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No. 81

ELECTRONICS

The Maplin Magazine

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SEPTEMBER 1994 • £2.00

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Excellent PWM Drill Speed Control Project

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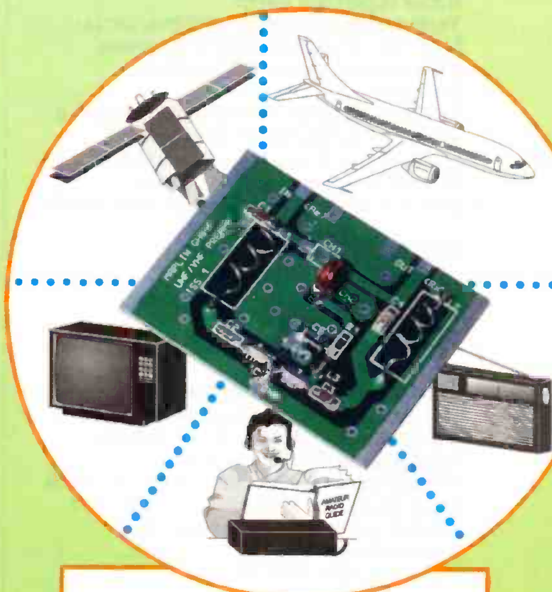
SEPTEMBER 1994
VOL 13. No. 81

IN THIS ISSUE...



ABOUT THIS ISSUE . . .

Hello and welcome to this month's issue! As well as the usual fine collection of projects and features, this month sees the introduction of Maplin's first 'surface mount' project – the VHF/UHF Preamplifier. At first sight, the size of surface mount devices may be a little off-putting, but clear step-by-step constructional details have been included, and with a little persistence, anyone can learn the correct technique. Any comments regarding surface mount kits would be greatly welcomed!

How Fast?

The PWM drill speed controller will be a very useful addition to any hobbyist's workbench (we find it indispensable in the labs); it allows the drill's speed to be accurately controlled from zero to the maximum speed, it is overload proof, and can provide up to 125W of power for even the most demanding of tasks. The controller can also be used to control the speed of model trains, cars, and boats.

On Tow

Now that summer has finally arrived, those of you with caravans and trailers will, no doubt, be thinking of taking a holiday. The split charge unit will help to avoid the frustrations that can be caused by a flat battery; it has been designed to be able to replace an existing unit, is able to charge an auxiliary battery, and simultaneously supply power to a 12V DC operated appliance, such as a refrigerator.

Universal Theme

In July 1969, the world's attention was drawn skywards as people eagerly awaited the first manned lunar landing. This July, 25 years later, attention was again focused on the cosmos as people the world over waited for the collision between the comet 'Shoemaker Levy 9' and Jupiter. Astronomers are hoping that this rare event will provide clues to help solve some of the mysteries concerning the planet's structure. We continue with this astronomical theme by taking a fascinating look at SETI – the Search for Extra-Terrestrial Intelligence (you may be interested to note that there will also be an article on Jupiter in the very near future).

Apologies

We would like to apologise to those of you waiting for the features on 'Circuit Switched Networks' and 'Improve Your Circuit Design'; due to unforeseen space limitations, we have had to postpone these articles until the next issue.

Lectures

I would like to wish good luck to any of our readers who are about to embark on courses of higher/further education; I am sure that you will find *Electronics* to be a valuable source of supplementary information which will complement your lecture notes.

Finally . . .

I hope that you enjoy reading this issue as much as we have enjoyed putting it together. Happy reading!

R Ball

P.S. Don't forget that the new, full colour, 1995 Maplin Catalogue will be 'on the shelves' at Maplin shops and any branch of **WHSMITH** from the 2nd September.

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CONSUMER PRESS

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Published by Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Tel: (0702) 554155. Fax: (0702) 553935.
Lithographic Reproduction by Planagraphic Studios, 18 Sirdar Road, Brook Road Ind. Estate, Rayleigh, Essex SS6 7UY.
Printed in the United Kingdom by St Ives (Caerphilly) Ltd. Mid-Glamorgan, CF8 3SU.

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UK NEWSTRADE DISTRIBUTION

United Magazine Distribution Ltd., 16-28 Tabernacle Street, London EC2A 4BN. Tel: (071) 638 4666. Fax: (071) 638 4665

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Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

1 Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering iron, side cutters, pliers, wire strippers and screwdriver). Test gear not required and no setting-up needed.

2 Easy to build, but not suitable for absolute beginners. Some test gear (e.g. multimeter) may be required, and may also need setting-up or testing.

3 Average. Some skill in construction or more extensive setting-up required.

4 Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.

5 Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

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Kits, components and products stocked by Maplin can be easily obtained in a number of ways:

Visit your local Maplin store, where you will find a wide range of electronic products. If you do not know where your nearest store is, refer to the advert in this issue or Tel: (0702) 552911. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance.

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Technical Enquiries

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics*, the Customer Technical Services Department may be able to help. You can obtain help in several ways; over the phone, Tel: (0702) 556001 between 2pm and 4pm Monday to Friday, except public holidays; by sending a facsimile, Fax: (0702) 553935; or by writing to: Customer Technical Services, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Customer Technical Services are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
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Readers Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about *Electronics* and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read — your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editors discretion. Any correspondence not intended for publication must be clearly marked as such.

Write to: The Editor, Electronics – The Maplin Magazine, P.O. Box 3, Rayleigh, Essex, SS6 8LR.

TECHNOLOGY WATCH!

with Keith Brindley

It is about time that telephone numbers became portable. By that, I mean everybody's telephone number should be allocated such that by dialling a number you can contact the person you want, wherever he or she may be.

Of course, as long as the person is around the phone point in question, that's partly true now. As long as the telephone terminal itself rings loud enough to let Fred down the bottom of the garden know somebody's trying to call him, and as long as he can run all the way up the garden path before whoever's trying to get in touch gives up and puts the handset down at their end, then the number *is* portable. But then, I've got fairies at the bottom of my garden, too.

Give Fred (or Wilma, for that matter) a cordless 'phone, and the portability runs to 100m or so around the house. If Fred and Wilma live in the bounds of BT's digital exchanges they may be able to buy the *Call Diversion* facility offered by BT. Other telephone providers (Mercury, Orange and so on) have similar services, as well. Give Fred and Wilma cellular 'phones and number portability exists wherever they are – as long as they are within a transmission cell.

But that is not what number portability *really* means. True number portability means having a telephone number allocated to you which goes with you, wherever you might be. In the bath, in the local JungleBurger fast-food restaurant, in the Bedrock drive-in, in the Inn – without having to fork out an extra £7 a quarter to BT for its prehistoric *Call Diversion* ability.

Real number portability means being able to move cave, move business quarry, go on holiday, go to the in-laws or the outlaws, go anywhere; safe in the knowledge that anyone can contact you simply by dialling your ordinary number (and not being told by a computer *please hold while we try to connect your call*).

Real number portability means having properly equipped digital exchanges which can be programmed with each user's number, so that any user who moves to the vicinity of a new exchange, or simply wants to have a call automatically transferred to a different exchange line on their existing exchange, temporarily or permanently, can do so with the minimum of fuss.

It is surely a simple enough concept. Everyone who has a telephone at present has an allocated number. Whether it's 071 123 4567 or whatever, it is a telephone number and it *is* unique to the address to which it is allocated. The change from the existing method to a portable method simply relies on the allocated number being allocated to a user – not an address.

It would be ideal if an allocated number could go with the user wherever the user goes – on a short-term or a long-term basis. A single number (effectively the property of the user) which can be used for any and all the telephone and telecommunications services which the user chooses to opt into. Whether an ordinary telephone, a fax, a cellular telephone, video-on-demand, or whatever. It is (naturally) what other telephone providers like Mercury have been screaming out for, since antediluvian (read *General Post Office*) times. All that appears to be preventing the implementation is the old dinosaur BT itself.

If a telephone number belonged to an individual in this way, it could mean all sorts of things. A number could actually describe the individual in much the way an individual's bank account number, or National Insurance number, or National Health Service number, or even a Birth Certificate number does. Indeed, it could even be used as such by *all* the relevant authorities, dispensing with all other numbering systems. It makes sense, if otherwise ringing alarm bells on the Big Brother front.

But of course, we are still back in the stone ages with our telephone service, aren't we? I mean, no-one really believes that we have an up-to-date, efficient system, or that the UK telephone and telecommunications market has been properly deregulated, or that fair competitive practices exists, or that there is no monopoly of services, do they? I mean, do pigs fly? Do BT 'phones feature a Mercury button?

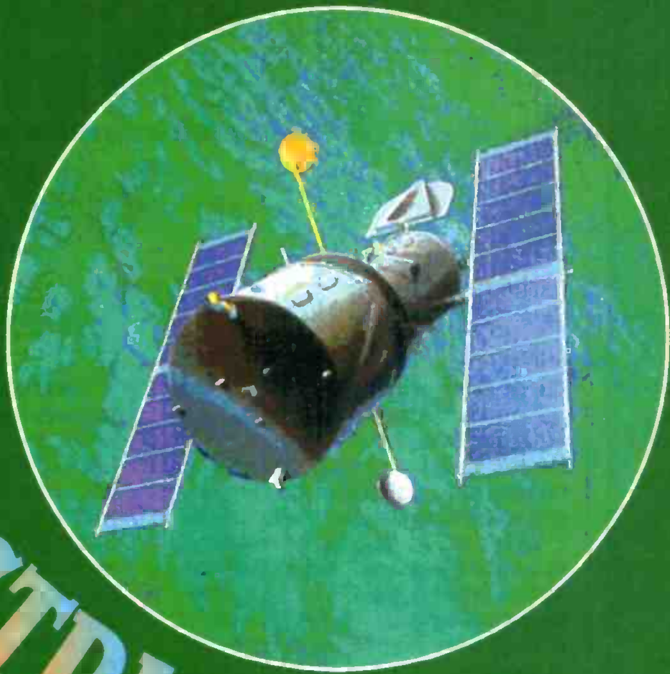
Taking a RISC

I have covered Intel's response towards the Apple/IBM/Motorola initiative and the move towards reduced instruction set computing (RISC) and the PowerPC already in this column, and a feature article in *Electronics – The Maplin Magazine* noting how Intel appears reluctant to admit that RISC is the obvious next phase in personal computer microprocessor architectures. Till now Intel was steadfast in its complex instruction set computing (CISC) approach with its current 386, 486 and Pentium devices. Recently, though, Intel has signed a deal with Hewlett Packard to co-develop a microprocessor which will run 86-series CISC code together with RISC code of HP's Precision Architecture format. While not exactly being a direct admission that the current Pentium is up a dead-end alley, it's the next best thing and can almost be viewed as something of a rushed response to a most favourable public reaction over PowerPC RISC devices. Nevertheless, it's doubtful whether the new microprocessor stream will be on tap before 1999.

The opinions expressed by the author are not necessarily those of the publisher or the editor.

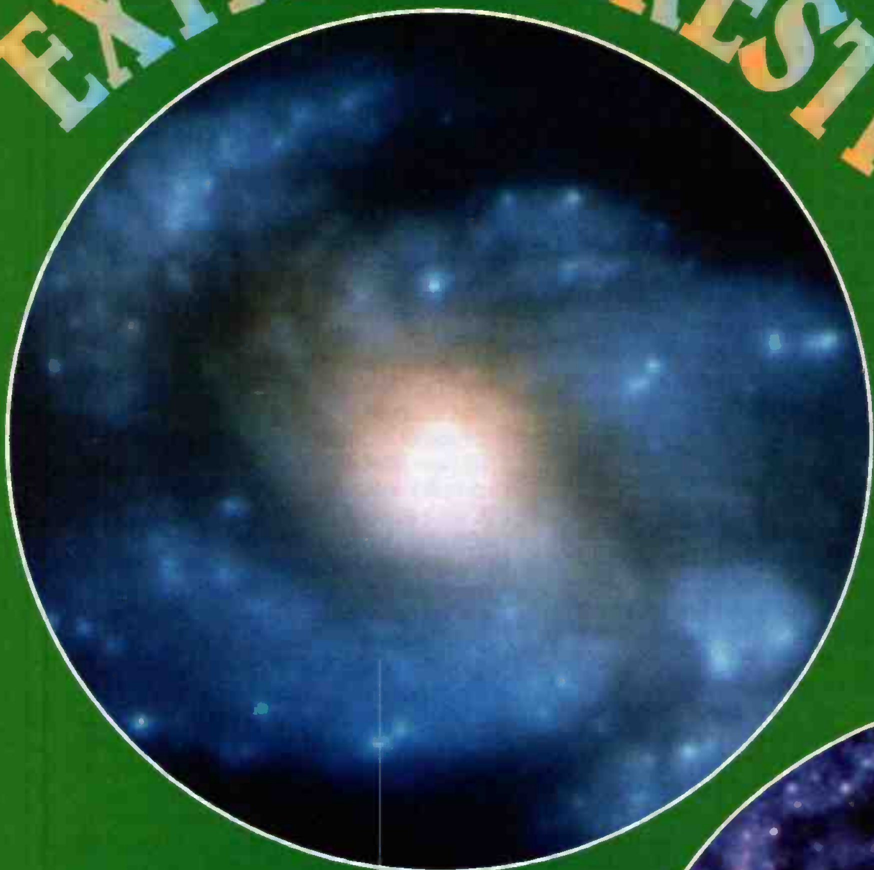
The Vastness of Space

As modern astronomy reveals a picture of a vast universe, so also, speculation about the possibility of the existence of 'extra-terrestrial' forms of life becomes more rooted in scientific probability. Within our 'local' galaxy, the milky way, a half trillion stars (1 trillion = 10^{16}) are considered to exist; of these, several billions are similar in size and temperature to our own sun.



EXTRA-TERRESTRIAL LIFE- The Search Goes On!

by Douglas Clarkson



Above: Wide Field Planetry Camera 1.
Right: Wide Field Planetry Camera 2.

RECENT studies in the Orion Nebula (our 'backyard'), undertaken using the Hubble Telescope, have indicated that nearly half of emergent stars have encircling discs of material, which will probably develop into planetary structures. This gives an indication that, in the Milky Way alone, there are likely to be hundreds of billions of planetary systems. There is therefore increasing confidence among astronomers that 'life', in some shape and form, must exist elsewhere in the Milky Way.

Looking further out into space, the scale of the universe is even more difficult to appreciate. Photo 1 shows part of a composite picture, taken by the Hubble Telescope, of the Spiral Galaxy M100. This galaxy is estimated to lie several tens of millions of light years from the Earth. Hubble now allows discrete stars to be 'imaged' at that immense distance, and so, at a stroke, the amount of available information about the universe has increased enormously. This will allow theories about the origin and evolution of the physical universe to be better developed and tested – hopefully giving an insight into the possibilities of life elsewhere.

Expanding further into the universe, to the hundreds of billions of galaxies which are now known to exist, the problem becomes one of the human mind to 'comprehend such vastness'. SETI initiatives, are however, directly related to our 'own backyard' – things close-by within our own galaxy, the Milky Way. It may turn out to be the case, though, that intelligence will never be able to bridge the gap between galaxies.

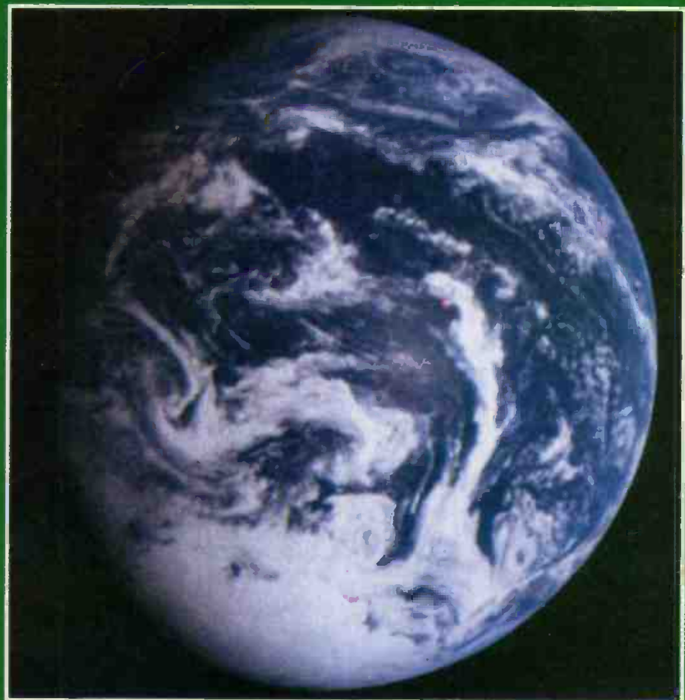
The Cycles of Life

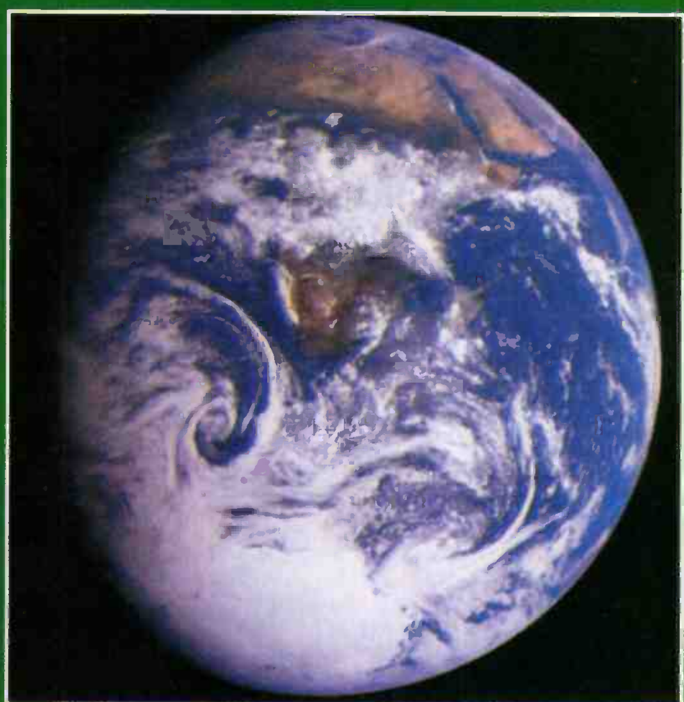
The first traces of life on earth are dated from micro fossils, around 4 billion years old. During this time, life on earth has developed from slow evolutionary beginnings, to today's incredibly rich and diverse eco-culture. With estimates of the age of the Milky Way at around 12 billion years, our solar system is somewhat of a relative newcomer, or even a late developer! If other civilisations have emerged, and similar time scales are required for their development, then the majority of such civilisations would be more advanced than our own – if they had managed to survive at all!

It may also be said, that as the Milky Way (in particular) gets older, then the number of intelligent civilisations will also increase – but only for as long as the host star systems remain stable. Stars have allotted lifespans, which are determined by the complex considerations of stability of nuclear fusion processes. There could, for example, exist the scenario of a star system, which in 3 billion years develops life forms to some level of sophistication, but which is destroyed as the star becomes unstable and expands into a Red Giant. Its process of development is cut short – the end points of its evolution are not allowed to manifest. As Earth's civilisation has developed its technology, it has also sent out its calling card – radio, radar and television emissions. Thus the 'presence' of the earth is being propagated within a sphere (already 100 light years in radius) which is expanding ever outwards.

Thus one by one, other planetary systems within the Milky Way are gaining the potential to detect such emissions, and hence the Earth itself! This form of signalling is, however, merely a by-product of today's technology. As more and more use is made of the electromagnetic spectrum, the strength and wavelength distribution of this 'calling card' signal will increase. Unfortunately, this increase in the level of transmitted signals will make it increasingly difficult to detect weak signals of extra-terrestrial origin. It was this perspective (a window of opportunity to scan for radio signals from intelligent extra-terrestrial life) which had been the inspiration of NASA's SETI (Search for Extra-Terrestrial Intelligence) initiative.

Below left: Photo 1. (Wide Field Planetary Cameras 1 & 2). New Hubble picture of the Spiral Galaxy M100 showing for the first time clear details of individual stars at this distance. Courtesy NASA.
Below: Photo 2. An oasis of life? – Earth as captured by fly past of Galileo in 1990. Courtesy NASA.





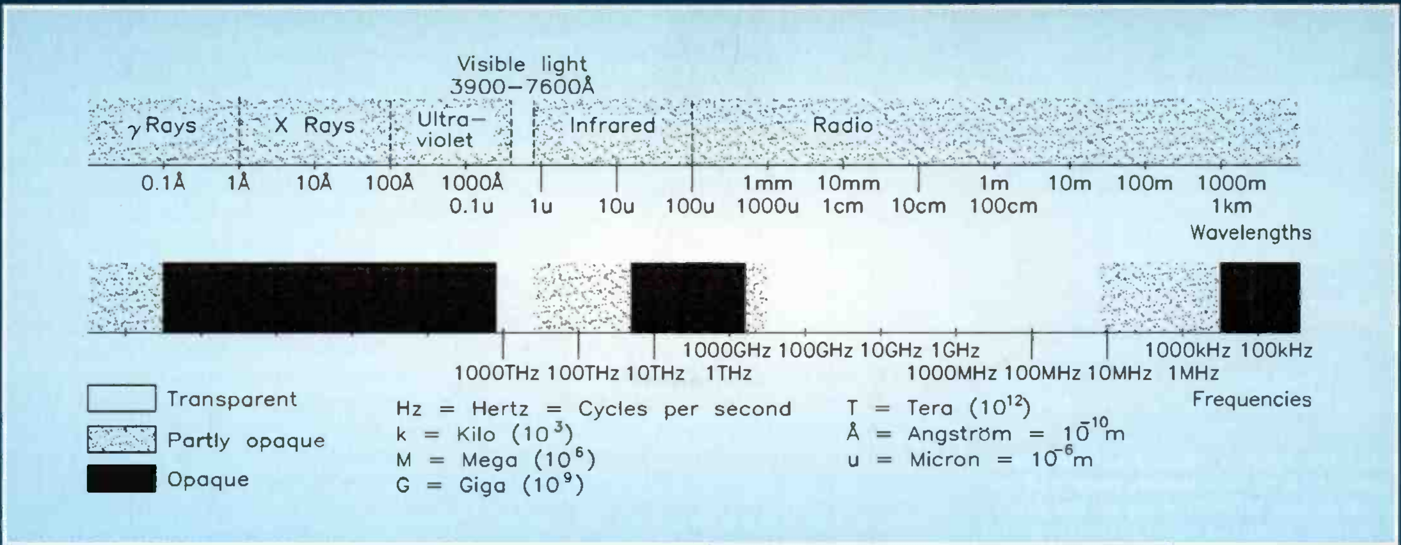


Figure 1. The degree of relative transmission through the earth's atmosphere across the electromagnetic spectrum.

Current space technology has problems with 'planet hopping' in our solar system, let alone venturing off to our nearest stars; it is certainly easier to 'listen' for activity. Even if civilisations have technology no more advanced than our own, we should still be able to detect signals from sources up to 1,000 light years away, and within this range, there are tens of millions of stars.

Photo 2 shows pictures of the Earth, taken from space, by the Galileo spacecraft in 1990. Against the blackness of space, the Earth does indeed look like an oasis of life. Is this the only planet within the universe that is teeming with life?

Figure 1 indicates the degree of relative transmission, through the earth's atmosphere, across the electromagnetic spectrum. The band of 'radio waves' from around 10MHz to 500GHz provides, by far, the biggest 'window' on the universe. In 1996, two satellites will be launched, and they will enable observations to be made from space (Russia's RadioAstron and Japan's VSOP satellites). Existing large radio-telescopes are also continuing to have their performance upgraded by improvement of geometry of the receiving dish, or by improvement in sensitivity of the signal detection systems.

It is difficult to gain a perspective on the scale of the Milky Way. Figure 2 shows a representation of our sun's position and the 1,000 light year zone within which signals could be detected. The Milky Way has a diameter of around 100,000 light years, and the sun is about 30,000 light years from the galactic centre.

Chain of Developments

Getting our feet back on earth, it is useful to consider the period of time during which people have been aware of radio signals from space – a mere 40 years. During the 1950s, there was growing public interest in the possibility of extra-terrestrial life. The scientific community, however, kept its distance. In the often quoted words of the nuclear physicist Enrico Fermi, "Where is everybody?", implying that no contact had apparently been made.

In 1959, two Cornell physicists – Giuessippi Cocconi and Philip Morrison, wrote (in *Nature*) about the potential of using microwave radiation to communicate between the stars. Frank Drake, a young radio astronomer, undertook a two month scan in 1960, using an 85ft antenna. Project 'Ozma' scanned two stars – one of which was 'Epsilon Eridani', about 11 light years from the earth. Monitoring took place at 1420MHz – the line of neutral hydrogen. This marked the beginning of earth-based monitoring for extra-terrestrial intelligence. Subsequent investigations by Canadian astronomers, in 1987, detected that the Epsilon Eridani system did in fact have a large planet orbiting the star.

Frank Drake first had his interest sparked in 1957, while observing emissions from the Pleiades at a wavelength of 21cm – there is a characteristic spectrum from this star system due to Doppler shift. Suddenly, a new distinctive signal appeared on the chart recorder, which resembled 'a rounded hill with a pylon'. Young Frank Drake felt 'rapture' at what looked to him like a cosmic 'hello'. Whatever the signal was, it acted as a stimulus to develop more structured searches. A current picture of the pioneer is shown in Photo 3.

In the 1960s, interest was shown by the Russians – in undertaking nearly omnidirectional observations to observe large areas of sky, rather than target searches of specific star systems.

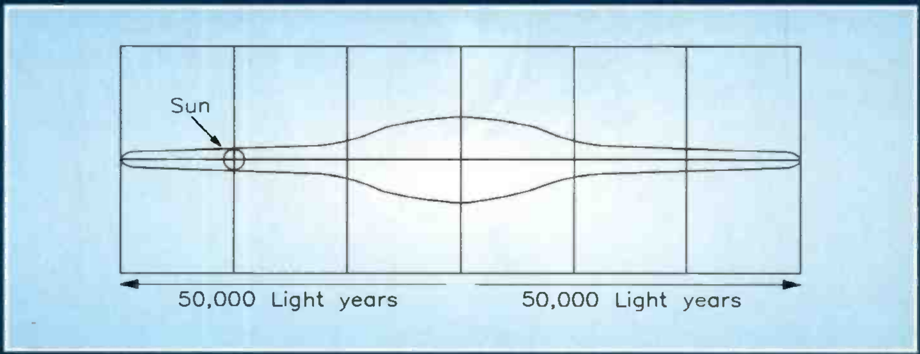


Figure 2. Relative position of 'listening zone' of 2,000 light years diameter around the sun within the Milky Way.

Photo 3. Frank Drake, SETI pioneer and enthusiast.
Courtesy Seth Shostak, SETI Institute.

Within NASA, Project Cyclops was initiated in the early 1970s; the aim was to undertake a comprehensive study of the technology required for such investigations. As the technology developed, in the 1970s, several independent observing programmes became established.

The Planetary Society's Project 'META' (Megachannel Extra-Terrestrial Assay), initiated by Professor Paul Horowitz of Harvard University, uses the 84ft radio-telescope at Harvard, and the Smithsonian Astrophysical Observatory. The system can scan 8·4 million narrow channels, and looks for strong signals near to the natural frequencies emitted by hydrogen or hydroxyl molecules. Since it became operational in September 1985, 'interesting' events, such as narrow-band structures and strong signal detection, have tended to take place at the rate of two per year.

The University of California's SERENDIP (Search for Extra-terrestrial Radio Emission from Nearby Developed Intelligent Populations) project operates using a 65,000

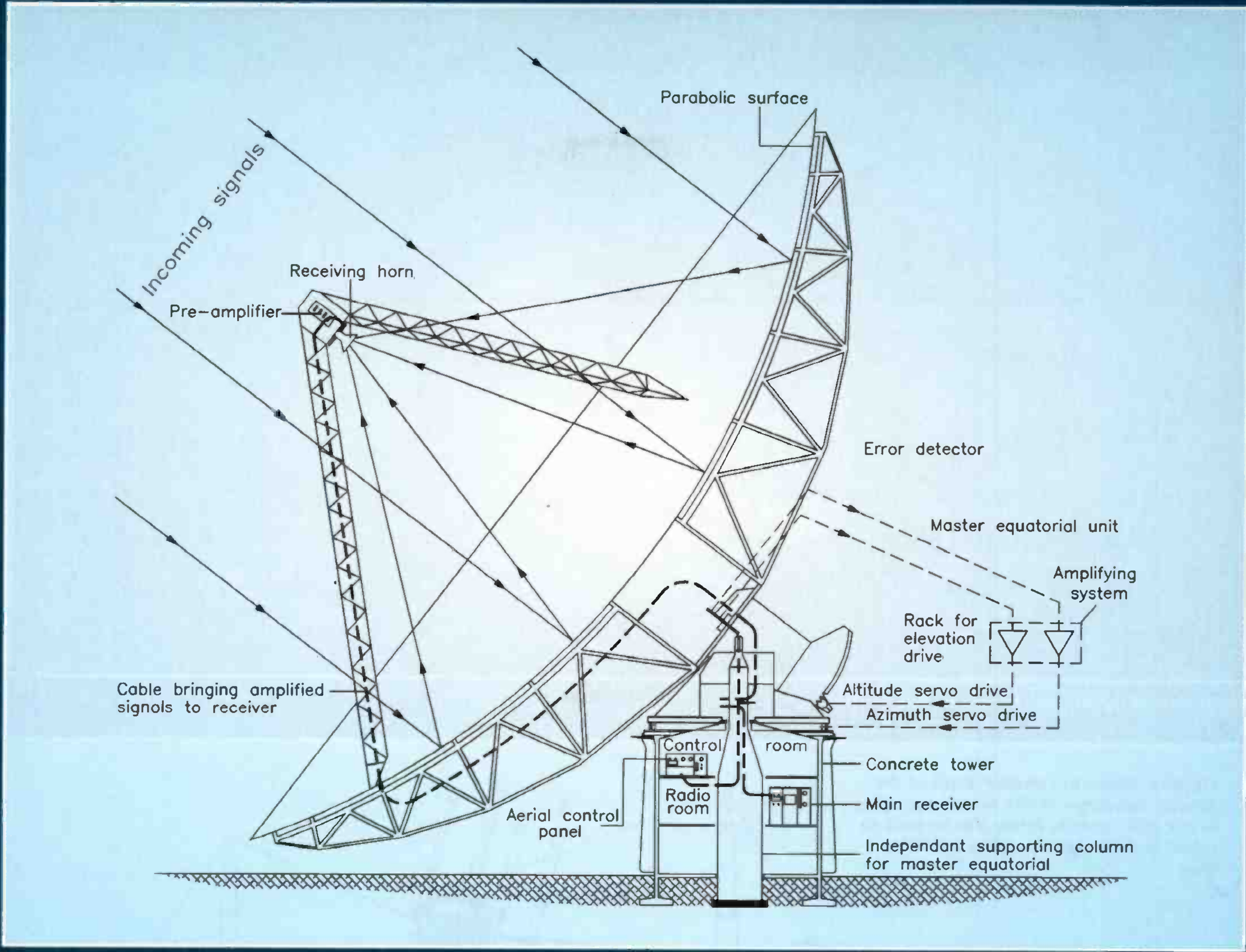


Figure 3. Details of the Parkes Observatory, New South Wales.

channel receiver at the national Radio Astronomy Observatory's 92 metre antenna in Green bank, West Virginia. While this system does not scan emissions as finely as the META system, it covers a wider range of frequencies.

An observation programme, also funded by the Planetary Society, has been in operation at the Ohio State University since 1973. Researchers associated with this project are quietly optimistic about some of the signals they have received – especially with one detected in 1977, which was described as the 'Wow' signal. This signal contained data within a 10kHz band, and the astronomers involved never identified the source, and as far as we know, the signal had never been repeated.

Initially, the telescope was of a fixed construction, and it rotated as a point on the earth's circumference. The telescope has been modified so that it can hold a fixed point for up to two hours, in order to continue investigation of interesting signals. The telescope is principally used to monitor transmissions between 1,400MHz and 17,000MHz – a frequency band known as the 'water hole,' and within which there is a low level of background noise. The assumption is that extra-terrestrial intelligence would know this, and send any 'information' signals within this band. There is a consensus of opinion, within scientific circles, that 'no signal' has yet been detected, and 'interesting' signals, when re-examined, have proved to be only noise.

Within the former Soviet Union, the MANIA (Multichannel Analysis of Nanosecond Intensity Alterations) system has been active since the 1970s. A six metre reflector has been used to look for very rapid fluctuations, in the visible light, from objects such as the 'Crab nebula SS433'. It was also planned to build a new SETI-type facility in south-central Asia.

Formal SETI programmes became established in the late 1970s at NASA's Ames Research Centre, and at the Jet Propulsion Laboratory (JPL) Pasadena. It was resolved that work at Ames would involve a targeted search of the nearest 1,000 sun-like stars, while JPL would undertake a general 'Sky Survey', in which all directions would be systematically swept. The targeted search would

The Parkes Telescope

The Parkes Telescope is in fact about 20km north of the town of Parkes in New South Wales. The 64m diameter dish was completed in 1961, and incorporates many innovative design features attributed to Sir Barnes Wallis (then Chief Engineer of Vickers) including aspects of the mounting system and the guidance system. The initial SETI search plan was to scan 172 star systems which are visible from the southern hemisphere. A diagram of the telescope is shown in Figure 3.

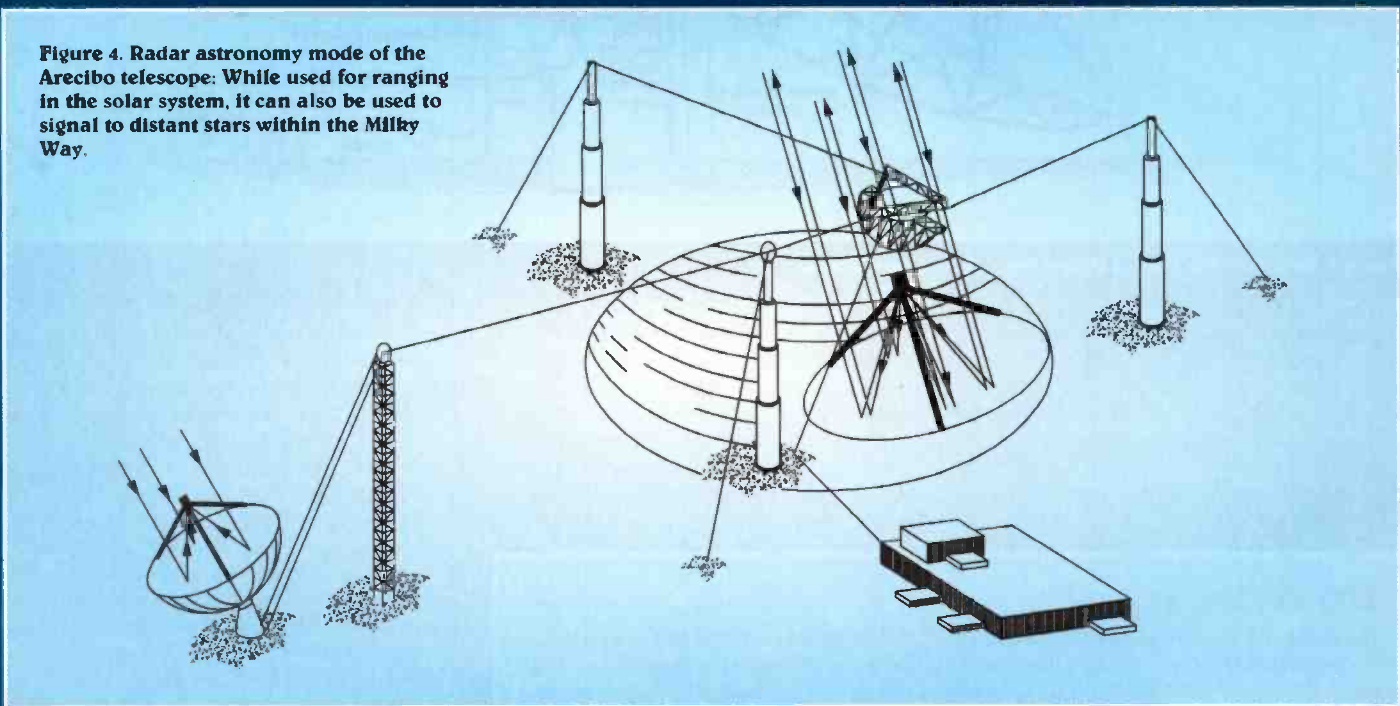
The Big Ear at Arecibo

The 310m diameter Arecibo radio-telescope, located near Arecibo in Puerto Rico, and operated by Cornell University, is used both to listen to 'greater universe', and also undertake radar-like mapping of the solar system using powerful 70cm and 12·6cm transmitters. An aerial view of the telescope is shown in Photo 4. Used in 'echo mode', as shown in Figure 4, the 450,000W 12·6cm transmitter is used to track objects and to measure distances accurately. Such a system has been of considerable value to NASA in increasing the accuracy of flight-control for space probes in the Solar System. As a signalling device to the universe, the Arecibo facility is unsurpassed. Signals sent out, in narrow beams, from the transmitter should be able to be detected anywhere in the Milky Way! In relative terms, the signal transmitted from the Arecibo transmitter would be around 10 billion times stronger than our sun.

There have already been exercises in sending coded data to other stars. In 1974, a coded message was broadcast containing details of the structure of our solar system, the elements important for life, the structure of the DNA molecule, and the shape of the human figure. Such data was sent from the Arecibo Observatory to the M13 star cluster, some 25,000 light years distant.

Aerial view of the Arecibo telescope, Puerto Rico.

Figure 4. Radar astronomy mode of the Arecibo telescope: While used for ranging in the solar system, it can also be used to signal to distant stars within the Milky Way.



scan suns of a similar type to that of our own – spectral types F, G and K with luminosity class V. Funding was eventually provided in 1988, after a decade of study and preliminary design. During this period, the technology available to undertake such investigations, developed considerably. This High Resolution Microwave Survey (HRMS) was planned to be a ten year initiative; it began to make its first observations on 12 October 1992.

NASA's 10 year SETI initiative led to the development of digital receivers which could scan tens of millions of radio channels simultaneously, with a typical bandwidth of 1Hz. This made the process of scanning for intelligent life possible within a realistic timescale. However, increasing interference from the microwave bands of telecommunications satellites means that it is important to undertake such observations now.

The Rebirth of SETI

In the closing months of 1993, it was announced that NASA was withdrawing funding for the SETI (Search for Extra-Terrestrial Life) project. Although the SETI project represented less than a tenth of one per cent of NASA's budget, the initiative fell foul of a general funding squeeze from Congress. This had an immediate effect on the search at JPL, where between 30 and 40 hours per week of the General Sky Survey was being undertaken.

There are hopes however, that the project will again come to life under the private funding of the 'City Institute' in California, as Project Phoenix. It is estimated that the City Institute initiative will require funding of the order of $3 to $4 million per year. Significant investment in the upgrading of the data capture/processing system will also be required.

Fortunately, the considerable investment in planning and technology of SETI is being preserved by this private funding of the SETI initiative. The process of observation has indeed been halted, but it is planned to resume during 1995. Effectively, the targeted search has been delayed by about 6 months, but the general sky survey is cancelled, with no immediate prospect of it being resumed.

At the present moment, radio-telescopes within the northern hemisphere, which have the potential for such survey work, are either being upgraded, or are heavily occupied in conventional radio-astronomy activities, and are not available for Project Phoenix. However, it has been proposed that the radio-telescope at Parkes (New South Wales, Australia) may be used for the project.

Interest is centred, primarily, in the range of microwave wavelengths between 1GHz and 10GHz. This represents a 'window' within the electromagnetic spectrum, which is not influenced by 'background noise' (created by spiralling electrons within galactic magnetic fields), and 'detector noise' in earth-based listening stations. It is also assumed that this will be the range of frequencies most likely to be used by any extra-terrestrial intelligence.

Part of the problem with undertaking detailed scanning of such a wide bandwidth is setting meaningful signal bandwidths at each centre frequency being scanned. It has been determined that very short bandwidth signals (of less than 1Hz) would be broadened to a minimum of 1Hz, as a result of proroga-tion through space. It is therefore anticipated that a channel bandwidth of 1Hz will be used for scanning captured data.

If the bandwidth of 1Hz was scanned through 1GHz of signal, with 15 seconds of data being captured in each channel, then this would take around 475 years to complete. Data capture and data processing systems are being developed which will be able to scan 30 million continuous channels. This is largely undertaken with the aid of extremely powerful computer systems to analyse the frequency content of the signals. Conventional radio-astronomy observatories typically analyse between 100 and 1,000 channels in the monitoring of radio signals from deep space.

With this type of equipment available, a scan across 10GHz of signal, with a dwell time of 1 minute in each channel, could be undertaken in about 5 hours. It would be reasonable therefore, to undertake a 'local' sweep of 1,000 such objects in a total of around 5,000 hours of observation time. Taking into account the logistics of achieving line-of-sight contact with the required objects, the investigation programme is more likely to take several years.

It is impractical to store the vast volumes of data captured by the system. The real-time processing, while monitoring the 30 million concurrent channels, stores only a small fraction of the available data. Specific software routines store 'interesting' data for further investigation. Present plans are for the observational phase to last until 2001, though this is dependent upon availability of radio-observatory facilities.

What If . . .

Signals which have an apparent extra-terrestrial origin will be required to be received by at least two observatories. If any signal is detected and confirmed in this way, then there already exists a protocol for the 'Declaration of Principles Concerning Activities Following the Detection of Extra-terrestrial Intelligence'. As can be imagined, however, it is important that great care is undertaken to ensure correct interpretation of data before a public announcement is made. If an announcement is made, it will probably be made directly to news agencies and not through levels of political control.

One of the more basic types of data to be transmitted would be that of an image. It would be reasonably simple to determine its 'frame size', and decode its representation.

If, however, a signal is received, a so-called 'Post-Detection Protocol' is being drafted. Presumably, it would be for the bodies such as the United Nations to decide the nature of any response.

Summary

It is disappointing, and a perhaps an indication of the 'wisdom' of politicians, that NASA's SETI Project was terminated in order to save a few cents in NASA's budget. It is also rather surprising that no specific multi-national initiative had been set in train. The basic attitude of the workers of Project Phoenix is very positive and outgoing. It is recognised only too well what 'contact' would mean for humanity at large – it would be the biggest scientific discovery of all time! Cherished viewpoints of the 'uniqueness of man' would be swept away, and social and scientific theories would have to be extensively revised. In the decision not to fund SETI, is there evidence of a 'Do Not Disturb' desire in certain levels of society – perhaps believing that revelations could bring about social instabilities?

So, the next time you tune in the radio, be aware that soon a radio telescope dish near you could be listening to 30 million channels at once for signs of intelligence (even on terrestrial radio channels, the search for intelligent material can be elusive).

Points of contact:

Australia Telescope National Facility: CSIRO Radiophysics Laboratory, P. O. Box 76, Epping, New South Wales 2121, Australia.
SETI Institute, 2035 Landings Drive, Mountain View, California, CA-94043, USA.
Tel: +1 415 961 5005.
National Astronomy and Ionosphere Center, Cornell University, Space Sciences Building, Ithica, New York, 14853-6801.
Tel: +1 607 255 3735.

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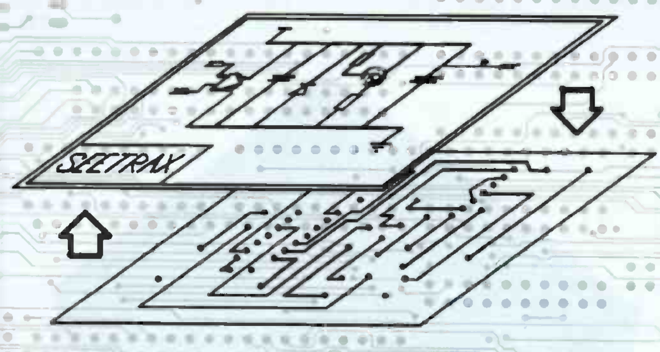

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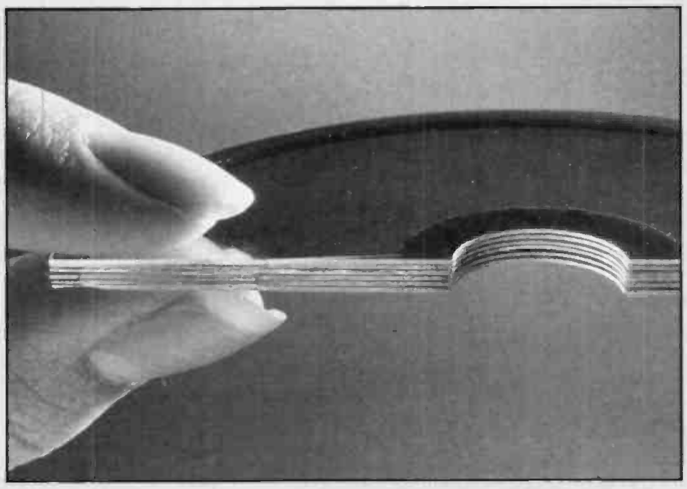
NEWS Report



IBM Makes World-Record Disk-Drive Recording Head

IBM scientists have revealed what is believed to be the world's most sensitive sensor for detecting computer data on magnetic hard disks. They expect this new design will be used in disk-drive products by the turn of the century to store information nearly twenty times more densely than is possible today.

Called a spin-valve head, the new sensor is already five times more sensitive than today's best commercially available disk-drive sensor. This capability is due to the giant magneto-resistive (GMR) effect, which was discovered less than six years ago. IBM's spin valve is the first high-density recording head design to take advantage of the GMR effect.

Scientists performed this work at IBM's Almaden Research Center as part of the Advanced Magnetic Recording Laboratory (AMRL) joint program between Almaden and SSD. The scientists used the sensor to read data bits written onto a magnetic hard disk at a density of 1 billion bits per square inch.

The spin valve's stronger signal gives disk-drive designers the option of packing more bits into a given area of disk surface, thus increasing the data capacity of the disk drive – or relaxing other design constraints to increase performance, such as faster data rate, by spinning the disk faster – or ruggedness and reliability, by flying the head farther from the disk. Much of the data-density increases would come from a sixfold decrease in the magnetic bit track width – from 3 to 0·5 microns – that this spin-valve design permits. Contact: IBM Tel: (0705) 561780.

Fibre-Channel Transceiver

The RCC700 is a CMOS transceiver which operates at serial data rates up to 265M-baud and integrates all the required transceiver functions onto a single low power chip. The RCC700 is the most integrated product available, incorporating 8B/10B Encoder/Decoder, a Serialiser and De-serialiser, a Phase Locked Loop Frequency Synthesiser, a Phase Locked Loop Clock and Data Recovery, and a Byte Alignment circuitry. The alternative RCC701 device is available which does not feature the 8B/10B Encoder/Decoder functions and provides a 1-bit parallel Interface.

Complete evaluation PCB assemblies are available for fibre or coaxial interfaces, which feature on-chip loopback for diagnostics, and which are compatible with IBM's OLC card footprint, featuring a similar 48-pin connector for ease of installation, and evaluation of high-resolution graphic display terminals, high-speed test equipment or video data transmission equipment.

The RCC700 and RCC701 require a single +5V supply and draw 600 and 550mW of power respectively, measured when operating at 200M-baud.

Applications for the RCC700 include Fibre Channel, ESCON, SSA, ATM, Bus Extender, Digital Video Communications and Test and Instrumentation. The Fibre-Channel standard also provides a common interface for HIPPI, IPI and SCSI standards. Contact: Microelectronics Technology, Tel: (0844) 278781.

AA Available in Lithium

Ever Ready has introduced the first 1·5V AA size lithium battery. Branded Energizer Hi Energy Lithium, the AA battery will give around three times longer life than the alkaline equivalent and is particularly recommended for photographic, computer and business equipment applications.

Lithium cells for specialist applications have been around for some time, with the market seeing significant growth in recent years. Since 1986, sales of lithium have increased from £4 million to £18 million – an increase of over 450% – and in volume terms lithium now accounts for 3·2% of the total battery market.

However, the most popular battery size, the AA – which accounts for 60% of all battery sales – has not until now enjoyed the benefits which lithium technology can bring. The potential for the new Energizer Hi Energy Lithium is therefore enormous as it can be used in all appliances that take AA size batteries, including Walkmans, hand-held games and toys.

The batteries will retail on blister cards of two with a recommended selling price of £5.99 per pack. Contact: Ever Ready, Tel: (071) 622 5549.

At Last – a CD Player that DJs can Mix it With

DJs, more than most, know that the supply of vinyl records – traditionally essential to the arts of creative manipulation like cutting and scratching – is beginning to dwindle. The favoured 12in. single format is being slowly relegated to specialist shops – and is getting more expensive to obtain.

Like it or not, CDs are becoming the dominant format and, as 12in. singles start approaching the price of CD albums, all DJs know that it is time for an alternative. CDs have many advantages for DJs. They are much more robust, will not wear out like records and are easier to store. What's more, the better sound quality will be important in commercial mix production.

Recognising that the purge on vinyl is going to hamper the DJ's creativity, Pioneer has just launched its CD-J500 CD player, which is equally at home in a bedroom studio, a mobile disco,etc.

Unlike current CD players on the market, the CD-J500 is built to withstand the rigours of professional use, and will find a place alongside the legendary Technics SL-1200 turntable on the DJ mixing console. The top-loading CD-J500 is ruggedly constructed with ergonomically-arranged controls, an easy-to-read display and an anti-vibration CD transport that will prevent skipping – even with the loudest and bass-heaviest sound systems.

A well-built CD player is important to a DJ environment, but equally important are the features that give the DJ the ability to 'play with the music' as they can with vinyl. The CD-J500 has a roster of features that will appeal to DJs, including those which could never be implemented on a turntable.

The most crucial is the jog dial, which allows DJs to manipulate the CD as easily as they would a record, but with none of the wear and tear. Music can be searched frame-by-frame, and cue spots selected with extreme accuracy.

For beat mixing, control over the tempo is essential – the CD-J500 is one of the very few CD players that have this function. A slicer control gives ±10% control over the pitch. In a Pioneer 'first', another control allows the music's pitch to be locked – even if the tempo is changed. You can now speed up or slow down the music's beat without changing the pitch of the music or vocals.

An easy-to-use 'loop' or function allows any phrase of the CD to be sampled and looped as many times as desired. In addition, a cue-point sampler will store up to a second of CD-quality sound, and the stored phrase can be accessed by hitting a button – and laid on top of the music being played on the CD. If the DJ normally uses a sampling workstation for this, it can be freed for other activity.

The CD equivalent of the slip-mat is provided on the CD-J500 – a 'quick start' function memorises the start point of a track, allowing the rhythm of the music to be matched with split-second accuracy. Contact: Pioneer, Tel: (0753) 789789.

Maximum Product Development

Maxim have been busy in the fabrication labs this month. Five new products available now include:

Integrated Power Supply
The MAX781, which features a 3·3V supply, dual PCMCIA analogue controllers, a programmable battery charger, five high-side level translator outputs and an SPI serial interface in a single shrink small outline (SSOP) package. It accepts inputs from Ni-Cd or Ni-MH battery stacks of 5 to 8 cells (5 to 18V), making it suitable for PDAs and other wireless computers.

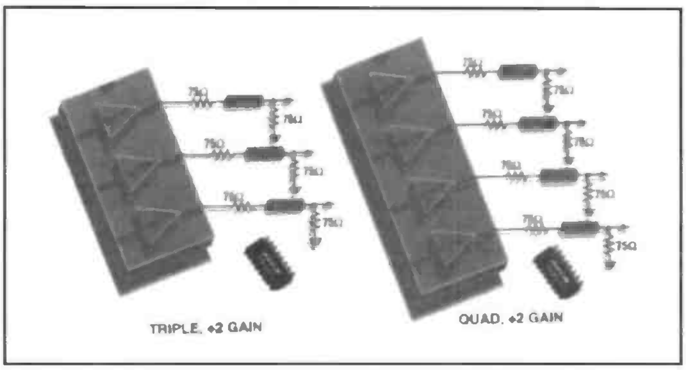
Two Cells In – RS-232 Out
The MAX218, which is claimed to be the first to produce true RS-232 output levels when powered from two battery cells. Operating from two alkaline, Ni-Cd or Ni-MH cells, the MAX218 converts from input voltages of +1·8V to +4·25V. The new design integrates a step-up DC-to-DC converter and charge pump inverter to produce true RS-232 levels with improved efficiency. Data rates are guaranteed up to 12k-bps to allow rapid downloading of information.

100MHz Triple and Quad Wideband Video Buffers
The MAX467-MAX470 are triple and quad buffers designed with closed-loop gains of +1 or +2 (6dB). Ideal for driving 50Ω or 75Ω back-terminated coaxial cables, they feature the lowest differential gain/phase error (0·01%/0·03°) in the industry. Specified for ±5V supply operation, these devices guarantee an output drive of ±2·5V into a 75Ω back-terminated load (150Ω).

100MHz Broadcast Quality Crosspoint Switches
The MAX458/MAX459 8 x 4 video crosspoint switches are monolithic ICs intended to replace multiple switches, amplifiers and logic, and as a result save a tremendous amount of board space and design time. The MAX458 includes four digitally controlled, 100MHz unity-gain-stable output buffers (A_v=+1) and differential phase and error of only 0·02° and 0·06% respectively. The MAX459 includes four 90MHz, 300V/µs amplifiers with a fixed gain of +2 for driving 150Ω back-terminated cable directly, without external feedback resistors.

Isolated RS-485 in Single Package
The MAX1480 is a complete, 500V rms isolated RS-485 transceiver – including optocouplers, transformer and diodes – all in a 28-pin package. Why waste time designing and debugging a discrete isolated RS-485 solution when you can plug in the MAX1480 for under £8?

The MAX1480A is guaranteed to run at data rates up to 2·5M-bps, making it ideal for high-speed applications. The slew-rate limited MAX1480B, with a guaranteed 250K-bps data rate reduces EMI 100% over other RS-485 transceivers. Slew-rate limiting reduces reflections, so error-free data can be transmitted over longer cable lengths. Contact: Maxim, Tel: (0734) 845255.



MPEG Comes to PC

VideoLogic has launched a VESA Media Channel-based PC card to conform to the Motion Picture Experts Group (MPEG) standard for video playback. Called MPEG Player, the card offers users the capability to run full screen, full motion CD-based software on desktop PCs with TV-quality images and CD-quality sound.

MPEG has defined open ISO-supported standards for the compression and decompression of video and audio signals and their synchronisation during playback. MPEG achieves its efficiencies by exploiting the fact that movies and motion video contain sequences of frames in which individual frames are only marginally different from previous and subsequent ones. MPEG encoding only records the differences between frames, resulting in an algorithm that achieves compression ratios up to 200:1 over normal video.

Using MPEG, a single speed CD-ROM drive can deliver TV-quality video and CD-quality audio on a standard PC, and up to 75 minutes of synchronised video and audio can be squeezed onto a single CD-ROM.

First generation boards used the VGA feature connector approach, which made them difficult to install, hardware overhead-intensive, and constrained the expansion of a PC.

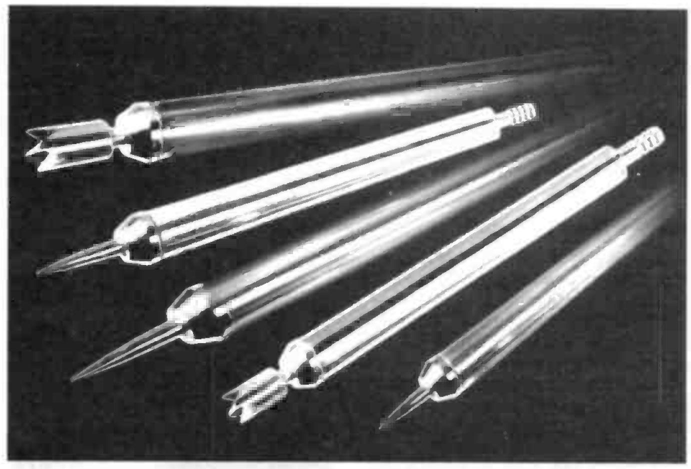
In contrast, the MPEG Player card delivers higher quality images and sound at a lower cost and allows users to continue to maximise the potential of a PC. In particular, the VideoLogic PowerStream video processor incorporated in MPEG Player, provides real-time video dithering and scaling using an algorithmic technique called SmoothScale which removes the jagged edges associated with some of the cruder interpolation techniques, offering the benefits of better quality video playback. Contact: VideoLogic, Tel: (0345) 626353.

Watch out for the forthcoming article in *Electronics* on MPEG.

90 and 100MHz Pentium Processors

Intel has introduced new Pentium processors running at frequencies of 90 and 100MHz.

The new Pentium processors will be manufactured in volume at Intel's advanced microprocessor production factories in Ireland and Santa Clara. With the 3·3V, 0·6µm, 4-layer metal advanced process technology, the chip is approximately half the size of other members of the Pentium processor family. This announcement comes on the heels of Intel's demonstration of a 150MHz Pentium processor at the IEEE International Solid State Circuits Conference (ISSCC) in San Francisco last February. Contact: Intel, Tel: (0793) 430763.



Pneumatic Test Probes from Peak

Peak has introduced a range of pneumatically operated test probes in which the probe is 'fired' pneumatically to make a positive contact with the item under test, unlike conventional spring probes where the item under test pushes the probe down.

The positive firing action means that the probes can be controlled to make contact at precise times. This is often required in applications such as sequential functional testing, where probes have to be contacted at specific times in the test cycle. Contact: Peak, Tel: (091) 387 1923.

Research Machines on the Up

Oxford-based Research Machines has had a record first six months with pre-tax profits to 31st March up 204·1% to £155,000 on the same period last year.

The company has also seen a 3·4% increase in turnover to £28·7m. Its half-yearly success story, as Research Machines put it, is in part due to the National Council for Education and Technology's £1·4m investment in multimedia Window Box personal computers for primary schools.

But Research Machines' main market is in secondary schools where it claims a 52% market share. However, the company is not nearly so dominant in primary or further education where it has roughly a quarter of the share.

The other main player in the computers for schools market is Acorn. Research Machines see that all its products are Windows-based as a major strength, whereas Acorn's are not.

In line with the announcement of its financial results, Research Machines has announced a new-based personal computer range in an attempt to jump aboard the multimedia bandwagon, and what is more important, in the belief that falling prices for Pentium microprocessors will mean that they will become more accessible for schools.

The Pentium professional has a 60MHz processor with 256K-byte cache. It has a 210M-byte hard disk, 8M-byte memory, MS-DOS and Windows. A 90MHz system will be available later in the year. Contact: Research Machines, Tel: (0235) 826000.

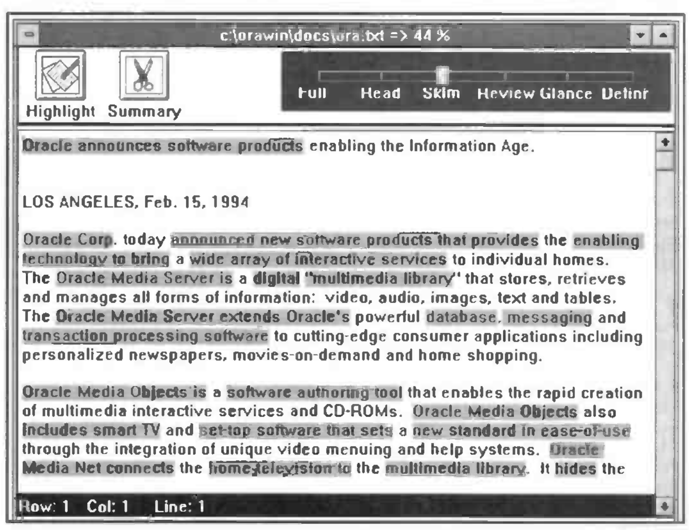
Data Analysis

Oracle UK has introduced Oracle ConText, claimed to be the first data management software capable of analysing the content and meaning of unstructured text, estimated to make up to 90% of today's electronically stored data.

Since Oracle ConText can automatically search and retrieve a summary of relevant information, it reduces the prospect of information overload, providing a competitive edge to a range of businesses.

Oracle ConText, a natural language processor, analyses the structure of documents, and understands their content. It assigns importance to words and sections of English writing, then reduces the text down to its main elements. This allows documents to be summarised without human intervention, delivering only the most relevant and valuable information.

Oracle ConText can be used by information providers and publishing companies. Other typical applications will include market research, newswire monitoring, R&D knowledge bases, intelligence gathering, patent search and litigation support. Contact: Oracle, Tel: (0344) 860066.



What's On?

Caught in the Net

You could get 'Caught in the Net' when Dan O'Brien, journalist and cybernaut, hands you a packed lunch of Jolta Cola and Ublik sandwich and drives you down the hard shoulder of the world's computer superhighways.

From the fleshpots of the White Sands Missile Range to the man who was Prince Philip, from the million-dollar cyclist, to the Hacker Who Bred Too Fast. You'll see it all, in person, on television.

'Caught in the Net' is all about Internet. The information superhighway. The infobahn. An international data network with over 13 million members who meet where none can go, and who talk without saying a word. About love. About fear.

'Caught in the Net', from 10th August to 3rd September, at The Pleasance, Edinburgh documents the history of hacking and explores the characters, legends and arcane information of the Internet. The show is written and

performed by Dan O'Brien, writer and journalist for *The Guardian*, TV's Spitting Image, Radio 4's Week Ending and the technical pages of *Personal Computer World*.

Dan previously appeared in the Oxford Revue and co-wrote and performed last year's sell-out Edinburgh Fringe sci-fi spectacular 'It Happened Tomorrow'. 'Caught in the Net' is an hour-long one-man show which features the latest in multi-media equipment, allowing Dan to happily surf through every node of cyberspace, using a transfixing combination of live computer readouts, video footage and a closed-circuit TV camera monitoring events backstage. Contact: The Pleasance, Tel: (031) 556 6550.

Radio Conference

The Sixth International Conference on Radio Receivers and Associated Systems will be held at the University of Bath, from 26 to 28 September 1995.

The Conference will deal with all frequencies from ELF to millimetre-wave. Sessions will be devoted to receiver integrated circuits, receiver measurements and performance, radio systems, mobile and personal radio, paging and cordless communications, antennas and propagation, receiver design, spread spectrum and digital receiver techniques.

Throughout the world, radio receivers are by far the most common types of electronic equipment. Over the past few years considerable advances have been made in the science and technology upon which the design of receivers depends. At the same time new system requirements are making increasing demands on receiver designers and are leading to the evolution of essentially new types of receivers. Contact: IEE, Tel: (071) 836 0190.

Radio Pioneer

This summer sees celebrations taking place in Liverpool to celebrate the centenary of the world's first public demonstration of radio by Sir Oliver Lodge.

