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No. 64

ELECTRONICS

APRIL 1993 · £1.75

The Maplin Magazine

Britain's Best Selling Electronics Magazine

Build a low-cost Bench Amplifier, an In-Circuit Transistor Tester, Plus Other Great Projects!

New Series Starts this Issue... Using Professional Audio Equipment

Find out How Vehicles can be Weighed on the Move!

Win a Radio Pager!

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Discover the secrets - Designing Your Own Mains Transformers!

6 PROJECTS

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EDITORIAL

Hello and welcome to the April Issue of 'Electronics'. Earlier this year I said that there would be an increase in the number of projects each month – lo and behold, there are six in this issue! The Low-Cost Bench Amplifier is one of those projects that you just can't do without. It's ideal for assisting fault-finding, project development work and just about any other situation when you need to check for the presence (or absence) of an audio signal source. There's also the In-Circuit Transistor Tester – another invaluable weapon in the hands of the electronics enthusiast and service engineer. Both projects are easy to build – and they won't burn too big a hole in your pocket either!

This issue sees the start of a brand new series on professional audio equipment. Tim Wilkinson – an experienced BBC broadcast engineer – takes us step by step through the fascinating world of broadcast and recording engineering. This series gives many tips, circuits and suggestions for anyone involved in working with audio equipment – at all levels. John Woodgate also returns with an authoritative feature on how to design and build your own mains transformers.

Plus there's how to build a 15W amplifier and power supply, how overladen lorries can be detected whilst on the move and the chance to win a top of the range radio pager, what more could you want? So until next month, I hope you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

R Ball

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PROJECTS

FEATURES

REGULARS

Prices of products available from Maplin, shown in this issue, include VAT at 17.5% (except items marked *NV* which are rated at 0%) and are valid between 5th March 1993 and 31st August 1993. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue. To avoid disappointment, when intending to purchase products from a Maplin store, customers are advised to check availability *before* travelling any distance.

NEWS Report

Videophone on Hold

So the much heralded videophone not only missed Christmas and the New Year, but could be delayed until Easter. First Amstrad pulled the sales plug, and then BT failed to meet its target. The GEC analogue videophone, it seems, has been having problems with poor picture quality (introduced by compression, which is necessary to broadcast pictures on the narrow bandwidth of a telephone line) while keeping to a marketable price of £400. Even the US is having problems. AT&T has now cut the price of its 2500 videophone by a third to $1,000 but, as a result of the greater interest caused as a result, installed the system at a hotel group.

A Better Image

New from Lascar Electronics is the DMX908, an eight-character by two-line dot matrix display. The unit features large characters, a low current consumption and a low-profile panel mounting bezel. Electrical interface is compatible with industry standards, connection being by a standard IDC header. Its design gives a high contrast and a wide viewing angle, and LED backlighting is fitted as standard. Details: (0794) 884567.

Meanwhile, Apple Computer has introduced a broad collection of colour and greyscale imaging products for Macintosh personal computers. According to Apple, every Macintosh user can now have the capabilities of a professional design agency. Colour scanning is as simple as pushing a button. Sophisticated colour matching is built in.

At the same time, industry giants Kodak, Sony and Hitachi have agreed a standard for home-based thermal dye transfer printers. These printers are designed to produce colour prints from video and digital sources, including video cameras and electronic still cameras.

Experience VR with MPS

The stunning world of Virtual Reality can be experienced on the Maplin Professional Supplies (MPS) stand at the NEPCON Electronics Show, which takes place at the NEC Birmingham between 23rd and 25th March. VR, as captured in the public imagination through such films as 'Lawnmower Man', is a new technology that lets you enter a three dimensional computer-generated world – a world where anything is possible.

You can experience the delights of foreign travel without leaving home. Find yourself on a beach in Paradise Island, on the stage of Miss Saigon, or even making a speech in the House of Commons. You can walk round a building which does not exist. You can walk through doors and windows, and float inside a cloud. You can pick up an object from an imaginary floor and plan your new workshop, enter a bloodstream or fly a Tornado fighter. VR is very much a world where the sky is not the limit. Turned on? If you are visiting NEPCON, don't miss the MPS stand (2600).

Canon Fires Off Another Record

Canon are in the news this month, having produced its 100,000,000th cartridge since production of cartridges for personal plain copiers and laser printers began, back in 1982. The company produced its 50,000,000th cartridge in 1990, and has been able to increase production to produce the same amount in just two and a half years – to meet the increasing demand. Today, cartridge production takes place at nine sites – including three in Japan, and one each in China, the USA and France. Together, these facilities produce 2,000,000 cartridges every month. Canon is also claiming the world's fastest 3·5in. magneto-optical disk drive, which has 10 times the writing speed of other devices. The system can record at 2·3MB per second, and can store a total 350MB – 2·7 times more than conventional magneto-optical disks.

Cable Emerges

The UK Cable and local telephone service looks set for strong growth this year with the number of new subscribers – estimated at 300,000 – joining the existing 540,000. The Cable Television Authority has also reported a total of over 110,000 telephone lines installed by January this year. Of these, 93,000 are residential and 17,000 business lines. With cable now passing some 2·056m British homes, the stage is set for considerable growth this year – with or without those notorious late night Dutch TV channels and the now on-hold Channel 5 licence.

Meanwhile, the latest Astra television satellite, 1C, is scheduled for launch this May. This will increase the available capacity, at the orbital position of 19·2°E, to 48 transponders. Will they find enough broadcasters to fill available capacity, we ask ourselves – after all, their transponder rental charges are notoriously high. Late January saw the demise of women's channel Lifestyle, together with the popular Lifestyle Satellite Jukebox. In addition, Screensport and Murdoch-owned Eurosport have merged – presumably to make any subscription plans easier to implement. There are industry rumours that Sky One (and presumably Sky News) plan to encrypt and charge for their services soon, possibly to coincide with the planned launch of children's channel Nickelodeon in October; Sky's publicity department confirmed that these rumours existed, and did not deny them. This explains why so much money has recently been spent on advertising Sky's present bouquet of channels on billboards and terrestrial television; after all Sky channels have been 'hard' encrypted, people will think twice before installing equipment of significantly less cost than a year's subscription to all of Sky's services, including the previously 'free' ones. Highly popular Thames/BBC channel UK Gold 'soft' encrypts, for copyright reasons, using the Videocrypt system (developed by News Datacom, in which Sky also has a significant stake). UK Gold chose Videocrypt presumably for compatibility with existing systems; in addition, with soft encryption no smart card (these are expensive to produce – even in volume) is required. Whether the channel is forced to charge for its service (part of a 'mini-subscription' package that also includes Nickelodeon, Sky One and Sky News) earlier than planned remains to be seen. Whichever way you look at it, the 'increased choice' of satellite television is set to become increasingly expensive in the future. Too much choice? We'll leave you to make up your own mind – but do bear in mind that advertising revenue is a finite resource!

ITC – A Plea for Common Sense: A Personal Comment by Martin Pipe

Now that Sky has been relieved of its duty towards BSB viewers, the original Marcopolo satellite remains in geostationary orbit (31°W) with no apparent function. At the time of writing, the satellite's transponders just give a message giving Sky's Livingston telephone number 'for details of alternative services'. But what happens next? As 'Electronics' readers will no doubt be aware, the second Marcopolo satellite was 'flogged off cheap' to the Swedes, who have moved the satellite to an orbital position of 0·8°W and renamed the satellite 'Thor'. Unfortunately, due to the fact that the first Marcopolo is a couple of years older than the second, no-one wants to buy it since the limited remaining lifetime (still five years – or more) is distinctly unattractive to existing commercial satellite operators.

In 1992, the ITC invited bids from broadcasters interested in the British DBS franchise. But none, as was reported in these pages some time back, passed the 'quality threshold'. You can draw your own conclusions on this matter!

With the new broadcaster option denied, why then can't the ITC come to its senses and consider the most *obvious* use for BSB's old home – that of relaying terrestrial channels. There are many remote areas in the United Kingdom for which the provision of a television relay station is simply not economically viable. In addition, television reception in many built-up areas suffer from 'ghosting', probably the best-known form of multipath distortion. Here, the signal from the transmitter may, in addition to its most direct route, be reflected off large metal objects (including the frameworks of large buildings). The tiny deviation from the direct route imparts a delay (even with radio waves travelling near the speed of light, it's still significant!) which means that the signal arrives at the receiver slightly later. These reflections produce the irritating 'ghost images' that are perceptible on many TV pictures, and cause corruption of teletext data. The structure of London's recently-erected Canary Wharf Tower is causing so many problems with TV viewers in the area that an expensive relay station is being considered!

For the benefit of the ITC, several further advantages (if original BSB DMAC equipment is used) follow:

- ★ The original Eurocypher encryption system used by BSB could be implemented so that the channels cannot be watched outside the UK, which would keep the actors and broadcasters' unions happy. This system also provides other 'plus' points in the areas of licence renewal, and barring certain forms of programme from minors.
- ★ Excellent picture quality – and NICAM stereo sound already built into the system.
- ★ A welcome boost for the UK electronics industry, retailers and dish installers.
- ★ Low start-up costs – as Marcopolo is in orbit already.
- ★ Low short-term (5 or so years) maintenance costs, compared to the installation and renewal of relay stations.
- ★ Five (more if you count the back-ups!) channels available – BBC 1/2, CH4 and the two most significant ITV regions (the latter could be open to a franchise option; the money raised could be put towards the purchase of a replacement satellite).
- ★ Existing relays could derive their source signal from Marcopolo for best results.

The only disadvantage would be the cost of a replacement satellite, which will be required in 5 to 7 years time. The present Government, of course, would be unlikely to cough up any of the money. As we have discussed, part of the required sum could be raised from ITV franchise revenue; most ITV companies would jump at the chance of nationwide coverage, and the weight that it carries when it comes to negotiating advertising rates! In any case, the cost would be significantly offset by the reduced (or eliminated) cost of additional replacement relay stations and transmitters. And of course, there are the incalculable benefits brought to the manufacturing and service sectors. Even if the renewal option is not considered, 5 years (if the system was to be implemented fairly quickly) is a significant period of time – most modern consumer electronics items are designed to give a similar service life.

What do *you* think (ITC employees enthusiastically included)? I can be contacted at the editorial address.

Ironically, it was the ITC's predecessor, the IBA, that developed the superb DMAC system in the first place!

All Aboard!

Philips Communications was given just 22 days to completely upgrade the public address, ship alarm and in-port fog alarm systems for the QE2, whilst docked recently in Hamburg. The 69,000 tonne Queen Elizabeth 2, the world's most famous ocean liner, now boasts a new bridge control panel which provides paging, sounding of alarm signals, and the playing of pre-recorded instructions to passengers and crew. Other facilities include 6,888W of amplifier power, in addition to twelve 20W music systems for the boat deck, and additional emergency warning equipment.

Joint Venture in Portugal

Texas Instruments and Samsung Electronics, at the end of 1992, announced the signing of a letter of intent for the multimillion dollar manufacturing investment of Texas Instrument's semiconductor assembly and test plant in Porto, Portugal. Both companies will use the plant to assemble and test their own integrated circuits.

The Porto facility is currently dedicated to the assembly and testing of high-volume linear and general-purpose logic integrated circuits. The planned agreement, which is expected to qualify subsidies from the Portuguese government, includes new capacity and capital upgrades to establish assembly and test production lines for dynamic random access memories (DRAMs) and advanced logic products.

Samsung plans to use the Portugal plant to assemble and test DRAMs, while Texas Instruments will upgrade current assembly and test equipment at the site to more complex, advanced logic products.

Mains Power in Your Car

'Until now,' say Merlin Equipment, 'you had to rely on noisy and expensive generators for 240V power to operate mobile radio communications on computer systems'. But now help is at hand with a range of DC to AC inverters, which can be either plugged into the cigarette lighter in the car, or wired direct to the battery. The system, according to the company, is ideal for microwave ovens, video recorders, TVs, computers, battery chargers (?) and power tools. Details: (0491) 613027.

Multicore Hosting Workshops

A series of hands-on workshop sessions covering circuit board repairs and soldering process techniques are being held in the UK during the first half of the year. Participants completing one of the four two-day sessions will receive a certificate of competence which employers may consider to be part of a vocational qualification. Participants are invited to bring along their own boards for evaluation. Details: (0442) 233233.

BT Trials Caller ID

BT is undertaking a trial of Caller Line Identification (refer to 'The Quango Speaks' in last month's News Report) in order to evaluate the possibility of a national service. Some 600 subscribers have been issued with a special display to attach to their telephones (with a further 23,000 users having the benefits explained to them), and the option of suppressing display of their number on a CLI-equipped phone. As outlined in last month's report, it is likely that, in a fully-implemented system, this option would be chargeable. As can be expected, BT is acting in association with Oftel and the Data Protection Registrar, who are concerned that customers should be able to conceal their number when making calls. (However, apart from making the privatised BT lots more money, this would appear to defeat the entire object of CLI!)

Plug It!

Consumer safety is given an extra plug with the publication of the DTI's consultative document for draft plugs and sockets regulations. The regulation proposes that all domestic electrical appliances should be supplied fitted with an approved 13A plug by the end of next year. We say 'at last'! Copies of the draft regulation are available; tel: (071) 215 3284 for more details.

How One Bugs a Mobile

While the future of the Royal Family remains under discussion, cellular network companies are keen to play down the continued risk of eavesdropping. Both Vodaphone and Cellnet maintain that two highly sensitive radio receivers are required to listen to each of the frequencies, and thus each side of any mobile telephone conversation – true enough if the intentioned eavesdropper is not within the transmission envelope of a base station. Assuming that they are, a single receiver locked on to a cell base station is all that is required. A suitable receiver in the form of a radio scanner is likely to set you back between £100 and £1,000.

Mobile telephones are effectively radio transmitters; the best opportunity for illegal reception occurs when a static individual is in the countryside where the cells are large because of lower air-traffic. Where a mobile user moves between cells, the transmit and receive frequencies change; amateur scanner users would find it difficult to track a call, although those able to decode carrier data would be able to track a call among the numerous cell channels.

By way of prevention, mobile communication manufacturers are switching from the analogue switching system to a more secure digital scheme, where carrier data is encrypted. Individual users can also use scramblers, but the price-tag (several hundred pounds) deters most users – bearing in mind that the caller and receiver must both be equally equipped.

Meanwhile there is always the threat of the law; those illegally intercepting calls run the risk of a £2,000 fine or two years in jail, under the 1985 Interception of Communication Act. Deliberate eavesdropping is illegal under the 1949 Wireless Telegraphy Act, along with the disclosure of information. Although such penalties would easily be offset by the huge fees paid by tabloid newspapers for a juicy story, no prosecutions had been made for any of the recent much-publicised cases at the time of going to press!

Events Listings

Now Open: 'Flight' Aeronautics Gallery, Science Museum, London. Tel: (071) 938 8000.

10 to 14 March. IMREX '93 International Model Railway Exhibition, Westminster, London. Tel: (071) 833 1840.

11 to 13 March. CADCAM, NEC Birmingham. Tel: (071) 404 4844.

23 to 25 March. NEPCON, NEC Birmingham. Tel: (081) 948 9800. Don't forget to visit the Maplin Professional Supplies Stand!

24 to 31 March. CEBIT, Hanover. Tel: (081) 688 9541.

20 to 23 April. Which Computer Show, NEC Birmingham. Tel: (081) 948 9837.

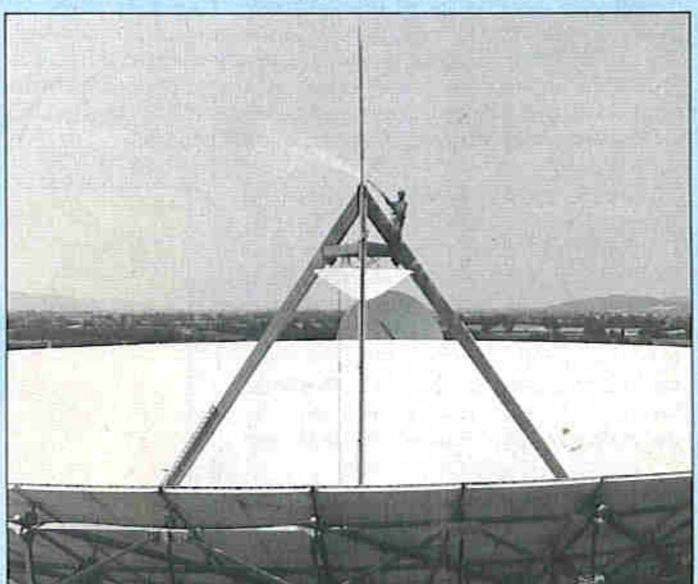
23 to 25 April. 4th MIDI and Electronic Music Show, Wembley. Tel: (081) 547 1183.

Electronic Music Show, Wembley. Tel: (081) 547 1183.

24 April. Marconi Birthday Exhibition, Wireless Museum, Puckpool Park, Seaview, I-o-W. Tel: (0983) 567665.

Please send details of events for inclusion in 'Diary Dates' to: The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR.

PICTURE CAPTION CHALLENGE

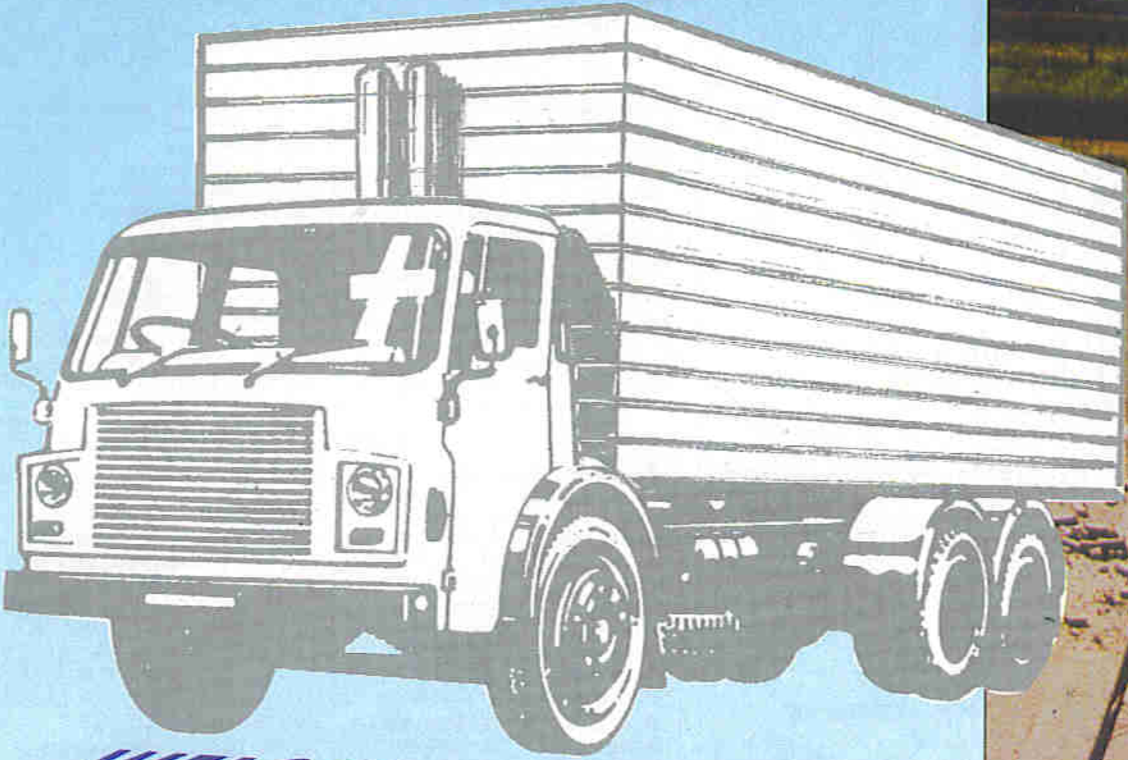


A cleaning-up operation this month for our Caption Competition. No prizes, not even a fireman's helmet. But a challenge nevertheless!

Just what is going on?

- ★ A fireman demonstrates his art to passing eagles.
- ★ Traffic warden painting no-parking signs for UFOs.
- ★ Mary Whitehouse cleaning up satellite television.

Almost. It is actually a BT rigger perched precariously on one of the upturned support arms of a new satellite dish – part of the framework at the BT earth station near Hereford. The aerial provides a fast response service, enabling BT to target specific satellites in order to distribute, for example, television newsfeeds at the 'last minute'.



WEIGH-IN-MOTION

Try making a journey from the north of the country to the south – with monotonous regularity, you will find it punctuated by roadworks. Whether you try the A1, the M6, or some tedious diversion by 'B' roads, interruption to your journey is inevitable. The lifetime of a road is not infinite – like most structures, they require habitual repair and become unsafe if not adequately maintained. In the United Kingdom, a staggering £1·2billion is spent every year on road repairs.

by Stephen Waddington

The weather is responsible for some of the damage, but the principal culprit is traffic, and in particular heavy lorries – Department of Transport research reveals that in general terms, structural road wear is proportional to the fourth power of vehicle weight. In other words, the wear caused by a single 10-wheel, 40 tonne lorry, with a cab weighing one tonne is equivalent to approximately 100,000 cars.

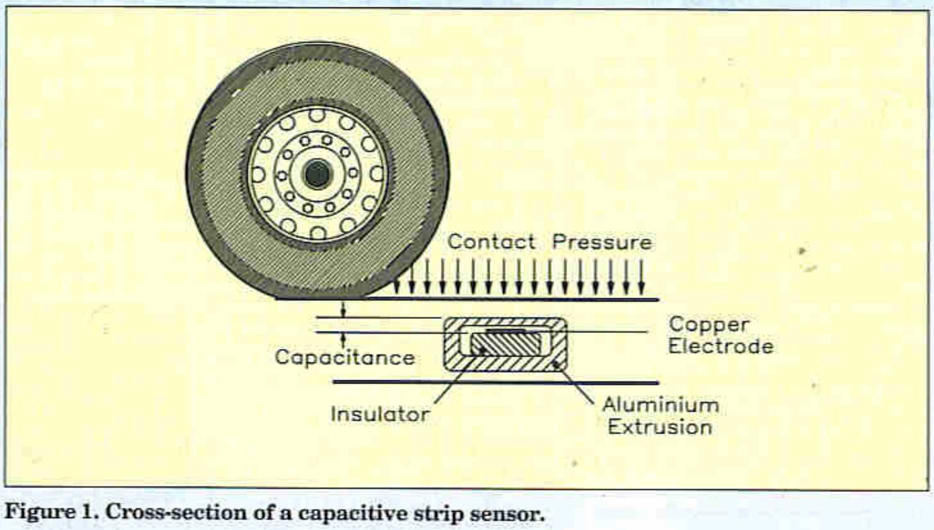


Figure 1. Cross-section of a capacitive strip sensor.

Road Wear

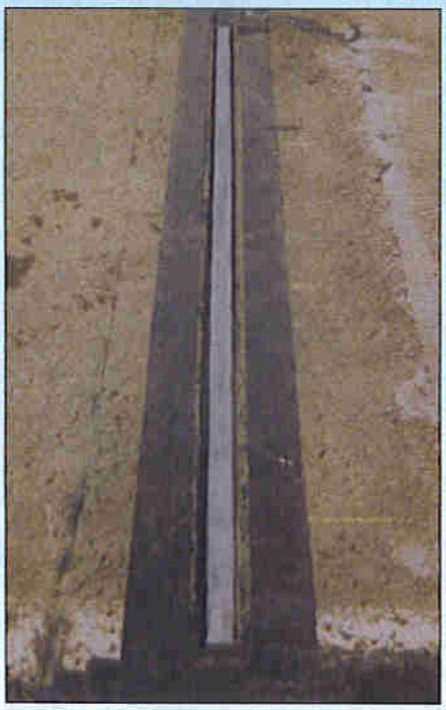
Road wear is a complicated process and many factors are involved. The continual action of tyres rolling over a road deck gradually wears the surface smooth, reducing the resistance to skidding. In addition, persistent pounding squeezes the upper layers of asphalt downwards and sideways, forming ruts caused by the wheels of regularly passing traffic. But the most obvious reason for resurfacing work, is the effect of vehicle loads being applied and removed millions of times over the surface – the break up of the whole road structure is inevitable.

In the United Kingdom, constant repair to the road network reduces the effects of damage and ensures a serviceable and safe road system. A sure way of minimising wear further would be to limit the number of vehicles using any one road. This is clearly not practical since new roads are built yearly and existing ones enlarged, specifically to cope with the increase in traffic. In fact, Department of Transport figures indicate that vehicle numbers are likely to continue to increase over the coming years. In the case of the most destructive vehicle, the heavy goods vehicle (HGV), numbers are likely to double over the next few years. Although no data exists on the number of foreign registered vehicles in the UK, an increase is expected in 1993 with the opening of the Channel Tunnel.

Study HGVs

Calculations have already shown that it is HGVs which are potentially most damaging to the road system, and any attempt to reduce deterioration must involve a study of such vehicles. Clearly, it would not be possible to ban HGVs, as such action would bring the country to a standstill. However, during last year's general election, some parties pledged to invest and ensure that more freight was carried by train, reducing the requirement for road haulage. Other plausible ideas include an increase in the use of the nations' canal and river networks for the movement of heavy goods.

A significant way in which the damage caused by vehicles can be contained is to ensure that the HGVs are loaded legally. A fully loaded 38 tonne lorry, can cause considerable damage, yet consider the effect, if that same lorry is overloaded by an additional 5 tonnes. Examples of dubi-



Top left: An installation engineer cutting out a slot for a strip sensor.
Top right: Cleaning the slot before strip sensor is inserted.
Left: Strip sensor in road.

ous fleet operators being found guilty by the local magistrate, of running overloaded vehicles, often feature in the local press. Competition is fierce, and the temptation to provide customers with a cost-effective service at the risk of illegally loading a lorry exists. Conscientious fleet operators will usually weigh a vehicle to ensure it meets legal limits before allowing it out of a loading compound and onto the public highway. Those avoiding this chore run the risk of being stopped by the police – a risk which many are willing to take in order to ensure reduced costs.

Mechanical Weighbridges

Mechanical weighbridges have previously been the only method by which authorities can check the weight of a vehicle. In such instances, it is up to enforcement officers to pull suspect vehicles aside for weighing. Invariably the percentage of those actually overweight is low – in the order of 20%. When you consider the average operating cost of a HGV is £25 per hour, the time spent holding legally loaded vehicles proves costly and irritating for both the driver and operator.

Weigh-In-Motion (WIM)

Scientists at the Transport Research Laboratory (TRL) in Crowthorne, Berkshire, together with numerous advisors, consultants and manufacturers have been considering the problem for some time. The result is Weigh-In-Motion (WIM) – the ability to weigh vehicles whilst they are moving. Electronic measurement of a vehicle's weight results in a dynamic reading, and by applying the appropriate mathematical algorithm, the actual static weight is determined, so providing an indication of actual vehicle weight. Accurate and reliable WIM preselection systems would enable enforcement officers to target the most seriously overloaded vehicles and avoid weighing those travelling legally. Law-abiding operators would benefit since their vehicles would not be stopped for weighing whilst the efficiency of enforcement operations would be greatly improved.

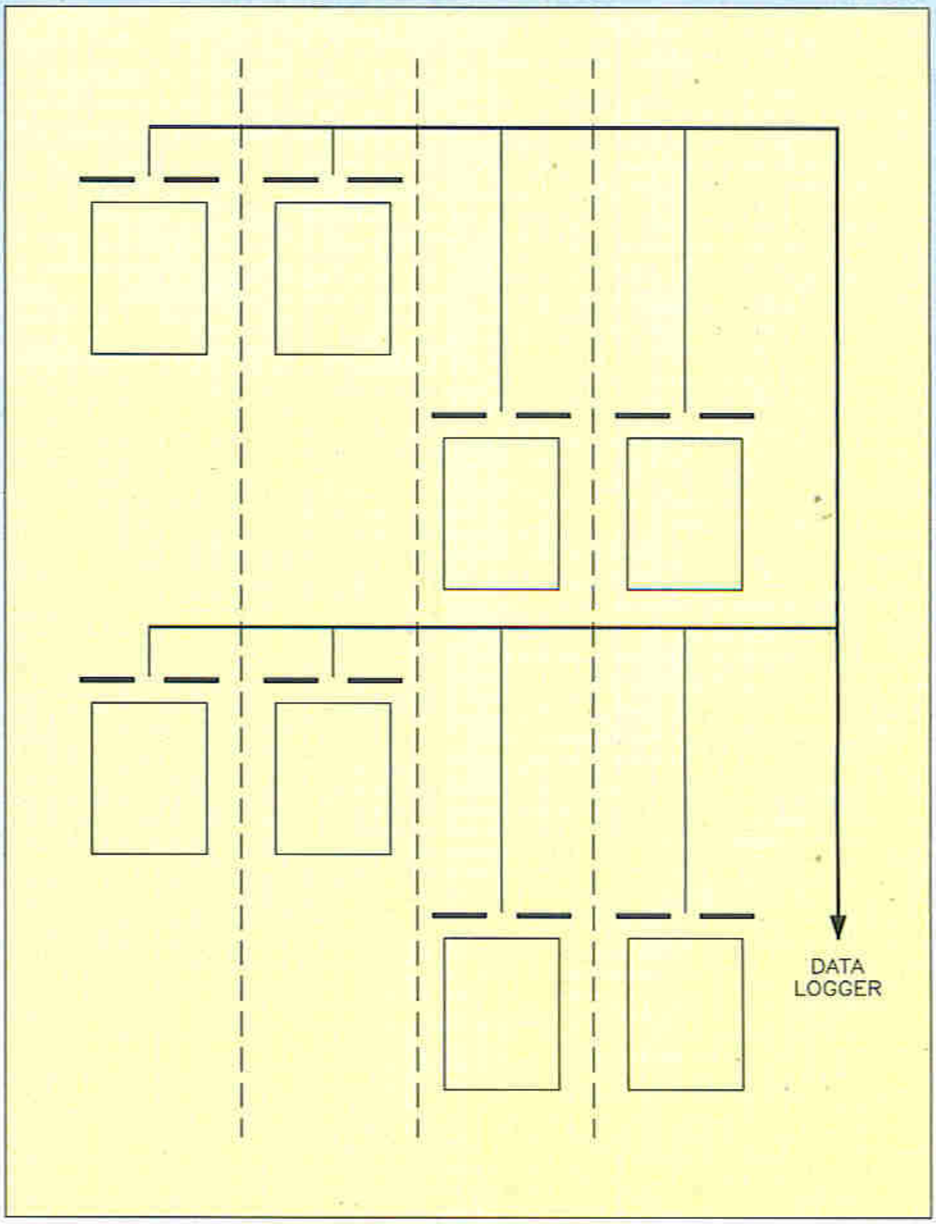


Figure 2. A typical multi-lane installation with two inductive loops and four sensors per lane.

Capacitive Strip Sensors

Mechanical weighbridges are unable to respond to vehicles moving at speed so a capacitive strip transducer has been developed for the purpose. Placed along the width of the road, the capacitive strip sensor responds to loads positioned along its length. Similar to a pressure-pad, the sensors deflect when contact with a load is made, but instead of a change in continuity, a variation in capacitance results. See Figure 1.

The sensors consist of a hollow tube of aluminium alloy with an insulator and copper electrode embedded inside. When a wheel runs over the sensor, the thin top plate of the tube deflects. This changes the sensor's capacitance – its capacity to store electrical charge between the tube and the inner electrode. The tyre force and thus weight of the axle is obtained by measuring the magnitude and duration of the capacitive change.

Ideally, WIM systems should be capable of measuring the static weight of a vehicle whilst it is moving at a reasonable highway speed. The best that can be hoped for is the instantaneous force of a passing vehicle. A single capacitive WIM sensor measures the instantaneous force generated by each axle as it passes. Unfortunately, the laws of physics tell us that additional forces operate, resulting in a value far removed from the static force and thus the real weight of each axle. As a vehicle, especially a lorry, moves along a road it reverberates on its suspension – an effect which could result in spurious figures. A WIM system must be able to cope with the vertical forces caused by suspension, braking and swerving. One answer is to use two sensor strips and mathematically average the outputs of the sensors in order to reduce the error associated with the interaction between the vehicle and the road profile.

More than One

The solution is to use not one WIM sensor, but several – the advent of low cost capacitive strip sensors provides the possibility of using several sensors along a road in order to compensate for the effects of dynamic forces in the determination of static loads. Golden River, traffic instrumentation engineers, propose such a layout. By installing a second sensor, a second sample and recording can be made. Several sets of sensors can be used in any one carriageway as Figure 2 shows. Higher levels of accuracy are achieved by the independent measurement of the left and right-hand vehicle axle weights. Inductive loops are used to detect the beginning and end of a vehicle so that the gross weight, that is the sum of the weights of each axle, can be determined.

Installation

Installation is relatively easy. A strip, in the road, is cut and cleaned and the capacitive strip is fitted in place. A separate slot cut parallel to the sensor carries the leads to an appropriate termination point at the edge of the road. The capacitive strip is then coated with a protective layer of epoxy resin.

Calculation

Obviously the sensors need a data logger, and in this instance a unit called the 'Marksman 600' is used.

After the passage of a vehicle, each of the capacitive strip sensor outputs are integrated for the duration of the tyre contact and the static weight of the vehicle determined. A laptop personal computer (PC) is then connected to a local port on the logger to display the data. This is usually done in real time with the display constantly updated, showing details of the last vehicle over the site. Operationally, the M600 might form part of a system involving variable message signs, or camera systems to automatically control and manage traffic bridges, or designated truck routes where static weighbridges may be located.

The outputs of several sensors, in a WIM array, can be processed in a variety of different ways to yield the exact weight of static loads. Numerical simulations of the outputs of WIM arrays with 1, 2, 3, 19 and 81 sensors, and with a variety of spacing arrangements including uniform, linear, geometric and logarithmic, have been evaluated by the TRL. Precise readings have been achieved with nine-sensors evenly spaced array.

The Mat that Measures

A scheme designed and currently under test by the University of Cambridge and Golden River Traffic, contemplates even further accuracy. Together they have designed a load measuring mat. The mat, constructed from a 13 millimetre thick sheet of polyurethane, is fastened to the road deck. Encapsulated within it, at 40cm intervals, are strip sensors – each sensor is embedded within the depths of the mat preventing ridges forming under the weight of a lorry. A prototype, tested in America on the Navistart test track at Fort Wayne, Indiana, contained a total of 96 sensors. The mat installation utilised six Golden River 'Marksmen 600' data loggers connected on a serial network, from which data was uploaded by a microcomputer after each test run.

During the initial testing period in America, various vehicular configurations were used each having a variety of trailers and suspension weights. The selection was intended to be a sample from an American freight fleet. Each vehicle was repeatedly driven over the mat, in either direction, each time at a higher speed. After a four day test period, all results were within 4% of actual dynamic weight – the 4% error being attributed to noise and small calibration errors. The fundamental ideal of any WIM system is to have dynamic and static weights that are exactly the same. The accuracy offered by the WIM mat approaches this ideal within an acceptable margin of error.

Assessing Damage

Now installed at the TRL, the mat is being used in a research and development project to assess the damage done to roads by large lorries – the determination of the weight of a vehicle being a secondary objective. Scientists wish to study the way in which a large vehicle moves along a road, and hopefully the findings may help answer many questions. "How can the lifetime of a road surface be increased ? Is air suspension better than steel ? Do certain types of axle cause more damage that others ?" The answers could lead to better designed trucks and superior road structures.

Marksman 600 data logger.

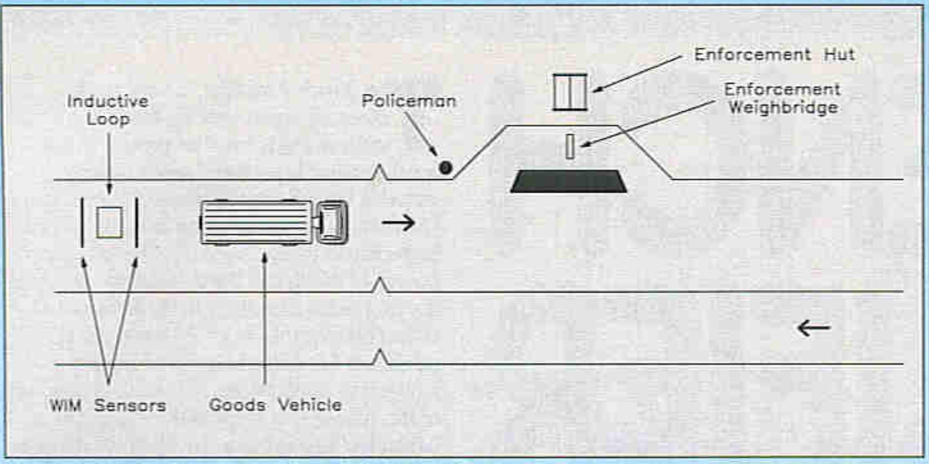


Figure 3. Typical layout of a preselection site.

Preselection Systems

Cost and further research have prevented the WIM mat being installed on a public road, but the accuracy offered could see the mat installed as a central part of a preselection system. Since 1988, the TRL has been evaluating a dozen or so WIM preselection systems throughout the country. Figure 3 shows a typical system. The WIM equipment is situated upstream of the enforcement site. A land-line to the enforcement area passes information about overweight vehicles to officers, who manually check their weight. More sophisticated designs include close circuit television cameras located at the sensor area. Pictures are passed to the enforcement site, so that officers can visually identify vehicles shown to be overweight by the computer.

The maximum permitted weight of axles and vehicles are laid down by the Secretary of State for Transport. Preselection systems identify overloaded vehicles by comparing the axle and gross weight with predetermined values based on the maximum limits set out in the Government's Construction and Use regulations.

The accuracy of the studies so far performed has been poor – this may be attributed in part to the sensors used for the tests. In all instances, the sensors have been of a piezoelectric type, which are inherently less reliable than the capacitive strip design. Secondly, the system is prone to classify vehicles wrongly, with the result that a large percentage are shown to be overweight. Although the use of WIM preselection systems generally resulted in higher 'hit' rates than those achieved by unassisted police officers, at a success rate of less than 50% they are not as good as expected. Enforcement officers expected a near 100% success rate, and a great deal of dissatisfaction resulted since the majority of vehicles that indicated as being overweight, were not.

WIM technology remains a fringe application of electronics. For the past thirty years, developments in the area have been reported at research conferences, but like so many innovative electronic schemes, it has never achieved public awareness. However, you can be sure that once the reliability of WIM measurement systems has been improved, freight operators caught out at preselection sites will be only too aware of the technology.

Acknowledgments

I would like to thank the following individuals and organisations for providing information and assistance in the compilation of this article:

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Mr. T. Deakin – Trevor Deakin Consultants Ltd, Trowbridge, Wiltshire.
Mr. T. Sulivan – The Department of Transport, Bristol.

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INFORMATION ON TAYLOR 45D2 VALVETESTER. Also copy of "Morse in Seven Days" by Vic Lewis, and wartime/pre-war "Radio Times". Tel: Douglas, (0983) 567665.

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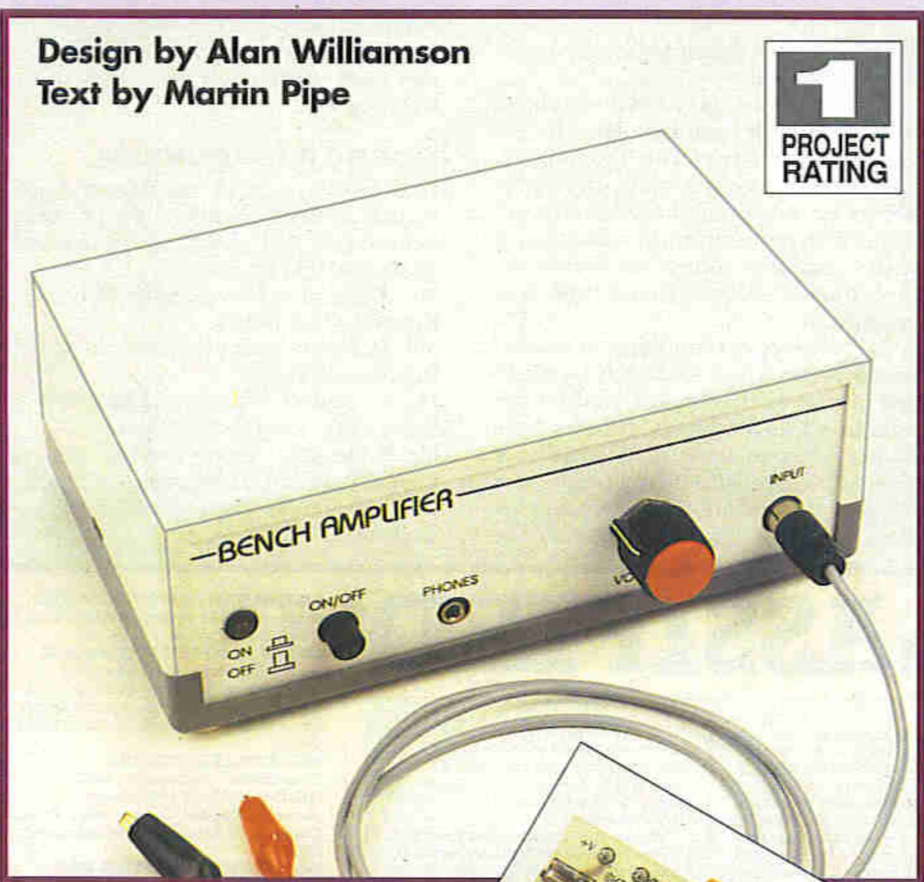
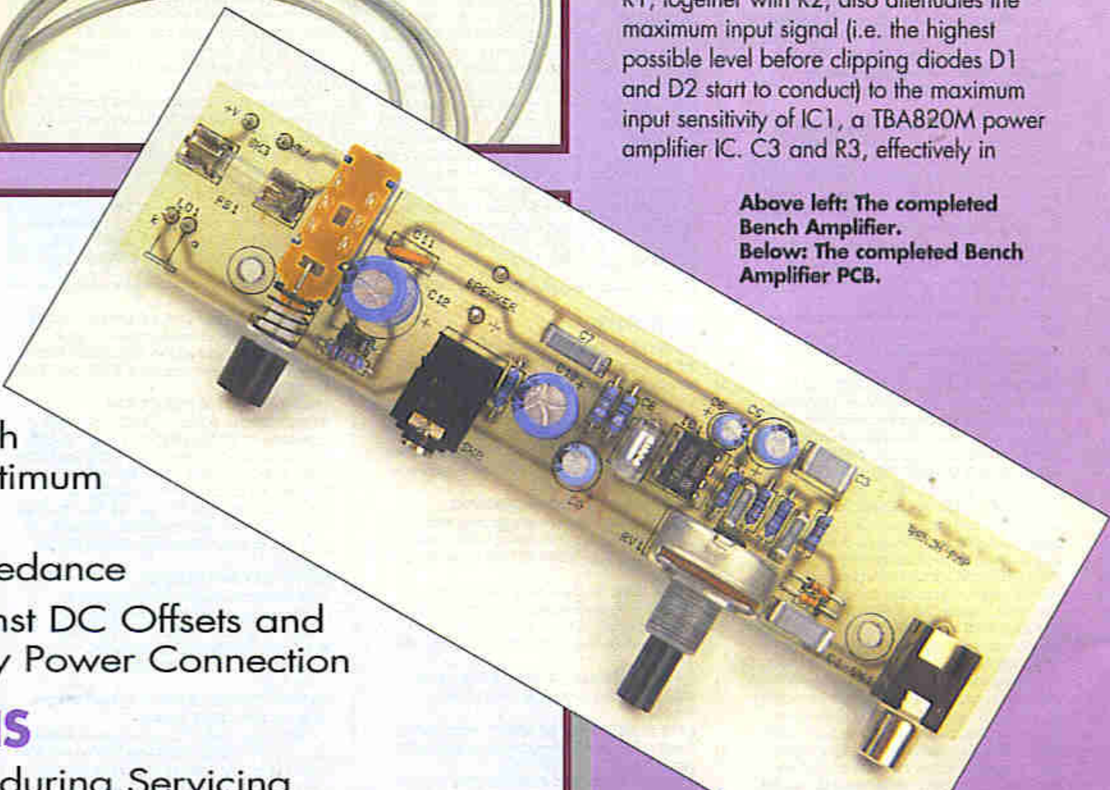
BENCH AMPLIFIER

Design by Alan Williamson
Text by Martin Pipe

1 PROJECT RATING





FEATURES

- ★ Excellent Value
- ★ 500mW Output Power
- ★ Input Bandwidth Limiting for Optimum Efficiency
- ★ High Input Impedance
- ★ Protected against DC Offsets and Reverse-Polarity Power Connection

APPLICATIONS

- ★ Signal Tracing during Servicing
- ★ Monitoring Audio Signals

The Bench Amplifier, a very useful piece of equipment for the home laboratory, is another project in the Low-Cost Test Equipment series, which includes the AF Signal Generator and the Minilab Power Supply (the latter will shortly be featured in 'Electronics'). The full output power of the Bench Amp is a little over half a watt before distortion starts to become objectionable. 500mW is, however, quite adequate for test-bench signal tracing and monitoring applications. The input impedance of the amplifier is approximately 400kΩ, which will prevent the circuit under test from being significantly loaded. Loading can often change a circuit's behaviour – not exactly desirable during servicing work! There is a second-order filter on the input of the amplifier that limits its bandwidth to 50Hz to 15kHz (–6dB). This means that all of the amplifier power is used at frequencies that the speaker can comfortably reproduce.

