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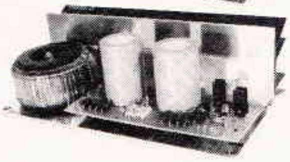

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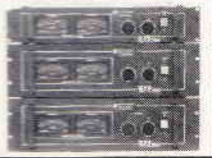

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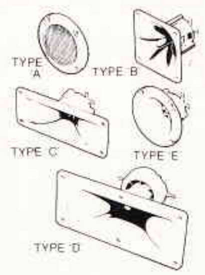

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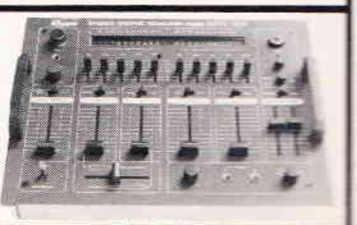

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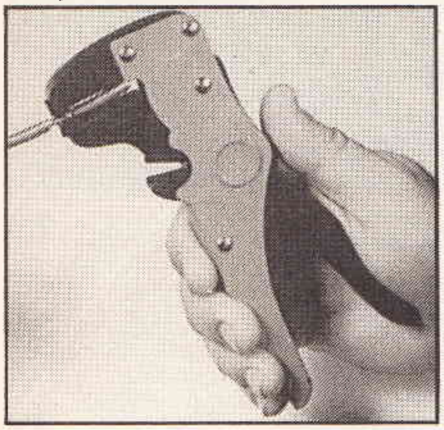

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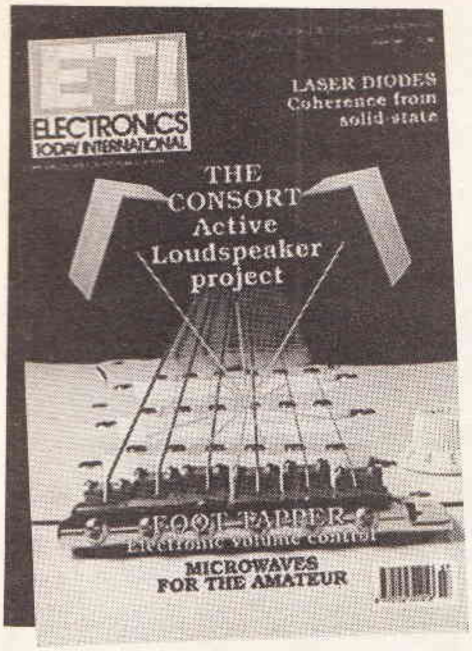

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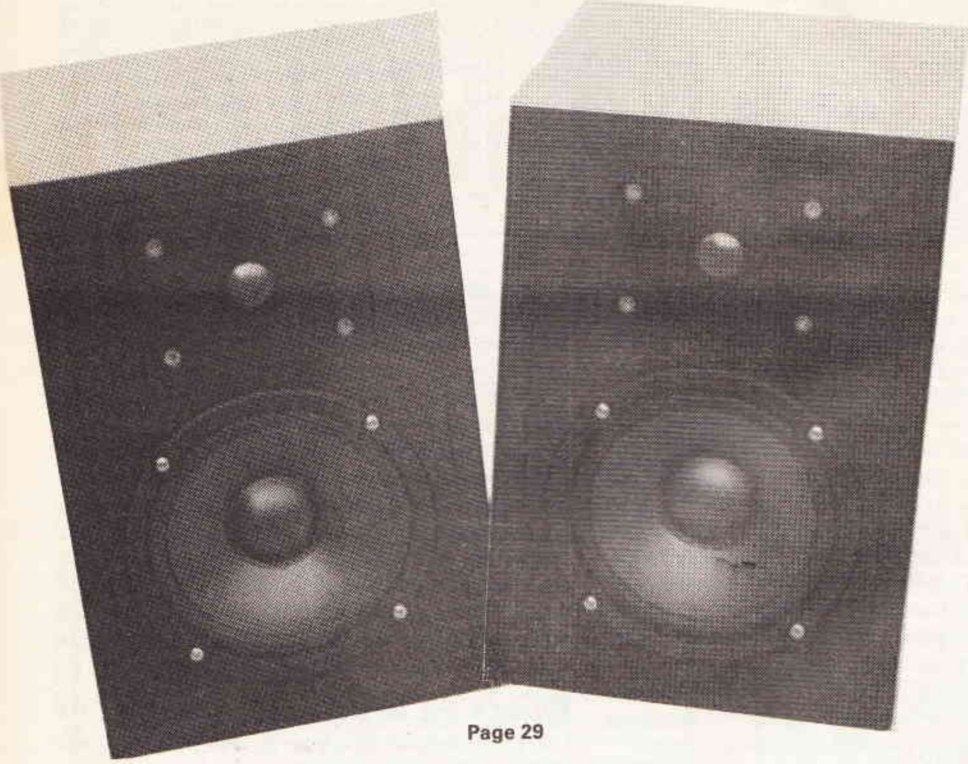

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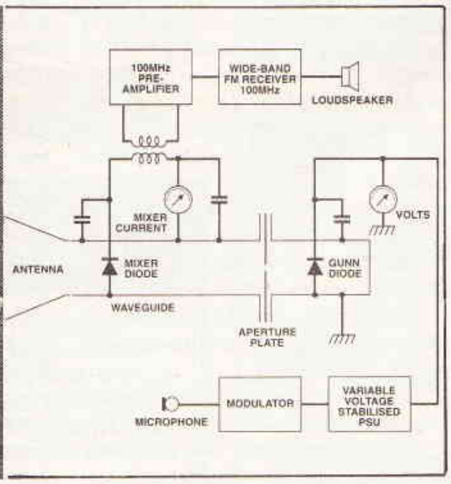

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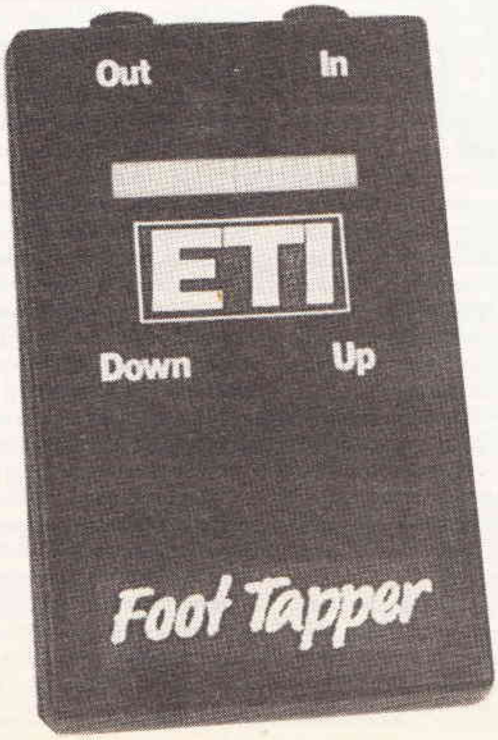

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Editorial

Firstly, I would like to thank you all for returning our reader survey. They will be a great help for future planning of the magazine. However, there is still time to get the last of them in and you could still win one of the fifty prizes on offer. As we have stated before, ETI is a test bed for ideas and experimentation. A large proportion of the projects we present throughout these pages are prototypes and are open to development. Construction and modification of our projects is encouraged and we of course will publish improvements and updates if the need arises.

Popularity

One of the prime objectives of the magazine is to present a gadget, gizmo or project, call it what you will, that is not currently commercially available. The appeal is enormous. Apart from the tremendous satisfaction of creating something new, the psychological aspect also has the 'Jones effect' to answer for. With gleaming pride, you demonstrate the wonder machine to others who can only gawk at in puzzled amazement when invited around for coffee.

All to often, the back-room boffins have built a prototype on the kitchen table years ago but have only regarded the beast as another experiment in the scheme of things that slowly gathers dust in the corner and continues to suffer increasing abuse from those that clean the houshold as to what it should be doing there. The notion that it might be appealing to others does not generally enter the mind of the creator let alone the possibility of industrial adoption to become a successful consumer product. That is where a magazine like ETI can be the springboard for bringing your wonder-box to the attention of all those who read it, including those in industry and education in the UK and overseas.

Paul Freeman.

OPEN CHANNEL

It's not often I focus my attention on computers and computing, but I'm going to this month. There's a number of reasons for this; all of them tied in with recent happenings in the field. I even reported on one of these happening last month — the current definition of Unicode, which is a 16-bit computer and communications code to replace ASCII.

Unicode, in itself, is no big deal. Its been accepted long enough by computer manufacturers and users that 8-bit ASCII isn't really good enough for modern day computers. Computers have to effectively look at each 8-bit word sequentially. Eight bits limit the numbers of different characters to a maximum of just 256, too. These factors have been barriers against large scale procedural developments in computing for a while. Unicode though, jumps through both barriers simultaneously, and consequently lays the way open for great changes in the ways computers function.

Currently, IBM dominates the computer marketplace with its personal computers with around 60% of total sales. Its interpretation of Microsoft's MS-DOS disk operating system (IBM calls its version PC-DOS) has been both a help and a hindrance to other manufacturers. With only one exception to the rule (I'll talk about the exception soon), computers generally have to be IBM-compatible for users to even consider buying. This is a pity because, while MS-DOS (and its derivatives) was a good operating system in its day, it now only holds back computers in its largely archaic manner and style. MS-DOS effectively limits a computer's performance in its dogged approach to file handling. There have been changes and upgrades but nothing to write home about.

However, computer procedural developments will be speeded up and enhanced over the next few years with first, reduced instruction set computer (RISC) architectures and second, transporter architectures. A group of companies has been formed recently to define a new range of computers using RISC microprocessors. The group's aim is to challenge IBM head on, with a completely new style of computer.

This has been attempted a few times before of course, with only one successful computer (the exception to the IBM-compatibility rule I mentioned earlier) — the Apple Macintosh. The Mac uses a totally different idea of operation known as the graphical user interface, in which users move around files and discs by pointing to on-screen icons. Its ease and efficiency of operation is reflected in the fact Apple has the second largest stake in the computer marketplace — some 10% of business sales, although much less than this in other areas such as home and education.

This stake is still small fish when compared with IBM's. It's probably true that IBM has more-or-less defined its own market share simply by allowing other manufacturers to produce IBM-compatible clones. The more clones there are, the more acceptable IBM-compatibility appears to users, so the more IBM computers are sold.

Apple has consistently chosen to shun this route; never in the machine's seven year history have Mac-clones been made. This has cost Apple a greater market share (and denied 95% of computer users a decent user interface for seven years). Apple computers have traditionally been quite expensive, too.

Microsoft (the originator of the MS-DOS operating system) has recently developed Windows 3, a partially successful attempt to emulate a graphical user interface on IBM and compatible computers. Windows 3 is currently the fastest selling software of all time, so it doesn't take a genius to realise that Apple's original decision not to allow Mac-clones was a mistake. Users want the Mac's type of user interface.

Interestingly, rumours abound that Apple has realised this and is about to licence its technology to other manufacturers, hence allowing clones to be made. Recently introduced low-cost Macs support these rumours, and will inevitably push up Apple's share in education, home areas and business.

What's on the Box?

Use of satellites to broadcast programmes direct-to-home via dishes and receivers opens up a vexed question regarding programme quality. Before Sky started transmitting its channels from the Astra satellite a couple of years ago there were only the four terrestrial channels to worry about. All sports events, films and general entertainment programmes were shared between them in a largely haphazard way.

Satellite television broadcasters are keen to develop their programme quality and content to compete and in many cases, beat the terrestrials channels. This is easily seen in the various sports channels (there are now three broadcast in English from Astra) and the variety of sports they now cover. Where traditionally cricket test matches, golf championships, boxing fights, tennis (specifically Wimbledon) and so on were all covered by terrestrial channels for just the price of the television licence, they can be seen one by one being bought up by the satellite channels. Sports fans need to ask themselves whether terrestrial television is supplying a valuable service at all.

Sky's two film channels show all new movies only a year or so after cinema release. Compare this with the terrestrial channels' wait of over five years or so, and any film buff has a valid reason to ditch terrestrial television. Sky News transmits 24 hours a day. While terrestrial news coverage is equal to content and quality, Sky News has the advantage in availability.

Where satellite television currently loses out to terrestrial, is in general entertainment. There are arguably too many transmissions of old American serials and too few home-generated quality drama and documentary programmes, but that will change as more revenue is recouped giving a kitty from which new programmes can be financed.

Satellite television is off to a fair start and is arguably the equal of terrestrial television. As more and more viewers realise programmes they want to watch are being snapped up by satellite channels and no longer available on the ground, sales of satellite television receivers and dishes could take off in a big way.

Terrestrial broadcasters need now to sit down and consider their options. If they are to provide a continuing service which people want, they must decide what their strengths are and consolidate them accordingly. If this job is left too late, few viewers will want what remains on offer.

Keith Brindley

READ\WRITE

ETI LETTERS

RIAA Track Record

Regarding M· Silvester's article on the RIAA curve, it was not clear (at least to me) why the curve was needed. The article implies that it is used to compensate for the characteristics of the listeners magnetic cartridge. Its primary purpose, however, is to compensate for the equalization used in making a record.

Perhaps, some additional explanation will help clarify the situation. When a record is made, there is a reference point called the turn-over frequency. During the cutting process, the method used to record frequencies above and below this point is different.

Below the turn-over frequency, records are made in a mode called constant amplitude. In this case, the amplitude refers to the movement of the cutting stylus. If the recording system was not equalized, then the amplitude of the cutter head would increase as the frequency decreases. At very low frequencies, the grooves would use up a large portion of the disk.

Records, of course, are made by having a specific number of grooves per inch of space. This restriction limits the amplitude that the cutting stylus can move. To restrict the cutters amplitude, the electrical input must decrease as the frequency is decreased The rate of change is 6dB/octave, and at 20Hz the amplitude will be -20dB.

As shown in Figure 2b of Mr Silvester's article, when the mechanical motion of the cutter is held constant, the played back signal from a magnetic cartridge will be frequency dependent. As the frequency changes, its output will also change by 6dB per octave.

For sound reproduction, the audio system must have a flat frequency response. This is obtained with the RIAA curve. Below the turn-over frequency it has a characteristic that is opposite to the one used in making the record. As shown in the article (Figure 4), at low frequencies the curve provides an amplitude increase of 20dB. As the frequency of the input signal increases toward the turn-over point (1kHz) the amplitude decreases.

When the recorded frequencies are greater than the turn- over point, the method is changed to a technique called constant velocity. In a recording system that has not been equalized, the amplitude decreases with increasing frequency. During play back, this characteristic will also cause the output from a magnetic cartridge to decrease. At 20kHz, for instance, the output of this cartridge maybe equal to or less than the record noise.

To overcome this problem, the frequencies above the turn-over point are increased in amplitude by 6dB/octave. Again as indicated in Figure 4, the RIAA compensates for this condition. At 20kHz, the amplitude is decreased by 20dB.

The RIAA curve is opposite to the one used during the recording process, and the result is a system with flat frequency response.

The above conditions are ideal. While recording companies adhere to their curve, there is no guarantee that equipment manufacturers do the same. Not only should a listeners sound system be checked to determine if it follows the RIAA curve, but also to find out if the left and right channel are matched. Any differences will alter the stereo effect.

While an oscillator and an audio voltmeter can be used to for this purpose, this technique is very time consuming. A better method is to use a simulator that duplicates the recording method. When this device is connected to the phono input of a stereo system, the user can monitor the preamps output. Any deviation from flat response is due to a problem with the circuit that provides the RIAA curve.

Ronald Wagner,Fremont, California.

Laser Transformers

With reference to Kevin Kirks article on Lasers in the May issue. I have considerable recent experience in designing switching power supplies for lasers both for use with 12V supplies and also direct from mains supplies, in the range from 1/2mW to 5mW tubes.

There does not seem to be any gapping of the transformer cores in the design given. I have found that with flyback switchers from the 12V supply that some gap is advisable to avoid core saturation. Whilst one may get away without gap for the mW tube, it was necessary for 1-5mW and therefore I used a standard gap for all sizes. This also results in more constant primary inductance. Also convention dictates that start-finish symbols be used on the transformer diagram. Whilst it may not matter in some circuits depending on the drive, it does help the coil winders to get it right every time. If any readers have problems with the transformer, I can offer limited quantity production together with professional impregnation, and the care necessary to locate secondary start and finish lead to avoid arcing. I trust the above comments are acceptable.

Norman E Peart,Oldham.

Anybody interested in the service should send requests via ETI Editorial.

Radio Controlled Falcons

I shall be much obliged if it is possible, easily, to let me know if you have given a project in ETI of a tracking set up, for example, a transmitter on the tail of a falcon as an instance to locate it — or the creature so equipped — with a direction finding receiver, if it has strayed from sight.

Alternatively you may be able to suggest some other course of enquiry I can follow.

S Head, Bury St Edmunds.

An interesting one this. ETI does not have a great track record on transmitter projects for the simple reason that although we might publish a design, it has been illegal to operate it without a licence. As you see, some might ask: Why publish a project that cannot be used?

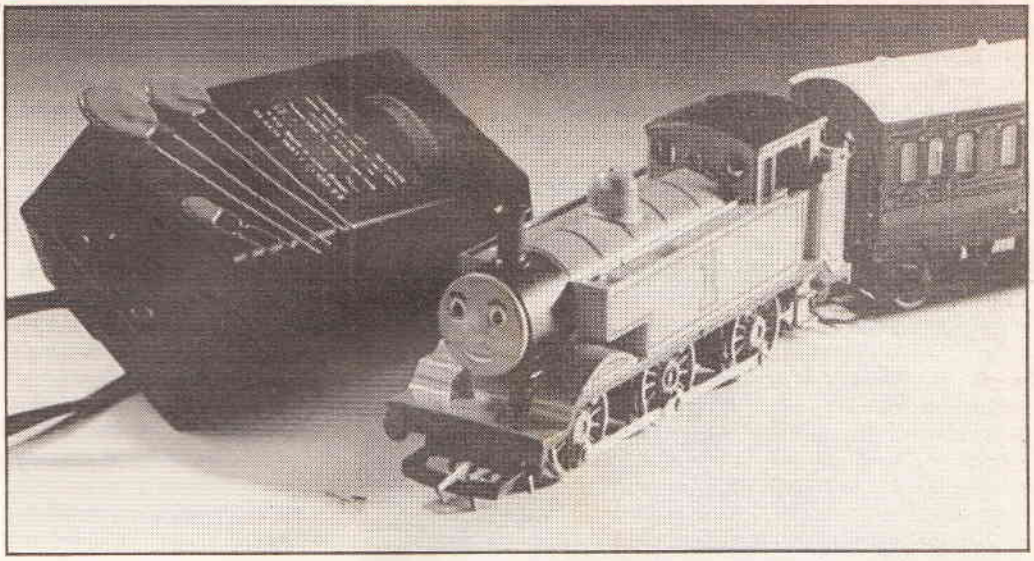
However, even though ETI has recently presented some transmitter designs connected with the world of surveillance they might still be too cumbersome for a poor bird to carry around all the time. The main shortcomings of many constructions are of weight and operating life. What is required is a surface mount design which produces minimal size and low power consumption with a clever antenna system using, say, the wings as a dipole. A very sensitive base receiver could be used for tracking. Better still, if a passive system similar to ground-based RADAR for detecting flying objects could be adopted at the bird end, then you can happily say good-bye to power supply problems. Other alternatives are Falcon wing powered generators to run the transmitter so the bird does all the work.

Interestingly enough, with a moving transmitter one could possibly detect speed and direction using the Doppler effect and with two base stations one could obtain positional information.

Well there we are dear readers, the seed has be sown, the guantlet has been thrown down, the ballon is up, the bird has flown and its over to you for an ETI Innovation of the year award. — Ed

ETI NEWS

CIRCUIT PROTECTOR



Raychem's Polyswitch circuit protectors are being used in transformers accompanying Hornby train sets and Scalextric sets.

The PTC (positive temperature coefficient) devices have been installed in all train set transformers by Margate-based Hornby Hobbies Ltd. for almost two years. Recently, they have also been incorporated into Scalextric transformers.

Hornby deputy engineering manager Mike Walters said the company had always used a variety of circuit protection devices in its units, but they changed over to PTC devices because of their minimal heat generation and compact nature.

These self-resettable devices are the fastest PTC thermistors available today. They undergo a large, abrupt change in resistance when an overcurrent or high temperature heat them above a specific point.

When tripped, the devices limit the current to a very low value thereby protecting the equipment against any damaging overheating.

The key to the design of the Polyswitch range is the lack of moving parts, which removes the possibility of malfunction through physical factors. The devices can be used in a variety of locations besides transformers, including battery-operated toys, personal computers, fax machines, electric motors, telephones and audio speakers.

ROYAL INSTITUTION HOST FUEL CELL SYMPOSIUM

International interest in fuel cell technology will be boosted again this September.

The Second Grove Fuel Cell Symposium is to be held at the Royal Institution, London during 24-27 September 1991. It's theme, on the commercial application of fuel cells, has already attracted worldwide interest.

In addition to researchers already engaged in fuel cell technology the Symposium will be of particular importance to those involved with advanced energy systems and energy and environmental policy making. Progress will be reviewed in the development and commercialisation of fuel cell systems and their applications, including power generation through transport and to speciality markets.

The first Sir William Grove Memorial Medal (made from platinum) will be presented to Dr Francis Bacon for his pioneering work in modern fuel cell technology.

Said Gary Acres, Chairman of the Symposium Steering Committee, 'With energy costs now going through the roof the fuel cell is coming into its own, especially as it is suitable for both power generation and vehicles with the added benefit of being virtually pollution free.'

William Grove invented the concept of the fuel cell in 1839 but it was the work of Francis 'Tom' Bacon, the Oxford graduate engineer who conceived the first hydrogen powered fuel cell. Fuel cells of the type designed by Bacon are still in use today, providing the power on board the space shuttle.

Fuel cells, involving direct chemical conversion of their fuel to electrical energy are more efficient and are the perfect power source for vehicles, being clean, silent and compact.

Although the fuel cell was conceived in the UK, nearly all the development work has been made within the US, with the greatest strides towards commercial exploitation ocurring in Japan.It is projected that fuel cells will hold a substantial share of energy markets within the next two decades, replacing some of the existing major power stations.

OPEN DAY AT MARTLESHAM

Demonstrations of global networking, videophones and satellite telephony along with optical fibres to carry more than 50 million calls are among a host of items in a display of leading edge technology unveiled by BT this week.

Developments such as intelligent networks, which will present customers with a mix of services and detect faults before they affect calls, are among 65 BT projects to be demonstrated at the company's 'Innovation 91' exhibition at the BT laboratories at Martlesham Heath near Ipswich.

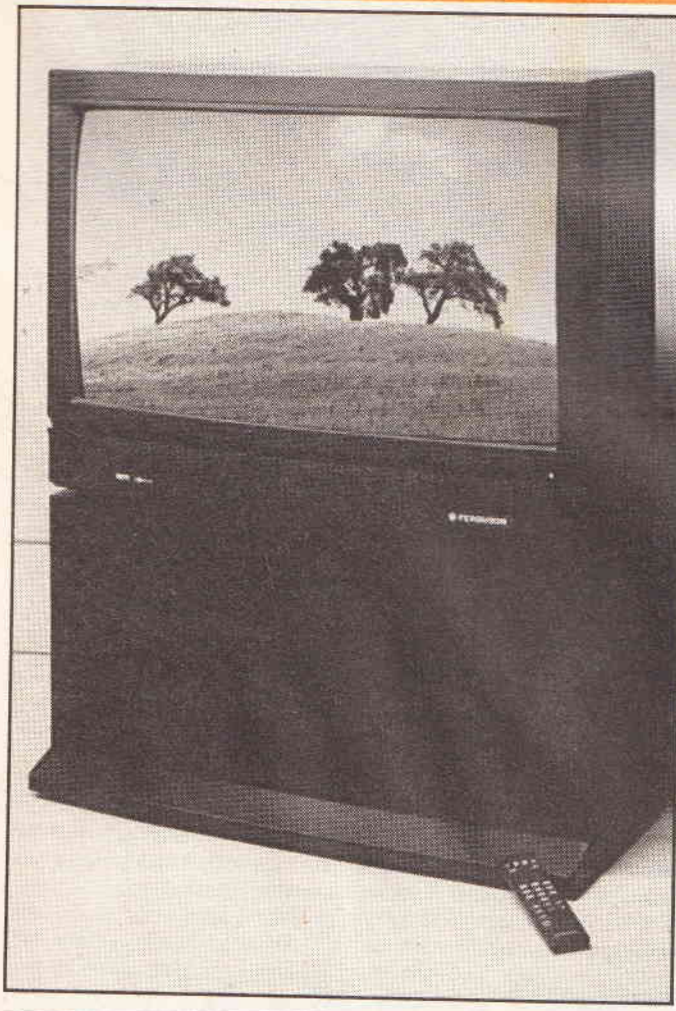
Timed to coincide with the launch of the new BT, the exhibition was designed to give customers a taste of the range of BT's technology and resources.

The projects demonstrated are among more than 1200 currently underway in BT's Development and Procurement division. The displays are organised around five themes:

- total mobility and freedom: new ways of keeping in touch on the move
- living in the 21st century: technology to make life easier
- doing business in tomorrow's world
- connecting the future: the network infrastructure that will support worldwide communications into the next century exerting the power of IT, through the computing systems that enable BT to provide new levels of customer service.

BT spends about 2% of its revenue on research and development. The direction of expenditure is moving away from components and materials to concentrate on systems, with software engineering now making up 50% of BT's activities.

FERGUSON TO LAUNCH UK'S FIRST WIDE-SCREEN TELEVISION



Ferguson, the manufacturer of TVs and video recorders to the UK market, is launching the country's first widescreen consumer television, capable of displaying programmes in 16:9 format (16:9 width to height aspect ratio, as opposed to the 4:3 aspect ratio of current televisions). The new set (A86W), also represents a milestone in TV technology as it features a high-scan (1250 line High Definition Television compatible) chassis that gives improved picture and sound performance. Whilst the new television is compatible with existing TV broadcasting it has been designed for the future and has the latest developments towards High Definition TV.

When receiving a signal in 16:9 format the new set automatically recognises the nature of the signal and displays the full picture. However the A86W also brings new dimensions to a 4:3 signal. Viewers will no longer have to watch widescreen films with either the sides cut off (when editing big screen films for broadcast to fit 4:3 screen ratio TV's, the side edges of the picture are often lost) or with a black band at the top and bottom of the picture. Widescreen films are viewed full picture, full screen, and the set also allows the viewer to 'zoom up' 4:3 images to occupy the entire width of the screen. Alternatively, the A86W allows the viewer to display a 4:3 signal fully in the centre of the screen between two lateral black bands, or place the image to the left of the screen, with the vertical strip on the right being used to display three pictures from other channels – referred to as POP (Picture Outside Picture). Another feature also enables viewers to create PIP (Picture In Picture) images on the screen, when monitoring other channels. PIP and POP pictures can be used to display any source material, whether it be from the built-in satellite tuner channels or input from a VCR.

The A86W is a NICAM set with 2 x 70 watts audio and surround sound capability, Fastext, built-in satellite receiver, and remote control.

According to Ferguson Director and General Manager, Alan McWalter the new model, which will retail at around £3500, is the first of a range of 16:9 products to be marketed by Ferguson and will be available in smaller sizes. "The A86W's price is only about 30% higher than existing top-of-the-range conventional 4:3 giant screen (80cm diagonal) televisions offered by certain competitors," stressed Mr McWalter.

Mr McWalter also predicted the 16:9 format will grow dramatically in the future, replacing the existing 4:3 format, and by the year 2000, more than half the TVs sold in the world will be 16:9 format products.

The 16:9 aspect ratio, which is that of most 35mm films, has been accepted by the CCIR as an international standard and decreed the 'TV format of the future'.

TELEPHONE LINKS TO KUWAIT

BT has become the first company worldwide to restore international direct dialled telephone links to and from Kuwait since the invasion in August, 1990.

BT has erected an earth station in Kuwait City that offers Kuwait a limited telephone service with the rest of the world, via the UK.

Mike Read, BT's Director of International Networks said: "We are delighted to be the first company to reconnect Kuwait with the rest of the world.

A BT spokesman said: "This is the only generally available international service to Kuwait and it is in high demand. If customers experience difficulty they should contact the international operator on 155."

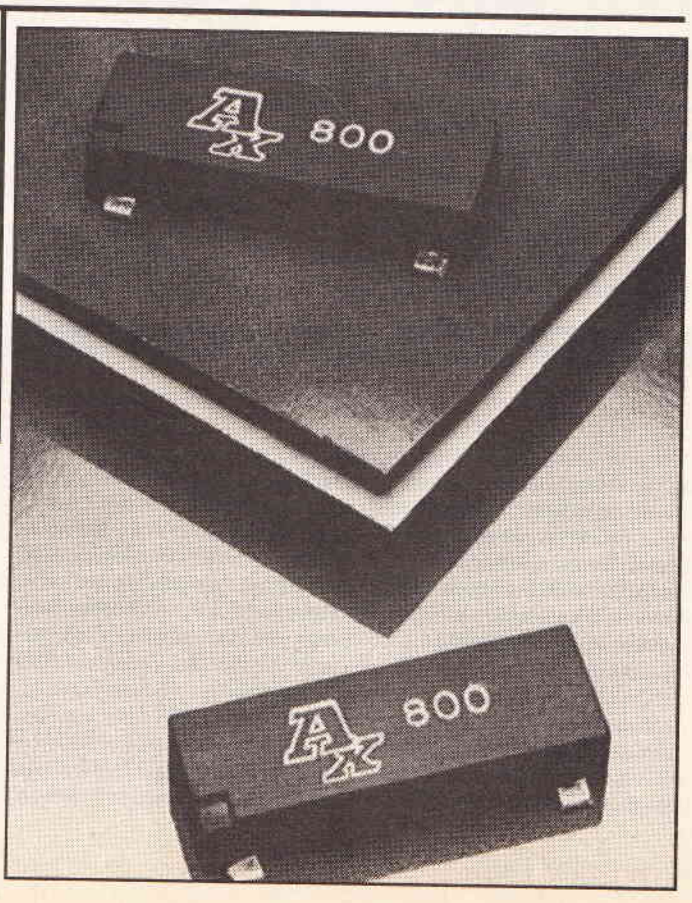
SURFACE-MOUNT RELAYS

The 800 Series low profile DIL reed relay from Astralux Dynamics has been specifically designed for use with surface mounting assembly techniques.

Approximately one third the weight of conventional DIL reed relays, 800 Series relays are moulded in high grade epoxy resin to withstand high temperatures.

Available in 5V and 12V nominal coil voltage versions, the relays have a maximum initial contact resistance of 150milliohms.

Contact: Astralux Dynamics Ltd, Tel: 0206-302571/5.



REDUCING ENERGY COSTS FOR BRITISH COMPANIES

A London based company claims to cut typically 25% from their energy bills by using a software package to monitor energy efficiency in their buildings. The package has been developed by energy consultants, EnTech, for commercial and public-sector premises. Savings are said to have been made by large organizations including Marks and Spencer, Royal Mail, British Rail, Shell, and the Severn Trent Water Limited are all using it to keep energy costs under control. EnTech has now produced a smaller version of the package — called S/STEM — which could bring corresponding benefits to medium-sized companies, with annual energy bills totalling less than £20,000 per site. Users of the service can either run the IBM-compatible software themselves, or supply meter readings and invoices to EnTech, who process the readings and make recommendations for energy saving.

S/STEM is used to monitor how much energy individual buildings use over the year, and compares this to how much they should be using. By giving early warning of equipment faults and changes in energy use, the package can pay for itself within 12 months, the company says.

Entech also offer a complete energy targeting service. The starting point is an energy survey of the individual buildings, including infra-red thermographic surveys which help uncover precise heat losses. Besides suggesting initial energy saving measures and they claim that £5,000 per year savings are common for bills of £20,000, with a maximum two-year pay-back time, EnTech feeds the information into S/STEM. The package then builds up a detailed model of the building's energy characteristics, and calculates its energy equation (energy input = useful energy + energy wasted). Building characteristics like building fabric, heating system, lighting, and equipment installed, passive heat received through windows, weather 'exposure factor' and even the body heat of the occupants are included. The software will calculate the corresponding energy costs from electricity, gas, oil and solid fuel tariff rates.

Each week or month, the user enters meter readings and/or invoices into S/STEM. The package runs on PC compatible computers and is 'menu driven'. Normally, readings are entered in batches; after each batch, S/STEM automatically highlights errors or unlikely values for correction by the operator. The software calculates the actual costs for each building using weather and tariff data which is regularly updated by EnTech for a yearly undisclosed maintenance fee. It compares these actual costs against target costs which were calculated from the energy characteristics of the buildings.

The software will produce management reports with graphs and charts to show up variations in energy usage by region, type of building, and deviation from energy target. It can compare year on year expenditure and print a ranking table of present and past months' performances. Future energy targets are calculated using '20-year average' weather data, and the operator can ask 'What If?' questions about energy consumption, for instance to discover the effects of replacing an oil-fired boiler by a gas-fired one, or the payback times of different types of insulation. A regular System Integrity Check helps ensure that data files are correct, complete, and free from viruses.

Contact: EnTech Energy Consultants Ltd, Tel: 071-833 3353.

S600 SUPERCOMPUTER EUROPE'S FASTEST SYSTEM

Siemens Nixdorf Information Systems Limited has announced the S600 supercomputer, Europe's fastest monoprocessor system. In independent tests, the S600 attained a real-time peak performance of 4.009 billion floating point operations per second (Gflops).

The S600 achieved its 4.009 Gflops performance in the 1991 LINPACK 1000 x 1000 bench test. The test compared the performance of various supercomputers in solving a system of linear equations, and placed the S600 ahead of systems manufactured by CRAY, NEC and Hitachi.

The S600 is the top model in the Siemens Nixdorf S-Series supercomputer range. The range is designed to handle complex applications in all fields of science and engineering, including the simulation of costly research trials in fields such as automotive design, plasma physics, oil exploration and chemical analysis.

The S600 has a rated theoretical peak vector performance of five Gflops and is available with one or two scalar processors, each of which delivers a sustained performance of 37.5 million floating point operations per second.

The motherboard is constructed from glass ceramics, giving a highly concentrated multilayer structure that increases overall processing speed. The scalar and vector processing units are both housed on the 61 layer board, accommodating 144 chips.

All logic circuits in the scalar and vector units are ultra high-speed, high density, LSI chips. The processor logic uses chips with 15,000 gates and a signal propagation delay of 80 pico-seconds. Vector registers, control registers and buffers use MOS-RAM chips with a 64kbit memory capacity, giving the S600 a cycle time of 6.4ns.

