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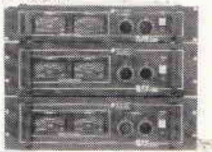

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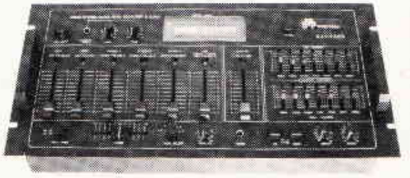

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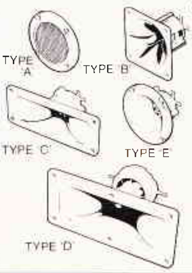

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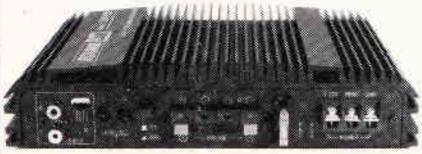

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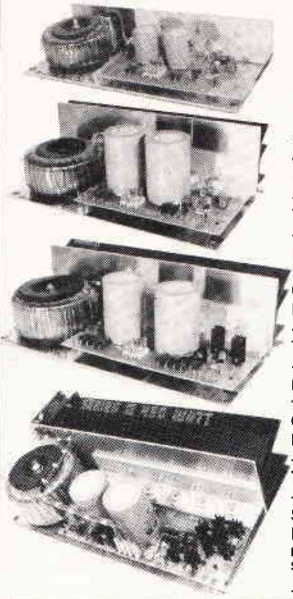

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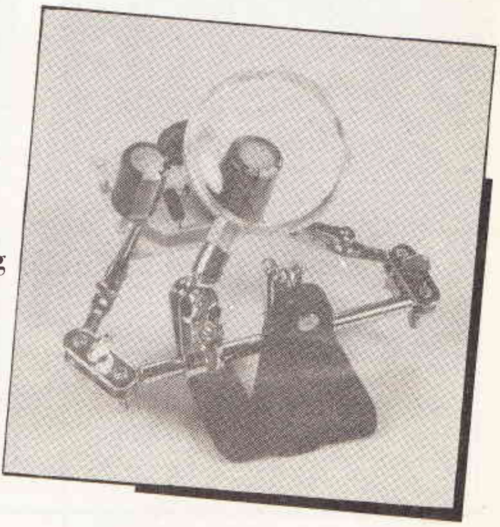

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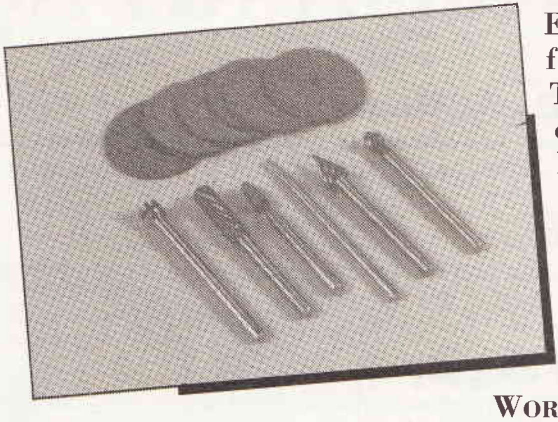

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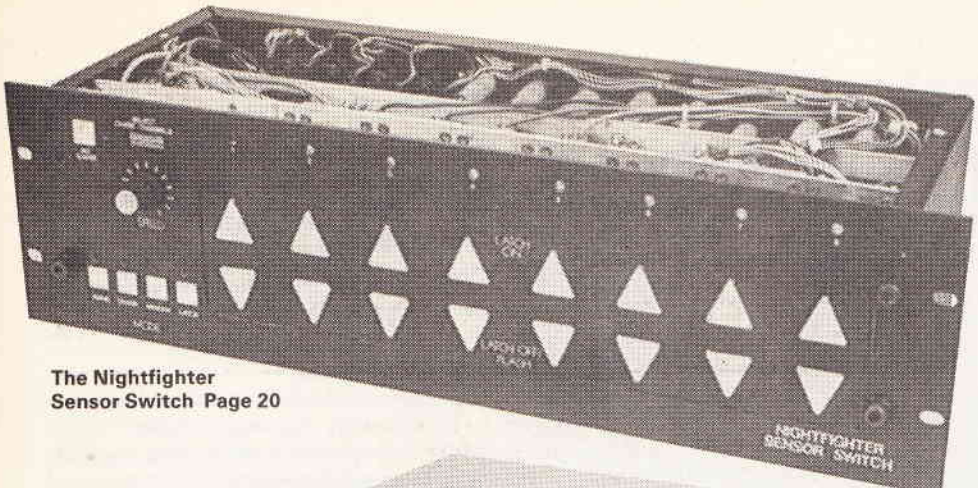

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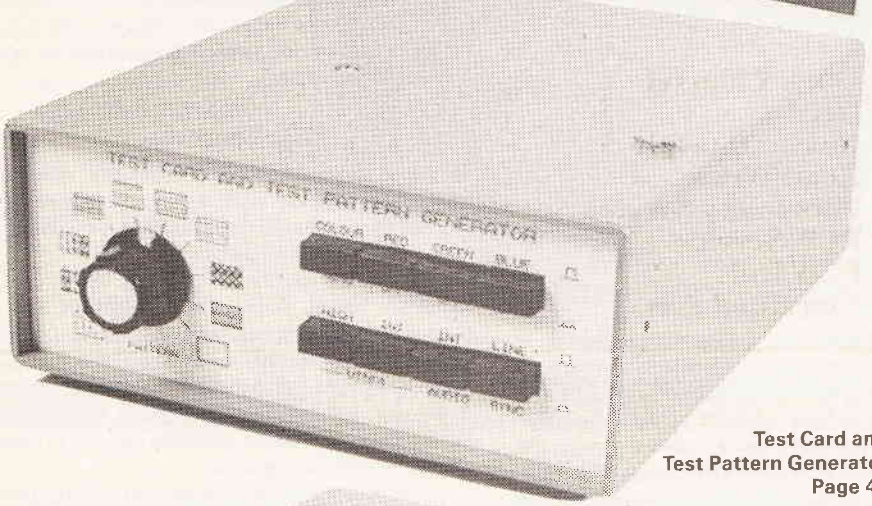

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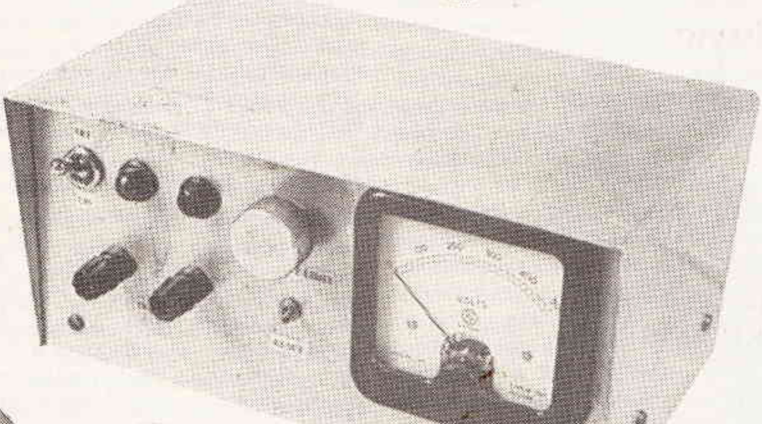

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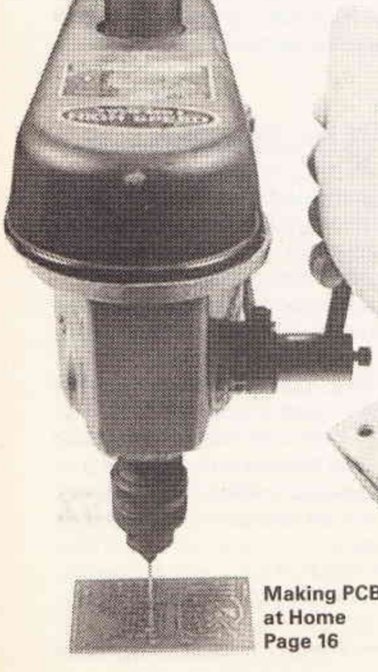

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Editorial

Changes to the school curriculum over the last few years to provide a broader learning base for our state children has been encouraged to keep abreast of developments in life. Sadly, as a lot of parents know and indeed children also know, the system lacks the resources and knowledgable staff to take on some of the new subjects now on offer. A crucial area of concern is of course electronics coming as it does under the technology hat.

I predicted a few years ago, coming from education, that we editors 'in the business' would begin to see the following arrive on our desks:

Dear Sir,

I am a sixth/fifth-year pupil studying A level/GCSE technology etc... Please can you design/modify/send/help me in any circuits relating to . . .

As much as it is frustrating for the pupil in not getting the information from school, it is also frustrating for us in not being able to spend the time on such investigations. Our younger citizens are trying to learn from a very narrow academic foundation and if we are not careful it could end in rejection of the subject.

We all know the lack of investment into science and technology in Britain puts us in the bottom league for scientific development but this deep rooted problem finds itself reflected in our dichotomous education system, and in a way is self perpetuating. Breaking traditional 'safe' values and investing in new horizons is too much of a risk-taking adventure according to the 'old greys'. It would have a better chance with younger minds in positions of parliamentary power with a scientific bakground, something that is presently lacking.

Maybe the British Euro-child of tomorrow should receive their science and technology education across in mainland Europe where greater importance is placed on such matters. I'll pass on the practicalities of such a move but various exchanges in other areas have been operating for many years.

Now the bandwagon of environmental issues is truly underway it might seem opportune to get 'people power' onto making the importance of science a politically important issue.

Paul Freeman

OPEN CHANNEL

Why, oh why can't we (I use the term we loosely to mean *the whole world*) get our act together and stop doing things in a multitude of ways: duplicating research and development efforts; manufacturing many different types of products which all do the same thing; offering a whole range of goods all-but-a-smidgin identical in what they do; then expecting everyone to make a fortune and be happy?

It may be a bit naive and simplistic of me (and no doubt Her Majesty's current Government will tell me it is) but I'm sure the spirit of competitive materialism which has pervaded the UK over the last twelve years (and the rest of the world, for that matter) doesn't always produce the best results for us poor plebs who use the goods, services and products which are thrown at us. Don't get me wrong! I'm not saying competition isn't a good thing. Regular readers will know I argue *for* competition whenever competition is warranted.

But surely there has to be a case to answer when *too many* commodities are available in a given market-place. In a simple example, take the town where I live. For argument's sake let's call it Mytown; a small University town of less than 50,000 residents. We've got a Macdonalds, a Wimpy, five pizza houses, umpteen Chinese takeaways, about ten curry houses and countless great British chippies. On top of this there must be well over twenty conventional sit-down-and-eat restaurants and dozens of pubs selling bar food. Unremarkably, there are almost weekly reports in our local rags about one or another eating outlet closing down due to lack of custom.

Now, as I say, I'm all for competition. But competition of this sort does no-one any good. No-one makes a good profit because sales averaged out between this lot don't add up to much. Customers don't see the real benefits of competition (that is, cheaper meals) because none of the eating outlets can afford to lower prices. Lower prices can only result if companies increase turnovers; and that can't happen because Mytown is a fixed size.

Where is all this relevant to electronics? Well, consider telepoint, that darling of the DTI which was to revolutionise personal communications. Two years ago, the Government thought we'd all be walking round with a telepoint 'phone in our pockets, briefcases or handbags by now. Then, all we need to do is to be within eyesight of a receiver/transmitter station and we can hook into the public telephone network whenever we want.

What happened? The DTI licenced four operators to do what two, or at most three, could easily do and so the system got out of hand. Handsets were too expensive, the four operators couldn't agree on a common standard, potential users couldn't be bothered, and operators started dropping like flies. Now there are only two operators left at the time of writing and the time is passed for the system. No-one wants it anymore, preferring to rely on real telephones or cellular carphones if they want to look cool.

Competition of this sort is self-defeating. It's happened in the computer business, of course. Larger companies take the lion's share of sales, while smaller fish are eaten or drown. Good ideas are stifled, prices remain high, customers are confused, fat cats get fatter. Yet still we don't learn.

Competitiveness should be monitored and controlled by governments. This way, consumers benefit by cheaper and better products and services, manufacturers and service providers benefit through increased profits, employees benefit by being in work. Chaotic competitiveness, unleashed and uncontrolled, is not a happy state of affairs.

The Big, Big Blue

Talking of large computer manufacturers, over the last few months IBM has been signing agreements with a number of companies worldwide, and it's interesting to speculate what it's all leading to.

These companies (including: Apple, Inmos, Motorola, Novell, Siemens and Wang) are all major players — if not leading players - in their own fields, and in one way or another have niches for themselves which even IBM has not yet been able to penetrate. Apple, for example, has its niche in graphics-orientated computer systems, Siemens niche is in communications, and so it goes on.

Is IBM looking to get a foothold in the few remaining corners of the computing market it doesn't already control? Is it wanting to be an even bigger blue whale in the sea of small fish it already controls? Are there going to be any small fish left at all in a few years, or is the big blue whale going to eat the remaining few all up?

DCC vs MD

It looks like Philips' digital compact cassette is going to win the impending war against Sony's mini-disc, simply because manufacturers want to make DCC and not MD. In alphabetical order, companies going to manufacturer DCC machines currently include: Bang & Olufsen, Blaupunkt, Grundig, Kenwood, Matsushita, Tandy, Thomson, Sanyo, Sharp, Sony (yes, that's right) and Yamaha. On the other hand, manufacturers who are to make MD machines are: Philips and Sony!

Maybe the impending war is really just a storm in a teacup.

Something To Be Nervous About

Siemens, Bull and Olivetti are going to produce a computer network, provisionally called the European Nervous System (don't blame me, I only report this rubbish!), which is to be pan— European and according to the European Commission's commissioner for research and development, Filippo Pandolfi, is essential to the future of the computer industry.

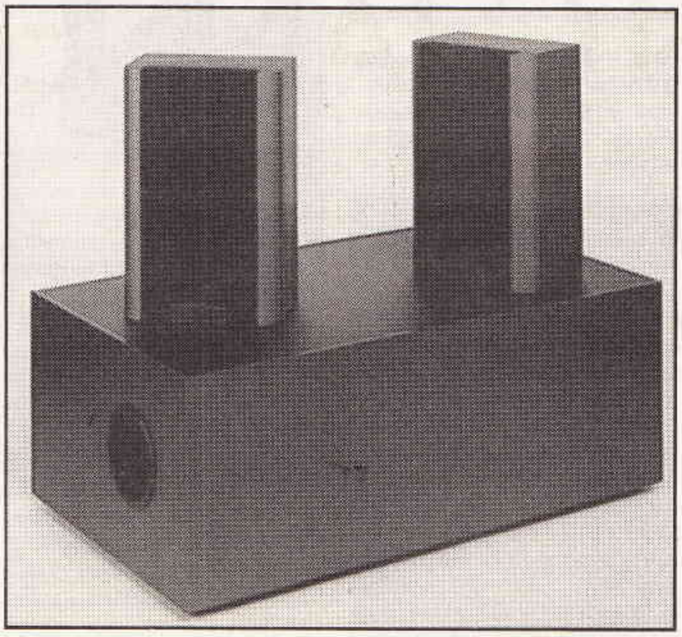
Of course it is. Building something like this will take years of research, years of development, and years of maintenance. It will cost millions upon millions of pounds and keep thousands if not millions of people in work. Companies throughout the continent will rush to use it, and be charged excessively high prices for the privilege.

Apparently IBM and Bull are in negotiations.
Apparently IBM and Olivetti are in negotiations.
IBM and Siemens have already negotiated.

Keith Brindley

ETI NEWS

SATELLITE SOUND FROM B.K.



BK Electronics has announced the launch of the new Sub-Woofer Satellite System from Studio Power.

At £129.00, including VAT, for two satellite speakers and one bass bin, BK Electronics believes this price level to be the lowest in the UK for a true sub-woofer system.

The design is targetted towards the customer who would normally choose a small, traditional pair of loudspeakers and, for a similar outlay, will be able to benefit from the addition of a single bass bin, giving a non-directional sub-bass sound, which may be hidden behind the sofa, curtains, or even under the coffee table! True stereo imagery is provided by the small satellite speakers.

All three units are finished in a deep grey, smooth metallic finish, with the satellites having contrasting black grilles.

The bass bin contains 2 × 6″ bass units, in a push/pull configuration.

The satellite units each contain a 1″ tweeter and a 3″ midrange unit. The system's power handling is 60 Watts RMS (90 Watts Peak Music Power).

The price, including VAT, is £129.00 plus £6.00 Postage and Packing, and is available from BK Electronics, Tel: (0702) 527527

LUCAS — DEVELOPING THE CAR OF THE FUTURE

Every year, 50,000 people are killed on the roads of the European Community. More are seriously injured. Both the European Commission and the various governments are committed to reducing these figures substantially. Lucas Automotive is playing a key role in developing safety-related technologies for improved safety and traffic efficiency, with other car component manufacturers throughout Europe, under the PROMETHEUS programme.

Two demonstration systems, developed by Lucas with Jaguar, cover Collision Avoidance and Autonomous Intelligent Cruise Control.

Collision Avoidance

As part of the PROMETHEUS programme, a team of engineers at the Lucas Advanced Engineering Centre in Solihull, UK., and other Lucas divisions, has been collaborating with major European companies, including Jaguar, to develop collision avoidance systems suitable for fitment to the majority of road vehicles.

The systems use various sensing methods — optical, infra-red and radar — to detect where the road is and the location of other objects (vehicles, people, stationary objects) that are likely to cross the path of the vehicle equipped with the system. The system then assesses what threat these objects could represent and assists the driver in selecting the safest course of action.

There is an enormous amount of research and development to be done to achieve results. The driver has to learn to trust the system and not generate an unjustified sense of security. Indeed, the driver will remain responsible for the actions of his vehicle for the forseeable future.

Machine systems have to be programmed to reliably detect hazards. They must also support, not distract or interfere with, the driver. For example, a system which automatically applied the brakes when the driver was trying to accelerate in order to overtake a hazard would increase the risk of a collision.

A single method of sensing is not capable of generating all the information necessary to produce an acceptable collision avoidance system.

Current work indicates that a vision system will be effective in good conditions but it will be necessary to use infra-red cameras before systems can operate in poor visibility or darkness.

The use of infra-red cameras was vividly demonstrated in the Gulf War but are extremely expensive. The Lucas collaboration with Pilkington, who are also participating in PROMETHEUS, will enable the company to benefit from improvements in this area at the earliest opportunity.

Other methods being investigated include vehicle mounted video cameras and microwave radar systems.

Autonomous Intelligent Cruise Control

Whilst practical Collision Avoidance systems are a long term goal, there are spin-offs from that technology which can be applied to produce products in the medium term. The technologies associated with advanced sensors developed by Lucas Advanced Engineering Centre is being applied by the Lucas Chassis division in the development of an Intelligent Cruise Control system which provides the driver with vehicle speed control in all traffic situations as well as enhancing passenger comfort and reducing driver fatigue. The system gives the driver the option of having the car automatically control its lateral position relative to the vehicle in front.

The Jaguar demonstration car has a prototype Lucas system using a millimetre wave radar sensor linked to electonically controlled actuators which maintain a set time interval of vehicle separation using automatic brake and throttle control. Development work is continuing aimed at providing the potential for improved tracking control under cornering conditions and further improvements in control algorithms that will refine the system even more.

THERMAL CUT-OUTS ENSURE OVERHEAT SAFETY

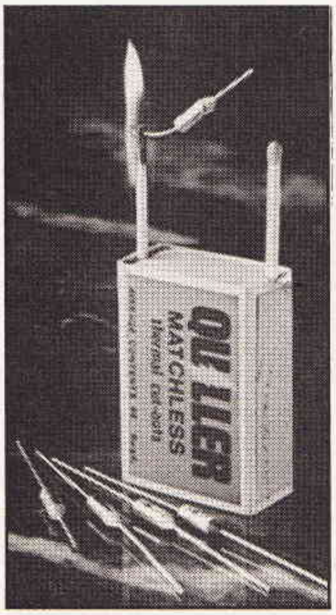
Thermal cut-outs, the latest new product from Quiller, provide a reliable method of isolating supply lines in applications where dangerous over-heating must be avoided.

Typically, the devices are installed in temperature sensitive areas of equipment — in-line with electrical supplies where they monitor the temperature. In the case of equipment failure, overheating is accurately detected, based on a pre-determined cut-off temperature. At this point the device goes open circuit. Once 'blown' the component has to be replaced, after the problem has been rectified.

Application areas include the protection of fuel-pumps, transformer and battery pack systems, and in domestic appliances such as washing machines and irons.

Six ranges are available, with temperatures ranges from 60°C to 240°C. Maximum recommended operating currents range from 5A to 25A, with voltage from 240V to 277V (AC resistive).

For further details, contact Quiller Limited, Tel: (0202) 417744.



ADVANCED SOLDER PASTE

Fry's Metals has launched Aquatrak solder paste. It includes a formulation which helps avoid the use of organic cleaning solvents on circuit boards.

Aquatrak provides the overall performance of a rosin based paste, in a water soluble form, giving excellent cleaning results.

Residues left after soldering are minimal and are removed by cleaning the circuits in water. They create no environmental hazard if they are washed into the main drainage system.

Aquatrak combines technically superior solder powder and flux for consistent bonding.

For further information contact Fry's Metals Limited, Tel: 081-665-6666.

MOBILE PHONE INDUSTRY TO LAUNCH ROAD SAFETY CAMPAIGN

The UK mobile phone industry, in conjunction with Douglas French MP, are seeking ways of promoting greater road safety amongst mobile phone users.

The campaign, was launched by the mobile phone industry's representative trade body the FCS at the national mobile communications exhibition at the Wembley Conference Centre. The FCS will seek to press mobile phone users who use their communication links whilst driving, to adopt more stringent safety methods while telephoning from their car.

In particular, the campaign will endeavour to persuade users of portable equipment to install properly approved car kits with hands free microphones and perhaps even the new generation voice activated systems. The object of the campaign is to eliminate the familiar scenes of drivers attempting to control their car whilst trying to tap out telephone numbers — an act which necessitates one, if not two, hands.

According to David Savage, Chairman of the Cellular Service Providers Committee within the FCS, and which represents the major air time suppliers to over 95% of the country's cellular users:

"Whilst there is evidence to suggest that the correct and proper use of a mobile phone in a moving vehicle is no more dangerous than tuning the car radio the industry is concerned about the mis-use of hand-held portable telephones amongst its car driving subscriber base.

"The most potentially distracting action by any car driving user is that of manually dialling a number. This is clearly compounded when a portable is used by a driver without an approved car kit.

"We will also be urging the manufacturers to reduce the cost of the necessary car kits to be proportionally more in line with the cost of handheld portable cellular telephones" he said.

Douglas French MP has long been an active campaigner for some form of legislation or safety guidelines to be introduced to eliminate the dangerous use of mobile phone equipment amongst car drivers.

NEW PROCESS TO REPLACE CFC 113 CLEANING AGENTS

Highly encouraging cleaning performance results have been achieved by ICI with a cleaning process the company has developed as a cost effective replacement for CFC 113 solvents in the electronics industry.

The new cleaning process, which has no potential to deplete the ozone layer, uses a unique hydrocarbon alcohol formulation, called 'Evolve'. The formulation is specially developed to work in a novel multi-stage cleaning plant, which ICI has designed specially for use in flux removal applications.

Following customer trials, the product and process will be introduced to the UK market in 1992.

The development of the new process is part of ICI's £100million overall CFC replacement programme. The benefits of the new process have been extensively assessed against a number of key production criteria. These include high cleaning performance, inherent worker safety, ease of use, minimal process time, zero ozone depletion potential (ODP) and minimal overall environmental impact.

NO PROOF OF HEALTH RISKS FROM ELECTROMAGNETIC FIELD SAYS IEE

Fears over possible health risks from exposure to electromagnetic fields are greatly exaggerated, and have little basis in fact according to a report published today by the Institution of Electrical Engineers.

The IEE report comes in response to increasing concern over the possible biological effects of magnetic fields from overhead power cables, house wiring, electrical appliances and VDU's. Recent claims have attempted to link cancer, suicide, miscarriage and personality change to exposure to electromagnetic fields.

An IEE Working Party, chaired by Dr Tony Barker, Consultant Medical Physicist, Sheffield Health Authority, spent a year studying reports of laboratory tests, and medical investigations from around the world. It's Report concludes that there is no evidence to show a firm link between exposure to low frequency electromagnetic fields and damage to health.

Public concern, the IEE report claims, has been fuelled by media sensationalism and had led to unnecessary alarm and widespread 'electrophobia' — the irrational fear of electromagnetic fields.

Epidemiological reports studied suggest a very slight increase in the risk of brain cancer and leukaemia for workers in some electrical areas. However, they do not provide a definite connection with electric or magnetic field exposures and may be due to other occupational factors, such as exposure to solvents or other chemicals.

Laboratory studies reviewed by the IEE Working Party have also proved inconclusive. Most have been conducted on an ad hoc basis and have lacked independent confirmation. As a result, there is no widely accepted experiment which can demonstrate any biological effect of low level electromagnetic fields.

The report says there has been no national or international co—ordination of either medical or laboratory experiments, nor is there any universally accepted technique for measuring levels of exposure to electromagnetic fields. Both issues, it claims, must be addressed before any definite conclusion can be reached.

Speaking on the IEE findings, Dr Tony Barker said, "The Working Party was faced with numerous fragmentory, isolated and often contradictory reports. At the present time we must conclude that there is insufficient evidence to make a health risk assessment, or indeed, even to determine whether there is any hazard to health from electromagnetic fields".

POWERFUL SCIENTIFIC CALCULATOR IC CARD FOR CASIO SF-9500 DIGITAL DIARY

The ES650 Powerful Scientific IC Card is one of two new IC Cards recently introduced by Casio for their top-range SF-9500 Digital Diary.

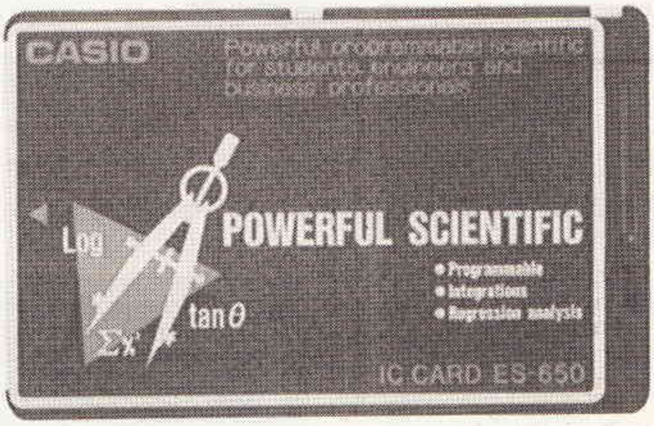
Plugging the ES650 Powerful Scientific into the SF-9500's expansion port, the Diary becomes a powerful programmable scientific calculator based closely on the Casio FX4500p, with all its functions plus a memory expanded almost fourfold to 4,095 steps.

The ES650 Powerful Scientific offers a selection of 112 scientific functions from basic arithmetic like fractions and percentages to advanced integration, statistical and base-n calculations, and regression analysis. The ES650 also incorporates 128 scientific constants.

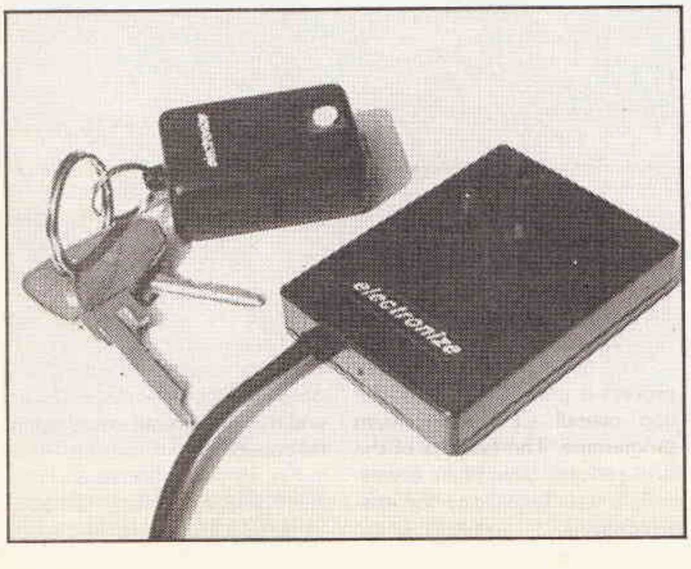
The Card's programming function enables multiple programs to be stored under their own filenames for recall.

Jump and sub-routine functions allow files to be linked together to conserve memory, while frequently used formulae can be stored in memory for one-touch recall.

The ES650 Powerful Scientific IC Card is priced at £49.99.



CAR ALARM WITH DIGITAL CODE



Two new products from electronize, a key-ring transmitter and a dash top receiver, are said to offer high security, with a digitally encoded remote control for the company's existing alarms. With a range of 59,046 possible codes the user can set the code. This has advantages for fleet operators, who may want the same code for more than one vehicle, or people who want several key sets for one vehicle.

The transmitter uses a high power multiple pulse infra-red system to give a range up to 5 metres whilst making it difficult to 'crack' with electronic scanning devices. The low profile receiver is designed to sit in full view on top of the dash. To warn off intruders, it has a high intensity red LED which flashes continuously when armed. A green light flashes once as the correct code switches off the alarm, so the owner always knows whether the alarm is on or off.

The transmitter and receiver are priced separately at £17.95 and £26.55 respectively. With an alarm and siren the complete coded system costs around £77 with D.I.Y. fitting. Self build parts kits are also available, bringing the system cost down to about £62.

For information contact:
Electronize Design Tel: 021 308 5877.

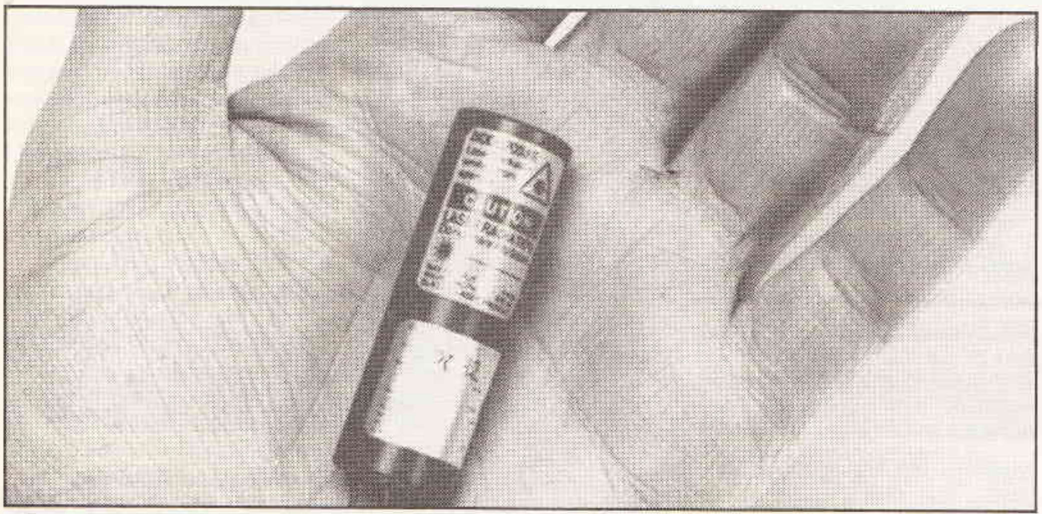
PHONEPOINT SUSPENDS SERVICE

Phonepoint, the consortium comprising BT, France Telecom, Deutsche Bundespost Telekom, Nynex International and Northern Telecom Europe, is to suspend its telepoint operations with immediate effect.

The parties in the Consortium have taken this decision because of what they see as adverse market conditions for a telepoint service in the UK. However it is hoped that a telepoint service may be made available by Phonepoint in the future should conditions become more favourable.

Phonepoint will be contacting all customers direct and will offer them a full refund on equipment purchased from Phonepoint. In addition BT will offer an alternative option to upgrade customers to the Cellular service on favourable terms.

SMALLER LASER DIODE MODULES



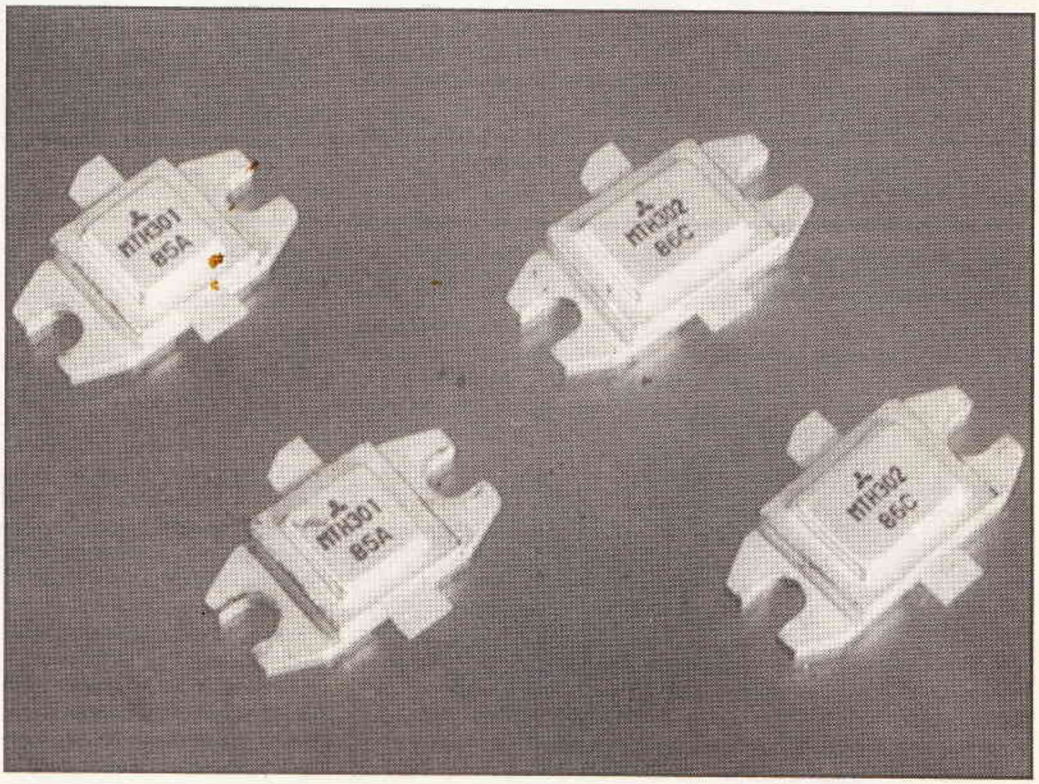
Compact visible laser diode modules in the Imatronic range now have an added modulation option. Modulated versions offer 1kHz to 100kHz modulation with a 1µs rise time and can be driven from any TTL compatible source. The small modules are suitable for replacing He:Ne lasers giving the advantage of ruggedness.

An infra-red version operating at 820nm has been added to the range and packaged in the same compact 49 x 16mm diameter housing. Units in both ranges include all the focusing optics and require 4-5.25V DC to drive them.

The new IR diodes are available with outputs set to 1 or 3mW. Units operating in the visible spectrum from 660-685nm offer outputs of 0.5, 1, 2 or 3mW dependent on model. All units come as a complete package with two colour coded flying leads for the connection of DC power.

Contact: Lambda Photometrics Ltd, Tel: (0582) 764334.

SILICON TRANSISTORS OUTPUT 40W AT 3.2GHz



Mitsubishi Electric is announcing the launch of its MTH301/302 S-band high output silicon transistors, putting silicon applications into the higher realms of 40W power output performance for 3.2GHz applications.

Silicon bipolar transistors are now replacing Klystron or travelling wave tube amplifiers through the demands for higher reliability and more compact designs. Furthermore, through more widespread demands to increase transmitting capacity in radio communications and radar, high frequency and high output are now essential.

To meet these increasing demands, Mitsubishi has developed its silicon bipolar transistors based on the company's developments in high frequency, high output transistors for radio receivers. The devices operate at 28V pulse, with a pulse width of 1ms and 50% duty cycle.