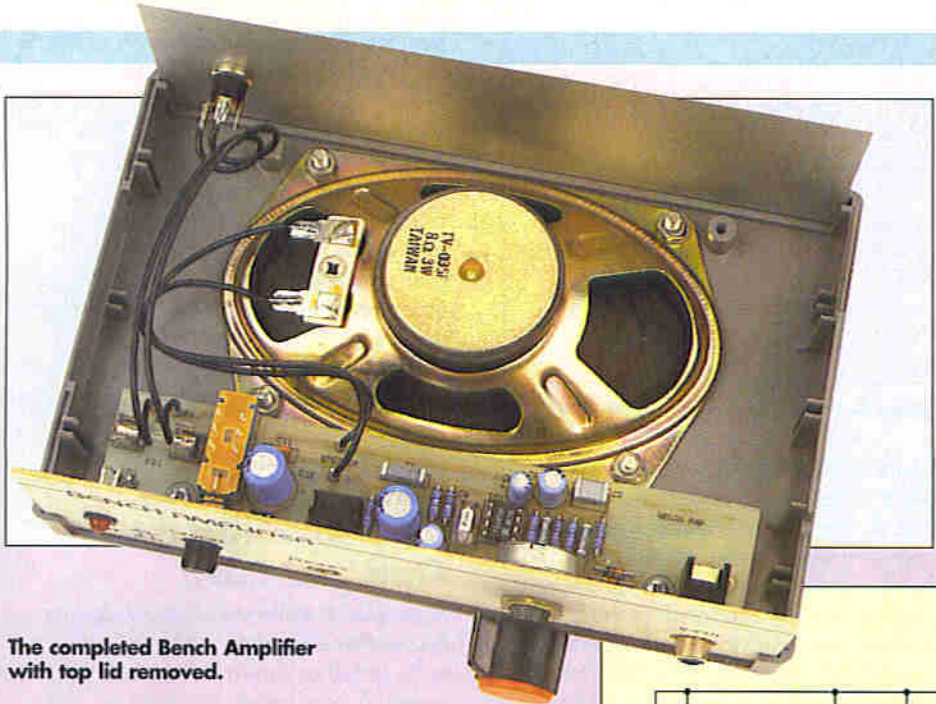
In conjunction with the low-distortion AF Signal Generator, the Bench Amplifier is very useful for servicing audio equipment. For example, if a multi-stage amplifier is faulty, each stage can be checked in turn.

Circuit Description

As can be seen from the circuit diagram of Figure 1, the input to the bench amplifier is AC-coupled by C1 so that any DC offsets present with the monitored signal will not damage the IC. RV1 is the input attenuator; in conjunction with C1, it also forms the first high-pass filter. Diodes D1 and D2 are present to limit excessive input signals. R1 and C2 form the first low-pass filter; R1, together with R2, also attenuates the maximum input signal (i.e. the highest possible level before clipping diodes D1 and D2 start to conduct) to the maximum input sensitivity of IC1, a TBA820M power amplifier IC. C3 and R3, effectively in

Above left: The completed Bench Amplifier.
Below: The completed Bench Amplifier PCB.

parallel with the input impedance of IC1, form the second high-pass filter. C4 and R3, also in parallel with the input impedance of IC1, form the second low-pass filter. The gain of IC1 is set by R4 and C5, while C6 is incorporated in the circuit to increase the chip's supply ripple rejection; note that IC1 has been designed to operate over a wide range of single rail supply voltages. The remaining components associated with IC1 are: C8, which is used for frequency compensation; C9 and R5, which are the bootstrapping components present to increase the input impedance of IC1; R6 and C7, which form the Zobel network



The completed Bench Amplifier with top lid removed.

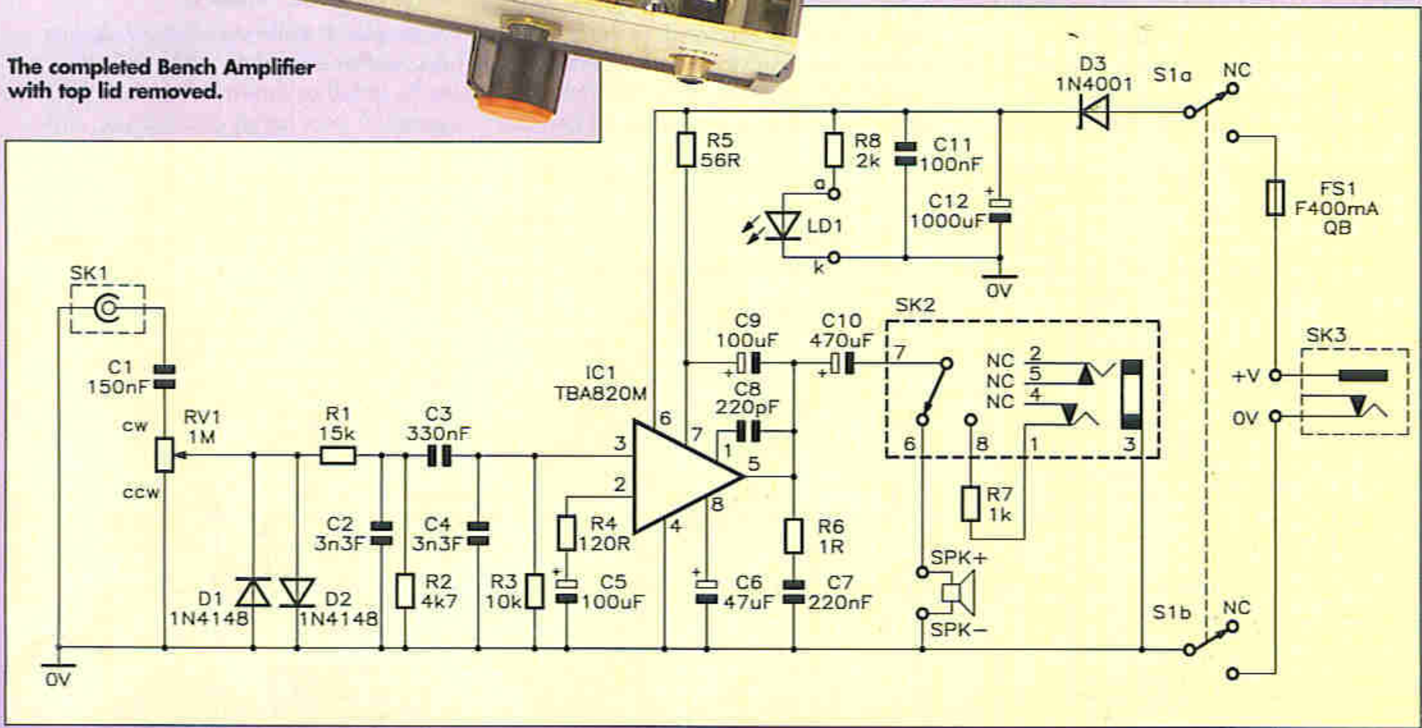


Figure 1. Bench Amplifier circuit diagram.

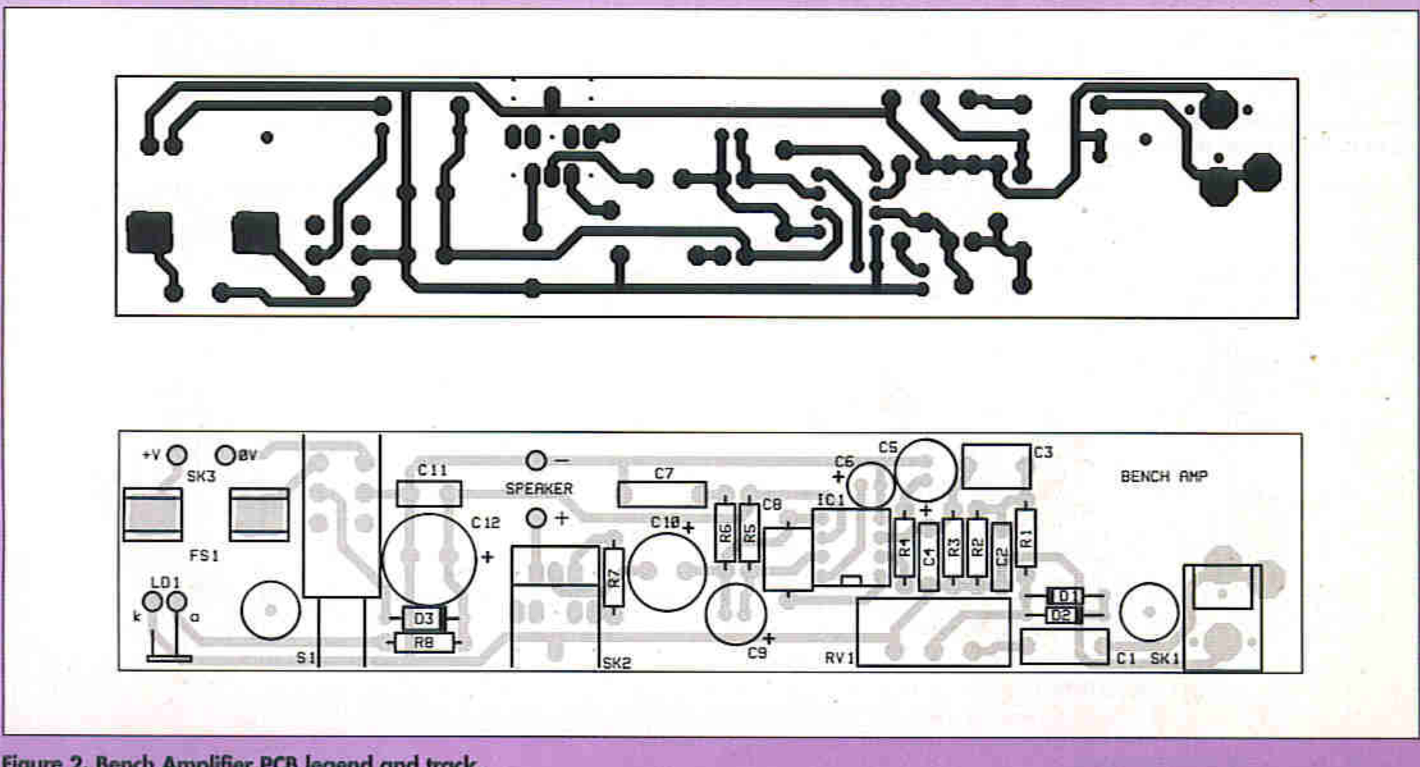


Figure 2. Bench Amplifier PCB legend and track.

(a filter that removes RF frequencies from the output); and C10, which AC-couples the output of IC1 to the speaker. Inserting a 3·5mm jack plug into the headphone socket, SK2, disconnects the speaker and switches R7 into the circuit; this resistor is present to limit the output volume and protect your ears! Power-on indicator LD1 is a low current LED; R8 is its series current limiting resistor. The remaining power supply components are decoupling capacitors C11 and C12; and D3, which has been incorporated to prevent damage to the circuit caused by accidentally reversing the connections to power socket SK3.

PCB Assembly

Before starting construction, read through the Constructors' Guide for good practical advice on kit-building, particularly if you are relatively new to the hobby. Begin PCB assembly by fitting the resistors, followed by the diodes; refer to the PCB legend in

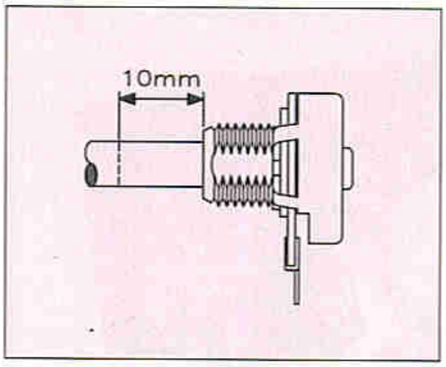


Figure 3. Trimming potentiometer shaft.

Figure 2. Ensure that the band on each diode corresponds to that shown on the legend. The same precaution should be applied when fitting the capacitors; C5, 6, 9, 10 and 12 are electrolytic devices, and must be correctly orientated. Fit the fuse into the fuse clips, insert the whole assembly into the PCB, and then solder the clips whilst holding the assembly flush to the PCB from the other side. Trim the shaft of RV1 to the length shown in Figure 3, and then fit it to the PCB. Install the switch (SW1) and the sockets (SK1,2). Note that these items must be pushed, as far as possible, against the PCB, otherwise the forces exerted on them may eventually cause their connecting tracks to lift from the board, causing intermittent operation. Fit the PCB pins from the component side, followed by the button for SW1.

Finally, check the PCB for solder bridges, whiskers, dry joints and misplaced components.

Fitting the Bench Amplifier into the Optional Case

If you plan to build your Bench Amp into the recommended box, holes first need to be drilled as shown in Figures 4 (front panel), 5 (rear panel) and 6 (base). Stick

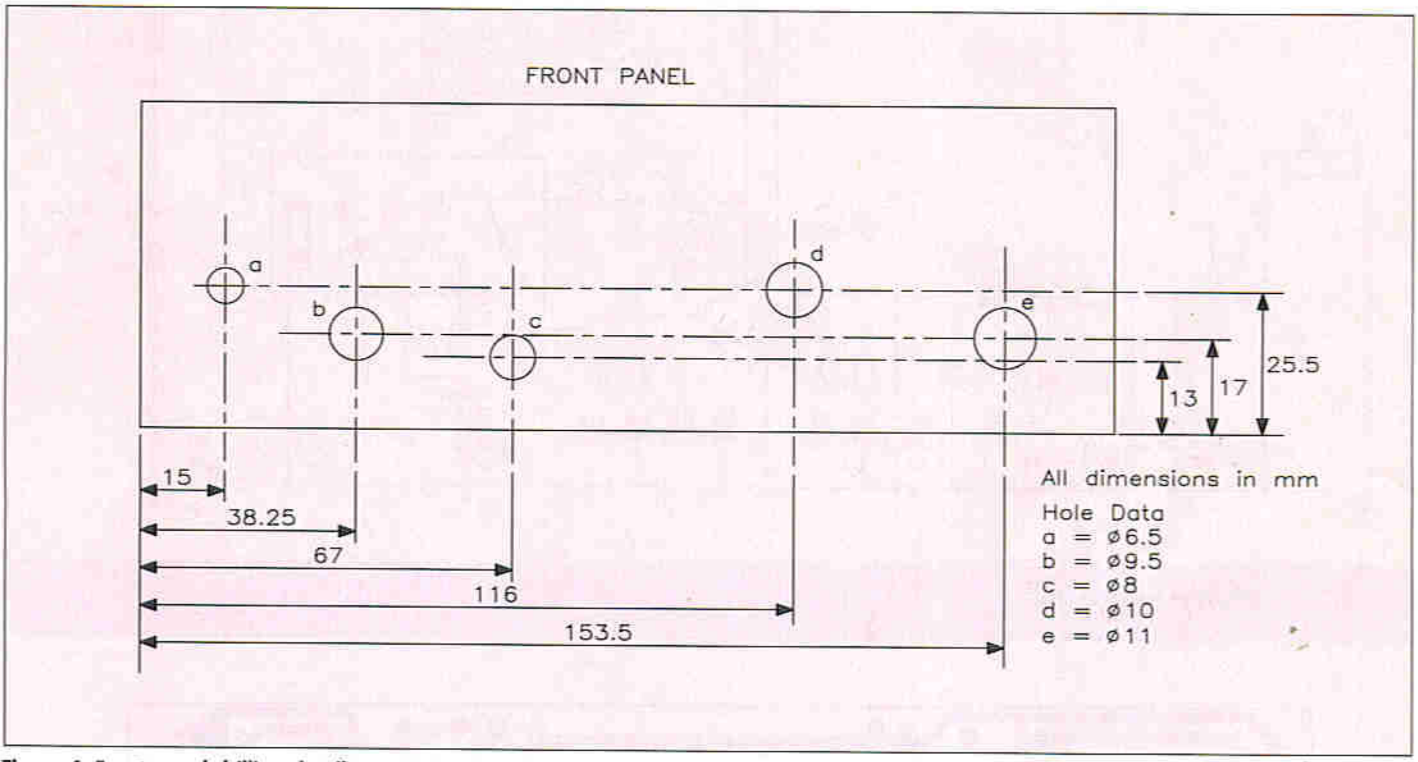


Figure 4. Front panel drilling details.

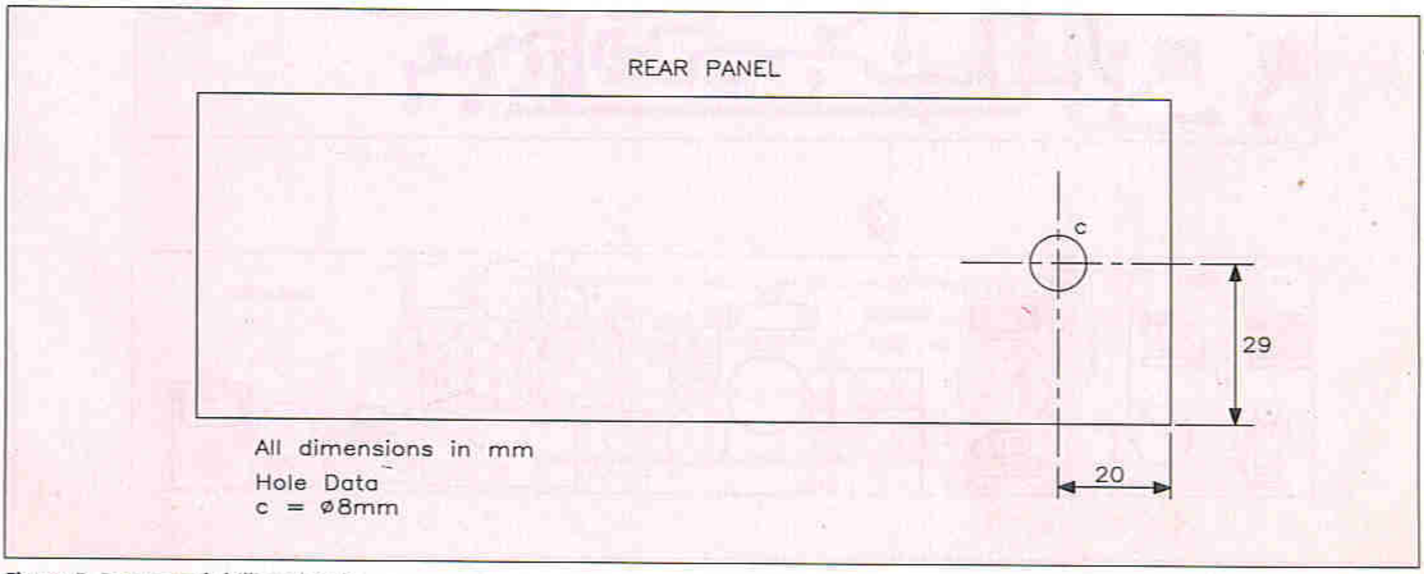


Figure 5. Rear panel drilling details.

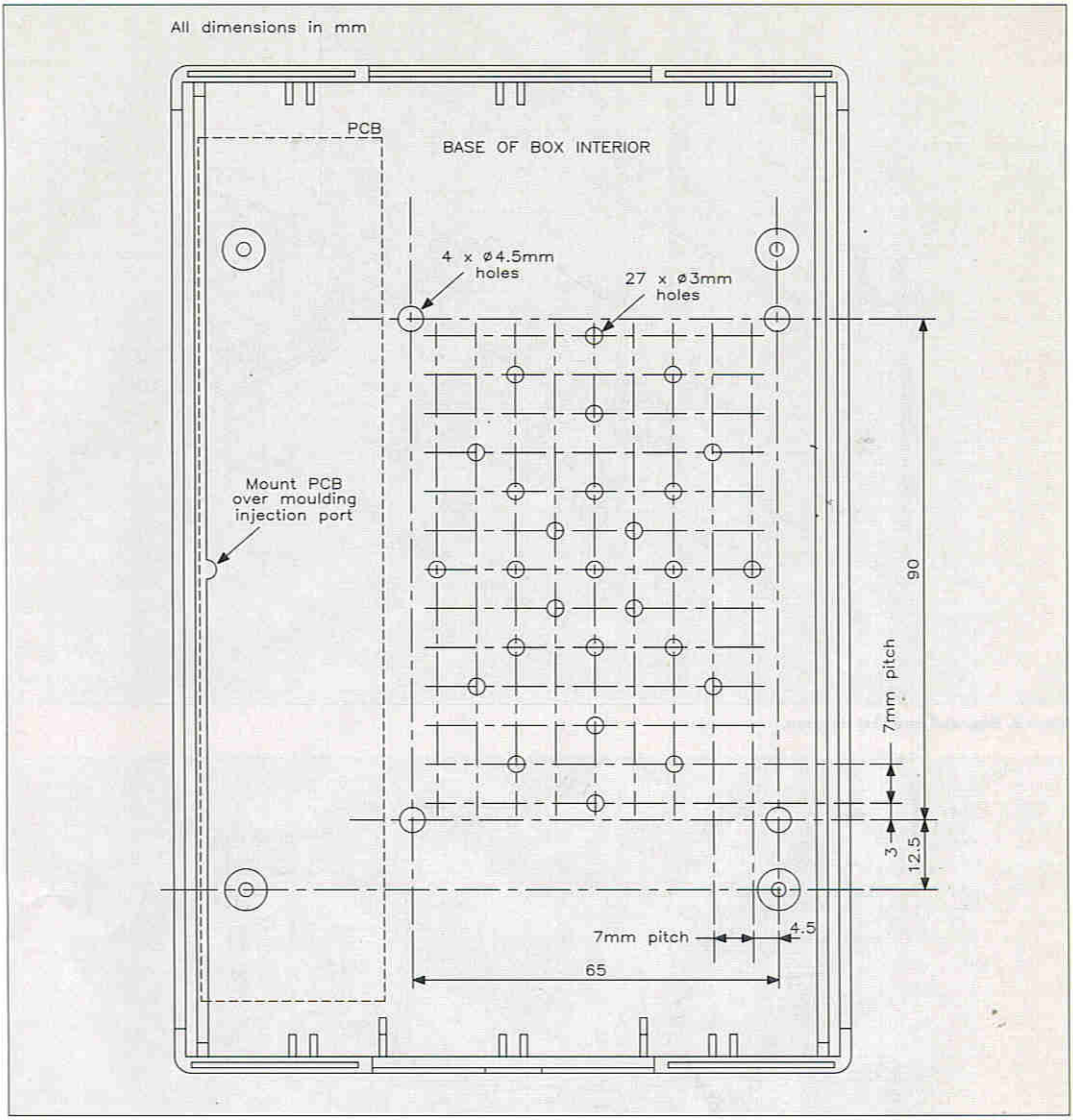


Figure 6. Base drilling details.

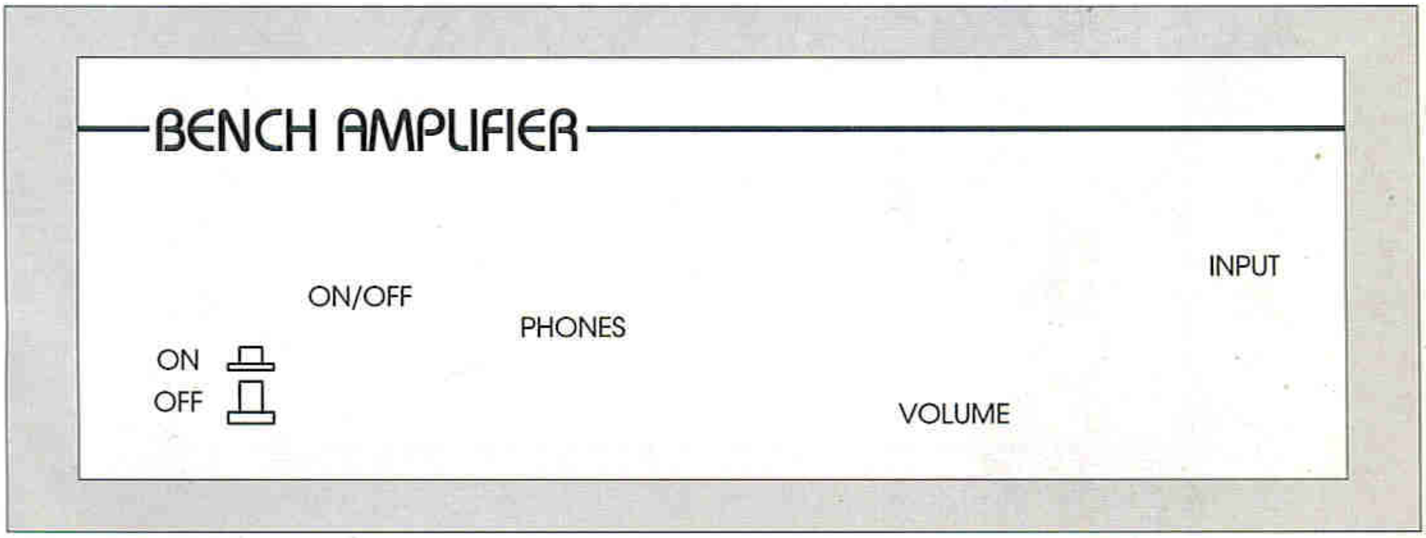


Figure 7. Front panel legend.

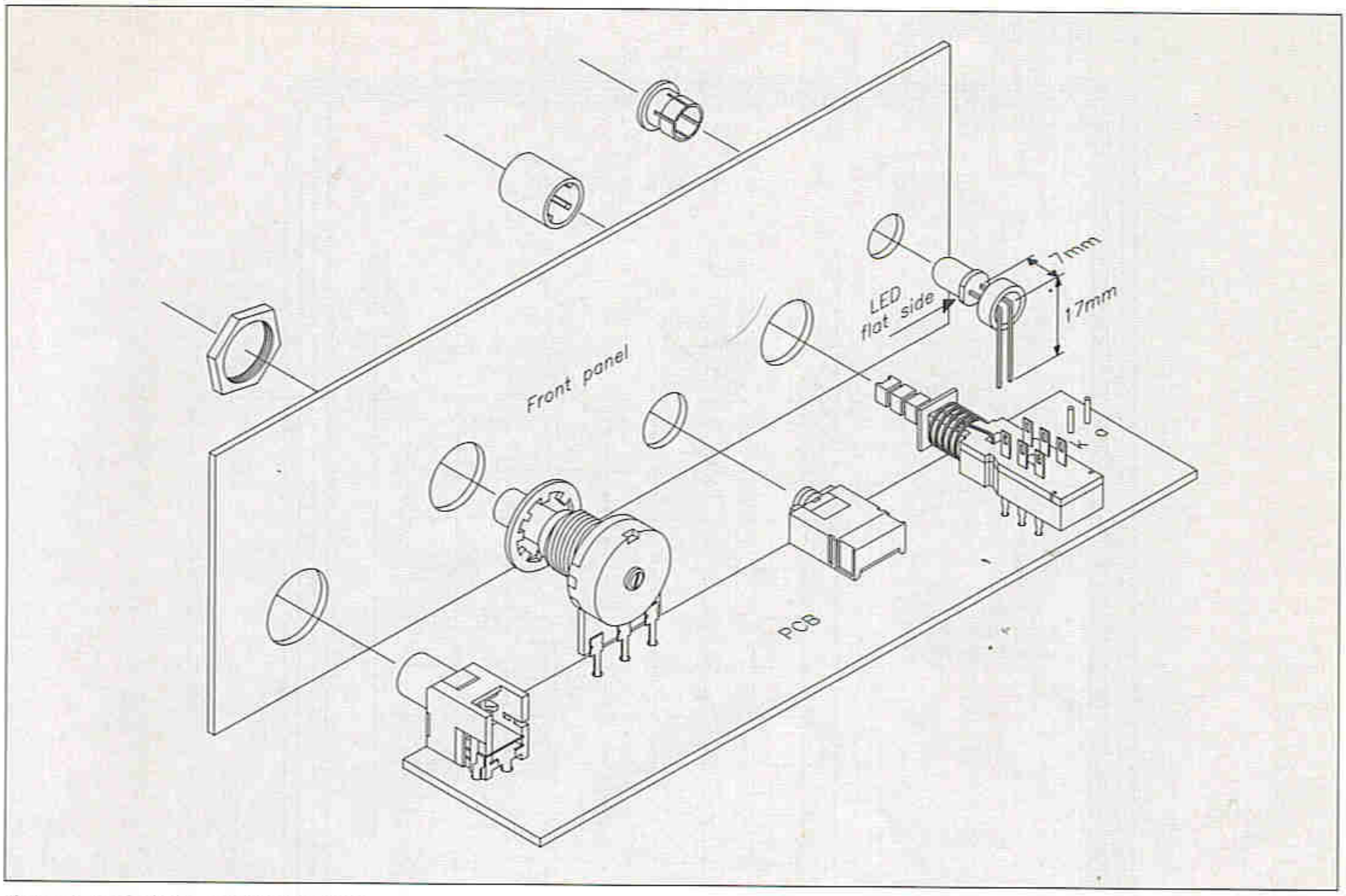


Figure 8. Exploded assembly diagram.

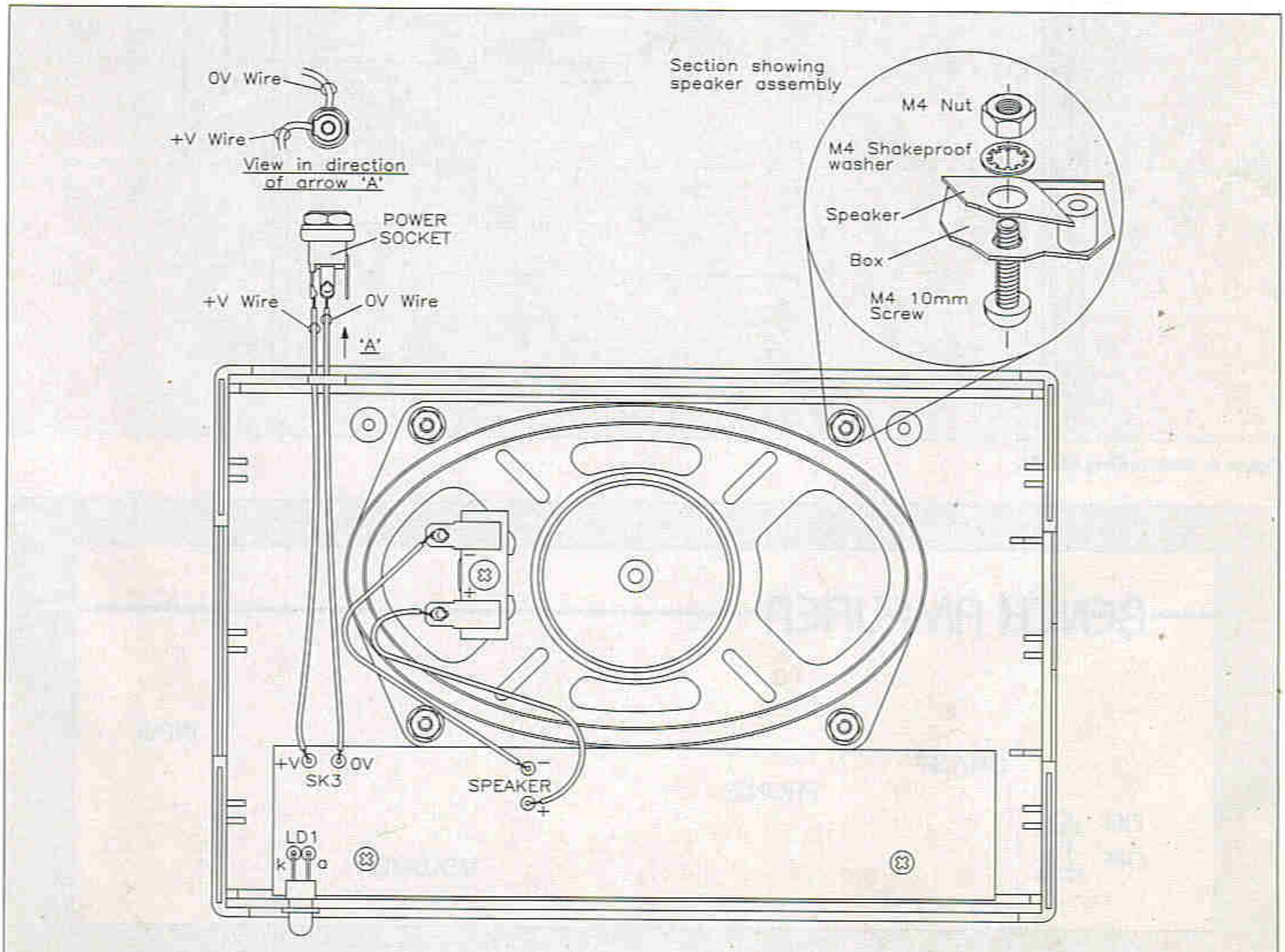


Figure 9. Wiring and speaker installation.

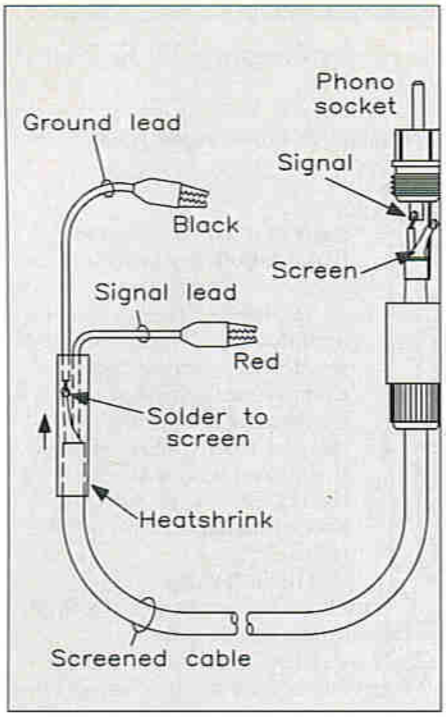


Figure 10. Making the test lead.

the self-adhesive panel (reproduced in Figure 7) legend to the (now drilled) front panel, and then cut out the holes using a sharp craft-knife or scalpel. Insert LD1's bezel into the panel, after trimming and bending the leads of the LED as shown in Figure 8. Insert the LED into the bezel, and lock it in position with the retaining ring.

Loosely assemble the PCB to the front panel as shown in Figure 8, holding it in place with RV1's securing nut. Note that the pot washer is fitted between the panel and the potentiometer.

Fit the whole assembly into the box, screw the PCB into position and tighten RV1's securing nut. Install the speaker into the box, as shown in Figure 9, and fix in place with the supplied M4 screws, nuts and washers.

Install the power socket into the rear panel, then slide the panel into the box. Solder the LED leads to the PCB pins marked 'a' and 'k' (refer once again to Figure 8). Wire up the power socket and speaker as shown in Figure 9. Finally, clip the two halves of the box together, and attach the rubber feet to the bottom of the box.

After making the test lead, as shown in Figure 10, the Bench Amplifier is complete and ready for testing.

Testing

Connect a 9V DC power source (e.g., XX09K battery eliminator) to the power socket (the centre pin is positive), plug the test lead into the phono socket, and turn the volume control anti-clockwise. Pushing the switch SW1 to its inner 'on' position, the LED should illuminate; if not, check the polarity of the supply. Connect a signal source (e.g., oscillator, radio, cassette player) to the test lead. As the volume control is turned up, the test signal should be heard from the speaker. When an earpiece or headphones is plugged into SK2, the speaker will be muted, but the sound source should still be heard, from the earpiece (or right headphone only in the case of stereo headphones).

Your Bench Amp is now ready for use!

BENCH AMPLIFIER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1	15k	1	(M15K)
R2	4k7	1	(M4K7)
R3	10k	1	(M10K)
R4	120Ω	1	(M120R)
R5	56Ω	1	(M56R)
R6	1Ω	1	(M1R)
R7	1k	1	(M1K)
R8	2k	1	(M2K)
RV1	1M Pot Log	1	(FW28F)
CAPACITORS			
C1	150nF Poly Layer	1	(WW43W)
C2,4	3n3F Poly Layer	2	(WW25C)
C3	330nF Poly Layer	1	(WW47B)
C5,9	100μF 25V PC Elect	2	(FF11M)
C6	47μF 25V PC Elect	1	(FF08J)
C7	220nF Poly Layer	1	(WW45Y)
C8	220pF Polystyrene	1	(BX30H)
C10	470μF 16V PC Elect	1	(FF15R)
C11	100nF 16V Minidisc	1	(YR75S)
C12	1000μF 16V PC Elect	1	(FF17T)
SEMICONDUCTORS			
IC1	TBA820M	1	(WQ63T)
D1,2	1N4148	2	(QL80B)
D3	1N4001	1	(QL73Q)
LD1	LED 5mm 2mA Red	1	(UK48C)
MISCELLANEOUS			
FS1	Fuse 20mm 400mA	1	(UJ77J)
S1	Latchswitch 2-pole	1	(FH67X)
SK1	PCB Phono Skt	1	(HF99H)
SK2	PCB 3·5 Stereo Switched Skt	1	(JM20W)
SK3	Panel Mount Power Skt 2·5	1	(JK10L)
	Elliptical Speaker 3W	1	(GL16S)
	LED Clip 5mm	1	(YY40T)
	Knob RN18 Red	1	(FD67X)
	Latchswitch Button Black	1	(KU75S)
	Fuse Clip 20mm Type 1	2	(WH49D)
	Pin 2145	1 Pkt	(FL24B)
	Wire 7/0·2 10m Black	1 Pkt	(BL00A)
	Cable Single Black	1 m	(XR12N)
	Screw-Cap Phono Black	1	(HQ54J)
	Croc Clip Red	1	(FS48C)
	Croc Clip Black	1	(FS49D)
	Steel Screw M4 x 10mm	1 Pkt	(JY14Q)
	Shake Proof Washer M4	1 Pkt	(BF43W)
	Steel Nut M4	1 Pkt	(JD60Q)
	Heat Shrink CP48	1 m	(BF89W)
	PCB	1	(GH36P)
	Front Panel	1	(DH84F)
	Instruction Leaflet	1	(XU15R)
	Constructors' Guide	1	(XH79L)
Optional (Not in Kit)			
	Verobox 215	1	(LQ08J)
	AC Adaptor Unreg. 300mA	1	(XX09K)

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.

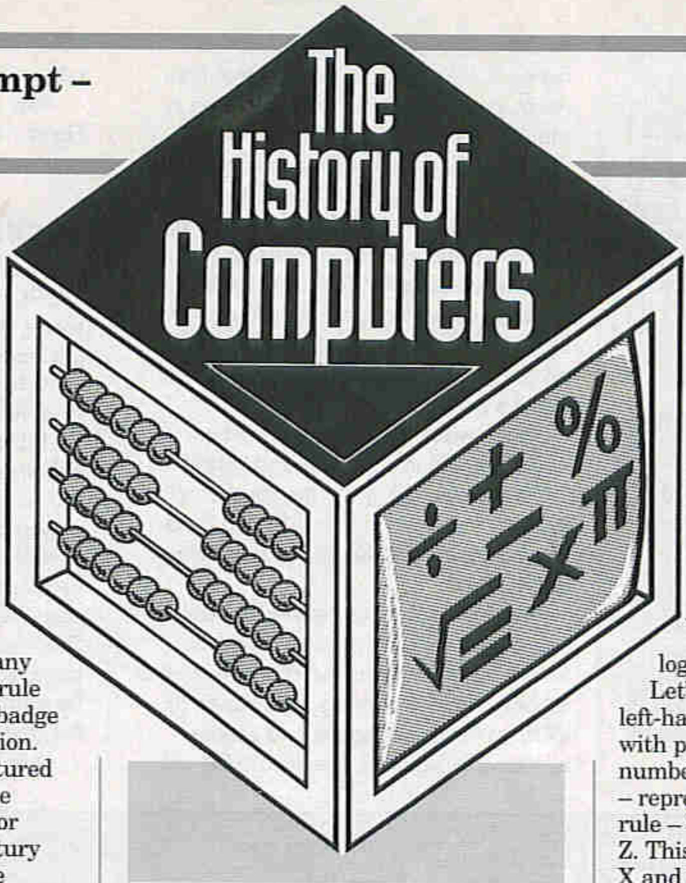
Order As LT30H (Low-Cost Bench Amplifier) Price £11.95

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 1993 Maplin Catalogue.

Low-Cost Bench Amp PCB **Order As GH36P Price £2.75.**
Low-Cost Bench Amp Panel **Order As DH84F Price £1.45.**

2. The Second Attempt – the Slide-Rule.



by Gregory M. R. Grant

The abacus reigned supreme for some 4,000 years. Its successor, the slide-rule, held sway for less than one tenth of that time. In these enlightened times the abacus is still used, the slide-rule hardly at all. There are people in many corners of the world who can still dazzle with an abacus. Conversely there is the odd codger like me who'd need some 10 to 15 minutes of familiarisation before giving anything approaching a passably versatile display with a 'guessing stick.'

Time was – and not all that many years ago either – when the slide-rule was king, widely regarded as the badge of office of the engineering profession. All the stars of the trade were pictured either using one, as in the wartime photograph of Sir Frank Whittle; or about to, as in the nineteenth century engraving of James Nasmyth. The advance of technology, though, spares no thought for what has been – only for what's to come. Perhaps the most obvious example of this is the slide-rule.

By the middle of the 16th century, Indo-Islamic numerals and place notation had permeated throughout Europe. They rapidly improved what calculating methods were then in use. This resulted in the further development of decimals, algebra, fractional calculation and logarithms. The latter formed the basis of the slide-rule – and much more besides.

In 1614, a Scottish theologian and mathematician published his 'Description of the Wonderful Logarithmic Canon', one of the outstandingly significant mathematical papers of the last 400 years. In it, John Napier put forward his method of multiplying numbers by adding their 'logarithms' and of finding roots by dividing a logarithm by the number of the root.

The logarithms we are most familiar with use the figure 10 as their base. Napierian logarithms, however, use a base of approximately 2·71828 which, although unusual, is most important as a base. This is because this rather odd number relates closely to events in the real world – NATURAL events, such as the growth and decay of charge on a capacitor, or the build-up and collapse of the magnetic field around an inductor. It's for this reason you'll sometimes find Napierian (or Hyperbolic) logarithms called 'natural' logarithms.

Napier's invention, though, was difficult to use in everyday work, and three years after his paper Henry Briggs, a geometry professor at London's Gresham College, brought out a small table of logarithms for numbers from 1 to 1,000. Seven years later he published 'Logarithmic Arithmetic', which contained the logs of numbers from 2,000 to 29,000 and 90,000 to 100,000.

Napier's brilliant origination inspired others, and three years after his death the English mathematician William Gunter developed a physical analogue of logarithms. What he did was take a sheet of parchment, on which he drew a grid of lines. Numbers could be divided and multiplied by adding and subtracting their lengths with a pair of compasses. Every point on the scale or line was exponentially distant from the others. As with logs, the principal operating criterion was the exponent. Not surprisingly, Gunter's discovery achieved some popularity with seamen and navigators.

In 1622, another English mathematician, William Oughtred, took a hard look at Gunter's origination. He rearranged the lines into two circles, re-calculated the numbers and arranged them on a stock of wood between two fixed slats. The slide-rule was born.

Yet another clergyman with a mathematical bent, Oughtred was the first man to realise that you could still use mechanical movement with the new mathematics, just as the abacus had been used with the old. So how do you go about calculating with a slide-rule?

The first thing to realise is that the scales along the rule are logarithmic, as in Figure 1. Let's move the upper rule until the left-hand edge of the one below it is level with point X, representing one of the numbers we want to multiply. The other – represented by point Y on the lower rule – is directly under a third quantity Z. This last is the result of multiplying X and Y.

In other words, the distance between points X and Y is a physical representation of their logarithmic relationship in numerical terms. So a slide-rule gets its computing abilities from mechanical manipulation, NOT mathematical processing.

Oughtred's first slide-rule was a circular one, which he followed a year later with a rectilinear example. The earliest rule, the sliding stock so familiar to us, first appeared in 1654, the work of Robert Bissaker. Later Seth Partridge, Henry Coggeshall and Thomas Everard would improve the original model throughout the 17th century. The next improvement would be that of accuracy in graduation, brought about by Matthew Boulton and James Watt around 1779.

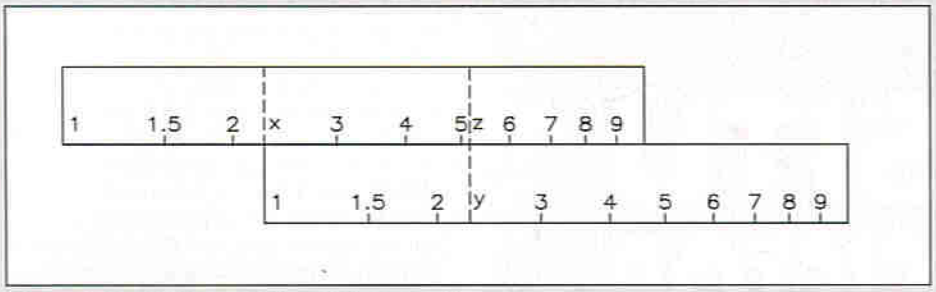
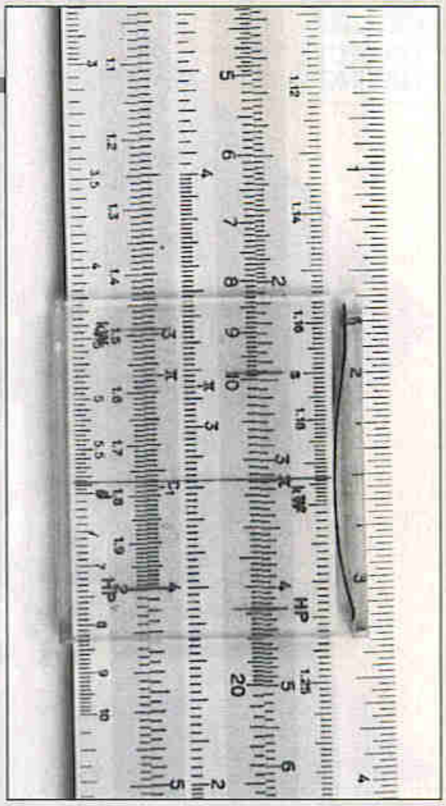


Figure 1. A rectilinear slide-rule in operation.



The first of the modern slide-rules was that made by a French artillery officer, Amédée Mannheim, in 1859, who was the originator of the cursor. Some 30 years later William Cox introduced scales on both sides of the rule and glass indicators also.

By far the most interesting slide-rules, though, were the specialist ones. In 1881, the American inventor E. Thacher brought out a large cylindrical rule containing two logarithmic scales. They were engraved on the edges of no less than 20 triangular bars which were divided into 40 sections. To operate it, you again needed a pair of compasses, with which you added and subtracted the values. It was accurate to four places of decimal.

This was the first of many such rules, all of them masterpieces of the instrument maker's art and latterly, capable of six-figure accuracy on a single operation. In fact, up to 20 years ago, almost all technical colleges, research laboratories and universities had access to at least one such rule for really accurate work.