Contact: Nixdorf Information Systems Ltd, Tel: 0344 862222

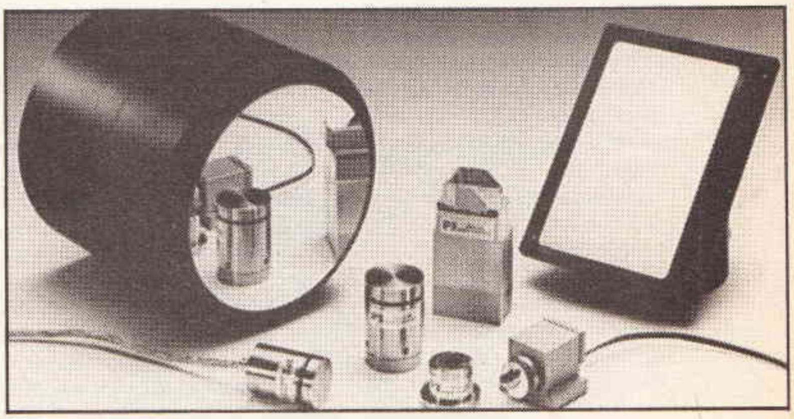
ADAPTIVE OPTICS

Among a new range of tilting mirrors available from Lambda Photometrics is the S380 This high-dynamic unit has a tilt angle range of 800 microradians in two axes, an angle resolution of 1 microradian and a response time of one thousandth of a second. The 100mm diameter mirror is 15mm thick and has a surface flatness to within one eighth of the wavelength of light measured at 632.28nm.

The unit is an adaptive optic system using a closed-loop pieoelectric actuator. The response time, resolution and accuracy of the mirror allows it to perform in many optical applications, such as accurately compensating for atmospherically induced image jitters in astronomical telescopes.

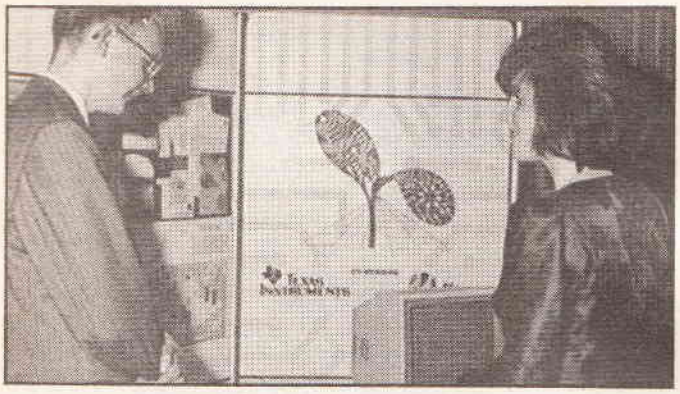
In operation, two integrated piezo transducers correct image distortion in real time by tilting the mirror in two axes simultaneously over an 800x800 microradian range. A closed loop servo system, comprising four high-resolution capacitance sensors, monitors and positions the degrees of tilt in the relevant axis to preserve a 1 microradian accuracy at all times.

Technology for the unit originates from an image stabilizer designed and built by Physik Instrumente for the European Southern Observatory's 2·2 metre telescope.



Further information contact: Lambda Photometrics Limited, Tel: 05827 64334

DUCHESS OF YORK PRESENTS YOUNG ELECTRONIC DESIGNER AWARDS



HRH The Duchess of York presented the 1991 Young Electronic Designer Awards at the Science Museum. The Duchess praised the work of all 21 finalists, saying how much she admired their ingenuity and their understanding of the science of electronics.

The 21 young designers, whose ages ranged from 12 to 24, came from 15 different educational establishments in all parts of the UK. The Texas Instruments' Prize of £2,500 for the most commercially viable project was awarded to Pollyanna Robinson (Junior); The Godolphin School, Salisbury. The Mercury Communications 'Planet Award' (also worth £2,500) for the most environmentally and socially aware technology went to Jonathan Saville (Intermédiate), Queen Elizabeth Grammar School, Wakefield. The three category awards were won by Stephen Brown (Senior), Royal Naval Engineering College, Plymouth; Jonathan Saville (Intermediate); and Pollyanna Robinson (Junior).

The Duchess commended the young designers for their breadth of vision and scientific skills. She said: "Schemes like YEDA are dependent on sponsorship from commercial organisations which aim to put something back into the community, provide incentives for tomorrow's workforce, play a positive role in reducing skills shortages and increase their corporate profile in educational circles".

The annual scheme is organised by the YEDA Trust (a registered charity) and is open to students between the ages of 11 and 25, at secondary schools, polytechnics and universities in the UK. There are three category prizes (under 15, 16-17 and 18-25) as well as the two special sponsors' awards.

EMPLOYMENT PROSPECTS IN ELECTRONICS

Employment prospects in electronics remain positive, making it one of only a few sectors in the country not showing a decline, according to the latest Quarterly Survey of Employment Prospects published by Manpower.

The Survey questioned over 1,500 companies throughout the country, across all industry sectors and the overall findings are yet another indication of deepening recession in the UK.

Although employers in the electronics sector anticipate more increases over decreases in employment prospects, a balance of + 16, the equivalent period in 1990 was + 20, suggesting that employers' optimism is fading. However, electronics is still well above the national average, which shows a balance of −2.

The majority of companies in electronics predict no change in employment prospects, with 72% of employers asked, anticipating levels remaining static during the second quarter.

Employers expecting increases in employment prospects over the next quarter have fallen, from 28% in 1990 to 22% for the coming three months.

Among those employers anticipating decreases in job prospects, the figure has marginally dropped, from 8% in 1990 to 6% for the coming quarter.

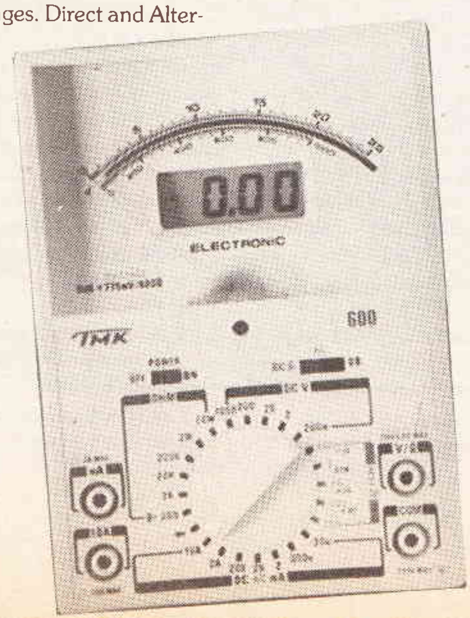
DUAL DISPLAY

The latest multitester from Alpha Electronics features a true combined analogue and digital display. In the centre of the large moving pointer analogue section is a 3½ digit liquid crystal display. These combine to show both varying and instant measurements.

The TMK 600 measures AC RMS voltage to 750V in 5 ranges with an analogue sensitivity of 1M Ohm/V DC voltage is to 1000V also in 5 ranges. Direct and Alternating current uses 7 ranges to measure up to 10A. Resistance together with an audible continuity feature use 6 ranges to cover 20M Ohms. Additional tests include diode and dBs.

It is battery operated and housed in a yellow ABS case. Designed to comply with the latest safety standards, it is fitted with an NBC ceramic fuse.

Contact: Quiswood Ltd on (0756) 799737.



A WEATHER EYE

Even during the recent high winds and severe cold weather, the motorway crossing the Severn Bridge remained open. This was partially due to the monitoring system of chart recorders supplied by The Instrument Centre (TIC) at Newport. Eight chart recorders are in the Severn Bridge headquarters and also at Avon police Department's Almondsbury base, from where traffic flow is controlled.

The system currently monitors the speed and direction of winds affecting the Severn and Wye spans together with making humidity and temperature checks. Wind speed and direction are recorded from voltage transducers while temperature and humidity are derived from current transducers. Each recorder operates up to four sensing channels.

One simple application is routine painting. The Forth Bridge principal of starting at one end and finishing at the other before starting all over again is a myth. In reality, each area requires different treatment at different times. Painting wet steel is a waste of time and money, so steel temperature and humidity readings will help determine the dewpoint. Having established that the steel condition is correct, a wind speed could help determine whether the working conditions are favourable and safe.

Further information contact Quiswood Ltd on (0756) 799737.

ETI NEWS stateside

Channel selectable video op amp

The KA-2444, integrates four video op amps on a single die and offers a wideband multiplexer and a high-impedance buffer on-chip.

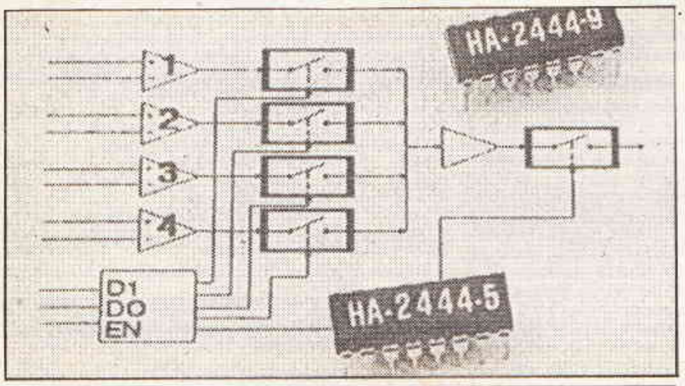
It is designed to replace four cross-points and digital control logic in video board applications, and can help minimize board space and cost in video systems.

Functionally, the HA-2444 is a channel-selectable video op-amp comprising of four differential inputs, a single ended output, and digital control. Also, the selectable quad op amp has been optimized to offer fast selection and low crosstalk. For instance, typical channel selection time is 60ns, with crosstalk rejection of 60dB at 5MHz.

Other key features of HA-2444 include unity gain bandwidth of 45MHz, gain flatness (to 10MHz) at 0.12dB, and low differential phase and gain of 0.03 degrees and 0.03%.

Commercial and industrial versions of the HA-2444 come in 16-pin plastic small-outline IC (SOIC) and dual-in-line packages (DIPs), while the 883-compliant units will be offered in 16-pin cerdips and flat packs.

Manufacturer is the Harris Corp. of Melbourne, California.



Developing more efficient solar electric panels

A three-year subcontract has been awarded by the Solar Energy Research Institute Solarex Corp., to develop large area, high-efficiency, multijunction thin film solar electric generating modules that convert sunlight directly into electrical energy.

Under the contract terms, Solarex and SERI will share the $6.5 million cost of developing advanced modules demonstrating a stable conversion efficiency of 12%. The contract also targets development of a small area (1cm^2) device with a 14% conversion efficiency.

Unlike typical single-junction solar cells, multi-junction solar electric devices are constructed of several solar cells 'stacked' on top of one another, each being designed to capture a different portion of the solar spectrum. The multi-junction architecture optimizes the device's ability to turn sunlight into electricity.

Multi-junction structures have already demonstrated impressive gains in stability over earlier single-junction devices. The Solarex-SERI contract will work with structures that utilize amorphous silicon-germanium and silicon carbon alloys.

Enquiries: Solarex Corp., Rockville, Maryland.

New class of conducting polymers

Chemical research being carried out at the California Institute of Technology may pave the way for a new class of conducting polymers to be used in practical applications, particularly in photovoltaic cells. However, the difficulty is to cast the complex polymers into thin films or wires. The long chain molecules tend to get tangled up with themselves, producing insoluble compounds that are very difficult to work with.

These complex molecules are being untangled by a method called Ring Opening Metathesis Polymerization, which is a catalytic process that unwinds complicated polymer structures. It transforms polyacetylenebased conductive polymers into a form that dissolves in organic solvents. The resulting solutions can be spin-coated on silicon substrates, yielding uniform conducting films.

The process results in no discernible variations of the films down to a resolution of 200nm.

The use of conducting polymers would eliminate the chemical reactions that plague metal and semi-conductor junctions. Active chemical effects degrade current flows across metal silicon contacts by trapping electrons.

Use of conducting polymers is especially promising for photovoltaic cells. Photocells based on metal and semiconductor junctions perform well below their theoretical maximum efficiency because of chemical reactions that take place in the junctions.

The chemically neutral polymer junctions are tested by coating an n-doped silicon substrate. Called polySi-COT which has been treated with the COMP Catalytic process. This is a conductive polymer with silicon side groups attached to every eighth carbon atom in a polyacetylene chain. Tests indicate that the electron flow across the polymersilicon interface is at the ideal value.

Compressed air conditioning system uses electronic timer

Supersaturated, hot, dirty air leaving a compressor must be cooled, cleaned, and dried. A compressed-air conditioning system consists of four components, an aftercooler, separator, dryer, and filter. In the past, companies have had to assemble systems from multiple suppliers and evaluate each component separately.

The aftercooler uses air, not water, to cool incoming air to within 5° of the ambient temperature. The separator uses a rotational force to lower the humidity in the air to below 100%, so the dryer functions more efficiently. The velocity with which the supersaturated air hits the side of the vessel causes excess water to drop out.

A coalescing filter removes compressor oils by trapping 5µm particles, eventually forming a droplet is absorbed onto the filter media.

Dessicant tablets absorb eight times their weight in water. New tablets are added periodically. A programmable electronic timer signals a gear-reduced motor to open a ball valve in the drain and discharge the condensate. Capacities vary from 35scfm at 75psig to 5,500scfm at 125psig operating pressure. Portable conditioners are also available.

Enquiries:Van Air Systems Inc., Lake City, Pennsylvania.

Faster CVD Process

A new chemical vapour deposition process hasx been developed which can be used tyo coat fibres, tapes and flat substrates with a thin film of superconducting material. It is 50 to 200 times faster than conventional deposition. The technique yields a coating 40-200um thick per hour of deposition, depending on conditions, versus only 1.2um/h for existing CVD technology.

A standard metal-organic CVD process, which evaporates materials and uses a carrier gas to transport then through a furnace, was modified to eliminate the complicated metal-source vapourizers. Since the flowrate, temperature and pressure must be controlled for each vapourizer, the process was delicate and time-consuming. To eliminate the need for complex controls, the Georgia scientists replaced the vapourizers with a powder feeder. A combination of finely ground yttrium, barium and copper metal-organic powders are mixed with argon, then flowinto the horizontal reactor, where deposition takes place.

The material has a critical temperature of 87K and can carry up to 40,000 A/cm^2 with no loss of superconductivity. Additional tests are being conducted to assess the mateirl's electromagnetic properties.

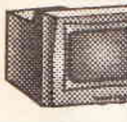
Georgia Institute of Technology, 225 N. Avenue N.W., Atlanta, Georgia 30332.

THE *ORIGINAL* SURPLUS WONDERLAND!

MONITORS

MONOCHROME MONITORS

THIS MONTH'S SPECIAL!



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

CALL FOR DISCOUNTS ON HIGHER QUANTITIES!

COLOUR MONITORS

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

20", 22" and 26" AV SPECIALS

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

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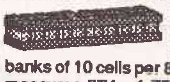

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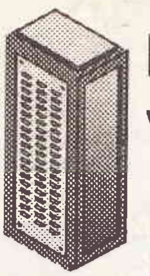

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Tech Tips

A selection of circuits from you the reader

Precision 10V voltage reference

This simple circuit was originally put together for use with the 'meter tester' described in the January 1991 issue. As it stood the circuit was invaluable but it suffered from the disadvantage that the meter under test had to be known to be accurate on at least one range or that a second calibrated meter was available. This is not always the case.

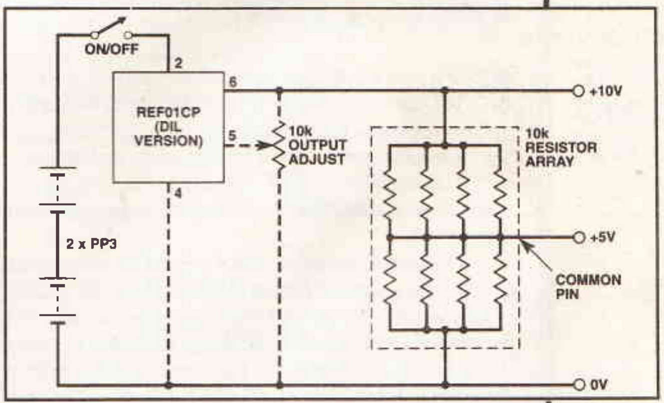
By using a low cost voltage reference device this circuit overcomes this drawback. The reference device produces 10V, accurate to 1% which matches the accuracy of the rest of the circuit. A separate power supply of more than 12V is required for IC1 and Q1, whilst the 10V reference is connected to the top of the reference resistor chain.

If an accurately calibrated meter is availiable (or can be borrowed) then the 10k preset shown dotted may be included, and used to trim the output to exactlly 10V. this preset should be a highly stable, preferably multi-turn cermet type to ensure the unit remains calibrated.

When used in conjunction with the meter tester, outputs of 10, 5, 2, 1, 0.5, 0.2, and 0.1 volts are obtained along with currents of 30, 15, 10, 6, 5, 3, 2, 1.5, 1, 0.6, 0.5, 0.3, 0.2, and 0.1mA.

To increase the usefulness of the unit as a stand alone voltage reference, a voltage divider was included to give a 5V output. Instead of using two resistors of the same value, an SIL eight resistor array was used. One end of each resistor is commoned allowing them to be connected as shown. Using this arrangement ensures a more accurate divide by two than descrete resistors. This is because the resistors are all fabricated on one substrate and so although their resistance may not be exactly that specified, all the resistors will be of a new identical value.

This 5V output must only be used for driving high resistance loads otherwise loading effects will affect its accuracy. It is therefore not suitable for feeding the voltage divider chain in the meter tester.



Single Chip Amp

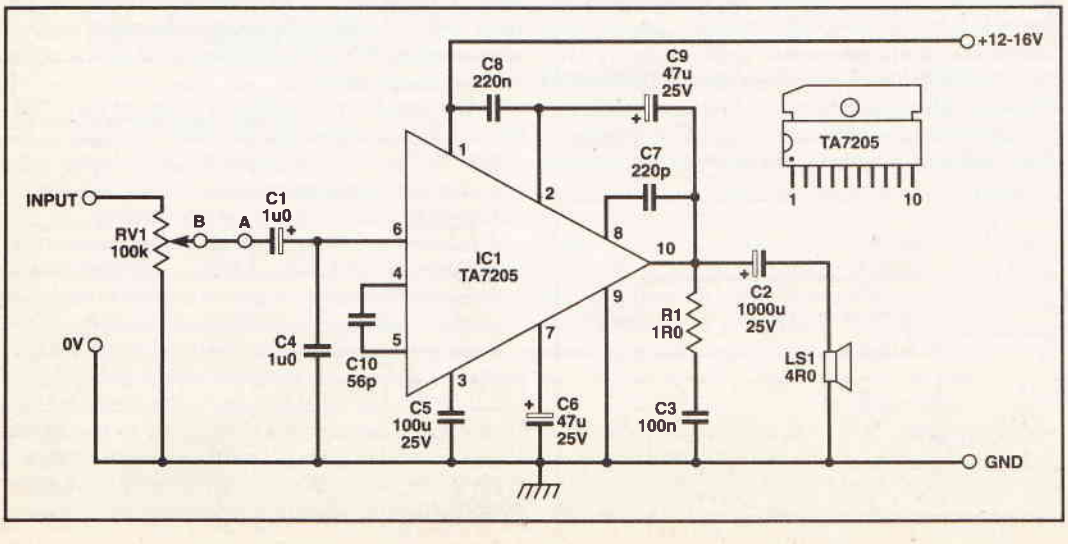
This single IC based audio amplifier delivers an output of about 10 watts into a 4R speaker load. The circuit gives low distortion figures and low hum levels, a clear sound reproduction with no stray inductions or picked up noises.

The circuit as shown uses a single channel amplifier IC type TA7205, which comes in a single 'in line' package. The input signal is fed to the amplifier from a pre-amplifier or any other suitable source, with adequate amplitude to drive the circuit through C1. The output signal is fed to the loudspeaker through the output coupling capacitor C2. C3 and R1 form a zoebel network to help in increasing the overall stability of the circuit. The remaining components set the frequency response characteristics of the amplifier.

No other controls other than volume controls have been used. Tone controls if required, can be connected between the centre tap of RV1 and the amplifier input ie between the points A and B.The amplifier chip needs no electrical isolation from the heat sink.The circuit can give about the expected output at a supply voltage of between 12 and 16 volts

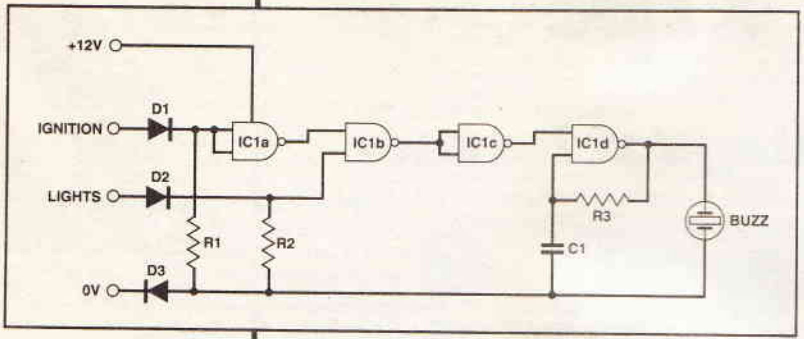
The amplifier must have a good heatsink without which the output quality will deviate otherwise the amplifier will shut itself off after it gets too hot.

Amrit Bir Tiwana, India



TECH TIPS

Car Lights Warning



Here is a circuit of a car 'lights-on' warning device that I have recently designed and built. It was inspired by an occasion when the headlights were left on all day and jump leads were required in the evening. Not too bad, except it was dark, cold and raining!

Circuit operation is quite simple. Gates a, b, and c detect the state of lights on and ignition off. When the output of gate c is high, the oscillator formed by gate d, R3, and C1 is enabled. The output is adequate to act as a warning. R1 and R2 are included to provide static protection and D1-3 provide protection against inadvertent reverse battery polarity.

D. J. Withers, Wilmslow, Cheshire

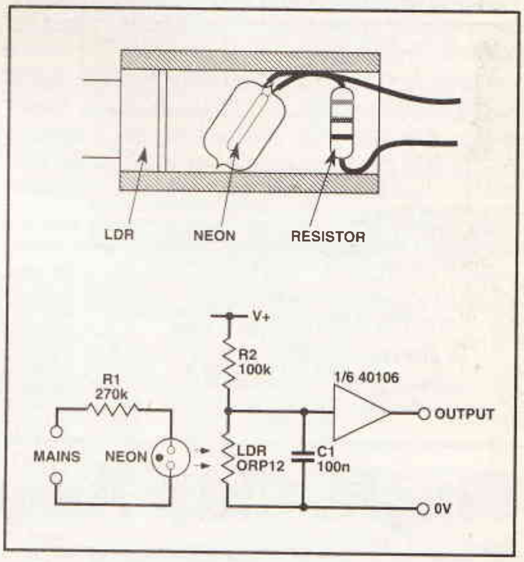
Mains Detector

Faced with needing to detect the presence of mains in a power circuit, with a logic output isolated from mains potentials, optical isolation seemed the obvious solution (you could use a transformer, isolating the circuit magnetically and reducing the voltage to manageable levels, but it would be bulky and relatively expensive).

The problem with traditional opto-isolators is the need to push about 10mA at 2V through the input LED — how exactly do you do that from raw mains? The dropper resistor would need to be a couple of watts!

I hit on the idea of a DIY opto-isolator, with a neon indicator shining on a Light Dependent Resistor. The arrangement is shown in the drawing, with the neon, its limiter resistor, and the LDR cemented into an opaque, insulating tube (it must be light-tight, as the LDR is quite sensitive). The logic output gives a nice, clean, high output when mains is connected across the input (if you want the inverse output, swap the positions of R2 and the LDR in the circuit).

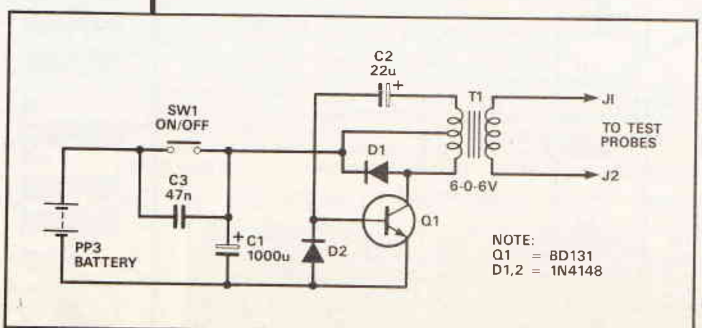
Ken Wood, Newport, Gwent



Simple Neon Tester

Upon purchasing a bulk package of untested neon indicators, I was faced with the problem of testing each one to see if it was operational. Since the ratings were varied, from 110V up to 440V, trying to test them from the mains proved impossible. Therefore this simple neon tester was designed to solve this problem.

The main component of this device is the mains transformer, used to step-up the battery volts to several hundred volts AC. The transistor switches the current flowing through one half of the secondary. The other half of the secondary provides a signal that is 180° out of phase with the driven half and via C2 and D2, feeds this signal back to the base of the transistor. Diode D2 stops any high reverse voltage from the windings damaging Q1 and helping to provide a reasonably clean waveform.



A small mains transformer is used for T1, typically 3VA rating. This low rating limits the maximum current the transformer can deliver, enough to light a neon bulb but not enough to give a lethal shock should one's fingers accidentally touch the high voltage contacts! If desired, a transformer with two secondaries can be used, with a small loudspeaker and limiting resistor connected to this other secondary to give audible warning of operation.

The supply to the circuit is provided by a PP3 battery. This is connected to the circuit by a push switch SW1, and smoothed by C1. Capacitor C3 prevents any arcing on the contacts of SW1, helping to reduce wear and external noise interference.

In operation, the neon would be connected to the test probes and SW1 pressed. If the neon lights then it must be OK, if not then it can be thrown in the bin.

When building this device, most of the components can be obtained from the junk box, since most medium sized power transistor would do and the actual transformer used does not matter too much, as long as the usual secondary voltage is in the range 5-0-5 up to 12-0-12, but it must be a centre tapped winding.

Neil Johnson, Rye.

Back to Basics

6

Inductive Reactance is the subject of this months course in basics by Paul Coxwell.

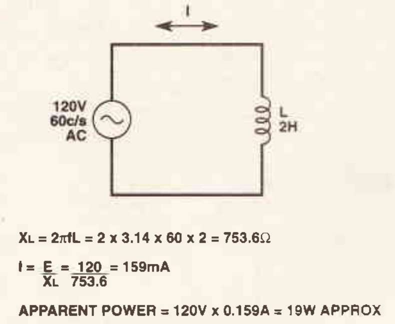


Fig.1 Inductive Circuit

Last month's installment left us examining simple inductive circuits. We have seen how to calculate the inductive reactance of a coil and how Ohm's Law can be used to work out the current that flows for any given applied voltage. Figure 1 shows the circuit under consideration.

We saw that power in a resistive AC or DC circuit is directly proportional to both voltage and current, and can be calculated by finding the product of these two values. From the way in which an inductor stores and releases energy in the form of a magnetic field, we also saw that no power is consumed by a purely inductive circuit. This however, contradicted a calculation of apparent power in the circuit.

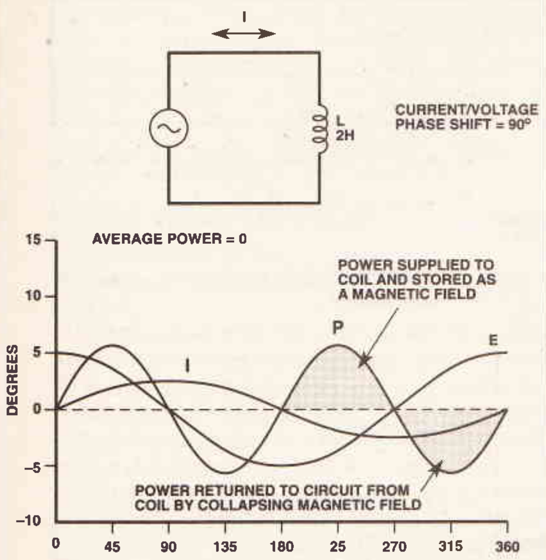


Fig.2 Power in an Inductive circuit

The phase relationship between current, voltage, and power in an inductive circuit is shown in Figure 2. The shaded positive half-cycle of the power curve represents the amount of energy stored by the inductor as a magnetic field. The shaded negative half-cycle represents the energy returned to the circuit when the magnetic field collapses. Notice that the shaded areas are equal in size; the power taken and the power returned are equal, so the circuit consumes no power. Current is still flowing in the circuit, however, and an ammeter inserted in series would register this current. The current is sometimes referred to as "watt-less power," and to distinguish it from normal power that is dissipated it is measured in different units. The unit of power is the watt (w) and the unit used for measurement in an inductive circuit is the volt-ampere (VA). The VA measurement is called reactive power, but it should always be remembered that no power is actually consumed in theory.

In the circuit shown, the apparent power obtained by multiplying the voltage applied by the current measured would be 0.159 VA. The true power is zero, because no energy is actually used up by the circuit. It is important to realize the difference between true power and apparent power: True power represents the energy that is actually consumed by the circuit; apparent power is the value obtained by way of the usual power calculation with voltage and current. In a purely resistive circuit the true power and apparent power are equal, so true power can be determined by multiplication of voltage and current values.

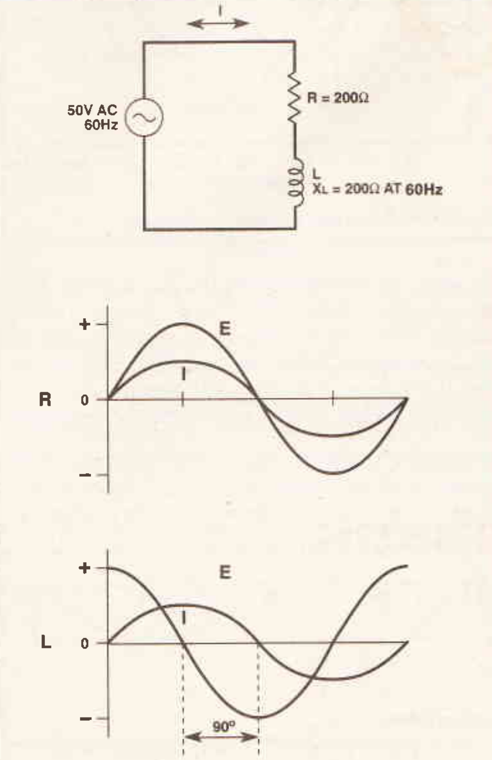


Fig.3 RL Circuit

Resistive-Inductive Circuits

Figure 3 shows a series circuit comprised of both resistance and inductance. The two graphs indicate the current and voltage phase relationships in each part of the circuit. A resistor has no way in which to store or release energy, and the voltage dropped across it will always be in direct proportion to the current flowing. The voltage across the resistor therefore, is in phase with the current flowing. The inductive part of the circuit, introduces a phase shift, because the inductor causes current to lag voltage by 90°. The voltage across the inductor is out of phase with the current.

In a series circuit, the same current flows through each part of the circuit, so the current through the resistor and the current through the inductor must be in phase implying there is a 90° phase shift between the resistor and the inductor voltage.

Vector Diagrams

In dealing with resistive circuits we saw that the total voltage applied to the circuit is equal to the sum of the individual voltage drops across each component in that circuit. Simple addition and subtraction works so long as the voltages are all in phase, which is the case for a purely resistive circuit.

Out-of-phase voltages cannot be combined so easily. Figure 4 shows two individual voltages, E_1 and E_2. To obtain the total voltage curve, E_T, it is necessary to take many points along the cycle and add the instantaneous values of E_1 and E_2 together. At zero degrees,

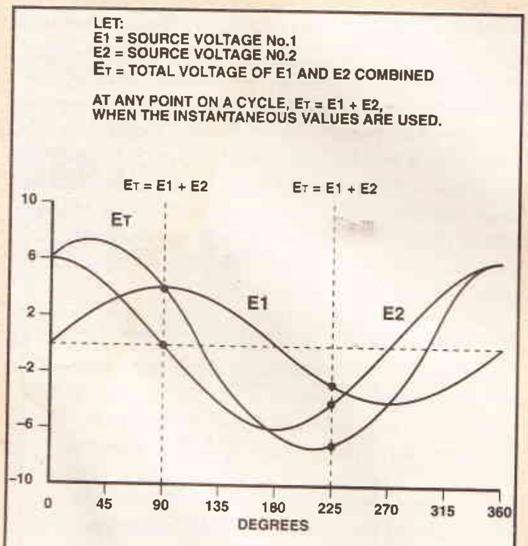


Fig.4 Combining out of phase voltages

E_1 is zero, so E_T is equal to E_2. At 225 degrees, E_1 is approximately −3 and E_2 is around −4, giving a total voltage at that point in the cycle of approximately −7 volts. Look closely at the peak values of each voltage curve. E_1 peaks at 4V and E_2 at 6V. Normal addition of these values would give the total voltage an amplitude

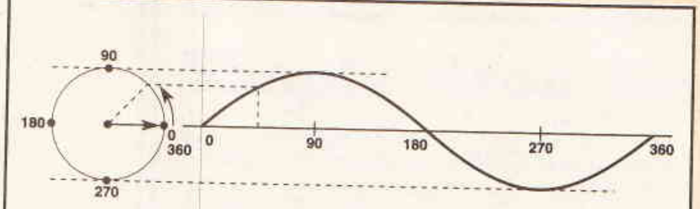


Fig.5 Basis of vector diagrams

of 10V peak, but E_T actually peaks at around 7.5V. When two out-of-phase voltages are combined, the total voltage is always less than that obtained by direct addition.

Fortunately, there is a much simpler way to represent out-of-phase waveforms than by plotting them in full. Figure 5 shows the basis from which vector diagrams are derived. Imagine that the line drawn in the circle is pivoted at the centre so that it can turn through 360°. Zero degrees is to the right and the arm turns in a counter-clockwise direction. In the position shown, the end of the arm is at the zero line on the sinewave. As the arm starts to move upward, the end of it rises gradually, until at 90° it has reached a maximum positive value. As the arm passes 90°, the end of it starts to fall back toward the zero line, reaching it at 180°. The second half-turn of the arm gives a similar process for the negative half of the sinewave.

A continuous sinewave can be represented by the rotating vector. Assume that the vector is at 90° (pointing upward). If the length of the vector were to be increased, it would represent a sinewave of greater amplitude. A vector thus represents two quantities: phase angle and amplitude.

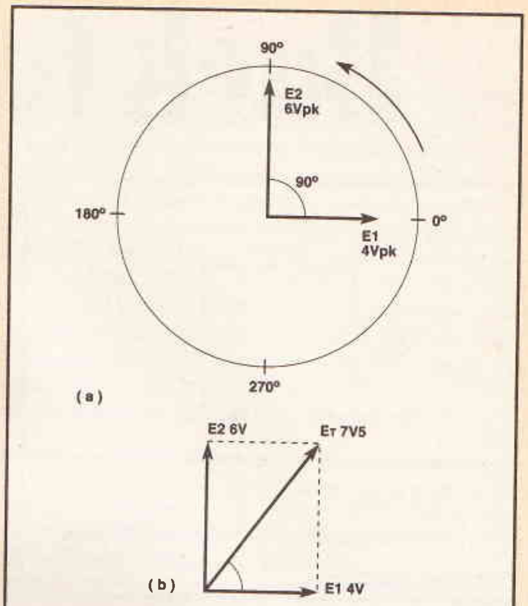
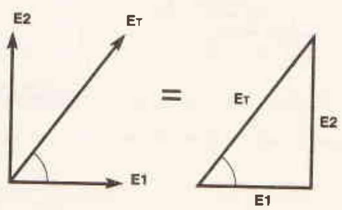


Fig.6 Representing voltages as vectors

The two voltages E_1 and E_2 from Figure 4 are shown as vectors in Figure 6. E_1 is assumed to be at zero degrees, because on the original graph the cycle started at the zero degree point. E_2 was leading E_1 by 90°, so it is drawn upright to the 90° point. Remember that the vectors are assumed to be rotating counter-clockwise, so if any point on the circumference of the



FROM PYTHAGORAS' THEOREM:

$E_T^2 = E1^2 + E2^2$

OR

$E_T = \sqrt{E1^2 + E2^2}$

SIMILARLY:

$E1 = \sqrt{E_T^2 - E2^2}$

AND

$E^2 = \sqrt{E_T^{\,2} - E1^2}$

Fig.7 Pythagorus' Theorem

circle is taken, E_1 will always pass a quarter of turn after E_2. It can be said that E_1 lags E_2 or that E_2 leads E_1; the descriptions are equivalent.

