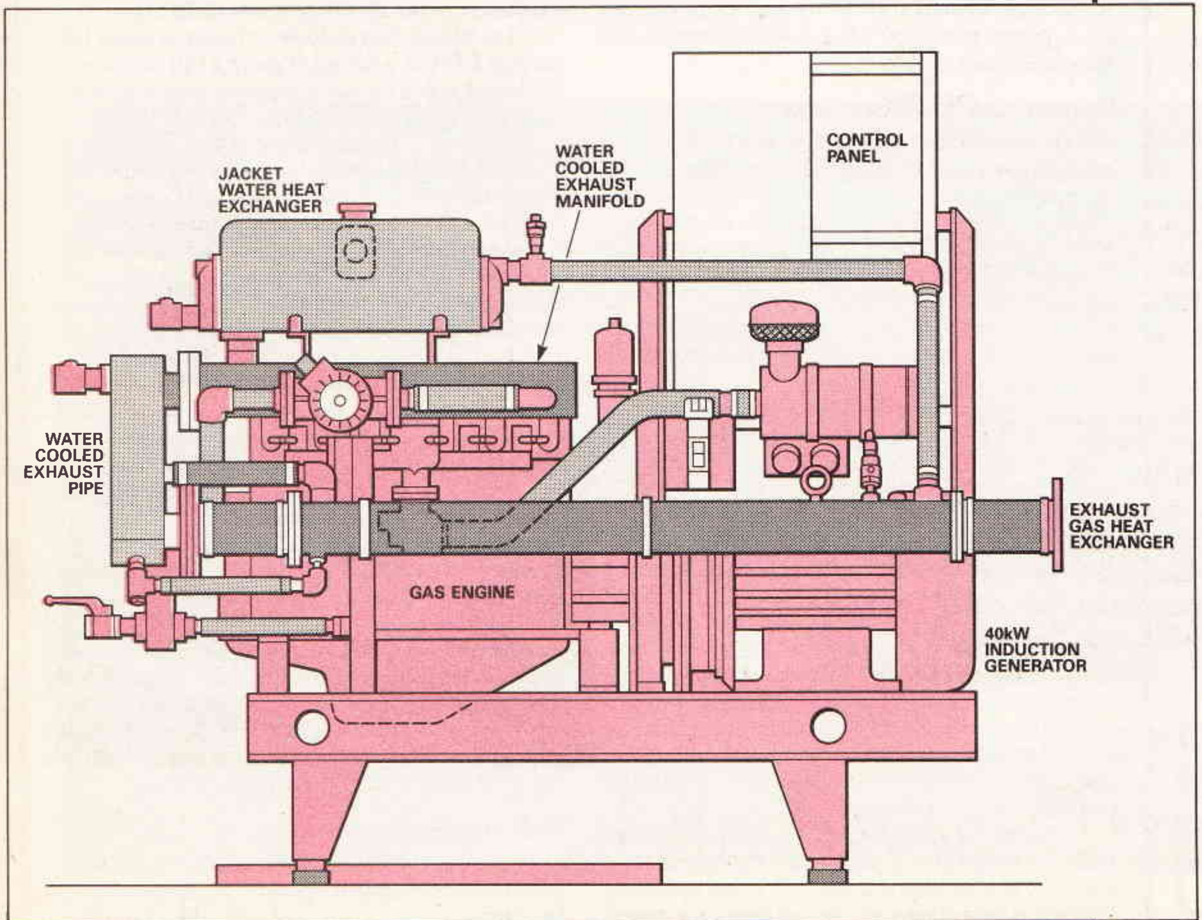
However, there is an approach, becoming increasingly widely used, which enables industrial and commercial organisations to generate power with nearly 90% efficiency. Using this approach, electricity is generated on the organisation's own premises, and the heat produced is used to warm buildings, provide hot water, and in industrial plants, to provide process steam. The system is called Combined Heat and Power (CHP) generation.

Saving On Heat And Power Bills

For most industrial organisations, energy costs and requirements fall in to two types: fuel, such as oil or gas, used for space and process heating: and electricity, used for lighting and motive power. CHP provides both types of requirement, with significant cost savings even after the overheads have been taken into account.

The system can be made even more profitable by connecting it in parallel with the electricity board supply. If the generator produces more electricity than the owner needs, the surplus flows back to the grid. The 1983 Energy Act requires electricity boards in Britain to pay for any electricity they receive in this way.

Premises which are most likely to benefit from CHP are those whose heat and electricity requirements reach peak demand at roughly the same time, and who need heating for more than about 4,500 hours a year. Below this demand, it may take too long to recover the costs of installation and maintenance personel.



This can include hotels, hospitals and old people's homes, which have a demand for constant space and water heating as well as electricity. A typical CHP system in such a building might provide about 40 kW of electricity and between 50 to 200kW of heat in the form of hot water. Leisure centres are another type of organisation which can benefit, by heating the water in swimming pools using CHP.

An industrial plant which requires large supplies of process steam can produce this using a CHP system, developing several megawatts of electricity as a useful by-product. If this is in excess of demand, the extra electricity can be sold back to the electricity board. The heat produced by CHP can also be used for absorption chilling, for example, to cool computing equipment.

Most CHP systems use natural gas as fuel, in a spark ignition engine similar in operation to an automotive petrol engine. However, some larger plants are now using gas driven turbines to meet higher heat and electricity demands. Both types of system are designed with an emphasis on reliability, low maintenance requirements and long lifetime.

Controlling A CHP System

Micro-electronic control provides the key to efficient use of CHP. For greatest efficiency, the output of the CHP system is generally adjusted to meet heat demand rather than electricity demand. The electricity is best regarded as the by-product of CHP.

The heat supply is controlled in response to demand, with stand-by conventional boilers being brought in at times of peak demand for hot water and heating.

At times of high electricity demand by the owner of the CHP system, electricity will be imported from the grid, while at times of low demand, excess electricity in phase with the grid, is exported for sale.

Micro-electronics is also used to ensure the safety of the CHP system and its operators. It is used to monitor parameters such as the level of output and the pressure of cooling oil, and will disconnect the system if things go wrong.

Types of CHP System

We can now have a closer look at how CHP systems work. There are two main types of CHP system, and the system used will depend on the requirements of the user. Organisations such as hotels, hospitals and leisure centres will be most likely to use a gas engine to provide space and water heating, together with some of the electricity required. Larger industrial plants may well have greater demands for high grade heat, using a gas turbine to supply process steam as well as heat and electricity.

When choosing a suitable size of system, the best approach is to choose a size that supplies a normal summer heating load, with stand-by boilers to provide extra heat whenever required.

Small Scale CHP Systems

Hot water, space heating, and swimming pool heating are typical applications of small scale CHP systems They produce between about 20kW and 200kW of electricity. Natural gas and air are mixed in a carburettor and fed to the internal combustion engine which drives the alternator in phase with the grid supply. Heat is recovered from the engine jacket and oil cooling systems as hot water, typically at around 80 °C. Low-level heat for space heating may also be recovered from the exhaust gases.

The block diagram in Figure 1 shows the flow of heat and power in a small scale CHP. The electrical efficiency of a gas engine is about 25%, but by utilising the heat of the engine and exhaust gases, the overall efficiency can be increased to over 90%.

A process controller adjusts the output to meet demand. This is normally to meet heat rather than electrical demand. At peak times electricity can be imported from the grid supply. Extra heat can also be supplied if necessary, from stand-by boilers.

Large Scale CHP Systems

For large industrial plants with high requirements for electricity, heat and process steam, a large scale CHP system, using gas-driven turbines, is more suitable than a gas engine. These turbines can produce up to around 15 MW of electricity.

Natural gas is fed to a combination chamber, driving the turbine, and the alternator. The gases leave the turbine at temperature around 450° C. An after-firing burner can be used to increase the heat produced, by burning more gas in the turbine exhaust.

High grade heat is recovered from the gases by a heat recovery unit, producing steam. This can be used as process steam for plant requirements, or may be directed to a steam turbine driving a second generator.

Figure 2 shows the flow of heat and power in a large scale CHP system.

Recovering Costs

Costs are quickly recovered on a small-scale CHP system, with many companies recovering the expense of installation within 2 to 3 years. It takes only slightly longer to recover the installation costs of a large-scale CHP system, with payback typically within 5 years.

There are plenty of examples of the substantial savings which can be made. The Bakers Almshouses in the London Borough of Waltham Forest required heating, hot water and electricity for 52 houses, many occupied by elderly people. The Borough Council commissioned a CHP in September 1988. The CHP unit was supplied by Applied Energy Systems Ltd, and was installed by British Gas. The cost of the installation of the 26 kW unit was £27,000.

The total savings per year on heat and power bills are over £7,000, a saving of about £140 per tenant. In addition to this, the sale of excess energy is expected to make about £2,600 a year.

If energy requirements differ from those predicted, CHP can be less profitable than expected. The Devon and Cornwall Police Headquarters installed a 132 kW CHP unit in January 1986. However, performance for the first year was found to be about £2,700 less than predicted, making the payback period correspondingly longer. This was because the calculations were based on continuous availability at full load, whereas the unit availability was only 93%, and ran at loads between 50% and full power. Nonetheless, the actual savings of about £14,800 in the first year were still substantial.

Let's hope that more and more organisations will be prepared to make this worthwhile investment. Perhaps one day, very small scale CHP will be supplying heat and electricity to private homes. Widespread use of CHP could result in lower demand from power stations, perhaps reducing the number of power stations in the future.

As well as saving money for the user, lower consumption of fossil fuel conserves exhaustable fuel resources and reduces the output of gases such as carbon dioxide, which contribute to the greenhouse effect.

And that's a saving we'd all welcome.

Acknowledgements

Our thanks go to British Gas plc and Applied Energy Systems Ltd for assistance given in the preparation of this article.

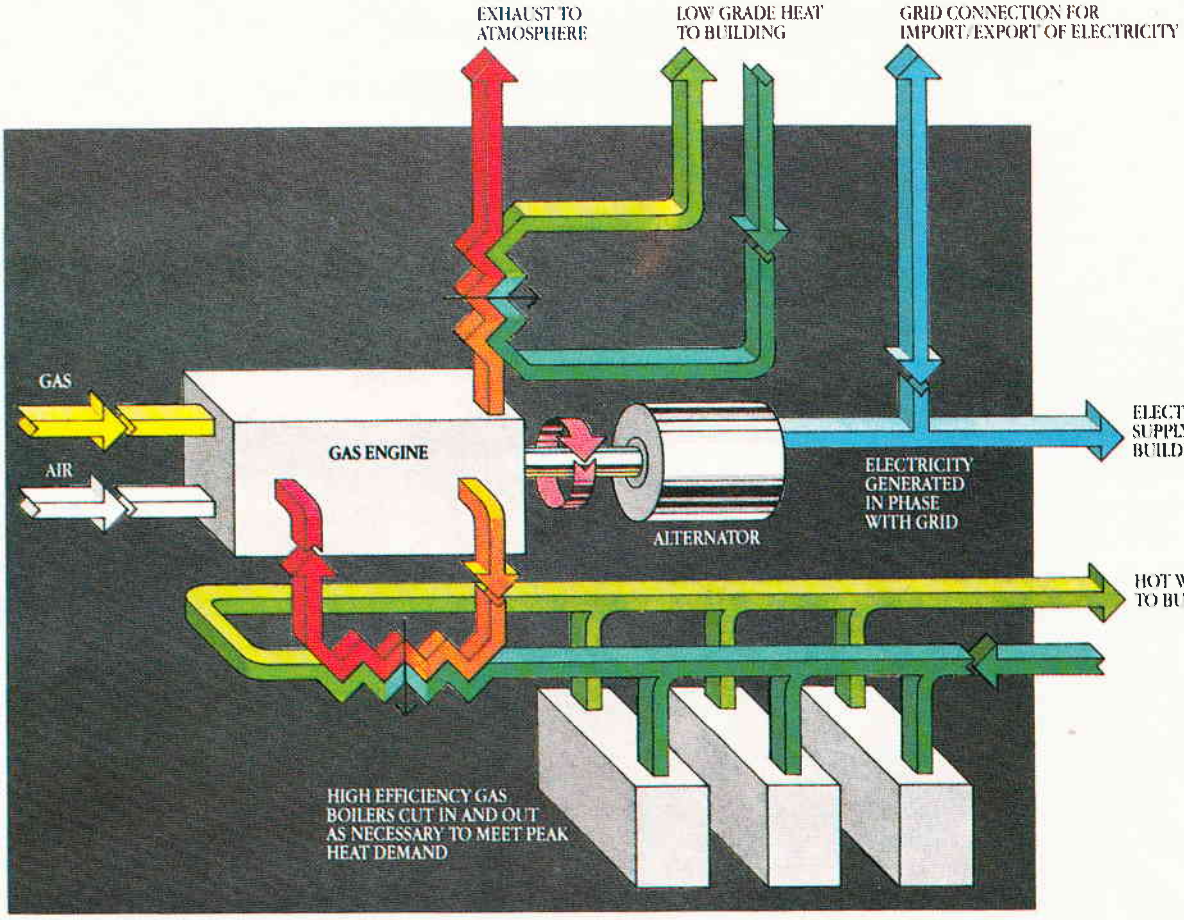


Fig. 1 Small Scale CHP System (Courtesy of British Gas plc)

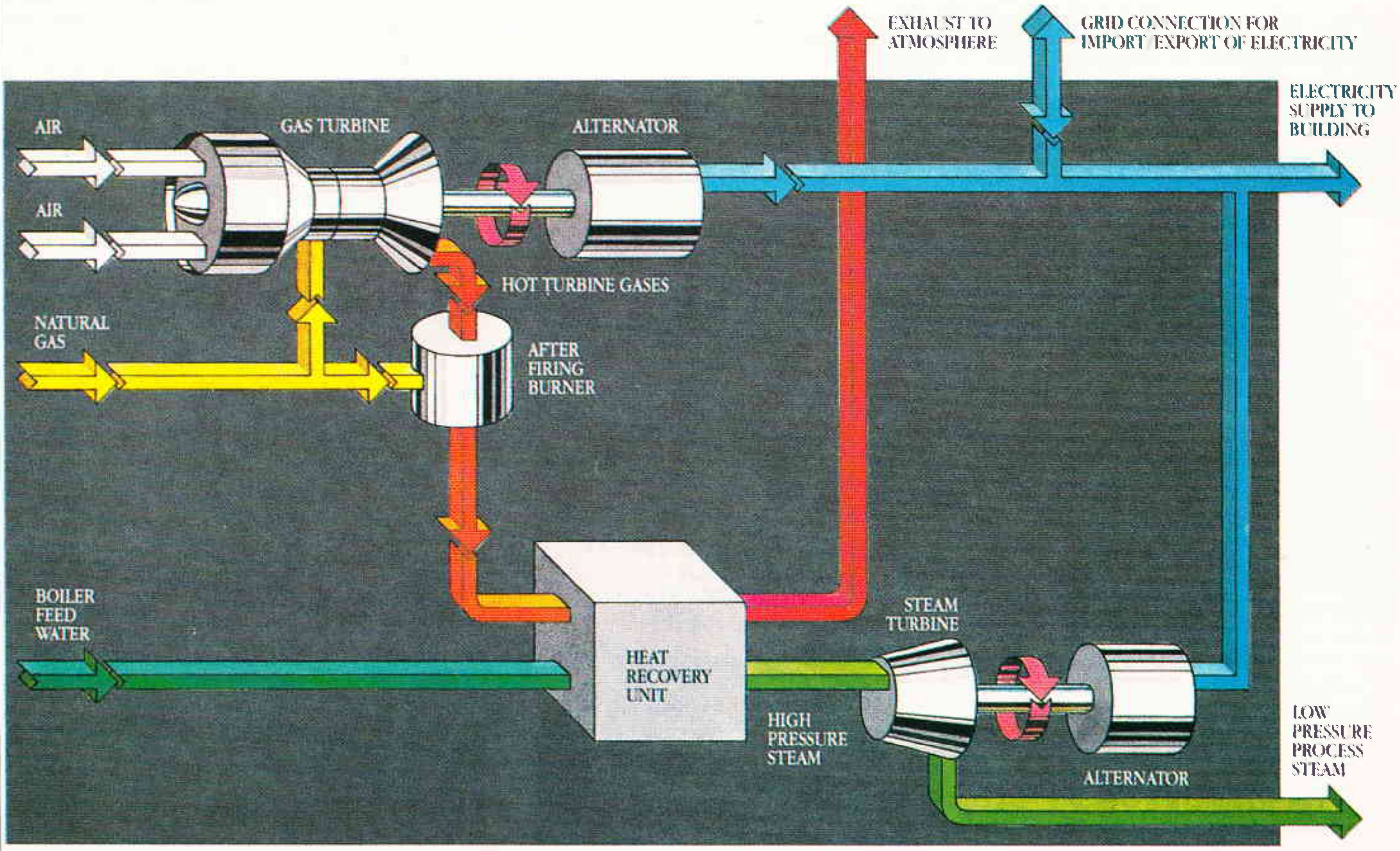
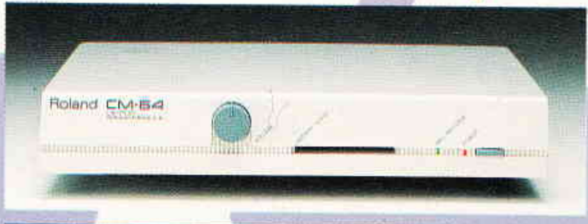


Fig. 2 Large Scale CHP System (Courtesy of British Gas plc)

ROLAND'S DESK-TOP COMPUTER MUSIC RANGE

CM-64 LA/PCM

The CM-64 LA/PCM Sound Module gives a maximum 63-voice polyphony, is 15-part multi-timbral (including rhythm part) for full orchestral reproductions and provides 64 PCM preset tones and, from the wonderful world of LA synthesis, 128 synthesizer presets, 30 percussion sounds plus 33 sound effects for the rhythm part. The CM-64 also accepts U-110 sound sample library cards and incorporates an on-board digital reverb.



CM-32L CM-32P

The CM-32 LA Sound Module provides all the LA capabilities of the CM-64, is 32-voice polyphonic and 9-part multi-timbral and likewise has built-in digital reverb. The CM-32P PCM Sound Module contains the CM-64's PCM section with its 64 presets, is 31-voice polyphonic and 6-part multi-timbral, has the same digital reverb, and is U-110 sound-card compatible.