By the early 1950s, the first plastic slide-rules appeared and a Northrop Aircraft Corporation engineer, Dick Bemis, built a circular rule the size of a dining table. Probably the largest rule ever made, he used it for aerodynamic calculations.

Less than a quarter of a century into its active life, the slide-rule faced competition; the first mechanical calculator appeared.

To be continued...

MAPLIN'S TOP TWENTY KITS

POSITION			DESCRIPTION OF KIT	ORDER AS	PRICE	DETAILS IN		
1.	(1)		L200 Data File	LP69A	£ 4.75	Magazine	46	(XA46A)
2.	(3)		Live Wire Detector	LK63T	£ 4.75	Magazine	48	(XA48C)
3.	(2)		LED Xmas Tree	LP83E	£ 9.95	Magazine	48	(XA48C)
4.	(7)		MOSFET Amplifier	LP56L	£20.95	Magazine	41	(XA41U)
5.	(8)		Car Battery Monitor	LK42V	£ 9.25	Magazine	37	(XA37S)
6.	(5)		Lights On Reminder	LP77J	£ 4.75	Magazine	50	(XA50E)
7.	(9)		TDA7052 1W Amplifier	LP16S	£ 4.95	Magazine	37	(XA37S)
8.	(6)		1/300 Timer	LP30H	£ 4.95	Magazine	38	(XA38R)
9.	(4)		LED Xmas Star	LP54J	£ 7.75	Magazine	41	(XA41U)
10.	(10)		Courtesy Light Extender	LP66W	£ 2.95	Magazine	44	(XA44X)
11.	(12)		IBM Expansion System	LP12N	£21.95	Magazine	43	(XA43W)
12.	(11)		Partylite	LW93B	£12.45	Catalogue	'93	(CA10L)
13.	(13)		Mini Metal Detector	LM35Q	£ 7.25	Magazine	48	(XA48C)
14.	(14)		UA3730 Code Lock	LP92A	£11.45	Magazine	56	(XA56L)
15.	(15)		I/R Proximity Detector	LT00A	£10.95	Magazine	54	(XA54J)
16.	(16)		RS232 TTL Converter	LM75S	£10.75	Magazine	31	(XA31J)
17.	(-)	NEW ENTRY	Music Maker	LT09K	£ 3.95	Magazine	57	(XA57M)
18.	(17)		MSM6322 Data File	LP58N	£12.95	Magazine	44	(XA44X)
19.	(-)	NEW ENTRY	Beginners AM Radio	LP28F	£ 8.95	Magazine	42	(XA42V)
20.	(19)		TDA2822 Stereo Amplifier	LP03D	£ 7.95	Magazine	34	(XA34M)

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.

1

PROJECT RATING

IN-SITU TRANSISTOR TESTER

by Terry Pinnell

FEATURES

- ★ Tests NPN and PNP Transistors – In or Out of Circuit
- ★ Easy to Use – 2-LED Indication of Transistor Condition
- ★ Low Power Consumption
- ★ Easy to Build
- ★ Low Cost

APPLICATIONS

- ★ Testing Ex-Equipment Transistors
- ★ Servicing

I made this little device about ten years ago, and it has proved to be one of the most useful items of test gear on my workbench. Transistor testers of more conventional design have been published regularly in the electronics hobbyist magazines, and many digital multimeters now also include facilities for testing transistor gains. But all of these assume the transistor is in splendid isolation, with its leads neatly available and disconnected from other circuitry. In unique contrast, the unit described here can also test a transistor which is still permanently connected in its circuit.

If your projects always work first time – and never go wrong – then you probably won't need this gadget. But I suspect most hobbyists have similar problems to mine. Once a project has been assembled, Sod's Law dictates that it will exasperatingly refuse to do what it should. Or it will fail months (or even years) later, when all memory of its design and peculiarities have long since faded away, and you must fall back on any records you made, or on the original published article (if any).

Of course, there are many possible reasons for a project failing to work – like poor soldering, careless wiring, polarity-reversed capacitors or diodes, and even (admit it!) an overlooked run-down battery or blown fuse. But experience indicates that faulty transistors take a high place in this league-table. Their failure can be attributed to a variety of causes. It could be because they had been connected wrongly, or that too much heat was applied when soldering. Perhaps current flow was excessive, because of incorrect resistor values, eventually burning out the transistor. If the usual protective surge diode associated with the switching of inductive loads (such as relays) is of inadequate rating, then the transistor might survive a hundred operations and give up the ghost on the next.

However, whatever the cause, it usually becomes blindingly obvious only after you've discovered it! Until then it can be an infuriating mystery. When the circuit dies on you and you've checked all the obvious things, shaken it around a bit, applied a soldering iron hopefully to a few random joints and changed the odd IC, then sooner or later you'll want to check out the transistors. In some cases, if you have a clear idea of the circuit's principles and are comfortable with a bit of basic electronics theory, then you can methodically perform tests with your multimeter and logically draw conclusions about each transistor's status. But if you are not such a masochist, then you need the In-Situ Transistor Tester. It avoids any unsoldering, can be used even in a crowded circuit, and reliably gives a clear indication of the component's condition, for both NPN and PNP types.

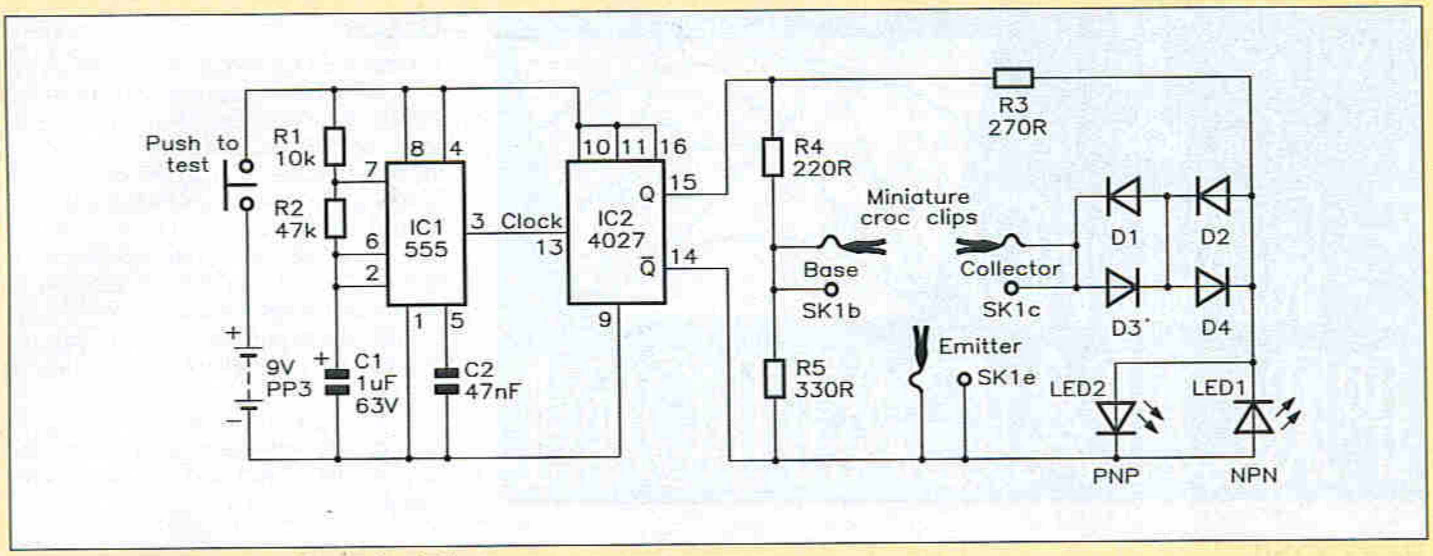


Figure 1. In-Situ Transistor Tester circuit diagram.

Circuit Description

The full circuit diagram is shown in Figure 1. When power is applied via the push-button, a conventional 555 astable multivibrator produces square pulses at a frequency of about 10Hz. These clock the 4027 CMOS J-K flip-flop, IC2. Note that IC2 is actually a dual device, but only one of the two flip-flops is used here. With both inputs taken to +V, each positive-going edge of the clock input (pin 13) causes the output (pin 15) to go high and low alternately – the flip-flop effectively divides the signal frequency by two. Note that when pin 15 is high, the complementary output $\bar{Q}$ (pin 14) is low, and vice versa.

These outputs are at a low-ish impedance and can provide quite a large maximum current (around 10mA) at the 9V supply level used here, which is more than enough to drive the bases of most transistors, including power types.

To understand how the transistor section of the circuit works, let us take an NPN type as an example, and consider each half of the astable cycle in turn. Figure 2 shows the situation when Q is high and $\bar{Q}$ is low – the transistor is switched on, via current limiting resistor R4. This means that the two LEDs are effectively shorted out, because the voltage drop across D1 and D2 is about 1·2V – significantly less than the 1·8V or so needed by the LED. As a result, neither LED is lit during this period.

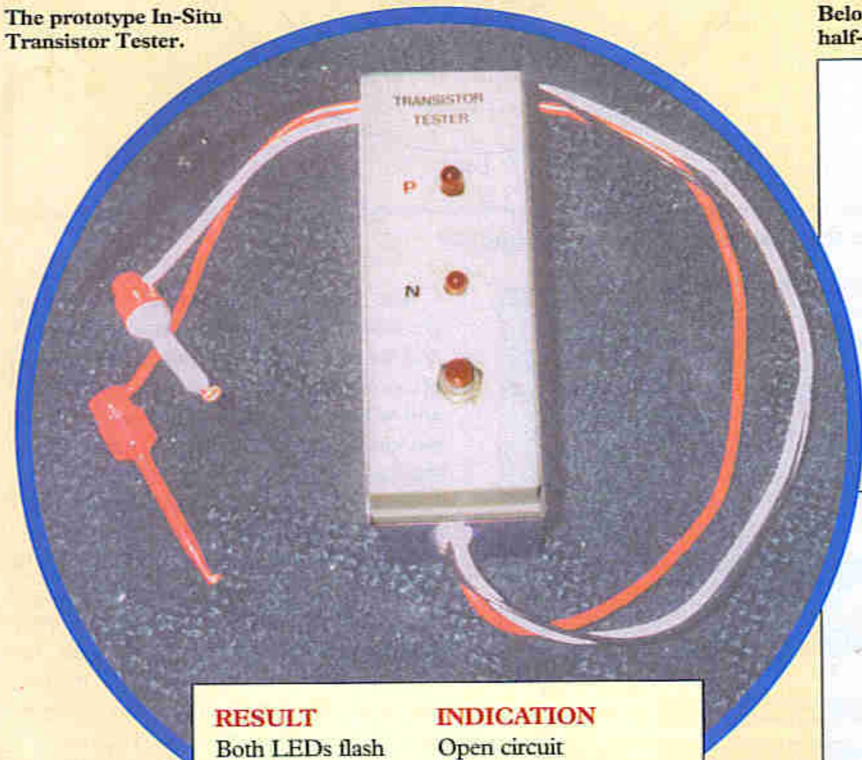
When the flip-flop outputs change polarity during the second half of the cycle, with Q now low, the status is as in Figure 3. The transistor is now reverse-biased, so it is switched off and all current flows through LD1, via limiting resistor R3. LD1 therefore flashes on and off, correctly indicating a properly functioning NPN transistor under test.

A similar analysis will show that LD2 flashes for a good PNP type.

An open-circuit transistor (perhaps burnt out) will pass current on neither half-cycle, so both LEDs will flash on and off alternately. However, if the transistor is shorted out between collector and emitter it will always conduct, and therefore neither LED will be lit at any time.

The four diodes (D1, D2, D3 and D4) are present to allow for situations where the transistor has a base-collector or base-emitter short. Here, the other (working) junction

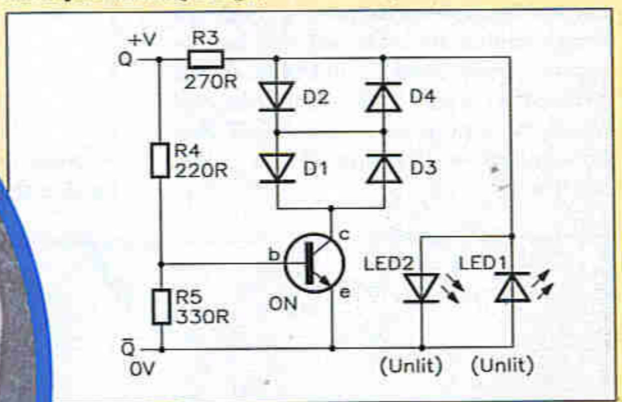
The prototype In-Situ Transistor Tester.



RESULT	INDICATION
Both LEDs flash	Open circuit
or	Base-Emitter short
or	Base-Collector short
LED1 flashes	NPN OK
LED2 flashes	PNP OK
Neither flash	Collector-Emitter short

Table 1. Possible transistor test results.

Below: Figure 2. Effective circuit for NPN transistor during half-cycle when Q is high.



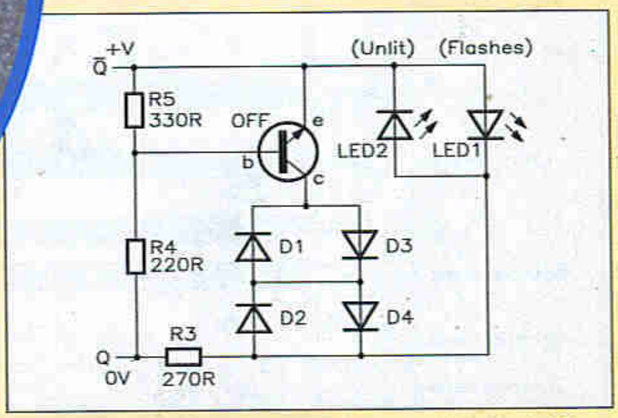
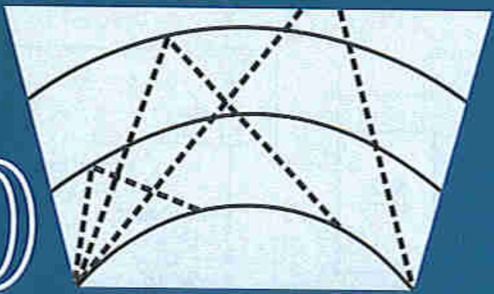


Figure 3. Effective circuit for NPN transistor during half-cycle when Q is low.

Continued on page 20.

A Listener's Guide to RADIO PROPAGATION



PART ONE

by Ian Poole G3YWX

It is quite easy for short wave listeners, and radio amateurs, to obtain better results from their equipment by simply knowing a little about propagation. Not only is the study of propagation useful, but it is also interesting. In some ways it is a bit like predicting the weather. Conditions change from one frequency to another, and from one day to the next. The time of day, the time of year, and the time in the 11 year sunspot cycle, all have a bearing on the state of propagation. In addition to this, the weather can govern the reception conditions on some frequencies. Even though all of this may seem complicated, it is possible to quickly get a grasp of the principles and use them to the best advantage.

When looking at the way signals of different frequencies are affected, there is a rough divide between signals below approximately 30MHz, and those in the VHF portion of the frequency spectrum, and above. As a starting point, it is probably best to look at those frequencies below 30MHz first.

Basics

It is common knowledge that signals on the short wave bands are bounced around the earth by the ionosphere. This enables signals to be regularly heard from the other side of the world. However, to understand how this happens, a look at the earth's atmosphere is needed. See Figure 1.

It can be seen that the atmosphere can be split into a number of different areas or layers. The one closest to the surface of the earth is called the troposphere, and it is this area that has the most affect on our climatic changes.

A little higher up, is the stratosphere, and as far as radio propagation is concerned, this layer has little effect, and it is rarely mentioned.

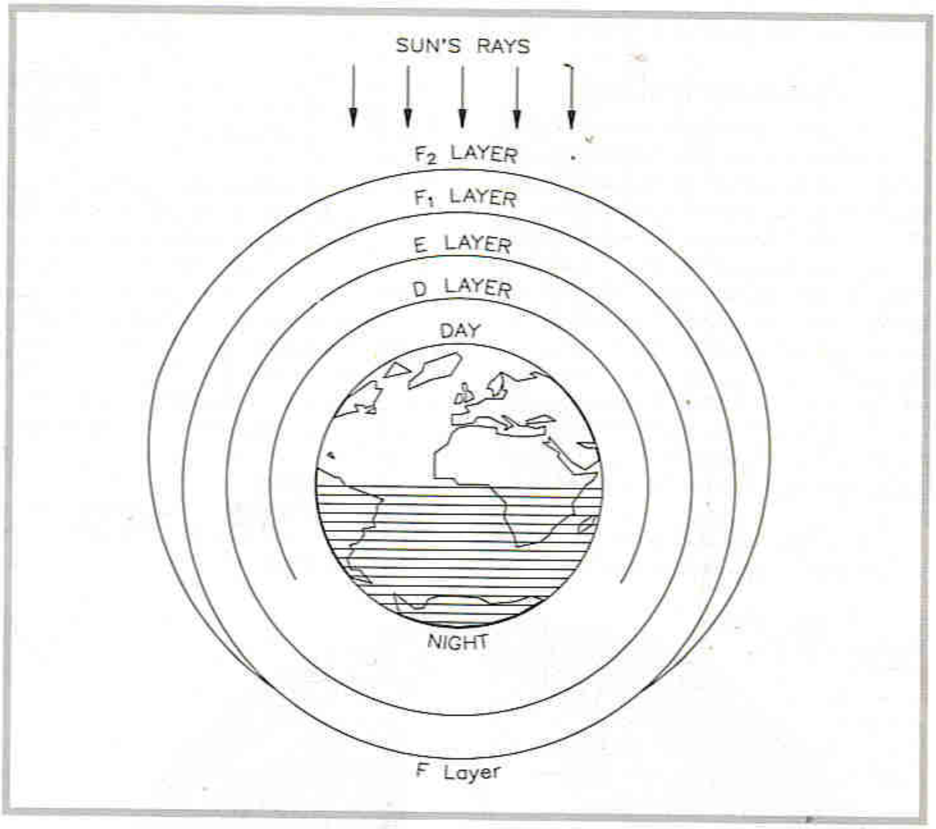


Figure 2. The ionospheric layers by day and night.

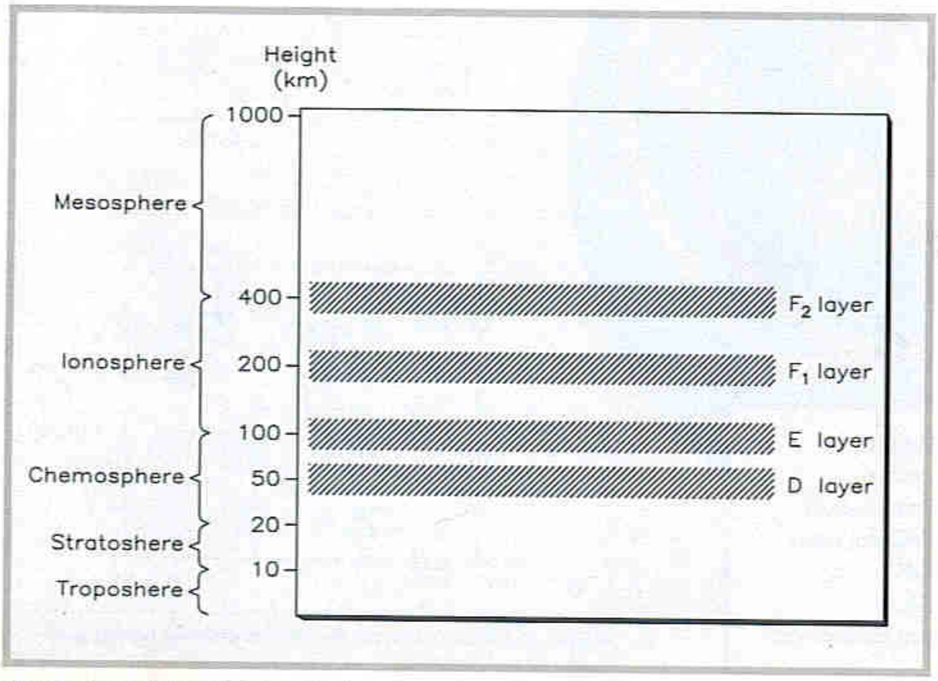


Figure 1. The make up of the earth's atmosphere.

The same is not true for the next two layers which are known as the chemosphere and the ionosphere. It is here that a number of ionised layers are found. These layers bend and reflect radio waves, and provide us with worldwide communications – for which the short wave bands are renown

As these ionised layers are in the upper reaches of the atmosphere, it is hardly surprising that they are greatly affected by the sun. In fact, it is the sun which has caused the ionisation in the first place. Accordingly, fluctuations in the state of the sun, i.e. sunspots, as well as the seasons and the time of day, will affect these layers, and hence the state of radio propagation. See Figure 2.

The lowest of the ionised layers is the 'D-layer', which is in the chemosphere at a height of approximately 50km. It is only present during the day when the sun causes the ionisation in the chemosphere to rise. This layer absorbs radio waves in the low frequency portion of the spectrum with the result that, during the day, only local signals can be heard. At night, when this layer is not present, signals from much further afield can be heard.

The next layer occurs at a height of approximately 100km. This is called the 'E-layer', and instead of just absorbing signals, it manages to reflect some of the signals – providing they have managed to pass through the 'D-layer'.

Finally, above the 'E-layer', resides another layer called the 'F-layer', which also reflects signals, and being the highest layer, it is mainly affected by the sun. During the night, when the sun has no effect, it consists of a single layer at a height of approximately 250km. However, during the day, this layer splits into two. The lowest layer, called the 'F1-layer' is about 200km high, and the second layer, called the 'F2-layer' is between 300 and 400km high.

Changes with Frequency

To understand how these layers affect radio signals, imagine a radio transmitter that can tune its signal over a wide range of frequencies. When it is operating at low frequencies, up to the long wave broadcast band, the signal spreads out in all directions along the ground, and can be heard over a considerable distance. This mode of propagation is, not surprisingly, called a ground wave. For these low frequencies it is very effective, because the attenuation caused by the ground is relatively small – for instance, the BBC Radio 4 long wave transmitter at Droitwich can be received over most of the UK as well as over a large area of Europe.

As the signal increases in frequency, attenuation of the ground wave increases. Medium wave transmissions still rely on the ground wave but their coverage is much reduced. For example, the BBC national networks, Radio 1 and Radio 5, need several transmitters to cover the UK. Also, this reduced coverage makes the medium wave band ideal for local radio stations, such as the BBC and Independent Local Radio.

Normally, stations on these frequencies do not expect to use ionospheric reflections because the 'D-layer' absorbs the signals. However, at night, when the 'D-layer' has disappeared, stations from much further afield can be heard. Some listeners stay up into the early hours of the morning, when many of the European stations are off the air and interference levels are lower, so that they can listen to stations that transmit from across the Atlantic.

As our imaginary transmitter moves up in frequency, the ground wave signal coverage becomes much less. Also, the effect of the 'D-layer' is reduced until signals can finally penetrate it. When this happens, the signal will reach the next layer up, which is the 'E-layer'. This layer will bend, or refract, the radio waves so that they are reflected back to earth. The signals that are reflected in this way are called 'skywaves' – for obvious reasons. See Figure 3.

As the signal frequency increases still further, the signal will be affected less by the 'E-layer' and will penetrate further into it. Finally, a stage is reached when the signals pass through and travel on to the 'F1-layer'. Again, this layer will bend the signals and reflect them back to earth. However, as the frequency increases again, the signals will pass through and travel on until they reach the 'F2-layer', where the same thing happens again, and they are reflected back to earth. However, eventually a frequency is reached, when the signal will pass through all the layers and travel on into outer space.

Hops and Distances

Sometimes, it is possible to hear only one side of a conversation, when two stations are in contact on the same frequency. The reason for this is quite simple. The signals leave the transmitting aerial and travel towards the ionosphere where they are reflected back to the receiver. In fact, they leave the aerial at a variety of angles so that they will hit the ionosphere at different places. However, if they hit the ionosphere at too steep an angle, they will pass straight through. As there is a gap in which the ground wave signal cannot be detected, and the reflected signal starts to appear, there is an area where no signal can be heard. This is called the 'skip' or 'dead zone', this shown in Figure 4.

As the individual layers in the ionosphere are at different heights, signals will be received at varying distances from the transmitter, depending on which layer reflects them. As a rough guide, the maximum distance for 'E-layer' propagation is about 2000km, whereas the 'F-layer' will give about 4000km.

With these maximum distances in mind, this does not explain how signals can be heard from places all over the world. As an example, it is quite easy to hear stations from Australia and New Zealand, shortly after sunrise, on the 20m amateur band. The most common way in which this happens is when the signal uses several hops, as shown in Figure 5. In this case, the signal leaves the transmitter and is reflected by the ionosphere. When it reaches the earth, it is reflected back up to the ionosphere, and so forth. Even though the earth is not always a good reflector, the amount reflected is quite sufficient for signals to propagate in this way. However, each reflection, whether it is by the earth or

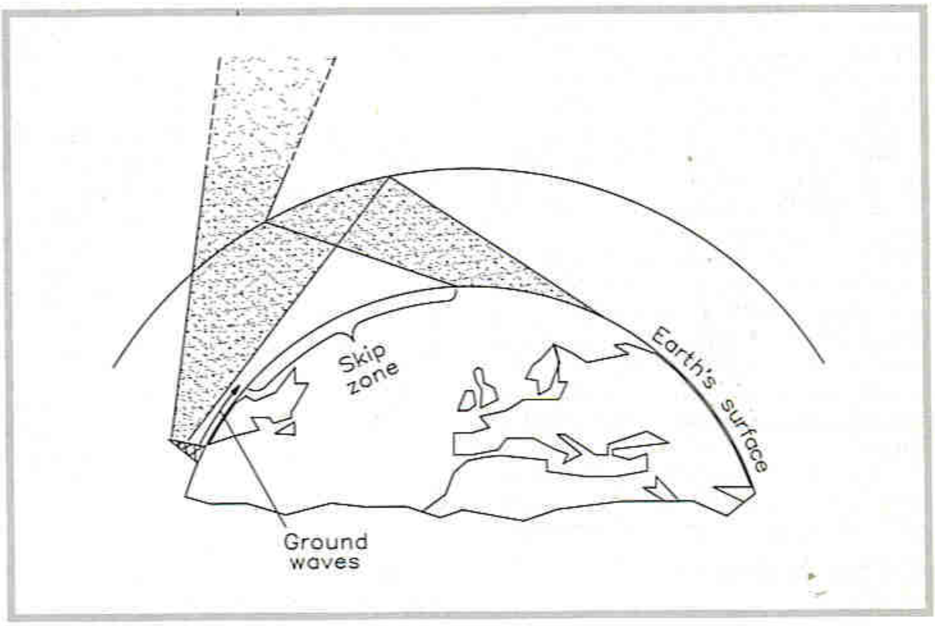


Figure 4. Skip Zone.

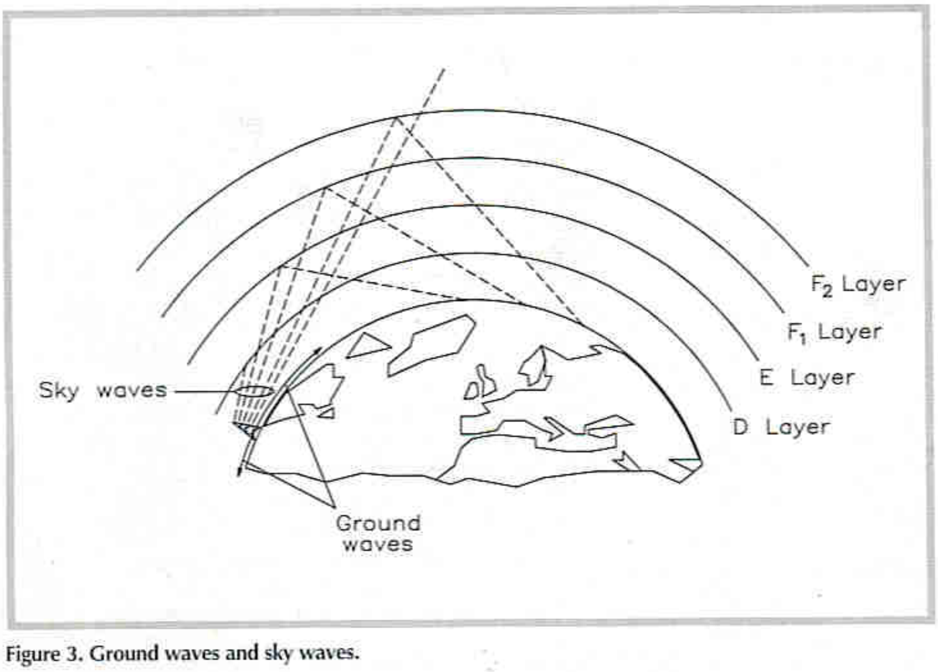


Figure 3. Ground waves and sky waves.

the ionosphere, will reduce the signal strength. Even so, it is still quite common to receive good, strong signals over vast distances.

Summary

Signal propagation on the HF bands can vary quite markedly with time. In addition, frequencies in different parts of the spectrum will behave in totally different ways. To get a real feel for the properties of the various bands, there is no substitute for actually listening to stations on these bands, to appreciate just what can be received. However, it is possible to give a very broad guide, bearing in mind that conditions can change quite markedly over comparatively short periods of time.

It has already been mentioned that the medium wave band gives local coverage by day, but at night stations from further afield can be heard. This pattern remains broadly true for frequencies a little higher than this band. However, as the frequency increases, the coverage area starts to increase too. At frequencies up to 5MHz or so, it is possible to receive stations in many parts of the UK during the day, and stations outside the UK at night. At around 10 to 15MHz, stations from all over Europe can be received by day, then particularly around sunrise and sunset, the distances reached can be much greater. Also, propagation during the night is often good for stations in places such as the USA, which are often audible for long periods of time. Higher in frequency, the propagation becomes a little less reliable. Often the bands will produce their most distant stations during the day and will 'close' at night, so that no stations can be heard. This is particularly true of frequencies in the higher portion of the spectrum, towards 30MHz. In addition, the highest frequencies will not support long distance propagation, via the ionosphere, in periods of low sun spot activity. This occurs over an eleven year cycle, and we have just passed the peak, so the high frequency bands should become less active in the following years.

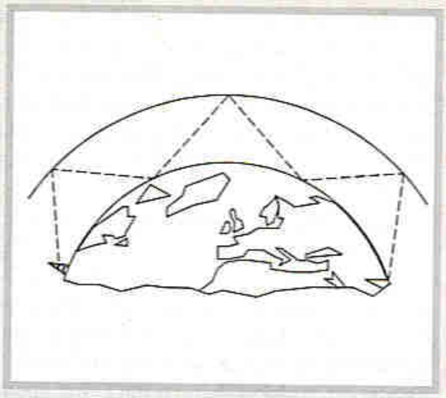


Figure 5. Multiple Hops.

It must be remembered, that signal propagation below 30MHz is only part of the story. Above this, it is every bit as interesting although distances are not as great, except when satellites are used.

In-Situ Transistor Tester continued from page 17.

would act as a diode, conducting on half-cycles – misleadingly indicating a good component. If D1 and D2 (or D3 and D4) conduct, the voltage dropped across them is about 1·2V. If the transistor was functional, only about 0·1V would be dropped across it – so in total, the voltage across the diodes and transistor would be about 1·3V, insufficient for the LEDs to be activated on those half-cycles when the transistor is on. On the other hand, if the transistor has a base-collector or base-emitter short, then the voltage drop across it will be about 0·6V, giving a total of approximately 1·8V – enough to light up the appropriate LED. As a result, both LEDs will flash, as they would for the quite different fault of an open-circuit transistor. All these possible results are summarised in Table 1.

Power consumption is low; in fact the prototype's original 9V PP3 battery lasted until quite recently – not bad Ever Ready!

Construction

The method of construction is not critical – you can use stripboard or even etch your own PCB, if you like. I built the original In-Situ Transistor Tester circuit on a small piece of Veroboard. As you can see from the photograph, I used an empty photographic slide container to house this project, and it still looks OK after ten years. A small project box from the current Maplin range would be more suitable, though!

In addition to the three miniature crocodile clips, a transistor socket could be mounted onto the case for the convenient testing of new or unsoldered components.

Due to its simplicity, this circuit should be easy to assemble. The standard rules of electronic construction, as outlined in the Constructors' Guide, apply here – in particular, make sure that polarised components (D1 to D4, C1, IC1, IC2) are wired up correctly. Once your circuit has been built up, it is always good practice to check it for solder bridges, misplaced components, dry joints and so on – mistakes spotted now save frustration and expense later.

Use

For virtually all the tests I've ever made, the unit has worked perfectly. There are conceivable situations, however, when it is theoretically possible for the tester to give a misleading result. For example, transistors that have particularly low value resistors across their base-collector or base-emitter junctions may prove problematic. R4 should prevent this from happening, unless such resistors have a value of 47Ω or less. In practice, though, even power transistors can usually be satisfactorily tested in-circuit.

The In-Situ Transistor Tester is also useful if, like me, you tend to hoard old transistors. Sometimes you may even be unsure whether they are NPN or PNP, much less whether they work or not! Using this unit, you can quickly answer both questions.

In summary, short of unsoldering the faulty component and replacing it, this handy little gadget just about does it all!

Note

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

IN-SITU TRANSISTOR TESTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1	10k	1	(M10K)
R2	47k	1	(M47K)
R3	270Ω	1	(M270R)
R4	220Ω	1	(M220R)
R5	330Ω	1	(M330R)
CAPACITORS			
C1	1µF 63V Minelect	1	(YY31J)
C2	47nF 16V Ceramic	1	(YR74R)
SEMICONDUCTORS			
IC1	NE555	1	(QH66W)
IC2	4027BE	1	(QX16S)
D1 – D4	IN4148	4	(QL80B)
LD1, 2	LED 5mm Red	2	(WL27E)
MISCELLANEOUS			
	8-pin DIL Socket	1	(BL17T)
	16-pin DIL Socket	1	(BL19V)
	PP3 Battery Clip	1	(HF28F)
	Alkaline PP3 Battery	1	(FK67X)
	Wire 7/0·2 Red	1 Pkt	(BL07H)
	Wire 7/0·2 Black	1 Pkt	(BL00A)
	Wire 7/0·2 White	1 Pkt	(BL09K)
	Stripboard	1	(JP46A)
	Miniature Crocodile Clip Red	1	(FM37S)
	Miniature Crocodile Clip Black	1	(FK34M)
	Miniature Crocodile Clip White	1	(FK37S)
	TO18 Transistor Socket and/or	1	(WR29G)
	TO5 Transistor Socket	1	(WR31J)
	Push-to-Make Switch	1	(FH59P)
	Housing e.g.: Hand-held Case with Battery Compartment	1	(ZB17T)
	Constructors' Guide (if required)	1	(XH79L)

The Maplin 'Get-you-Working' Service is not available for this project.
The above items are not available as a kit.

PROJECT RATING 2

15W POWER AMPLIFIER MODULE

Design revised by Dennis Butcher
Text by Martin Pipe and Dennis Butcher

FEATURES

- ★ 15W RMS Output Power (into 4Ω load)
- ★ Short-Circuit Protected
- ★ Low Distortion
- ★ Amplifier and Power Supply Kits Available
- ★ Low Cost

APPLICATIONS

- ★ Superior Replacement Amplifier Module for Most Music Centres
- ★ Monitor Amplifier
- ★ Bench Amplifier

This article describes a 15W Hi-Fi amplifier module based around the TDA2030A IC; this design is an improvement on the existing tried and tested 15W TDA2030 amplifier that has given consistently high performance for over 12 years. By a careful redesign of the original PCB layout, and a few judicious component changes, the performance has been considerably improved over the original. As you can see from the specifications (refer to Table 1), the total harmonic distortion (THD) has been reduced to less than 0·1% across the board (it was originally as high as 5%), with a useful increase in the output power. All of this adds up to an extremely versatile little (literally – it only measures 63 x 60mm!) amplifier with a very useable output power rating. The output, incidentally, is completely short-circuit proof and, although the over-stressing of any electronic device is not recommended, the built-in thermal protection means that the IC is capable of surviving most fault conditions. Construction is quite easy, as the component count is low, and no elaborate test equipment is required for setting up the completed amplifier. It is worth noting that all the test figures quoted are 'worst case'; they were achieved using the uncased prototypes in an electrically 'noisy' environment (laboratory bench-top), and all connections were made with unscreened cable; provided that reasonable care is taken in construction and installation, the results obtained in normal use should actually be far better!

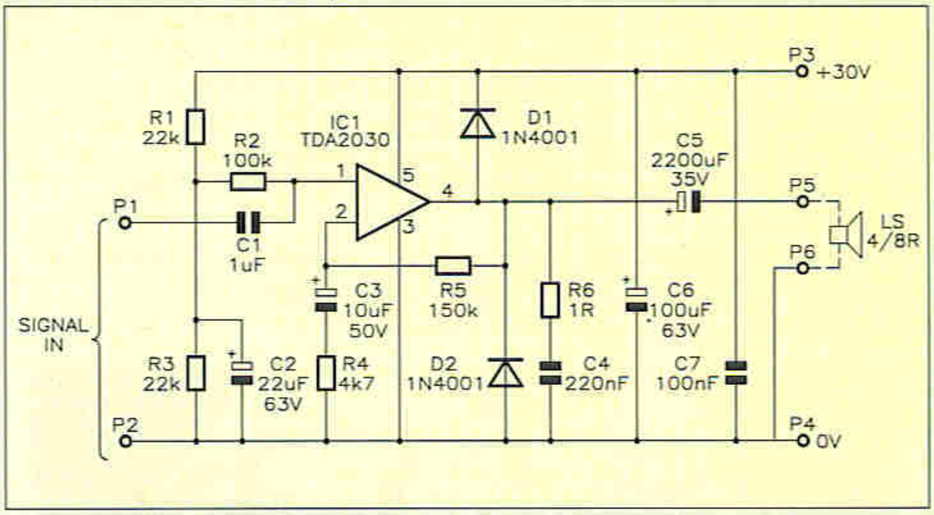


Figure 1. 15W Amplifier Module circuit diagram.

The assembled Power Supply.

Circuit Description

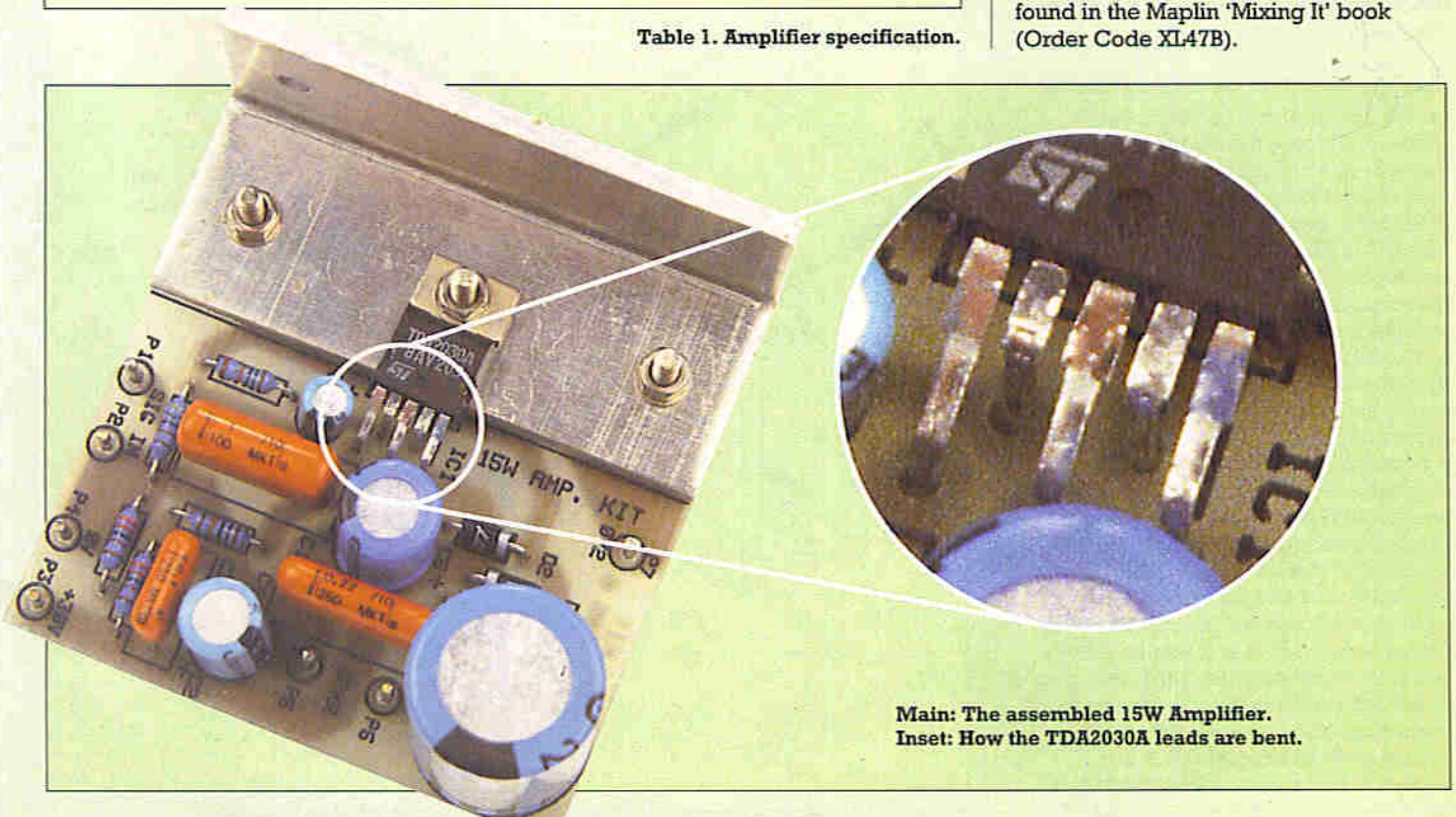
Referring to the amplifier's circuit diagram of Figure 1, it can be seen that most of the circuitry is contained in the TDA2030A (IC1), the pinout of which is shown in Figure 2. C3, R4 and R5 are the components that control the closed-loop gain of the amplifier; to experiment with the gain of the amplifier, any or all of these three components may be altered in value – within certain constraints of course! Note that the manufacturer recommends that the closed-loop gain should always be higher than 24dB; any lower, and the amplifier will become unstable.

The input is ac-coupled by C1, and should therefore be easy to interface to a preamp or line-level source such as the output of a cassette deck or microphone preamp. Some useful ideas may be found in the Maplin 'Mixing It' book (Order Code XL47B).

Maximum Supply Voltage:	40V DC
Output Short Circuit Protection:	Continuous
Input Sensitivity for maximum output (4Ω speaker load):	244mV RMS (–10·03dBu)
Input Sensitivity for maximum output (8Ω speaker load):	288mV RMS (–8·59dBu)
Total Harmonic Distortion * (mono into 4Ω):	0·05% (15W RMS)
Total Harmonic Distortion (mono into 8Ω):	0·05% (11W RMS)
Total Harmonic Distortion (stereo into 4Ω):	0·1% (15W RMS)
Total Harmonic Distortion (stereo into 8Ω):	0·1% (11W RMS)
Bandwidth:	20Hz to 100kHz (4Ω)
Bandwidth:	10Hz to 100kHz (8Ω)

* Using LT24B PSU module(s) and YK86T transformer.

Table 1. Amplifier specification.



Main: The assembled 15W Amplifier.
Inset: How the TDA2030A leads are bent.

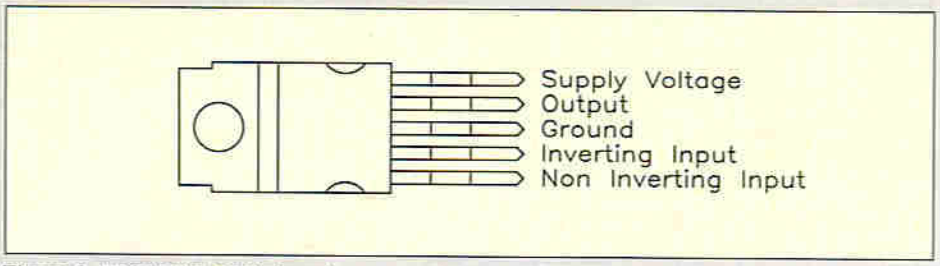


Figure 2. TDA2030A (IC1) pin-out.

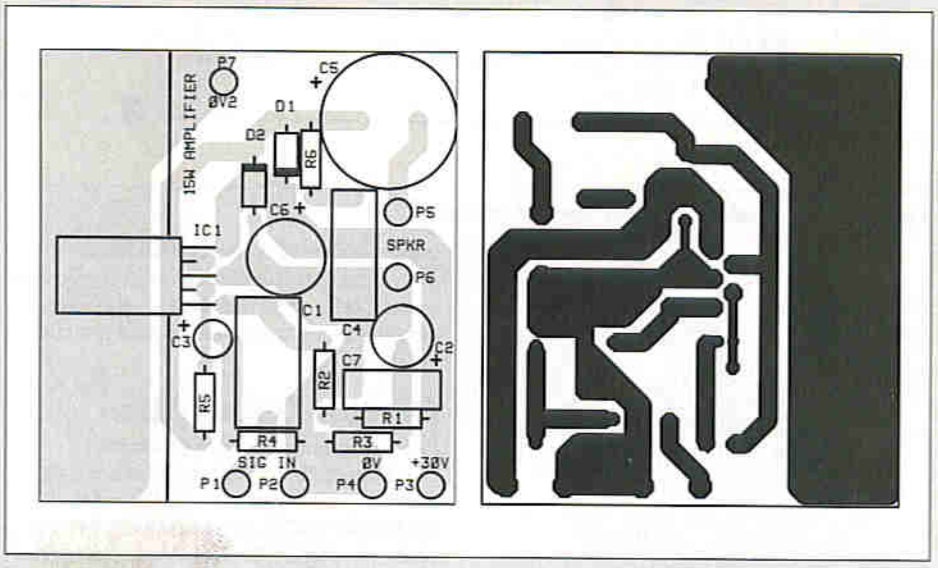


Figure 3. Amplifier Module PCB legend and track.