Vector diagrams are usually drawn without the outer circle, and our example is extended to the second part of Figure 6. Notice how two dotted lines have been drawn, each parallel to one of the existing vectors. The point at which these lines meet represents the angle and amplitude of the sum of the two out-of-phase voltages, so a third vector can be drawn from the centre to that point.

So long as the diagram was drawn accurately to scale, the length of the third vector E_T, can be measured to obtain the correct voltage. In addition, the angle between the zero line and the vector E_T can be measured with a protractor to give the amount of phase shift between E_1 and E_T. Phase angle is represented by the Greek letter theta as shown, and in this example the phase angle is approximately 56°.

The vector diagram has a noticeable resemblance to a right triangle (see Figure 7). All that is necessary is to move vector E_2 across to the right, and the three vectors do then form a right triangle. Pythagoras' Theorem states the relationship between the sides of such a triangle: The square on the hypotenuse is equal to the sum of the squares of the other two sides. The hypotenuse of the triangle is simply its longest side, which will always be opposite the 90° angle. Using the formulae shown any value can be calculated if the other two are known. This application of Pythagoras' Theorem is important to much electrical work.

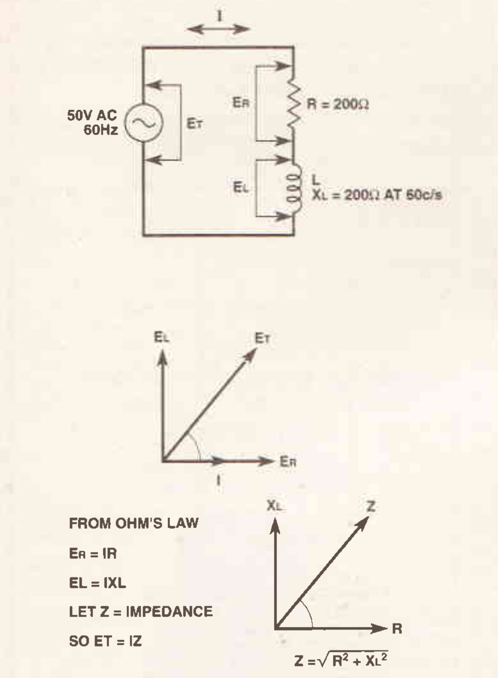


Fig.8 Application of vectors in RL series circuit

Application Of Vector Diagrams

It is now possible to develop a vector diagram for the RL series circuit we examined earlier. This is shown in Figure 8.

Current in a series circuit is the same wherever it is measured, so the current waveform is used as a reference and drawn at zero degrees. The voltage drop across a resistor is always in phase with the current through the resistor, so E_R is in phase with I and drawn along the same zero-degree line.

The voltage across an inductor leads the current by 90° as we have seen, so the vector representing E_L is drawn at the 90° point on the diagram. The applied voltage E_T, is then added by extending the vectors to form a rectangle. The diagram shown gives an overall representation of the current and voltage waveforms in the circuit, without the need to plot out individual sinewaves.

$Z = \sqrt{R^2 + X_L^2} = \sqrt{200^2 + 200^2} = 283\Omega$

TOTAL CURRENT, I = ET/Z = 50V/283Ω = 177mA

TO CALCULATE THE RESISTOR VOLTAGE:

ER = IR = 0.177 x 200 = 35.4V

TO CALCULATE THE COIL VOLTAGE:

EL = IXL = 0.177 x 200 = 35.4V

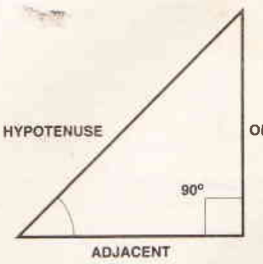
Fig.9 Solution for circuit

Ohm's Law can be successfully applied to each part of the series circuit or the circuit as a whole. The resistor voltage can be calculated from the current and the value of resistance; the inductor voltage can be calculated from the current and the inductive reactance of the coil at the specified frequency.

Impedance

So far, we have seen two different properties that restrict the flow of current: resistance and inductive reactance. In a circuit comprised of both resistance and inductance both will affect the current, and the combined restriction is called impedance (represented as z).

As with out-of-phase voltages, it is not possible to simply add the resistance and inductive reactance together in order to calculate the total impedance of the circuit. Refer to the formulae in Figure 8 once again. The common factor to all three equations is I, because the current is the same in each case. This implies the ratio of one voltage to another will be in the same proportion as the ratio of resistance to reactance, or impedance. The voltage vectors can be redrawn to represent resistance, reactance, and impedance, as shown. Applying Pythagoras' Theorem once more gives the method for calculating impedance when the resistance and reactance are both known.

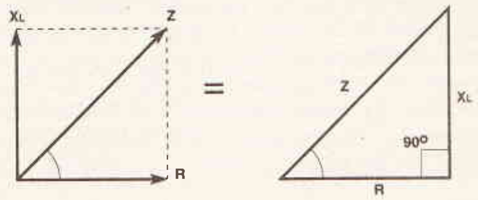


$$\text{SINE } \emptyset = \frac{\text{OPPOSITE}}{\text{HYPOTENUSE}}$$

$$\text{COSINE } \emptyset = \frac{\text{ADJACENT}}{\text{HYPOTENUSE}}$$

$$\text{TANGENT } \emptyset = \frac{\text{OPPOSITE}}{\text{ADJACENT}}$$

Fig.10 Basic Trigonometry



$$\text{SINE } \emptyset = \frac{X_L}{Z}$$

$$\text{COSINE } \emptyset = \frac{R}{Z}$$

$$\text{TANGENT } \emptyset = \frac{X_L}{R}$$

$$\text{POWER FACTOR} = \frac{\text{TRUE POWER}}{\text{APPARENT POWER}} = \frac{R}{Z}$$

Fig.11 Power factor calculations

The vector diagram for a series RL circuit can, therefore, be used to represent either voltages or impedance. The values of resistance and reactance are known in the example circuit, so the impedance can easily be calculated (Figure 9). Once the total impedance is known, circuit current can be determined by

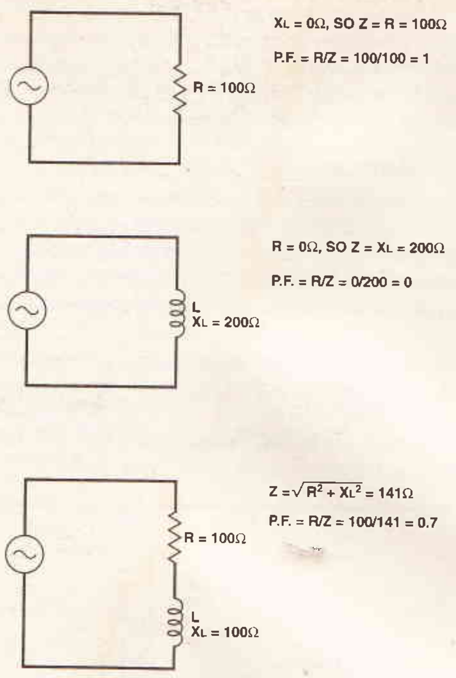


Fig.12 Calculating power factor

using Ohm's Law with the total applied voltage. The voltage drop across each individual component can then be calculated by applying Ohm's Law to each section. Notice how the direct sum of E_R and E_L is greater than the applied voltage. Always remember that vector addition must be used when dealing with out-of-phase voltages.

Power Factors

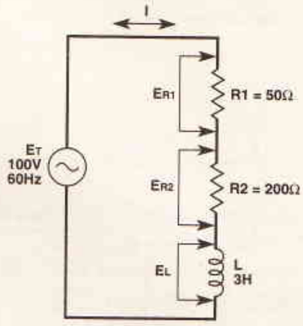
The three basic trigonometrical functions are also used extensively with electrical calculations, and they are summarized in Figure 10.

When two out of three values are known, whether for voltage or impedance, the appropriate formula can be selected in order to calculate the phase angle. If the values of resistance and inductive reactance, R and X_L, are known, the phase angle can be calculated by using the tangent function. If all three values are known, any one of the formulae may be used to give the same result. Some of the current flowing in a series circuit containing inductance does not consume power. It is the ratio of consumed power to apparent power that determines the power factor of a circuit. If all the current is used to dissipate power, the power factor is one, as true and apparent power are equal. Circuits that contain only inductance gives a power factor of zero, because no power is used up — it is only apparent, or reactive power. In a combination circuit the power factor will be somewhere between zero and one (Figure 12).

Power is only consumed by the resistive portion of the circuit, so the value given as the power factor specifies how much of the apparent power really is used.

To finish, Figure 13 shows another series RL circuit. Try to calculate the values for the items listed and then check your answers in Figure 14.

Next month we continue our look at inductive-resistive circuits and examine parallel combinations.



CALCULATE:
1. INDUCTIVE REACTANCE OF COIL
2. CIRCUIT IMPEDANCE
3. CIRCUIT CURRENT
4. VOLTAGES ER1, ER2, EL
5. PHASE ANGLE
6. POWER FACTOR

Fig.13 Series RL circuit example

1. $X_L = 2\pi fL = 2 \times 3.14 \times 60 \times 3 = 1{,}130.4\Omega$
2. $Z = \sqrt{R^2 + X_L^2} = \sqrt{(200 + 50)^2 + 1{,}130.4^2} = 1{,}158\Omega$
3. $I = ET/Z = 100/1{,}158 = 0.086A$
4. $ER1 = IR1 = 0.086 \times 50 = 4.3V$

$ER2 = IR2 = 0.086 \times 200 = 17.2V$

$EL = IXL = 0.086 \times 1{,}130.4 = 97.2V$

5. $\cos \emptyset = R/Z = 250/1{,}158 = 0.216$

$\therefore \emptyset = 77.5^{o}$

(COULD USE $\sin \emptyset = X_L/Z$ OR $\tan \emptyset = X_L/R$ INSTEAD)

6. POWER FACTOR = R/Z = 0.216

NOTE THE RELATIONSHIP BETWEEN P.F. AND PHASE ANGLE

P.F. = $\cos \emptyset$

Fig.14 Solution to problem

Laser Diodes

Douglas Clarkson reports on the construction and the latest uses of semiconductor lasers

It has taken nearly 30 years for the laser diode to become today's important means of creating laser radiation. Whether in bar code readers, CD music players or optical fibre communications links, diode lasers are playing a lead role in harnessing the benefits of new technology.

The general enthusiasm felt about laser diodes in the world of electro-optics arises from the rapidly increasing range of applications. While the telecommunication market primarily at wavelengths of 1330nm and 1550nm is a significant one, the volume production market is dominated by devices in the shorter range of wavelengths (670 to 850nm) which are used for example for optical storage systems and bar code scanners. The present most popular wavelength optical is 670nm (1nm = 1 millionth of a millimetre), though industry analysts expect 630nm (very close to the HeNe laser output) to become increasingly important.

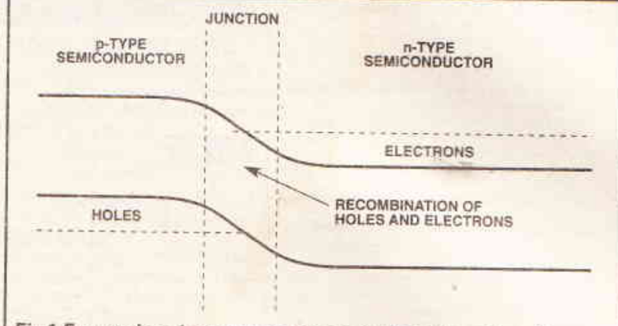


Fig.1 Energy band structure of heavily doped p-n junction, showing energy transition of electron-hole recombination.

A range of so called 'lead salt' lasers emit wavelengths in the range 2.7 to 30 microns. These specialist lasers have applications primarily in spectroscopy where they are used to sample the chemical composition of substances.

While it may appear that laser diodes are just as easy to drive as conventional LEDs, there remain, various points of difficulty in a 'do it yourself' approach to designing and building drive circuitry. While these difficulties may in time be overcome, they should certainly be recognised by the electronics enthusiast.

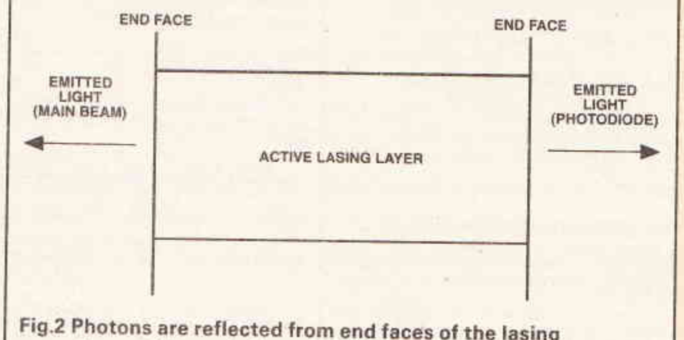


Fig.2 Photons are reflected from end faces of the lasing channel. The main beam is emttied from one face and typically a much lower intensity beam from the opposite face for output monitoring using a photodiode

The Theory of Diode Lasers

In harnessing the function of laser diodes, it is useful to introduce some theory. There is certainly a strong similarity between the function of an LED and that of a laser diode. This common element is the generation of optical radiation as a result of the passage of current through a semiconductor device.

Figure 1 outlines the energy levels considered to be present in a p-n semiconductor junction. The n-type material provides a source of relatively mobile electrons while the p-type material provides a source of 'holes' or gaps into which the electrons can migrate. When an electron at a higher energy level combines with a hole in the narrow junction layer, the electron is left in an excited state and can release its energy as a photon of light. The greater the energy of the transition, the 'harder' the wavelength of the radiation. Before the lasing action can take place, there is the requirement for 'population invertion' to occur in which the action of the current flowing across the junction creates larger than normal number of electrons in an excited state.

For a given energy transition E, the frequency of the radiation, f, is given by:

$$f = \frac{E}{h}$$

where h is Planck's constant.

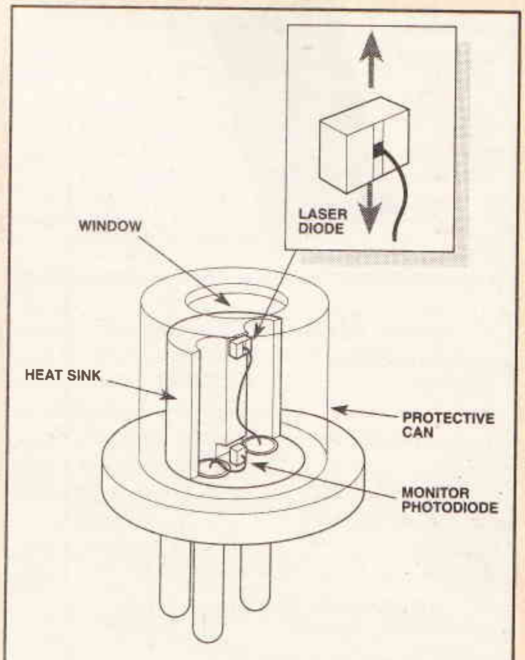


Fig.3 See through view of a typical low power laser diode mounted in a protective can

When the electron/hole recombination takes place, there is created an intermediate excited state in the atomic structure which decays within a typical relaxation time. Where a photon is released in this way it is called spontaneous emission. The photon has random phase and direction in space. It is possible for a photon of light to trigger this emission process. This mechanism is termed stimulated emission. The induced photon will have identical properties to the triggering photon as regards direction of travel, polarisation and phase. The act of stimulated emission can be considered to be one of 'exact' amplification.

Even within a conventional LED there will be a number of photons released by stimulated emission, but the paths of photons within the junction will still tend to be haphazard and noncoherent.

When the area of the junction is contained within parallel optical reflectors, then it is possible for a build-up of radiation to take place as shown in Figure 2. The end faces of the diode naturally undertake this mirror function. If a photon is initiated which is propagated initially in a path parallel to the reflecting faces, and it stimulates emission of photons in a similar direction, then the radiation will sweep backwards and forwards through the lasing region gathering additional photons until equlibrium is reached.

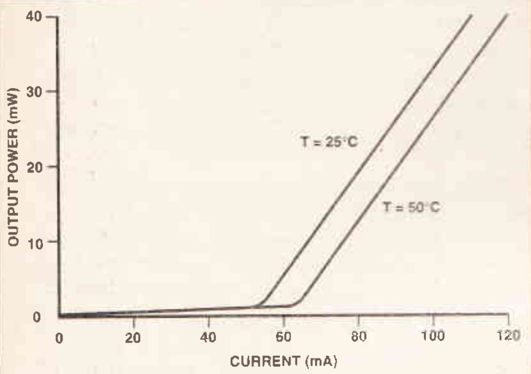


Fig.4 Typical output power of GaAlAs laser diode as a function of current at 25°C and 50°C

The radiation across the junction is coherent, ie it will be of similar phase. This is in contrast to non-laser light where the phase of individual photons is non-coherent.

It is necessary to allow the light to escape from the region where laser radiation is being stimulated. This is undertaken at the output face of the diode by normal transmission out of the device at the air/semiconductor junction. The opposite end of the lasing channel is made more poorly transmitting in order typically to drive a sensing photodiode for feedback/control applications.

Figure 3 shows a typical design of a laser diode. It shows a monitor photodiode to assist in drive electronics. The heat sink is important in stabilising the operating temperature of the laser diode when in operation.

The efficiency of GaAlAs lasers delivering 10-70mW of power is around 10%.

The human eye's response to colour peaks at about 550nm and falls off relatively sharply at longer wavelengths (towards the red) and shorter wavelengths (towards the blue). The conventional red He-Ne ion tube laser emits a wavelength of 633nm. While this is not in the most sensitive region of the eye, its radiation will appear some 14 times as bright as a laser diode of similar output power but emitting radiation at 680nm. At 650nm the ratio falls to a value of around 2.

In these laser diode applications where perception of output levels is relevant, there is a natural tendency to shorten the wavelength of the laser diode output in order to improve its 'eye efficiency'. In applications in telecommunications there is no requirement to shift down the output wavelengths towards the visible region. To do so would probably increase sharply the attenuation losses in optical fibres.

Provided diodes are protected from damaging electrical transients and operated within specified temperature limits, operation lifetimes can effectively be 'for ever'. The criteria for determining device lifetimes vary between manufacturers. NEC, for example, use the condition of determining the time within which a device will require an increased drive current of 20, while maintaining a 3 mW output at 50°C. This equates to a MTF (mean time to failure) of 36000 hours. Even better performance is predicted at lower temperatures (750,000 hours at 25°C or 85 years of continuous operation). Use is made of the Arrhenius equation in predicting the elapsed time before failure at a given activation energy and reference temperature.

The level of heat dissipation is therefore an important consideration for laser diode devices.

Single homojunction laser diodes can only be driven in pulsed mode due to reduced power handling ability. Double heterojunction lasers can be driven in both continuous and pulsed mode. Rise times vary between 1ns and 0.1ns and so called 'relaxation' oscillations are a feature of the initial rise edge of the light output. One Giga bit per second data streams have been demonstrated on commercial fibre optic systems driven using laser diode devices.

Laser diodes are primarily operated as current driven devices rather than voltage driven devices. Figure 4 indicates how the output optical power varies with drive current and Figure 5 how the output current varies with diode voltage. Control of output optical power is more readily undertaken by directly controlling the diode current rather than the diode voltage. This is on account of the steepness of the I-V charactaristic of the laser diode. The temperature of the device and the operating current can affect the wavelength of the emitted radiation. The variation of wavelength with drive current is typically 0.025nm/mA for GaAlAs devices. The effect of temperature is more significant and is typically 0.3nm/mA. It will therefore be necessary in some applications to introduce some element temperature stabilisation, eg using a thermoelectric cooling unit.

The frequency stability of a laser diode can be complicated by so called 'mode hops' where through, for example, gradual wavelength drift due to temperature change, the device can hop to a mode at a slightly different frequency. In communication systems, this is highly undesirable since it can change the signal losses along fibre links.

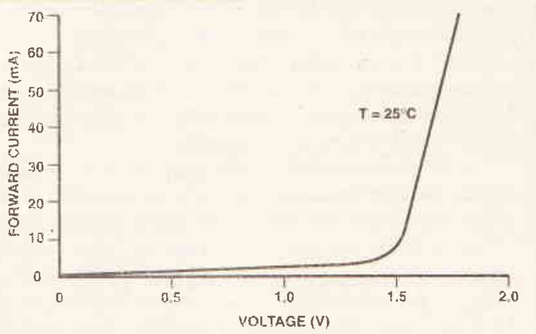


Fig.5 Typical I-V characteristic curve for GaAlAs laser diode

The output beam from the emitting strip of a laser diode is elliptical in output and emerges typically at an angle to the central axis of around 40°. The value of this angle is often referenced in term of the value of 'numerical aperture' where this value is the SIN trignometric function of the emergent angle. If the output is plotted as a function of contour radius, the typical Gaussian TEM^{00} mode profile is observed. The effective beam radius is taken as the point at which the output intensity has fallen to $1/e^2$ of the central value. This corresponds to 13.5% of central axis power.

The light from the diode is normally polarised with the electric vector parallel to the laser junction diode. The ratio of the degree of parallel to perpendicular component is usually around 500:1 at normal levels of drive current. Close to the lasing threshold this value is smaller, due to the higher proportion of light from spontaneous emission which is not polarised.

Frequency Doubling Systems

There has been significant interest in producing blue-green coherent laser radiation using laser diodes. A fundamental problem, however, in that semiconductor materials have not been identified which will directly produce a photon of blue-green energy. Instead, ways have been found to trigger the release of two quantae of relaxation energy to produce a photon of 'doubled' energy.

One method of undertaking this process is called self frequency doubling (SFD). A new material, NYAB, for example, will deliver about 3% at wavelength 531nm from laser diode excitation radiation a 1062nm. High power blue-green laser diode devices are some way off at present and even the present low power devices are expensive.

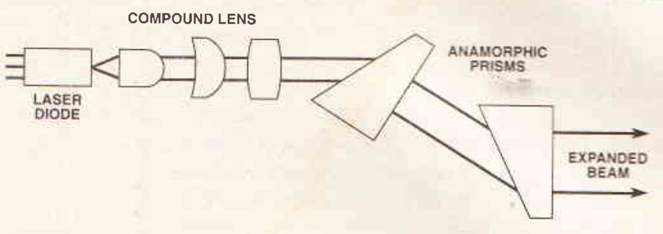


Fig.6 The compound lens produces a collimated wavefront and the anamorphic prisms expand up the minor axis of the output beam to make the beam profile more symmetrical

Beam Collimation

Optical interfaces are required to transfer the highly divergent output beam into a collimated symmetric beam of light. The nature of the application will determine the quality of the option required.

Figure 6 shows the design of a professional system, where an initial compound lens manufactured from elements of glass of different refractive indices minimises lens aberration. The collimated wavefront can be expanded in one plane by a pair of anamorphic prisms. This is to expand the 'short' axis of the elliptical cross section of light, emitted from the rectangular aperture of the diode surface. Values of magnification of 2, 4 and 6 are typically available.

For low cost applications, spheres can be used to collimate light from laser diodes as shown in Figure 7. With the output aperture of the diode located at the focal point of the sphere, a collimated beam will be produced, though of poorer optical quality than a compound lens system. Typical sphere diameters are 2, 3 and 5 mm. Anti reflection films typically of MgF are available for specific wavelengths of 633, 830, 1300 and 1550nm. Such spheres are often used for specific fibre to fibre coupling, where the beam cross section is significantly increased.

Power Supply Design

The theory of driving laser diodes is straightforward in as much as they are essentially current driven devices, with typically operating currents of around a few tens or hundreds of mA. It is the extreme sensitivity of the device to static and voltage spikes which certainly makes them difficult to interface using conventional design and construction techniques.

Due to the remaining high cost of laser diodes (typically around £50 but falling), while a circuit can be designed using low cost components, a hobbyist approach to construction can lead to a high cost of blown diodes. Even research establishments with considerable expertise in electronics may blow several devices before perfecting the design of their own circuits.

Initially the functioning of typical drive circuits is described. Figure 8 outlines the main features of a drive circuit. The current flowing is given by:

$$\frac{V_{fixed} - V_{var}}{R}$$

where V_{fixed} is a reference voltage and V_{var} is a voltage set by independent current adjustment and modulation signals. The clamp circuit prevents the voltage falling below a specific threshold value, hence limiting the output current. Normally circuits include a feedback control mechanism utilising an integral photodiode element in the laser diode unit.

Special precautions have to be taken to prevent turn on and turn off spikes which are a feature of normal power supply designs. Special filters are required to undertake this function. These cannot be allowed to interfere with the current modulation facilities of the device.

There are a range of approaches to implementing digital modulation of the diode current. One method is to establish high level and low level current limits for the high and low level logic signals (usually TTL). The modulation signal controls a fast cross over switch for switching between the current sources.

Circuits require, in addition, features to improve diode longevity such as automatic smooth current ramps during power on and power off. Specialist laser diode 'bench' power supplies Once set parameters have been specified and checked, the diode can be switched in.

Working with Diode Lasers

When handling diode lasers, strict antistatic precautions should be observed. Earthed wristbands should, for example, be worn. Also, soldering irons should be earthed. A silicon diode can be used as the dummy load during set up/ proving of circuits. Laser diodes will have typical specification for soldering at a temperature of 260°C for no more than 10 seconds at 2 mm from the laser body.

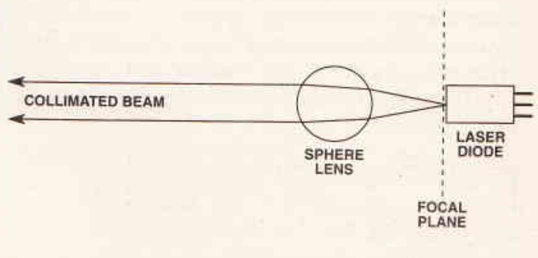


Fig.7 Sphere lens collimates the output from the laser diode though does not correct for asymmetry in beam profile

Figure 9 shows a simple circuit used with an NEC NDL 3200 diode while Figure 10 shows a circuit for optical mean power control for STC laser diodes. In Figure 10 the 3140 amplifier IC1 compares the set value of laser current $I_{(f)}$input to pin 2 with the feed back value registered on pin 3. The output of IC1 is fed to the inverting input of IC2 via a pair of 1N4148 diodes. The current signal from the integral photodiode is fed back to the input of IC2. This controls the maximum value of IF and provides an optical power control of the laser diode. Modulation current can be AC coupled into the laser diode cathode. Where a 50R impedance driver is used, a 47R terminating resistor should be series mounted as close to the laser pin as possible. A highly stable, transient free power supply should be employed.

'Off the Shelf' Modules

At present laser diodes are expensive for the hobbyist to purchase in small qualtities. What can be more attractive, is to purchase the laser diode module as an integral package with case, lens system and power supply. Since a volume manufacturer can purchase laser diodes at large discount, they can be incorporated into a 'ready to run package for the equivalent purchase price of a single laser diode or less.

In the UK, the Applied Laser Systems laser diode, which is a Class 3a laser with output at a wavelength of 670nm, is available from Spiers Robertson of Bedford for £125 + VAT. The ALS module runs from a 5-10V DC power supply and can deliver between 1 mW and 5mW of output of deep red light using a single lens element. The beam diameter is 4mm by 0.6mm and it expands typically to a 120mm diameter circle at 15 metres range.

The device is small and compact, approximately 2.85mm diameter and 14.7mm long with a current consumption typically of 55mA which can be supplied by a battery. As an off the shelf ready to run option there is a lot to recommend it. The He-Ne laser, however, with its more eye sensitive response, can be run at lower power levels for the same apparent level of illumination.

Speirs Robertson can be contacted at:
Moliver House,
Oakley Road,
Broxham,
Bedford
Tel: 02302 3410

Safety Considerations

The use of lasers is strictly controlled by national and international standards. In the UK the appropriate standard is BS7192. This provdes definitionson the various classes of laser ranging from Class 1, Class 2, Class 3, Class 3a and Class 4. Typically low power diode lasers will either be Class 1 or Class 2 though the exact classification will depend on power output, whether pulsed or continuous and wavelength of radiation. The standard allows determination of what Class is applicable to a particular mode of laser radiation.

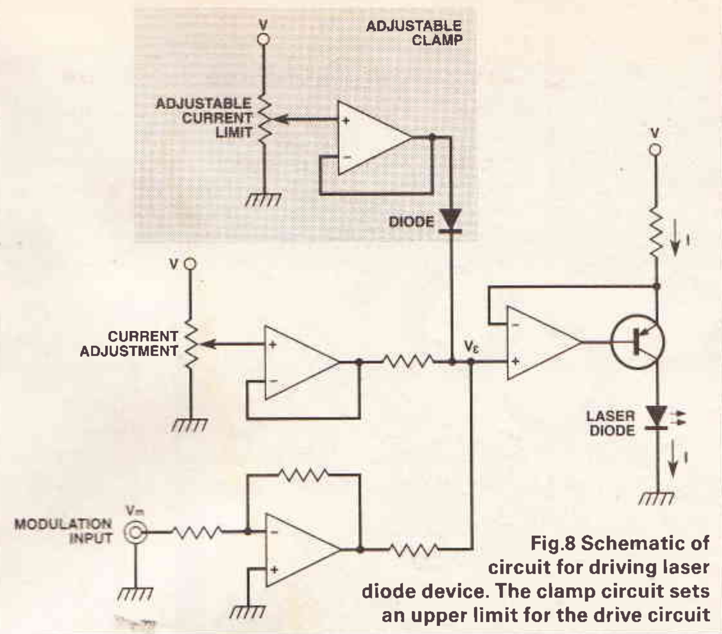


Fig.8 Schematic of circuit for driving laser diode device. The clamp circuit sets an upper limit for the drive circuit

Looking Ahead

Laser diodes have already found a broad range of applications in the fields of telecommunications, medicine, and optical data storage. There is every indication, however, that as their cost is reduced still further, wholly new applications will come to light. It is a challenging prospect.

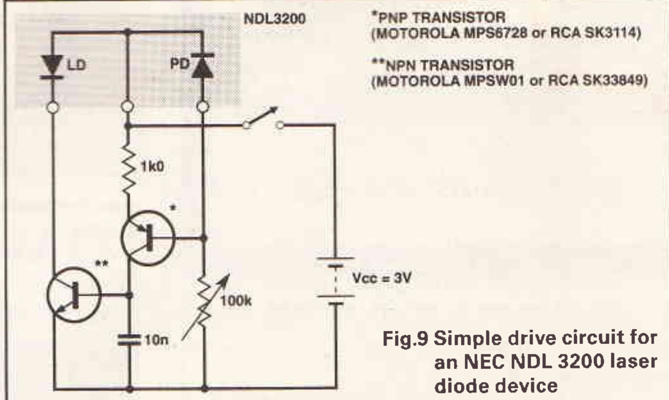


Fig.9 Simple drive circuit for an NEC NDL 3200 laser diode device

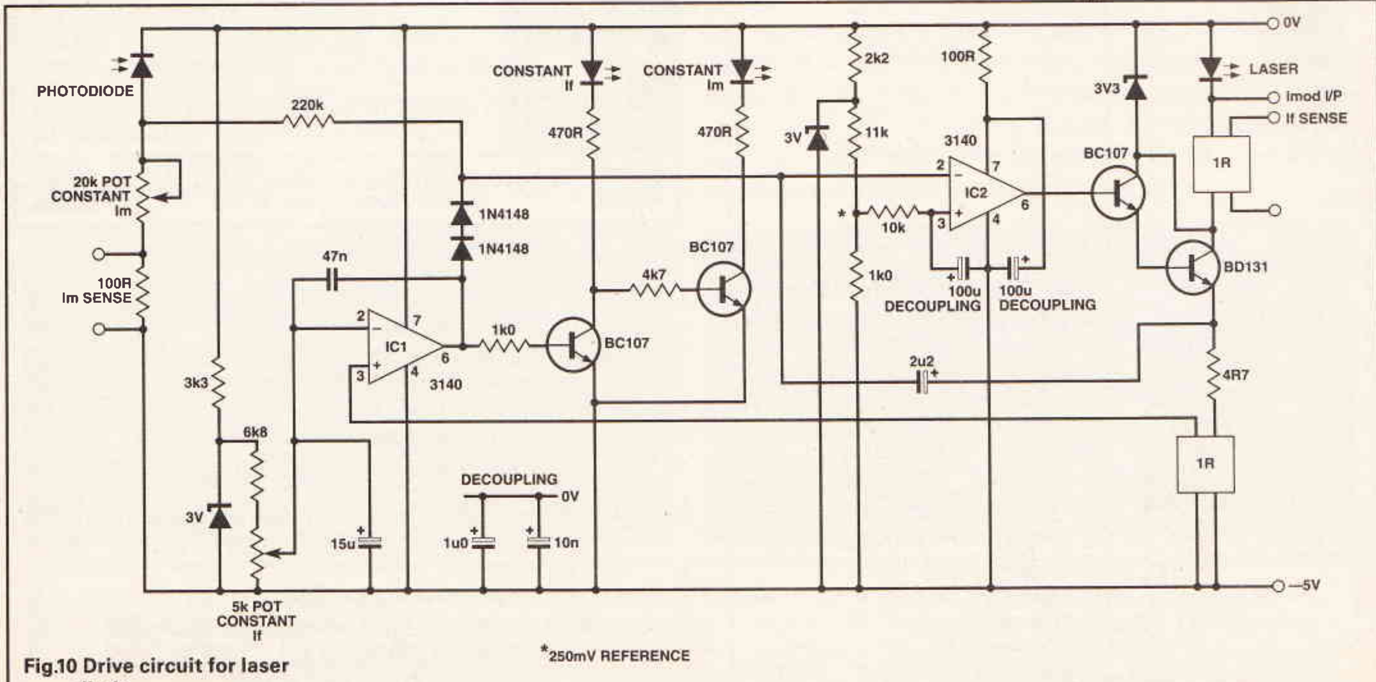


Fig.10 Drive circuit for laser diode

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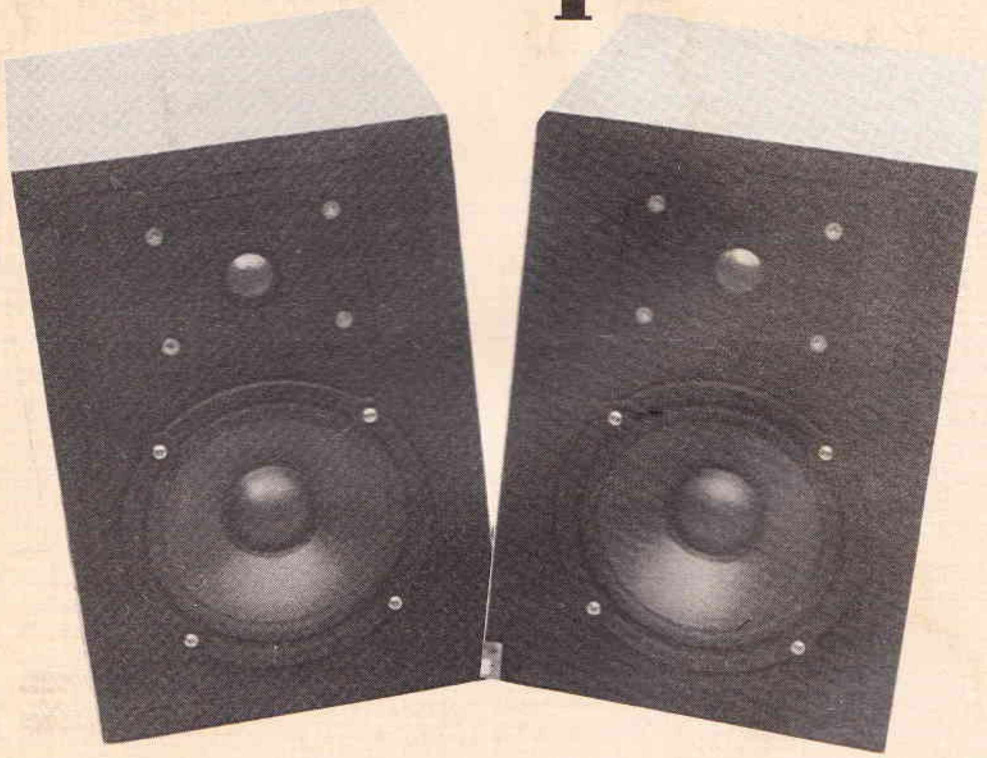
Consort Speaker



PROJECT

Influenced by ETI projects, Peter Roberts has produced another active loudspeaker design

Here is a Loudspeaker project with a difference. The Consort is an active design with a negative output resistance amplifier, which increases the damping and lowers the bass distortion. It was inspired by the ETI speaker articles (July 89) and the Flatmate project (May 90) of Jeff Macauley, also the work of Thiele. Thiele published his loudspeaker design work 30 years ago this year. Happily the advent of operational amplifiers makes it much easier now than it was then to implement Thieles ideas. The writer absolutely agrees with Mike Fox's comments in the K2 loudspeaker (ETI Feb 91) that the loudspeaker has not been given the importance it deserves by the specialist media. This design uses different techniques to achieve the same ends as the K2.