Lodge developed the ideas of Maxwell and Hertz to carry out experiments before the work of Marconi. His book *Signalling Through Space Without Wires* was published in 1894.

Many of Lodge's experiments were carried out between the Victoria Building within the University of Liverpool and Lewis's department store. He coined the term coherer for his very sensitive detector and was the first person to use resonance for selective tuning.

At this time Lodge was Professor of Physics at Liverpool, before going on to become one of the foremost UK scientists of the day. In 1925, he was elected the third president of the Radio Society of Great Britain. Contact: Radio Society of Great Britain, Tel: (0707) 659015.

LIVE '94 The Consumer Electronics Show

LIVE '94 promises to be the most exciting consumer electronics event ever held in the UK. LIVE '94 brings consumers and manufacturers together so that the visitor can see and hear exactly what these new products have set out to achieve – and get their finger on the pulse of these new technologies and systems. Consumers at the show are invited to:

Take part in the making of LIVE television and radio broadcasts.

Preview new releases for Christmas – movies, music, games and software.

Go hands-on with PCs, PDAs, multi-media and *edutainment*.

Attend seminars and master-classes run by top specialists.

Don't forget that Maplin Electronics will be there as well, so visit the stand, and have a chance to speak to us in person.

LIVE '94, to be held at London's Earls Court, will run for six days from 20 to 25 September and expects over 200,000 consumers to take an early opportunity to get their hands on the consumer electronic goodies launched for the Christmas season. Contact: LIVE '94, News International Exhibitions Ltd., London, Tel: (0891) 500 103

DIARY DATES

Every possible effort has been made to ensure that the information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments please contact event organisations to confirm details.

2 August. Talk on Aerials, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

7 August. Toy and Trade Collectors Fair, National Exhibition Centre, Birmingham. Tel: (0526) 398198.

7 August. Radio Society of Great Britain, Annual Spares Sale, Woburn Abbey, Woburn. Tel: (0525) 290666.

10 August to 3 September. 'Caught in the Net', at the Pleasance, Edinburgh. Tel: (031) 556 6550.

20 August. Evening on the Air, Crystal Palace & District Radio Club, All Saints Parish Church Rooms, Beulah Hill. Tel: (081) 699 5732.

3 September. Wight Wireless Rally, National Wireless Museum, Arreton Manor, near Newport, Isle of Wight. Free admission and free stands to both public and traders. Tel: (0983) 567665.

4 September. Applied Optics & Optic-Electronics Conference, Institute of Physics, York. Tel: (071) 235 6111.

5 September. EMC – 9th Electro-magnetic Compatibility Conference, Institution of Electric Engineers, Armitage Centre, Manchester. Tel: (071) 240 1871.

6 September. Annual General Meeting at Wells Hall Old School, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

6 September. Energy '94, Olympia National Hall, London. Tel: (071) 370 8207.

8 September. Hi-Fi Show, Ramada, Heathrow, London. Tel: (081) 686 2599.

11 September. The 13th Lincoln Ham Radio Festival – Hamfest, Lincolnshire Show Ground, Lincoln. Tel: (0522) 525760.

11 to 24 September. Plasma Light & Sound Show, Earls Court, London. Tel: (071) 244 6433.

12 September. Opening Night and Dayton '94 by Herb Asmussen OZ7SM and George Beasley G3LNS. Stratford upon Avon and District Radio Society. Tel: (0789) 740073.

20 to 22 September. CEMEX '94 – Circuit Equipment Exhibition, National Exhibition Centre, Birmingham. Tel: (0705) 665133.

20 to 25 September. LIVE '94, The Consumer Electronics Show, Earls Court, London. Visit the Maplin stand, and have a chance to speak to us in person. Tel: (0891) 500 103.

26 September. Top Band DF Construction by Geoff Foster G8UKT. Stratford upon Avon and District Radio Society. Tel: (0789) 740073.

26 to 28 September. The Sixth International Conference on Radio Recievers and Associated System, University of Bath. Tel: (071) 836 0190.

4 October. Talk on Electrical Safety and Regulations, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

10 October. Inside your PC by Martin Rhodes G3XZO. Stratford upon Avon and District Radio Society. Tel: (0789) 740073.

15 to 16 October. Warley National Model Railway Exhibition, National Exhibition Centre, Birmingham. Tel: (021) 558 8851.

24 October. QRP by Norman Field G4LQF. Stratford upon Avon and District Radio Society. Tel: (0789) 740073.

26 to 27 October. Instrumentation, Sandown Exhibition Centre, Sandown. Tel: (0822) 614671.

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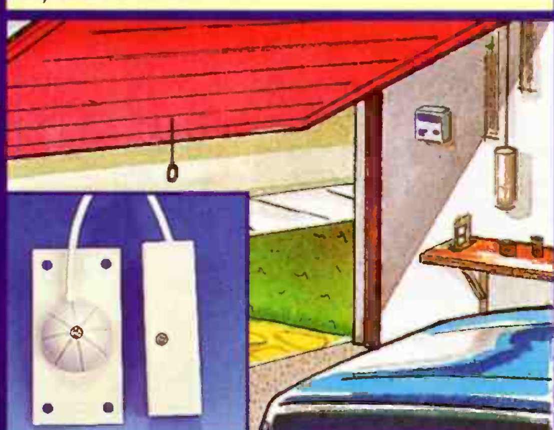

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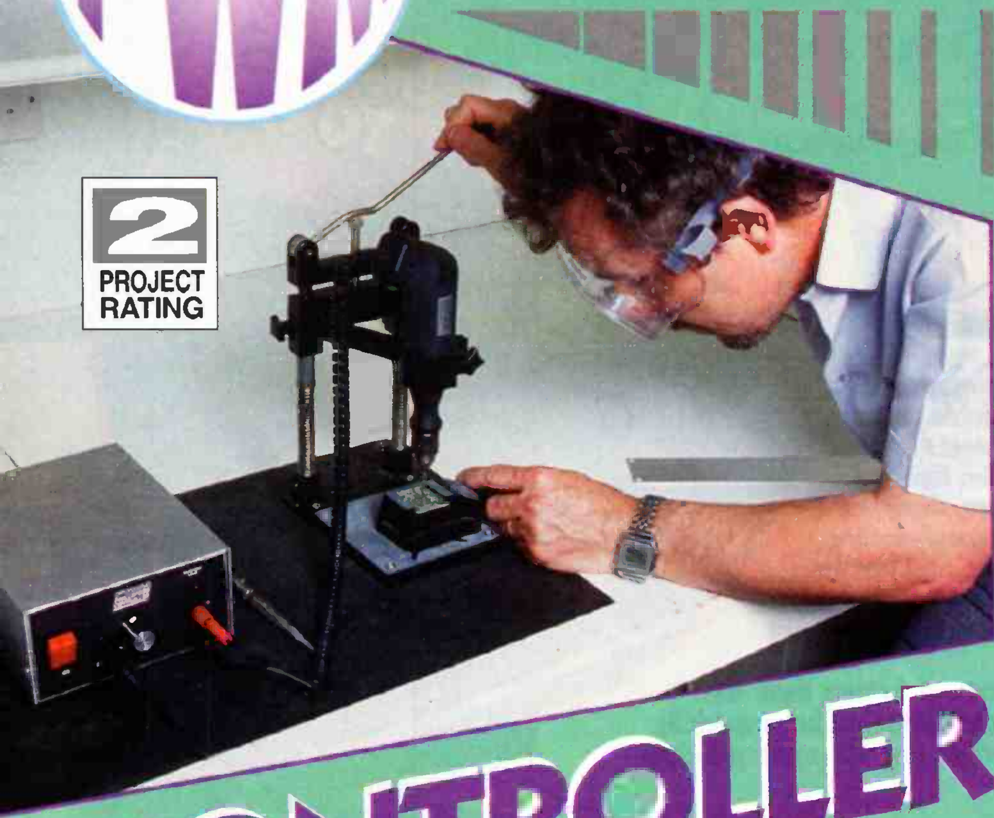
PWM DRILL SPEED CONTROLLER



2 PROJECT RATING

Many of us who own a mini drill for making PCBs and drilling project boxes, only have a general-purpose low-current variable-voltage bench PSU to power it up. More often than not, the PSU voltage collapses when asked for more than an amp or two. The drill PSU project presented here, is short-term overload proof (3 seconds maximum) and provides 100W of power for even the most current-hungry drill. The PWM (pulse width modulated) PSU even has an on-board 'current limit' LED indicator.

FEATURES

* High-current power rating
* Short-term overload proof
* Optional foot pedal control

APPLICATIONS

* Hobby drills
* Model train sets
* Remote-controlled model cars/boats

Above: The Drill Speed Controller in use in the Maplin Lab.

Right: The assembled unit ready for use, please note: the box shown is not included in the kit and must be purchased separately.

KIT AVAILABLE (LT64U)
PRICE £14.99

Design by Alan Williamson
Text by Alan Williamson and Robin Hall

THE drill speed is variable from zero to the maximum RPM of the drill. The project also has the option of a foot speed controller, allowing for fine control of the speed and for hands-free operation.

The PWM Drill Speed Controller can be used (when suitably modified) for controlling the speed of model trains or even remote-controlled model cars or boats.

Circuit Description

The block diagram of the PWM Drill Speed Controller is shown in Figure 1, and the circuit diagram in Figure 2; these will assist the reader to understand how the circuit operates.

IC1 is configured as a voltage-controlled Schmitt trigger oscillator; resistors R2 and R3 provide the Schmitt trigger function and R4 and C1 the oscillator components. The potentiometer RV1 adjusts the mark-to-space ratio of the oscillator to provide the pulse width modulation. Figure 3a illustrates PWM near minimum output, Figure 3b at half output, Figure 3c near to maximum output and Figure 3d at maximum output. The CA3140 op amp was specifically chosen because the output of the op amp will lock up when the input is taken within 1V of the supply voltage. This would normally be a disadvantage in most circuits but in this application it is an advantage as full power can be achieved.

The optional jack socket (JK1) is the input socket for the optional foot speed controller. The resistor R1 prevents the (non-inverting) input of the op amp from floating in the event of the wiper of RV1 becoming

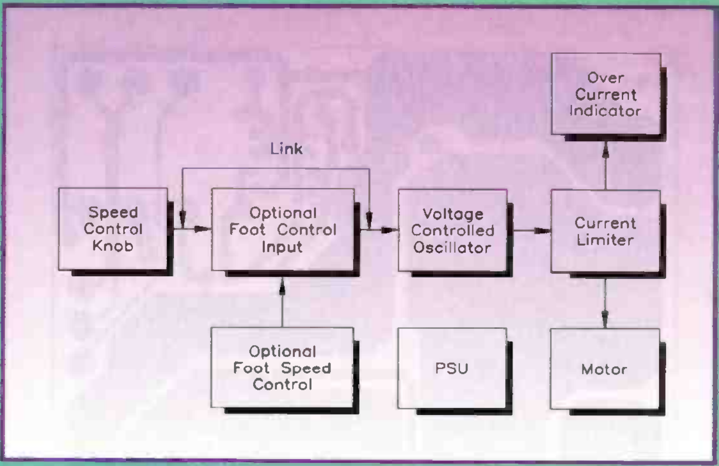
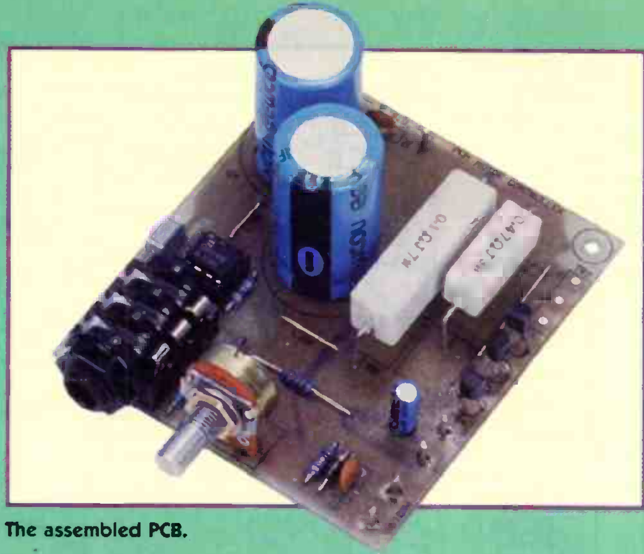


Figure 1. Block diagram of the PWM Drill Speed Controller.



The assembled PCB.

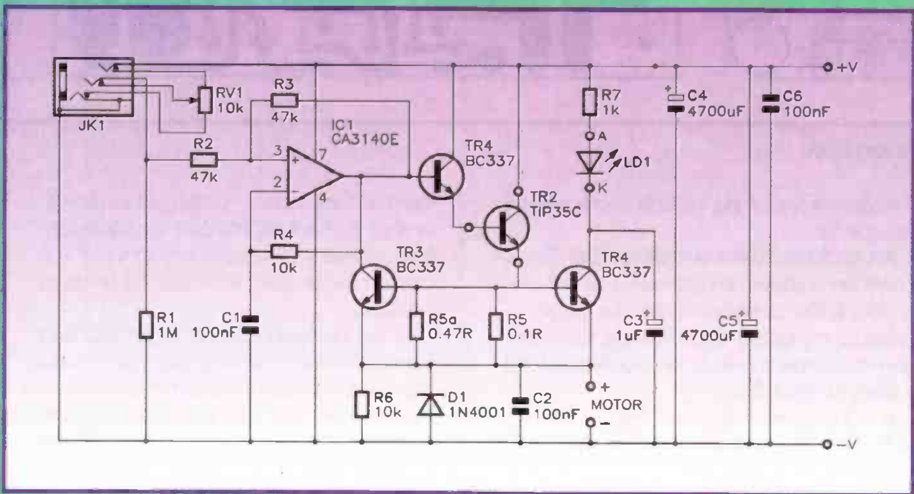


Figure 2. Circuit diagram of the PWM Drill Speed Controller.

intermittent; or such as when the foot controller is being plugged in.

The output of the op amp is buffered by the emitter follower TR1 to provide plenty of drive current to the power transistor TR2 (TR1 combined with TR2 form a Darlington pair). Resistors R5 and R5a monitor the output current by developing a voltage across them.

In an overcurrent situation, the voltage across R5 and R5a is approximately 0·7V (the base-emitter junction voltage of TR3 and TR4). Transistor TR3 turns on and then partially shuts down the Darlington pair TR1 and TR2 (only partially because TR1, TR2, TR3, R5 and R5a have now become a constant current source).

Transistor TR4 is also turned on, illuminating the LED (LD1) which indicates an overcurrent condition. With the potentiometer set to near minimum, the capacitor C3 effectively 'stretches' the narrow current pulses through the LED, enough to enable the *persistence of vision* to take over.

Resistor R6 provides a minimum load as well as discharging the motor suppression capacitor C2; the diode D1 protects the power transistor from any induced emf produced by the motor. Capacitors C4, C5 and C6 provide the necessary supply decoupling.

Altering the current limit is easily achieved. The current limit value is approximately equal to 0·7V divided by the value of R5 in parallel with R5a, e.g. (0·7V ÷ 0·1Ω) + (0·7V ÷ 0·47Ω) = 8·489A. The minimum value for R5 and R5a is 0·1Ω (7W), this gives a maximum current of 14A. However, the power transistor TR2 *must* have adequate heatsinking, i.e., for 14A, a minimum heatsink of 0·5°C/W is required.

Construction

Construction is fairly straightforward, refer to the Parts List and to Figure 4a for the PCB legend and Figure 4b for the track layout. Begin with the smallest components first, working up in size to the largest. All components are mounted on the PCB except TR2 and LD1. Decide whether the optional foot speed controller is to be used or not, as changes will have to be made to the controller, PCB and to the case.

If you are new to project construction please refer to the Constructors' Guide (XH79L) for hints and tips on soldering and constructional techniques.

Use component wire off-cuts for the links on the PCB and, additionally, if the optional foot speed controller is not to be used, fit three wire links in the JK1 position. If the optional foot speed controller is to be used, then fit the optional ¼ in. stereo jack socket in place of the three links.

Insert the PCB pins from the track side except the pins for TR2, which are inserted from the component side of the PCB.

The high-power resistors (R5 and R5a) should be mounted 5 to 10mm above the PCB; this is to allow plenty of ventilation around the resistors as they will become hot in full load applications.

Cover the tinned copper track areas, which are free from solder resist, with a thick layer of solder.

Be careful to orientate correctly the polarised devices, i.e. electrolytic capacitors, diode, LED, transistors and IC. The IC should be inserted into the socket last of all.

Thoroughly check your work for misplaced components; solder whiskers, bridges and dry joints. Finally, clean all the flux off the PCB using a suitable solvent.

Case Assembly

Mark out the holes required for the optional box type AB15; refer to Figure 5a for the front panel, Figure 5b for the base, and Figure 5c for the rear panel. Drill, cut and file the holes, removing all the burrs. Note that the two terminal post holes on the front panel are specially shaped, as is the hole for the mains connector. Take care with the TR2 fixing hole, as the transistor is required to be closely bonded to the case (do not forget to add some thermal compound).

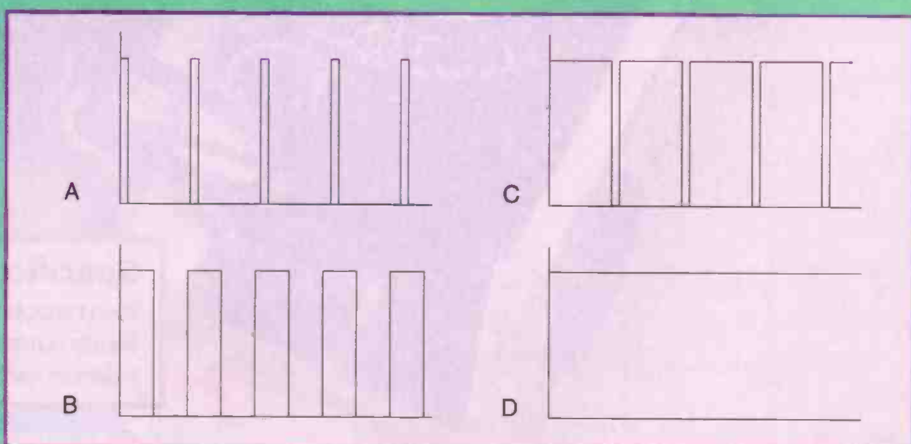


Figure 3. The PWM Drill Speed Controller Waveforms.
(a) Near minimum output. (b) At half output. (c) Near maximum output. (d) At maximum output.

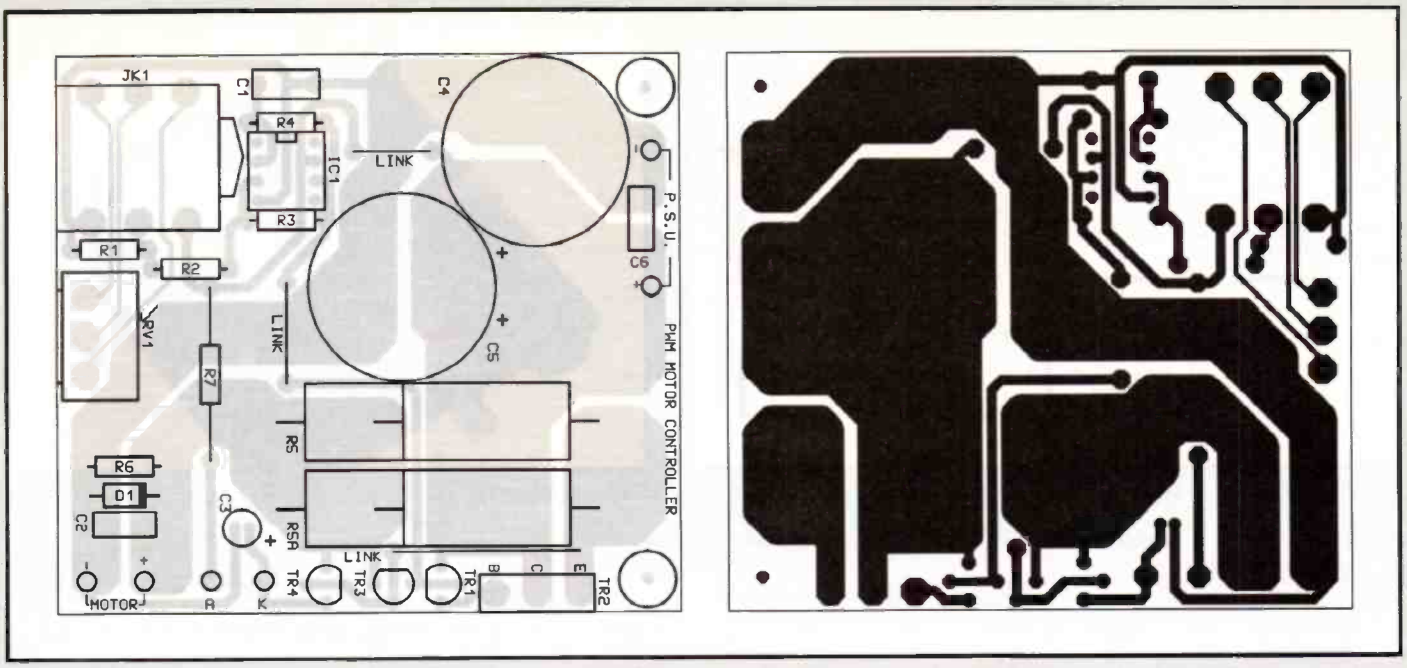


Figure 4. The PWM Motor Speed Controller PCB legend and track.

A plastic front panel label has been included in the kit (DE86T), and is shown in Figure 6. Fit the front panel label; trim around the holes with a sharp knife.

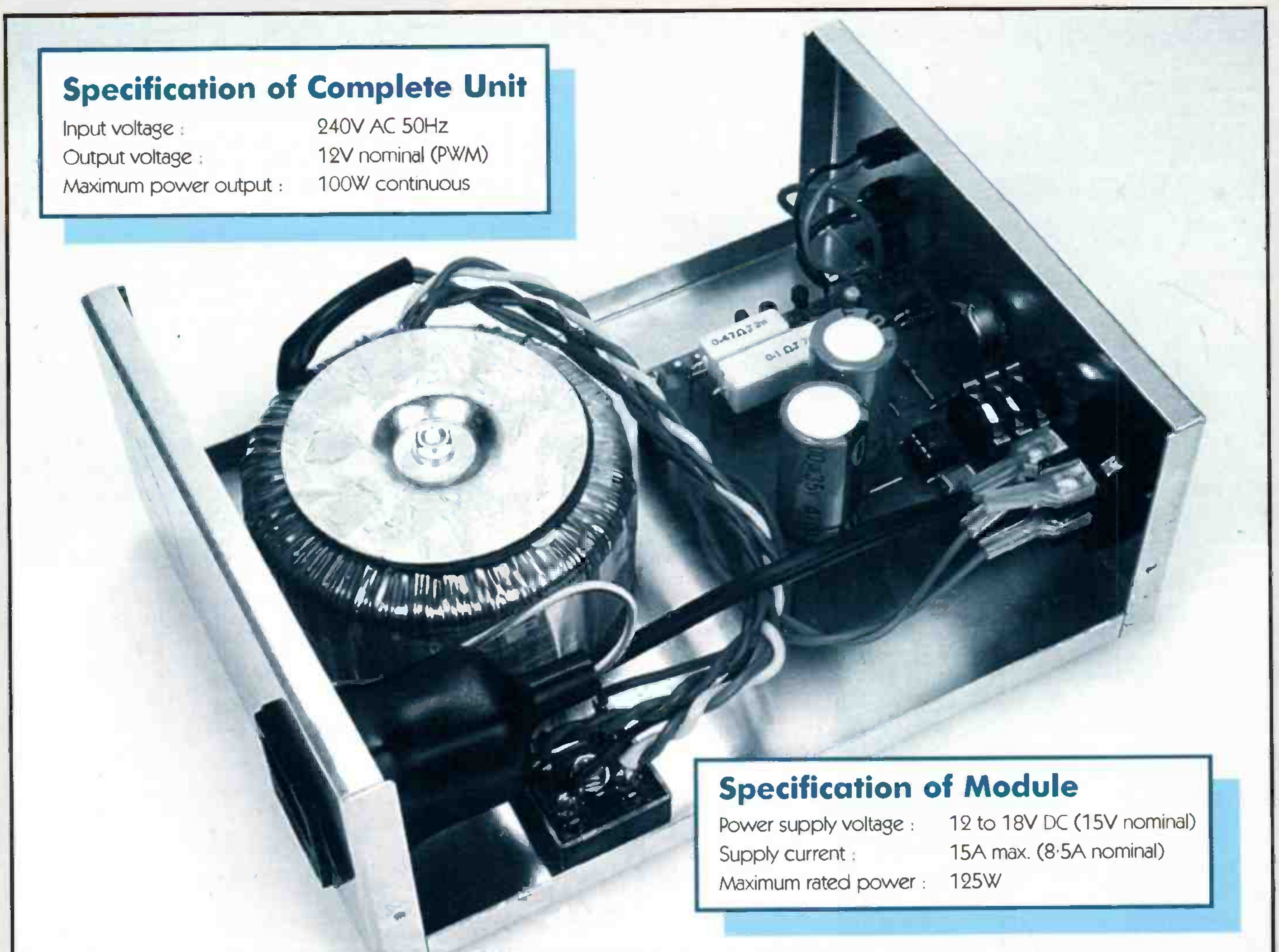
Fit the two terminal posts to the front of the case, with the holes having been properly prepared they will not turn when fixed into position.

The PCB potentiometer requires modification before fitting, see Figure 7. This shows removal of the lug and shortening of the spindle.

An exploded view of the PWM Drill Speed Controller is shown in Figure 8a. This will assist in placing the components into the case. A further exploded view showing the mains connector, mains switch, jack socket and pot is given in Figure 8b.

Bolt the power transistor (TR2) to the bottom of the case using an M3 bolt, adding thermal compound; no thermal insulating washer is required. Preform the transistor leads, these will be soldered to three PCB pins on the underside of the PCB when in position.

Fit the insulated spacers to the PCB and then fit the assembly into the case. Carefully place the spindle of the potentiometer and the optional ¼ in. jack socket through the respective holes on the front panel; these



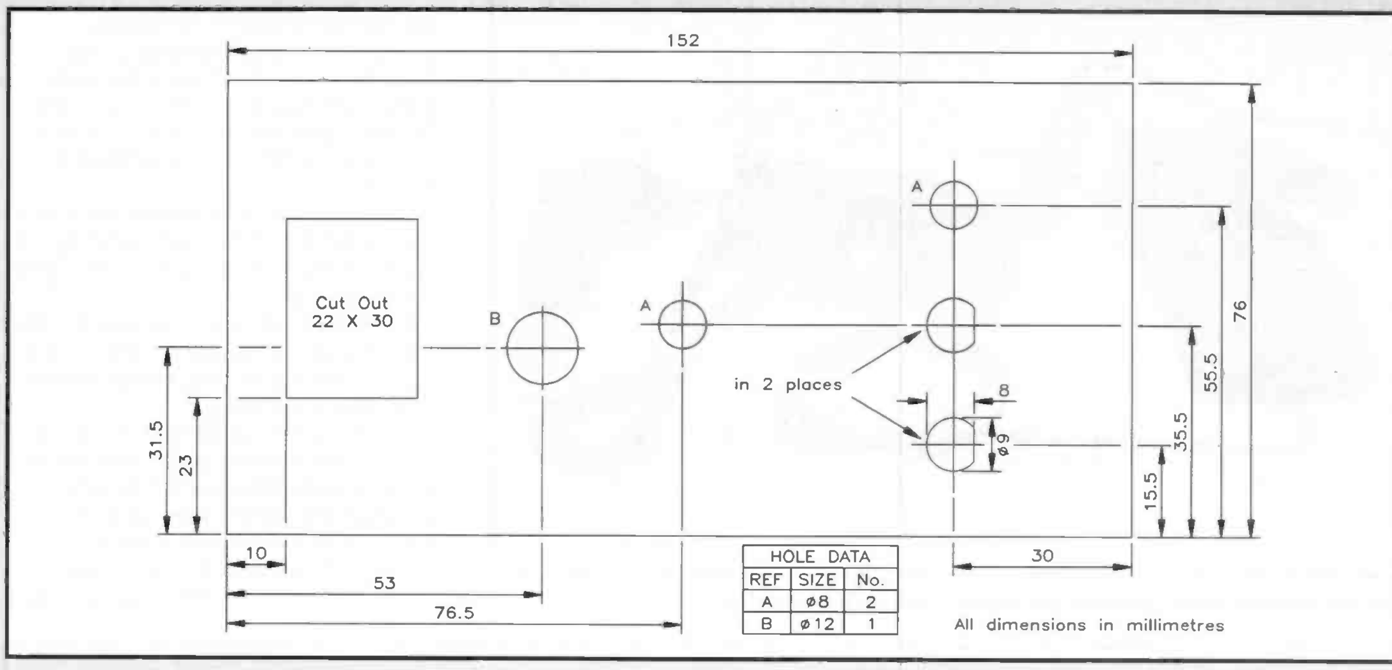
Specification of Complete Unit

Input voltage :	240V AC 50Hz
Output voltage :	12V nominal (PWM)
Maximum power output :	100W continuous

Specification of Module

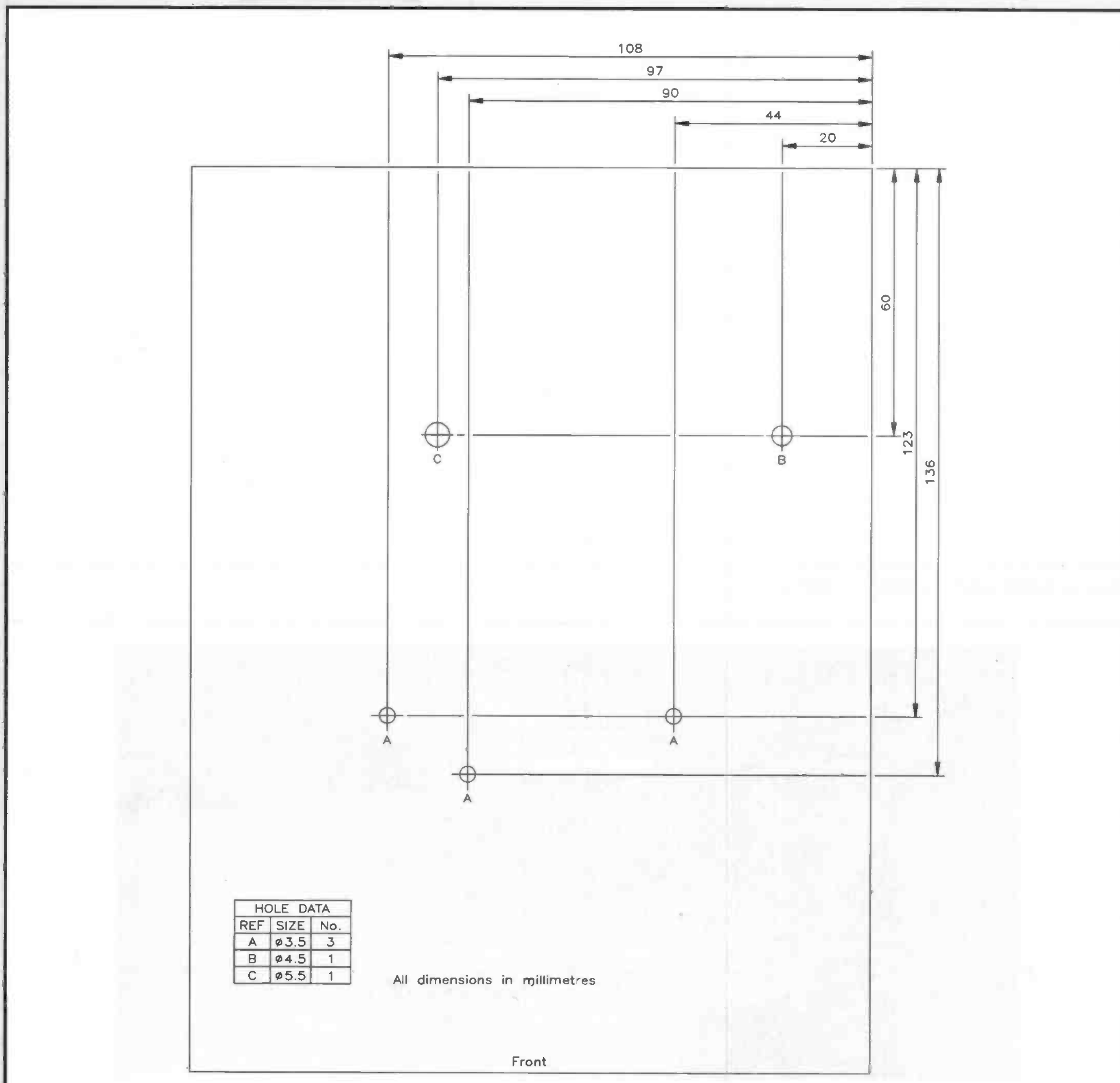
Power supply voltage :	12 to 18V DC (15V nominal)
Supply current :	15A max. (8·5A nominal)
Maximum rated power :	125W

Inside the Drill Speed Controller.



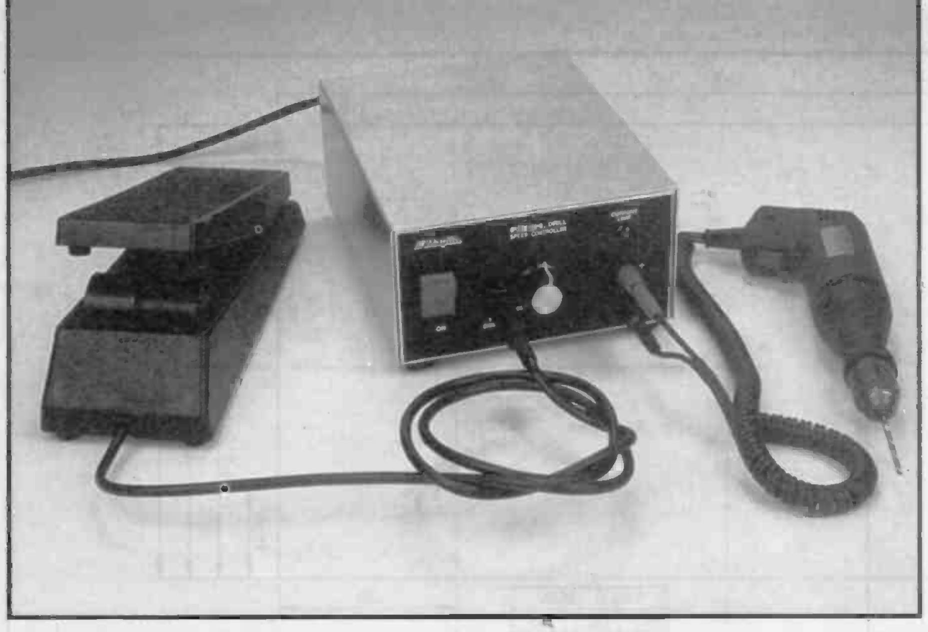
HOLE DATA		
REF	SIZE	No.
A	ø8	2
B	ø12	1

Figure 5a. Drilling details for the front of the box.



HOLE DATA		
REF	SIZE	No.
A	ø3.5	3
B	ø4.5	1
C	ø5.5	1

Figure 5b. Drilling details for the base of the box.



The Drill Speed Controller, optional foot controller and a typical PCB drill.

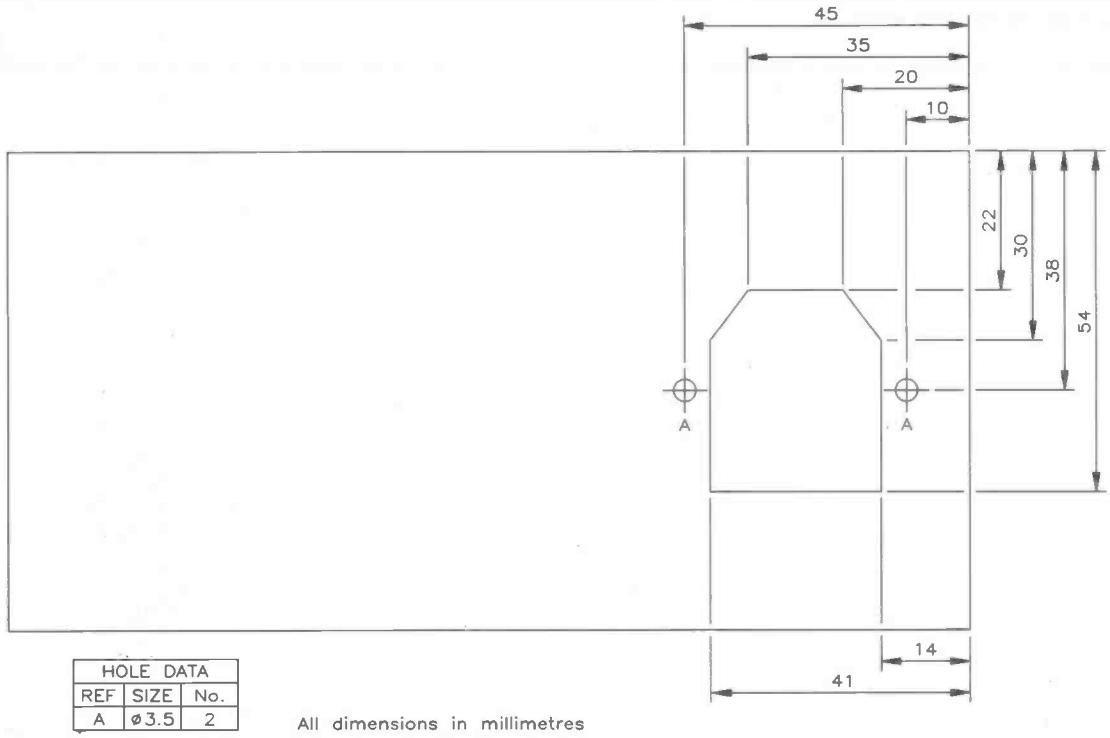
are then held in position by washers and lock-nuts. Next fit the knob on the potentiometer making sure that the knob is aligned with the legend on the front panel. The preformed legs of TR2 should now be in line with the PCB pins and soldered in each case.

Bolt the rectifier to the bottom of the box using an M4 bolt, shakeproof washer and M4 nut. It may be necessary to rotate the rectifier when wiring up.

Fit the mains connector (not forgetting the M3 solder tag) to the rear of the box, using two M3 countersunk bolts, two shakeproof washers, and two M3 nuts.

Next fit the toroidal transformer; there are two neoprene washers and a metal washer of the same diameter. Use the M5 bolt provided with the M5 washer and M5 nut to secure the assembly to the box.

Refer to Figure 9a for the low-voltage supply wiring from the PCB to the terminals,



HOLE DATA		
REF	SIZE	No.
A	ø3.5	2

Figure 5c. Drilling details for the rear of the box.

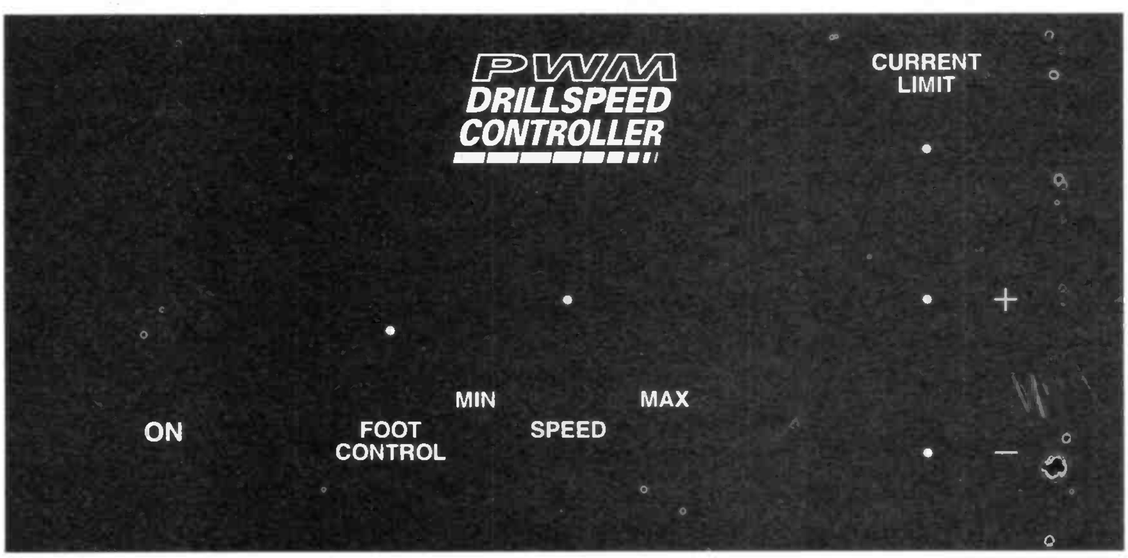


Figure 6. Front panel label (shown actual size).

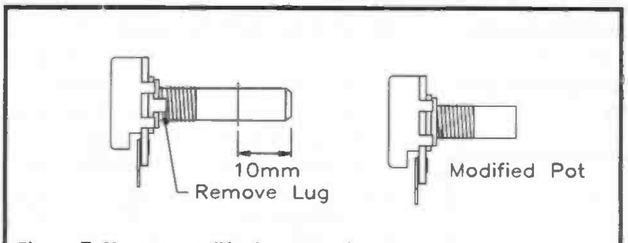


Figure 7. How to modify the potentiometer.

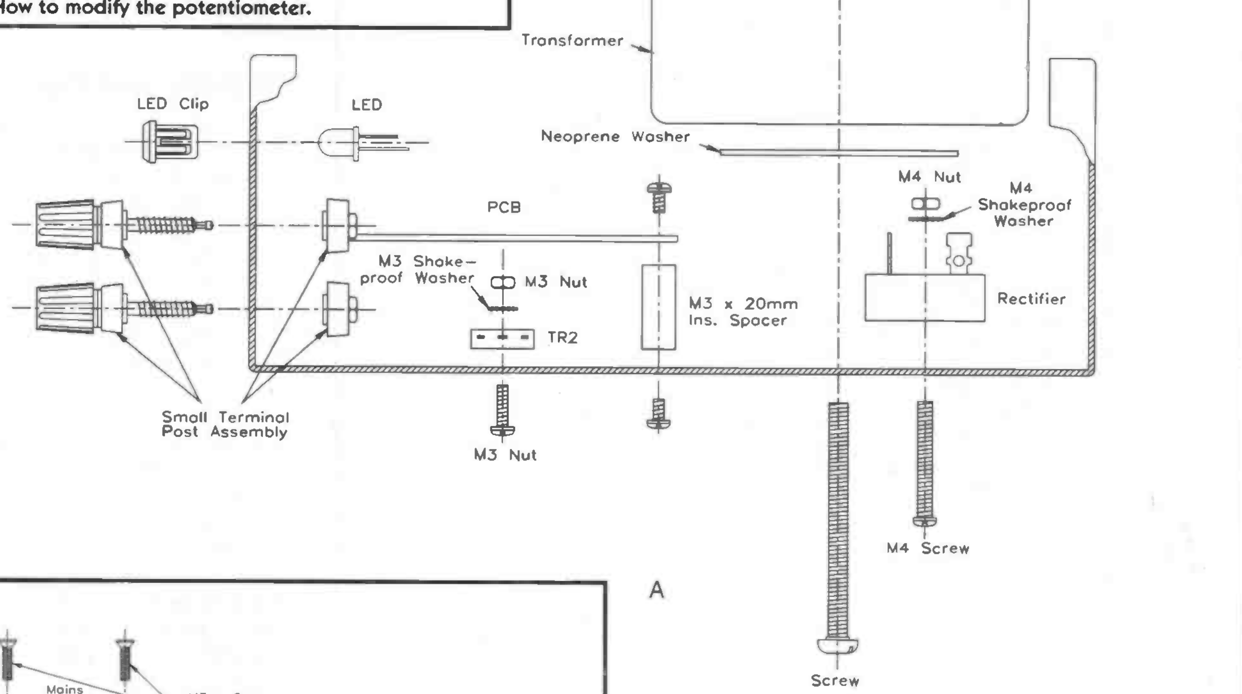


Figure 8a. PWM Drill Motor Speed Controller exploded assembly.

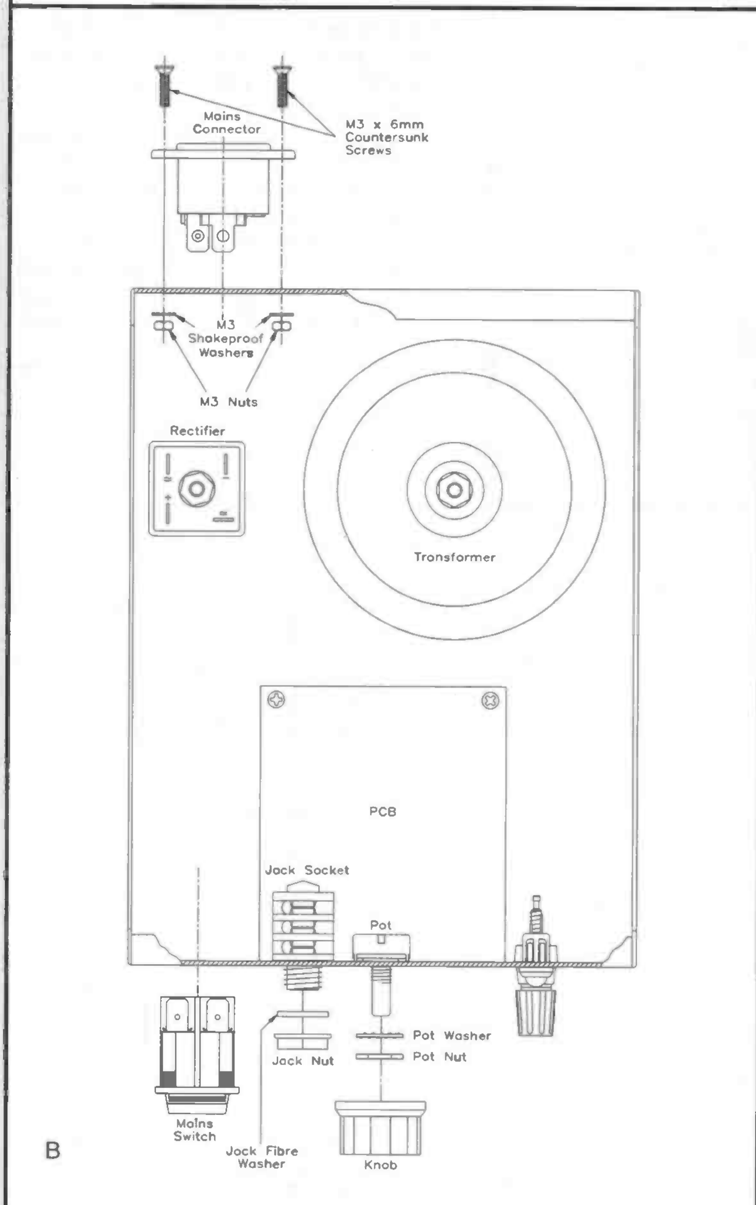


Figure 8b. PWM Drill Speed Controller exploded assembly.

Inside the optional foot controller.

The optional foot controller.

LED, and bridge rectifier, and from the toroidal transformer to the bridge rectifier and back to the PCB. Figure 9b shows the mains wiring including the earth arrangements. Remember to fit the insulating rubber boot to the wires before soldering the wires to the power connector. For the earth connection use the green and yellow wire and M3 earth tag as mentioned earlier.

For *your* safety, it is important that insulation is applied to all the exposed mains connections.

Complete the project by fitting the cover to the case and a 20mm T 1A (time-lag) fuse to the mains inlet fuse drawer.

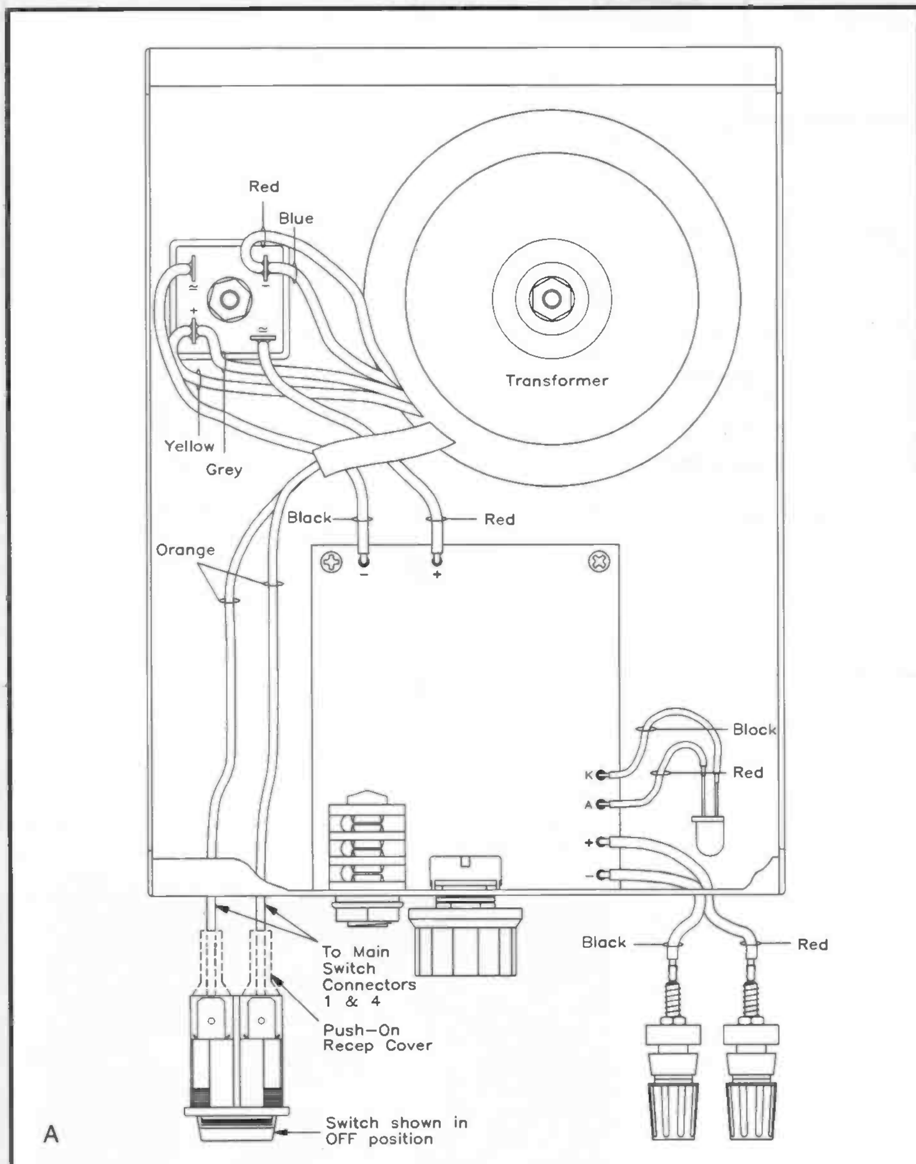
If the optional foot speed controller is to be used, then a wiring modification is required. Open up the foot pedal, locate the potentiometer and desolder the screened cable. Solder a suitable length of three-core mains wire to the tags and to the ¼ in. stereo jackplug (refer to Figure 10). Refit the base plate and it is now ready to be tested.

Testing and Use

On no account must power be applied to the circuit with the lid removed from the box, as mains voltage is potentially lethal. The mains must, therefore, always be treated with the greatest respect.

Turn the control knob fully anti-clockwise to ensure that the mains switch is off. Apply power to the project; turn on the mains switch (the switch should illuminate) and connect a load (e.g. motor or 12V light bulb) to the terminal posts. Slowly advance the control knob clockwise. If you are using a motor, it may begin to whine at this point. The LED will also illuminate (this will probably depend upon the stall current of the motor). Continue to advance the control, the motor will begin to turn and increase in speed as the control is moved further clockwise until full speed is achieved. When the control knob is approximately at the half-way point, the LED will extinguish. This is due to the motor having a build-up of inertia and maintaining a magnetic field, which increases the reluctance (the magnetic equivalent of resistance) and prevents the motor from drawing the stall current.

If the optional foot pedal has been implemented, testing the foot pedal is similar to the front panel control. Insert the jackplug into the socket on the front panel and apply



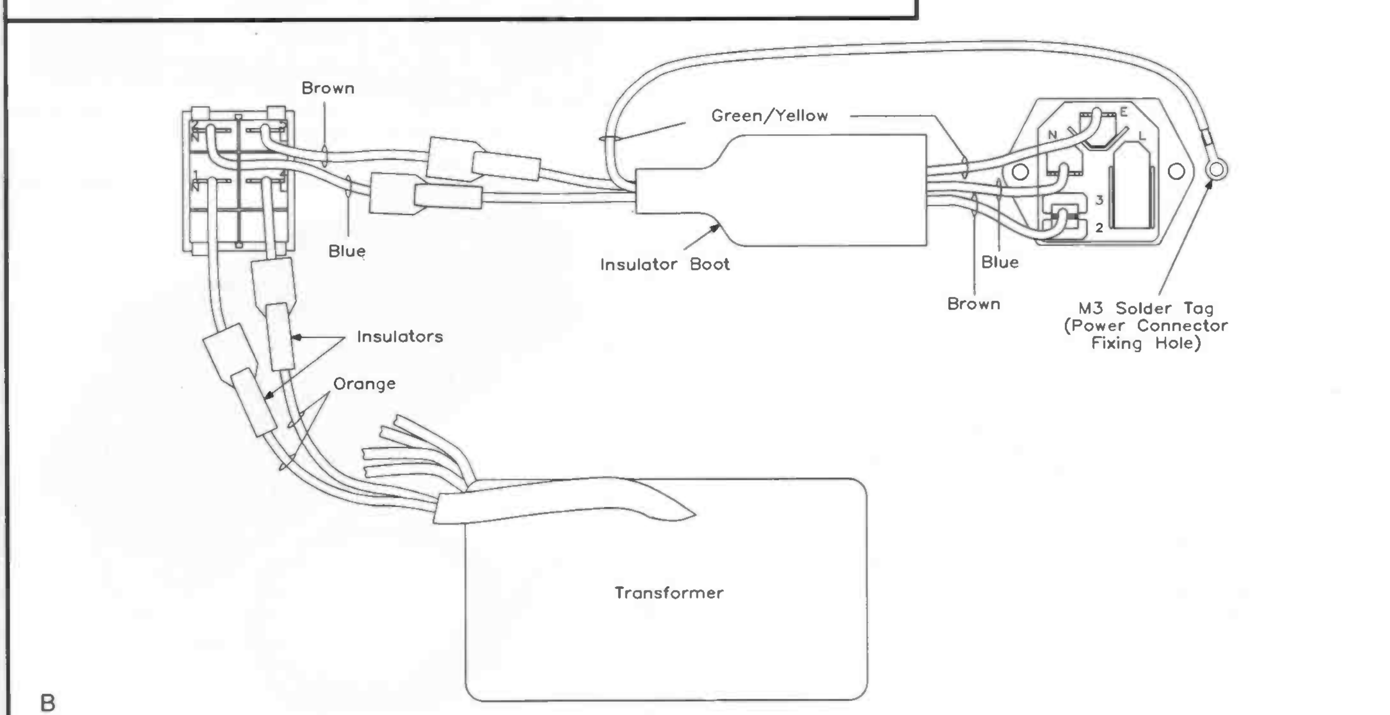


Figure 9. (a) Low-voltage and transformer primary wiring; (b) mains-voltage wiring.

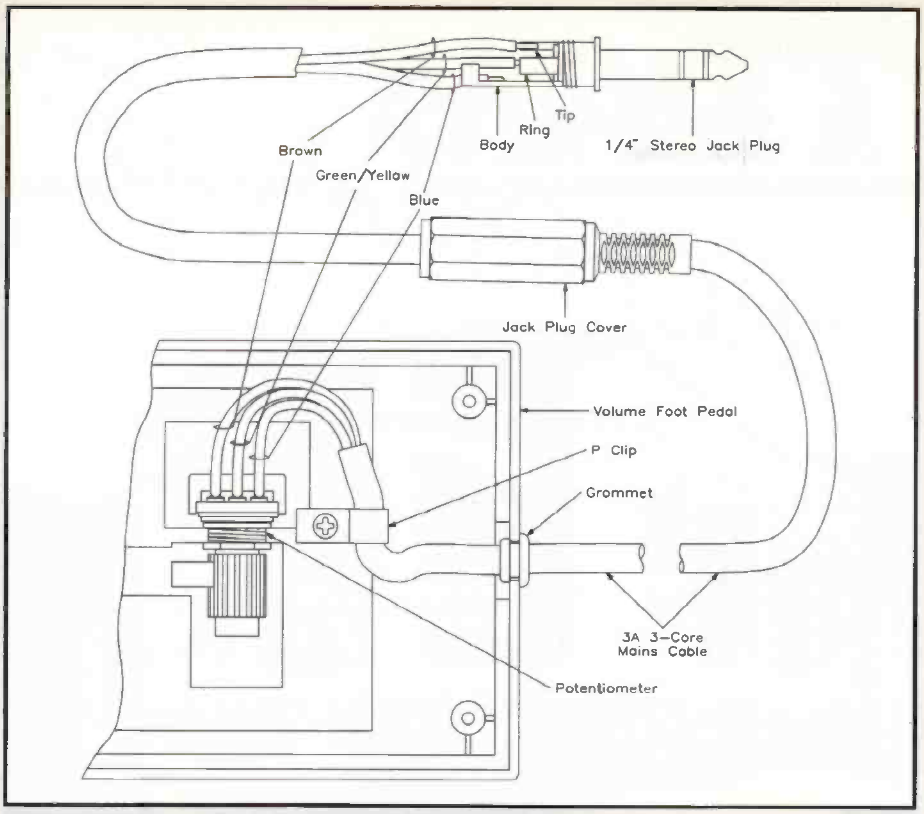


Figure 10. How to modify the volume pedal for use as a foot speed controller.

pressure on the pedal. The motor will be controlled as before, with the exception that the front panel control will not operate at this point.

Never directly short-circuit the output of the PWM Drill Speed Controller at or near maximum output for more than one or two seconds, as the power transistor will have to dissipate around 120W of power; this will cause TR2 to overheat.

This problem can be alleviated somewhat (in other higher power applications) by reducing the thermal resistance, i.e. increasing the heatsink size and/or adding forced air cooling. However, in practice this may not be a problem; the Maplin Lab PWM controller has been in constant use for the last three years without problem.

Important Safety Note

It is important to remember that mains voltage is potentially lethal. Full details of mains wiring connections are shown in this article.

Every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit. Safe construction of the unit is entirely dependent on the skill of the constructor, and adherence to the instructions given in this article.

PWM DRILL SPEED CONTROLLER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1	1M	1	(M1M)
R2,3	47k	2	(M47K)
R4,6	10k	2	(M10K)
R5	0Ω1 7W Wire Wound	1	(L0.1)
R5a	0Ω47 3W Wire Wound	1	(W0.47)
R7	1k	1	(M1K)
RV1	10k Miniature Linear Potentiometer	1	(JM71N)
CAPACITORS			
C1	100nF Polyester Layer	1	(WW41U)
C2,6	100nF 50V Disc Ceramic	2	(BX03D)
C3	1µF 100V Radial Electrolytic	1	(FF01B)
C4,5	4700µF 35V Radial Electrolytic	2	(JL30H)
SEMICONDUCTORS			
IC1	CA3140E	1	(QH29G)
TR1,3,4	BC337	3	(QB68Y)
TR2	TIP35C	1	(UJ28F)
D1	1N4001	1	(QL73Q)
LD1	5mm Red LED	1	(WL27E)
MISCELLANEOUS			
	8-pin DIL IC Socket	1	(BL17T)
	Single-ended PCB Pin 1·3mm (0·052)	1 Pkt	(FL21X)
	M3 × 10mm Steel Bolt	1 Pkt	(JY22Y)
	M3 Shakeproof Washer	1 Pkt	(BF44X)
	M3 Steel Nut	1 Pkt	(JD61R)
	Front Panel Label	1	(DE78K)
	PCB	1	(GH86T)
	Instruction Leaflet	1	(XU80B)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
JK1	¼ in. Stereo PCB Socket	1	(FJ05F)
	Metal Box Type AB15	1	(XB71N)
	120VA 15V Toroidal Transformer	1	(DH63T)
	K01 Bridge Rectifier	1	(BH47B)
	5mm Convex LED Clip	1	(UK14Q)
	10A 250V AC Dual Rocker Neon Switch Red	1	(YR70M)
	Fused Mains Euro Chassis Plug	1	(FT37S)
	Insulated Cover For Fused Mains Plug	1	(JK67X)

Red Terminal Post Small	1	(FD72P)
Black Terminal Post Small	1	(FD69A)
Push-on Receptacle Covers	1 Pkt	(FE65V)
Knob Type K7B	1	(YX02C)
T1A 20mm Fuse	1	(WR19V)
13A Plug & Cable Black	1	(CY32K)
3A Two-core Mains Cable Black	1m	(XR47B)
6A Wire Green/Yellow	1m	(XR38R)
30A Wire Black	1m	(XR57M)
30A Wire Red	1m	(XR59P)
Extra-Flexible Wire Black	1m	(XR40T)
Extra-Flexible Wire Red	1m	(XR44X)
M3 × 20mm Insulated Spacer	1 Pkt	(FS38R)
M3 Solder Tag	1 Pkt	(LR64U)
M3 Steel Nut	1 Pkt	(JD61R)
M3 Shakeproof Washer	1 Pkt	(BF44X)
M3 × 6mm Steel Bolt Countersunk Pozi	1 Pkt	(BF36P)
M4 Steel Nut	1 Pkt	(JD60Q)
M4 Shakeproof Washer	1 Pkt	(BF43W)
M4 × 16mm Steel Bolt Pozi	1 Pkt	(JY16S)
Stick-on Feet Square	1 Pkt	(FD75S)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LT64U (PWM Drill Speed Controller) Price £14.99

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1994 Maplin Catalogue

PWM Drill Speed Controller PCB
Order As GH86T Price £3.29

PWM Drill Speed Controller Front Panel Label
Order As DE78K Price £2.29

TRAM TECHNOLOGY ON THE MOVE

Electric transportation in city centres is often suggested as the solution to congestion and pollution. However, conventional tramway infrastructure is expensive, and overhead wires cause a visual intrusion. Here Stephen Waddington describes a self-contained no-wires minitram that uses a combination of battery and flywheel energy storage.

by Stephen Waddington
BEng(Hons)., M.I.E.E.E, A.I.E.E, A.I.T.S.C.