D1 and D2 protect IC1 from any induced emf generated by the inductance of the speaker coil; if these components were not present, the amplifier IC could be damaged. C5, meanwhile, protects the speaker from the dc offset on the output of the IC. R1 and R3 hold the input at half the supply voltage so that the output waveform will be symmetrical; R2 is present to keep the input impedance high. R6 and C4 form a Zobel network, which helps to remove any stray RF frequencies from the output. Finally, C6 and C7 decouple the power supply rail.

Amplifier Construction

Before embarking on construction, a read of the Constructors' Guide may prove beneficial, particularly to novice kit builders. Referring to the PCB legend of Figure 3, insert and solder the PCB pins (P1 to P7), all resistors, capacitors and diodes. Ensure that all the electrolytic capacitors and diodes are fitted with the correct polarity.

Carefully straighten the leads of IC1 by clamping lightly in a vice or a pair of large pliers, before reforming them as shown in Figure 4. This rearrangement is necessary because the IC's leads were originally designed for vertical, rather than horizontal, mounting. Referring to Figure 5's oblique view of the PCB, fix the bracket to the PCB using two of the 6BA bolts, nuts and washers. Carefully mount the IC onto the bracket (locating the leads in the PCB at the same time) using the remaining 6BA hardware, after smearing a small amount of heat transfer compound (not supplied) onto the mating surfaces, if required. It is important to understand that the tab of the IC is connected internally to pin 3, and is therefore at 0V potential; this pin must always be connected to the most negative part of the amplifier circuit and as such it may be desirable to isolate the tab from the heatsink by using an insulating bush and greaseless washer as shown in Figure 6, and leaving pin 7 (0V2 – discussed later) unconnected. After finishing construction, check your work for misplaced components, dry joints, solder bridges and the like.

Power Supply Arrangements

The following details are for a 30V DC unregulated power supply suitable for powering the 15W amplifier module. Note that one such supply module is required for each amplifier (i.e. two are needed if you are building a stereo amplifier). Only one transformer is used, however; the YK86T transformer is rated at 120VA, which can supply ample current for two amplifier modules). For mono applications, the two secondaries are wired in parallel; for stereo applications, however, each secondary feeds a separate amplifier module (see Table 2). A PCB is available for this project, and all of the components (except for the transformer itself) are available as a kit of parts. Transformer apart, the supply itself consists of a bridge rectifier, fuseholder and a total of 4,400µF of reservoir capacitance, which are shown in the circuit diagram, Figure 7.

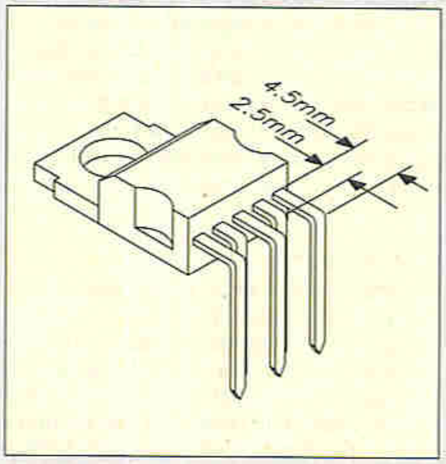


Figure 4. Reforming the leads of IC1.

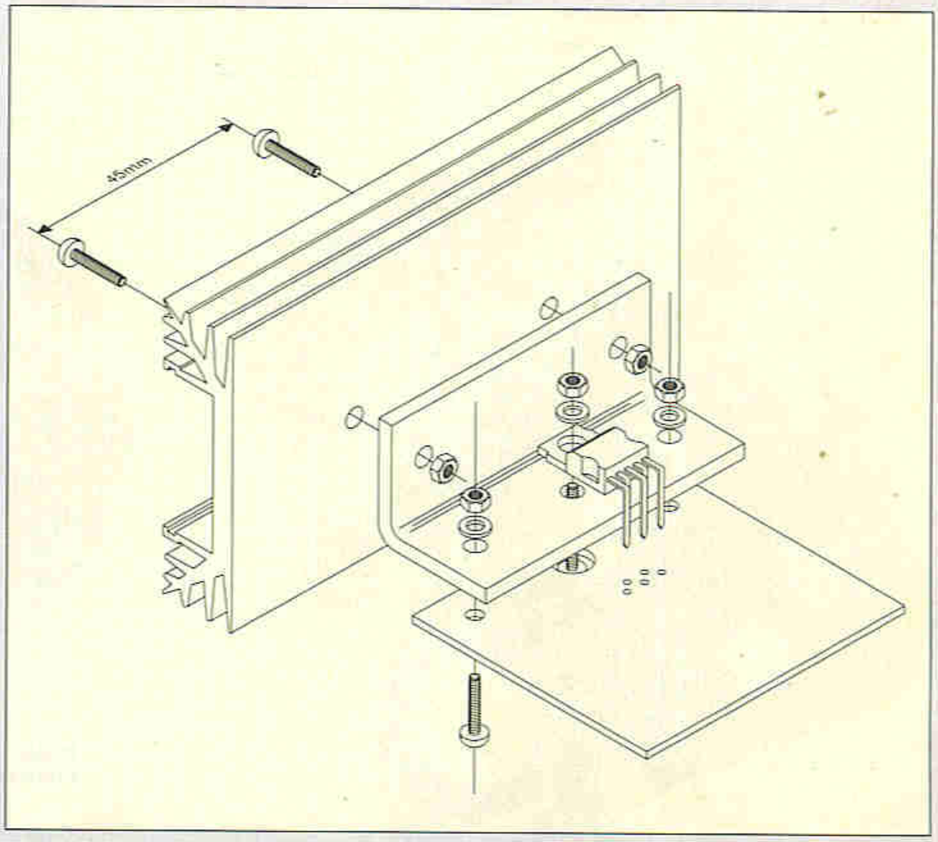


Figure 5. Mechanical assembly of Amplifier Module (non-isolated heatsink).

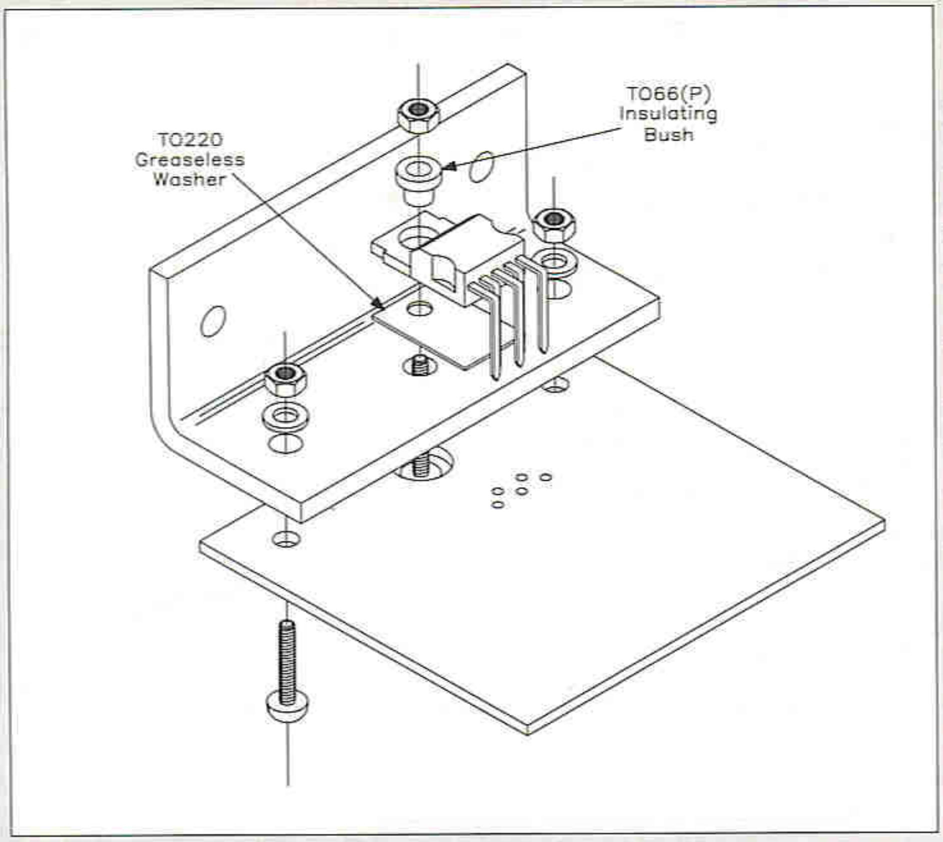


Figure 6. Mechanical assembly of Amplifier Module (isolated heatsink).

	PSU 1/Pin 1	PSU 1/Pin 2	PSU 2/Pin 1	PSU 2/Pin 2
Mono PSU	Red/Blue	Yellow/Grey	—	—
Stereo PSU	Red	Yellow	Blue	Grey

Table 2. Transformer secondary wiring.

Constructing the Power Supply PCB

Referring to the PCB legend of Figure 8, solder all components and PCB pins into place. It is important to ensure that the two reservoir capacitors, C1 and C2, are inserted the correct way round. Note that the two fuse clips should be pushed down as close as possible to the PCB, before soldering them in place. After finishing construction, check your work – particularly the polarity of the capacitors!

Installation

The amplifier(s) may be fitted into any case of a suitable size. Although it is feasible to install the completed modules into a plastic box, we would recommend the use of a metal case, which will provide good electrical screening of the amplifier and wiring. In addition, it will provide some degree of heat dissipation – but this cannot be a proper substitute for a suitable heatsink! Note that a metal case must be properly earthed, if it is also going to accommodate the mains supply. If you are not building the LT24B power supply as described in this article, the one used must be capable of supplying between +25V and +40V at 1·2A per amplifier. This applies in situations where a suitable supply rail is already present in existing equipment.

The amplifiers are best mounted as far away as possible from the power transformer, to avoid the possibility of hum being induced into the amplifier circuitry; a possible layout is shown in Figure 9. This, of course, will vary depending on the size of the case, and other requirements specific to your chosen application.

Once a suitable layout has been decided, the transformer and modules can be fitted. Using the mounting hardware supplied, fit the transformer onto the chassis or case; the round metal plate and one rubber washer go over the top of the transformer, while the other rubber washer goes under the transformer; fit the 2BA solder tag on the screw before fitting the nut. Spacers should be used to hold the amplifier and PSU modules above the bottom of the case; this is particularly important if a metal case is used! Solder the secondary connections to Pin 1 and Pin 2 of each power supply module, as determined from Table 2.

Note that the mains earth should be soldered to the solder tag associated with the transformer mounting screw, but not to 0V on the PSU, otherwise an earth loop – a major cause of hum – may be introduced. Figure 10 shows how to fit the fuseholder, and a mains switch should one be required. It is important to insulate all connections at mains potential with heat-shrink sleeving. Alternatively, purpose-designed insulating boots are available for panel-mounting fuseholders (FT35Q) and switch terminal blades (FE65V). If an insulating boot is to be used with the chosen fuseholder, it should be held in place with a cable tie, as shown in Figure 10.

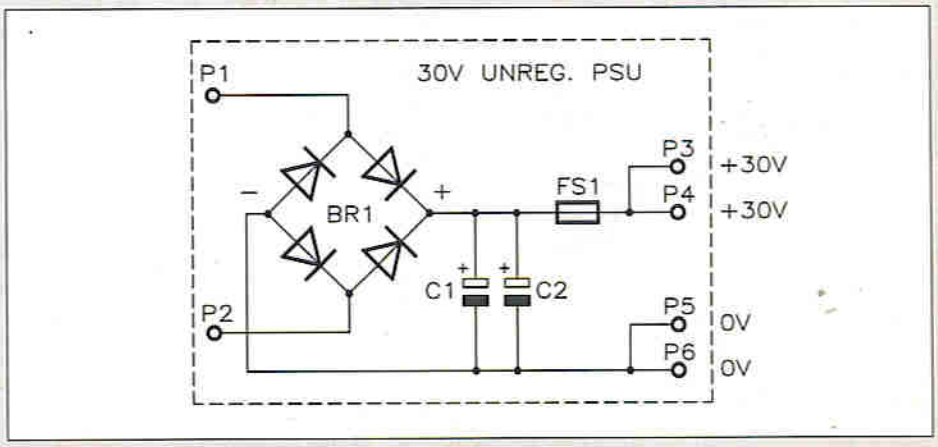


Figure 7. Power Supply Module circuit diagram.

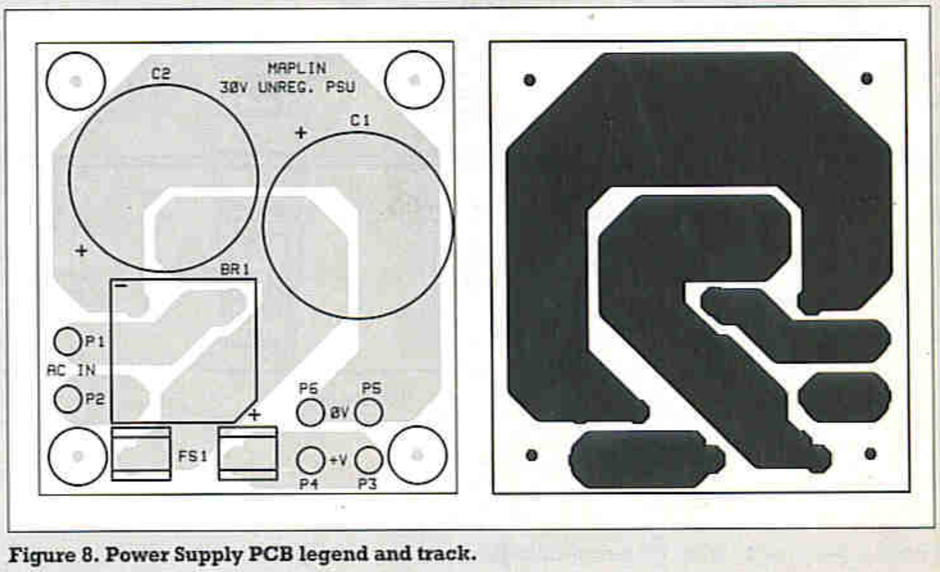


Figure 8. Power Supply PCB legend and track.

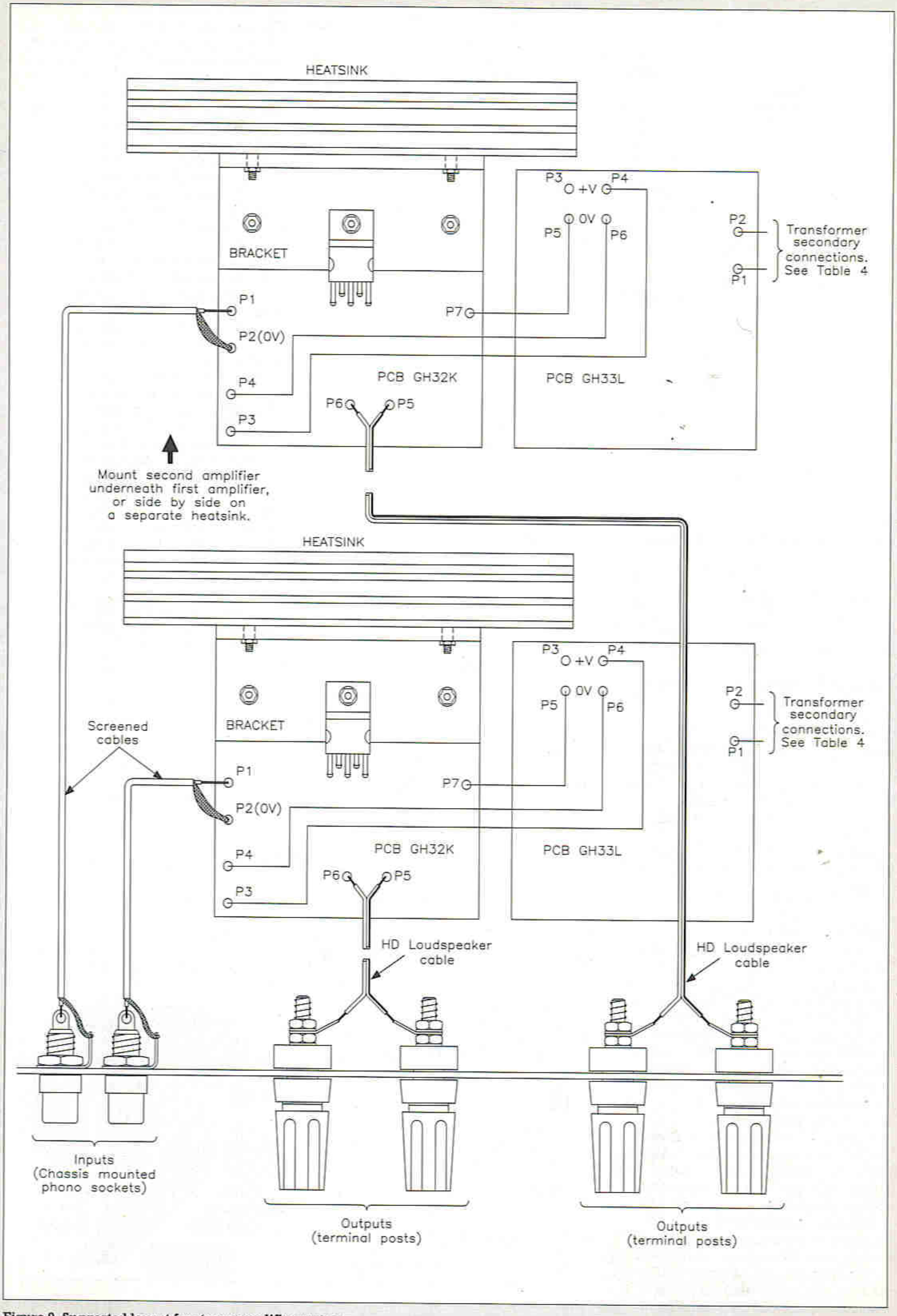


Figure 9. Suggested layout for stereo amplifier system.

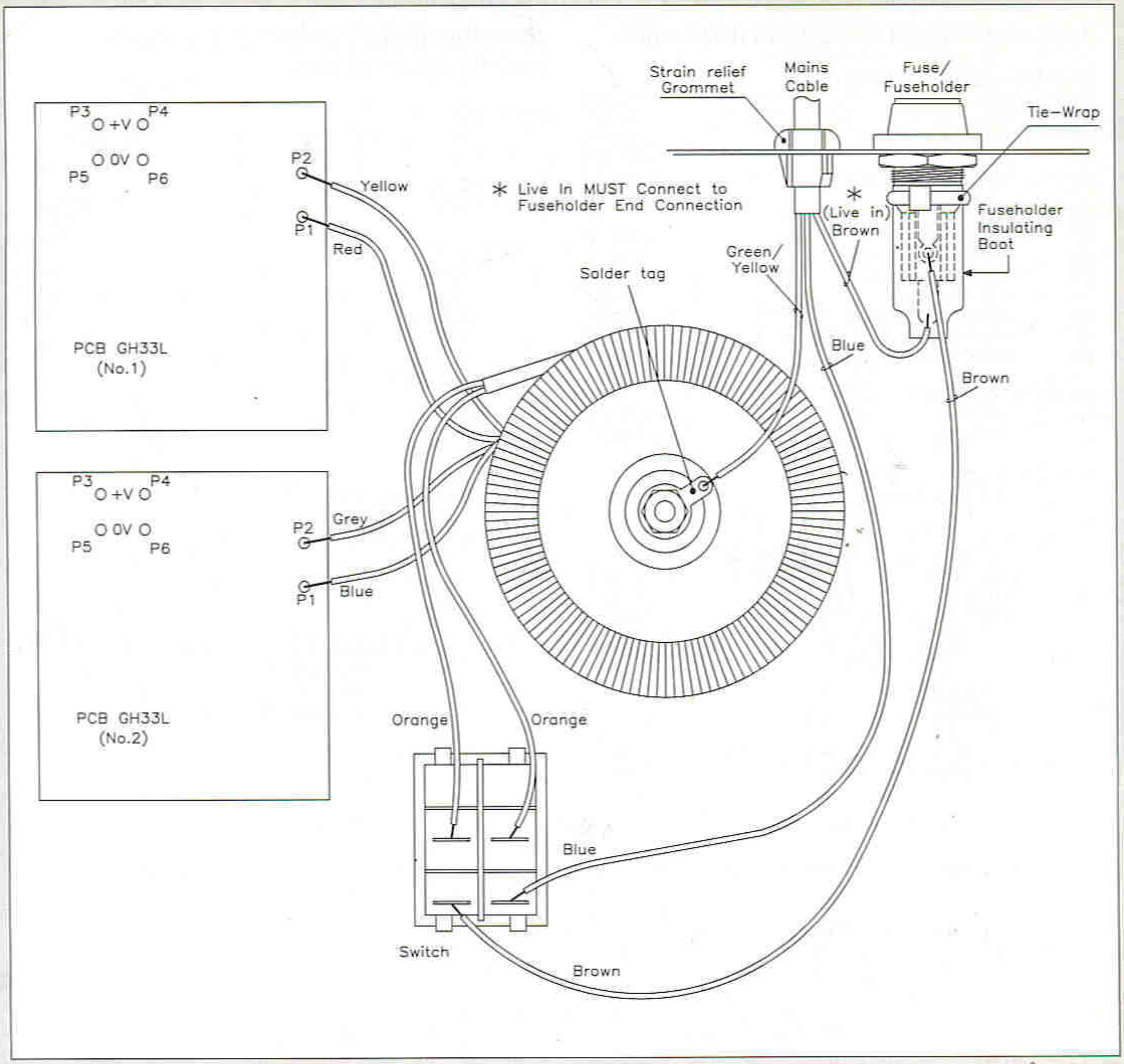


Figure 10. Transformer and mains wiring (stereo system shown).

It must be understood that the heatsink bracket is not adequate for normal use, and should be bolted to the case and/or heatsink, such as Heatsink 4Y (FL41U). Thermal compound should be smeared at the contact point between the mating surfaces.

Testing the Power Supply

Remove FS1 (if fitted). Connect a multimeter, set to a suitable DC voltage range, between Pin 5 (0V) and the positive side of C1. Apply power to the circuit and check that the off-load voltage is about 36V (±1V). Disconnect the power, remove the multimeter and fit FS1. Repeat the tests for the second power supply, if used.

Final Construction

Connect each PSU to pins 4 (0V) and 3 (+30V) of the corresponding amplifier using heavy-gauge insulated wire. Lengths of wire (XR32K, black; XR36P, red) are supplied with the kit for this purpose; keep the connections as short as possible.

Connect pins 5 and 6 of each amplifier to a suitable speaker with good quality speaker cable (e.g., XR60Q). When selecting speakers for use with the amplifier modules, bear in mind that although this amplifier is rated at 15W RMS, it is capable of delivering up to 30W on transient peaks. Speaker sockets can be used, particularly if the amplifiers are being built into a case; chassis-mounting 2-pin DIN sockets (HH31J) or terminal posts (e.g., HF02C, black; HF07H, red) can be used, depending on your personal taste and the amplifier's intended application. An audio source, at a level of around 250mV RMS, should then be connected to the amplifier's input pins, 1 and 2 (note that Pin 2 is 0V). Alternatively, an input socket could be used – a chassis-mounting phono socket (e.g., YW06G) is ideal. If you require a socket that is isolated from the case, (JZ05F, black; JZ06G, red) could be used. A further connection may be made from the PSU 0V to Pin 7 (0V2) on the amplifier; this is not essential but provides a good ground connection to the heatsink bracket and the corresponding copper track on the underside of the PCB, and can help to reduce noise. As mentioned earlier, this pin should be left unconnected if you wish to isolate the circuit from the case.

Testing the Amplifier(s)

First ensure that the audio input is set to minimum, switch the power supply on; gradually increase the audio input level and check that the output shows no audible distortion throughout the full power range. If you are using a second amplifier for stereo applications, connect this in the same manner and repeat the tests.

15W AMPLIFIER MODULE PARTS LIST

RESISTORS: All 1% Metal Film			
R1,3	22k	2	(M22K)
R2	100k	1	(M100K)
R4	4k7	1	(M4K7)
R5	150k	1	(M150K)
R6	1Ω	1	(M1R)
CAPACITORS			
C1	1μF Polyester	1	(BX82D)
C2	22μF 63VPC Elect	1	(FF07H)
C3	10μF 50V PC Elect	1	(FF04E)
C4	220nF Polyester	1	(BX78K)
C5	2200μF 35V PC Elect	1	(JL28F)
C6	100μF 63V PC Elect	1	(FF12N)
C7	100nF Polyester	1	(BX76H)
SEMICONDUCTORS			
D1,2	1N4001	2	(QL73Q)
IC1	TDA2030	1	(WQ67X)
MISCELLANEOUS			
	15W Amp Bracket	1	(YQ36P)
	Pin 2141	1 Pkt	(FL21X)
	PCB	1	(GH32K)
	Bolt 6BA x ½in.	1 Pkt	(BF06G)
	Washer 6BA	1 Pkt	(BF22Y)
	Nut 6BA	1 Pkt	(BF18U)
	Heavy Duty Speaker Cable	1m	(XR60Q)
	Instruction Leaflet	1	(XU07H)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Heatsink 4Y	1	(FL41U)
	TO66(P)	1	(WR23A)
	Heat Transfer Compound	1 Tube	(HQ00A)
	Heavy Duty Speaker Cable	As req.	(XR60Q)

30V UNREGULATED POWER SUPPLY MODULE PARTS LIST

CAPACITORS			
C1,2	2200μF 63V PC Elect	2	(JL29G)
SEMICONDUCTORS			
BR1	PW01	1	(WQ57M)
MISCELLANEOUS			
FS1	Fuse 2A A/S	1	(WR20W)
	Fuse 20mm Clip Type 1	2	(WH49D)
	Pin 2141	1 Pkt	(FL21X)
	PCB	1	(GH33L)
	Wire 3202 Black	1m	(XR32K)
	Wire 3202 Red	1m	(XR36P)
	Instruction Leaflet	1	(XU07H)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
S1	Neon Switch Red	1	(YR70M)
FS3	Fuse 1¼in. 1A	1	(WR11M)
TR1	Toroidal Transformer		
	120VA 24V	1	(YK86T)
	Fuseholder	1	(FA39N)
	Fuseholder Boot	1	(FT35Q)
	Tie Wrap 102	1	(BF91Y)
	Miniature Mains Cable	As req.	(XR01B)
	Strain Relief Grommet 5R2	1	(LR48C)
	Push-on Receptacles	1 Pkt	(HF10L)
	Push-on Receptacle Covers	1 Pkt	(FE65V)
	Tag 2BA Solder	1 Pkt	(BF27E)
	Chassis Mounting Phono Skt.	2	(YW06G)
	Chassis Mount 2 pin DIN Skt.	2	(HH31J)

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

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

Order As LT23A (15W Amplifier Module) Price £7.95.

Order As LT24B (Unregulated 30V PSU) Price £6.95.

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

The following new items (which are included in the kits) are also available separately, but are not shown in the 1993 Maplin Catalogue.

15W Amplifier Module PCB **Order As GH32K Price £2.45.**

Unregulated 30V PSU PCB **Order As GH33L Price £2.45.**

NEXT issue

In next month's super issue of 'Electronics – the Maplin Magazine', there are some really great projects and features for you to get your teeth into! The May issue is on sale April 2nd, available from Maplin's regional stores, and newsagents countrywide, and of course by subscription (see page 21 for details). To whet your appetite, here's just a taster of some of the goodies on offer:

INDUSTRIAL ELECTRONICS ASSEMBLY

The first of a two-part feature by Keith Brindley, that looks at the much-misunderstood world of industrial electronics assembly. Despite the apparent complexity – huge rooms full of impressively large and expensive automata – the principles used are themselves ingenious yet simple.

PC RELAY CARD

Bored with games, spreadsheets, databases and word-processing? If you are, then put your PC to practical use with this eight-relay plug-in card, which is suitable for any IBM PC, XT or AT computer (or clones). Each relay will switch up to 24V DC (50V AC) at up to 2A, and is fully programmable from BASIC. This inexpensive little card opens up the world of robotics, automation and control to your computer!

FRAME RELAY PUT PLAINLY

Just what is Frame Relay – what does it do, and why is it so important? Frank Booty comes up with the answers!

WALKAMP

OK, those 'Walkman' type cassette players are fine for personal listening (although bus and tube travellers may be inclined to disagree!), but what if more than one person wants to listen to (not just recognize!) whatever's playing? Alan Bradley's 'Walkamp' provides the answer, and it's a lot cheaper than a 'ghetto blaster'!

SHORT WAVE BROADCASTING TODAY

Despite the widespread use of satellites for disseminating radio programmes over a wide area, short wave broadcasting is still used as much as ever. Regular radio correspondent Ian Poole looks at its past, present and future.

CAR HEADLAMP MONITOR

Almost all of us ('Electronics' editorial team included!) have tried, and subsequently failed, to start the car, eager (no doubt) to get to work in the morning. It then becomes painfully obvious that the batteries have become run down – simply because you didn't turn the lights off after parking the car the previous evening! By installing this simple gadget, you could spare yourself the inconvenience of an unnecessarily immobilised car.

Plus, of course, there's all the usual features for you to enjoy!

'ELECTRONICS – THE MAPLIN MAGAZINE'

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE.

TECHNOLOGY WATCH!

with Keith Brindley

One of the vague pleasures of my job as a freelance journalist is to see a very wide range of new products. I'm a gadget-lover, and getting to grips with some of these things often gives me a high point to otherwise dreary days.

One of the things I've been taking a look at recently is the variety of computer-aided musical training systems. The best I've come across (unless anyone can point me towards a better one) is the Miracle Piano Teaching System. To be honest I've never been particularly struck on computer-aided education. I first got involved with them back in 1976 but in those days the term *computer-aided* had a totally different meaning than it does these days. First off, there simply weren't any personal computers around, so computer-aided meant being tied to a mainframe in a local university, say, or building the guts of it yourself. I did both and, frankly, became aware of the vast resources required to make any system viable in commercial terms. Second, the system you make is rarely of a type which could become hugely popular – I mean, who would want to fork out thousands on a system to teach you to cook beans on toast or, in my case, teach a 16-year-old to operate a lathe?

Nowadays things are different. There are several computing platforms around (DOS, Apple, Amiga, Acorn and so on) which all have their attempts at computer-aided education. A personal computer makes life significantly easier for the system designer. A well-defined and trusted operating system makes programming simpler, as well as making any program available to a vast range of potential users. There is still a problem, however, in which of the available platforms to run your system on. The biggest-selling platform; PC DOS, is basically just business orientated, so writing your education software for that market will probably mean you won't sell many systems. On the one hand, as it's an education-based program maybe you'd be best going for Acorn or even Amiga platforms. On the other hand (it helps to have as many hands as possible to play the piano, I guess), by far the most popular musical computing platform is the Atari, but of late the Apple is becoming a front runner. Which do you choose?

Of course, if you want real sellability, how about writing your program for multiple platform use. And while you're at it, what about a games platform like Nintendo? Write your software for that and you're *really* going to hit the market you're after. If your software's like a game to use, imagine the many millions of potential sales.

The Miracle Piano Teaching System has done just that. It's available on the three main computing platforms (DOS, Apple and Amiga – sorry, Acorn, whoever's heard of the BBC Model B outside of our fair isles?) and also on Nintendo (in an admittedly cut-down version). So as far as getting the market right, full marks so far to the Miracle.

So what is it? What else is special about it? Well, it comes complete with a four-octave synthesiser keyboard with velocity-sensitive keys. It has some 128 synthesised instruments and can be played separately from the computer. That in itself is pretty impressive.

Learning through the program which comes with the keyboard is quite straightforward, although it's done in a way designed to stimulate the learner through colourful graphic displays and structured procedures which don't leave you with the impression you're doing anything quite as rigid as you actually are.

As you enter the program you are shown a picture of six rooms which you enter as you want. The idea is that you go through a series of 36 lessons which are all correlated within the six rooms, so what you learn in one room you can reinforce and practise in another.

In the Administration room you sign on, register and set the system up to suit.

In the Classroom you are taught the necessary steps of each lesson.

In the Arcade you have games to reinforce things taught in the classroom, or play along with other tunes at the level you're at.

In the Practice Room you do just that; practise the tunes you have been taught so far.

In the Performance Hall you play along with the Miracle's synthesised orchestra, again to the level you're actually at.

Finally, there's the Studio, with its seven-track digital recorder, in which you can compose your own tunes, with all the instruments available on the keyboard at hand.

These facilities alone are probably worth the money, but when you consider the complementary and fully co-ordinated learning tool this gives you, the Miracle is simply stunning in its potential. But is this enough? Can you really learn to play the piano with it?

Well, that's up to the user. If you do two lessons a day, along with all the backup practice, playing and performing required then you probably *can* learn to play the piano in just three weeks – which is the cleverly disguised claim made for the Miracle. Most people, on the other hand, will probably only manage a couple of lessons and the necessary practice a week, so six months is a more conservative estimate. And then you've got to stick at it. It'll probably take someone with a strong will to complete the course. I gave up after lesson five, which shows the extent of my will power, I suppose.

There's no doubt that the Miracle Piano Teaching System is good. Not that there's no precedent, of course. Computer-aided education systems of whatever sort have been around for long enough. But where the Miracle scores (pun intended) is in its availability. There's been nothing around yet which is ported across to all the major computer platforms. The Miracle is the first, and it serves to illustrate what I think will be the trend; not just in computer-aided education programs.

In business computer use, multiplatform availability isn't totally new. Most business applications such as word processors and spreadsheets are now available on at least two platforms. But the Miracle is really the first general-purpose application which bridges the computer gap between platforms. I expect there'll be many more.

For those interested, the Miracle Piano Teaching System is distributed by MindScape (0444 246333). Price is between £249 and £349, depending on computer platform.

A GUIDE TO PROFESSIONAL AUDIO PART ONE

by T. A. Wilkinson

The aim of this series is to give an insight into the world of professional audio, from an engineering and technical point of view. The series will cover many aspects of the industry, and will hopefully encourage anyone with an interest in audio to aspire to greater things.

Defining the 'professional' in professional audio is no easy task, as there is no single parameter that categorises a piece of equipment as being particularly suited for use in a professional environment. It is more a case of taking a global look at the way in which certain types of equipment are used in a certain environment, and to what standards they have to conform. This, of course, also includes the human element because the users, musicians, producers and engineers all form an integral and invaluable link in the audio chain.

In the first part, we take a general look at the standards currently in use within the industry. Most of the topics covered in this issue will be examined in greater, more technical detail later in the series.

Standards

Standards play a vital role within the industry. The most basic of these standards must be safety. Safety in itself is now a major industry, and safety standards cover a diverse range of subject matter from C.O.S.H.H (Control Of Substances Hazardous to Health), to lifting and handling. Almost anything you can imagine will have some safety regulations attached to it! But perhaps the most relevant to us would be electrical safety. The recent changes in the 1989 Electricity at Work Regulations now demand very strict control over the electrical equipment to be found at the workplace, and this involves us all. As users, we should feel secure in the knowledge that the equipment we come into contact with is safe to use, but we should also show regard for the safe operation of equipment; the familiar 'there are no user serviceable parts inside' warning must be respected!

As maintenance engineers we are responsible, to a greater or lesser extent, for the continuity of equipment safety. This may be as basic as ensuring that the equipment outer panels are refitted correctly following a repair, or perhaps final electrical safety testing before the equipment is released to its users.

The Electricity At Work Act now demands that all electrically-operated equipment in use at the workplace undergoes thorough and regular safety testing. This testing includes such items as visual inspection, insulation testing, earth continuity and leakage/load testing. When a piece of equipment has been tested it should be clearly labelled, and detailed records of testing must be kept.

Interconnection Standards

The subject of interconnection standards can be grouped into the areas of electrical, audio, fixed and temporary wiring.

Electrical Interconnections

As you will know, there are several types of connector used to make a mains termination to a unit. Some are good, some are bad and some are downright dangerous! However, there are really only two types (excluding the European 2-pin type used on domestic type Hi-Fi equipment) in general use within the industry. The more common connector is the 3-pin IEC (aka CE22) type. This is available in many forms, such as chassis and cable mounting inlets and outlets (Photo 1) those attached to cables being the factory-moulded type or the rewirable type. The chassis type is available with integral fuseholders, switches and filters. On the whole this is a very flexible connection system. However, in its standard form, it does not contain an in-built latching mechanism, and it is quite easy to inadvertently remove the connector from its mating counterpart–disasterous during a live programme! To overcome this problem, some manufacturers provide a U-shaped metal bracket, which is attached to the chassis inlet and then pushed over the incoming plug, making the connection system more secure mechanically.

The less common type of mains connector is the XLR LNE type, which is widely used within the broadcasting environment. This connection system, again available in various forms, is similar in appearance to the very robust locking audio 'XLR' connector, but of course is non-compatible and is easily distinguished by its red insert and red strain relief sleeve. Its in-built mechanical latching device provides a fast and secure method of locking together the two mating connectors. The reason for its comparative rarity is that it is 'not suitable for mains connections to equipment for domestic use', as defined in the Low-Voltage Electrical Equipment (Safety) Regulations 1989, and is therefore only found within the professional environment.

Audio Interconnections

A cursory glance through the connectors section of the Maplin Catalogue shows a vast array of connectors for audio use. Whilst there are no strict guidelines governing their use, there are some generally accepted conventions within the industry, and the connector must meet certain requirements.

As (most) professional equipment operates with 'balanced' lines (two antiphase signal wires, and earth) the connector must have 3 pins. It must be very robust and able to withstand the rigors of frequent and rough handling (anyone who has de-rigged an outside broadcast at 2.00 a.m.in the pouring rain will understand!), and it should be fairly easy to terminate and accept a wide variety of cable types. Low noise is of paramount importance with any connector, but particularly so when used with low-level signal sources such as microphones. A typical microphone may well need to be amplified by a factor of 1000 (60dB) or more to bring it up to usable level. It follows that any noise introduced by the microphone connectors will also be amplified by a similar amount. For example 20μV of noise directly attributable to connection becomes a significant 20mV when amplified by a 60dB microphone preamplifier!

The 3-pin XLR type connector is universally accepted as a low-noise, high quality and reliable connector (see Photo 2). It is suitable for use across the audio spectrum in terms of its ability to handle a very wide range of signal levels (from low level microphone signals to signals well in excess of line level). It has the benefit of a built-in fast-action latching mechanism. The contact pins are usually silver-plated for low noise, and are securely anchored to a plastic insert which slides into the outer shell. This robust shell is normally of metal construction, and will be nickel-plated or anodised to combat corrosion. There are many manufacturers of XLR connectors, but I favour those who do not use screws in their outer casing and cable clamping device; the lack of such screws speeds up the making of leads.

Photo 2. XLR audio connectors.

The usual method of termination is shown in Figure 1, with pin 1 to screen, pin 2 'hot' (+ phase) and pin 3 'cold' (−phase). There are, of course, exceptions to this and it would be foolish not to check the manufacturers specification when making up cables for a new piece of equipment.

The other audio connector in general use within the professional audio industry is the 'B' gauge P.O. 316 type jack connector (Photo 3). This plug and socket system was the type originally used in Post Office telephone exchanges (as featured in old black and white films!). Its appearance is similar to that of the domestic 'A' gauge jack connector used on many Hi-Fi units as the headphone connector. However, the 'A' and 'B' types are not directly compatible and are easily distinguished by inspecting the tip of the plug, the 'B' gauge being smaller and more rounded. The P.O. 316 is normally made of brass, and has a slide-over plastic sleeve, available in a wide variety of colours for identification purposes. At the cable entry end of the plug, the hole through which the cable passes has a coarse thread machined into the surrounding metal. The jack plug is literally screwed onto a correctly prepared cable; this action gives an effective screen-to-body termination without the need to solder, and the cable will be adequately clamped to the plug.

Like the XLR connector, the P.O. 316 is usually used with balanced lines, and therefore has 3 contact areas. The sleeve (body) is used for the screen or earth, the tip is used for the 'hot' (+ phase) signal wire, while the ring is reserved for the 'cold' (−phase) signal wire. Figure 2 shows how to wire an XLR to a P.O. 316 and maintain the correct phase.

A complete system of temporary interconnections is provided by the P.O. 316 jack plug and socket. It is used on a massive scale for 'jackfields' in recording studios and broadcasting installations. A jackfield is effectively a board of sockets; each piece of equipment in a typical studio would have its inputs and outputs available at this easily accessible point. A typical 3-row jackfield is shown in Photo 4. The signal sources (tape recorder, microphone amp etc.) would be hard-wired to the bottom row of jacks ('source' jacks). The source jacks are wired, via a set of interruptible contacts on the middle row ('break' jacks), to their destination (mixer, etc.). This signal is available on the top row of jacks ('listen' jacks) for monitoring purposes. Inserting a jack plug into a 'break' jack allows an alternative signal to replace the signal originating from the source jacks, and so pass to the destination. This is known as 'patching' or 'overplugging'.

To eliminate (almost!) messy wiring

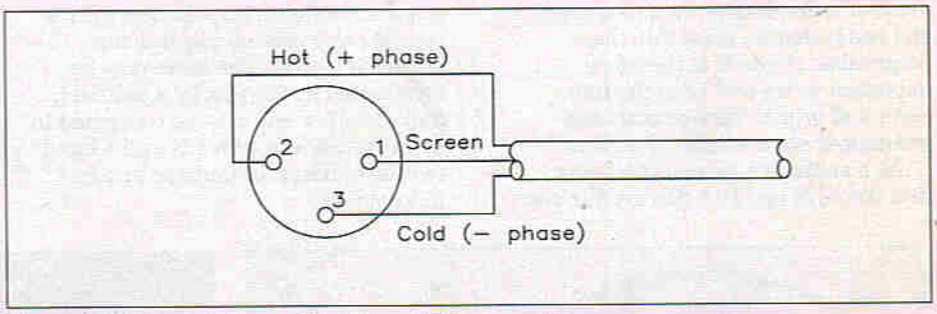


Figure 1. Wiring a balanced-line to an XLR connector.

Photo 1. IEC (left) and XLR (right) mains connectors.

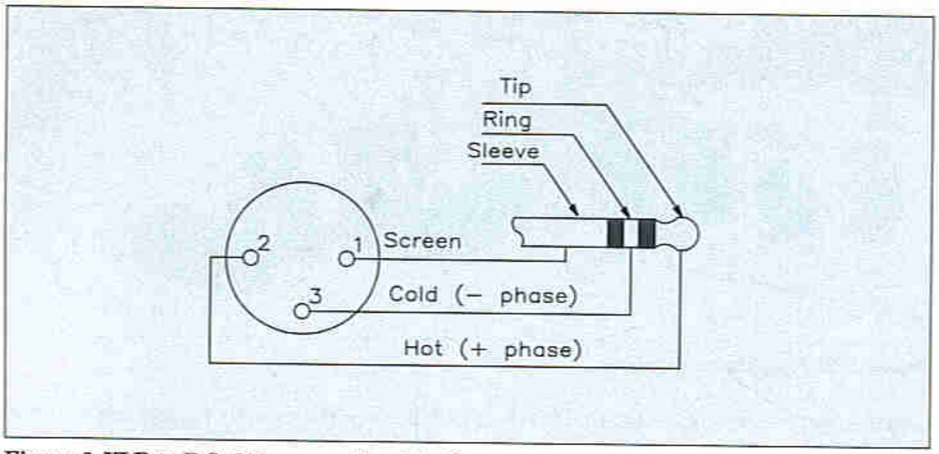


Figure 2. XLR to P.O. 316 connection details.

in studios, most of the alternative signal routing (patching or overplugging) will be done on the jackfield using cables known as 'patchcords' or 'double-enders'. These are simply lengths of very flexible cable with tinsel conductors, terminated at each end with a P.O. jackplug. Patchcords are available ready-made in lengths from 300mm to over 3 metres. There are also special-purpose patch-cords in use, which are identifiable by the colour of the outer sheath. For example a red cord is unscreened, while a yellow cord is a 'phase-reverse' cord (this connects the tip of one plug to the ring of the other and vice versa). Beware of the yellow patch cord – it is invaluable when needed, but if used in error the results could be disastrous! Patchcords are also available with a P.O. 316 plug at one end, and a 3-pin XLR (male or female) at the other.

All ready-made patchcords are expensive – a typical 600mm double-ender is currently priced at around £9.00, and so patchcords are often made up by maintenance engineers – particularly if a non-standard length, or odd combination of connectors, is required.

Although the P.O. 316 is a high-quality connection system, it perhaps has one slight failing. Since the jack is made of brass, it does tend to tarnish, and can introduce noise into the programme chain. It is therefore important to try and keep the brass clean and bright. Various tools and substances are available to do this.

As a summary, we can safely say that the XLR and P.O. 316 are the two most commonly found connectors in the industry, but there will, of course, be exceptions to this, and an engineer may have a large array of other types in his workshop in an effort to deal with anything that he is likely to encounter.

Fixed and Temporary Wiring

In general terms, fixed wiring refers to the permanently installed wiring that is used to connect together the various technical areas within a building. This wiring may be as simple as providing 'tie lines' between studios and control rooms, or as complex as the complete audio wiring installation within a radio station or recording studio complex. This fixed wiring is made up of many multiway cables, each capable of carrying dozens of pairs of audio signal wires. These multiway cables are made up of a number of insulated solid-core conductor wires twisted into pairs, colour coded for identification purposes and screened in foil with an outer PVC jacket. When you consider the huge amount of cabling that may be used in a large complex, the fact that this cabling is fixed means that flexible cable is not required, solid core conductors offer a considerable cost saving over the stranded variety. The cable may be terminated at one end by a jackfield, and the other end may be connected to a wiring block, a series of multi-input connector boxes, or perhaps another jackfield.

Temporary wiring or cabling falls into none of the above groups. It is the sort of cabling brought out when it is needed. An example may be a very long run of flexible multi-pair cable occasionally used for a location recording or outside broadcast. This will be terminated with a large multi-pole connector (such as the round military type or a '516 rack and panel' type connector) at each end, or perhaps a multipole connector at one end, and each pair at the other end terminated with its own XLR connector. Temporary cables are usually unique, and are constructed to a particular specification.

Fixed and temporary wiring installations will be examined in greater detail in more relevant sections, later in this series.

Professional and Semi-professional Equipment

Having gained an insight into how we connect various units together, it would be useful to examine the essential differences between professional, semi-professional and domestic equipment.