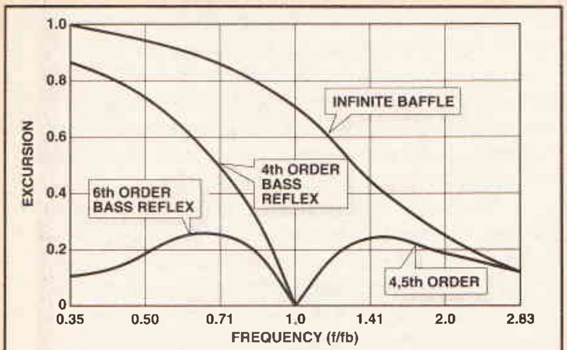


Fig.1 Cone excursion against frequency for different designs (Cabinet, drive unit and cut-off frequencies identical)

Design

The aim of the Consort is to give an extended bass response (-3dB at 38Hz) in a small cabinet size (12.7 litres). Also to give a high quality sound, whilst being cost effective, these are compatible, despite what some

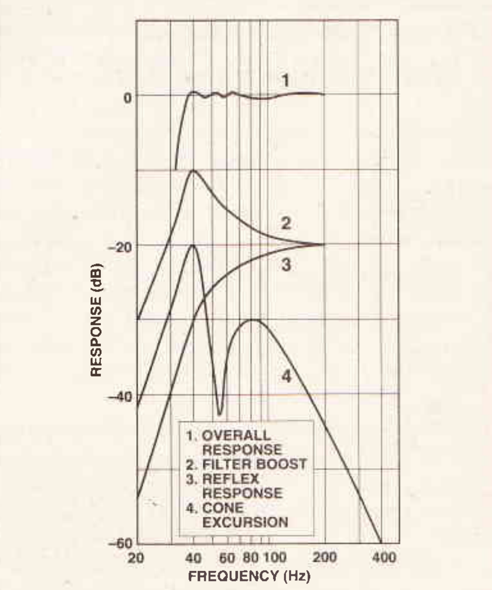


Fig.2 Individual and overall reponses to speaker parts

would have you believe. The unit uses a 165mm polypropylene coned woofer and a British made Acoustic Engineering Ltd metal dome tweeter.

Like the Flatmate it is a sixth order bass reflex design. To see why this is used, look at Figure 1 which shows the cone excursion with frequency for various designs. Note how much lower the cone excusions are for the bass reflex than the infinite baffle design. The extra filter in the sixth order design lowers the excursion below f_{box} compared with the standard 4th order bass reflex design. The curves also show predicted zero-excursion at the box tuning frequency (determined by the port) This is where all the sound is

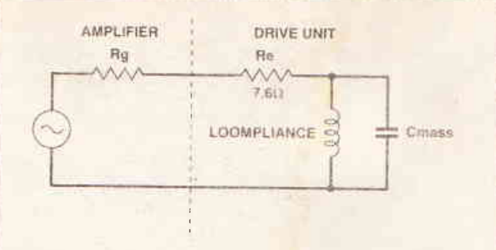


Fig.3 Simplified equivalent circuit of amplifier/ speaker

theoretically coming out of the port. In practice losses will mean that the cone movement is not zero but it will be low.

The sixth order design presents 3 main possibilities. Either a higher acoustic output for the same cone movement or lower distortion for a given sound level, alternatively the useful response can be pushed lower in frequency for the same cone excursion that the infinite baffle would give. This latter option is used in The Consort. To observe this. Figure 2 shows the bass boosted signal applied from the extra filter. This equalises the speaker response giving an overall flat characteristic. The overall response is a correctly aligned Chebychev high pass filter with in this case 0.1dB of ripple.

For this design the port is tuned to 90% of the drive unit resonant frequency and the extra filter to 67% of the resonance giving a -3dB point at 66% of the driver resonance (58Hz), thus giving the -3dB level at 38Hz.

As Jeffs article pointed out there are 3 drive unit parameters one must know for designing a bass reflex speaker. These are the resonant frequency, the Qts and the volume equivalent of compliance, this last being a measure of the stiffness of the cone and coil surrounds. For any design there will only be one combination of parameters which is correct. It is difficult to achieve this combination, which is why the bass reflex speaker is tricky to design.

The first aspect of the design is the proposed box size. The air in the box acts as an acoustic spring. This compliance has to be matched to the drive unit compliance by a factor (1.31 for this design). Now most woofers are designed for infinite baffle use, which demands a high compliance of typically 60 litres or more. This would give a box size 60/1.31 about 45 litres, which is a big box. It is difficult to find low compliance drive units. The writer found one with a compliance of 14 litres which gives a box size of 14/1.31 i.e 10.7 litres. In practice 2 litres are taken up with the port tube, drive unit volume and electronics volume so the final internal size is 12.7 litres.

Unfortunately the drive unit has a Qts of 0.79 which is too high for this design, which requires 0.38. Thiele's work suggested using a negative output resistance amplifier to lower the woofer Q (another way of saying increasing the damping) and it has the added benefit of lowering the distortion. The woofer specified has to be used; any other unit will not work properly.

Negative Resistance

A simplified equivalent circuit for an amplifier/speaker combination is shown in Fig .3 The inductor and capacitor represent the suspension compliance and cone and coil mass respectively. They form a tuned circuit which gives the free-air resonant frequency. Unfortunately the coil resistance Re, stops the amplifier from applying more damping. Damping is achieved by partially shorting out the tuned circuit. If the amplifier output resistance, Rg could be made negative the total resistance in the circuit would be less and more damping would be applied to the tuned circuit.

The March 91 Blueprint in ETI shows how to realize the negative resistance circuit. Basically a sense resistor in the woofer output lead, senses the current and positive current feedback is used to make the output resistance negative. A word of warning; if the total resistance in circuit is negative i.e the coil resistance is less than the negative resistance, the circuit will oscillate because the gain of the amplifier is theoretically infinite.

The formula for the reduction in Q is:

$$Q(required) = 1/Qm + 1/Qe\ (1/(1 + Rg/Re))$$

where Qm and Qe are the drive unit mechanical and electrical Q's respectively . For this design Qm is 3.1, Qe is 1.06, Q required is 0.38 and Re (coil resistance) is 7.6R. Giving a value of Rg of −4.5R. In practice, to

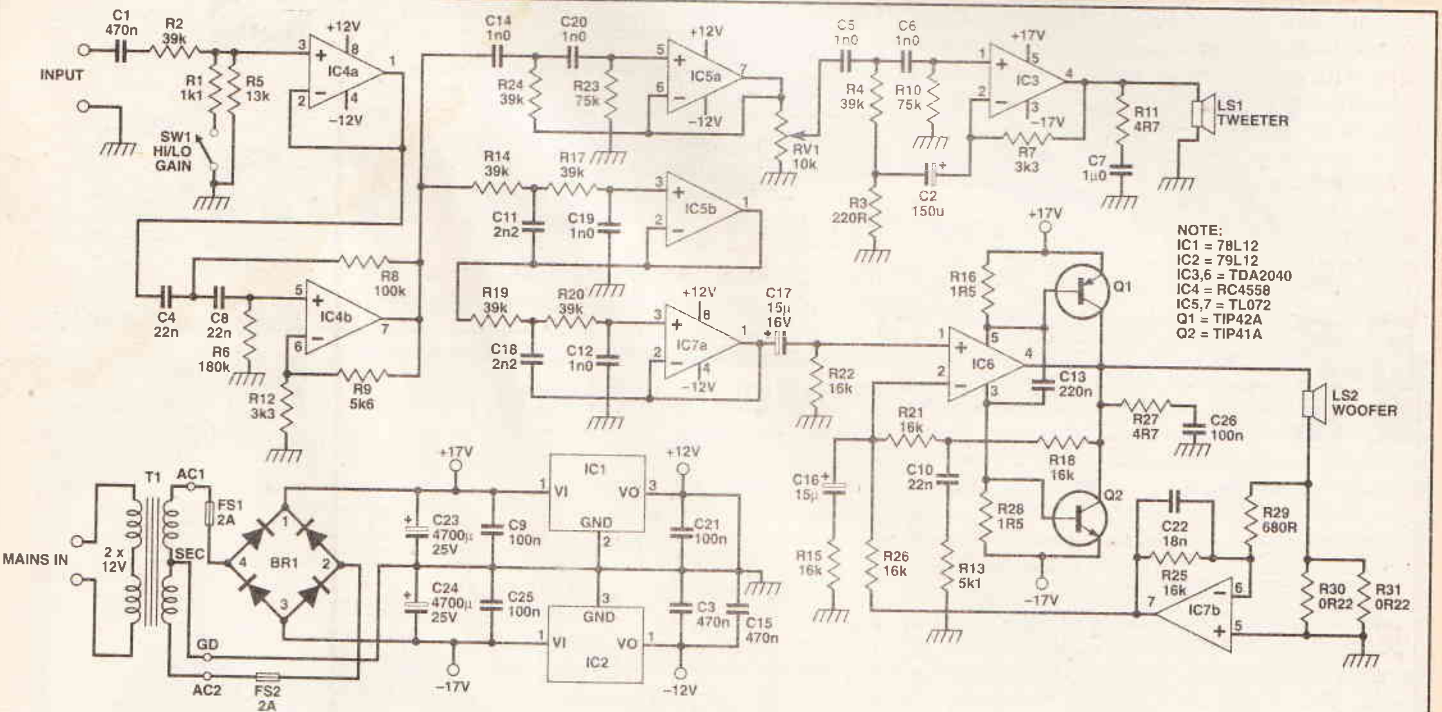


Fig.4 Complete circuit diagram of The Consort

PROJECT

compensate for voice coil heating and the consequent increase in resistance, a value of −5R is used.

Circuit Design

Integrated circuit power amplifiers are used to implement the amplifier design. This simplifies the design of the negative resistance circuit. The positive feedback is rolled off at higher frequencies. This stops the rising drive unit impedance (caused by the inductance of the voice coil) lowering the output. At high frequencies the negative resistance does not acoustically damp the speaker, anyway. The negative feedback is reduced at the same time giving a flat response into the speaker load. The ICs have a distortion of 0.03% so are genuine hi-fi components. Transistor power assistance is used on the woofer amplifier to lower the distortion at the low frequency extreme. Since the maximum voltage these amplifiers will take is 40V, the transformer secondaries should be no greater than 12V.

PCB Construction

The building of the electronics is simplified because all components bar the transformer are PCB mounted. The Veropins for the connections should be fitted to the PCB first as they may need some force applied. A tap with a light hammer with the PCB supported on a wooden block is easiest. The electrolytics, bridge rectifier and ICs only go one way round. A link is required between holes B and C on the PCB. The power transistors and power ICs should be fixed on the heatsink before soldering. See Figure 5. The kits have predrilled and tapped heatsinks. Using a multimeter check for insulation between the device mounting screw and the device metal case. Once all the components have been soldered in and the fuses clipped in, a test can be done by connecting the transformer (careful with the mains here!) and switching on. Check that the supplies are about 17v and the supplies to the 8 pin ICs pins 4 and 8 are −12 and +12V respectively. The output DC voltages should be zero. If the voltages are zero speakers may be connected up (after switching off). Touching the input pin should now produce a hum.

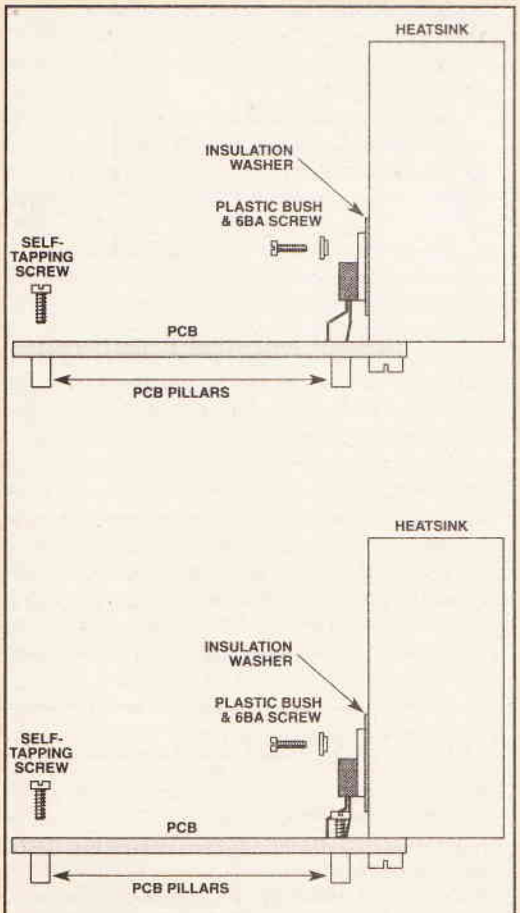


Fig.5 Heatsink mounting details

Cabinet Construction

15mm chipboard or MDF board is used for the construction of the cabinet (except for the baffle) and may be plain, melamime or laminate faced. The writer used laminate faced material for the prototype. This produces slightly stiffer panels which give better panel damping. it would be easiest to buy the panels cut to size. The prototype baffles were made by glueing together a 12mm plywood sheet with a 4mm plywood sheet. The 12mm plywood being cut with a jigsaw to accept the speakers apertures and the 4mm plywood cut to match the speaker face. When the two are glued together the recess or rebate for the speakers is formed. The edge of the woofer inner hole should be bevelled slightly. The tweeter terminal cutouts are marked out by drawing around the gasket, then enlarging to 12mm sq. The drive units can now be offered up and the blind mounting holes marked and drilled with a 2.5mm drill.

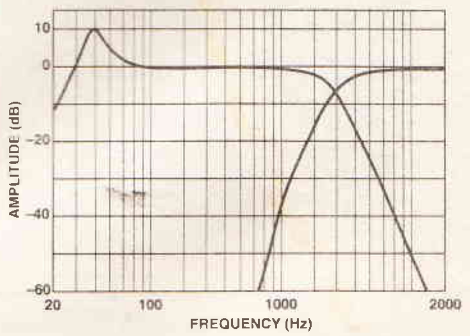


Fig.6 Actual response of woofer and tweeter outputs

If you have a router then you can use chipboard/MDF for the baffle and cut the recesses with the router. A jigsaw was used to cut the recess plate cut-out and port tube apertures in the back panel. A Flapwheel is useful here for smoothing out irregularities. The port tube is a 152 mm length of 50mm plastic tubing which is glued into the back panel with epoxy adhesive. 12mm square battens should be pinned and glued to the sides, top and bottom panels 16mm in from their front edge for the baffle to seat against (leave clearance for the corners). The sides, top and bottom are now screwed and glued together. If plain chipboard is used wood glue can be used, but for faced material epoxy resin or similar is better. The faced surface (where glued) should be keyed with wet and dry paper. At this point check for leaks and seal with epoxy resin or polyfilla. To work properly the cabinet must be leak-proof!

Panel damping material may now be applied. Wickes flashing strip being self adhesive and apparently made from pure bitumen is ideal for this. A 100mm wide strip is applied in a continuous length around 4 sides of the cabinet (except where the PCB is to be). Obtain a 3m roll and use it up on a pair of boxes, if neccesary applying a double layer. If unfaced board is used the surface should be sealed before sticking the self adhesive strip (do not use the supplied primer for this unless you want to wait a week for it to stop outgassing vapours).

The strip should be well smoothed down when sticking it. The pilot holes for fixing the transformer and PCB can now be drilled.The transformer can be mounted on the panel damping material to stop the

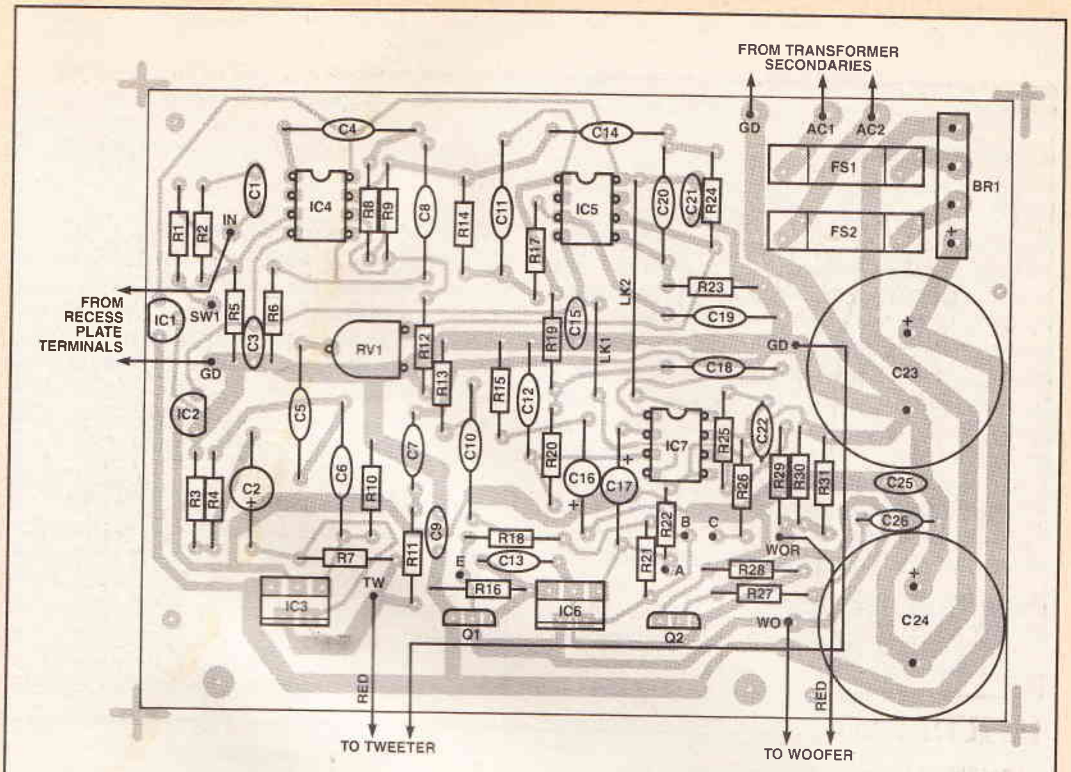


Fig.7 Component Overlay for The Consort

cabinet acting as as sounding board for any transformer mechanical noise.The back panel can now be screwed and glued in. Check for leaks again.

Assembly

Solder some twisted pair leads to the PCB for the inputs, outputs and supply. Set the pot RV1 toto halfway in its travel. Fit the transformer and PCB to the cabinet. The mains cable gland can now be fitted to the recess plate, which has built-in terminals. Solder the input wires to the terminals and run the mains lead through the gland. Temporarily fit the recess plate to the back panel. Connect the transformer and loudspeakers up, so that you can check everything works at this stage. It is best to set the tweeter level up now. Put the woofer temporarily in its baffle and the baffle temporarily in the cabinet. Apply a music signal and set the pot RV1 to give the correct treble balance when compared with another hi-fi speaker. When the tweeter level has been set and you are happy that everything is OK, switch off, disconnect the speakers, and clamp the leads to the cabinet, so they will not rattle.

The front baffle may be glued and screwed in. After connecting the speakers up, the woofer is sealed to the baffle by applying a continuous bead of silicone sealant to the recess. Use the supplied gasket to seal the tweeter. The drive units are then screwed to the baffle, the woofer with 3/4″ No.8 self tapping screws and the tweeter with CSK 3/8″ No. 10 screws. The woofer fixing is improved by using a 19mm dia. washer under the screw. The recess plate has a gasket to seal it.

In Use

The ideal position for the speakers, would be on stands, about 0.5 metres away from the rear wall. Put on your favourite record/CD and lie back and enjoy it. Used for television sound and especially digital stereo these speakers immeasurably enhance the experience of watching a film or TV prog. with decent sound (which most of them have). The deep bass gives an ambience similar to being in a cinema. The Consort could be used as a 'minimalist' system by feeding a CD player output directly into the loudspeaker inputs, or as an upgrade to a MIDI system.

Finally, most passive speaker designs have optimum damping and bass response when driven from the near zero output impedance of modern amplifiers. Indiscriminate use of the negative resistance technique on a passive design, could actually reduce the bass output, by overdamping the bass drive unit.

HOW IT WORKS

See circuit diagram Figure 4. Cl is a DC blocking capacitor to remove any DC offsets the user might apply from his signal source. This is followed by a switchable potential divider to make the overall gain of the system either unity (one) or ten. SWI (optional) is closed or the SW1 terminal is linked to ground to give a gain of one. The switch could be fitted to the rear recess plate.

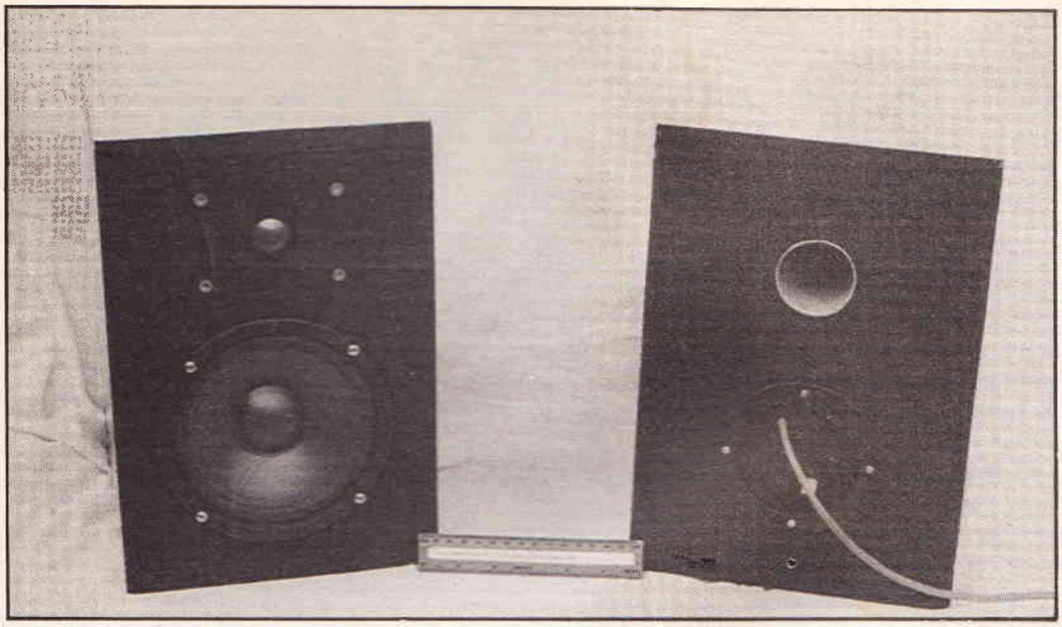
Unity gain is provided so that existing amplifiers and their settings can be used, also A-B comparisons made with passive speakers. If more gain is required the switch (or link) is opened giving a gain of ten times. Amplifier IC4a is used as a voltage follower, a low noise IC is specified here.

The extra filter, which gives the sixth order, is built around IC4b. It has a Q of 3.3 giving a gain of 10.4dB at 40 Hz. The Q is given by $1/(3-a)$ where a is $(R10+R13)/R13$ and the turn over frequency by $1/(2\pi\,R7C5)$ for C5=C9 and R7=R9. This is followed by the cross over filters which are cascaded 2nd order types giving a cross-over frequency of 2.9kHz. The 2nd high pass filter for the tweeter is built around the power amplifier. potentiometer RVI controls the tweeter output. The pot could be replaced with a rear recess plate mounted one.

Positive current feedback is applied to power amplifier IC6 by amplifier IC7b. The positive feedback is rolled off at high frequencies by C23. To compensate for the loss in gain at high frequencies, the negative feedback around IC6 ie. R19 and R22,is shunted by C11 and R14 giving less feedback and hence more gain at high frequency. An overall flat response is obtained. The negative resistance is given by: $-(R31/2)\,R26(R22+R19)/R27R30$. See Figure 6 for the actual response measured across the woofer and tweeter outputs, the woofer output being loaded by a 7.6R resistor.

BUYLINES

A designer approved kit for constructing a pair of loudspeakers is £188 inc. VAT and carriage. A PCB kit is £55 a pair inc. and a drive unit kit also containing the speaker fixings, port tubes, the transformers, mains leads, glands and recess plates is £94 a pair inc. A flat-pack tvpe cabinet kit is available in black ash finish for £39 a pair inc. All from Memex Electronics Ltd, 1 Icknield close, Ickleford, Hitchin, Herts SG5 3TD



PARTS LIST

RESISTORS (all 1% metal film except R30,31 10%)

R1	1k1
R2,4,14,1719,20,24	9k
R3	220R
R5	13k
R6,8	180k
R7,12	3k3
R9	5k6
R10,23	75k
R11,27	4R7
R13	5k1
R15,18,21,22,25,26	16k
R16,28	1R5
R29	680R
R30,31	0R22
RV1	10k preset

CAPACITORS

C1	470n poly
C2	150µ 6V3
C3,15	470n 25V Ceramic
C4,8,10	22n 1% polypropylene
C5,6,12,14,19,20	1n0 2.5% polystyrene
C7,26	100n 100V poly
C9,21,25	100n 25V Ceramic
C11,18	2n2 2.5% poly
C13	220n 100V poly
C16,17	15µ 16V
C22	18n 5% poly
C23,24	4700µ 25V

SEMICONDUCTORS

IC1	78L12
IC2	79L12
IC3,6	TDA2040
IC4	RC4558
IC5,7	TL072

MISCELLANEOUS

BR 1	BRIDGE RECTIFIER 4A 200V
Q1	TIP42A
Q2	TIP41A
T1	2×12V 2A Secondaries
FS 1	2 Fuses 2A 20mm
Fuse Clips	
Heatsink	
PCB	
TO220 Mounting Kit (4)	
Terminal Pins	
Mounting Bushes	

SPEAKER COMPONENT LIST

165mm Polypropylene cone woofer
AEL metal dome tweeter
Recess Plate
Port Tube
Gland for mains lead
2 Core Mains lead
Fixing screws and washers
REMEMBER to double quantities for a pair

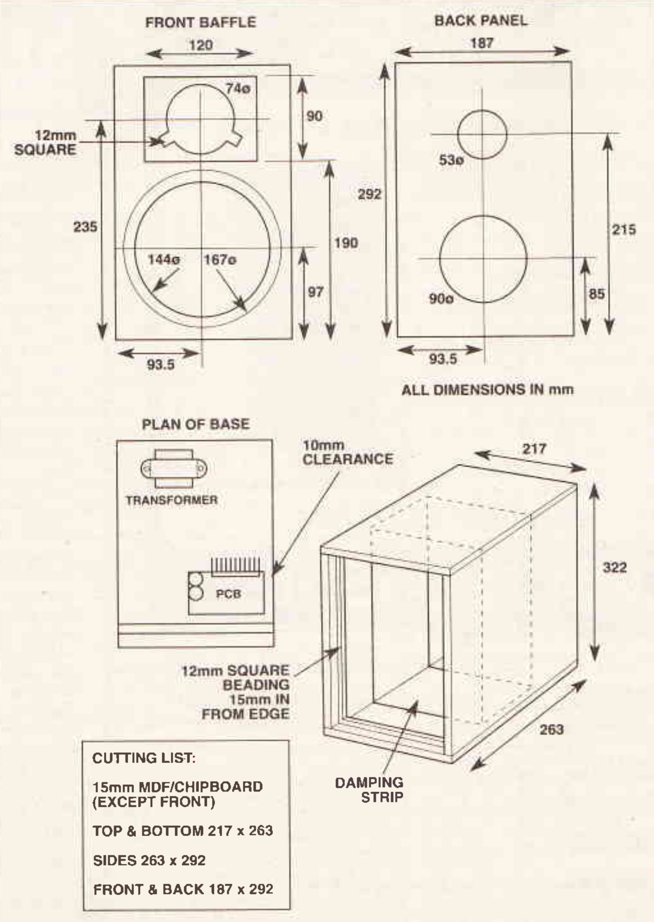


Fig.8 Constructional details of cabinet

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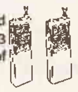

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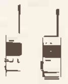

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TELEPHONE AUTODIALLERS. These units, when triggered will automatically dial any telephone number. Originally made for alarm panels. BT approved. £12.00 ref 12P23 (please state telephone no req'd).

25 WATT STEREO AMPLIFIER c. STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69 (Circuit dia included).

LINEAR POWER SUPPLY. Brand new 220v input +5 at 3A, +12 at 1A, -12 at 1A. Short circuit protected. £12.00 ref 12P21.

MAINS FANS. Snail type construction. Approx 4"x5" mounted on a metal plate for easy fixing. New £5.00 5P166.

POWERFUL IONIZER KIT. Generates 10 times more ions than commercial units! Complete kit including case £18.00 ref 18P2.

MINI RADIO MODULE Only 2" square with ferrite aerial and tuner. Superhet. Req's PP3 battery. £1.00 ref BD716.

HIGH RESOLUTION MONITOR. 9" black and white Phillips tube in chassis made for OPD computer but may be suitable for others. £20.00 ref 20P26.

BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92, PACK OF 100 £30.00 REF 30P16

CB CONVERTORS. Converts a car radio into an AM CB receiver. Cased with circuit diagram. £4.00 ref 4P48.

FLOPPY DISCS. Pack of 15 31/2" DSDD £10.00 ref 10P88. Pack of 10 51/4" DSDD £5.00 ref 5P168.

SONIC CONTROLLED MOTOR One click to start, two click to reverse direction, 3 click to stop! £3.00 each ref 3P137.

FRESNEL MAGNIFYING LENS 83 x 52mm £1.00 ref BD827.

BULL ELECTRICAL

250 PORTLAND ROAD HOVE SUSSEX BN3 5QT TELEPHONE 0273 203500

MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £2.50 POST PLUS VAT.

PLEASE ALLOW 10-14 DAYS FOR DELIVERY

VISA

FAX 0273 23077

LCD DISPLAY. 4 1/2 digits supplied with connection data £3.00 ref 3P77 or 5 for £10.00 ref 10P78.

ALARM TRANSMITTERS. No data avaliable but nicely made complex transmitters 9v operation. £4.00 each ref 4P81.

100M REEL OF WHITE BELL WIRE figure 8 pattern ideal for intercoms, door bells etc £3.00 a reel ref 3P107.

TRANSMITTER RECEIVER SYSTEM originally made for nurse call systems they consist of a pendant style transmitter and a receiver with telescopic aerial 12v. 80 different channels. £12.00 ref 12P26

CLAP LIGHT. This device turns on a lamp at a finger 'snap' etc. nicely cased with built in battery operated light. Ideal bedside light etc £4.00 each ref 4P82.

ELECTRONIC DIPSTICK KIT. Contains all you need to build an electronic device to give a 10 level liquid indicator. £5.00 (ex case) ref 5P194.

UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36.

ONE THOUSAND CABLE TIES! 75mm x 2.4mm white nylon cable ties only £5.00 ref 5P181.

PC MODEMS 1200/75 baud modems designed to plug into a PC complete with manual but no software £18.00 ref 18P12

ASTEC SWITCHED MODE POWER SUPPLY 80mm x 165mm (PCB size) gives +5 at 3.75A, +12 at 1.5A, -12 at 0.4A. Brand new £12.00 ref 12P39.

VENTILATED CASE FOR ABOVE PSU with IEC filtered socket and power switch. £5.00 ref 5P190.

IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4,5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167.

CUSTOMER RETURNED switched mode power supplies. Mixed type, good for spares or repair. £2.00 each ref 2P292.

DRILL OPERATED PUMP. Fits any drill and is self priming. £3.00 ref 3P140.

PERSONAL ATTACK ALARM. Complete with built in torch and vanity mirror. Pocket sized, req's 3 AA batteries. £3.00 ref 3P135

POWERFUL SOLAR CELL 1AMP .45 VOLT only £5.00 ref 5P192 (other sizes avaliable in catalogue).

SOLAR PROJECT KIT. Consists of a solar cell, special DC motor, plastic fan and turntables etc plus a 20 page book on solar energy! Price is £8.00 ref 8P51.

RESISTOR PACK. 10 x 50 values (500 resistors) all 1/4 watt 2% metal film. £5.00 ref 5P170.

CAPACITOR PACK 1. 100 assorted non electrolytic capacitors £2.00 ref 2P286.

CAPACITOR PACK 2. 40 assorted electrolytic capacitors £2.00 ref 2P287.

QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92.

LED PACK. 50 red leds, 50 green leds and 50 yellow leds all 5mm £8.00 ref 8P52

FERRARI TESTAROSSA. A true 2 channel radio controlled car with forward, reverse, 2 gears plus turbo. Working headlights. £22.00 ref 22P6.

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

TOP QUALITY MICROPHONE. Unidirectional electret condenser mic 600 ohm sensitivity 16-18khz built in chime complete with magnetic microphone stand and mic clip. £12.00 ref 12P42.

WASHING MACHINE PUMP. Mains operated new pump. Not self priming. £5.00 ref 5P18.

IBM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186.

COPPER CLAD STRIP BOARD 17" x 4" of 1" pitch "vero" board. £4.00 a sheet ref 4P62 or 2 sheets for £7.00 ref 7P22.

STRIP BOARD CUTTING TOOL. £2.00 ref 2P352.

3 1/2" disc drive. 720K capacity made by NEC £60.00 ref 60P2

TV LOUDSPEAKERS. 5 watt magnetically screened 4 ohm 55 x 125mm. £3.00 a pair ref 3P109.

TV LOUDSPEAKERS. 3 watt 8 ohm magnetically screened 70 x 50mm. £3.00 a pair ref 3P108.

BBC TRACKBALLS Once again in stock only £4.00 ref 4P86

CROSS OVER NETWORKS 8 ohm 3 way Japanese made units. Excellent units avaliable at only £2.00 for a pair! ref 2P363

SPEAKER GRILLS set of 3 matching grills of different diameters. 2 packs for £2.00 (6 grills) ref 2P364

50 METRES OF MAINS CABLE £3.00 2 core black precut in convenient 2 m lengths. Ideal for repairs and projects. ref 3P91

4 CORE SCREENED AUDIO CABLE 24 METRES £2.00 Precut into convenient 1.2 m lengths. Ref 2P365

TWEETERS 2 1/4" DIA 8 ohm mounted on a smart metal plate for easy fixing £2.00 ref 2P366

COMPUTER MICE Originally made for Future PC's but can be adapted for other machines. Swiss made £8.00 ref 8P57. Atari ST conversion kit £2.00 ref 2P362.

6 1/2" 20 WATT SPEAKER Built in tweeter 4 ohm £5.00 ref 5P205

5" X 3" 16 OHM SPEAKER 3 for £1.00!! ref CD213

ADJUSTABLE SPEAKER BRACKETS Ideal for mounting speakers on internal or external corners, uneven surfaces etc. 2 for £5.00 ref 5P207

PIR LIGHT SWITCH Replaces a standard light switch in seconds light operates when anybody comes within detection range (4m) and stays on for an adjustable time (15 secs to 15 mins). Complete with daylight sensor. Unit also functions as a dimmer switch! 200 watt max. Not suitable for flourescents. £14.00 ref 14P10

2 MEG DISC DRIVES 3 1/2" disc drives made by Sony housed in a 5 1/4" frame 1.2 meg formatted. £66.00 ref 66P1.

360K 3 1/2" DISC DRIVES 1/2 height £25.00 ref 25P26

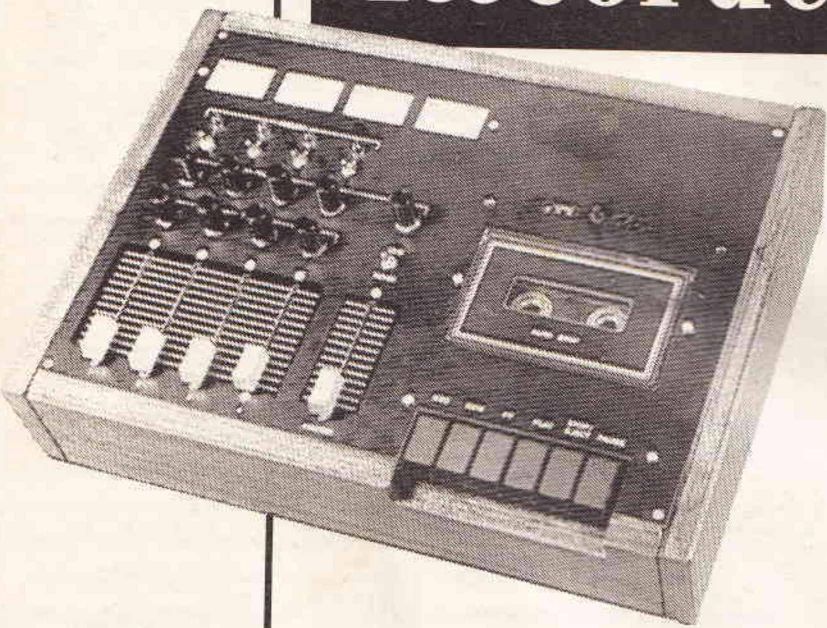
40 CHANNEL TRANSCEIVER 4 WATT OUTPUT, HANDHELD SQUELCH CONTROL ETC £70.00 EACH REF 70P1

OR AVALIABLE AS A PAIR WITH NICAD BATTERY PACKS FOR £150.00 REF 150P1

Illuminated channel display, 10 section aerial, Hi-Low power switch, external aerial socket, DC charger socket, 12v DC power socket, carrying strap and owners manual.

SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

Four Track Recorder Update



Tom Scarff provides some modifications to the Bias/Erase oscillator.

In the original design of the four-track cassette recorder (ETI Nov'90) the Bias/Erase Oscillator specified was the Toko 724 BOR 1078N, however it appears this unit is no longer available from any source.

Unfortunately Toko do not manufacture a physically similar unit, so a replacement will involve some modification to the original PCB design.

One design that could be used is shown in Figure 1 which utilises the erase heads as part of the feedback network of a Clapp Oscillator. The wiring modifications require that the earth returns from the erase heads and the erase dummy loads are connected back to the oscillator. This means the variable resistor of the erase dummy load should not be connected to the ground line on the PCB.

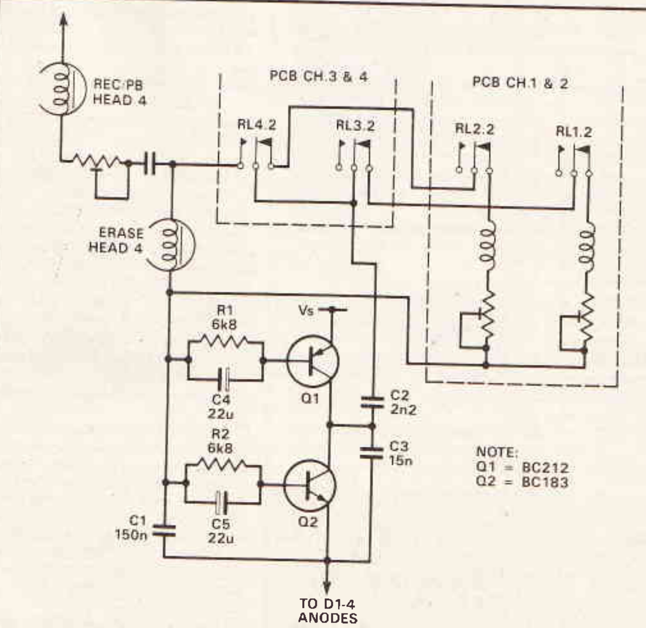


Fig. 1 Wiring circuit for Bias/Erase oscillator and connections to dummy load.

With the components specified the circuit operates at the original Bias/Erase frequency, however it should be noted that it depends on the four-track erase head being used.

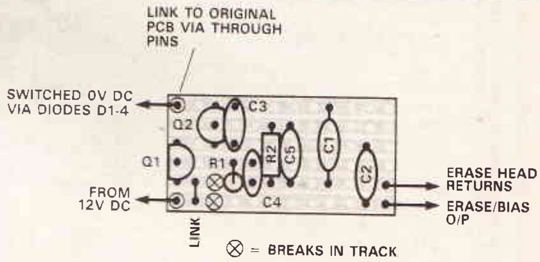


Fig. 2 Component overlay for Bias/Erase oscillator.

If necessary the component values can be changed to suit other heads. The capacitor C2 can be varied to change the frequency and the output voltage can be increased by increasing the value of C3 and reducing the value of R1 and R2. However experimentation may be required as some variations of components will cause oscillation to cease.

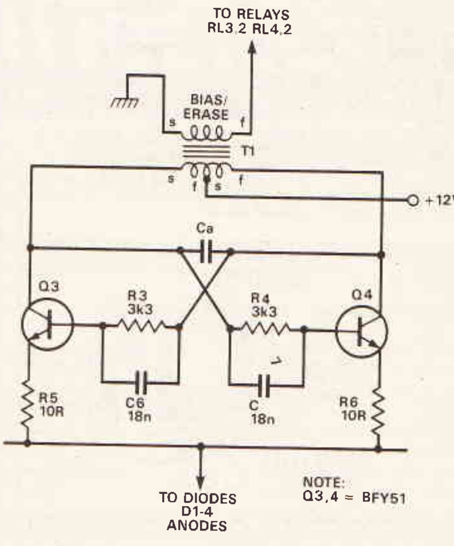


Fig. 3 Alternative Bias/Erase oscillator.

If the required output voltage cannot be obtained the loading on the oscillator can be reduced by including bias traps, a parallel tuned L-C network, in series with the output amplifiers.

The components for the oscillator can be mounted on a piece of 0.1" matrix Veroboard as shown in Figure 2 with two Vero through-pins providing the connections and mounting to the original PCB.

While the above circuit is suitable for the minimum number of changes to the original circuit it is very component dependable and a better overall solution may be to use a separate current-switching oscillator as shown in Figure 3, but this will require the winding of a suitable transformer.

PARTS LIST

RESISTORS (all ¼W 5%)		Ca	sets frequency 0.1μ approx
R1,2	6k8		
R3,4	3k3	**SEMICONDUCTORS**	
R5,6	10R	Q1	BC212
		Q2	BC183
CAPACITORS		Q3,4	BFY 51
C1	150n		
C2	2n2	**MISCELLANEOUS**	
C3	15n	T1	Primary, 5+5 turns 26SWG
C4,5	22μ		Enamel wire, Secondary, 100 turns 34SWG
C6,7	18n		Pot core 26mm Type LA2332 or equivalent

Amateur Microwave Equipment

Geoffrey Heys G4GEB reports on some amateur equipment used at SHF

In this article we will have a look at some items of equipment designed and built by the radio amateur and examine some theoretical aspects concerning this equipment.

Radio Amateurs are allowed to operate on a range of microwave frequencies shown in Table 1.

Table 1
AMATEUR MICROWAVE ALLOCATIONS

Abbreviated frequency allocations in MHz.
1240-1325.
2310-2450.
3400-3475.
5650-5680.
5755-5765.
5820-5850.
10000-10500.
24000-24250.
47000-47200.
75500-76000.
142000-144000.
248000-250000.

Of the frequencies seen here, probably the most popular band is the 10,000MHz or 10GHz.band. This corresponds to a wavelength of 3cm and falls within what is known as X-band. The reason for its popularity is because it has been easy to construct free running oscillators working on this frequency, using either klystrons or Gunn effect devices. In recent years there has been increasing use of the lower frequency bands with equipment that converts from , 70cm, using either narrow band FM or SSB.

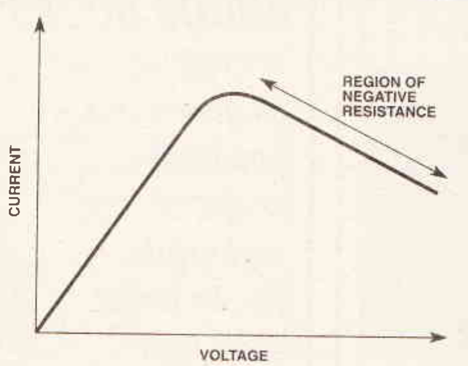


Fig.1 Voltage versus current characteristic of a Gunn diode

Methods Of Propagating Microwaves

Coaxial cable can be used to propagate microwave frequencies.It has the advantage that the used frequency is almost unlimited, but somewhat lossy. These losses consist of two parts, series losses in the copper conductor and shunt losses in the dielectric. The copper


1GHz Transceiver of in-line mixer type

losses depend on the cable size and vary directly with the square root of the frequency, the dielecric losses are independent of cable size and vary directly with the frequency. Dielectric losses become increasingly important in the microwave region. The use of braid as the outer conductor produces severe attenuation at frequencies like 10MHz compared to solid conductors.

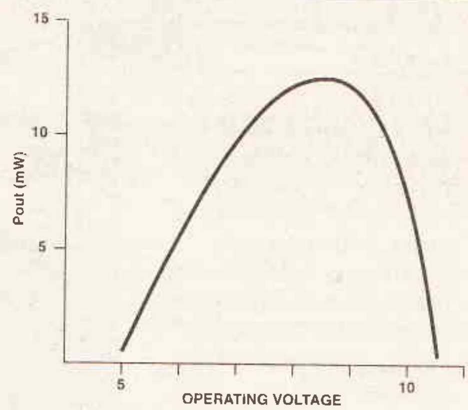


Fig.2 Output power versus operating voltage for a low power Gunn diode

Sometimes 'lossy' coaxial cable is deliberately used as an isolating device, usually in test equipment. Coaxial cable is not used professionally for carrying high radiofrequency power since it suffers from voltage and thermal breakdown.

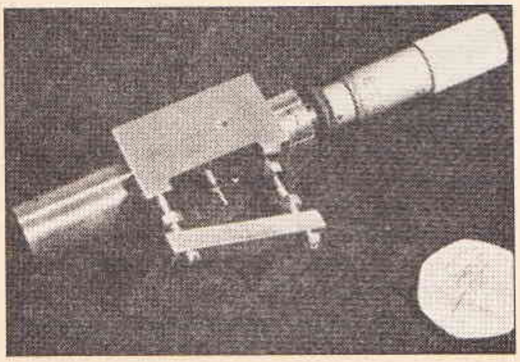
An alternative to coaxial cable is the use of waveguide. This is a hollow tube of metal through which electromagnetic energy can be transmitted. Waveguide may be circular or rectangular in cross section. The way in which the energy is sent out can be explained by considering how electric and their associated magnetic fields behave when confined by the waveguide. Circular waveguide is rarely used in ama-

SHF

teur equipment so we will deal with rectangular type. It can be shown that electromagnetic radiation can be propagated in a given guide in an infinite number of wave types or modes. In general there are two types of mode, these are 'transverse electric' (TE) waves because their electric fields are transverse to the axis of the guide and 'transverse magnetic' (TM) waves because their magnetic fields are transverse to the guide axis. (Electro-magnetic waves consist of an electric component and a magnetic component, one being perpendicular to the other.)

Each mode has a lower critical frequency below which it will not go down the guide. This is known as the cut-off frequency for that mode. In a given size of waveguide the mode with the lowest cut-off frequency is known as the lowest mode for that guide and will be the only one propagated if the frequency is greater than its cut-off frequency and less than the cut-off frequency for the second lowest mode. So the lowest mode cut- off frequency is comparable to the size of the guide. In general the lowest mode is used in waveguide, this being called the TE_{10} mode. The cross sectional dimensions of the guide are selected according to the frequency in use, which in practical terms means that waveguide 16 is used for operation at 10GHz.; another similar waveguide size is known as 'Old English'.

Waveguide has comparatively low transmission loss when compared with coaxial cables. Its disadvantage is that a certain size of guide cannot be used below a critical frequency and it is seldom used above twice this frequency. Another point in favour of waveguide is that components may be built inside and around it, enabling a complete, waveguide based RF system to be assembled. It is also more resistant to breakdown at high power than coaxial cable.



Absorption Wavemeter for X-Band

Waveguide may be straight, bent or twisted to a variety of shapes, it may also take the form of flexible waveguide. It is joined by using flanges and sometimes these flanges have RF chokes machined into them.

Wavemeters

In order to comply with the licencing conditions it is highly desirable to be able to measure the frequency of operation of equipment. (This is particularly so when using free running oscillators compared with crystal controlled equipment). Nowadays it is possible to obtain digital frequency meters that operate up to many Gigahertz. Needless to say, these are expensive. An alternative approach is to use an absorption wavemeter. There are several designs for these which give various Q values, but all operate on a similar principle. They are self calibrating, which means it is not necessary to refer to a frequency standard. The wavemeter shown in the photograph is one of these for operation at 10GHz. It consists of a rod, actually the shaft of a micrometer which is set coaxially in a cavity. The cavity is loosely coupled into waveguide via a small pick-up wire. Power is absorbed from the RF system when the rod resonates, which is when the rod is electrically either one quarter or three quarters of a wavelength long. A calibration graph can be prepared relating micrometer setting to frequency. The difference between the readings is half a wavelength, frequency is obtained from:

$$f\,(\text{MHz}) = \frac{C}{2(R1-R2)}$$

where R1 and R2 are in millimetres and C = 299,600. for air at 25°C and 30% humidity.

Absorption of power can be conveniently detected by a reduction in the mixer current of the receiver.

Antennas

Antennas for the lower frequency microwave band are commonly multi-element directional arrays, the Yagi

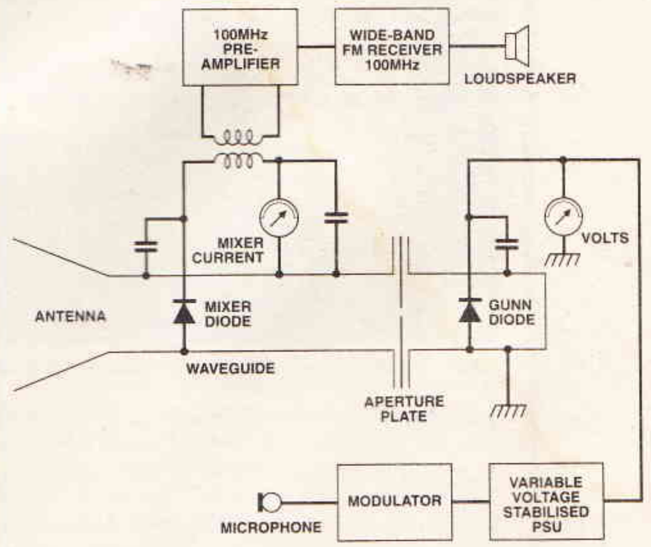


Fig.3 Simplified diagram of a wide band FM transceiver using a Gunn diode oscillator and an in-line crystal mixer for operation at 10GHz.

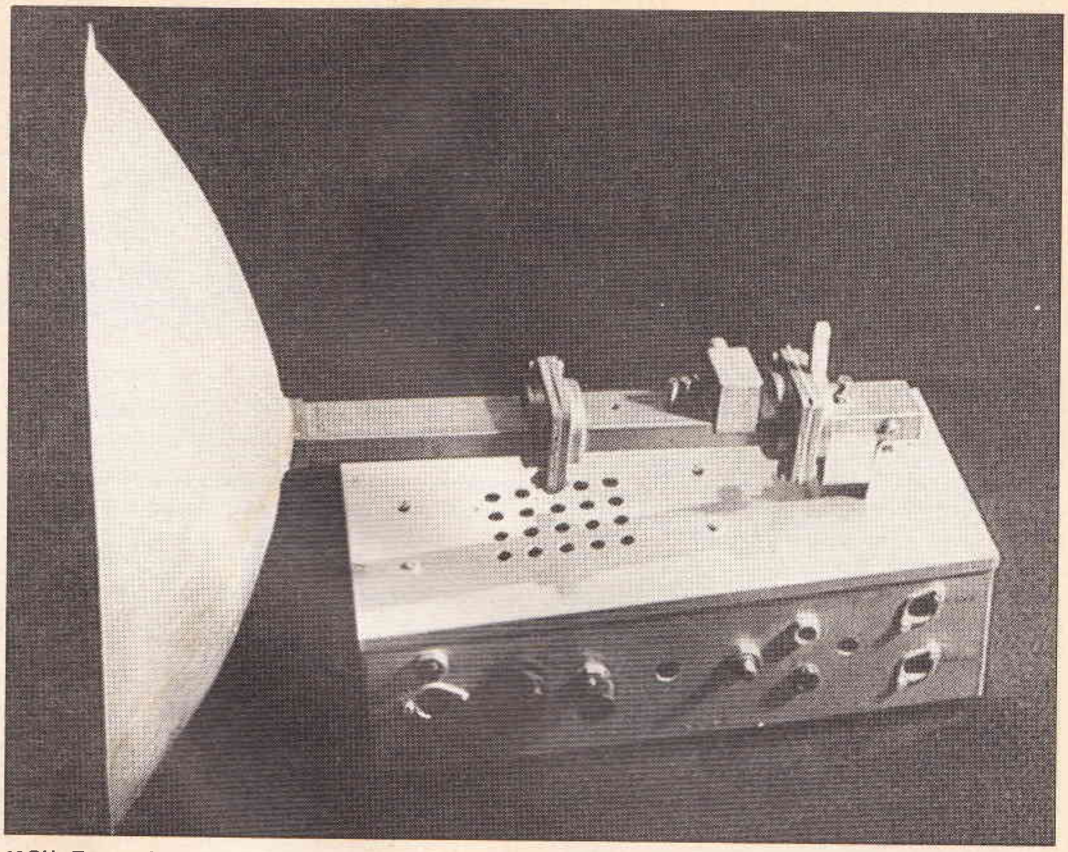
for example. For the higher frequency Bands other forms such as the parabolic dish and the horn are usually used. The parabolic dish is characterised by having high gain and narrow beamwidth, the larger the dish area the higher the gain and the more narrow the beamwidth, both these qualities are dependent on the frequency used. Dishes are invariably fed using waveguide and there are many ways of doing this.

Horns are interesting, they are easier to make than a parabolic reflector, although it is possible to buy dishes and make the feed arrangement. They can be made to provide a defined gain of say 20dB which is useful in measurement work with equipment. As with the dish, the gain and beamwidth characteristics are frequency dependent. Horns provide a good match for the waveguide used. Also they do not need any adjustment. These characteristics are useful when using free-running, waveguide based oscillators which are often sensitive to mismatch.

Microwave Oscillators

The use of the Gunn effect device or Gunn diode is nowadays a preferred method of generating RF at low power directly in waveguide, these are suitable for use in wide band FM equipment, usually in the 10GHz band. They are gallium arsenide two electrode oscillators which exhibit the intriguing characteristic of negative resistance. This can best be shown by looking at Figure 1.

The diode is placed in parallel with the electric plane in the centre of a waveguide cavity, that is, a



10GHz Transceiver of in-line mixer type showing assorted electronics

small section of waveguide which has an opening at one end only. The diode and the cavity, the dimensions of which are adjustable to achieve tuning, form a resonant circuit generating RF. The cavity may be tuned using an adjustable short at the closed end, or by the insertion of a screw of suitable dielectric material such as PTFE. Approximately 7 volts is applied across the diode. This voltage is usually made variable, the P_{out}/voltage characteristics of the diode are shown in Figure 2. Power out is typically in the region of 5-15mW for the low power types, for example the Philips CXY 11.

These oscillators can be tuned slightly by varying the applied voltage and is a way of modulating the equipment when a Gunn diode is used as a transmitter. Audio modulation is applied to the power supply which produces wide band frequency modulation Gunn oscillators are normally incorporated as a local oscillator for the receiver mixer. Some designs of transceiver such as the 'in-line mixer' use the same oscillator cavity as transmitter and receiver local oscillator.

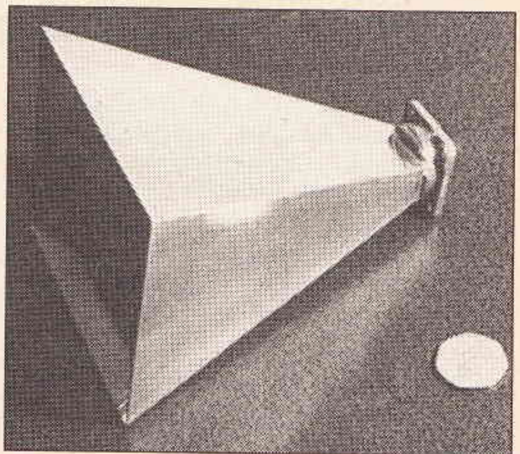
Klystron oscillators are valve devices which are also used to generate RF directly in to waveguide. They are also easily modulated to provide wide band FM. Probably the simplest design for a micro-wave transceiver was known as the 'Polarplexer transceiver'. This operated on 10MHz. and used a klystron which simply fed into a metal pipe shorted at one end. Positioned in the pipe was a mixer diode and a tuning screw. With two of these units you could be on the air on 10GHz in no time.

Receiver Mixers

Microwave receivers adopt the superheterodyne principle. Mixing takes place in a crystal diode placed in parallel with the electric field in a waveguide cavity, which receives both signal frequency and signal injection from a local oscillator. A crystal rectifier is very efficient as first mixer at X-band frequencies (10GHz). At low RF power levels crystals, act as square law detectors, which means the rectified crystal current is proportional to the RF power. The crystal current is usually monitored and the level of local oscillator injection set to give a current of about 2mA for optimum performance. Types used for 10GHz are the 1N23 or the coaxial CV2154.

The recovered intermediate frequency is the sum or difference between the signal frequency and the local oscillator frequency and is commonly set to 100MHz for wide band FM operation. This allows a conventional WBFM receiver circuit to be used. In practice almost any frequency could be selected as an intermendiate frequency.

The impedance of the crystal is usually matched to the waveguide by means of matching screws set in the middle of the broad face of the waveguide. This is a common method of achieving matching between waveguide components in mixer cavities, oscillators and antennas.



20dB Horn aerial for 10GHz

Some Transceiver Principles

An example of a simple transceiver for 10GHz is the 'in-line' crystal mixer design. A simplified diagram for this type of equipment is given in Figure 3. This is a waveguide design in which a Gunn diode oscillator with an aperture plate at the front of the cavity is fed directly into a section of waveguide containing a crystal mixer. The aperture reduces the RF fed into the crystal mixer to suitable levels for mixing, producing a mixer current of 1-2mA. It also increases the Q of the Gunn oscillator which results in increased stability. In receive operation the crystal mixes the signal from the antenna with the oscillator. If these are separated by 100MHz, this produces an intermediate frequency of 100MHz. This can be fed into a 100MHz. wide band FM receiver.

Since the Gunn oscillator also 'sees' the antenna, the design will work as a transmitter if the voltage supply to the Gunn diode is modulated either from a microphone or a tone generator.

With this design of transceiver the mode of operation is duplex, in other words it is possible to transmit and receive at the same time. An alternative arrangement is to feed the output from a Gunn oscillator into the mixer cavity using a directional coupler which diverts one tenth of the RF power into the mixer and feeds the rest into the antenna for transmit purposes. In this case duplex operation is possible with the use of two antennas, alternatively a waveguide switch has to be used and the operation is simplex. Another method is to use a device known as a circulator. This does what its name implies, its operation is based on the properties of a ferrite material placed in waveguide and it circulates RF in one direction only.

With equipment such as just described it is possible to obtain contacts over distances of 100km or so using a line of sight path.

2.0-2.6GHz Signal source using microstrip PCB circuit board

Planar Transmission Lines

In the professional environment, planar microwave designs are beginning to dominate low power applications for both commercial and military uses. This is because of their performance, ease of fabrication and resulting low cost. Recently there have been amateur developments using a form of planar transmission line known as microstrip. (This is probably a result of the increasing availability on the surplus market of transistors that are able to operate at microwave frequencies. signal sources for 10GHz and the lower frequency microwave bands can be constructed using microstrip provided you have access to the required test equipment.

Let us consider some aspects concerning microstrip. Microstrip is a development of stripline, which is essentially flattened coaxial transmission line. Microstrip is configured with the conductor parallel to a ground plane, the material between them forming a substrate. As there is more electromagnetic field in the air than in the microstrip, there is rather poor isolation between circuits mounted on the same substrate. Adjacent circuits are therefore mounted in channelized compartments with absorber material on some walls. Another technique is to make the channel width small enough to prevent propagation, similar to a cut-off waveguide. The circuitry is photolithographically etched on one side of the substrate and it is easy to mount devices requiring connection between surface conductors. Substrates used include ceramics, sapphire and quartz, semiconductors and the softer, ceramic and glass filled Teflon (PTFE).

There are three main contributing factors to loss in microstrip, these are: Resistive losses in the strip, dielectric losses due to heating effects in the substrate and radiation losses due to the antenna action of the microstrip.

The photograph shows the circuit side of an item of microstrip equipment designed by an amateur. It is a signal source for the frequency range 2.0-2.6GHz. and consists essentially of a crystal controlled oscillator followed by a frequency multiplier chain. Provided the component specification is followed exactly the design gives reproducible results. Anyone considering constructing such designs will however, require access to some sophisticated test equipment for alignment purposes.

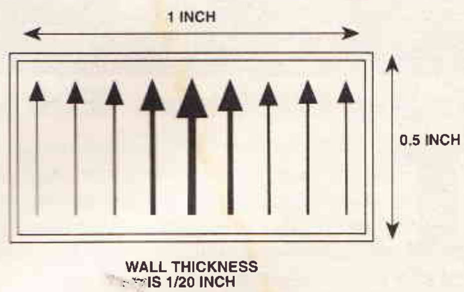


Fig.4 Cross section of waveguide 16, showing the elctric field in TE10 mode. The magnetic field is perpendicular to this.

I wish to thank Sam Jewell, G4DDK, for allowing me to include a photograph of his 2GMz source. I would also like to thank Dr Mike Dixon, G3PFR, for sending me a comprehensive list of suppliers.

List Of Suppliers.

J. BIRKITT. 25,The Strait, Lincoln. LN2 1JF. Tel. 0522 20767.	Various surplus RF transistors Gunn diodes, mixer diodes, components. Send for list.
ELECTROMAIL PO Box 33, Corby, Northants. NN17 9EL. Tel. 0536 204555.	Mail order. Catalogue same as RS Components. General components inc. chip resistors & capacitors.
RSGB Microwave Committee Components Service. Lambda House, Cranborne Road, Potters Bar, Herts. EN6 3JE.	Mixer/multiplier diodes. GaAsfets. PTFE PCB material. Selected PCB's & critical components for them. 24GHz modules & waveguide.
J Edmondson, G6KKA. Wigg Farm, Blackshaw Road, Hebden Bridge, W Yorks. HX7 7JA	Spun dishes to about 36in. Enquire first.
METSPIN Ltd. 94b, New Brighton Road, Emsworth, Hants. PO10 7QS. Tel. 0243 373712.	Spun dishes to 84in. Enquire first, ask for Mr Cousins.
P G Sergeant G4ONF 6 Gurney Close, Costessey, Norwich, Norfolk. NR5 0NB Tel: 0603 747782	Absorption wavemeters for 10 & 24GHz. Enquire first
Microwave Society c/o Glen Ross, C8MWR 81, Ringwood Highway, Coventry. Tel. 023 616941.	WG16 flanges. Dishes to 23in. Gunn diodes, 24GHz. modules. 10GHz. WB TX/RX PCBs Enquire first.

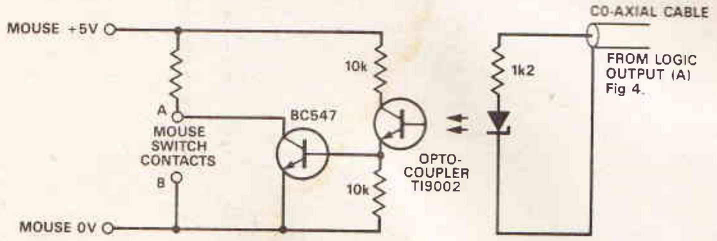
Versatile Temperature Measurement

2

AJP Williams continues with constructional details of his temperature controller and presents a variety of applications for its use

Timing the Pulse Width

The pulse width can be timed approximately using a storage oscilloscope or more precisely using separate electronic timer. As I had no timer available I decided to use my Archimedes computer to provide me with a low cost timer with an accuracy of ±10ms.



THE CIRCUIT SHOWN ABOVE IS DUPLICATED ONCE FOR EACH CHANNEL
SWITCH CONTACT (A) IS MOUSE SWITCH 2 FOR CHANNEL 1
SWITCH CONTACT (A) IS MOUSE SWITCH 3 FOR CHANNEL 2

Fig.9 Timing Circuit

The circuit shown in Figure 9, uses the pulse to simulate mouse key presses via an optical coupler for isolation. The computer then interrogates the key presses using the Basic program shown in apprendix 1. This program is written for timing 2 pulses (one from each channel) where the pulses overlap each other. Similar programs can be writtn for 2 pulses where no overlap occurs, and for a single pulse.

Other Uses – Voltage Standard

The Voltage reference output (Figure 4 see last month) enables the voltage reference to be used externally via a voltage follower (IC5). This output can be used to give a useful voltage standard for calibrating voltmeters. The voltage can be set using the three temperature switches (R11) from 10mV to 11.1V in steps of 10mV. The settings above assume that R12 (Figure 4) is set in its fully anti clockwise position. This control can be used in conjunction with R11 to set the reference voltage to any value from about 2mV to 11.1V.

The accuracy of this voltage source depends on whether 1% or 0.1% resistors are used for R11. Using 0.1% resistors, the accuracy should be within ±0.2% from 1V to 10.1V with decreasing acccuracy as the output voltage is lowered due to a small residual voltage across R12 in its anticlockwise position.

Estimation Of Fluid Flow Rate

Equipment was set up as shown in Figure 13.

The platinum resistance sensors were attatched to a 15mm copper pipe and the tap adjusted to give a particular flow rate,this being determined by timing the filling of a measuring jar.