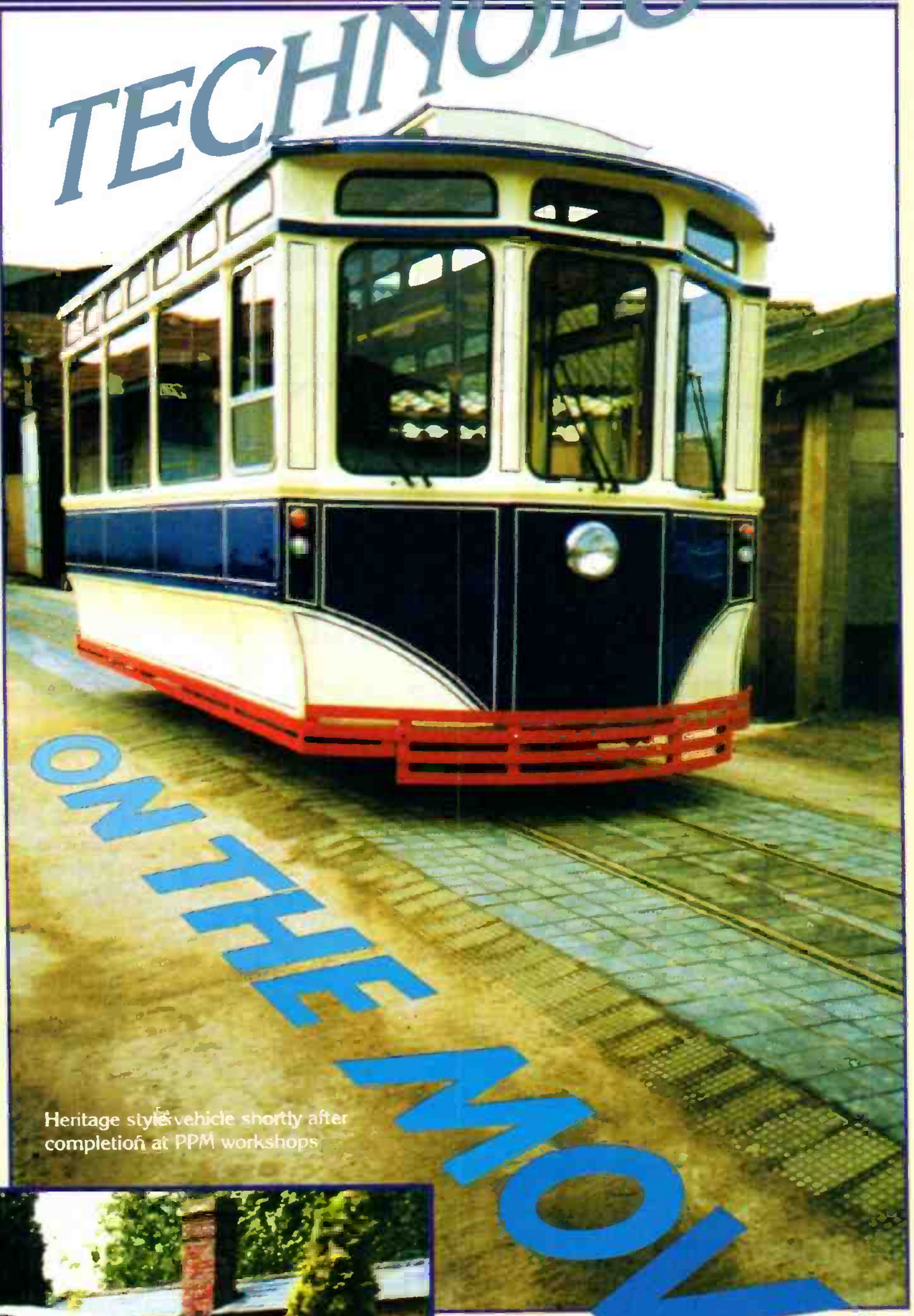
TRY navigating any of the UK's major cities during the rush hour and your journey will be punctuated by queues of traffic. In a car your foot will rarely leave the clutch and the chances of progressing beyond second gear are minimal. Try walking or cycling and you face the wrath of frustrated motorists, coupled with the added hazard of carbon monoxide fumes.

Traffic Delays

Overseas, cities in continental Europe and America are no better; in the developing regions of Asia Pacific, car travel is totally impossible. While visiting Singapore, at the beginning of the year, a companion and I rented a hire car. It was a pointless exercise. Typical journey times for even short distances through the city had to be measured in hours. In the end we walked everywhere, clocking up only thirty kilometres in the car over a four day stay.

Park and Ride

So what is the answer? In some cities such as York and Cambridge, cars are banned at certain periods of the day. Instead park-and-ride schemes operate from the city periphery. This is a highly effective method of eliminating congestion, though is often unpopular with local residents who see such schemes as an infringement of civil liberty, preventing free movement within their home city.



Heritage style vehicle shortly after completion at PPM workshops.

Modern style 14-seat PPM Minitram on show at demonstration track.

City Congestion

According to the AA, the UK lines up well in the city congestion stakes. Typical crawl rates for major cities in Asia Pacific where traffic management systems are minimal include: Bangkok 1·2km/h; Singapore 8km/h; Hong Kong 12km/h. Against these figures, the Department of Transport claims that the average speed through our slowest city, London, is 16km/h. So the good news is – it could be a lot worst.

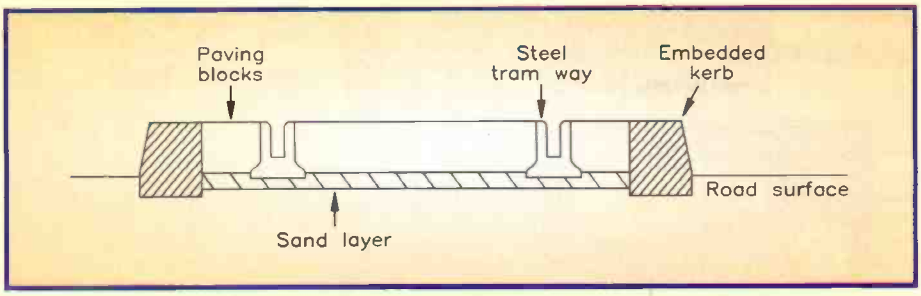


Figure 1. PPM Minitram rails are installed on top of existing road sections.

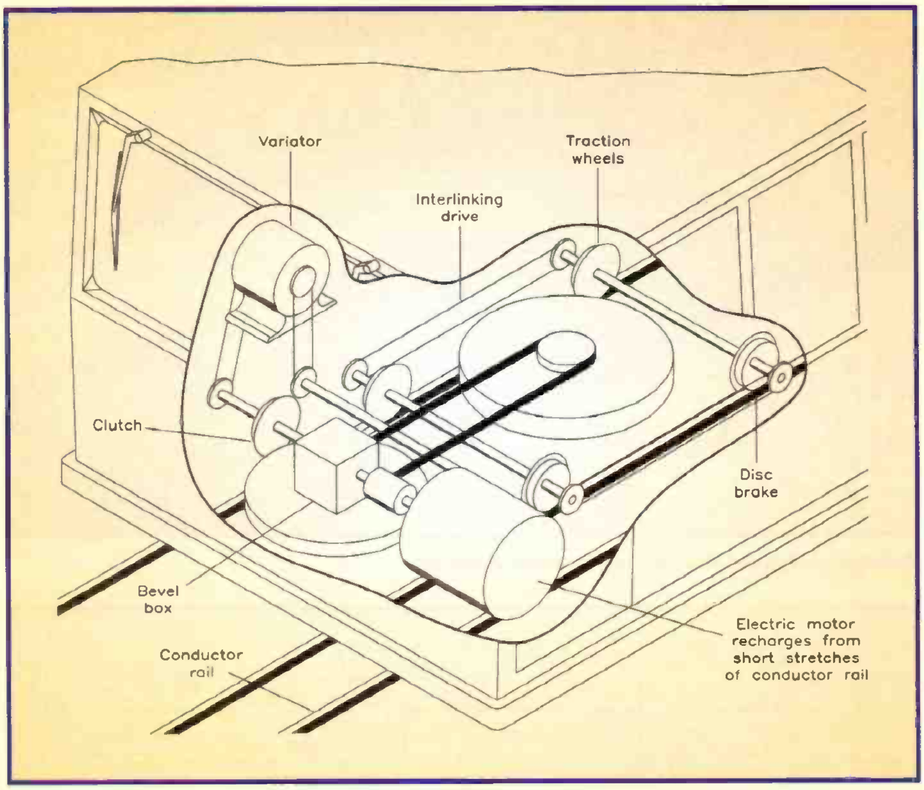


Figure 2. Cross-sectional view of the mechanical system within the PPM Minitram.

Batteries are No Go

When initially investigating methods of vehicle propulsion, PPM looked at using batteries alone. Unfortunately, calculations showed that, even for a small vehicle, present-day battery technology would not be able to provide continuous power throughout an 18-hour day. Ironically the bulk and weight of batteries themselves dramatically increases the power required to move even a small one- or two-person vehicle.

As John Parry MBE, Chairman of Parry Associates explains: "You would think the solution would lie in simply adding more batteries, but the law of diminishing returns sets in. Each time you add a set of batteries, the unladen weight of the vehicle increases and more and more of the energy in the batteries is used to transport the batteries themselves leaving proportionally less for the payload".

Flywheel Technology

Even emerging battery designs crush the futuristic ideal of mass-produced electric vehicles. Furthermore, the efficiency and reliability of battery powered vehicles are hindered by the mechanical vulnerability of batteries, and, the potentially abusive charging regimes which would be required to keep a vehicle serviceable. It is little wonder therefore that design engineers at PPM looked towards other methods of propulsion.

Flywheel energy storage – where relatively large amounts of energy are retained within a large and heavy rotating wheel – allows fast and frequent recharging. Direct vehicular motion is achieved by transferring mechanical energy from the flywheel to a drive shaft and set of traction wheels. The flywheel is recharged by decoupling the drive shaft, and replacing it instead with an electric motor, which is able rotate the flywheel up to speed.

An alternative solution is to improve public transport systems. However, the cost of bus travel is often ridiculously expensive in relation to the distance travelled. Additionally, buses themselves add to congestion and pollution albeit at a reduced *per capita* rate when compared with other forms of vehicular transport.

Metro Schemes

Electrified metro schemes are now the environmental vogue. Indeed over forty local authorities within the UK have studied the possibility of easing traffic congestion by implementing electrified track passenger transport schemes. To date, Manchester is the sole crusader, with perhaps two or three other projects still under consideration. Elsewhere, plans have been scrapped, essentially because of the high capital investment costs, coupled ironically, with environmental concerns over matters such as overhead power line and track requirements.

Now, a UK company claims to be able to counter these problems. Parry People Movers (PPM), a group within Parry Associates (based at Cradley Heath in the West Midlands), has developed a low-cost, self-powered, urban electric transport system called the 'PPM Minitram'. It differs from conventional tram schemes in that it is totally self-contained and thus self-propelled. There is no need for overhead cables as the vehicle contains its own innovative on-board power system in the form of a battery and flywheel combination.

PPM Minitram contactor butts up to power source to recharge flywheel.

The PPM Minitram

The Minitram system retains the use of conventional tram tracks, but these are installed on top of existing road sections as shown in Figure 1, rather than buried below the road surface.

Target markets

Airports	Industrial parks
City centres	Parklands
Exhibition centres	Seaside fronts
Historic towns	Universities

The PPM flywheel powered light rail is not the first attempt to use flywheels to propel vehicles. The Swiss company Oerlikon built a series of very expensive flywheel powered buses to deal with a transport crisis caused by a shortage of petroleum fuel, and the lack of wire for conventional overhead systems during World War II. These latterly saw service in Ghent and the Leopoldville, in the latter running for 19 years until political chaos overwhelmed the Congo nation.

Flywheel technology is now enjoying renewed attention and is currently the subject of academic study throughout the world, with numerous groups investigating size, weight, optimum speed, transfer mechanisms and

Flywheel specification

Maximum rotational speed:	4,000rpm
Continuous running time for zero load:	2 hours
Power storage:	1 to 2kWh
Weight:	250kg
Diameter:	1m
Width:	50mm

mounting positions. In the PPM Minitram, engineers have kept within the bounds of conventional engineering, opting for a 250kg flywheel, mounted horizontally, directly below the vehicle's floor as shown in Figure 2.

Clutching at Mechanics

A complex clutch system allows direct mechanical transmission from flywheel to rail wheels. Earlier flywheel systems, such as the Oerlikon vehicle, transferred power through generators and electric motors, and this was a wasteful and needless double conversion. The PPM Minitram uses Continuously Variable Transmission (CVT). Here, a handwheel is used to vary the gearing ratio between the flywheel and the railwheels. This system has the advantage of allowing braking power to be transferred back to the flywheel, instead of being dissipated by the brakes as heat, as in conventional vehicles.

PPM Minitrams are fitted with conventional automotive gear lever controls for forward and reverse drive. The electric motor used to power-up the energy-storing flywheel has a thyristor speed control, which is used to power the flywheel up from standstill. During other charge-up cycles it is used as a switch to transfer mechanical motion from the motor to the flywheel.

The thyristor control is the principle means of applying regenerative braking (which puts energy back into the flywheel), which coupled with the use of rails, allows a high level of energy efficiency. John Parry explains: "Steel wheels on steel rails consume far less energy than rubber tyres running on roads, so the limited energy stored in a flywheel can carry the vehicle further before it needs to recharge".

The range of a vehicle on a single flywheel charge is about 4km with a recharge taking approximately 60 seconds. This is ideal for city-based passenger transportation where vehicles rarely travel for more than five minutes between passenger stops. An additional benefit from locating a horizontal flywheel below the deck of a PPM Minitram is that the gyroscopic force from the spinning mass stabilises the vehicle, reducing both pitching and rolling, thereby improving the passenger's ride.

Recharging

In practice the flywheel will be recharged in small doses at routine passenger stops preventing unnecessary delays. Here electric current set at 72V DC is supplied to the motor that recharges the flywheel up to its full capacity. As the PPM Minitram approaches a stop it automatically butts up against the shrouded track-side conductor as shown in Figure 3, and current is switched on via a series of energised magnetic sensors.

Besides regular recharging provision along a tramline, the PPM Minitram carries a small-capacity battery for emergency power and ancillary devices such as lights, horn and

Prototype pedestrian stop with power source alongside.

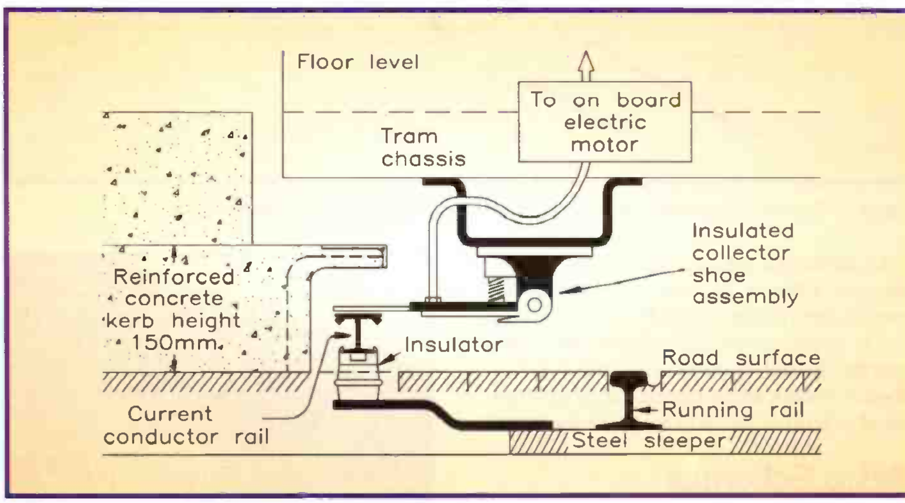


Figure 3. Track-side conductor for recharging the flywheel.

wipers. This emergency system provides six full charges of the flywheel – which is considered sufficient for even the worst case scenario – should a PPM Minitram be delayed, or prevented from reaching a recharging point at a passenger stop. PPM also makes provision for long uphill journeys where the energy in the flywheel might be exhausted. Here, track-side conductors allow the PPM Minitram to pick up power enabling the tram to sustain the flywheel's momentum.

Driver Controls

A main brake lever linked to a set of disc pads on the front axle is provided for emergency braking. It also interlocks with the clutch, disengaging the flywheel. The clutch is also used to move the vehicle from rest, disengaging the motor drive. A ratchet handbrake lever is used to apply shoe brakes to the rear wheels of the PPM Minitram to hold it at rest, similar to a convection motor vehicle.

Single PPM tram unit capability

Maximum Speed:	50km/h
Dimensions for standard Minitram:	1·95m Width 2·10m Height 3·19m Length
Weight:	3 to 4·5 tonnes
Passenger Capacity:	14 seated 11 standing

A Flywheel Multiple Unit (FMU), consisting essentially of two single units coupled together, has the capacity to carry up to 50 passengers. PPM estimates that allowing for a one minute running interval, an FMU service would provide passenger capacity of 3,000 per hour.

Instrumentation and switch controls combine automotive and light rail features as shown in Figure 4. The level of energy stored in the vehicle's flywheel is monitored by way of a rev counter placed alongside the Minitram's speedometer.

Cost

The cost of the PPM Minitram systems, including hardware design and commissioning, starts at around £90,000 for a simple one car system, rising to around £1 million for a typical town centre park-and-ride system. PPM claims that this is a fraction of the cost of the alternative street run transport schemes. The low price is expected to open up entirely new markets for passenger schemes from industrial complexes to heritage parks and from university campuses to hospitals.

A single-car system is currently operating at Himley Park, Dudley in the West Midlands and consumes 1 unit of electricity for every 4km of travel. Although originally intended solely for demonstration purposes, it was recently licensed for carrying the public by HM Inspectorate of Railways.

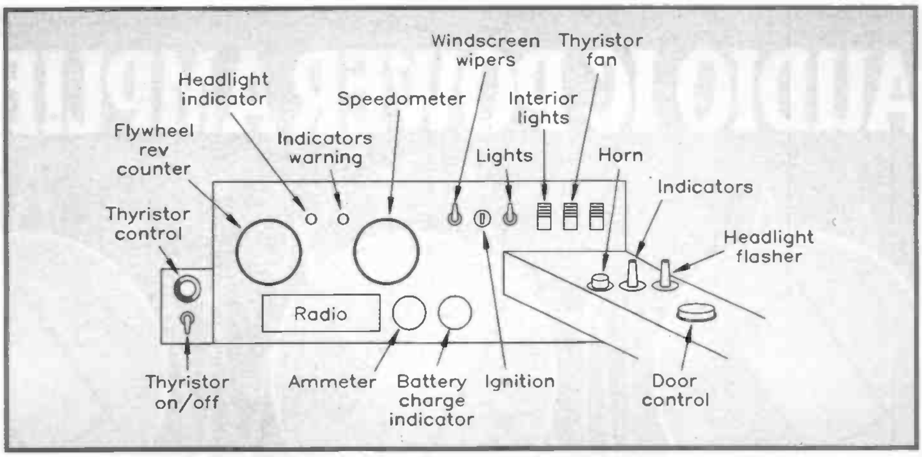


Figure 4. PPM Minitram driver's control panel.

The Future

So is the PPM Minitram the total solution to city-wide transportation needs? John Parry and his colleagues at PPM think so. Their task is now to convince local authorities and the business community of the PPM Minitram's value. As the BBC Tomorrow's World team concluded when it recently showcased the PPM Minitram – it's an idea that is gathering momentum.

Further Information

For further details of the PPM Minitram contact: Lawrence Davrill, Rail Projects Manager, JPM Parry & Associates, Overend Road, Cradley Heath, West Midlands B64 7DD. Tel: (0384) 69171.

ATTENTION!...ATTENTION!...ATTENTION!...ATTEN-

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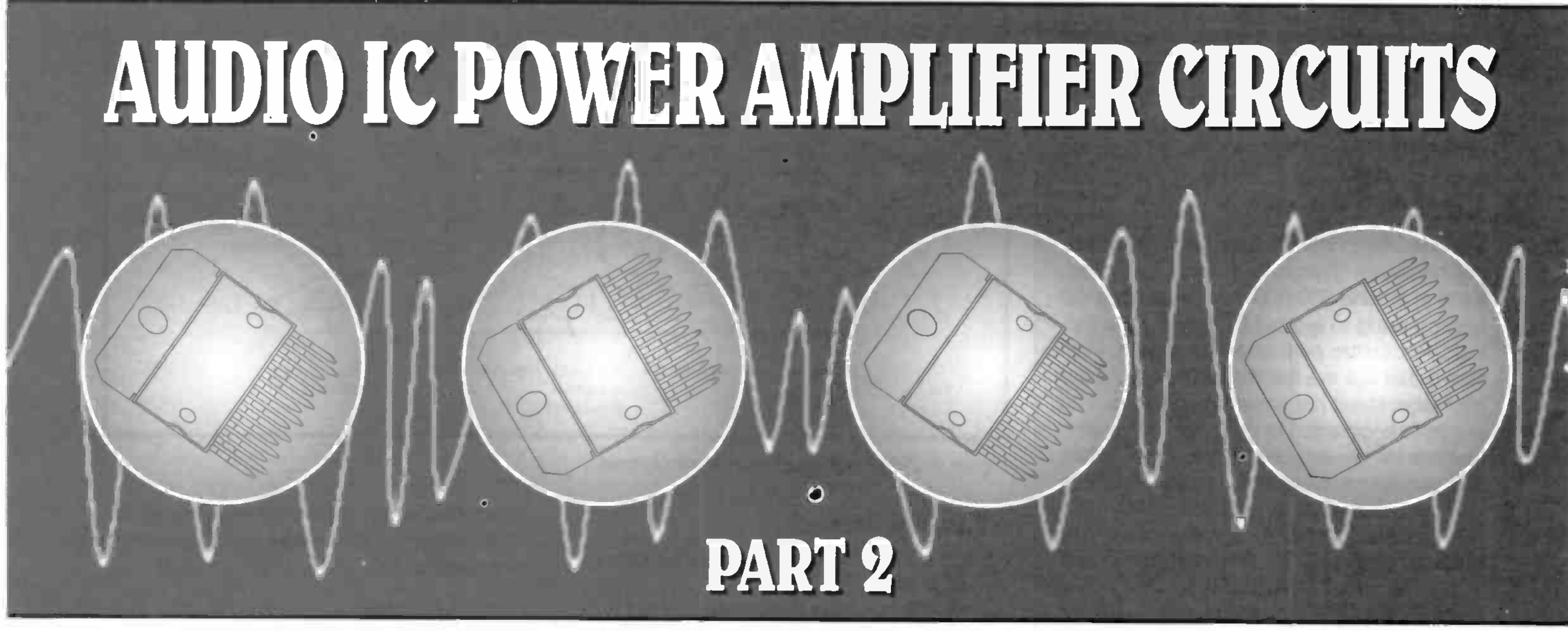
AUDIO IC POWER AMPLIFIER CIRCUITS



PART 2

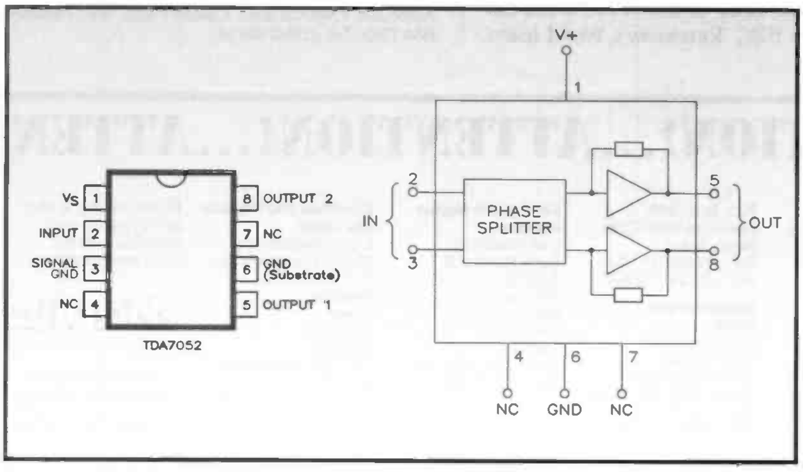


Figure 22. Outline and basic internal circuit of the bridged-output TDA7052 IC.

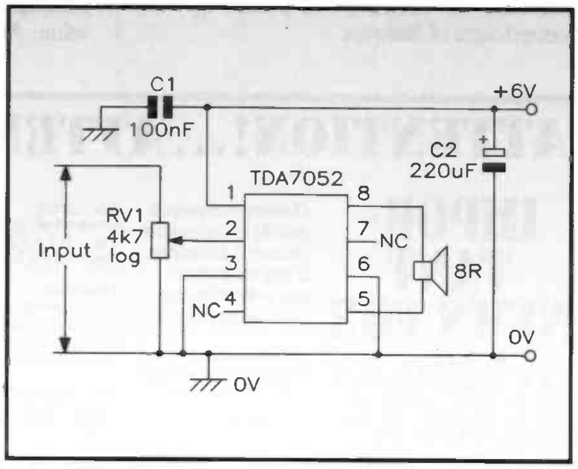


Figure 23. Simple 1·2W TDA7052 amplifier circuit.

Ray Marston presents a further selection of IC power amplifier circuits in the second part of this three-part miniseries.

LAST month's opening part outlined some of the basic principles of modern audio power amplifier design (including that of 'bridge mode' amplification and power boosting) and presented a variety of practical low-power designs based on op amps and on the LM386, LM398 and LM831 range of power amplifier ICs. This month continues with the 'IC' theme by showing a variety of ways of using the TDA7052, TDA2822, LM1877, TBA820M, and LM380/LM384 range of devices in practical power amplifier applications.

TDA7052 Applications

The TDA7052 is a simple low-voltage audio power amplifier IC that is specifically designed for use in bridged output-driving applications; it can feed 1·2W into an 8Ω load when powered from a 6V supply. Figure 22 shows the outline, pin notations, and simplified internal circuit of the device, which is housed in an 8-pin DIL package. In essence, its input section forms a phase-splitting amplifier that feeds anti-phase signals to the inputs of two identical medium-power amplifier stages. This gives a bridged form of output drive to an external load that is direct-coupled between pins 5 and 8. The IC gives a fixed 40dB of voltage gain, can use any supply in the 3V to 15V range, and typically gives less than 0·1% distortion at a 100mW output power level. Figure 23 shows the IC's standard and ultra-simple basic application circuit.

TDA2822 Circuits

The TDA2822 is a simple low-voltage 'dual' amplifier IC that can use any DC supply in the 1·8V to 15V range, and in which the voltage gain of each amplifier is internally fixed at 40dB. Figure 24 shows the outline and pin notations of the device, which is housed in an 8-pin DIL package. Figure 25 shows the IC's standard application circuit, as a stereo speaker or headphone amplifier that is powered from a 6V supply; note that this same basic circuit can be powered from a 3V supply and used to drive headphones at up to 20mW per 32Ω channel, or from a 9V supply and used to drive 8Ω speakers at up to 1W per channel.

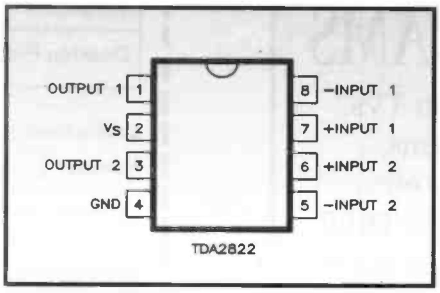


Figure 24. Outline of the TDA2822 low-voltage stereo amplifier IC.

LM1877 BASICS

The LM1877 is one of the classic 'greats' in the history of audio power amplifier ICs. In the mid-1970s there was a very popular series of dual power amplifier ICs known as the LM377/378 and 379. They had almost identical internal circuitry, but differed in their voltage ratings and packaging styles, and thus, in their power rating. In the late 1970s the LM1877 was introduced as an improved plug-in replacement for the LM377, but the LM377/378/379 series remained so popular that they remained in production until the late 1980s, when they were finally phased out. Now, only the LM1877 remains in production (after almost fifteen years), and it is still as popular and versatile as ever.

The LM1877 is housed in a 14-pin DIL package with the outline and pin notations shown in Figure 26, and can generate up to 2W per channel into an 8Ω load. It can use any supply in the 6V to 24V range, and houses a pair of identical amplifiers, each with a high-impedance differential input stage and a fully protected output stage. In use, the input stages are meant to be DC-biased at half of the supply voltage, and a bias generator (available via pin 1) is built into the IC for this purpose. Note that, in practice, pins 3, 4, 5, 10,

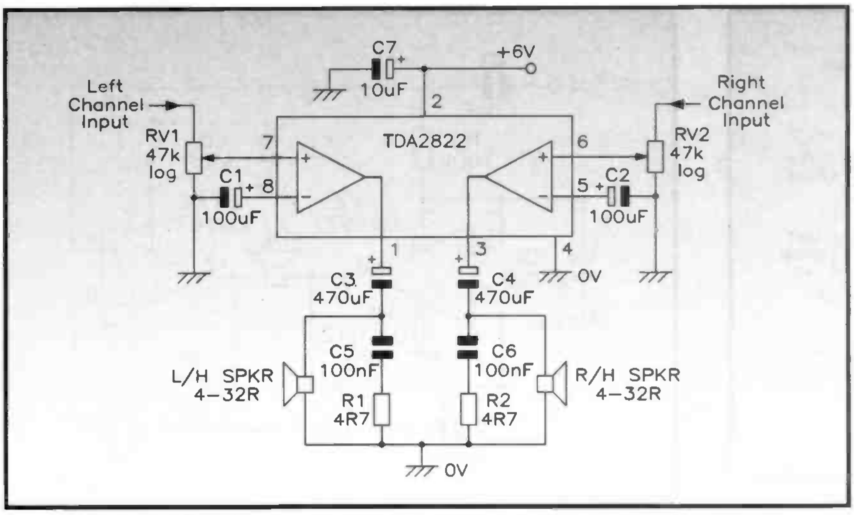


Figure 25. Basic TDA2822 application circuit.

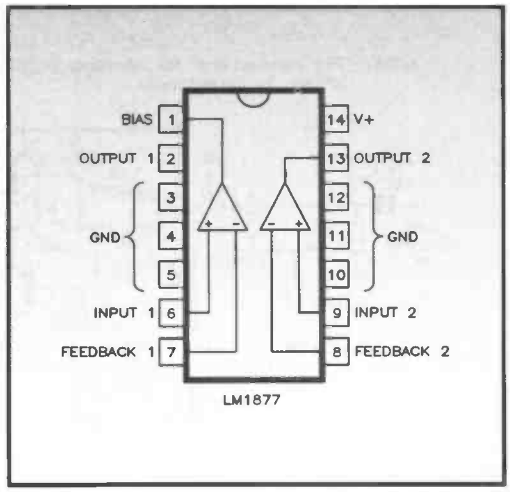


Figure 26. Outline and pin notations of the LM1877 dual 2W audio power amplifier IC.

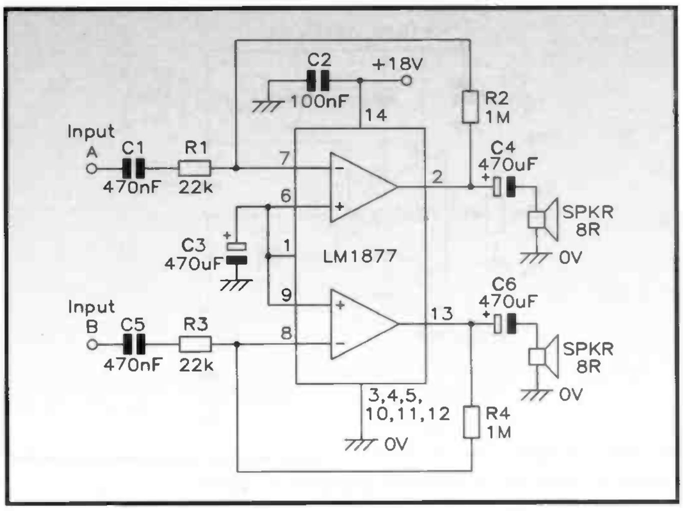


Figure 27. Simple inverting stereo amplifier gives 2W per channel output.

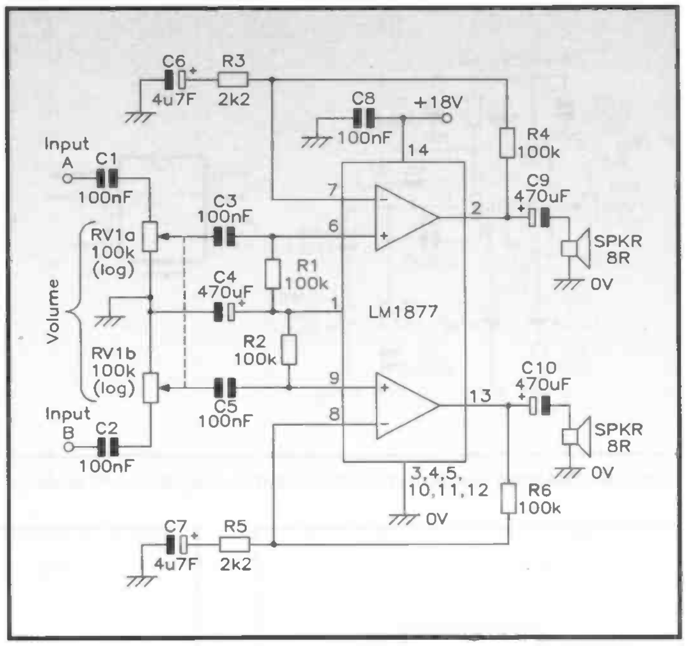


Figure 28. Non-inverting stereo amplifier gives 2W per channel output.

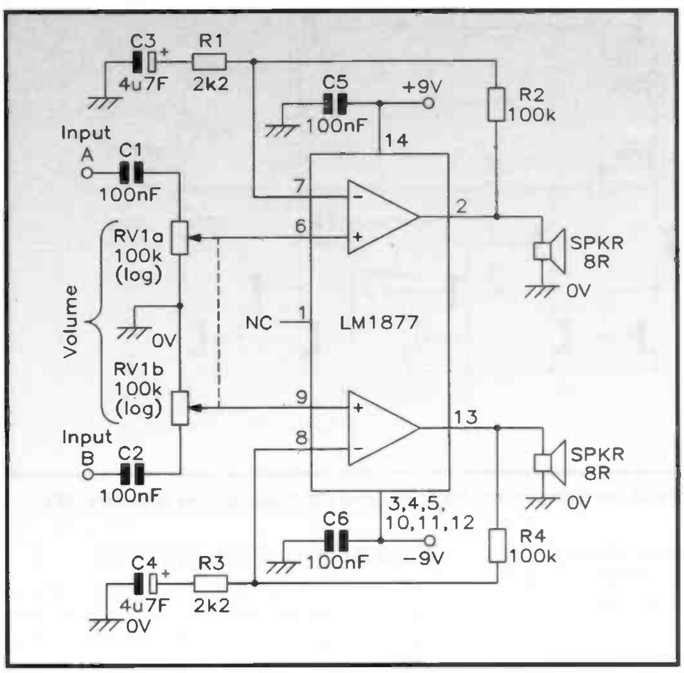


Figure 29. Non-inverting 2W per channel stereo amplifier using a split supply.

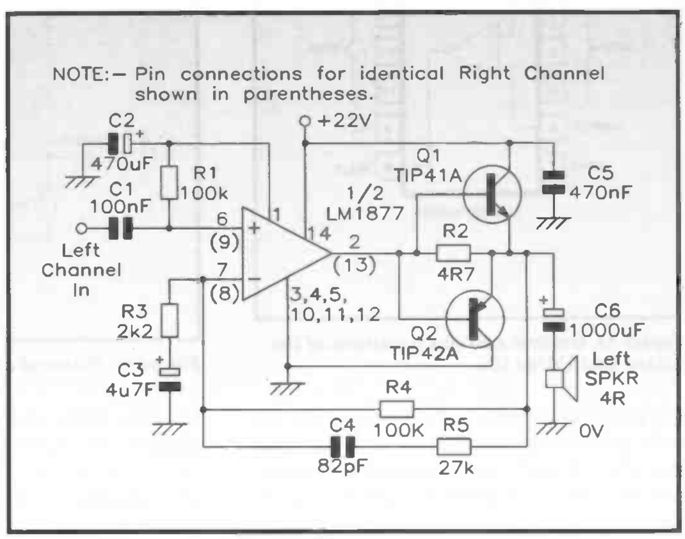


Figure 30. One channel of a 10W per channel stereo amplifier using a single-ended supply.

11 and 12 should be soldered to a grounded PCB heatsink if the IC is to be used at its full output power level.

The LM1877 is a very easy IC to use. Figure 27 shows the connections for making a simple inverting stereo amplifier powered from a single-ended power supply. Here, the amplifier is biased by connecting each non-inverting input pin to the BIAS terminal (pin-1), and the closed-loop voltage gain of each amplifier is set at approximately x50 by the ratio of R2/R1 or R4/R3; each amplifier has an input impedance equal to the R1 or R3 value (22k), and needs an AC input signal of 80mV rms to give a full 2W output into an 8Ω speaker load.

Figure 28 shows how the above circuit can be modified for use as a non-inverting amplifier. The voltage gain of each half is again set at roughly x50, in this case by the ratio of R4/R3 or R6/R5, and the non-inverting input terminals are biased via the internal network of the IC.

Figure 29 shows how the above non-invert-

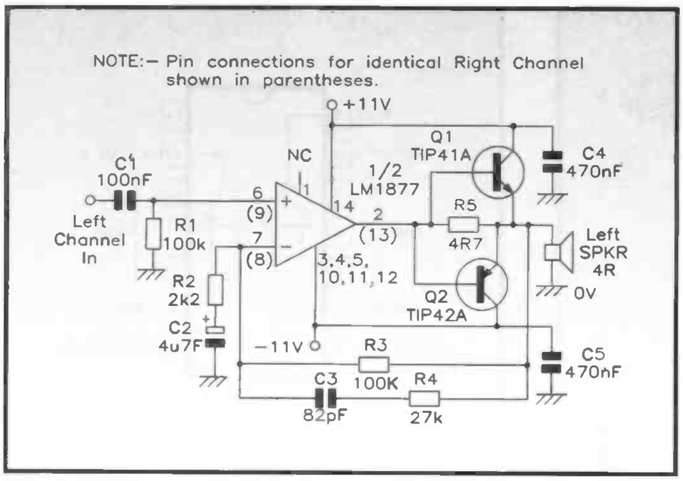


Figure 31. One channel of a 10W per channel stereo amplifier using a split supply.

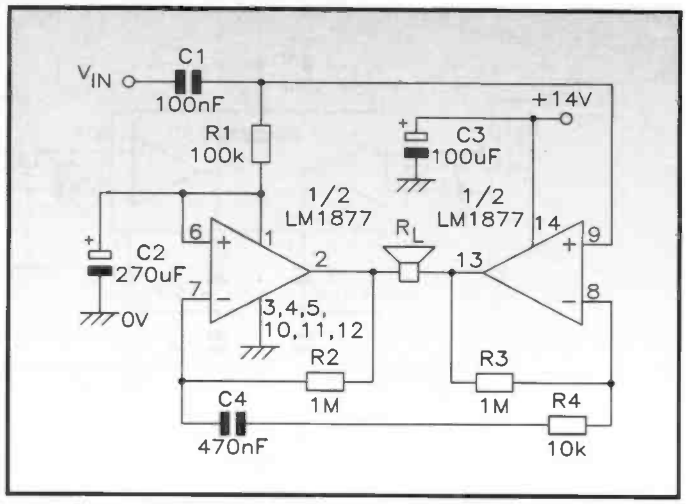


Figure 32. Bridge amplifier circuit using an LM1877 'dual' IC.

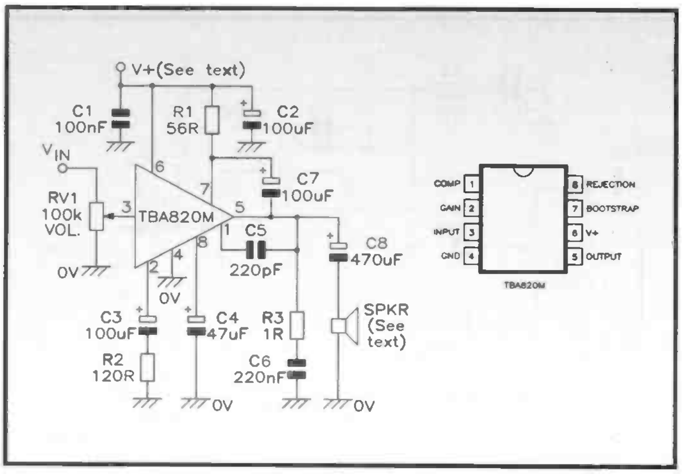


Figure 33. TBA820M low-power audio amplifier circuit and IC outline.

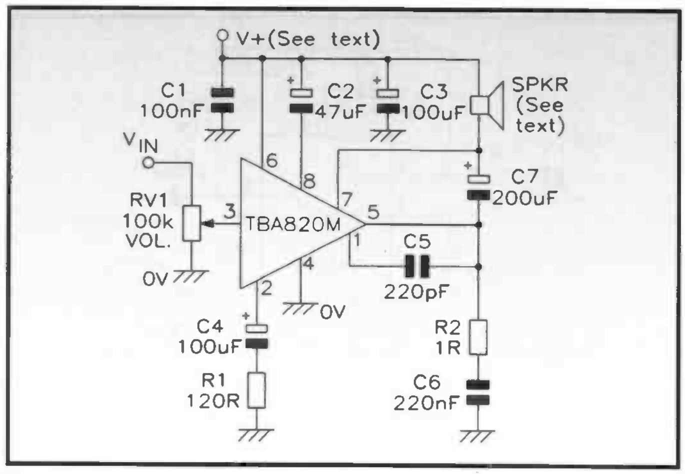


Figure 34. Alternative TBA820M application circuit.

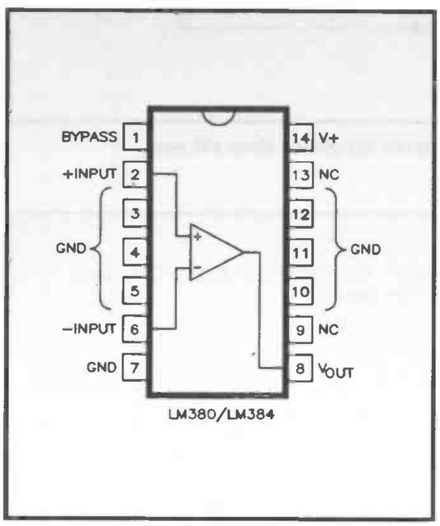


Figure 35. Outline and pin notations of the LM380 and LM384 ICs.

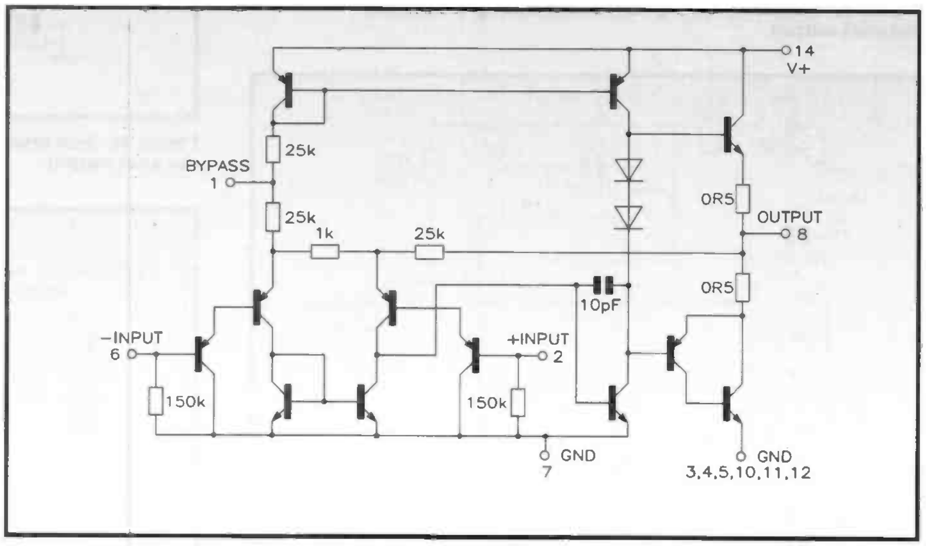


Figure 36. Internal circuitry of the LM380 and LM384 2W and 5W audio power amplifier ICs.

ing amplifier circuit can be modified for use with split power supplies. Note in this case that the internal bias generator is ignored, and that the non-inverting input of each amplifier is DC-coupled to the ground 'half-supply' point via volume control RV1.

Figure 30 shows a highly effective way of boosting the available output power of one half of the LM1877 to 10W, via a couple of power transistors. This remarkably simple circuit generates a typical THD of only 0·05% or so at a 7W output power level. At very low power levels, Q1 and Q2 are inoperative, and power is fed directly to the speaker via R2. At higher power levels, Q1 and Q2 act as a normal complementary emitter-follower and provide most of the power drive to the speaker. R2 and the base-emitter junctions of Q1-Q2 are effectively wired into the negative feedback network of the circuit, thus minimising signal crossover distortion.

Figure 31 shows how the above circuit can be adapted for use with a split power supply. This circuit produces negligible output DC-offset, thus enabling the speaker to be direct-coupled to the circuit's output.

Finally, Figure 32 shows how the two halves of an LM1877 can be used to make a bridge-configured mono amplifier, which can feed 4W into a direct-coupled 8Ω speaker or other load, when powered from a single-ended 14V supply.

TBA820M CIRCUITS

The manufacturers describe this device as a low-power amplifier that is capable of generating a few hundred milliwatts in a 4Ω to 16Ω speaker load, although it can, in fact, generate as much as 2W in an 8Ω load. The IC is housed in an 8-pin DIL package, can operate from supplies as low as 3V, and features low quiescent current, good ripple rejection, and low crossover distortion.

Figure 33 shows the outline and pin notations of the TBA820M IC, plus a practical application circuit for the device. Here, R2 determines the voltage gain of the IC; C7 provides a 'bootstrapping' feedback signal from the output of pin-5 to the input of pin-7

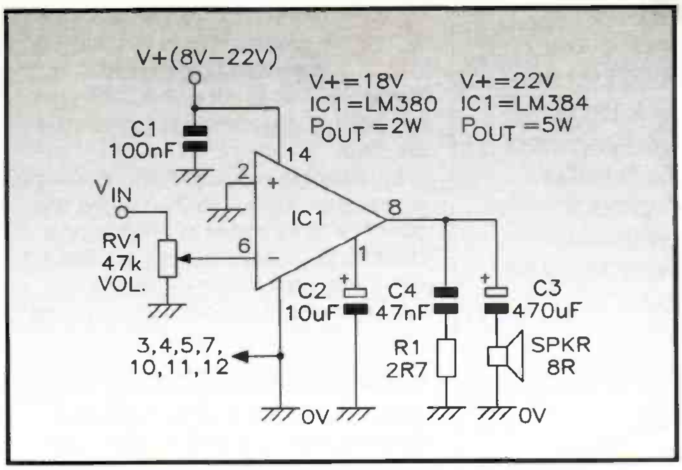


Figure 37. 2W or 5W amplifier with simple volume control and ripple rejection.

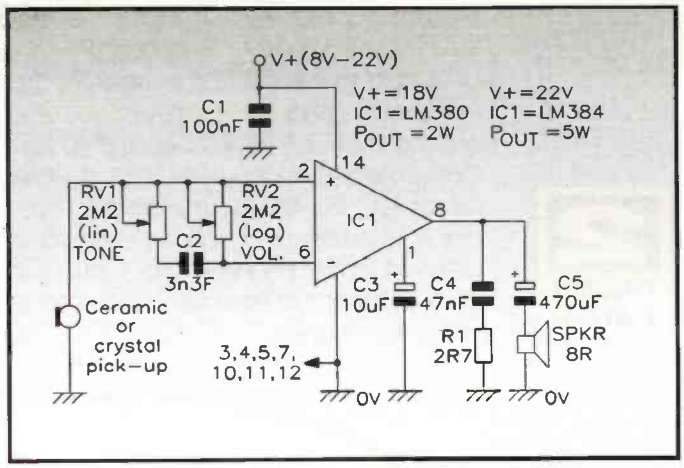


Figure 39. 2W or 5W phono amplifier with 'common mode' volume and tone controls.

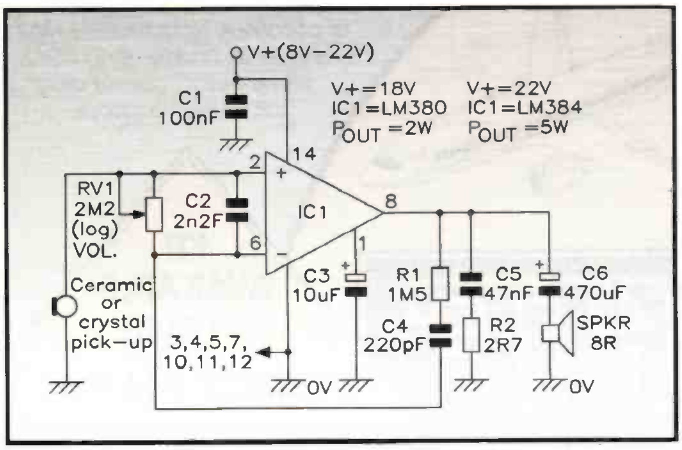


Figure 38. 2W or 5W phono amplifier with RIAA equalisation.

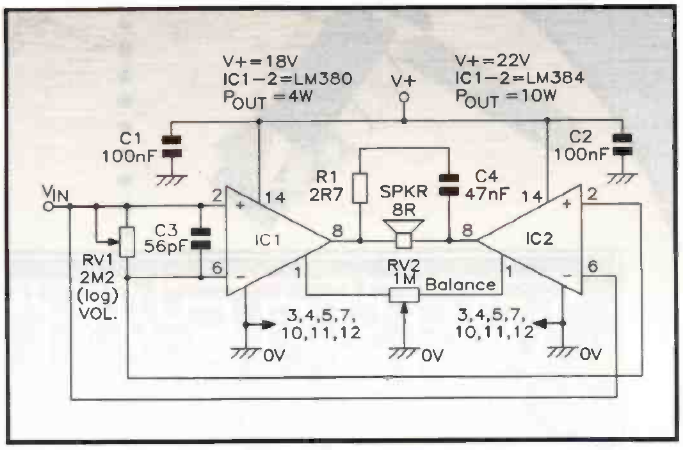


Figure 40. 4W or 10W bridge-configured amplifier.

(to boost the impedance of an internal load resistor), and R3-C6 form a Zobel network across the loudspeaker, which is connected between the output and ground.

Figure 34 shows a simple variation of the above circuit; the 'speaker' is wired between the output and the positive supply rail, and C7 acts as both a bootstrapping and a load-coupling capacitor, thus providing an overall saving of two circuit components. Note in both of these designs that each circuit can use a maximum supply voltage of 16V with a 16Ω speaker, 12V with an 8Ω speaker, or 9V with a 4Ω speaker.

LM380/LM384 CIRCUITS

The LM380 (Figure 35) is probably the best known of all power amplifier ICs. It can work with any supply voltage in the range 8V to 22V, and can deliver 2W into an 8W load when operated with an 18V supply (but needs a good external heatsink to cope with this power level). Its differential input terminals are both ground referenced, and the output automatically sets at a quiescent value of half the supply voltage. Its voltage gain is fixed at x50 (= 34dB), the output is short-circuit proof, and the IC is provided with internal thermal limiting.

The LM384 is simply an 'up-rated' version of the LM380, capable of operating at supply values up to 26V, and of delivering 5·5W into an external load. Both types of IC are housed in a 14-pin DIL package, of which pins 3, 4, 5 and 10, 11, 12 are intended to be thermally coupled to an external heatsink. Figure 36 shows the internal circuitry that is used by both ICs.

To conclude, Figures 37 to 40 show some practical applications of these two audio power amplifier ICs. Figure 37 shows how to use either IC as a simple (x50) amplifier with enhanced (via C2) ripple rejection and a very simple form of volume control (via RV1). Figure 38 shows how to use either IC as a 'phono' amplifier with RIAA equalisation (via R1-C4). Figure 39 shows how to modify the circuit for use with so-called 'common mode' volume and tone controls. Finally, Figure 40 shows how to use a pair of these ICs in the 'bridge' mode, to give a maximum output of either 4W or 10W.

A further selection of applications of audio power amplifier ICs (including 'dual' types), with maximum power ratings in the approximate range 6W to 40W, will be given in part three next month.

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VHF/UHF PREAMPLIFIER

PROJECT RATING 2

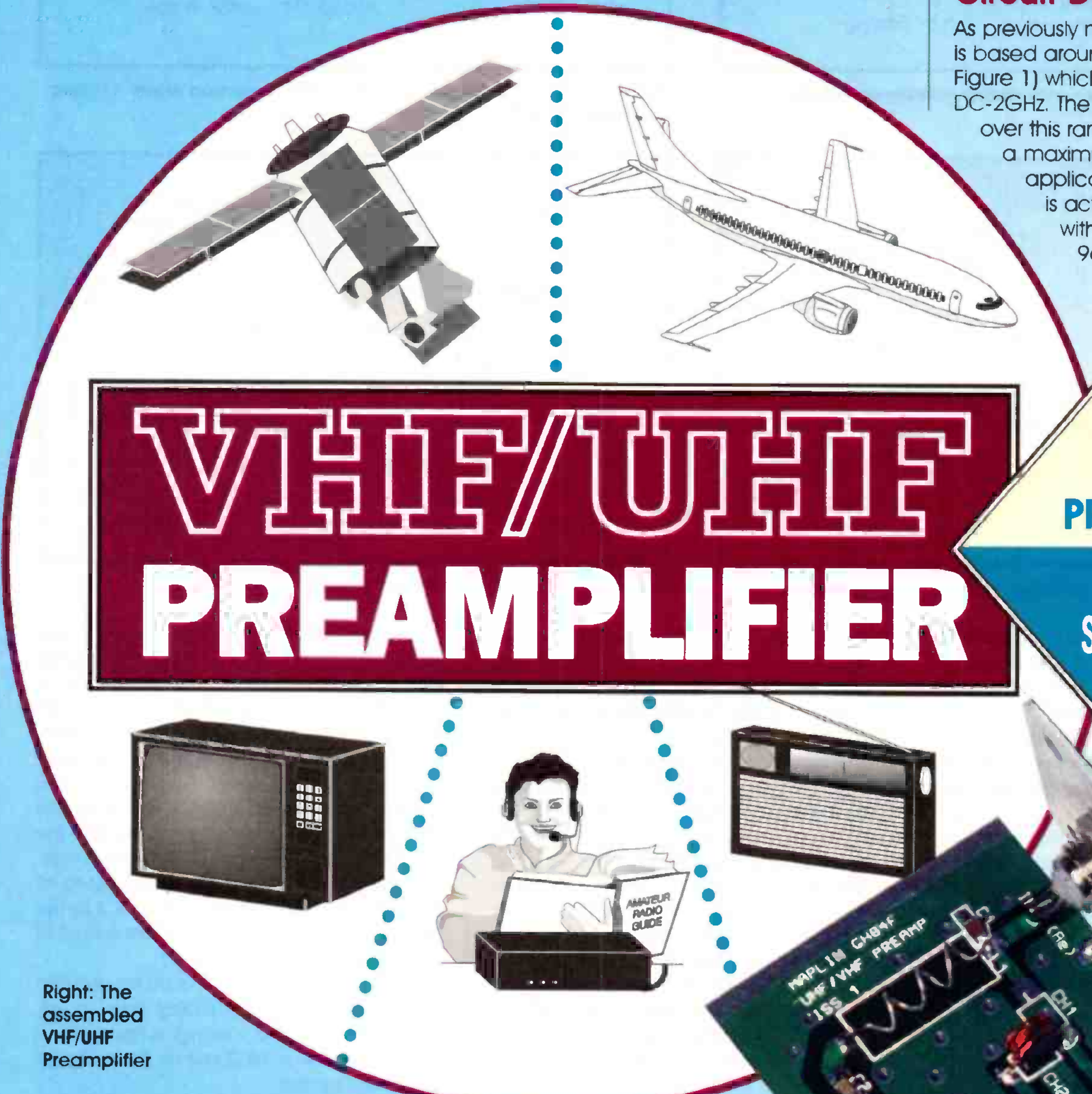
This preamplifier was originally intended for use with the MAPSAT VHF Weather Satellite Receiving System; it was designed to be a replacement for the previous Maplin VHF preamplifier kit. However, the new design is based around a MAR-6 MMIC (Monolithic Microwave Integrated Circuit), which is unconditionally stable across its entire range (DC-2GHz). This means that the preamplifier is highly versatile, and can be used for any number of different applications. Photo 1 shows the typical response characteristics of the preamplifier for selected frequency bands.

ONE of the main applications of this preamplifier in the MAPSAT system is to compensate for long feeders between either the VHF aerial or the Down Converter, and the MAPSAT Receiver.

By using the preamplifier to boost the signal level applied to the feeder, the effect of any sources of interference close to the feeder is reduced. This is especially useful if the receiver is located near to a computer or printer.

Circuit Description

As previously mentioned, this circuit is based around a MAR-6 MMIC (see Figure 1) which has a stated range of DC-2GHz. The gain is at least 16dB over this range, and may rise up to a maximum of 19dB for certain applications. Note that the MAR-6 is actually usable up to 4GHz, with a typical gain of around 9dB at this frequency.



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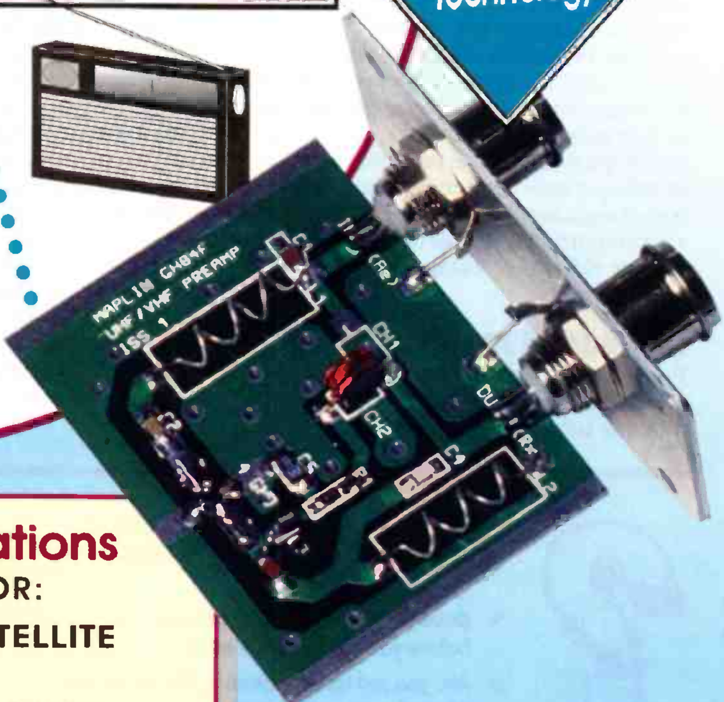


Right: The assembled VHF/UHF Preamplifier

Features

- ★ Multi-range VHF/UHF preamplifier
- ★ Low power consumption
- ★ Power supply through coax cables
- ★ High gain
- ★ No tuning required
- ★ Surface mount components

Applications

IDEAL FOR:

- ★ VHF SATELLITE BAND
- ★ UHF TV BAND
- ★ FM RADIO BROADCAST BAND
- ★ AMATEUR RADIO BANDS
- ★ AIRCRAFT BAND

Design by Dennis Butcher
Text by Dennis Butcher and Dean Hodgkins BEng (Hons)

A block diagram of the VHF/UHF preamplifier is shown in Figure 2. The circuit comprises three main parts: a low-pass filter on the input; the amplifier itself; and a high-pass filter on the output. The full circuit diagram is shown in Figure 3.

Filters

The filters were designed to match the impedance of the inputs/outputs to the MAPSAT system; this is a 75Ω system, and the MAR-6 is a 50Ω device. In practice, the loss from a 75/50Ω mis-match is only about 0·18dB at each port, and so the preamplifier could be used in either a 75 or 50Ω system, with only a negligible loss. The filters are a simple 'L' type, which means that component tolerances, temperature variations, etc. will have a minimal effect at the design frequencies. Also, no expensive test equipment or specialist knowledge is required in making them.

The input matching network is formed by L1/C1 and is a low-pass filter (see Figure 4).

The formulae required to work out the reactance of L1 & C1 are shown below:

$$X_L = \sqrt{R1 \times R2 - R2^2} \qquad X_C = \frac{R1 \times R2}{X_L}$$

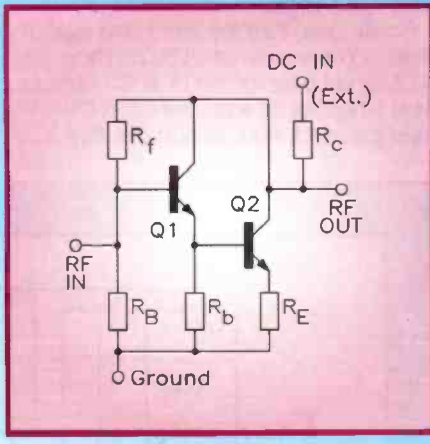


Figure 1. Internal circuit diagram of the MAR-6 chip.

Now that we have X_L & X_C, we can use the following formulae to work out the actual values of L1 & C1 which will be required at our chosen working frequency:

$$L = \frac{X_L}{2 \times \pi \times f}$$

$$C = \frac{1}{2 \times \pi \times f \times X_C}$$

If our 'working frequency' is to be 137·5MHz (the centre of the VHF Weather Satellite band), then the results are as follows:

L1 = 41nH
C1 = 11pF

To make a practical filter, therefore, we need a 10pF capacitor and a 40nH inductor.

The output matching network is formed by C3/L2 and this makes a high-pass filter. Fortunately, the two formulae

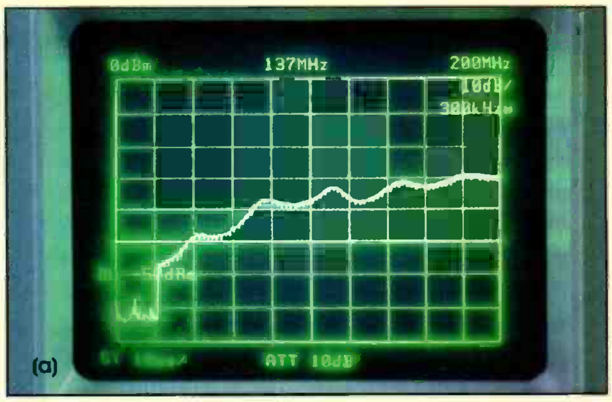


Photo 1. Typical response characteristics of selected frequency bands, as shown on a spectrum analyser: (a) the TV band (471 to 854MHz); (b) the VHF satellite band (137 to 138MHz).