CF-10

Next in the range comes the CF-10 Digital Fader. This is an easy-to-use mixing controller with the feel of an analogue audio mixer and featuring 10 multiple MIDI channels, designed to mix song data for sequences created on a PC or MIDI sequencer, it also enables control change messages for volume and panning to be transmitted to external MIDI devices.

CN-20

The CN-20 Music Entry Pad facilitates the programming of basic song data on a PC. It offers, for instance, easy editing of data pre-recorded from an external keyboard in real time. Its multi-purpose fader can be assigned to control a variety of MIDI information such as Control Change Bender and Aftertouch over any of the 16 MIDI channels.

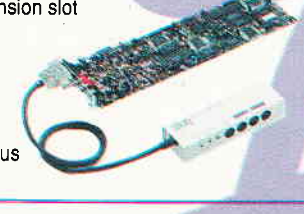
CA-30

Last of the modules is the CA-30 Intelligent Arranger. Designed to be linked with the CM-64 or CM-32L, the CA-30 is a sophisticated auto arranger with similar intelligent arranging functions as found on Roland's best-selling E-20 Intelligent Synthesizer. With the CA-30, even complete beginners can create interesting and convincing song data.

CM SUPPORT

Supporting the CM modules themselves are three peripheral components. The LAPC-1 LA Sound Card fits into the expansion slot of an IBM-PC for instant access to the great sounds of Roland's MT-32 Multi-Timbre module. The MCB-1 is an optional MIDI connector box for the LAPC-1, allowing the LAPC-1 to be used as an interface with external MIDI devices. And the MPU-IMC is a MIDI interface compatible with Micro Channel Architecture, the new IBM bus format used on the PS/2 PC.

LAPC-1



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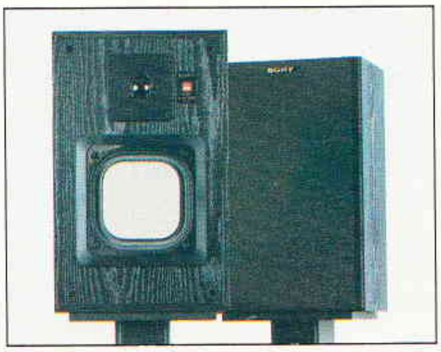
ETI Audio news

Yamaha in its unceasing pace of development bring us a new sound for the '90s. The SY77 is the latest in a long line of synthesisers to bring ever more sophisticated sounds to the amateur and professional alike.

Crammed with so much sophistication you can spend a lifetime with this very powerful machine and still not achieve a fraction of the sounds it can produce just as we did around the DX7 and its mind boggling power of arrangements.

The SY77, a music workstation, can be considered as being made up of three basic building blocks. The first of these is a set of in-house instrument music samples of CD quality called Advanced Wave Memory 2. These sounds can be manipulated by digital filters in real time and layered or blended by the second building block, the AFM tone generators. 4 Megabytes of ROM gives a lot of sampled sounds. The Advanced Frequency Modulated tone generators are a development of the 6 operator system adopted in the DX7 but now with 45 algorithms and 16 different preset waveforms instead of simple sine waves used in the DX7. The third block called Realtime Convolution and Modulation allows the first of these blocks to be used as part of an algorithm adding further harmonic content to the sample. Other effects to manipulate the sound apart from the digital filters are Dynamic panning, where the sound can be moved in any direction and varied speed across the stereo sound field with an envelope generator, 40 preset reverb effects, 4 modulation effects, 16 track sequencer and many others besides. The SY77 has a recommended retail price of £1999.00.

We will be bringing you a full feature on the Yamaha SY77 in the next couple of months



Sony has released five models in its ES speaker range. The new range is designed in Europe and manufactured entirely in the UK. The all British speakers contain the Actual Pictonic Motion APM 'flat diaphram' drivers now common to all Sony's speakers.

The design was a joint effort between the Wega speaker plant in Germany and UK audio experts. The design is based on the idea that everybody in the world has different listening preferences and these small subtleties come about as a result of language differences and intonation.

All the models are of reflex design and have 4mm banana connectors especially for the UK audiophile. The APM 181ES, intended for use with amplifiers with outputs of 25W-120W into 8R, has three drivers of which the 19mm titanium dome tweeter is nitrided for extended frequency response.

Prices in the ES range are from £100 to £690.

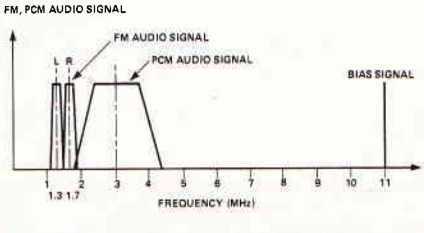
JVC has developed a new digital audio system for its S-VHS video cameras. Extra high quality sound is based upon a newly developed Depth Multiplex recording system which allows video and audio signals to be recorded on different layers of the magnetic tape: the high quality digital sound being placed on the lower level.

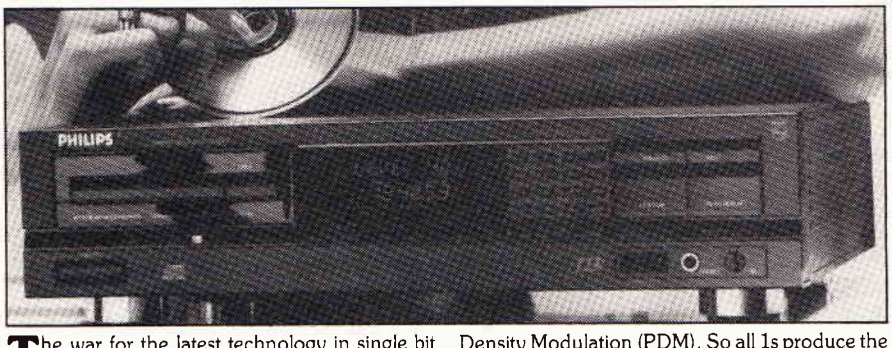
Stereo sound is recorded at a 48kHz sampling rate with 16 bit quantisation using a modulation system of Quadrature Phase Shift Keying.

Current S-VHS and S-VHS-C tapes are compatible on the new machines and up to 6 hours playing time is possible with a ST120 S-VHS tape in EP mode.

Super VHS was developed in 1986 to increase the picture quality of the new established VHS system to more than 400 lines of horizontal resolution.

JVC hopes to penetrate a varied market from amateur to semi-professional including usage in the software industry and the new audio visual era, a euphemism perhaps for large screen pictures.





The war for the latest technology in single bit stream compact disc players is now hotting up as more and more players emerge onto the marketplace.

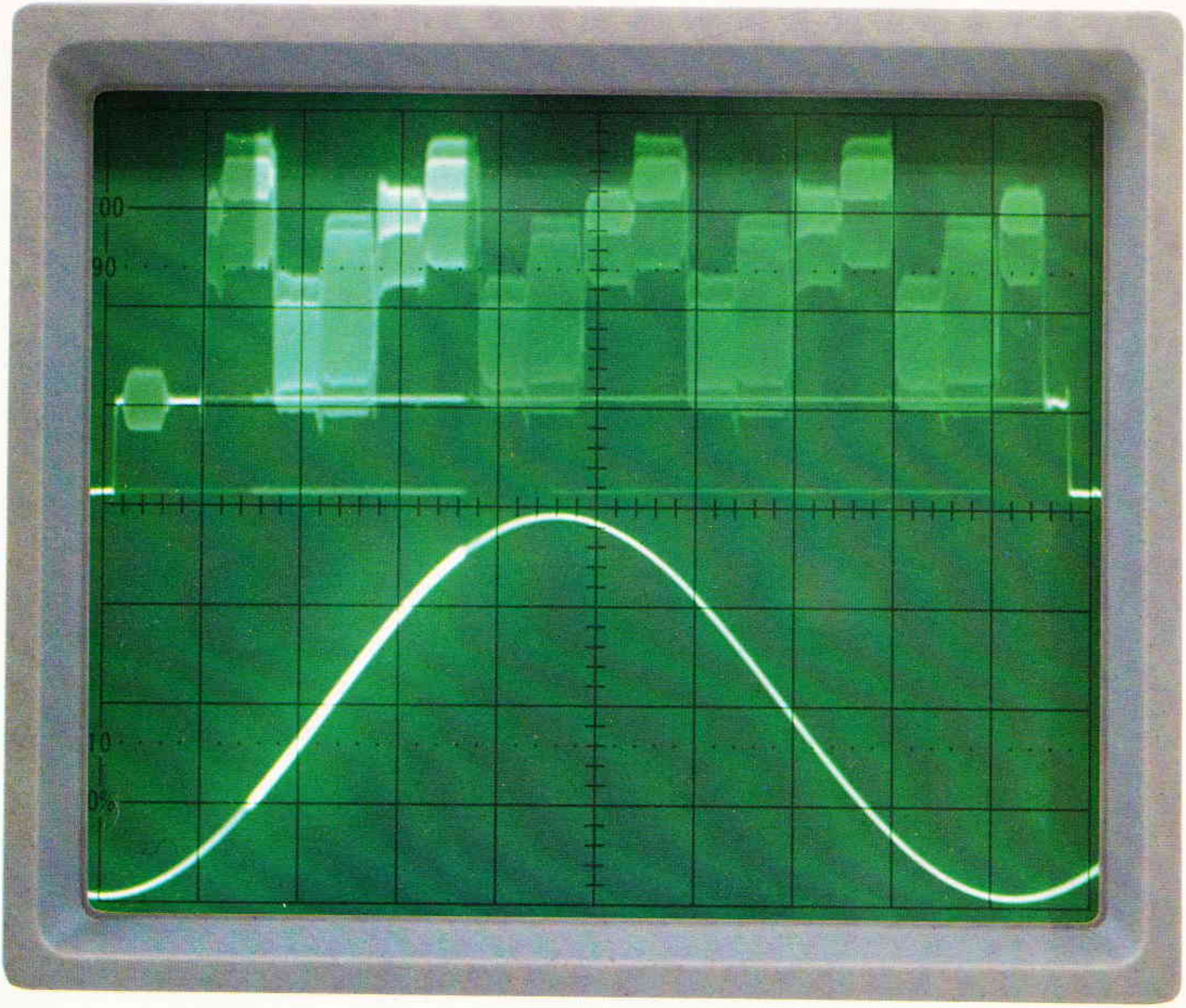
The new Philips development in compact disc technology, called bitstream, is setting new standards for digital audio quality. The latest disc player (CD840) offers 256 times oversampling in the one bit digital to analogue conversion.

The 16 bit digital samples read from the compact disc are turned into a single stream of data and converted into analogue voltages for use in the normal way. The technique eliminates any non-linearities and crossover distortion that would normally occur in multi bit converters.

The bitstream generates positive and negative currents for 1s and 0s at over 11 million times a second. The ratio between these two determines the level of current. The principle is called Pulse Density Modulation (PDM). So all 1s produce the maximum current, all 0s the maximum negative current and alternate 1s and 0s produce no current.

Amongst the many facilities on the player is a multifunction display that tells you what it's doing throughout the motions of playing the disc and it can even show you what is playing provided the title is programmed in.

Also featured is a double favourite track selection where the listener can store their best tracks. It's suggested the double memory is for 'his' and 'her' best tracks or for perhaps pop and classical. Apart from the normal additions of remote control and random order programming, a rather interesting feature is the CD record synchronisation. If your hi-fi system also has a Philips cassette deck, the CD player can send control messages to start and stop the tape at the correct time for perfect recording on both sides of the tape.



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Review: GRAPHIC EQUALISERS

The latest graphic equalisers are packed with features and flashing lights. Geoff Bains reviews models from Tandy and from Maplin.

All living rooms are not created equal. Neither are bedrooms, theatres or concert halls. That's why some clever guy with a passion for hi-fi and shares in sliders invented graphic equalisers.

Ardent ETI readers will already know what a graphic equaliser is. It provides filtering for an audio signal with a series of band-pass filters tuned to a number of centre frequencies (for domestic purposes, usually ten for each channel at one octave intervals) to provide a cut or boost at those frequencies and shape the frequency response of your audio system.

The equaliser sits in the signal path between the pre-amp and power amp. With an integrated amplifier it's usual to make use of a specially provided loop-through or a tape send and return.

Now, in the good old days, graphic equalisers were something that only the particularly fanatical or flashy would consider, or the dedicated electronics hobbyist.

One of the first practical hobby designs was in ETI, over ten years ago and Maplin provided a kit, complete with metalwork front and wooden sleeve. This allowed you to build a reasonable quality graphic equaliser for about £70.

Today, the call for equaliser kits has waned somewhat as an equivalent machine can be bought, all ready made and sparklingly smart looking, for £50. Graphic equalisers are so cheap that they are built into every rough and ready stack audio system and even into many personal stereos.

The Far Eastern hi-fi empires have made sure kits will not see the light of day again by upgrading the whole idea of a graphic equaliser into something altogether more fantastic. These are so fancy and feature-filled that no sane hobbyist without a degree in plastic moulding and metal working (not to mention no mean skill as an electronics designer) would dream of attempting their like outside the bounds of the Korean factory.

Two such models which come from the lands of the East via Tandy and Maplin get the going over here. First though, it's worth thinking just why you might want a graphic equaliser in the first place.

Knob Fever

I can't help feeling the main reason most graphic equalisers are bought has to be that they are the single most efficient way of increasing the number of controls sported by your audio system. Even the simplest graphic equaliser offers over 25 extra knobs. That's bound to impress the neighbours, isn't it?

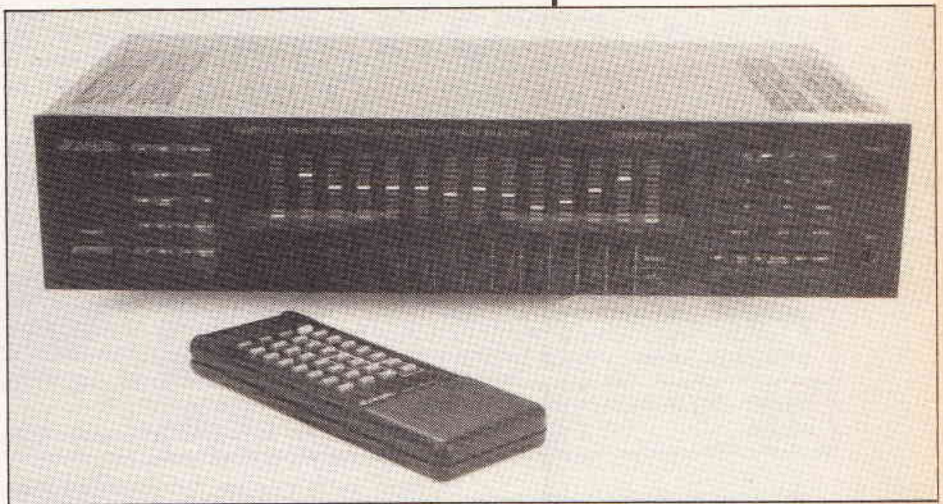
Well, probably not, but it's still a good argument for many buyers. And why not, with all the effort put into making your hi-fi, your TV, even your washing machine look as trendy as possible, add some Far East far-out high tech to the stereo?

However, most potential buyers will be after at least the illusion of adding something to the signal path too.

Strictly speaking, a graphic equaliser is there to reduce your sitting room (or wherever the beast is operating) to the same even, flat frequency characteristics of a professional recording studio — where the piece you're listening to was produced in the first place.

It is possible to do this by ear. You could tweak your graphic equaliser with a little boost in upper mid-frequencies to compensate for the deadening qualities of the Persian rugs adorning the walls. However, you would have to have a pretty good ear to do the job properly.

Instead, the proper thing to do is to invest in a pink noise generator, a flat response microphone and a spectrum analyser to provide a flat frequency source and means to monitor the room response while compensating with the equaliser.



Needless to say, most people don't invest in all that. Instead, they buy graphic equalisers as over-the-top tone controls — you adjust the response of your system to suit not only the room acoustics but your own warped idea of the 'right' sound and the music playing

At this point, the hi-fi purists raise their hands in horror — what, more tone controls? Surely the idea is to take them out altogether. Well, maybe for purists, but the rest of us do like to mess around with the sound.

What separates the models is what else the clever designers have packed around the basic facilities to tempt our craving for gadgetry.

Maplin

However, if it's more lights than the flight deck of the Starship Enterprise you're looking for, the Maplin computer memory graphic equaliser is unequalled.

This is an equaliser without a slider in sight. The whole thing is electronically controlled and can even be operated with a remote control from the comfort of your armchair.

The front panel is largely taken up by an enormous spectrum analyser display of over 150 LEDs in three colours. This display shows both the amplitude of the 12 frequency bands (in average or peak hold modes) of both channels together, and the 'position' of imaginary sliders. Separate channel level displays are also provided.

With the equaliser in adjust mode and either left, right or both channels selected, a rocker at the base of each display column adjusts the amount of cut or boost for that frequency band.

Some aids to quick setting are provided — a level button to restore all the 'sliders' to centre position and a rather unneccessary (but fun) reverse button which turns each slider's cut values to an equivalent amount of boost and vice versa.

More buttons select the source and signal routing, overall volume, display sensitivity, an equaliser bypass, signal muting and even a display dimmer.

However, the Maplin equaliser also includes automatic equalisation. This harps back to the real purpose of such a machine in the first place. A built-in pink-noise generator is switched on and a flat-response microphone plugged into the front panel socket. With the amp volume suitably adjusted it is now simply a matter of pressing 'auto EQ' and the unit cuts and boosts each band for a flat response. Simple.

In use, the system seems a little arbitary, rarely giving exactly the same result. However, it was tested using a rather inferior microphone. With a professional model I am sure it would perform better.

Any equaliser setting (manual or automatic) can, at the push of yet more buttons, be stored in one of four memories to be instantly recalled at a later date.

These memories are volatile and last only as long as the equaliser is plugged in (the power switch on the front puts the machine into standby mode). Of course, there is use for several equaliser settings available at the touch of a button unless the equaliser is to be used for just super tone control.

However, such considerations are perhaps altogether too serious. The Maplin equaliser is a treat to use and (dare I say it) to play with. That just about every function is available on the remote control (32 more buttons!) only adds to the both the enjoyment and the amazing value.

It's a pity then that its audio performance does not live up to its digital control abilities.

The main problem is noise. Turn up the equaliser volume (and turn down the amp) and the signal is positively swamped in noise. This is not only mains hum but a fair amount of digital filter sampling noise too.

This is a shame because, otherwise, the Maplin equaliser proves truly superb. At first this model seems expensive — nearly £200 for a graphic equaliser in these days of £50 units.