The hot clamp was a pair of pincers with rounded jaws that could be conveniently clamped on to the pipe with good thermal contact. With the hot clamp removed,water was allowed to flow for a long enough time to obtain thermal equilibrium. R11 on both

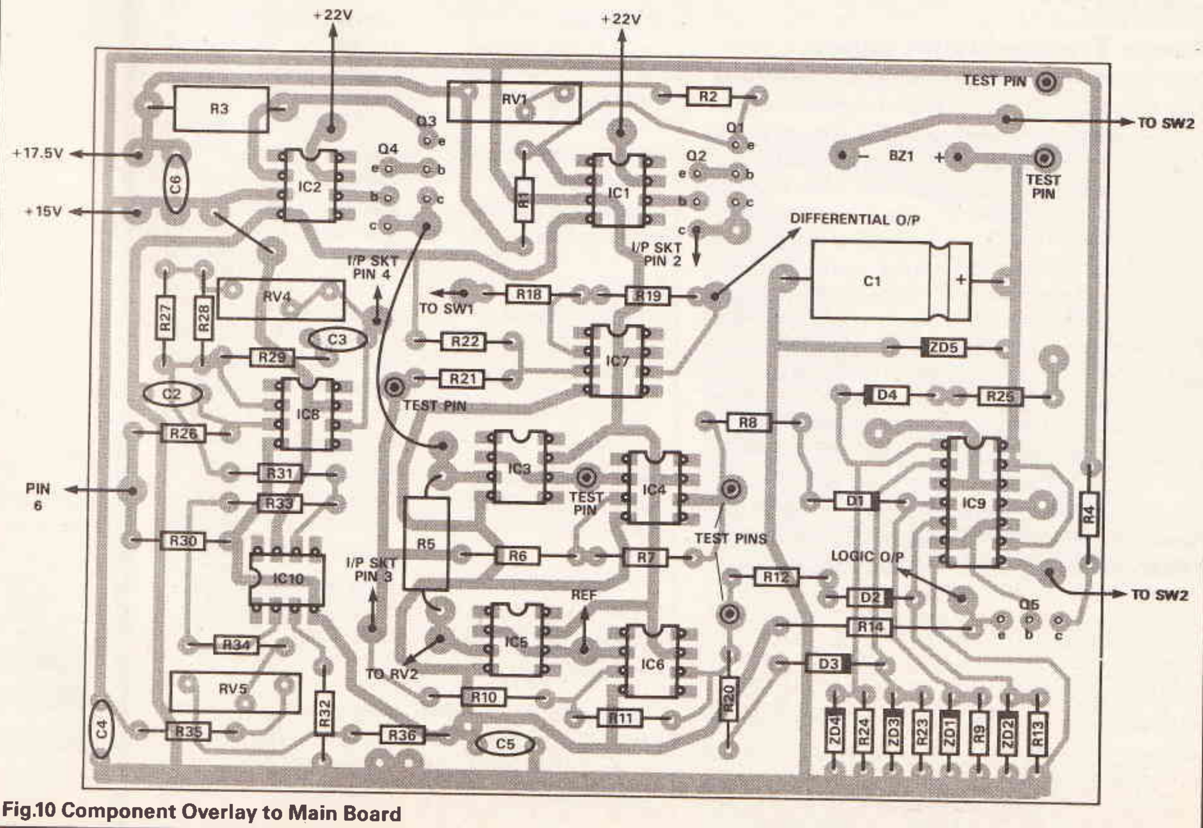


Fig.10 Component Overlay to Main Board

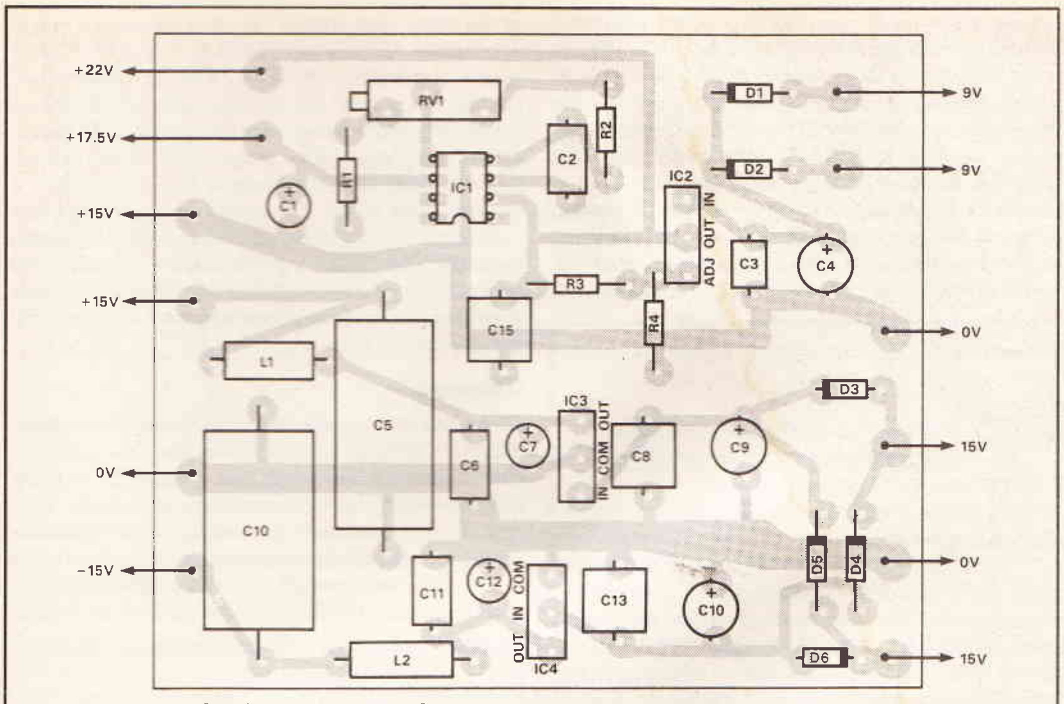


Fig.11 Component Overlay to power supply

channels was adjusted so that the reference temperature was about 0.1° Celcius above the pipe temperature. The hot clamp was heated on a gas stove then transferred to the pipe in the position shown in Figure 13.

When the heated water reaches the first sensor the timing begins (using logic output 0) and when it reaches the second sensor the timing ends. The distance between the sensors-the time taken for the water to flow between the sensors and the bore of the pipe are all known therefore the flow rate can be calculated. Using this method and comparing it with the flow rate determined by measuring the filling of a measuring jar gave the following results.

Flow rates from 3mL per second to 40ml per second within ±45%

By restricting the flow rate to rates above 10ml per second the results all had a negative error therefore in this range the estimation could be improved by adding on say 20% to the measured results. My water head was insufficient to try flow rates above 40ml per second.

The reason why the percentage error starts to go positive at low rates of flow is that the heat starts to be transferred quicker through the copper pipe than through the moving fliud.

It would appear that this method of measurement could be considerably improved by mounting a thin insulated wire element within the tube and perhaps discharging a capacitor through the element to produce the thermal step required in the fluid. The sensors could also be mounted inside the tube with their thin edge facing the flow direction to prevent the flow being unnecessarily disturbed.

Measuring the Capacitance value of Large Electrolytic Capacitors

The external circuit used is shown in Figure 14.

Connect the output of Figure 14 to the signal output of channel 1 with channel 1 probe removed. Adjust R11 to 1° Celcius,this sets the reference voltage to 0.1V.

If the electrolytic capacitor has not been used recently reform it by applying a suitable voltage until the charging current becomes very low and constant.

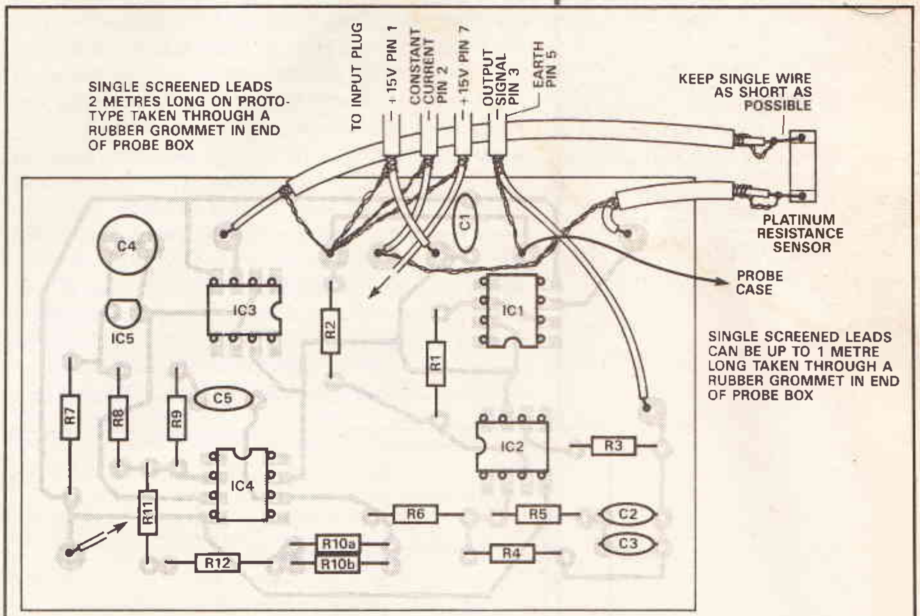


Fig.12 Probe Component layout and wiring

Put the capacitor into the position shown in Figure 14 with the switch SW1 left closed for 1 minute. Open SW1 and record the time taken for the capacitor voltage to rise from 0.1V to 0.2V ie by timing the pulse from Logic Output (A) in Figure 4. Note the average voltage across R during this timing period is 10V. The capacitance value can be read directly in terms of time as indicated below.

	Value of R	Time
10000μ to 1000μ	100k	10s to 1s
1000μ to 100μ	1M	10s to 1s
100μ to 10μ	10M	10s to 1s

Additional Apparatus Measuring The Low Temperature Emission Coefficient

The dimensions of the test apparatus shown in Figure 14 are not critical,the main requirement is that the large aluminium plate must be much larger than the two test plates. Make a small aluminum plate just large enough in width so that it can be drilled to take a temperature sensor mounted in a TO92 case, and about 2cm in length. Attach the small aluminium plate to the centre of the large aluminium plate on the upper surface with superglue,so that the longer length of the small plate runs parallel to the long side of the large plate. The aluminium plate is coated with matt black paint on its lower surface and any paint that is electrically insulating on its upper surface. A heating element of 28 gauge enameled copper wire is fastened to the upper surface of the plate with the aid of masking tape. Start by sticking the first length of wire

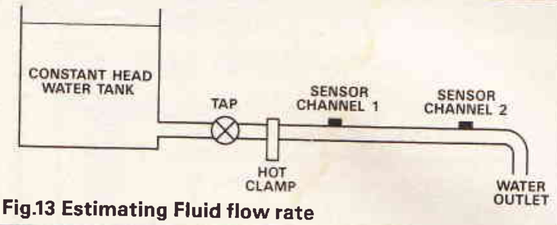


Fig.13 Estimating Fluid flow rate

along the length of the plate about 0.5 cm from the edge. Turn the wire back on itself so that the second length lies parallel to the first length and 0.5cm away from it. Stick this wire down with masking tape and then repeat the procedure until the whole plate is covered. A small strip of wood can be fastened to the inner side of each of the wood ends (Fig 14 to support the aluminum plate. The top of this plate should be 25mm from the top of the wood ends,so that when the sheet of expanded polysyrene is in position the top of this sheet is flush with the top of the wood ends.The cover sheet of hardboard can be screwed with wood-screws to the wood ends to hold everything below in position. At the rear of the apparatus a strip of plywood 130mm wide and long enough to reach from one wood end to the opposite wood end is screwed to the wood ends so that the lower end of the plywood is just above the bottom of the wood ends. A similar strip of plywood 60mm wide is screwed between the two wood ends at the front,but in this case it is mounted so that the top edge of the strip is flush with the top edge of the wood ends. These strips make the whole structure firm

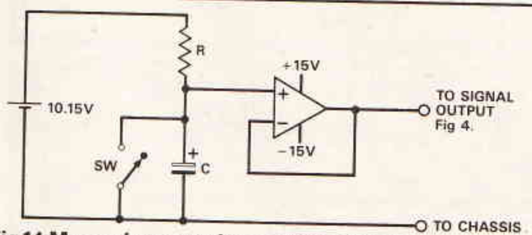


Fig.14 Measuring capacitance value of large electrolytic Capacitors

while leaving gaps so that hot air from the warmed plate can convect upwards. Eventually the apparatus will be pulled over the test plates and because the convected heat can easily escape upwards there is negligible heat transfer by convection from the hot plate to the test plates.

The test plates are copper plates 300mm × 167mm × 1mm. The one plate is coated with lamp black that has a low temperature emission coefficient of 0.95 The other test plate is coated with a surface that is under test.

The Temprature Control Circuit

The control circuit is shown in Figure 12. The LM35DZ temperature sensor has an output of 10mV per degree Celcius. This sensor is mounted in the small block on top of the large aluminium plate shown in Figure 19. IC1 is a 1.2V voltage reference,R2 and R3 form a potential divider that reduces the 1.2V to 480mV. When the temperature of the aluminum plate approaches 48° Celcius. The output of the LM35DZ sensor approaches 480mV so that the input to IC2 becomes very small hence the temperature stabilises at 48°. This temperature is not critical but I felt it best to always work at the same temperature to ensure consistent results. The temperature is also typical of a working solar panel. The power supply voltage was determined by two heavy duty power supplies already available. The 2N3055 Power transistor is mounted on a plain aluminum sheet 250mn × 90mm which was then long enough to be able to be screwed to one of the wood sides in Figure 19.

Theory

All bodies whose temperature is above zero degrees Kelvin (−273° Celcius) emit electromagnetic radiation The magnitude bandwidth and wavelength is determined primarily by the temperature of the body. With regard to efficient use of solar energy we are predominantly concerned with radiation from the sun, which is a body at a temperature of about 6000° Kelvin and radiation from collector surfaces warmed by the sun

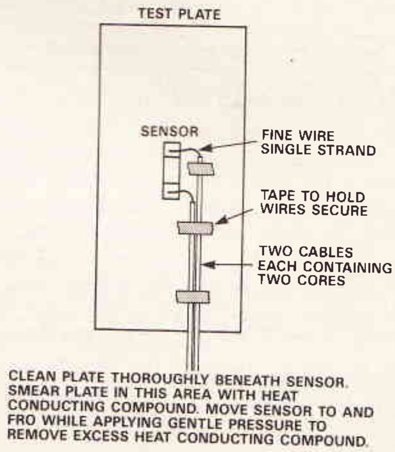


Fig.15 Mounting the platinum resistance sensors on the test plates

which can have temperatures ranging from the ambient temnerature to 100°C or more. Most of the radiation from the sun is in the range of 0.3 microns to 3 microns, while the radiation from a collector at 100° Celcius, ranges from about 3-50 microns. Using these values an ideal collector surface would have an absorption coefficient of 1.0 from 0.3 microns to 3 microns and a zero emission coefficient from 3-50 microns. In the real world this is impossible.

Over the same wavelength range the absorption coefficient has the same value as the emission coefficient and in our case it is easier to measure the absorption coefficient. In practice if we can obtain a surface with an absorption coefficient of 0.95 from 0.3-2 microns and then changing to an absorbtion coefficient of 0.1 when the wavelength is below 4 microns then we shall have a good selective surface.Obviously there are many other factors to consider such as the variation of the surface characteristics with time,temperature and humidity.

The emission coefficient (e) can be defined as:

$$e=\frac{\text{(Power emitted by body under test)}}{\text{(Power emitted by a similar black body)}} \qquad \text{Eqn 1}$$

As we will be doing each range of tests at the same temperature we can say that:

$$e=\frac{\text{(Power absorbed by body under test)}}{\text{(Power absorbed by a similar black body)}} \qquad \text{Eqn 2}$$

The Power absorbed by a body (in watts) can be expressed as:

Mass of body×Specific Heat of body×4.2×Rate

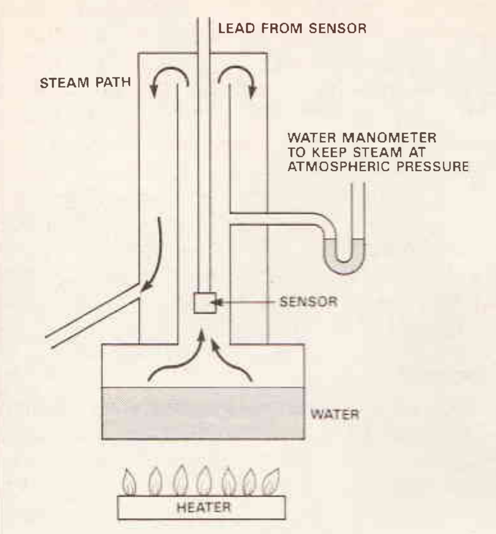


Fig.16 Keeping the temperature sensors at 100° Celcius

of Rise of temperature of body

This means that equation 2 can be written as:

$$e=\frac{\text{Mass of body}\times\text{Specific Heat of body}\times4.2\times\text{Rate of rise of temp}}{\text{Mass of black body}\times\text{Specific Heat of black body}\times4.2\times\text{Rate of rise of temp}} \quad \text{Eqn 3}$$

In our case the bodies we are considering are copper plates,all of which have the same mass and specific heat.so these quantities will cancel in equation 3 together with the (4.2) which is the conversion from calories to Joules.

Now

$$e=\frac{\text{(Rate of rise of temperature of plate under test)}}{\text{(Rate of rise of temp of black body plate)}} \quad \text{Eqn 4}$$

We will be measuring the rate of rise of temperature by measuring the time taken to move through 1° Celcius.

ie rate of rise of temperature=(1 degree)/(Time taken to move through 1 degree)

Substituting this expression into Equation 4:

$$e=\frac{\text{(Time taken for black body to move through 1 degree C)}}{\text{(Time taken for plate under test to move through 1 degree C)}} \quad \text{Eqn 5}$$

The theoretical 'black body plate' will move through 1 degree faster than the plate under test because a black body is the best possible absorber of radiation.This implies that the value of 'e' will always be less than unity.

Using equation 5 we can (in the mind) find the emission coefficient of a reference plate.This reference plate is one which other plates can be compared against.

$$e_{REF}=\frac{\text{Time taken for black body to move through 1 degree C}}{\text{Time taken for reference plate to move through 1 degree C}} \quad \text{Eqn 6}$$

If we now use a particular surface for the reference plate whose value of 'e' is known from previously published work, then re-arranging equation 6 we get

Time taken for black body plate to move through 1 deg C= $(e_{REF})\times$(Time taken for ref plate to move through 1 deg C)

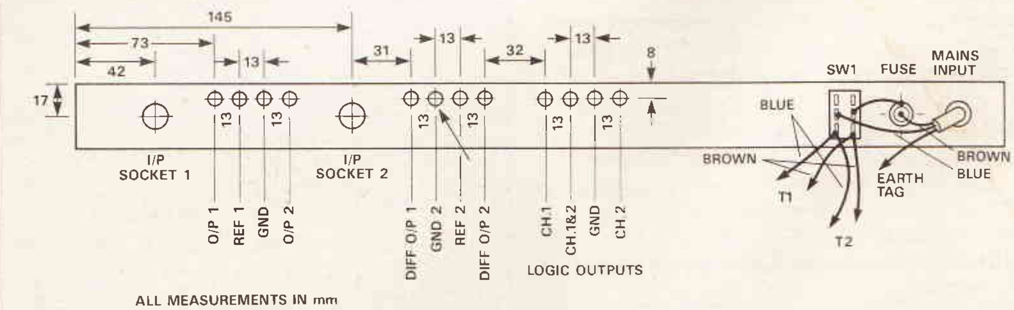


Fig.17 Wiring diagram

We can use this expression back into equation 5 to give:

$$e=\frac{e_{REF}\times\text{(Time taken for reference plate to move through 1 degree C)}}{\text{Time for plate under test to move through 1 degree C}} \quad \text{Eqn 7}$$

In practice we will now use equation 7 as this eliminates the need for a theoretical black body plate. Lampblack which is thicker than 0.003inch can be used as a reference with

e_{REF}=0.95 when checking low temperature emission coefficients and

e_{REF}=0.96 when checking solar absorption coefficients.

Less fragile surfaces can be used as references by checking them against the lampblack surface.

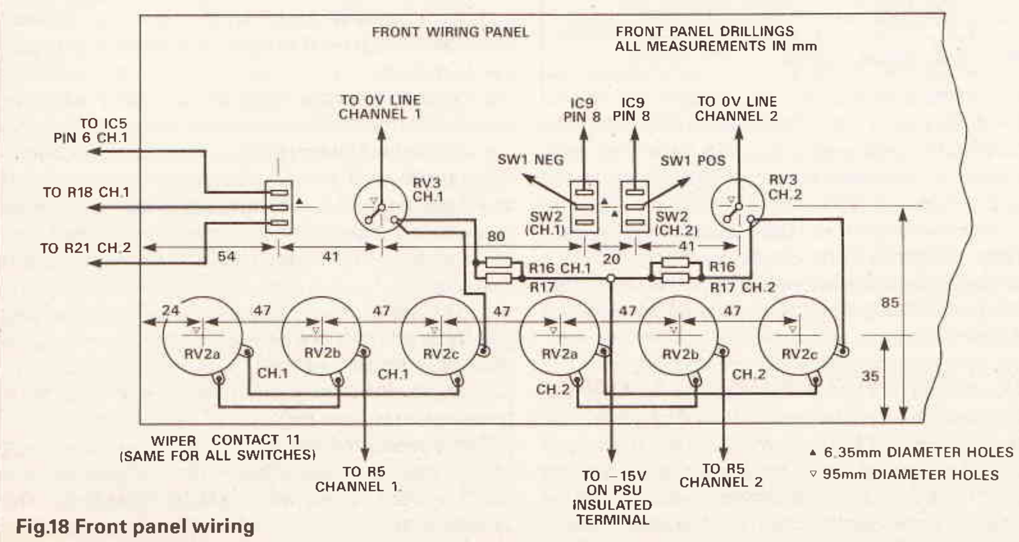


Fig.18 Front panel wiring

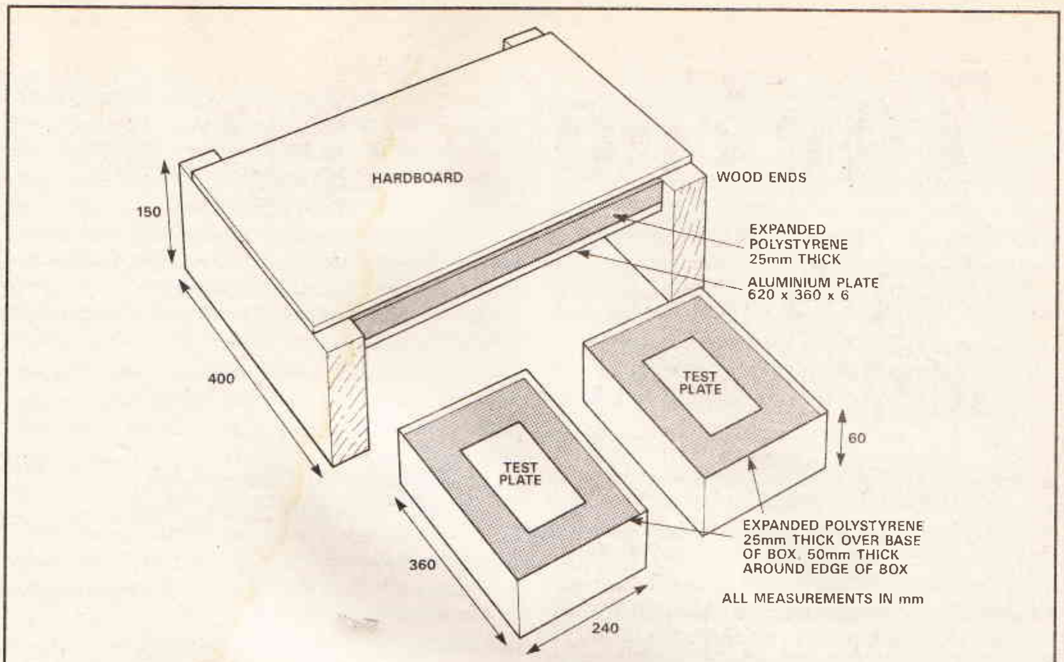


Fig.19 Test apparatus for measuring low temperature emission coefficient

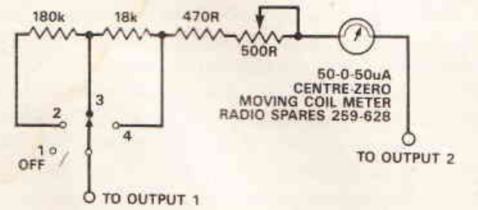


Fig.20 Indication of output using an analogue meter

APPENDIX 1
Keeping the temperature sensors at 0° Celcius

Make some ice cubes by putting purified water into a clean ice cube tray in a freezer. The ice cubes can be then put into a thick plastic bag so that they can be crushed without being contaminated and then pour the crushed ice into a clean thermos flask. The semiconductor sensors need to be put inside a small metal tube that is sealed at its lower end and just sufficient space to take the sensors. I used the top off a fountain pen that was made from one piece of metal and as a result was completely water-proof. You will need some thermal conducting compound in the bottom of the tube to ensure good thermal contact with the tube. Where the wires from the sensor come out of the tube, bind PVC tape around the wires and around the tube so that a waterproof seal is formed to prevent the possibility of water entering the tube. Push the tube into the ice so that the top of the tube is still out of the crushed ice. Where the wires come out of the flask plug the remaining space with a wad of cotton wool to minimise heat flow into the flask.

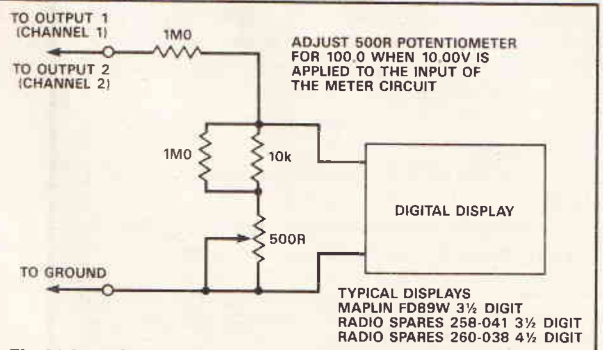


Fig.21 Interface with digital display

Record the temperature at intervals of time even though the recorded temperature may well be in error at this stage. From these readings you will note that the temperature will very slowly rise as heat from the surroundings seeps into the flask. When the temperature reaches zero degrees Celcius it will remain constant for a long time as the change of state from ice to water occurs. It is advisable to shake the flask occasionally by gently tapping it on a firm surface to keep the ice and water mixed. Obviously the constant temperature period will depend on how good the thermal insulation of your flask is, but you should be sure of at least a couple of hours to recognise that you are in the stable region and another couple of hours to make any adjustment to the equipment.

The freezing point reduces by 0.0075°C for an increase of atmospheric pressure of 1013 millibars (one atmosphere) The worst case change in atmospheric pressure from the average value is about ±50 millbars. This will give a change in the freezing point of 0.00037° Celcius which means that atmospheric pressure changes can be ignored regarding the zero reference point.

The double-walled vessel in the apparatus shown above reduces any reduction in temperature in the region of the sensor. The air pressure must be monitored by means of a barometer and the following correction made:-

Change in temperature from the 100° Celcius point=$273\times10^{-4}(760\text{-}P)$

Where P is the Atmospheric pressure in millimetres of mercury.

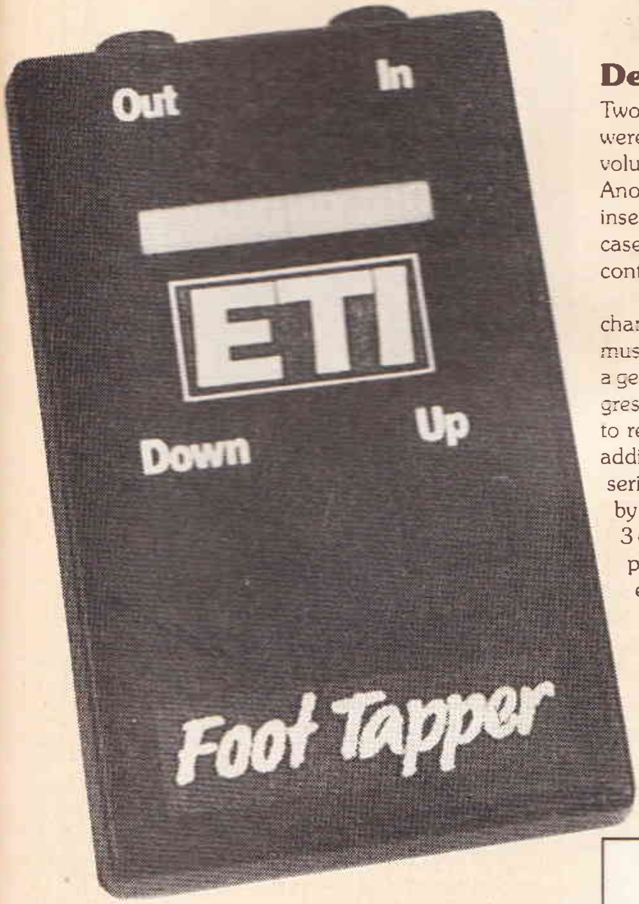
If no atmospheric pressure correction is made the worst case error will be a little over 1 degree.

The method of calibration shown above is probably only suitable for the sheathed type of sensor. As my platinum reistance sensors were the unsheathed type (to give the smallest time constant possible) and since setting up the apparatus for the 100° point is rather tedius, I took the easy way out and did the calibration against an accurate resistor as described earlier. Since many of the measurements are comparitive this method gives sufficient accuracy for most purposes. *Alternative method* Calibrate the 2 platinum resistance sensors using the resistance method. Replace one of the platinum resistance sensors with a semiconductor sensor. Mount the two sensors on a metal plate. By cooling and heating the plate adjust the semiconductor sensor so that it indicates the same as the Platinum resistance sensor at 0 & 100°.

The Foot-tapper

PROJECT

Paul Stephenson presents an electronic footpedal for guitarists.



There are quite a number of effect and control pedals available for the electric guitarist including Chorus, Echo, Distortion and Overdrive to name but a few. One device that seems to be missing from the commercial ranges is a simple volume control pedal. The problem is that a guitar player needs both hands to play his instrument. If he is singing as well he may not even be able to leave the microphone to reach the amplifier.

The level control on the guitar can be used but, depending on the effects in use, more than just the overall volume may be changed. For instance, if there is an overdrive in the chain, the drive level will alter and thus the amount of distortion.

What is required is a foot operated volume control as the last device in the effects chain. A number of 'SWELL' pedals are available but these can require quite a level of expertise to master. They are particularly prone to moving as you lift your foot off the pedal.

The idea for this project is to provide a foot operated unit with one button to raise the volume and one to lower it. When no buttons are being pressed the unit will hold a set level. A display is provided so that the user can see immediately at what level the unit is set.

The unit provides for a boost or cut of 12dB in 1.5dB steps. Each press of a button causes the level to change by one step. There is an auto-repeat feature on the buttons so that if a button is held down the level will continue to step until an end-stop is reached.

The unit is in use by the author and has been found to provide just the 'Hands-Free' operation that is required.

Design Approach

Two basic approaches to the volume control problem were considered. The first possibility is to use a linear volume control IC or FET circuit to set the overall gain. Another method is to select one of a set of resistors and insert it into the feedback loop of an op-amp. In both cases some simple digital circuitry would be required to control the system.

In both cases it is important to remember that the change of gain with each step is not linear. Each step must be 1.5dB. This is represented mathematically by a geometric progression rather than an arithmetic progression. For those too far removed from school maths to remember, an arithmetic progression proceeds by adding a constant number each time resulting say in a series, 3 5 7 9 11. A geometric progression proceeds by multiplying by a constant number each time, eg 3 6 12 24 48. The reason for this need of a geometric progression is associated simply with the way our ears work so we are stuck with it!

For this design it was decided to go with the switched resistors approach since it was felt to be easier to implement and had a better chance of working first time, which it did!

Since the unit must be battery powered all the devices must be low power. All the logic devices were selected from the CMOS 4000 series since they may also operate at 3 to 15V. This enables the use of the popular PP3 type battery with no need for a regulator circuit to generate a separate 5V logic supply.

Choice of case is always a difficult decision for this type of project. It is important that the finished product looks tough and professional yet the resources for a specially cast case are obviously not available for a one off. Also special bezels around displays can be difficult to find at a justifiable price. The selected case is a plastic box designed for hand-held use. Actually it is a touch on the light side for a foot operated unit but does

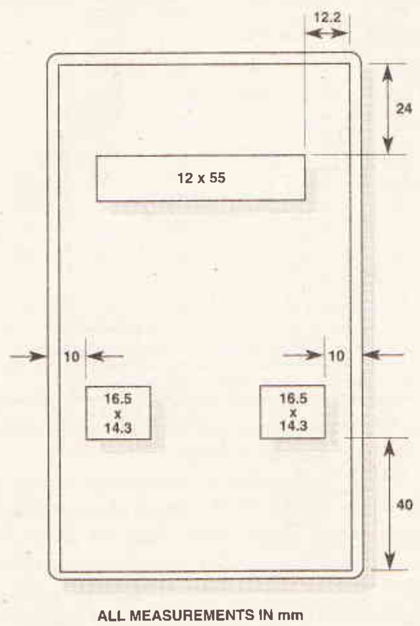
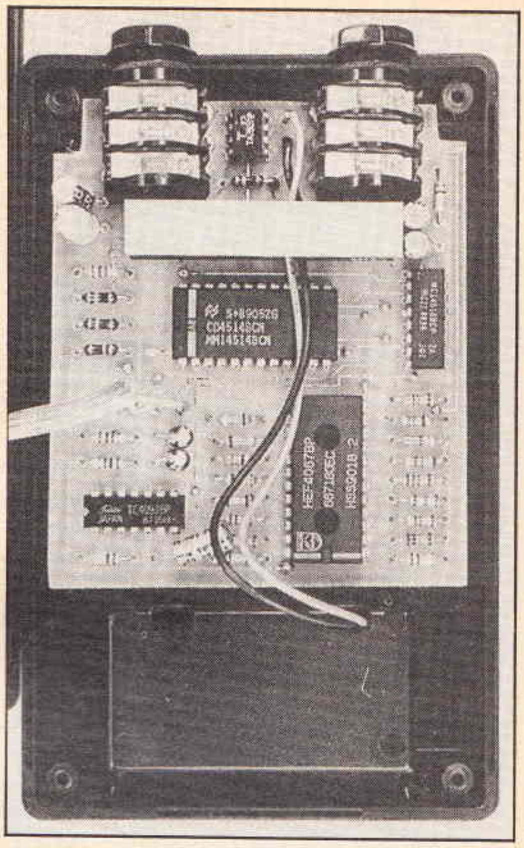


Fig.1 Front panel cutouts

have the advantage of a battery compartment for the PP3 battery. The solution to the problem of making the display 'pretty' is Lexan.

Lexan is a material used for the little indicator lamps in the dashboard of your car. Small squares of it are printed with little logos for left-turn, ignition etc. and mounted with small bulbs behind them. This project uses a sheet of the material to cover the whole front panel. It is screen printed from behind with the lettering and a little window is left for the display to show through. The whole effect is very professional.



PCB Assembly.

The first job is to assemble the circuit board. If you are not using a PTH (plated through hole) board it will be necessary to install 24 through pins. The board has been designed with the use of such through pins in mind. There is only one connection to a component on the top-side of the board, to R25. If you do have to install through pins, the variety that come on a strip and break off after insertion are a great deal easier to use. You should next insert the terminal pins for the switch and battery connections. Terminal pins are also used for the jack sockets. This is because the PC-mount type of jack socket can be difficult to find, so the board is laid out for the more common solder lug types.

Next, insert the resistors. Here is a chance to learn your resistor colour code if you do not know it already! Some of the resistors come from the E24 series. The E24 series has 24 values in each decade rather than the usual 6 or 12. As a result there are some less familiar resistor values. Capacitors are next, taking care with the polarity of the electrolytics.