Output for the MTH301 is 16W, with a 40W output proclaimed for the MTH302, both at 3.2GHz and both with a collector efficiency of 30%. The base ground design devices measure 20 x 16mm overall x 5.5mm high for the MTH301 and 22 x 16mm overall x 5.5mm high for the MTH302.

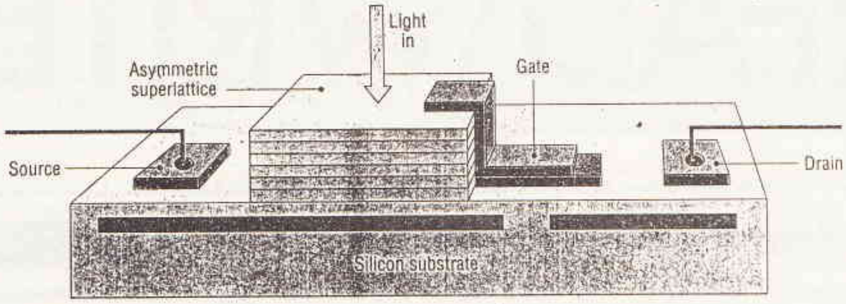
For further information contact: Mitsubishi Electric UK Ltd, Tel: 0707-276 100.

ETI NEWS stateside

Integrated opto-electronic systems

SHEDDING LIGHT ON FETs

An asymmetric superlattice acts as the FET's gate



Standard field-effect transistors could form the basis for integrated opteolectronic systems in an approach that integrates the FETs with asymmetric superlattices, according to scientists at AT&T Bell Laboratories.

The compound lattices are formed from alternating layers of indium gallium arsenide, indium aluminium arsenide and indium phosphide and respond to light in the same way that capacitors respond to electric charge. Light stimulation causes the energy bands to tilt so that electrons and holes separate in each layer of the superlattice, storing the light energy in an electric field. Since FET gates operate as capacitors, the new superlattice could be easily integrated into the gate site of a standard FET, generating the same switching effect as an electronic gate. The result would be an optically switched transistor that might be surprisingly easy to manufacture.

While many designs for phototransistors have been proposed and tried, the current design is unique in its direct integration into standard VLSI circuits.

"We have verified the operation of single FETs controlled by photonic gates, but the true test will be how well they integrate into actual circuits. The usefulness of this approach will be determined by the noise properties of the devices when they are operating in specific circuits," said Serge Luryi of Bell. The superlattice can switch between charged and neutral states in only 2ps, and experiments with a superlattice combined with a state-of-the-art FET show switching speeds on the order of 200 Ps.

The fact that crystal defects actually enhance the operation of the new device may be a boon for practical applications.

Making 2-D holographic slices

An organic dye called protoporphyrin is enabling scientists at the University of Southern California to record images in precise time slices.

The new technique, called 'time-resolved holography,' lets researchers capture a specific two-dimensional slice from a three-dimensional image projection. The technique could be applied in medical imaging, where an image at a specific depth is required for analysis.

Conventional holograms encode an image as an interference pattern in photographic film. In place of the film, the scientists dope the face of a polystyrene block with protoporphyrin. The surface is a plane of vibrating dye molecules, each with a slightly different resonant frequency. When light reflected from the object strikes the polystyrene, the protoporphyrin molecules absorb energy at their fundamental resonant frequency, preserving a brief frequency profile of the image.

Because the molecules continue to vibrate, light arriving slightly later can retune the frequency profile. By slightly delaying the reference beam pulse, an interference pattern is recorded at a specific time out of the total interval, during which reflected light arrives at the image plane. However, a permanent image requires continuous repetition of pulses timed at precisely the same instant.

Increasing current density of yttrium-barium-copper oxide

A method of improving the current-carrying ability of single crystals of the yttrium-barium-copper-oxide high-temperature superconductor has been developed by scientists from IBM's Thomas J. Watson Research Centre at Oak Ridge National Laboratory, Argonne National Laboratory, Ames Laboratory and Iowa University.

The superconductor is bombarded with tin ions, at 580, to introduce defects into the material's crystal structure in the form of columns, 20 atoms wide. The defects increase the maximum current by improving the 'pinning' phenomena — preventing the motion of magnetic field lines that would otherwise produce electrical resistance.

At 77 Kelvin, the critical current density was 450,000 amps/cm^2 in a magnetic field of 1 Tesla. A proton-bombardment technique provides similar results, but only in low magnetic fields. The strength of the pinning and the values of the critical current density for these crystals are the largest ever observed in bulk Y-Ba-Cu-O at liquid-nitrogen temperatures in high magnetic fields. The critical current density also increases with the dosage of ion bombardment.

Liquid crystals

A new liquid-crystal switch activated by laser light may improve large area displays and optical memories. The effect has been demonstrated at Hercules Inc.'s Research Centre in an experiment with a slightly modified standard liquid-crystal cell.

Liquid-crystal cells are formed by sandwiching the liquid crystal between two glass plates coated with transparent polyimide which has microscopic grooves that cause the liquid-crystal molecules to line up in the same direction.

Molecules are switched into a different alignment with the application of electric or magnetic fields, depending on the type of liquid crystal. The Hercules experiment is a simple variation on this method, where the polyimide is doped with a dye called diazodiamine. The dye causes a realignment of the liquid crystals when illuminated with laser light, and the effect is fully reversible. Illumination of the same area with light that is polarized at right angles to the original beam will realign the crystals and erase the image.

Laser-activated switching means that very small areas of microns or less can be switched, leading to applications such as adaptive optics. The Hercules researchers demonstrated the effect by writing a 10-micron-pitch diffraction grating in a liquid-crystal cell. The same technique could produce read/write holograms or dense read/write optical memories.

READ\WRITE ETI LETTERS

Problem Page

I am intrigued by the idea of being able to exercise while relaxing, as described in the box here from a mail order catalogue. Any idea how it works? I'm sure it must be possible to come up with a more affordable version. It might make an interesting project.

I have another problem. My car radio is a mid-eighties Ford 3-Waveband model. The FM reception is fine with the engine off, but sounds muffled when the engine is running (no interference, just as if someone has turned the treble right out). The medium and long wave are very strange- they give no reception at all to start with, but I have found that if I drive under high tension grid wires, it suddenly gives a crackle and bursts into life! The reception is then fine until the engine is turned off again. Then I have to look for more power lines to drive under to get it going again. I've had the radio out and apart on my test bench, where it seems to work fine. Put it back into the car and it is the same as before! I'm baffled. I could always buy another radio but I"d rather like to know what is going on — have you come across anyhting like it before?

Gary Smith,
Heworth, York

Firstly the Lean Machine, I can understand and suggest the mechanism but I'm not so sure about the concept. It sounds like a good old case of electrical nerve stimulation to twitch the muscles (remember Galvani and his frogs legs). A movement of muscle tissue expends energy and so on. Well this little box of tricks produces electrical pulses of varying frequency and amplitude to stimulate nerves via electrodes.

Believe it or not there is an established side to these machines and they are used for pain releaf. If you have known a pregnant mother in labour then you might know about a 'TENS' machine. Electrodes are placed on the back either side of the spine and the pulsing nature of the box sends messages to the brain to stimulate the production of endorphins, the bodies natural pain killing drugs. It's a non invasive way to dull pain. If ETI had appeared in Victorian times you might have seen adverts for various dangerous electrical therapies in air and in water!

As for sitting down to try to loose body fat, I've never heard so much nonsense — what's wrong with a walk or jog in fresh air!

Your other problem with the radio, the gremlins do seem to have crept in. From what you say it must have something to do with the car-body shell and/or aerial system being affected by the engine running. Is your car shell at the same potential as the negative terminal of the battery when the ignition switch is on? Do you have good aerial connections? Is your engine suppresor capacitor working? Will there ever be another radio like it? If listeners are tuned in to this hum of intrique, why not write in and reveal all? — Ed.

Lean Machine now with 10 toning pads

While our old Lean Machine had eight toning pads, this new model has ten, meaning you can now effortlessly exercise up to five different muscle groups at once! Lie back and relax while the machine stimulates muscle activity and gently pulls your figure back into shape. It's especially good for firming thighs, tightening the waist and reshaping hips. New 'Soft-Start' facility ensures a gentle increase in the impulse before reaching full frequency. Lean Machine comes in a smart briefcase and is either mains-operated (240V AC) or, for complete portability, also runs on 6 HP2 batteries (not supplied). **10-pad Lean Machine £99.95.**

PCs

As a college lecturer in engineering I, along with the students, use PCs and associated peripherals a great deal. With respect to this, would it be possible to increase the number of projects you publish that are designed in the form of a standard 8-bit or 16-bit IBM PC expansion board.

Suggestions include:

- A Serial/IEEE convertor board. (This would allow the PC user access to the IEEE standard and easy instrumentation control. Further external devices could then be connected to this IEEE port allowing a great deal of potential expansion (for future ETI projects). A total of 16 devices, with their own addresses, could be connected in a daisy chain to a single expansion port of a PC!, all under software control.) Possible devices using the board could be:
- A voice recognition card.
- A burglar alarm with software monitoring.
- Robot control.
- Domestic environment control with software monitoring.
- An electronic lab — allowing computer control of experiments (very useful for practicals in GCSE).
- Shortwave radio under software control.
- A weather station where the computer monitors and records changes in temperature, pressure and humidity. (Could use this for psychic investigations for the brave of heart!)

I realise that many of these cards are available commercially (at high cost), but I think it would be more instructive to build these projects from scratch since this would not only save money, especially important in education establishments, but would provide a valuable insight into software control of hardware. I hope you can consider some of the ideas.

Kevin Molby,
Leeds.

We certainly will, ETI is open to anybody who has such a project for us to feature.

PCBs

Regarding Colin Long's letter (October), I use Easy PC, print out artwork (×1 scale) using a 9-pin dot matrix printer, and then have this photocopied onto acetate sheet at a cost of about 45 pence.

Using this method, I have produced a number of PCBs, both single and double sided, with enough detail to allow tracks to pass between IC pins easily.

As for the optical diffraction, if you arrange the artwork so that the toner side of the copy is in contact with the board during exposure, this is not a problem.

You may find that the copy is not sufficiently dark — experiment with the copier's contrast control and with exposure times to remedy this (or use a pen to darken the tracks).

You will also discover that photocopiers tend to produce copies which are slightly 'stretched'. The actual difference in size between the original and the copy is very small, and is not a problem as component leads still reach the necessary pads. However, if the PCB is to be double sided, make sure both sides of the layout are stretched along the same axis!

Lastly, am I to understand from Paul Shlackman's article that the PIN number is stored on the cash-card itself? CSE Computer Studies taught me that the PIN isn't stored on the card!

Daniel Brook,
Mill Hill, London.

PCB Design To Prototype

I hope that I may be able to answer the question that Mr Carstens posed in the September issue of ETI. I am assuming that he wishes to produce the positives in house from EasyPC based on an IBM compatible, as I need to do when I am preparing a manuscript for publication. The positive is also used to produce the prototype PCB for testing and this again is done at home. The system I use has produced boards for both standard wired and surface mount components so I am quite happy that the output is reproducible and accurate on the 1:1 scale. The main problem is that output from a computer is not cheap by any means and the answer may not suit Mr Carstens.

The way I achieve the output is using a plotter with the necessary software in the PC. Whilst for paper output the choice of pen is simple, when you need to get the output on an acetate film then things get very difficult. A local analytical laboratory carried out some tests for me on the use of acetate film, drafting film (which is opaque) and on tracing paper. Only acetate film lets through nearly 100% of the light that falls on it at the wavelength of the UV lamps in the exposure units. In the others it is about 1 to 2% so there is no choice but to use the glossy film.

The plotter that I use is the Roland DXY1100, the lowest cost version of the range but I suspect that any other plotter will do providing it will accept a pen of the only type that I find will work. Also the plotter must be able to draw accurately on the acetate sheet. The DXY1100 is good in this respect as the acetate is held firmly down on a baseplate and the pen is moved over it by the drive system. Plotters that grip the acetate and move it in one direction whilst the pen moves perpendicularly may have problems if the acetate slips in the drive.

The only pen/ink system that I can get to work consists of a 0.25mm tungsten carbide plotter drawing point with a cross groove and Staedtler 748 ink in black: Staedtler makes a high density black ink called 747 but every time I have tried to use it the ink dries too quickly and the drawing is destroyed by the pen blocking and lifting one of the already drawn items. 748 ink does not seem to dry too quickly, but if you use it on a hot summer afternoon then you do get the same problem as with the 747 ink. Staedtler are well known world-wide so there should be no problem with getting the ink.

The pen comes from Dia-Nielsen a German company whose UK office is at Lonsto House, 1-3 Princes Lane, London N10 3LU. 01-444 7108 but they do not sell direct although they may be able to help with offices outside the UK. In Southern England where I live they can be obtained from Artworker Ltd and my local branch Artworker Southampton, Frobisher House, Nelson Gate, Southampton SO1 0GX holds them in stock. The type used is the F73142.

Flat tipped wet ink pens do not work as they cannot get enough ink onto the acetate film to get sufficient density into the tracks and pads, neither do ceramic tipped water based pens as the tracks end up as a line of dots. Overhead oil based pens should work but don't because the oil based ink creeps before it dries and all the sharp edges disappear and closely drawn tracks merge into a large fussy blob.

The pen needs an adapter/ink supply unit to fit the plotter to be used. At just under £30 for the plotter point you can see that they are not a disposable item so you must also get hold of a cleaning kit and Rotring come to the rescue with their Pen Cleaning Unit which includes 10 sachets of special chemical to dissolve the remaining ink out of the pen once it has been washed quickly under the cold tap to remove the unused ink.

As I said it is not cheap but the system I use works well for me and gives the advantage that high quality drawings can be produced on paper as well.

David Silvester,
Southampton.

Some helpful tips from David. It seems to me that what is required is a clear plastic sheet with a matt surface and a roughness of paper. Only then will ink pens take to it easily. — Ed.

Video Niceties

We have received many replies to the video 'life' problem. From the letter, it became obvious that I do not have a home video and therefore had no cause to ask the same question. Here are a couple of replies.

With reference to the letter from M. P. Scotford in the Read/Write column of the October 1991 issue.

The answer to his video problem is quite simple (when you know), if the record prevention tab is removed from the back of the tape (as with most prerecorded tapes) the recorder will automatically play it as soon as it's inserted, whilst if the tab is in place the recorder will wait for you to press Play or Record or whatever. Some manufacturers make quite an issue of this in the manual calling it an Automatic Playback System or something!

If only all lives little problems could be solved that easily!

Paul Stenning,
Hereford.

With regard to Mr Scotford's letter concerning cash machines and video tape, I think I can throw some light on the latter. Video machines these days are very intelligent beasties. Whilst loading the tape against the heads, they have a quick look at what is recorded. Then they do a quick scan round the house and start to play the porno tapes just as ones wife/girlfriend/mother/lodger is about to walk into the room. This is all designed to cause maximum embarrassment to oneself and the videos then sit there with a smug grin on their faces.

Seriously though, it is all to do with having the 'no record' tab broken off. If the video machine thinks the tape is a pre-recorded one, it tries to save you the bother of finding the remote control because it knows that you are probably the worse for drink anyway.

Steve Marland,
Wigan.

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E9111-7	Nightfighter — Master Controller PSU	K
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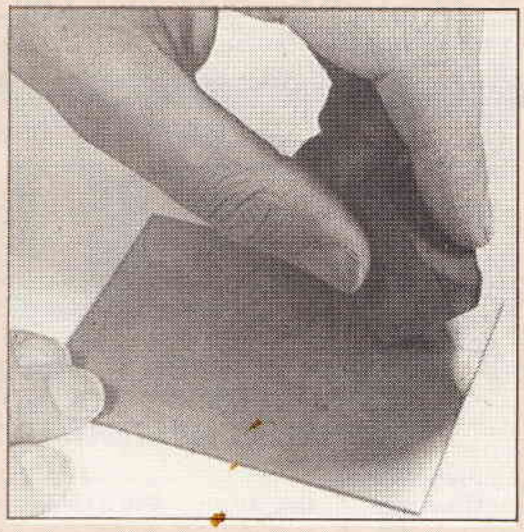
Partly cleaned copper-clad board

Making PCBs at

A beginners guide to home produced PCBs by Geoff Martin.



Cleaning board with block eraser

In response to demand, we present some information on making a printed circuit board at home. There are a variety of ways of acheiving a 'one-off' or indeed a few PCBs for home use and this article sets about giving a few tips.

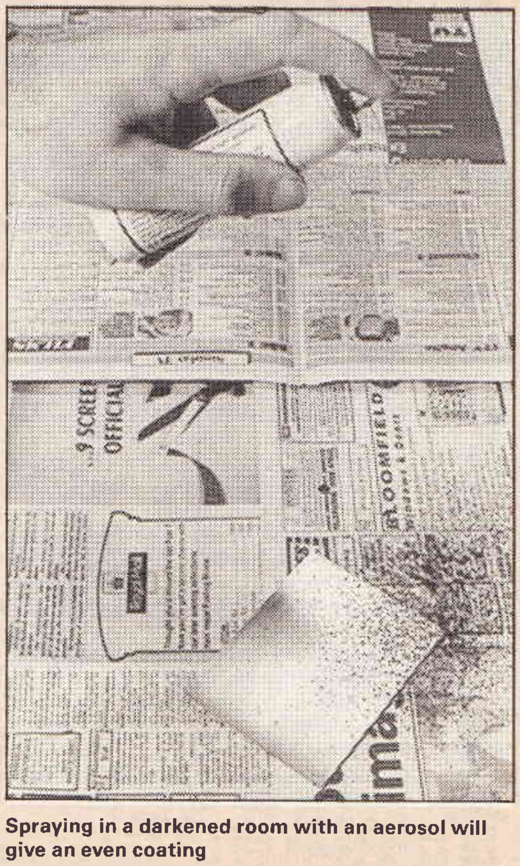
Board types

Copper-clad board is available in several varieties. The board presented free with this issue of ETI is of the SRBP type. It is a reinforced bonded paper with a thin copper sheet and should be strong enough for many purposes. It can be cut, filed and drilled very easily. The other common type of board is the fibre-glass one. Although more expensive it is more durable than the SRBP version. Double-sided copper clad boards are usually made from epoxy glass or fibre glass as it is usually known. The only small disadvantage to using fibre glass boards is that drill bits have to replaced more frequently. I say replaced because nobody in their right minds would try to sharpen a 1mm diameter drill.

Now before you do anything else to any copper clad board, check the condition of the copper surface. If boards have been lying around for years they will have oxide on the surface and will therefore need cleaning. A clean and grease free surface is important to the processes which come later. Highly recommended for ease of cleaning is the little block cleaners that look like an eraser. They contain abrasives in a silicon rubber base. Otherwise household abrasive powders, a cloth and water will do the job making sure not to get your finger prints on it. So even though your free PCB may look clean, it has to be shining bright.

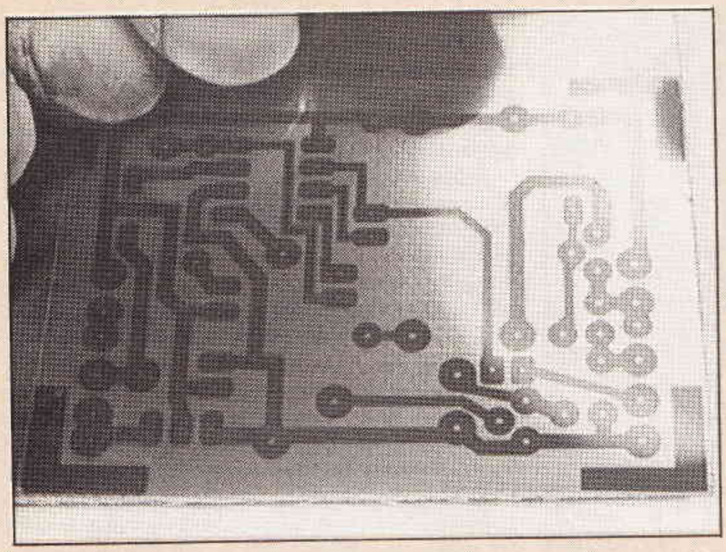
Photosensitivity

To get any form of professional reproduction on the surface of the copper, it has to be firstly coated with a photo-sensitive chemical. An important aspect here is that the coating should be even over the surface. That is why the photo-resist chemical is usually sold in an aerosol form for home use. Greater users of the chemical will buy the liquid in bulk containers and then spray on using some other form of aireated spray. Aerosol cans of positive photo-resist are available from many component suppliers and if used regularly and moderately they will give good value for money.



Spraying in a darkened room with an aerosol will give an even coating

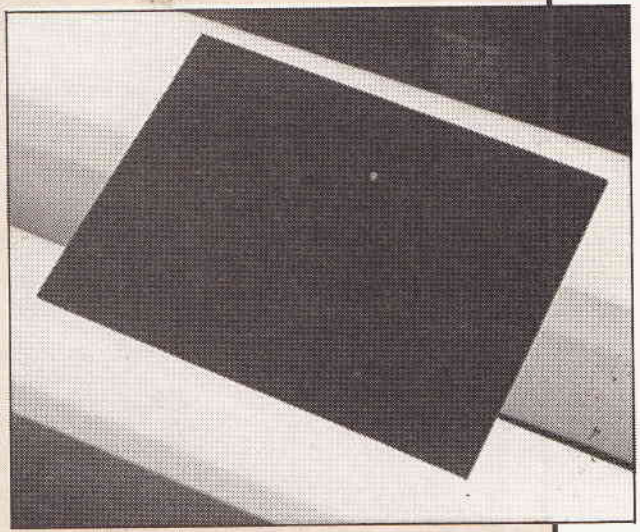
PCBs



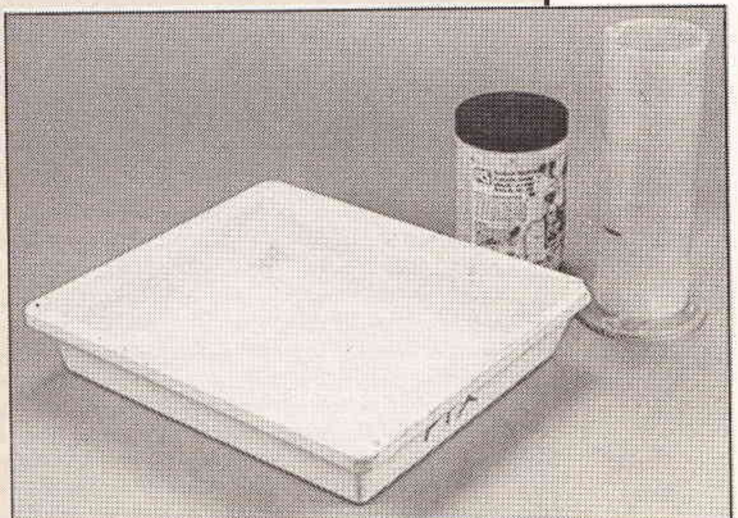
Placing foil on prepared board

Home

A UV exposure unit



Exposing the board face down



Materials for development

To spray our clean board requires a darkened area with just enough light to see what you are spraying. It would also be wise to spray in a clean workshop area. Paper towels or old newspaper must be placed down first before spraying and it is advised that it is carried out in a ventilated but not draughty area as the smell is quite considerable.

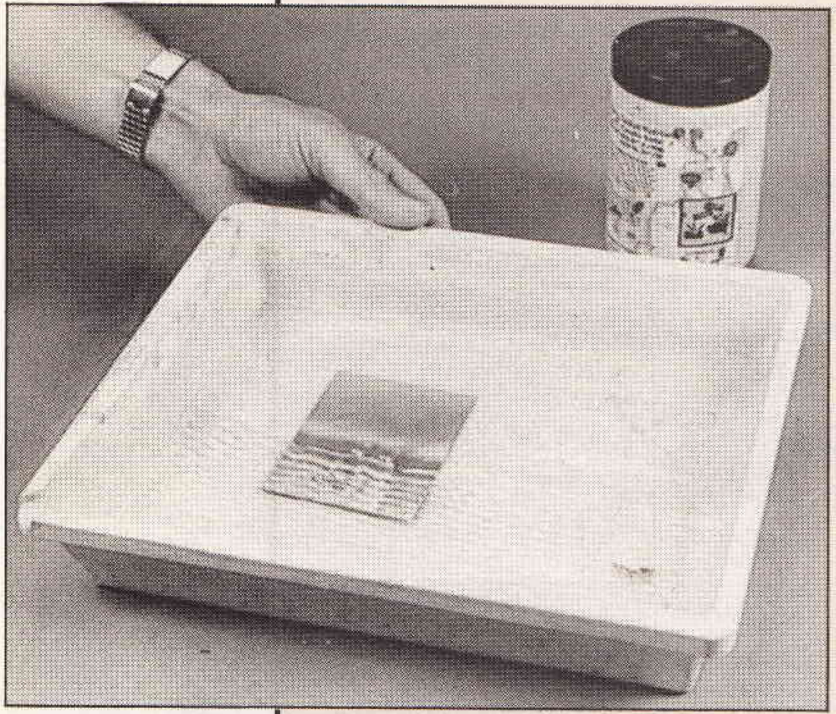
The amount and the distance you spray comes with experience and very often overspraying is common. This results in excessive developing solution being used to remove exposed areas. As a rough guide spray at a distance of about 9 inches sweeping backwards and forwards until an even coating can be seen.

Drying time depends upon temperature and if the room happens to be in the high twenties Celcius it might take only 15-20mins to go tacky but a few hours to dry. If you have a small oven to hand the drying time is a matter of minutes.When handling the board make sure not to touch the surface. Using a pre-sensitised board instead of spraying is an easy option but is more expensive and less fun.

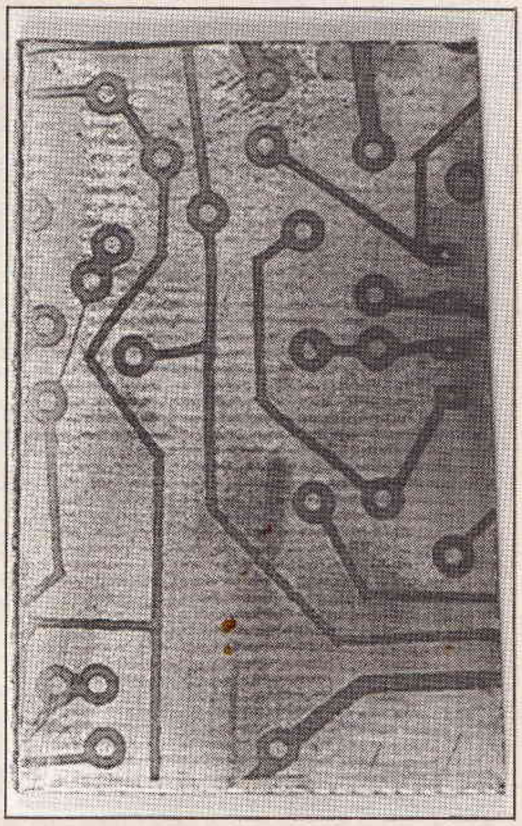
The next stage is to mask the surface with our foil, Details on the various ways to make foils will appear next month. Most foils either clear acetate sheet or photographic film will not adhere to the photosensitive surface and on these it is wise to have corner markers on the foil to align with the copper-clad board. Our free sticker foil given away with ETI next month with not suffer from any misalignment owing to adhesion. More about this next month.

IT IS ESSENTIAL THE CORRECT SIDE OF THE FOIL IS PLACED ON THE BOARD. . Not paying attention at this stage and proceeding to the etched board with the wrong side will result in a useless board and a few heated quotes about yourself like "You incompetant imbecile" or words to that effect. We only have to do it once!

As we have to expose it to some sort of light source it is well to consider the various ways at this stage. The most obvious is natural sunlight. It is bright



Developing the board



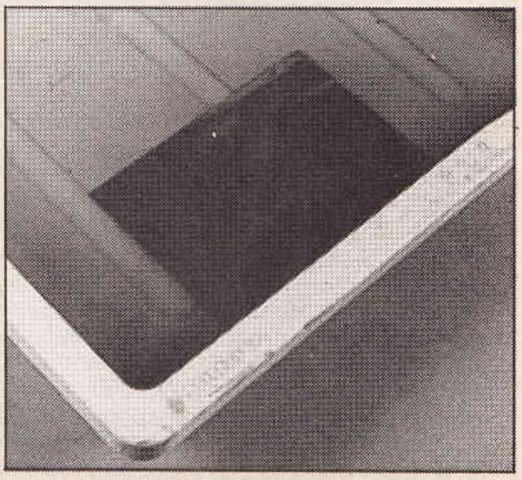
A developed but un-etched board

and when shining is uniform over the surface of the board. The disadvantage is the variable brightness owing to cloud and this gives an unknown exposure time. So the next thing to do is to turn to predictable artificial light. Using a single household light bulb suffers from the effect of giving uneven illumination over the board and hence uneven development. The next best thing is a reflector lamp like the sort in used in downlighters or at discos. Again the problem here is that they can only be used for small area boards. We need some way to spread the light. An ideal solution is to use a plastic Fresnel lens and place the lamp at the focal point. This gives a flat surface to place the board on and provide an even illumination. Those who have access to an overhead projector can expose the board and film on the top where one normally puts the display. Exposure time will have to be experimented with but 5-10 mins may prove sufficient.

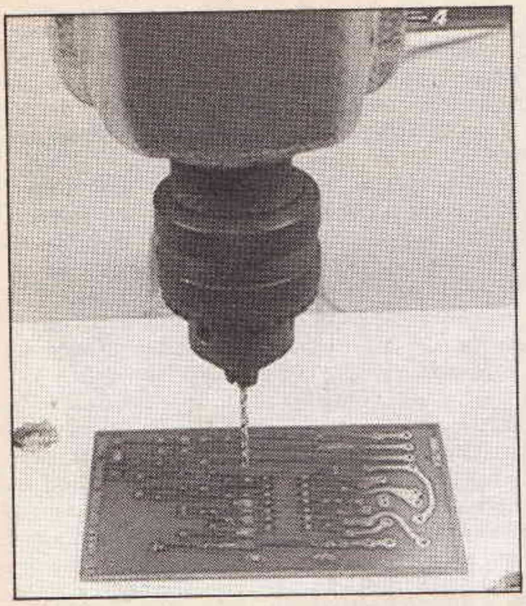
The standard but more expensive home method of exposure is the use of the UV timer box. This consists of an electronic timer and a couple of mini fluorescent UV tubes. The use of UV will speed up exposure time. The logic of this is in the Physics. UV wavelengths have a higher energy per photon to provide the chemical changes on the surface. The emitted radiation has to be contained in a box to protect your eyes.

Now we have exposed our board it needs to be developed. That means we have to remove the areas of photosensitive coating that has 'seen the light' so to speak. The liquid to do the job is a solution of Sodium Hydroxide or caustic soda. For convenience this chemical comes in pellet form and when transported through the postal system or by any other means has to be sealed from water. Moist Sodium Hydroxide can be just as dangerous as acid spills, so it has to handled with care. The concentration for the development of our board is a dilute solution (in the order of 7 grammes of pellets to 1 litre of water). You soon know

Etching materials



Etching board in orange solution of Ferric Chloride

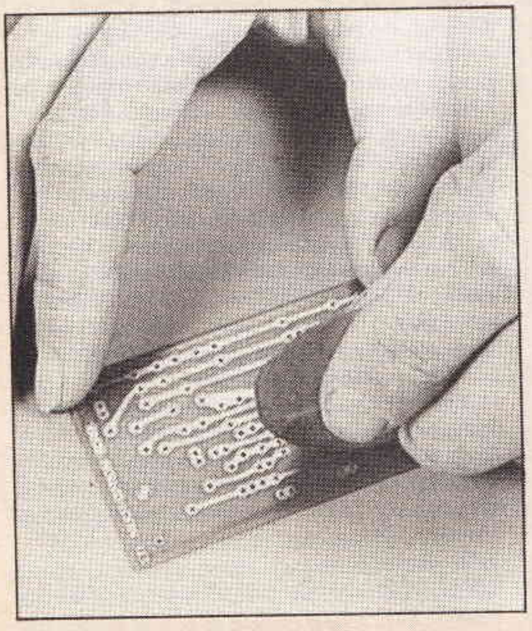


Drilling the holes with drill in stand

Using a 12V hand-drill

if it is too concentrated when you see all the photosensitive layer disappear from the copper. Developing the boards will require a tray, the best being one of the normal plastic photographic trays.

Assuming you have removed the foil and all is well, the board should be placed in the tray and rocked gently within the solution. Gradually you will see the outline of the trackwork appear. This is the most fascinating part of the process and has similar parallels to seeing a normal photographic picture appear in solution. This action has to take place in a room with a low level of light. If you happen to be a photographer the best place to be is in the darkroom illuminated by a safelight. Wait until the copper is visible on the exposed areas before removing. Wash under a tray of clean water and pad it dry with a paper towel.



One way of cleaning the trackwork with abrasive

Etching Process

Various copper dissolving chemicals can be used but the most popular is Ferric Chloride crystals which turn the copper into copper ions in solution with a green colour of Copper Chloride. The main problem is one of etching time. But if we remember our chemistry from school, we can make good use of a rule of thumb that the rate of reaction doubles for every 10° rise in temperature. So hot Ferric Chloride solution will do the job much better. Find an old Pyrex glass beaker to heat it up in, not a metal container. It is well to leave the board in the hot etchant in a plastic tray for a few minutes to get the reaction going. Then it requires some form of agitation. This can be acheived by rocking the tray to and fro. A quicker method is to quickly pour the etching solution back into the glass beaker so the solution can be poured over the board tilting the tray and board at an angle of about 30-40 degrees. Hot etching solution moving at great speed over the surface will have the greatest impact.

If you want to spend money on etching tanks they are available. These will heat up the liquid and will also agitate the board or the solution. Some would even adopt ultra-sonic agitation.

Protecting the circuitry with a lacquer

Cleaning Up

When the last dregs of copper have been eaten away, it is time to remove and clean it up. Firstly wash away any traces of Ferric Chloride solution under a shallow tray of water. It is worth stating here that it is unwise to pour Ferric Chloride solution down the drains.

There are three ways to remove the photo-resist material on the copper trackwork. Firstly by an abrasive powder and pad or by using a stronger caustic soda solution than previously used for development or an organic solvent like Acetone.

The PCB should now be drilled ideally using a 12V modelling drill or a drill in a stand that can take a pin chuck. The hole sizes will vary according to the component lead diameter but a 0.8-1.0mm will be sufficient for most holes.

Finally an optional extra but sometimes worthwhile if the board is going to sit on the shelf, is the use of an aerosol lacquer. It protects the trackwork from oxidation and will take solder in the normal way.

Next month we look at making a foil pattern.

4

The Nightfighter

In this fourth part, Mike Meechan constructs a sensor switch to zone the light displays.

The final part of the series covers the Sensor Switch peripheral unit. Part 1, 2 and 3 showed the design and construction of the Master Controller and Dimming/Switch Packs respectively — this final featured unit interfaces between the two, allowing the operator to select, via a touch sensitive 'keyboard', which zones of lights are on at any one time. Some explanation of the terminology might be of interest to those readers not actively involved in nightclub lighting.

Almost all nightclubs — and some of the more upmarket mobile discos — will have more than one type of lighting effect fitted eg strobes, pinspots, neon, stage lights (Parcans), UV lamps, kinetic effects such as scanners (a sweeping searchlight effect) and perhaps even a laser. If all of the effects and lights were switched on all of the time, for one thing the venue would be flooded with hundreds of thousands of candelas of light and for another, the lightshow would have no dynamics or excitement whatsoever.

Instead, each effect is switched, sometimes using ordinary multi-gang lightswitches. We start to run into problems when we want to switch on or off something of more than two gangs eg a bank of four channel lighting. We can of course switch the Neutral line but that means the switch contacts handle the combined currents of all four channels (this switching of the Neutral can be used for special effects, some of which we'll discuss later) or alternatively we can allocate a separate controller for each bank/zone — of different lights. This, too, has its merits, but is obviously expensive and different zones will never be synchronised to each other. Better to have one Master and a number of slaves under central control, as in the Nightfighter system.

If the central control is now in the form of a touch sensitive keyboard, we can enable whole zones of lights very easily and in time with the music — playing the lights rather like a musical instrument.