However, this unit is streets ahead of such simple equalisers. A peek inside gives some idea of the complexity of this machine. There are approaching 70 ICs in there, more than many fully fledged computers, and there's certainly more circuitry in this than most items of hi-fi.

Of course, it's not complexity but performance that counts. Nevertheless, the Maplin Computer Memory Graphic Equaliser wins a place in my system without too much trouble.

Tandy

The Tandy model was one of the first of the more-than-just-knobs equalisers for a reasonable price. This is the top of the Tandy range and costs about £119.95.

There are ten frequency intervals for each channel, each giving a useful 12dB cut or boost. An enormous range of sockets and switches gives you just about every option of playing or recording equalised or original sound from and to the amplifier and two tape decks.

The sliders are nice and smooth with a centre click and comfortable knobs, but the switches on the front are tacky silver plastic jobs which severely let down the overall look. Fortunately, next to the dreaded 'Realistic' logo, they look positively classy.

The main extra the Tandy Equaliser has is a spectrum analyser. This is a small LED affair about 8×5cm with 90 LEDs. A 21st slider controls the display sensitivity. This is certainly pretty, even if it is of little use. The manual sums up the expected serious use of the analyser by ignoring it almost completely.

The real gimmick for this equaliser is the *IMX Expander* unit to give 'a dramatic live feel' to music. No, it's not a dynamic range expander but just a boring old stereo width control as found on many ghetto blasters. Even if you think such a device has much place in a proper audio system, it adds so much distortion as to be positively dangerous to serious listening.

Otherwise the Tandy equaliser proves excellent value for money. Although the spectrum analyser is only pretty, it doesn't affect the sound quality. This is pretty good. There is little noise or distortion added by the extra circuitry. Only if you crank your power amplifier up high (without an input) will you hear the small amount of hum introduced by the equaliser.

So long as you keep the IMX Expander firmly switched out, the Tandy graphic provides a reasonably priced model that is neat to look at too.

Conclusion

Although it is difficult to describe any graphic equaliser as truly hi-fi, they are nevertheless popular items. Both these models perform their basic task well (albeit with some extra noise added). They also add an entertaining display to your system and in the case of the Maplin model, their very use is entertainment in itself.

To someone who has spent his life with the old ETI/Maplin kit graphic equaliser of yesteryear, excellent value modern ready-built models come not only as something of a revelation but as a joy also.

Specifications Claimed

	Tandy	Maplin
Price	£119.95	£194.95
Number of bands	2×10	2×12
Interval	1 octave	1 octave
Band cut/boost	+/−12dB	+/−10dB
Distortion	0.015%	0.009%
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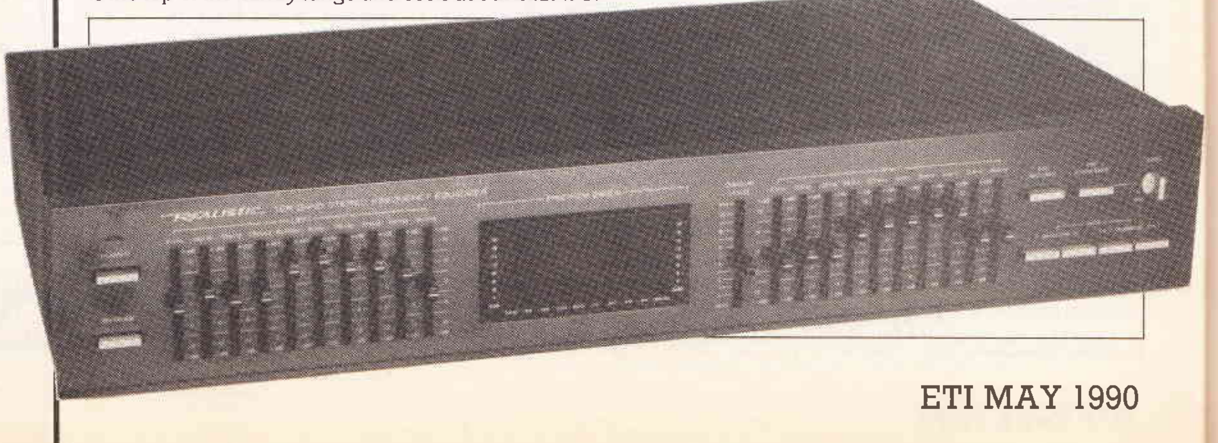

REVIEW

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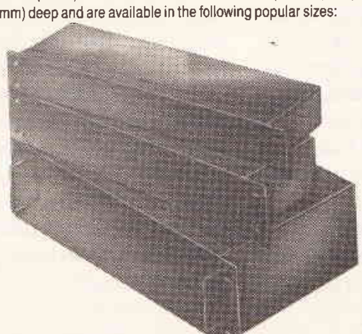

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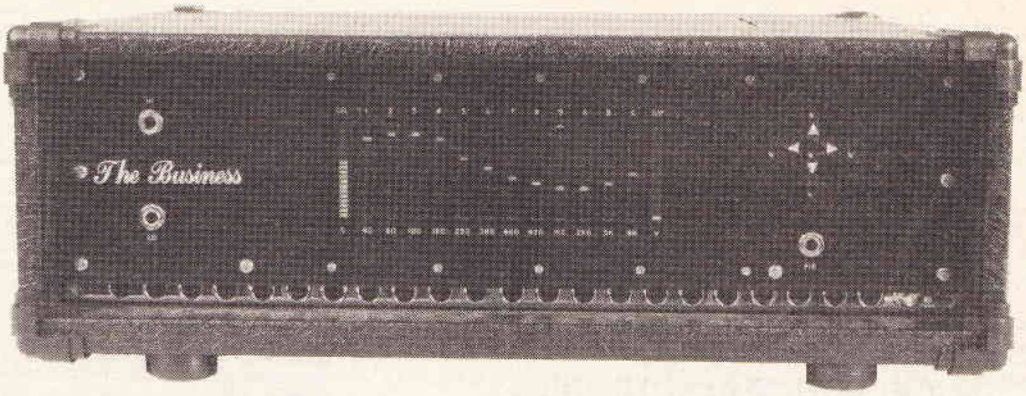


THE BUSINESS

Part 3: Case Construction

Bob Whelan completes his masterpiece of engineering known as a bass amplifier.

If a job is worth doing, it's worth doing properly and with the business amplifier the case construction is no exception. Ruggedness is an essential feature when touring with the band and it has certainly paid off. This final part also features the display board, the main power supply and final testing and checking procedure.

The first thing needed to start construction is the chassis. The chassis is made from 16 gauge mild steel and welded at the seams for strength. Only the back and front cut outs are detailed on the drawing. This helps to keep the costs down and allows for exact fitting of the various components in the chassis. The first thing to do is to go along to a sheet metal works and get them to make the chassis. Specify a bare metal finish as a few holes still have to be drilled in the base. The finish on the chassis is chrome plating. This can only be done once all the fixing holes have been drilled in the chassis. This would also be a good time to go to an engraving and panel making company and get them to make the front panel. This is manufactured from 10 gauge black anodised aluminium with engraved lettering in white. The final appearance of the amplifier depends to a great extent on the quality and finish of the front panel, so it is wise to spend just a little extra and get a good professional firm to do the job. (Now available from the new ETI front panel service included in this issue.)

Construction begins with the heatsink. This is a Marston Palmer forced air cooled assembly that offers very efficient heat dissipation within a restricted volume. The output devices are mounted on eight external platforms. Heat generated by the devices is conducted from the platforms to the cooling fins within the assembly and is removed by a flow of air provided by a fan bolted to one end of the unit. The airstream through the assembly is totally confined and no baffles or ducting are required. The eight heatsink platforms should be drilled for the MOSFET output devices. A T03 heatsink washer is useful as a template for drilling the platforms. When assembled, the heatsink platforms are electrically isolated from each other so no insulating washers are required for the output devices. Fixing screws for the MOSFETS are M4 × 16 high tensile set screws (Electromail 525-802) with a flat washer and full nut. A 4BA solder tag is fixed under the washer on the outermost screw for the MOSFET source connection. The clearance holes for the gate and drain pins should be drilled M4 to reduce the risk of shorts. Assemble the heatsink as per the instructions supplied but turn the front plate around so that the two fixing holes are accessible. The four 2SJ50 devices should be on the left side of the heatsink assembly looking from the front, the four 2SK135 devices on the right. The fan can be bolted on to the heatsink assembly using M4 set screws. When the chassis is available, the power supply transformers, capacitors, board mounting brackets and die cast boxes should be positioned as in Fig. 1 and the fixing holes drilled. Fixing is by M4 × 16 high tensile set screws, flat washers and full nuts. Transformer T1 is supplied with a fixing bolt. The heatsink assembly is fixed in the chassis by the four screws supplied with the fan filter and two M4 high tensile set screws in the front plate of the heatsink assembly to the chassis base. The amplifier's front panel fixing holes are M4. The front panel is positioned level with the top of the chassis, leaving the row of holes in the lower front of the chassis clear for the fan airflow. The DC protection board fixing holes are M2.5. Two holes are required for the fan filter in the back panel. The fixing screws are supplied with the filter. Once these holes have been drilled and deburred, the chassis can be chrome plated for finish.

Assembly of the Display PCB. Again screw down the 16 pin plug before soldering to the board. Assemble the board according to the circuit diagram and overlay diagram. (Fig. 2 and Fig. 4) The point to be careful with

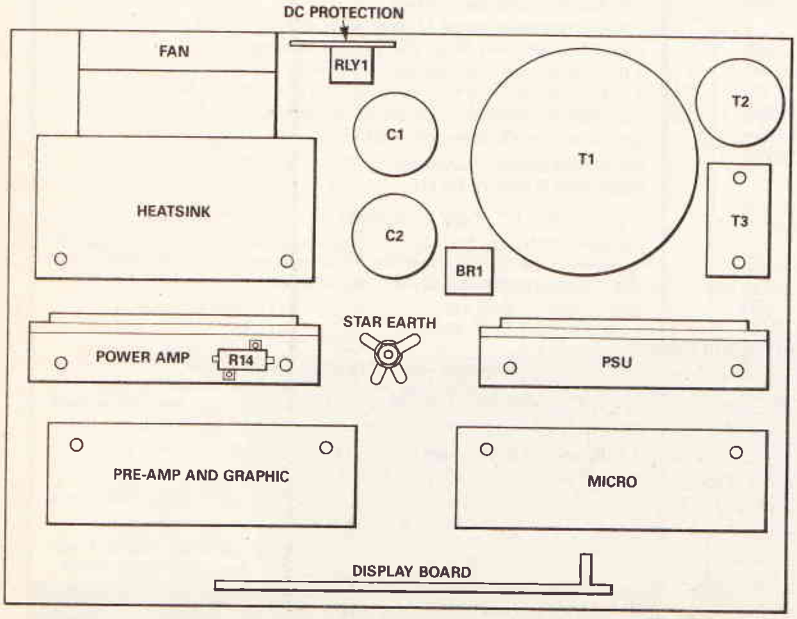


Fig. 1 Layout of main component parts in the case

on this board is the orientation of the LED displays. These are mounted on the foil side of the PCB. Some types have the manufacturer's code printed on the anode side, some types have a chamfer at one corner to indicate the anode. Make sure the displays are in the right way round. This board will be tested when it is assembled in the amplifier.

Chassis Components

The amp has a star earthing system to reduce the risks of earth loop problems. The earth is a M4 × 16 high tensile set screw with flat washer and full nut. This should be fixed in the chassis and well tightened up. A drop of locktight solution on all the fixing screws is recommended. Next secure transformers T2 and T3 with M4 screws. Using 16/0.2 equipment wire, connect the secondary windings of T2 in series to give 12V output and the secondary windings of T3 to give 15-0-15V, the centre 0 tap being connected to the earth screw. T2 has a screen connection, this should also go to the earth screw. Termination of the 16/0.2 wire to the earth screw is via 4BA solder tags. Use 16/0.2 wire to connect up the primaries of T2 and T3 as per the wiring diagrams Fig. 4. Now fit transformer T1. T1 has a fixing screw supplied. Do not over tighten the fixing screw as this can distort the chassis. Now fit the mains input filter and the cannon type loudspeaker connector using M3 screws. Next the mains switch, then the bridge rectifier and the capacitors C1 and C2 using M4 screws. Connect the earth terminal of the mains filter to the earth screw using 32/0.2 green equipment wire

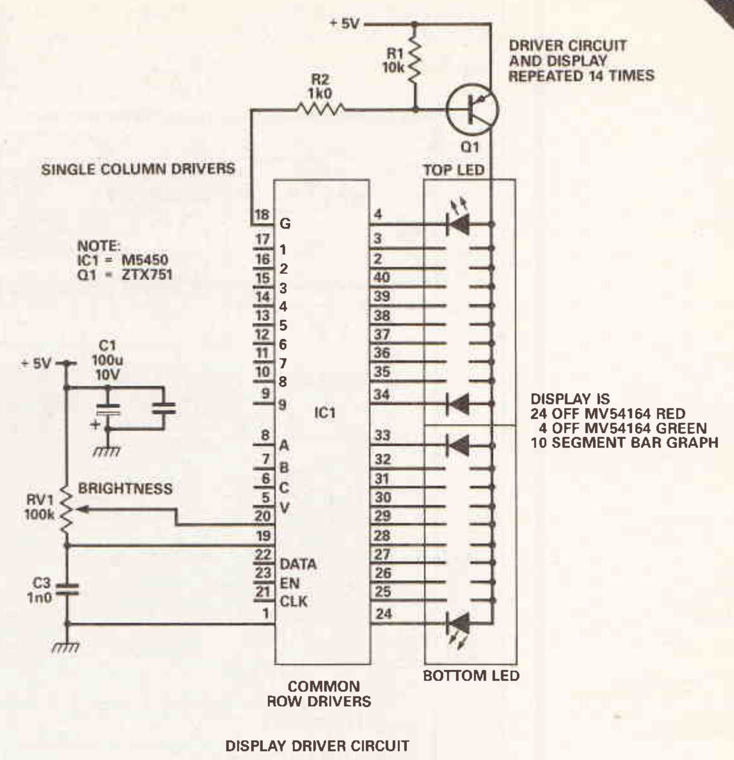


Fig. 2 Circuit diagram of the display board

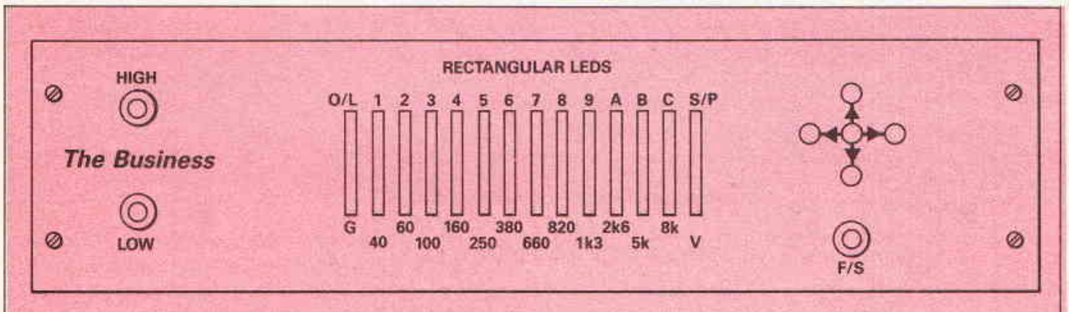


Fig. 3 Front Panel detail

(Maplin order code XR35Q.) Ensure a good mechanical connection is made to the mains filter terminal before soldering.The method used to terminate the wire to the earth screw is to cut off with side cutters the plastic insulation from a 4BA eyelet crimp terminal, strip back, tin and trim the wire, crimp the wire into the terminal and then solder. Finally, use a neoprene expandable cable sleeve to cover and protect the joint. If the proper cable sleeve application tool is not available, use long nose pliers dipped in a little oil or Vaseline to stretch and apply the sleeves. Next wire up the live and neutral from the mains filter to the outer teminals of the mains switch. Sleeve these connections for safety. Now connect the primaries of T1 and T3 to the centre terminals of the mains switch, again sleeving these for safety. Connect the secondary of T1 to the bridge rectifier for 45-0-45V, taking the two centre tap wires to the earth screw via 4BA eyelet crimp terminals. Complete the wiring of the power supply components as per the circuit diagram Fig. 2 and the wiring diagram Fig. 4 using 32/0.2 equipment wire. Fix the pre-amp psu in the chassis and connect the AC secondaries from T2 and T3 to the board. Use 32/0.2 wire for the two earth leads from the pre-amp psu to the earth screw. Put a flat washer and a full nut on the earth screw and tighten it up. The power supply is now ready for testing.

The safest method of testing electronic equipment and power amplifiers is to use a variac transformer and slowly turn up the mains supply while monitoring the output of the equipment under test. Variac transformers can be picked up quite cheaply from electronic surplus suppliers.

With three transformers in the amplifier, a fair turn on surge can be expected. The amplfier uses a 10A anti-surge fuse in the mains filter. Ensure that the mains flying leads for the fan are safe. Double check the wiring and turn on the amplfier's mains switch. Use a DC voltmeter to monitor the voltage on C1 and C2 with respect to ground and slowly turn up the variac. If everything is well, a symmetrical supply of about +83 and −63 volts should be on C1 and C2 when the mains have been fully turned up. The pre-amp power supply should have +15, −15 and +5 volts with respect to ground on the appropriate pins. If that is so, turn off the power. Be careful as C1 and C2 will remain charged for some time.