In recent years, the amount of development and technical innovation in domestic-type audio equipment has been massive. This renders many units as potentially very usable in the professional environment; indeed, many units are now being used in this way. A typical example is the range of high-quality DAT recorders and CD players now available – some manufacturers have had the foresight to modify a suitable basic domestic unit into a 'pro' version with great success. In addition, some professional audio specialist dealers will take a basic unit from a manufacturer such as Technics, and build in their own 'pro kit', then re-market the unit as a 'pro version'.

The essential differences between professional and semi-professional equipment concern the operating levels of inputs and outputs, the method of connecting units together and the fact that professional units (unlike most others) use balanced inputs and outputs throughout. A comparison of 'line' level signals is shown in Table 1.

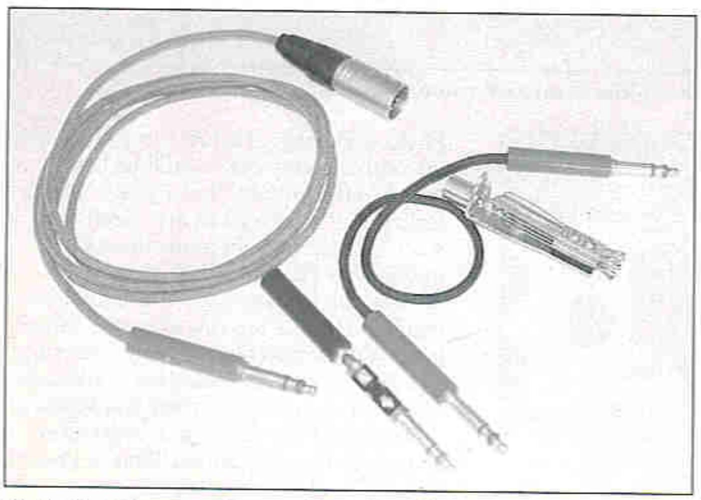


Photo 3. Jack connectors and patchcords.

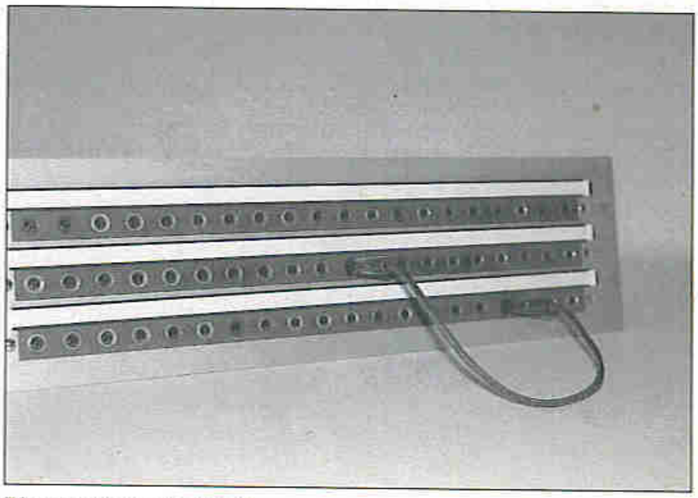


Photo 4. 3-row jackfield.

DOMESTIC / SEMI-PROFESSIONAL UNITS	
Connectors:	Phono/DIN/Jack etc.
Signal Levels:	Wide, ranging from –20 to >0dBu unbalanced
PROFESSIONAL UNITS	
Connectors:	XLR or P.O. 316
Signal Levels:	0dBu balanced

Table 1. Comparison between domestic/semi-professional and professional interconnection standards.

As can be seen, the range of line input/output levels and connector types offers no standardisation with semi-professional equipment. The input and output levels of a semi-pro unit may vary considerably with different manufacturers, and the same can be said of the connections used, with some manufacturers preferring RCA phono types and others DIN or ¼ in. jacks. There simply is no standardisation – which is essential in the professional environment.

Signal levels and connections aside, another important factor is that of reliability. Whilst in general terms, most competently designed modern electronic circuits can be assumed to be fairly reliable, the same cannot be said of mechanical systems – the mechanical items will undoubtedly fail first. Manufacturers of professional equipment containing many moving parts, such as tape recorders, invest vast R&D resources into the mechanical components and build these up to a specification rather than down to a price. Similarly, equipment enclosures are another area where professional equipment scores well. These tend to be well-built, and usually look practical and functional rather than high tech and pretty.

This reliability factor highlights perhaps the main area of difference between semi-professional and professional equipment. Organisations such as the BBC, who design and specify equipment, demand the best but this can lead to over engineering. Someone once said of BBC engineering, "an elephant is really a mouse, built to BBC specifications!"

Balanced Line Operation

The term 'balanced' generally refers to the inputs and outputs of equipment, to the external connections between them and the cables used to carry the audio signals. Truly professional equipment will always have its inputs and outputs balanced by the use of a transformer or electronic balancing system. In simple terms balancing means using two wires to convey the audio signal. These two wires, known as a balanced line, will (to all intents and purposes) be identical to each other and have the same electrical properties such as resistance and capacitance.

In addition, neither wire will have a direct connection to earth. The balanced line will take the form of two insulated wires twisted together (hence the term 'twisted pair') and will have an overall screen, the whole assembly being covered by an outer jacket of a PVC-type material.

The great advantage of using balanced lines is that of noise rejection. Any noise induced on the cable will be eliminated, as each of the wires in the pair will carry an equal amount of phase and phase noise, and therefore a cancelling action will occur as shown in Figure 3. This is extremely important in long cable runs, where audio cables may come into close proximity with mains-carrying cables, or in other hostile environments where electrical noise or RFI may be a problem. The need to eliminate, or at worst reduce, any stray noise is paramount in any system.

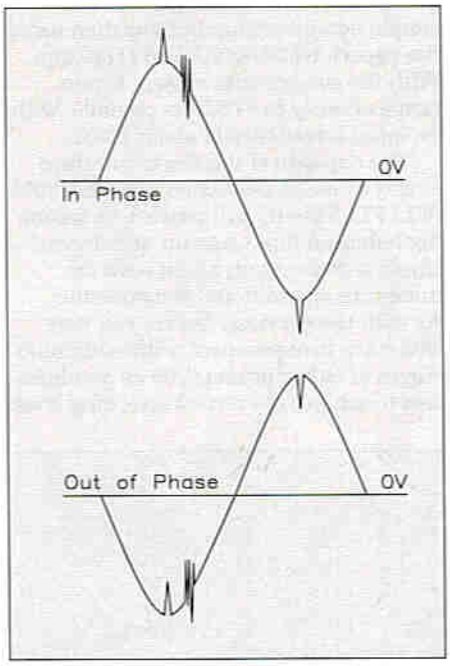


Figure 3. Balanced signal and noise.

A simple example of a balancing arrangement is shown in Figure 4. This is the commonly-used transformer balancing system. Here, the output of an unbalanced amplifier is connected to a transformer with a turns ratio of 1:1. This transformer (also known as a repeating coil or 'rep' coil), removes the earth path from the signal carrying wires, and due to its turns ratio of 1:1, maintains the amplifier's output impedance and output voltage level. The output of the rep coil is now said to be balanced and, as the signal has no reference to earth, it is said to be 'floating'. Our signal is now fed down a balanced line to another rep coil at the input of another amplifier. Again, this rep coil has a turns ratio of 1:1, and therefore will have little or no effect upon the audio signal. The rep coil 'unbalances' the signal and re-instates the earth reference to the amplifier. In reality, most equipment will use an arrangement similar to this as it is only necessary to create this balanced arrangement at the equipment inputs and outputs. Whilst good transformers are not cheap, this system offers a simple and very effective method of providing balanced inputs and outputs.

Electronic Balanced-Line Systems

Some manufacturers, particularly with keenly priced equipment, offer 'electronic balancing' of inputs and outputs, and others offer a combination of, perhaps, transformer balanced inputs with electronically-balanced outputs. A typical example would be a distribution amplifier with, say, 10 outputs, the input being balanced with a transformer and each of the 10 outputs being electronically balanced. This would offer a considerable cost-saving to the end-user, but many professionals still prefer and even insist on transformer balancing throughout. The reasons for this are probably one of standardisation, and the fact that the transformer does offer a greater degree of DC isolation and RFI rejection.

An example of a possible arrangement for electronic balancing is shown in Figures 5a and b. In this set up, the amplifier output is fed to a further stage for balancing (Figure 5a). This consists of two voltage-followers. One voltage follower is a non-inverting type, providing the +phase output, and the other will invert the signal through 180° providing the –phase output. Both voltage followers will have unity gain (thus maintaining the correct signal level), and they will be designed to present the correct impedance to the next piece of equipment. Figure 5b shows an amplifier input with electronic balancing. Again, two voltage followers with 180° phase difference are used, and are fed to the differential input of an amplifier stage. The output of this will be the signal, returned to its original unbalanced state.

These diagrams are a simple way of describing how it may be done, and different manufacturers will achieve the same result in a variety of ways.

A practical example of electronic balancing is shown in Figure 6. The system is based around the SSM2142

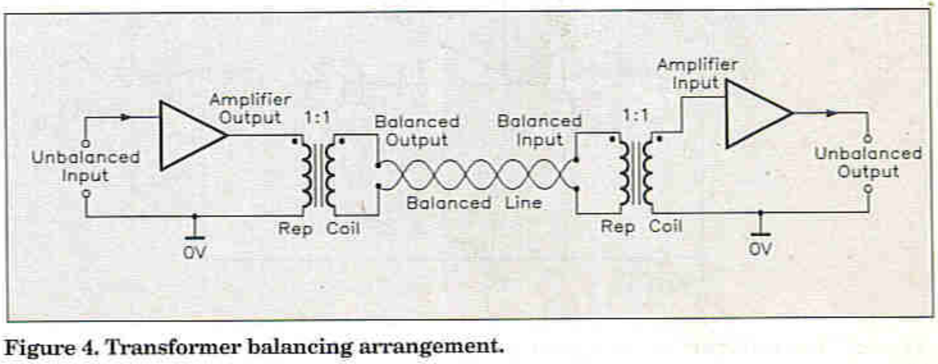


Figure 4. Transformer balancing arrangement.

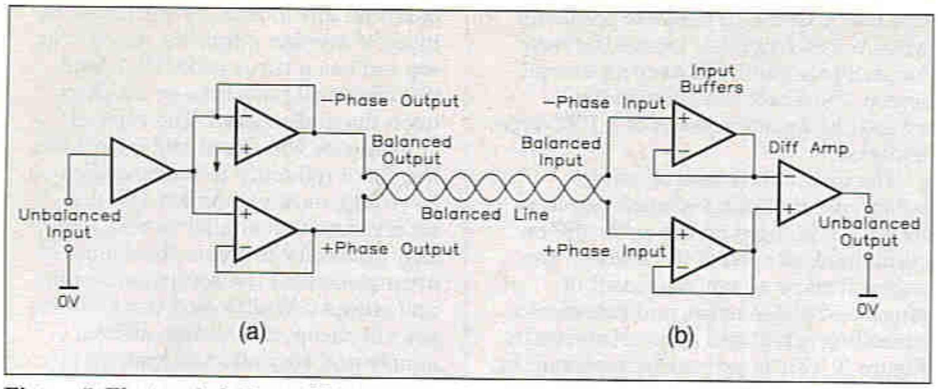


Figure 5. Electronic balanced-line system (a) – transmitter; (b) – receiver.

balanced line driver IC (Order Code UM54J). This device has the ability to derive a balanced floating output from a conventional single-ended input, and has extremely low noise and distortion figures. It requires only a handful of components to achieve the desired result. The SM2142 was also the basis of Alan Williamson's similar Balanced Line Transmitter project, which was featured in Issue 49 (January 1992) of 'Electronics', and has a kit of parts (including high-quality PCB) available for it (Order Code LP49D).

You will recall that to interface semi-professional to professional equipment, it is necessary to use some means of balancing the signal, and providing any required change in level. The SSM2142 is an ideal device around which to base an output interface circuit, however, in its standard form, the SSM2142 has a differential gain of 6dB (gain of 2) and, depending on the application, more overall gain may be required. To overcome this problem an input stage can be added as shown in Figure 7. This is a simple non-inverting configuration using the superb NE5534A (YY68Y) op amp. With the components shown, a gain range of unity to +15dB is possible, with an input impedance of about 20kΩ.

The opposite of the above interface circuit could be built using the SSM2016 (UL17T). This IC will convert an incoming balanced input into an unbalanced single ended output, again with the minimum of additional components. As with the previous device, you may well have to experiment with additional stages of either attenuation or amplification to achieve the correct operating level.

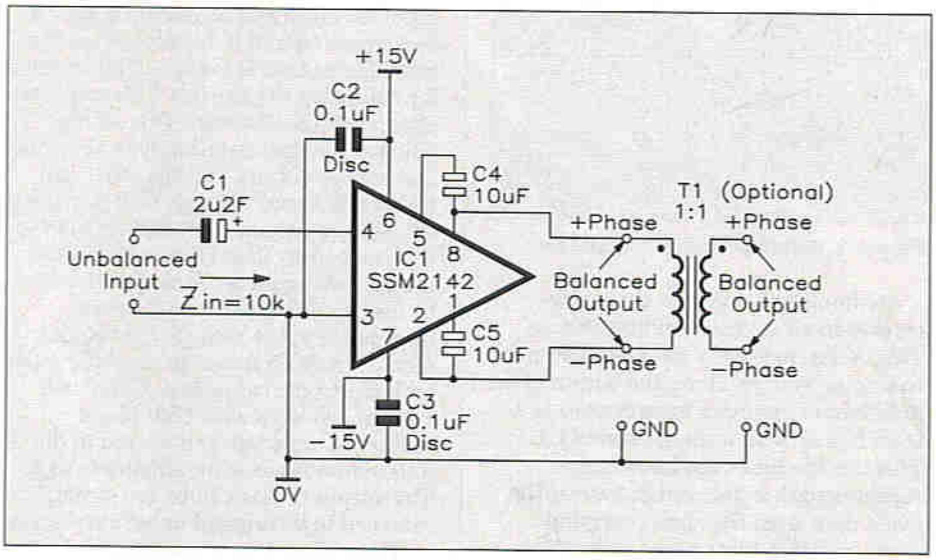


Figure 6. Practical balanced-line driver based around SSM2142 device.

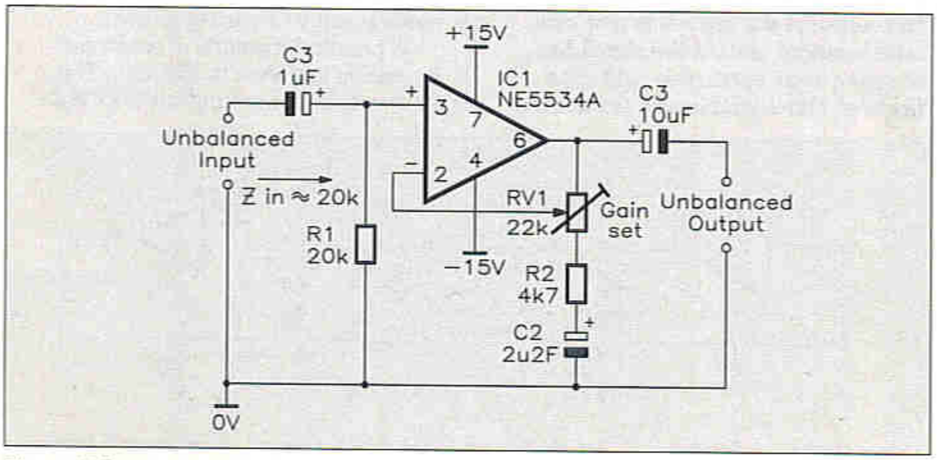


Figure 7. Input stage (0 to 15dB gain) suitable for use with circuit of Figure 6.

The SSM2016 IC was also featured as a 'Data File' project in Issue 41 (December 1990/January 1991) of 'Electronics'.

Operating Levels

As we saw in the comparison table, we can assume that professional equipment operates around the '0dBu' or '0' level (zero level) convention. This would be the case with most professional units which offer line level inputs and outputs. It is important to realise the origins of this magical '0' level figure. To help us with this we need to have a brief look at the history of the decibel.

The Decibel in Audio

The decibel will be familiar to many readers interested in audio, video, and RF. Its origins date back many years and is a derivative of the term Bel. In practice, the Bel was found rather too large to be useful with the signal quantities to which it referred, and so was decimated to 'deciBel' (one tenth of a Bel), the common abbreviation being dB.

The dB is the usual method of quantifying audio signal, and in simple terms it is a very useful way of comparing or expressing the relationship between the ratios of two quantities. In itself the dB has no unit and is dimensionless, and it merely serves to express a difference between two voltage or power levels at two specified points of a circuit or system. Decibels can be expressed in a positive or negative way; thus an increase in gain of, say, 10dB can be expressed as +10dB or said to be 'up' by 10dB. Similarly, a decrease in gain of 10dB can be expressed as –10dB, or said to be 'down' by 10dB.

Decibel and Voltage Ratios

With a few simple rules relating to the relationship between decibels and voltage ratios, it is quite easy to calculate a level of gain or loss fairly accurately. There are several key dB values (and hence voltage ratios) shown in Table 2 which, if committed to memory, make this task easier.

DECIBELS	VOLTAGE RATIO
0	1
6	2
10	3·16
20	10
40	100
60	1000

Rule 1 – Remember the key values above.
Rule 2 – If a simple approximate assessment is all that is required, do not get bogged down with over complicated mathematics.
Rule 3 – Multiplying voltage ratios is the same as adding dB.
Rule 4 – Dividing voltage ratios is the same as subtracting dB.

Table 2. Key dB Values.

Examples

From the above information, we can see that 60dB (x 1000) can be derived from the addition of 40dB (x 100) and 20dB (x 10), simply by adding the dBs (40 + 20 = 60), or multiplying the ratios (100 x 10 = 1000).

This, of course, works for 'less round' numbers, and simply requires a little more thought. For example, 34dB is 40dB minus 6dB, which is a division of the two voltage ratios (100 divided by 2), and so 34dB is a gain of 50. Try it for yourself to get a feeling for how dBs work – in no time at all, you will be able to quickly assess dB values!

As a point of interest, there is a point where the voltage ratio and the decibel have the same numerical value. At about 29dB, the voltage ratio is also about 29.

Whilst the above information may be of use, it is also important to take a brief look at how the dB is derived.

The relationship between the Bel, the decibel, and power and voltage is shown below.

$$\text{N Bel} = \log_{10} \frac{P1}{P2}$$

And, with the decibel being one tenth of a Bel, this gives:

$$\text{N dB} = \log_{10} \frac{P1}{P2}$$

where '$\log_{10}$' is the common logarithm and can be abbreviated to 'log'.

Because we can relate power to voltage in terms of:

$$P = \frac{V^2}{R}$$

we can now refer to voltage levels in terms of dB by:

$$\text{N dB} = 20 \log \frac{V1}{V2}$$

The above statement assumes that 'R', the impedance across which the measurement was made, remains constant, and that V1 and V2 are measured across similar impedances.

The decibel notation can only express absolute power or voltage levels when reference is made to some predetermined quantity, and therefore a statement such as 'amplifier output is 20dB' is meaningless as we have no yardstick with which to compare this.

There are many references (suffixes) which are used with dB to express absolute values.

The standard accepted international audio reference level is 0·775V RMS (774·597mV). This is the voltage developed when 1mW of power is dissipated into a load of 600Ω. The accepted term for this is 0dB (1mW), commonly known as 0dBm. To be absolutely correct when using the dBm notation, the load resistance or impedance should be 600Ω. The figure of 600Ω was established as a standard impedance because it was said that this closely resembled the impedance of a typical transmission line.

In most areas of general audio work, where we are dealing with voltage levels rather than power levels, it is considered normal practice to omit the requirement to measure signal levels across equal impedances, and so strictly speaking the dBm notation should not be used; however, this is not always the case and the dBm is very often misquoted. A more useful dB notation for audio work involving voltage levels is the 'dB (0·775V)', also known as 'dBu'. The dBu does not take account of 'the impedance at the point of measurement or the impedance associated with the reference'.

We can express dBu or dB(0·775V) as:

$$\text{N dBu} = 20 \log \frac{Va}{0{\cdot}775V}$$

Where Va is the measured or given RMS voltage level.

The above expression can be used in many ways. For example, a unit may have a specified output level of 1V RMS, but we may want to know what this is in terms of dBu. Applying our last expression and replacing Va with 1V will give the required result:

$$\text{N dBu} = 20 \log \frac{1V}{0{\cdot}775V}$$

Breaking down this expression into its component parts:

$$\frac{1V}{0{\cdot}775} = 1{\cdot}29V$$

Now take the common log ($\log_{10}$) of 1·29:

$$\log 1{\cdot}29 = 0{\cdot}1106$$

Now simply multiply this result by 20:

$$0{\cdot}1106 \times 20 = 2{\cdot}21\text{dBu}$$

Simple! We have now established that our 1V RMS produces 2·21dBu, but on the other hand, we may be given the (unlikely) fact that a unit has a specified output level of 2·21dBu, and need to know the RMS voltage level producing it. Because we instantly recognise that the dB notation used has a suffix attached to it (i.e., the 'u' suffix), we can make some assumptions. Firstly, we know that our reference voltage is 0·775V RMS, and secondly we do not need to take account of impedances. Converting the given figure of 2·21 dBu to voltage is really very simple – it is, in fact, a reversal of the previous procedure, and can be shown as:

$$\text{Vrms} = \frac{2{\cdot}21}{20} \text{Alog} \times 0{\cdot}775$$

where 0·775 is our reference voltage, and 'Alog' (Antilog) is the inverse of the common logarithm.

This can be broken down as :

$$\frac{2{\cdot}21}{20} = 0{\cdot}1106$$

Now take the antilog of 0·1106 :

$$0{\cdot}1106 \cdot \frac{1}{\log} = 1{\cdot}290$$

Now multiply 1·290 by our reference of 0·775V :

$$1{\cdot}290 \times 0{\cdot}775V = 1V$$

So our 2·21dBu is a signal voltage level of 1V RMS, which confirms our original calculations!

To get back to my original point, 0dBu or '0' level (zero level) is the standard international audio reference level, being 0·775V RMS.

Homework!

As a little teaser to end this section, I will leave you to ponder over the following. A measured sine wave is said to be 50Hz @ 49·8 dBu. What is its RMS voltage level? Easy! Answers next time.

Audio Signal Measurement

The need to measure audio signal level is critically important in any professional system, such as a recording studio or broadcasting station. However, it is not simply a matter of quantifying a voltage level for the sake of technical accuracy. Just as important is the need to balance or blend together our signals. I am sure you would agree that there would be no great pleasure in continually adjusting the volume control on a radio set or Hi-Fi unit to maintain the same amount of loudness, simply because the signal source itself was varying in volume due to a lack of control during the recording or broadcasting of that signal (Although most broadcast and recording studios do use compression, in one form or another, unfortunate as that may be! – Ed.). The signal must be controlled to a level that does not become so great to cause distortion, or so small that noise elements become a problem.

Let us take as an example the recording of an orchestra. This involves dozens of sound sources – different instruments, each playing at a different volume, all have to be controlled, balanced, and blended together to produce a sound that is correct in its component parts, as well as being at the correct overall level. During the recording process, it is the job of the sound balance engineer to achieve this result – and to make sure that the triangle can be heard and is in correct proportion to the rest of the ensemble!

Similarly, when you listen to your favourite radio programme, a great deal of control will (should?) have been exercised to balance the music and speech elements. Because a 'lively' piece of music will have a greater dynamic range and perhaps much larger transients than a single human voice, it is necessary to mix together different quantities of each to give a pleasant, well-balanced overall sound. The mixing or balancing of sounds will be done using some kind of instrument.

The human ear can, to a certain extent, be a very useful instrument with which to measure audio signals. However, whilst our ears are very good at assessing quality, and the balance of sounds, they cannot be reliably used to measure absolute levels. We therefore need to rely on some mechanical means to do this, and this should ideally be some kind of meter.

Meters

There are two types of meter currently in common use within the industry; these are the VU (Volume Unit) meter and the PPM (Peak Programme Meter).

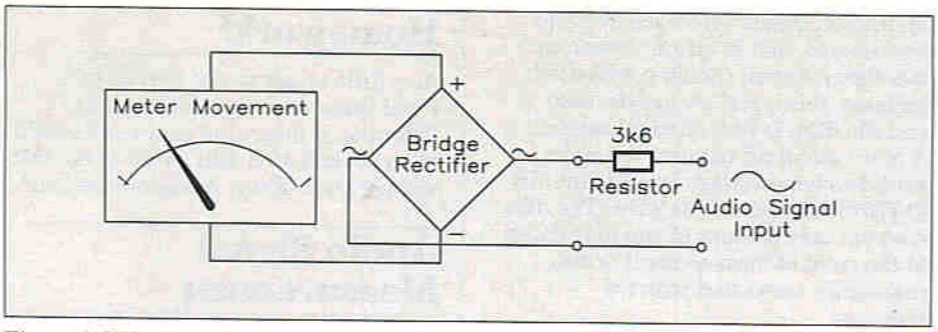


Figure 8. VU meter arrangement.

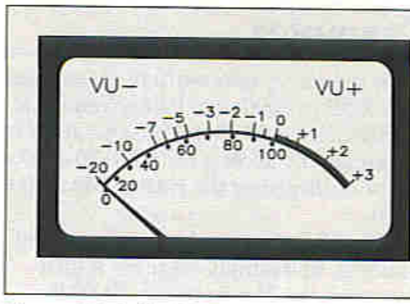


Figure 9. Typical VU meter. Note logarithmic scale.

Most readers will have used a VU meter at sometime, as these are the devices normally found on domestic cassette and reel-to-reel tape decks. Strangely, VU meters occasionally turn up on amplifiers and similar devices, but I fail to see any useful purpose in this – maybe it's just another sales gimmick!

The VU Meter

The VU meter is a unit of American origin, and was originally intended to give a measurement of the energy contained within the signal waveform.

The meter is a fairly simple device which consists of a moving coil meter movement, together with a rectifier and a driving resistor. The unit is connected across the signal to be measured. As it is a passive circuit arrangement, the VU meter requires no power supply, and can be driven directly from the signal source as shown on Figure 8.

The common scale of the VU meter is shown in Figure 9; the upper scale is marked from –20VU on the left, to +3VU on the right. The section from 0VU to +3VU is usually marked in red. The lower scale is a percentage scale and is marked from 0% to 100%. The 100% mark corresponds to 0VU. In a properly-specified meter, an indication of 0VU will occur when a signal voltage of 1·228V RMS is applied across the meter. If we recap on the section on dBs, it was stated that the international reference level of 0dBu corresponded to a voltage level of 0·775 VRMS. Applying 0dBu to a VU meter gives a reading of –4VU and, as we know, applying 1·228 VRMS to a VU meter gives a reading of 0VU. We can work out that 0VU is equivalent to a signal of approximately +4dBu.

$$N\ dBu = 20 \log \frac{1{\cdot}228}{0{\cdot}775} = 4\ dBu$$

VU Meter Advantages

Low-Priced;
Requires No Power Supply;
Requires little Maintenance and Calibration.

VU Meter Disadvantages

Difficult to Assess Peaks of Waveform;
Non-Linear Scale Cramped and Difficult to Read;
Speed of Movement becomes Fatiguing during Prolonged Use;
Does not Always Truly Represent the Audio Waveform.

The PPM

The PPM (Peak Programme Meter) was designed and developed by the BBC, and is intended to give an accurate indication of the peak levels of complex waveforms, such as those found in audio signals. It is commonly used to optimise and control signal levels with the intention of preventing distortion and overload in transmission lines and recording situations.

The PPM system comprises of a high-quality moving-coil meter movement, together with an active electronic driver card. The PPM has a fast attack (rise) time, slow decay (fallback) time (typically 3 seconds) and a near linear scale. It is available in two common forms – the single-pointer type, and the twin pointer type. The single meter is generally used to monitor a mono signal, or one channel of a stereo signal. The twin type has two independent pointers housed in one casing. Two varieties of the 'twin' type are available; the 'AB' version and the 'M + S' version. The 'AB' version is used to monitor the independent left and right components of a stereo source simultaneously. The pointers of the 'AB' version are coloured red (left channel or 'A') and green (right channel or 'B') respectively. The other version of PPM is the 'M+S' version – this is also used to monitor stereo sources, but in a different way. The 'M+S' meter monitors the sum and difference of the two channels. The 'M' signal is derived by summing the A and B channels together (A + B), whilst the 'S' signal is derived by subtracting the B channel from the A channel (A – B). Meters of this type are used to assess the 'stereoness' (width of image) of a stereo signal (more on this later in the series). The pointers of 'M + S' meters are coloured white (sum) and yellow (difference). Some PPMs have switching to enable them to operate in either AB or M + S mode.

Figure 10 shows the PPM scale, which has white markers on a black background. The linear scale is marked simply with the numbers 1 to 7. Each division between 1 and 7 corresponds to 4dB; therefore a 24dB range is available between 1 and 7. With the meter pointer vertical (at position 4), 0dBu is indicated, and so it is quite easy to establish a signal level relative to this. For instance, an indication of PPM 2 is equivalent to –8dBu, whilst an indication of PPM 6 is equivalent to +8dBu, and an indication of, say, PPM 3.5 is equivalent to –2dBu.

Because of the performance of the PPM, (fast attack, slow decay and the simple scale), the system is very much easier to read, and as the pointer is not frantically whizzing to and fro like that of the VU meter, the PPM is less demanding of, and so less fatiguing to, the operator. The characteristic movement of the PPM pointer is in part controlled by the time constant network shown in the block diagram of Figure 11.

A typical example, of the use of a PPM, would be a situation where pieces of music were interspersed with speech, such as a radio broadcast. The normal

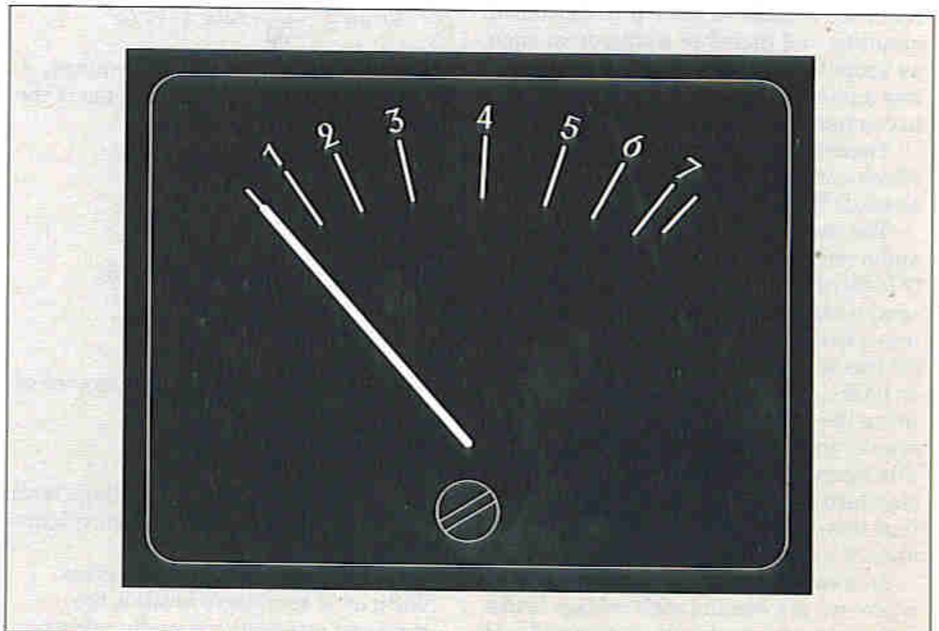


Figure 10. PPM scale. The linear section between 1 and 7 has 4dB per division.

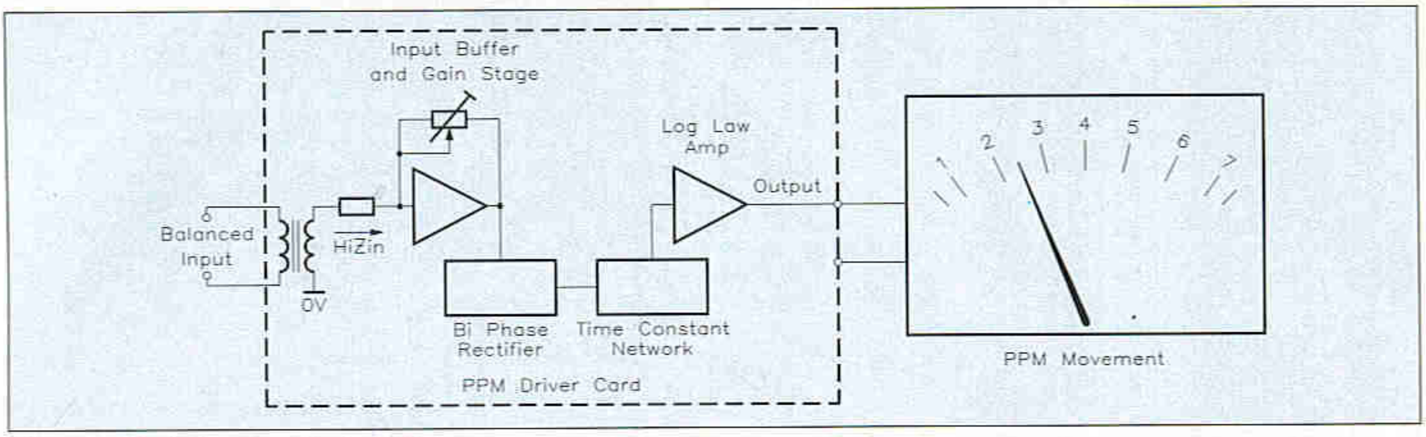


Figure 11. Block diagram of typical PPM.

convention would be to allow the speech and music elements to peak to a certain level. For example, speech would peak to PPM 6, while music would register at a (defined) level between PPM 4 and PPM 6; note, however, that this largely depends on the style and nature of the music. Classical music may be allowed to peak to PPM 6 during transients, whilst rock music, with its limited dynamic range, may be limited to PPM 4. Of course, the peak levels of music and speech must be sampled before being broadcast, and the operator would attempt to establish the loudest passage of the music and speech during a brief rehearsal, or when using the pre-fade listen (PFL) function of the mixing desk during the programme. These operations are known as 'taking level', and gain adjustments would be made to contain the maximum allowable peaks within the pre-defined limits.

PPM drive cards and meter movements are quite specialised, and are only really available through professional audio equipment dealers, and can be expensive – particularly the twin pointer varieties. A typical price for a single meter and drive card would be in excess of £100.00; add to this the cost of a power supply and enclosure, and the cost starts to rise. However, this is a high-performance and essential tool for professional audio applications.

PPM Advantages

Accurately Registers Peaks of the Programme Signal;
Linear Scale – Easy to Read;
Not Fatiguing to Operator.

PPM Disadvantages

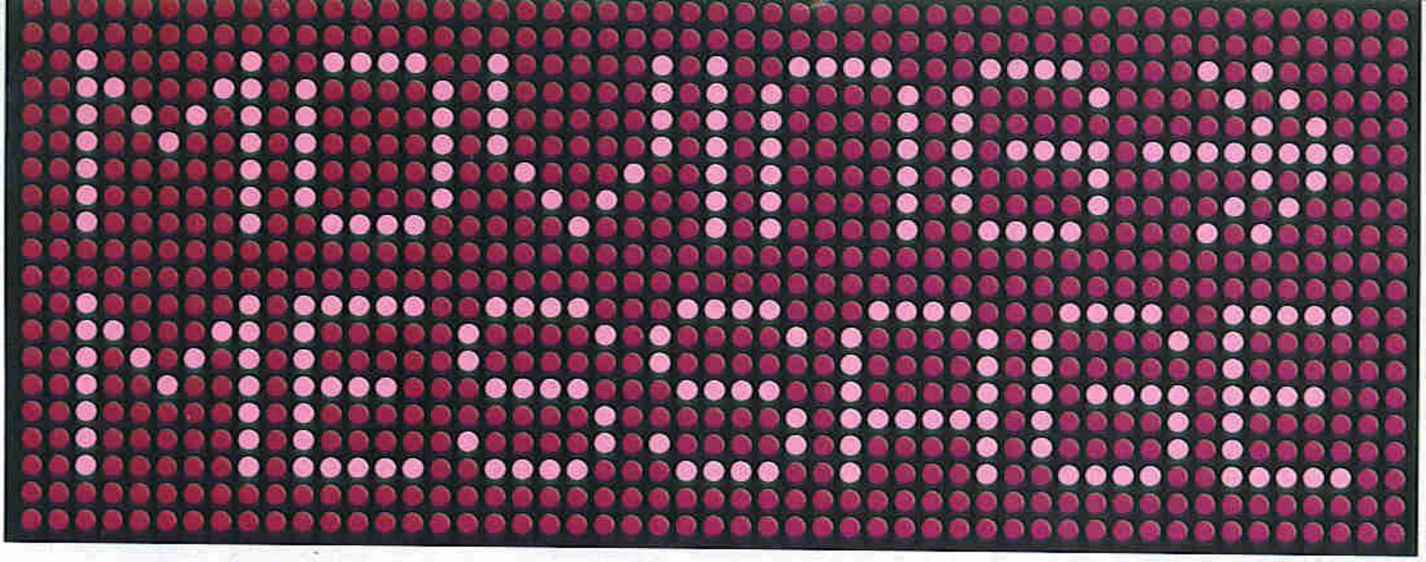
Requires Power Supply;
Requires Accurate Setting Up and Regular Calibration;
High Cost.

PPM Versus VU Meter

In reality, comparing PPM and VU meters is a pointless exercise because of their very different characteristics. If we were to place these two meters side by side and feed the same programme material to them, they would not appear to be monitoring the same material at all! The PPM would seem to be almost leisurely in operation, with the gentle and graceful traversing of its pointer against the high contrast simple scale. The VU meter on the other hand always seems to be running for the bus and never quite catching it. Add to this the cramped scale, and there is no comparison!

However, both meters have a role to play. Because the VU is easily available and of reasonable cost, it is by far the most common meter, and if used with some care can reasonably assess the average of the signal waveform. However, because it cannot accurately register the peak of the waveform activity (this is why peak LEDs are often seen with VU meters), it should never be used to monitor a transmission line or a serious recording session. The PPM can fulfil all that the VU cannot. It can be relied on to accurately assess programme peaks, and should always be used in any serious application. Both the PPM and the VU meter can, and often are, used together. A typical example is a mixing desk in a recording studio, where each channel of the desk has its own VU meter, but each group and the main outputs are monitored by a PPM. This situation is a good compromise, as it helps to keep costs down, whilst providing precise monitoring before any signals leave the desk.

Next month in Part Two, we look at microphones and microphone techniques.



DISPLAY SYSTEM

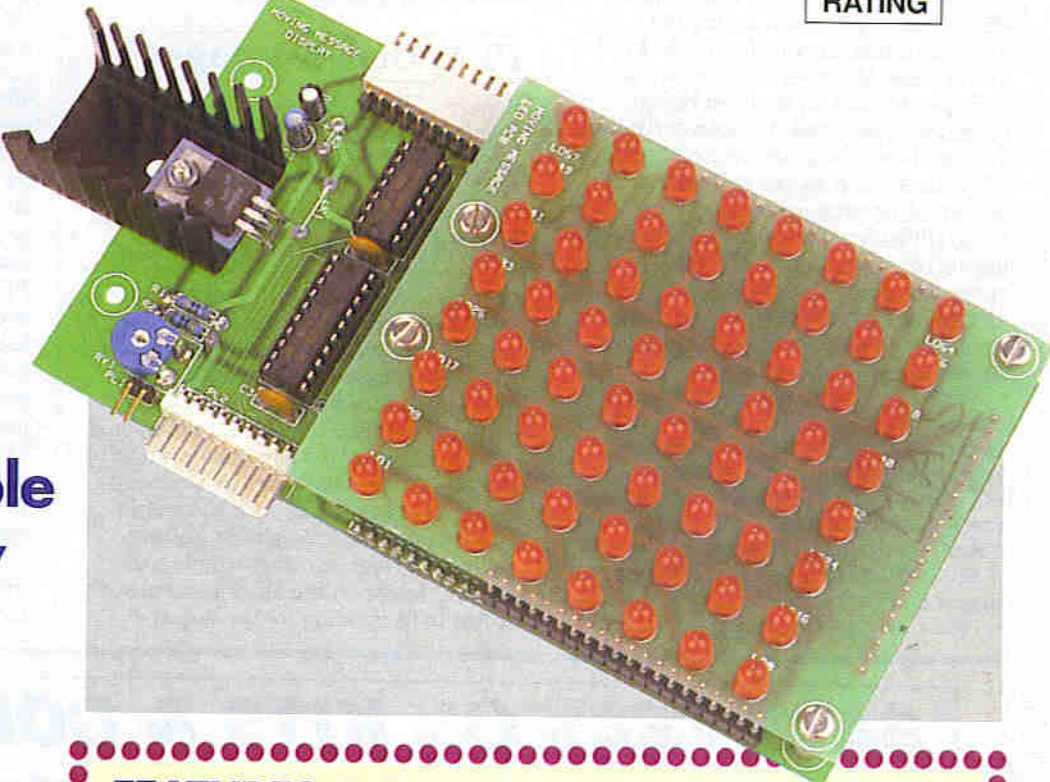
3 PROJECT RATING

PART THREE

Text by John Koushappas and Martin Pipe

Design by John Koushappas

Development by Tony Bricknell



Constructing the Expandable Power Supply

Unregulated Power Supply

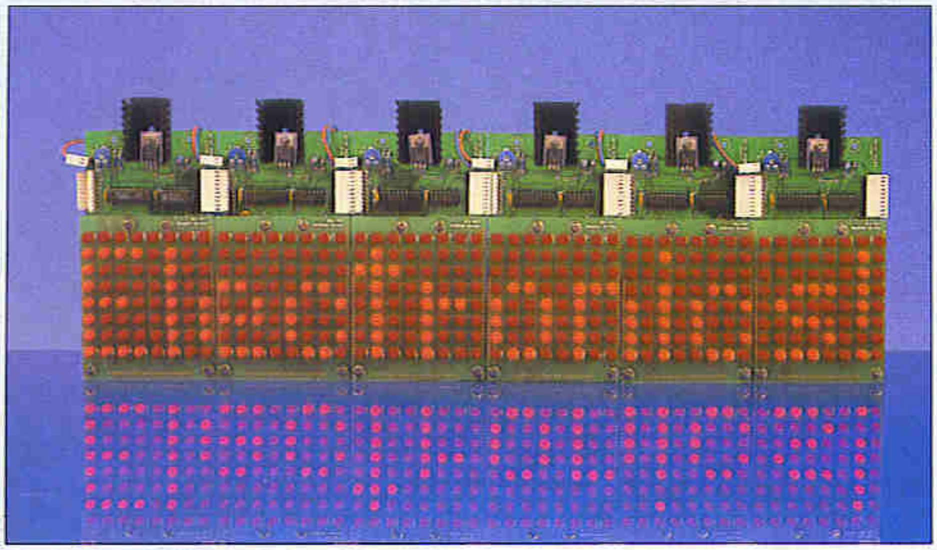
All of the modules in the Moving Message Display require an external mains-based power supply. This power supply needs to be capable of supplying an unregulated (but well smoothed) DC voltage of between 7 and 9V at a minimum current of 1A for each display module, and between 80 and 120mA for each controller module. With the appropriate components, the design to be described will provide sufficient power, at a voltage of 9V, for up to six Moving Message Display Modules, and the three associated Controller Modules. As the required voltage regulator circuitry is present on the display modules themselves, the power supply is of simple design. The PCB used, incidentally, is that of the 15W Amplifier PSU described elsewhere in this issue. Different sets of components are used, however – we use the plural form intentionally as the number of modules to be powered influences the specifications and ratings of the components required in each set. If you do have one of

FEATURES

★ Designed for use with any computer equipped with three 8-bit I/O ports – e.g., an IBM PC or compatible equipped with the Maplin 24-line PI/O card ★ Easily programmable from BASIC ★ Expandable to 32 boards by 'daisy-chaining' modules together ★ Large viewing area makes display highly readable in all lighting conditions ★ Programmable scrolling in all directions ★ Facilities for fade up/down ★ Programmable 'fizzle' effects ★ Direct pixel addressing for Speed (Animations, etc.) ★ Easy to Build

APPLICATIONS

★ Shop Displays ★ Announcements in Public Areas ★ Attention Grabbing! ★ Special Effects



A bank of display modules.

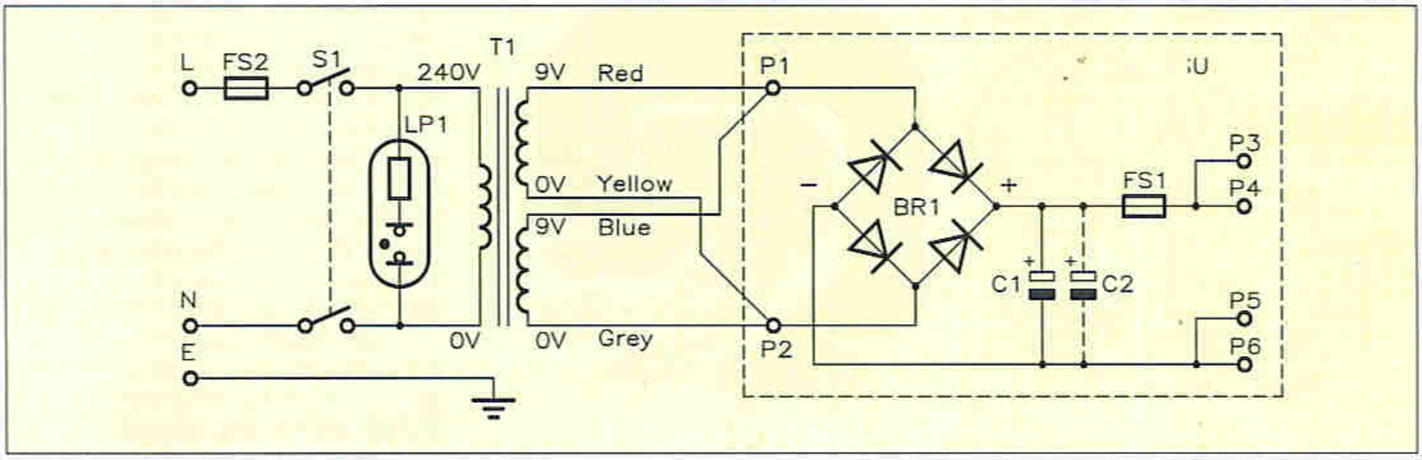


Figure 1. Unregulated Power Supply Module circuit diagram.

the 15W Amplifier PSUs, do not attempt to use it with the Moving Message Display – around 30V DC is produced with the amplifier transformer; the display system requires only 9V!