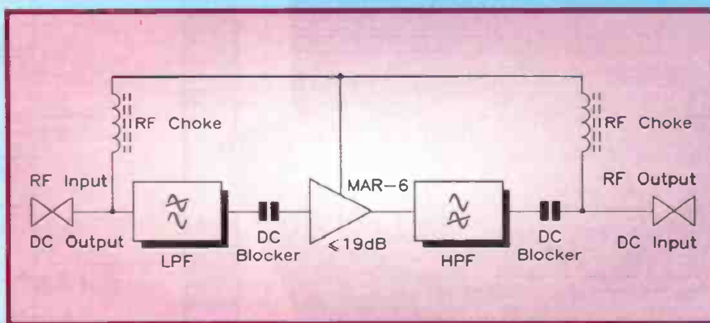


Figure 2. Block diagram of the VHF/UHF Preamplifier.

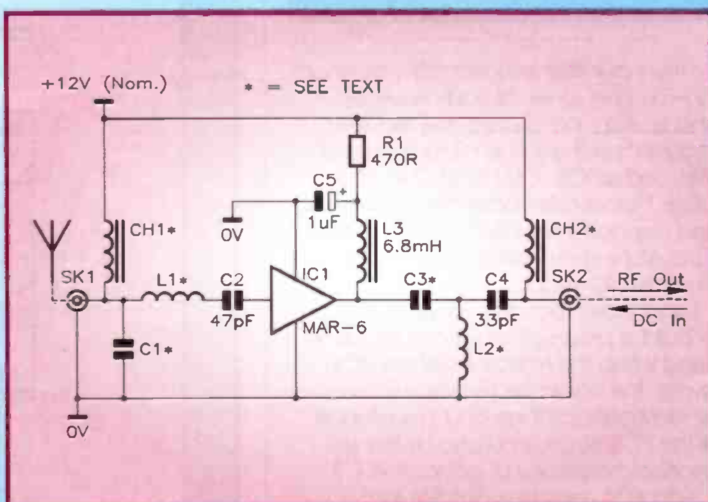


Figure 3. Circuit diagram of the VHF/UHF Preamplifier.

Frequency. Band (MHz)	L1	SWG	Turns	Dia.	C1	L2	SWG	Turns	Dia.	C3
50-51 (6-Metre Band)	110nH	24	5	6mm	29pF	113nH	24	5	6mm	30pF
"	"	22	6	5mm	"	"	22	2	10mm	30pF
137-138 (VHF Satellite Band)	41nH	24	3	3mm	10pF	41nH	24	3	3mm	10pF
144-146 (2-Metre Band)	39nH	24	3	3mm	10pF	39nH	24	3	3mm	10pF
430-440 (70cm Band)	13nH	24	1	3mm	3pF	13nH	24	1	3mm	3pF
88-108 (FM Radio)	52nH	24	4	3mm	14pF	64nH	24	5	3mm	17pF
471-854 (TV Preamplifier)	7nH	24	0	0mm	1·8pF	34nH	24	2	3mm	10pF

Table 1. Component selection for frequency options.

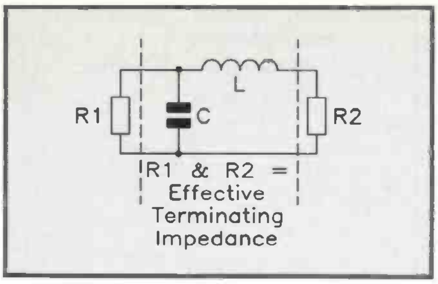


Figure 4. Low-pass input filter configuration of the VHF/UHF Preamplifier.

Specification

Power supply:	+12V DC (nominal)
Power source:	External PSU or via coax cables
Power Consumption:	16mA @ 12V
Gain:	up to 19dB
Frequency range:	100kHz to 1GHz

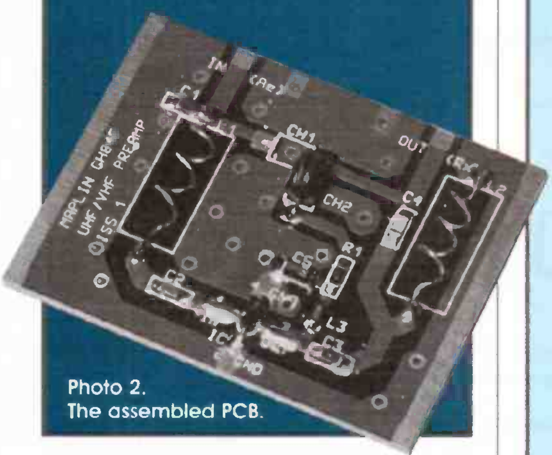


Photo 2. The assembled PCB.

for the input filter work equally well when R2>R1, and so we already have X_C and X_L. Also, in this case, the required frequency is the same as for the input filter, and so C3 = C1 and L2 = L1. Table 1 cross-references the coil winding and capacitor selection details for filter CL matching network calculations when R1=75Ω; R2=50Ω.

Using these formulae will enable you to build a preamplifier for any frequency band within the limitations of the PCB layout. The upper frequency is limited by stray capacitance and inductance of the PCB tracks, and also by the self-resonant frequency of capacitors C2, C3 and C4 (typical examples for surface mount types are given in Table 2). The values of C2 and C3 will also affect the VSWR (Voltage Standing Wave Ratio) of the input/output of the MAR-6, as shown in Figure 5.

The lower frequency is limited by two factors: First, the values of C2, C3 and C4 – these must be large enough to present an RF short-circuit at the lowest required frequency, and must not be self-resonant within the pass-band of the amplifier; Second, the values of L1 and L2 – these coils must be small enough to fit onto an area of 15 × 8mm, but lower frequencies need higher value inductors, and these tend to be larger.

Finally, note that the input and output filters can be eliminated by omitting C1 & L2, and by replacing L1 & C3 with a short length of TC wire, but C2 & C4 *must* be used. Also, remember that even a straight piece of wire has a finite value of inductance, and this will limit the upper frequency of operation.

Amplifier

The internal structure of the MAR-6 amplifier (shown in Figure 1) comprises a pair of transistors connected as a Darlington Pair, and a resistive biasing scheme. Note that both series feedback (in the form of R_E adjusting the emitter voltage of Q2) and shunt feedback (in the form of R_e adjusting the base

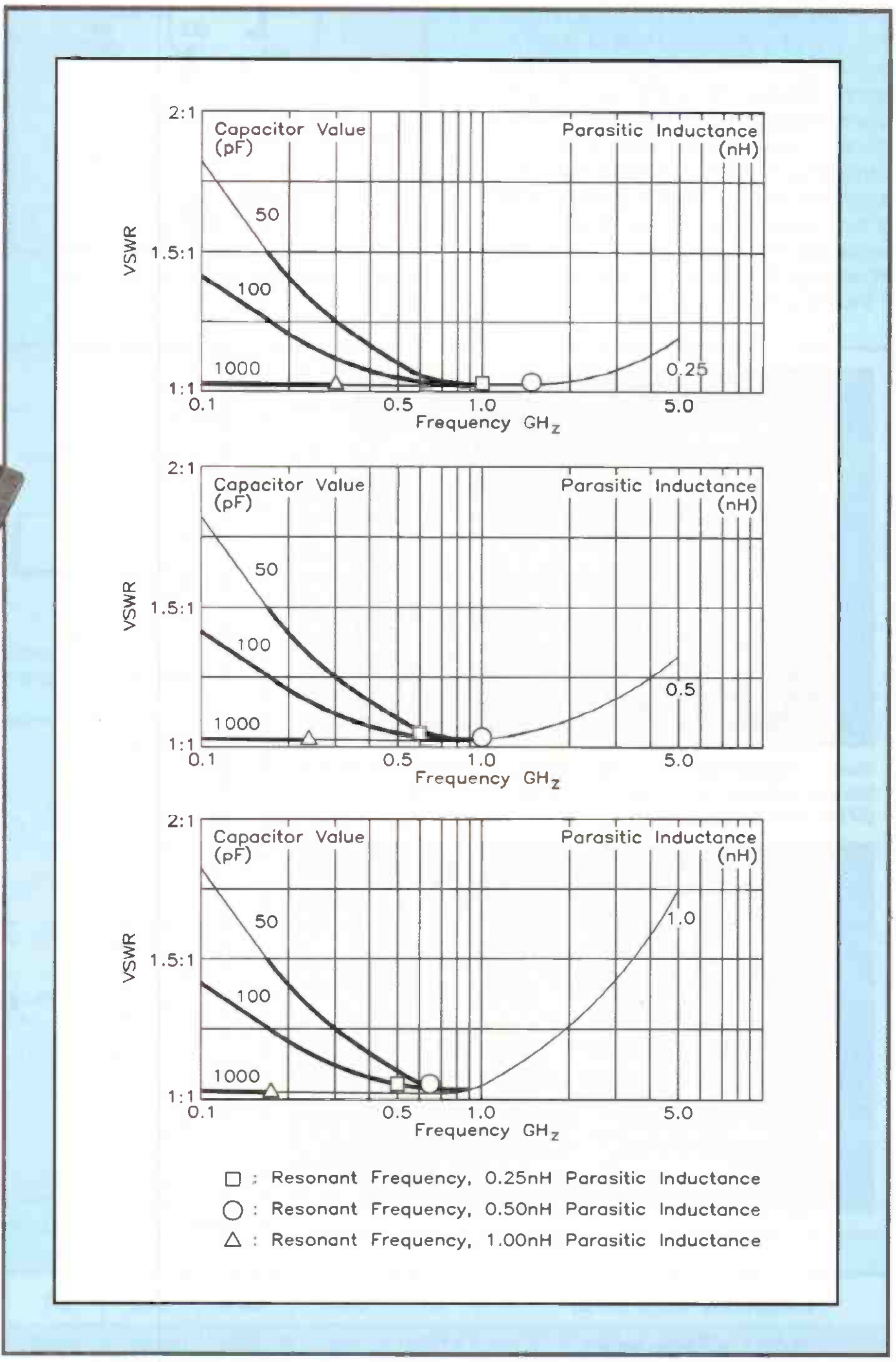


Figure 5. The effects of DC blocking capacitors on VSWR as a function of frequency, capacitance, and parasitic inductance for the VHF/UHF Preamplifier.

Self Inductance *	Capacitance				
	10pF	22pF	33pF	47pF	100pF
0·5nH	2·251GHz	1·517GHz	1·239GHz	1·038GHz	712MHz
1nH	1·592GHz	1·07GHz	876MHz	734MHz	503MHz

* Estimated from manufacturers data and experimentation.

Table 2. Typical self-response of capacitors.

voltage of Q1) are used to reduce the effects of variations in active device parameters. The resistor R_b decouples the quiescent bias point of Q1 from the beta of Q2 – without this resistor, the emitter current of Q1 would equal the base current of Q2.

Power Source

The power supply for this preamplifier is fed via the coax cable that carries the signal to the MAPSAT receiver. If your receiver does not supply 12V DC through the coax cable, then a power supply can be either purchased ready-made (PU1 Stock Code BW50E suitable for 40 to 1000MHz), or built very easily from a few stock components (Figure 10).

Power is supplied via the coax; CH3 passes the +12V (nominal) DC, but blocks the RF Signal; C4 is a blocking capacitor, which passes the RF Signal but blocks DC. If the power supply is also required to power another piece of equipment (e.g. the Down Convertor), then CH1 is also needed.

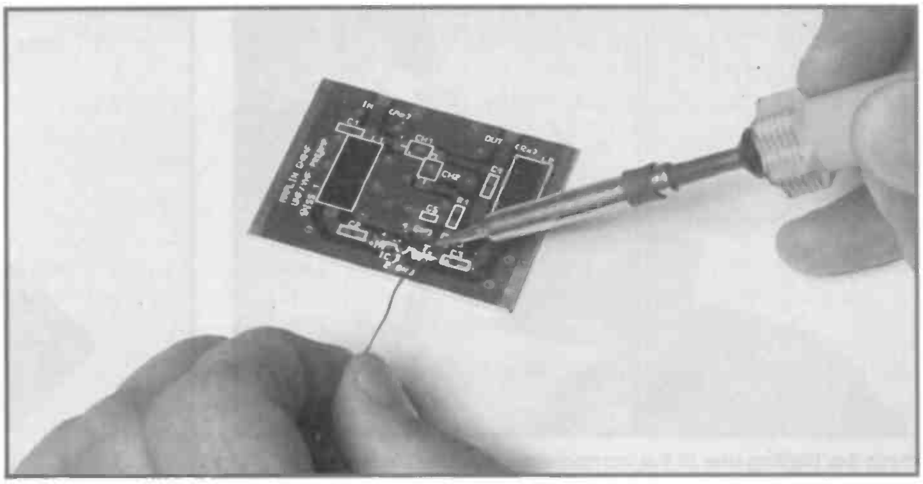


Photo 4. Mounting the MAR-6 IC chip.

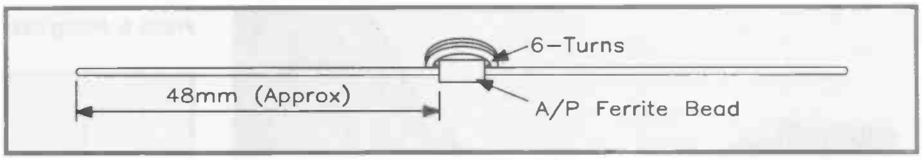


Figure 6. Making the chokes for the VHF/UHF Preamplifier.

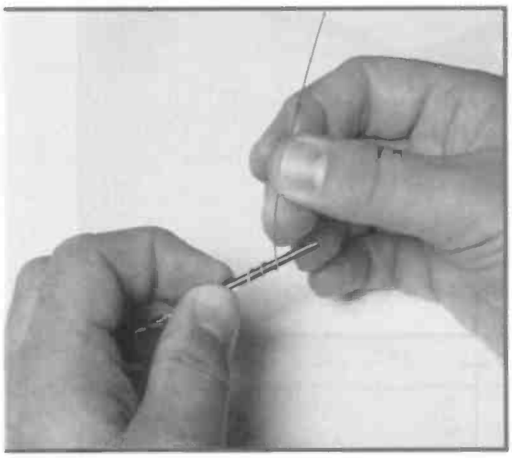


Photo 3. Winding the coils on a drill bit.

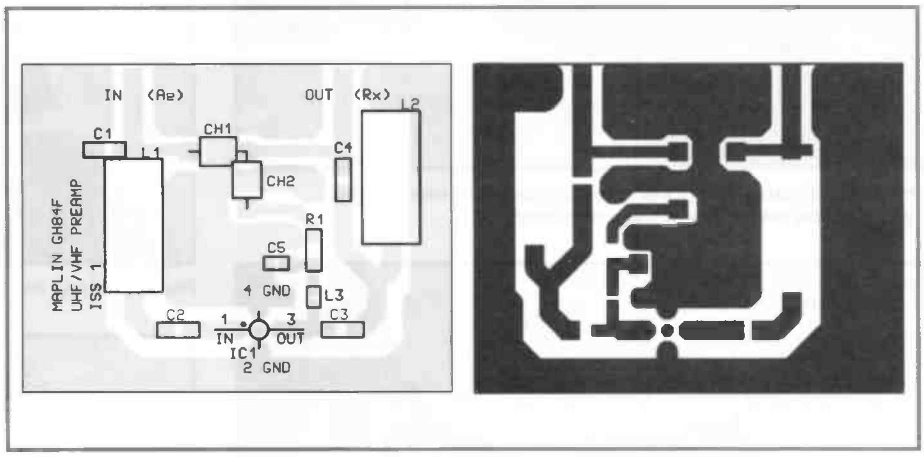


Figure 7. PCB Legend and ghost of component side track of the VHF/UHF Preamplifier.

Power Is supplied to the MAR-6 via a bias resistor of 470Ω; CH1 prevents any RF Signal from the amplifier's output from reaching the input, and acting as a negative feedback loop. C5 is only there to bypass any RF (to earth) which gets past L3

Construction Details

At first sight, the fact that this Is a surface mount project may seem daunting, but do not be put off. The component count is very low (see Photo 2), and there is a way to solder these tiny components using only 'ordinary' equipment.

Before you start, it may be useful to check that you have the following items laid out on your work area:

1. A low wattage soldering iron (15W or less) with a fine bit (0·5mm Is recommended).
2. A pair of tweezers or snipe-nose pliers.
3. A sheet of clean white paper (A4 is ideal) upon which to place each surface mount component, prior to positioning.
4. PCB cleaner and a small brush.

Observe the usual antistatic precautions before handling the MAR-6 IC; ensure that you touch an 'earthed' conductor (domestic water pipes, for example) to remove any static charge which you may have accumulated.

Step 1.

Select the required values of C1 & C2, and wind L1 & L2 from the tinned copper wire supplied in the kit, according to Table 1. Note that values are only approximate; nobody can be expected to wind a coil by hand with an accuracy greater than ±5nH. Similarily, the nearest standard value of capacitors should be used; where the values are very small, it is better to opt for a slightly smaller standard value, rather than a larger – the stray capacitance of the PCB layout will compensate (partly, at least).

The inductors are very easy to wind if you use the shank of a drill bit of the appropriate size as a 'former' (see Photo 3). Leave 'tails' of about 10mm at each end of the coil. Turns should be spaced at one 'diameter' distance apart; for example, a 3mm diameter coil has turns spaced 3mm apart.

The two 1mH chokes, CH2 and CH1, are made from two anti-parasitic ferrite beads using 500mm of 0·315mm emamelled copper wire. Using 200mm of the wire, wind 6 turns around one of the beads by passing it through the central hole to make a toroidal coil. Begin winding at about 45·5mm from one end of the wire to leave an equal amount at each end when finished (see Figure 6). The placing of the turns is not critical, but care should be taken not to scrape the enamel insulation on the sharp edges of the ferrite bead.

Make up CH2 (and CH1 if required).

Do not fit CH1 if you are connecting this preamplifier directly to an aerial which presents a DC short circuit, e.g., the MAPSAT VHF aerial, and most TV aerials.

Step 2.

Before attempting any soldering, ensure that you double-check that the type, value, and positioning of the components are correct. The PCB legend (see Figure 7) will assist you when positioning each item.

Mount IC1 (see Photo 4). Form the two 0V leads first by bending them down at 90°, approximately 1·5mm from the body of the device.

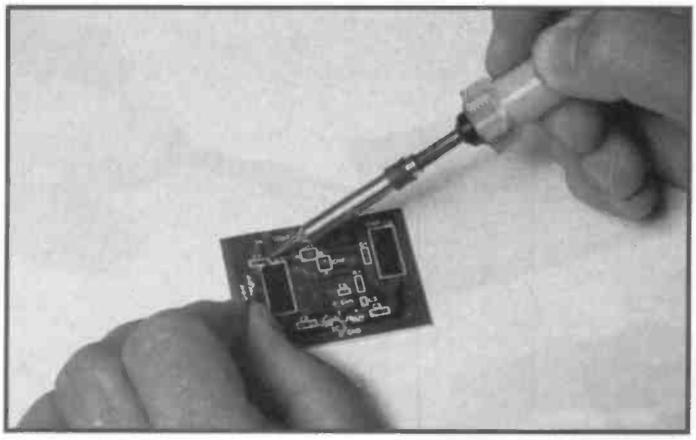


Photo 5a. Wetting one of the component pads with solder.

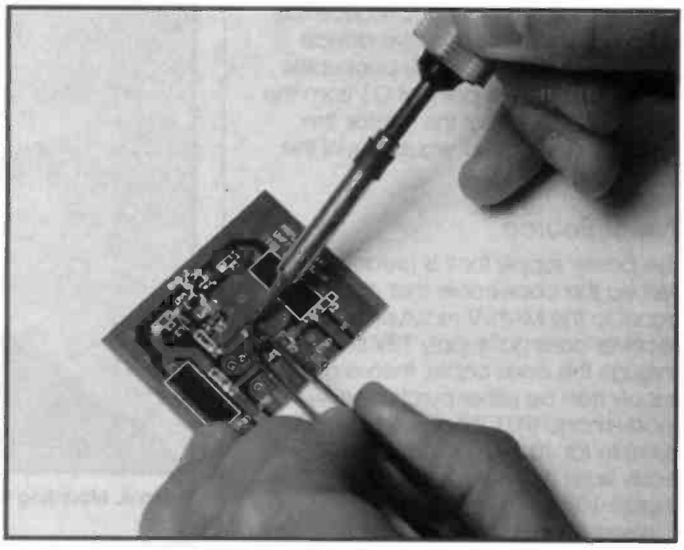


Photo 6. Fitting the chokes.

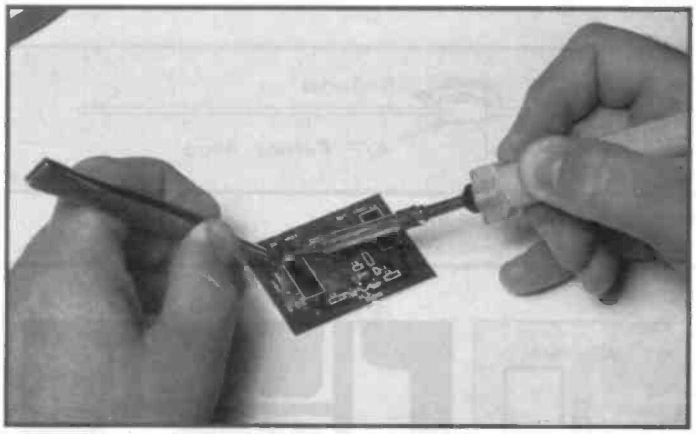


Photo 5b. Holding components in position with tweezers and reflowing the solder to wet the component.

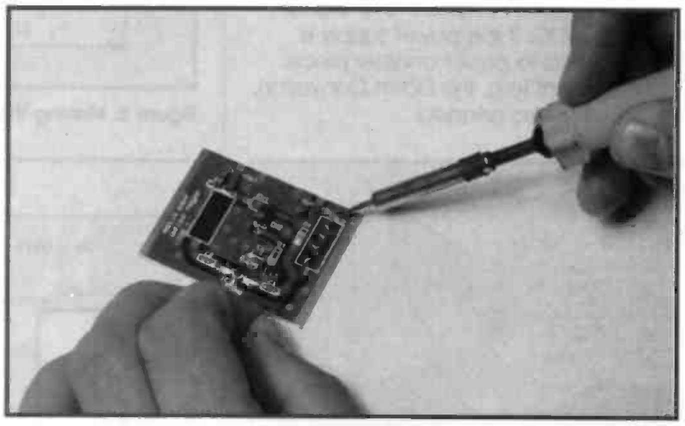


Photo 7. Fitting the tinned copper wire inductors.

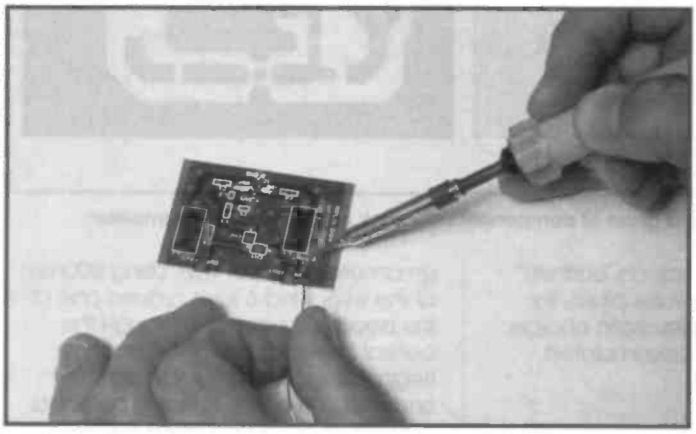


Photo 5c. Making the opposite joint of the component.

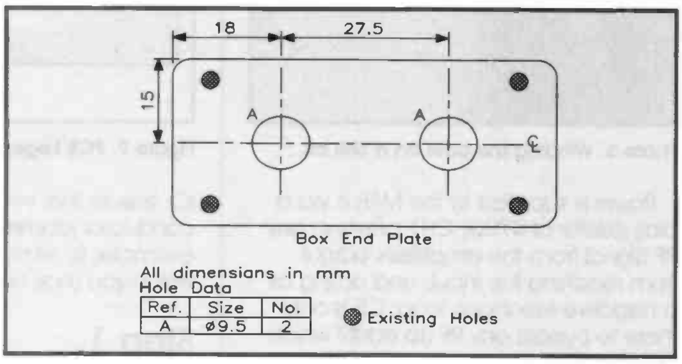


Figure 8. Box drilling of the VHF/UHF Preamplifier.

Insert the two leads through the holes in the pads, with the white dot on the package towards the C2 position; the plastic package should fit into the large hole, so that all four leads lay flat on the tracks. Hold the IC in position, turn the PCB over and bend the leads flat against the ground plane; turn the PCB back over – the IC should still be in its correct position.

Solder each of the four leads in turn, allowing the IC to cool in between soldering each lead. Note that the two 0V leads should also be soldered on the 'ground plane' side.

Step 3.

Following the photo-sequence (Photos 5a to c), solder the remaining components in position on the PCB in the following order: C1, C2, C3, C4, L2, C5, R1. Remember that C5 is a tantalum capacitor, and so be sure that the negative lead is fitted towards pin 4 of the IC. The positive lead, identified by a (+) symbol or white marking on the body of the capacitor, must be fitted towards the (+) symbol on the PCB.

The correct procedure is as follows:

1. 'Wet' one of the component pads with solder.
2. Hold the component in position using tweezers or snipe nosed pliers.
3. Reflow the solder to 'wet' the component (hold it in position until the joint cools).
4. Make the other joint.
5. Remake the 1st joint with fresh solder.

Step 4.

Trim the leads on CH2 (and CH1 if required) to the correct length, and solder in position, as shown in Photo 6.

Step 5.

Solder L1 and L2 into position (Photo 7), first offering each one up into position, and then trimming to leave the windings in the centre of the PCB positions. Ensure that no part of the windings is shorted out to the top plane.

Step 6.

Mark out and drill one endplate of the box (see Figure 8), and fit the two sockets in position, with the earth tags as shown in Figure 9. Fit one gasket (optional) to the inside face of each endplate. Screw the blank endplate firmly to one end of the box.

Step 7.

Solder the IN/OUT tracks of the PCB to the centre pins of the two sockets – a larger/hotter soldering iron may be

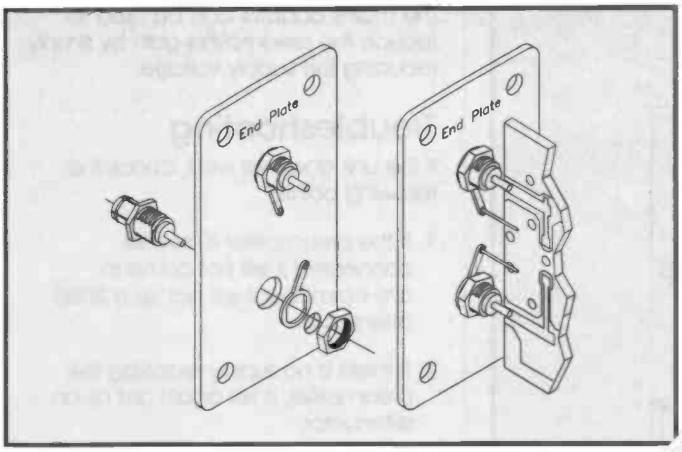


Figure 9. Final assembly of the VHF/UHF Preamplifier.

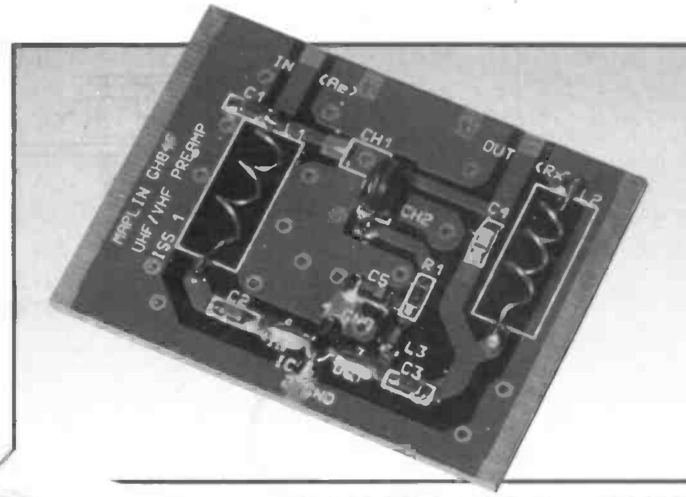


Photo 8. Close-up of the assembled PCB.

required for this. Note that the ground plane side of the PCB should be to the same side as the earth tags on the sockets (see Photo 8). Solder a short length of tinned copper wire between each of the two earth tags to the ground plane of the PCB; *keep the wires as short as possible.*

Step 8.

Check the PCB for any blobs of solder, and when you are happy, slide the assembly into the box – it will only fit one way – and secure it with the four remaining screws (see Photo 9). Note which connector is 'IN' (the aerial connector) before screwing the box shut.

Testing

The preamplifier is now ready for testing and installation; if you have built it to use with the MAPSAT Receiver, then power will be supplied from the receiver via the coax. If your receiver does not supply +12V DC via the coax, then a suitable power supply can be built as shown in 'PSU Assembly'.

Connect SK1 ('IN') to your aerial and SK2 ('OUT') to the MAPSAT Receiver (or your TV, scanner, etc. via the power supply) and tune into a suitable signal; the signal meter should show an increase in signal strength, and there should be a corresponding decrease in the amount of 'noise' or 'mush' heard with otherwise weak signals. When you are satisfied that your preamplifier is working correctly, disconnect it and transfer it to its final position which should, for maximum effect, be as close to the aerial as possible.

If the unit is to be fitted outdoors, the unit may either be fitted inside another waterproof box, or weather-proofed after installation by a coating of marine quality varnish around all the joints, screws and the two sockets – heatshrink sleeving can be used to cover plugs and sockets.

PSU Assembly

This section only applies if you wish to construct a PSU for the preamplifer – a PSU is only necessary if your receiver does not supply +12V DC through its coax cable.

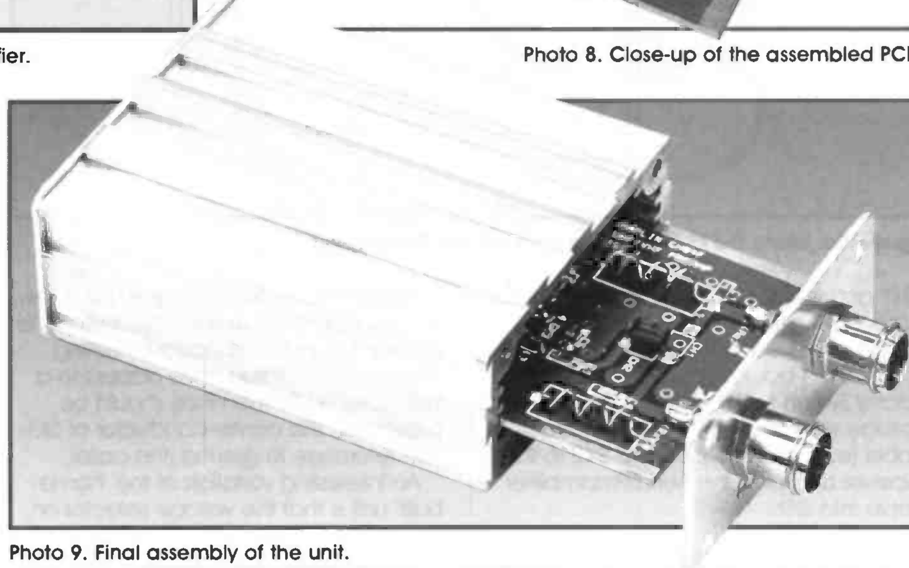


Photo 9. Final assembly of the unit.

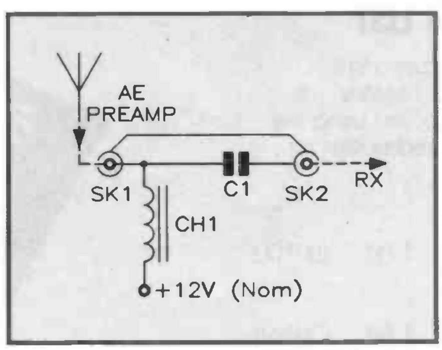


Figure 10a. Circuit diagram of the PSU interface for the VHF/UHF Preamplifier.

The circuit diagram is shown in Figure 10a, and the drilling and assembly details in Figures 10b and 10c. Note that this unit is only suitable for indoor use.

Referring to Figure 10b, drill the box, and then fit SK1 and SK2, with the earth tags to the inside, i.e. 'facing' each other as indicated in Figure 10c. Using a scrap of tinned copper wire, solder the earth tags together.

Solder C1 directly to the centre conductors of the sockets, keeping the leads as short as possible. Solder one end of CH1 to the SK1 side of C1.

Cut the multi-connector off the end of the mains adaptor lead; feed the lead through the strain relief grommet, leaving about 3in. free. Insert the grommet into the hole in the box.

Strip and tin about 5mm of the cable ends; slip the heatshrink sleeving over one conductor of the cable and then solder the prepared end to the free end of CH1. Slip the heatshrink sleeving over

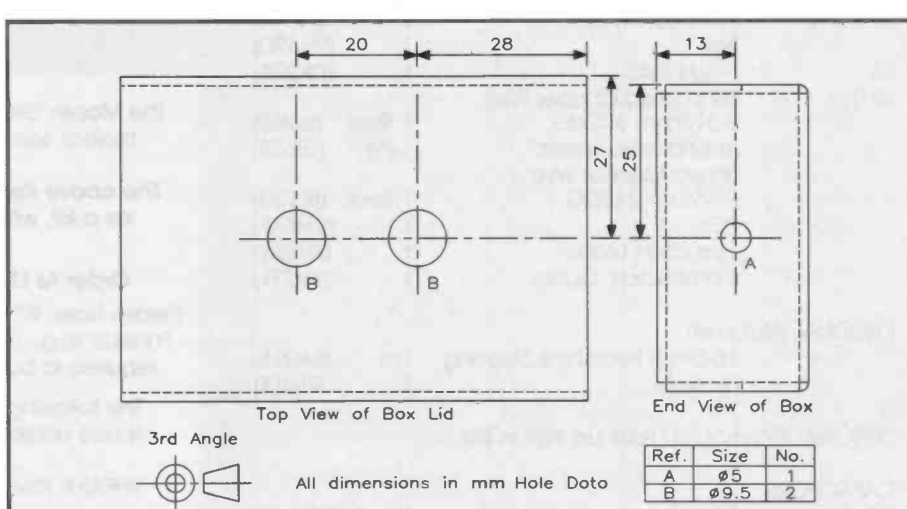


Figure 10b. Drilling of the endplate for the VHF/UHF Preamplifier.

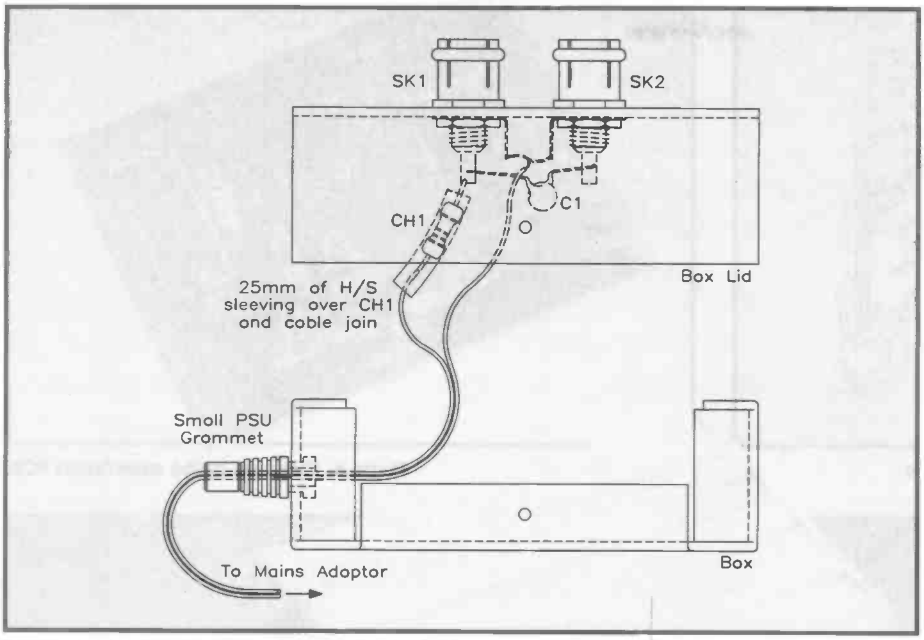


Figure 10c. Wiring the PSU interface to the VHF/UHF Preamplifier.

CH1 and the cable joint, shrink in position. Finally, solder the other cable to one of the earth tags.

Screw the box halves together; set the Polarity Switch to 'TIP POSITIVE' and the voltage selector to '12'. Using a suitable cable (e.g., XR29G), connect SK2 to the receiver and plug the Aerial/Preamplifier cable into SK1.

Plug in and switch on! If the unit does not appear to be working, first switch the polarity switch to the opposite setting and try again. If you have access to a voltmeter, +12V (nominal) should be present on the centre conductor of SK1, with reference to ground (the case).

An interesting variation of the 'home built' unit is that the voltage selector on the mains adaptor can be used to reduce the preamplifier gain by simply reducing the supply voltage.

Troubleshooting

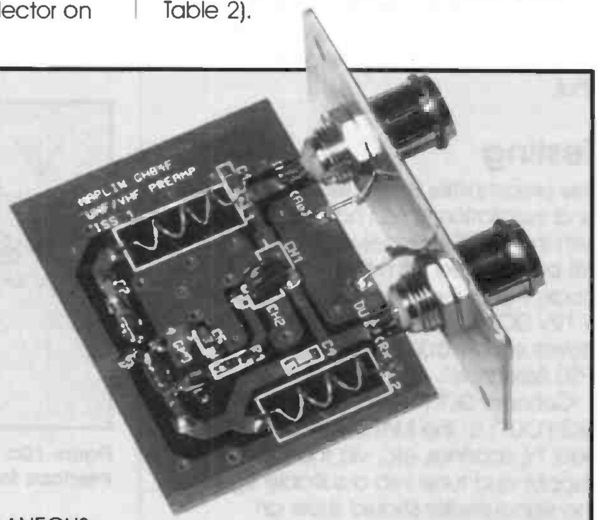
If the unit does not work, check the following points:

1. If the preamplifier is reverse connected it will not come to any harm, but it will act as a 20dB attenuator.
2. If there is no supply reaching the preamplifier, it will again act as an attenuator.
3. Funny noises, squeaks, pops, patterns of severe interference on TV channels – the preamplifier has probably started to oscillate. The main causes of this are poor connections to the groundplane, and dry solder joints, etc. Check all nuts, solder joints and coax plugs (the centre connector of some plugs has a screw connection – it is best to discard the screw and solder the centre conductor directly.

Note that the use of non-chip capacitors of >33pF in a preamplifier, which is designed to operate at frequencies of (or above) 300MHz, will often result in the capacitors oscillating due to their high self-inductance (See Table 2).

VHF/UHF PREAMPLIFIER PARTS LIST

The kit parts list includes all of the parts to make a VHF Preamplifier for the 137 to 138MHz or 144 to 146MHz bands. Alternative components may be selected using the information given in the text to modify the preamplifier for different bands.



RESISTORS			
R1	470Ω Surface Mount	1 Pkt	(DJ10L)
CAPACITORS			
C1,3	10pF SMD Ceramic	1 Pkt	(DH86T)
C2	47pF SMD Ceramic	1 Pkt	(DH89W)
C4	33pF SMD Ceramic	1 Pkt	(DH88V)
C5	1μF 16V SMD Tantalum	1	(DK22Y)
SEMICONDUCTORS			
IC1	MMIC MAR-6	1	(DK24B)
MISCELLANEOUS			
SK1, SK2	HQ Coax Socket	2	(FE10L)
	Box	1	(YN49D)
L3	6·8μH SMD	1	(DK23A)
CH1,2	Enamelled Copper Wire 0·315mm 30SWG	1 Reel	(BL40T)
	Anti-Parasitic Beads	1 Pkt	(LB62S)
	Tinned Copper Wire 0·56mm 24SWG	1 Reel	(BL15R)
	PCB	1	(GH84F)
	Instruction Leaflet	1	(XU88V)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in kit)			
	16·5mm Heatshrink Sleeving	1m	(BA01B)
	Gasket	1	(FE40T)
OPTIONAL External PSU Parts List (Not in Kit)			
CAPACITORS			
C1	10pF Ceramic	1	(WX44X)
MISCELLANEOUS			
SK1, SK2	HQ Coax Socket	2	(FE10L)
CH1	1mH Choke	1	(WH47B)
	Small PSU Grommet	1	(JP42V)
	6mm Heatshrink Sleeving	1m	(KC42V)
	Box	1	(LF13P)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LT73Q (VHF/UHF Preamp) Price £14.99

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately, but is not shown in the 1994 Maplin Catalogue

VHF/UHF Preamp PCB **Order As GH84F Price £3.99** by Keith Brindley

Getting to know Test EQUIPMENT

PART 2

Analogue Test Equipment

The most common piece of analogue test instrument encountered in the laboratory is the plain and simple multimeter that uses a moving-coil movement as its display. What's more, the analogue meter is the most common piece of test equipment of all; an odd state of affairs since the analogue meter is not particularly accurate. However, it is a versatile and general-purpose tool which will give reasonable results in many applications.

The moving-coil movements of today represent the culmination of developments over the 150 years since it was first discovered that a current, passing through a wire suspended in a magnetic field, created a force which tended to move the wire. In the moving-coil movement, the wire is coiled; the coil rotates in proportion to the amount of current, see Figure 1, turning and taking with it a pointer that points to a graduated scale, thus indicating the value of the current. Its extreme simplicity, yet comparative accuracy, means that the moving-coil movement forms the basis of many items of test equipment. Indeed, until just a few years ago, most measurements taken in electrical and electronic circuits were carried out using the moving-coil analogue display. Today things are beginning to change and, although still a very popular instrument, the analogue meter is slowly being overtaken by its digital counterparts. It will be some years yet, however, before the moving-coil movement itself is made obsolete – if ever, because in some measurements the movement gives a better display than is usually possible from available digital devices.

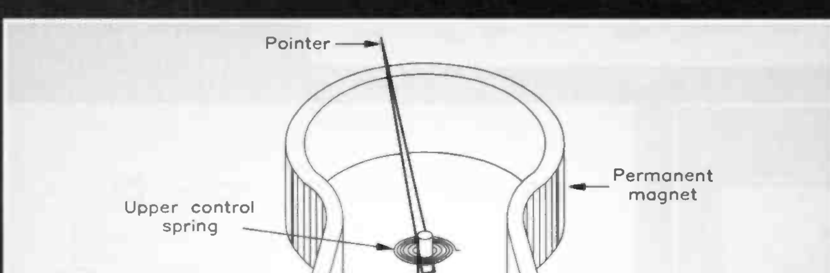


Figure 1. The working components of a moving-coil meter movement.

General-Purpose Meters

Moving-coil movements are generally manufactured with sensitivities ranging from about 10μA to 1mA, at full-scale deflection (FSD). FSD occurs when the pointer is deflected to its farthermost point by the current. The coil within the movement has resistance, of course. This ranges in value from about 5Ω to 5000Ω, which from Ohm's Law means that voltages of 50μV or so to 5V will deflect the pointer to its FSD position. Any one coil will only be able to measure one particular range of values of current or voltage, of course, so if the movement is to be used to measure a number of ranges of values, some way of converting the values to be measured to within the movement's own range, must be incorporated. In its simplest form, this is a single resistor connected either in series, or in parallel, with the movement.

These descriptions are necessarily short. Ensure that you know exactly what the kit is and what it comprises before ordering, by checking the issue of *Electronics* referred to in the list.

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MODEL STEAM TRAIN CHUFFER

Add the extra dimension of sound to your layout with this realistic steam engine sound simulator. The rate of chuffing varies with the track voltage, i.e. train speed, and when the engine is stationary the sound of escaping steam can be heard. The unit requires a supply of +15·5 to 36V DC and the audio output connects to your existing amplifier. (Optional case not included.)
Order as: LT39N, **£9.99**. Details in *Electronics* No. 79 (XA79L).

REUSABLE ELECTRONIC FUSE

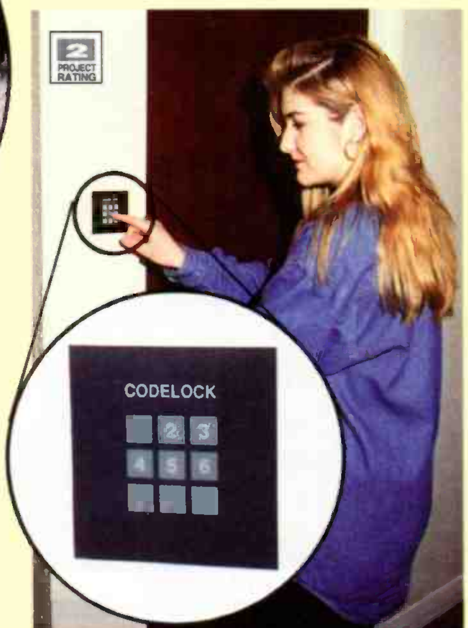
Help eliminate the hazards of accidental short-circuits during your experimental and development work with this simple-to-build project. The unit is connected in series with the unit being tested, and if the current drawn exceeds 200mA the electronic fuse will emit a short bleep and the LED will flash continuously. The current then falls to a very low holding level until the fault has been corrected. (Optional case not included.)
Order as: LT70M, **£12.99**. Details in *Electronics* No. 79 (XA79L).

INTELLIGENT Ni-Cd BATTERY CHARGER

Charging Ni-Cd batteries isn't as straightforward as you might think! Improper charging can damage the battery, cause reduced storage capacity or even result in an explosion! This intelligent charger is fully automatic and removes all these worries. Suitable for Ni-Cd batteries with voltages of 1·2V to 12V and capacities from 110mAh to 1·5Ah. (Optional case not included.)
Order as: LT55K, **£39.99** C2. Details in *Electronics* No. 79 (XA79L).

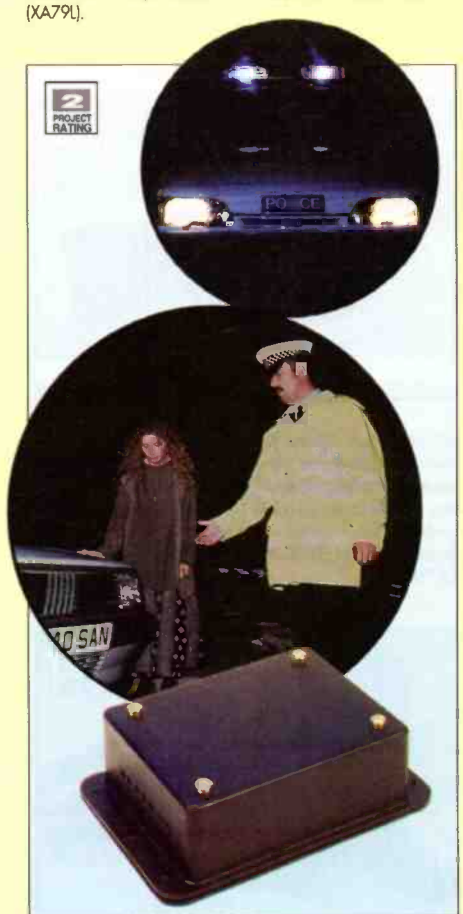
AERIAL ACTIVATOR

This project can improve the reception of your communications receiver by actively matching the aerial impedance to that of the receiver's input. This is achieved by using an impedance matching network which accepts a wide range of input impedance and converts it to the 50Ω level required by most receivers. In addition the preamplifier stage boosts the signal by 15dB. Frequency range is 150kHz to 30MHz in six wavebands and the unit can be powered either by an external 12V supply or by four internal AA batteries. (Batteries and optional case not included.)
Order as: LT58N, **£44.99**. Details in *Electronics* No. 80 (XA80B).



KEYCODE LOCK

With over 3,000 possible codes, this keypad entry system offers an electronic alternative to easily mislaid keys. A four-digit security code is wired into the system during construction. When the code is entered in the correct sequence, the unit provides a switched or pulse output for operating solenoid operated locks, etc.
Order as: VE76H, **£24.95**. Details in *Electronics* No. 80 (XA80B).



CAR LAMP MONITOR

Avoid the dangers of defective car lights! This project can monitor up to four groups of bulbs in your car and warn you immediately if any of them fail. The monitor works by detecting the current drawn by the working lamps, if a lamp fails the current drawn will drop, setting off the warning device of your choice. (Optional case not included.)
Order as: LT63T, **£9.99**. Details in *Electronics* No. 80 (XA80B).

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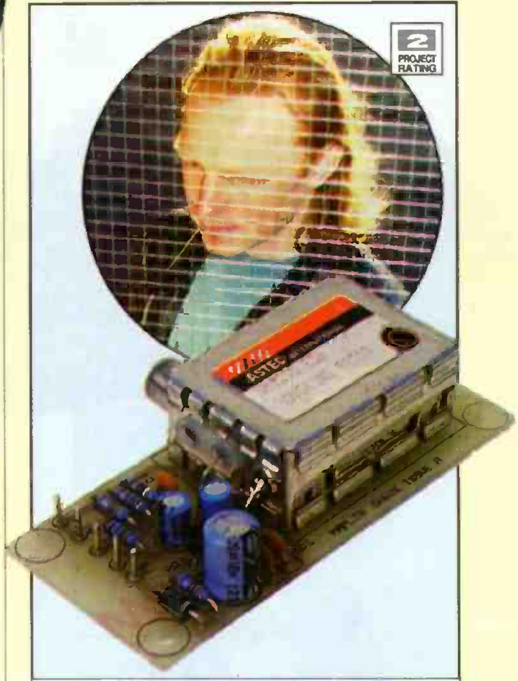
CAR INTERMITTENT WIPER CONTROLLER

An essential device for those of us with older cars and classics, that weren't built with anything more sophisticated than an on/off switch on the wipers! This simple to build project produces three delay periods, and has an LED indicator which lights during the delay period, reminding you that the unit is operating.
Order as: VE03D, **£12.95**. Details in *Electronics* No. 75 (XA75S).

AIRCRAFT BAND RADIO RECEIVER

Listen in on pilot and control tower communications with this super AM airband receiver. The kit is simple to build and requires little alignment. Frequency range is 118 to 135MHz and the receiver operating voltage is 9V. (Optional case not included.)
Order as: CP17T, **£29.95**. Details in *Electronics* No. 75 (XA75S).



CCD CAMERA TV MODULATOR

A low-cost unit which allows the Maplin colour and black & white CCD Camera Modules to be linked to any normal domestic TV with UHF aerial input. Applications include closed-circuit security systems, and interfacing equipment that only has video outputs to a normal TV receiver.
Order as: LT37S, **£9.99**. Details in *Electronics* No. 75 (XA75S).

The assembled receiver in its optional case (not included).

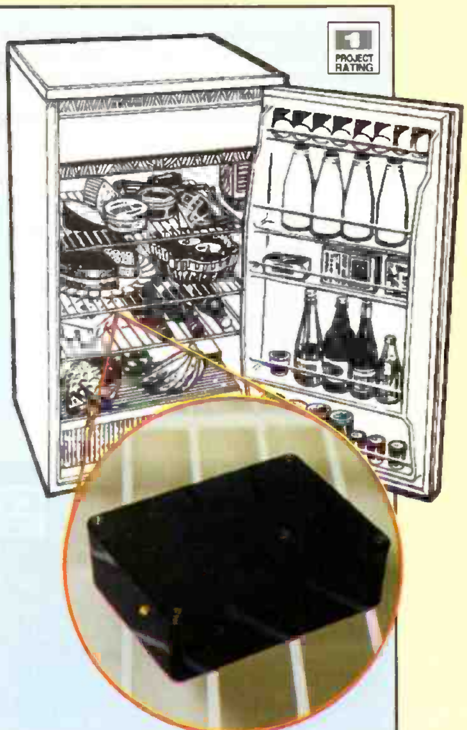
20 METRE ALL MODE RECEIVER

A 'direct conversion' 'DC' type receiver that is both simple-to-build and easy-to-use as there is no 'intermediate frequency' (IF). Frequency range is 13·85 to 14·50MHz and the receiver operates from a standard 9V PP3 battery (not supplied).
Order as: CP13P, **£31.95**. Details in *Electronics* No. 76 (XA76H).

The assembled transmitter in its optional case (not included).

20 METRE CW TRANSMITTER

A crystal controlled CW transmitter operating on the 20m band. The crystal frequency can be shifted by up to 5kHz by the VXO control. The transmitter operates from a +12 to +15V DC supply and has an RF output of 1W. Note: To operate this transmitter legally, either a full Class A Amateur Radio Licence or a restricted Novice Licence is required.
Order as: CP09K, **£31.95**. Details in *Electronics* No. 76 (XA76H).



FRIDGE CHECK

Is your fridge always as cold as it should be? This easy-to-build unit constantly monitors the temperature inside your fridge. If it exceeds a preset limit the alarm sounds, alerting you to the potential dangers of bacterial growth and food poisoning.
Order as: LT53H, **£8.49**. Details in *Electronics* No. 76 (XA76H).

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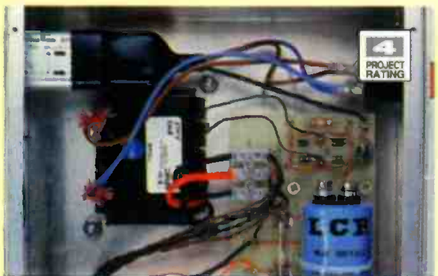
MILLENNIUM 4-20 VALVE POWER AMPLIFIER

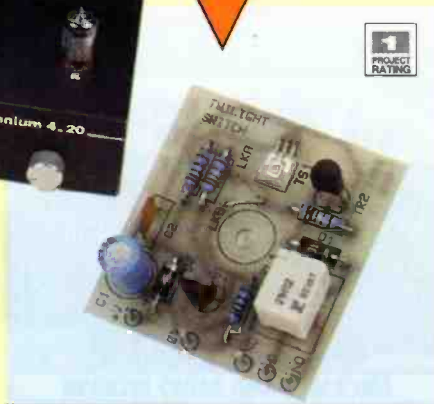
A superb 4-valve, non-hybrid, class AB1 push-pull amplifier with an output of 20W r.m.s. and low output distortion, producing that characteristic valve sound. Construction is simplified by the use of printed circuit boards and no setting up is required.
Order as: LT45Y, **Price £74.95** C6. Details in *Electronics* No. 74 (XA74R).

SAVE MONEY by buying these combined Millennium Amplifier kits:
Save £10! Complete Millennium Monobloc Amplifier Kit (1 x PSU & 1 x Amplifier kit)
Order as: LT71N, **Price £114.90** H12.
SAVE £20! Complete Millennium Stereo Amplifier Kit (1 x PSU & 2 x Amplifier kits)
Order as: LT72P, Price **£179.85** H18.



MILLENNIUM VALVE AMPLIFIER PSU

A Power Supply kit for the Millennium 20W Valve Power Amplifier. The supply is capable of powering up to two amplifier modules for a stereo system, or alternatively you could use two PSU kits and two amplifier modules to produce a pair of 'monobloc' amplifiers.
Order as: LT44X, **Price £49.95** C6. Details in *Electronics* No. 73 (XA73Q).



TWILIGHT SWITCH

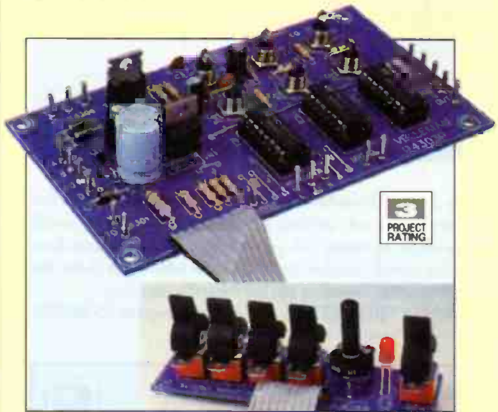
Using the ULN3390T opto-electronic switch, this versatile project senses the ambient light level and operates the built-in relay at dawn and dusk. Typical applications are automatic control of lighting, night-time security or anywhere that daylight related switching is required.
Order as: LT47B, **Price £5.95**. Details in *Electronics* No. 73 (XA73Q).

EXTRA LARGE LED DISPLAY

A choice of two 20cm (7 ½in.) 7-segment LED displays, catering for open-collector and open-anode circuits. Ideal for educational equipment, public displays, exhibitions, demonstrations, clocks etc. Connects to existing 7-segment display drivers. Operating voltage: 22 to 26V DC, maximum supply current: 400mA.
Order as: VF01B, Common Cathode Version, **Price £32.95,** or: VE63T, Common Anode Version, **Price £32.95**. Details in *Electronics* No. 74 (XA74R).

MODULAR GRAPHIC EQUALISER FRONT PANEL

A pre-drilled front panel and pre-printed foil to give a professional look to your completed equaliser project. The panel is suitable for a standard 19in. housing having a height of 2 units (2U).
Order as: VE41U, **Price £32.95** A1. Details in *Electronics* No. 74 (XA74R).



GRAPHIC EQUALISER PSU & SWITCHING UNIT

Part of the Modular Graphic Equaliser System. This project provides a regulated power supply for various of the other units in the system, a front panel mounted line input sensitivity control and also provides all of the necessary switching functions.
Order as: VE45Y, **Price £32.95**. Details in *Electronics* No. 73 (XA73Q).

AUTOMATIC REAR WIPER CONTROL UNIT

At last! Comprehensive control for rear window wipers, tied into the operation of the front windscreen wipers and gearbox. Facilities include: Single shot (when front wipers turned on), Intermittent operation (when front wipers on), and Auto wipe (Reverse gear selected and front wipers on).
Order as: LT46A, **Price £9.95.** Details in *Electronics* No. 74 (XA74R).

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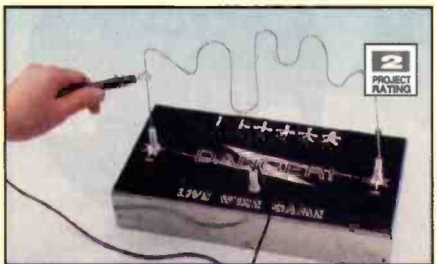
TV COLOUR BAR GENERATOR

Essential for accurately setting up TV and video equipment. The generator consists of two modules, a colour bar generator and a colour encoder. Although the modules are available separately, both are required for this project. The generator has both PAL composite video and PAL UHF RF outputs and can produce EBU, 100% and 75% colour bars.
Order as: LT50E, Colour Bar Kit, **£19.99**. Order as: LM66W, Colour Encoder Kit, **£24.95**. Details in *Electronics* No. 77 (XA77H).

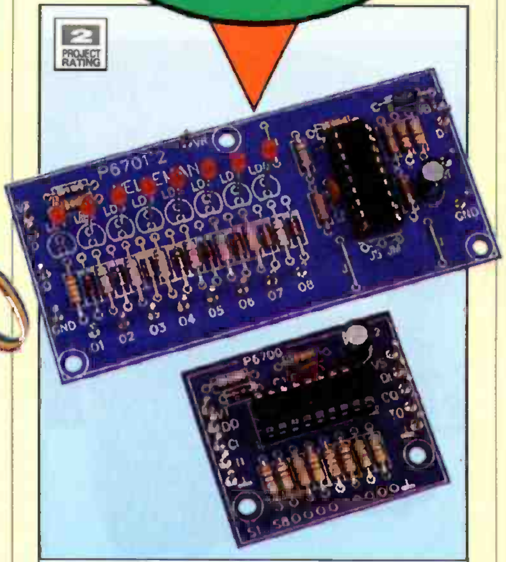


LIVE WIRE GAME

Roll-up! Roll-up! All the fun of the fair – and less of the hassle! This electronic variation on the traditional theme puts an end to the problem of whether a gentle touch actually rang the bell or not. A contact is clearly registered and the number of 'lives' can be preset helping to ensure fair play.
Order as: LT57M, **£19.99**. Details in *Electronics* No. 78 (XA78K).

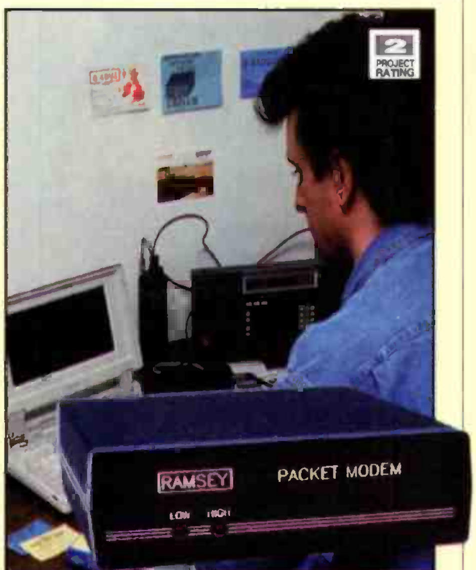
12V DC/230V AC INVERTER

Ever wished your car or shed had a mains outlet in it? Now it can, with this high efficiency 230V AC inverter. Powered from a car battery or alternator, the unit is ideal for emergency power backup and field service applications. Maximum continuous power output is 250W, drawing a maximum current of 25A from the DC supply.
Order as: VF35Q, **£119.95** B4. Details in *Electronics* No. 78 (XA78K).



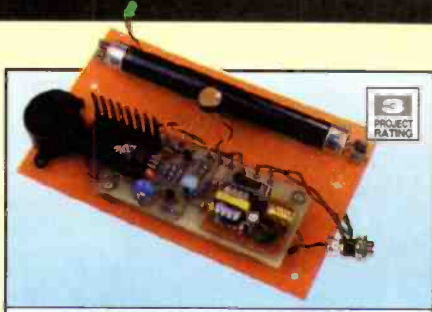
2-WIRE MULTI-CHANNEL SIGNALLING

How do you get up to 16 channels and a power supply down two wires? This clever project scans the transmitter inputs and converts them to serial data pulses superimposed on the DC power supply. The data is then decoded by the receiver and operates the relevant channel. Each transmitter and receiver pair can handle 8 channels, expandable to 16 by adding further modules.
Order as: VE70M, Transmitter, **£9.95**. Order as: VE71N, Receiver, **£17.95.** Details in *Electronics* No. 77 (XA77H).