Wiring up of the output devices on the heatsink assembly is the next step. The gate and the drain pins of the MOSFETS should be sleeved using neoprene sleeves. Make up eight gate leads using 16/0.2 equipment wire and solder to the ends of the leads the 820R gate resistors. Four leads in blue for the P type MOSFETs and four leads in purple for the N type MOSFETs (or the colours of your choice). The resistor to wire connection should then be sleeved for

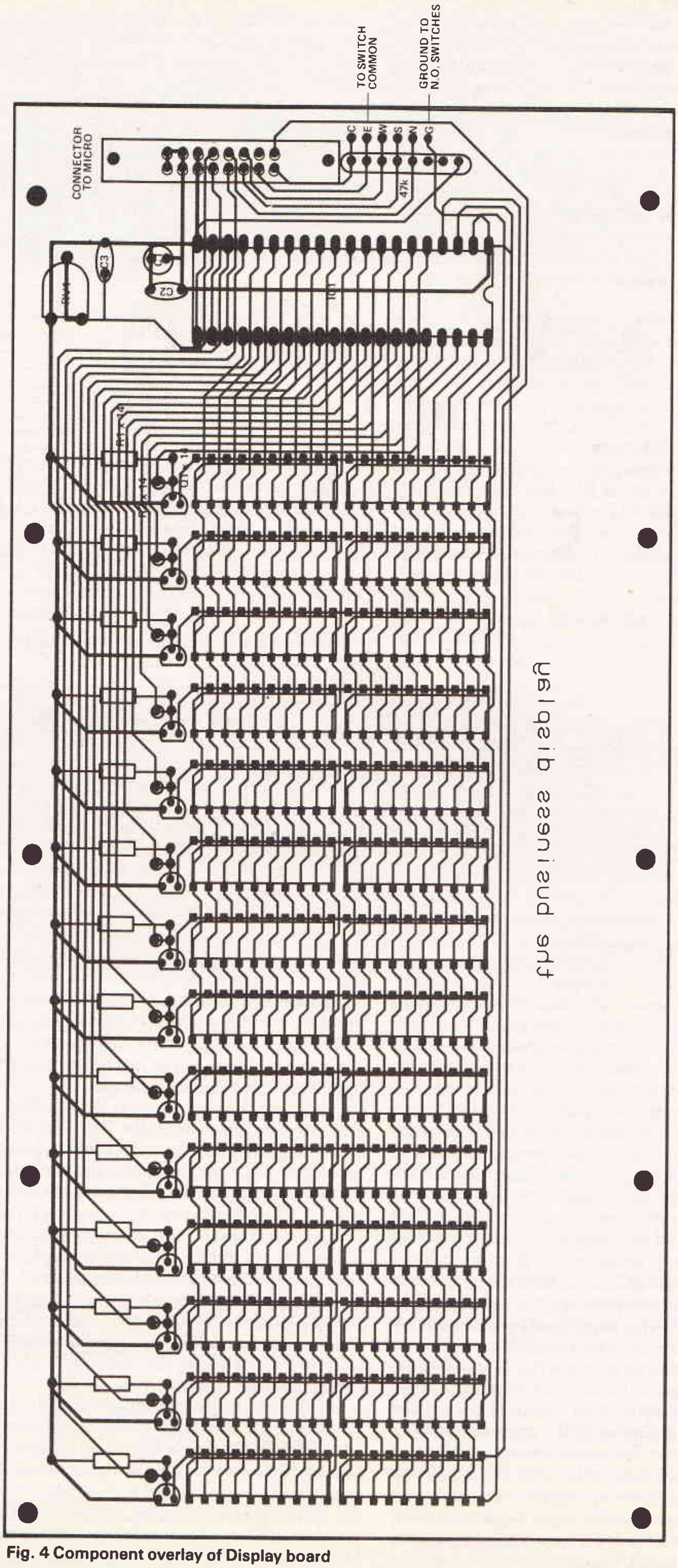


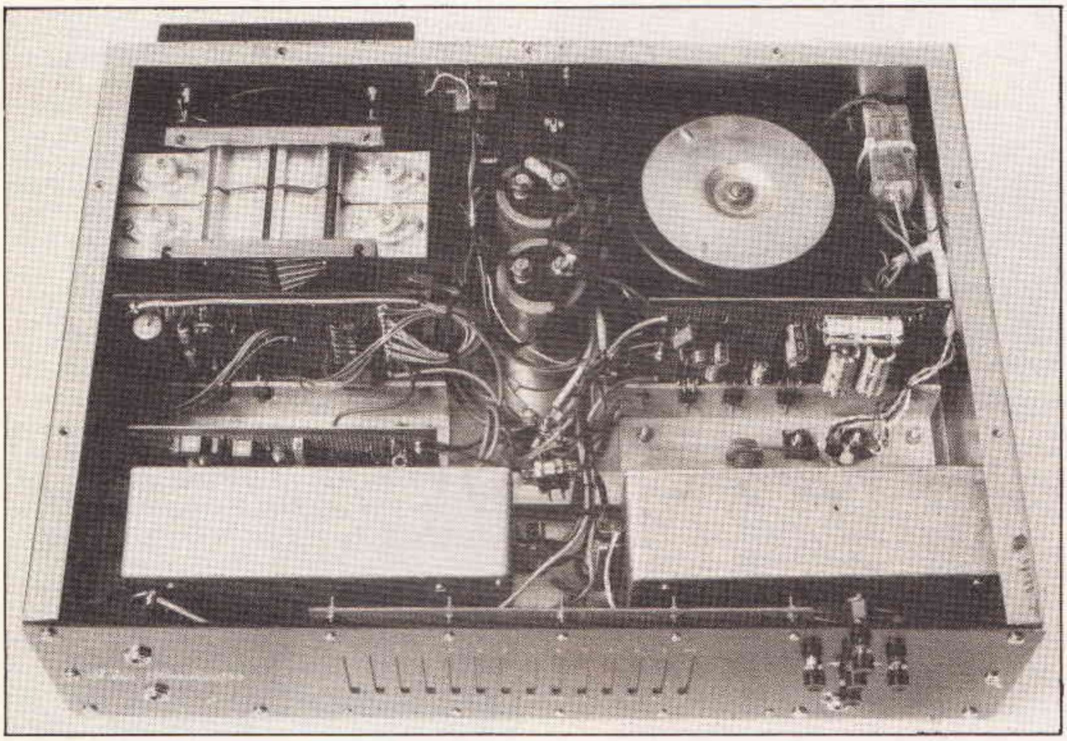
Fig. 4 Component overlay of Display board

insulation. Now solder the resistors to the gate pins of the MOSFETs. Apply a little silicon rubber compound or ten minute epoxy over the resistors to stop them moving about and ultimately breaking off. Then solder four leads of 16/0.2 equipment wire to the source solder tags on the P types in yellow and four leads to the source solder tags of the N types in orange. Finally, solder four leads of 32/0.2 equipment wire to the drain connections of the P types in black and four leads of 32/0.2 equipment wire to the N types in red. The leads can be laced or sleeved together as three groups, gate leads, source leads and drain leads. Route them away keeping the three groups separate. Use a 1K resistor to discharge C1 and C2 before working on the amp chassis. The DC offset protection board can now be screwed into position using M2.5 screws, washers and full nuts. Use 16/0.2 equipment wire to connect the +15 and −15V supplies of the board to the pre-amp psu, the earth from the board to the earth screw via 4BA solder tag and the AC from the board to the bridge rectifier.

Use red 32/0.2 equipment wire to connect the relay output from the board to pin 2 on the loudspeaker plug, and a flying lead on the relay input to go later to the power amps series output resistor. The DC protection circuit can now be tested. Hold the red flying lead at earth and power up the amplifier. The relay should close after about 2 seconds delay. Touch the red flying lead to the +15 or −15 volt supply, the relay should instantly open. Replace the flying lead to earth and the relay should close after the 2 second delay. Switch off the power and the relay should open instantly. Carefully discharge the caps C1 and C2 before continuing. Use green 32/0.2 equipment wire to connect pin 1 on the loudspeaker plug to the earth screw via 4BA eyelet crimp terminal.

Connect the mains leads to the fan and fix the heatsink assembly in place using the four fan filter screws and the two M4 chassis screws. It is impossible to reach the lower left hand nut on the fan filter fixing screw so a trick is first to hold it in position with its screw and stick it in place with a little ten minute epoxy. The power amp board can now be fixed in the chassis and the gate leads and source leads from the output devices connected up to the correct terminal pins on the power amp board. Connect the drain leads from the output devices to the power supply caps C1 and C2 using eyelet crimp terminals. The black wires to the negative supply, the red wires to the positive. It is possible to get two 32/0.2 leads into one crimp terminal. Connect up the power amp boards supply lines to C1 and C2 using 32/0.2 equipment wire. Connect up the two earths from the power amp board to the earth screw using 32/0.2 equipment wire and eyelet crimp terminals. Finally, connect the flying lead from the DC protection board to the series output resistor.

Now for the moment of truth. Double check the wiring. If an audio oscillator and an oscilloscope are available, inject a 1kHz sine wave into the input of the power amp and monitor the output with the scope. Do not load the amp output. Turn the pre-set pot on the power amp board fully clockwise. Use a DC



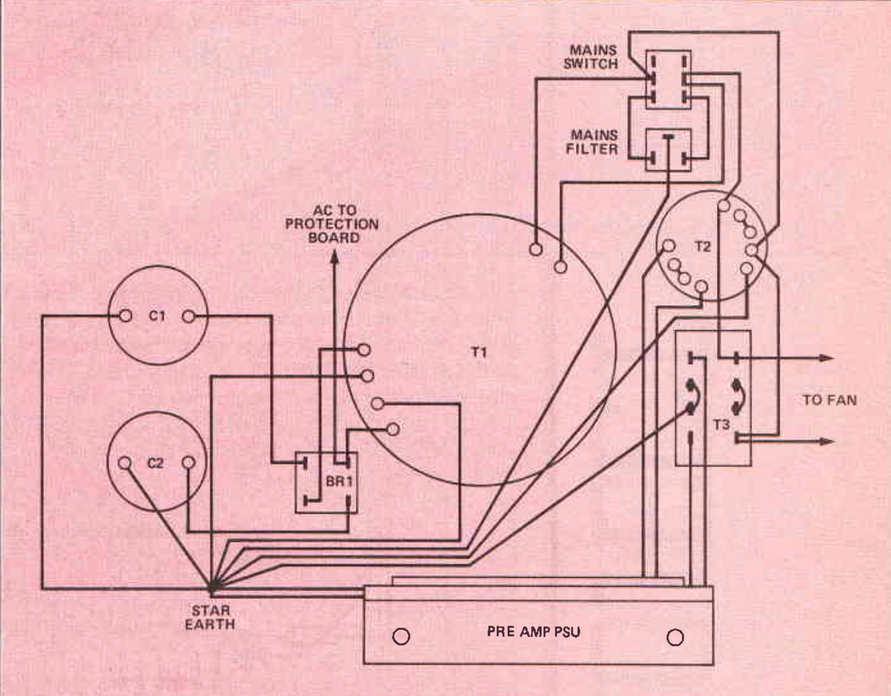
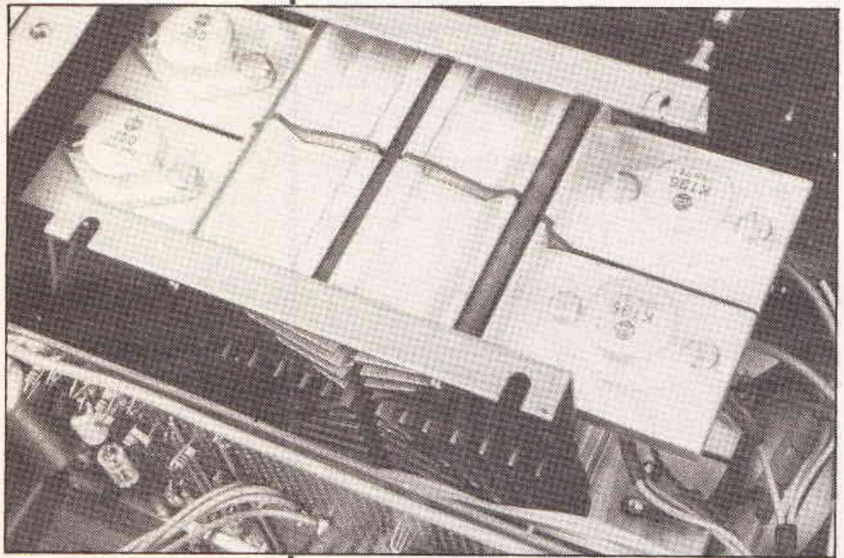


Fig. 5 Power supply wiring detail

voltmeter to monitor the amp output with respect to ground. Turn on the amp's mains switch and slowly wind up the variac transformer. If all is well, the 1kHz sine wave will appear on the amp output and the DC potential on the output will be less than +/− 200mV.



Heat sink for Bass Amp

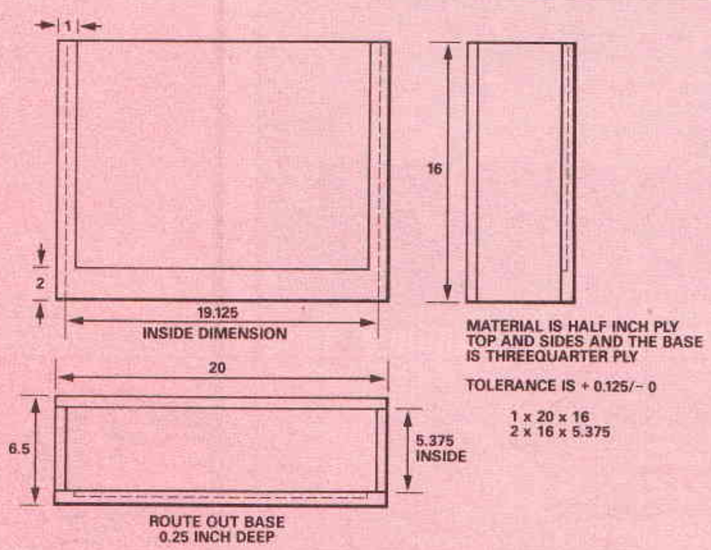


Fig. 6 Amplifier wooden sleeve

Measure the DC potential across any one of the 0.33 ohm 2.5 Watt source resistors on the power amp board and wind the pre-set anticlockwise for 40mV across the source resistor. This corresponds to 120mA quiescent current in each output device. Do not worry if equal current does not flow in all the devices. This sorts itself out once the amp is hot and driving hard. Switch off the amp. Connect a dummy 8 ohm load, and switch off the amp. There should be a short delay before the relay closes. The performance of the amp can now be checked. The amp should swing 40 volts AC on the output into 8R before clipping corresponding to $P=V^2/R=(40\times40)/8=200$ Watts of output power. A 10kHz square wave driven into 8 ohms in parallel with 2μF should show no ringing. The short circuit protection can be checked by loading the amp with 0R 33 ohm source resistor and slowly winding up the 1kHz input signal while viewing the output on the scope. A distorted limited waveform should be seen on the scope. The load resistor will get very hot. Switch off the amp and the relay should open instantly.

The next step is the panel assembly (Fig. 3). First fix in the input jack sockets, the footswitch jack socket and the five push-buttons. The neutral acrylic optical filter should be cut to fit in the panel recess. The material can be cut on a band saw without splitting. The matt finished side faces out to the front. The filter is held in place by the display board which can now be fixed to the panel using eight Pan head M2.5 x 20 screws, flat washers and full nuts. Do not cover tighten the nuts as this will distort the display board. Chemically blackened screws give the best visual finish to the panel. The push-buttons and footswitch jack socket can now be wired up to the board as per the circuit diagram and overlay.

The final stage in the assembly is to fit the micro and graphic pre-amp modules into the chassis and wire the whole thing up (Fig. 5.) Chassis fixing nuts and washers in the diecast boxes can be held in position with screws and then glued into place. When the epoxy resin is dry, the screws are removed and hopefully the nuts stay fixed in place. Clearance holes for the IDC ribbon cables to the display and graphic pre-amp can be cut in the lid of the micro diecast box and a clearance hole for the IDC ribbon cable from the micro can be cut in the lid of the graphic pre-amp box. Plug in and lock the IDC ribbon cables between the micro and graphic pre-amp and the IDC ribbon cable to the display. Screw the lids on to the diecast boxes and then screw the boxes into the chassis. Connect the earth leads from the boxes to the earth screw and the power leads to the appropriate terminal pins on the pre-amp psu, +5 volts to the micro and +15 −15 to the pre-amp. The front panel input jack sockets can now be wired up to the screened input leads from the pre-amp as per the circuit diagram. Also take a 32/0.2 earth wire from the jack socket earth to the earth screw. Plug the IDC ribbon cable from the micro into the display board. Screw the panel onto the chassis using eight pan head M4 x 16 screws with flat washers and full nuts. Chemically blackened screws give the best visual finish to the panel. Connect the output from the pre-amp to the power amplifier input. Do not connect the earth screen, just the signal wire. Sleeve the end of the screened wire to prevent the screen fraying out and shorting.

Providing the proper PCBs have been used and there have been no mistakes in the construction, the components are all in the right positions and there are no duf or dud chips, the program in the eprom is correct and there are no shorts or opens on the boards, the amplifier should be a first time flier! When the amplifier is turned on, it is muted until the volume is stepped up or down. Turn on the amplifier. Step the volume up or down and check the operation of the graphic and display. Step through the channels, setting up the graphic equaliser for each channel. The graphic band setting wraps around to the gain at each end of the display for setting channel gain levels. Turn off the amplifier, wait a bit, then turn it back on. Check that it has remembered the graphic and gain settings. If all is well, leave the amplifier on for as long as possible for a burn in of the components. If something is going to go wrong, it should show up early in the amp's life.

Trouble Shooting

If all is not well, do not panic. If we can isolate the faulty board, it can be put right. First check the power supply rails. A low rail indicating excessive current drain. Find the faulty board and check the components for shorts or low impedances. If a single column or row is out on the display, check the column driver transistor or the display chip. If the display shows just a single column on, or just a blurred mess, check the IDC ribbon cable and the micro circuit for the interrupt pulses and serial display data. If the pulses are missing, check the micro's system clock oscillator and the address and data lines. If the clock is present and the address and data lines are clocking, check the eprom and the 555 reset circuit. If the graphic is not working check the IDC ribbon cable and the serial data from the micro. The graphic equaliser band boost and cut adjustments should be silent. Pops and crackles from the graphic while adjusting band settings or changing channels indicate a faulty op-amp. Isolate the faulty op-amp by adjusting the graphic bands up and down and finding the one most sensitive. Then change that band's op-amp. Gain and volume adjustments should be silent, although a slight click is heard at a very high output levels. Excessive noise indicates a faulty op-amp in the attenuator circuits. Only the faintest hiss and hum should be heard from the amplifier when there is no input signal. If there is any noticable hum and noise, recheck the earth and signal wiring.