We now have the design criteria for a touch switch. It should have the following features:

- Latch on/Latch off and Flash facility.
- Memory function allowing preselection of channels for next selection whilst present selection is still running.
- Inbuilt chaser with CHANNEL IN CHASE/OUT CHASE facility.
- Optional sound activation of chaser.
- Easily expandable up to 8 channels.
- Option of zero-switched mains outputs.

The basis of most touch switch designs is deceptively simple. The touch switch relies for its operation on the fact that it has a very high input impedance, this also being true of the CMOS gate input.

This high impedance (typically in excess of 100M), low capacitance combination means that only a very low charge is required to influence the voltage at the input. The human body itself acts as a reasonable aerial for the 50Hz hum fields radiated by the electrical mains distribution system, so that the contact between body(hand) and high impedance input can form the basis for the trigger for a switch.

HOW IT WORKS

CHANNEL BOARD

TP1 and TP2 are the LATCH ON and LATCH OFF touch panels respectively. R1 and R2 limit input current to IC1d, IC1e Schmitt inverter gates which have their inputs held at a voltage determined by the SENSITIVITY pot and R3 and R4. Touching either touch pad causes the associated inverter to output a 50Hz square wave which then clocks the relevant discrete retriggerable monostables formed from IC2b, IC3b and associated components, the Q outputs of these remaining high until the 50Hz input signal is removed, since C8 or C9 is discharged every time the Schmitt inverter output goes low, thus preventing the one-shot from resetting. Once this clock signal is removed, C8 can charge via R7 and the monostable resets. This signal is used to control bistables IC2a and IC3a depending on whether MEMORY, LATCH/FLASH or CHASE mode is selected. In LATCH/FLASH mode, TP1 sets and TP2 clears the bistable IC, this touchpad also forcing the output high for the duration of the touch. In this mode, the LED is made, (via gates of IC6, IC7c, IC4c and IC1a), to show green for channel ON and off for channel OFF.

In MEMORY mode, IC3a is implemented as a D-type latch with the data input controlled by the Q output of IC2a which is routed through IC4c. TP1 and TP2 set or clear the latch respectively. The MEMORY button on the Master Control Board is used to clock the data through the latch to the output. The LED in this mode is made to convey one of four states:

GREEN — channel ON.

FLASHING GREEN — channel presently OFF but will switch ON at next selection.

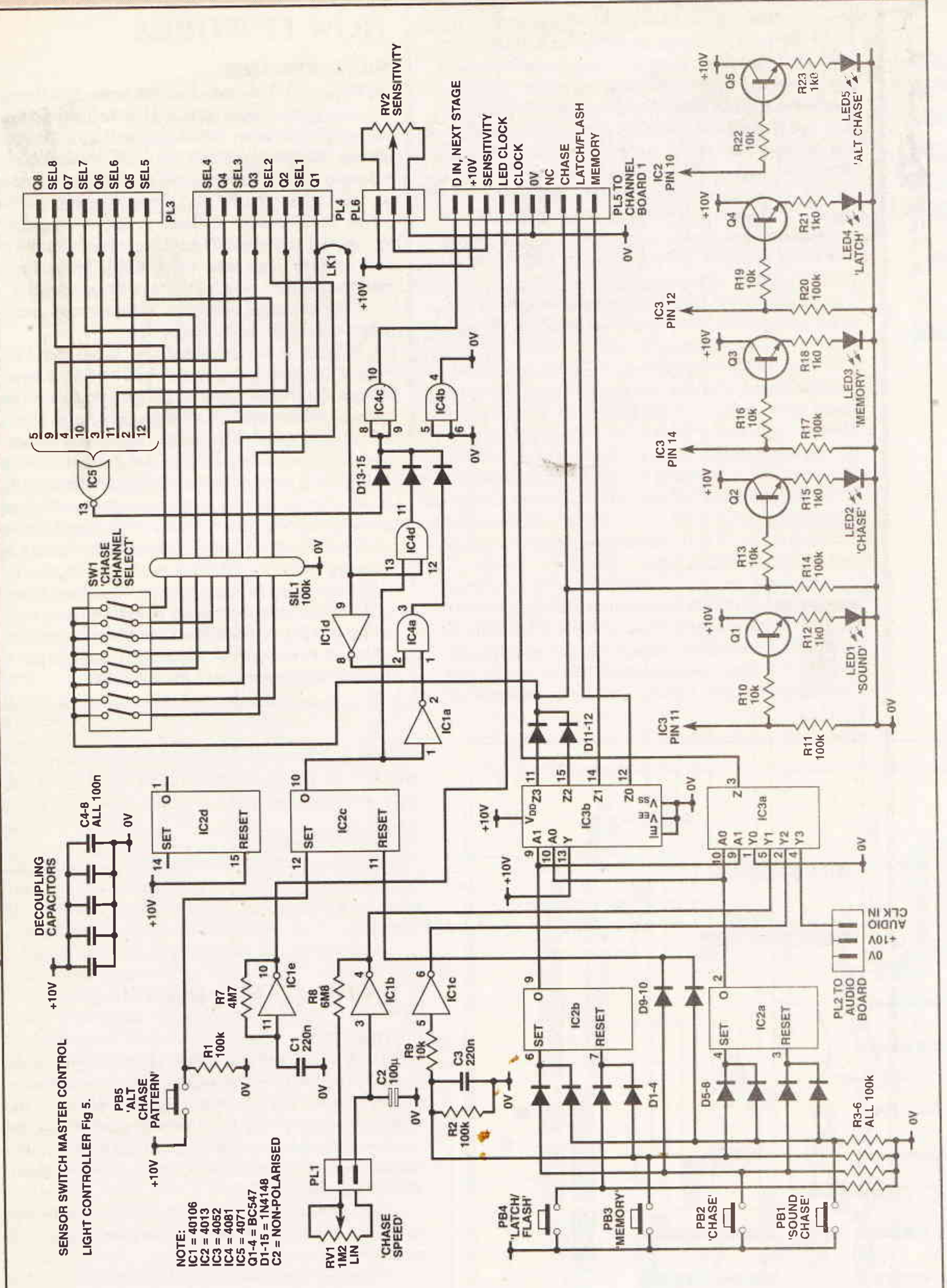


Fig.1 Sensor switch master control circuit

FLASHING RED — channel presently ON but will switch OFF at next selection.

LED off — channel presently OFF, no new selection.

The last mode, CHASE, cascades all of the latches on each channel board to form either a Johnson code or ring counter, depending on whether the Q or Q̄ output of the last stage is used as the code regenerating element.

The Q output of channel 1 bistable is used as the D input for channel 2, Q output of channel 2 used as the D input of channel 3 and so on and so forth. The CHASE CHANNEL SELECT switch, SW1 on the Master board, determines whether or not that particular channel is to be incorporated into the chase sequence. If it is set to OFF, that channel operates as in LATCH/FLASH mode, the Q output from the previous stage bypassing this channel via IC7b and IC7a cascaded SPDT analogue switches and being routed to the D input of the next stage selected for CHASE.

The LED shows GREEN — channel ON, RED — channel presently OFF but selected for CHASE routine and OFF, channel OFF and under manual LATCH/FLASH control.

Other gates on the board merely control the routing of the bistable input and output signals for the purposes of switching latch data, clock signals or the LED oscillator signal to the appropriate LED or gate input at the right time.

Some of the more sophisticated (and expensive) touch panels rely on change of capacitance at the input rather than change of voltage as in this design.

These types are inherently less prone to some of the problems associated with so-called inductive switching, such as spurious operation and liability to damage by static etc., and the capacitive design allows the switch to be sealed behind a waterproof membrane, thus protecting the delicate electronics from the ingress of beer, coffee etc. Unfortunately, the electronic implementation of this version calls for a reasonably complex circuit, too complex in fact to repeat four times on each channel board in addition to the other circuitry.

However, the simplicity and low cost of the featured design more than compensates for any compromises or shortcomings in its performance.

The design is implemented using one Master Control Board, one optional Sound Trigger Board (a pared down version of the Bass Beat Trigger in the Master Controller) and up to 8 Channel boards. Control signals from the Master Board are daisy-chained along to all of the channel boards. Outputs from each Channel board are fed back to the Master Control board and to a Connector board which then parallels connections to all low voltage rear panel connectors and a Triac Switching board if fitted.

The unit can be configured in one of three ways; as a low voltage control panel deriving its power from another unit (usually a Dimmer Pack fitted with an 18VA PSU), as a low voltage controller with integral 6VA PSU or as a controller with both low voltage and zero-switched mains outputs. The unit constructed will depend totally on individual requirements — the author's own unit features four channels of mains outputs and four of control.

HOW IT WORKS

MASTER CONTROL BOARD

The Master board selects mode of operation for the channel boards. PB1-4 each generate a unique two bit code from the Q outputs of IC2a, IC2b quad Set-Reset latches. The code addresses IC3a and IC3b, a dual analogue multiplexer/demultiplexer. IC3a is used as a multiplexer to select which of the three differently generated clock signals is routed to the CLOCK output pin on PL5. Clock signals can originate from the internal CHASE oscillator comprised of IC1b and associated components, from the MEMORY pushbutton (debounced by IC1c) or from the Sound Trigger board if fitted. IC3b is configured as a demultiplexer to switch one of four LED's on at the appropriate time.

IC1e is configured as a low frequency CMOS oscillator and is used to pulse the channel LED's when in standby mode.

The function of SW1 was explained in the Channel section. The Q output of each channel board is inputted via PL3 and PL4 to an 8-input NOR gate, IC5. LK1 is linked to whichever Q output has come from the last channel board fitted and will normally be connected to Position 1 when a full complement of channel boards is fitted. IC5 output is only high when all of its inputs are low ie when CHASE is first selected and so pre-loads the D input of the first channel selected for Chase as the first step of the sequence. This logic high is rippled through each of the selected stages until the last stage where upon it is fed back to the first stage D input via IC4a, D14 and IC4c. When ALT. CHASE is selected via PB5, IC2c is set, IC4a enabled and IC4d disabled so that the Q output of the last stage, inverted by IC1d, is now used as the D input of stage one. We now have a Johnson code or 'fill and empty' chase pattern. We can utilise this to create different chase patterns in the NORMAL chase mode as the ring counter will circulate however many logic ones there are present at the point in the ALT. CHASE where we change to NORMAL CHASE.

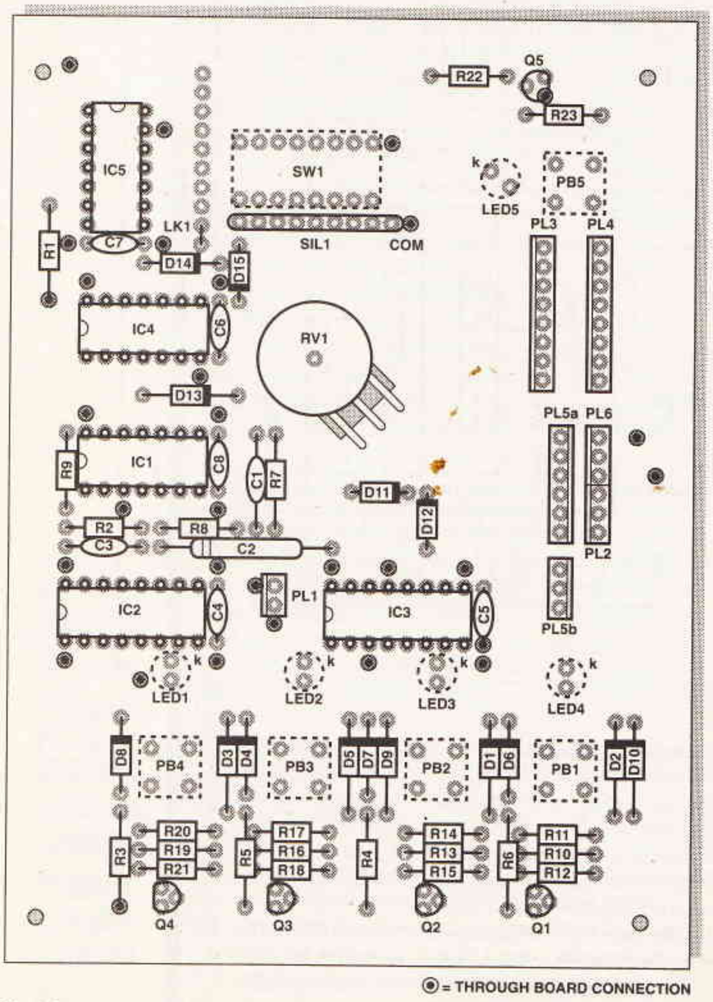


Fig.2 Sensor switch master control overlay

Construction

The construction of this unit is probably the most difficult of all three featured as it required many interconnections, some involved metal-bashing and the careful cramming of many PCB's into a rigidly defined space.

If reasonable metalworking facilities are available to the reader then the casing is probaby best home-constructed since most readily purchased enclosured of this ilk are rather large in depth dimensions, being anything up to 15" deep and more intended, one would think, for housing amplifiers, heavy duty PSU's and the Nightfighter controller. (However, since the prototype was first constructed, it has come to the attention of the author that one manufacturer of this type of enclosure now features cabinets of the size required — details are given in the Buylines section of this part of the series).

If it is intended that the Sensor Switch unit be vertically rack-mounted, cases of these sizes will provide no problems.

However it is envisaged that this unit be mounted horizontally or inclined at some angle, keyboard-style, where rear overhangs of these sorts of sizes may prove problematical.

If no facilities are available, most sheetmetal workshops will put the four or five bends required into a piece of aluminium for the price of a round of beers! ALL of the cutouts shown on the drilling diagram should be made unless the unit is to be completely without mains switching facilities. The triac mains outputs are wired, via rear panel mounted fuseholders to 6A IEC shuttered mains outlets. Colour coded and suitably rated wire should be used to connect between these fuseholders and the triac board PC terminals, looping the cable bunch from one end of the casing to the other as before. Parallel connections of these out-

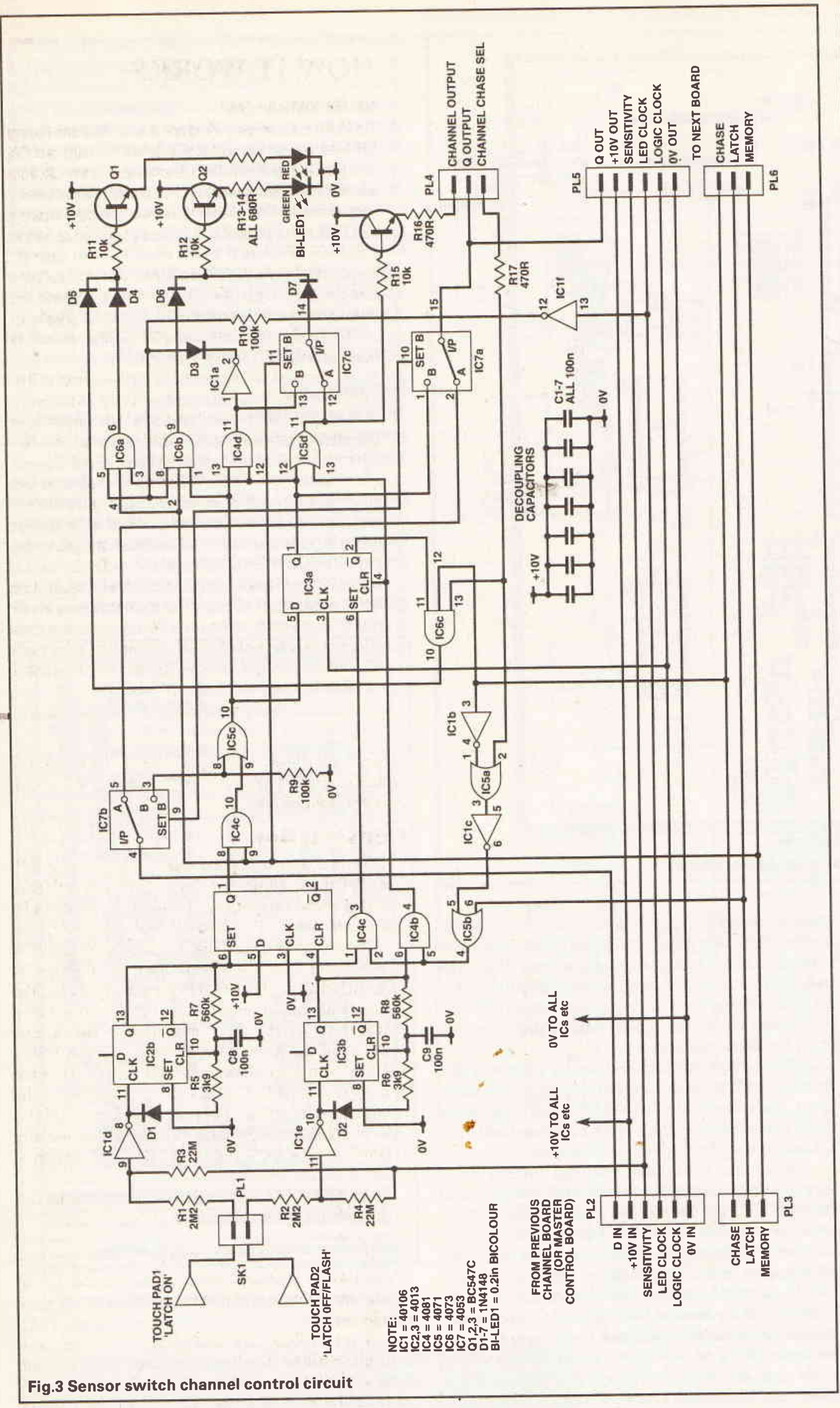
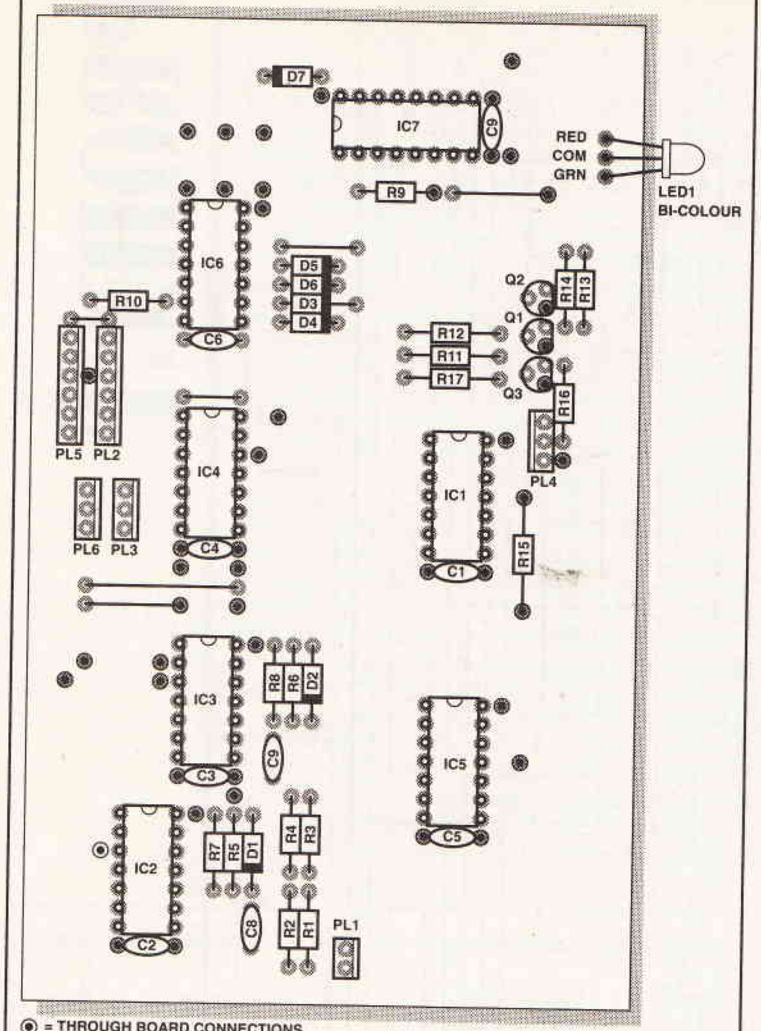


Fig.3 Sensor switch channel control circuit

puts are made to the Bulgin sockets, using the same pinouts as in Part 2. Each Neutral and Earth connection to these sockets should be wired individually to the Mains Input terminal block and neatly loomed and tie-wrapped, one earth connection being used to bond the chassis to Mains earth. All exposed mains connections should be sleeved and the fuseholders shrouded with rubber boots.

Drilling and cutting of the front panel should be commenced at this stage. In the author's prototype, a large, rectangular cutout of size shown in the drilling details diagram was made. A piece of clear Perspex was then cut so that it was of exactly the right size to fit this cutout. A piece of sheet aluminium, very slightly



◉ = THROUGH BOARD CONNECTIONS

Fig.4 Sensor switch channel control overlay

larger all round than the Perspex was then cut. Holes for the touch pads were then drilled in both, the holes in the aluminium being of larger diameter. The touch pads are then mounted using insulating bushes, washers 6BA nuts and the whole assembly offered up to the front panel cutout and glued around the perimeter using Araldite or similar.

Connection between the touch pads and the channel board is made using Minicon plugs with short flying leads terminated with M3 solder tags. Each touch pad should be checked for complete insulation between it and the front panel metalwork.

All of the PCB's are mounted (in the time-honoured Nightfighter fashion) on 1/2″ × 1/8″ aluminium bar fastened transversely inside the case. These strips are bolted on either side of the case to more aluminium strips running vertically inside the case. The photographs and diagrams show this more clearly. Should the unit be a powered version, the PSU and Switch board are mounted on a second set of centrally located transversely mounted bars, any cabling between front and rear panel being tucked neatly under or around the boards, depending on how many boards are fitted. Each Channel board is mounted at right angles to the front panel, being secured to the transverse mounting bars using 1cm wide strips of angle aluminium. Once again, a picture paints a thousand words and the diagrams show this far more eloquently.

Construction of the electronics is again very straight-forward, through-board pins, resistors and IC sockets being mounted first and the foil side components (LED's, switches) mounted last. However, it should be noted that the very cramped layout of the channel board necessitated some slightly unorthodox design features, all decoupling capacitor legs being soldered on each side of the board and thus providing the ground connection for the adjacent IC concerned.

There is a requirement for eight, 3″ long 6 way and 3 way plug to plug ribbon wire assemblies these providing connection between each of the channel boards and the Master, and also two rather unusual plug to plug assemblies which are shown in the diagram. Parallel connection between the rear panel CONTROL OUT D-type, triac board and each of the channel boards is made using a Connector PCB.

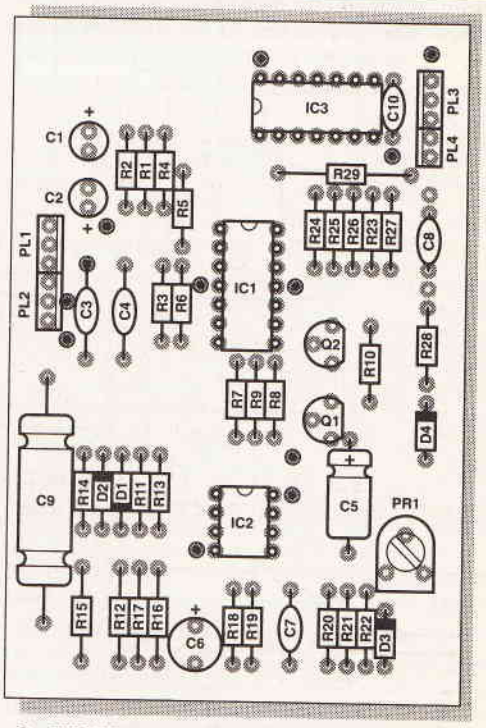
Finally, the optional Sound Trigger board is mounted piggy-back fashion on the Master board.

Setting up

The link on the Master board should be soldered into position such that it connects the $\overline{Q}$ output of the last channel to IC1 pin 9 (the other end of the link).

If the optional Bass Beat Board is fitted, the power supply and Audio Input connections are made via PL1. A short three way Minicon plug to plug connector is then used to provide power and the audio clock from PL2 to the Master board.

Should no Sound Trigger board be fitted, power supply connection is made directly from the PSU (or the rear panel D-type if the unit is unpowered), no connection being made to the 10V terminal on the PSU board.



◉ = THROUGH BOARD CONNECTIONS

Fig.6 Sensor switch sound trigger overlay

Mains input connections are made using a small piece of 30A terminal block which is mounted adjacent to the 20mm cable gland and behind the PSU.

Operation

Mains connection to the unit should be made using 13A cable or for powering from another unit, a 15 way D-type plug to socket lead should be constructed. It is left to the individual to devise some sort of splitter arrangement so that the channel outputs on pins 1 to 8 of the D-type are still readily accessible when using this

HOW IT WORKS

SOUND TRIGGER BOARD

This board is identical in all respects to the circuitry incorporated on the Master Controller Bass Beat Trigger for detection of the beat of the music. It differs only in that there is no oscillator section, no AGC wideband music section and that the Time Constant of the monostable section is much larger and is user variable via the front panel SPEED control.

approach. If ten core cable is used, the 0V connection should be made to the screen (braid) since this leaves the necessary two cores free for the plus and minus 10V connections. The unit which is being used as the remote power source will of course need to have the +10V and −10V connections made on the EXT. CONTROL OUT socket between pins 14 and 15 and the PSU plus and minus ten volt terminals.

The checking procedures for the triac and PSU boards follow exactly those given in parts 1 and 2 respectively.

Preset PR1 on the bass beat trigger board is adjusted for a voltage of 2.5V on pin 7 of IC2. Next, press each pushbutton in turn to ensure that its associated LED lights. Select LATCH/FLASH and verify that each of the touch pads on the upper row latches the relevant channel ON and that the lower touch pads turn the channel OFF or hold it ON for the duration of the touch. If there is no switching action or it is indeterminate, some adjustment of the SENSITIVITY pot may be necessary. The LED's on the triac board should be mimicking the front panel LED's.

Now clear all of the channels and select MEMORY. All of the LED's should be off. Run a finger along each of the upper LATCH ON pads and each LED should be flashing green. Pressing the MEMORY pushbutton again will cause the LED's to be a steady green and LED's on the triac board to be on. Pressing the MEMORY button again should have no discernible effect and all channels should remain on. Running a finger along the row of LATCH OFF touch pads will cause all of front panel LED's to flash red but the LED's on the triac board will remain unchanged.

Pressing the MEMORY button once more will switch all of the LED's, including the LED's on the triac board, off.

Ensure that all of the CHASE CHANNEL SELECT switches are in the ON position, turn the SPEED pot fully clockwise and press the CHASE button. All LED's will show red. After a short time, channel 1 LED should show green, then it should change to red whereupon channel 2 will show green until all channels have been cycled through in this manner and channel 1 again switches on. Now select ALT. CHASE and the chase routine will now be a fill and empty one, with channel 1, channel 2 etc all coming on sequentially until all channels are on. The channels will then sequentially switch off.

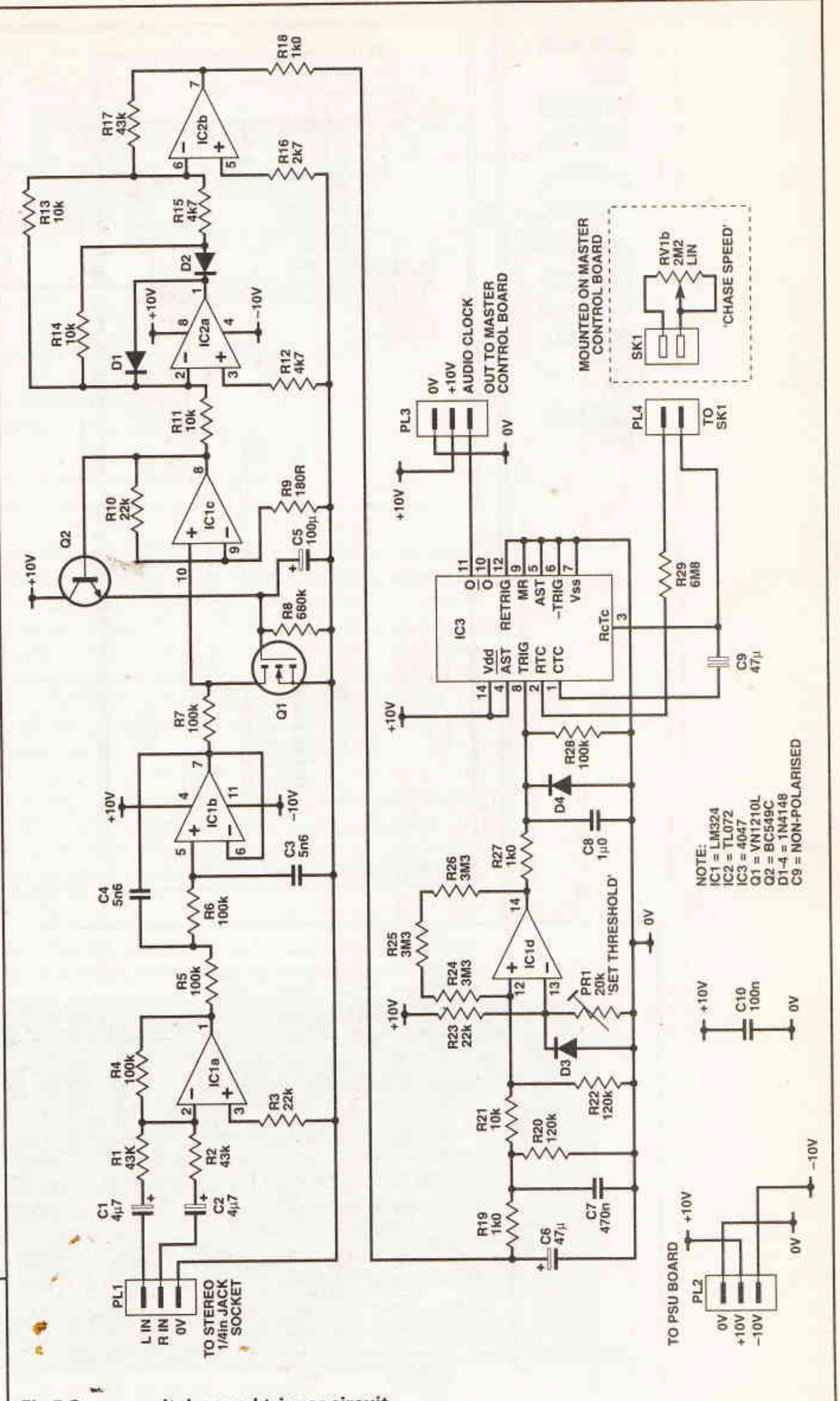


Fig.5 Sensor switch sound trigger circuit

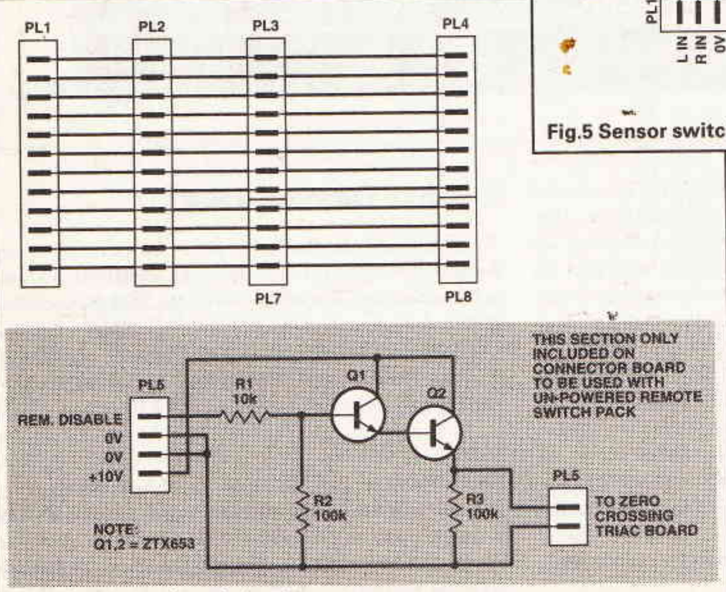


Fig.7 Connector board circuit

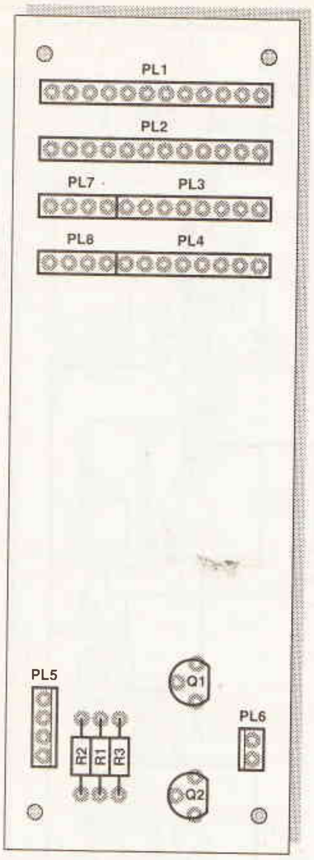
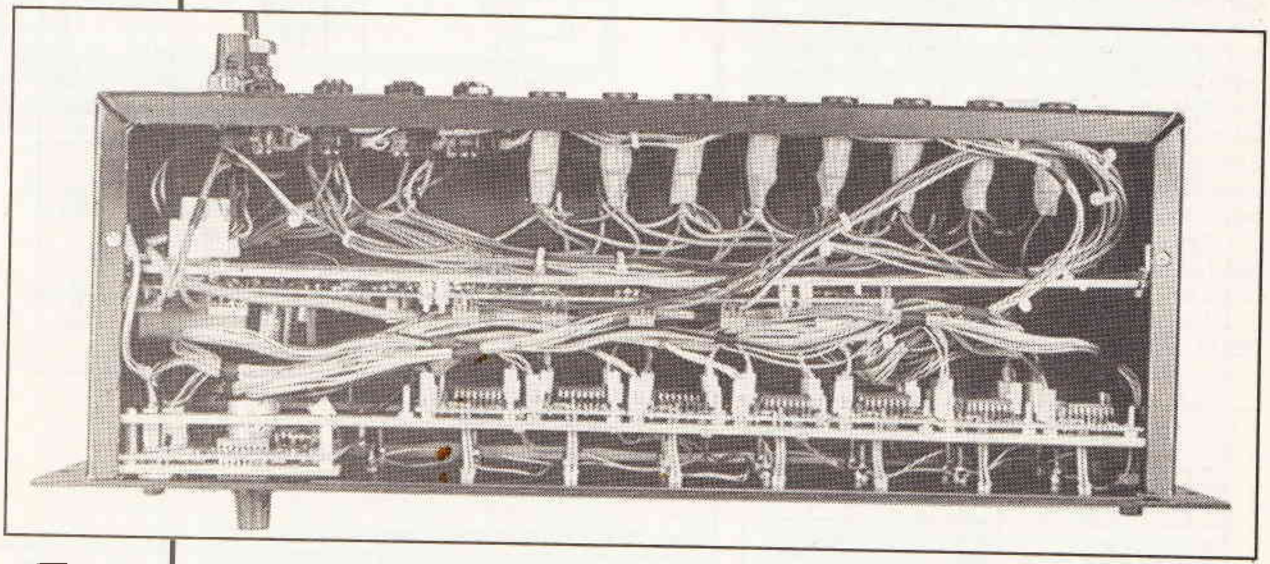


Fig.8 Connector board overlay



If we now revert to normal CHASE, the number of channels which are recycled in the routine (it was originally one) is determined by the number of channels which were on in ALT. CHASE at the time that we selected CHASE. This is useful for selecting chase routines of more than one channel. If a one channel chase is all that is required, either change modes when only one channel is on or select NORMAL as an intermediate mode and clear all channels before selecting normal CHASE. Finally verify that all of the channels can be switched in or out of the chase routine using the CHASE CHANNEL SELECT switches and that any so switched operate as in NORMAL mode. This facility should only be used infrequently as the CHASE CHANNEL SELECT switch has a very finite life (about 3000 operations).

The Sensor Switch is now fully set up and operational. All that remains is to connect it to the other units in the Nightfighter range. Figure 14 shows some possible configurations and permutations of the Master Controller, Switch/Dimmer Packs and Sensor Switch.