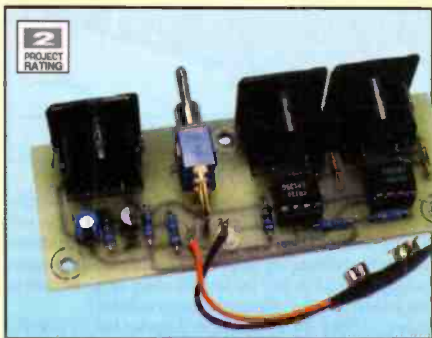
PACKET RADIO MODEM

Combine your amateur radio and computing hobbies with this radio MODEM! The project is supplied with software compatible with the IBM PC/AT but could also be used with other computers provided suitable software can be obtained. The unit communicates via the host computer's RS232 port and operates at 1200 baud. Power consumption is very small and the unit can, in fact, be powered direct from the serial data port of most compatible computers!
Order as: CP36P, **£59.95** A0. Details in *Electronics* No. 78 (XA78K).



FORGED BANK-NOTE DETECTOR

Sort out fake bank-notes with this notable Maplin project! Unlike counterfeit notes, the genuine article absorbs ultra-violet light from the built-in UV tube. A light dependent resistor in the detector changes its resistance depending on the amount of light reflected. If the note is genuine, an LED indicator lights and a buzzer sounds.
Order as: LT54J, **£14.99**. Details in *Electronics* No. 77 (XA77H).



SIMPLE MIDI MERGE UNIT

This easy-to-build project allows you to control a single MIDI sound module from two different sources. Apart from simultaneous operation from two MIDI sources, this simple unit can perform all the tasks normally undertaken by complex microprocessor controlled units costing many times more.
Order as: LT52G, **£14.99.** Details in *Electronics* No. 77 (XA77H).

CAR BATTERY CHARGE/DISCHARGE IDLE INDICATOR

Is your car's battery being charged as you drive, or is it waiting for the next cold, rainy morning for you to find out that it isn't? Keep an accurate eye on where the current is going with this inexpensive project. A 3-colour LED, mounted on the dashboard, indicates whether the battery is being charged, discharged or if a balanced condition is achieved.
Order as: LT56L, **£7.99**. Details in *Electronics* No. 78 (XA78K).

The most common piece of analogue test instrument encountered in the laboratory is the plain and simple multimeter that uses a moving-coil movement as its display. What's more, the analogue meter is the most common piece of test equipment of all; an odd state of affairs since the analogue meter is not particularly accurate. However, it is a versatile and general-purpose tool which will give reasonable results in many applications.

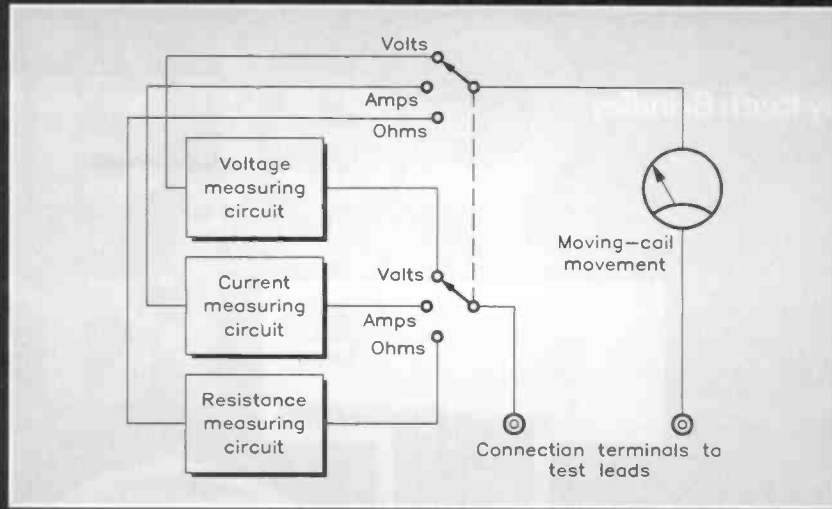
The moving-coil movements of today represent the culmination of developments over the 150 years since it was first discovered that a current, passing through a wire suspended in a magnetic field, created a force which tended to move the wire. In the moving-coil movement, the wire is coiled; the coil rotates in proportion to the amount of current, see Figure 1, turning and taking with it a pointer that points to a graduated scale, thus indicating the value of the current. Its extreme simplicity, yet comparative accuracy, means that the moving-coil movement forms the basis of many items of test equipment. Indeed, until just a few years ago, most measurements taken in electrical and electronic circuits were carried out using the moving-coil analogue display. Today things are beginning to change and, although still a very popular instrument, the analogue meter is slowly being overtaken by its digital counterparts. It will be some years yet, however, before the moving-coil movement itself is made obsolete – if ever, because in some measurements the movement gives a better display than is usually possible from available digital devices.

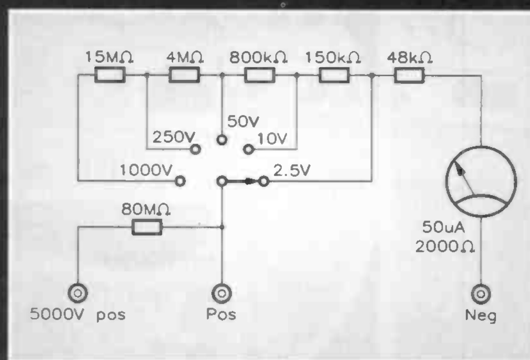
General-Purpose Meters

Moving-coil movements are generally manufactured with sensitivities ranging from about 10μA to 1mA, at full-scale deflection (FSD). FSD occurs when the pointer is deflected to its farthermost point by the current. The coil within the movement has resistance, of course. This ranges in value from about 5Ω to 5000Ω, which from Ohm's Law means that voltages of 50μV or so to 5V will deflect the pointer to its FSD position. Any one coil will only be able to measure one particular range of values of current or voltage, of course, so if the movement is to be used to measure a number of ranges of values, some way of converting the values to be measured to within the movement's own range, must be incorporated. In its simplest form, this is a single resistor connected either in series, or in parallel, with the movement.

When in series, the converter (known as a *multiplier*), effectively raises the total resistance, allowing the combination of movement and multiplier to measure a higher voltage. When in parallel, the converter (known now as a *shunt*) effectively lowers the total resistance, allowing the combination to measure higher currents. Note that in both cases, no more current passes through the movement's coil than before – i.e. only that sufficient to produce full-scale deflection of the pointer.

With an external power source such as a cell, the movement can also be used to indicate values of resistance. By connecting the movement in series with a cell and the resistance to be measured, the pointer indicates the current flowing through the resistor. As this current, from Ohm's Law, is *inversely* proportional to the resistance, the indication on the scale of the movement is *also* inversely



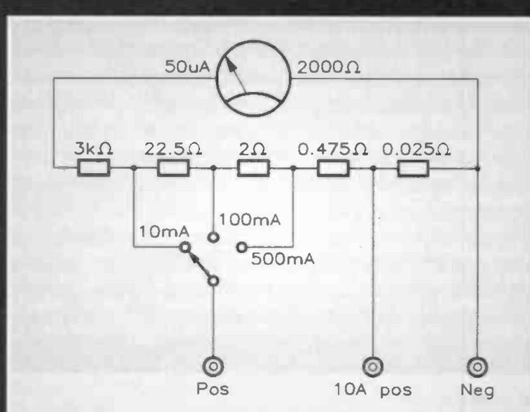


Above: Figure 2. Block diagram of a basic multimeter.

Left: Figure 3. 6-range DC voltmeter circuit, based around a 50μA movement.

proportional to the resistance. In effect, the scale graduated for resistance must be marked in the opposite direction to current and voltage scales – that is, the further up the scale the pointer is deflected, the lower the resistance being measured.

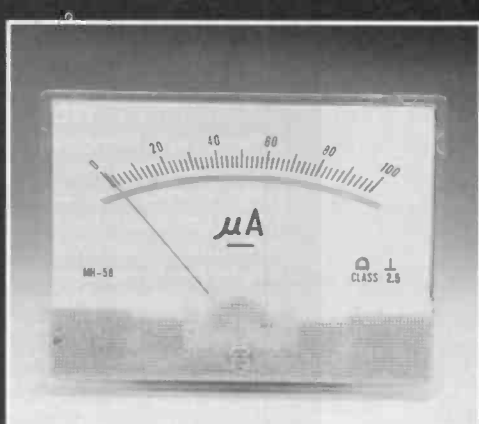
Using mechanical switches to switch multipliers, shunts and cells in and out of circuit with a moving-coil movement, an analogue *multimeter* – one capable of measurement of many ranges of voltage, current and resistance – can be constructed. Such an instrument is also known (particularly across the Atlantic) as a *volt-ohm-milliam-*

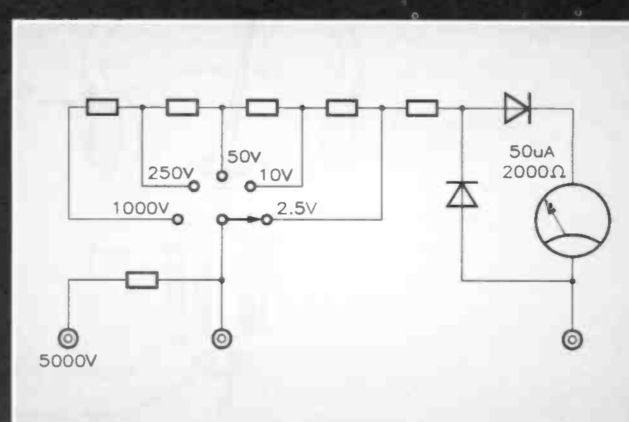


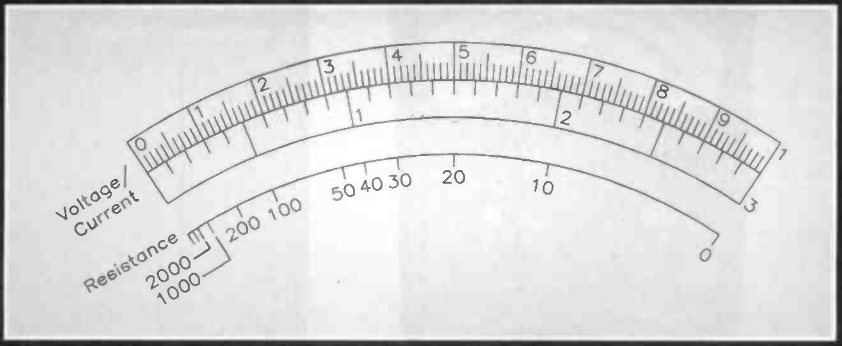
Left: Figure 4. 4-range DC current measuring circuit.

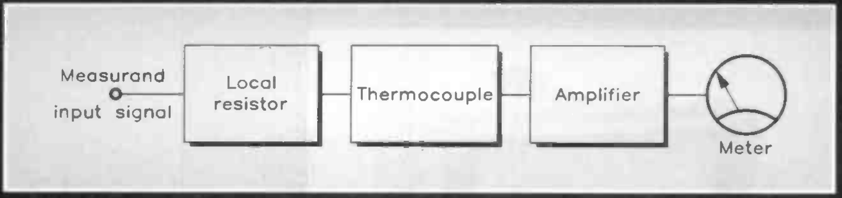
Below: Figure 5. 6-range AC voltmeter circuit. Compare with the circuit of Figure 2.

Right: A typical moving coil panel meter – 50μA large.









Top: Figure 6. Possible multimeter scale combination.

Above: Figure 7. Power meter. The thermal energy, generated by power dissipation in a resistor, is measured.

of the AC voltmeter circuit is reduced to 31·8% of its DC value, or 6360Ω/V. Interestingly, if a multimeter using this basic rectification technique is used to measure a DC voltage while set to an AC range, a reading much higher than expected would be displayed. This is because the voltage scales are calibrated to indicate the RMS amplitude of sine waves – that is, 0·707 of the peak value.

Similarly, a meter using a full-wave bridge rectifier indicates 1·11 times the DC voltage, since the average value of a full-wave rectified voltage is 0·636 of the peak value.

Circuits like this are not particularly accurate, because they rely on the measured voltage being of a pure sinusoidal form. Any small distortion in the voltage being measured causes a corresponding level of inaccuracy. In addition, circuit inductances and capacitances limit the upper frequency response of basic AC meter circuits to around 10kHz. Low frequency response theoretically goes down to 0Hz, but a practical limit is about 10Hz, since pointer vibration becomes objectionable at lower frequencies. They are, nevertheless, used in general-purpose analogue multimeters for their cheapness, sensitivity, and fast measurement speed.

Sources of Error

Multimeters are designed as utility instruments and, as such, have a moderate accuracy of around ±2% to ±5%. Higher quality analogue meters have correspondingly better accuracies. Provided that allowance is made for the loading effects that the instrument has on the circuit under test, this is more than adequate for most measuring needs.

Accuracy quoted for a multimeter is specified as a percentage of full-scale deflection, which means that accuracy is dependent on the position of the pointer on the scale for any particular measurement. For example, a meter specified as having an accuracy of ±4% has, in reality, an accuracy of ±40% if the reading is taken with the pointer at one-tenth of full-scale deflection. To avoid high inaccuracies, a multimeter would therefore normally be used to take measurements where the readings lie in the upper third of the scale, by having scale ranges which overlap – a possible multimeter scale combination is shown in Figure 6. The combination of careful use and good design helps to restrict reading errors to a respectable level.

As we saw earlier, the input resistance of a multimeter on its DC voltage measurement function ranges is typically around 20,000Ω/V. This means, however, that the meter on, say, its 10V range, has an input resistance of 200,000Ω, but 2,000Ω on its 0·1V range. As the effects of loading on the circuit under test increase, in inverse proportion to the input resistance, you have to bear in mind that the accuracy of the measured reading depends on the meter's resistance.

If the meter's input resistance is too low, it loads the circuit being measured, and causes voltages in the circuit to drop. In other words, using a meter whose input resistance is too low causes voltage drops to occur in the circuit – as you measure them. Effectively, you are measuring *the wrong voltages!*

In the end, it is up to you to remember that a low meter resistance has an effect on the reading, to the extent that the reading is not a true indication of the actual value. To ensure that the reading you take is quite accurate, you have to ensure the meter's resistance *is* high enough. But what, exactly, is high enough?

As a rule-of-thumb, the meter's input resistance should be at least (and preferably more than) ten times the resistance of the circuit under test, at the measured points. Less than this, and the meter loads the circuit, causing inaccurate readings.

Of course, it's not everyone who has the cash to spend on high-input resistance (and usually high cost) meters. Fortunately, however, there is a way round the problem, which you can use if you know your meter's input resistance is not ten times that of the circuit under test. You simply take this loading into account by recalculating the actual value, knowing the meter's input resistances at different ranges, and the values of readings indicated by the meter at those ranges.

It all revolves around the fact that meters *do* have different ranges, and that these different ranges always have different input resistances. So you can take two measurements which, because of their different input resistances, will indicate different voltage readings. The true voltage which exists at the measurement location – that is, when no meter is connected – can now be calculated using the expression:

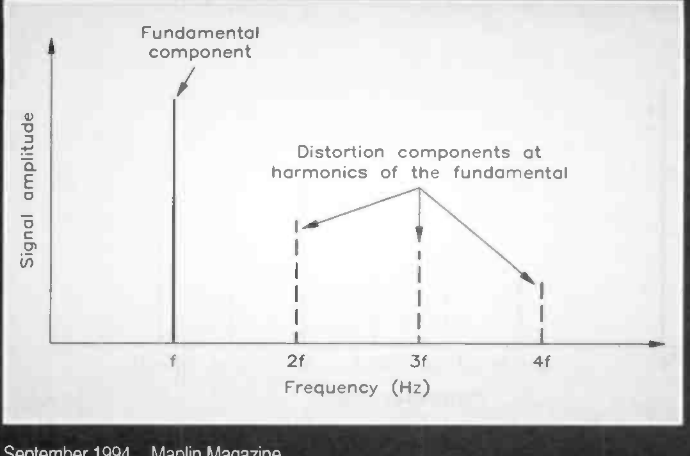
$$V = \frac{E_1 E_2 (R1 - R2)}{(E_1 R2) - (E_2 R1)}$$

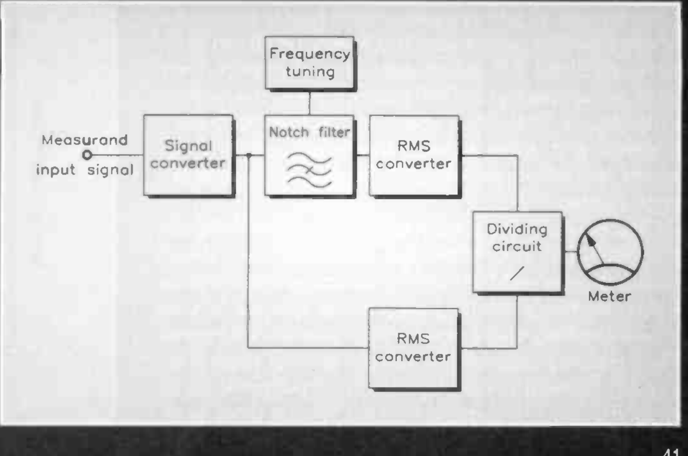
where V is true voltage, E_1 is the meter reading on first range setting, E_2 is the meter reading on second range setting, R1 is the input resistance of meter on first range setting, and R2 is the input resistance on the second range setting.

Another factor, which may affect accuracy of a measurement taken with an analogue meter, is the resolution with which the measurement is perceived by the user. Strictly speaking, of course, this is an error on the part of the user, and is not the fault of the instrument. There are two main errors possible here: firstly, lack of parallax (that

Below left: Figure 8. A fundamental frequency, and its three most significant harmonics.

Below right: Figure 9. Harmonic distortion measuring arrangement.





is, looking at the needle at an angle – because the needle is above the actual dial, an inaccurate reading will result); and secondly, judgment as to the exact position of the pointer.

Really, there are no answers to either of these problems – just be extra careful when you take your reading. Do this by making sure that you are directly over the dial when you estimate the reading, and double-check the reading to make sure that you have recorded the correct value.

Specialist Analogue Meters

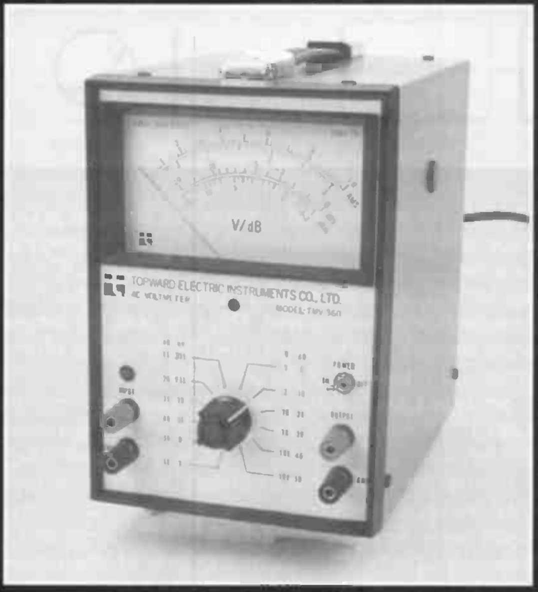
Where basic passive moving-coil movements do not give a high enough meter input resistance to give negligible loading effects, or where the correction method above cannot be used, it is possible to use active circuits in combination with the movement to increase resistance. Current amplifiers are used in such multimeters, based around an op amp or FET circuit, having input resistances in the order of megohms. These types of multimeters also allow more accurate measurement of AC voltages, because circuits can be included which allow true RMS readings, of frequencies up to 100MHz or so, to be taken – even if the test voltage is not a sine wave. Multimeters with these true RMS converter circuits are given a crest factor specification, which defines the types of waveform that can be measured accurately.

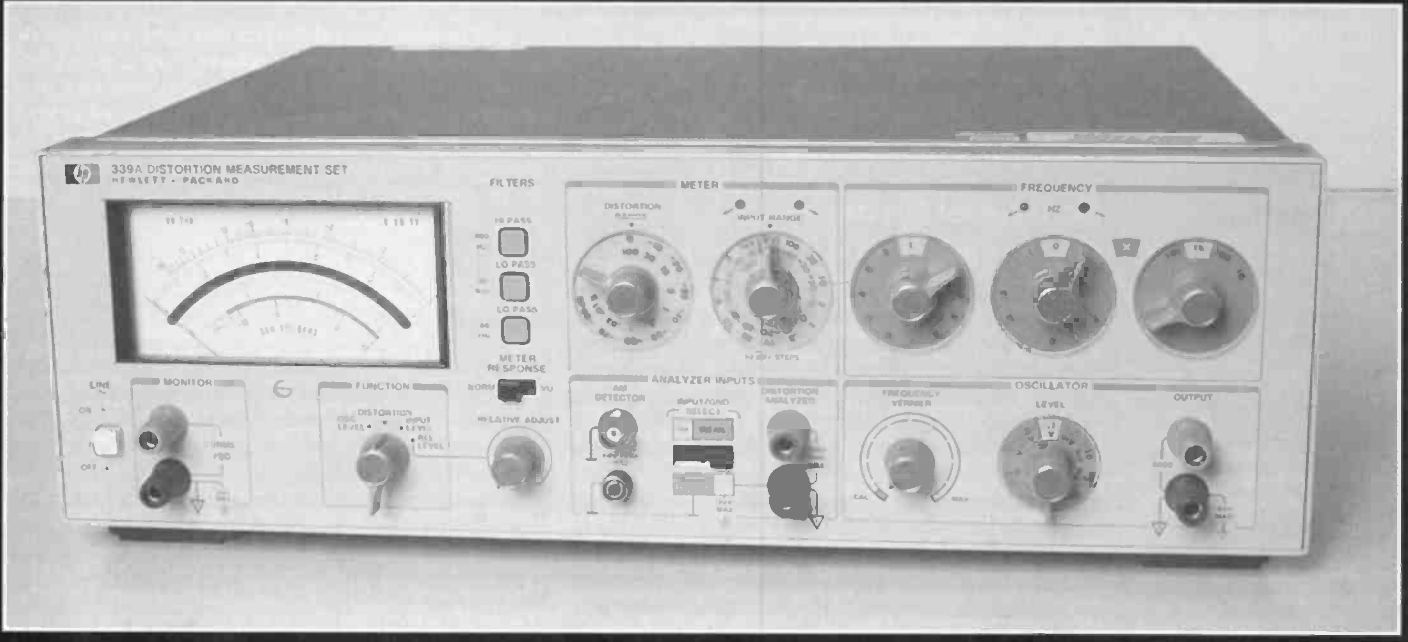
Analogue Power Measurements

The concept of a meter movement being driven by active electronics need not stop with creating just another multimeter (albeit with a much higher input resistance!). Other types of analogue meter may be constructed, using the standard moving-coil movement as the display device, but with the extra active circuits that define the meter's particular function.

A good example of this is the power meter that uses

Left: An analogue multimeter – Avo 8.

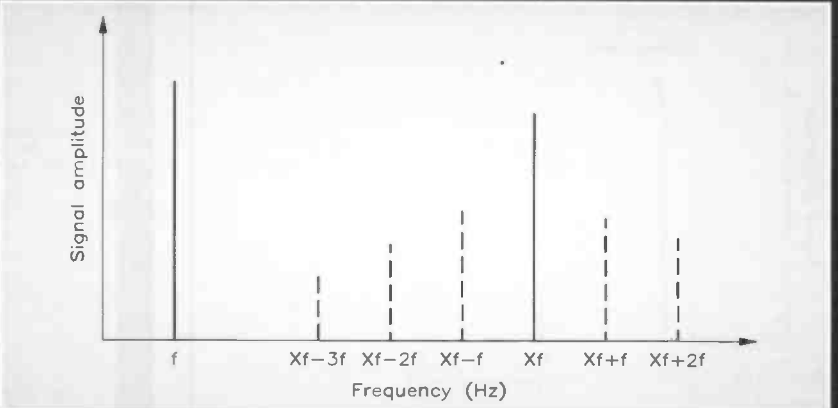




Below: Distortion analyser – Hewlett Packard.

thermal measuring techniques – the output of the device, whose power is to be measured, is attached to an internal resistive load. A thermocouple, or similar device, measures the temperature of the load relative to the ambient temperature. The output voltage of the thermocouple is amplified, and drives a meter movement which is calibrated to read power. Figure 7 shows the principle as a block diagram.

Most power meters are marked not only in milliwatts and watts, but in decibels also, and generally the 0dB mark coincides with the 1mW mark on the meter's scale. A dB scale means that the power meter can now be used to measure frequency response and signal-to-noise ratios. The frequency response of a circuit is most easily measured by applying an input signal to the circuit in frequency steps, and then measuring the output signal at those steps.



Bottom right: Figure 10. Intermodulation distortion, caused when two or more frequencies interact in a non-linear way.

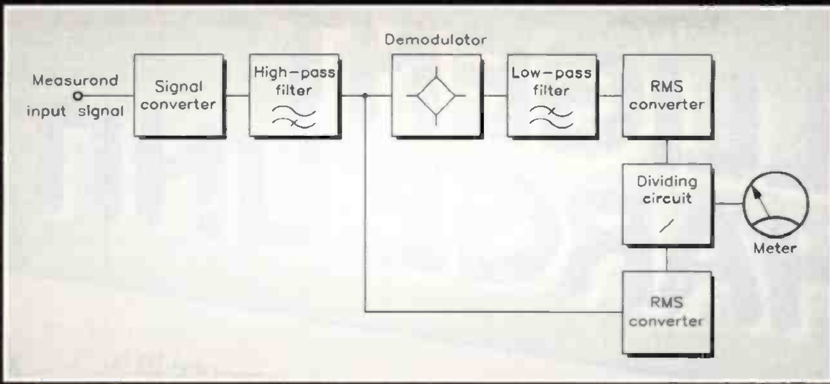


Figure 11. Intermodulation distortion measuring system.

The frequency response is defined as the band of frequencies within the two corner frequencies (the frequencies at which the circuit's output power falls by 3dB below the mid-band output power). Signal-to-noise ratios, on the other hand, are easily determined by measuring the output power of the test circuit – first with an applied signal, and then again with no signal. The change in power levels is the signal-to-noise ratio.

Distortion Measurements

Analogue meters are often used to measure distortion. Generally, the instruments used to do this are known as distortion analysers; they are, however, incorrectly named, because they do not analyse the distortion in the true sense of the word, they merely indicate the level of distortion present.

Distortion is a general term referring to the changes impressed on a signal as it passes through a system. If a system's output signal is different to the input signal in any way (amplitude changes excepted!), it is distorted. In this sense any differences – such as frequency response changes, phase shifts, or even noise – represent distortion. Some types of distortion refer to the addition of extra frequency components, which are related to the input signal frequency in some way. The most common types which need to be measured are harmonic distortion and a number of varieties of intermodulation distortion.

Harmonic distortion occurs where the extra frequency components added to the signal are harmonics (whole multiples) of the signal. So, if an input signal of f is applied to a system, the harmonically distorted output signal might contain frequency components of the frequencies f, $2f$, $3f$, $4f$, and so on. These additional frequency components of the harmonically distorted signal can be seen in Figure 8, which shows the signal amplitude plotted against frequency. The size of these additional frequency components, relative to the fundamental frequency component, determines the amount of harmonic distortion present. The measurement of harmonic distortion is, in fact, the ratio, expressed as a percentage, of the sum of all of the harmonics compared to the fundamental frequency component.

Figure 9 shows a block diagram of a harmonic distortion measurement system, which may be used in a distortion analyser. The signal converter block converts the applied signal to a reference level, typically 1V, so a combination of attenuating resistors and an amplifier would be used. Thus, signals larger than the reference level would be attenuated, while smaller signals would be amplified. The reference level signal is then applied to a notch filter, which is accurately tuned to remove the fundamental frequency component – thus leaving only the harmonics. After this, the harmonic-only signal is applied to an RMS converter. Meanwhile the reference level signal is applied direct to another RMS converter, without filtering. A dividing circuit calculates the ratio between the two RMS values, and the circuit's output drives a meter, the pointer position of which indicates the level of harmonic distortion. Older methods of harmonic distortion measurement required that the input signal was first manually set to an accurately defined reference level, then the RMS level of the harmonic components was displayed and the measurement taken. This newer method renders such a two-stage measurement unnecessary.

Intermodulation distortion occurs when two or more frequency components interact in a non-linear system, to produce additional components that are not harmonically related. Figure 10 shows a graph of amplitude against frequency for a case of intermodulation distortion, where the distortion is caused by interaction of two frequency components at frequencies of f and Xf. Distortion components may be produced at frequencies of $Xf-f$, $Xf+f$, $Xf-2f$, $Xf+2f$, and so on. The signals around the frequency component Xf are sidebands – identical to sidebands of a modulated radio signal.

There are other types of intermodulation distortion, each of which requires a slightly different measurement technique, but the basis of all intermodulation distortion measurements is shown in block diagram form in Figure 11. Like the harmonic distortion measurement system of Figure 8, the first block is a signal converter, which allows the input signal to be set to a reference level. The reference level signal is then passed through a high-pass filter, tuned to pass all frequency components above the lower of the two interacting frequency components. A demodulator circuit separates the sidebands (at f, $2f$, and so on) from the frequency component Xf. The signal is then passed through a low-pass filter, accurately tuned to remove the Xf frequency component. The remaining distortion components are then passed through an RMS converter. Meanwhile, part of the unmodulated signal (that is, the Xf component, complete with its sidebands) is passed through another RMS converter. The two signals are applied to a dividing circuit, which electronically calculates the ratio between the signals, and then drives the meter movement to display the result.

Modern distortion analysers are typically much more complex than these simple explanations would suggest. Top-of-the-range systems are more-or-less fully automatic in filter tuning and level setting, and have low-distortion oscillators incorporated, so that the user merely has to connect the circuit to be tested to the analyser, switch on and wait for the result to be displayed.

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WIRRAL AND DISTRICT AMATEUR RADIO SOCIETY meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF hunts, demonstrations and junk sales. For further details, please contact: Paul Robinson (G0JZP) on (051) 648 5892.

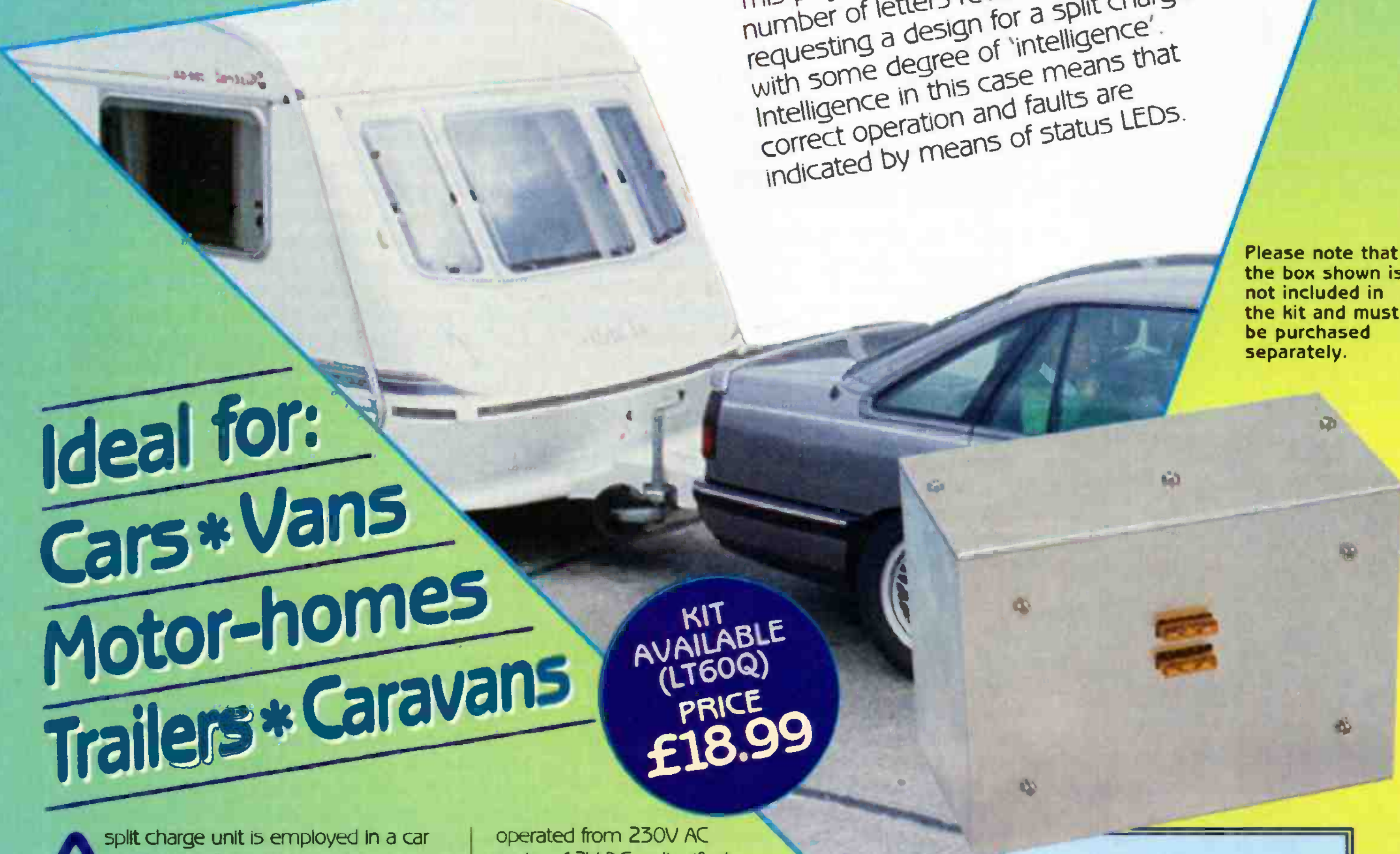
SOUTHEND & DISTRICT RADIO SOCIETY. Meets at the Rocheway Centre, Rochford, Essex every Friday at 8pm. Details F. Jensen (G1HQQ) P.O. Box 88, Rayleigh, Essex SS6 8NZ.

2
PROJECT RATING

by Joe Fuller

INTELLIGENT SPLIT CHARGE UNIT

This project was designed in response to a number of letters received from readers requesting a design for a split charge unit with some degree of 'intelligence'. Intelligence in this case means that correct operation and faults are indicated by means of status LEDs.



Please note that the box shown is not included in the kit and must be purchased separately.

Ideal for:
Cars * Vans
Motor-homes
Trailers * Caravans

KIT AVAILABLE (LT60Q) PRICE £18.99

A split charge unit is employed in a car or other similar vehicle to charge an auxiliary (second) battery. An auxiliary battery is often used to power 12V electrical accessories in a caravan or trailer. The use of such a battery ensures that the towing car's main battery is not discharged. The auxiliary battery can be located in the towing car's boot or in the caravan itself.

Modern caravans are often equipped with a multi-supply refrigerator. Such units can be operated from 230V AC mains, 12V DC or liquified petroleum gas (LPG). During transit, it is inadvisable for the refrigerator to be operated from LPG for obvious safety reasons; at such times, the refrigerator canbe switched to 12V operation. When the caravan is stationary it can be switched to LPG operation or AC mains operation (caravan parks often have electricity hook-up facilities).

FEATURES

- Charges Auxiliary Battery
- Powers Refrigerator
- Alternator or Ignition Switch Controlled
- Status Indicators
- Easy to Build
- Easy to Install
- Can Replace Existing Unit

Important Safety Warnings

Before starting installation work, consult the vehicle's manual regarding any special precautions that apply. Take every possible precaution to prevent accidental short circuits occurring since a lead-acid battery is capable of delivering extremely high current. Remove all items of metal jewellery, watches, etc., before starting work. Disconnect the vehicle's battery before connecting the module to the vehicle's electrical system. Please note that some vehicles with electronic engine management systems will require reprogramming by a main dealer after disconnecting the battery. Assuming a negative earth vehicle, disconnected the battery by removing the (−) ground connection first; this will prevent accidental shorting of the (+) terminal to the bodywork or engine. It is essential to use a suitably rated fuse in the supply to this project. For the electrical connections, use suitably rated wire able to carry the required current. If in any doubt as to the correct way to proceed, consult a qualified automotive electrician.

Both 'ordinary' car and marine and leisure batteries contain sulphuric acid, produce hydrogen gas and can deliver massive short circuit currents. For these reasons the following points should be observed:

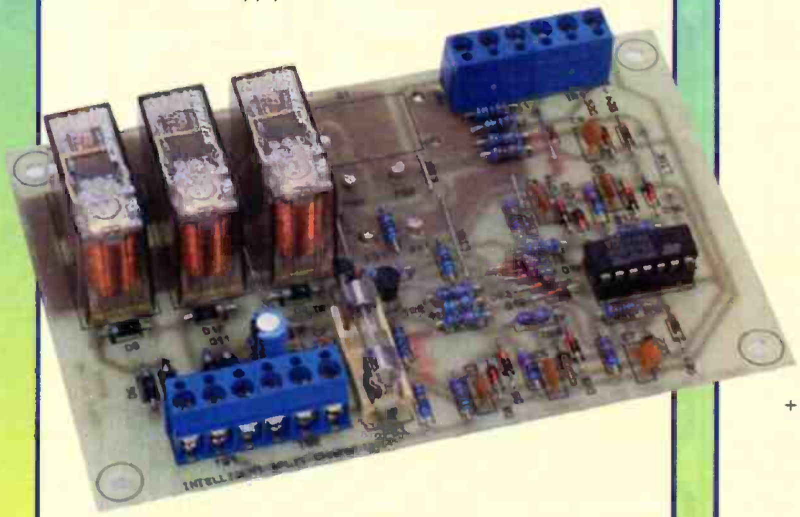
Follow the manufacturers Instructions on installation, charging, use and maintenance.

Avoid spilling battery acid – place the battery in a purpose designed enclosure and ensure it is firmly secured. Do not leave a battery unsecured in a car boot; it is liable to topple over and the battery acid will spill out. If contact is made with battery acid, flush the affected areas with plenty of cold water. Battery acid will rot clothing and cause severe chemical burns to skin. If battery acid is splashed into eyes, flush with cold water and seek urgent medical attention.

Hydrogen gas, when mixed with air, is explosive. Avoid sparks, flames or other sources of ignition in the vicinity of the battery. Marine and leisure batteries are often fitted with a vent-pipe to avoid the build-up of hydrogen – follow the manufacturers' instructions on use. Remember hydrogen is less dense than air so it will rise to the highest point in an enclosure.

Specification

Supply voltage range:	+10V to +16V DC
Maximum auxiliary battery output current:	10A
Maximum refrigerator output current:	10A
Supply current	
control input:	100mA maximum
monitor circuit supply:	50mA maximum



The assembled PCB.

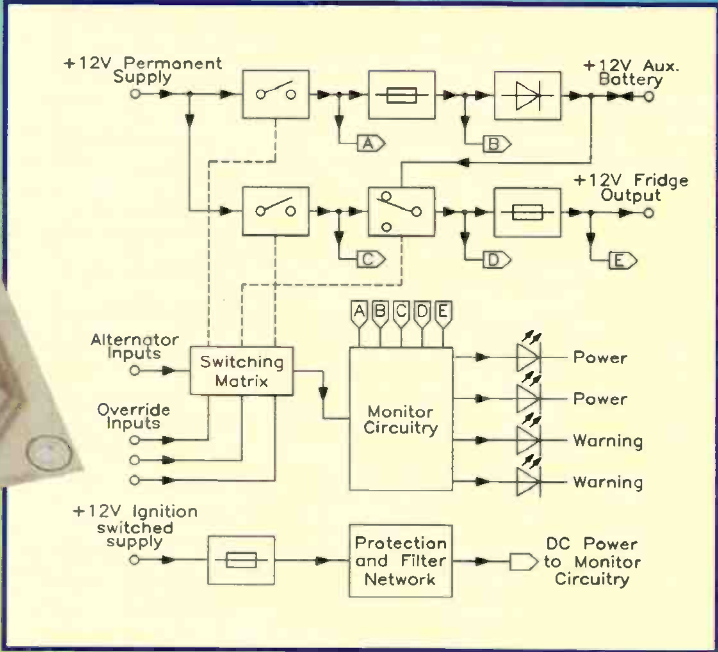


Figure 1. Block diagram of the Intelligent Split Charge Unit.

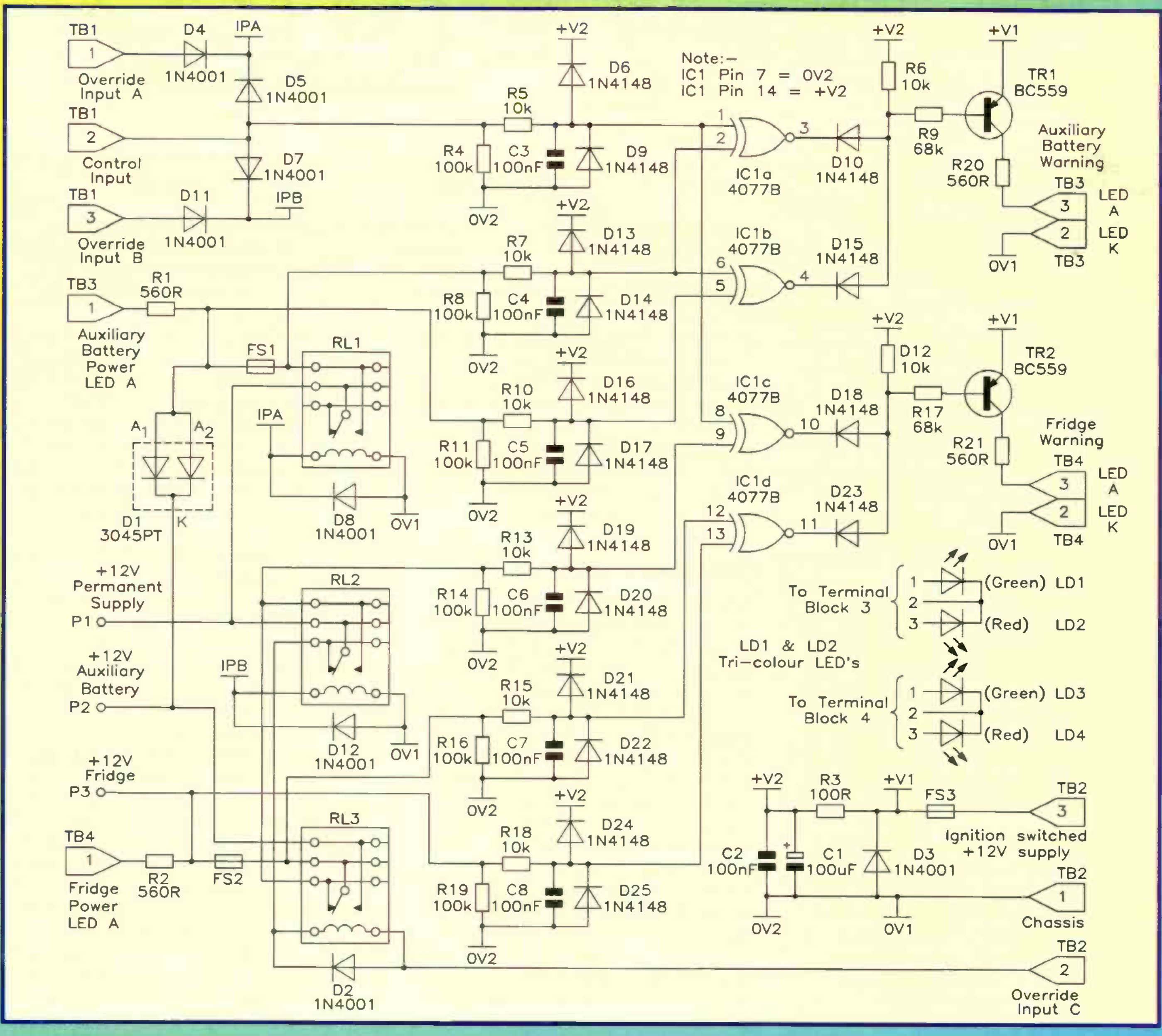


Figure 2. Circuit diagram of the Intelligent Split Charge Unit.

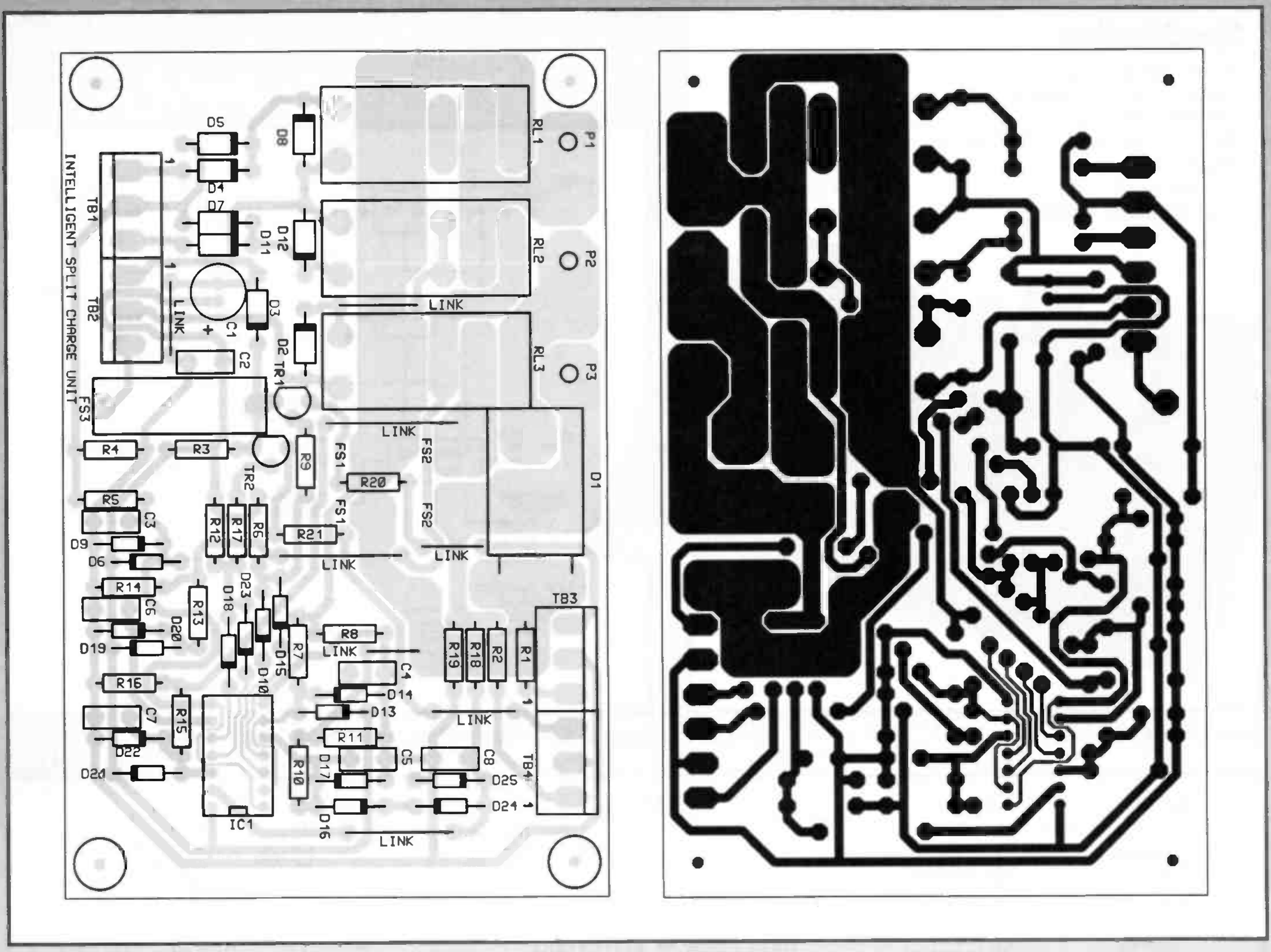


Figure 3. PCB legend and track.

The dual split charge unit presented here is able to simultaneously charge an auxiliary battery and supply power to a +12V DC operated refrigerator.

Any Old Battery?

The choice of auxiliary battery requires some thought and a little knowledge. All to often, people use an ordinary car battery, whilst a car battery will obviously work, its performance will be disappointing and life expectancy short. What is needed is a marine and leisure battery. Such batteries employ different design and construction to car batteries and cater for quite different requirements.

A car battery is only drained of charge when the car is started, or accessories (lights, radio, etc.) are used without the engine running. When the engine is running, the car's alternator supplies the needs of the car's electrical system and replaces the charge lost from the battery during starting. Thus it can be seen, in normal use, the battery is only ever partially discharged and then immediately recharged.

If a car battery is repeatedly discharged until flat and then recharged, it will soon loose capacity and become unusable. In a camping and caravanning application, this is the kind of treatment that an auxiliary battery will receive as a matter of course. What is needed is a battery designed for such treatment, a marine and leisure battery is intended to fit the bill.

Marine and leisure batteries are available from several manufacturers in a wide range of sizes/capacities. Smaller batteries will be sufficient for supplying basic lighting needs whilst a larger one will be needed if an electric water pump, colour TV, etc. are to be powered. The exact choice will depend on total demand for power, how long the battery should last before needing to be recharged and how big your wallet is! Good automotive stores, yacht chandlers and camping equipment suppliers will stock a range of marine and leisure batteries, and should be able to offer advice as to the best one to use in a particular application.

Charge!

Many readers will be familiar with nickel-cadmium cells/batteries and how they are charged. The method of charging a lead acid battery is quite different. In a car, with the engine running, the alternator provides a constant voltage output of 13·8V. This voltage is 1·8V higher than the nominal terminal voltage of a 12V battery.

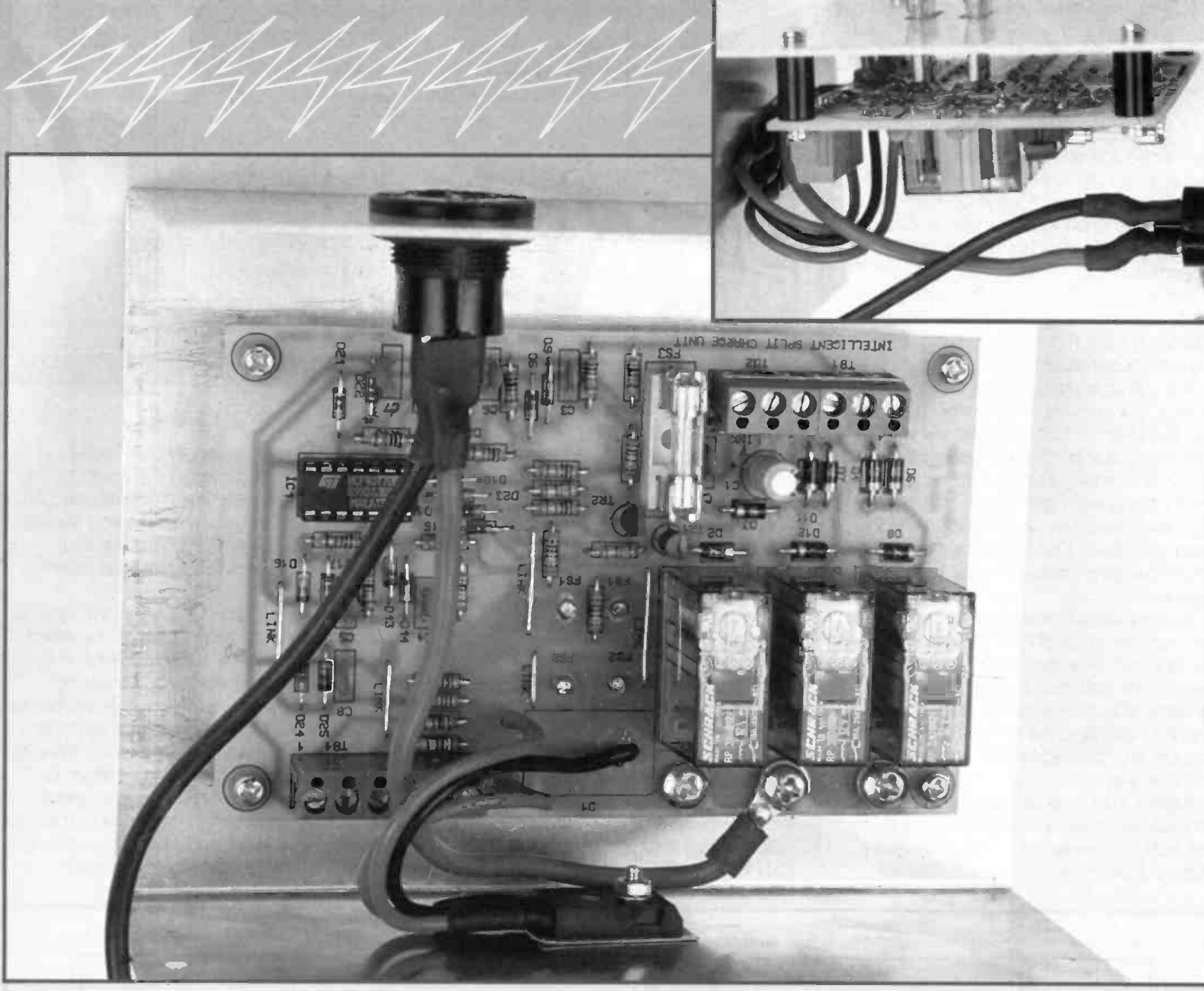
By the time a 12V battery's terminal voltage has fallen to 10V, it has lost most of its charge. Such a discharged battery will draw current from the alternator. As the battery charges, its terminal voltage will rise to meet the charging voltage. The charging current will correspondingly fall. When the battery reaches full charge, the amount of current drawn will drop to a low level at which point the battery will be continuously trickle charged and thus maintained at full capacity (lead acid batteries have a slight tendency to self discharge over a period of time).

In essence, to charge an auxiliary battery, simply requires it to be connected in parallel with the existing battery. However, things are not quite as simple as that for a number of reasons:

- If one battery was discharged and the other was fully charged, the discharged one would draw current from the charged one until equilibrium was reached.
- When current is drawn from the main battery, current would also be drawn from the auxiliary battery. For this reason, cabling to both batteries would have to be equally rated for the maximum load (starting).
- If lights were left on, both batteries would be discharged.

To overcome these problems, a split charging system is adopted. With such a system, the auxiliary battery is only connected to the main charging system when the alternator is generating sufficient output to charge the batteries. This is commonly achieved by using a relay which is controlled by the charge warning output from the alternator – normally this output is used to operate the dashboard charge warning indicator lamp. It is possible however, for problems to be encountered:

- Relay can become stuck in the open or closed condition: this will result in the auxiliary battery not charging. With the relay stuck open there is no path for the current to flow. With the relay stuck closed substantial current will flow from the auxiliary battery when the car is started, blowing the split charge circuit fuse, again with the same end result.



The assembled PCB; (Inset), side view of PCB.

The design presented here employs a relay and a high power (30A Schottky diode together these components ensure that current can only ever flow into the auxiliary battery from the main charging circuit and that charging only takes place when there is sufficient output from the alternator to charge the batteries. The Schottky diode was chosen for its low forward voltage and ability to withstand large current surges.

Circuit Description

The split charge unit can be effectively broken down into two main sections: the high current switching circuitry and low current status monitoring circuitry. The overall operation can be seen in simplified form in the block diagram shown in Figure 1. The circuit diagram is shown in Figure 2 and circuit operation is as follows:–

High Current Circuitry

A high current permanent +12V feed is supplied from the car's battery to P1 of the split charge unit. Relays RL1 and RL2 switch power to the Auxiliary Battery and Refrigerator Outputs, P2 and P3 respectively – RL3's presence may be ignored for the time being at least. RL1 and RL2 are switched by means of a simple diode matrix comprising D4, D5, D7 and D11. These diodes allow either relay to be switched individually or both of them together. D8 and D12 serve to arrest the potentially damaging high voltage spikes produced by the relay coils when they de-energise.

Normally, the Control Input, TB1-2 is connected to the charge warning indicator output from the car's alternator. This output rises from near 0V, at engine standstill, to (nominally) +13·8V, when the engine is running and the alternator is providing power to the car's electrical system. If the charge warning output is not easily accessible, the Control Input may be supplied from a circuit that becomes live when the ignition circuit is switched on.

When the Control Input is pulled high, diodes D5 and D7 conduct, each of which supply power to the coils of RL1 and RL2 thus causing them to energise. +12V is then fed to the Auxiliary Battery Output via FS1 & D1 and the Refrigerator Output via FS2. D1, a high current double Schottky rectifier diode ensures that the auxiliary battery cannot discharge by reverse feeding the car's electrical system.

It may be desirable to supply power to the Auxiliary Battery or Refrigerator Outputs at times when the engine is not running. This would be desirable when the car is stopped for a short while (at a service station, etc.) to maintain the supply to the refrigerator. Alternatively, the outputs may be used to supply other 12V accessories (+12V hand-held spotlight, etc.). Such use is facilitated by Override Inputs A and B, TB1-1 and TB1-3 respectively. Override Input A, when taken to +12V, switches on RL1 via D4 and supplies power to the Auxiliary Battery Output. Similarly, Override Input B, when taken to +12V switches on RL2 via D11 and supplies power to the Refrigerator Output. Care should be taken that the car's battery is not drained to such a level that there is insufficient charge to restart the engine. The time limit is a function of the current drawn and the capacity of the battery.

Indication that power is reaching the desired output is given by means of green LEDs connected to TB3-1 (Auxiliary Battery Power Status Output) and TB4-1 (Refrigerator Power Status Output). TB3-2 and TB4-2 provide 0V/chassis return connections for the LEDs. R1 and R2 serve to limit LED current flow to around 20mA.

RL3, which has so far been ignored, allows the auxiliary battery supply to be backfed to the Refrigerator Output when the engine is not running. This may be used for the same reasons as mentioned above, but without discharging the car battery (the current drawn is only that required to operate RL3). Such operation is enabled by taking Override Input C to 0V/chassis. D2 serves the same function as D8 and D12.

Low Current Circuitry

Fault detection is provided by means of IC1, a quad exclusive NOR (EXNOR) gate.

IC1 is a CMOS logic device and does not take too kindly to the harsh, electrically noisy, automotive environment. For this reason, each of IC1s inputs is protected from noise and spikes by a low-pass filter and a double diode clamp. Taking pin 1 of IC1a as an example, R5 and C3 form the filter and D6 & D9 form the clamp. Each of IC1's remaining inputs are similarly protected.

The supply to IC1 is also filtered; R3 and C1 & C2 performing this function. D3 and FS3 protect the monitoring circuit from inadvertent supply reversal.

The output from each gate is high when both of its inputs are at the same logic state (i.e. both high or both low) and low when both inputs are in different states (i.e one high and one low). During normal operation the inputs to each gate will be at the same logic level. However, under fault conditions, such as a blown fuse or jammed relay, the respective gate inputs will be at dissimilar logic levels.

IC1a monitors operation of RL1 and IC1b monitors the state of FS1; their outputs are NANDed by a discrete DTL gate based around TR1 and associated components. Similarly, IC1c monitors operation of RL2 and IC1d monitors the state of FS2; their outputs are NANDed by TR2 and associated components.

If either IC1a or IC1b's outputs go low, TR1 will switch on and supply current to the red LED connected to TB3-3 (Auxiliary Battery Warning Status Output). TR2 will switch on in response to a low level output from IC1c or IC1d, supplying current to the red LED connected to TB4-3 (Refrigerator Warning Status Output). TB3-2 and TB4-2 provide 0V/chassis return connections for the LEDs. R20 and R21 serve to limit LED current flow to around 20mA.

The complete Split Charge Unit ready for installation.

Construction

Referring to the PCB legend shown in Figure 3 and the Parts List, assemble the PCB following normal construction procedures. The Constructors' Guide (XH79L) supplied in the kit offers comprehensive advice on construction techniques. Start by inserting the seven wire links marked 'LINK' on the PCB legend. Next, with the exception of the FS1, FS2 and D1, proceed by fitting the components in ascending size order, i.e. 1N4148 signal diodes, 0·6W resistors, etc. Care should be exercised with all polarised devices that they are inserted with correct orientation. IC1 is a CMOS device and normal precautions to avoid electrostatic discharge should be observed.

If the suggested box listed in the optional parts list is to be used, it should be drilled as shown in Figure 4. Additional holes for cable entry, mounting, etc., should be drilled as appropriate. The suggested box is made of aluminium and is easy to drill and file with basic metal-working tools. However, sensible precautions should be taken to ensure safety when drilling; wear safety goggles to prevent eye injury caused by hot flying metal swarf. Avoid the temptation to remove metal filings from the box by

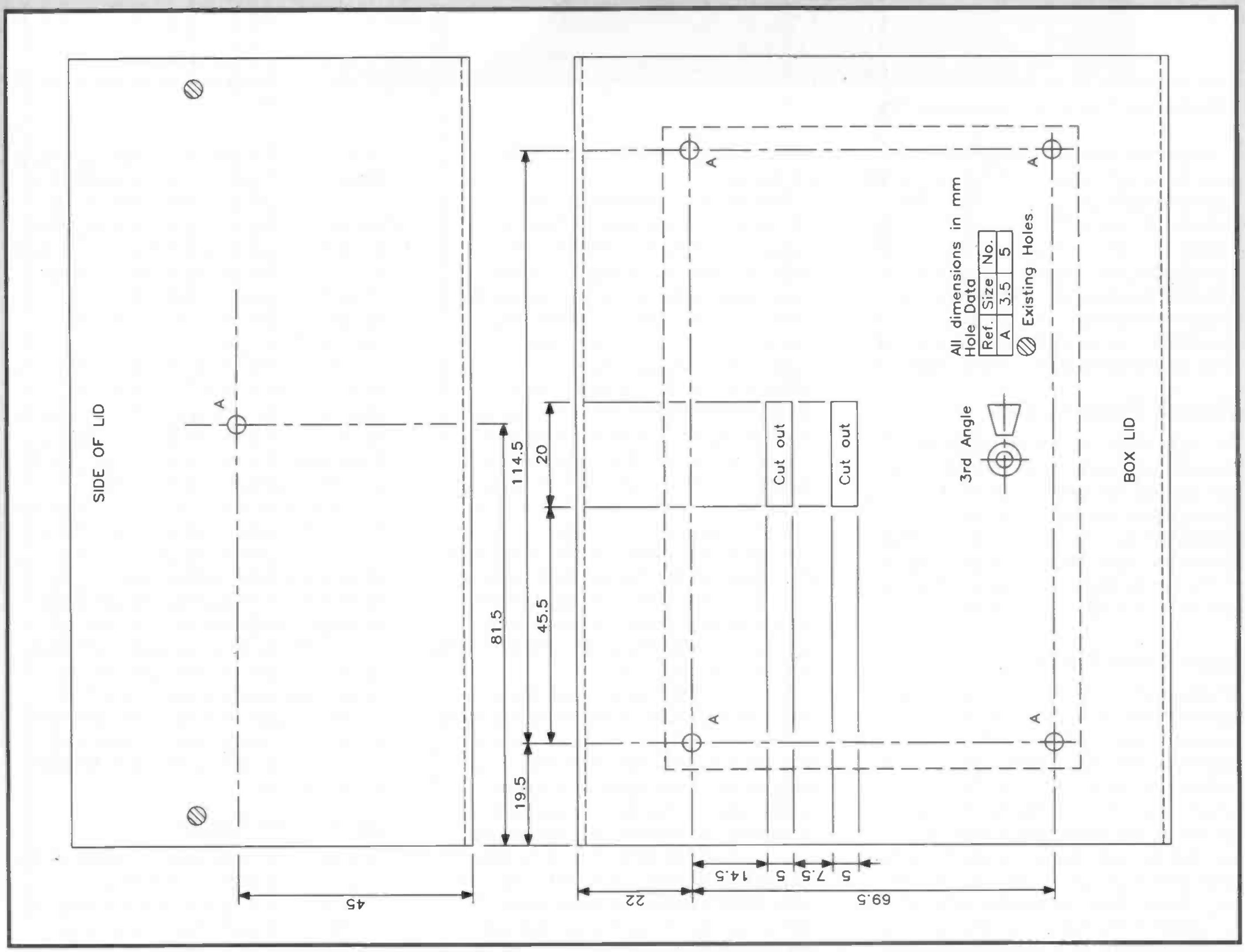


Figure 4. Drilling details of the suggested box.

blowing them out – you will end up with them in your eyes. Keep young children and pets out of the work area. Older children, who are eager to help, should be equipped with suitable safety goggles. All holes should be deburred with a file or a deburring tool.