The last thing to make is the wooden amplifier sleeve (Fig. 6). This is made from half inch marine plywood for the sides and top and three quarter inch marine plywood for the base. The base of the sleeve is routed out to allow clearance for the screw heads protruding from the base of the chassis. The sleeve extends over the front and back panels of the amplifier to protect them from knocks and damage. The amplifier is held in the sleeve by seven M4 × 20 pan head screws with seven M4 × 20mm diameter flat washers. These screws and washers should be chemically blackened for best effect. The screws pass through the top of the sleeve and thread into the tapped hank bushes fixed in the top of the chassis. The half inch ply top of the sleeve should be marked out and drilled for these fixing screws before assembling the sleeve. One way to do this is to lay a large sheet of drawing paper over the chassis top and mark the positions of the bushes. These marks can then be transferred to the wooden sleeve and accurately positioned centrally in the top. Drill out the seven holes M4 clearance. The sleeve can then be assembled. The sides are butt jointed to the top and base and glued and screwed together. The wooden sleeve is then covered with Vynide covering cloth stuck on with evostick impact adhesive. A leather strap handle is fixed with countersunk screws onto one side of the

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Table 1 Eprom hex dump

HOW IT WORKS

Power supply

The power amp is conventional in design, the main criteria being reliability and high power handling. Available output power of an amplifer depends on the power supply rating. The power supply is 45-0-45V 500VA toroidal transformer, 35A bridge rectifier and 4,700µ 100V smoothing capacitors (Fig. 7). Bridge rectifying and capacitor smoothing results in peak rectification of the transformers secondary AC waveform. This is the AC secondary volts times the square root of two, which gives a DC supply to the amplifier of 45×1.414=63.6V. The VA rating of the transformer is the AC secondary voltage times the maximum current that can be drawn continuously without the transformer overheating. Heat is the limiting factor, as a transformer will deliver as much current as demanded until it suffers overheating and ultimate meltdown. The amplifier will deliver 200 Watts into an 8 ohm load or 320 Watts into a 4 ohm load continuously without the transformer or the output devices overheating.

Display

The display is made up of 24 red and 4 green 10 segment bargraph LED ladder displays, arranged as 14 columns of 20 LEDs. The first column is green for gain indication, the top LED indicating pre-amp overload. The next 12 columns are red for graphic indication, the top LED in each column indicating the active band in set mode or the active channel in play mode. The 14th column is green and indicates the volume level, the top LED indicating set or play mode. The display board is mounted behind a Neutral acrylic optical filter which fits in the recess in the front panel and is held in place by the display. The filter greatly enhances the display image and contrast.

The display LEDs are driven by a M5450 display driver IC. This IC has 34 outputs which can each sink up to 15mA without external resistors. Programming of the chip is via three digital lines, DATA ENABLE, SERIAL DATA and CLOCK.

Programming is accomplished by taking DATA ENABLE low, then a 1 is the first bit clocked into the DATA line, followed by the 34 data bits. The 36th clock pulse loads the 34 bits of serial data into the segment latches, each logical 1 turning on the appropriate segment. The 36th clock pulse also generates a reset signal, which clears the registers ready for the next data stream following the next 1 detected on the DATA line. Outputs 1 to 14 drive the columns and outputs 15 to 34 dive the rows. Only 1 column is on at a time. The display is updated at approximately 70Hz. A brightness adjustment is provided.

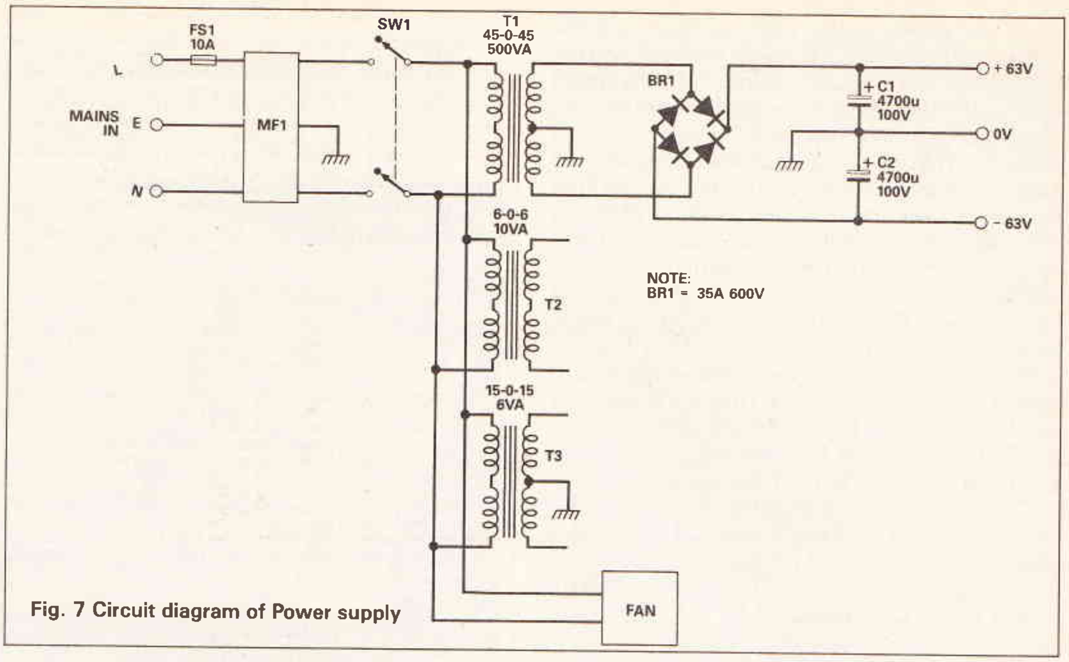


Fig. 7 Circuit diagram of Power supply

PARTS LIST

Display components

RESISTORS (all ¼ Watt)

R1	10k 14 off
R2	1k 14 off
RV1	100k cermet pre-set

CAPACITORS

C1	100µ 10V electrolytic
C2	100n ceramic
C3	1n polyester

SEMICONDUCTORS

IC1	M5450 Maplin UJ53H
Q1	14 off ZTX 751

MISCELLANEOUS

1 off 40 pin IC socket
5×SPCO momentary push switch Farnell 146-248
5×10mm black cap Farnell 4482
Stereo jack socket for footswitch
Mono jack socket for Lo input
Switched jack socket for Hi input Maplin BW80B
Maplin double footswitch YK75S

Display LEDs
4 off green 10 segment bargraph array Maplin YG33L
24 off red 10 segment bargraph array Maplin BY65V

Neutral acrylic display filter Electromail 588-746

BUYLINES

All the components are available from Maplin. The neutral acrylic filter is available from Electromail Part no. 588-746. Tel: 0536 204555. Ready programmed eproms can be obtained for £15 inclusive of VAT, post and packing from W and M Computers, Lasada House, 41 Trafalgar Street, Brighton BN1 4ED.

sleeve and the corners are protected with plastic cabinet corners. Four rubber feet are screwed into the base. Place the amp on the floor on its back panel and slide the sleeve over the amp into place. Secure the amp in the sleeve with the seven screws and washers.

That's it, finished. Now you may ask, did I achieve that elusive sound? The speaker cabinet that I am using with the amp is a Peavy Mega box. This is a ported full range cabinet containing one 15 inch speaker, a high quality crossover and two eight inch speakers. The nominal impedance of the cabinet is 4R, the amplifier delivers 320W into this load. The

PARTS LIST

Hardware and power supply

CAPACITORS

C1, C2	4700µ 100V electrolytic Farnell 114 19472 2inch vertical capacitor clip Farnell V4

SEMICONDUCTORS

BR1	35A 600V bridge rectifier Electromail 262-539 Standard 120mm square 240V AC fan. Electromail 509-226 Fan filter Electromail 508-510 6A Chassis plug with filter and fuse. Electromail 238-693 15A Mains switch Electromail 316-844 XCON 3-32 Loudspeaker plug Electromail 466-393

MISCELLANEOUS

T1	500VA 45-0-45 transformer Electromail 208-175
T2	10VA 0-6 0-6 transformer Electromail 207-784
T3	6VA 0-15 0-15 transformer Electromail 207-217

Marston Palmer Heatsink assembly
2×1 station module kit Farnell 148-449
1×2 station component kit Farnell 148-453

2 diecast boxes Maplin type M5008 order LH74R
2×6.5 inch lengths of 1.5 inch aluminium angle bracket
H20 expandable neoprene sleeves Electromail 399-596
2BA eyelet crimp terminals Maplin order code JH72P
4BA eyelet crimp terminals Maplin order code JH71N
No4×6.4 self tappers Electromail 525-969

BUYLINES

Alternative components can be used providing they have similar ratings and sizes.
Electromail PO Box 33, Corby, Northants, NN17 9EL.

amplifier fits size wise exactly on the top of the cabinet and so looks really good. The combination has a good sound and very wide frequency response to give gut rumbling lows and sweet highs.

It turns out that the sound of the bass depends more on the soul, feeling and techniques put into playing than the equipment used. A good player will sound good through a transistor radio, and a good player will sound even better through this amp.

I play in a loud pub rock band, and since I started to use this amp and cab, Martin, our guitar player, who thinks Motorhead in full swing is a quite middle of the road quartet, comes up to me after every gig and says, "You're a bit loud, Bob." After one gig, a guy came up to me and said "You get good bass sound, I could really feel those low notes, what amp is that you're using?" To which I replied "It's the Business man!"

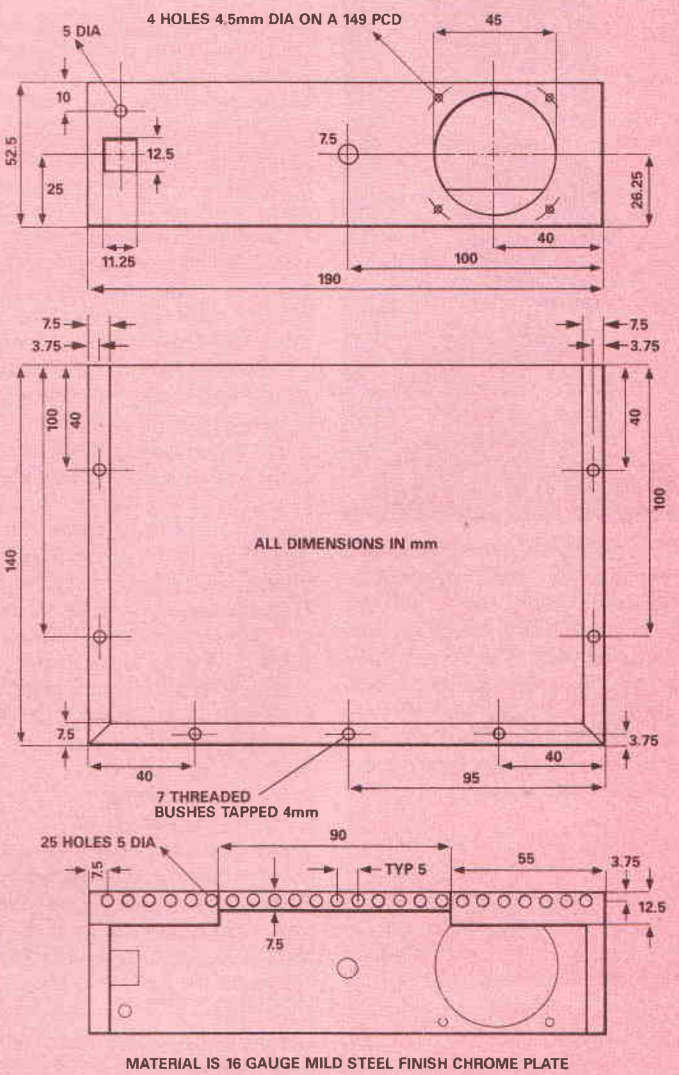
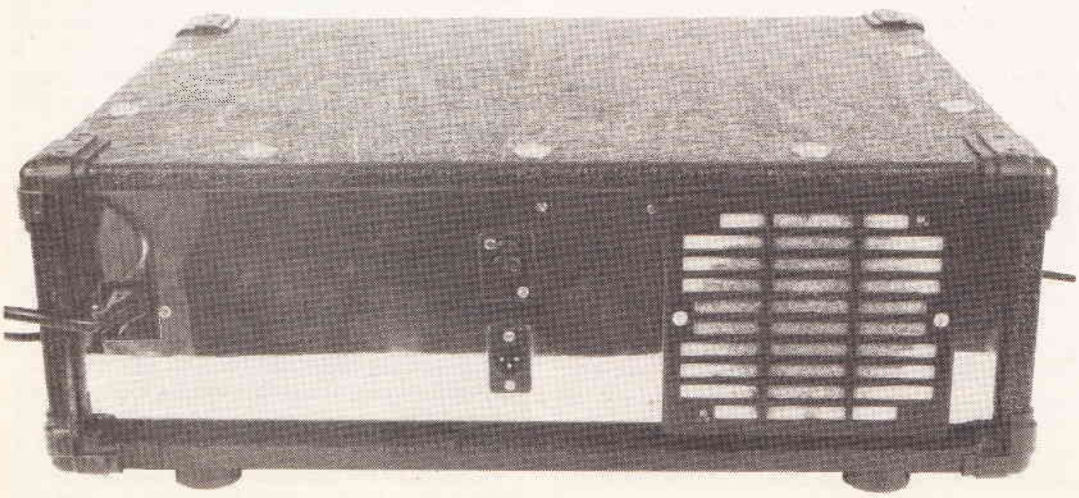
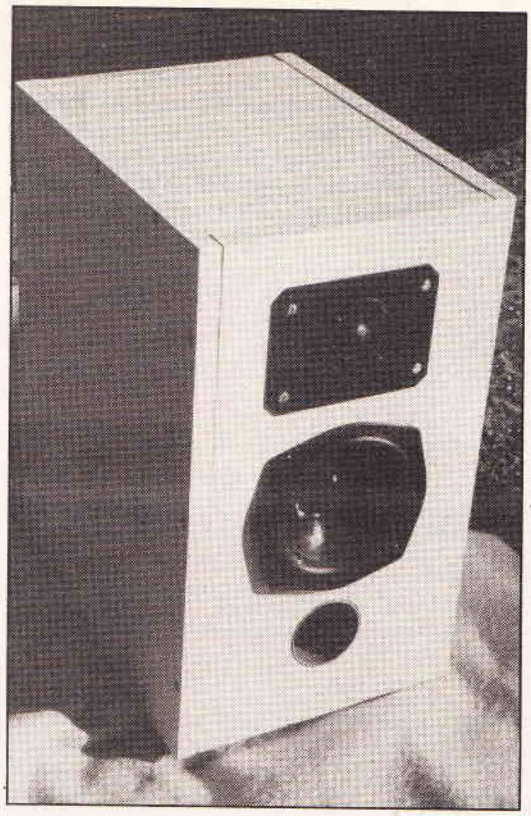


Fig. 8 Chassis dimensions



THE FLATMATE

A compact active monitor speaker system that sounds as good as any of three times the price. Jeff Macauley describes his best project to date



This design has been stimulated by my own continuing quest for sound perfection, a process which has been going on now for many years. In that time I have progressed from passive speakers to tri-amped three way systems with sub woofers. Most components in my audio system don't last very long because I am always striving for better sound. The single biggest step forward in this quest has been to change from passive to active speakers as these have a multitude of audible advantages.

For the last three years I have used a home brew active system consisting of a small sub woofer and satellite speakers. Although they are superior to any passive system I have heard, I am always on the lookout for a better design. The speaker system described here is the logical next step. Although it's not a low cost project, it will probably take a week of your spare time. But if you want good sound in a compact enclosure I don't think you'll find anything to better it, at least if you want change from a £1000.

My own requirements from a speaker system demand good bass extension to cater for my wide musical taste. My experience has shown that the most acid test of speaker system is good stereo play on Radio 4. Any speaker that cannot produce convincing results on voice material can't do justice to music. Really this isn't surprising. The human brain/ear system must have evolved with human voice recognition high on the list of priorities.

Most of today's speakers only respond down to about 50Hz. Even vinyl disc goes down to 30Hz and compact disks go even lower. Given a lower limit of 20Hz, itself a rather arbitary frequency, over an octave of response is lost. Unfortunately it isn't sufficient just to extend the response. What is required is a flat response down to these frequencies. Even just extending the response from 50 to 40Hz brings a whole new dimension to the listening experience. Bass signals are often felt as well as heard!

The lower cutoff, −3db point of this design is at 35Hz. This is the lowest possible cutoff using the Kef drivers. Careful computer aided design has also made it possible to achieve this result without the drivers hitting their end stops on loud transients. All this is achieved in a 0.72 cu ft enclosure. Moreover a pair is capable of generating 101db SPL at 1m at 35Hz. Generally speaking, low frequency information is present at lower levels than this and is as vital in communicating musical information as the high frequencies provided by a tweeter. Of course good bass is only one factor in producing a speaker system. For this reason a lot of attention has been targeted at the rest of the frequency range. It is not necessary to throw away all your other equipment to use these speakers either. They are designed simply to plug into your system's power or preamp output sockets.

The reasons for active speakers sounding better than passive are legion. To start with passive crossovers cannot be adequately designed from theory alone. If we assume that the speakers are pure resistances, it will result in response anomalies that no amount of polyester or polypropylene caps and aircored inductors can cure. To have even a reasonable chance of operating as calculated, steps must be taken to match the crossover to the actual speakers and cabinet used.

Sophisticated test equipment is required to get the response right. Even when this is done, there remains the problem associated with different driver sensitivities and the crossover's own influence on the speaker's response.

Although speakers are actually current driven devices they are designed to work best from low impedance sources. Crossover components and interconnecting cables can have an adverse affect. Furthermore as the complete system is driven from one amplifier, an overload in the midrange, where most of power is required, will generate harmonics in the tweeter. It's not unknown for tweeters to be blown by this means, not to mention the extra harshness and

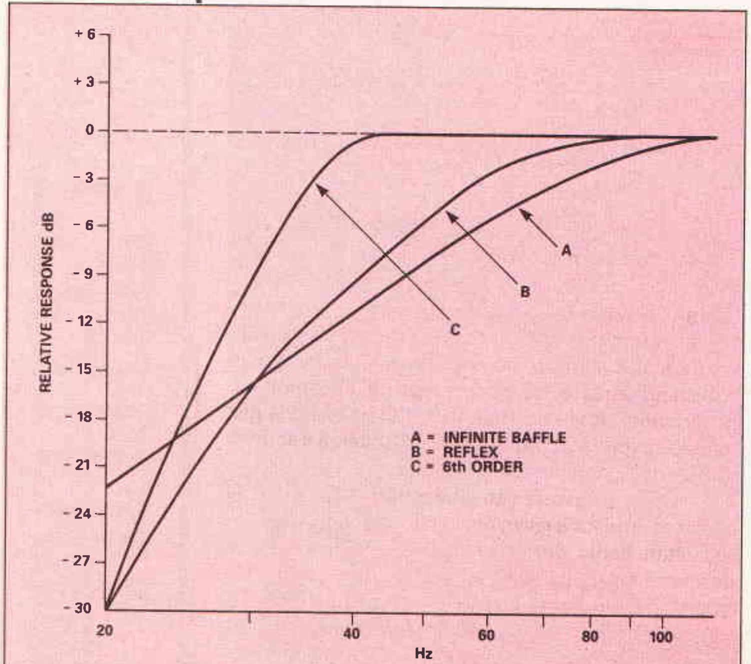


Fig.1 Relative response curves of speaker enclosures

distortion introduced. A complex passive crossover, as good ones usually are, also produce insertion loss and this translates into low efficiency.