Faultfinding

The PSU is of course the first port of call in this undesirable exercise. Much has been said already about the testing of this item and I won't bore you with further prose pertaining to it.

Next in line is the Master Control Board. Check that the correct voltages are reaching all of the IC's, that the bistables are toggling correctly when each of the buttons is pushed and that the multiplexer IC, once correctly addressed, is switching the correct output to input or vice versa. Checks for the Sound Trigger Board are as for the Bass Beat Trigger of the Master Controller. Once the Master board has been verified as working correctly, one can move on to any individual Channel boards which may be exhibiting problems. In the first instance, check that all of the Minicon socket-to-socket assemblies have been correctly fabricated and are plugged into the relevant sockets. Should faults persist at this stage, a wise investment might be a Logic Probe as further trouble-shooting involves tedious checking of individual logic levels on the pins of IC's. A comprehensive faultfinding guide for the dual channel board would consist in the main of reams of truth tables for each of the possible logic permutations. The one consolation for the reader is that it is statistically unlikely, but for a very foolish constructional error, that two channel boards will exhibit identical faults and that once one channel board is up and running, faultfinding can consist of comparing logic levels at identical points on good and faulty boards.

Further Development

As mentioned at the start of this section, there are some special effects to be had when we switch the Neutral connections as well as the Lives. Displays utilising this type of connection are known as Matrix displays. The Live connections are known as the X connections because they lie along the X-axis of the display and similarly the Neutrals are called the Y connections. To make the display chase along the Y axis ie a vertical column of lights sequencing along, we must switch all of the Neutrals on and chase the Lives. Similarly to chase along the X axis we must switch all of the Lives on and chase the Neutrals. We can do this using an 8-way triac board with four of the triacs switching Neutral and four switching Live. It would necessitate reprogramming the EPROM such that the first forty pro-

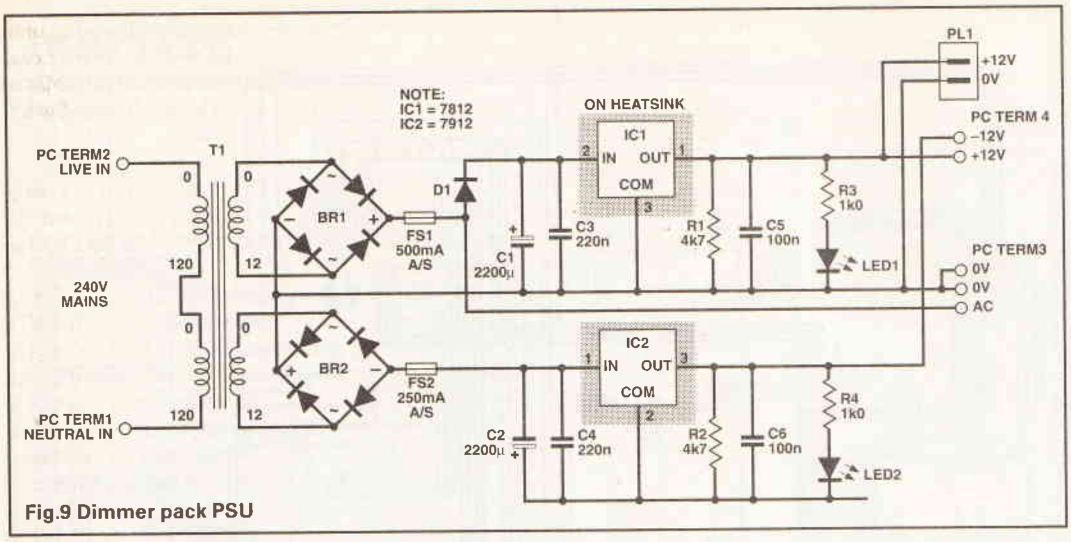


Fig.9 Dimmer pack PSU

grams are on X-axis and the second forty on Y-axis. Thus toggling address line A10 would switch axes. Sample lines of EPROM addressed for a one lamp chase are given below.

X-axis chase starting at EPROM address 00, ie sequence No 1.

00 F1 F2 F4 F8 F1 F2 F4 F8 F1 F2 F4 F8 F1 F2 F4 F8

Y-axis chase starting at EPROM address 40, Y-axis chase No 1.

40 1F 2F 4F 8F 1F 2F 4F 8F 1F 2F 4F 8F 1F 2F 4F 8F

The STROBE button could become the axis change pushbutton as it controls the A10 address line. D1 on the Output Mode board would need to be omitted so that the unit is no longer placed in Standby mode when PB4 is pushed, and the GO pushbutton would then select the other axis. EPROMS with contents suitable for a matrix-style display are available from the author, as is the EPROM necessary for the Master Controller. Any orders dispatched for the special edition EPROM will be accompanied by more detailed wiring diagrams of the alterations required.

The triac boards can also be used to control voltages other than 240V mains because the triac supply is directly accessible via the 2.5mm tails. This is useful where we want to control low-voltage lamps eg 24V Tubelight without wishing to purchase four or eight 24V transformers. The triac supply is simply connected to the secondary side of a suitably rated 24V Transformer and the triac outputs will now be at 24V for direct connection to the lamps. These low voltage/high current outputs will be more susceptible to voltage drops caused by I^2R losses in connecting cables which should be kept as thick and as short as possible.

It is a sad fact that the cost of the actual electronics is far outstripped by the cost of hardware such as connectors, enclosures, knobs, switches etc.

The cost of the project could be reduced by using

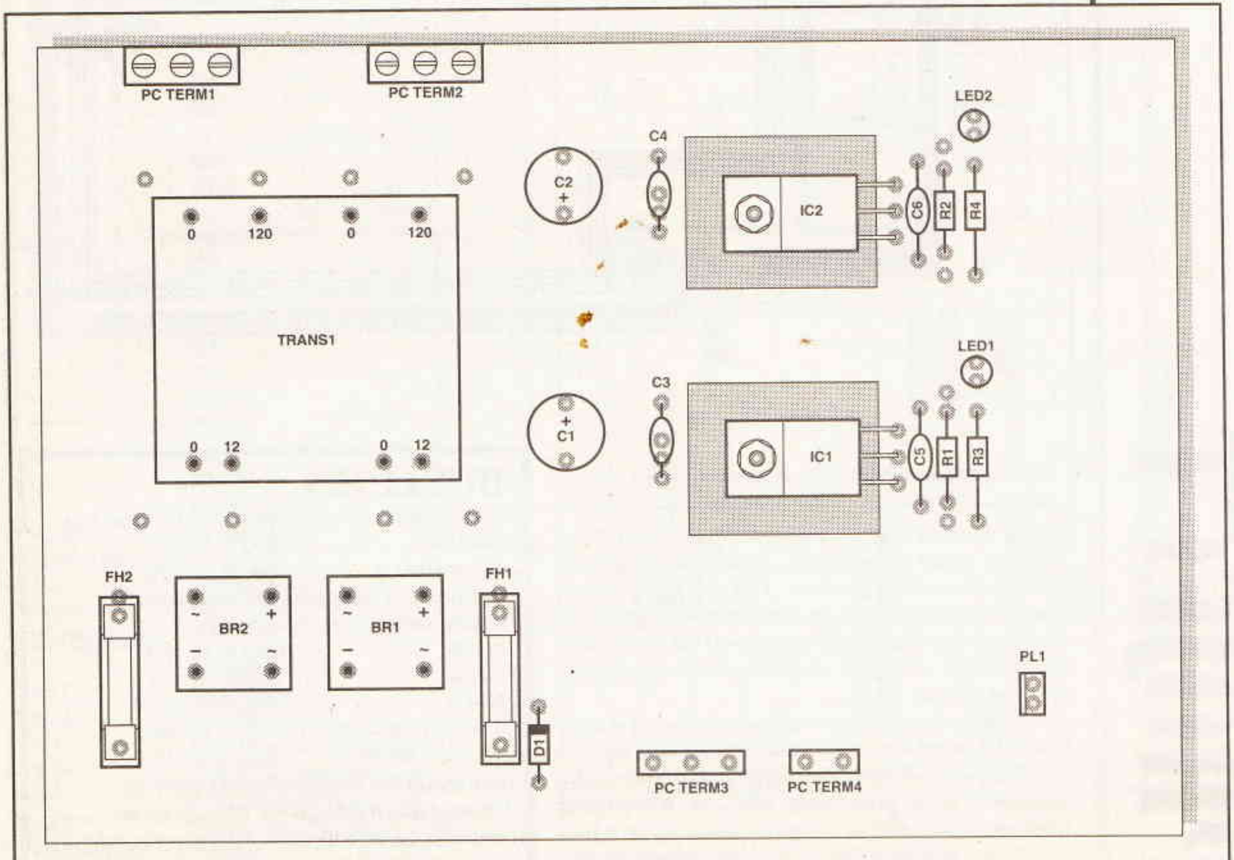


Fig.10 Dimmer pack PSU overlay

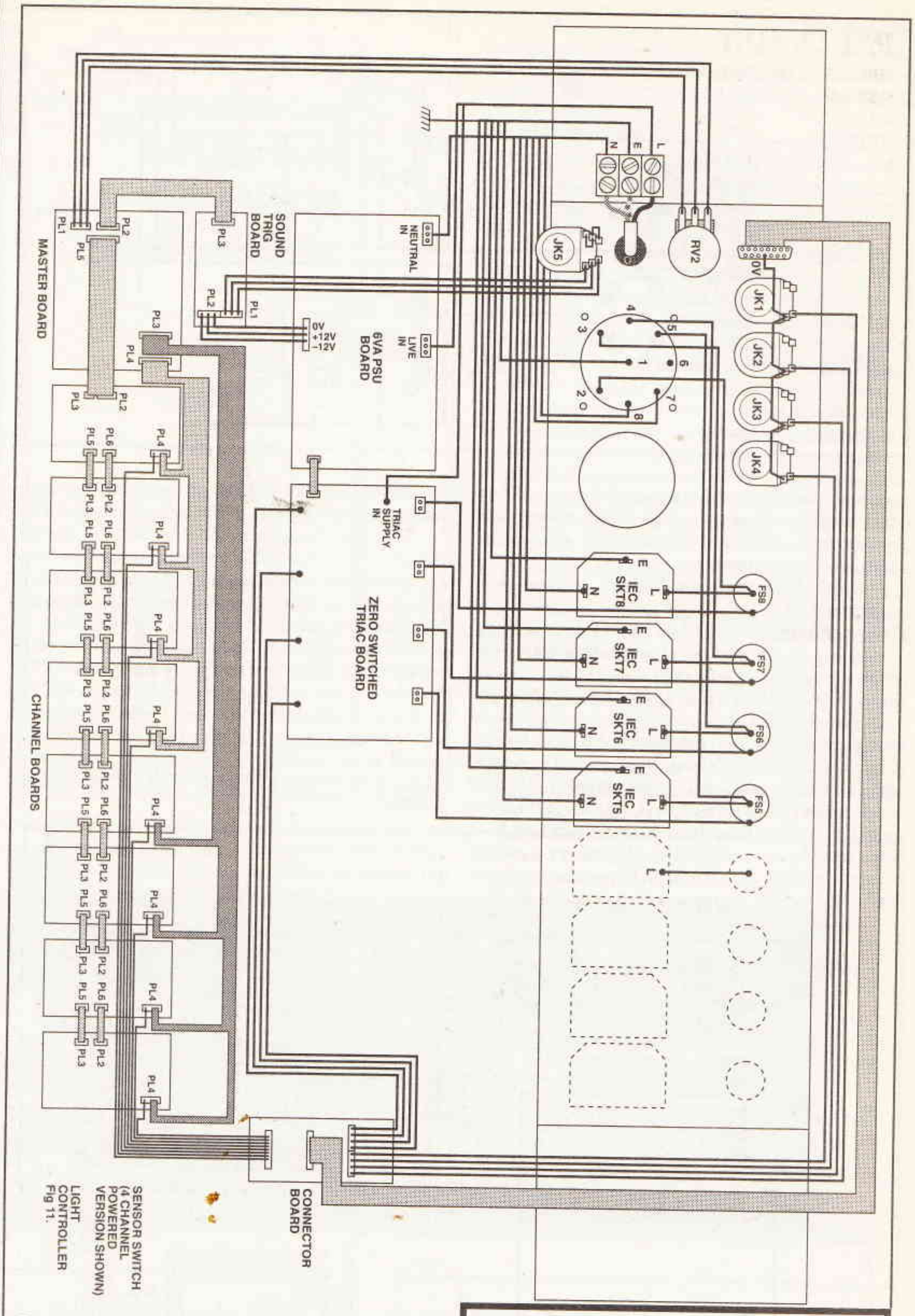


Fig.11 Interwiring diagram of sensor switch

less or cheaper mains connectors, hard-wiring all of the inter-board connections, chassis mounting fuseholders, less robust cases etc. This can prove to be a false economy as the units will be inherently less reliable, less professional-looking and the rig will take much longer to set-up, and dismantle when using terminal blocks.

Finally, the author is currently designing a stage lighting desk which will allow crossfades between two sets of presets, a memory facility for storing scene lighting levels, direct interfacing with the Nightfighter Dimmer packs, and an external control input which could be connected to the Nightfighter Master Controller.

BUYLINES

Keyboard switches (Alpha style) available from STC Components

Switch Base	(Stock No. 07352B)
Alpha-style Keycap	(Stock No. 028859C)

Black anodised 19" front panels, plastic encapsulated PCB-mounting transformers from RS Components

1U Panel	(Stock No. 502 455)
2U Panel	(Stock No. 502 461)
3U Panel	(Stock No. 502 477)
18 VA 12-0-12 Transformers	(Stock No. 208 349)
6 VA 12-0-12 Transformers	(Stock No. 208 844)

Touch pads, Minicon Connectors, Heatsinks, Opto-triacs, Interference Suppression Capacitors Toroidal Chokes and Miniature Pots all available from Maplin. Rack-mounting cases available from Rackz Products.

PARTS LIST

SENSOR SWITCH MASTER CONTROL

RESISTORS

R1,2,3,4,5,6,11, 14,17,20	100k
R7	4M7
R8	6M8
R9,10,13,16,19,22	10k
R12,15,18,21,23	1k
VR1	2M2 dual linear pot
VR2	1M linear pot
SIL1	100k SIL resistor array

CAPACITORS

C1,3	220n
C2	100µ non-polarised
C4-8	100n

SEMICONDUCTORS

IC1	40106
IC2	4043
IC3	4052
IC4	4081
IC5	4078
Q1-5	BC547C
D1-14	1N4148
LED1-4	0.1" yellow LED
LED5	0.1" green LED

MISCELLANEOUS

PB1-5	Click Switch & cap (Maplin FF87C, FF94C)
SW1	8-way DIL Switch (Maplin XX27E)
FL1	2-way Minicon plug
PL2,6	3-way Minicon plug
PL3,4	8-way Minicon plug
PL5	10-way Minicon plug
SK1	2-way Minicon socket-lead assy
SK2	3-way Minicon socket-socket assy
SK3,4	8-way Minicon socket to four 3-way and one 4-way socket assy (see text and diagrams)
SK5	10-way Minicon socket-socket assy
SK6	3-way Minicon socket-lead assy.

IC sockets to suit, PCB, veropins

CHANNEL BOARD

RESISTORS

R1,2	2M2
R3,4	22M
R5,6	3k9
R7,8	560k
R9,10	100k
R11,12,15	10k
R13,14	680R
R16,17	470R

SEMICONDUCTORS

IC1	40106
IC2,3	4013
IC4	4081
IC5	4071
IC6	4073
IC7	4053
Q1-3	BC547C
D1-7	1N4148
BI-LED1	0.2" Tricolour LED

CAPACITORS

C1-7	100n disc ceramic
C8,9	100n polyester

MISCELLANEOUS

PL1	2-way Minicon plug
PL2,5	6-way Minicon plug
PL3,4,6	3-way Minicon plug
SK1	2-way Minicon socket-lead assy.
SK2	6-way Minicon socket-socket assy.
SK3	3-way Minicon socket-socket assy.
TP1-4	Triangular Touch Pads (Maplin HYO1B)

IC sockets to suit, PCB, Veropins.

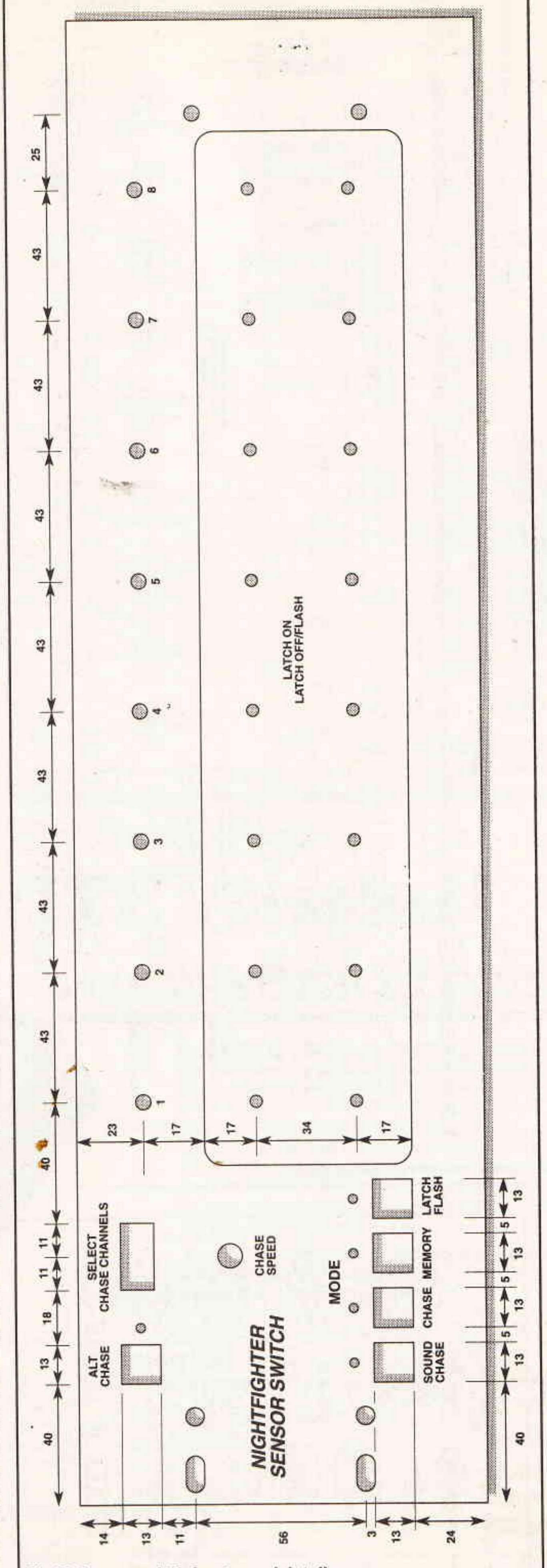


Fig.12 Sensor switch front panel details

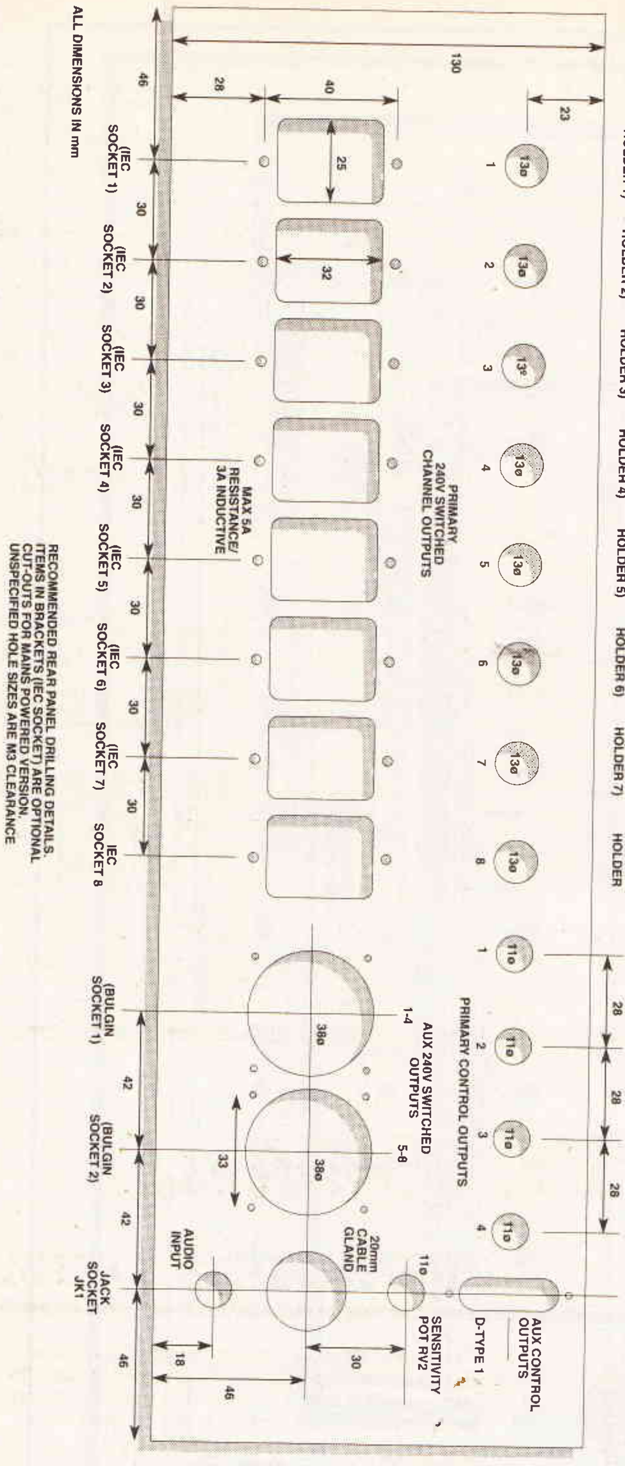


Fig.13 Sensor switch rear panel details

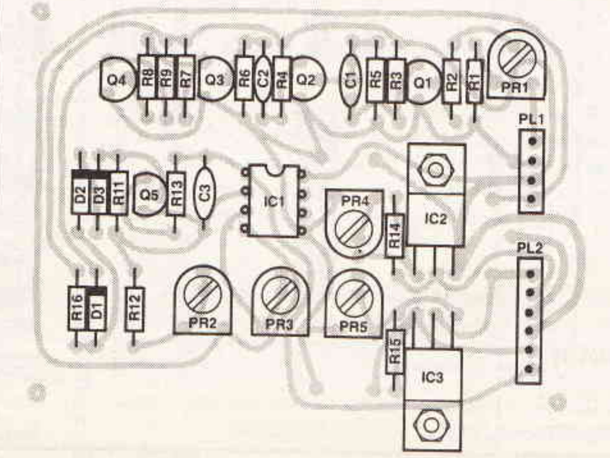


Fig.15 Corrected zero crossing detector and ramp generator overlay

SOUND TRIGGER BOARD

RESISTORS

R1,2,17	43k
R3,7,10,23	22k
R4,5,6,28	100k
R8	680k
R9	180R
R11,13,14,21	10k
R12,15	4k7
R16	2k7
R18,19,27	1k
R20,22	120k
R24-26	3M3
R29	6M8
PR1	20k horizontal preset

SEMICONDUCTORS

IC1	LM324
IC2	TL072
IC3	4047
Q1	VN1210L
Q2	BC549C
D1-4	1N4148

CAPACITORS

C1,2	4µ7 16V radial electrolytic
C3,4	5n6 polystyrene
C5	100µ 16v radial electrolytic
C6	47µ 16v radial electrolytic
C7	470n polyester
C8	1µ0 polyester
C9	47µ axial non-polarised electrolytic
C10	100n disc ceramic

MISCELLANEOUS

PL1-3	3-way Minicon plug
PL4	2-way Minicon plug
SK1	3-way Minicon socket/screened lead/stereo 1/4" jack socket assy
SK2	3-way Minicon socket to socket assy
SK3	3-way Minicon socket to flying lead assy
SK4	2-way Minicon socket to lead assy

MISCELLANEOUS TO COMPLETE SENSOR SWITCH

SK1	15-way D-type mounting socket
JK1-4	1/4" mono jack socket
JK5	1/4" switched stereo jack socket

3U black anodised front panel, matching case (see text), 6BA and M3 nuts, bolts, washers, solder tags, spacers, IEC 6A shuttered mains sockets to suit, Bulgin octal mains sockets to suit, 5x20mm panel mounting fuseholders to suit, 30A terminal block, 6A connecting wire of various colours, 20mm cable gland, 6VA PSU, Triac Switch board to suit, terminal block, mounting hardware as described in the text.

Error Round-up Part 1

Fig.2 PL2 'Bass Clock' is not connected to pin 9 'SW'. Pin 9 'SW' should be conneced to IC15 pin 2 'A1'. IC18 and IC19 Pins 4 and 10 on both chips should be labelled 'IN' not Vdd0 and Vdd1 respectively. Vdd1 on IC's 18 and 19 is pin 16 and is connected to +5V. Vdd0 on IC's 18/19 is pin 1 and is connected to +10V. D4 is omitted from Main Processor Board Parts List and is 1N4148. PL5 Pin 9 should be labelled STROBE EN.

Fig.3 C1,2 should be 100n disc.

Fig.7 Q3 FET, there should be no connection between gate and pin 3 of IC1d. Instead it should connect to the positive end of C6. The node of R34 and PR1 should connect to pin 13 IC2d.

Part 2

Fig.1 Q1-4 should be NPN transistors ie BC549.

Fig.2 C2 should be 750p and PR4,5 are 5k presets.

Fig.3 Wiper to RV101 should be labelled Point 2'.

Fig.7 Board (0-12V) supply is made via PL2 as in circuit and point to left of Link 1 should be labelled To Triac Supply.

Fig.8 PR1 was wrongly positioned and without R1. See amended diagram Fig.15 left.

Part 3

Fig.2 C1 positive at lower end, C2 uppermost and C5 to the left. C11 should be aligned vertically under R42 and connecting to R44.

Fig.3 PB1-8 and PB1-6 (Fig.4) should be highlighted as being mounted on the other side of board.

Fig.4 Foil should be turned vertically to line up.

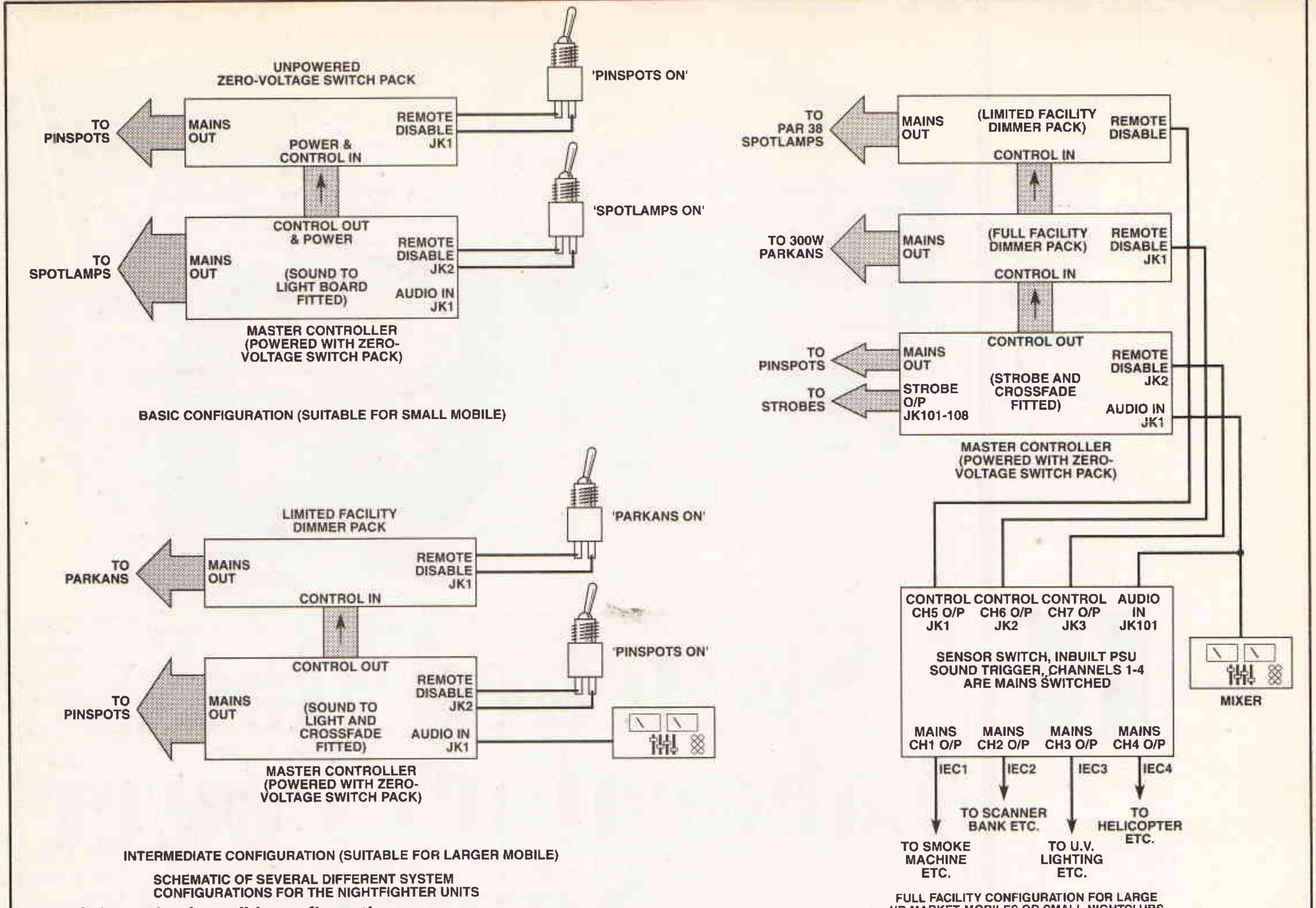


Fig.14 Schematic of possible configurations

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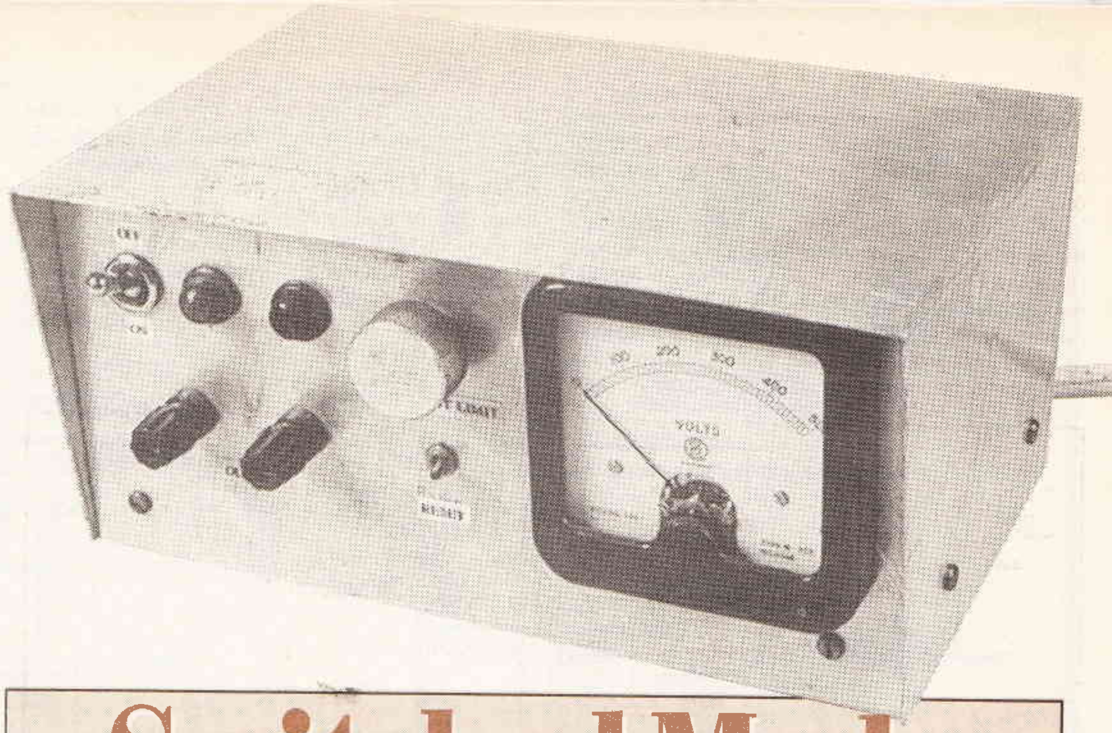


Switched Mode Laboratory Power Supply

Andrew Armstrong constucts using our free copper-clad board and foil, an efficient bench supply.

Recently I used my old laboratory power supply to attempt to restore life to a nickel-cadmium battery which had failed in such a manner that it had an internal short circuit. What sometimes happens is that crystals of cadmium grow across the separator causing a short circuit. If the battery is charged at the time, a current will flow through the crystal and melt it back onto the plate.

What had happened in this case was that the battery had been left unused for too long, all its charge had leaked away and it had become short circuited. To attempt to restore it, I turned the voltage on the power supply well above the normal cell voltage for a NiCad, and proceeded to dab the power supply connections onto the NiCad in an attempt to melt the internal short circuit. Unfortunately, my power supply, which I built almost 20 years ago, gave way before the short circuit did. It would no doubt have been possible to delve into the Veroboard and messy soldering and carry out a repair, but I decided instead that this was an omen, and that it was time for me to start again from scratch and design a new power supply using up to date technology.

The current output at lower voltages had proved inadequate in the past, and was to some extent limited by thermal considerations. Therefore, I resolved to design and built a laboratory grade switched mode power supply which would be able to deliver at least 1 amp at 30 volts, 2 amps at 15 volts and, if possible, a maximum current of at least 5 amps at 5 volts.

The advantages of using switched mode technology are that little heatsinking is required, and that at currents below the maximum rating of the supply the output power is more or less constant. It really is possible to supply much more current to the load than is drawn from the main reservoir capacitor.

Topology

I considered a number of different types of circuit for the job. My first decision was that I would use a conventional mains transformer to isolate the supply from the mains to avoid the difficulties of having to design a safe switching/isolation transformer. This decision simplified the design of the supply considerably, because a circuit topology employing a single storage inductor could be used.

My choices were then between the well known configurations of flyback, buck-boost (a kind of inverting flyback converter in which the output voltage can be above or below the input voltage), series buck regulator, or the less well known Cuk converter. One requirement from a laboratory power supply is that it shall provide a substantially noise-free output. The

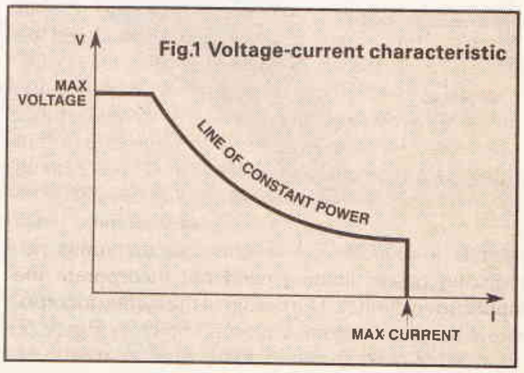


Fig.1 Voltage-current characteristic

high ratio of peak current to average current in flyback converter designs makes low noise and ripple harder to achieve, so the first two configurations were ruled out.

The Cuk converter was a serious possibility. In theory it is possible to reduce both input and output ripple in a Cuk converter to zero, so that a very low output noise and ripple should be possible. Unfortunately the complexity of a Cuk converter is greater than that of other converter types, and the requirements for near-zero output ripple are difficult to achieve. The need for a replacement power supply precluded the use of a topology which is not yet widely known, and about which there is little conventional wisdom. Therefore the series buck topology was chosen.