Power Supply Variations

The Unregulated Power Supply designed for use with the Moving Message Display Module is based around the 15W Amplifier PSU PCB. It accommodates a bridge rectifier, fuse and reservoir capacitor(s). The required mains transformer is too large to be mounted on the PCB and so is separate, being wired to the PCB by means of PCB pins. The overall circuit diagram is shown in Figure 1.

The bridge rectifier converts the AC output from the transformer into a full-wave rectified AC voltage, which is then smoothed by a reservoir capacitor, C1 (and C2 where fitted). The smoothed DC voltage is then output via a fuse, FS2, which protects the power supply against an overload which may, for example, be caused by a short circuit.

As mentioned earlier, the actual component types used depend on the number of display modules to be powered. The variations are summarised in Table 1. Note that the increased reservoir capacitance required for larger loads can be obtained by increasing the value of the capacitor, or by fitting a second (there are two suitable positions – C1 and C2 – available on the PCB). In addition, the transformer and fuse ratings are increased to allow for the extra demands made by a larger system.

The Display Controller boards derive their power supply from connector PL1 (pins 1 and 2) on each odd-numbered Display Module (refer to Part 2). The current drawn should not exceed 120mA for a fully populated Master; the others should draw somewhat less. The Moving Message Display Module's voltage regulator has 300mA of specified headroom to cover this requirement.

Because you are expanding the system – possibly continuously – you must remember to upgrade the unregulated power supply each time. If you intend to build an expandable system larger than a Base System, you should use the larger (50VA) toroidal transformer.

Number of Modules	Transformer, T1	Bridge Rectifier, BR1	C1	C2	FS1
1	0 to 9V, 0 to 9V 1·66A, 1·66A Order Code YK09K	PW01 WQ57M	4700µF FM83E	—	1·25A A/S UJ96E
2	0 to 9V, 0 to 9V 1·66A, 1·66A Order Code YK09K	PW01 WQ57M	4700µF FM83E	—	2·5A A/S UJ97F
3	0 to 9V, 0 to 9V 1·66A, 1·66A Order Code YK09K	PW01 WQ57M	10,000µF JL31J	—	3·15A A/S RA11M
4	0 to 9V, 0 to 9V 2·77A, 2·77A Order Code YK14Q	PW01 WQ57M	10,000µF JL31J	—	5A A/S RA12N
5	0 to 9V, 0 to 9V 2·77A, 2·77A Order Code YK14Q	PW01 WQ57M	10,000µF JL31J	4700µF FM83E	5A A/S RA12N
6	0 to 9V, 0 to 9V 2·77A, 2·77A Order Code YK14Q	PW01 WQ57M	10,000µF JL31J	10,000µF JL31J	6·3A A/S RA13P

Table 1. Power Supply Options.

Unregulated Power Supply PCB Assembly

Construction of the Power Supply PCB is perfectly straightforward. Orientation of the reservoir capacitor(s), C1 and C2 (where fitted) is critical – the minus symbol embossed on the capacitor(s) must point away from the '+' symbols printed on the PCB legend, which is reproduced in Figure 2. Failure to observe correct polarity may cause the capacitors to act as very effective mortars! Of equal importance is the correct fitting of the bridge rectifier, BR1. The positive symbol moulded into its casing must line up with that of the PCB legend – a dot or 'missing corner' may also indicate the bridge rectifier's positive terminal.

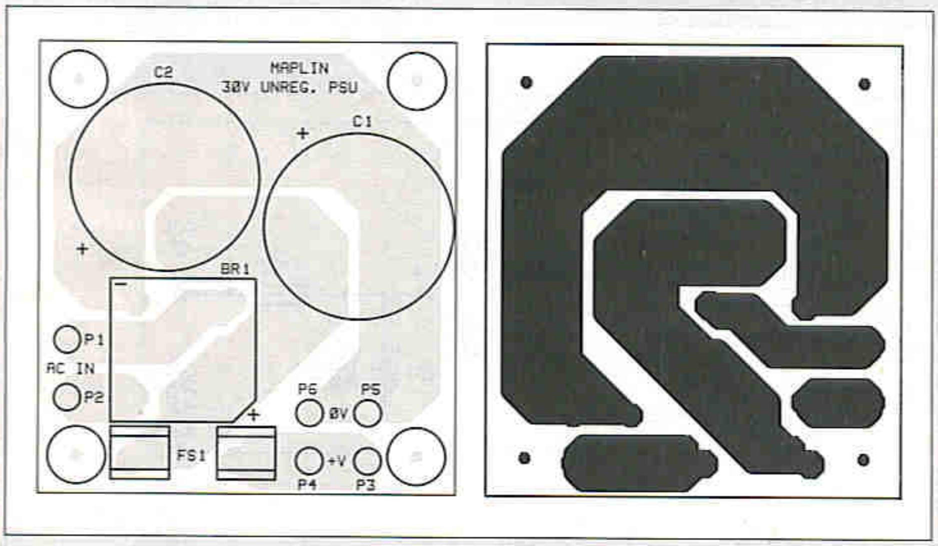


Figure 2. Unregulated Power Supply PCB legend and track.

The PCB pins are fitted from the track side of the board – these should be pressed in with a hot soldering iron. Additional information on soldering and general assembly, should you require it, can be found in the Constructors' Guide (XH79L).

When wiring up the transformer, it is important that it is wired up correctly – otherwise the fuse may blow and/or the transformer will burn out. The correct wiring details are shown in Figure 1. In short, the 'start' ends of each secondary winding (red and blue) are both connected to P1, while the 'finish' ends of each secondary winding (yellow and grey) are both connected to pin 2. Note that this colour code applies to both transformer types used with the Moving Message Display system.

Expansion of the PCB for use with a greater number of modules is easy. Moving up from a Base System, for example, simply involves desoldering the old components and replacing them with those capable of coping with the extra load – as outlined in Table 1.

Wiring up the Power Supply to the Moving Message Display

Each moving message display module must have its own power supply wires coming from the power supply source – an example of a 'fully loaded' power supply with 6 display modules is shown in Figure 3. It is critically important to ensure correct polarity – pins P5 and P6 are the power supply ground, while the positive supply rail is present on pins P3 and P4. Failure to observe correct polarity may cause severe damage to each Moving Message Display Module and Controller Module – so please check that all connections are correct. In addition, do not daisy-chain the power supply, as this can cause several problems and could even be dangerous. Make sure that you use cable of a suitable rating, as each display module requires 1A of current.

When your system goes beyond a six display board system, it is necessary for you to build a second unregulated power supply which can then take your display system's expansion up to 12 display modules (and 6 controllers). When doing this, be sure to link the 0V supply rails together at the sources of their outputs. Incidentally, a 12-board system would contain 96 LEDs across and so would be as large as most commercial display panels. Furthermore, because of the larger pitch used in our display, it would be some 30% longer as well.

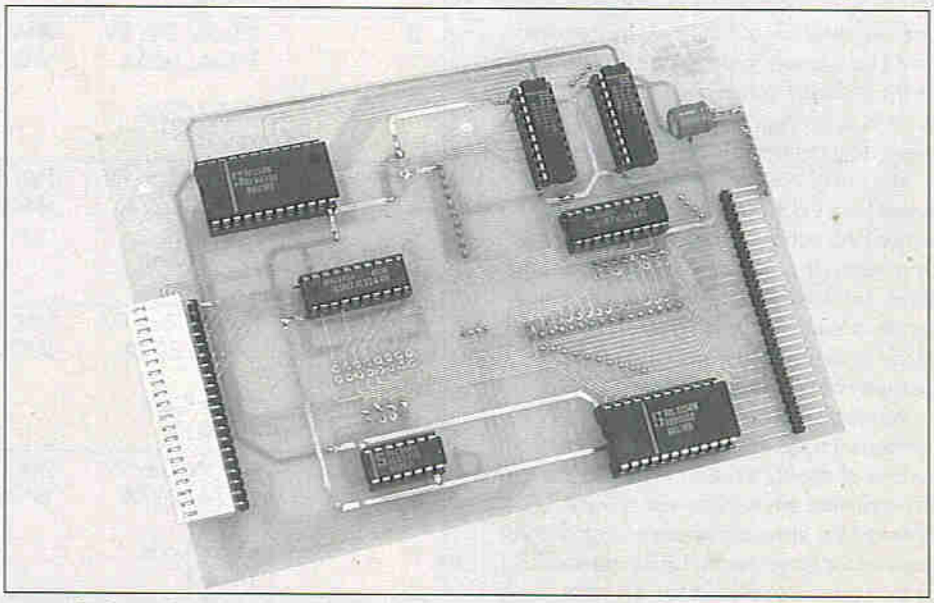
Regulator Bypass Link on Display Module

The regulator bypass link, LK1, is intended for use in situations where you may have a power supply capable of providing 3·9V at the large currents required (approximately 35A for a fully expanded system). Under such circumstances, the regulator components (IC1, RV1, R1, R2) would be omitted from each Display Module. Note that a separate 3·9V feed (connected to PL1) is required for each Module – the arrangement would be similar to that of Figure 3, except that the Unregulated Power Supply Module shown in the drawing would, of course, be a high-power (e.g., switch-mode) regulated one.

Safety Ground Links On Display/Controller Modules

The safety ground links provided on the Moving Message Display Module (LK2) and the Controller Module ('SAFETY GROUND') are there for two reasons. Firstly, they provide a safety net for inter-board grounding. This is important if a ground does not make properly, from one display board to the next, via the power supply ground return wire – something that may be particularly relevant after the Moving Message Display System has been in use for a long period of time. Secondly, making this link can secure the common ground between one board and the next, and the power supply common, thus preventing a potential difference building up between one board's common line and the next, thus preventing TTL logic level problems occurring along a long daisy-chain.

In most circumstances, these connections are unlikely to be required. If the power supply connections have been made consistently, no problems should occur and the first problem will be avoided. The second problem is more difficult to predict. However, no problems have been encountered with the prototypes and these links were left unmade. If problems are encountered (differing brightnesses of the LEDs, incorrect data being displayed, etc.), experimentation with the safety grounds is encouraged when everything else has been checked.



Controller board, component-side.

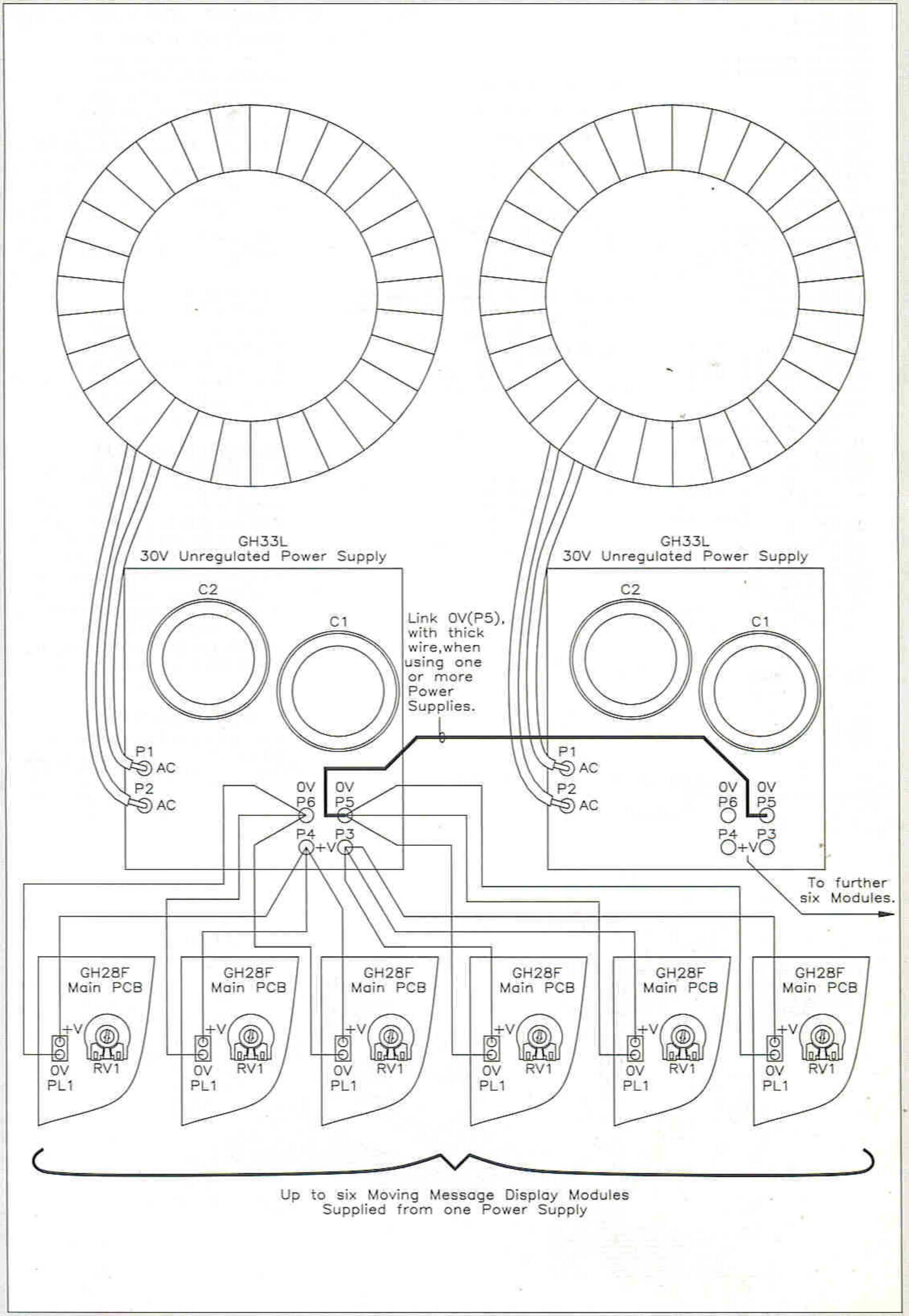


Figure 3. Wiring the PSU Module to (up to 6) Display Modules.

```
1000 KEY OFF
1010 COLOR 15,1
1020 CLS
1030 PRINT:PRINT:PRINT
1040 PRINT:PRINT:PRINT
1050 PRINT"                    Moving Message Display "
1060 PRINT
1070 PRINT"                     Moving Message Demo"
1080 PRINT
1090 PRINT"                       John Koushappas"
1100 PRINT
1110 PRINT"           (C) Copyright 1992 Maplin Electronics Plc."
1120 PRINT
1130 PRINT"                                V1.0"
1140 LET NOUGHT%=0
1150 MODULES%=2                        :' Number Of Modules In System
1160 ACROSS%=8*MODULES%-1              :' i.e. 8 LEDs Per Module
1170 LET BASEADD%=&H300                :' Base Address pointer - set to suit
1180 LET DATAPORT%=BASEADD%            :' Port A = Data Port
1190 LET CONTROLPORT%=BASEADD%+1       :' Port B = Control Port
1200 LET OE%=BASEADD%+2                :' Port C = Display Output Enable
1210 LET CR%=BASEADD%+3                :' Control Register for initialising 8255
1220 OUT CR%,128                       :' Initialise ports A, B, C as output ports
1230 OUT OE%,1                         :' Switch display on
1240 DIM ARRAY%(90)                    :' Create an array for the image
1250 DATA 0,0,0,0,0,0,0,0,0            :' blank screen to start with
1260 DATA 0,0,0,0,0,0,0,0,0            :' blank screen to start with
1270 DATA 0,0,0,0,0,0,0,0,0            :' blank screen to start with
1280 DATA 0,0,0,0,0,0,0,0,0            :' blank screen to start with
1290 DATA 255,2,4,2,255,0              :' M
1300 DATA 252,10,9,10,252,0            :' A
1310 DATA 255,9,9,6,0                  :' P
1320 DATA 255,128,128,128,0            :' L
1330 DATA 129,255,129,0                :' I
1340 DATA 255,4,8,16,255,0             :' N
1350 DATA 0,0,0,0,0,0,0,0,0,0,0        :' blank screen to end
1360 DATA 0,0,0,0,0,0,0,0,0,0,0        :' blank screen to end
1370 DATA 0,0,0,0,0,0,0,0,0,0,0        :' blank screen to end
1380 DATA 0,0,0,0,0,0,0,0,0,0,0        :' blank screen to end
1390 FOR B%=0 TO 90                    :' Loop length of message data
1400 READ ARRAY%(B%)                   :' Load array with message data
1410 NEXT B%
1420 FOR B%=1 TO 10
1430 FOR FRAME%=0 TO 80
1440 FOR DISWINDOW%=0 TO ACROSS%
1450 OUT CONTROLPORT%,DISWINDOW%
1460 OUT DATAPORT%,ARRAY%(FRAME%+DISWINDOW%)
1470 OUT OE%,3
1480 OUT OE%,1
1490 OUT OE%,3
1500 NEXT DISWINDOW%
1510 NEXT FRAME%
1520 NEXT B%
1530 SCREEN 0
1540 KEY ON
1550 CLS
1560 END                               :' Phew!
```

MAPLIN.BAS Program.

Testing and Interfacing

Modifying the Lead

In Part 2 of this series, we gave wiring details for a lead that interfaced the Moving Message Display Module to the PI/O Card. This enabled the single Moving Message Display Module to be fully tested. However, this lead will only work with a single display module – to work with a Base System (i.e. two Display Modules and a Controller Module) upwards, the lead requires modification. This is because the connections are different for the control bus, and there is an additional line to wire in – refer to Figure 4.

Test Program

Listing 1 is a full listing of the MAPLIN.BAS program shown last month, with all the modifications needed to run on a Base System. It will also work on a system of up to 4 display modules with a changing of one variable, Modules%, from 2 to 4. Type this program in and save it as "MAPLIN2.BAS".

Modifying The MMDM Diagnostics Program for use with the Base System

Listing 2 is a 'typeover' for DIAGNOSE.BAS, which was originally published in Part 2 – just load in DIAGNOSE.BAS and type over the lines shown. This program will now allow you to carry out, on the Base System, most of the tests that you carried out on the single module. Save the program under a different name, for example, "BASETEST.BAS". One important aspect to notice in the program is the way data is now clocked into each column.

Testing the Base System

Power up the Base System, and run the BASETEST.BAS test program diagnostic. Run through each test and observe the display.

Continued on page 47.

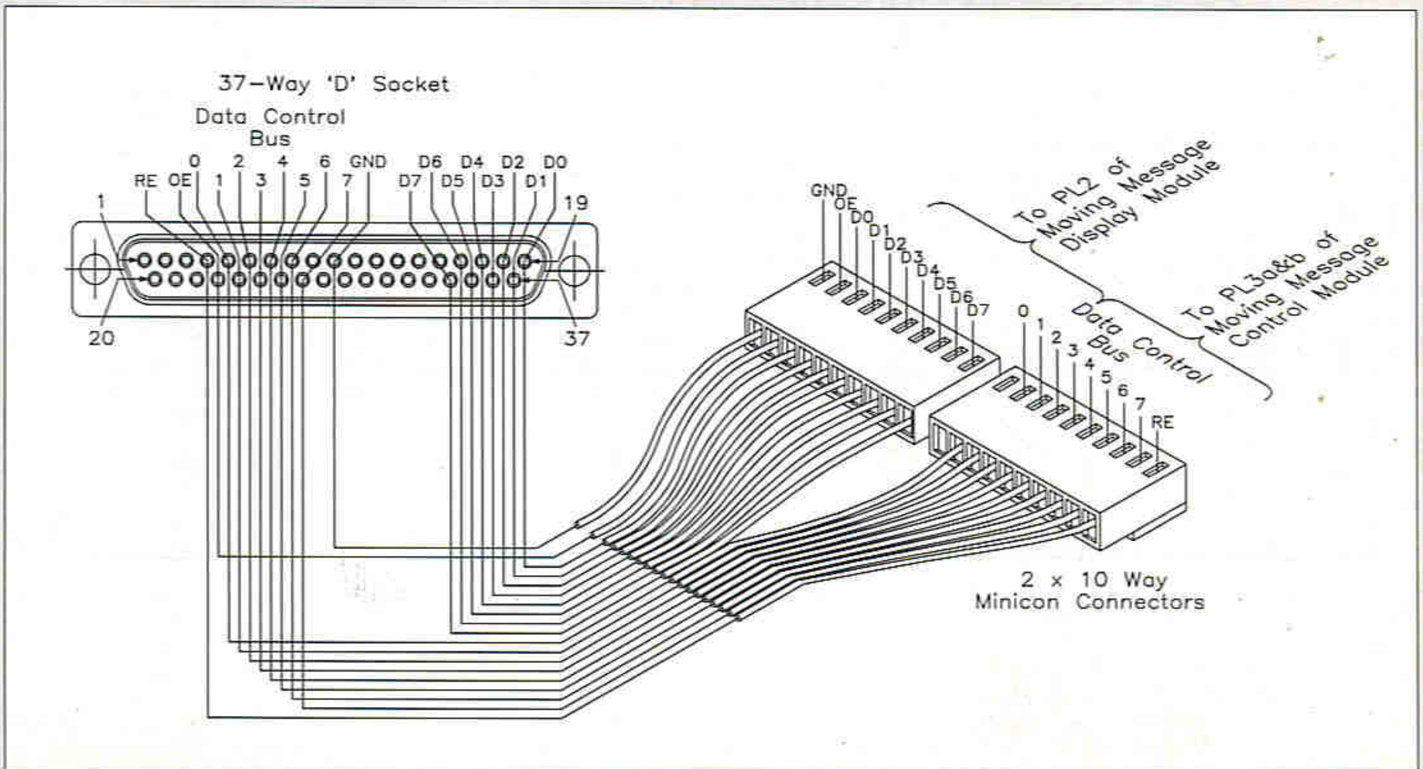


Figure 4. PC I/O Card to Base System interface lead details.

THE LEADING L·A·N OPERATING SYSTEMS IN EUROPE

by Frank Booty

One of the greatest battles of the computer and networking industry for a decade is underway now, even though it is being waged quietly. All the major suppliers are fighting to win the battle for the next generation of software for the PCs of the future. At stake is the development of the basic software which will make it possible to integrate the many current operating systems, and to convert software so that it can be used by new PCs.

Such a development process will call for a prominent role for networks and network operating systems. The network of the future will be able to interconnect everything. A consumer mass market will develop in which every type of machine will be controllable from the window on the screen. Indeed, a sophisticated market is expected to emerge in which mainframes (otherwise dubbed 'megaservers') will be linked in global networks. Thus the network of the future will be transferring vast quantities of data. Will the outcome of this intense activity in network operating systems development be the emergence of one, dominant supplier?

People not on a network now may soon expect to be, and all the market research companies agree on this point. Over 81% of all companies now have at least one LAN installed. However, with some two thirds of the European cake going to Novell (see Dataquest's chart) in 1990 (latest available figures), some would argue that the potential buyer of a Network Operating System (NOS) should look no further. By connecting his company's PCs to a network, he can easily squeeze more power out of less substance. His fast 386-based file server will deliver data to any workstation over the LAN faster than an AT class PC's local hard disk can push it down the bus.

Window on the Future

IDC reckons that some $12 billion are being ploughed into the fight to come up with the NOS of the future. Vast resources are being used in the development labs of the largest DP (Data Processing) suppliers on the integration of operating systems. The ultimate goal is to present the desktop computer (and maybe the notebook computer, etc.) as a 'window to the world'. This concept has been saddled with the terminology 'Object Linking Embedding', which means that from a single window it will become possible to reflect all objects (where everything is considered to be an object). Such a system will treat both a block of wood and a computer application as objects, which can be packaged and passed on, providing that the machines and networks have sufficient capacity.

The year 1991 was characterised as a time in which market players fought to capitalise on 3Com's exit from the sector (to concentrate on other areas). IDC argues that future success will depend on the ability to integrate DOS, OS/2, Mac and UNIX platforms into networks while providing security and network management functions with links to mainframes and minis. All LAN operating systems currently lack pieces of the jigsaw necessary to establish distributed processing systems.

There is also the oft heard criticism about the lack of sophisticated network applications, for the higher end LAN operating system products, such as NetWare 386 and LAN Manager 2.0. However, it is a fact that application developers have an unenviable dilemma in deciding whether to write to one of the competing application programming interfaces (APIs), and chance on its success, or risk missing the wave by waiting for standards or clear market leaders to emerge.

IBM is said to have used at least $5 billion on the development of OS/2 (version 2.0) and Pink NetWare, which is currently being developed with Apple. Hewlett-Packard's New Wave has, to date, cost some $2.5 billion, and NCR has consumed about the same amount of cash on Co-operation. Then you have to add Microsoft's $1.5 billion investment in NT-Windows. All of these systems have been developed as combinations of screen-picture generation and server solutions which give access from a single desktop machine to every conceivable type of computer. It should be pointed out that the development of these systems cannot be separated from network operating systems, because they have been developed as integrated solutions.

The market research company Gartner Group opines that the integration expected to take place will be good for users. Integration means that the network operating system gives users access to mainframes and databases. But even if this integration occurs, says Gartner, applications development for users will be able to take place independently of the underlying network operating system – which is definitely regarded as a 'good thing'.

A New Dawn from 1994

Apart from the PC operating systems mentioned already, network operating systems such as Novell's NetWare, Microsoft's LAN Manager, IBM's LAN Server, Banyan Vines and 3Com's 3+Open have been developed – 3Com withdrew from this market in 1990. According to IDC, the battle will, in effect, be over at the beginning of 1993 without many people realising it (apart from those actually involved of course). This is in spite of the fact that it is the most important strategic fight which has occurred in the computer industry during the past decade.

Everyone appears to be fighting against Microsoft. The introduction of Windows has made it possible for all 'old-fashioned' PCs to have a graphic screen display for applications. But DOS is still the basis. The old MS DOS, now used by some 80 million PCs, is too limited for the complex tasks demanded of it by computers today. In particular, it cannot handle the large amounts of memory required for current programs.

In the mid-'80s, Microsoft reasoned that the single user PC did not have a guaranteed future – one reason being the rise of the network. Thus it was that IBM and Microsoft joined forces in 1987 to develop the OS/2 network operating system, with the Microsoft LAN Manager and IBM LAN Server products introduced at a later stage. None of the elements in this package have been a success. Today, the more that Microsoft reveals about its network strategy, the clearer it is becoming that the company's aim is to position its own Windows product as the industry standard for network screen displays. Clearly emerging as the main threat in the future, however, is Pink NetWare – i.e. IBM, Apple and Novell. But in the short term the main enemy will continue to be OS/2 (version 2.0).

Microsoft intends to introduce New Technology Windows (NT-Windows) early this year. It is Microsoft's true 'window' to data management in the '90s, i.e. 'Object Linking Embedding'. IBM claims that OS/2 is now what NT-Windows will be at some future time, which may be true. But here Microsoft has been cunning. It has recently announced special tools which will allow developers to write products for the yet to be launched NT-Windows, which can run immediately on the new Windows 3.1. This trick appears likely to ensure a lot of immediate development work on applications, and hence plenty of products for NT when it does arrive. IBM has been expected to put much of its proven marketing muscle behind OS/2. But it does look as if OS/2 will become something of a specialised item, used for such onerous tasks as running database servers. Important certainly, but not quite the mass market product that IBM must be expecting.

The Gartner Group takes the view that there has been a great deal of speculation about the possible death of LAN Manager at such time when NT-Windows is introduced. Gartner thinks Microsoft is losing some $50 million a year on LAN Manager, and the product does not possess the necessary modern functions for network based data management. In actual fact, it only copes with file and printing functions. However, LAN Manager has been Microsoft's vehicle for selling its own applications, such as spreadsheets and word processing. As Microsoft does not care to sell these applications on Novell servers, LAN Manager has been preserved as a necessary expense.

Two Winners?

Microsoft's network strategy is based on capturing a market share until its own really competitive product (NT-Windows) is launched, says Gartner. LAN Manager is expected to survive as a discreet set of services and interfaces in operating systems with wider ranges of functions, like NT-Windows, UNIX and OS/2. But IBM's LAN Server is expected to be finished when NT-Windows is ready.

IDC believes that this Network Operating System fight has room only for two winners – with IBM/Apple and Microsoft expected to split the market between them. This is expected to occur before the end of 1993. HP and NCR will have their supporters, but there are not expected to be many of them.

From a historical viewpoint, the Data Processing market appears to be going through a repeat of earlier efforts. Everyone is trying to set their own standards (you want standards? OK. Which one do you want?). This was the scene in the infancy of the computer industry – who remembers the farcical situation we had in the early to mid-'80s, where umpteen different makes of 8-bit computers were deliberately incompatible with each other, to the extent that even their respective floppy disks were recorded so differently as to be unreadable by any other machine? Similarly, the new network industry will continue to be increasingly lucrative, because the volume of information to be transferred between the various incompatible systems will grow unabated.

Before any of these new 'Object Linking Embedding' systems see the light of day and the market is carved up, more than 100 million PCs will have been sold. Many of them will have DOS Windows. With the first version of NT-Windows, Microsoft will be able to migrate DOS machines to chosen, simpler networking functions which are known today through Novell NetWare and LAN Manager. This is expected to happen this year. So as well as the development of new 'Net Object Systems', which will appear as network operating systems, work is going on in parallel to pull the existing PC population into the network world, albeit at a lower level.

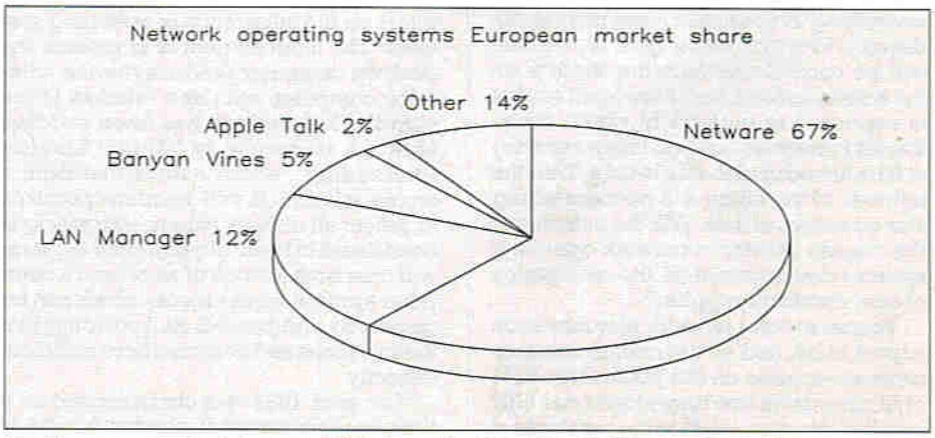
This means that, providing other suppliers develop products which support drivers for these interfaces, NT-Windows will be a short cut to the many heterogeneous networks in companies, because NT-Windows will probably set the standard. Users will only have to link-up with the DP system in one single procedure. In so doing, NT-Windows will create considerable marketing problems for the suppliers of the existing operating systems, Novell NetWare and Banyan Vines, since NT-Windows will treat them as 'objects' and package them.

The Future

Novell NetWare, which has about 60% of the global market for network operating systems must (in marketing terms) continue to collaborate with IBM, DEC, HP and others who use its products in conjunction with their server solutions. Novell has also acquired Digital Research, a company known for its DOS expertise, which can be regarded as a counterbalance to Microsoft.

IDC believes that Microsoft, having set the standard for PC operating systems now intends to set the standard for the coming decade's 'Window' to all types of operative systems and machines. And that's not just in the computer industry, but also for washing machines, video recorders, compact disc players, etc. – indeed everything electronic. The computer of the future will be a control centre from which the user will be able to do most things. The computer industry is not regarded as big enough for Microsoft.

However, the one point which appears to have been missed in all the talks of battles and winners is this: people have been keen to broadcast the advantages of open systems and the disadvantages of being locked into a single supplier (aka IBM, etc.). Why then is everyone expressing keen desires to lock themselves into a single supplier with Windows?



The European market share for NOS shows that Novell's NetWare accounts for some two thirds of total revenue. The LAN Manager revenue includes LAN Manager, LAN Server and 3+Open.

Individual Views

LAN software leader Novell entered the PC operating system market in October, 1991, with its purchase of Digital Research, who manufactured its own versions of DOS. Although many have seen the move as an attempt to counter Microsoft's combined LAN, a main concern is having more network management capabilities built into PC operating systems. Being a key player in both PC and LAN operating systems offers advantages and disadvantages, which Microsoft has been quick to pick up on. Picking whether network related services on the PC would be invoked by a peer to peer or client server operating system becomes more a packaging than a technical issue (according to Microsoft). Some quarters have supposed that NT Windows will have peer to peer capabilities. Disadvantages lie with the belief that if a PC operating system is designed to run best with one type of LAN, it may not be as efficient with another. It is for this reason, that IBM is thought to have implemented a range of network functions in OS/2, that it will attempt to implement in a manner neutral to network operating systems.

Ideally, a network operating system should be invisible to the user. Good multitasking should ensure performance exceeding that of DOS and should provide a platform on which users can work as they did before they were connected. Of all that is available, the word is that only Novell's duo of NetWare products offer enough performance to tempt one to start networking.

Sadly lacking in this market are value for money items. PC markets are traditionally associated with low prices, clear manuals, free support, ease of use and value to buyers. This is not the case with networking. It is difficult to install a network operating system and it is fair to say all the systems have confusing screen messages and obscure, even esoteric, printed documentation.

Banyan launched Version 5.0 of its Vines product at CeBIT, Hanover, this year, which includes many enhancements. There are now no criticisms of its complex installation and unfriendliness. It now supports Apple Macintosh clients and both AppleTalk Phase 1 and 2 enhancements, together with zones (similar to groups of users) are supported. OS/2 workstations are supported by Microsoft's server message block protocol, and to cope with this extra client base, Banyan has redesigned the disk filing system (making it similar to facilities offered by NetWare). There's also the ability to direct one print job to multiple printers.

LAN Manager 2.1 is a much improved and reasonably priced product, particularly looking at past events and previous problems. Indeed Microsoft seems to be fighting Novell close in, as LAN Manager goes out of its way to embrace NetWare. Both workstations and servers can connect with NetWare servers. For mixed network systems, this is seen as a good implementation of cross operating system support. A client can now view and access LAN Manager and NetWare servers and their associated resources. Further, the two types of file server are now able to recognise and communicate with each other.

When Novell first produced its NetWare range an E-mail package was bundled free. Not today though. Only Banyan's Vines and DEC's Pathworks offer complete packages. However, Novell scoops the laurels from other areas. Only NetWare comes close to offering a consistent menu-driven method of operating the network, for both users and administrators – it also provides those all too rare attributes of solid and good performance and good reliability. Only when the competition picks up on these points will there be options. When this will be remains to be seen.

Moving Message Display System continued from page 44.

```
1120 PRINT"                               Base System Pattern Tests"
1530 LET ACROSS%=15                  :'   Number Of Bits Across The Display
1710 PRINT"                     Base System Pattern Tests"
1860 FOR X%=0 TO ACROSS%    :'          Loop Length Of Display
1870 OUT CONTROLPORT%,X%    :'          Control Port Number
1882 GOSUB 3000             :'          Clock the data in
1902 GOSUB 3000             :'          Clock the data in
2000 PRINT"                This routine not available for Base System ":RETURN
2180 FOR X%=0 TO ACROSS%    :'          Loop length of display
2190 OUT CONTROLPORT%,X%    :'          Open weighted control line
2202 GOSUB 3000             :'          Clock the data in
2222 GOSUB 3000             :'          Clock the data in
2320 FOR X%=0 TO ACROSS%    :'          Loop length of display
2330 OUT CONTROLPORT%,X%    :'          Select control line
2352 GOSUB 3000             :'          Clock the data in
2372 GOSUB 3000             :'          Clock the data in
2550 OUT CONTROLPORT%,X%
2562 GOSUB 3000             :'          Clock the data in
2582 GOSUB 3000             :'          Clock the data in
2800 FOR X%=0 TO ACROSS%    :'          Loop length of display
2810 OUT CONTROLPORT%,X%    :'          Control port number
2822 GOSUB 3000             :'          Clock the data in
3000 '          Subroutine to toggle data in
3010 '
3020 OUT OE%,3
3030 OUT OE%,1
3040 OUT OE%,3
3050 RETURN            :'     simple!
```

Typeover lines for DIAGNOSE.BAS Program.

You should know what to expect on the display because all the tests are the same as those you carried out on the single module. If you encounter any faults, you'll have to get the logic probe out again! If nothing appears at all, on any of the tests, check the control line from port C, bit 1. This is the WRITE line, an active low line that toggles in every bit of data. Check that it actually reaches IC4 pin 19. Check also the data port, the control port and the OUTPUT ENABLE line to the display modules, as any of these could also cause a blank display if you cannot see them pulsing or active during a program run.

When all is well, testing of the Base System is complete!

Next Month

In the fourth and final part of this series, we will look at the final testing and use of the complete Moving Message Display System.

UNREGULATED POWER SUPPLY PARTS LIST

CAPACITORS (Refer to Table 1)				
C1		4700µF 16V PC Elect	1	(FM83E)
	or	10,000µF 16V PC Elect	1	(JL31J)
C2		4700µF 16V PC Elect	1	(FM83E)
	or	10,000µF 16V PC Elect	1	(JL31J)
SEMICONDUCTORS				
BR1		PW01 Bridge Rectifier	1	(WQ57M)
MISCELLANEOUS (Refer to Table 1)				
T1		30VA 9V Toroidal	1	(YK09K)
	or	50VA 9V Toroidal	1	(YK14Q)
FS1		Fuse 20mm A/S 1·25A	1	(UJ96E)
	or	Fuse 20mm A/S 2·5A	1	(UJ97F)
	or	Fuse 20mm A/S 3·15A	1	(RA11M)
	or	Fuse 20mm A/S 5A	1	(RA12N)
	or	Fuse 20mm A/S 6·3A	1	(RA13P)
		PCB	1	(GH33L)
		Fuse Clip 20mm Type 1	2	(WH49D)
		PCB Pin 2141	1 Pkt	(FL21X)
		Instruction Leaflet	1	(XU06G)
		Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items are not available as a kit.

MAINS TRANSFORMERS

Part One
From Theory to Practice

J. M. Woodgate
B.Sc.(Eng.), C.Eng., M.I.E.E., M.A.E.S., F.Inst.S.C.E.

The idea of writing this short (two part) series came from a request to design a transformer using the Maplin kit YJ63T. Having bought the kit, I found that, while the trusty Catalogue gave me quite a lot of information, it did not give me as much as I would really like. Negotiations with the Kindly Editor (in which he pointed out that, unless I was really determined to starve, it was about time I wrote some more articles) produced some sample transformer kits for measurement. In the meantime, I have bought an Acorn A5000 computer, to replace my BBC Micro in due course (i.e., when I learn to drive the A5000 reasonably well!), and this is a good opportunity to try out yet another word processor (Impression II).

The question always at the beginning of an article is where to start. Since we shall be talking mostly about transformers designed around the Maplin kits, we should get down to practical details as soon as possible, so here goes!

History

The transformer was invented by Michael Faraday, and it is interesting that his first design was a toroidal transformer (nothing to do with Taurus the bull, but from Latin *torus*, an anchor-ring), consisting of two coils of insulated copper wire wound on a ring of soft iron, and completely insulated from each other. Faraday found that electrical energy could pass from one coil, the *primary* winding, to the other, by conversion to magnetic energy in the iron core and reconversion to electrical energy in the output coil, or *secondary* winding. Working with DC as he originally was, Faraday could not obtain a continuous energy transfer, but the invention of the alternator, and alternating current, changed the picture completely. The transformer can change the voltage of an AC supply without losing much energy, i.e., it is an efficient process. By contrast, efficient conversion of DC supply voltage is only now possible, using high-speed electronics, over 150 years later.

Towards an Equivalent Circuit

That sounds impressive, doesn't it? Actually, it is not all that difficult (unless I foul up the explanation, that is!). Let us apply an AC voltage to a simple transformer with two windings. When we think about what the input and output currents 'see', there are clearly the resistances of the two windings, R_p and R_s (Figure 1a). If there is nothing connected to the secondary winding, there is, of course, no secondary current. The primary current then 'sees' the primary winding as an inductor, and some current flows through this. Since it is this current which produces the magnetic flux in the iron core, it is called the magnetizing current, and its value is (very nearly) independent of any load that may be connected to the secondary winding. Unfortunately, the process of magnetizing the core is not entirely without losses: if it were, the magnetising current would lag an applied sinusoidal voltage by exactly 90°. In fact, the losses consist of two parts, the hysteresis loss, which is due to the fact that it takes energy to magnetise the iron, first in one direction and then in the other (we shall see more of this later), and the eddy current loss, which is due to currents induced in the iron itself by the alternating magnetic field. The hysteresis loss is a property of the iron itself, and it is up to the metallurgists to produce good materials, while the eddy current loss is minimised by making the core up of thin sheets, or *laminations*, which are insulated from each other by a layer of blue iron oxide or insulating varnish.

There are two things that can be done to the iron to reduce its hysteresis loss; alter its chemical composition and alter its crystal structure. Actually, chemically pure iron is not too difficult to make, and is quite good, but we can do better for less money. As normally made, iron contains a small percentage of carbon, and this is bad news for hysteresis loss, so it is eliminated in the process of making transformer iron. However, adding a few percent of silicon improves the iron a good deal, and virtually all power transformer cores are made of silicon iron (not 'silicon steel', because there is virtually no carbon). As regards the crystal structure, this can be changed by various types of heat treatment, both before and after the iron receives its final winding into a toroid or stamping into laminations, by allowing the iron to cool in a hydrogen atmosphere (no, I don't know how this works), and by cold-rolling the iron in strip form so as to align the microscopic grains in the material all in the same direction. Such material is called 'grain-oriented', and is the highest performance material normally used for mains transformers. However, its magnetic properties are much better in the direction of rolling than across it, so this material is rather better exploited if used in toroidal cores than in stacked laminated cores.

You can tell by the surface appearance what sort of material you have: heat treated material has the blue iron oxide film on its surface, hydrogen-annealed material is grey and shiny, while grain-oriented material is usually light grey on one side and has a faint pattern of parallel lines on the other. Older transformers may have plain grey, grainy material, which may be coloured on one side. If you knew the colour code, you could tell what grade the material was.

The losses in the iron may be lumped together as a resistance R_i in parallel with the primary winding (Figure 1a). The next step is to put a pure resistive load R_{load} on the secondary winding, and see what effect that has on the primary side (Figure 1b). To do this, we consider a secondary voltage V_s and current I_s, which produce a power in the load equal to $V_s I_s$. Now, the best we can do is to supply exactly this power to the primary winding, for that represents 100% efficiency, which is OK because we have allowed for all the losses in the three resistors in Figure 1a. For the present, you will have to take my word for it that, if the primary winding has n_p turns, and the secondary has n_s turns, then:

$$V_p / V_s = n_p / n_s = N$$

where N is called the *turns ratio*.

But we also know that the power into the primary winding is equal to that in the load:

$$V_P I_P = V_s I_s$$

so that

$$I_P = V_s I_s / V_P = I_s / N$$

Thus

$$V_P / I_P = N V_s / (I_s / N) = N^2 V_s / I_s = N^2 R_{load}$$

In words, the resistive load on the secondary winding looks from the primary side as a resistance N^2 times as big. Note that *N* is not necessarily larger than 1: it may well be smaller, even though we usually quote turns ratios as 'something to 1'. This result enables us to complete our equivalent circuit (Figure 1c), and although we worked out the 'N^2' rule for a pure resistive load, it applies for any load impedance Z_{load}. It also applies to the resistance R_s of the secondary winding itself.

Magnetising the Core

So far, we have assumed nothing about possible limits on the amount of power that we can transfer from primary to secondary via the magnetic field in the core. There does not appear to be any practical limit to the degree to which a vacuum, or air, can be magnetized, but at mains frequencies an air-cored transformer would have very poor efficiency. However, we cannot expect there to be no limits when we use an iron core, and in fact there are quite definite limits. The magnetizing current flowing through the primary winding produces a magnetic field strength *H*. This is the product of the current and the number of turns of wire in the winding, divided by the length of the magnetic circuit (the magnetic path through the core), and is measured in ampere (turns) per metre (Am^{-1}). If the core were a vacuum or air, instead of iron, this magnetic field strength would produce a magnetic induction or magnetic flux density *B*, measured in tesla (T), given by:

$$B = \mu_o H$$

where μ_o is called the *permeability of space*, and has the value $4\pi \times 10^{-7} Hm^{-1}$ (henrys per metre). But iron is a 'magnetic' material (strictly, a ferromagnetic material, which is not very helpful, because the 'ferro' bit simply means 'like iron'!), which means that a given *H* produces a great deal more *B* than it would in air, and we express this as:

$$B = \mu_o \mu_r H$$

where μ_r is the *relative permeability*, and the product $\mu_o \mu_r$ is known as the *absolute permeability* μ. Everything would be very easy if μ_r were constant, but it not only varies with *H* but the way it varies exhibits the property of hysteresis that we mentioned before. Looking at Figure 2, we assume that we apply a very low frequency voltage to the primary winding so that we can 'watch' what happens, and we arrange to switch on as the voltage passes through zero on its way up. To find *H*, we can measure the current through the winding, to which *H* is proportional. We can find *B* by processing the secondary winding voltage, as we shall see. What we find is that for the first quarter-cycle of the voltage, the B-H curve is traced out from O to A, but ever afterwards the curve is traced round the S-shaped loop ABCD, and this failure to return by the outgoing path is what is known as hysteresis. It occurs in other situations as well as in electromagnetism, and results in a loss of energy. The loss is proportional to the area of the loop, and since we want the loop to be as tall as possible (giving a high value of *B* at saturation, see below), the only way to minimise the area is to make the loop as thin as possible. The loop is symmetrical about the origin, and the value of *H* at which the curve cuts the H axis (i.e. where $B = 0$) is called the *coercive force;* therefore to minimise hysteresis loss the *coercive force* must be made small. This is exactly the opposite to the requirement for materials for permanent magnets and recording tape.