An active crossover on the other hand overcomes all these problems. The response obtained from the system is independent of the speaker's parameters. If you have chosen your crossover frequency sensibly a textbook perfect response is obtained. The full damping factor of the amplifier is applied directly to the voice coil. Interconnections can be kept short to avoid the necessity of expensive cables. If the bass driver overloads, the effects are only confined to that driver. Harsh distortion is not coupled to the tweeter. Transient response and sound pressure levels are improved due to the lack of attenuation from a passive crossover. Catering for the sensitivity of the driver is also simple. It can be done with a potentiometer or simply by altering the gain of one of the amplifiers.

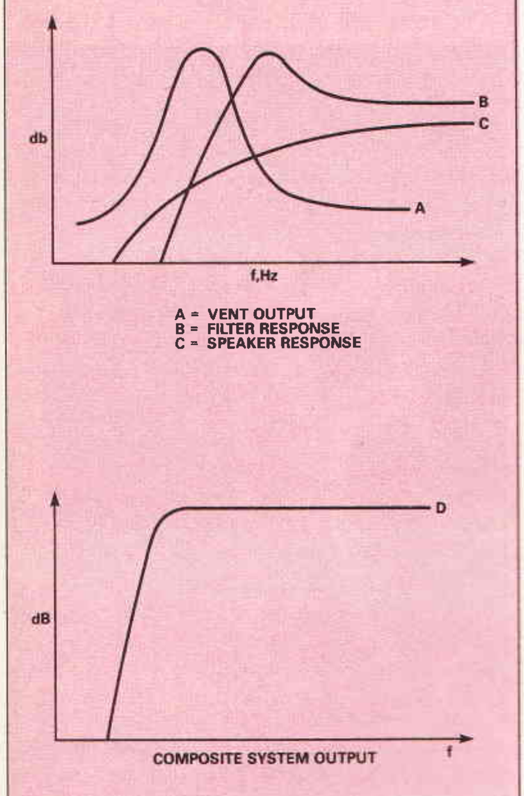


Fig.2 System response curves

As I am not the world's greatest craftsman, the design has deliberately been kept as simple as possible without compromising sound quality.

The basic idea behind this design was to produce a system capable of producing a flat output (35Hz-20kHz ±3db) whilst maintaining a size compatible with domestic harmony. Many promising speaker designs don't see the light of day because of this last factor! Along with these requirements was a smooth midrange and treble with the best possible driver integration. The latter makes active circuitry almost mandatory. In any case the complexity of the electronics used would make a passive realisation of this design almost impossible. I also like to hear a good stereo image and this requires a small cabinet to ensure good horizontal sound dispersion.

Achieving this level of performance requires the balancing of many factors, some of which appear to be contradictory. To understand the basic problem of getting good extension from a small cabinet, we have to return to basics.

The problem is that loudspeakers have a dual nature. Half electrical and half mechanical, they occupy a grey area where electrical currents are changed into sound.

The electrical side of matters is more or less solved. But the mechanical motion of the coil causes back currents to flow and modifies the electrical circuit. This looks like a resistor with an inductance in series. Now the mechanics can be a problem. Dominating the behaviour of the system is the fundamental resonant frequency of the speaker. This resonance occurs because the mass of the cone and the compliance of the surround act like a mechanical tuned circuit. A good analogy is a weight suspended on a spring. Pull the weight down and release it and the system will oscilate. The weight in this case is cone mass and the spring the surround compliance.

If you take a speaker, place it face up on a table and feed low frequencies into it, you will not hear anything. This is because the bass frequencies have a very long wavelength compared to the speaker cone diameter and the sound wave produced from the rear of the cone is 180° out of phase with those from the front and they cancel each other out. An acoustic short circuit occurs. To prevent this happening has been the life work of many engineers over the last 50 years or so.

The simplest solution is to mount the speaker in an airtight box so that the rear radiation is trapped inside. This is quite a good idea except for the fact that the trapped air effectively reduces the compliance of the surround, so increasing the resonant frequency. Below resonance, the output falls rapidly. To compound matters, it also raises the Q of the resonance and unless properly designed will lead to peak in the bass response and a poor transient response.

Such systems, so called infinite baffle speakers, are now commonplace. So too is the reflex system.

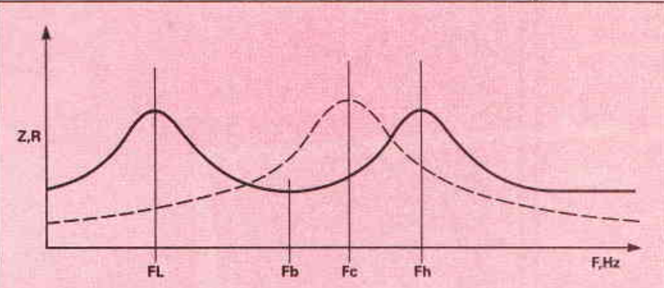


Fig.3 Resonant peaks

Here the speaker is mounted in a cabinet which is tuned to a specific frequency by a port or duct. These systems also work very well when properly designed. Another seldom mentioned advantage of the reflex enclosure over the infinite baffle types is that the resonant frequency of the driver is only slightly raised. Below resonance, the cone's motion is controlled by the surround rather than the cone mass and severe frequency distortion occurs. Luckily the ear can withstand quite a lot of this type of distortion on programme. It is said that 40% thd at 80Hz is just audible on programme material. In isolation it sounds awful!

Reflex enclosure can give a useful extension in bass response for a given enclosure size. Because they are often badly designed they have gained an ill deserved reputation for poor transient response. In fact the transient response of any system depends on the Q of the low frequency roll-off. It is quite easy to make an infinite baffle enclosure which is inferior to the bass reflex in this respect.

The key to getting good sound from a given speaker has now become more of a science than a black art. This has been mainly due to work of Thiele and Small who showed that a speaker system's low frequency response can be modelled by an electrical high pass filter. Most of the information to design good reflex systems using this method was described in my previous article.

There is however another way to get extra low frequency extension from a reflex cabinet without sacrificing quality. This involves using a high pass filter in series with the power amp driving the speaker and redesigning the enclosure. Unfortunately the precise mathematics are beyond the scope of this article.

These filter assisted speakers have been christened 6th order alignments by our American cousins. They are so called because the roll-off slope

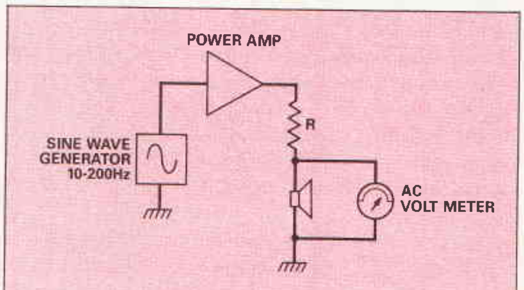


Fig.4 Resonant frequency of driver measurement

of a reflex enclosure is 4th order whilst the roll-off imposed by the filter is 2nd order. As both roll-offs are effectively in series they add to produce a 6th order response. To get a clear idea of the results look at the diagram comparing roll-off rates and bass extension (Fig.1). To make things simple I have plotted the response obtained by using the speakers in the same cabinet but using different forms off-loading. Curve A shows the simple infinite baffle. Note that the response hits −3dB down at about 75Hz. The rate of roll-off though is slow, eventually attaining 12B/octave, a second order response.

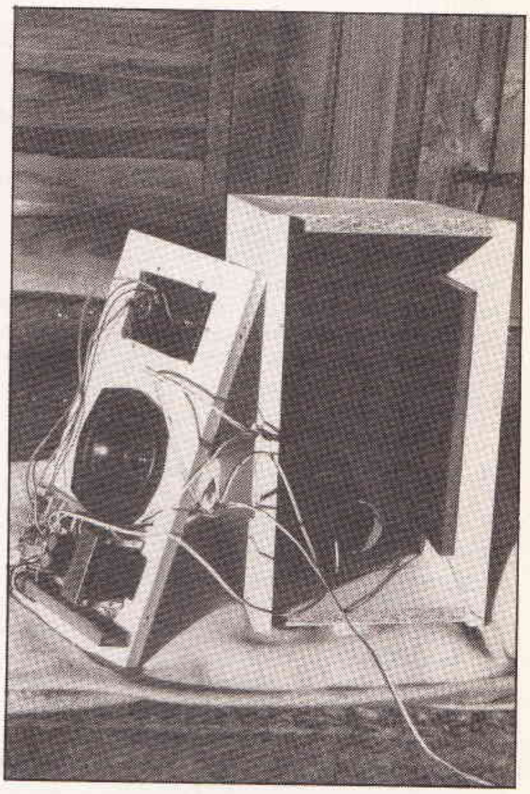
Curve B shows the response of the reflex loading. Here the −3dB point is much lower, about 60Hz and the roll-off rate is greater again, 24dB/octave, a 4th order response. Lastly the response of the 6th order design. Here the −3dB point is at 35Hz and the rolloff is 36dB/octave. The real point of note though is the flatness of the curve which remains within ±0.3dB of the 0dB line from 40Hz up.

To explain the basic idea, Fig 2 shows the result of the speaker rolloff, high Q filter and vent resonance and the resultant response curve of the complete system. The design described here uses this method of bass extension. The interaction between driver filter and vent causes the low frequency roll-off to occur at 36dB/octave. A 6th order alignment. The response Q is very close to the ideal 0.7 and ripple is less than 0.3dB, completely inaudible. Another advantage accrues from this rapid roll-off. Sub audio trash is effectively eliminated giving a tighter cleaner bass.

Since this design needs an auxiliary filter anyway it makes sense to fully activate the design and make it totally self contained. To this end, the equalisation, crossover and power amplifiers are all contained within the speaker. Normally the units can be driven directly from the speaker output of an existing amp. Extra gain can be switched in to make the units compatible with the output of any preamp that can deliver a 500mV output. Thus a complete audio system could be made simply with the speakers and a CD player at one extreme or simply hooked on to an existing system without circuit modification.

Having described the outline of the project we can get down to the more specific parts of the design. One problem that afflicts small speakers is that they suffer from diffraction. This means that at low frequencies where the wavelength of the sound is very long compared with the cabinet dimensions the sound field is propagated omnidirectionally. As the input frequency gets higher, a point will be reached where the wavelength assumes the dimension of the cabinet and the sound field is confined to the front of the cabinet.

The sound output of a well designed speaker will be constant with frequency and the net result is that the speaker will exhibit a step in the response giving boosted higher frequencies in relation to the bass. This design tackles the problem in a rather novel way. Two



bass drivers are used. One is mounted conventionally on the front baffle whilst the other is mounted on the rear. So at bass frequencies the two drivers contribute equally to the sound field. As the frequency is raised the on axis response increases from the front driver whilst the rear driver reduces its contribution. The net result is an output that stays essentially omnidirectional and flat up to the crossover frequency. Another advantage of having two drivers mounted in this way is that they can be used in push pull eliminating distortion at low frequencies. Last but not least two identical small drivers appear to operate as one larger speaker but with a better transient response due to the lower cone masses.

A pair of KEF B110 5 inch bass/midrange drivers are used in this design. The choice of this driver was prompted by several factors. From the point of view of bass performance, a small cabinet could be used because of the small Vas and Qts of the unit. Also the midrange accuracy of this speaker is excellent, being extensively used in BBC monitors. KEF also has an admirable record of quality control. Speakers are supplied in matched pairs ideal for this application.

So much for the bottom end. What about the top? Here the choice is more varied. Initially a ribbon unit was considered but difficulties encountered in getting a stable supply knocked that idea on the head,

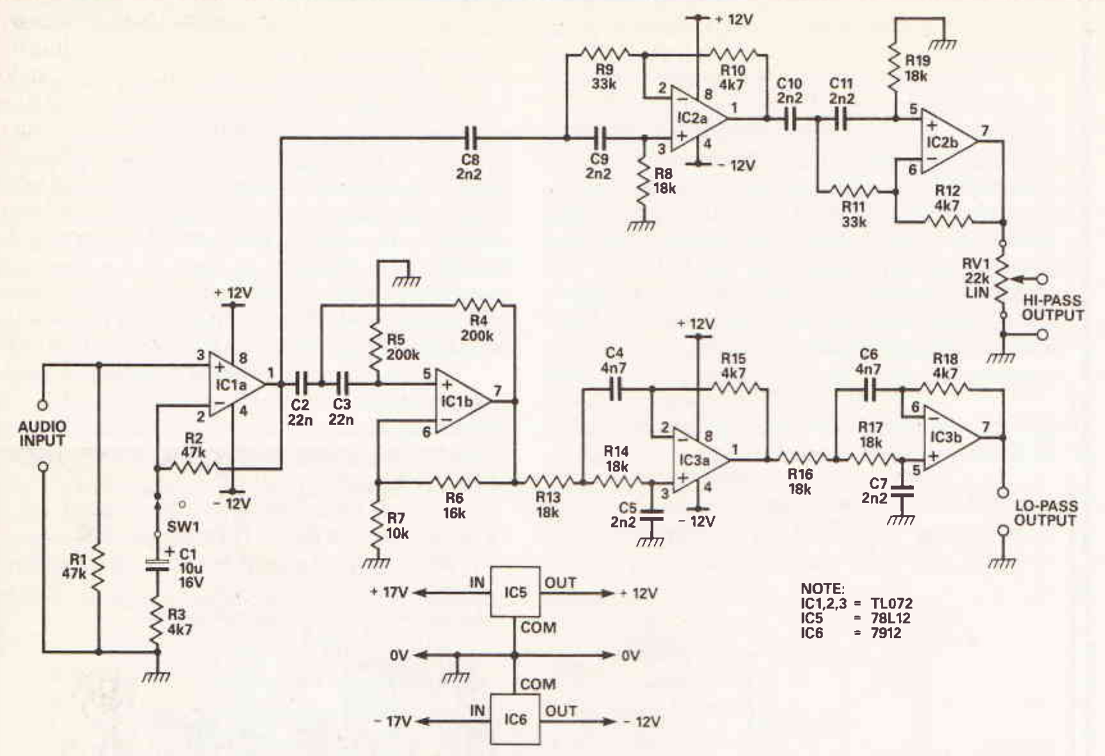


Fig.5 Circuit diagram of crossover and equalisation (for one channel)

promising as it was. Instead, new metal dome tweeters are used. These are a great improvement on the older soft dome types and use pure Titanium for the dome. This material gives a pure piston type of output to well beyond the audio spectrum.

Soundwise they have the same clarity as ribbons or a good electrostatic unit. They are also easy to interface with the woofers especially in an active system. All this leads us rather neatly into the other major problem: where and how to crossover between the drivers.

There are two major problems with a crossover network. The first is where to crossover. To ensure a flat response, the crossover frequency needs to be within the working range of both drivers. The tweeter will respond down to 2kHz and the upper roll-off of the B110 is 5kHz. A crossover frequency of 3kHz was thus chosen. As for the slope other filters have phase angle problems. This leaves the 4th order type. With a rolloff of 24dB/octave, the range over which both drivers operate is small. This means there are no problems with the driver non linearity. The two signals are also in phase so for these reasons this filter order was the type finally chosen.

Turning to the cabinet. The dimension for this type of design are fixed by the physical charactaristics of the B110, namely Vas, Qts. For drivers used in this way the cabinet must be 0.61 cu ft tuned to 37Hz by a suitable vent.

The series high pass filter must also have a turnover frequency of 37Hz and a Q of 2.7. Actually the cabinet is very slightly oversized to account for the extra volume taken up by the damping pads, electronics and drivers. If this were neglected the correct response could not be obtained.

Tuning the cabinet

Although there are several formulae available for calculating the required vent length, they are not always 100% effective. The reasons for this aren't always obvious. Perhaps it is as well to remind ourselves that the ediface of mathematics assumes perfection in the real world, ultimately an impossible situation. The mathematics leads us close to the real world solution but the final honing of a design must depend on measuring the completed system and adjusting matters accordingly. There is little enough published information on how to tune an enclosure correctly and so the following is presented in the hope that it will stimulate those who wish to experiment.

This design has already been optimised and the design is as near real world perfection as it is possible to get. In other words you can build the design as it stands with confidence that you will be with ±0.3dB of the published curve. The critical ear can just perceive ±1dB.

When choosing a vent the aim is to choose the largest diameter comensurate with an acceptable vent length. Too small a diameter can lead to chuffing noises and high air velocity in the vent. Pragmatism must rule here and a 2 inch inside diameter drainpipe tube was chosen. On the prototype I calculated just over 8.5 inch for the duct. Initially I decided to cut the vent oversize by an inch. This will set f_b, the box resonant frequency, slightly lower than requires. The vent length can then be trimmed to the correct size using the methods installed in the cabinet. Vent mounting was effected by cutting a nominally 2 inch diameter hole in the front baffle. This is easily done with a hole cutter.

Cut a hole in a scrap piece of wood first to check that the tube can be slid into it. It is easier to cut the hole slightly oversize and pad out the diameter of the vent than to struggle to enlarge a smaller hole.

To measure the box tuning frequency (f_b) directly is difficult. At this frequency, the vent's output is at its maximum whilst the speaker's output is at its minimum. The solution is to measure the impedance curve below 100Hz. This will reveal two peaks f_l and f_h above and below f_b respectively (Fig.3). The resonant frequency of the driver must also be measured with the vent closed, f_o. The usual setup to measure this is shown in Fig 4.

A high value resistance is connected in series with the woofers which is fed through a power amp from a signal generator. The voltage across the woofers will be proportional to the speaker's impedance, and this is monitored by an AC voltmeter connected across the woofers. A resonance shows up as peak in the meter reading.