Rx	dB	Gain	Value	E24	dB	Gain	Value	E24	dB	Gain	Value	E24
7	−8	.40	251.2	270k	−16	.16	631.0	620k	−24	.06	1,584.9	1.5M
8	−7	.45	223.9	220k	−14	.20	501.2	510k	−21	.09	1,122.0	1.2M
9	−6	.50	199.5	200k	−12	.25	398.1	390k	−18	.13	794.3	750k
10	−5	.56	177.8	180k	−10	.32	316.2	330k	−15	.18	562.3	560k
11	−4	.63	158.5	160k	−8	.40	251.2	270k	−12	.25	398.1	390k
12	−3	.71	141.3	150k	−6	.50	199.5	200k	−9	.35	281.8	270k
13	−2	.79	125.9	130k	−4	.63	158.5	160k	−6	.50	199.5	200k
14	−1	.89	112.2	110k	−2	.79	125.9	130k	−3	.71	141.3	150k
15	0	1.00	100.0	100k	0	1.00	100.0	100k	0	1.00	100.0	100k
16	1	1.12	89.1	91k	2	1.26	79.4	75k	3	1.41	70.8	68k
17	2	1.26	79.4	82k	4	1.58	63.1	62k	6	2.00	50.1	51k
18	3	1.41	70.8	68k	6	2.00	50.1	51k	9	2.82	35.5	36k
19	4	1.58	63.1	62k	8	2.51	39.8	39k	12	3.98	25.1	24k
20	5	1.78	56.2	56k	10	3.16	31.6	33k	15	5.62	17.8	18k
21	6	2.00	50.1	50k	12	3.98	25.1	24k	18	7.94	12.6	13k
22	7	2.24	44.7	43k	14	5.01	20.0	20k	21	11.22	8.9	9.1k

Resistor R25 – 100k. All resistances in kilohms unless indicated

Table 1. Alternate resistor values for different step sizes.

You will not be able to use sockets for the integrated circuits because of the depth of the switches on the front panel. These may foul the 4067/4093 devices if a socket is used. You could use sockets for the other devices if you wish, though they are both fairly robust and with only battery power available it is unlikely that you will have to change them. Assuming you get them in right way round of course! You must remember that CMOS devices are prone to static damage and the usual precautions must be observed.

An extended socket is required for the Bar LED modules to raise them into position behind the front panel window. To get to just the right height requires one ordinary socket and one extended socket.

Mounting the jack sockets requires a little dexterity. First of all the solder lugs should be cut off flush with the plastic body of the sockets. Each socket may then be carefully pressed into position between the six terminal pins and solder applied to the joints. Care should be taken not to melt the plastic of the socket too much or else the spring contacts will tend to lift out of the plastic body of the socket.

The Case

Figure 1 shows the locations for the cut-outs on the

Gain in dB	Linear Gain	R25 Value	E24 Value
-3	.7	70.8	68k
0	1.0	100.0	100k
3	1.4	141.3	150k
6	2.0	199.5	200k
9	2.8	281.8	270k
12	4.0	398.1	390k
15	5.6	562.3	560k
18	7.9	794.3	750k
21	11.2	1,122.0	1M
24	15.8	1,584.9	1.5M

All Resistor values in kilohms unless shown.

Table 2. Alternate R25 values for Different Centre Gains

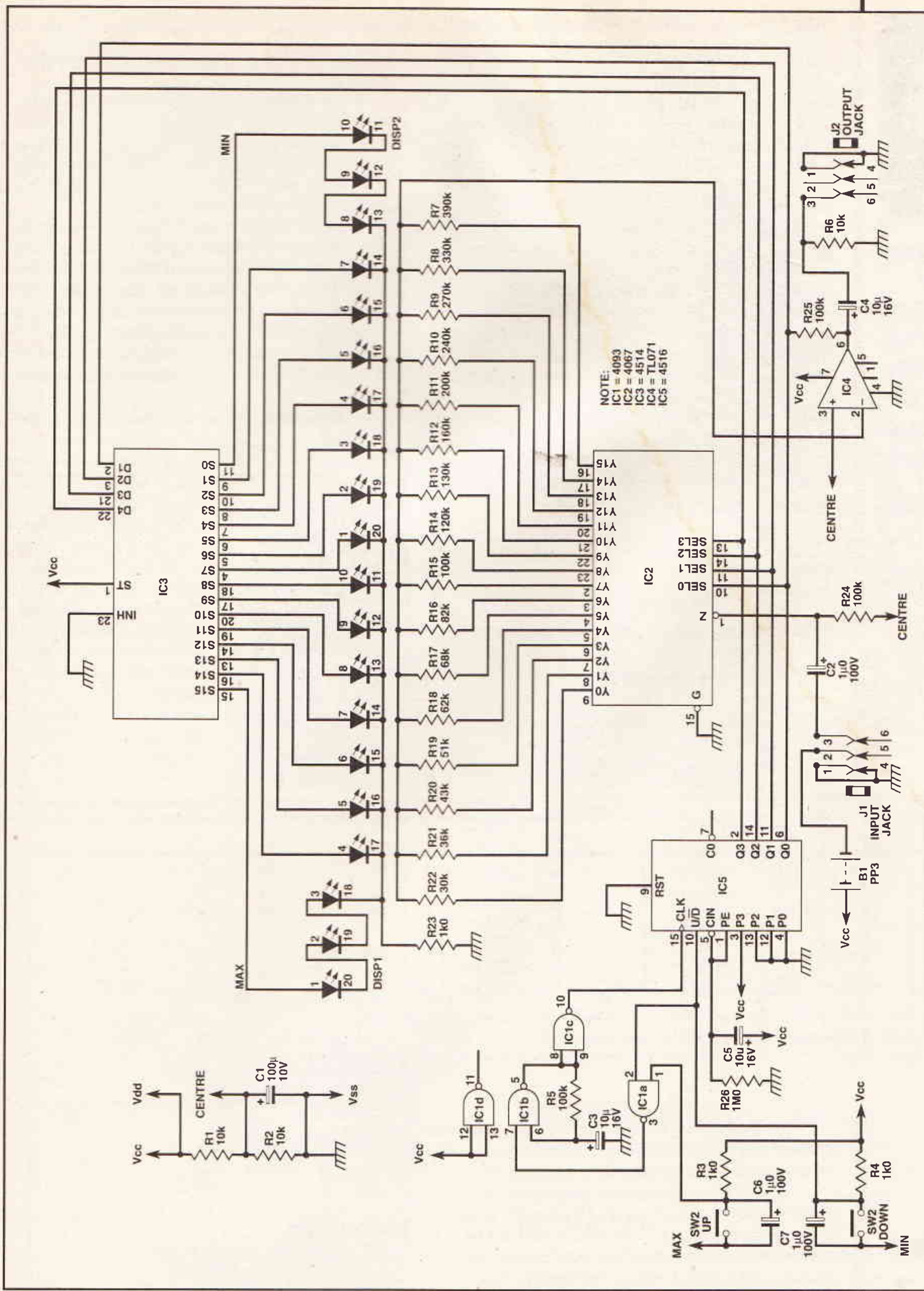


Fig.2 Circuit diagram of the electronic footpedal control

front panel of the case. Chain drilling and filing is the only way for a one-off I'm afraid. Fortunately the case is made of a rather soft plastic and the process should only take a few minutes.

The holes for the two switches are marked on the Lexan escutcheon for the front panel. These should be cut out with a scalpel or craft knife. The escutcheon has a peel-off backing which may now be removed. Carefully position the escutcheon inside the recess on the front panel of the box and then tub it down into place.

The holes for the two jack sockets should be drilled with the case assembled. The centre line for the holes is the join between the two halves of the case. Drill a small pilot hole first, say 3mm, then drill the 1mm holes.

Final Assembly and Testing

The solder lugs on the switches are a little deep for this application and should be trimmed to about 2mm with a pair of side cutters before pushing the switches through their holes on the front panel. Connections should be made to the centre and more distant contact on the back of each switch. About 100mm of connect-

HOW IT WORKS

The schematic diagram shows the full circuit diagram for the Volume Control Unit. The circuit is basically an inverting amplifier based around the op- amp IC4. The JFET input TL071 is used because of its low noise characteristic and ability to cope with the full audio frequency range.

Since the op-amp is basically a bi-polar device, ie. it needs a positive and a negative rail, the battery supply is split into two by the potential divider Rl and R2. All the analogue signals are referenced to the centre rail which takes the place of the 'ground' in a truly bi-polar circuit.

The input resistor for the op-amp is one of the sixteen R7 to R22. The selection is performed by the 4067, 'one of sixteen analogue de-multiplexer'. This device works like a one-pole 16-way switch to small analogue signals. The common connection is at the Z input. The 'wiper' of the switched is moved by the binary signals placed on its SEL inputs.

The binary signals are also de-coded by IC3, a 4514 a 'one-of-sixteen digital decoder'. This device performs the same job as the 4067 but provides digital outputs and as a result is cheaper. Each output is used to light one LED, or in the case of the end groups, three LEDs. In the end groups the LEDs are placed in series so that no more current is drawn from the battery.

The only remaining job is to generate the binary signals. IC5 is a pre-settable UP/DOWN counter. The pulses on the CLK input cause the device to count and the signal on the U/D input sets the direction. IC1 is a quad 2-input schmidt NAND gate. The Schmidt bit in this case just means it is very easy to make an oscillator from one gate, IClb. The oscillator is gated so that it runs only when a button is pressed.

The oscillator runs when an input to IC1a goes low. The switches are connected to the drives for the end LEDs so that the counter does not 'wrap-around' and cause an unwanted, large shift in the output level.

R26 and C5 perform a reset function. When the circuit is first powered up, C5 will take a second or so to charge up through R26. During this time the Clock Disable and the Parallel Load pins on the 4516 are held high. This causes the levels present on the data input pins to be loaded into the device thus selecting R15 and setting the display to its middle position.

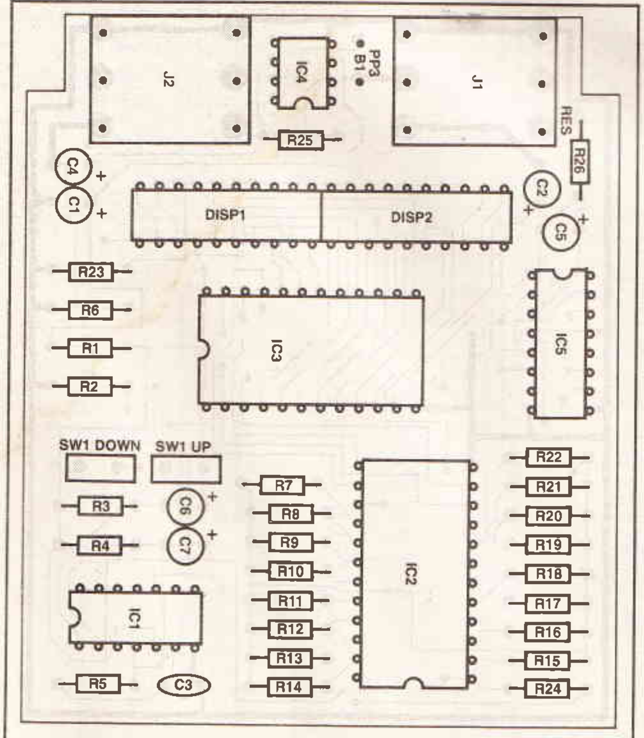


Fig.3 Component Overlay for The Foot-tapper

ing wire is required for each connection.

Remember to thread the battery connector through the hole in the battery compartment before soldering the wires to the PCB, observing polarity.

The PCB sits in the case by loosening the nuts on the jack sockets and sitting the board in the case with the nuts on the outside. The nuts should not be tightened down until the case has been assembled. This should be left until all testing has been done since the screws which hold the two halves together tend to damage the plastic pillars into which they are screwed if the operation is done repeatedly.

Give the board a careful visual final check before you connect a battery. Ensure that there are no blobs of solder between tracks and that all leads have been successfully soldered. If all is well connect a battery. The unit is switched on by inserting a jack plug into the input socket. The centre LED in the display should light up. If it doesn't then something is wrong, perhaps you have put the bar LED's in wrong way around. Check the power on the integrated circuits, it will probably be something simple like this.If the display lights correctly press the up button and verify that the display

PARTS LIST

RESISTORS(all 1/4w)

R1,R2,R6	10k
R3,R4,R23	1k
R5,R24	100k
R7	390k
R8	330k
R9	270k
R10	240k
R11	200k
R12	160k
R13	130k
R14	120k
R15,R25	l00k
R16	82k
R17	68k
R18	62k
R19	51k
R20	43k
R21	36k
R22	30k
R26	1M

CAPACITORS

C1	100μ/10V
C2,C6,C7	1μ/100V
C3,C4,C5	10μ/16V

SEMICONDUCTORS

IC1	CMOS 4093
IC2	CMOS 4067
IC3	CMOS 4514
IC4	TL071 op amp
IC5	CMOS 4516
LED1,2	10 Segment Bar LED

MISCELLANEOUS

BAT1	PP3 Battery and Connector
J1, J2	Stereo JACK Secket
SW1, SW2	Push Button Switch
Terminal Pins	
Through Pins	
Connecting Wire	
Box	

BUYLINES

All of the components are available from either RS Components or Farnells (Tel 0532-636311) with the exception of the Lexan escutcheon and the PCB.

The Push-switches are by MORS, part No. 150-216 from Farnells.

PROJECT

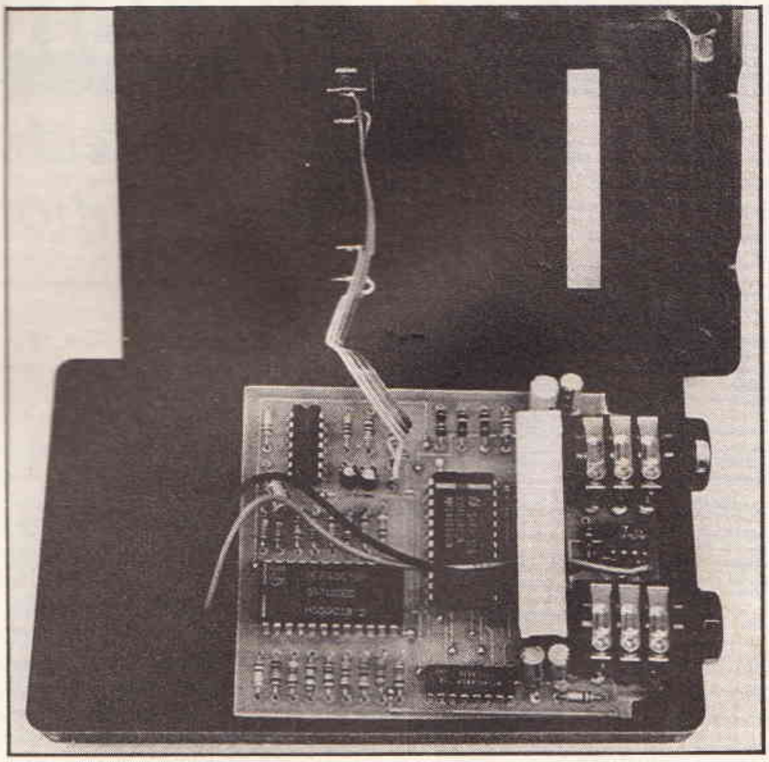
steps one to the right and that holding the button down causes the display to continue stepping until it reaches the end. At each end the display will light up three segments to show that it has reached the end of its travel. The down button should behave similarly.

If the system looks as if it works correctly then now is the time to see if it sounds alright. Connect up a sound source and an amplifier and see if the volume level rises and falls as required

The Step Size.

The values shown in the schematic diagram for the gain setting resistors are chosen to give 1.5dB steps. Since there are 16 possible values of resistor this gives a boost of up to 12dB and a cut of up to −10.5dB. The choice of 1.5 dB steps gives a fairly subtle change in level for each step, it was selected because 1dB is the smallest audible step and also because ±12dB is sufficient for most applications. You may decide that a different step size is more appropriate for your application.

Using the two tables you may be able to devise a variety of uses for the basic circuit given and we would be interested to hear of any you find.



Since the gain of the circuit is set by the input resistor in an inverting op-amp configuration, the input impedance of the system will vary with the gain. As long as the input impedance is higher than the output impedance of the driving device all will be well. If you do experience problems with this then try connecting the unit to the send and return loop on the amplifier rather than directly in the effects chain.

High Definition Television

The Broadcasting Technology Association Proposal

7b

James Archer looks at the final batch of American proposals for HDTV

Another proposal to ACATS that has since been virtually ignored in the technical press, possibly because many of the desirable features are only offered as future developments, is from the Broadcasting Technology Association (BTA). The system as submitted is really an improved NTSC system rather than a full HDTV proposal. Signals from what could be an HDTV source are first converted to a 525 line interlaced 4:3 format, and the signal processing in the studio consists of adaptive pre-emphasis to improve the detail that can be seen in dark areas of the picture, and quasi constant luminance processing. With appropriate receiver cicuitry, a reference timing signal is inserted into the video signal to cancel ghosting which occurs over the transmission path. It is assumed that line doubling circuitry would be used in the receiver converting incoming picture signals to progressive scan. The receiver would also use complex three dimensional filtering to separate the luminance and chrominance signals.

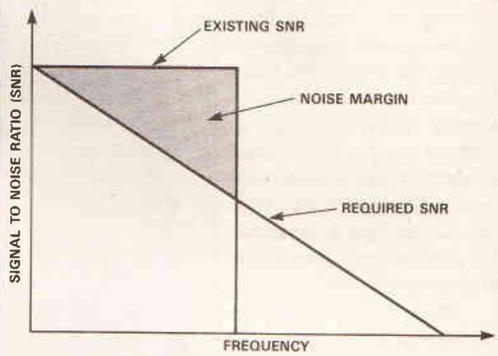


Fig.11 Basic explanation of how noise margin can be used to provide additional information in a compatible way.

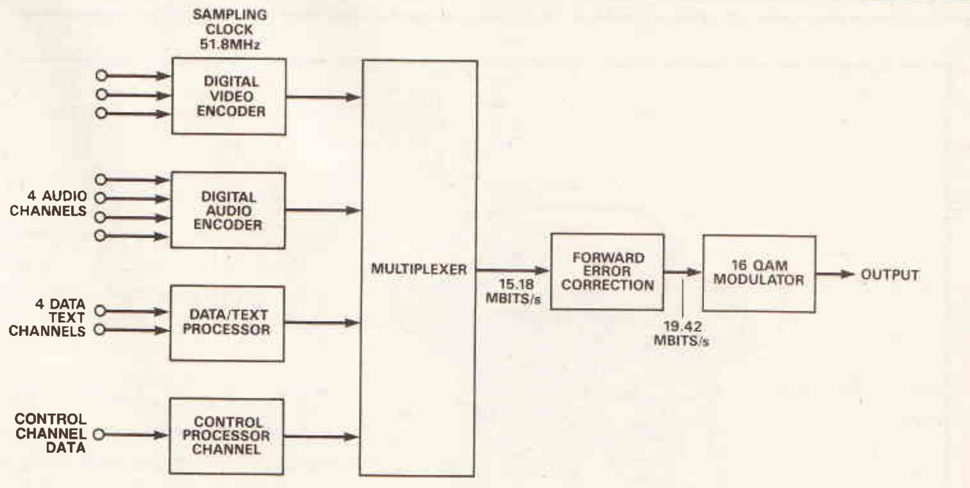


Fig 12 Digicipher Coder

The Noise Margin Method of hiding Enhancement Information

A group of researchers from the MIT and from Bell Laboratories have put forward details of their experimental work on an ATV system which uses a novel method of hiding the augmentation information within the normal NTSC signal. The result is a signal which can be carried over a standard 6MHz channel and gives perfectly acceptable results on standard NTSC receivers, whilst offering enhanced resolution and wider aspect ratio pictures to viewers with an ATV receiver.

The idea is that when an NTSC picture is transmitted over the air and received on a standard NTSC set providing a picture with a satisfactory signal to noise ratio (SNR), some parts of the picture signal spectrum actually have a higher signal to noise ratio than would be strictly necessary to provide an acceptable picture. The difference between the actual signal to noise ratio in these parts of the spectrum and that absolutely necessary to provide good pictures is called the 'noise margin', and this area can be used to carry extra information to back up the standard NTSC picture. This extra information can be extra picture detail and extra information for widescreen pictures, but if it is to remain compatible with ordinary NTSC sets, it

HDTV

must have the appearance of a noise signal as far as the receiver is concerned. For a standard NTSC TV the only effect of this extra information will be a slight worsening of the signal to noise ratio in some picture areas. The system has been carefully designed so that this high frequency noise is virtually invisible under most viewing conditions. Nevertheless, the 'sine qua non' of the noise margin method of hiding enhancement information is that the original NTSC pictures must have a signal to noise ratio sufficiently good to provide noise free pictures.

Figure 11 provides a simplified explanation of how the 'noise margin' occurs, and how the extra enhancement information can be squeezed in.

The human eye has the characteristic of apparently not seeing a reducton in picture quality (SNR) as the frequency of the picture detail becomes higher. The diagonal line in Figure 11 is therefore representing this characteristic, and is labelled 'required SNR' - note this SNR becomes lower as the frequency rises. The rectangle represents the signal to noise ratio of the actual received picture, with all spectral components having the same SNR, as has been found in practice for good quality NTSC pictures, and is therefore labelled 'existing SNR'. The top triangle then represents the area of the signal capable of carrying enhancement information to construct a higher definition widescreen picture. The way to obtain a wider aspect ratio has not yet been finalised, but the authors favoured the technique of vertically cropping the picture, adopted in other systems.

As with other techniques described earlier, this system uses other tricks to squeeze in even more information. Together with the noise margin idea, extra sound information is added to the signal by taking advantage of the human eye having a lower temporal bandwidth for colour than for luminance, so a 15Hz chrominance flicker is not easily noticed. The temporal rate of the chrominance signals is therefore reduced by half, to 15 fps by making each successive pair of chrominance frames identical. The digital audio signals are then added to the chrominance signals using opposite polarities on successive picture frames. Subtracting the two frames will then provide the audio information, whilst adding them will cancel out the audio and produce the colour information.

The noise margin method of enhancement can provide an EDTV system with pictures that have twice the normal NTSC resolution in the stationary areas, and as a bonus, digital audio can be added to the chrominance signals.

Liberty Television/Weaver proposal

Although it has not yet been officially submitted to ACATS, yet another ATV system was proposed at the NATPE programming conference at the end of 1989, and if it does nothing else it illustrates that the situation regarding ATV standards in the USA is still very fluid. Jon Weaver of Liberty Television, a New York production house, suggested that if an 1800 line 72Hz fps system were introduced, it would allow for simple transcoding between 1250/50, 1050/59.94, and 1125/60 standards. No firm technical details have yet been revealed, but it seems that an 1800 line 72Hz system would be likely to stretch the present state of the art as far as cameras, recorders, and video processing equipment are concerned, so it seems that this is an unlikely contender for the ATV honours.

The Digicipher HDTV system.

Although many people were beginning to think that an ATV system based upon some combination of several of the previously systems could eventually win through in the American market, it became plain that new developments are still forthcoming in the ATV field when General Instruments announced yet another proposed system in June 1990. Its Digicipher system has resulted in a great deal of discussion amongst engineers, some of whom are extremely sceptical about whether the fascinating proposal can ever be turned into a working system.

Digicipher is an all-digital HDTV system that, it is claimed, can be transmitted over a standard 6MHz wide television channel, in either the VHF or UHF bands. Additional advantages claimed are that the decoder complexity is low, and that low transmitting power can be used, allowing the transmissions to make use of otherwise 'taboo' channels. Compatibility is achieved by simulcasting the Digi-Cipher information with a standard NTSC signal on another channel.

In order to achieve the miracle of squeezing a digital television signal through a 6MHz channel a 'highly efficient unique compression algorithm' is used to vastly reduce the data rate that is required. In common with many other researchers in this field, GI have decided to adopt a coding system based on motion compensated discrete cosine transform (DCT) coding to achieve this. Such a system can only work because successive television images nearly always contain a large amount of similar information, so that by cutting

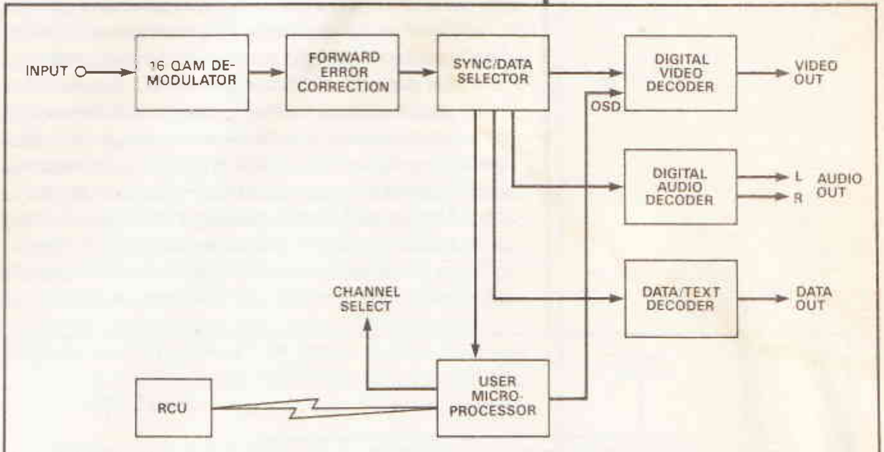


Fig 13 Digicipher decoder

out the redundant information, (the information is repeated from one image to the next), only essential data, giving the details of the changes which have taken place from one field to the next, need be sent. The Digicipher system compresses the signal by first predicting how the next frame will appear, and then sending the difference between the prediction and the actual image. The simplest way to predict what the next image will be is to use the previous field. Since some parts of the picture contain less redundancy than others, the result is a variable data rate which can sometimes be difficult to handle. This differential pulse code modulation (DPCM) idea works well if there is little movement present or if there is little spatial detail, but can collapse completely under some conditions.

As with many of the other systems using temporal compression, motion estimation and compensation techniques are used with the coding process. The Digicipher system uses large blocks of pixels, called 'superblocks', and provides a motion vector to give information about each of these blocks.

Using as its source a 1050 line/59.94 fps interlaced picture, the Digicipher digital video encoder takes the Y,U,V signals and samples them at 51.80MHz, implements the compression algorithm, and generates a video data stream. Four channels of digital audio plus four 9600 baud data channels and the necessary control and synchronising data are then multiplexed together with the video data, to provide a 15.8Mbit/s data stream. Forward error correction data is then added, bringing the data rate up to 19.42 Mbit/s, and this data is then fed to a 16-state Quadrature Amplitude Modulator (16-QAM), in which the amplitude and the phase of the transmitted signal are varied. With 16-QAM four amplitudes and four phases are usually used, and QAM was probably chosen in preference to PSK because it has better noise tolerance and therefore better resistance to errors. The multi-level, multi-phase 16-QAM signal can then carry the complete audio and video data stream within a bandwidth of only 4.86MHz.

In the Digicipher decoder the 16-QAM demodulator receives the incoming signal from the tuner, demodulates it and provides a 19.42 Mbit/s data stream. The demodulator circuitry contains an adaptive equaliser which can compensate for distortions to the off-air signal caused by multi-path reception. The data then passes to the forward error correction circuitry, to correct random and burst errors and should provide errorfree data to the sync/data selector. The selector maintains overall synchronisation and demultiplexes the data stream to provide separate streams for video, audio, and data.

Digital Transmission

For transmission, the use of digital modulation permits a much lower transmitter power, perhaps as much as 30dB less, to achieve the same signal to noise ratio and coverage area as for analogue NTSC signals. This helps enormously in limiting potential interference to existing transmissions, and allows the system to make use of the 'taboo' channels. Since it is claimed the digital signals take up only a 6MHz bandwidth, there should be no problems in passing them along existing cable networks, allowing them to carry HDTV signals with the minimum of modifications, and the signals should also be suitable for use over Multichannel Microwave Video Distribution Systems (MVDS) and over satellite links. GI even claims that 'all-digital recording and playback of its HDTV signals is within the reach of current technology for consumer use, since the total data rate is less than 20Mbit/s. With Digicipher claiming so many different advantages, it is no wonder that the sceptics are shaking their heads!

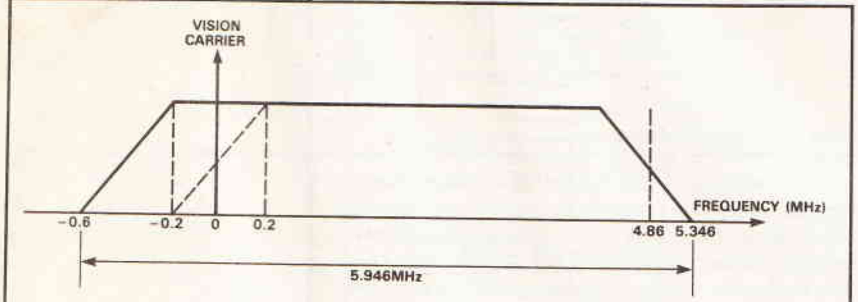


Fig.15 RF spectrum occupied by a Narrow MUSE signal

MUSE for the USA — A Japanese Hierarchy of Systems

The systems proposed by NHK for the American market have deliberately been left until the last part of this article, mainly because we have already considered the detailed operation of the MUSE system. The variants of the MUSE system that have been proposed all work using some of the same basic principles as the system described earlier, but they have been extensively modified so the signals can be squeezed into the bandwidths the FCC has said will be made available.

The original MUSE system was designed primarily for satellite broadcasting, and uses an 8.1MHz wide baseband channel to carry a 16:9 1125 line picture with 1440 horizontal picture elements. Such a signal will not fit into a standard NTSC channel, and so three major variations of MUSE have been developed to try to find a system that would be acceptable for the North American terrestrial transmission system. Since the basic MUSE system is totally different from NTSC there is no way in which it could truly be called compatible, since the MAC-like nature of the signals means that a decoder box would be necessary to provide NTSC viewers with a picture; the only way in which compatibility could really be claimed under the rules of the FCC 'game' would be if the modified MUSE signals could be fitted into a 6MHz channel which parallels a standard NTSC channel carrying the same programme material, the so-called 'simulcast' technique. The three suggested ATV versions of MUSE are called 'Narrow MUSE', which uses the 'simulcast' technique, and 'MUSE 9', and 'MUSE 6' which are completely redesigned versions of MUSE that can also provide pictures on NTSC receivers. Figure 14 shows how they fit into the hierarchy of MUSE systems for all purposes, from wideband satellite transmissions to narrowband terrestrial ones.

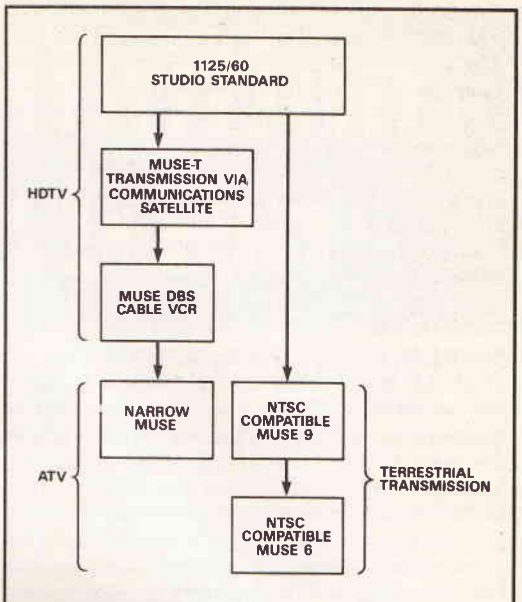


Fig.14 The MUSE Family

Narrow MUSE

The essential features of Narrow Muse are that it is an ATV system with four channels of digital audio that can be carried in a 6MHz wide radio frequency channel, so that it can be 'simulcast' with an NTSC signal on another channel. To reduce the bandwidth from that of the normal MUSE signal the number of scanning lines is reduced from 1125 to 750, but this should be sufficient to provide an HDTV display if appropriate upconversion is carried out in the receiver. Even this reduction in lines is not sufficient to let the signal pass through a 6MHz channel, so multiple sub-sampling is used, to provide a further reduction in bandwidth . Stationary parts of the image are sub-sampled with a combination of field offset and frame offset sampling, whereas moving parts are processed using line offset sampling, which means that moving areas will have lower resolution; as we have seen before, this will be acceptable to the eye. Essentially then, the Narrow MUSE system uses line reduction and multiple sub-sampling to reduce the spectrum required to just over half of that needed for standard MUSE, giving a baseband video signal with a bandwidth of 4.86MHz which can then be transmitted using vestigial sideband

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Amplitude Modulation within the confines of a 6MHz wide radio frequency channel, as shown in Figure 15. The digital audio is transmitted during the vertical intervals, and there are two options available, giving four channels at moderate quality or two channels at high quality.

The picture quality which Narrow MUSE can provide is better than that available from the MUSE-6 and MUSE-9 systems which will be described next, primarily because the Narrow MUSE system is not constrained by NTSC compatibility.

MUSE 6

The MUSE-6 system provides pictures with twice the static resolution of NTSC, a 16:9 aspect ratio, obtained by cropping the picture vertically, and improved chrominance resolution, and yet it fits comfortably within the limits of a 6MHz wide NTSC channel and provides acceptable pictures on NTSC receivers. The improvement in horizontal resolution is obtained by frequency multiplexing different parts of the picture information. The parts of the frequency spectrum above 3.9MHz are divided into two, one extending from 3.9-5.8MHz and the other from 5.8-7.7MHz. These two components are interleaved into an NTSC signal by using two frame-offset subcarriers. The multiplexing of the high frequency components is only carried out on static areas of the picture.

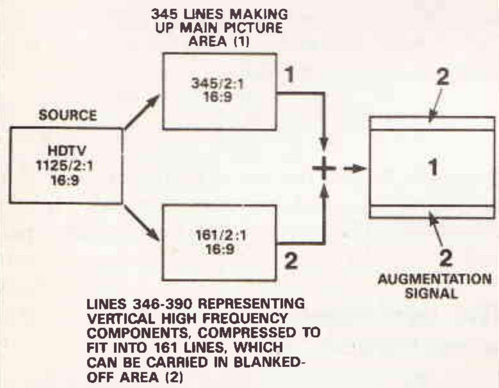

Fig.16 How the vertical resolution is improved in the MUSE-6 system

The 16:9 aspect ratio picture has only 345 basic scanning lines, which would give a vertical resolution around half that required for an ATV picture. Once again, multiplexing is used to improve things, as is shown in Figure 16.

The first 345 lines of the cropped picture are transmitted normally, but the vertical high frequency components, corresponding to lines from 346-690, are time multiplexed during the extended vertical blanking periods, ie, they are carried in the masked off portions of the picture area above and below the visible image. There are some 160 lines in the extended vertical blanking period, so to carry the lines from 346-690 it is necessary to compress the information from two lines so that it fits into one of the lines in the masked off area. In order to permit this, the horizontal resolution of the extra lines, (ie the vertical high frequency components of the picture), must be reduced by a half.

In a similar manner the chrominance signals can be given enhanced resolution by frequency multiplexing the high frequency parts of the chrominance signals into the high frequency luminance signals that are carried in the masked off parts of the picture.

Figure 17 shows the basic method of operation of the MUSE-6 NTSC compatible system.