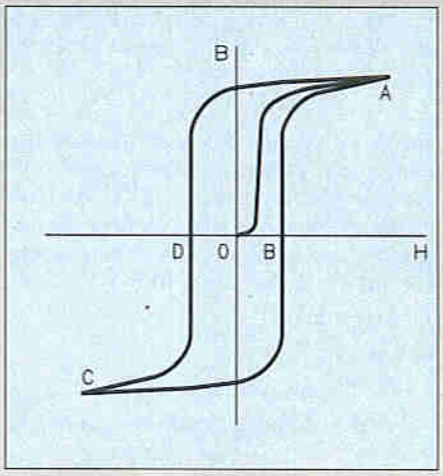


Figure 2. Drawing of hysteresis loop showing initial curve and loop.

The absolute permeability at a given value of *H* or *B* is represented by the gradient or slope of the B-H loop at the appropriate point, and we can see that for high values of either variable the permeability drops to a low value (eventually to μ_o). Under these conditions, the iron is said to be 'saturated' – it can't 'absorb' any more magnetization. Once again, it is down to the metallurgists to produce materials with higher values of induction at saturation. The silicon iron alloys are considerably better in this respect than pure iron, having saturation inductions in the order of 1·5T, and grain-oriented materials can be used up to about 1·7T in toroidal cores.

We have looked at the relation between magnetic field strength and current in some detail, and now we have to look at the relation between magnetic flux density and the applied voltage. We are just looking at the primary winding, either because we have not yet wound the secondary winding, or because it is there but has no load connected to it. The relation in question is the fundamental equation of electromagnetic induction:

$$V = -n \, d\Phi/dt$$

where *n* is the number of turns and $d\Phi/dt$ is the *rate of change* of the total magnetic flux Φ with time. Flux is measured in weber (Wb), so the unit of flux density, 1 tesla, is $1 Wbm^{-2}$. The minus sign in the equation just signifies that the voltage which is produced by the changing flux acts to oppose the change. For example, if the change in flux is produced by a decrease in the current in the winding, the voltage produced is of the right polarity to tend to *increase* the current. The total flux Φ

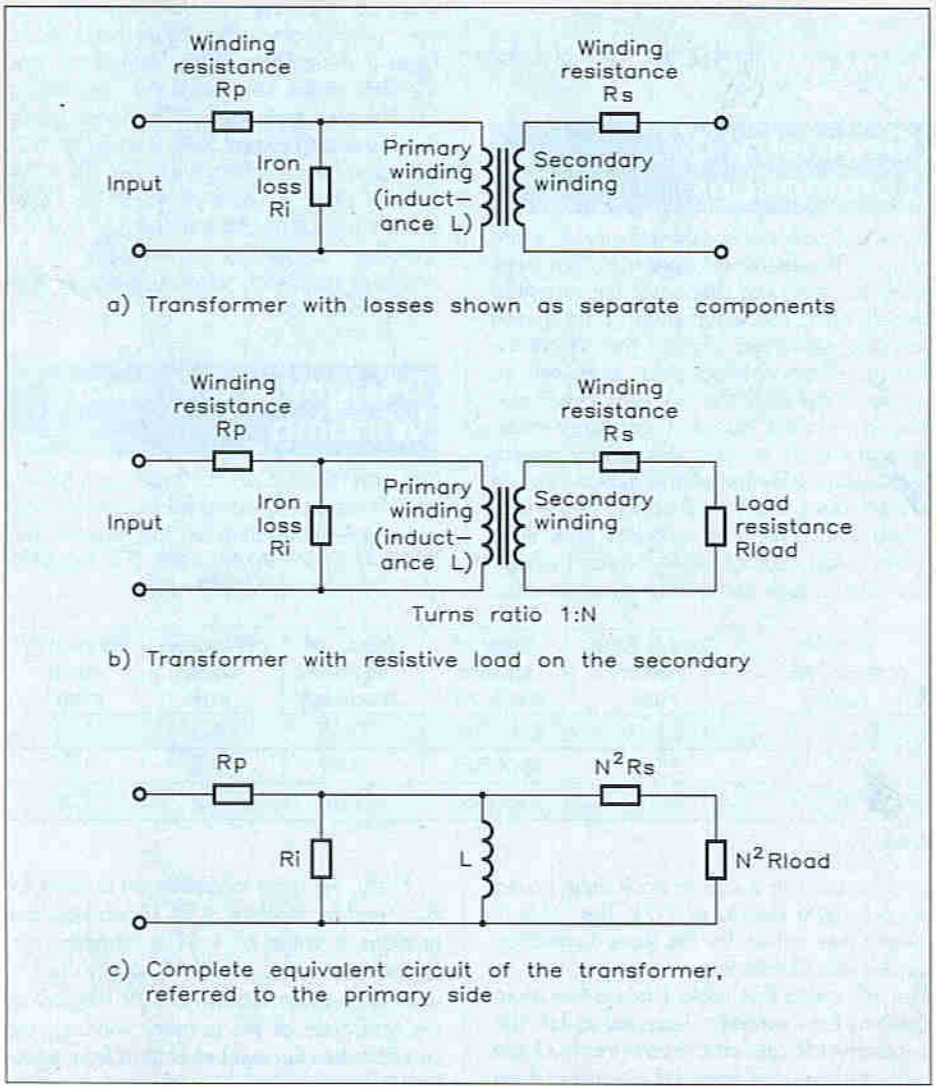


Figure 1. Transformer equivalent circuits: a) Transformer with losses shown as separate components; b) Transformer with resistive load on the secondary; c) Derivation of the equivalent circuit of a transformer.

is just the flux density multiplied by the area of cross-section a of the core on which the primary winding is wound:

$$V = -na\, dB/dt$$

This is the relation we need, between flux density and voltage, and explains why the transformer does not work on DC. With direct current, the rate of change of magnetic field strength, and therefore of flux density, is zero. For sine-waves, we can write:

$$B = B_{max}\sin\omega t$$

so that:

$$dB/dt = \omega B_{max}\cos\omega t$$

where $\omega = 2\pi f$, and f is the frequency. This leads to:

$$V_{max} = -2\pi f na B_{max}$$

since the maximum value of $\cos\omega t$ is 1. Although it is the maximum flux density, B_{max}, that we must watch to avoid saturating the iron, we are usually interested in the RMS voltage V, and this is $V_{max}/\sqrt{2}$, so we get:

$$V = 4{\cdot}44 f na B_{max} \ldots (1)$$

and this equation enables us to find the maximum flux density from the applied voltage, although we derived it the other way round:

$$B_{max} = V/4{\cdot}44 f na$$

Displaying Hysteresis Loops and Checking for Saturation

Since V is proportional to the time-differential of B, we can derive B from V by *integrating* V with respect to time, and this is an operation that can be done electronically, by deriving a current proportional to V and using this to charge a large capacitor. The voltage across this capacitor then represents the time-integral of the current. There are more sophisticated methods of integration, but this one is quite good enough for the present purpose. Using this technique, we can display hysteresis loops on an oscilloscope (if it has an X-input facility). The circuit is shown in Figure 3. The voltage across the small resistor R_1 is proportional to the input current and therefore to the magnetic field strength H, and is applied to the X-input. The voltage across the capacitor is proportional to B, and is applied to the Y-input.

Since the relationship between B and H is non-linear (μ varies with H), and we normally force B to be sinusoidal by applying a sinusoidal input voltage V to the transformer, H, and therefore the input current I, is not sinusoidal but peaky, and the further into saturation we drive the core, the more peaky the current waveform becomes. So we can see how far into saturation we are driving the iron, either by looking at the hysteresis loop, or, less fun but more scientific, by measuring the input current for a series of increasing input voltages and looking for the onset of saturation as a steep increase in current for a rather small change in voltage. If possible, we should measure the peak current, as it is a more sensitive indicator, but the true RMS current, or even the average rectified current (as measured by an analogue multimeter) will do, even though the actual measured values may be inaccurate. Examples of these

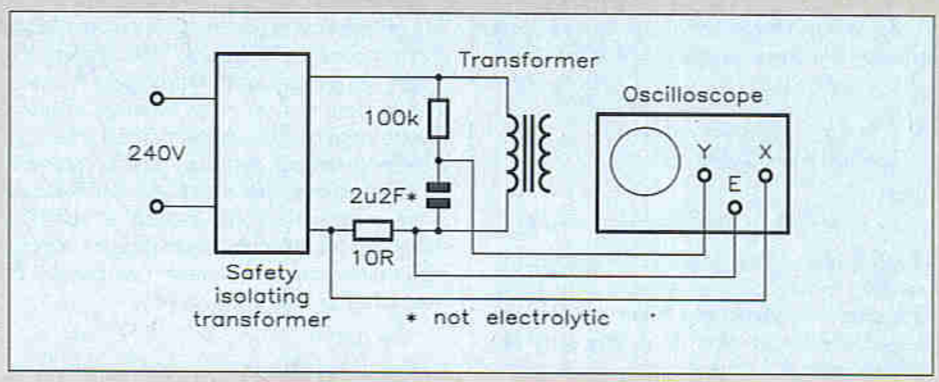


Figure 3. Circuit for displaying hysteresis loops.

measurements, for the Maplin kit primary windings, are shown in Figure 4.

Practicalities at Last

When we come to apply the *B-V* equation to a real transformer, we find the first practical question, which concerns the value of a to be used. The core is made up of thin sheets, and it is not all iron. There is at least one insulating layer on each sheet, and there are thin layers of air between the sheets. However, we can find out how much iron is in the core by weighing it. The manufacturer will tell us the density ρ, and from this, the volume v of the core and the mass m we can determine the stacking factor k_s, the fraction of the core area which is actually iron:

$$k_s = m/\rho v$$

To save you doing this, the value of k_s for Maplin kits is 0·95.

Geometry of Laminations

In the early days of transformers, many weird shapes of laminations were tried, but eventually the *scrapless* shape has become most widely used. This is shown in Figure 5, and the idea is that two 'E's and two 'I's can be stamped from a rectangular strip with no waste of material. The magnetic circuit also has a near as possible constant cross-sectional area, which gives a very regular relationship between all the dimensions. As shown, these are based on the centre limb width T, and we can calculate from them some useful characteristics for each size of lamination, such as the area of cross-section and the mass of a square stack (here based on a relative density of 7·7). The Table 1 gives these values for the three lamination sizes in the Maplin kits.

You will notice that Table 1 has a few more columns than we have discussed so far. The winding width and area data fit into this table best, and we shall soon be looking at them in more detail. They cannot be calculated, rather they are measured on the actual bobbins supplied with the kits. As is usually the case, the bobbins have been designed to provide the same winding area for the primary as for the secondary, whereas the primary should really have a little more area, since it has to supply not only the output power to the secondary winding but also the transformer losses.

Maplin code/VA rating	Centre limb width mm	Area of square stack m²	Mass of square stack kg	Winding width mm	Winding area mm²
YJ61R/20	22	0·00046	0·45	13·5	121
YJ62S/50	25·4	0·00065	0·69	15·5	155
YJ63T/100	28·8	0·00082	1·08	17·9	206

Table 1.

Iron Loss and Magnetizing Current

The sum of the power losses due to hysteresis and residual eddy currents in the core is known as the *iron loss*. We can estimate the iron loss and the magnetizing current for a given lamination size and maximum flux density. For the type of iron used in the Maplin kits, the iron loss at 1·5T at 50Hz is in the region of 4·2Wkg^{-1}. I would not want to be very precise about the figure because the holes in the corners of the laminations, and the slots at the centres of the long edges, affect the value somewhat. The same applies to magnetizing current, but it is easier to check this value by measuring a sample. The 20VA sample gave a value of 45mA at 240V, which leads to 240 x 0·045/0·45 = 24VAkg^{-1} at the flux density used for the design of the primary winding, which is rather higher than 1·5T.

Designing a Primary Winding

You won't need to do this if you use a Maplin kit, but the article would be incomplete without some information on this subject. DO NOT ATTEMPT TO MODIFY THE PRIMARY WINDING IN A MAPLIN KIT!

Firstly, we have to decide on a value for B_{max}, and for modern 3·5% silicon iron laminations a value of 1·5T is appropriate. Suppose we have a 24V AC supply and we want to transform it down to 10V. Neglecting the resistance of the primary winding, we can calculate the number of turns from equation (1):

$$n = V/4{\cdot}44 f a B_{max}$$

We know V and B_{max}, and f is 50Hz, but

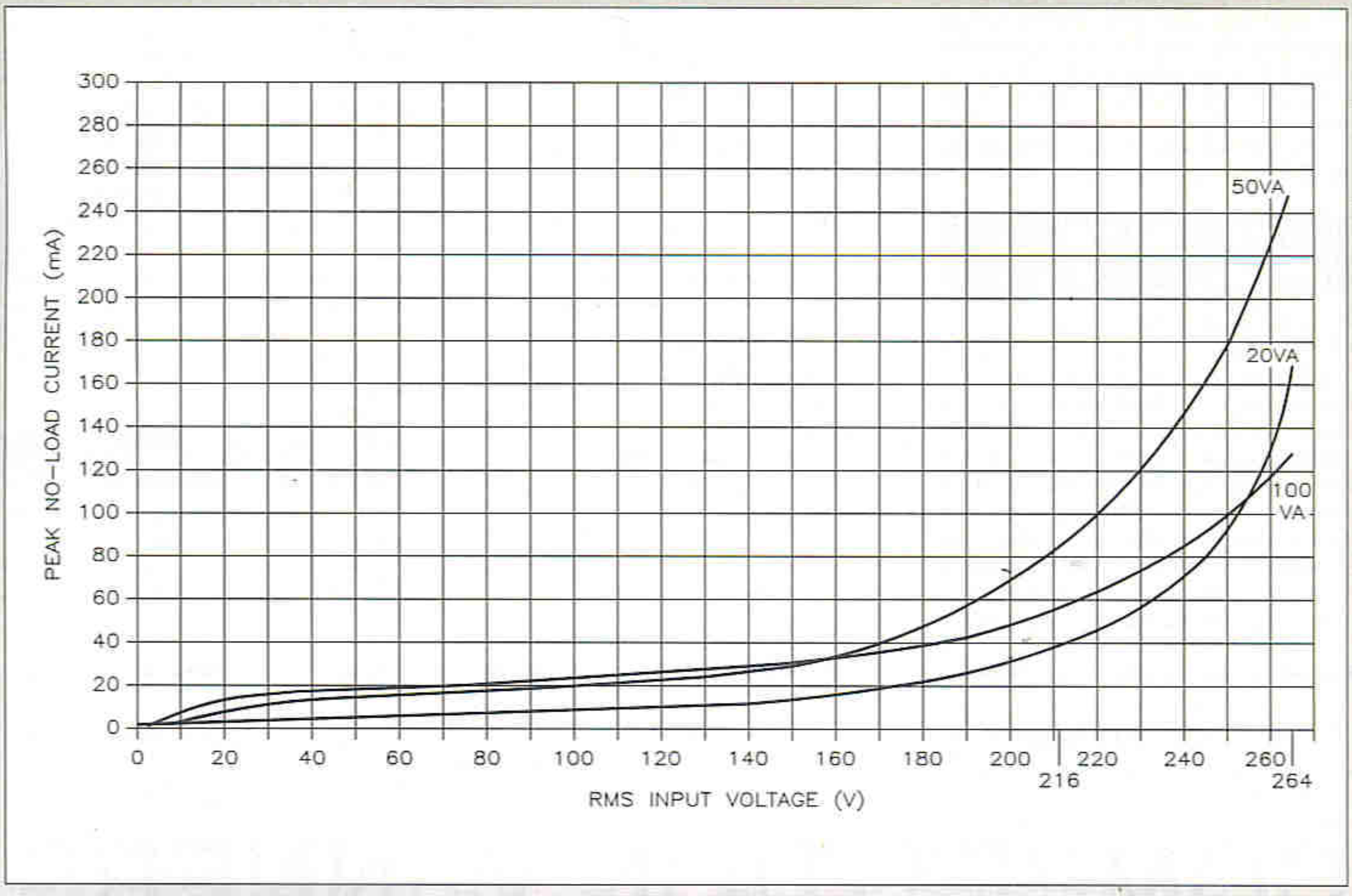


Figure 4. Magnetizing current graphs.

what about a? We will see later how to determine how big the core has to be, in terms of how much power we need from the transformer, but for now, assume we are using laminations from the 20VA kit YJ61R. Perhaps surprisingly, the laminations in the kits are inch-sizes, not metric, but the one we are looking at has a centre-limb width T of ⅞in., which is very close to 22mm. The bobbin moulding is designed to take a 22mm stack of laminations, a 'square stack', so the area is:

$$a = k_s T^2 = 0{\cdot}95 \times 0{\cdot}022 \times 0{\cdot}022 = 0{\cdot}00046 m^2$$

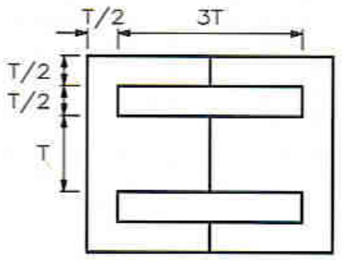
Don't forget that the answer has to be in square metres, even though they are rather big units for the purpose. From this we get n = 156·67 turns, or 157 in practice. This implies 6·54 *turns per volt*, a term much used in practical transformer design. The figure in the catalogue for this size of lamination is 6·04, indicating a higher value of B_{max}, and therefore higher losses. My transformer will run cooler, but I won't be able to get as much power through it. However, this is not the whole story, because we have ignored the winding resistance: we have to, because at present we do not know how to calculate it, and we can't measure it until we have all the data required to make the winding. The iron loss current, and the magnetizing current itself, produce a voltage drop across this resistance. When the transformer is loaded, there is a further voltage drop across this resistance, so the voltage actually available to produce the magnetic flux is less than the applied voltage. For example, the resistance of the primary winding in the Maplin 20VA kit that I have measured is 91·3Ω, and the primary current at 20 VA input on a 240V supply is 20/240 = 0·083A, to which we have to add 0·008A for the iron loss and 0·045A of magnetizing current at 90° phase. So the voltage drop across the resistance is 91·3 x $\sqrt{(0{\cdot}091^2 + 0{\cdot}045^2)}$ = 9·27V, which is 3·9% of the input voltage. This is why the flux density in the core is only 'nearly' independent of the loading; it is actually highest when the transformer is not loaded. The power losses due to the winding resistances are collectively known as the *copper loss*.

Now we have almost all the information needed to complete the design of our primary winding. We know that we need 157 turns of wire, and we know the winding area available: it is 121mm². The first thing we have to allow for is that we are using *round* wire to fill a *rectangular* area, so even theoretically we can only fill a fraction $\pi/4$ of the area with wire. If we wind the wire very carefully, we can fill about eight tenths of the theoretical winding area with wire, although this decreases for thicker wires (over about 0·5mm diameter) to about seven tenths. This value is called the *space factor*. So the total cross-sectional area of our 157 turns is 121 x $\pi/4$ x 0·7 = 65·5mm² and the area of one turn (one strand) is thus 0·423mm². Now, we need wire tables to find what wire size corresponds to this area, and there is a new British and European standard on the subject, BS EN 60182-2:1991. The designation 'BS EN' shows that this is a standard agreed not only in Britain but in seventeen other European countries as well. We can't just use the wire diameter information given in the catalogue because enamelled wires are specified by the diameter of the *bare* wire. The standard gives that information, and indicates that 0·56mm (diameter) wire is the largest that will fit in the available area. The actual maximum diameter of 0·56mm enamelled wire is 0·606mm. Luckily, Maplin stock this (BL28F or YN84F), but how much do we need? We can work this out either in terms of length or as weight, but in each case we need to know the *mean turn length*. This is another well-used term in practical design, and it obviously appears again when we look at winding resistances. While the geometry of scrapless laminations tells us that, if we assume the turns are square, the mean turn length is $6T$, this does not work very well in practice. Measurements on the actual bobbin of the 20VA kit show that the inside turn length is 100mm. The outside turn length can be found by winding a turn of white cotton around the outside of the primary winding and measuring it. Why white cotton? Well, it's easy to mark the crossing point with a pen and measure between the resulting two marks! I measured 134mm this way, so the mean turn is (100 + 134)/2 =117mm. In contrast, $6T$ = 132mm, quite a bit too big. If we couldn't cheat by measuring an existing winding, we could take $5{\cdot}3T$ as a reasonable guide. This is the sort of information that you only find in transformer designers' 'little black books' (actually, mine is black, but it's an A4 ring-binder!), and points up the saying, 'The way to design transformers is to have designed transformers before'.

It is now easy to work out the length; it is simply the number of turns multiplied by the mean turn length, and that comes to 157 x 117 = 18,369mm or 18·4m. This is comfortably within the length of a 50g reel. To work out the weight, we multiply the actual winding area taken up, $n\pi d^2/4$, where d is the diameter of the *bare* wire, and the mean turn length to get the volume of copper, and then multiply by the density, which is 8,933kgm^{-3}, watching that we use consistent units all the time! This gives 0·0387kg or 38·7g. While this is 17·4m of wire (calculated from the data in the Cables section of the catalogue), rather than 18·4m as we calculated the other way, the results agree within about 5%, which is quite good for this sort of calculation. The difference is due to the fact that the winding area is not completely filled by the stock size wire: the next standard size up (0·63mm) would fit on (just).

Current and VA Ratings

Now that we know the wire size, we can finish the design by finding how much current it will carry. Coiled up, wire will carry much less current for an acceptable temperature rise than it will when stretched out, because the heat is concentrated in a small volume and there is less surface area through which it can escape. For small transformers, we can take the maximum permissible *current density* to be 4·0Amm^{-2} (or 4·0MAm^{-2}, yes, megamps; a wire with a cross-section of 1 square metre is a BIG wire!). We have a wire area of $\pi d^2/4$ = 0·246mm^2, so the maximum permissible current is 0·984A (in reasonable agreement with the value given in the Catalogue!). Now you may notice something odd. The transformer kit is rated at 20VA, but here we have a 24V primary winding which will carry 1·0A, so the input VA could be as high as 24. However, it is the output rating which is 20VA, and we have to supply the copper loss, the iron loss and the magnetising current in addition at the input. We must make sure that the losses are not too big, because they appear as heat, and the transformer must not get too hot.



Magnetic path length = 6T
Window area = 1.5T^2
'Geometric' mean turn length = 6T (about 10% larger than the true value)
Volume of square stack (i.e. stack height = T)= 6T^3

Figure 5. Geometry of scrapless laminations.

Things to Come

In Part 2, we shall see how to calculate losses, maximise efficiency and deal with more than one secondary winding. There will be more tables of values, and more arcane 'fiddle factors' will be disclosed.

COMPETITION WINNERS

Virgin Atlantic Competition

The questions and correct answers to the Virgin Atlantic competition, which appeared in issue 59 (November) were as follows:

1. Who recorded the hit album 'like a Virgin'?
Madonna

2. Is Heathrow close to: (a) Hampstead Heath (b) Rotton Row (c) Slough, Middlesex?
Slough, Middlesex

3. The earliest flight of an airship was in:
1852

4. The first transatlantic aeroplane flight was made via:
Lisbon

5. The first round the world flight took:
Twenty-five weeks

The three lucky winners, drawn out of the editor's threadbare hat, who will be receiving a Virgin Atlantic T-Shirt are: G. Butler, Dun Ladghaire, Ireland; M. J. Weir, Laxdale, Isle of Lewis; M. McKibbens, Gosport, Hampshire.

Christmas Quiz

The questions and correct answers to the Christmas Quiz competition which appeared in issue 60 (December) were as follows:

1. Who had the most popular Christmas record?
Bing Crosby

2. What is the colour of Rudolph's nose?
Red

3. What is the traditional custom on Boxing Day?
Seasonal gifts are handed out to the servants.

4. What traditional TV programme can you count on?
A James Bond Movie

The five lucky winners, drawn out of Santa's sack, who have won a book of their choice from the Top 20 Books in issue 60 are: J. Price, Leyton, London; S. Wilson, Thornhill, Cardiff; D. E. Reilly, Ardglass, County Down; J. Muir, Gartcosh, Glasgow; F. R. Heaton, Preston, Lancashire.

MOMI Contest

The questions and correct answers to the Momi Contest which appeared in issue 60 (December) were as follows:

1. Is Hollywood a suburb of: (a) San Francisco (b) San Diego (c) Los Angeles?
Los Angeles

2. Spot the world's most famous film dog.
Lassie

3. Spot the odd one out.
Sound of Music

4. What does the film code PG stand for?
Parental Guidance

The six lucky winners of a family ticket for MOMI are: D. M. Evans, Bradwell Village, Milton Keynes; A. Stevens, North Walsham, Norfolk; P. Belden, Coalville, Leicestershire; G. Brown, Luton, Bedfordshire; J. C. White, Littlehampton, West Sussex; M. W. Divall, Dartford, Kent.

The three runners-up who receive a copy of the glossy MOMI souvenir brochure are: Mr. Field, Oswestry, Shropshire; Mr. Whitehead, Chingford, London; H. Medhurst, Colchester, Essex.

DISCOVERING SATELLITE TELEVISION

Part Five
Beyond The Grave (Continued)
by Martin Pipe

99-Channel and Tunable Audio Upgrade for Amstrad Receivers

BSB receivers are not the only ones ripe for conversion. Millions of Amstrad receivers have found their way into UK homes over the last four years, and have introduced many to the weird and wonderful world of satellite television. Although they offer good performance and are very easy to use, they are somewhat limited in their features. The SRX100/200 offers decent stereo sound – with the proper Panda-1 de-emphasis – and decent picture. Unfortunately, like so many early Astra receivers, they are only equipped with 16 channels, and six fixed audio modes based around the two 7·02/7·20MHz and 7·38/7·56MHz narrowband subcarrier pairs. As a result, the audio from mono-only non-Astra channels that rely on 6·5/6·6/6·65MHz or 5·8MHz (Telecom) subcarriers will not be recovered. In addition, many satellite radio stations are also inaccessible. If you only want the English-speaking channels on Astra, and don't have any aspirations towards a motorised system, then fine. Otherwise read on....

RSD Communications of Stirling have been marketing upgrades for Amstrad receivers for several years now. Originally, the SRX200E (the 48-channel European version of the SRX200) microcontroller could be obtained from Amstrad for a few pounds, providing a cheap upgrade. Presumably drawn to its attention by the large number of chips that were being sold, Amstrad immediately hiked up the price of the replacement chips to nigh on a hundred pounds. Rather than succumb to this blatant act of profiteering, several third-party companies and dealers decided to go their own way and produce their product. RSD Communications is one such company. A goldmine for Amstrad SRX/SRD owners, their product range includes fixed (6·6MHz) and tunable audio boards, 48/99-channel upgrades and SRX100 remote control kits. For the purposes of this article, the SRX200 99-channel and tunable audio upgrades were supplied for review (£59.95 for both).

Installation

Both upgrades arrived in a small box, with all of the required hardware, a high quality (turned pins) 28-pin IC socket, a replacement microcontroller clock crystal, overlays for the front panel and remote control, and a leaflet describing installation and use. Before fitting the 99-channel upgrade, the Amstrad's Motorola (6805 instruction set) microcontroller needs to be removed. It is imperative that this is done with the correct desoldering tools, otherwise the board may be damaged. 'Electronics' readers should have no problems, however. The 2MHz crystal is then replaced by one with long leads, so that it can be mounted flush to the board – as far as the existing components will allow. I would recommend that some heatshrink sleeving is used to cover the crystal can and exposed leads. Perhaps RSD could include this with future upgrade kits – it certainly saves you the hassle of trying to find the roll of insulating tape that you knew you had somewhere!

The 28-pin IC socket is then soldered in the position originally occupied by the IC. The 99-channel upgrade board, a high-quality glass-fibre double-sided PTH affair, is then plugged into the fitted socket. The board, which appears to contain additional RAM and a program ROM, has a 28-pin socket into which the Amstrad microcontroller is inserted. The way it all fits together is very clever!

If you buy the 99-channel and tunable audio upgrades together, the four interconnecting wires have already been fitted. If you buy them separately, you will have to make the interconnections yourself! The tunable audio board is effectively an I²C bus-controlled frequency synthesiser, based around the 4046 PLL chip. A pair of leads supply power to the board, being soldered

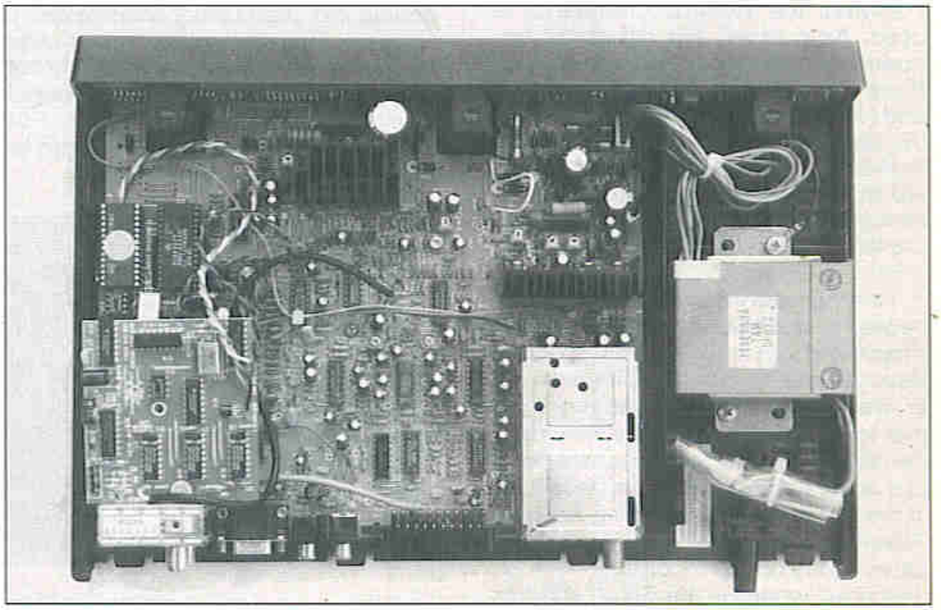


Photo 6. The RSD upgrades, shown fitted to an elderly Amstrad SRX200. The receiver now has a new lease of life!

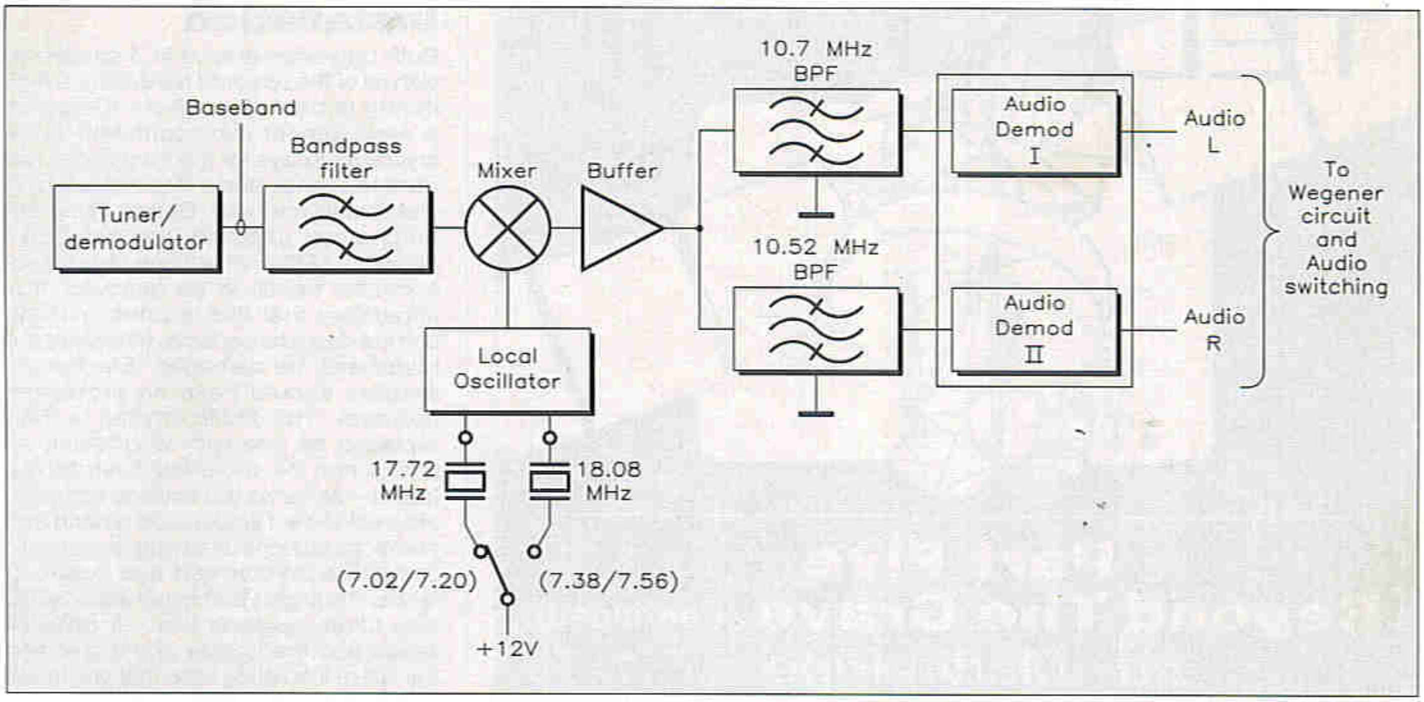


Figure 5. Block diagram of 'Amstrad-style' fixed-subcarrier audio system.

directly to the power and ground pins of a convenient IC on the Amstrad unit's PCB. The other connection is a screened cable, containing the synthesiser output, that is soldered to the main board.

The Amstrad audio system, shown in Figure 5, is simple but effective. Based on the superheterodyne principle (refer to Ian Poole's article in Issue 59 of 'Electronics'), its circuit is based around a local oscillator (LO) that can be switched to operate on either 17·72 or 18·08MHz. The LO is then mixed with the baseband signal. And now for the clever bit. Th mixed signal is sent to two demodulators, each via a different ceramic IF filter; one is centred on 10·52MHz, the other 10·7MHz. When the incoming subcarriers are 7.02 and 7·20MHz, the 17·72 LO frequency is used. As a result, the difference frequencies applied to the relevant IF filters are (17·72 – 7·02 =) 10·7MHz and (17·72 – 7·20 =) 10·52MHz. When the desired subcarriers are 7·38 and 7·56MHz, the LO is switched to operate at 18·08MHz, whereupon the different frequencies will still be 10·7MHz (18·08 – 7·38) and 10·52MHz (18·08 – 7·56).

Relying upon the 180kHz spacing between subcarrier pairs, the design is simple and very effective. It is also useless, without modification, if you want to receive the other subcarriers; note that multi-satellite receivers with independently tunable audio subcarriers use an arrangement like that described in the first part of 'Discovering Satellite Television' (issue 59 of 'Electronics'). Later, a very cheap modification will be described whereby the 7·74/7·92MHz fixed subcarrier pair can also be received on a receiver with an Amstrad-style audio tuning system; predictably, this involves making the LO operate on another frequency with the addition of another crystal. To receive tunable audio however, the RSD board replaces the switched LO's output with its synthesised one; this involves desoldering the mixer's coupling choke (L308 on the SRX100/200) on the LO side and soldering the output to it. To avoid the fixed oscillator (which is physically located near the mixer for obvious reasons) beating with the variable one, the two crystals are removed.

Once all the soldering has been done, the board is mounted on a pillar conveniently moulded into the bottom of the case by Amstrad! The final touch, save for reassembly (and of course, the compulsory check-over), is to fit the supplied self-adhesive overlays onto the remote control (SRX200 only) and the receiver's front panel. The whole upgrade procedure – 99 channels and tunable audio – can be completed in an hour.

Performance

The SRX200, when fitted with these upgrades, is a different receiver. It retains the original's ease of use but provides those useful features desirable in all modern receivers with any pretence of multi-satellite reception – namely tunable audio and a reasonable number of presettable channels. And, unlike most modern receivers, all control operations are accessible from the front panel. Tuning the receiver in is just the same as before, except that 99 channels are now available. As the overlay indicates, some of the 16 channel buttons are now redundant. Only buttons '0' to '9' are now used to select the channel (1st digit first, e.g.,'0' followed by '9' for channel '9', or '2' followed by '4' for 24). The buttons originally designated for selecting channels 15 and 16 are now used to pace up and down the channels. Even for the Astra system (48 possible channels in total), bearing in mind the increased number of radio stations accessible by virtue of the tunable

Photo 7. Front panel of modified Amstrad SRX200, showing the new overlay. A similar overlay is fitted to the remote control unit.

audio, 99 channels are more than enough.

Operating the Tunable Audio

Tunable audio is very easy to operate. A press of the 'audio' button on the front panel or the remote enables you to access what you couldn't before. That first press of the audio button shows you the current status – the 7-segment LED on the far-left of the display indicates, with a 2-segment vertical bar on the left or right, left or right tuning mode. Both bars illuminated indicates that the unit is in 'stereo' mode. Another press of the audio button enables you to cyclically select either left, right or stereo tuning modes. As you will no doubt appreciate, because of the design of the Amstrad receiver the left and right channels are always fixed 180kHz apart – the provision of both left and right tuning modes does seem, to me at least, somewhat superfluous; when tuning in the stereo mode, this fact becomes apparent.

Bearing in mind that the Wegener specification stipulates this 180kHz spacing, there is no problem – until you try to get the Telecom 2B-delivered radio stations in stereo; these use non-standard spacing. The subcarrier tuning range has been sensibly set between 5·0 and 9·5MHz in 20kHz steps – enabling you to access all present and future radio stations, including the Telecom ones 'out of reach' of most normal receivers with a 5·5 to 8·5MHz tuning range. Tuning the receiver is done, predictably, using the 'tune' buttons on the receiver's front panel, the audio frequency being shown on the remaining 3 digits of the Amstrad's display. RSD have also thoughtfully provided their system with preset audio modes for the most commonly-used subcarriers – these can be invoked by pressing the channel 'up' and 'down' buttons. The audio settings are saved for the channel in question by pressing the 'store' button.

Although the RSD system adds two powerful features to a receiver hitherto regarded as obsolete (reflected in the current market rate), the set's ease of use is maintained. The Amstrad receiver can now, after all, be used with a motorised or second dish in a multi-satellite set up. But how does it perform? The 99-channel upgrade peformed without a hitch. However, a lot of low-frequency noise marred the audio channels. A 'phone call to RSD revealed a manufacturing problem with the audio board (some incorrect component values associated with the PLL chip). Once the proper components had been fitted, the noise was greatly reduced – but it still had not gone completely. Perhaps I'm being overcritical, though – in all other respects, the upgrade performed flawlessly. Due to the fact that the narrow-bandwidth ceramic filters are retained, you would expect 'spittiness' on the wide-bandwidth primary subcarriers. This was not apparent, and neither were any significant 'pumping' effects introduced by the Wegener expander circuit, which is in-circuit permanently. What the problem encountered did demonstrate was the excellent service provided by RSD – I had a chance to talk to the board's designer who was very helpful, faxing down circuit diagrams.

Like the Trac-modified BSB receiver, a major shortcoming is the lack of (magnetic) polariser interface – essential for realistic multi-satellite reception. LNB voltage switching for polarisation control or band-switching, is provided, but surely a bit of extra programming, a D-to-A converter (easy to do with a shift register-based serial-to-parallel converter and a few weighting resistors) and current amplifier, would not cost that much to implement, and would increase the versatility still further, particularly if it could be programmed per channel. One of the polariser controllers shown in Figures 2 and 3 will suffice for the present, though.

Many Astra receivers (e.g., Pace/Ferguson receivers, which do admittedly offer mono subcarrier tuning) use the Amstrad's method of obtaining the stereo subcarriers. Perhaps, therefore, we may see upgrades introduced for these receivers, although they did not sell in such large numbers as the Amstrad sets. It is probably worth contacting RSD to find out – if there's a large enough demand, they will probably consider it.

Note that a RSD 99-channel/tunable audio upgrade kit is also available for the Amstrad SRD400.

TESUG 'Extended Audio' Modification for Amstrad SRX/SRD Receivers

This simple modification, suggested by Eric Wiltsher of The European Satellite User Group (TESUG), should also work with other receivers that use the Amstrad's method of deriving the narrow-bandwidth subcarriers. TESUG, incidentally, offers help and advice on all satellite matters to its members, as well as a teletext service (page 270 of Superchannel's 'Supertext'). From Figure 6, it can be seen that the modification involves switching in a 18·432MHz crystal (Order Code FY84F) in place of one of the others. When switched in, it enables the 7·74 and 7·92MHz subcarriers, and thus several new radio services on Astra, to be obtained. With the local oscillator running at 18·432MHz, the difference frequencies will be (18·432 – 7·74 =) 10·692MHz and (18·432 – 7·92 =) 10·512MHz, which are, for all practical purposes, the centre frequencies of the two IF filters! A simple changeover switch (e.g., FH98G), mounted on the rear of the receiver (or perhaps a more elaborate switching system) can be used to switch between the crystals, and therefore the subcarrier pairs. Note that a 10kΩ (M10K) resistor is also required. All wiring to and from the switch should use screened cable (XR88V is ideal) and be as short as possible; in addition, the crystals and resistor should be as close as possible to the relevant position on the PCB. For Amstrad owners, the new audio mode will be available on the 'AU1' setting if the 17·72MHz crystal was replaced, or the 'AU2' setting in the case of the 18·08MHz crystal.

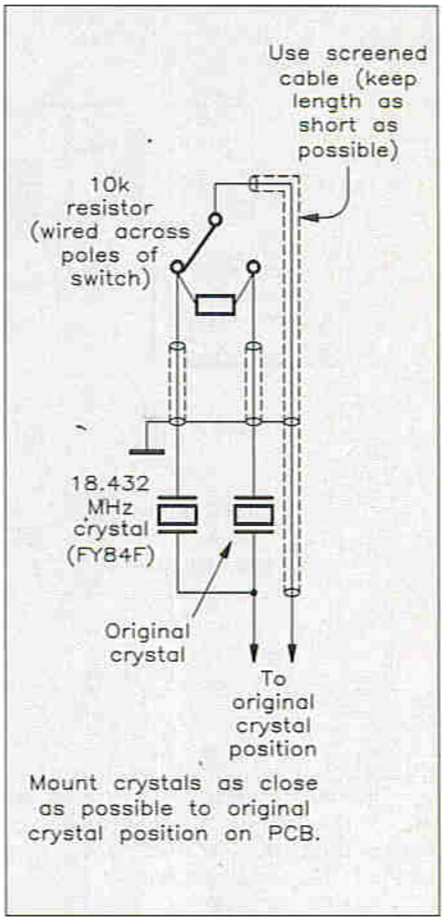


Figure 6. TESUG's 'extended audio' modification for receivers with a fixed-subcarrier audio system.

A Complete System

A complete multi-MAC system, with tunable audio and genuine Wegener sound correction (which most multi-satellite receivers still lack!), can be obtained by linking up a Trac/Ferguson receiver, configured as a transcoder, with an RSD upgrade-equipped Amstrad SRX200 as shown in Figure 7. Note that the Amstrad SRX200 also

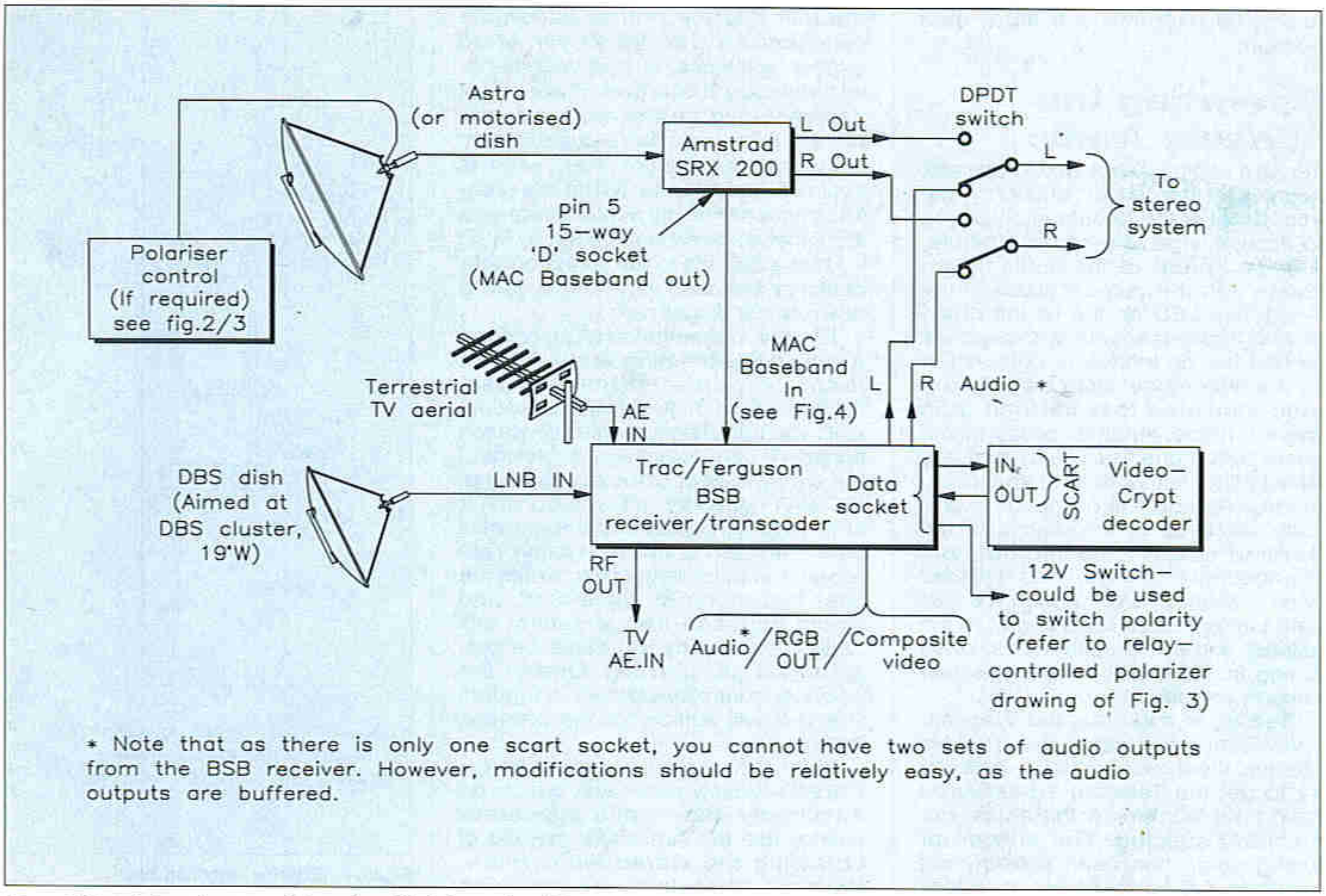


Figure 7. Complete system, consisting of modified Amstrad and Ferguson receivers, together with Astra and DBS dishes.

gives good weak-signal performance – unlike many dedicated multi-satellite receivers I could mention, threshold extension techniques are employed in the Plessey SL1455 baseband demodulator circuit. Bearing in mind the low resale prices of the obsolete receivers at the heart of the system, with careful shopping a complete system (with second-hand 60cm dish/LNB for Astra and Squarial for DBS) can be put together for less than £200, including the RSD and Trac upgrades. Let's hope that some greedy entrepreneur ('middle-man' in French!), reading this article, does not buy up all these receivers to make a quick profit out of the rest of us!