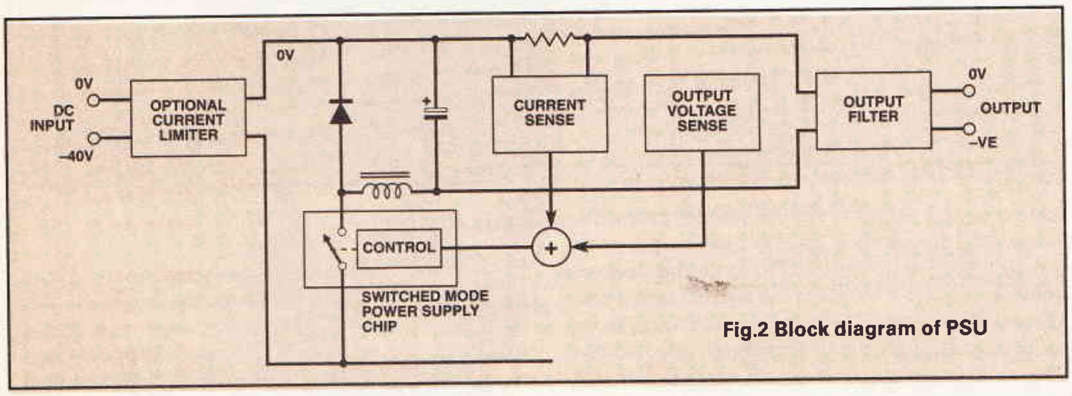


Fig.2 Block diagram of PSU

The next requirement was to choose the detailed method of designing the power supply. Many approaches are possible; a completely discrete design might be tried, or a standard switched mode control IC might be used to control discrete circuitry. The reliability and precision demanded from a laboratory power supply precluded the use of a simple discrete design, so an integrated circuit was chosen.

After careful consideration, the LT1070 switched mode IC , which incorporates a switching element on chip, and which provides cycle by cycle switch current limiting, was chosen. This IC appears to offer the best characteristics suitable to a laboratory power supply, consistent with a reasonably simple circuit design. These include being proof against short circuits and overload, and providing accurate output control under a wide range of load conditions.

Constant Power

There are two approaches to avoiding overloading the mains transformer. One is to limit the output current of the unit to the maximum DC which can be supplied using the transformer with a bridge rectifier and reservoir capacitor. This has the disadvantage that at low output voltages only a fraction of the total available power is utilised. If power rather than current can be limited, then more current can be made available at lower output voltages. This power limit is of course subject to the maximum voltage available, and the maximum current which the regulator can control. An output current and voltage characteristic such as that shown in Figure. 1 would be the ideal. I considered the possibility of doing this entire control using the control loop of the switched mode regulator IC, but I decided that because power limiting can be provided by input current limiting (given a more or less constant output from the transformer) a separate current limiter circuit may be preferable. This would provide a useful extra short circuit protection for the power supply. It also permits a modular construction so that units not requiring power limiting need not incorporate the input current limiter. The design of the system incorporating the input current limiter is shown in Figure. 2, but this project is to produce the switched mode voltage regulator. The current limiter module is planned as a future project.

Circuit Design

When designing a buck regulator, one naturally thinks of the switching element in the positive line. The LT1070 does not readily lend itself to this, however, because it's switching transistor is connected to the ground pin of the IC. It is possible to design a positive buck regulator using the LT1070, but because the operating current of the chip must flow continually in the output, this would not be suitable for any power supply in which the load can approach zero.

There is no good reason not to regulate in the negative supply, in which mode the LT1070 functions very well, so that is the approach taken in this design. The development circuit diagram which may be subject to minor modifications before part 2 next month, is shown in Figure. 3.

Starting at the input, a substantial electrolytic capacitor C1 is provided on the PCB to limit the need for substantial circulating currents off the board. A linear voltage regulator, IC1, is provided to supply the operating current for the LT1070, IC2. This is because the maximum voltage rating of the LT1070 for its power supply input is 40 volts, and a nominal 40V supply cannot be relied upon never to exceed 40 volts. Accordingly, a 35-volt regulated supply is supplied to IC2. The switch transistor of the LT1070 is rated at 60V, which is more than adequate to cope with variations in the DC input voltage.

The LT1070 is a current mode control chip which incorporates an internal oscillator whose frequency is set to approximately 40kHz by on-chip components. Internal circuitry monitors the current through the switch transistor, and it is this measured current which is fed back internally to adjust the mark:space ratio of the switch. External feedback adjusts the aiming point of the switch current rather than adjusting the mark:space ratio directly. This is what is meant by current mode control. Feedback loop stability is set by R3 and C3.

External feedback applied to the FB terminal and is compared internally with a 1.24V bandgap reference to generate an error voltage. In the design shown in Figure. 3, this input is protected from excessive voltage under fault conditions by the zener diode D1. R4 forms part of a potential divider referred to the output voltage. More about this later.

When the switch output is on, the negative supply is fed to the left-hand end of L1. When the switched current reaches the aiming point, the switch turns off and the input of L1 (connected to the Vsw terminal of IC2) rises to one diode drop above 0V, and the current in L1 starts to decline. Under most load conditions, the current in L1 exhibits triangular-shaped ripple but does not decline to zero. C4 substantially smooths this ripple, giving a more or less constant voltage.

The output current is fed through R5 to provide a

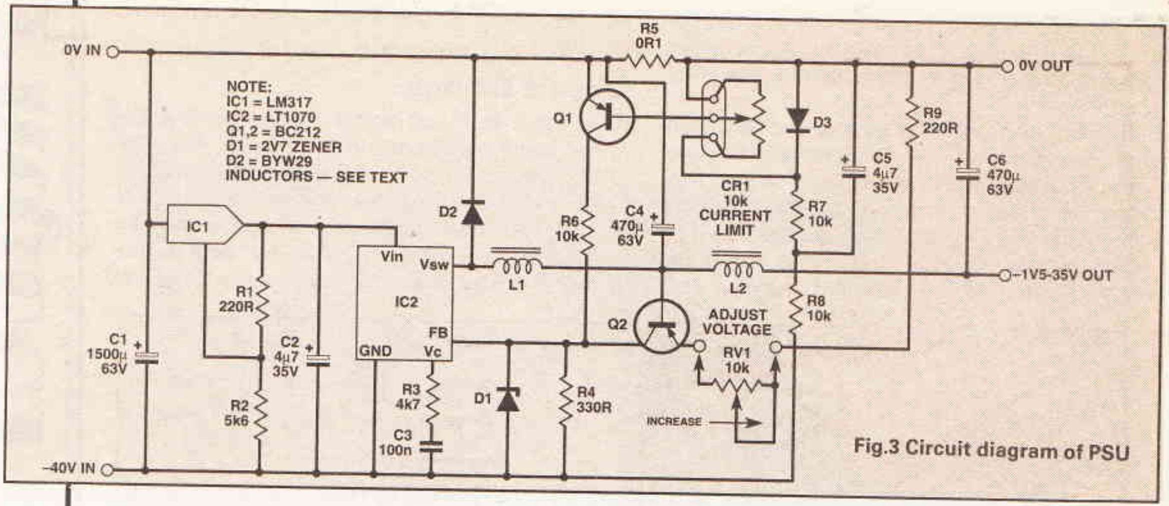
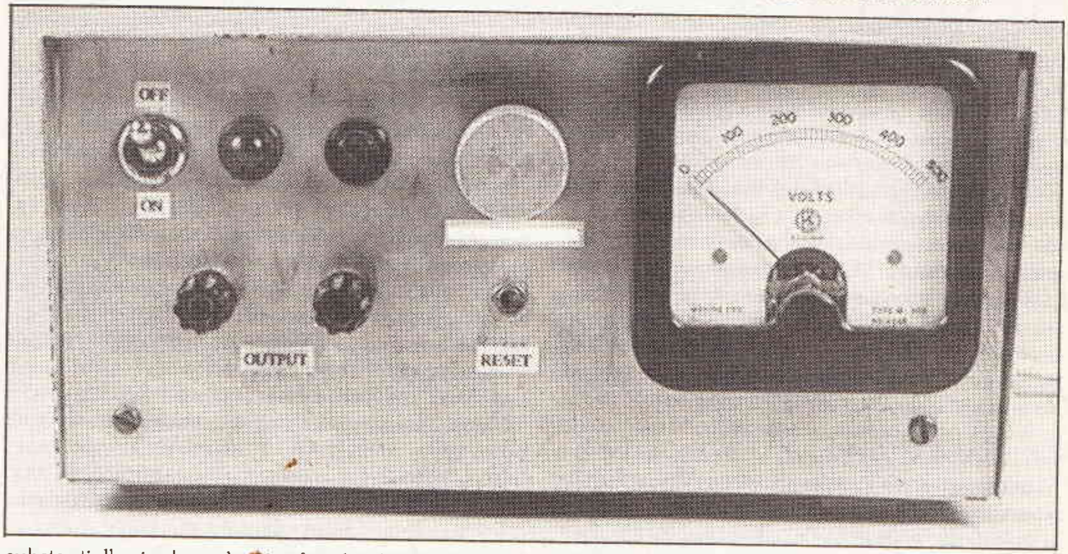


Fig.3 Circuit diagram of PSU

signal to use for variable output current limiting. The voltage drop across R5 is used to turn on Q1, which provides a positive current into R4 raising the feedback signal and therefore reducing the switch current aiming point. If the base of Q1 were simply connected to the output side of R5, then current limiting would take place at approximately 6A, which corresponds with 0.6V across the base/emitter junction Q1. This could be increased but not reduced by adjusting the current limit potentiometer. To compensate approximately for the base/emitter drop of Q1, a biasing diode D3 is supplied. The diode is forward-biased by means of a current flowing through R7 and R8. This current is made substantially ripple-and noise-free by the addition of C5. This arrangement permits the current limit to be adjusted almost down to zero.



Voltage control

The feedback input of IC2 is referred to the negative supply, which is not either of the output supply connections. In order to refer the output voltage to the negative supply, Q2, R9 and the voltage adjustment potentiometer are used to inject a current into R4 proportional to the output voltage. Clearly the voltage across R9 and the potentiometer is less than the output voltage by the base-emitter junction of Q2. Because the base/emitter junction of a transistor is affected by temperature, the output voltage is also temperature dependent to some extent. This in only significant when the output voltage is low. The value of R9 is chosen so that the minimum output voltage is approximately 1.5V.

Because this is a laboratory power supply, extra output filtering to remove ripple and switching noise is provided to L2 and C6.

Inductors

The inductors used in this power supply must be able to handle an average DC of 5A without either saturating or overheating. To keep the current ripple within bounds, the inductance of L1 should exceed 150 microhenries at no load to allow for the reduction of inductance that occurs even before saturation as current increases. L1 may be made by winding 50 turns of 1mm (or preferably 1.25mm) wire on a T104-40 core available from Cirkit — alternatively, a ready-made inductor available from Maplin (type JL73Q) may be used. L2 should consist of 30 turns would on a Cirkit T94-40 core.

Initial experiments have shown that this filtering arrangement provides a very clean output, save that there are spikes at the switching frequency of a very short duration, and of approximately 20mV peak to peak amplitude symmetrical about the DC output voltage. The filtering does not completely remove the spikes, because there is stray capacitance between the input and the output of the inductors, while the capacitors C4 and C6 possess an unwanted equivalence series inductance and resistance. To make the output still cleaner, it is planned that a low value inductor and a ceramic or polyester capacitor are incorporated at the output terminals of the unit.

The use of a metal case, and a mains filter, should keep all radiated interference within the box, giving a supply as interference-free as a linear design.

Details of the final circuit design and construction will be provided next month. The PCB sticker provided free with next months issue will be to the final design, which may differ slightly from the circuit shown in Figure 3.

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Negative Feedback

A P Stephenson looks at the standard ways of improving op-amp performance

Cheap voltage amplifier ICs with enormous gain have been with us long enough for them to be taken for granted. Except in certain specialised fields, the days of designing and building a voltage amplifier from discrete components to bump up some weak voltage, have long since gone. Instead, we simply bung in one of these off-the-shelf 'op-amps' and sit back — at least, that's the theory!

In practice, it is not quite so simple because the enormous gain and low cost have only been achieved by sacrificing stability and predictability. The gain (A) of an op-amp may be specified as 40,000 to 200,000 so a particular specimen, even of the same type number taken at random, could have a gain anywhere within these two extremes.

Apart from the actual gain variation, even the lower figure is probably far higher than required so something must be done to tame down the gain to some desired figure and to ensure that the tamed-down gain is predictable.

This is where feedback or, to be more precise, where negative feedback comes in. In fact, the design of a voltage amplifier using one or more op-amps is now reduced to the relatively straightforward problem of designing a suitable negative feedback system.

Although the above discussion has been primarily concerned with its effect on op-amps, feedback in some form or other pops up in various — and sometimes unexpected — areas of design so a sound knowledge of the underlying principles is essential.

Advantages of Negative Feedback

The most important design parameters of an amplifying system are:

- Voltage gain.
- Input resistance.
- Output resistance.
- Frequency bandwidth.
- Distortion.
- Noise.

The application of negative feedback to an amplifier will, in addition to lowering and stabilising the gain, increase the frequency bandwidth and reduce distortion. The signal to noise ratio is not improved but noise and hum in the output stage can be reduced.

A less obvious, although equally important, advantage is its ability to modify the input and output resistances of an amplifier. In short, gain is sacrificed in return for control over essential design parameters.

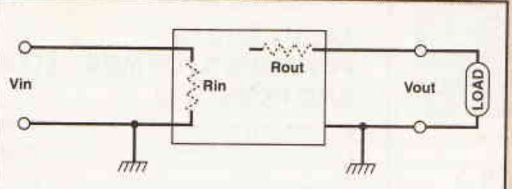


Fig.1 Four terminal amplifier

The Open-Loop gain (A)

Figure 1 shows any four-terminal amplifier which may, or may not, be an op-amp. The input signal, Vin, is amplified and appears as Vout. The ratio, Vout/Vin is defined as the open-loop gain. Thus:

$$A = Vout/Vin$$

The input resistance, R_{in}, is what the applied signal 'sees' and the output resistance, R_{out}, is what the final load 'sees' looking backwards into the amplifier output terminals.

The Feedback Fraction (B)

Feedback can be applied to any amplifier and consists of a network which taps off all or some fraction of the output and feeds it back to the input. The amount tapped off is defined as the Feedback Fraction, B.

Example: If one fifth of the output is tapped off, then $B = 0.2$

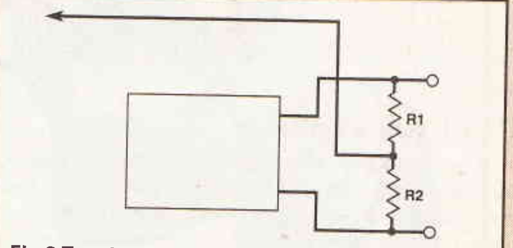


Fig.2 Tapping off a feedback fraction

Figure 2 shows how a simple divider network across the output can produce any desired value of 3 by suitable choice of resistors. This method of obtaining B is called voltage feedback. An alternative way of obtaining B, called current feedback, is treated later.

The General Feedback Equation

To simplify the discussion, the method of obtaining the feedback is not considered and the amplifier shown in Figure 3 is drawn with the input and output ground terminals omitted.

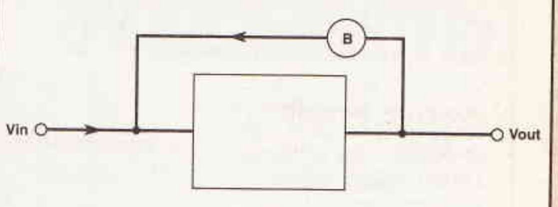


Fig.3 Schematic view of feedback

Since the voltage fed back is $B \times V_{out}$, the combined input to the amplifier, V_a, is given by:

$$V_a = V_{in} + BV_{out}$$

The black box has an open loop gain $A = V_{out}/V_a$ so,

$$V_a = V_{out}/A$$

These two equations allow V_a to be eliminated from the contest to leave,

$$V_{out}/A = V_{in} + BV_{out}$$

A bit of algebraic juggling rearranges this into a more convenient form:

$$V_{out}/V_{in} = A/(1-BA)$$

The ratio, V_{out}/V_{in} is the new gain resulting from the application of feedback. It is called the Closed-Loop Gain, distinguished from the open-loop gain by the symbol A^1. The final feedback equation becomes:

$$A^1 = A/(1-BA)$$

To summarise, an amplifier with open-loop gain A will have a closed loop gain of A/(1−BA) when a fraction B of the output is fed back to the input.

The Phase Relationship of B

The equation derived above has not taken into account the sign of B because of the need for a solution which catered for either positive or negative feedback.

In general, B should be written as a vector quantity, having the polar form, $B = |B| \angle ø$

where |B| is the modulus and ø the phase angle or argument. The most frequently encountered values of ø are:

a) ø = 0°, in which case B is a simple positive fraction rendering the polar form superfluous.

b) ø = 180°, in which case, B is a simple negative fraction, again rendering the polar form superfluous. The general equation can therefore be split into two versions:

Positive feedback: $A^1 = A/(1\text{-}BA)$ (B is positive)

Negative feedback: $A^1 = A/(1+BA)$ (B is negative)

The term BA, sometimes called the loop gain, is important because it determines the quality of the feedback and is why the open-loop of an amplifier should be high.

Positive Feedback

This is considered first to get it out of the way. Note from the above positive feedback equation that the closed loop gain will be greater than the open-loop gain! Although this may seen an attractive way to increase the gain still further, it is seldom used in amplifiers because it is inherently unstable and will increase distortion instead of reducing it.

In the special case when BA = 1, the denominator would fall to zero and the closed loop gain would rise to infinity! An input signal would be quite redundant because the output would be an enlarged version of the input noise — in short, it would be oscillating.

It could be argued that positive feedback would be useful if there was not so much of it. To test this out, assume the open-loop gain is a modest 10,000. For AB to be less than 1, B must be less than 1/10,000. This means that if the output is 10 volts, only one millivolt fed back will cause the amplifier to go over the top. It should be clear from all this that positive feedback, although having no worthwhile role in amplifiers, can still earn its keep in oscillator design.

Negative Feedback

The equation for negative feed back is repeated here for convenience:

$$A^1 = A/(1+BA)$$

Example 1: If A = 1,000 and B = 1/100 then A^1 = 1,000/(1+10) = 1,000/11 = 90.9091.

Example 2: If a = 600 and B = 1/20 then A^1 = 600/(1 + 30) = 600/31 = 19.3548

Example 3: If A = 1,000 and B = 1, then A^1 = 1,000/(1001) = 0.9990.

Example 4: If A = 50,000 and B = 0.5 then A^1 = 50,000/(25,001) = 1.9999

Four examples to explain such trivial arithmetic may seem excessive but they draw attention to a rather unexpected relationship between B and A^1:

When A was 1,000 and B was 1/100, A^1 was nearly 100.

When A was 600 and B was 1/20, A^1 was nearly 20.

When A was 1,000 and B was 1, A^1 was nearly 1.

When A was 50,000 and B was 0.5, A^1 was nearly 2.

These figures suggest that in the above four cases, the approximate value of A^1 is 1/B. To show that this is no coincidence, the negative feed back equation can be re-arranged into the following form:

$$\frac{1}{\frac{1}{A}+B}$$

It follows that if $\frac{1}{A}$ is $<$ B (which it usually is) the equation can be simplified even further to the approximate form:

$$A^1 = \frac{1}{B}$$

This is a remarkable result! It shows that providing we have an amplifier with a reasonably large open loop gain, the closed loop gain is virtually independent of the amplifier!

Providing multifigure accuracy is not required, to know that B is 0.2 allows A^1 to be taken as 5 without working through the full equation or knowing anything much about the actual amplifier.

Examples:

If B = 0.1 then A^1 = 10

If B = 0.01 then A^1 = 100

If B = 0.002 then A^1 = 500

The following bit of arithmetic provides additional confirmation that the closed-loop gain depends very little on the open-loop gain:

If A = 1000, and B = 1/10, then according to the full feedback equation, $A^1 = A/(1+BA) = 1000/101 = 9.901$.

Now suppose, due to age or substitution of another specimen, A falls to 500 (half its previous value) then $A^1 = 500/51 = 9.804$.

Thus, even though A was halved, A^1 only changed from 9.901 to 9.804.

Distortion reduction

Transistors, providing they are correctly biased and are not overdriven, are reasonably linear amplifiers. That is to say, the output is a fairly authentic replica of the input. Nevertheless there is some distortion because the collector/base transfer function is slightly curved. An amplifier is judged, amongst other things, by the percentage harmonic distortion introduced.

Owners of cheap transistor radios, blaring out pop with the wick turned full up, seem to tolerate 15% or more distortion with a surprising degree of equanimity. In contrast, the distortion oozing out from one of those tall impressive looking 'music centres' will probably not exceed 1%. But any hifi system churning out Vivaldi with a distortion figure greater than 0.1% should blow its fuses with shame.

Negative feedback is a powerful weapon for combating distortion as can be seen by the following rough and ready rule:

Negative feedback reduces distortion in the same ratio as the gain is reduced.

Example: Assume an amplifier with an open-loop gain of 1,000 has a distortion figure of 10%. If feedback reduces the gain to 100, the distortion will fall to 1%.

The ability of negative feedback to reduce gain is easily understood but why it reduces distortion may not be so obvious. The following intuitive approach avoids a page full of algebra:

Assume a perfect signal enters the amplifier but, due to transistor imperfections, the output is distorted. The output will contain an enlarged version of the signal and an additional packet of unwanted harmonics that were not present at the input.

Because the feedback is negative, the actual input to the amplifier will be the difference between the signal and the feedback voltage. Because the feedback voltage contains the additional distortion components, the actual input to the amplifier must contain this distortion. But — and it is a big but — the input distortion is opposing the output distortion, so the overall effect is self cancelling. Figure 4 shows some curves which may help in following the argument.

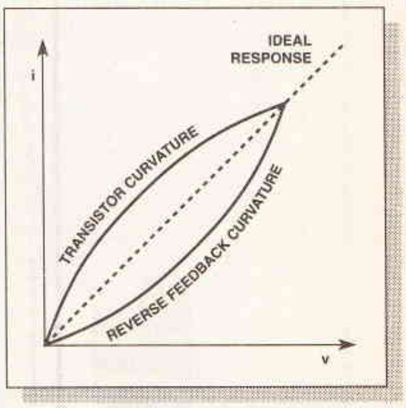


Fig.4 Cancellation of distortion by feedback

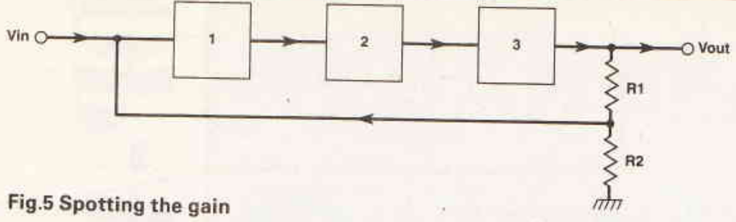


Fig.5 Spotting the gain

Unravelling circuitry

Figure 5 shows a three stage amplifier circuit in block form with a two-resistor divider generating the feedback fraction. Although the actual amplifier circuit may be quite complex, the overall gain of the stage can quickly be traced by remembering it is, for all practical purposes, equal to 1/B. The feedback fraction is clearly $R_2/(R_1 + R_2)$ so $1/B = (R_1 + R_2)/R_2$ which is indeed the closed loop gain. Once this feedback loop is spotted there is no need to worry about the individual gains or wade through complex circuit detail in order to calculate gain.

Example: If $R_1 = 9k$ and $R_2 = 1k$ then the total gain of the amplifier is $10k/1k = 10$.

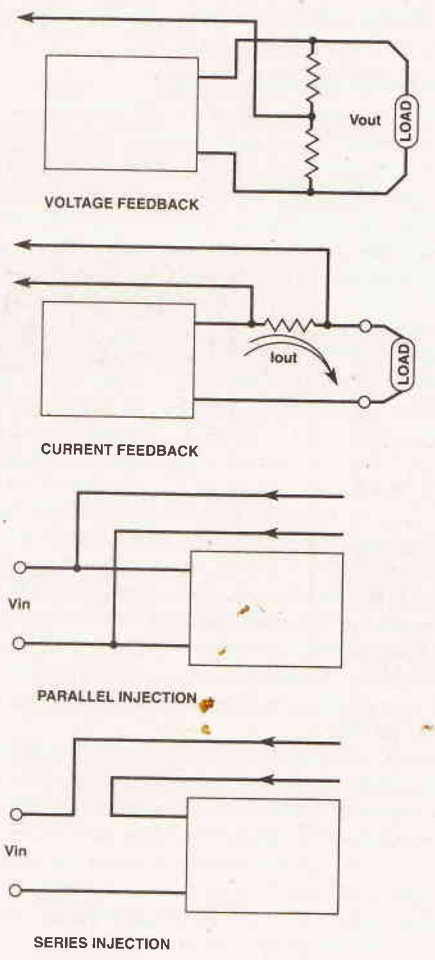


Fig.6 Feedback variations

Feedback variations

Only the basic principles of negative feedback have so far been discussed but there are, in fact, two distinct categories of feed back (Figure 6):

a) *Feedback type*
   Voltage feedback lowers R_{out}.
   Current feedback increases R_{out}.

b) *Injection method*
   Series injection increases R_{in}.
   Parallel injection decreases R_{in}.

Output Resistance (R_{out})

Using voltage feedback

If the load demands more current, the tendency is for the output voltage to fall due to the increased voltage drop across the output resistance. But, because the feedback voltage is proportional to output voltage, this will drop as well causing the gain to rise. The rise in gain tends to offset the tendency of the output to fall so the effective Rout is reduced.

Using current feedback

If the load demands more current, again the tendency is for the output voltage to drop. However, the feedback voltage is proportional to the output current so the feed back voltage rises, the gain is reduced and so the output voltage falls even lower. The effective Rout is thus increased.

The Input Resistance (R_{in})

Series injection

The current which the amplifier demands from the input signal will now be less because the feedback voltage, Vfb and the input signal are in opposition. The amplifier input current is now $(V_{in}\text{-}V_{fb})/R_{in}$ instead of V_{in}/R_{in} so the effective R_{in} is increased.

Parallel injection

There is now an additional load across the input terminals. The greater the signal, the greater the feedback voltage so the input tends to drop still further. The effective R_{in} is therefore decreased.

How much is R_{in} and R_{out} changed?

To know that feedback can change R_{in} and R_{out} is all very well but it raises the question — by how much? Mathematics can, of course, provide the answer but the manipulations can become tedious. Providing a little accuracy is sacrificed, the following rough and ready rule is quite useful:

Change of R_{in} or R_{out} = ratio of open loop gain to closed loop gain

Example: Assume an amp has an R_{in} of 10k and Rout of 1k with an open loop gain of 100.

If the closed loop gain is 20 (1.5th of its open loop value) the resistances will change by a factor of five. If voltage feed back is used with series injection, this will cause R_{in} to increase from 10k to 50k and R_{out} to decrease from 1k to 200R.

It is worth mentioning at this point that amplifying voltages demands a high Rin and a low Rout so voltage feedback with series injection is indicated. Also amplifying currents demand a low R_{in} and a high R_{out} so current feedback with parallel injection is indicated.

Multiple Feedback Loops

Feedback is not always applied in one main loop from output back to input. There may in fact be intermediate loops within stages instead of, or in addition to, the main outside loop. Figure 7 shows one possible arrangement. To calculate the overall closed loop gain, proceed as follows:

1. First find A^1 for stage 1.
2. Find A^1 for stages 2 and 3.
3. Multiply the two results together to find the 'open loop' gain before the final loop is closed.
4. Find the final total closed loop gain.

Example: If A^1 of stage 1 is 10, A^1 of stages 2 and 3 is 20. The intermediate open loop gain is therefore $10 \times 20 = 200$. Assume the feedback fraction, B, is the main outside loop is 0.1. The final closed loop gain is therefore $1/B = 1/0.1 = 10$.

It may seem that the intermediate loops are superfluous because the above figures show that the final closed loop gain is dependant only on the outside loop. However the designer's reasons for the apparently useless inner loops may be due to R_{in} and R_{out} requirements rather than gain. It may be, for some reason, that the loop from stage 3 back to stage 2 has used series injection to lessen the load on stage 1 output.

It should be clear from all this that the ability of feedback to modify R_{in} and R_{out} is a powerful weapon in any designer's armament.

Instability

So far, the virtues of negative feedback have been rather over-stated so, to set the record straight, it is only fair to point out that too much of it can actually cause, instead of curing, instability! The trouble is due to certain circuit elements which have been so far ignored in the interests of simplicity. For example, it has been assumed that the phase angle of the feedback fraction was either zero of 180°. However, there will be several coupling capacitors and stray shunt capacitance in most amplifiers which, in conjunction with resistive elements, function as frequency, and therefore phase shift, filters. At extremes of frequency, either at the lower or the upper end of the band, the phase shift caused by each of them can approach 90°. In a multi-stage amplifier, these phase shifts can be cumulative and effect the phase angle of the feedback fraction. At the extreme frequencies of the band when large amounts of feedback are acting, the additional phase shift could swing the feedback angle from 180° right round to 360°. In this situation, the feedback becomes positive instead of negative so the amplifier, quite rightly, decides to change into an oscillator! Such a disaster can be prevented by either reducing the amount of feedback, or reducing the internal phase shifts in the amplifier. If the amplifier behaves itself over the expected frequency range when B = 1 (100% feedback) it can be given a complete bill of health.

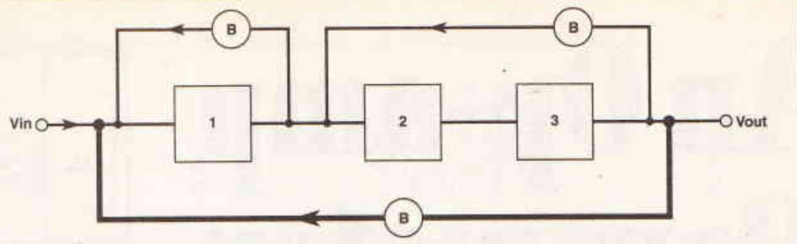
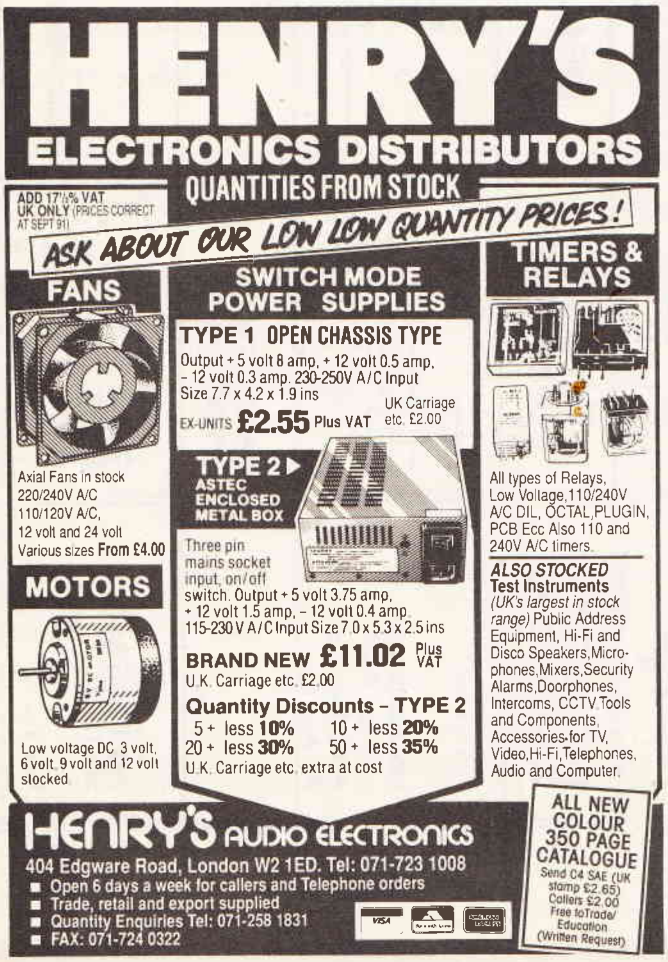


Fig.7 Multiple feedback loops

Summary

1. Feedback is positive or negative according to whether the open-loop gain is increased or decreased.
2. Positive feedback is used in oscillators but hardly ever in amplifiers.
3. Negative feedback reduces the gain but in return:
   a) ensures the gain is virtually independant of the internal amplifier parameters and
   b) reduces distortion and
   c) modifies R_{in} and R_{out}.
4. Providing open loop gain is high, closed loop gain is 1/B approximately.
5. Voltage feedback lowers R_{out}.
6. Current feedback increases R_{out}.
7. Series injection increases R_{in}.
8. Parallel injection decreases R_{in}.
9. The changes brought about by negative feedback are in the same ratio as the gain is reduced.
10. Too much negative feedback can sometimes cause instability.



An Op-amp Parameter Display Chart

By Bryan Hart

The accompanying chart has been devised with two main objectives: to make the definition of Operational Amplifier parameters more appetizing and informative than is possible with the mere word-statements in textbooks and manuals; to produce as a pictorial check-list for assessing the likely effect of device parameters in a 'new' op-amp application. Most of the chart is self-explanatory, but bear in mind the following points.

The DC bias and peak-amplitude quantities are represented by upper case letters with upper case subscripts, if required. Thus V_{CC+} specifies the more positive of the two op-amp rail supplies. Small-signal quantities representing changes about bias conditions are shown by lower case letters with lower case subscripts, eg i_b for increment in bias current. The symbol Δ indicates a change that is not necessarily small.

Total instantaneous quantities are represented by a lower case symbol with an upper case subscript (eg v_G for signal generator output).

A given parameter is sometimes specified in manufacturers' data sheets and application notes by a variety of symbols. While it is not claimed that all possible choices have been exhausted, the common ones are listed in Column A.

Rail supplies are shown for reference in B1. However, V_{CC+} V_{CC-} are omitted for clarity from Column B where they are not directly involved in parameter definition.

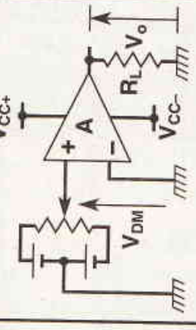
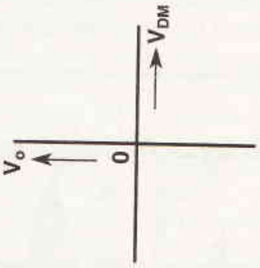
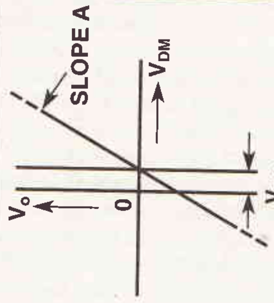
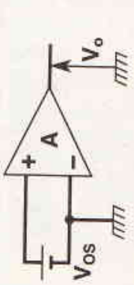
Column D shows straight line ('piece-wise linear') approximations to characteristics that are not always precisely linear. Any practical departure from linearity is only likely to affect critical, state-of-the-art, applications.

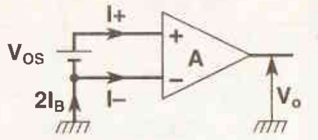
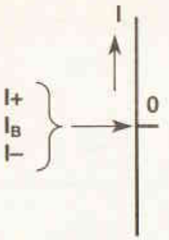
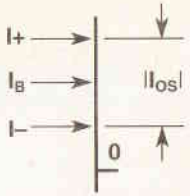
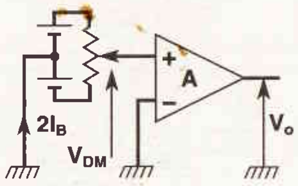
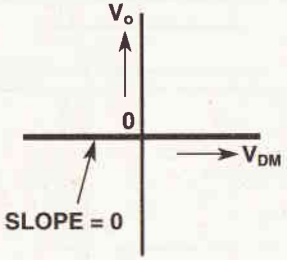
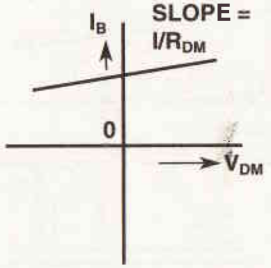
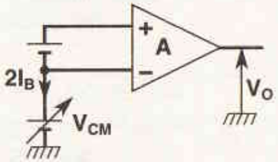
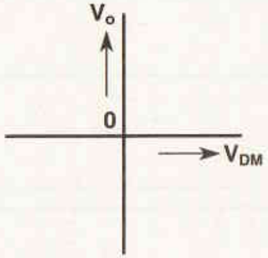
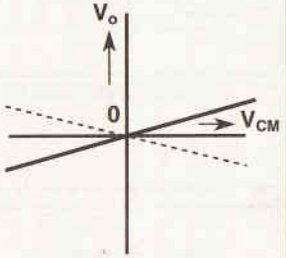
All the parameters are to some degree temperature-dependent but only those whose temperature sensitivity is likely to cause application problems are normally specified in data sheets by a temperature coefficient (TC). For an arbitrary parameter X, TCX = ΔX/ΔT for a specified ΔT. Relevant TCs are shown as Related Parameters (RP) in the boxes of Column E.