The suggested box is supplied covered with a protective plastic film, do not remove this until all drilling and filing is complete, otherwise it will become very badly scratched. The drilling details can be marked on the protective film with fine tipped indelible pen. A centre punch should be used on all hole centres, which will help prevent the drill bit skidding. The larger holes and slots can be filed out if suitably sized drill bits are not available, but make frequent checks on progress as it is very easy to file out too much metal!

The final appearance of the box can be substantially improved by spray-painting before assembly. Aerosol car paints are ideal for this and produce excellent results if care is taken. Briefly: rub the box down with extra fine abrasive paper; prime the metal surface with metal primer; apply several thin, even coats of paint and allow to dry thoroughly before attempting assembly. If lettering or graphics are to be used, apply several coats of lacquer to give durability. For more detailed guidelines, refer to David Smith's *Finishing Off* series published in issues 53/May 1992 to 56/August 1992 (inclusive) of *Electronics*.

FS1 and FS2, which are blade type car fuses, are fitted to the *solder* side of the PCB by means of ¼in. blade receptacles. These are fitted as shown in Figure 5.

Connect the Schottky rectified diode to the PCB using 10A wire, as shown in Figure 5 – use heatshrink sleeving to cover the exposed connections.

To increase the current rating of the high current PCB tracks it is *vitally important* to apply a *generous* coating of solder to the wide bare tracks not covered with solder resist. Recheck the PCB, ensure that there are no solder splashes bridging any PCB tracks. It is a good idea to spray the PCB with Clear Protective Lacquer (but wait until testing is complete before doing so!), but make sure that the relays and terminal blocks do not suffer lacquer ingress.

Referring once again to Figure 5, fit the PCB into the box using M3 × 15mm threaded spacers. Secure the Schottky diode to the case using M3 hardware and a silicone insulating washer. The device specified has an isolated mounting hole and thus does *not* require an insulating bush – however, the silicone washer *must* be used, otherwise the metal case will short circuit to the diode substrate. Fit the fuses into their holders.

Testing

A bench power supply capable of delivering +12V DC at 200mA, or a *fuse* protected 12V supply from a battery can be used to test the Intelligent Split Charge Unit. Referring to the wiring diagram shown in Figure 6, connect four LEDs to TB3 and TB4 – the LEDs connected to TB3-1 and TB4-1 should be green (power) and the LEDs connected to TB3-3 and TB4-3 should be red (warning).

Connect TB2-1 to 0V and connect P1 to +12V, at this stage no relays should energise or LEDs illuminate. Connect TB1-2 to +12V, RL1 and RL2 should energise and both green LEDs should illuminate.

Remove the +12V connection from TB1-2 and transfer it to TB1-1, RL1 should energise and the green LED connected to TB3-1 should illuminate. Using a multimeter, set to a suitable DC volts range, check that +12V is present on P2 with respect to 0V.

Remove the 112V connection from TB1-1 and transfer it to TB1-3, RL2 should energise and the green LED connected to TB4-1 should illuminate. Using a multimeter, set to a suitable DC volts range, check that +12V is present on P3 with respect to 0V.

Remove the +12V connection from TB1-3 and transfer it to P2, no LEDs should illuminate. Connect TB2-2 to 0V, RL3 should energise and the green LED connected to TB4-1 should illuminate. Using a multimeter, set to a suitable DC volts range, check that +12V is present on P3 with respect to 0V.

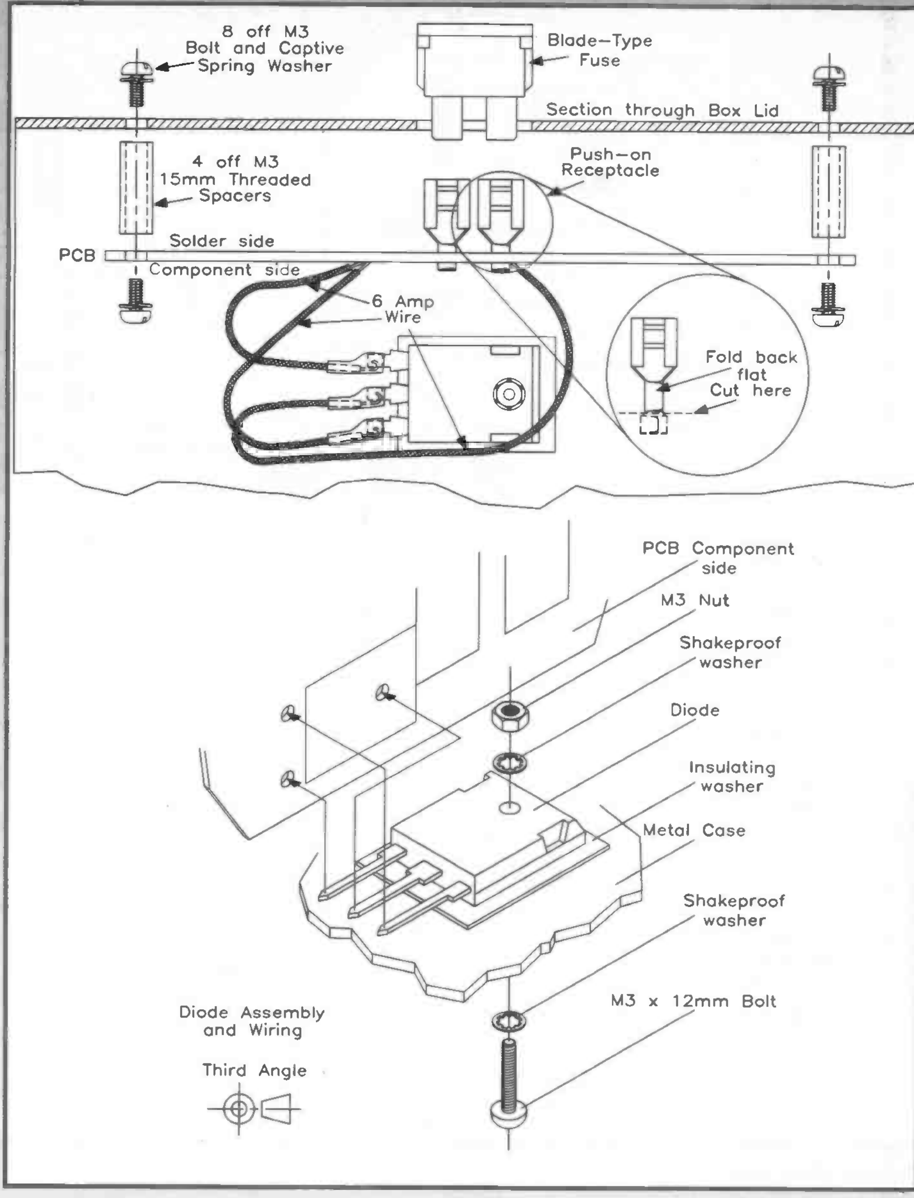


Figure 5. Exploded assembly diagram.

Connector/Pin No.	Function
TB1-1	Override A Input (+12V to switch)
TB1-2	Control Input (+12V to switch)
TB1-3	Override B Input (+12V to switch)
TB2-1	0V/Chassis
TB2-2	Override C Input (0V to switch)
TB2-3	+12V Ignition Switched Supply Input
TB3-1	Auxiliary Battery Power Status Green LED Anode
TB3-2	Auxiliary Battery Status LED Cathodes
TB3-3	Auxiliary Battery Warning Status Red LED Anode
TB4-1	Refrigerator Power Status Green LED Anode
TB4-2	Refrigerator Status LED Cathodes
TB4-3	Refrigerator Warning Status Red LED Anode
P1	+12V Permanent Supply Input
P2	+12V Auxiliary Battery Output/Input
P3	+12V Refrigerator Output

Table 1. Intelligent Split Charge Unit connector designations.

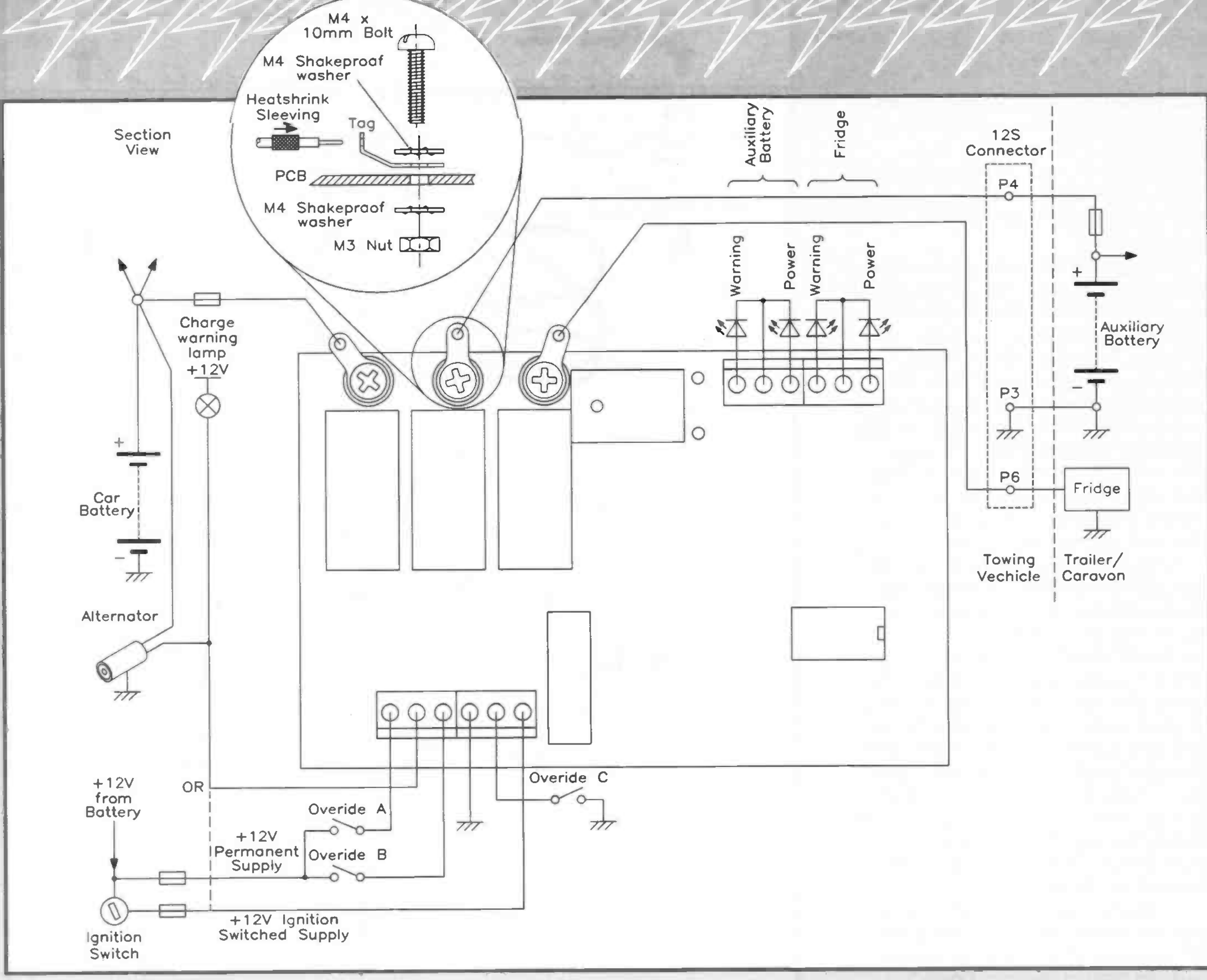


Figure 6. Wiring diagram.

Without removing any of the previous connections, connect TB1-3 to +12V, RL2 should energise and RL3 de-energise. The green LED connected to TB4-1 should remain illuminated.

Remove the +12V connections from P2 and TB1-3; remove the 0V connection from TB2-2. Connect TB2-3 to +12V, both red LEDs will flash briefly. Connect TB1-2 to +12V, both green LEDs should illuminate.

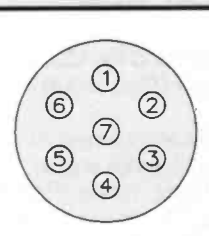
Remove FS1, the green LED connected to TB3-1 should extinguish and the red LED connected to TB3-3 should illuminate. Refitting FS1 should restore the previous condition.

Remove FS2, the green LED connected to TB4-1 should extinguish and the red LED connected to TB4-3 should illuminate. Refitting FS1 should restore the previous condition.

Carefully remove the covers of RL1 and RL2 by *gently* squeezing the *short* faces of the plastic case and pulling upwards.

Carefully insert a thin piece of paper between the normally open contacts of RL1. The green LED connected to TB3-1 should extinguish and the red LED connected to TB3-3 should illuminate. Removing the paper should restore the previous condition.

Carefully insert a thin piece of paper between the normally open contacts of RL2. The green LED connected to TB4-1 should extinguish and the red LED connected to TB4-3 should illuminate. Removing the paper should restore the previous condition.



Pin No.	European Designation	Function	Wire Colour
1	L	Reversing Lights	Yellow
2	54G	Spare	Blue
3	31	0V/Chassis	White
4	R	Auxiliary Battery	Green
5	58R	Warning Light	Brown
6	54	Refrigerator	Red
7	58L	Spare	Black

Figure 7. 12V supplementary connector pinout.

Remove the +12V connection from TB1-3. *Carefully* close the normally open contacts of RL1. The green LED connected to TB3-1 should illuminate and the red LED connected to TB3-3 should illuminate. Releasing the contacts should restore the previous condition.

Carefully close the normally open contacts of RL1. The green LED connected to TB3-1 should illuminate and the red LED connected to TB3-3 should illuminate. Releasing the contacts should restore the previous condition.

Carefully refit the plastic cases of RL1 and RL2.

Remove the +12V connection from P1, both red LEDs should illuminate and both green LEDs should extinguish.

Assuming that the Split Charge Unit performed as described, testing is complete. If results other than those described were experienced, recheck all stages construction for errors.

Installation

Before starting installation, read the warnings given at the beginning of this article. A workshop manual, such as the popular Haynes series, will greatly assist wire tracing. Use a multimeter or a circuit tester to confirm wiring arrangements *before* wires are cut. All connections must be both mechanically and electrically sound. Where wires are joined, solder, crimp or terminal block connectors should be used. All connections should be fully insulated to prevent short circuits.

Find a convenient location for the unit to be fitted, e.g. boot, and secure the box using M4 hardware. Referring to the wiring diagram shown in Figure 6 and the 125 connector pinout diagram shown in Figure 7, make the electrical connections.

The status LEDs and override switches should be conveniently located. Care should be exercised when choosing and siting the override switches to prevent accidental operation. The override switches need only be fitted if they are required – they are not essential to the basic operation of the unit.

The high current connection between the car battery and the split charge unit should be made with 30A wire and include a 20A fuse fitted as physically close to the battery as possible.

The output connections from the split charge unit to the auxiliary battery and the refrigerator should be made using 10A wire. The connection to the auxiliary battery should include a 10A fuse fitted as physically close to the auxiliary battery as possible. The 0V/Chassis connection TB2-1 should be made using 10A wire.

These protection measures may appear to be over the top, but are required to avoid excessive current flow if accidental short circuits occur.

The remainder of the connection can be made using low current hook-up wire, multicore 'burglar alarm cable' is ideal. The cathodes of the status LEDs may alternatively be returned to car chassis instead of TB3-2 and TB4-2 if this saves wiring. The control input TB1-2 may be connected to either the charge warning output from the alternator *or* the ignition switched +12V supply (*not both*); the alternator's charge warning output is preferable but it may not always be accessible or suitable. In case of doubt or problems, use the ignition switched +12V supply. *Do not* use the main charge output from the alternator, otherwise the split charge unit will be permanently enabled. The +12V power input TB2-3 *must only* be connected to the ignition switched +12V supply and *not* the alternator charge warning output. Override inputs A, TB1-1, and B, TB1-3, should be connected via independent switches to the +12V permanent supply. Override input C should be connected via an independent switch to the car chassis.

Double-check *all* connections before reconnecting the car battery.

Use

With the ignition switched off and all override switches off (if fitted) all the status LEDs should be extinguished.

Alternator Controlled

Turn on the ignition, both red warning status LEDs will briefly flash. Start the car, when the charge warning light extinguishes, both green power status LEDs will illuminate. Turn off the ignition and both green power status LEDs will extinguish. Similarly, if at low engine revs the charge warning light illuminates (or the engine stalls), both green power status LEDs will extinguish.

Ignition Controlled

Turn on the ignition, both green power status LEDs will illuminate. Turn off the ignition and both green power status LEDs will extinguish.

Warning Indication

If the supply fuse to the Split Charge unit blows, or the fuses within the Split Charge Unit blow, the appropriate red warning status LEDs will illuminate when the engine is running (alternator controlled) or the ignition is switched on (ignition controlled). Similarly, if a relay becomes stuck open or closed, the appropriate red warning status LED will illuminate. If a relay becomes stuck open, the appropriate green power status LED will not illuminate. If a relay becomes stuck closed, the appropriate green power status LED will permanently illuminate.

Override Switches

Override switch A allows power to be fed to the auxiliary battery output when the engine is not running/ignition is switched off.

Override switch B allows power to be fed to the refrigerator output when the engine is not running/ignition is switched off.

Note: care should be exercised when using override switches A and B that the car battery is not drained to the point where the car will not start.

Override switch C allows power to be backfed from the auxiliary battery to the refrigerator output when the engine is not running/ignition is switched off.

To check that the auxiliary battery is connected and its fuse is intact, operate override switch C with the ignition switch off; the *refrigerator* power status LED will illuminate if all is well.

INTELLIGENT SPLIT CHARGE UNIT PARTS LIST

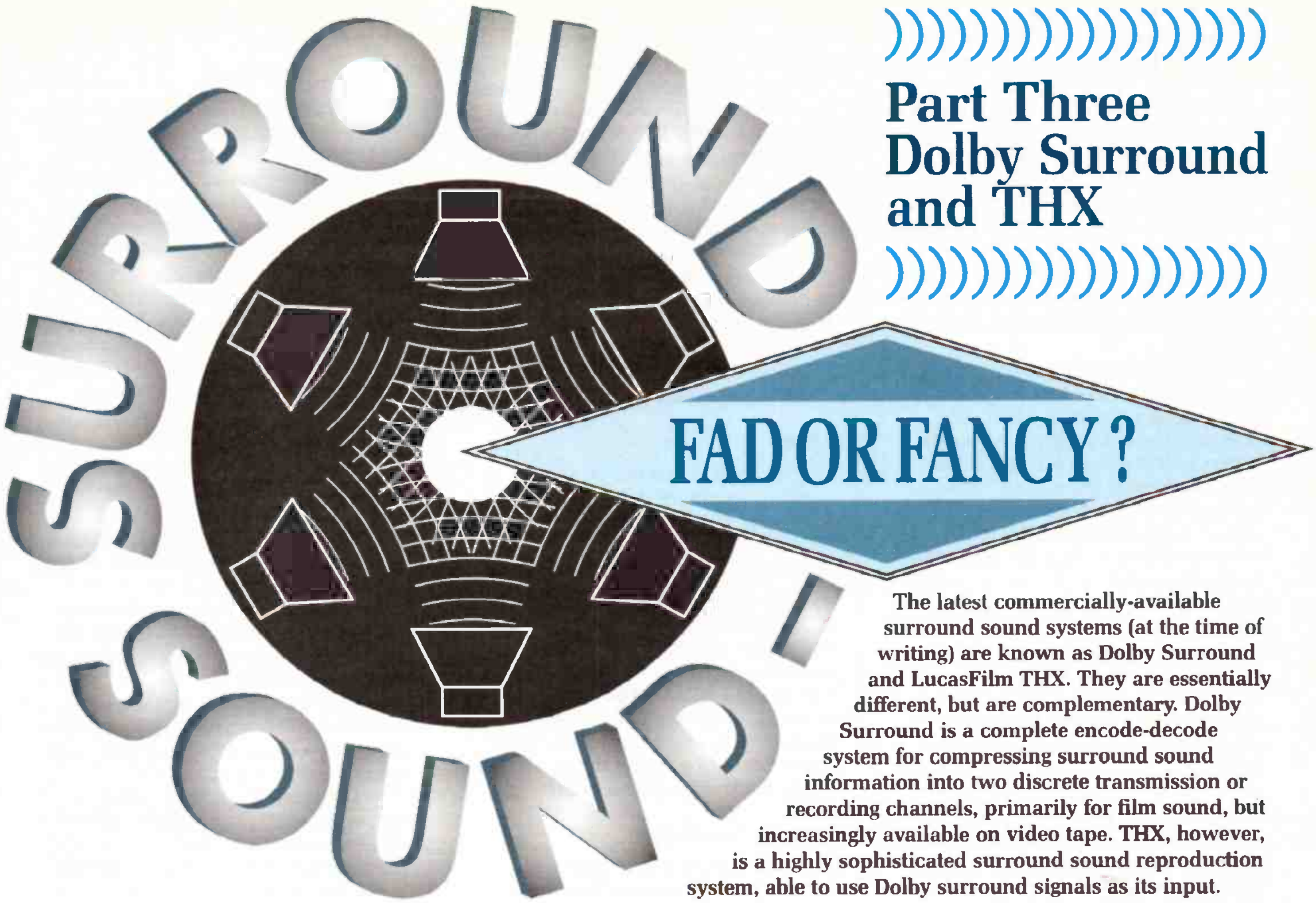
RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1,2,20,21	560Ω	4	(M560R)
R3	100Ω	1	(M100R)
R4,8,11,14,16,19	100k	6	(M100K)
R5,6,7,10,12,13,15,18	10k	8	(M10K)
R9,17	68k	2	(M68K)
CAPACITORS			
C1	100µF 25V Radial Electrolytic	1	(FF11M)
C2-8	100nF 50V Disc Ceramic	7	(BX03D)
SEMICONDUCTORS			
D1	MBR3045PT	1	(GX38R)
D2-5,7,8,11,12	1N4001	8	(QL73Q)
D6,9,10,13-25	1N4148	16	(QL80B)
TR1,2	BC559	2	(QQ18U)
IC1	HCF4077BEY	1	(QW47B)
MISCELLANEOUS			
RL1-3	12V 16A Relay	3	(YX99H)
	20mm Fuseholder	1	(DA61R)
	T100mA 20mm Fuse	1	(WR00A)
	Push-On Receptacle	1 Pkt	(HF10L)
	10A Blade Fuse	2	(KU21X)
	3-way PCB Terminal Block	4	(JY94C)
	14-pin DIL Socket	1	(BL18U)
	M3 × 12mm Steel Bolt	1 Pkt	(JY23A)
	M3 Shakeproof Washer	1 Pkt	(BF44X)
	M3 Steel Nut	1 Pkt	(JD61R)
	TO3P Silicone Insulator Washer	1	(UK86T)
	10A Wire Red	1m	(XR36P)
	3·2mm Diameter Heat Shrink Sleeving	1m	(BF88V)
	4·3mm Insulated Tag	1 Pkt	(JH71N)
	M4 × 10mm Steel Bolt	1 Pkt	(JY14Q)
	M4 Steel Nut	1 Pkt	(JD60Q)
	M4 Shakeproof Washer	1 Pkt	(BF43W)
	PCB	1	(GH82D)
	Instruction Leaflet	1	(XU77J)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

M3 × 15mm Threaded Insulated Spacer	1 Pkt	(FS37R)
30A Wire Red	AsReq	(XR59P)
30A Wire Black	AsReq	(XR57M)
10A Wire Red	AsReq	(XR36P)
10A Black Wire	AsReq	(XR32K)
4-way Low Current Cable	AsReq	(XR89W)
6-way Low Current Cable	AsReq	(XS54J)
8-way Low Current Cable	AsReq	(CW70M)
4·3mm Insulated Tag	1 Pkt	(JH71N)
Aluminium Box	1	(XB69A)
Grommet	1	(JX65V)
M4 × 10mm Bolt	1 Pkt	(JY14Q)
M4 Nut	1 Pkt	(JD60Q)
M4 Shakeproof Washer	1 Pkt	(BF43W)
5mm Red LED	2	(WL27E)
5mm Green LED	2	(WL28F)
5mm LED Clip	4	(UK14Q)
20A Blade Fuse	1	(KU23A)
10A Blade Fuse	1	(KU21X)
Fuse 20mm T100mA	1	(WR00A)
In-line Fuseholder	1	(RC71N)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.
Order As LT60Q (Intelligent Split Charge Unit Kit) Price £18.99
Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately, but is not shown in the 1994 Maplin Catalogue
Intelligent Split Charge Unit PCB **Order As GH82D £4.29**



Part Three Dolby Surround and THX

The latest commercially-available surround sound systems (at the time of writing) are known as Dolby Surround and LucasFilm THX. They are essentially different, but are complementary. Dolby Surround is a complete encode-decode system for compressing surround sound information into two discrete transmission or recording channels, primarily for film sound, but increasingly available on video tape. THX, however, is a highly sophisticated surround sound reproduction system, able to use Dolby surround signals as its input.

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When we come to look in detail at Dolby Surround and the LucasFilm THX reproduction system, we find techniques similar to those used in the early quadrophonic systems. But in Part 2, we saw that those systems were based on less than perfect understanding, and that the Ambisonic system employs the most practicable and appropriate techniques for two- or three-dimensional surround-sound of live sound via loudspeakers (higher accuracy is now claimed for some developmental systems using headphone reproduction). Does this mean that the new systems are just throwbacks to old, imperfect technology?

WHEN YOU KNOW WHAT FOR, YOU KNOW WHY!

There is no doubt that the people at Dolby Laboratories and LucasFilm are very clever, and are well aware of the pitfalls of oversimplification that caused the quadrophonic fiasco, so we can discount the possibility that they just made a 'big mistake'. What we have to do is to ask what the objectives of Ambisonics and Dolby Surround, with or without THX, are.

The basic purpose of Ambisonics is to *recreate*, or at least *simulate*, an original sound field. This largely presupposes a live, acoustic performance, which creates that original sound field. By contrast, the Dolby Surround system was developed for the reproduction of film sound, particularly including special effects. The full story of the system development is told by the kindly Editor in *Electronics – The Maplin Magazine* Volume 9, No. 37, April/May 1990 (XA37S), and obviously I can't reproduce it all here. The vast majority of big-studio film sound is not recorded simultaneously with the action, and it is obvious that special effect sound is wholly artificial. Not even Cecil B. de Mille could stage a volcano or earthquake to order! Since there is, in this case, usually no 'original sound field' at all, Ambisonic techniques are not necessarily even practicable. But there is another, very significant difference – Ambisonics is purely a *sound* system, whereas Dolby Surround is essentially a system for reproducing sound associated with moving pictures. This involves two (related) novel considerations. The visual cues from the picture tend to make the sound appear to come from the picture area, even when it doesn't. This was discovered in the 1950s, when television sets with side-facing loudspeakers were first made. The effect tends to narrow the front 'stage' of two-channel stereo reproduction; you may notice the effect on NICAM stereo broadcasts of live music, when you turn the picture off and on, but should the illusion break down for any reason, and the sound appear to come from somewhere other than the picture area, the effect is both initially startling and eventually annoying. Unintentional centre-front image shift is not desirable and should never occur in an Ambisonics system, but in sound-with-pictures it can be disastrous. Consequently, Dolby Surround pays considerable attention to centre-front localisation, and in some cases a centre-front loudspeaker is added to the system. This not only improves localisation for a central listener, but also reduces the tendency for the sound to localise on the nearer loudspeaker for an off-centre listener. This latter effect could alternatively be counteracted by adopting an optimum directional response for the loudspeakers, as shown by Hugh Brittain in 1958. But the optimum directional response is difficult to achieve: for example, the Canon cylindrical enclosures with asymmetrical diffusers can achieve it over a certain frequency range, but very large diffusers are required for full frequency range operation, or even down to only 500Hz.

DOLBY SURROUND ENCODING

There are only two physically separate channels on the filmstock, so the encoding process is a 4-into-2 matrix. This again sounds dangerously close to quadrophonics, but a great deal more is now understood about correct matrixing techniques. In any case, there is usually no 'original sound': the whole programme signal is more or less an artefact, so there is no prospect of obtaining a more purist starting point. We have to trust the film sound technicians to record the most artistically and technically effective set of four signals that they can. For example, localisation is essentially poor in the surround channel, so if it is necessary to produce a discrete sound localised to the rear of the listeners, some C-channel signal is included in the mix; this pulls the location forward a little but improves localisation a lot.

It can also be shown that the localisation provided by the left and right loudspeaker drive signals is consistent with the stereophonic law of tangents, mentioned in Part 1 of this series. Furthermore, if the left and right loudspeakers subtend an angle of 90° at the central listening position, the replay localisation matches the directional encoding of the Blumlein coincident crossed-lemniscate microphones. The addition of the centre loudspeaker causes a narrowing of the sound stage, but with the improvement in centre-stage localisation mentioned above.

In the encoder (Figure 19), the left and centre input signals are added, with 3dB loss applied to the centre signal, and the same process is applied to the right and centre signals. The 'surround' signal, which is basically an 'effects' channel in this system, has a more exciting life. It is first attenuated by 3dB, then band-limited quite steeply at 100Hz and 7kHz before passing to a modified Dolby B noise reduction encoder. It then passes to a +90° wideband phase-shift network before being added to the left-plus-centre signal (the result being called L_t), and to a –90° phase-shifter before adding to the right-plus-centre signal (the result being called R_t). The two composite signals are then optically recorded on the film, usually with further Dolby A noise reduction applied.

This encoder is relatively simple, except for the wide band phase-shifters. Depending on the accuracy required, these may require several sections and several op amps. It is possible to use the technique adopted in some Ambisonic equipment, whereby, before adding two signals required to be in quadrature, one is shifted in phase 45° one way and the other is shifted 45° in the opposite direction. Wide band phase-shifts of 45° are considerably easier to achieve than 90° phase-shifts.

DOLBY SURROUND DECODING

While it is not possible to recover the centre channel signal separately from the left and right signals just by adding L_t and R_t together (the crosstalk is –3dB), the left and right signals themselves are highly separated (i.e. very low crosstalk, only due to stray effects), and it can be seen that the surround signal can be recovered separately by subtracting R_t from L_t. If everything is balanced correctly, this operation cancels out any centre signal, which is thus highly separated from the surround signal. This is essential, because a high level of crosstalk here would ruin the illusion entirely, with centre-front speech also coming from the surround loudspeakers. However, the crosstalk between the surround signal and the recovered left or right signals is also only –3dB, which does not seem to be enough – but it is when some more magic is added.

There are two sorts of officially approved Dolby Surround decoder. The simpler one is called a 'passive decoder', which it is not, because it contains op amps and things (but good technical names are rare and precious). An example of a truly passive decoder is the Hafler loudspeaker-level matrix described in Part 1. In the 'passive' Dolby Surround decoder, the surround signal is delayed by 15ms to 30ms so that, for any reasonable loudspeaker layout and room size, the front signals arrive at the listener first. The sound is then localised at the front due to the 'precedence (Haas) effect' in human hearing (where the directional cue is taken from the first sound to arrive, if it is not too weak in relation to the later sound). A block diagram of a 'passive' decoder is shown in Figure 20.

The more complicated (much more complicated!) type of decoder is called 'Pro-logic'. This does all sorts of clever things, some of them commercially confidential. Basically, it applies logic steering successfully, in a way that was virtually impossible in quadrophonic decoders in the 1970s. Control signals are produced by full-wave rectifying each channel signal, and calculating their ratios. From these ratios, further

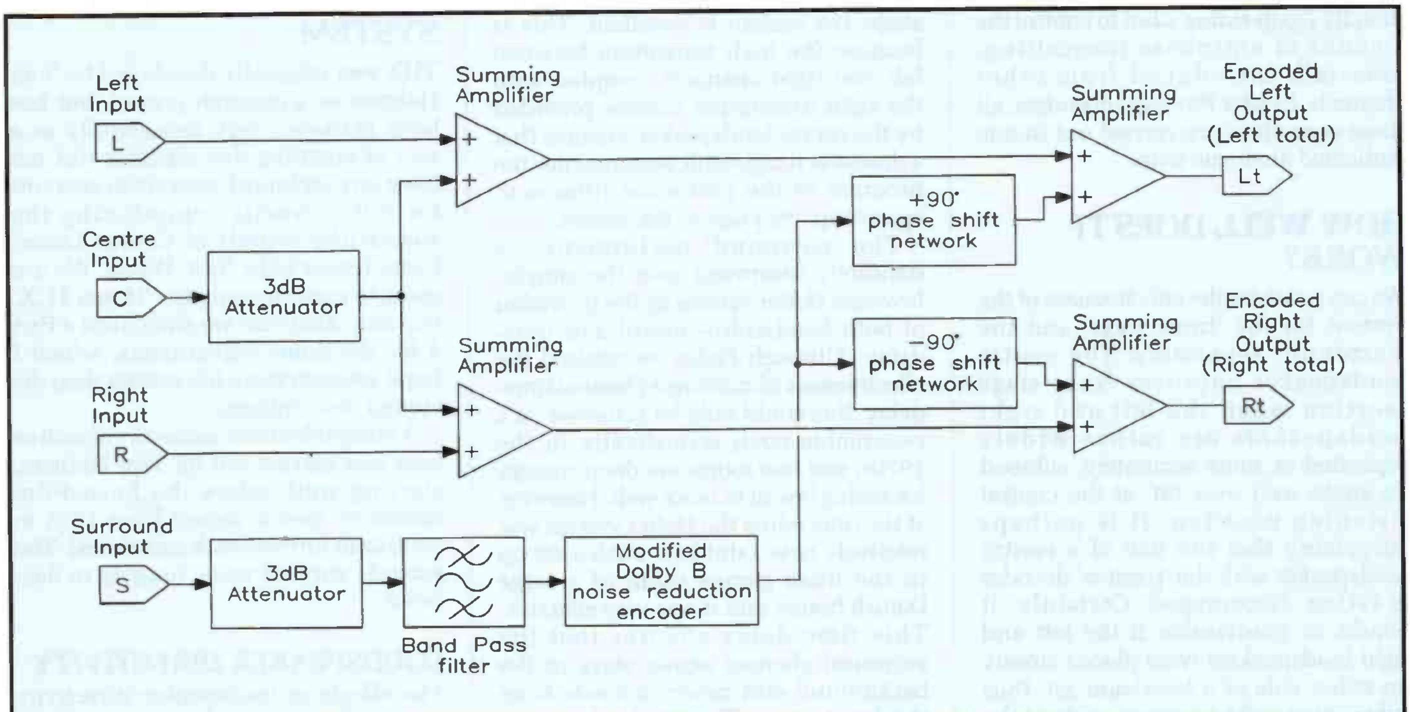


Figure 19. Dolby stereo encoder.

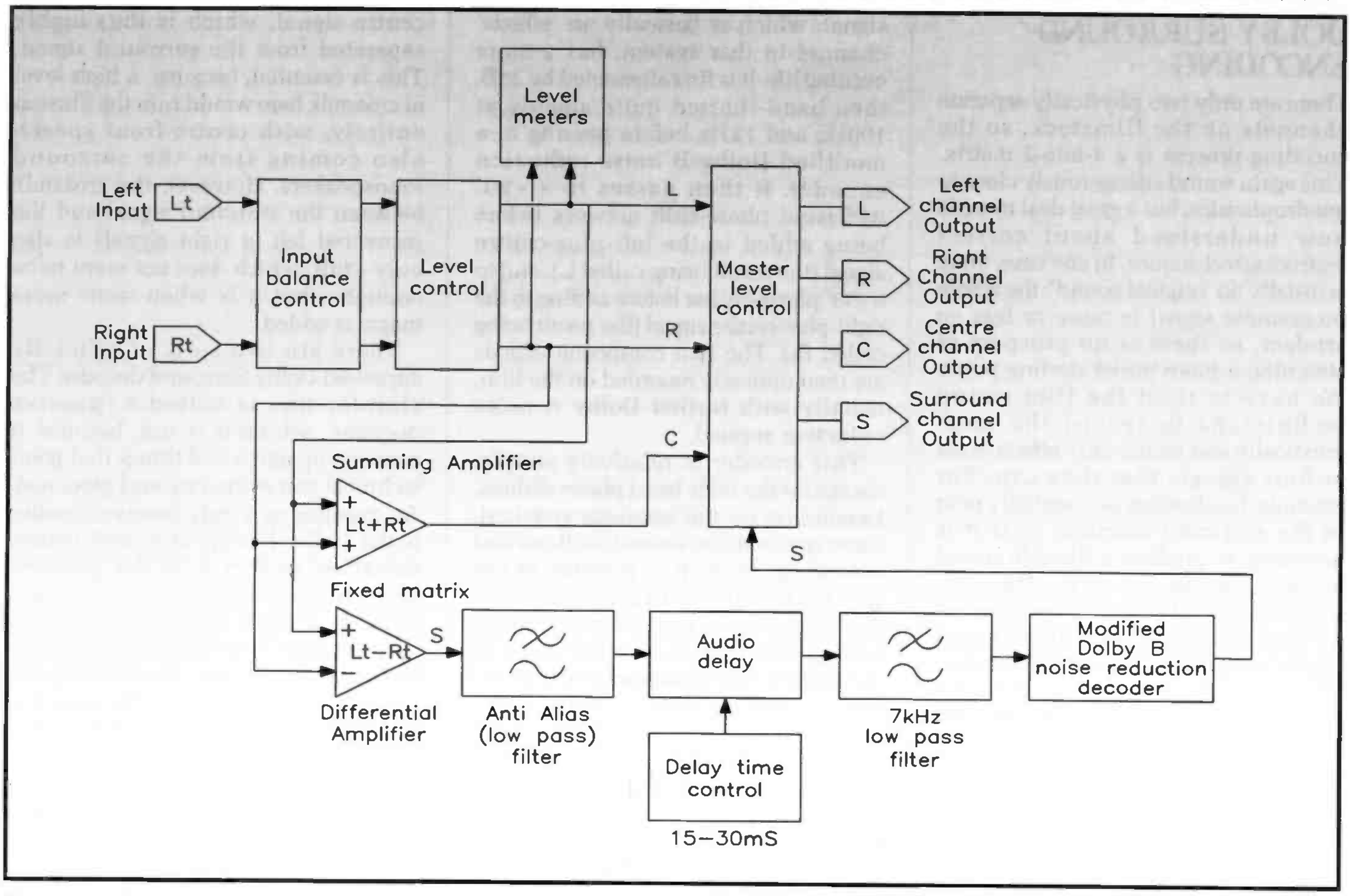


Figure 20. Dolby Surround 'passive' decoder. The level meters and level control are required so that the Dolby-B decoding is correctly applied; the Centre Channel is optional and the Fixed Matrix can be realised as an M-S matrix.

control signals are derived, which are then used to adjust the gains of eight voltage-controlled amplifiers. These form an adaptive matrix, in which the levels of the loudspeaker drive signals are set so as to enhance localisation – particularly when the signal in one of those channels should be dominant. Pumping effects are prevented by using the VCAs, not to vary the channel gains directly ('gain-riding'), but to control the amount of antiphase (cancelling) crosstalk introduced from other channels. In later Pro-logic decoders, all these operations are carried out in one dedicated analogue chip.

HOW WELL DOES IT WORK?

We can consider the effectiveness of the system for the 'front stage' and the 'surround' separately. The centre loudspeaker improves front stage location when the left and right loudspeakers are rather widely separated or, more accurately, subtend an angle well over 60° at the central listening position. It is perhaps surprising that the use of a centre loudspeaker with the 'passive' decoder is rather discouraged. Certainly, it would be inadvisable if the left and right loudspeakers were placed closely on either side of a television set, thus subtending quite a narrow angle at the listeners' positions. But that is exactly the arrangement which many TV manufacturers are heavily promoting at the moment. The two small satellites are supplemented by a centre loudspeaker mounted in the TV pedestal stand. Though it is neat and widely acceptable as room furnishing, it does not seem to be the best technical solution by a long way.

For film sound effects on the front stage, the system is excellent. This is because the high separation between left and right channels, coupled with the tight directional control provided by the centre loudspeaker, ensures that a dramatic image-shift accompanies the progress of the police-car (dinosaur, spaceship, etc.) across the screen.

The 'surround' performance is definitely improved over the simple, low-cost Hafler system by the provision of both bandwidth-control and time-delay. Although Hafler recognised the effectiveness of surround-channel time-delay, this could only be achieved (at a reasonable cost) acoustically in the 1970s, and few rooms are deep enough for such a layout to work well. However, at the time when the Hafler system was relatively new, I did hear such a set-up in the huge games room of a large Danish house, and it was very effective. This time-delay ensures that the surround channel signal stays in the background and never distracts from the front stage. The 'Hafler box' can achieve this in the absence of a delay only through real-time knob-twiddling by the listener, which is why it is designed as a hand-held unit. As for the front stage, the high separation between centre and surround channels ensures a dramatic image shift as the space-ship (police-car, dinosaur, etc.) flies overhead.

THE LUCASFILM THX SYSTEM

THX was originally developed by Tom Holman as a research project, but has been marketed very successfully as a way of ensuring that cinemas did not have any technical reasons to account for not correctly reproducing the spectacular sounds of George Lucas' films (especially *Star Wars*). We are going to consider only the 'Home THX' version, otherwise we shall need a Part 4 for the home experiments, which I hope are even more interesting than the system descriptions.

A comprehensive series of subjective tests was carried out by Tom Holman, starting well before the LucasFilm initiative, over a period from 1974 to 1989 (and further work continues). The subjects covered were, roughly in date order.

LOUDSPEAKER DIRECTIVITY

The effects of loudspeaker directivity on localisation and naturalness of reproduction:

This experiment showed a strong interaction between programme content and the optimum directional response for 'naturalness'. This is very bad news because directivity is very difficult to control, and certainly cannot be varied (except by switching to different loudspeakers!) for different programmes. A later experiment confirmed that the direct-to-reverberant balance of the original recording depends on the directivity of the monitor loudspeakers used by the recording engineer. Hence, some control over this balance at the reproduction stage is desirable because the directivity of the listener's loudspeakers, and the effects of the local listening environment may well require a different optimisation.

A further experiment showed that, in a cinema, loudspeaker directivity should be controlled so as to cover the audience (and only the audience) uniformly; the whole of the seating area should be well within the dominant direct sound field. While this technique makes music sound rather 'drier' than in a concert hall, where much of the audience is in the dominant reverberant sound field, this can be allowed for in the recording process.

SURROUND LOUDSPEAKERS

The effects of adding Hafler-type surround loudspeakers:

This experiment showed the value of a 10ms to 20ms time-delay, and reversed-polarity connection (abandoned later, in favour of a more effective 'decorrelation' process), in preventing the surround loudspeakers from producing distracting 'dominant' sounds – particularly when associated with moving pictures. It also disclosed a major feature of the THX system – the advantage of using dipole-radiator loudspeakers positioned to the sides of the listening area, rather than conventional loudspeakers sited to the rear. Moreover, the surround loudspeakers should be visually as well as acoustically self-effacing. Further experiments showed that the 'timbre' (tone colour – what distinguishes a clarinet from a flute, or a cheap guitar from a costly one, whilst playing the same note) of the sound from the surround loudspeakers differed disconcertingly from that of the front stage. For home use, where only two surround sources are necessary, as opposed to the twenty-two (!) required for a large cinema, the effect is not so severe, but with four surround loudspeakers it is quite marked. A special equalisation was developed for the two-source case by comparing the frequency responses of the front and surround loudspeakers, as measured with a dummy head, in a listening room. The need for this equalisation was considered to be due to the difficulty of interpretation, by the ear-brain system, of the rather unusual sound field created by the surround sources.

CENTRE CHANNEL

The effects of adding a centre channel:

Film sound systems, even in the very early days (with such classics as *Fantasia*), have always had a centre channel. This was largely due to the wide angular separation of the left and right loudspeakers – at least as seen from the cheap front seats. The experiment showed that, good as the phantom image produced by optimised two-channel reproduction can be, the centre loudspeaker made a definite improvement (but one that was almost impossible to describe in words).

PRE-EMPHASIS

The effects of pre-emphasis of the film sound on reproduction in the home environment:

Cinema sound systems have a standardised (ISO2969/BS5550-7-4-1) frequency response which is flat to 2kHz and then falls at 3dB/octave (to make life difficult for audio designers?). Modern film sound is recorded with the inverse of this response so that, when reproduced through a well set up home high-fidelity system, it should sound too toppy, and the experiment confirmed that it often does. Moreover, the experiment determined an optimum home-environment de-emphasis characteristic (which may or may not match the ISO curve exactly).

DECORRELATION

Decorrelation of the left and right surround loudspeaker drive signals:

You can experience the need for this by facing your stereo loudspeakers towards each other and listening in mono between them – the sound will often appear to come from inside your head. This is due to the fact that the two signals are substantially identical. So, how can we make them 'not identical' ('decorrelate them') without actually altering their individual sounds? The experiment showed that neither complementary comb-filtering (a technique used to make 'synthetic stereo' from mono recordings) nor inter-channel phase-shifts, nor time-delays, worked well enough (without introducing unwanted phenomena). The method eventually adopted was to introduce small, random pitch-shifts between the left and right surround signals – a technique which would have been extremely difficult until a few years ago.

SIDE-EFFECTS (PUN INTENDED)

The experiments produced some unexpected psycho-physical effects. For example, the sound of, say a motor cycle, which is panned (by swinging the camera, not the pan-pot!) rapidly

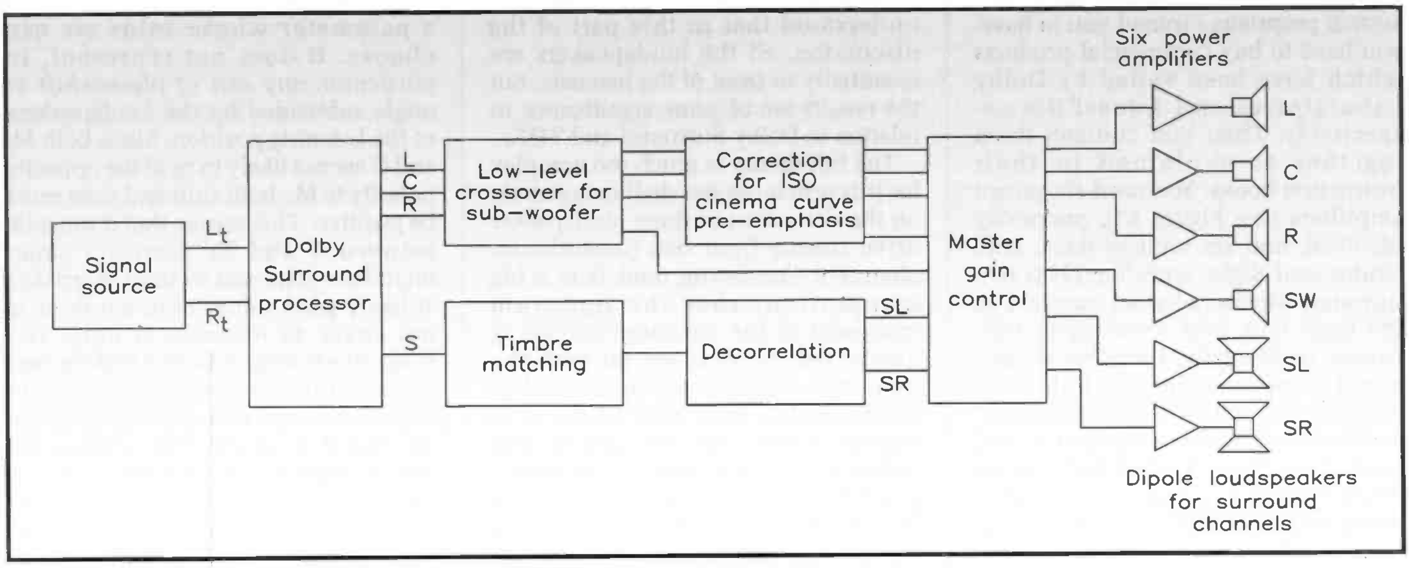


Figure 21. Basis of a Home THX reproduction system.

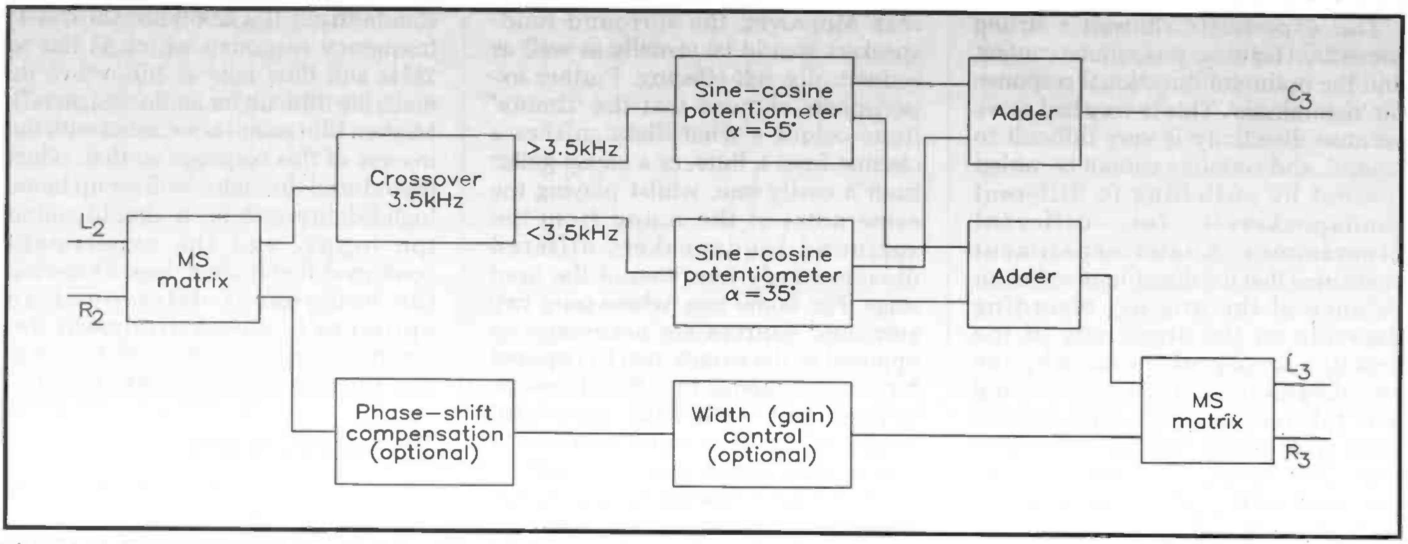


Figure 22. Michael Gerzon's frequency-dependent 2- to 3-channel converter.

off-screen to the left, appears to move to the left beyond the left loudspeaker even though there is no physical explanation for this. It appears that even though there is no possible visual localisation (because the motor cycle has been panned out of shot), our experience of the behaviour of motor cycles is such that *we hear the sound from the direction in which we would expect to see its source.* Truly, the human brain has the most unexpected properties, and this one is evocatively called the 'exit-sign effect'!

Another unexpected effect was that sounds balanced (as is usual film-studio practice), whilst viewing a monochrome print, seem brighter, cleaner and generally more attractive, but curiously, rather quieter (2dB to 3dB) than when viewing a colour-print. Perhaps it would be more accurate to say that the listener/viewer tends to turn up the sound level by 2dB to 3dB for the colour print – perhaps because the sound is more pleasing for the other reasons.

HOME THX EQUIPMENT

To get the full benefits of Dolby Surround and Home THX that the system proprietors intend you to have, you have to buy commercial products which have been vetted by Dolby Laboratories and LucasFilm respectively. Then you connect them together as explained in their instruction books. You need six power amplifiers (see Figure 21), preferably identical, and six loudspeakers: Left, Centre, and Right, with (for THX) two surround dipole radiators matched to the front trio, and a matching sub-woofer. Incidentally, I see that at least one TV manufacturer's publicity department thought that 'sub-woofer' meant something less good than a 'real woofer', so they changed the product description to 'super-woofer'. Perhaps their next move will be to offer cathode-ray tubes filled with something more marketable than nothing!

The Home THX processor operates on the L, C, R and S signals from the Dolby Surround decoder. The sub-woofer channel is derived by matrixing and low-pass filtering the L, C and R signals, which are also sent to the three de-emphasis filters to flatten the signal spectra above 2kHz. The S signal is first sent to the timbre-matching equaliser, to ensure that the sound quality does not change as sounds move from front to side or back, and then to the decorrelation circuits, which are possibly variable-pitch processors driven by pseudo-random clocks. The differential pitch-change is probably very small, perhaps less than a semitone. Even so, some musical ears may well notice it, although it may be 'perceptible, but not disturbing', to borrow a concise phrase from the former CCIR.

MORE LOUDSPEAKERS THAN CHANNELS

In 1992, Michael Gerzon published a full theory of 'the derivation of n_2 loudspeaker drive signals for front-stage stereo from a smaller number n_1 of transmission signals'. It should be understood that in this part of the discussion, all the loudspeakers are essentially in front of the listeners, but the results are of some significance in relation to Dolby Surround and THX.

The full theory is much too complex for this article, so we shall concentrate on the derivation of three loudspeaker drive signals from two transmission channels. Assuming (and it is a big assumption) that the optimum treatment of the surround signals is unaffected by what we do with the front-stage signals, we can proceed in the following way. First of all, it is simpler to deal with the sum M_2 and difference S_2 of the transmission signals L and R. Circuit functions that derive the sum and difference of two input signals have transfer functions that can be represented as a 2 × 2 matrix (a matrix is an array of numbers), whose elements are either +1 or −1:

$$\begin{pmatrix} M_2 \\ S_2 \end{pmatrix} = \frac{1}{\sqrt{2}} \times \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix} \times (L\ R)$$

The multiplier $1/\sqrt{2}$ is necessary so that the total energy (or power) in the signals is preserved, i.e:

$$M_2^2 + S_2^2 = L^2 + R^2$$

This matrix also has the useful property that if we apply it twice, we end up with the original signals. This means that we can use one design of matrix in at least two places, and leads to the thought that it might be a good idea to make an experimental surround processor in modular form.

To get three channels from two, we first derive the two channel sum and difference signals M_2 and S_2. We then submit them to some processing to produce M_3 and S_3 signals, and finally, derive the three output signals, which we shall call L, C and R. According to Gerzon's analysis,

$$M_3 = M_2 \sin\alpha$$
$$C_3 = M_2 \cos\alpha$$
$$S_3 = S_2$$

The quantity α is not a real angle, but a parameter whose value we can choose. *It does not represent, in particular, any sort of phase-shift or angle subtended by the loudspeakers at the listening position.* Since both M_3 and C are not likely to be of the opposite polarity to M_2, both sinα and cosα must be positive. This means that α must lie between 0° and 90°. Gerzon's paper includes a graphical method of arriving at likely good values of α, but there is not space to describe it here. His subjective testing indicated that the best compromise over the whole audio frequency range is in the region of α = 45°, but it is worthwhile making the matrix frequency-dependent so that α can be set to 35° at low frequencies, progressively changing to 55° from 3·5kHz upwards. It is also possible to play tricks at frequencies below 150Hz, where there is little stereo effect. If the centre loudspeaker has an extended low-frequency response, a value of $\alpha = 0^\circ$ is appropriate, whereas if the centre unit is a small 'filler', the bass input can be restricted simply by setting $\alpha = 90^\circ$. For sound-with-pictures, where centre image stability is vital, a value of α in the region of 25°, instead of 35°, is likely to be desirable. A further possibility is to put a gain control in the S chain, which gives control of the stereo stage width. As an example of the process of recovering the actual loudspeaker drive signals L_3, R_3, C_3 and S_3, we can take the rather simple case with $\alpha = 45^\circ$:

$$L_3 = M_3 + S_3 = \frac{M_2}{\sqrt{2}} + S_2 = \left(1+\frac{1}{\sqrt{2}}\right)L - \left(1-\frac{1}{\sqrt{2}}\right)R$$

$$C_3 = \frac{M_2}{\sqrt{2}} = \frac{L}{\sqrt{2}} + \frac{R}{\sqrt{2}}$$

$$R_3 = M_3 - S_3 = \frac{M_2}{\sqrt{2}} - S_2 = -\left(1-\frac{1}{\sqrt{2}}\right)L + \left(1+\frac{1}{\sqrt{2}}\right)R$$

A block diagram of a typical decoder of this type is shown in Figure 22.

SINE-COSINE POTENTIOMETER

If we are going to make an experimental processor with variable α, we need a sine-cosine potentiometer to control the matrix coefficients. It is possible to buy these, but not from Maplin, and they are often very expensive. Luckily, it is possible to make a very close approximation from a single linear pot, such as FW85G or JM85G (10kΩ is a convenient value), by connecting a resistor (of about 1·6 times the pot resistance from the signal source) to each end of the track, and earthing the slider, as shown in Figure 23a. The two ends of the track are then connected via resistors, of about eight times the pot resistance, to the inverting inputs of two buffer amplifiers, which restore the insertion loss of the network. This approximation has an error of –0·9dB at the centre of the pot, which is tolerable (Figure 23b).

NOT A DIGRESSION

You may wonder why I mentioned Gerzon's work on front-stage systems, at this point, in an article on surround sound. The reason is, in fact, that the Gerzon 3:2 matrix with $\alpha = 45^\circ$ is near optimum for reproducing signals intended for use with two front loudspeakers, subtending an angle of 60° at the listening position (i.e. conventional stereo with optimally placed loudspeakers) through three front loudspeakers (left, centre and right), with left and right subtending an angle of 90° at the listener. It is perhaps surprising that the literature on Dolby Surround does not make any specific angular or distance recommendations on loudspeaker layout, which may be the reason for the use of a centre loudspeaker with the 'passive' decoder not being recommended.

Passing Dolby Surround encoded signals through a Gerzon 3:2 45° matrix, with an added side-chain to recover and process the S signal, produces L and R signals at +4·7dB relative to the S signal (i.e. some gain in the S channel is needed), with separation of C and S signals from L and R at 4·6dB relative, and L/R antiphase crosstalk at –15·4dB relative. The C signal is of the correct composition, containing no S signal if the L/R balance is correct, but is 3dB low in level, which can easily be made up. There is obviously ample scope for experiment with different decoding processes, loudspeaker layouts and source material.

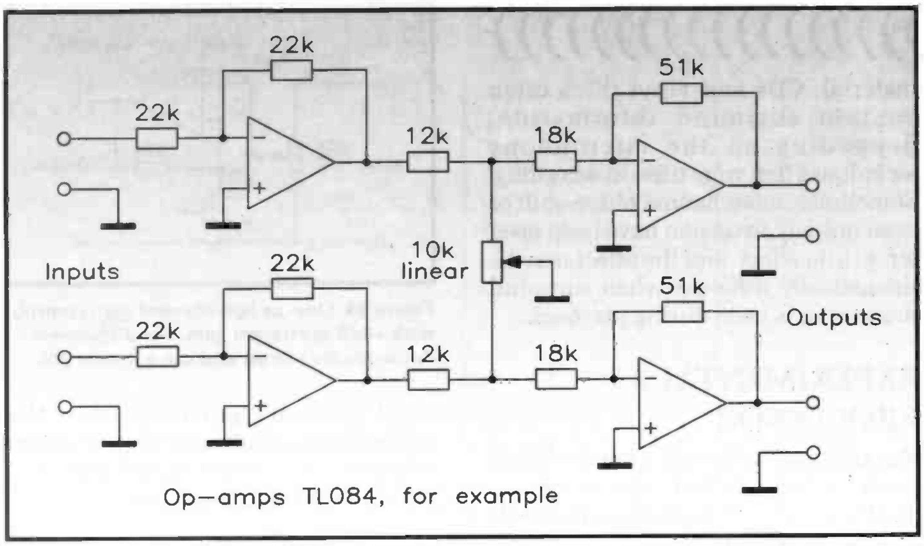


Figure 23a. Approximate sine-cosine potentiometer with buffering and gain make-up.