A quantitative measurement is not required — simply a qualitative one. It is important that the signal generator is accurate otherwise your results will be meaningless! First the resonant frequency of the drivers in the sealed box was measured by taping a piece of card across the vent thus sealing it. f_o came out at 62Hz. Next the vent was unblocked and the frequency swept from 10Hz upward. The two resonances, f_l and f_h were found to occur at 18.5Hz and 62Hz respectively. With some real numbers to work with, f_b can be calculated from,

$$f_b = ((f_l^2 + f_h^2) - f_c^2)^{1/2}$$

Knowing this we can work out the amount of tubing to cutoff to obtain the required f_b,

$$\lambda Lv = -2\lambda f_b(lv + 1.46r)/f_b,$$

where λLv is the length to remove from the vent, λf_b is an amount to increase the measured f_b to the desired f_b, and f_b and l_v are the measured f_b and vent length respectively, r is the vent radius and all dimensions are in inches. Putting our values in the equation yields a 2.65 inch reduction in vent length to obtain the desired response. This new vent length is 6.85 inch. Incidently, even with the 9.5 inch vent, the response was still within 0.6dB with the same −3dB point. So this procedure will appeal most to perfectionists.

The Circuit

The full circuit diagram of one channel is shown in Fig 5. The other channel is of course identical. The whole circuit is based on the use of the low noise TLO72 dual bifet op amp. Active filters based around discrete circuits were tried but didn't perform as well. Four are used per channel. Input signals from either the existing amplifier outputs or preamp output is fed across R1. This component sets the input impedance of the stage at 47k and refers IC1a's inverting input to ground. S1 is normally open when driving the circuit from an amplifier. The high input impedance of the speaker incidently means that your amplifier will operate in pure push pull class A when driving it. This reduces distortion in the drive signal.

When S1 is open IC1a operates as a unity gain buffer providing a low impedance drive for the rest of the circuitry. When closed C1 and R3 are connected in circuit and the stage gives a gain of 11. This is suitable for direct connection to a preamp output. From the output of this stage, the signal is sent in two directions. Considering the path through IC1b first. C2,3,R4,R5 form the filter for the bass eq circuit. With the components chosen, the turnover −3dB frequency is 37Hz. To obtain the correct Q this stage needs voltage gain. This is the function of R6 and R7.

From the output of this stage the signal is fed into the low pass section of the crossover network. A separate dual op amp is used for this function. To obtain the desired filter characteristic, two 2nd order stages are cascaded.

The Q of a 4th order filter is the product of the Qs of the 2nd order stages. The ideal Q for a filter stage is 0.5 since this gives critical damping. To obtain this, the 2nd order stages require a standard butterworth Q of 0.7. Simple Sallen and Key filters are thus used. IC3a uses R13,R14,C4 and C5 to provide this function. The output is fed directly to the identical filter based around IC3b. The output from IC3b is the bass channel. The output of IC1a is also fed into the high pass section of the crossover built around IC2. Here the circuit is essentially the same as that built around IC3 but the filter components are transposed. Again the 4th order characteristic is produced by cascading two 2nd order types with a Q of 0.7. C8,C9,R8 and R9 form the filter around IC2a. C10,C11,R11 and R19 form an identical filter based on IC2b. The output from IC2b is the treble signals.

A regulated supply line is used to power the active filters. Nothing more sophisticated than a pair of standard voltage regulator chips are used. Since the ripple rejection of these devices is 60dB and the op amps are the same, it follows that 120dB of isolation is obtained. Put another way 1V ripple on the main supply lines would produce a signal of 1μV at the op amp's output.

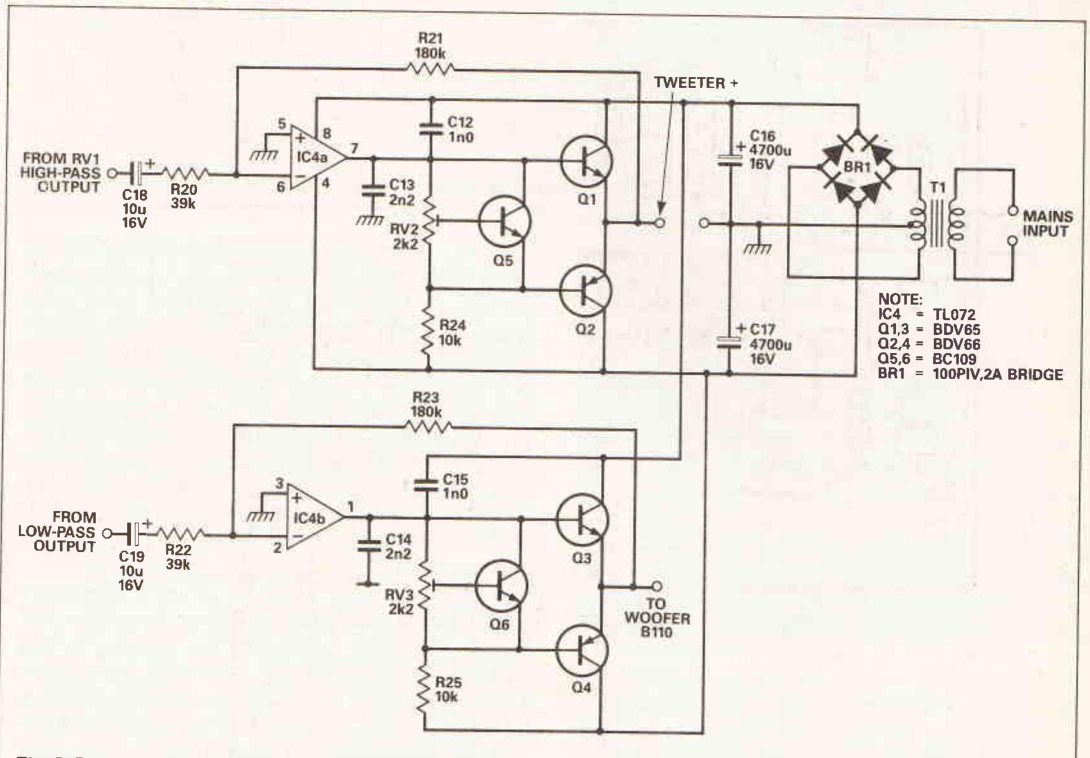


Fig.6 Circuit diagram of power amp and PSU (for one channel).

Main Amplifiers

Having obtained signals of the correct bandwidth for drivers we now require power amplifiers to drive them. Two power amps are employed per channel and both are identical (Fig 6). Taking the bass section of the amp, the signals from IC3b's output are coupled into R20. R20 and R21 form the overall negative feedback loop of the amp. Gain is defined by the ratio of R21 to R20 at 4.6, 13dB. Using this amount of negative feedback ensures a thd, at 10W output of 0.003% at all frequencies across the audio spectrum. The op amp IC4 is used in a 'brains and brawn' circuit. The op amp provides the voltage gain whilst the output stage provides the brawn.

The output stage comprises a complementary pair of Darlington transistors used in the emitter follower mode. Despite the extensive direct coupling is achieved with C16 and C17. The hum and noise produced by the circuit is well below the threshold of hearing at 1m.

Construction

The construction of the speakers splits neatly into two parts: the cabinet and the electronics. It is probably easier to start with the electronics first as these can then be tested with the drivers before mounting.

To make life as easy as possible all the components except for the transformer, S1 and the output sockets are mounted on a single PCB. The only requirement when assembling this is to ensure that all the polarised components are mounted correctly, especially ICs!

The output transistors are mounted on the heatsinks by means of the insulating kits provided.

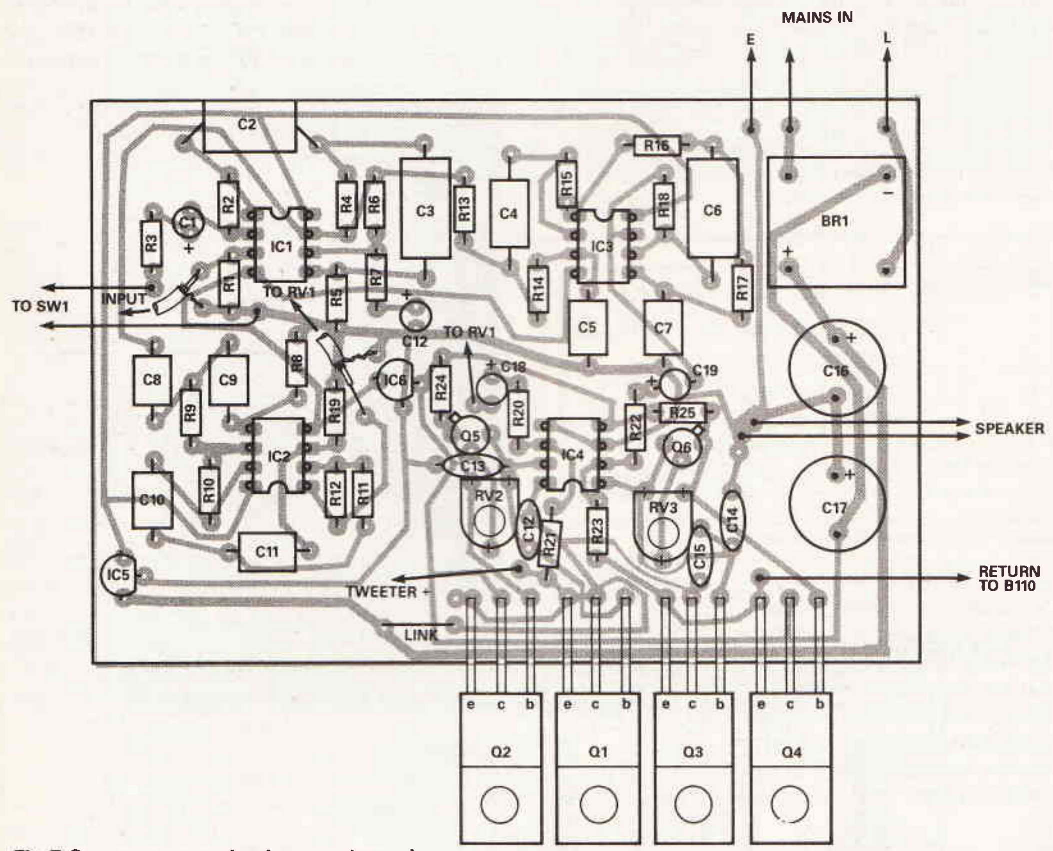


Fig.7 Component overlay for one channel

employed throughout the circuit, the offset at the speaker terminals is only a few millivolts allowing direct connection. Bias for the output stage consists of a transistor, Q5 used as a V_{be} multiplier. Adjusting RV2 allows the quiescent current of the output stage to be set. In practise, due to the high level of negative feedback around the circuit the amplifier performs satisfactorily with the slider set at halfway around the track. C12 and C13 ensure stability. The non inverting inputs of IC4 are connected directly to ground. The sensitivity differences between the woofers and tweeter are catered for by RV1 thus adjusting the gain of the tweeter channel. This allows you to adjust the balance to compensate for you own room acoustics. The response in an anechoic chamber is miles away from the results obtained in the average lounge. Here room decor influences the perceived balance between high and low frequencies.

The main power supply is also very conventional. Mains input is stepped down by T1 and full waved rectified by BR1. A centre tapped secondary is used to produce a dual power supply. Smoothing

Ensure that there is no connection between the collector, middle pin and the heatsink with a multitester switched to a resistance range. If a connection is found dismantle the assembly and refit. It is necessary to debur the mounting holes to prevent perforation of the transistor mounting washers.

Check your work thoughly for dry joints and correct connections before fitting the veropins. Once you're satisfied that all is well mount the assembly on the rear panel of the cabinet. At this stage you can attatch flying leads to the board and connect up the transformer. Wire a couple of 100R resistors in series with the transformer secondaries. Temporarily connect the woofer and tweeter and attach a mains lead. Set RV2 and RV3 sliders to midposition. Check all your connections again. Switch on. Nothing should happen! A finger touched at the input should produce a buzz from the speakers. If a wrong connection has been made the 100R resistors will burn out. Don't despair if this happens — the 100Rs will prevent serious damage. Find the fault, rectify it, then try again.

ETI Audio

PROJECT

Assuming all is well, the 100Rs can be shorted out and a music signal applied. The output should be undistorted. Having got this far, disconnect the electronics and start work on the cabinets.

The last task is to drill out the recess plates and mount the switch and input sockets. Once this is done attention can be turned to the cabinet.

Cabinet

The first essential of successful cabinet design is to get the pieces cut accurately. There is nothing worse than having to plane down panels, except perhaps trying to plug gaps! The answer to this problem is simple. Find a reliable timber merchant. It's well worth the price of a pint to ensure you get what you're paying for.

Assuming your panels are OK lay them out and mark them up on the inside surface with side, top etc.

It's surprising how easy it is to get confused if this

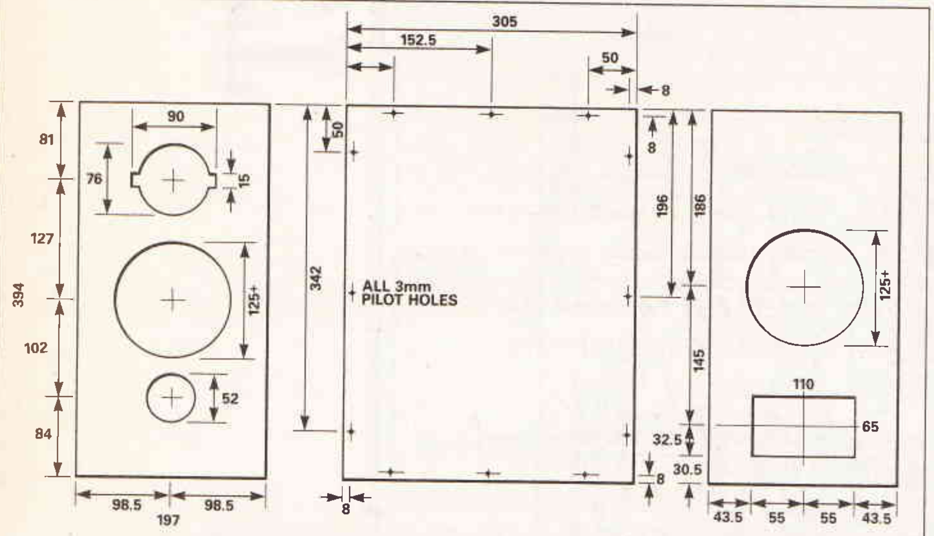
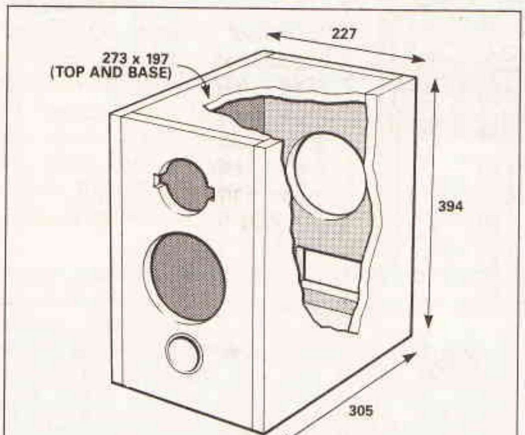


Fig.8a Speaker cabinet dimensional details



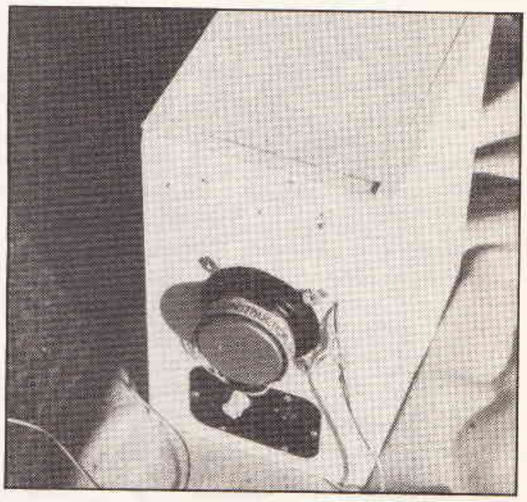
b Complete enclosure

isn't done. It will also allow you to select panels so that the smooth edges point outward not inward! I have specified medium density 15mm thick shelving board for this project. There is no objection to selecting high density thicker boards but under no circumstances choose a thinner material. The dimensions will also have to be changed to maintain the required volume. The 15mm board is quite adequate for the task at hand especially as no high internal pressures are generated. Another advantage is that this board is available with several decorative finishes which saves work later.

Fig 8a shows the cutting detail of the panels. Start by cutting the mounting hole for the B110 in the rear panel. A template as well as the T screws are supplied with the speakers. Having cut the hole, drill a ⅜" (10mm) hole near the edge to take the connecting wire. Mount the speaker with the hardware provided. Note that the speaker mounts with the magnet outwards, ie, in reverse. Mount the speaker from the inside of the enclosure tigtening the frame down to the panel. Don't forget the gasket! While you're at it cut out the mounting hole for the recess plate and mount this with self tapping screws. Put this panel aside.

The rest of the cabinet can now be constructed. The prototypes were glued and screwed together. The cabinet has been so designed that the panels are self supporting without the need for battens. Smear glue across the appropriate edges of the panels and bring these together allowing to dry.

Readers of my previous articles will know that I prefer 'Thixofix' contact adhesive for this job. The glue is applied to both surfaces, left for 15mins to cure then brought together. They can be slid into the desired position. Firm pressure will then stick them permanently together. A substantial number of screws



(48) are used to fix the panels together. Mark out the screw positions and drill an ⅛" (3mm) pilot hole. Countersink these to take the screws. To avoid blisters it is as well to invest in a set of screwdriver bits to fit your drill. This makes the screwing a 20 minute task! Having screwed the panels together the mounting holes for the other two drivers can be cut. The front B110 is mounted in the same way as the rear except that it is pointing in the correct direction! The tweeter is mounted with four ½ inch (12mm) No 8 self tapping round head screws. Cut the mounting hole for, and mount, the vent.

Pick up your soldering iron again and make the connections between the drivers and PCB. Note that the front woofer and tweeter are connected in phase whilst the rear woofer is connected in parallel with the front one but antiphase. Failure to invert phase between them will result in no bass output.

Damping is necessary to prevent excessive cabinet vibration and resultant coloration. This is achieved by applying two damping pads to the interior of the side panels. These are self adhesive. Simply remove the backing paper and press them into position.

Finally screw the rear panel into position and seal the cabinet joins. This is best done by mixing some filler and smoothing it along and into the joins between the panels. Wipe off any excess with a damp cloth. Ensure that you go all the way round as this procedure will completely seal the cabinet against unwanted air leaks.