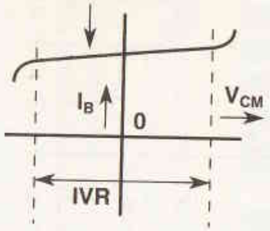
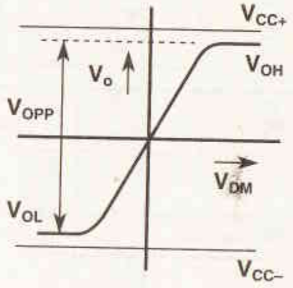
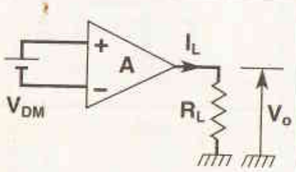
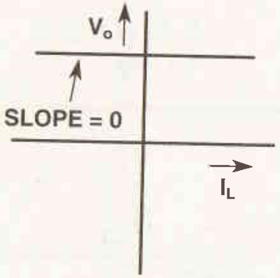
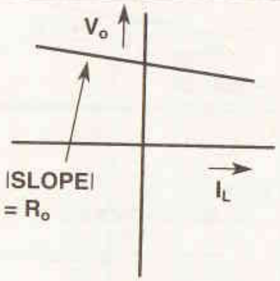
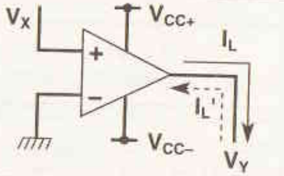
Typical parameter data for the op-amp type 741 are listed in Column F because of the widespread popularity of this industry standard. The data refers to $V_{CC+} = +15v$, $V_{CC-} = -15v$, T = 25°C, unless otherwise stated.

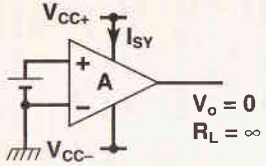
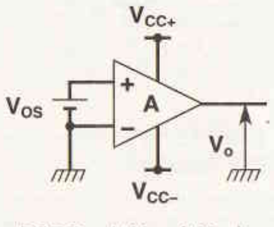
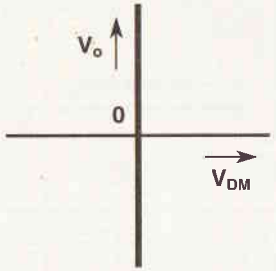
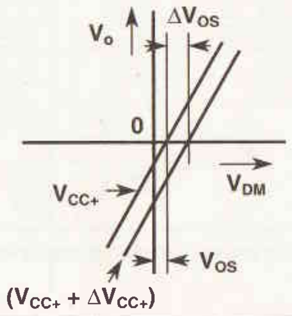
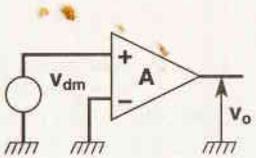
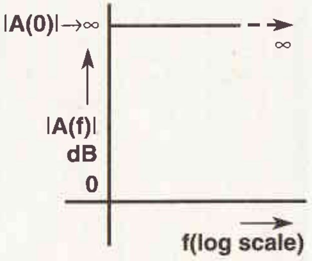
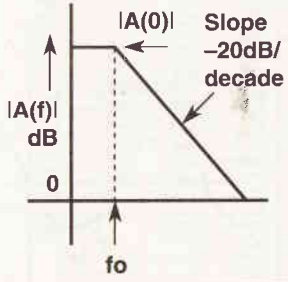
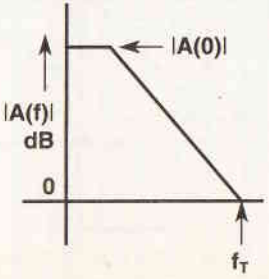
NGS means not generally specified.

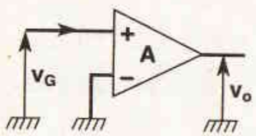
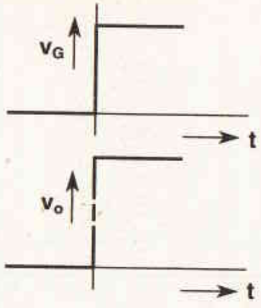
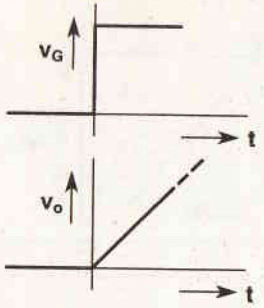
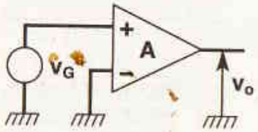
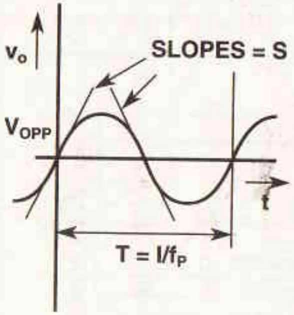
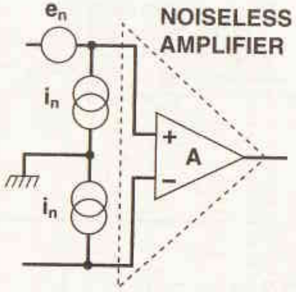
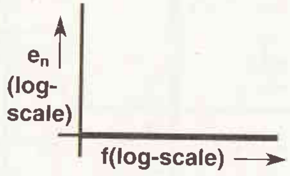
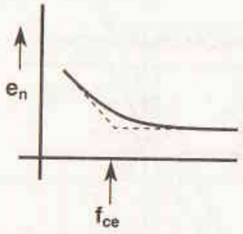
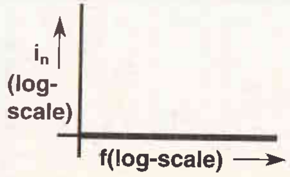
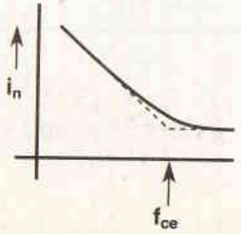
Since integrated amplifiers first became available over twenty-five years ago, special op-amps have been developed to optimize groups of related parameters, i.e. to produce characteristics resembling those in Column C. This helps to explain the wide variety of op-amps available. It is not possible, with current monolithic IC technology to optimize all parameters simultaneously.

	A	B	C	D	E	F
	PARAMETERS & SYMBOL(S)	**DEFINING CONDITIONS**	**IDEAL O.A.**	**IDEAL O.A.**	**COMMENTS**	**741**
1	VOLTAGE GAIN A, A_V, A_{VO}, A_{VOL}, A_D, A_{DM}, A_{VD}	 $A = \Delta V_o/\Delta V_{DM}$ for specified R_L(min)			ALSO KNOWN AS: LARGE SIGNAL GAIN; DIFFERENTIAL GAIN; DC GAIN; OPEN-LOOP VOLTAGE GAIN.	200,000 OR, 200V/mV OR, 106dB FOR $R_L \geq 2k\Omega$
2	(INPUT) OFFSET VOLTAGE V_{OS}, V_{IO}, V_{IS}	 $V_{DM} = V_{OS}$; $V_O = 0$; $R_L = \infty$	$V_{OS} = 0$ (SEE DIRECTLY ABOVE)	DEFINED ABOVE, 1D	SHOWN, ARBITRARILY, AS POSITIVE $\lvert V_{OS}\rvert$, ONLY, SPECIFIED R.P. $TCV_{OS} = \Delta V_{OS}/\Delta T$	1mV N.G.S.

3	INPUT (BIAS) CURRENT I_B, I_{IB}, I_{BIAS}	 $I_B = (I+ + I–)/2$ $V_{DM} = V_{OS}$; $V_O = 0$; $R_L = \infty$		 I+ SHOWN GREATER THAN I–, BUT COULD BE LESS	$I_B > 0$ FOR BIPOLAR TRANSISTOR O.A.s BUT CAN BE < 0 FOR F.E.T. O.A.s	80nA
					R.P. $TCI_B = \Delta I_B/\Delta T$	N.G.S.
4	INPUT OFFSET CURRENT I_{OS}, I_{OFFSET}	AS ABOVE, 3B. $I_{OS} = \|I+ - I-\|$	0	AS ABOVE, 3D	MAGNITUDE, ONLY, SPECIFIED TYPICALLY, $Ios \sim I_B/5$	20nA
					R.P. $TCI_{OS} = \Delta I_{OS}/\Delta T$	N.G.S.
5	INPUT RESISTANCE (DIFFERENTIAL MODE) R_{IN}, R_{DM}, T_i	 $R_{DM} = \Delta V_{DM}/\Delta I_B$				2MΩ
					R.P. INPUT IMPEDANCE, Zi Zi = (v_{dm}/i_b) AND IS FREQUENCY DEPENDENT	N.G.S.
6	COMMON-MODE (VOLTAGE) GAIN A_{CM}	 $V_{DM} = V_{OS}$ SO $V_O = 0$ FOR Vcm = 0 $A_{CM} = \Delta V_o/\Delta V_{CM}$			Acm CAN BE > 0 OR < 0. SIGN NOT IMPORTANT IN PRACTICE ONLY $\|A_{CM}\|$	N.G.S. (BUT, CAN BE ESTIMATED FROM 1F AND 7F)
7	COMMON-MODE REJECTION RATIO CMRR, ρ	AS ABOVE, AND 1B $\rho = \|A_{CM}/ADM\|$ USUALLY EXPRESSED IN dB	∞	—	VALUE GIVEN IS FOR D.C. AND L.F. ρ IS FREQUENCY-DEPENDENT LIKE A_{DM} (SEE 15D)	90dB

8	COMMON-MODE RANGE (INPUT VOLTAGE RANGE) IVR	SEE 6B INPUT RANGE FOR LINEAR OPERATION	∞	R_{CM} = I/SLOPE IN IVR 	—	$-13V \rightarrow +13V$
9	COMMON-MODE INPUT RESISTANCE R_{CM}	SEE 6B $R_{CM} = \Delta V_{CM} / \Delta I_B$	∞		 R.P. $Z_{cm} = v_{cm} / i_b$	N.G.S. N.G.S.
10	OUTPUT VOLTAGE RANGE V_{OPP}	(SEE 1B) OUTPUT SWING, SYMMETRICAL ABOUT $V_o = 0$, BEFORE (QUOTED) DISTORTION OCCURS. R_L SPECIFIED	∞		POSITIVE AND NEGATIVE SATURATION LIMITS, V_{OH}, V_{OL} RESPECTIVELY, ARE APPROX 1V5 FROM POWER SUPPLY RAILS FOR BIPOLAR O.A.s	26V ($R_L = 2k\Omega$)
11	(OPEN-LOOP) OUTPUT RESISTANCE R_o	 $R_o = \lvert \Delta V_o / \Delta I_L \rvert$ AT QUOTED V_o, I_L, IN OUTPUT VOLTAGE RANGE			PULSE MEASUREMENTS MINIMISE THERMAL EFFECTS R.P. $Z_o = -v_o/i_o$ AND IS FREQUENCY DEPENDENT	75Ω ($V_O = 0V$) N.G.S.
12	SHORT-CIRCUIT OUTPUT CURRENT I_{SC}	 $I_L \leq I_{SC}$: $V_X = V_{CC+}$, $-V_{CC-} \leq V_Y \leq 0$ $I_L' \leq I_{SC}$: $V_X = V_{CC-}$, $V_{CC+} \leq V_Y \leq 0$	∞	—	INTERNAL CURRENT LIMITING MEANS APPROX CONSTANT CURREENT OUTPUT I_{SC} CAN FLOW INDEFINITELY R.P. $P_{D(MAX)}$ (SEE 13E)	25mA

13	(TOTAL) POWER DISSIPATION P_D		∞	$P_D = 2V_{CC+} I_{SY}$ FOR $\lvert V_{CC-}\rvert = \lvert V_{CC+}\rvert$	N.B. SPECIFIED FOR $V_o = 0, I_L = 0$	50mW
					R.P. $P_{D(MAX)} \geq I_L \lvert V_{CC(MAX)}\rvert$	500mW (≤ 55°C)
14	POWER SUPPLY REJECTION RATIO PSRR	 $PSRR = \lvert \Delta V_{CC+}/\Delta V_{OS}\rvert$			NORMALLY DEFINED FOR A SYMMETRICAL VARIATION IN V_{CC+} AND V_{CC-}	90dB
					R.P. POWER SUPPLY SENSITIVITY PSS PSS =1/PSRR	30µV/V
	FREQUENCY RESPONSE A(f)	 $\lvert A(f)\rvert = \lvert v_o/v_{dm}\rvert$ $\angle A(f) = \angle v_o/v_{dm}$			← ASYMPTOTIC BODE GAIN PLOT FOR USUAL CASE OF A SINGLE POLE RESPONSE	
					REALTED CURVE IS BODE PHASE PLOT	
15	SMALL SIGNAL BANDWIDTH; –3dB BANDWIDTH; OPEN-LOOP BANDWIDTH fo	SEE ABOVE, 15B	∞	SEE ABOVE, 15D	APPLIES ONLY FOR *SMALL* AMPLITUDE SIGNALS. (SEE 17 FOR LARGE SIGNAL CASE)	~10Hz
	UNITY-GAIN OPEN-LOOP BANDWIDTH; UNITY-GAIN CROSSOVER FREQUENCY: GAIN-BANDWIDTH PRODUCT f_U, f_T, GBW	SEE ABOVE, 15B	∞		$f_T = A(0)fo$, FOR SINGLE POLE RESPONSE	~1MHz

16	SLEW(ING) RATE S, SR	 $S = \vert\Delta V_o/\Delta t\vert_{MAX}$ FOR v_G 'LARGE' (e.g. 10V)			S APPLIES FOR FASTEST-GOING OUTPUT, POSITIVE-GOING OR NEGATIVE-GOING	0V5/µs
17	FULL-POWER BANDWIDTH: (FULL-POWER FREQUENCY; LARGE-SIGNAL BANDWIDTH) FPBW, f_P, f_{MP}	 SINEWAVE INPUT AMPLITUDE PRODUCES v_o (peak) = V_{OP} (SPECIFIED)	∞		f_P = LIMITED BY SLEW RATE S $f_P = S/2\pi V_{OP}$ USUALLY, $V_{OP} = V_{OPP}/2$	N.G.S. (BUT CALCULATE FROM S AND V_{OP}, ~6kHz FOR V_o = 13V)
18	INPUT NOISE VOLTAGE (SPECTRAL) DENSITY e_n (vs f)				e_n IS r.m.s. NOISE VOLTAGE PER UNIT BANDWIDTH (1kHz) USUAL UNITS: $nV/\sqrt{Hz}$ (f_{ce} = "FLICKER' NOISE "CORNER' FREQUENCY)	N.G.S.
	INPUT NOISE CURRENT (SPECTRAL) DENSITY i_n (vs f)				i_n IS r.m.s. NOISE CURENT PER UNIT BANDWIDTH (1kHz) USUAL UNITS: $pA/\sqrt{Hz}$ (f_{ce} = "FLICKER' NOISE "CORNER' FREQUENCY)	N.G.S.

UNIDEN SATELLITE RECEIVER Brand new units (model 8008) £60.00 ref 60P4Y also some 7007s also £60.00 ref 60P5Y

SPECTRUM +2 COMPUTER Built in data recorder, 128K, psu and manuals £59.00 ref 59P4Y

SPECTRUM +3 COMPUTER Built in disc drive, 128K, psu and manuals £79.00 ref 79P4Y

AMSTRAD CPC464 COMPUTER No manuals but only £79.00 ref 79P5Y

AMSTRAD CPC6128 COMPUTER Again no manuals but only £149.00 ref 149P4Y

AMSTRAD GT65 Green screen monitor £49.00 ref 49P4Y

AMSTRAD PORTABLE PC'S FROM £149 (PPC1512SD). £179 (PPC1512DD). £179 (PPC1640SD). £209 (PPC1640DD). MODEMS £30 EXTRA.NO MANUALS OR PSU.

AMSTRAD PC BARGAIN!!!!!!

PC 1512DD COMPLETE WITH CGA COLOUR MONITOR, 2 DISC DRIVES, MANUALS ETC ONLY £249.00 REF 249P4Y

HIGH POWER CAR SPEAKERS. Stereo pair output 100w each 4ohm impedance and consisting of 6 1/2" woofer 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30 00 Order ref 30P7Y

2KV 500 WATT TRANSFORMERS Suitable for high voltage experiments or as a spare for a microwave oven etc. 250v AC input. £10.00 ref 10P93Y

MICROWAVE CONTROL PANEL Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. £6.00 ref 6P18Y

FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29Y

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VGA PAPER WHITE MONO monitors new and cased 240v AC. £59.00 ref 59P4Y

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CUSTOMER RETURNED 2 channel full function radio controlled cars only £8.00 ref 8P200Y

WINDUP SOLAR POWERED RADIO! FM/AM radio takes NICAD batteries complete with hand charger and solar panel 14P200Y

240 WATT RMS AMP KIT Stereo 30-0-30 psu required £40.00 ref 40P200Y

300 WATT RMS MONO AMP KIT £55.00 Psu required ref 55P200Y

ALARM PIR SENSORS Standard 12v alarm type sensor will interface to most alarm panels. £16.00 ref 16P200Y

ALARM PANELS 2 zone cased keypad entry, entry exit time delay etc. £18.00 ref 18P200Y

35MM CAMERAS Customer returned units with built in flash and 28mm lens **2 for £8.00** ref 8P200Y

STEAM ENGINE Standard Mamod 1332 engine with boiler piston etc £30 ref 30P200Y

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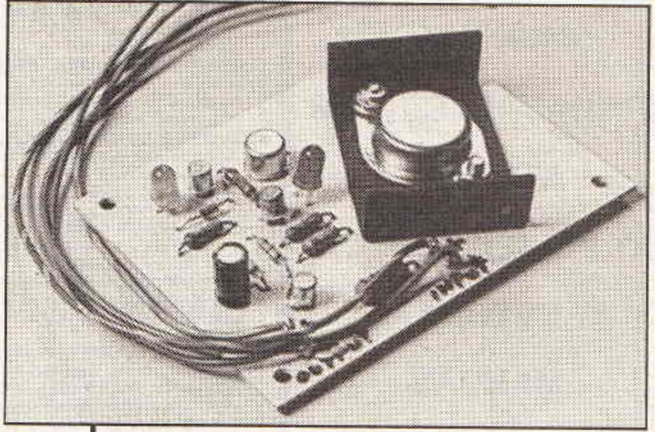


JR Nowicki reports on the discrete component side of regulation

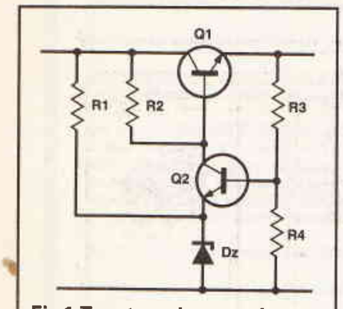


Fig.1 Two transistor series regulator

Although discrete component regulators are considered to be out of date by many in the electronics world they still represent an attractive method of providing the supplies for a number of electronic equipment and experimental circuits. The basic regulator is shown in Figure 1. Its continued popularity in spite of the many integrated regulators readily available, stems from the design simplicity and the ease of construction for power supplies, which are often required for non standard voltage or current levels, for which standard integrated circuit regulators are not available.

Figure 1 shows a two transistor series regulator. The circuit consists of a zener diode reference Dz and a transistor comparator amplifier Q2 controlling the series transistor regulator Q1. This basic circuit suffers from the disadvantage that the output voltage is affected by the output current and input voltage variations, so the circuit has poor regulation. The regulation can be greatly improved by feeding the zener diode from the regulated output. This is achieved by connecting the resistor R1 to the emitter side of the series regulator transistor Q1 and replacing the resistor R2 by a constant current source as shown in Figure 2.

Figure 2 highlights an improved series regulator. Both circuits shown can easily be damaged by accidental overloads or short circuit and therefore a form of protection circuit is usually incorporated into the design. In addition to over current protection sometimes an over voltage protection is also included, but more often some kind of indication is required for power on and for overload condition. This can easily be fulfilled by the use of light emitting diodes (LEDs) as shown in Figure 3.

This circuit was designed to provide a constant output voltage of 5V at 500mA. The 2N3055 power transistor, Q1, is used as a series regulator together with a 2N3053 (or equivalent) transistor, Q2, connected as a darlington pair. The combination reduces the current on the control circuit and allows an LED to be used as a reference in place of a zener diode. The advantage of using an LED is that it can provide both, a good reference and at the same time it provides the power on indication. This function is performed by LED2, a green LED which provides a reference voltage of about 2V when operating at 12mA. The transistor Q4 is the usual comparator/error amplifier controlling the base current of the darlington pair. The transistor Q3 together with an LED1 and resistors R1 and R2 form the constant current feed for the series regulator. A red LED is used this time. The LED operates at about 150µA, therefore practically extinguished, nevertheless provides about 1.5V reference for the constant current transistor Q9.

The transistor Q5, diode D1 and the resistor R5 comprise the overload protection circuit. Finally, the resistor R3 together with LED1 provide an overload indication.

Normally, only the green LED is on when the power supply is in operation. Applying progressive overload the red LED begins to glow and the green LED is dimmed. Finally, as the progression to the short circuited output is complete the green LED turns off and the red LED is turned fully on. The short circuit current is approximately given by the base emitter saturation voltage $V_{be5(sat)}/R5$, thus

$$Isc = V_{be(sat)}/R5=0.7V/1R=700mA$$

It is worth mentioning that the series transistor requires a heat sink since under the short circuit condition, with an input voltage of 10V there is about 7 watts power dissipation in the device. If the supply voltage is

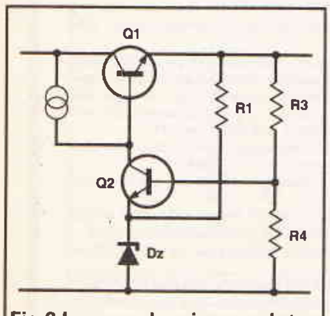


Fig.2 Improved series regulator

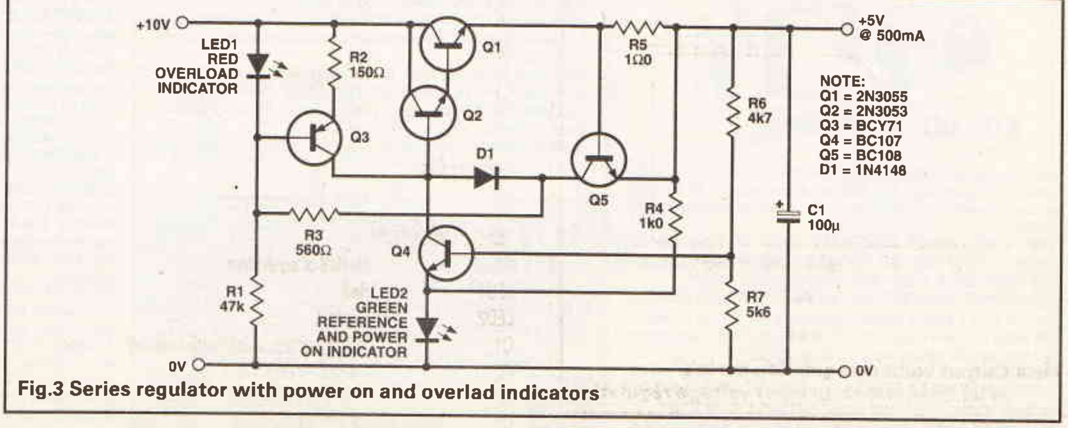


Fig.3 Series regulator with power on and overlad indicators

increased to 20V the dissipation rises to 14 watts. Also, from the reliability point of view, the power rating of the load current monitoring resistor R5 should be of the order of 3W even though the maximum power dissipation is only about 0.5W.

The effectiveness of the LEDs as reference devices in regulator circuits is demonstrated in the load current (I_L) and input voltage (Vin) regulation curves shown in Figure 4a and 4b.

In order to enable an investigation of the circuit operation a printed circuit board artwork including the component layout are given in Figure 5.

A modified version of the series regulator circuit described above is shown in Figure 6. Here the comparator amplifier is in the form of a differential amplifier, transistors Q4(a) and Q4(b). The circuit has an advantage over the previous arrangement in that the reference diode current is kept constant and independent of the load current variations thus enabling further improvement in regulation for both the load current and the input voltage variations.

In addition to the above improvements the overload circuit is of the foldback type. The short circuit current is limited to approximately 100mA thus reducing the power dissipation in the series transistor under the overload condition.

Another variation of the series regulator incorporating power on and overload indicators is outlined in Figure 7. This time an op-amp is used as a comparator/error amplifier. This circuit was designed to provide an output voltage of 18V at a load current of 50mA.

Although the above circuits were designed for specific voltage and current levels the circuits can be easily modified for other voltages and currents. The output voltage can be adjusted by suitably altering the value of the resistor R6 and the current limit can be set by changing the value of the current monitoring resistor.

All the above circuits provide useful ideas for monitoring power on and overload protection which can be extended to include an indication of over voltage protection.

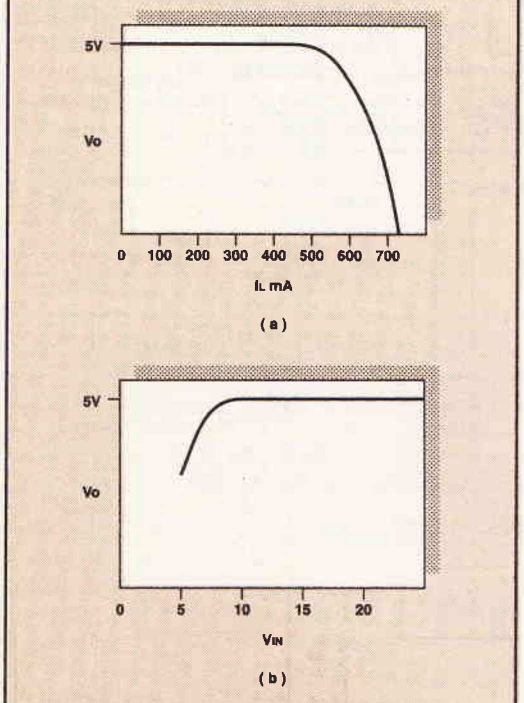


Fig.4 Output voltage regulation curves a) load regulation b) Input voltage regulation

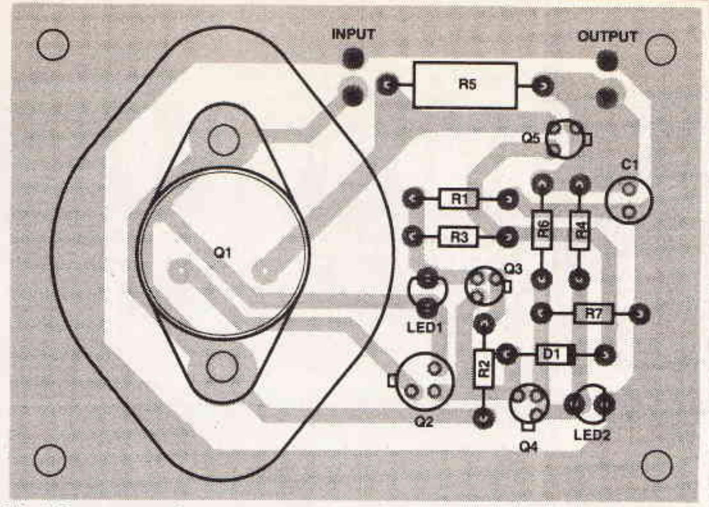


Fig.5 Component layout

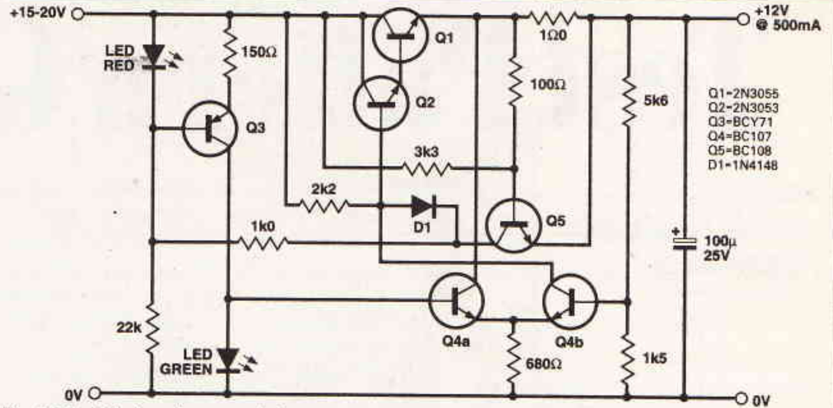


Fig.6 Modified series regulator

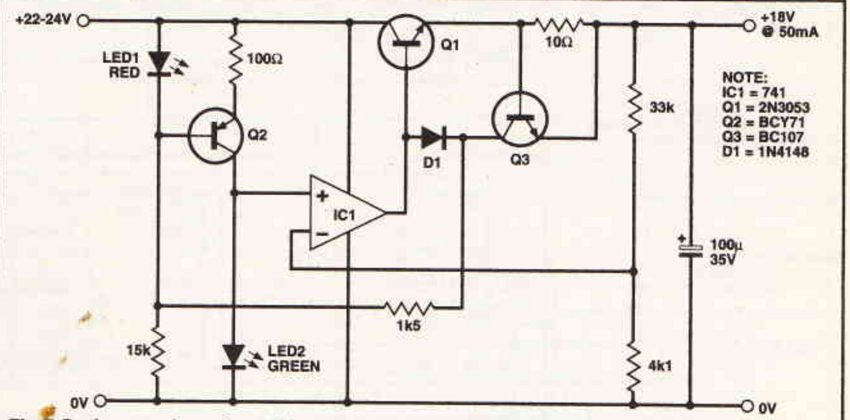


Fig.7 Series regulator for 18V at 50m

PARTSLIST

RESISTORS

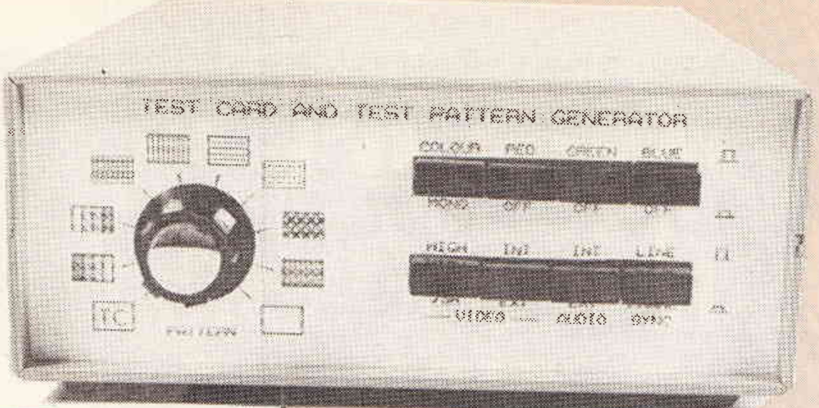
R1	47k
R2	150R
R3	560R
R4	1k
R5	1R0,WW,3W
R6	4k7
R7	5k1

CAPACITORS

C1	100µ/16V Electrolytic

SEMICONDUCTORS

D1	1N4148 or equivalent
LED1	Red
LED2	Green
Q1	2N3055 or equivalent with heatsink
Q2	2N3053 or equivalent
Q3	BCY71 or equivalent
Q4	BC107 or equivalent
Q5	BC108 or equivalent



1

Video Test Card And Test Pattern Generator

Paul Stenning introduces an invaluable aid to TV servicing.

There have been several designs of test pattern generators published in the past, invariably they produce the standard cross-hatch pattern, possibly horizontal and vertical lines, and may-be a grey-scale. Most current designs are based around the ZNA234E monochrome test pattern generator IC.

This is adequate for monochrome (black and white) equipment, however for servicing colour televisions and video recorders, something a little more comprehensive is really required. The instrument featured here provides an impressive range of patterns including a full colour Test-Card, colour bars, cross-hatch, grey-scale, focus grip, colour purity patterns and more — for considerably less cost than a commercial unit of lower specification!

The unit also features a basic sine-wave audio oscillator, set at 800Hz. The audio oscillator, set at 800Hz. The audio and video outputs are available from the audio and video output sockets and, for more modern equipment, the SCART socket. An RF modulator is provided for connection to the aerial socket of UK standard Televisions and Video Recorders (readers in other countries using the PAL standard may need to obtain a suitable type of modulator locally). The audio and video signals to the modulator are individually switchable to either the internally generated signals or to the external audio and video input and SCART sockets.

A Scope Trigger Output socket is provided to give reliable triggering on an oscilloscope when trying to view the video signals, the output from this can be switched to either line or frame sync.

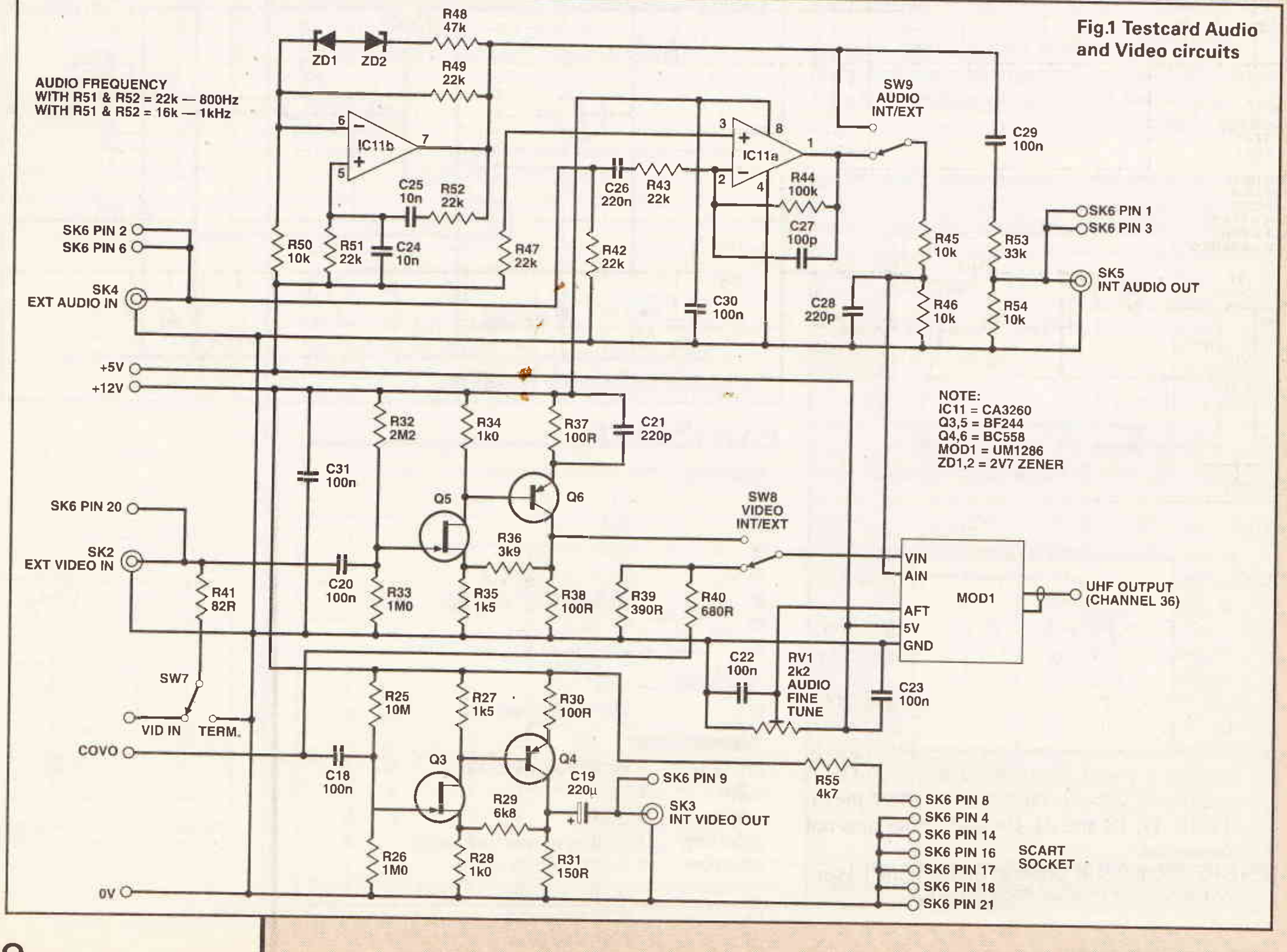


Fig.1 Testcard Audio and Video circuits

Features and Specifications

Test Card: Full colour Test-card featuring colour bars, grey scale (0%, 25%. 50%. 75% and 100%), frequency bars (0.5, 1.0, 1.25, 1.66, 2.5 and 5.0MHz), cross hatch, low frequency blocks and needle pulse.