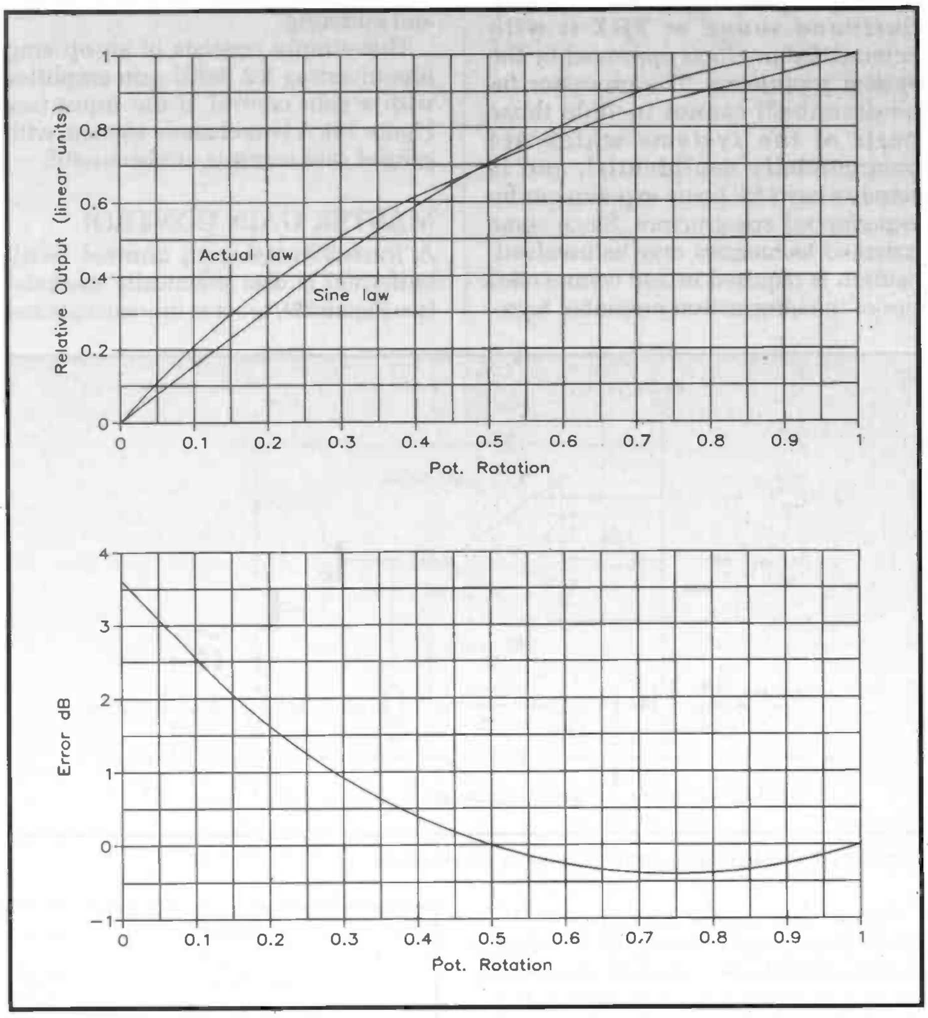


Figure 23b. Characteristics of the approximate sine-cosine potentiometer.

SOFTWARE

The obvious source of Dolby Surround programme is video tape. The tape may or may not be labelled with the Dolby Surround logo. Off-air terrestrial NICAM stereo, or satellite broadcasts of films recorded in Dolby Surround will also be a good source of programme material. CDs and vinyl discs often contain surround information, depending on the microphone techniques that were used in recording. Sometimes, interchannel phase-shift or even polarity inversion have been used for artistic effect, and the effect may be dramatically different when surround processing is used during playback.

EXPERIMENTAL PROCESSOR

You will have gathered, from the broad hints earlier in this article, that a modular system is most appropriate for an experimental processor.

It should be clearly understood that the only way to obtain genuine Dolby Surround sound or THX is with commercial products approved by the system proprietors. The processor (to be described) cannot include those parts of the systems which are commercially confidential, and is purely a basis for home experiments by experienced constructors. Since some patented techniques may be involved, caution is required in any *commercial* use of the information presented here.

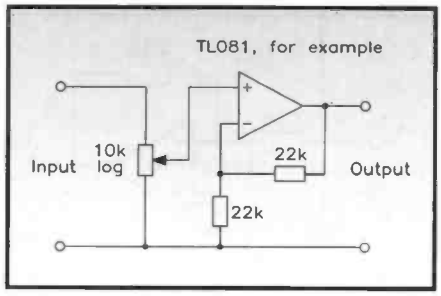


Figure 24. One- or two-channel gain control, with +6dB maximum gain. For 2 channels, duplicate the circuit and use a 2-gang pot.

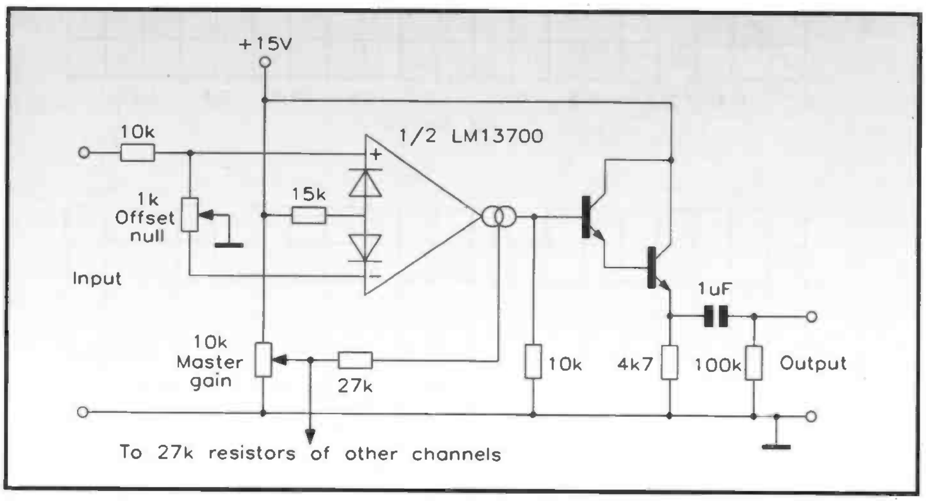


Figure 25. Electronic gain control for four or six channels.

Approved commercial products, embodying proprietary processing systems, tend to be at the high-price end of the market, at least when the processing system is newly introduced. This is because if any but very good products were approved, audible defects might be unjustly attributed to the proprietary system. By demonstrating the system, when embodied in the highest quality products, such potential criticism can be obviated.

The experimental processor consists of the modules described below, some of which may be used more than once – it is not necessary to build all of the modules initially in order to make a working processor. In some cases, it is possible to give fairly full details of the module, but in other cases it is necessary to refer extensively to the data sheets of the active devices – and then only general guidance for the experienced constructor can be given, otherwise this article would take up a whole issue of the magazine.

LEVEL CONTROL

1- or 2-channel gain control, with gain and buffering.

This simply consists of an op amp non-inverting ×2 (6dB) gain amplifier, with a gain control at the input (see Figure 24). A two-channel version, with ganged gain controls, is also useful.

MASTER GAIN CONTROL

A four-channel gain control (with buffering) is also practically essential (see Figure 25), to act as the conventional 'volume-control', but four-gang pots are not easy to obtain. A four-channel voltage-controlled-amplifier (VCA), using the CA3080 (YH58N) or LM13700 (YH64U) is perhaps the best solution.

SINE-COSINE POTENTIOMETER

The basic idea has already been explained, but for a modular system it is worth including input buffering, which should be inverting in order to preserve signal polarity (see Figure 23).

15-30ms TIME-DELAY (WITH ANTI-ALIAS AND GLITCH FILTERS)

This is most conveniently achieved with a bucket-brigade delay line, and of the range available from Maplin, only the MN3011 (UM65V) will give 30ms delay at an acceptable bandwidth (see Figure 26). The much less costly MN3207 (UR67X), however, will give 18·3ms delay with a clock frequency of 28kHz, and the *input* signal band-limited to 7kHz. Both devices derive their clock pulses from the MN3101 clock driver (UM66W). The delay device has to be preceded by an anti-alias filter, and followed by a reconstruction filter which can also provide the 7kHz low-pass filtering required in the surround channel. There is a Data File article in the January 1992 issue of *Electronics* (XA49D), and both a PCB and a kit are available.

M-S OR Σ–Δ MATRIX

This is easily produced from a quad op amp (see Figure 27), although layout might be easier with two duals. There seems no reason to use anything more exotic than a TL084 (RA72P), particularly since this module is one of which several units may be required.

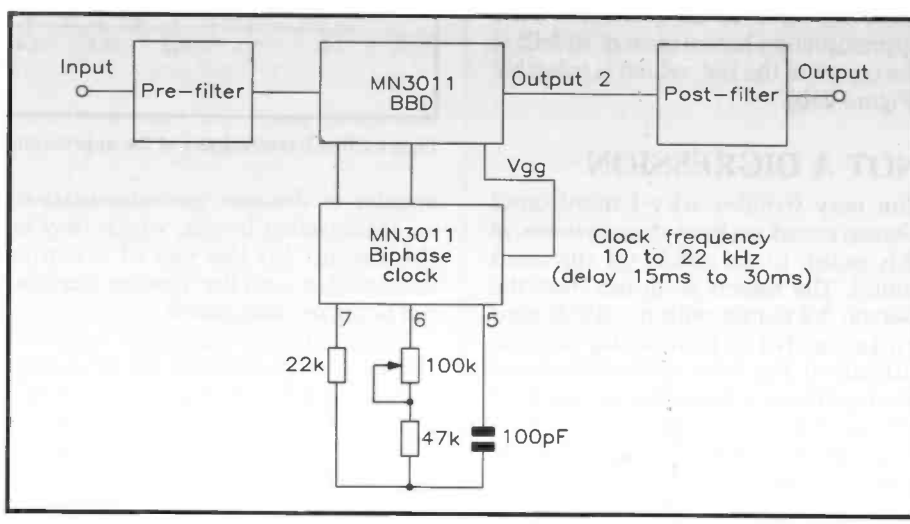


Figure 26. Variable time-delay for surround channel. Refer to the MN3011 data sheet for details of biasing the input pin via the input filter, and for other information. Additional information can also be found in issue 49 of *Electronics* (XA49D). The MN3011 supply voltage should be –15V for best noise performance.

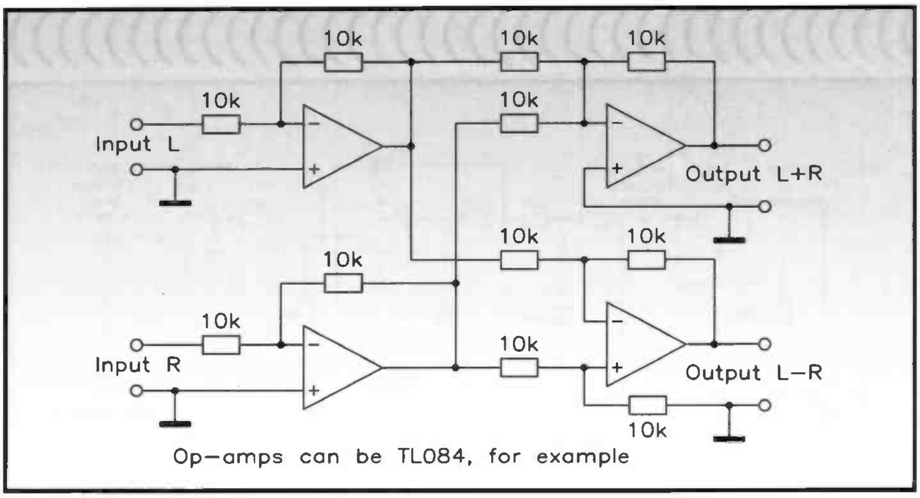


Figure 27. M–S or Σ–Δ matrix.

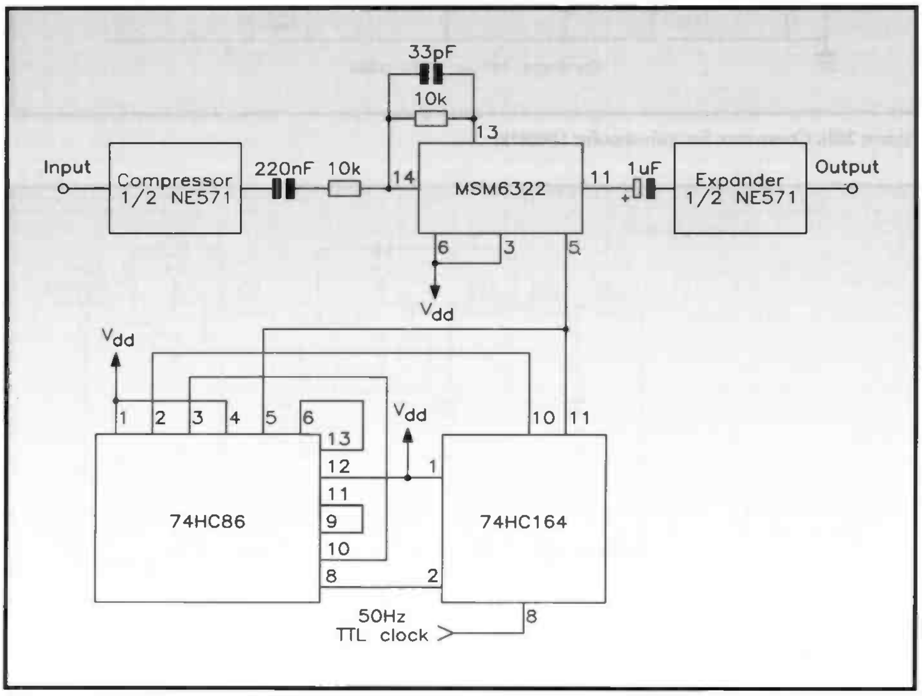


Figure 28. Basis of a pitch-shift decorrelator. The MSM6322 is used in a unity-gain mode at the 'line' input. For further information on this device, see the Data File in issue 44 of *Electronics* (XA44X). The multiple inversions in the 74HC86 are to prevent latch-up in the 'all-zeroes' condition.

DECORRELATOR (PITCH-SHIFTER)

This is one of the most interesting modules (see Figure 28). It just happens that Maplin supply the MSM6322 speech pitch controller (UL76H). While this is capable of pitch-shifts of over one octave, we must probably limit it to one semitone (the smallest available shift), otherwise discordance is likely to be disturbing. The device is made for use in frivolous products, and has 8-bit quantisation, which implies a signal-to-noise ratio of no more than 48dB. Luckily, full details of the use of this device, with optional pre-compression and post-expansion, using an NE571 to improve the signal-to-noise ratio, were given in a Data File in the June 1991 issue of *Electronics* (XA44X). A PCB and a kit are also available.

To produce the random pitch-shift (either in one surround channel only, or independently in left and right surround channels), a pseudo-random binary sequence (PRBS) generator is appropriate. This can be made from an 8-bit shift register, such as 74HC164, and an exclusive-or gate 74HC86, arranged to give a sequence of length 63 (6 bits). With a clock-frequency of 50Hz (how convenient!), random pitch-shift durations from 10ms to 630ms are obtained, which is probably satisfactory. The way to test this is to point the surround loudspeakers at your ears, from equal distances, and adjust the decorrelation to eliminate any in-head sound images. There is ample scope for experiments here. The MSM6322 should be used in the 'BIN' (binary) pitch-selection mode (pin 6 to V_{DD}), with pin 3 at logic 1 and the PRBS output applied to pin 5. This gives an upward pitch shift of a semitone when the pin is at logic 1. Although the use of the device in this way requires it to be followed by a 4kHz low-pass filter, remember that the surround signal has had a modified Dolby-B processing at the encoding stage, which means high-frequency emphasis at low signal levels, and should be low-pass filtered at no more than 7kHz anyway. The audible effect of the low-pass filtering is thus less than might be expected.

CROSSOVER FOR SUBWOOFER

Suitable circuits are shown in Part 2 of my series on sub-woofers, in the March 1994 issue (Vol. 13 No. 75, XA75S). The crossover frequency should be no higher than 100Hz for best results (Figures 29a and 29b).

CROSSOVER AT 3·5kHz FOR FREQUENCY DEPENDENT MATRIX

The same circuits as for the sub-woofer can be used, but with appropriate changes to the component values (Figures 30a and 30b) of course! The simple version can use a 10k resistor, and a 4·7nF capacitor, while for the third-order version, the capacitor values in the low-pass filter should be divided by 17·5. In the high-pass filter, the capacitor values should be changed to 4·7nF and the resistor values divided by 1·75, which by chance gives answers close to preferred values.

DE-EMPHASIS TO MATCH THE ISO CINEMA SOUND CURVE

Here, a variable-slope filter (Figure 31) allows much experimentation. Only a shallow slope is required above 2kHz.

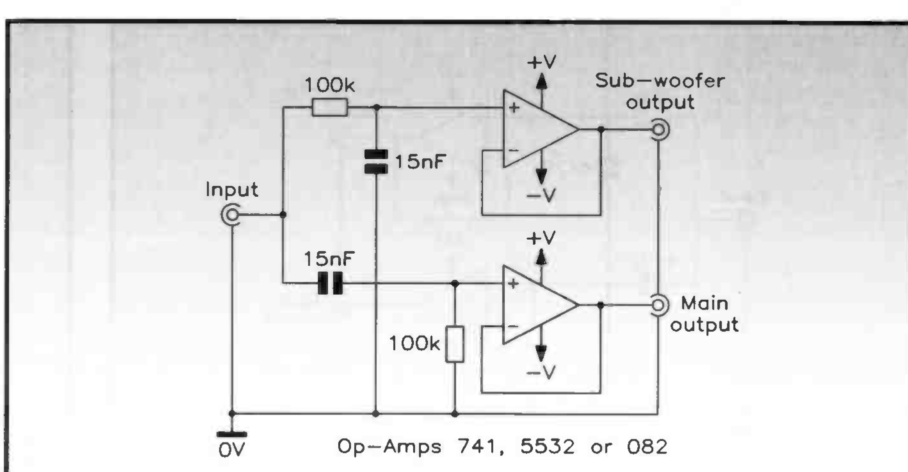


Figure 29a. Crossover for sub-woofer (100Hz).

TIMBRE-MATCHING FOR DIPOLE SURROUND LOUDSPEAKERS

This is a very subtle process (Figure 32), and the required response shape depends on which loudspeakers are used. The test is whether the sound quality changes disturbingly when panned from centre to surround. In order to check this, another module is necessary (Figure 33). This is also interesting to use with just two-channel stereo, since it allows panning two signals from mono, through two-channel stereo, to L-R in the left channel and R-L in the right channel which, therefore, requires opposite polarity connection of the two surround loudspeakers. This is because, for both Dolby Surround and THX, the overall polarities of the two surround channels must be the same. This module may also be used to investigate the effects of varying the direct-to-reverberant balance in two-channel reproduction.

The actual timbre-matching may require a variable-slope filter as for the ISO de-emphasis, but ideally a narrow-band graphic equaliser (with band-centre frequencies of 2, 2·5, 3·2, 4, 5 and 6kHz at least, but preferably more bands with closer spacing) should be used. When this has been set, its frequency response can be measured and a simpler, fixed equaliser designed to match.

POWER AMPLIFIERS

Recalling that up to six power am-plifiers are required, it is necessary to use low-cost (but not low-quality) options. The 15W power amplifier kit (LT23A) is a very good choice, offering low distortion and a wide frequency response. At least three power supply modules are required for six amplifiers. It could be convenient to make active loudspeakers, each being fed with both signal and DC power from the modular processor.

LOUDSPEAKERS

Again, because of the number required, an economical solution is necessary. The sub-woofer can be designed as described in the previous series. For the front channels, the lowest-cost solution of adequate quality is probably the 165mm low-cost loudspeaker GL13P. In fact, five identical units, with this driver mounted rather off-centre in a 600mm square baffle (or 1000mm × 400mm) will provide everything except the sub-woofer. The surround loudspeakers are arranged, for THX-type experiments, with the baffle edge-on to the listeners' ears, so that they are completely free to act as dipole radiators. The front loudspeakers of this type also act as

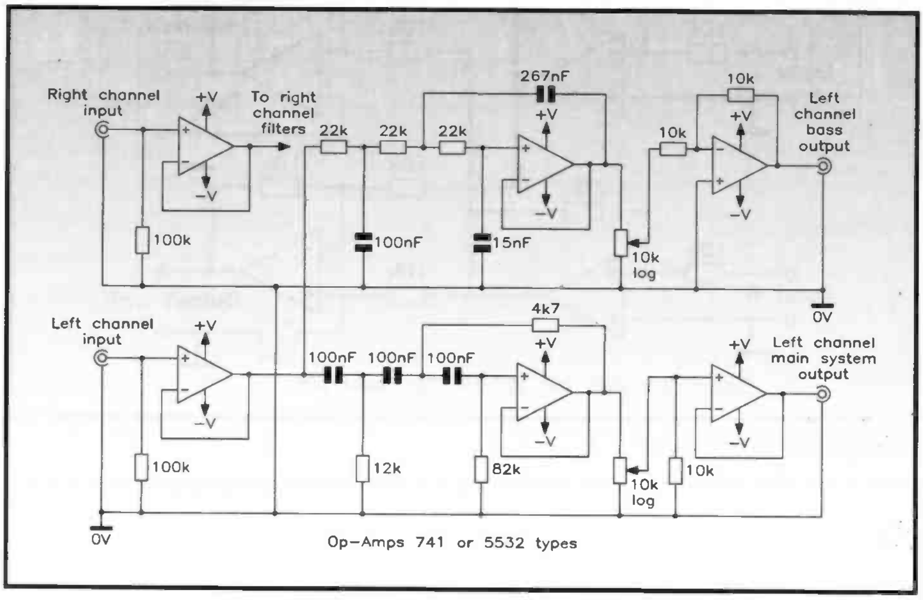


Figure 29b. Crossover for sub-woofer (100Hz)

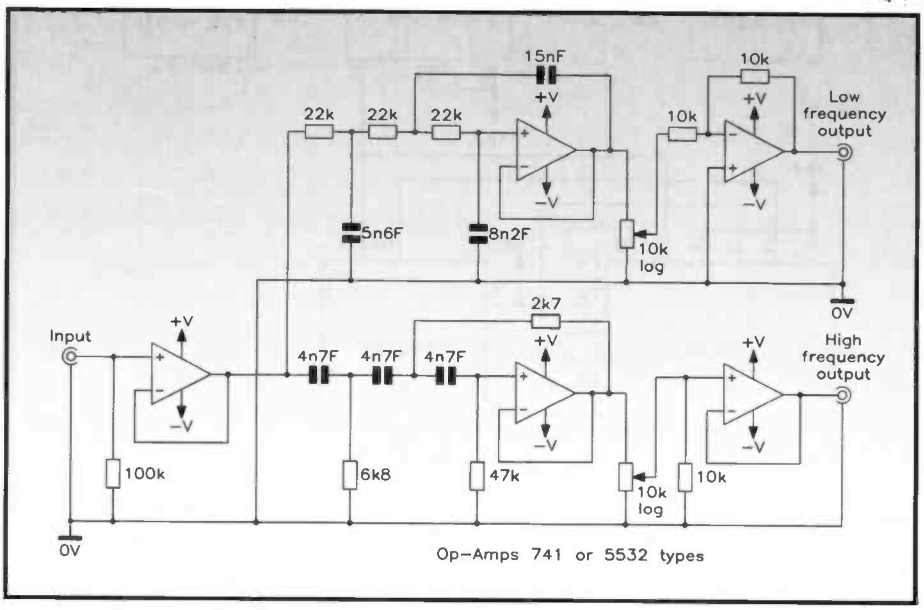


Figure 30b. Crossover for Gerzon-type matrix (3·5kHz).

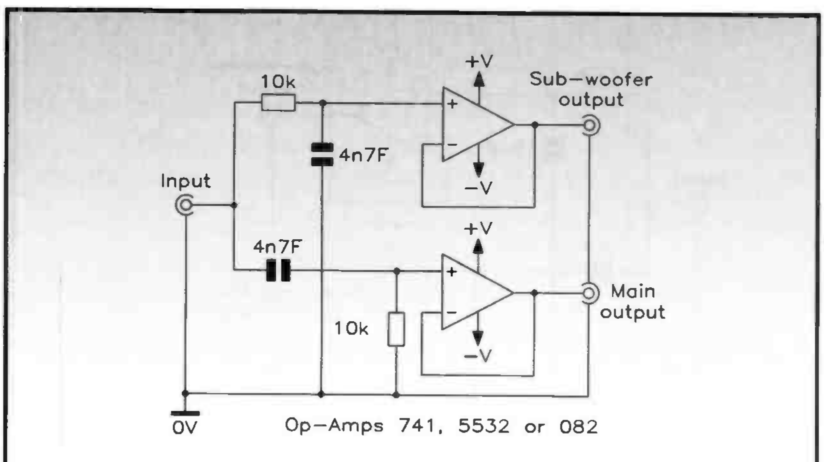


Figure 30a. Crossover for Gerzon-type matrix (3·5KHz).

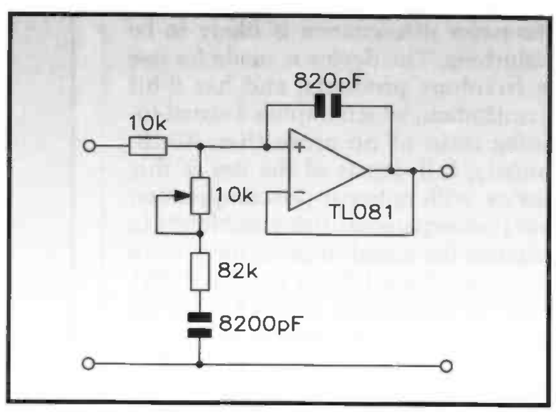
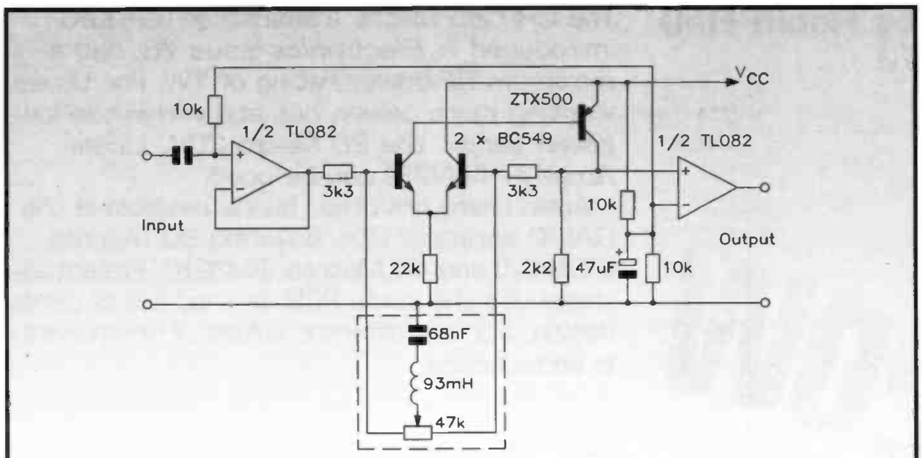
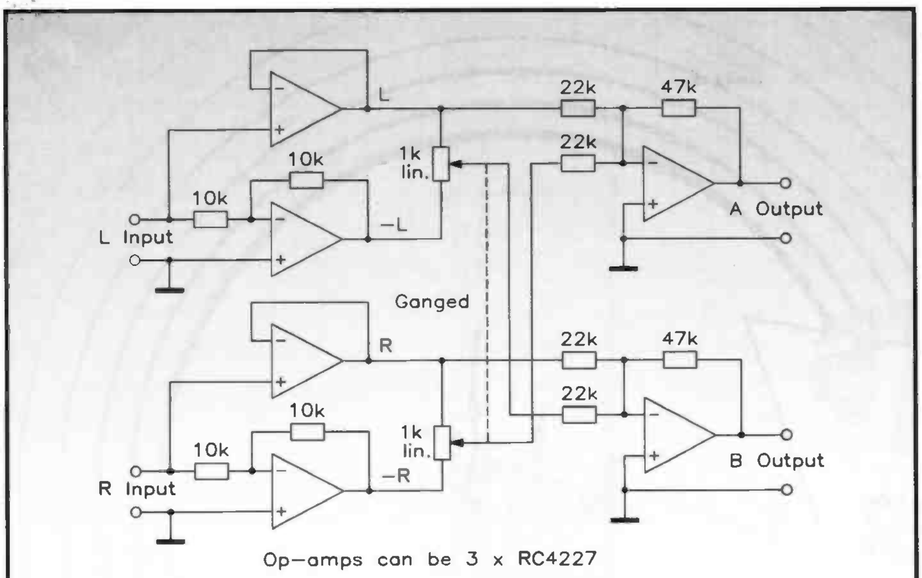


Figure 31. Variable-slope filter for approximating the ISO house-curve de-emphasis. Slope varies between nearly zero and –1dB/octave. For a greater range, reduce the 82k resistor *slightly*.



The closed feedback loop forces the BC549 base voltages to be equal and opposite. The LC circuit 'shorts' either the input signal, or the feedback: at the mid-position of the pot, the response is flat. The 'boxed' section is repeated for each band, scaling both L and C values by the frequency ratio. The values given are for 2kHz. Adjust the bandwidth for each band separately by including a resistor in series with the inductor. Note the method of biasing the transistor bases, and cancelling the offset at the output.

Figure 32. Principle of the graphic equaliser for timbre-matching.



As the pot slider moves down, the A output changes from L + R (mono), through L only, at the mid-position (separate channels), to L – R (difference) at the bottom. The B output, meanwhile, changes from L + R, through R only, to R – L, which is the difference-signal in reverse polarity.

Figure 33. Mono-stereo-surround pan module.

dipoles of course, but you listen to the front radiation. Improved results for the surround loudspeakers may be obtained with two drivers fixed to the 1000mm × 400mm baffle, facing in opposite directions.

The next step up in quality is the RC90X twin-cone 8in. (200mm) unit. It would be worthwhile using three of these for the front channels, but they are rather better than is probably justified for the surround channels. You could use either the GL13P or the 206mm GL14Q for the surround loudspeakers (the great difference between the high-frequency responses of these units mentioned in the Catalogue is technically correct, but the subjective effect is nowhere near so marked). The use of multi-driver systems (i.e. with tweeters and crossovers) represents not only a considerable cost increase, but also much complication in matching the timbre between front and surround.

FULL CIRCLE

This is the end of the present series, which I have found fascinating to research – not as far back as Blumlein and the Bell Laboratories work, but at least from the original 'Stereosonic' paper, through the following fifty years. Even without trying too hard, I have found more material than I could possibly use: in particular, it was impossible to treat the failed four-channel systems of the Seventies, and their defects, or the higher mathematical analyses of Michael Gerzon in any depth.

Thanks are due to Tom Holman of LucasFilm and Roger Furness of Minim Electronics for valuable information and discussions, but all errors are, of course, my responsibility.

MAPLIN'S TOP TWENTY KITS

POSITION	DESCRIPTION OF KIT	ORDER AS	PRICE	DETAILS IN		
1. (1) ◄►	TDA7052 1W Amplifier	LP16S	£4.95	Magazine	37	(XA37S)
2. (3) ▲	MOSFET Amplifier	LP56L	£20.95	Magazine	41	(XA41U)
3. (5) ▲	SL6270 AGC Mic Amplifier	LP98G	£8.75	Magazine	51	(XA51F)
4. (7) ▲	15W Amplifier	LT23A	£7.95	Magazine	64	(XA64U)
5. (4) ▼	Universal Mono Preamp	VE21X	£5.95	Catalogue	'94	(CA11M)
6. (2) ▼	LM386 Amplifier	LM76H	£4.60	Magazine	29	(XA29G)
7. (8) ▲	TDA2822 Stereo Power Amp	LP03D	£7.95	Magazine	34	(XA34M)
8. (6) ▼	8W Amplifier	LW36P	£7.95	Catalogue	'94	(CA11M)
9. (9) ◄►	Stereo Preamplifier	LM68Y	£4.95	Magazine	33	(XA33L)
10. (11) ▲	Flasher	LP96E	£2.95	Magazine	52	(XA52G)
11. (18) ▲	SSM2017 Microphone Preamp	LT31J	£12.95	Magazine	69	(XA69A)
12. (10) ▼	Music Maker	LT09K	£3.95	Magazine	57	(XA57M)
13. (15) ▲	50W Hi-Fi Power Amplifier	LW35Q	£19.95	Magazine	67	(XA67X)
14. (17) ▲	TDA1514 50W Power Amp	LP43W	£19.95	Magazine	40	(XA40T)
15. (12) ▼	Watt Watcher	LM57M	£5.75	Magazine	27	(XA27E)
16. (13) ▼	Video Preamplifier	LP60Q	£12.95	Magazine	44	(XA44X)
17. (14) ▼	I/R Remote Tester	LP53H	£7.95	Magazine	44	(XA44X)
18. (–) NEW ENTRY	SSM2015 Microphone Preamp	LP42V	£12.75	Magazine	39	(XA39N)
19. (–) NEW ENTRY	Water Level Indicator	LP90X	£2.95	Magazine	50	(XA50E)
20. (19) ▼	2.5W Audio Amplifier	VE12N	£8.95	Catalogue	'94	(CA11M)

Over 150 other kits also available. All Kits supplied with instructions. *The descriptions are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate project book, magazine or catalogue mentioned in the list above*

KIT AVAILABLE (RU32K)
PRICE £49.95

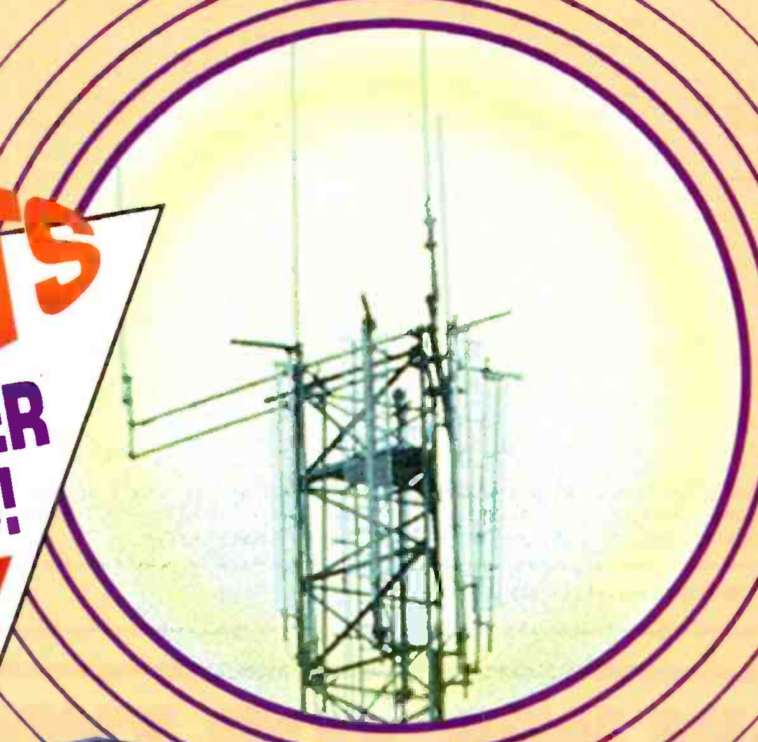
20 Metre 20W LINEAR AMPLIFIER

BOOSTS RF POWER RATING!

Text by Robin Hall G4DVJ

The QRP 20 Metre Transmitter (CP09K) introduced in *Electronics* Issue 76, had a maximum RF power rating of 1W. For those wanting more power, but still within the low power range, the 20 Metre 20W Linear Amplifier (QAMP) can be used.

Again there are other bands available in the QAMP series of kits, covering 80 Metres (RU34M) and 40 Metres (RU32K). Essentially these use the same PCB as they are of similar design, but use different values of components in some cases.

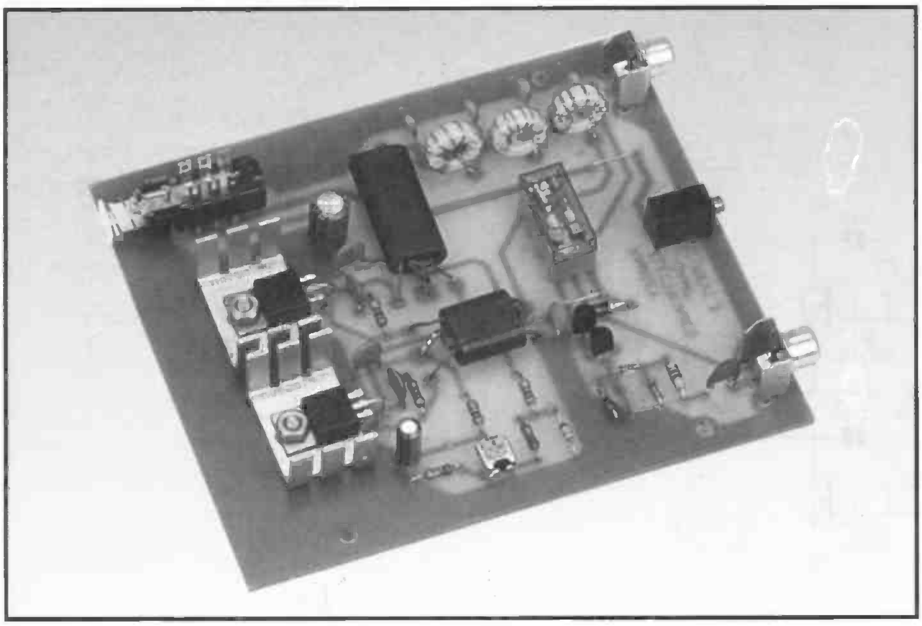


2 PROJECT RATING

Please note the case shown is not included in the kit and must be purchased separately.

Specification

DC power supply voltage:	+12 to +15V DC
Supply current:	3A maximum
RF output power:	20W maximum
Frequency range:	14 to 14·4MHz
Mode:	CW, SSB, AM
Rated antenna load impedance:	50Ω
PCB size:	120 × 102mm



The assembled 20 Metre 20W Linear Amplifier PCB.

THE QAMP range of power amplifiers are designed to be driven by transmitters with output powers of ½ to 2W, and this means that they can not only be used with the Ramsey range of QRP transmitters, but with other types of QRP transmitters as well. There is a built-in T-R (transmit/receive) relay which bypasses the amplifier and enables a receiver to be used.

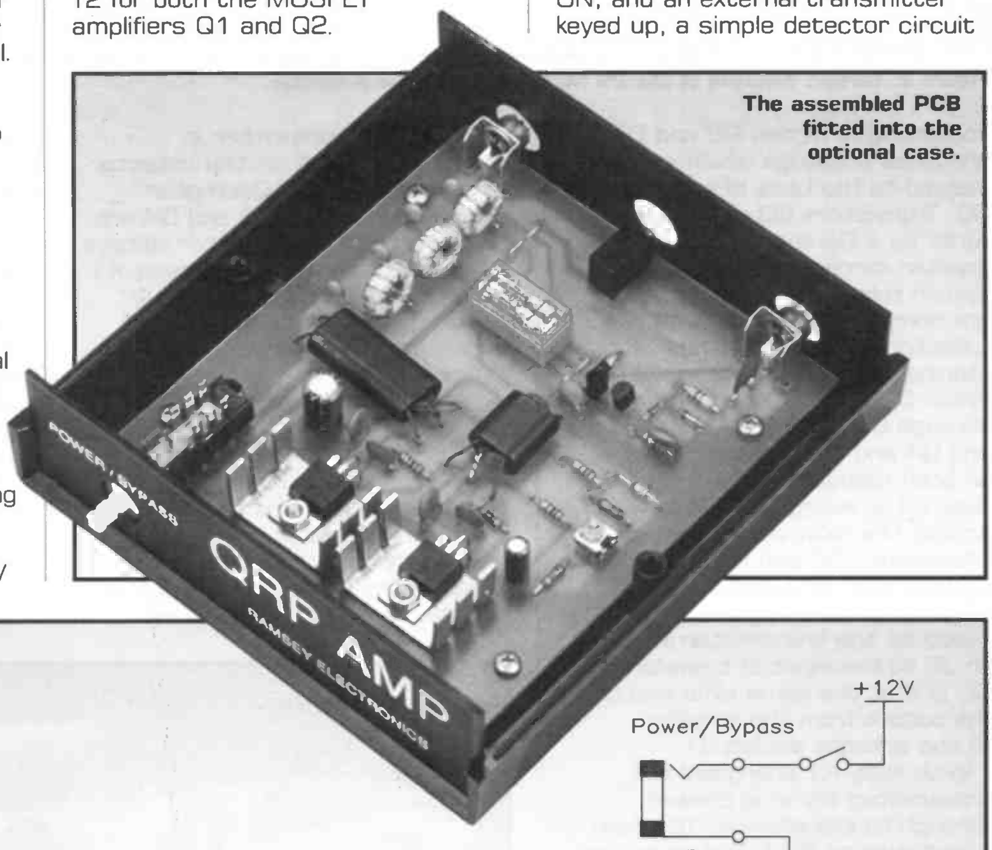
Circuit Description

For assistance in understanding the circuit the block diagram is given in Figure 1, and the circuit diagram in Figure 2. The QAMP obtains its power from an external regulated +12V DC supply, which is then fed via socket J3 and the Power/Bypass switch S1. The voltage is then fed directly to various parts of the circuit, including the centre tap of transformer T1 and the two MOSFET power transistors Q1 and Q2. The +12V DC supply is fed directly to the aerial switching relay, and to the 6·2V Zener diode D1, which supplies the bias supply through the centre tap of transformer T2 for both the MOSFET amplifiers Q1 and Q2.

The tuned antenna for the band is connected to the input socket J1, and the transmitter/receiver is connected to the output socket J2. Normal impedance matching of 50Ω applies to both. When the Power/Bypass switch S1 is in the OFF position or with no power to the QAMP, relay K1 is de-energised and there is a straight-through connection.

The MOSFET power transistors Q1 and Q2 form the main part of the amplification of the module and are biased in the 'slightly on' state to set the operating conditions for best gain and linearity. This is set by the bias network R2,3,4 and bias adjust potentiometer R4. The adjustment of the bias voltage sets the amount of current through the MOSFETs, and thus the gain (see the set-up instructions). The power obtained from the amplifier is directly dependent on the supply voltage (maximum +15V DC), the bias set-up and the input power (½ to 2W) from the source transmitter.

With the Power/Bypass switch ON, and an external transmitter keyed up, a simple detector circuit



The assembled PCB fitted into the optional case.

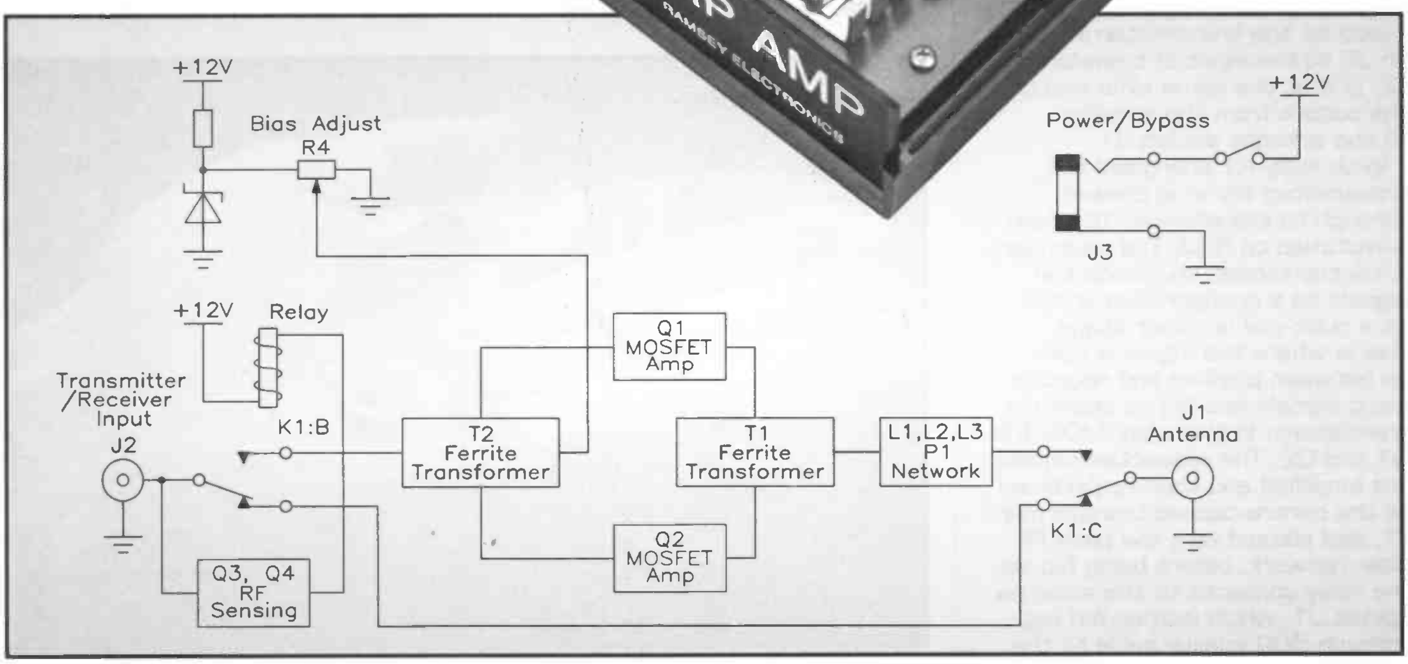


Figure 1. Block diagram of the 20 Metre 20W Linear Amplifier.

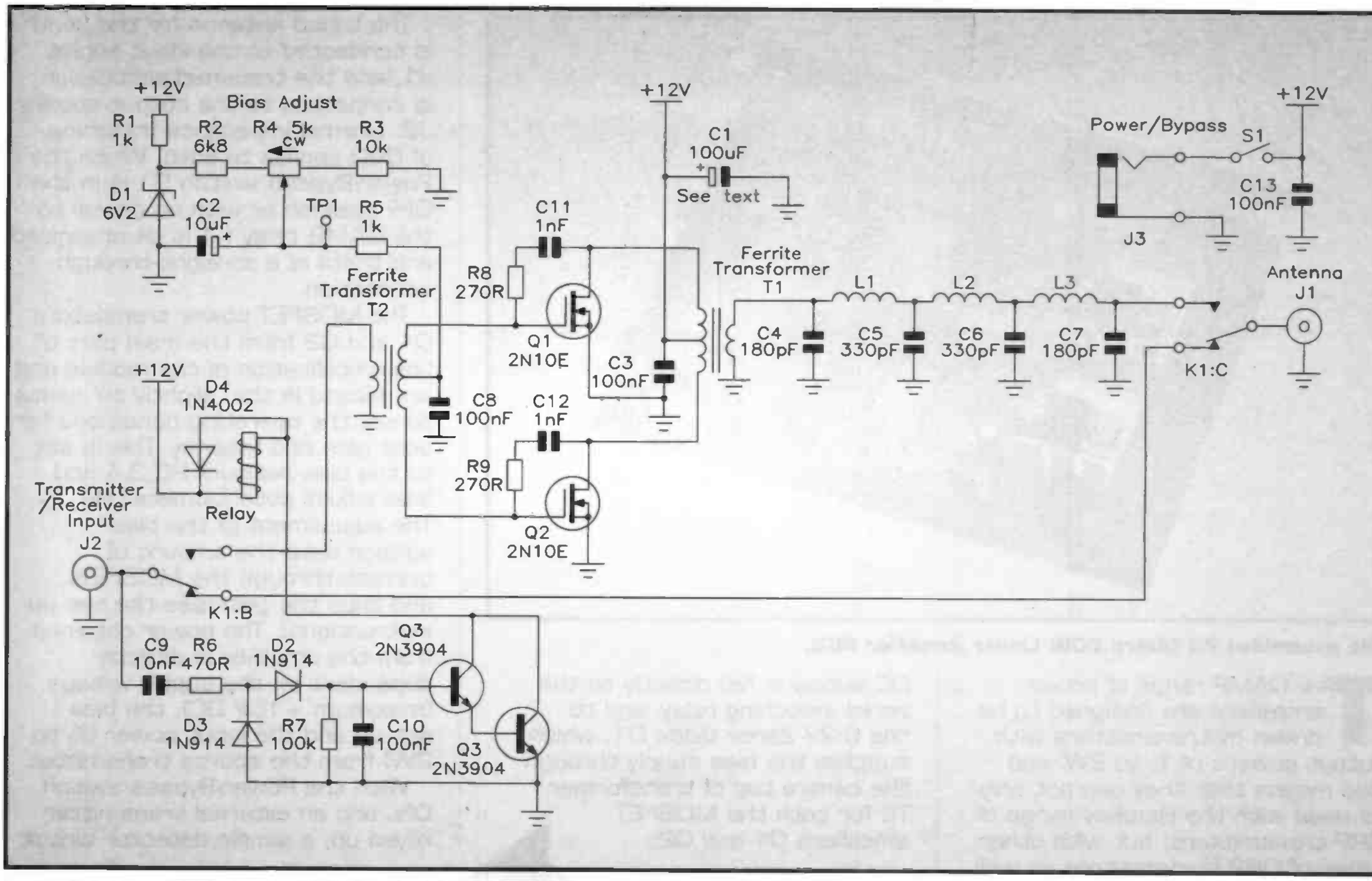


Figure 2. Circuit diagram of the 20 Metre 20W Linear Amplifier.

consisting of diodes D2 and D3 produces a voltage which is then passed to the base of transistor Q3. Transistors Q3 and Q4 are wired as a Darlington pair for greater current capability (to switch relay K1), and these are normally biased off, with the collector voltage of Q4 high, thus keeping relay K1 de-energised. When D2 detects the RF passing through C9 and R6 it biases on Q3 and Q4 and the collector voltage on both transistors falls, thus relay K1 is energised. D4 is wired across the relay coil to protect transistors Q3 and Q4 from the induced emf produced by relay K1 when it de-energises. This switches the transmitter input on J2 to the input of transformer T2, and at the same time switches the output from the amplifier to the antenna socket J1.

With relay K1 energised the transmitted signal is passed through to transformer T2 which is matched to 50Ω. The secondary is centre-tapped and feeds the signals to a configuration known as a push-pull amplifier stage. This is where the signal is split up between positive and negative going signals and fed to separate transistors, in this case MOSFETs Q1 and Q2. The respective signals are amplified and then recombined at the centre-tapped transformer T1, and passed to a low pass PI filter network, before being fed via the relay contacts to the antenna socket J1, which is then fed out through 50Ω coaxial cable to the antenna.

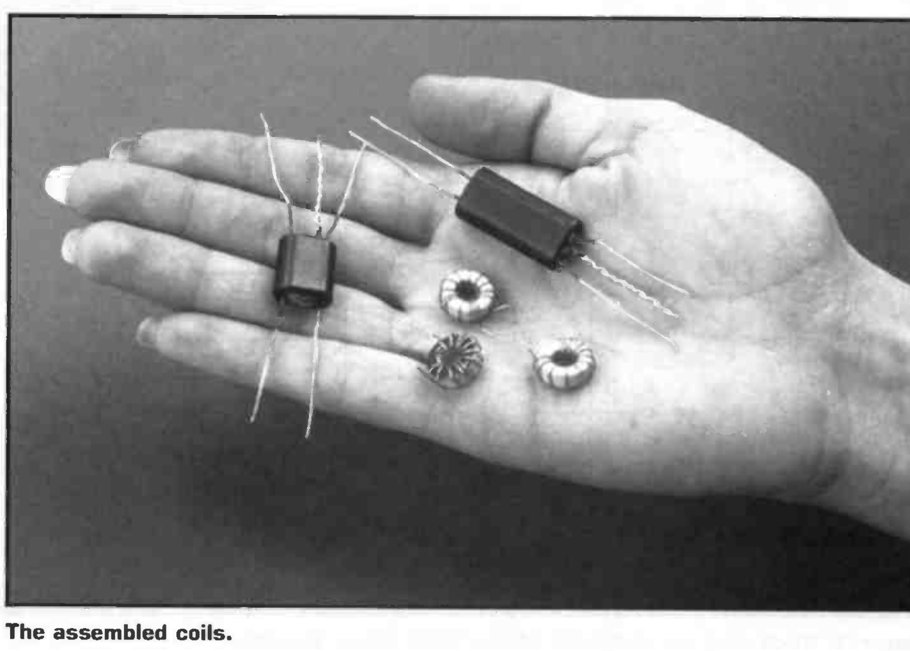
When the transmitter is dekeyed voltage from the detector circuit ceases, the Darlington pair of transistors Q3 and Q4 are biased off and the collector voltage rises again, de-energising relay K1 which then switches socket J2 direct through to J1 thus bypassing the linear amplifier stage.

Construction

The QAMP kit includes all the components required to build the power amplifier. It is a good idea to sort out and identify the components before soldering them in place. In this kit there are a number of coils and transformers to be assembled separately. Figure 3, which shows the PCB legend and track will assist PCB assembly.

There are very good instructions supplied with the kit and they show a logical path to follow. If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful practicable advice on how to solder, component identification and the like.

It is best to solder the larger components first, such as the switch, jack sockets, power socket, potentiometer and relay. Note that this is contrary to our normal recommendation and is



The assembled coils.

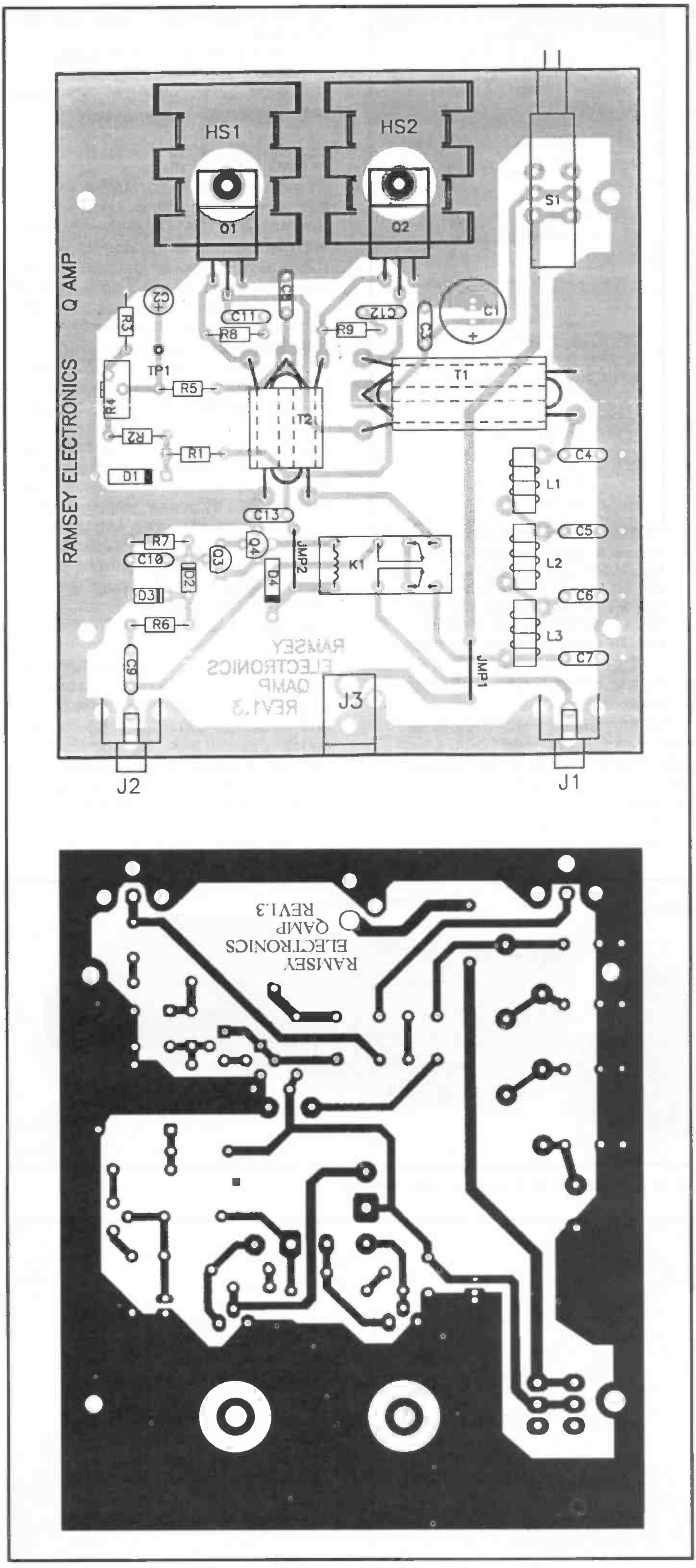


Figure 3. Legend and track of the 20 Metre 20W Linear Amplifier.

based on Ramsey's recommended assembly sequence and check list.

It is important to orientate the semiconductors correctly on the PCB. Next fit the resistors, shaping the wire leads to suit the holes in the PCB. When fitting the electrolytic capacitors onto the PCB, make sure that the correct polarity is observed.

There are two MOSFET power transistors that require their leads to be prepared before mounting and soldering to the board (see Figure 4). Both of these MOSFETs have heatsinks which are held in position by a nut and bolt.

There are three toroid RF coils to be wound. The toroid formers are identical and have been painted with yellow paint on one side for identification.

Cut two 8in. lengths of the smaller sized enamelled wire and following the drawing in Figure 5a thread the wire gently through one of the toroid cores; this becomes L1. When the wire has been positioned correctly (this might take a couple of attempts), tin the wire that has been left free. Modern enamelled wire does not require to be scraped clean first as the heat of the solder melts the enamel, although surplus burnt enamel may have to be cleaned off after tinning. Repeat the procedure for L3. Avoid breathing the vapour given off as it is poisonous!

Next cut a 9½ in. length of the smaller sized enamelled wire and wind 14 turns through the core for L2, see Figure 5b, and solder as before. It is advisable to mark this toroid so as not to confuse it with the other two.

There are two ferrite cores T1 (large) and T2 (small) that also require to be wound with enamelled wire. Note that the following details are different in the 40m and 80m versions.

T1 is the larger of the two ferrite cores. Cut 10in. off the thick enamelled wire and thread gently three times through the core (see Figure 6a). Pull each turn tight, but make sure that the enamel is not scraped off the wire. If there is too little or too much wire left then it has not been wound correctly, and will have to be rewound. Next cut another 9½ in. length of the thick enamelled wire; wind one turn through the core and loop out by 1in.; then twist the loop together tightly, see Figure 6b. Run one more turn through the core in the same direction. Tin each of the ends of the wires with solder, up to the ferrite core.

T2 is the smaller of the two ferrite cores. Cut off 11in. of the thick enamelled wire and gently thread the wire through the core (see Figure 7a). Again pull each wire tight, making sure that the

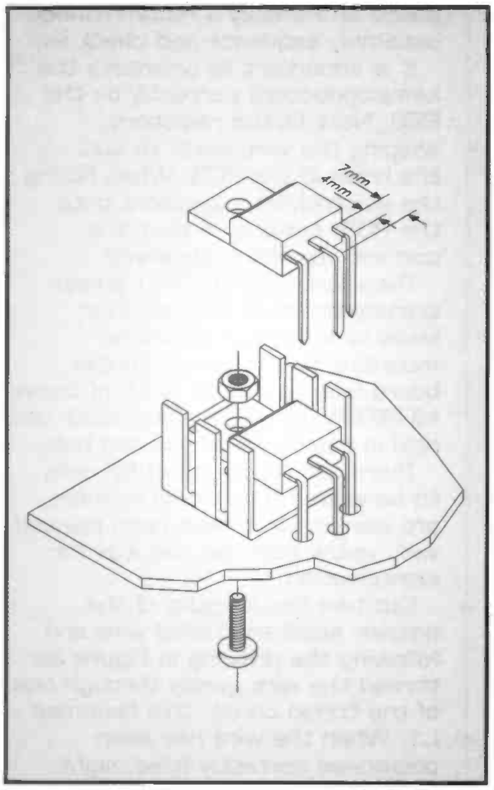


Figure 4. Preforming the legs of the 2N10E power MOSFET and mounting to heatsink.

enamel is not scraped off the wire. Note that there should be six turns through the core.

Next cut 8in. off the thick enamelled wire, wind one turn through the core and loop out by 1in.; then twist the loop together tightly, see Figure 7b. Tin each of the ends of the wires with solder

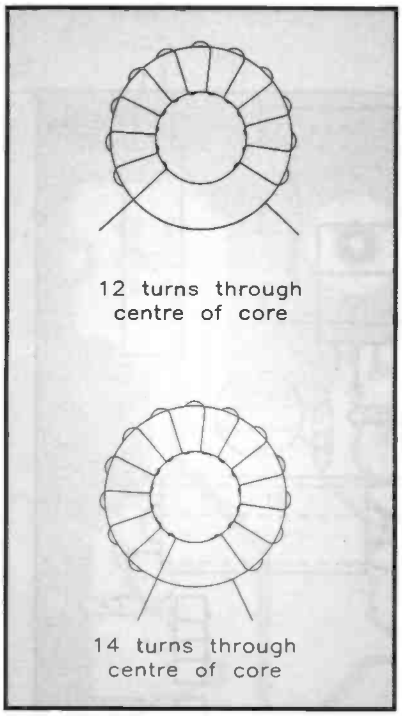


Figure 5. Construction of the toroid RF coils L1 and L2.
(a). L1 toroid RF coil showing the 12 turns through the core.
(b). L2 toroid RF coil showing the 14 turns through the core.

up to the ferrite core, including the twisted loop.

The transformers having now been wound, proceed to fit them onto the board into their locations. The toroid types are fitted vertically – make sure that L2 is in the centre. The ferrite cores are fitted as per the legend in Figure

3. All excess wires should now be trimmed.

Optional extras, not included in the kit, are a pre-drilled case (RU35Q), interconnecting RF leads, and a suitable power supply.

Setting Up

To set up the QRP amplifier the following equipment is required, such as a +12V DC power supply with at least a 3A capacity. For maximum RF power output use a supply capable of +13 to +14V DC – most amateur radio supplies are within this range. A suitable dummy load (or aerial), a QRP transmitter such as the 20 Metre Transmitter, and coaxial leads for interfacing between units, are also required.

Connect the transmitter (do not switch the transmitter on at this point) onto the power amplifier and the +12V DC power supply and connect a multimeter set up to read current in series with the amplifier. Preferably connect a dummy load, or failing that an aerial, to the amplifier. Rotate the bias potentiometer R4 fully counter-clockwise.

Apply power to the amplifier but do not turn on the transmitter. Measure the current drawn by the amplifier and adjust R4 for a reading of 250mA. Do not let the current exceed 500mA, if the current drawn is excessive switch off immediately and check the board and connections. The current being correct, check

The 20 Metre 20W Linear Amplifier wired up to an external transmitter and receiver.

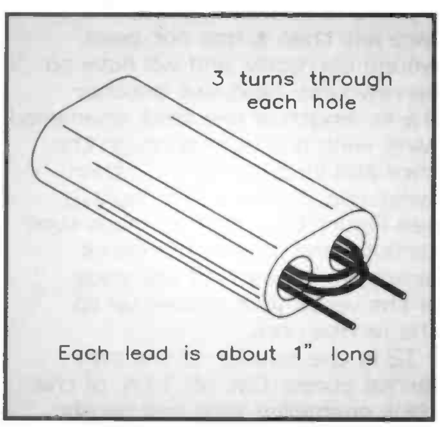
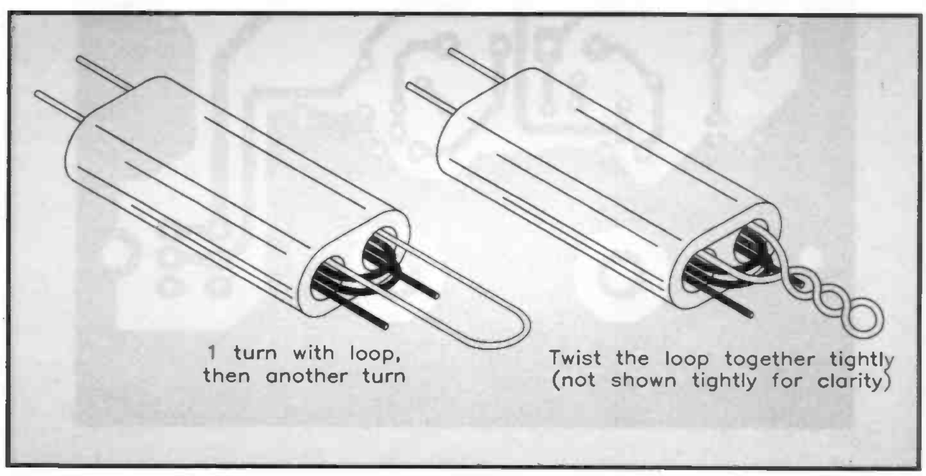


Figure 6a. Construction of the RF T1 transformer showing secondary windings.