All that remains is to hook your new speakers into position and enjoy the rewards of your efforts! Good listening.

PROJECT

PARTS LIST

COMPONENT LIST FOR ONE ENCLOSURE

RESISTORS (all 1% metal oxide)

R1,2	47k
R3,10,12,15,18	4k7
R4,5	200k
R6	16k
R7,24,25	10k
R8,13,14,16,17,19	18k
R9,11	33k
R20,22	39k
R21,23	180k
RV2,3	2k2 preset
RV1	22k Lin pot

CAPACITORS

C1,18,19	10µ/16V
C2,3	22n/1% polystyrene
C4,6	4n7 polystyrene, 1%
C5,7,8,9,10,11	2n2 polystyrene, 1%
C13,14	2n2 Ceramic
C15	1n ceramic
C16,17	4700µ/16V

SEMICONDUCTORS

IC1,2,3,4	TL072
IC5	78L12
IC6	79L12
Q1,3	BDV65
Q2,4	BDV66
Q5,6	BC109
BR1	100PIV, 2A BRIDGE

MISCELANEOUS

12-0-12VAC SEC, 240V PRI Mains transformer
Transistor mounting kits
Heatsink
S1 Single pole switch
Recess dish
4mm sockets
KEF B110, SP1003
AUDAX Tint tweeter
2" Diam tube for vent
PCB

BUYLINES

Remember, you will need to double everything in the Parts List for a pair.

A full designer approved kit which contains everything bar the wood panels for a stereo pair of flatmates is available from 'BEWBUSH AUDIO', 47b ELMER ROAD, BOGNOR REGIS, SUSSEX PO22 6DZ. The price is £299.00 +£7 p&p. Order as FL1 kit. A kit of electronics and hardware only is available for £129.00 +£3 p&p as FLE2 kit.

Drivers can be obtained from 'WILMSLOW AUDIO' who advertise in this magazine.

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10¾" by 7¾" (273 by 197mm)	4
1¼", No 6 countersink head screws	48
2" PVC drainpipe for vent	2

OOPS!

Virtuoso Power Amplifier (November 1989)
In the circuit diagram: the base of Q49 should go to R46, and not R47. Bases of Q45, 43 should be connected. R44 should be 220k.

Low Voltage Alarm (January 1990)
Resistor R1, shown in the circuit diagram as 1k0, should be 4k7 as in the Parts List. Pins 9 & 11 of IC1 on the PCB should be linked. This is incorporated in PCBs from the ETI PCB Service.

Motorcycle Intercom (January 1990)
On the circuit diagram, R2 and R6 should be 100k, not 100R. Pins 1 & 5 of IC1 should not be connected to earth. Pin 2 should be connected directly to the junction of R2 & 3 — not to earth too. Capacitor C10 should be an electrolytic with positive uppermost. Junction of R39 & 20 should be labelled ½Vcc. All references to 0V5 should read ½Vcc. On the PCB overlay, R2 and R6 should be transposed. Similarly, R8 & 9 should be transposed.

Digital frequency meter (November 1989)
Regarding Fig. 3. The line from pin 1 of IC1 to pin 2 of IC8 should connect to the Latch/Enable Stobe common line. It is shown crossing.

Fig. 4. The wirelink from IC13 pin 1 to the Latch/Strobe common line for IC's 7-10 is not shown on component overlay. A wire link should be inserted.

If built as shown, IC's 7-10 are held permanently latched and no digits are passed from counters. The display will be a random set of static digits.

Output 7 of IC 15 drives both Q5 and IC12a via D8. If output 7 does not reach a valid high level then the display is not enabled showing a zero with no input. To cure this drive Q5 from output 8 (pin 9) of IC 15. Base resistors of Q5-12 (R's 41-48) may be adjusted to provide sufficient drive depending on the gain of the transistors used. They may be reduced to about 3k3 if necessary.

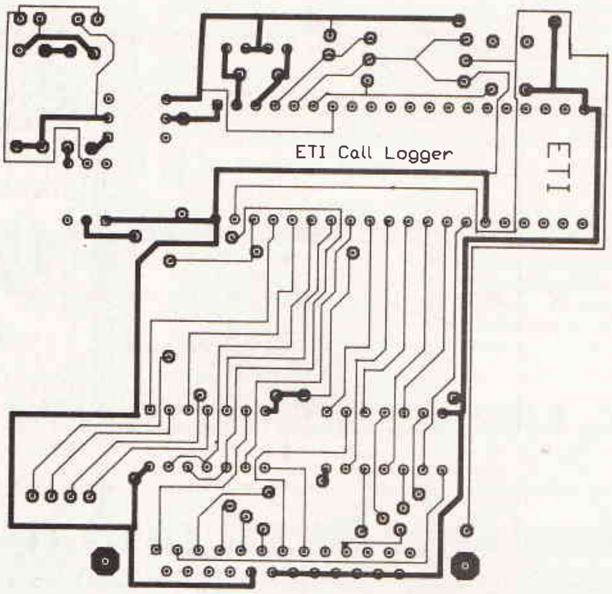
Eprom Emulator (February 1990)
Under the construction heading, the bracket should include and read: so for example the $0000 -$1FFF and $8000-$9FFF blocks are an illegal pair. The 18th line should read: If you are thinking of using non adjacent blocks. Fig. 5. shows a label LK9, it should be LK3.

Oscilloscope (February 1990)
Fig. 3. does not show the polarity of diodes D105,6. The cathodes point up the page. Diode D304 is a 1N4148. Capacitors in the deflection amplifiers parts list are incorrectly numbered and should be C205,206,213 and not C105, 106, 113.

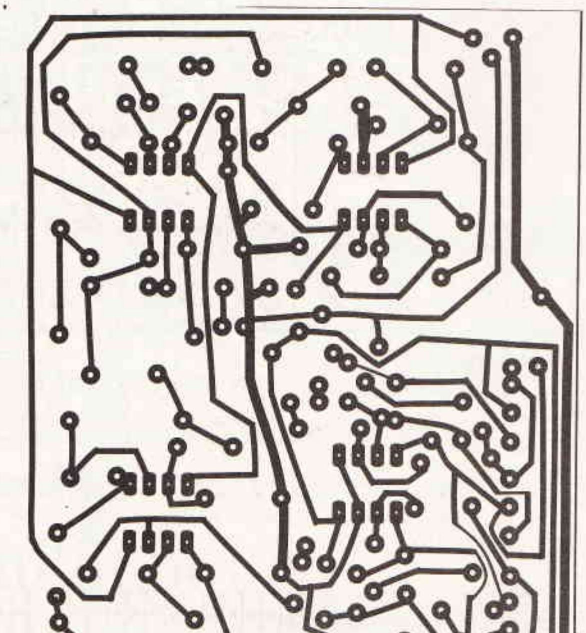
Text refers to inductors L203, 204; these should be L201, 202. Inductors L101,102,201,202 are wound on 100k 0.5W resistors. The value of R201 should be 820R. The PCB track connecting RV301 to R313 should be extended to the pad of link 17. The foil on page 60, for the motherboard is at 95% of full scale. Approximate test voltages for power supply are: Junction of C102/R101, +220V; Positive HT to drivers, +150V; Anode of D107, −450V.

Navigate (April 1990)
Fig. 1a Maximum/minimum signal captions should be reversed.

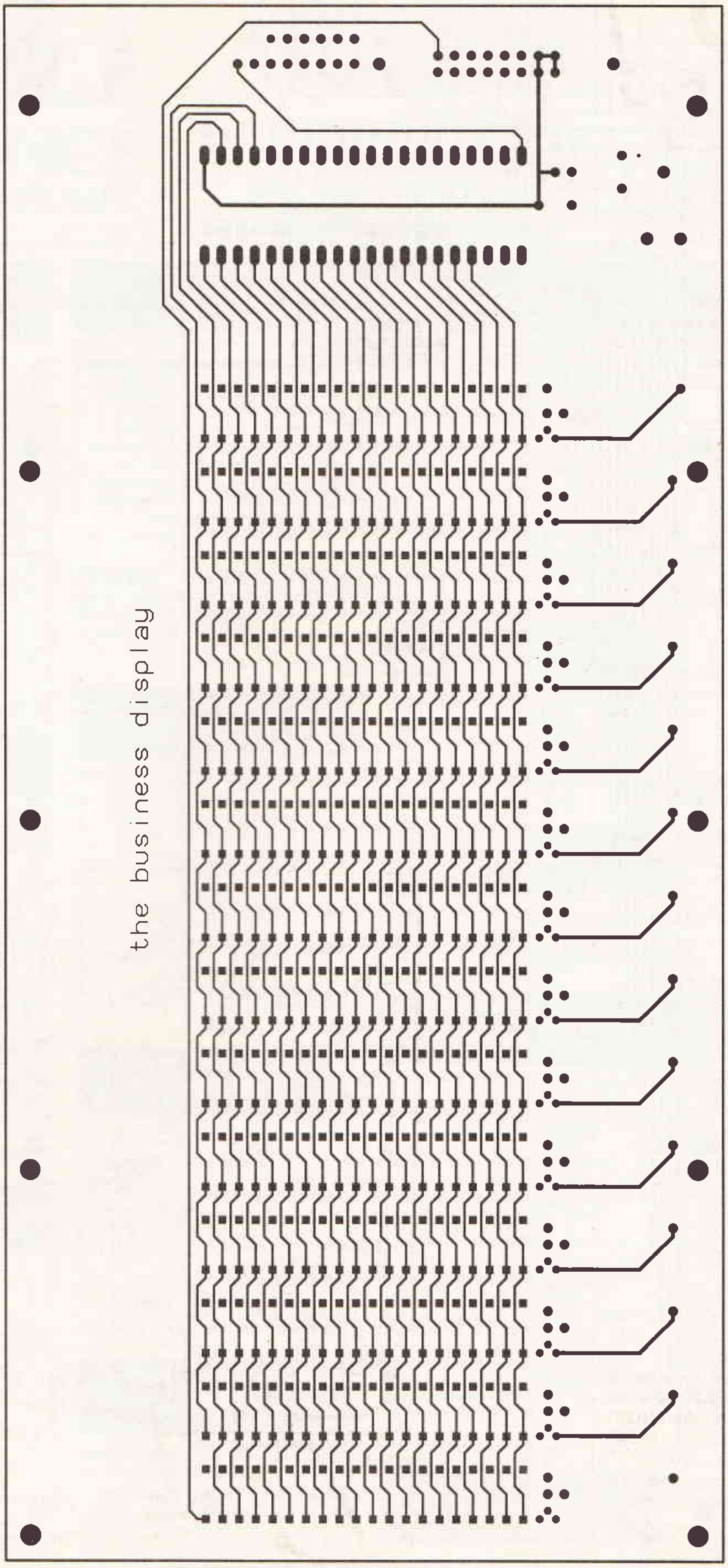
PCB FOIL PATTERNS



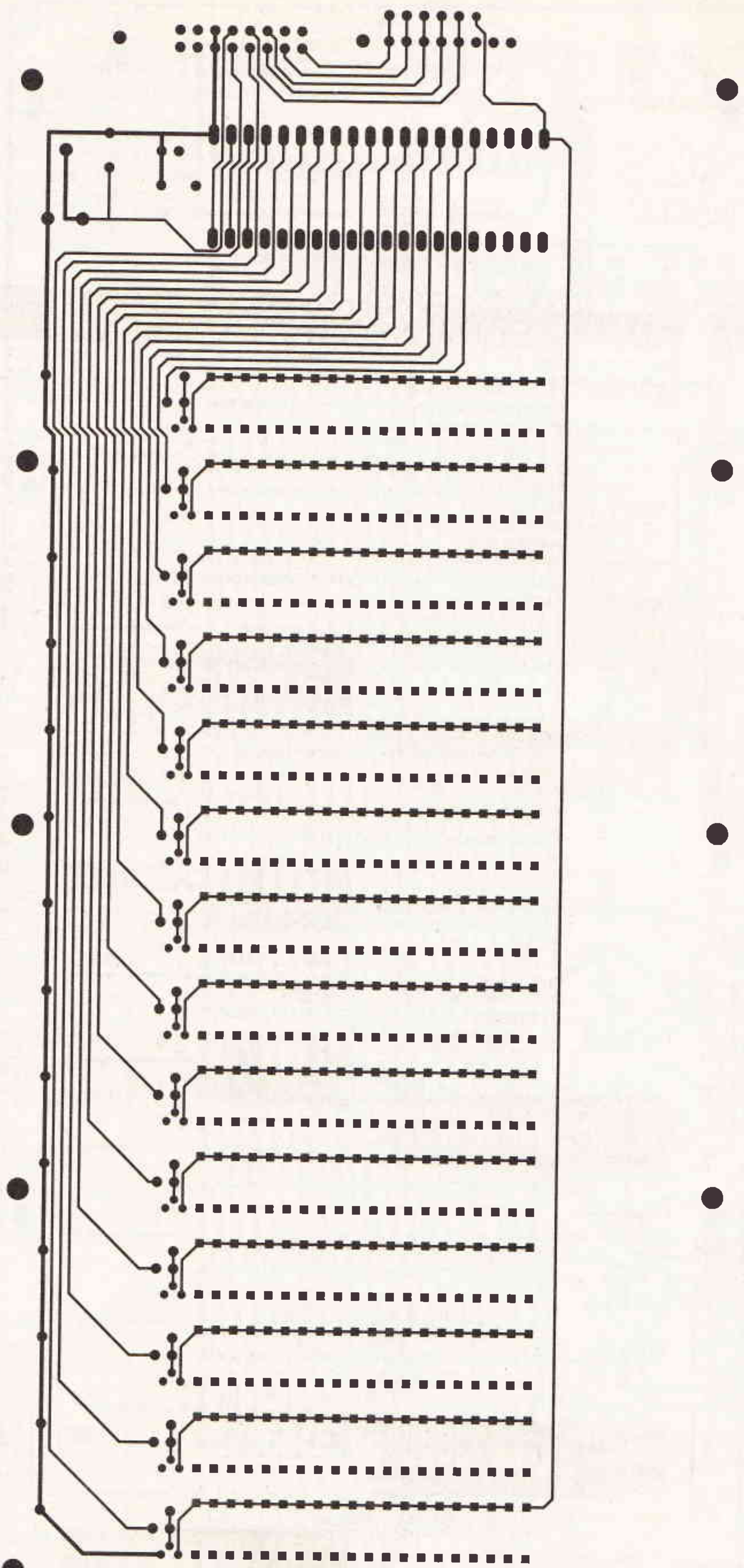
Phone lock and call logger foil



The Flatmate PCB foil



The Business Display Copperside foil



The Business Display Topside foil

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Dual power leads (BBC Micro to 2 Disk Drives) ...... £4.00 each
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EPROMS ...... 27C128-25 £2.50 each 27C256-25 £3.50 each
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6264 8K Byte SRAM ...... −15 £3.00 each −12 £3.80 each
65256 32K Byte rams ...... £7.00 each
8K Byte NV ram chips ...... £3.00 each £10.00 four
20-pin dil low profile IC sockets ...... £0.50 /10 £4.00 /100
40-pin dil low profile IC sockets ...... £0.60 /10 £5.00 /100
Keyboard, 100 keys on board, LCD & micro i/f ...... £8.00 each
Toroidal mains transformer, 12V 4A & 0.4A, 12-0-12 1A & 2A, 9-0-9 2A ...... £4.00 /1 £6.00 /2 £8.00 /3
*Video Tapes, E180 VHS ...... £2.50 each
*Smoke detectors, small size ...... £7.00 each
*Smoke detectors, large with escape light and pause feature ...... £13.00 each

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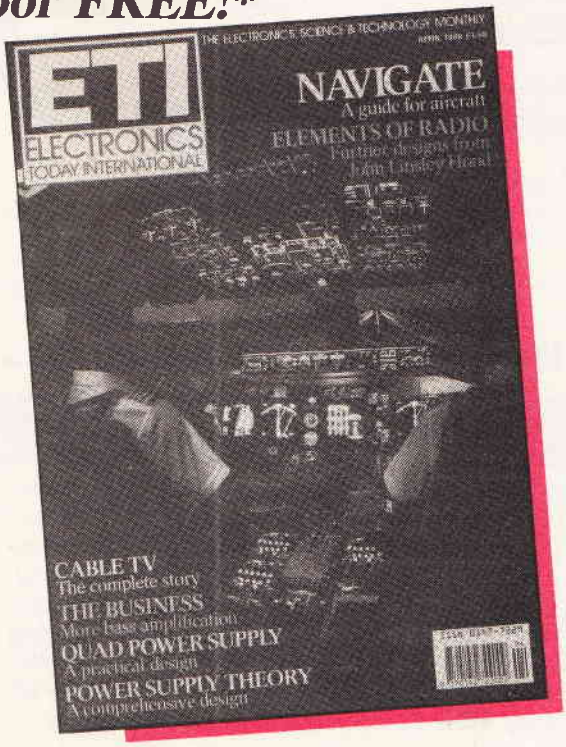

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NEXT MONTH

In our Audio supplement next month, we review a budget 12-channel professional mixer, there's a project called the Fecko box which gives some interesting fuzz and echo effects from a simple circuit and the latest in 'yuppie' status symbols. Yes if you're worried about in-car noise spoiling your enjoyment of your favourite CD's, we've a feature on active noise cancellation for the car industry.

Nikola Tesla was an extraordinary man. In recent years, the world has begun to wake up to the fact that Tesla was not only a genius but a clever inventor, in fact some would say even a magician. Even today some of his ideas from a century ago are now being re-investigated. We present a feature on this remarkable man and give details of his most celebrated machine, the high frequency, high voltage coil now called the Tesla Coil.

Another feature in the June issue is the history of the telephone and its operation, together with an idea for a DIY telephone and a mini project for an extension bell.

Other projects include a photographic timer and a surveillance bug detector. So there's every excuse not to miss the June issue of ETI, the quality tech mag.

Your newsagent will be able to supply you as from May 6th.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

In the oh-so-tempting April issue, how dare you not to have bought it, you missed so many good features. We saw the second part of the Business bass amp, that unique amplifier with its own microprocessor for remembering each little ambiance of tonal quality. We featured articles on radio beacons for flight path navigation, the story of Cable television part 1 and power supply design theory with a natty little project with four power supplies all rolled in one. We also carried some useful information on how to patent your idea outside this country and John Linsley Hood continued his series on Elements of Radio. A limited number of back copies are available from our usual dept: Select Subscriptions (address in contents page).

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