Other Patterns: Colour bars 1 (black to white), Colours bars 2 (white to black), Cross hatch, Vertical lines, Horizontal lines, Dots, Focus grid, Blank raster, White raster.

Colour/Mono Switch: Removes chrominance (colour information) from Video signal, thereby converting colour bars to grey scale, and removing herringbone patterns.

Red/Green/Blue Switches: Completely remove information for that colour from video signal.

Internal Audio: 800 Hertz (nominal) Sine wave.

Video Out: 1V Pk-Pk PAL Composite video from pattern generator, BNC socket.

Audio Out: 500mV RMS, 800Hz Sine Wave, Phono socket.

Video In: 1V Pk-Pk PAL Composite video, Input Impedance 75R or 500k switchable, BNC Socket.

Audio In: 500mV RMS into 10k, Phono socket, 30Hz to 15kHz ±3dB.

SCART Socket: All signal levels as above. Pins 1 and 3, Audio out. Pins 2 qand 6, Audio in. Pin 19, Video out. Pin 20, Video in. Pin 8, +12V via 4K7. Pins 4, 14, 16, 17, 18 and 21, Ground. Other pins not connected.

RF (UHF) Output: UK Channel 36 (591.5MHz) with 6MHz Sound Carrier. Phono socket.

Scope Trig Output: 5V Pk-Pk at 10k, switchable Line or Frame.

Power Input: 240V AC 50Hz at 6VA or 11-13V DC at 120mA (see text).

The PAL colour encoder (IC9) is capable of producing 64 colours, however for this application only 10 are required. There are 2 data lines on IC9 for each of the 3 primary colours, labeled R0 and R1 for red, G0 and G1 for green and B0 and B1 for blue. Taking the red lines for example, if R0 only is high a fairly dark red (50% of maximum brightness) is produced, if R1 only is high, the colour is brighter (75% of maximum brightness), if R0 and R1 are both high the colour is maximum brightness (saturated, the same brightness as white), and if R0 and R1 are both low no red is produced. The same arrangement applied for the green and blue data lines. By applying various codes to the data lines, the primary colours can be mixed in various combinations to produce an impressive range of colours.

The truth table below shows the codes required for the ten colours used in this application:

Colour	R0	R1	G0	G1	B0	B1
Black	0	0	0	0	0	0
Blue	0	0	0	0	0	1
Red	0	1	0	0	0	0
Green	0	0	0	1	0	0
Magenta	0	1	0	0	0	1
Cyan	0	0	0	1	0	1
Yellow	0	1	0	1	0	0
Dark Grey	1	0	1	0	1	0
Light Grey	0	1	0	1	0	1
White	1	1	1	1	1	1

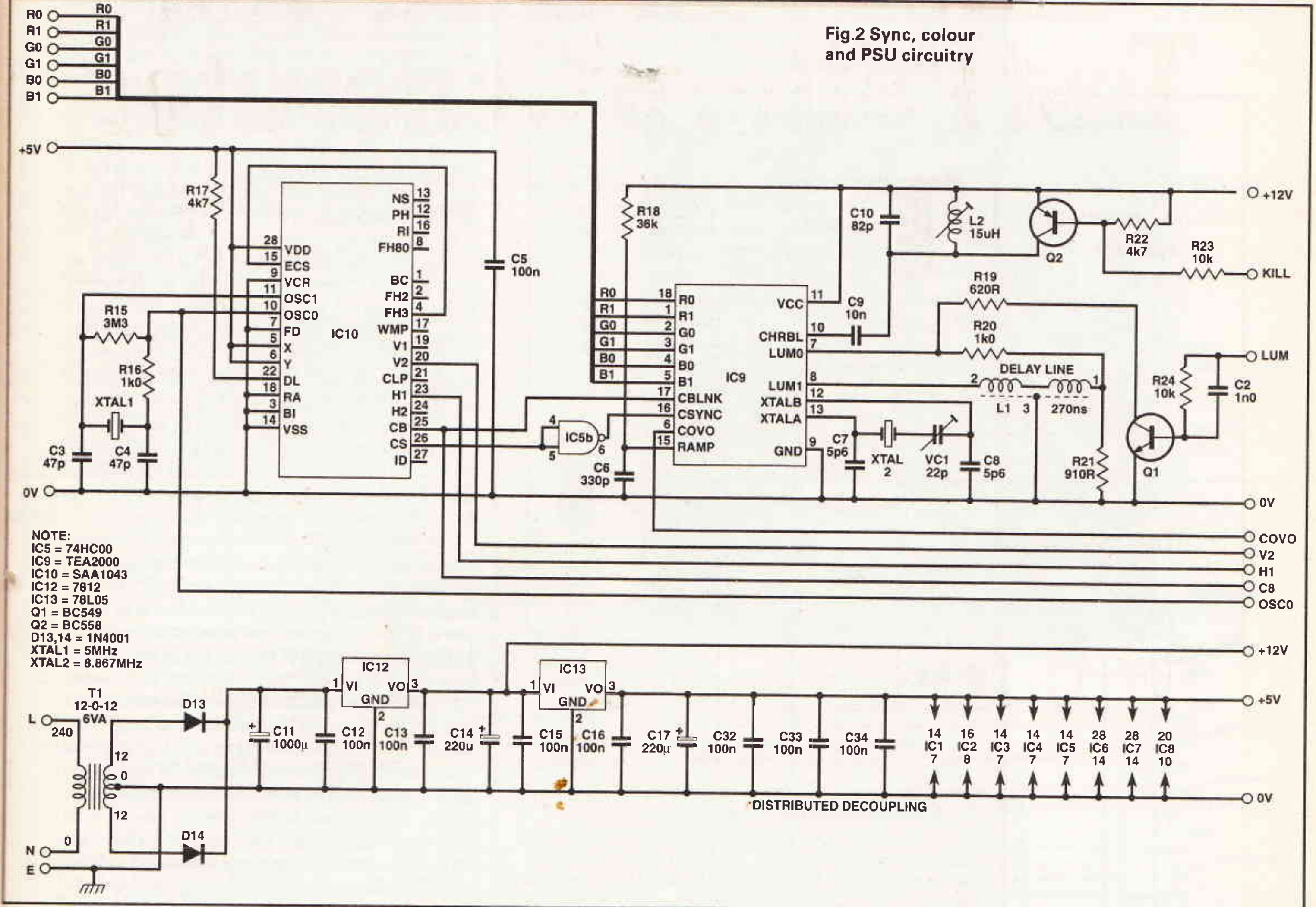
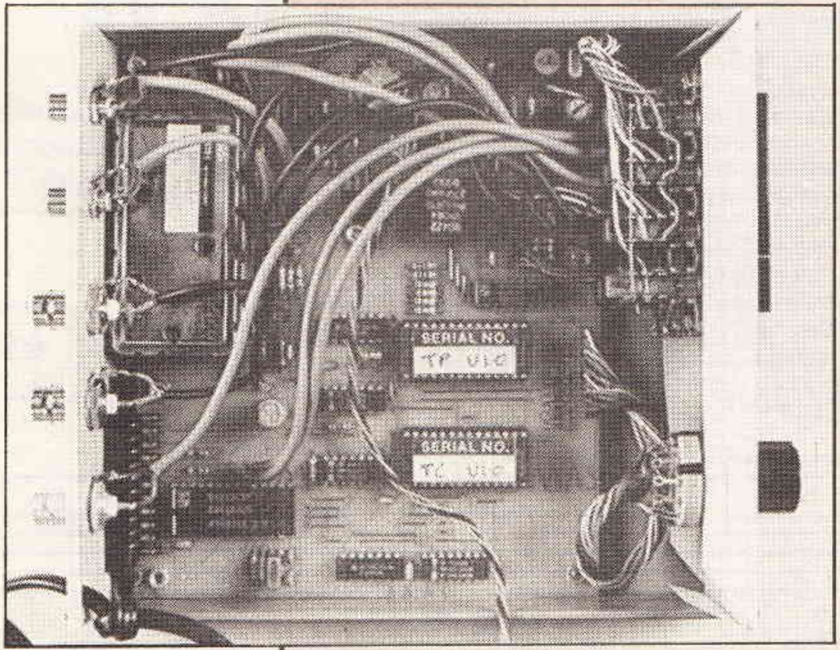


Fig.2 Sync, colour and PSU circuitry

NOTE:
IC5 = 74HC00
IC9 = TEA2000
IC10 = SAA1043
IC12 = 7812
IC13 = 78L05
Q1 = BC549
Q2 = BC558
D13,14 = 1N4001
XTAL1 = 5MHz
XTAL2 = 8.867MHz

From the above truth table it can be seen that all the colours except black, white and grey are used at the 75% brightness level, this level is chosen mainly because a good grey-scale is produced if the colour bar pattern is selected and the chrominance (colour information) is disabled. The logic levels on lines R0, C0 and B0 are always the same, these 3 lines therefore share one data line (D0) from the EPROMs, leaving more data lines available for other purposes, R1, G1 and B1 are connected to data lines D1, D2 and D3 respectively.

Unfortunately the TEA2000 (IC9) will only produce two shades of grey, 50% and 75%, for the test card an additional grey at 25% is required. This is achieved using Q1 and R19 to reduce the luminance signal level at the luminance delay line. This transistor is controlled by data line D4, when the 25% grey is required, the 50% grey is selected and D4 is taken high (a slight problem with this arrangement is that when the test card pattern is selected, and all three colours are switched off, a faint pattern will still be present, however since the instrument would never be used in this manner, it was not considered important).



The power supply uses a standard 12-0-12 volt centre tapped mains transformer, with full-wave rectification, giving about 17 volts DC across C11. This is regulated to 12 volts and 5 volts using two standard 3-pin regulator ICs (IC12 and IC13).

If requird T1 could be removed, IC12 linked out, and the circuit powered from 12 volt (±1 volt) batteries for portable use. Current consumption at 12 volts is about 120mA, so a small rechargable sealed lead-acid battery would be a good choice. The maximum supply voltage for IC9 is 13.2 volts, so ensure this is never exceeded (disconnect the battery when charging).

Construction

All the components except the switches, sockets SK1 to SK5, mains transformer T1 and resistor R4 are mounted on the PCB. This is a single sided board, about 185 × 165mm in size, and will be available from the ETI PCB service next month. There are 45 links and it is advisable to fit these first, using tinned copper wire, about 24 SWG. The remaining components can then be fitted in the usual size order. Note that there are tracks between many of the IC pins so a fine tipped soldering iron and due care should be used. All the ICs except IC12 and IC13 (the regulators) should be fitted in sockets, and should not be inserted until the power supply voltages have been checked — see Testing and Setting-up next month. Veropins may be used for the off-board connections if desired. Take care particularly when fitting the inductors, crystals and variable capacitor since they are easily damaged by rough handling and excessive heat. When fitting the modulator, ensure it is well down, then twist the mounting tags by about 45° and solder. Do not connect the wires from the modulator to the board until the power supply voltages have been checked.

The prototype was housed in a plastic case approximately 170 × 70 × 190mm, however this was

HOW IT WORKS

Most of the difficult work is done by IC9 (TEA2000), the PAL Colour Encoder IC, and surrounding circuitry (see Figure 2). This IC produces the luminance (brightness) and chrominance (colour) signals and combines them to form the PAL standard composite video output. The IC requires 6 bit colour data, giving a total of 64 possible colours; it also requires composite sync and blanking signals which are produced by IC10 (SAA1043), a Universal Sync Generator IC. Various other signals are obtained from IC10 for use as clock and timing signals for the remainder of the logic circuitry. The H1 and V2 signals from this IC go to SW1, which selects the signal to connect to SK1 (Scope Trig Socket) via R4. The colour data required by IC9 is stored in EPROMs IC6 & IC7. IC6 contains the data for the test card whilst IC7 contains the data for the other patterns.

The address lines of the EPROMs, IC6 & IC7 are controlled by two counter IC's, IC2 & IC3 (note that only one EPROM, either IC6 or IC7, is selected at any one time, depending on the position of SW2). The first counter, IC2 (74HC4040), is clocked by a 5MHz clock signal taken from the crystal (XH1) of IC10 (via IC1b); the counter is reset at the end of each scan line by the composite blanking signal (CB), also from IC10. This counter controls the EPROM address lines A0 to A7. During the non-blanked period of a scanned line (when CB is low) there are actually 258 clock pulses, so lines A0 to A7 count up from 0 to 256 (00h to 0 and 1 (00h and 01h) again. The fact that the first two "pixels" in each line are repeated again at the end of the line is of no consequence since this has been allowed for when planning the pattern data.

A second counter chip, IC3 (74HC4024), is normally clocked on each line by the composite blanking signal (via IC5a), and reset at the end of each frame by the V2 (Vertical Pulse 2) signal, also from IC10. Six output lines from IC3 control the remaining six address lines on IC6 (we will come to IC7 later), however since there are only six address lines this gives a maximum count of only 64 lines. Since there are about 280 visible lines per half frame (remember the 625 lines are made up over 2 frames), some means of obtaining the 280 lines is required. The obvious approach would have been to use larger EPROMs (more address lines), however these could be difficult to obtain and get programmed, and would make the unit more complex and expensive than planned. The Test-Car pattern has many sections where one line is repeated several times over, so the following arrangement was designed, where the same data in the EPROM could be used for several lines if required. If data line D7 goes high the rising edge resets another counter, IC4 (74HC4024), via C2 and R2. Output line Q5 of this IC goes low which switches the CB signal off of IC3 and on to IC4, via IC5a and IC1b. After 16 pulses on the CB line, line Q5 goes high again, switching the CB signal back onto IC3. Therefore if D7 is high during a picture line, that line is repeated 16 times. With careful pattern programming the 64 sets of line data produed the required full 280 line picture.

The above arrangement is fine for IC6, the Test-Card EPROM, which only contains one frame, IC7 on the other hand contains the data for 8 patterns. However these other patterns are made up of only 8 picture lines repeated several times over to make up the frame. Therefore only the lower 3 address lines from IC3 need to be connected to counter IC7, the upper 3 address lines from IC7 are connected to positions 2 to 8 of SW2 (Pattern Select), via diodes D3 to D11, which act as an 8 into 3 line binary decoder, in conjunction with pull-up resistors R6 to R8. Switch position 1 selects IC6 and disables IC7, giving the Test-card pattern.

The data line outputs of IC6 and IC7 are connected to an 8 bit D-type latch, IC8 (74HC574). This latch is clocked by the 5MHz clock via IC1c. The main purpose of this is to remove the effects of the propagation delays of a little tight for comfort. Since the instrument is mains powered, a slightly larger earthed metal case would be more suitable. The PCB is mounted at the rear of the case, with cut-outs in the rear panel for the SCART socket and the UHF output socket on the modulator. The other sockets are also mounted on the rear panel.

All the switches are mounted on the front panel, a suitable legend for this will be featured next month. Switch SW2 is a rotary type, 1-pole 12-way, with the stop set at position 10 (note that no connection is made to pin 10, although position 10 is used). The other switches are the Japanese type latching switches, and are mounted in two banks of four. The individual switch latches are left in place and the interlocking mechanism is not used.

Part 2 will feature more construction including the template for the front panel, the component overlay, the Parts List and an interwiring diagram.

IC2 and IC6/IC7, which would otherwise give rise to black vertical lines on the picture, particularly at points where several address lines are supposed to change state simultaneously. IC8 is also used to produce the 5MHz part of the frequency grating on the test-card. If line D6 is high the 5MHz clock signal is applied to the OE (Output Enable) pin of IC8, due to IC5c & IC5d. When this clock signal is high the outputs are disabled and are pulled low by resistors R11 to R14, when the clock is low the outputs are enabled and high due to D0 to D3 being high; thereby giving a 5MHz signal on all the colour data lines. The outputs of IC8 are also disabled (due to IC5 c) when SW2 is in position 9, giving the Blank Raster pattern.

The colour data outputs of IC8 connect to IC9 via switches SW3 to SW5. These switches enable each of the primary colours to be switched on or off independently.

If switch SW6 (Colour/Mono) is closed, Q2 is turned on which removes the chrominance from the signal by effectively shorting out the chrominance filter circuit (L2 & C10) of IC9.

The composite video output from IC9 (COVO), is attenuated by R39 and R40, and fed to SW8 (the Int/Ext Video switch); it is also buffered by a video amplifier comprising of Q3, Q4 and surrounding circuitry, and fed to the Video Output socket (SK3), and pin 19 of the SCART socket (SK6). The external video input from SK2 or pin 20 of SK6 amplified by another similar video amplifier circuit, built around Q5 & Q6. The input impedance of this amplifier is about 500k, but can be reduced to about 75R by closing SW7. The output of this amplifier circuit, built around Q5 & Q6. The input impedance of this amplifier is about 500K, but can be reduced to about 75R by closing SW7. The output of this amplifier is also fed to SW8. Either the internal or external video, as selected by SW8, goes to the RF modulator MOD1.

The audio oscillator is built around IC11b and is a standard Wein Bridge circuit, with zener diodes used to control the negative feedback. The output is connected to SW9; and also attenuated to 500mV RMS (by R53 and R54), and fed to the Int Audio Out socket (SK5), and pins 1 & 3 of the SCART socket (SK6). The frequency is set to 800Hz, but can be changed to 1kHz if required by reducing R51 and R52 to 16K.

The External Audio input is amplified by IC11a. The gain is arranged such that a 500mV input gives the same drive to the modulator as the internal audio generator. The bandwidth is limited to 30Hz-15kHz by C26 and C27. The output also goes to SW9, IC11 is powered from the 12 volt supply, with the 5 volt supply used as the mid-rail. The outputs are about 8 volts peak-to-peak, centered at the 5 volt level. SW9 selects either the internal or external audio, and R45 & R46 reduce the level to about 4 volts peak to peak, centered at 2.5 volts, which is the correct level for the RF modulator, MOD1. C28 removes the small amount of 6MHz carrier signal that seems to come out of the modulator's audio input, and would otherwise find its way onto the Audio Output socket. RV1 is the 6MHz audio carrier fine tuning control.

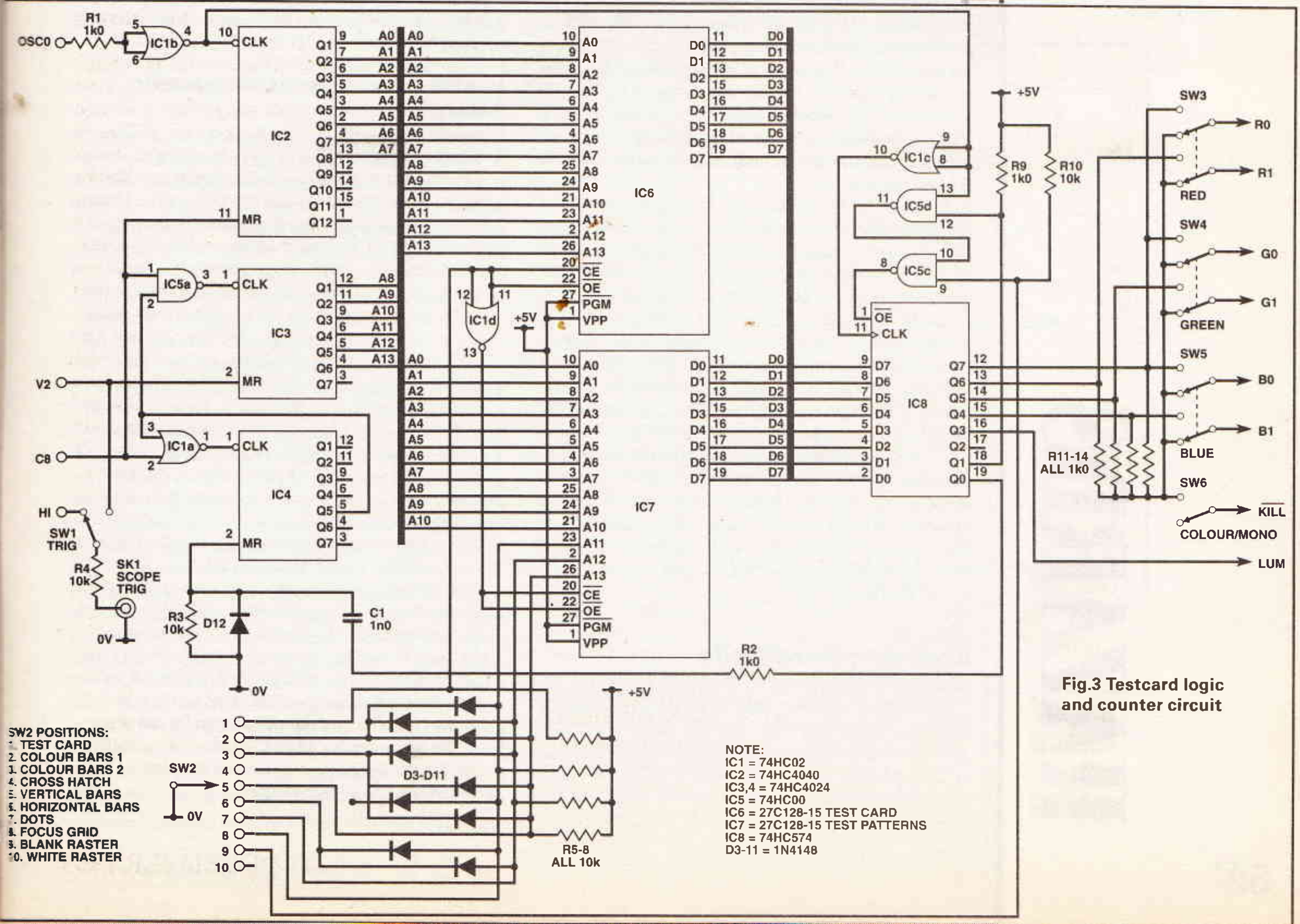


Fig.3 Testcard logic and counter circuit

Electromagnetism And Man

How does natural electromagnetic radiation affect our existence? Douglas Clarkson investigates.

As silicon technology forges forward at a never slackening pace and the electronic age forces greater and greater levels of dependence on its function, the true understanding of the interaction of electromagnetic fields on individuals is only beginning to dawn. In some ways, science has progressed along two directions — one that of acceptable science with its set of Nobel Laureates and another of workers not acknowledged to be part of 'acceptable' science. Gradually, a broad body of work in the evaluation of electric and magnetic fields on the population which previously has been ignored is acquiring increased respectability. One reason for this development is because horizons in the scientific community are generally expanding. Another factor can be identified in the development of measurement equipment to confirm effects and influences which previously remained undetectable.

Also, additional factors have been at work which have distorted open investigation of electromagnetic effects. The role of governments in presenting entrenched attitudes towards the possible effects of electric and magnetic fields from power lines can be identified almost the entire world over, with the exception possibly of the Soviet Union. In this scenario it is a government ploy to underestimate any possible risk to the community. There has also been a linked influence of military agencies to play down the possible risks associated with electro-magnetic radiation both in relation to direct exposure of military personnel and indirect exposure of the community living around military establishments.

There is no doubt that any developments in understanding of such effects have taken place in spite of this negating, damage limitation attitude. No doubt had appropriate resources been made available since, for example, World War II, then present understanding of electro-magnetic radiation and its effects would be considerably more advanced. Nevertheless, careful integration of diverse research themes, such as for example outlined in the landmark book 'Electromagnetic Man' written by Cyril Smith and Simon Best can bring to light a whole new perspective on such matters.

More importantly, the authors of the book make a reasonable case for considering and evaluating electromagnetic field interactions with man in a much broader context than traditionally undertaken. Mechanisms of interaction with the immune system and environmental pollutants are identified as especially relevant.

Limits to Sensitivity

While allergies to everything from house mites to E123 food additive can be demonstrated by, for example, skin allergy testing is there any awareness of the existence of so called 'electromagnetic allergies'? The work of Dr Jean Munro at her facility at Breakspear Hospital, Abbots Langley, Hertfordshire has demonstrated that such electric allergy sensitive patients do exist.

Measurements of the field signals which can be demonstrated to induce allergic reactions under controlled conditions provide a value of a lower limit of human sensitivity to electro-magnetic radiation.

Studies have shown that for specific sets of patients, such field strengths are of the same order of intensity as those radiated by commonplace electronic and electrical equipment such as televisions, PCs and microwave ovens. This is very much like saying that while the normal tolerance of say E123 food additive is 1mg per typical body weight, some people react adversely to 1 micro gram per typical body weight.

Such work indicates that mechanisms exist which cause the human body to be sensitive to very low levels of electromagnetic radiation and that specific levels which could be tolerated by some individuals would adversely affect others.

This work would seem to indicate that even such low level fields can produce an interaction in all individuals some individuals have a much lower level of tolerance for any changes thus initiated. The nature of the factor or factors which give rise to this lack of adaption to perturbation is unclear. Clearly in view of the increasing electromagnetic pollution in the environment, it is important to gain much better understanding of the relevant processes and mechanisms involved.

Testing and Electromagnetic Allergies

The process of testing for electromagnetic allergies at Dr Jean Munro's facility provides an interesting insight into the degree of skill required to adequately diagnose such conditions. It is of course necessary to isolate the patient as much as possible from stray electromagnetic interference and chemical allergens. Patients with electro-magnetic allergies demonstrate a range of sensitivities ranging from hyper sensitive to sensitive.

The basic method used is to establish an electromagnetic field around the patient using a standard signal generator and determine the patient's response. Initially the generator may even be positioned outside the clinical room where the patient is being observed if a particularly strong reaction is anticipated. Generally the tests commence at a frequency of around 1kHz and a gradual sweeping of frequencies is undertaken, with note being made of frequencies which bring about adverse patient response. Typically each frequency is monitored for 10 seconds to determine any reaction. This procedure might seem simple to undertake, however it is important that the patient is adequately screened from stray fields which could confuse the diagnostic process. A patient may, for example be discovered to be free from all symptoms at 8.4Hz, 450Hz, 4kHz, 25kHz, 350kHz, 20MHz, 320MHz and sensitive to all frequencies above 350MHz.

The surprising nature of her work is not that she has consistently been able to demonstrate electromagnetic allergies in patients but that no one has previously apparently been able to effectively demonstrate such effects.

Limitations on Scientific Curiosity

Such work indicates that all aspects of electromagnetic pollution should be investigated in a more open-minded way. The many benefits of the electronic age are here to stay though they should not be introduced at the expense of the general health of the population. Where emission levels can be reduced through expedient design and planning, then this is both relevant and sensible. Before the process of gaining a better insight into scientific understanding of such matters is undertaken, it is relevant to gain a perspective on social health matters by considering the vexed question of smoking and health.

It is understood all to well that smoking kills approximately one person every five minutes in the United Kingdom, yet companies are still allowed to promote and advertise their wares. This indicates two valid principles. Firstly, free market commercial enterprises, whatever the product they distribute and sell, will never volunteer to pack up their enterprises for the common collective good. They have generally to be coerced by legislation and will certainly try to muddy the waters of scientific debate. Secondly, governments can identify their own interests too closely in the maintenance of the status quo. They carry the notion that it is only by the fingers that they hold in the dyke of scientific curiosity in relation to environmental health that prevents the whole edifice of present economic structures tumbling down. This is a flawed approach to looking after the real interests of the population.

Back to Basics

The electro-magnetic spectrum covers a very broad range of wavelengths. It is quite appropriate to consider a photon of light energy, or a photon of infra red radiation interacting with matter on the basis of a bundle of energy being exchanged in the absorbing system. The photon can be considered to be associated with electric and magnetic fields which are 'bundled' within the small area of the photon. Moreover, the fields can be considered to be oscillating within the photon at the 'frequency' of the radiation. For a photon of green light this frequency is of the order of 10^{15}Hz. Also, where such photons are radiated in a random, haphazard way from a radiating surface such as a glowing filament, the phases and orientations of the fields within each photon will be random. It is relevant to consider what the fields would look like if a snapshot could be taken of them.

It is known that the E and B fields are at right angles to each other as shown in Figure 1. The photon can be imagined to be a region within which a 'bubble' of such fields is oscillating. Can any estimations be made of what the fields are within the photon? Introducing some very approximate calculations assuming:

i) the energy of the photon of green light is contained in a volume of diameter equal to the wavelength of the radiation.

ii) the formula for energy can be taken to be taken to be: 0.5 $\epsilon_0 E^2$ where ϵ_0 is the permittivity of free space and E is the Maximum electric field vector.

This gives a value of E of about 8×10^5 volts per metre 'in the eye of the photon' as it were. This is perhaps an unconventional way of considering electromagnetic radiation. It does indicate in a simplistic way that as photon energies increase and their wavelength becomes shorter and the energy more localised, then the values of the E and B fields in the photon increase sharply.

Conversely, as the wavelength increases the E fields associated with a specific photon will decrease but they will occupy a greater volume, assuming this is comparable with the wavelength of the radiation.

What this analysis indicates is that there are two factors involved in how electromagnetic radiation interacts with the human body. One will be relevant to individual photon events and the other will be relative to the ability of the organism to tolerate any given level of electromagnetic interaction. Table 1 indicates the notional photon flux from a 1 watt electromagnetic generator unit.

Type of Radiation	Wavelength	Number photons per second
Ultra violet	300nm	1.5 10^{18}
Infra red	3.0µm	1.5 10^{19}
Radar	3cm	1.5 10^{23}
Radio frequency	3 metre	1.5 10^{25}
Radio frequency	30 metres	1.5 10^{26}

Table 1: Photon numbers produced by specific radiation types for 1 Joule of energy.

Distance from power line (metres)	Value of field (micro Tesla)
10	20
20	10
40	5
50	4
100	2

Table 2: Variation of value of magnetic field value (peak) as a function of distance from power line for a line carrying 1000 Amps current.

This indicates that with increasing wavelength the number of quantae equivalent to a specific amount of electromagnetic radiation also increases. This is what gives a longer wavelength EM radiation its more definitive 'wave' properties — there are more 'photons' to aggregate up to a probabilistic wave front. In this situation it is possible to detect the localised E and B fields of the electromagnetic radiation.

Electro-magnetic Pollution

Most of the public awareness of electromagnetic pollution has centred on the controversy regarding overhead power lines where they are erected close to or in some cases over populated areas. Directly under the lines an electric field amplitude of 10kV/m and a magnetic field amplitude in the region of 20 micro Tesla would be expected. At a distance of 100 metres, these values would be expected to fall to less than 1000V/m and less than 2 micro Tesla. A typical fluorescent tube should glow in the dark when it is subjected to a field of 2.8kV/metre. The current through the tube should be in the region of a few hundred micro amps.

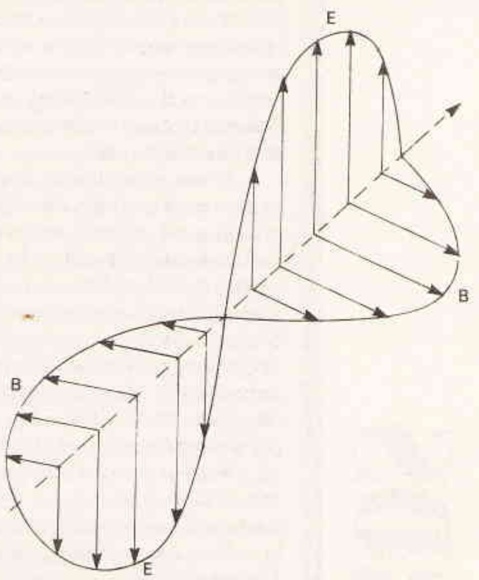


Fig 1. Diagram of E and B vectors within the radiation field.

A typical power line will consist of lines at a voltage of 400,000V and carrying up to around 5000 Amps maximum current. The magnetic element, which seems to be that component most implicated in EM pollution of this type, varies according to the current being carried along a specific line according to the equation:

$$B = \frac{\mu_0 i}{2\pi r}$$

where μ_0 is the permeability constant $4\pi \times 10^{-7}$, i is the current in Amps and r is the radius from a long straight wire in meters. Table 2 indicates the variation in field with distance r from a conductor carrying 1000 amps using this equation.

This field value, however, can be modified by patterns of current flowing in parallel supply lines on the pylon. Also, the size of the magnetic field amplitude can be expected to vary with the current transmitted along the line. Under conditions of light loading the current may be set at around 100 Amps while at peak demand times it could increase by a factor of ten. Thus a single measurement in the vincinity of a pylon in the middle of summer could vary significantly from the value obtained during a cold spell in the middle of winter.

One feature of such power distribution fields is that they are largely coherent as they interact with individuals, while the fields of discrete items such as domestic appliances is not uniform. Researchers indicate that such coherent fields are likely to have more of an effect than incoherent ones, multiplying the associated risk factors by as much as three.

One feature which is seldom mentioned in connection with power lines is the presence of harmonics on the distribution lines, usually in the magnetic field signal. A common harmonic frequency is that of 300Hz though the harmonic spectrum usually extends above 3kHz. Sometimes this so called corona effect can be heard on a car radio as a vehicle drives under a power line. In studies of EM pollution from power lines, it is relevant therefore not to ignore such harmonic effects.

Estimating Power Line Risks

The saga of the uptake of ionising radiation in the form of X-rays and Radium is estimated to have cost around 500 lives of its early users and developers. Dose limits of such ionising radiation have progressively been reduced as additional information has come to light. So too with non-ionising electromagnetic radiation, 'official' levels of safe values are likely to be reduced as additional information comes to light.

If asked, a UK based Power Distribution company would probably not set a safe upper limit of environmental exposure from power lines. Everything would be safe, no questions asked. A well read consultant in EM pollution would probably indicate that he would tolerate an exposure value of 15nT or 0.015 micro Tesla. This value would typically be observed for dwellings greater than 200 metres from the power distribution line. The EM consultant would also conclude that higher levels of exposure would be associated with increasing cancer risk. A value of 1 micro Tesla (approximately 70 times the 'safe' level) would, for example, be considered to be associated with an increased cancer risk ratio of 23.

A member of the public would find it difficult to identify 'expert' opinion in this subject area and is likely to be targeted by conflicting sources of information and attitudes of belief.

The World Health Organisation which dealt specifically with Environmental Health Criteria for Extremely Low Frequency (ELF) Fields made a relatively cautious assessment of the situation in 1984:

> It is not possible from present knowledge to make a definite statement about the safety or hazard associated with long term exposure to sinusoidal electric fields in the range 1-10kV/m. In the absence of specific evidence of particular risk or disease syndromes associated with such exposure, and in view of experimental findings on the biological effects of exposure, it is recommended that efforts be made to limit exposure, particularly for members of the general population, to levels as low as can be reasonably achieved. (WHO, 1984, p18).

It is quite clear that the sense of this directive implies that high voltage power lines should be routed so as to minimise the exposure of EM pollution to the public. It specifically does not say, however, that all is well, there is no need to worry, which has been the view consistently presented by the Power Distribution companies.

A subsequent report in 1987 by the International Radiological Protection Agency and the World Health Organisation on static and time varying ELF magnetic fields indicated that 'significant biological effects' could only be detected at levels around 5000 micro Tesla. More significantly, however, it was indicated that 'the suspected carcinogenic effects of ELF magnetic fields occur at 0.1 to 1 micro Tesla at more than a 1000 times lower'. Basically what the report is saying is that existing studies indicate risk factors have been demonstrated for the lower field values around 0.1 micro Tesla but that larger studies need to be taken to provide a more comprehensive picture before radically lower levels of exposure are recommended.