6b. Construction of the T1 RF transformer showing 2-turn centre-tapped primary.

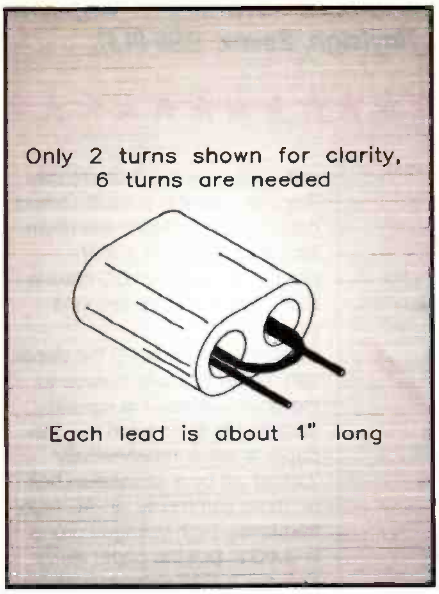


Figure 7a. Construction of the RF transformer T2 showing primary windings.

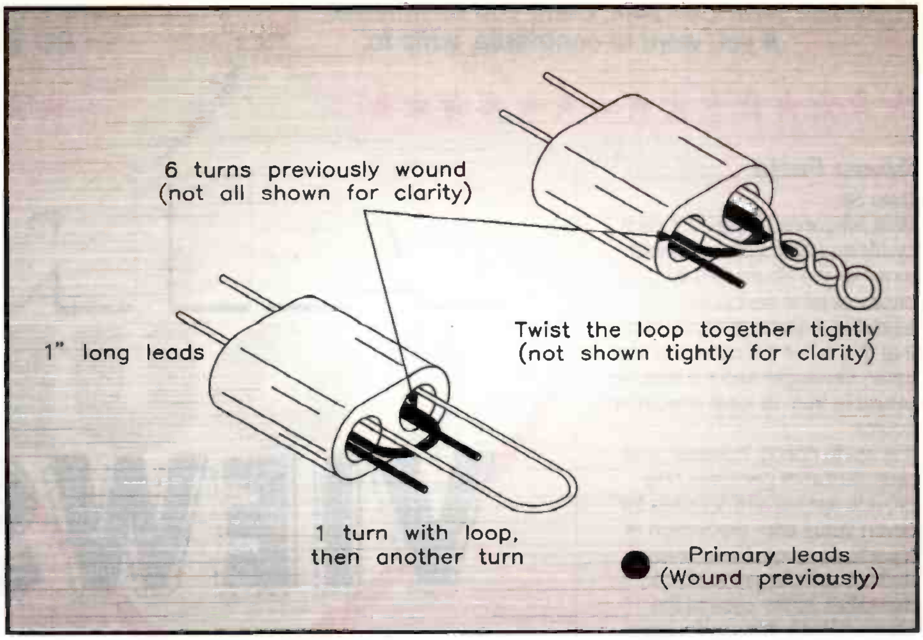


Figure 7b. Construction of the RF transformer T2 showing secondary windings.

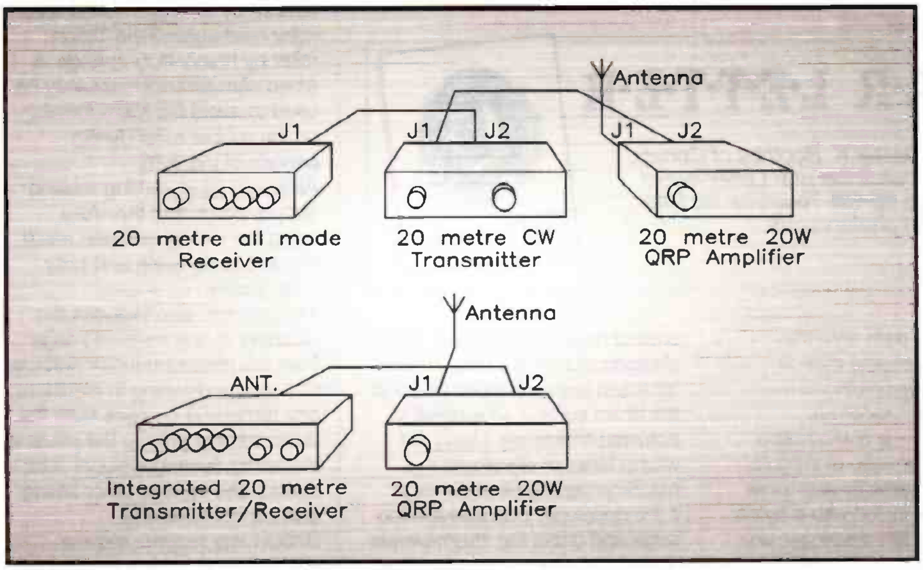


Figure 8. Wiring of the linear power amplifier with external transmitters/receivers.

the voltage on TP1 is within the range of +3·2 to +3·5V DC.

When the conditions have been met and are correct, switch on the transmitter and key it up. The meter set to current should read 1 to 3A on transmit and 250mA on standby. The changeover relay will be heard to operate as well. An RF power meter in series with the dummy load or aerial will indicate the output power of the amplifier.

Additional Information

QRP operation is a complete hobby in itself and there are clubs for the enthusiast such as the G-QRP Club which produces a monthly magazine *Sprats*. For the general radio amateur or shortwave listener, there is the Radio Society of Great Britain (RSGB), which publishes *RadCom*.

An article on The Amateur Radio Novice Licence by Ian Poole appeared in *Electronics* June 1993 Issue 66, and Amateur Radio on the HF bands by Ian Poole in *Electronics* March 1994 Issue 75. The article on the 20 Metre CW Transmitter and All Mode Receiver appeared in *Electronics* April 1994 Issue 76.

Acknowledgment

Thanks to Waters and Stanton Electronics of Hockley for supplying the initial kit and case, and for the use of facilities at their 'on site' demonstration radio station.

Continued on page 69.

NEXT issue

There are more terrific projects and features heading your way in next month's super issue of *Electronics – The Maplin Magazine*, including:

PROJECTS
CAR INTERIOR LIGHT CONTROLLER

A very useful addition to many older, and base model cars, most of which do not have the sophisticated courtesy light feature of higher models. Fitting this project to your car will allow the courtesy light to remain illuminated for approximately 30 seconds after the vehicle's doors have been closed. It also adds an extra feature which many top models do not have – in the event of a door being inadvertently left open, the courtesy light will automatically turn off after approximately 10 minutes, thus avoiding a flat battery.

LC METER ADAPTOR

How often have you thought, that you would like to check those spare un-marked capacitors and inductors lying about in the bits box? This project will enable the hobbyist to measure those unmarked capacitors and inductors, and find out if they are in satisfactory working order, or finally retire them to the rubbish bin. It will also be useful when having to make up precise inductor values for projects, especially if they are not readily available as off the shelf values.

LOUDSPEAKER PROTECTOR

This project has been designed to protect Hi-Fi loudspeakers from damage due to faults occurring within the output stage of a power amplifier. A fault of this nature nearly always causes a large DC current to flow, and it is *this* current which 'burns out' the loudspeaker. This module will 'disconnect' the speakers as soon as a DC voltage is detected. The module can be mounted in the loudspeaker cabinet, and is also suitable for protecting car stereo systems.

WAH WAH PEDAL

Unlike other designs, this Wah Wah has a number of extra features, including adjustable resonance, which determines the subtlety of the effect, and adjustable range, used for both guitar and bass guitar (in fact, on any electric musical instrument such as keyboards and electric violins). The circuit also features a compander that reduces noise in the circuit and improves the harmonic content of the output, making a very warm, rich sound.

FEATURES

Special features include a fascinating look at the 'Hubble Telescope'; 'Mains Safety' covers all aspects of electrical saftey; 'Very Small Aperture Terminals' examines satellite-based networking; 'Designing Transistor Stages' explains basic transistor biasing and usage. A new series, 'Filters', also begins next month, covering all aspects of filtering. Other features continue with the third instalment of 'Test Equipment', plus the concluding part of 'Audio Power Amp ICs'. All this, plus all your favourite regulars as well!

ELECTRONICS – THE MAPLIN MAGAZINE

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE

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P.O. Box 3, Rayleigh, Essex, SS6 8LR.

AIR YOUR VIEWS

Dear Editor

S·T·A·R L·E·T·T·E·R

In this issue, Mr K. Boothby of Conwy, Gwynedd, wins the Star Letter award of a Maplin £5 Gift Token for his letter concerning photocopiers.

Spare Parts

Dear Sir,
With reference to the complaint by Mr de Rivaz (Issue 80) that toner for the Sharp SF740 photocopier is no longer available, I can confidently state that this is not the case and that toner, developer and masters are available from at least one known source.
It is worth noting, however, that manufacturers generally only provide spares and supplies for seven years after production of a particular model has ceased, and are not obliged to do so thereafter. In the case of the Sharp SF740, this model does not appear to have been on sale in the UK in 1987 and therefore fits in with the above criteria.
Another point to consider is the economics of providing support for a very small user group at affordable prices. The office equipment sector is a far more competitive market than most others, with a large body of makers marketing a mainly incompatible range of machines.
On the subject of modifying different machines to accept various toners, the reply given was the right one. Whilst Mr de Rivaz was correct in stating that most photocopiers use electrostatic principles, he is oversimplifying the process to a great degree.
The general process in most photocopiers is as follows:
Charge – the photoconductive drum or belt is evenly charged with a high (5kV+) positive or negative potential (according to type).
Exposure – a reflection of the illuminated image is transmitted via the optics path onto the photoconductor and charge is dissipated according to the amount of light received.
Development – a combination of the optimum ratio of irregular-shaped iron particles and toner 'spheres' are mixed with a nylon paddle within the developer unit. The mix carries an electrostatic charge as a result of the agitation and is controlled by a bias voltage applied to the insulated unit. The developer unit has a magnetic roller positioned at the correct distance and angle to the photoconductor surface. Toner is attracted to the charged areas of the drum surface as a result of potential difference. Using the wrong toner or developer in a machine can result in damage if the developer particles are too large and cross the 'drum-sleeve distance' thereby scratching the photoconductor surface.
Pre-transfer – a fluorescent lamp is shone at the drum surface to weaken the holding charge enabling the toner to be removed from the drum readily.
Transfer – as the correctly timed paper is presented to the drum face it passes over a 5kV+ positive or negative DC corona that 'pulls' the toner onto the paper.
Separation – because the paper carries the opposite charge to the drum surface it is naturally attracted to it. To avoid this the paper is either mechanically 'picked' off by a separation belt or, more commonly, an AC high-frequency, high-voltage corona is used to pull the paper away.
Fixing – a 1kW (approximately) halogen lamp situated within a rotating Teflon coated roller is used to fuse the polymer toner onto the paper. Pressure is also applied by having a silicon rubber roller held against the Teflon roller by heavy-duty springs. A timed cam arrangement may be used to avoid flat spots forming on the rubber roller during periods of inactivity.
All toners have varying melting temperatures and therefore using the wrong type can result in inadequate fixing and poor copy quality.
The process also includes the cleaning of any residual image from the photoconductor surface, pre-charge cleaning to eliminate any remaining charges from the drum surface prior to the process restarting, toner/developer ratio control and various other timing and control functions.
Should any readers require assistance or advice in obtaining parts, supplies or information for their photocopiers I am more than happy to oblige. I can be contacted on 0492 572637 or 0374 814267 (mobile).

How Much?

Dear Editor,
May I, through your letter column, add further to the letter by Mr John de Rivaz about photocopiers. Perhaps someone in the photocopying business would like to comment about my points as well as those raised by Mr de Rivaz.
My 'gripe' about photocopiers is the astronomical cost of various parts for these instruments. I own a Minolta which is a few years old now but still works well enough for my requirements – I only run about two to three hundred copies of anything in an average year so it is not exactly hammered into the ground.
However, I recently had to replace the rubber roller which runs very hot, and also the gear wheel at the end of the roller. The gear wheel – which is just a small plastic cog, probably costing about 50p to make, was quoted at a little over £24, and the rubber roller was £64. I have also just purchased a bottle of toner and a bottle of fuser oil. These two items with VAT and postage and packing came to just over £40.
Another sore point about these machines is the dreaded 'call out' charge if one has to call in the engineers for any reason. In my area, it is currently about £40, which includes the first half-hour. Any subsequent time is charged at about £15 per hour, or part thereof. Quite a lot of the TV repair people round here have no call out charge, unless they actually do a repair but, of course, there are lots of these people about and the market is very much more competitive. Try finding a small businessman who repairs photocopiers from home!
I know that these machines are a bit of a mystery to the average man in the street and, therefore, you are at the mercy of the engineers who repair them. There is also a sort of 'closed shop' attitude, I think, within the trade to keep the charges artificially high.
I am sure any comment from within the trade would be most welcome.

R. J. Abraham, Winchester.

We have received a number of letters on the subject of photocopiers this month, and it appears that the gauntlet is well and truly down. Let's see if someone in the industry will accept the challenge!

From Small Acorns . . .

Dear Editor,
Keith Brindley's article, 'The Quiet Revolution', in the July 94 edition of the Maplin Magazine made very interesting reading, especially where it was dealing with current developments in the use of RISC processors.
It was disappointing however, that in this context he failed to give credit to the Acorn range of RISC computers. His short mention of Acorn left the impression that their contribution began and ended with the BBC range, and gives no credit at all for the faith that Acorn have demonstrated in RISC.
How about the excellent Archimedes range, and its successors (still called 'Archimedes' by many Acorn enthusiasts)? Here is a (largely)

British manufacturer, with a high-class product equal, in many respects, of the Macintosh and IBM PCs, with a superior operating system, which deserves to find some support in the British technical press, don't you think? I wonder if the reason it fails to impress is due to some sort of computer 'snobbishness', or is it simply a question of commercial exclusiveness?
It may be true that the software so far available for the Acorn range is not so voluminous or incredibly complicated as that for the more business-orientated dominant types, but there is much excellent stuff around, and usually it is a good deal more reasonably priced than that for the IBM and Mac PCs. Also, thanks to RISC, Acorn software does not gobble up memory and disc space at the incredible rate of that for the 'giants'.
I would like to suggest that Keith Brindley has a look at the current Acorn range, and has a try of the latest 'Acorn PC' (yes, they are using the term PC now, and why not if that is what is needed to sell their goods? It just stands for personal computer, after all!). Many schools still put money in the Acorn coffers, and schools do not have any to waste!

D. Bambury, Basingstoke.

Several readers have commented on this subject, and your views have been noted. It is true that Acorn are definitely worthy of a mention, but as far as worldwide sales are concerned, Acorn's success is limited, in the main, to the U.K. educational market. The article dealt with the next generation of 'super PCs', which would, presumably, be aimed at business users and academic researchers. Schools do not necessarily need and, may not be able to afford machines with this magnitude of power. You may, however, be interested to note that there will be an article on the Acorn range of RISC computers in the near future. Keep watching this space.

Generator Safety

Dear Sir,
Point Contact's reference to a small 1kW generator caught my eye, and reminded me that I have been using something similar for twenty years now. It started during the spate of electricity strikes in 1974. Generating my own electricity was awesome for me, and so I asked the local electricity Customer Services Department how to go about it. They were cooperation itself because they do get some nasty experiences mending cables that they have isolated, but which local householders had made live because they had not turned off their mains supply before starting their generators!
They recommended the installation of a changeover switch which automatically separates the house circuit from the mains supply and, at the same time, switches in the generator. They also included the fitting of an earth leakage circuit breaker, which automatically cuts off the generator output in the event of any stray live current. This system, though a little expensive, is very safe both for the user, and for the poor jointers mending the mains. It also removes Point Contact's lethal three-pin plug hazard, which I suggest he does something about before it does for him!
Love your Magazine – I've had them all, but yours is so very far out in front on almost every subject – well done!

G. Churcher, Staffordshire.

I hope that any readers who own generators have taken similar precautions.

20 METER 20W LINEAR AMPLIFIER – *continued from page 67.*

20 METRE 20W LINEAR AMPLIFIER PARTS LIST

RESISTORS (All ¼W 5%)		
R8,9	270Ω	2
R6	470Ω	1
R1,5	1k	2
R2	6k8	1
R3	10k	1
R7	100k	1
R4	5k	1
CAPACITORS		
C1	100µF	1*
C2	10µF	1
C3,8,10,13	100nF	3
C4,7	180pF	2
C5,6	330pF	2
C11,12	1nF	2
C9	10nF	1
SEMICONDUCTORS		
D1	6V2 1·3W Zener	1
D2,3	1N4148	2
D4	1N4002	1
Q1,2	2N10E	2
Q3,4	2N3904	2
MISCELLANEOUS		
K1	Relay DPDT 12V	1
S1	PCB DPST Switch	1
J1,2	PCB Phono Sockets	2
J3	2·5mm DC Power Socket	1
HS1,2	TO220 Vaned Heatsink	2
L1-3	Toroid Coil Core Yellow	3
T1	Large Ferrite Transformer Core	1
T2	Small Ferrite Transformer Core	1
	0·642mm Enamelled Copper Wire	4Ft.
	0·510mm Enamelled Copper Wire	3Ft.
	M3 × 10mm Bolt	2
	M3 Nut	2
	PCB	1
	Leaflet	1
OPTIONAL (Not in Kit)		
CQRP	Plastic Case (Includes Knobs, Feet & Screws)	1 (RU35Q)

* This value may be changed, i.e. 100µF to 200µF with no effect on performance.

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available in kit form only.
Order As RU32K (20 Metre 20W Linear Amplifier) Price £49.95 D1
Order As RU35Q (QAMP Case) Price £14.95
Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

Stray Signals

by Point Contact

Recorded Pictures

Always somewhat behind the times, the PC household did not acquire TV until long after all the neighbours. Likewise, a video recorder did not appear on the scene until a few years ago. Now that we have one we find it very useful – in strictly limited circumstances! It gets used for just one or other of two purposes, trips down to the Video Hire shop not appearing on our agenda. We use it to 'move' a programme from when it is inconvenient or impossible to watch it 'live' – it's broadcast too late at night or we are out at the time – or to 'store' a programme for later consumption when it clashes with another programme which we don't want to miss. Thus the only recorded material we watch is stuff that has been broadcast previously.

Although at one time, PC used a cine camera for recording the highlights of holidays, nowadays we content ourselves with stills, usually 35mm colour negative film for prints. I suppose the long-unused cine cameras (one B & H with a three lens turret of Taylor Hobsons, and one Bolex with a couple of excellent Bolex lenses) could have been superseded by a camcorder, but at the time they were so huge and heavy (not to mention expensive) that it just didn't happen.

When you think about it, there is a fundamental difference between a camera (cine or still) and a camcorder. The former captures a scene directly and irreversibly by the action of the light upon a light-sensitive emulsion, although it is true that subsequent development is necessary. With a camcorder, the process is carried out in two completely separate stages: Firstly, the solid state camera 'tube' turns the light into an electrical signal, and secondly, the signal is recorded on magnetic tape. Indeed, the two stages were originally carried out in separate equipment, with the recorder part being carried dangling from a shoulder sling. Only later were the TV camera and the recorder combined into a single camcorder. If the picture was required for immediate rather than later use, e.g. broadcasting, it need never be recorded at all, and I wondered if there was a corresponding non-recording photographic technique. Perhaps the camera obscura (Latin for a blacked-out room) fits the description. Here, a long-focus lens set in the wall (or a rotating turret) projects a picture of the outside world, via a mirror at 45 degrees, down onto a white-topped table.

If you do want a permanent record, then a camera is the only choice, unless you happen to be an artist with time to spare. An 8mm cine camera was designed so that it could also take single shots. With a film lasting four minutes, at 16 frames a second, you could take around 3840 pictures on the one film – a lot more than the 36 exposures on a 35mm film. In principle, the camcorder could be used likewise, accommodating goodness knows how many shots on a single tape cartridge. Electronic stills cameras have in fact been developed, but have not as yet had any significant impact on conventional camera sales – I suppose it is only a matter of time.

Music, Chatter and Non-Music

PC was interested to read, in the letters column of one of the electronics magazines, a number of letters all bemoaning the same thing; namely, the deterioration of Radio 3, which – following its extension to all-day broadcasting, from being the evening only Third Programme – was billed as being a music programme. Now, it has become largely a chat programme, with presenters wittering on endlessly, interspersed with only brief periods of music. Worse still, the 'music' which they choose to broadcast is, as often as not, simply not worthy of the name.

Whilst passing discords have always formed an effective part of music (even long before the romantic era) – they were used to provide a piquant contrast to the prevailing mood of harmony and concord – many modern composers produce 'music' which consists monotonously of discords and not much else; lacking any recognisable melodic interest and, as often as not, any discernible rhythmic coherence. PC, having a very catholic taste, finds that even the most extreme modern music is acceptable provided one adjusts the volume level accordingly. One can categorise composers by the appropriate level relative to 'normal listening level', such as one would use for composers from before Josquin des Pres, to Mahler and after. Thus a 'parson's egg' composer such as Stravinsky or Bartok rates anywhere in the range 0 to −30dB depending upon the piece. Some other composers seem to be much more predictable with, for example, Edgar Varese rating a consistent −60dB on the PC preferred scale.

Those of us who would like to have some pleasant music to accompany our work (being it pounding a wordprocessor or whatever), are looking elsewhere for a suitable source. Initially, Classic FM looked as though it might provide an answer, but while the music is uniformly acceptable, there is as much idle chatter as on the Beeb. Worse still, much of it is of a degree of infantile inanity that has to be heard to be believed. So, in desperation, PC has unearthed an old reel-to-reel recorder and a pile of 7½in. reels of quarter inch tapes. The tapes covered an extremely diverse range of music of the highest quality (even if the recordings weren't!), all recorded off-air in the dim and distant past.

Tailpiece

Nonsense has abounded throughout the centuries, and one current outbreak is 'politically correct speech', meaning 'a mealy-mouthed reluctance to call a spade a spade'. Instead, it becomes a gardening implement or some other such nonsense. In conversation the other day, Mrs PC was astounded to hear that lecturers at the technical college in the county town some miles from here are now referred to as 'facilitators'. The students there are no longer students, but 'units of ......' (something or other) – in the face of such idiocy the memory just gives up! Can you cap this with an even more ridiculous example of politically correct speech? A prize of a year's free subscription to *Electronics – The Maplin Magazine* is offered for the most bizarre example received. Obviously its use must be documented in print, and the Editor's decision in the matter will be final.

Yours sincerely,

Point Contact

The opinions expressed by the author are not necessarily those of the publisher or the editor.

by J. K. Redpath

The circuits and information presented here must be considered as a basis for your own experimentation. No warranty is given for suitability in particular applications, reliability or circuit operation. Maplin cannot support, in any way, the information presented here. However, where possible, we will endeavour to check that information presented is correct, and that circuits will function as stated.

6 MINI CIRCUITS

1. CMOS 4001/4011 Chip Tester
2. CMOS 4017 Chip Tester
3. CMOS Heads or Tails Indicator
4. LM3909 Signal Injector
5. Soil Moisture Tester
6. Go/No Go Thyristor Tester

CMOS 4001/4011 Chip Tester

This circuit (Figure 1) was designed to enable a quick go/no go test to be done on CMOS 4001 (Quad 2 input NOR gate) and 4011 (Quad 2 input NAND gate) ICs. It will be found to be useful for checking 4001 & 4011 ICs, as found in 'bargain basement' packs, or on the 'surplus' circuit boards which can be purchased. Incidently, both types of IC have the same pin-out, which means that you can use the same test socket for both devices.

There are a number of ways in which these ICs can be tested, including: checking the truth table operation of NAND and NOR gates; checking the static characteristics of the gates; or even using one set of gates as a timer to control an astable, made from the other set of gates. However, it was felt that it would be easier to test these ICs by using both halves of the chip to construct two separate astables, the output of which are used to drive LEDs. This gives a reasonable idea of how well the chip will work, and it is a fairly quick test to make.

Circuit operation is very simple. To test a 4001 or 4011, insert the device into SK1, and then press switch S1. Power will then be supplied to the device under test. The circuit breaks down into two parts. Pins 1 to 6 are connected such that with R1 and C1, a standard astable multivibrator is formed. The square wave output from this astable is fed to LD1 via R2. The frequency of oscillation is about 2·5Hz. Pins 8 to 13 are connected such that with R3 and C2, a second astable is formed. Output from this astable is fed to LD2 through R4. Frequency of oscillation is again about 2·5Hz. A low frequency of operation was chosen so that the flashing of the LEDs could be clearly seen.

If the device under test is working properly, then both LEDs should flash on and off when S1 is pressed. If S1 is pressed, and either or both LEDs do not flash, then it is reasonable to assume that the IC is suspect. Finally, make sure that S1 is off when removing the device under test, or it could be damaged! Typical current consumption of the unit when S1 is pressed is 6mA. There are no special construction requirements. When testing, standard antistatic precautions should be taken when handling devices.

CMOS 4017 Chip Tester

This circuit (Figure 2) was designed to allow the quick testing of the popular CMOS 4017, which is often used for frequency divider circuits, sequencing circuits, etc. It will prove to be useful for testing 4017 devices, found in 'bargain basement' packs, or from old surplus circuit boards, etc. The 4017 is a 1-of-10 decoder, meaning that on receipt of input

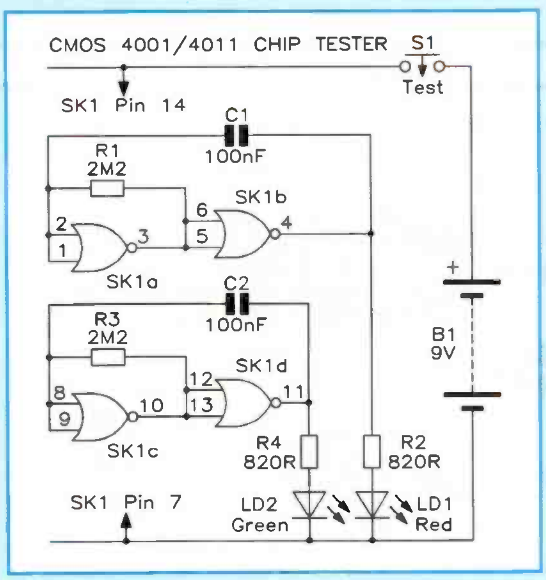
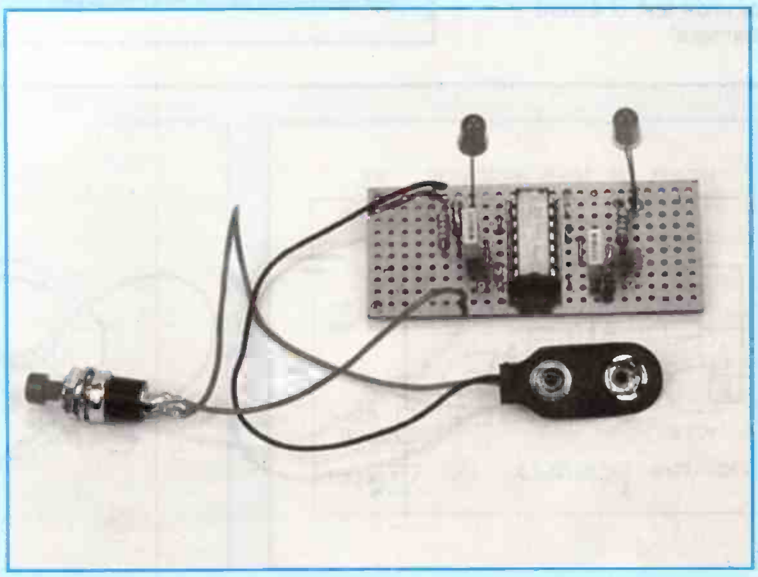


Figure 1. CMOS 4001/4011 chip tester.



The assembled CMOS 4001/4011 chip tester.

clock pulses, each of the 10 outputs will, in turn, be switched high and then low. There is also a carry output, as well as reset and clock-inhibit inputs.

Circuit operation is as follows: Insert the device under test into SK1, and then close S1. IC1a, IC1b, R1 and C1 form a standard astable multivibrator that feeds clock pulses of about 2·5Hz into the clock input of the device under test. With S2 and S3 left open, each output of the device under test should go high then low in sequence, turning on LD1 to LD11 in sequence through current limiting resistors R4 to R14. After LD10 has turned off, LD11 will turn on, LD11 indicates the state of the carry output. The carry output is often used to connect to the clock input of another 4017 when cascading devices to provide longer count sequences. After LD11 is turned on, it will stay on until LD6 goes high, and then turns on again after LD10 goes low. The cycle will then start over again.

The reset and clock-inhibit inputs to the device under test are 'active high', thus taking them to a high logic level will activate them. These lines are normally held low by R2 and R3. When S3 is closed, clock pulses into the device under test are inhibited, and the last output to go high will stay high. However, if LD11 is on at the same time as another LED, as explained above, then both LEDs will remain on. Opening S3 again will cause the LEDs to turn on and off again in sequence, as before. Closing S2 will reset the device, and regardless of which LED was on before, LD1 and LD11 will be turned on and LDs 2 to 10 will be turned off. Opening S2 will allow the LEDs to turn on and off in their normal sequence, as before. C2 provides supply decoupling. Current consumption will vary from about 6mA with one LED on, up to about 13mA with two LEDs on. Finally, make sure that S1 is turned off when removing the device under test, or it could get damaged!

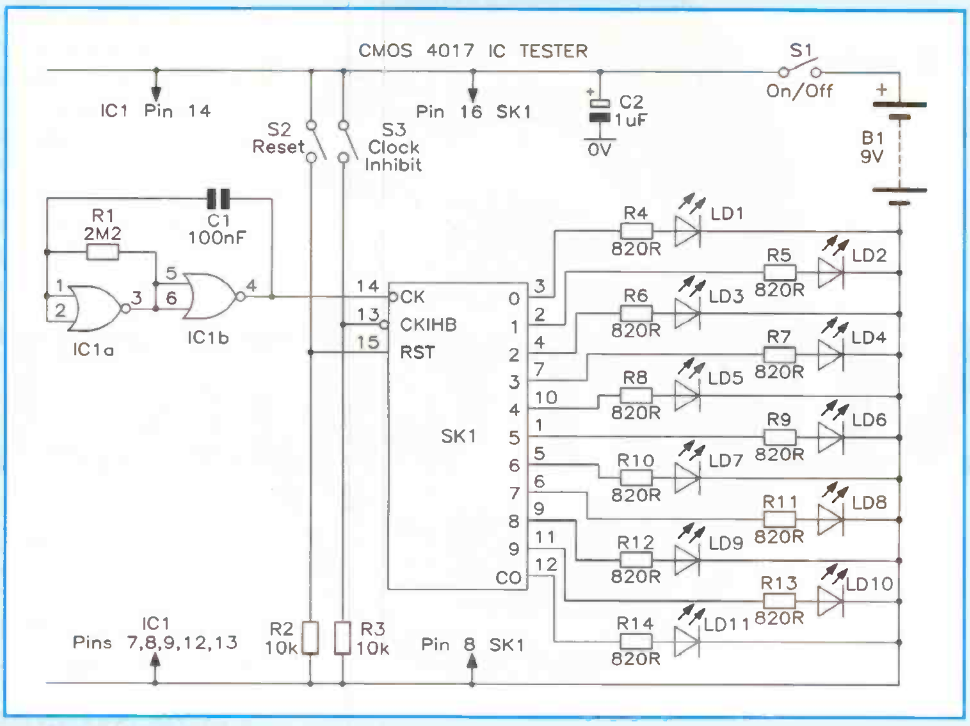
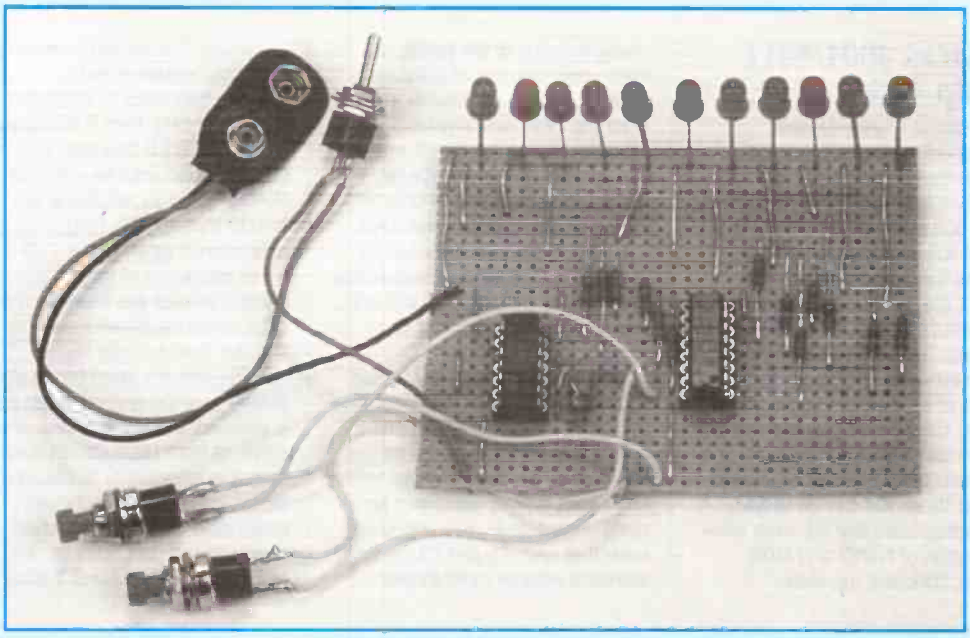


Figure 2. CMOS 4017 IC tester.



The assembled CMOS 4017 IC tester.

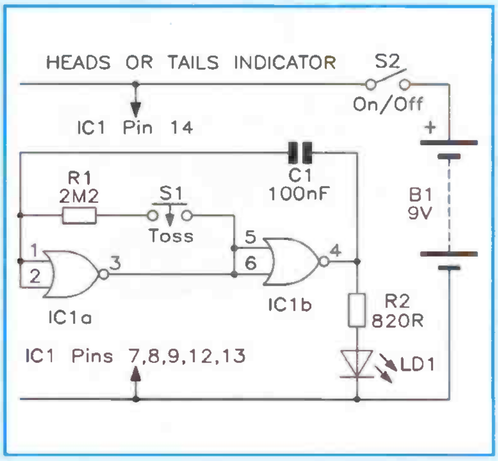
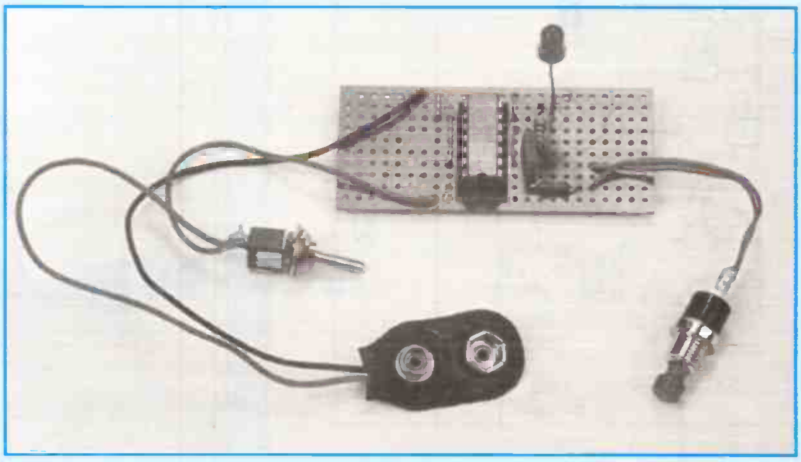


Figure 3. Heads or tails indicator.



The assembled heads or tails indicator.

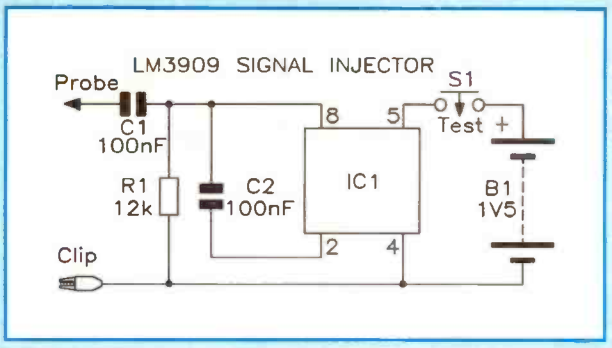
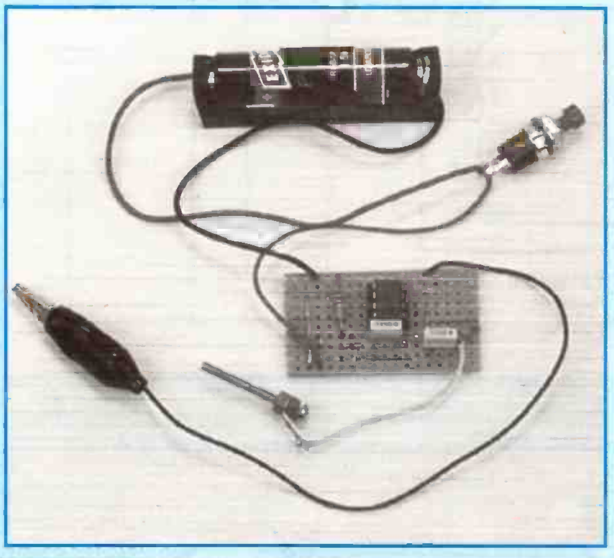


Figure 4. LM3909 signal injector.



The assembled LM3909 signal injector.

There are no special construction requirements for this circuit. When testing, standard antistatic precautions should be taken when handling devices.

CMOS Heads or Tails Indicator

The following is a simple circuit (Figure 3) that simulates the popular 'heads or tails' method of decision making. As such, it can prove very useful for games, or for simple demonstrations of probability theory. There are a number of ways in which heads or tails can be generated, such as using an astable multivibrator to drive a toggled flip-flop circuit, and then stopping the pulses from reaching the flip-flop. You then get your heads or tails indication from the flip-flop. You can also use a pseudo-random noise generator to drive a flip-flop, or just use an astable multivibrator, whose operation is interrupted. The latter method was used here, as it is quite simple and very inexpensive to implement.

Circuit operation is as follows: S2 is the on/off switch. IC1a, IC1b, R1 and C1 form a standard astable multivibrator. The operating frequency of this astable is about 2·5Hz. S1 is the toss switch; initially when S2 is closed, S1 will be open and LD1 will be either on or off due to the randomness of switching-on. When S1 is pressed, the astable will oscillate and produce a square wave signal to flash LD1 on and off. Releasing S1 will cause the astable to stop oscillating. C1 feeds the output level at IC1b back to the input of IC1a, and helps to keep the output of IC1b at the same voltage level as it was when S1 was opened. Therefore, the output of IC1b will retain its voltage level from the instant that S1 was opened. If LD1 is on, this can be 'heads' and LD1 off can be 'tails'. With the frequency of operation chosen, it's not that easy to predict what the outcome of opening S1 will be. A development of this circuit would be to make a duplicate of the astable, utilising the unused gates of IC1 and some additional components, so that you can simulate the tossing of two coins.

Current consumption is quite low, about 2·5mA when the circuit is oscillating; less than 1mA when LD1 is off and about 5mA when LD1 is on. There are no special construction requirements for this circuit.

LM3909 Signal Injector

The LM3909 is an IC that was developed specially for flashing LEDs. However, it is very versatile and can be used for a wide variety of applications, such as: low power warning indicators, toys and novelties, sound generators, etc. In this application it is being used as a very simple square wave signal generator, which can be used for the testing of amplifiers, radio circuitry, etc. The reason for choosing this particular device is that the typical current consumption is less than 1mA, leading to longer battery life. Also, the external component count is quite low, which means that the circuit can be made very small if desired. In addition, it was decided to use this device to show that signal injector circuits do not have to be based around 555, CMOS or op amp circuits, as they quite often are.

The following text shows how it can be used as a signal injector (Figure 4). C2 and R1 are the timing components, and C1 is an AC coupling capacitor, which is used to couple the output of the device to other circuits. The circuit works by charging and discharging C2 through R1 which is in parallel with the internal 'slow RC' resistor and other internal circuitry. The 'mark' time is determined roughly by C2 and R1 in parallel with the 'slow RC' resistor, and the 'space' time by C2 and a small internal transistor load resistor.

The output waveform is a pulse waveform with a large mark to space ratio, a frequency of about 1·5kHz, and an output voltage of about 2V Pk-to-Pk. When in use, you connect the clip to the ground of the circuit into which you wish to inject a signal. Then, connect the probe to the desired test point and press S1. There are no special constructional requirements for this circuit; the probe was made using a bolt, a solder tag and some nuts for fastening it to a case. The current consumption of the circuit is about 0·4mA.

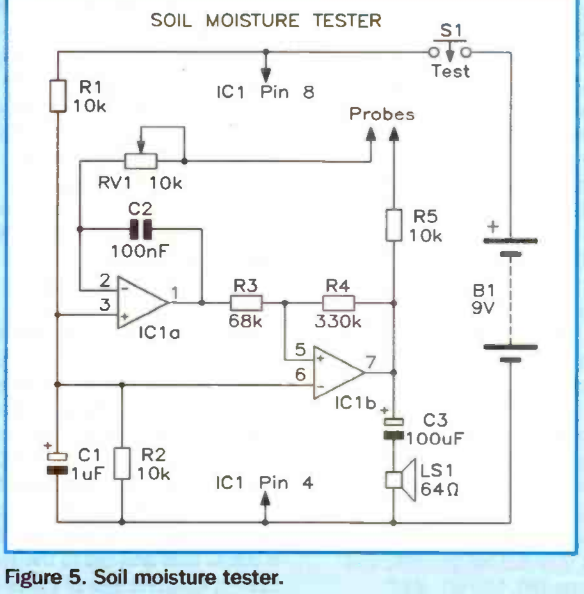
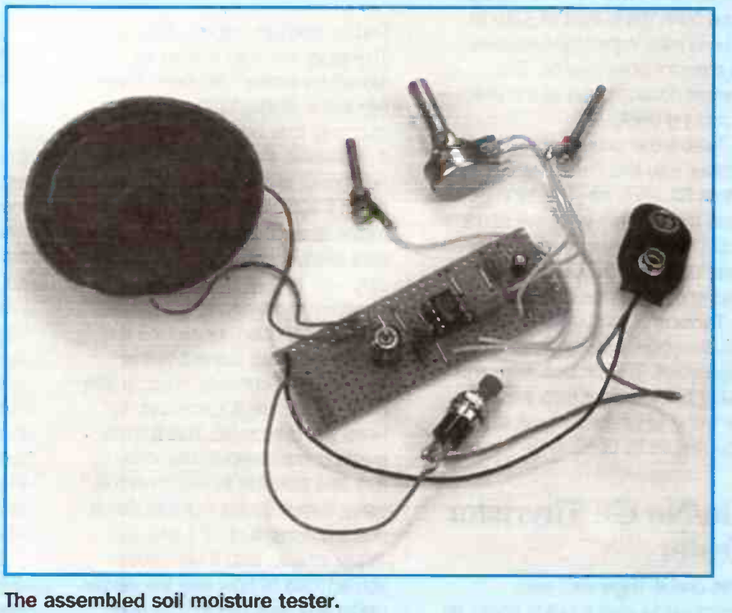


Figure 5. Soil moisture tester.



The assembled soil moisture tester.

Soil Moisture Tester

This circuit (Figure 5) was designed to give gardeners a quick indication of how wet or dry the soil is in their gardens or greenhouses. It can also be used to test how wet or dry the soil of house plants is. The usual way to determine the wetness or dryness of soil electronically is to measure the resistance of the soil, and then give some kind of visual or aural indication of its value. For a visual indication, you can use circuits that drive moving coil meters or bar graph displays. However, these can be costly. It was decided to use a circuit that gave an audible indication of soil resistance because it was cheaper, and with practice you can gauge the wetness of the soil quite quickly.

The circuit is described below. It is based around a well-known square wave oscillator circuit. IC1a is an integrator, with C2 being charged and discharged through RV1, the soil resistance, and R5. IC1b forms a Schmitt trigger circuit, whose switching points are determined by R3 and R4. When the soil is wet, its resistance will be low, and therefore C2 charges and discharges faster. Therefore, the frequency of oscillation of the circuit will be higher. When the soil is dry, the resistance between the probes will be higher, and C2 will charge and discharge at a slower rate, and the frequency of oscillation of the circuit will be lower. RV1 allows the frequency of operation to be varied when the circuit is in use. The frequency of operation can be varied between about 1·3kHz for very wet soil, down to 100Hz or less for very dry soil. R1 and R2 are biasing components for IC1a and IC1b, setting the non-inverting and inverting inputs to half of the supply voltage. C1 provides AC decoupling for R2. C3 feeds the output of IC1b to LS1. It may seem unusual not to have some kind of buffer circuit between the output of IC1b and the loudspeaker, but there is enough drive from the output of IC1b to drive a high impedance speaker at a reasonable volume. The current consumption of the unit is around 9mA.

To use the circuit, place the probes into the soil to be tested, press S1 and note the tone. A low tone means that your soil is dry and should be watered. A high tone means that your soil is wet and should not be watered.

There are no special construction requirements for this circuit. The probes were made using bolts, solder tags and nuts for fixing to whatever type of case you decide to use.

Go/No Go Thyristor Tester

This circuit (Figure 6) was designed to give a quick go/no go test of thyristors that you might find in 'bargain packs', etc. Thyristors are also known as silicon controlled rectifiers. They are like a diode, in that current can only flow one way through it. However, the thyristor has an additional terminal, known as the gate; if sufficient current is applied to the gate, then the device will stay permanently latched on. The only way to turn the device off is to either short-circuit the anode-cathode junction, or reduce the anode-cathode current below the 'holding' current, which is the minimum current necessary to keep the device on. The former method was used in this circuit. It is also possible to test thyristors using a multimeter, but this circuit has the advantage of being less 'fiddly' to use, and it also gives you an idea of how well the device under test switches from a non-conducting to conducting state.

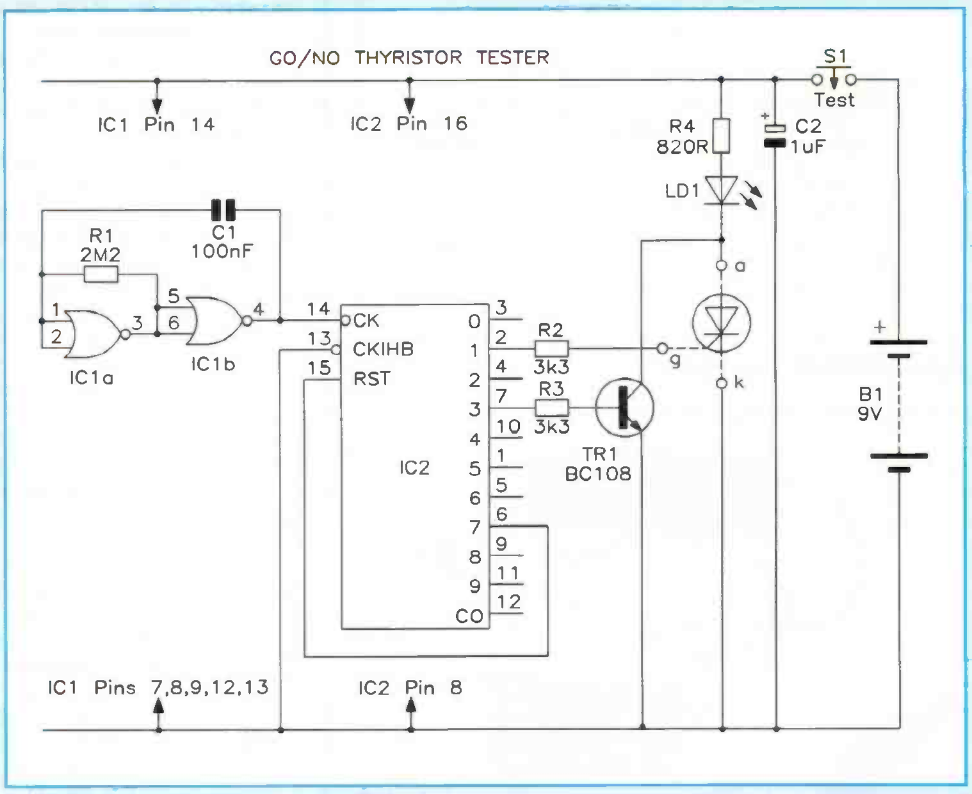
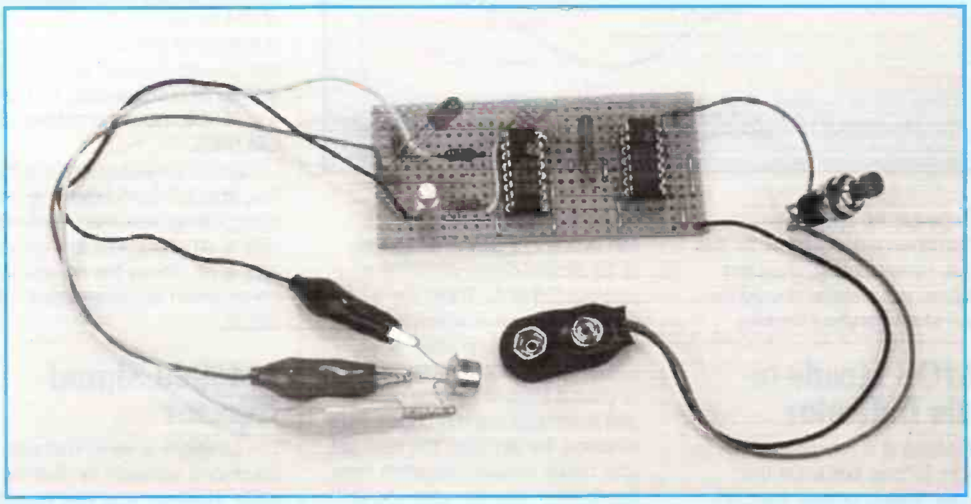


Figure 6. Go/no go thyristor tester.



The assembled go/no go thyristor tester.

Circuit operation is as follows: IC1a and b form a standard astable multivibrator, with a working frequency of about 2·5Hz; R1 and C1 set the frequency of the astable. Pulses from the astable are fed to the clock input of IC2, which is a '1-of-10 decoder'. As successive pulses are fed to IC2, each of its outputs will go high then low, in sequence. When the last output goes high/low, the sequence starts again. When output 1 of IC2 goes high – roughly to the supply voltage – this voltage will be fed to the gate of the device under test through R2. This turns on the thyristor, and LD1 will be illuminated. R4 is the current limiting resistor for LD1.

Now, two clock pulses later, output 3 of IC2 will go high, and this turns TR1 fully on, short-circuiting the anode-cathode junction of the device under test and, therefore, turning it off. LD1 will now be extinguished. When output 7 of IC2 goes high five clock pulses later, IC2 is reset and the whole sequence starts over again. S1 is the on/off switch, and must be pressed down long enough to see if the device under test works. C2 is a supply decoupling capacitor.

If, when testing a thyristor, LD1 is permanently on, or it does not come on at all, then the thyristor is probably suspect. When connecting a device to be tested, you can use either flying leads and clips, or sockets. Flying leads and clips were used on the prototype. A red lead and clip were used for connecting to the anode, a black lead and clip to the cathode, and a yellow lead and clip to the gate. Current consumption of the unit is about 11mA.

MINI-CIRCUITS PARTS LISTS

Please note that these Mini Circuits are not available as kits nor are they eligible for the Maplin 'Get-You-Working' Service.

CMOS 4001/4011 CHIP TESTER

RESISTORS: All 0·6W 1% Metal Film			
R1,R3	2M2	2	(M2M2)
R2,R4	820Ω	2	(M820R)
CAPACITORS			
C1,C2	100nF Polyester	2	(BX76H)
SEMICONDUCTORS			
LD1	LED Red	1	(WL27E)
LD2	LED Green	1	(WL28F)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
SK1	14-Pin DIL Socket	1	(BL18U)
B1	9V PP3 Battery	1	(FK58N)
	Battery Clip	1	(HF28F)

CMOS 4017 CHIP TESTER

RESISTORS: All 0·6W 1% Metal Film			
R1	2M2	1	(M2M2)
R2,R3	10k	2	(M10K)
R4-R14	820Ω	11	(M820R)
CAPACITORS			
C1	100nF Polyester	1	(BX76H)
C2	1μF 100V Electrolytic	1	(FB12N)
SEMICONDUCTORS			
IC1	CMOS 4011	1	(QX01B)
LD1-LD11	5mm Red	11	(WL27E)
MISCELLANEOUS			
S1,S2,S3	SPST Toggle	3	(FH97F)
B1	9V PP3 Battery	1	(FK58N)
	Battery Clip	1	(HF28F)
SK1	16-Pin DIL Socket	1	(FJ65V)
	14-Pin DIL Socket	1	(BL18U)

CMOS HEADS OR TAILS INDICATOR

RESISTORS: All 0·6W 1% Metal Film			
R1	2M2	1	(M2M2)
R2	820Ω	1	(M820R)
CAPACITORS			
C1	100nF Polyester	1	(BX76H)
SEMICONDUCTORS			
LD1	5mm Red	1	(WL27E)
IC1	4001	1	(QX01B)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
S2	SPST Ultra-Miniature Toggle	1	(FH97F)
B1	PP3 9V Battery	1	(FK58N)
	Battery Clip	1	(HF28F)
	14-Pin DIL Socket	1	(BL18U)

LM3909 SIGNAL INJECTOR

RESISTORS: All 0·6W 1% Metal Film			
R1	12k	1	(M12K)
CAPACITORS			
C1,C2	100nF Polyester	1	(CX21X)
SEMICONDUCTORS			
IC1	LM3909	1	(WQ39N)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
B1	1·5V Battery	1	(FK55K)
	Battery Holder	1	(YR59P)
	8-Pin DIL Socket	1	(BL17T)
	Black Crocodile Clip	1	(FK34M)
	6BA × 1in. Bolt	1	(BF07H)
	Solder Tag	1	(BF29G)
	Nuts	2	(BF18U)

SOIL MOISTURE TESTER

RESISTORS: All 0·6W 1% Metal Film			
R1,R2,R5	10k	3	(M10K)
R3	68k	1	(M68K)
R4	330k	1	(M330K)
RV1	10k Linear	1	(JM71N)
CAPACITORS			
C1	1μF 100V Electrolytic	1	(FB12N)
C2	100nF Polyester	1	(CX21X)
C3	100μF 10V Electrolytic	1	(FB48C)
SEMICONDUCTORS			
IC1	TL082	1	(RA71N)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
B1	PP3 9V Battery	1	(FK58N)
	Battery Clip	1	(HF28F)
LS1	64Ω 0·1W	1	(YT27E)
	8-Pin DIL Socket	1	(BL17T)
	6BA × 1in. Bolt	2	(BF07H)
	6BA Solder Tags	2	(BF29G)
	6BA Nuts	4	(BF18U)

GO/NO GO THYRISTOR TESTER

RESISTORS: All 0·6W 1% Metal Film			
R1	2M2	1	(M2M2)
R2,R3	3k3	2	(M3K3)
R4	820Ω	1	(M820R)
CAPACITORS			
C1	100nF Polyester	1	(BX76H)
C2	1μF 100V Electrolytic	1	(FB12N)
SEMICONDUCTORS			
LD1	5mm Red	1	(WL27E)
IC1	CMOS 4001	1	(QX01B)
IC2	CMOS 4017	1	(QX09K)
TR1	BC107	1	(QB31J)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
B1	PP3 9V Battery	1	(FK58N)
	Battery Clip	1	(HF28F)
	14-Pin DIL Socket	1	(BL18U)
	16-Pin DIL Socket	1	(BL19V)
	Red Crocodile Clip	1	(FM37S)
	Black Crocodile Clip	1	(FK34M)
	Yellow Crocodile Clip	1	(FK35Q)

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NEW BOOKS

Windows NT – The Complete Reference

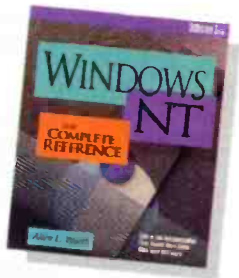
by Allen L. Wyatt

Windows NT is the long-awaited and highly regarded operating system from Microsoft, being a direct descendent of Microsoft Windows. NT provides fresh competition for the OS/2 and Unix operating systems, but with the advantage of being able to draw from the hugh base of Windows users.

Microsoft developed Windows NT with the following objectives: to allow full exploitation of the microprocessors on which Windows NT was designed to run; retain the simple, object-orientated user interface introduced with Windows; provide simple transparent access to network services; retain compatibility with the vast array of DOS and Windows products; and lastly, to allow for future growth and extensibility.

This book is carefully designed to teach you all you want to know about the Windows NT operating system. It offers an excellent and detailed tutorial on all aspects of the topic. The book provides total coverage from installation and basic commands to advanced operating systems, so allowing a successful change to Windows NT.

1993. 660 pages, 185 x 230mm, illustrated. American book.



Order As AA69A
(Windows NT) £21.95 NV A2

Home Security

by Vivian Capel

It is a sad fact of life that burglary is increasing at an alarming rate, and the necessity to secure one's home has never been greater. The purpose of this book is to provide practical, independent advice and guidance on securing the home. It shows the burglar's preferred methods of entry, the weak points he looks out for, many of the tricks he uses, and what you can do to thwart him.

There is a vast range of security devices available to the public, and large sums of money can be spent on an installation. However, weak links can still be left unrecognised – except by the burglar. Good independent advice is not readily available, as most security firms will obviously favour their own products.

This book explains the pros and cons of an alarm system, discusses which features are important, and clears away the mystery surrounding those technical terms and expressions. It shows how to install a system, how to prevent faults, and what to do if any occur. Other security devices are given a critical scrutiny along with further measures to avoid becoming a victim of crime.

This is a thorough and straightforward guide to the wide range of technologies and devices used to maintain security in the home and small premises. A must for all those who are about to install an alarm system or improve their home security.

1994. 186 pages. 234 x 150mm, illustrated.

Order As AA86T
(Home Security) £14.95 NV

Electronic Music and MIDI Projects

by R. A. Penfold

Home-made equipment has been part of the electronic music scene for as long as there has been electronic music. In the early days it was often impossible to find ready-made equipment and it became necessary to build the required piece. The limited amount of commercially available equipment tended to be expensive, again making it preferable to construct suitable pieces.

The projects described in this book are primarily aimed at keyboard players and are easy to build – even complete beginners to project building will find them easy to assemble. All the projects are explained in detail, with full instructions on assembly. They are accompanied by clear, precise, easy to follow circuit diagrams, schematic drawings, component layout and lists. The basic mixer, MIDI tester, MIDI lead tester, metronome, electronic swell pedal, THRU box, and MIDI automatic switcher are all well suited to beginners. Other projects included are the analogue echo unit, stereo mixer, MIDI patchbay and the byte grabber. None of the designs require the use of any test equipment in order to set them up – any setting up is very straightforward and described in detail.

If you are into MIDI and desire to expand your system cheaply, then this

book is ideally suited for your needs.

1994. 140 pages. 245 x 190mm, illustrated.

Order As AA81C
(Music MIDI Projects) £9.95 NV

MS-DOS 6.2 Upgrade For Dummies – Includes Genuine Microsoft Software!

by Dan Gookin

This special edition in the highly regarded Dummies Series comes complete with genuine Microsoft MS-DOS 6.2 Upgrade Software, and includes a detailed chapter on installing the software.

The book is organised into seven parts with each part containing several chapters. These chapters incorporate individual sections that enable the book to be modular – self-contained sections about particular DOS topics that can be read at any time.

New features include the ScanDisk program which is designed to replace the old CHKDSK command. ScanDisk has the ability to fix problems and to spot any possible future problems, and fixes them as well.

A range of utilities for protecting your files and computer information is provided, including a new backup command – MSBackup. There is an Anti-Virus program for protecting against PC viruses and an Undelete command for retrieving accidentally erased files. DoubleSpace allows the user to store more programs and files on the hard drive without affecting the way the computer is used.

MS-DOS can now handle extremely large hard drives, thus removing the need for hard disk partitioning. There is now direct support for the new 2·88M floppy drives. An extensive HELP command is included plus quick help on all DOS commands at the DOS prompt.

MemMaker is a memory optimisation program that makes it easy to shift device drivers and memory resident programs from conventional memory into the upper memory blocks. This frees up the conventional 640K memory for program use. This program is only suitable for 386, and higher, processors.

The opening chapter, dealing with the installation of MS-DOS 6.2, makes the whole process of installing the program very painless. This chapter will be extremely useful for the novice and those who have a dread of DOS.

The upgrade program is supplied on three 3½in. high-density disks, which are to be found in special wallets at the rear of the book.

1993. 406 pages. 235 x 186mm, illustrated. American book.

Order As AA80B
(DOS 6.2 For Dummies) £59.99 (Including VAT).

Build Your Own Multimedia PC

Aubrey Pilgrim

Since the introduction of Windows 3.1, Multimedia has become one of the more advanced computer technologies, and is now the fastest growing, since the PC was first introduced. Multimedia adds a whole new dimension to the PC in business, education, training and entertainment. The aim of this book is to provide everything you need to know about multimedia PCs – no experience is required.

Part one of this comprehensive book discusses the components that are needed in order to take full advantage of multimedia. The main component is the computer and each part is discussed together with its assembly. Older computers are up-gradable and can be brought up to MPC specifications. By using step-by-step illustrations it is possible to assemble a MPC to take advantage of today's multimedia software. Advice is also given for those who would rather buy a ready-made system. Part two is concerned with multimedia products such as CD-ROMS, sound boards, speakers and microphones. Further chapters discuss MIDI and music, presentations, graphics, image acquisition, voice recognition and much more. The final part is a general discussion on essential software, sources and troubleshooting.

This book will also benefit those businesses that want to make use of their computers and so contribute towards increased productivity, better presentations, and help to create training tools. A CD-ROM is included and provides a wide variety of software that you can try on your new multimedia computer.

Highly recommended book.

1994. 356 pages. 185 x 232mm, illustrated. American book.

Order As AA85G
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