The source, as with all MUSE systems, is an 1125 line 60Hz 2:1 interlace picture with a 16:9 aspect ratio. The source is sampled at 31.9MHz for luminance and 15.4MHz for each of the colour difference signals, and these sampled signals are then fed into a noise reducer and applied to a motion detector, which examines adjacent fields and determines the difference between them. The prior noise reduction is necessary because the difference signals from the adjacent fields will contain noise, which could lead to the motion detection circuitry becoming confused. The main signal is then converted from 1125 lines to 750 lines, interpolations between fields being used on static parts of the picture and just the current field information for moving parts of the image. It is then necessary to convert the field rate from the 60Hz of the source to the 59.94Hz which is required to ensure compatibility with NTSC; the conversion is done by reading the information into field stores at the 60Hz source rate and then reading it out at the slower 59.94Hz rate. The signals are then passed to a matrix and a non-linear processor to provide signals of an appropriate gamma for the NTSC system, and they then enter the circuitry which carries out the arrangements for ensuring that the masked off parts of the picture carry the enhancement information.

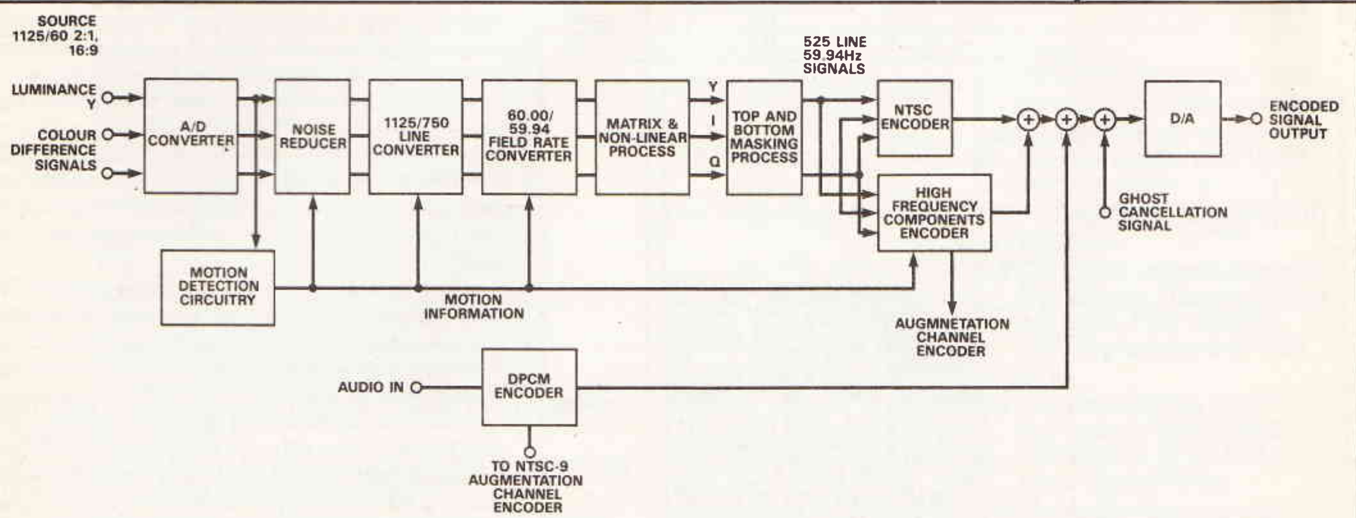

Fig.17 The MUSE-6 Encoding system

As shown earlier, the Y I and Q signals from the matrix form a 750 line signal which is divided vertically into two separate components representing the high frequency and low frequency parts. The low frequency part provides the information for the central part of the picture, whereas the high frequency part, after horizontal band- limiting, is compressed, and this information provides the top and bottom parts of the masked-off picture. The Y,I, and Q signals are then pushed into an NTSC encoder, and the high frequency component signals are separately encoded. Digital audio and ghost cancellation signals are added to the vision signals before transmission. The resulting MUSE- 6 signal can be carried in a standard 6MHz wide NTSC radio frequency channel, and will provide a standard NTSC receiver with an NTSC picture. ATV receivers will be able to make use of the extra information that the MUSE-6 signals contain in order to provide an 1125 line widescreen picture with better resolution.

MUSE-9

The MUSE-9 system uses a main channel which is identical to MUSE-6, but in addition it makes use of another 3MHz wide channel to carry further augmentation information. MUSE-9 is therefore compatible with existing NTSC receivers in the same way as MUSE-6. The augmentation channel, which occupies 2.1MHz of the baseband channel, provides extra information which can be used to increase the resolution of the moving parts of the picture, and to provide extra digital sound channels and an improvement in the quality of the original digital audio signals. The augmentation channel signal is transmitted as a 525 line signal in which the extra movement information about the high frequency parts of the picture is time division multiplexed with the digital audio signals. Using vestigial sideband modulation the augmentation information can be carried within a 3MHz radio frequency channel, and the main and augmentation channels can either be transmitted by one transmitter in a 9MHz wide contiguous band, or by two separate transmitters, as shown in Figure 18.

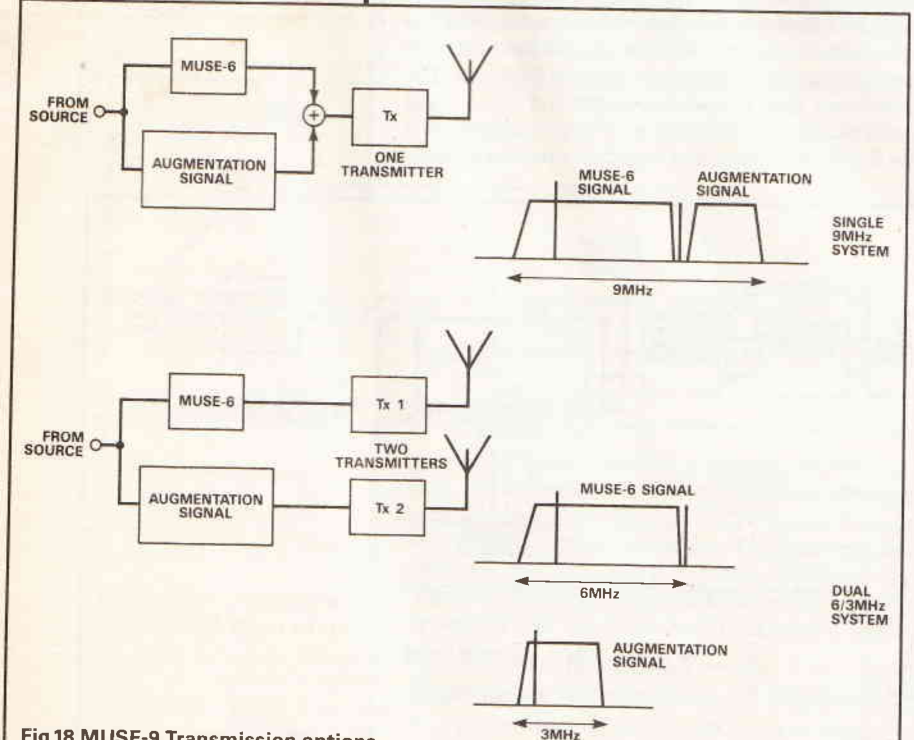

Fig.18 MUSE-9 Transmission options

It is felt that where possible the single 9MHz channel option would be preferable, since this is likely to avoid possible problems with amplitude and phase differences between the main signal and the augmentation signal.

MUSE for ATV

All of the three MUSE systems that have been proposed for American ATV use an 1125 line 60Hz source. Narrow MUSE provides the highest quality pictures and is closest to the original MUSE system in that it does not produce a signal which can be used by NTSC receivers, although it does fit into a single additional 6MHz channel, so that 'simulcasting' can provide 'compatibility'.

MUSE 6 provides NTSC receivers with a fully compatible signal, can produce widescreen pictures and two channels of digital audio on an ATV receiver. By the addition of an extra 3MHz wide augmentation channel MUSE-6 is transformed into MUSE-9, an NTSC compatible ATV system which has better resolution of the moving parts of the image than MUSE-6 and provides improved audio.

The US ATV proposals – thoughts and conclusions

We have looked at many potential ATV systems for the United States, and since many of the improved techniques in one system could just as well be used to improve some of the other systems, the number of possible permutations is enormous. Not all the proposals will be submitted for testing; at the time of writing it seems that towards the end of 1990 only about eight companies will provide complete systems for testing, although there is, of course, still time for others to join them.

The problems of critical assessment

The author is very much aware that in this series of articles the multiplicity of proposed ATV systems has been described fairly uncritically. It is a major disadvantage of having to rely on manufacturers' descriptions of what their systems can achieve whilst not yet being able to judge them in practice. Until side by side tests and demonstrations of the various systems have been carried out it will not be possible to reach sensible conclusions on which systems are best. It is important to remember that a system which performs perfectly in the laboratory may turn out to have severe problems when transmitted over air. Practical transmission systems may have to pass the signal through cable and microwave links and then through several transmitters in tandem before it finally reaches the home by means of a less than perfect antenna assembly. Received signals are likely to suffer from noise, ghosting, and selective frequency distortions which could play havoc with an ATV signal, especially if it has had its complete frequency spectrum packed full of the extra information that is necessary to provide enhanced pictures and sound.

In general the techniques used for proposed ATV, use some combination of an increased bandwidth, reduced diagonal resolution, and reduced temporal resolution to provide increased vertical and horizontal resolutions when compared with NTSC. It is possible to make some predictions of the likely problems with each type of system, although at this stage it is only fair to manufacturers to say that each would probably claim to have ways of minimising or avoiding the defects. From a normal understanding of engineering principles and the author's in-built conviction that 'you don't get something for nothing' it seems reasonable to assume that those systems with the largest bandwidth should give the best performance, provided the bandwidth has been used optimally. Also, the ATV systems have generally been designed to provide some degree of NTSC compatibility, in accordance with the FCC requirements, and this factor may act as an important constraint on what would otherwise be the optimum usage of the available spectrum. Most of the techniques used in the various ATV systems actually trade off one parameter for another, as we have seen, and it is usually a case of removing information that the human visual system is not too aware of in order to include extra information giving more detail to the picture that the eye and brain find important.

So the systems which provide improved resolution, whether vertically or horizontally, generally provide reduced performance in one way or another when motion is present in the pictures. Reduced temporal resolution is the inevitable result of some of these systems; the MUSE and North American Philips proposals need more than one frame to update a picture, using 15 frames per second, whilst the Del Rey system sends only 10 fps and the Glenn VISTA system has a 7.5 fps update rate. The system proposals from Bell (SLSC), Scientific Atlanta HDB-MAC, and CBS should all provide full temporal resolution, whilst the David Sarnoff / NBC ACTV proposal is likely to suffer some loss of temporal resolution because of interframe averaging techniques.

The systems which include the separate transmission of side panels for wider aspect ratio pictures could suffer from problems; as an example, if the side panel signal to noise ratio is not as good as the main picture, as it often will not be, then under certain reception conditions it may well be possible to see the joins between the main picture and the edges. The systems which use a 16:9 or 5:3 picture as the basic system picture will not suffer from this problem, but may cause compatibility problems with NTSC sets displaying blank strips at the top and bottom of the picture, as we have seen.

The various sub sampling processes work extremely well for much of the time but can cause patterned artefacts and irritating motion effects to some pictures. Even the display improvements which may be obtained from receivers providing continuously scanned pictures from incoming interlaced signals are not always without technical cost — upconverting to higher line numbers can produce visible artefacts. In the same way that the colour subcarrier of an NTSC signal can break through to provide luminance patterning on a picture, systems that use extra subcarriers, such as the David Sarnoff/ NBC ACTV system could result in further interfering patterns if the relative signal levels are not carefully controlled, as can happen when signals are sent over a difficult transmission path. Opponents of the Genesys system find it difficult to believe that all the extra information needed can be squeezed into a standard NTSC channel without the extra information causing some sort of degradation; only time and stringent testing will show who is right.

Disadvantages apart, several systems will result in the ordinary NTSC viewer actually receiving better quality pictures than before; as just one example it seems that the preprocessing of picture signals in the Faroudja SuperNTSC proposal should mean NTSC pictures will suffer much less from cross-colour and moire patterning.

Predictions are always very difficult in the television game, and it will be even more difficult than usual to predict the outcome of this particular race. Although it is tempting for engineers to believe that the 'best' technical system will win, a far more probable outcome will be that a consortium of manufacturers and broadcasters will decide to adopt the system that can most quickly be brought to market, and which can most quickly be made to pay!

Part eight of this series, in next months issue of ETI, will look at progress towards a world standard, and will do some crystalball gazing as to what the 1990s hold for the television viewer.

Fire Detection Systems

2

ALARMS

In this second part, Vivian Capel examines the electrical circuits for fire alarms

Circuits

If we first consider intruder alarm circuits, which may be more familiar, we can appreciate how the fire detection circuit works. The main intruder alarm detection circuit consists of a loop having sensors with normally-closed contacts connected in series. When actuated, a sensor goes open-circuit thereby interrupting a constantly circulating current which triggers an alarm condition in the control box. The reason for this arrangement is that the circuit is thereby constantly monitored when active, and any breakage or disconnection produces an alarm signal. An auxiliary normally-open circuit is also used for pressure mats which go short-circuit when stepped on.

However, some degree of sophistigation is required for protection from tampering when not in use, and supply of power to active sensors such as infra red and ultrasonic detectors. For the first of these, an extra loop is provided which carries current - 24 hours a day and thereby gives an indication of a fault in the wiring even when the system is switched off. Power supply for sensors requires yet another pair of wires in the cable.

In the case of the fire detection circuit, it can be either a straight-forward normally-open or a closed loop if only mechanical heat detectors and manual call points are used. Electronic detectors need a DC power supply which would normally require an extra pair of wires. Some form of monitoring is required to ensure the circuit is always on guard and that any faults are indicated. This too would seem to require extra conductors.

However, the amount of cable needed to give adequate fire protection to even medium-sized premises is considerable, far greater than that required for an intruder alarm system. A four or six-wire circuit would entail a lot of work in connecting each detector, and be very costly. The circuit commonly used for modern fire detector systems ingeniously accomplishes all these requirements with only two wires. Here's how it works.

The circuit is normally open, and the detectors are connected in a chain in parallel across the circuit. Each one has a pair of input terminals for the incoming wires and an output pair which are linked internally to them, for the outgoing ones to the next detector.

If a single pair of terminals were used with both incoming and outgoing wires twisted together and wrapped around them, a loose terminal could incapacitate that detector but would not break the connection to the next. So there would be no indication of a fault. This arrangement ensures that any loose or disconnected terminal breaks the chain and so registers a fault. The chain continuity is completed by a high impedance termination across the last detector which can conveniently be connected across its output terminals.

DC Supply

A DC supply of 24V is applied across the circuit, so the detectors are polarized with positive and negative markings which must be observed. The detector has a semi-conductor output stage across the line, along with a comparator and other circuitry. These take a small current, nominally 0.1mA in the quiescent state, but when actuated, the output stage goes low resistance and a large current of at least a hundred times that amount flows. The increased current is sensed by the control box which sounds the alarm.

As all detectors take a quiescent current it follows that there is a limit to the number that can be connected to any single circuit. The maximum current is usually specified on the control box. Commonly 4mA, this allows 40 detectors to be connected. However, the 0.1mA rating is nominal and the actual current is frequently smaller, so a few detectors over the calculated maximum can usually be accomodated if required.

Manual call points take no current so any number can be connected to a circuit. They can be mixed with other detectors in any order, but they must be of the normally-open variety for this type of circuit.

Monitoring

To monitor the condition of the circuit, a small AC voltage is superimposed on the 24VDC. The resulting current flows along the circuit and through the end-of-line termination, which consists of a capacitor and diode. This of course blocks the DC supply. Thus the circuit is open to DC but closed to AC and thereby is able to provide detection, DC supply, and monitoring functions using only two wires. As long as the AC current flows, the circuit must be continuous, but any cessation of the current produces a fault indication at the control box.

Additional security against faults can be obtained by a ring circuit. This is a chain that has both ends returned to the control box in the manner of a ring main electrical circuit. The end-of-line termination is connected to a point about half-way around. If a break occurs at any point, all detectors are still connected to the system. Further safeguards are isolators placed around the circuit to limit the effect of any short circuit, to those detectors between two isolators.

The BS 5939 specifies that any open circuit in a ring detector circuit should be indicated and identified within 60 minutes. Although the circuit is fully operative with such a break, there is now no back- up path, and a second break would take out all sensors between the two breaks. A short circuit should be indicated as a fault within 100 seconds.

Spurs

All circuits should consist of either a single chain or a ring. No spurs should be connected in at any point, nor can two chains be run from a common start. The reason being that monitoring would be defeated. If an end-of-line termination was omitted from the spur, it would be unmonitored. If one was fitted to it as well as the main chain, monitoring current would flow through both. So if there was a fault on either the spur or the main chain from the spur connection onward, monitoring current would still flow through the other termination, and the fault would not be indicated.

Zoning

All detection circuits should be divided up into zones and connected to a separate zone input on the control panel. Each of these has an indicator so that when triggered it shows immediately which is affected. In addition, each zone has a fault indicator which is actuated if the monitoring current ceases.

The rule for zoning is that one zone should serve only one fire compartment. A fire compartment is an area which could contain a fire for a period without spreading to adjacent compartments. If out of control of course, such a spread would eventually be inevitable. Usually a fire compartment is defined as an area enclosed by walls, ceiling and floor. Each storey is a separate compartment unless the total floor area of the whole building is less than 3230ft^2 (300 m^2), in which case the whole building is a single fire compartment and can be served by a single zone.

The floor area of a single zone even if on the same storey must not exceed 21,500ft^2 (2,000 m^2). Storeys having a larger area than this must be divided into separate zones. Stairwells, lightwells, liftshafts and the like are single fire compartments even though they extend through several storeys. Each shaft should thus be on a separate zone.

In some cases there may be split levels and dividing walls which may make it difficult to define a compartment. In such situations the search distance necessary to visually locate a fire should not be greater than 100 ft (30 m).

So the rules for defining fire compartments are such that it enables not only the location of a fire, but its extent and confines to be quickly determined from the control panel. This information is invaluable to the fire services so that they can most effectively deploy their resources.

Detector cables

Some control panel manufacturers specify maximum resistance values for detector circuit cables. A high series resistance could reduce the detector current when actuated, and as this also produces a voltage drop to the detector output device, the current would be reduced further. Uncertain operation would result.

The specified maximum resistances are usually far greater than would be obtained with any but the largest installation. A typical value is 150R, but flat 16/02 mm cable has a resistance of 7.2R per 100m in both conductors. It would therefore require a run of 2,100m or 7,000ft to exceed the resistance. Even 7/02 mm cable, which has a resistance of 16.4R, could run for 900m or 3,000 ft before reaching 150R. The picture would be changed if any other resistance such as circuit isolators was introduced.

A maximum cable capacitance is also usually quoted. If excessive, this capacitance could shunt the monitoring current and thereby bypass the end-of-line termination. So a fault would not be indicated. Here again though, the maximum capacitance' quoted are far greater than are likely to be encountered with actual cables. A typical value is 0.5u, but with a capacitance of some 27p per ft, or 90p per metre, it would need 5,500m or 19,500ft of 16/02mm to reach that value. Thinner cable has even lower capacitance.

Bell monitoring

It would be pointless to ensure fault-free operation of the detector circuit if an unreported fault could appear in the bell circuit. This too must therefore be monitored continually and any break, signalled.

The method of monitoring the detectors would not work with the bells because they have a much lower resistance than the detectors and would bypass the AC monitoring current. So, a different system is used.

A resistor is connected across the end of the line, and each bell has a diode in series with it. When the system is on guard, a reverse current is passed around the circuit. This is blocked by the diodes from flowing through any bell, but passes through the terminating resistor. As long as this current is flowing, the bell circuit must be complete, so if it ceases, a fault is indicated on the control panel. Any short-circuit increases the current above normal, and this too produces an indication on the panel.

When an alarm is triggered, the polarity of the circuit is switched back to normal, and thus the applied power flows through the diodes to actuate the bells. The terminating resistor is of relatively high value, so its shunting effect is negligible across the circuit.

Bells intended for fire alarm systems often have a diode built- in. The diode reduces the applied voltage by about 0.5V, but with 24V operation, this is a small proportion and so has little effect. It is worth noting that some of these bells are rated 12- 24V, and so can be used for intruder alarms. At 12V, the diode does have an effect on volume, so should be removed or shorted out when so used.

Bell wiring

It is desirable that the system keeps sounding for as long as possible after a fire has broken out to ensure that all including anyone who may have been asleep, are roused and aware of the emergency. Wiring to the detectors is not important at this stage, they have done their job in triggering the control box. It is the cable to the bells that needs to be protected. The BS 5939 specifies that preferably, heat-resistant cable should be used for these circuits, or if other types are used they should be protected against direct heat in some way.

Silicon rubber insulation can withstand temperatures up to 390 F (200 C), but is expensive PVC electrical installation cable or elastomer insulated textile braided cable can be used if protected by conduit.

Cable resistance for bell circuits is more significant than that of the detectors because the higher current could lead to an appreciable voltage drop, especially when there are many bells on the circuit. Using 24V as standard instead of 12V for alarm systems helps because the current is only half what it would be for 12V bells, so the voltage drop is halved too. Whatever voltage drop does occur, its proportion to 24V is only half what it is to 12V. So, the total effect of cable resistance is a quarter of what it would be at 12V.

If of solid wire, the BS 5839 further stipulates that cable should be not less than 1.0mm^2 in diameter, or 0.5mm^2 for stranded wire. Anything less than 1.0mm^2 should not be drawn into a conduit unless it is twin twisted which has greater strength, in which case conductors down to 0.5mm^2 can be drawn.

The Standard also states that fire alarm system cables should be segregated from all others. This can be done by running them in conduit, ducting, trunking, or if exposed, by running them with a separation of at least 300mm from any other. If none of these is practically possible, special easily identifiable cable should be run, or it should be labelled at intervals of not more than 2 metres.

All connections other than those to the detectors should be made in junction boxes labelled 'Fire Alarm'.

In the next article we will discuss what factors govern the location of detectors and bells.

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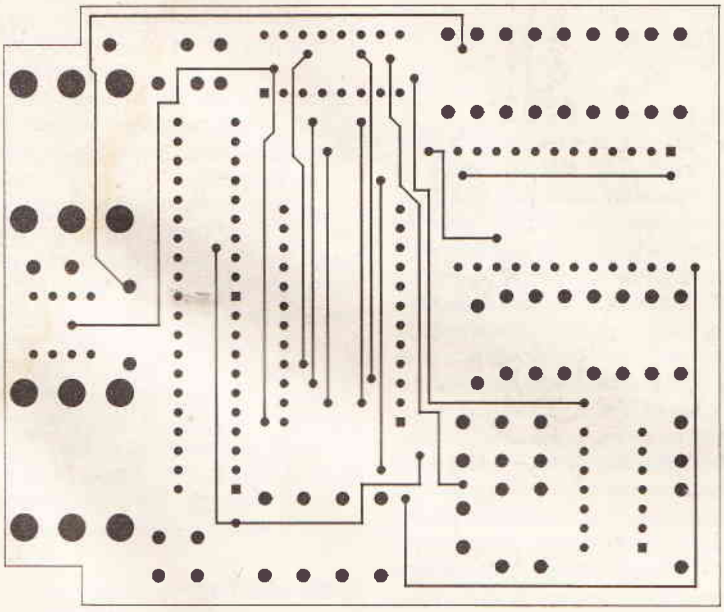
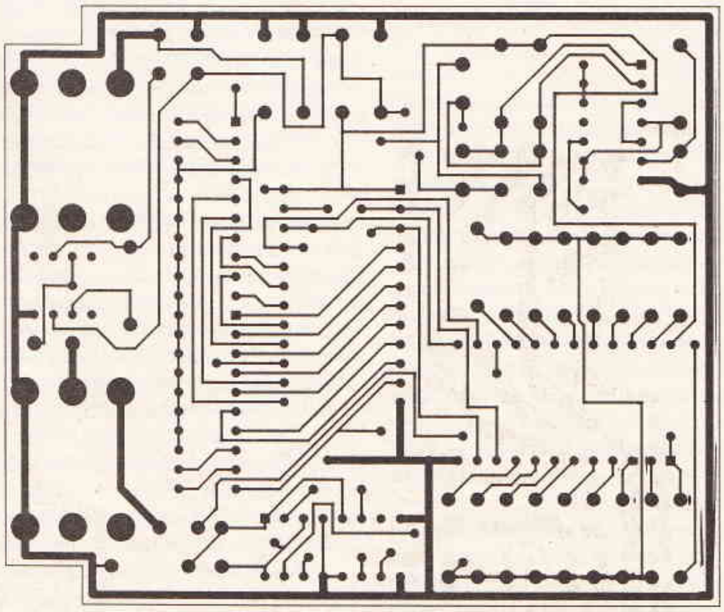


The Foot Tapper — top side



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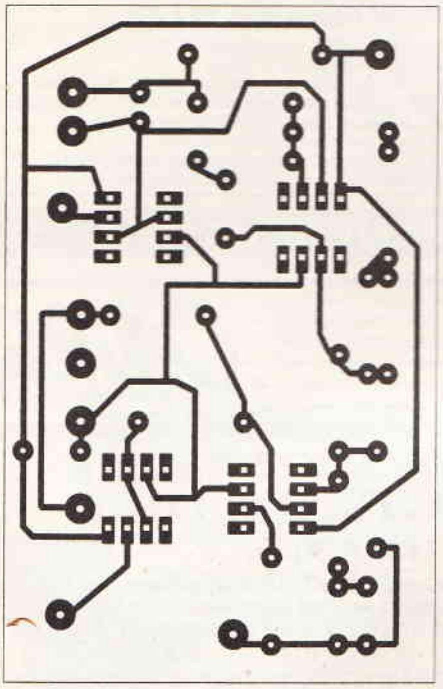

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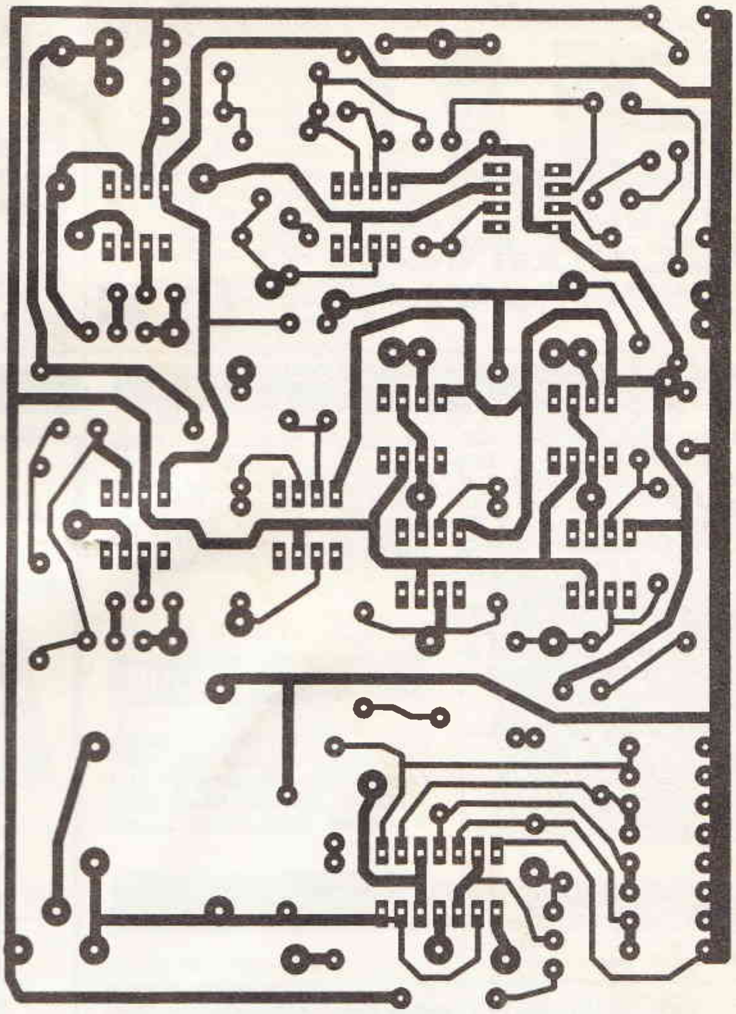

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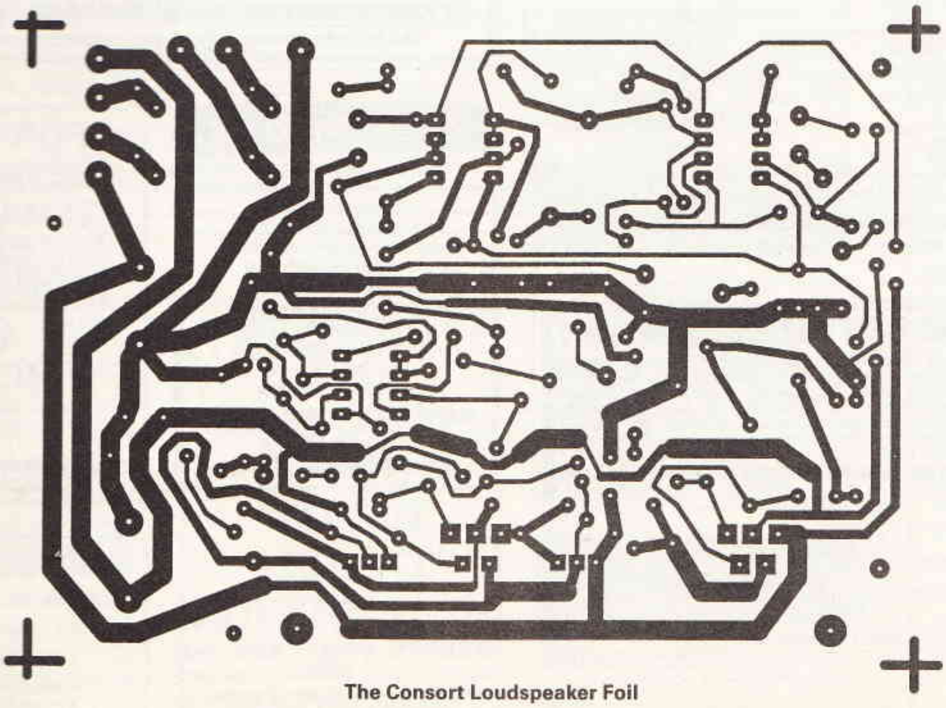

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PCBs for the remaining projects are available from the companies listes in Buylines.

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E9005-1	Business Display	O
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E9006-1	Dark Room Timer	G
E9006-2	Telephone Extension Bell	C
E9006-3	Telephone External Bell	D
E9006-4	Fecko Box	G
E9006-5	Bug Spotter	E
E9007-1	Guitar Practice Amp	G
E9007-2	Digital Frequency Meter	M
E9007-3	Footstep Alarm	E
E9007-4	Transistor Tester	C
E9007-5	Decision Maker	J
E9008-1	AC Millivoltmeter	K
E9008-2	Temperature Controller	N
E9008-3	FM Generator	L
E9009-2	Slide Projector Controller	E
E9009-2	Ultimate Diode Tester	D
E9009-3	The Entertainer	G
E9010-1	Component Tester	F
E9010-2	Active Contact Pickup	E
E9010-3	R4X Longwave Receiver	C
E9011-1	The Autocue (2 boards, 1 double sided)	N
E9011-2	Infra-lock transmitter (2 boards)	K
E9011-3	Infra-lock receiver	H
E9011-4	Four-track cassette recorder (record/playback one channel)	F
E9011-5	Four-track cassette recorder (Bias/erase oscillator board	K
E9012-1	Infra Switch	F
E9101-1	Remote Control — Main Board	J
E9101-2	Remote Control — Display Board	H
E9101-3	Remote Control Timeswitch — Transmit board	E
E9101-4	SBC Micro-Controller Board	F
E9101-5	SBC Practice Interface Board	F
E9101-6	5 in 1 Remote Sensing Switch	E
E9102-1	Remote Control Timeswitch — receiver board	F
E9102-2	Anti Theft Alarm (2 bds)	H
E9103-1	Ariennes Lights	L
E9103-2	64K EPROM Emulator	N
E9103-3	SSB Radio Receiver	G
E9103-4	Active Loudspeaker board	H
E9104-1	Testmeter Volts	E
E9104-2	Active Direct Injection Box	F
E9104-3	EPROM Eraser	F
E9104-4	Digital Tachometer	F
E9104-5	Radio Calibrator	F
E9105-1	Modulator Laser (2 boards)	H
E9105-2	Thyristor Tester	F
E9105-3	Frequency Plotter	K
E9106-1	Laser Receiver	F
E9106-2	Temperature Controller — Power Supply	G

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NEXT MONTH

As time flies rapidly into the heat of the summer once again ETI has a mixed bag of items for you to read on the beach, in the hotel or in the tent.

We finalise our series on laser topics with a look at how the medical profession use these invaluable tools to cut, repair or destroy unwanted material.

In the light of TV manufacturers producing the first wide screen, higher definition TV sets, James Archer looks at a possible world standard for the next generation sets.

Back to basics examines capacitive and inductive reactance and we start a two part article on Fault finding to give you ideas on what to do with that heap of scrap in the corner that is crying out to be mended

If you are at home, the option is there to turn to more practical matters. ETI presents two model railway controllers for you to decide which most suits your needs for motor control or try constructing The Hemisyc.With the long awaited return to biofeedback techniques, here is a machine to help you relax and be creative.

All this and more at your newsagent on 5th July.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

The June issue included:

Fire Detection systems Part 1
Local Operating Networks
Piezo-Film Technology
Temperature Controller Part 1
Laser receiver
Temperature Sensor ICs
Supercomponents-Component quality

Back issues are available from Select Subscriptions (Address on this page).

ADVERTISERS' INDEX

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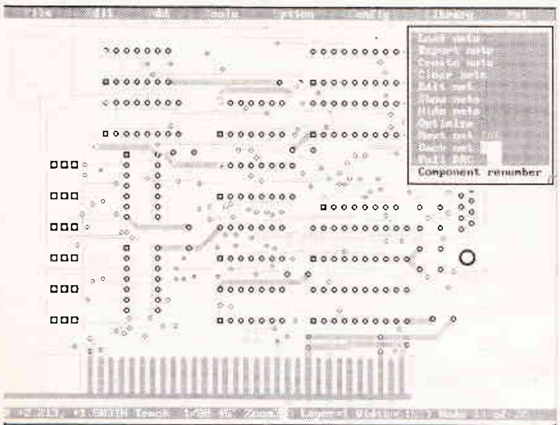

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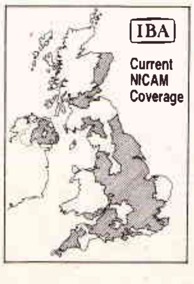

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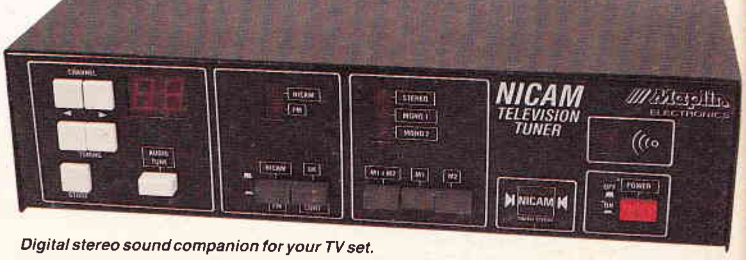

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