In the United Kingdom, the National Radiological Protection Board (NRPB) proposed levels of continuous 50Hz exposure of 2.6kV/m and 174 micro Tesla for a proposed standard in 1986 which has subsequently been published.

A factor of 10 between two sets of safety criteria is a matter of after dinner discussion, but a factor of a 1000 is not a topic for polite conversation.

It is relevant to note that various states in the USA have introduced their own legislation for the introduction of high voltage power lines. This action was undertaken when it was perceived that the process of updating national and international standards to take account of new research findings was excessively slow. In Florida, for example, the field levels at the edge of the 'right of way' under the line (where no buildings would be sited) the electric field limit was set at 1.5kV/m and the magnetic field limit at 5 micro Tesla under maximum operating condition. A typical width of right of way under power transmission lines was set at 190 feet.

It is obvious, that real progress in determining a true picture requires extensive research initiatives. There seems a reluctance on the part of governments to resource adequately any meaningful research programmes. This can only delay the resolution of the problem of Extremely Low Frequency fields.

The CEGB announced in 1988 that it was initiating a £500,000 research programme to study EMF bio-effects. Areas to be investigated include an independent epidemiological study of all new diagnosed childhood cancer cases in England and Wales in relation to patterns of EMF exposure. Other more significant research initiatives are being undertaken in the USA. This work will hopefully provide additional information regarding safe exposure limits in years to come.

The Fishpond Scenario

The authors of Electromagnetic Man became significantly involved in investigating persistent reports of adverse health effects caused by overhead power lines at Fishpond in Dorset in England. What unfolded from 1973 when such problems came to be experienced by the local inhabitants has acted like a catalyst to muster public opinion and more importantly collect scientific evidence against the siting of high power lines through populated areas.

More impotantly, the effect of such electromagnetic pollution in association with other environmental pollutants such as pesticides has been suggested as an area which needs significant additional investigation. It is suspected that such other environmental pollutants can act to decrease the body's tolerance to such ELF fields and hence trigger carcinogenic effects at much lower levels. The use of pesticides has increased in the USA from an estimated 200,000lb in 1950 to 4,000,000,000lb in 1986, though in this period the percentage loss of crops to pests has doubled. Many researchers indicate that it may be essential to investigate ELF field interactions in association with other environmental factors.

Fishpond is a small village with around 30 people in permanent residence. By 1987 a selection of 23 reports of 'non-specific' health problems had come to light, the most serious of which included four heart attack deaths, two of which could be described as 'sudden' or unexpected and two of which related to a history of heart trouble which apparently became more severe after moving to the village. The set of 'non-specific' problems also included three cancers and various conditions such as dizziness, loss of muscle strength when outside, cataracts, severely swollen limbs, sleeplessness and blackouts.

Specific incidents such as blackouts, disorientation and dizziness were also observed immediately after the lines at Fishponds were (without the knowledge of the inhabitants) uprated from 275kV to 345kV.

The authors of Electromagnetic Man keep an open mind on whether the Fishpond episode is an isolated episode in chronic ELF field pollution aggravated by specific local problems or if it is representative of what is taking place over large tracts of populated areas overhung by power lines. It shows the significance of the case cannot be ignored.

More General Exposure Patterns

While individuals are exposed to electromagnetic fields from a range of sources, it is estimated that about 80% of domestic exposure is due to overhead and underground power lines with the remainder being made up by domestic appliances. The table below indicates the typical magnetic field values for a TV and a microwave oven at different distances.

Item	at 3cm	at 30cm	at 1 metre
TV	2.5-50µT	0.04 to 0.2µT	0.01 to 0.15µT
microwave oven	75-100µT	4 to 8µT	0.25 to 0.6µT

In electric distribution, the currents of three phase systems are essentially balanced so that the magnetic field component is largely cancelled out. Also, the small finite field around a balanced system will decrease according to an inverse square rule while the field around an unbalanced wire will only decrease according to the inverse of the distance. This emphasises the importance of ensuring that wiring systems are installed to minimise any imbalance of currents.

Typical 'domestic' ELF field exposure can now be readily measured using specific hand held meters costing a few hundred pounds. Remote from overhead or underground power lines, the fields would be expected to vary considerably in the domestic environment. Measurements in high rise flats can indicate that the degree of balancing of currents can vary considerably between ground and upper floors. One set of measurements, for example, indicated a peak ground floor value of 0.4µT and a peak top floor value of 0.015µT — a ratio of approximately 13.

An investigation of cases of suicide and depression by a Dr. F. Perry in Leeds provided evidence to link such clinical conditions to exposure to ELF fields. In high rise flats, there appeared to be higher incidence of depression and suicide at ground floor levels.

It has been pointed out, however, that fields in bedrooms are more significant due to the greater amount of time spent there. It is not unheard of on the continent for beds to be located within rooms in positions to specifically minimise ELF exposure. Consultants in EM pollution would probably NOT use an electric blanket.

Occupational Exposure

Occupational exposure in the form of working with computing equipment is assuming increased importance primarily because the use of such equipment is becoming so widespread. 'Officially' according to UK based NRPB, computer equipment such as VDUs present no hazards and can be considered safe. A range of studies have indicated that the problem needs further examination with regard to exposure limits. It is difficult to often remove other environmental/occupational factors from such analyses. Within the EEC it is hoped to initiate legislation to harmonise the levels of exposure within member states. It is relevant to draw states. It is relevant to draw attention to the very real possibility of individuals having electromagnetic allergies. Levels of EM exposure which could be tolerated by most of the population would be problematic for this sub-group of the population.

Researchers also indicate that in assessing exposure risks from VDUs, often exposure from the sides and rear of such equipment could be significantly higher than from the front, so that apparent levels of exposure would depend significantly on layout of staff and equipment within a specific installation.

Enter The Military

The cat and mouse game centering on bombarding the American Embassy in Moscow with microwaves is has been public knowledge since 1972 even though the American intelligence were aware of the bombardment since 1953. Also it was only since 1976 that defensive screens were installed to protect embassy staff. One embarrassment for the American authorities was that the level of the radiation was significantly below 'official' levels for safe exposure. While a notional 10mW/cm^2 was considered to provide a measure of safety, the Moscow Embassy radiation was about 5 micro Watts/cm^2, during the period January 1973 to August 1975. The 'hostile' radiation was in fact at level a factor of 2000 lower than Western safety limits. Additional beams came into play from August 1975 though when the defensive screens were installed the level of the bombarding radiation fell to about 2 micro Watts/cm^2. Subsequently in January 1979 the radiation essentially ceased though was detected briefly in 1983. Subsequently from March 1988 a much weaker higher frequency band around 10GHz has been detected.

A range of studies were initiated to try to determine the nature of any health risk. In response to public pressure, the most detailed medical review of all staff posted to the Moscow embassy during the time of bombardment was undertaken in 1976. Its findings showed that the incidence of disease was indeed higher in specific categories. It is relevant also to note that three ambassadors posted to Moscow subsequently died of cancer.

The general body of opinion is that the radiation was deliberately used to undermine the health of the embassy staff and in particular that of the Ambassador since the beam was centred on his office. Yet there still seems to be missing pieces to the puzzle. Was in fact the presence of microwaves a red herring and the health problems were caused by an additional subversive agent as yet unannounced or undetected?

Clearly detailed information of the subversive use of EM radiation such as microwaves is not for the public domain in the West or in the East. There is no doubt that considerable investigation is undertaken in the world's R&D community into possible military applications of electromagnetic radiation. This was at its height during the Cold War but it is continuing at a significant pace. The bulk of this work will never be made public. The secret nature of this work covers the distinct areas of general technological function and also the potential health hazards of such systems to users or targeted individuals.

Conclusion and Summary

With the approach of the end of the 20th century, an understanding of the electromagnetic nature of man and the interaction with electromagnetic fields is finally being achieved is manifestly untrue. This rather disappointing state of affairs has largely come about by restrictions on research into the adverse effects of electromagnetic radiation on individuals.

Recently, many more interesting lines of investigation are being unearthed which as yet have been scarcely researched. Developments in sensor technology have tended to increase the nature and scope of research to be undertaken. This expansion is also tending to link in concepts already identified by practitioners of Alternative medicine such as acupuncture, colour therapy, and in particular homeopathy to name but a few. It seems likely the mechanistic model of the human individual is too restrictive to allow a satisfactory model to be determined.

The 1990's have proved so far to be an interesting decade. Old empires of political thought can crumble if pushed hard enough. Is our view of electromagnetic radiation and its effect on the individual likely to suffer a similar fate?

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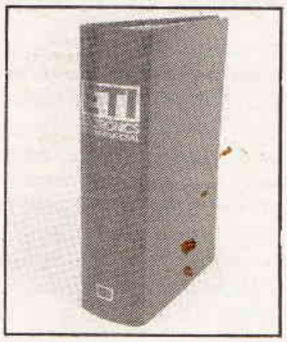

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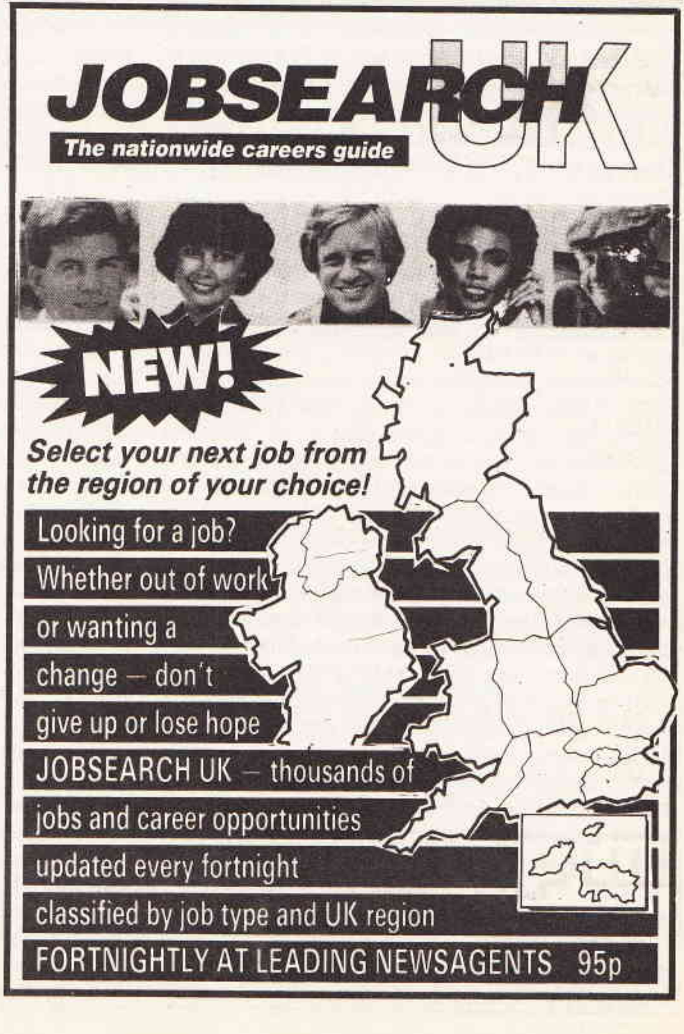
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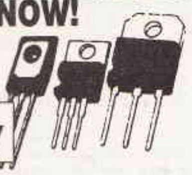

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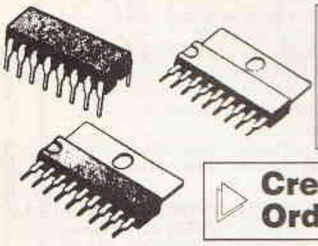

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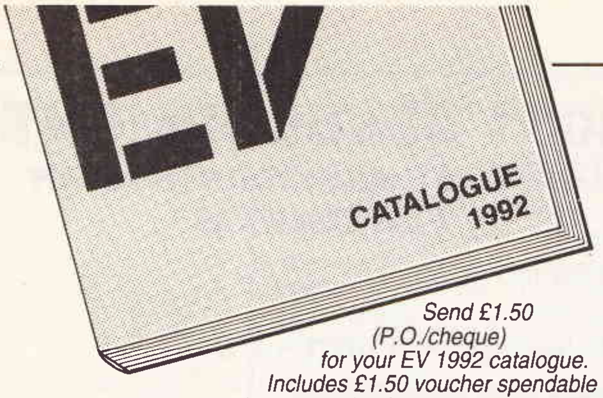

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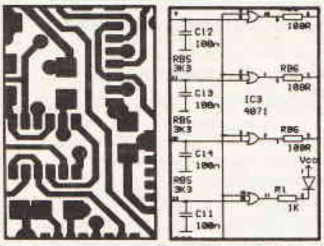	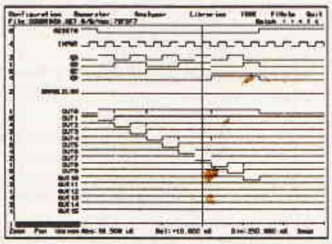	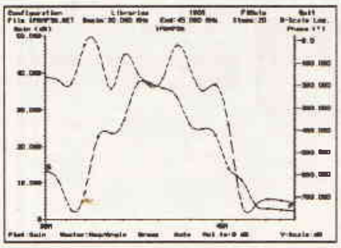	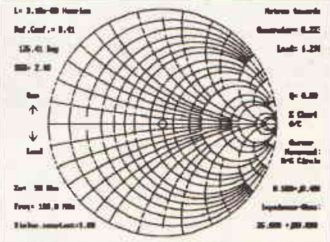
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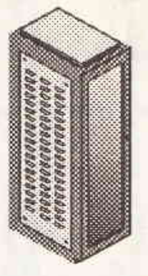

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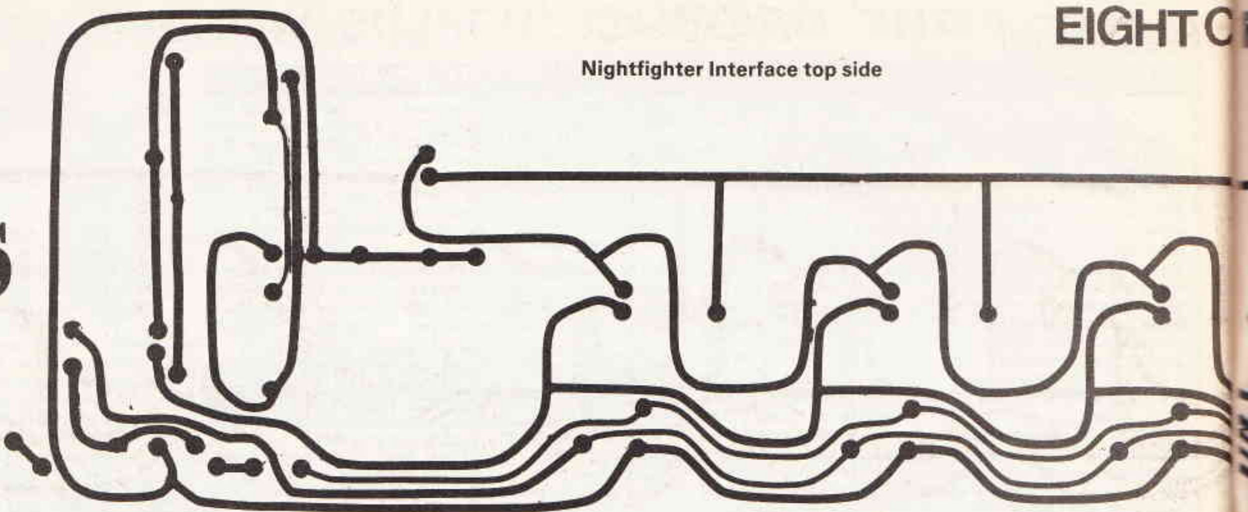
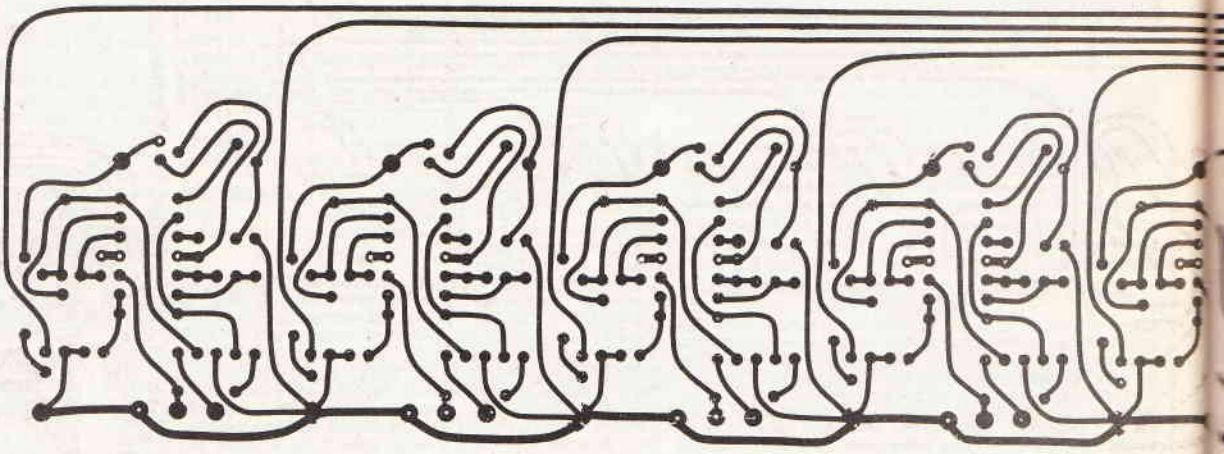
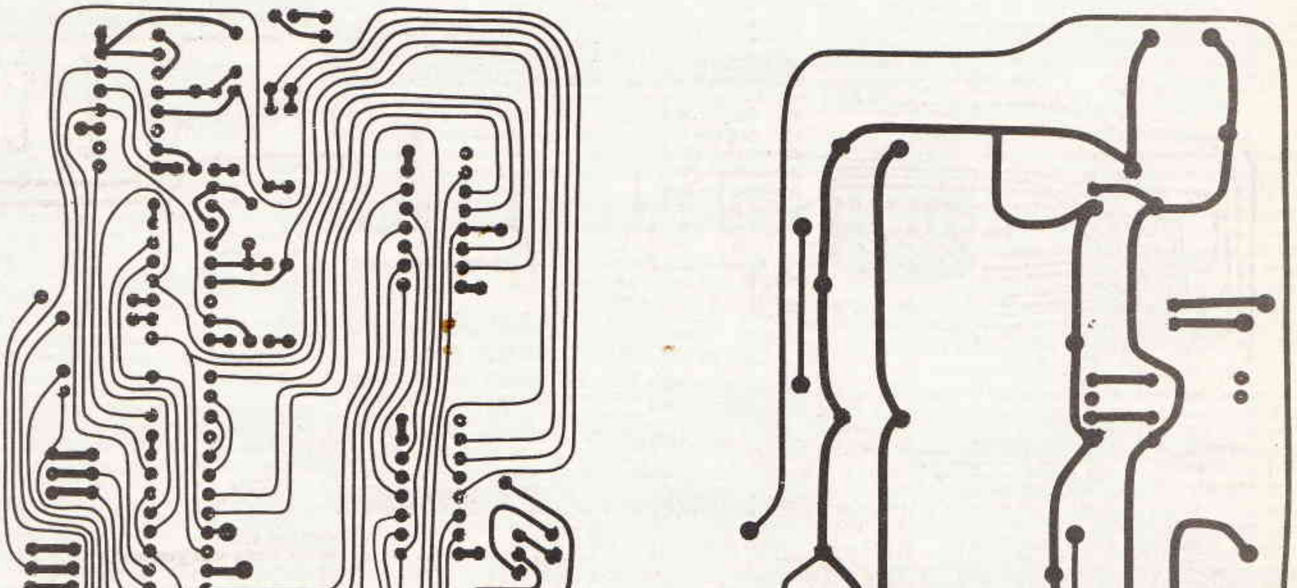


Nightfighter Eight Channel Input Interface (solder side)



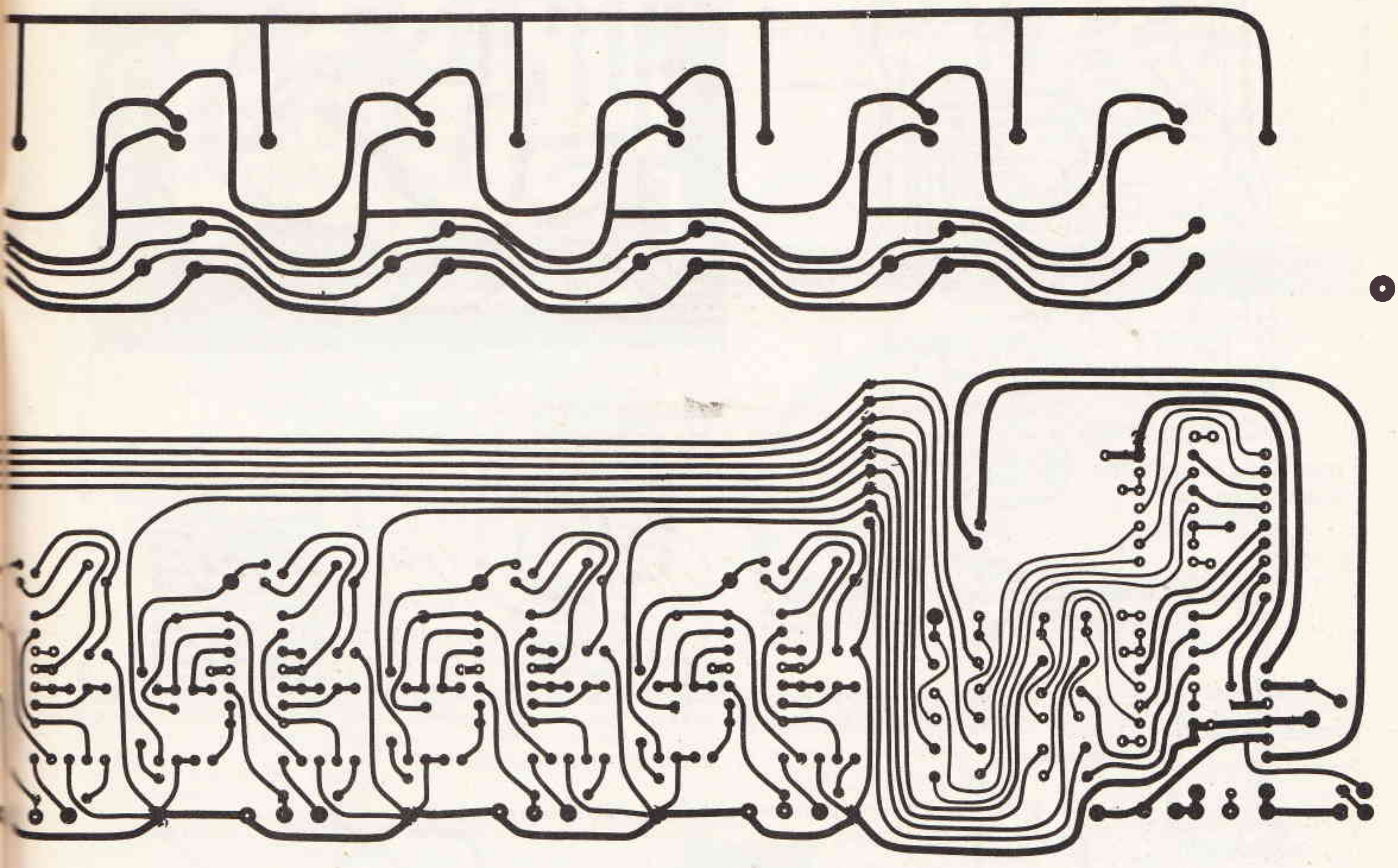


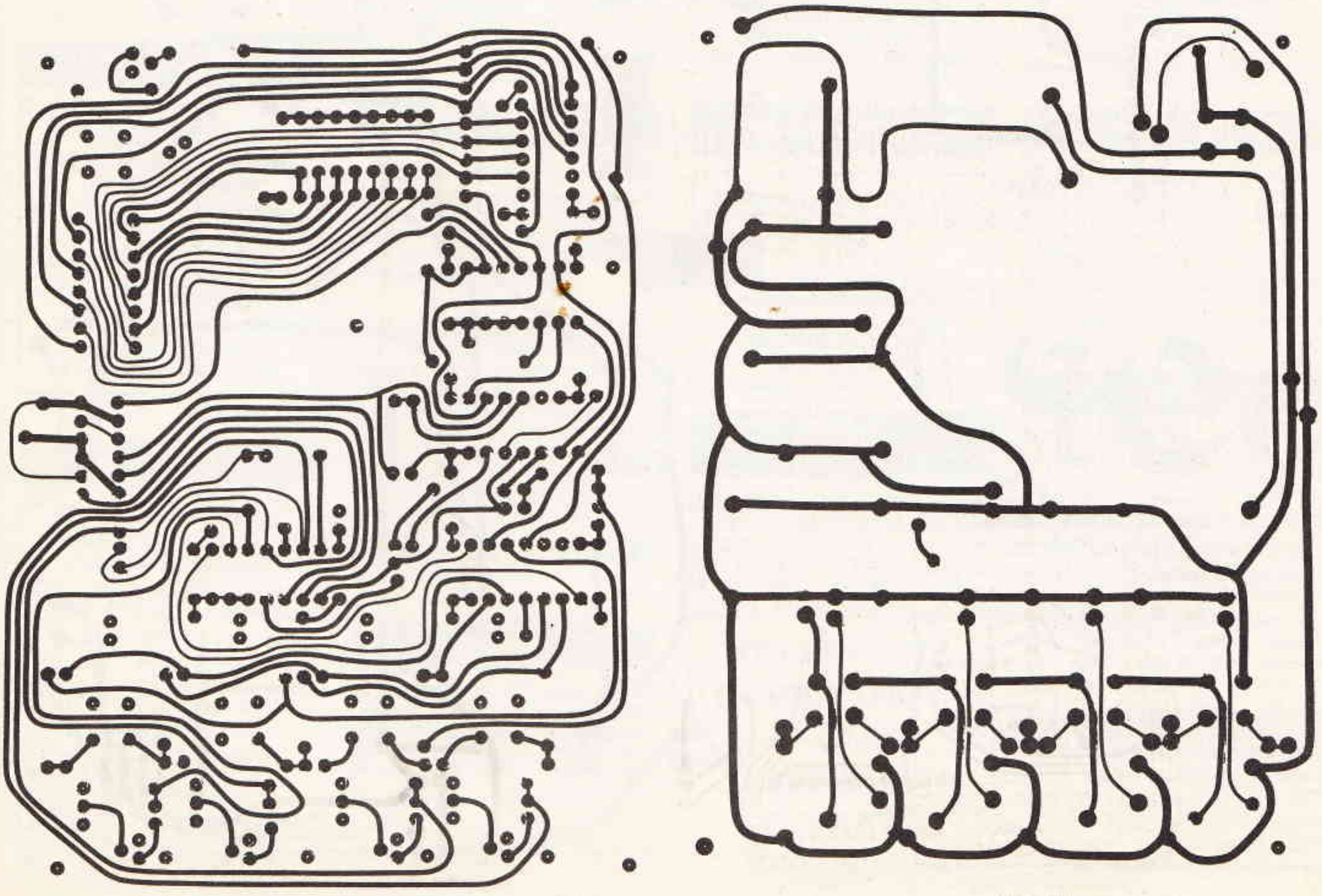
solder side

top side

Nightfighter Sensor Switch Channel Board

HANNEL INPUT INTERFACE

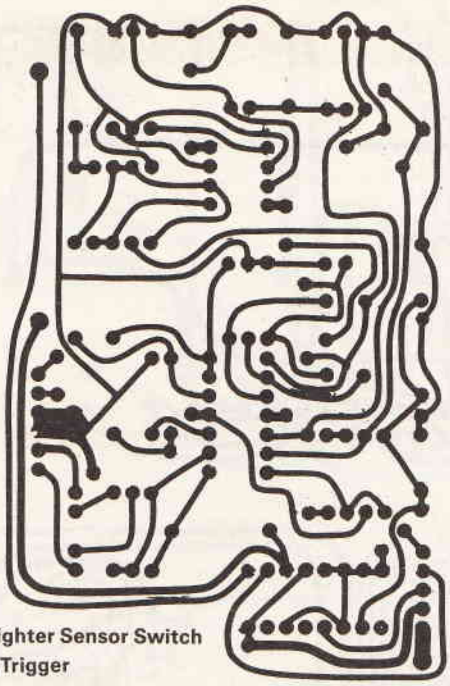




solder side

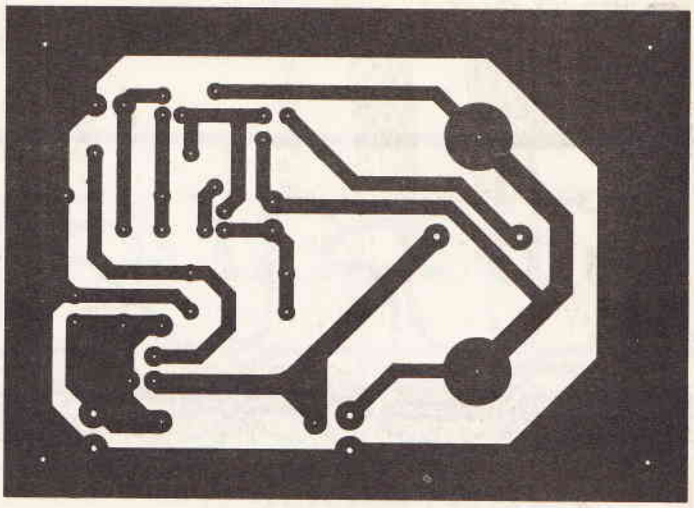
top side

Nightfighter Sensor Switch Master Control

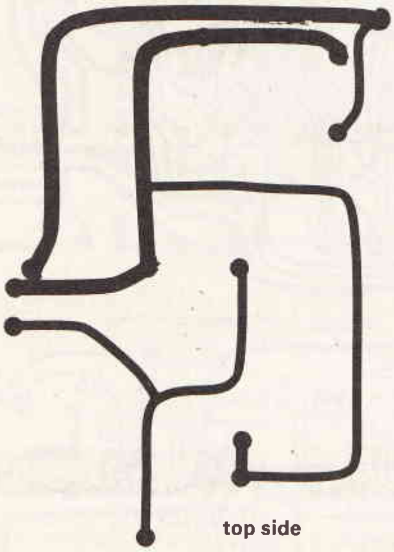


Nightfighter Sensor Switch Sound Trigger

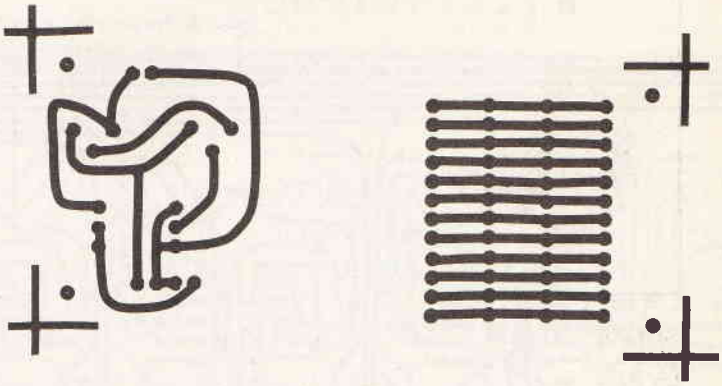
solder side



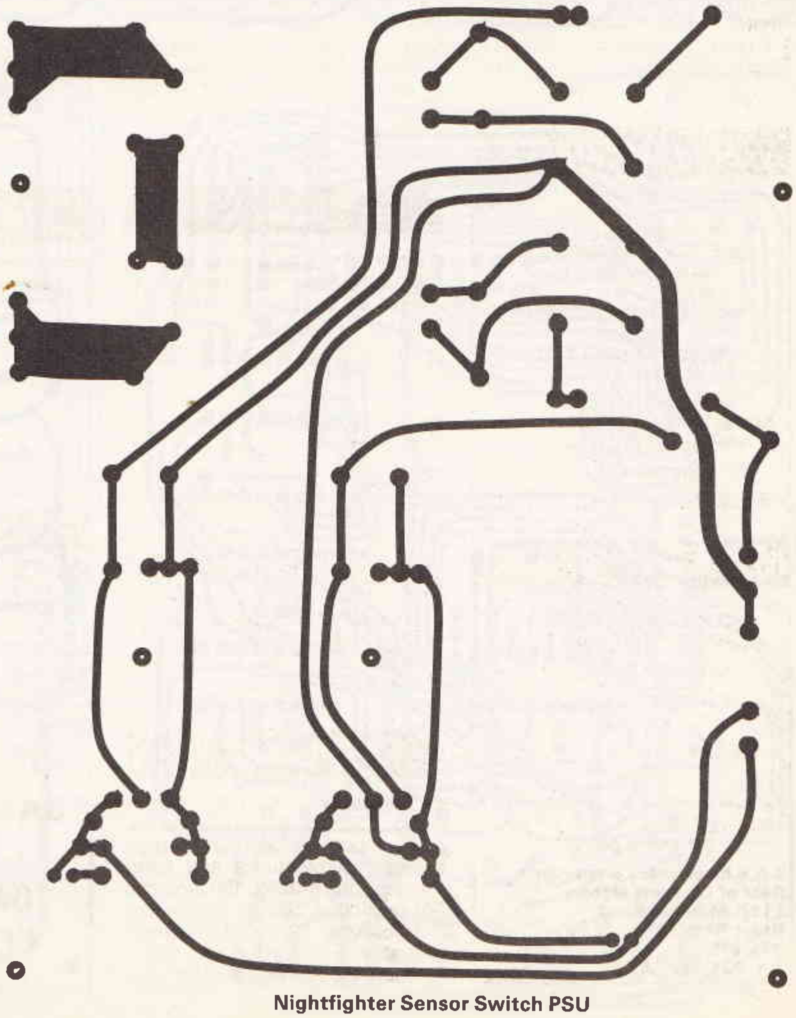
Power On and Overload Foil



top side



Nightfighter Connector Board

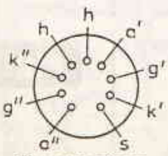


Nightfighter Sensor Switch PSU

Hybrid audio Pre-amp Nov 91

The text makes passing references to IC1, a regulator. This was included in an initial design but not included in the final design for the power supply. It should therefore be ignored.

Arrows from C2 and C13 in Fig.1 should be ignored. A take-off wire in Fig.2 labelled D4a should go to the indicator LED, LED 1. The foil was not printed on the foil pages as the author wanted to retain the rights to the design.



Pin connections E88CC (bottom view)

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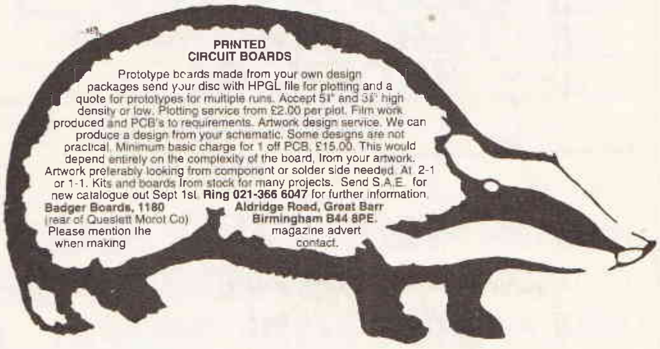

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NEXT MONTH

Next month we will have arrived at the Christmas issue once again and another free gift, a PCB sticker foil for you to experiment with. An article tells you how to use your free gift and how to make foils.

We can offer the ultimate in enlarger timers if you are a photographic boffin. It could even turn the kettle on to make the tea.

To put you in the festive mood why not try making our LED Star project for the christmas tree. It's an ideal way to get rid of all those surplus LEDs.

We continue with the Test-Card Generator a versatile tool for the TV serviceman and a laboratory power supply which uses our free foil pattern.

On the theory side we start a new series on audio mixing desks. Also we cover Star-delta transforms and we continue in our course on Test-gear basics postponed from this month.

The Christmas issue of ETI will find its way on to the newsstand on December 6th.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

The November issue contained articles on:

Digital pulse transmission
Waves and Particles
The final part on Back to basics
Test-gear basics Part 1
The Nightfighter Part 3
Hybrid Audio Pre-amp
Switched-mode power supply

A limited number of back issues are available from Select Subscriptions (Address shown in column to the left).

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