Prices (at time of writing)

Ferguson SRB1 BSB Receiver – £15.00 to £40.00 (depending on supplier, and whether dish is included).

Trac Ferguson BSB Upgrades – DIY PAL/MAC Conversion Kit, £49.00; ready-converted exchange PCB, £69.00; complete unit with DBS aerial, £149.00; D2MAC software ROM, £19.00.

RSD Amstrad Upgrades (specify receiver) – Tunable audio and 99 channels, £59.95; tunable audio only, £35.35; 99 channels only, £39.95; 48 channels for SRX100/200, £19.95; remote control upgrade for SRX100, £24.95.

TESUG Audio Upgrade – less than £3.00 if components bought from Maplin.

Contact Names and Addresses

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Acknowledgments

I would like to thank Bob Exelby of Trac Satellite Systems, John Ross from RSD Communications, and Eric Wiltsher of The European Satellite User Group for making this article possible.

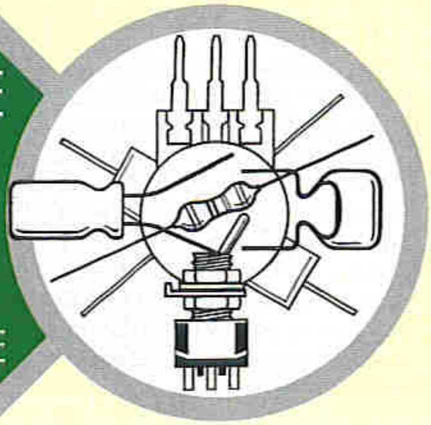
Important Note

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 has no connection with the third-party companies mentioned in this article and cannot support problems or answer queries related to their products. If your equipment is covered by an extended warranty, it must be borne in mind that attempting any such modifications are likely to invalidate it.

Stop Press

Trac report that the 'shimmering noise' problem on the Ferguson BSB PAL/MAC upgrade has now been cured. A 1N4007 (or equivalent) diode is simply wired between two transistors; its anode should be soldered to the base of TV19, which is located on the Ferguson main board, and its cathode connected to the collector of T3, which can be found on the Trac PAL PCB. *This information is intended for those who already have a Trac-upgraded receiver, as the modification outlined here is fitted to all upgrades currently being sold.*

PASSIVE ELECTRICAL COMPONENT GUIDE
PART THREE



Ray Marston takes an in-depth look at modern inductors, transformers, and switches in the last part of this special three part feature.

This series of articles aims to provide the reader with a concise, but comprehensive, guide to the symbology, pertinent formulae, basic data, major features, and identification codes, etc., of the five major types of modern passive components.

Guide to Modern Inductors

Symbols

Figure 38 shows the basic set of symbols that are internationally recognised as representing various types of inductor. These symbols may be subjected to some artistic variation – the basic 'inductor' symbol may, for example, consist of a set of interconnected loops or of joined-up arcs, as shown. The number of loops/arcs may vary from three to ten, or more. Similarly, in inductors with iron-dust or laminated cores, the number of vertical columns used to represent the cores may vary from one to three, etc.

Basic Formulae

In its simplest form, an inductor consists of a straight or coiled length of conductive wire. Its inductance value (L) is proportional to the wire's length, but also depends on the shape and gauge of the wire, and on the shape and dimensions of the coil. The basic unit of inductance is the Henry, but in practice submultiples of this unit, such as mH (millihenry), µH (microhenry), and nH (nanohenry) are widely used in electronics.

The reactance (X) of an inductor is proportional to frequency (f) and to inductance value, and Figure 39 shows the formula that relates these parameters to one another. If precise parameter values are needed from these formulae, they can easily be found with the help of a calculator. Alternatively, a whole range of values can be rapidly found – with a precision better than 20% – with the aid of the nomograph of Figure 25 (shown last month) and a ruler. To use the chart in this way, simply lay a straight edge so that it cuts two of the L, f, or X columns at known parameter values, and at the points where the straight edge cuts the third column is the unknown value.

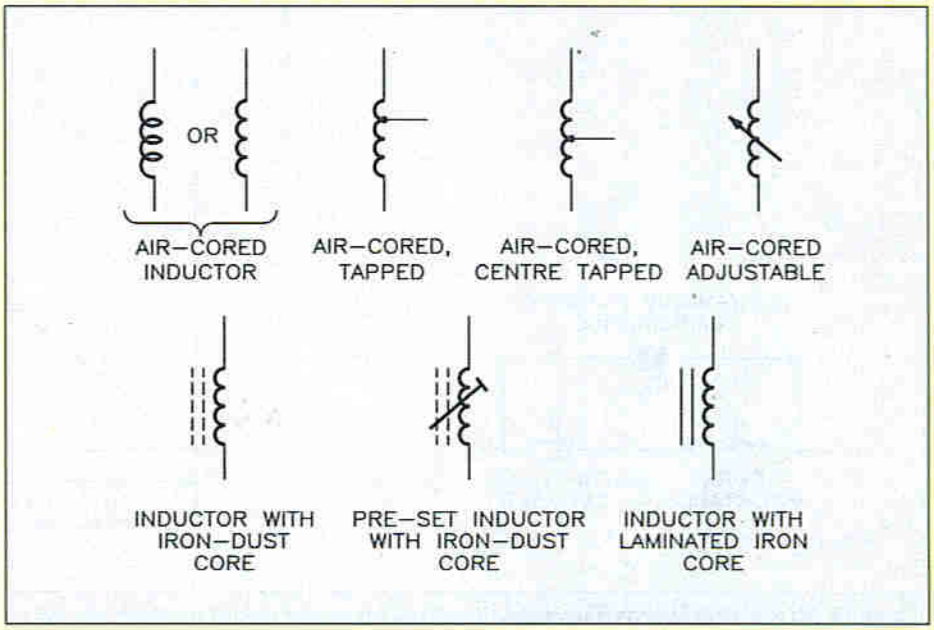


Figure 38. Internationally-accepted symbols for various types of inductor.

Reactance (X_L) of an inductor:

$$X_L = 2\pi f.L \quad f = \frac{X_L}{2\pi L} \quad L = \frac{X_L}{2\pi f}$$

where: X_L = reactance, in ohms
L = inductance, in microhenrys (µH)
f = frequency, in MHz

Figure 39. Inductive reactance formulae.

Figure 40 shows the basic formula used to calculate the effective values of several inductors wired in series or in parallel. It is assumed that there is no inductive mutual coupling between the components.

One of the most important parameters of an inductor is its Q value, or reactance-

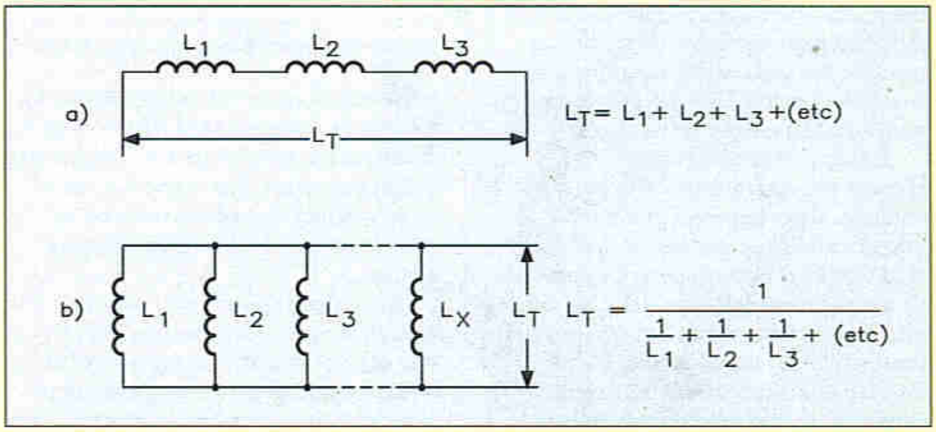


Figure 40. Method of calculating combined values of inductors in (a) series or (b) parallel.

The Q of an inductor varies with frequency, and is given by:

$$Q = \frac{2\pi f.L}{R}$$

where: L = inductance, in µH
f = frequency, in MHz
R = effective series resistance, in ohms

Figure 41. Inductive 'Q' formula.

The simplest inductor consists of a straight length of round-section conductive (usually copper) wire. This has an inductance that is proportional (non-linearly) to the wire's length but is inversely proportional to its diameter, as shown by the formula and worked examples of Figure 43. The 0·4mm wire size is roughly equal to the American 26 'AWG' or the British 27 'SWG' gauges, and the 4mm size to 6AWG or 8SWG. In practice, most wires used in electronics have diameters in the range 0·21mm to 2·64mm, and the table of Figure 44 gives details of the standard set of wire gauges within this range. The 'turns per linear inch' winding figures are derived by averaging data from several different sources.

The inductance of a wire can be greatly increased by forming it into a coil or solenoid. The inductance of an air-cored coil depends on the dimensions of the coil, and on the thickness and the spacing of its wire. The formula that relates these parameters is highly complex and of little practical value. A reasonably simple and practical formula can, however, be derived by making a few sensible assumptions about the coil. Specifically, if it is assumed that the wire diameter is small (less than 10%) relative to the coil diameter; that the wire is close-wound in a single layer; that the coil's length is within the range 0·4 to 3 times the coil diameter, then the formulae of Figure 45 can be used to determine the inductance of a coil, or to find the number of turns of wire needed to create a specific inductance.

Home-made coils can easily be wound on a variety of commercially available air-cored formers. Figure 46 lists some practical inductance values that can be greatly increased by winding it on a simple ferrite rod core, or can be increased even further if the coil forms a toroid; all of these techniques are widely used on commercially available air-cored formers, and Figure 46 also lists some practical inductance values obtained on these, using formers of various diameters, etc. These values are derived from manufacturer's data, and are similar to those indicated by the Figure 45 formulae. Note that many small

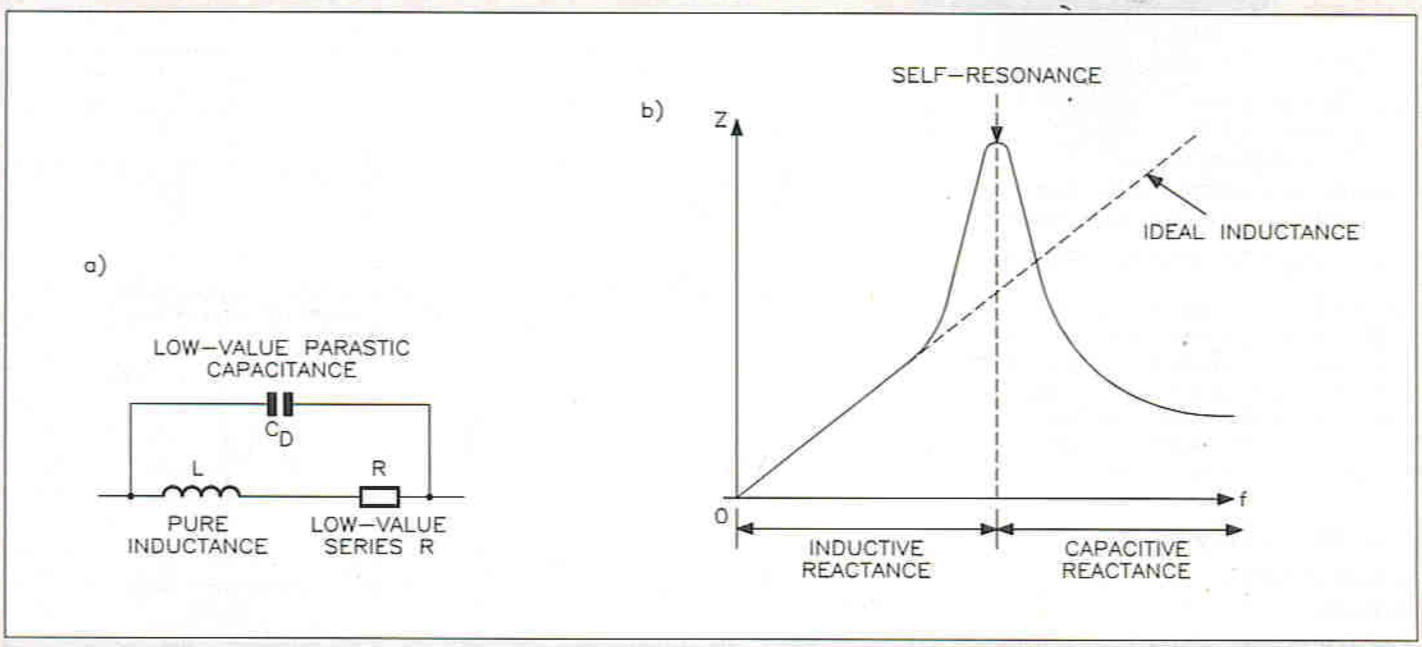


Figure 42. All practical inductors have the simplified equivalent circuit shown in (a), and exhibit the self-resonance shown in (b).

to-resistance ratio – Figure 41 shows the formula for 'Q'.

Practical Inductors

All practical inductors have the simplified electrical equivalent circuit of Figure 42a, in which L represents pure inductance, R represents the components resistive element, and C_D represents its inherent 'distributed' self-capacitance. All practical inductors thus have a natural self-resonance frequency, dictated by their L and C_D values. Figure 42b shows the characteristic response curve that results – the coil's reactance is inductive below resonance, resistive at resonance, and capacitance above resonance.

Practical inductors are normally classed as being either 'coils' or 'chokes'. Coils are used as inductive elements in tuned circuits, etc., and are characterised by having high values of Q, low values of self-capacitance, and excellent inductive stability. Chokes are used as simple signal-blocking and filtering elements, in which Q, self-capacitance, and precise inductance values are non-critical.

The inductance of a straight length of round-section wire is given by:–

$$L = 0{\cdot}0002b[(2{\cdot}303 \times \log_{10}\frac{4b}{d}) - 0{\cdot}8]$$

where: L = inductance, in µH
d = wire diameter, in mm
b = wire length, in mm

Wire Diameter	Wire Length			
	25mm (1in.)	100mm (4in.)	250mm (10in.)	1000mm (40in.)
0·4mm	0·03µH	0·122µH	0·411µH	1·68µH
4mm	0·018µH	0·076µH	0·296µH	1·222µH

Figure 43. Formula and examples related to self-inductance of a straight wire, in free air.

Wire Diameter Bare		Wire Gauge		Turns Per Linear Inch		
mm	in.	AWG	SWG	Enamel	Enamel & Single Cotton	Double Cotton
2·64	0·104	—	12	9·09	8·8	8·4
2·59	0·1019	10	—	9·6	9·1	8·9
2·34	0·092	—	13	10·2	9·9	9·3
2·305	0·097	11	—	10·7	—	9·8
2·04	0·080	12	14	11·9	11·3	10·7
1·82	0·072	13	15	13·17	12·5	11·8
1·63	0·064	14	16	15·0	14·0	13·0
1·45	0·0571	15	—	16·8	—	14·7
1·42	0·056	—	17	16·9	15·7	14·5
1·29	0·0508	16	—	18·9	17·3	16·4
1·22	0·048	—	18	19·7	18·0	16·8
1·15	0·0453	17	—	21·2	—	18·1
1·02	0·040	18	19	23·5	21·0	19·5
0·91	0·036	19	20	26·2	24·0	21·2
0·812	0·032	20	21	29·2	26·1	23·0
0·72	0·028	21	22	33·0	29·1	25·5
0·644	0·0253	22	—	37·0	31·3	27·2
0·61	0·024	—	23	38·3	34·2	28·4
0·573	0·0226	23	—	41·3	37·0	31·0
0·56	0·022	—	24	41·6	37·2	31·6
0·51	0·020	24	25	45·5	39·0	34·0
0·46	0·018	25	26	51·0	43·0	37·0
0·42	0·0164	—	27	55·1	46·2	38·0
0·405	0·0159	26	—	58·0	47·0	40·0
0·38	0·0148	—	28	61·0	50·2	41·0
0·361	0·0142	27	—	64·9	52·0	42·0
0·35	0·0136	—	29	66·0	52·2	43·0
0·32	0·0125	28	30	72·5	55·0	46·0
0·29	0·0116	—	31	77·5	59·8	48·0
0·286	0·0113	29	—	81·6	61·0	51·8
0·27	0·0108	—	32	82·7	62·0	48·0
0·255	0·0100	30	33	88·0	64·0	49·7
0·23	0·0092	—	34	98·3	65·5	52·9
0·227	0·0089	31	—	101·0	69·0	57·2
0·21	0·0084	—	35	105·8	73·0	58·0

Figure 44. International copper-wire table.

(up to about 0·5in or 12mm diameter) formers have a provision for fitting an adjustable core or 'slug'. This enables the coil inductance to be varied over a limited range. Providing the coil length is within the limits 0·3 to 0·8 x diameter, then the use of either iron-dust, ferrite, or brass cores will give maximum inductance increases of x2, x5, or x0·8 respectively.

High values of inductance can be obtained by using various multilayered forms of coil construction. Alternatively, a coil's inductance value can be greatly increased by winding it on a simple ferrite rod core, or it can be increased even more, by winding it on a ferrite ring, so that the coil forms a toroid. All of these techniques are widely used on commercially manufactured inductors.

Another way of obtaining a high inductance value is to wind the coil on a bobbin, which is then shrouded in a high permeability material. In low-frequency applications, this material may take the form of iron laminations, but at higher frequencies, it usually takes the form of a ferrite pot core, as shown in Figure 47. These ferrite cores have a typical permeability or 'mu' value of between 50 and 200, and a typical specific inductance or A_L value in the range 150 to 400nH/turn. The diagram shows the basic formulae used with these pot cores – note that L and A_L must use the same units (such as μH) in these formulae. Thus, to find the number of turns needed to make a 10mH inductance, using a core with an A_L value of 400nH, simply divide 10,000μH by 0·4μH (=25,000), and take the square root of the result (=158), to find the number of turns needed. From the core's data sheet, the gauge of wire to use can be determined.

A vast range of ready-built coils and chokes are available from specialist component suppliers – the values of these are usually clearly marked in plain language. However, some RF chokes have their values indicated by a colour-code system, and this usually takes the form shown in Figure 48. To the left is a broad silver band, followed by a standard three-band colour code that gives the inductance value (in μH), and finally, by a narrow band that indicates the component's tolerance (gold = 5%, silver = 10%).

Guide To Modern Transformers

Symbols

A transformer is an electromagnetic device that 'transforms' the electrical AC energy at its input into electrical AC energy at its output, usually (but not always) with some change in the output voltage. It works by coupling the generated electromagnetic AC field of its input, or 'primary' winding, into the

$$L = N^2 \left(\frac{d^2}{18d + 40b} \right)$$

$$N = \frac{\sqrt{L\,(18d + 40b)}}{d}$$

where: L = inductance, in μH
d = coil diameter, in inches
b = coil length, in inches
N = number of turns

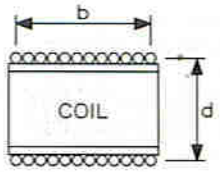
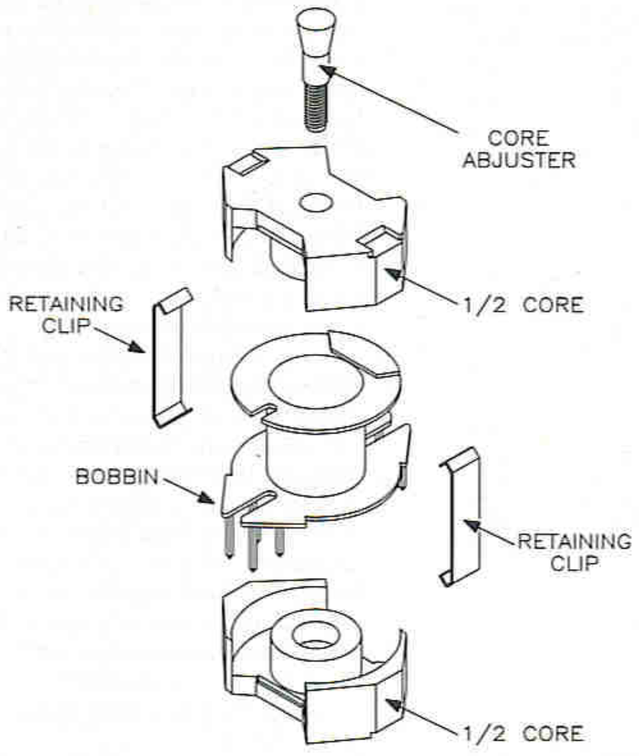


Figure 45. Formulae concerning the inductance of single-layer close-wound air-cored coils.

Coil Inside Diameter and Length	Coil Turns Per Inch					
	4	6	8	10	16	32
	Coil Inductance, in microhenrys (μH)					
½in.	0·036	0·08	0·144	0·224	0·58	2·4
⅝in.	0·084	0·136	0·33	0·51	1·32	5·4
¾in.	0·108	0·243	0·432	0·684	1·78	7·2
1in.	0·28	0·644	1·18	1·85	4·73	19·04
1¼in.	0·55	1·26	2·24	3·5	8·5	—
1½in.	0·975	2·2	3·9	6·125	15·75	—
1¾in.	1·56	3·54	6·3	9·9	25·5	—
2in.	2·38	5·4	9·54	15·1	38·9	—
2½in.	4·79	10·8	19·3	30·1	—	—
3in.	8·12	18·3	32·5	51·6	—	—

Figure 46. Examples of inductances obtained on a selection of commercial air-cored coil formers, using 1/1 coil diameter/length ratios, at various turns-per-inch values.



$$L = N^2 A_L$$

$$N = \sqrt{\frac{L}{A_L}}$$

where: L = inductance of assembly
A_L = specific inductance of pot core
N = number of turns of coil

Note: L and A_L are in like units, i.e., µH or mH, etc.

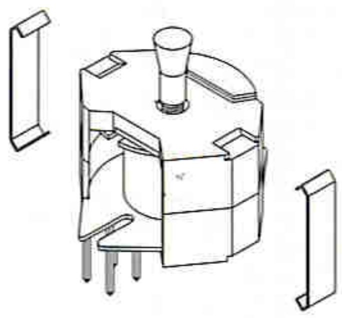


Figure 47. Exploded view of pot core assembly, together with basic design formulae.

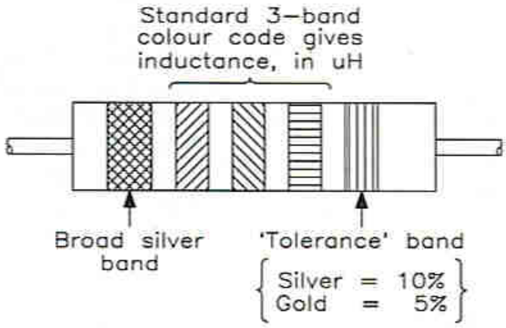


Figure 48. Colour code used on some encapsulated RF chokes.

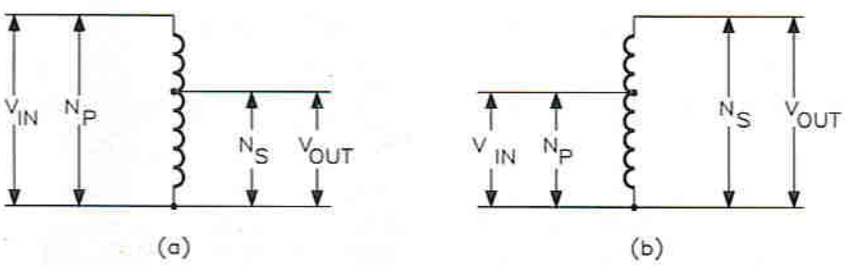
output, or 'secondary' winding – thereby inducing a turns-related AC voltage in the secondary winding. The simplest version of such a device is the auto transformer, in which the primary and secondary networks share a common winding. This device can be used to provide a stepped-down or stepped-up output voltage. Figure 49 shows the standard symbols used to represent both versions of the autotransformer, together with the basic formula that defines the relationship between their input and output voltages.

The most widely used type of transformer is the 'isolation' type, which uses two or more sets of windings that are electromagnetically coupled but are electrically isolated from one another. Figure 50 shows a selection of basic symbols used to represent various types of isolation transformer. These symbols may be subjected to some artistic variation.

The diagrams of Figures 49 and 50 show only the basic symbols used to represent various types of transformer. In actual circuit diagrams these symbols may be subjected to some degree of elaboration, as shown in the examples of Figure 51. Thus, an IF transformer may be shown complete with a tuned and slugged primary and a screened can, as in Figure 51a. A pulse transformer may be shown with an in-phase or an anti-phase output, as indicated by the large dots in Figure 51b and 51c. Figure 51d shows a pair of tapped secondary windings connected in-phase, to give an output of 15V.

Basic Formulae

A transformer's secondary voltage is proportional to its secondary-to-primary turns ratio and to its input (primary) voltage. The input current is proportional to the secondary current and the transformer turns ratio, as shown by the formulae of Figure 52. Its input impedance is proportional to its secondary load impedance and to the square of its



$$V_{OUT} = V_{IN}\ \frac{N_s}{N_p}$$

where:
N_p = number of primary turns
N_s = number of secondary turns

(c)

Figure 49. An auto transformer can be used to provide (a) a stepped-down, or (b) a stepped-up output voltage. In either case, the formula of (c) applies.

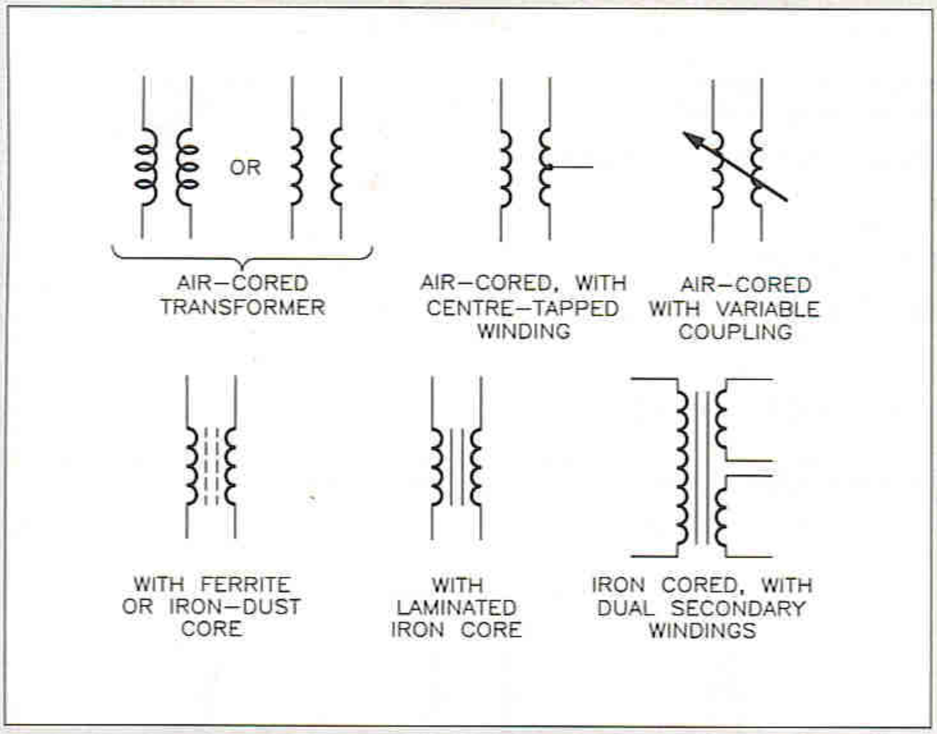


Figure 50. Standard symbols for various types of isolation transformer.

primary-to-secondary turns ratio, as shown in Figure 53.

Since its input impedance is proportional to its load impedance, etc., one obvious transformer use is as an impedance-matching device. Figure 54 shows the basic formula that relates to this application, together with a worked example. This shows that a 7·07 primary-to-secondary turns ratio can be used to match a 4Ω load to a 200Ω input impedance.

Practical Transformers

Transformers are made in much the same way as ordinary inductors. RF types are usually air cored, HF types may be ferrite or iron-dust cored, and low-frequency types are usually potted in ferrite, or use a laminated-iron core, etc. A vast range of commercial transformers, of all types, are readily available, but if a suitable type is not available, it is usually a fairly simple matter to build one to suit a personal specification.

In the case of mains (power line) transformers, complete kits of parts, together with adequate instructions and a ready-built primary winding, are available from specialist suppliers. As a hypothetical example of how to use one of these kits, suppose that specification calls for an 11V, 4A secondary winding. This calls for a minimum transformer power rating of 44VA, and the nearest standard size to this is 50VA. The instruction sheet shows (perhaps) that the required number of secondary turns can be found by multiplying the 11V by 4·8 and then adding 1% for each 10VA of loading. This results in a total of 55 secondary turns. A further look at the instruction sheet shows that the best wire size, in this case, should have a diameter of about 1·25mm (18SWG or 16AWG). That completes the design procedure – it's as simple as that!

Guide to Modern Switches

Symbols

To complete this survey of modern 'passive' basic components, this final section takes a brief look at switches and simple switch applications. Modern electromechanical switches come in several basic versions, and a selection of these are shown in Figure 55. The simplest switch is the push-button type, in which a spring-loaded conductor can be moved so that it does, or does-not, bridge (short) a pair of fixed contacts. These switches come either normally-open (n.o) Figure 55a, in which the button is pressed to short the contacts, or normally closed (n.c) Figure 55b, in which the button is pressed to open the contacts.

The most widely used switch is the

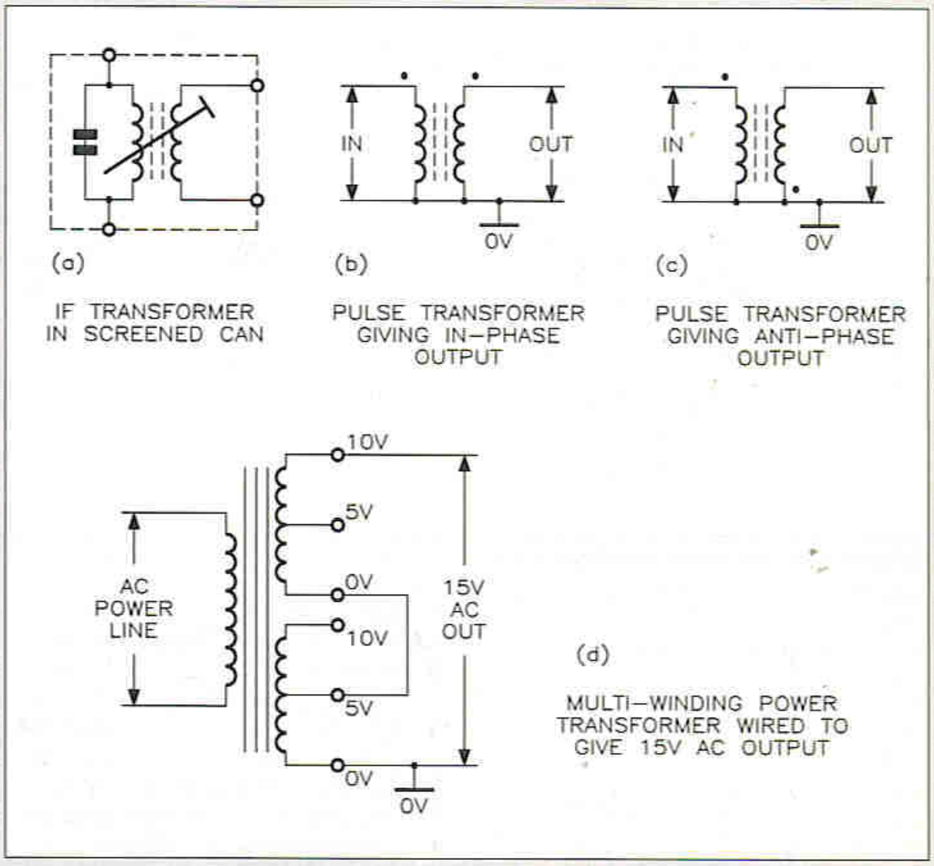


Figure 51. Miscellaneous examples of transformer applications, as shown in circuit diagrams.

$$V_s = V_p \left(\frac{N_s}{N_p}\right)$$

$$I_p = I_s \left(\frac{N_s}{N_p}\right)$$

where :

V_s = secondary voltage
V_p = primary voltage
N_s = number of secondary turns
N_p = number of primary turns
I_p = primary current
I_s = secondary current

Figure 52. Transformer design formulae related to V, I, and turns ratio.

$$Z_p = Z_s \left(\frac{N_p}{N_s}\right)^2$$

where:

Z_p = input impedance of primary
Z_s = impedance of secondary load
N_p = number of primary turns
N_s = number of secondary turns

Figure 53. Transformer impedance ratio formula.

$$\frac{N_p}{N_s} = \sqrt{\frac{Z_p}{Z_s}}$$

where:

Z_p = required primary impedance

Z_s = impedance of secondary load

$\frac{N_p}{N_s}$ = necessary primary-to secondary turns ratio

Example: To match a 4Ω load to a 200Ω input impedance:–

$$\text{Turns ratio } \frac{N_p}{N_s} = \sqrt{\frac{200}{4}} = \sqrt{50} = 7{\cdot}07$$

Therefore primary must have 7·07 times as many turns as the secondary.

Figure 54. Transformer impedance-matching formula, with worked example.

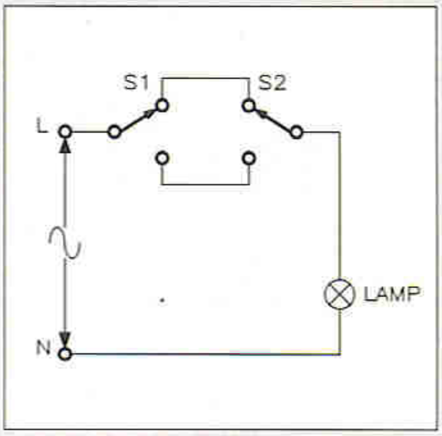


Figure 57. 2-switch ON/OFF AC lamp control circuit.

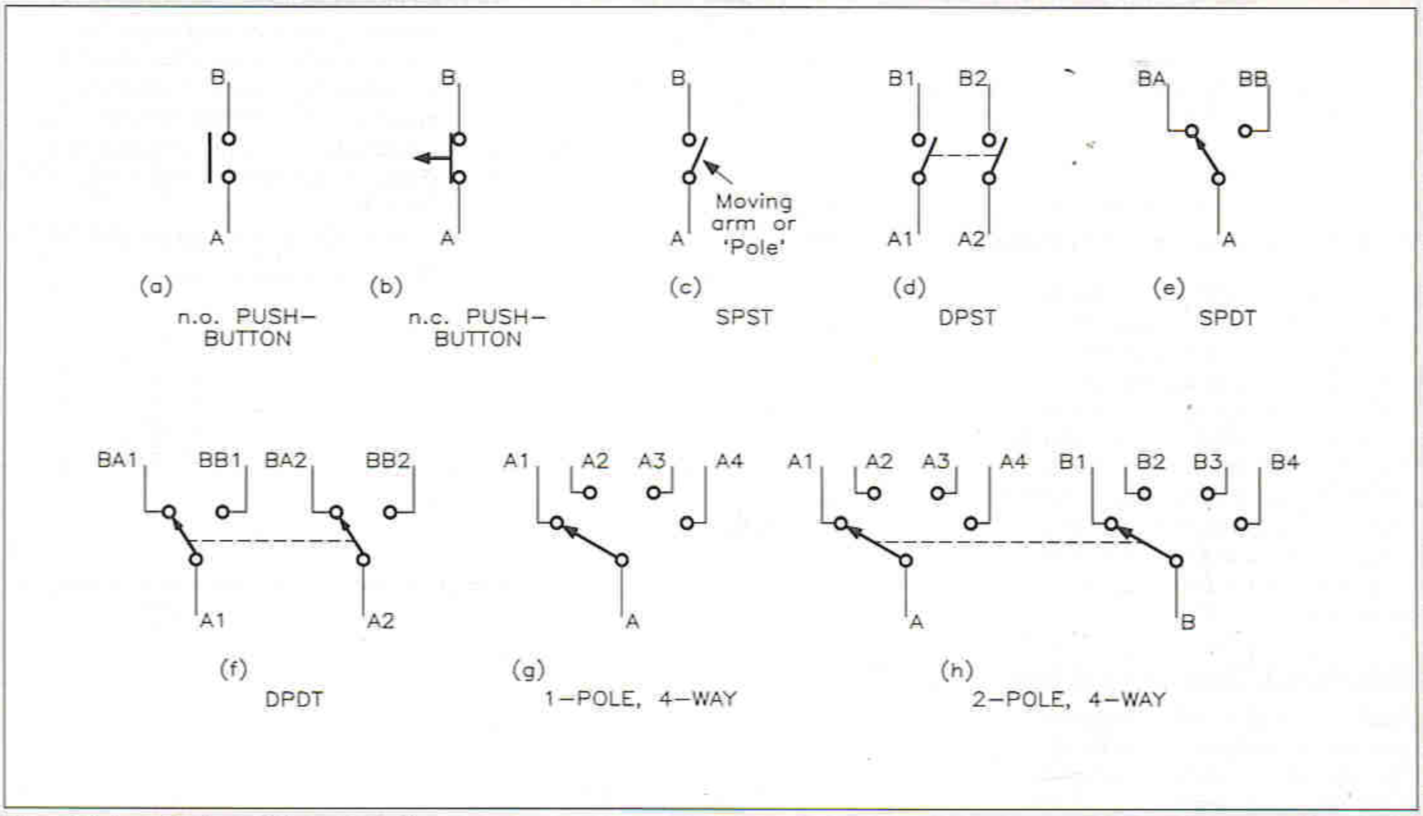


Figure 55. Some basic switch configurations.

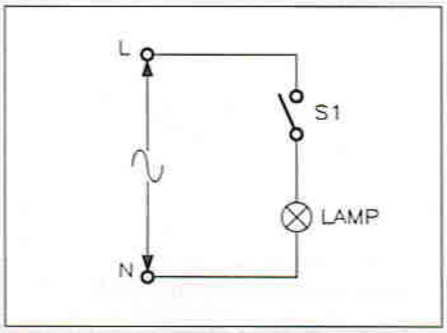


Figure 56. Single-switch ON/OFF AC lamp control circuit.

moving arm type, which is shown in its simplest form in Figure 55c. This has a single spring-loaded (biased) metal arm or 'pole' that has permanent electrical contact with terminal 'A'. The pole either has or has not got contact with terminal 'B', thus giving an ON/OFF switching action between these terminals. This type of switch is known as a single-pole single-throw, or SPST, switch.

Figure 55d shows two SPST switches mounted in a single case with their poles 'ganged' together so that they move in unison, to make a double-pole single-throw, or DPST, switch.

Figure 55e shows a single-pole double-throw (SPDT) switch in which the pole can be 'thrown' so that it connects terminal 'A' to either terminal 'BA' or 'BB'. This enables the 'A' terminal to be coupled in either of two different directions or 'ways'.

Figure 55f shows a ganged double-pole or DPDT version of the above switch. Note that these multiway switches can be used in either simple ON/OFF or multiway power distribution/selection applications.

Figure 55g shows how the 'A' terminal can be coupled to any of four others, thus giving a '1-pole, 4-way' action. Finally, Figure 55h shows a ganged 2-pole version of the same switch. In practice, switches can be designed to give any desired number of poles and 'ways'.

Two other widely used electric switches are the pressure-pad type, and the microswitch. The pressure-pad switch which takes the form of a thin pad easily hidden under a carpet or mat, which is activated by body weight. The microswitch is a toggle switch activated via slight pressure on a button or lever on its side, which enables the switch to be activated by the action of opening or closing a door, window or moving a piece of machinery, etc.

Basic AC Power Switch Circuits

The simplest application of a power switch is as an ON/OFF control device, such as that used to turn a filament lamp on and off. In AC line-powered applications, the circuit must take the series form as shown in Figure 56. S1 is connected to the live, phase or 'hot' power line, and the lamp is wired from the switch to the neutral line. This will minimise the consumer's chances of getting a shock when changing the lamp.

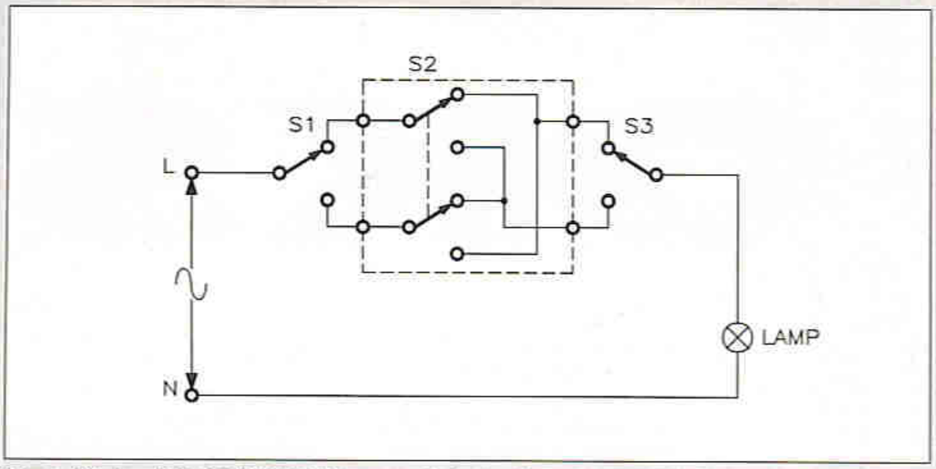


Figure 58. 3-switch ON/OFF AC lamp control circuit.

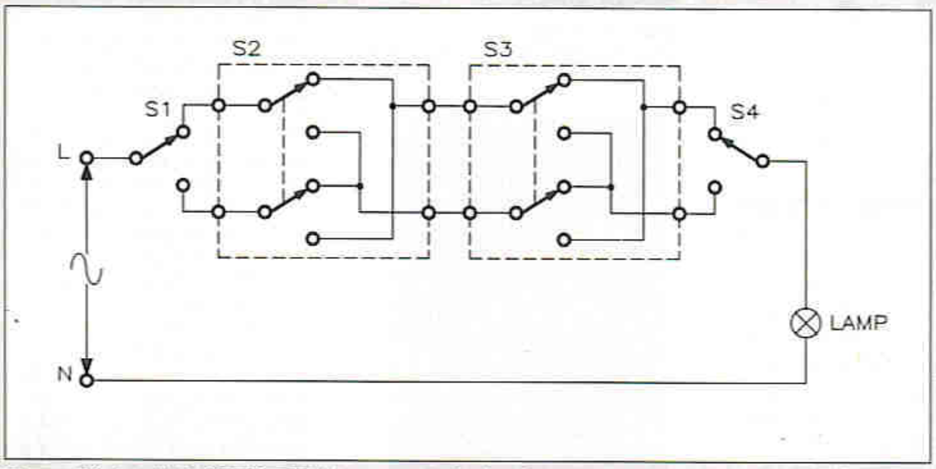


Figure 59. 4-switch ON/OFF AC lamp control circuit.

This simple circuit allows the lamp to be switched on and off from one point only.

Figure 57 shows how to switch a lamp on or off from either of two points, by using a two-way switch at each point. Two wires (known as strapping wires) are connected to each switch, so that one or other wire carries the current when the lamp is turned on.

Figure 58 shows the above circuit modified to give lamp switching from any of three points. Here, a ganged pair of 2-way switches (S3) are inserted in series with the two strapping wires. The S1-S2 lamp current flows directly along one strapping wire path when S3 is in one position, but crosses from one strapped wire path to the other when S3 is in the alternative position.

Note that S3 has opposing pairs of output terminals shorted together. In the electric wiring industry, such switches are available with these terminals shorted internally, and with only four terminals externally available (as indicated by the small white circles in the diagram). These switches are known in the trade as 'intermediate' switches.

In practice, the basic Figure 58 circuit can be switched from any desired number of positions, by simply inserting an intermediate switch into the strapping wires at each desired new switching position. Figure 59, for example, shows the circuit modified for four-position switching.

NEW BOOKS

Electronic Projects for Your PC

by R. A. Penfold

The IBM PCs and compatibles are now the dominant computers in virtually every aspect of microcomputing, and are now the clear choice for anyone who is interested in DIY hardware add-ons. Most other 16 and 32 bit computers are not as well suited to operation with user add-ons, as they were not designed with this type of add-ons in mind. The PCs are much more accommodating due to there expansion slots, which make it easy to add special interfaces – home brewed or otherwise.

This handy little book provides a number of useful PC add-ons including: digital input/output ports, analogue to digital and digital to analogue converters, voltage and current measurement circuits, resistance meter, capacitance meters, temperature measurement interface, constant voltage model train controller, pulsed model train controller, position sensors, stepper motor interface, relay and LED drivers and triac mains switching interface.

The ports and projects featured utilise the basic eight bit PC expansion bus, and are therefore suitable for use with any PC or compatible which has the standard ISA or EISA expansion bus. In practice, this means anything from the original PC through to the modern 386 and 486 PCs.

The book assumes that the reader has a certain knowledge of PC computer interfacing.
1992. 105 pages. 178 x 110mm, illustrated.

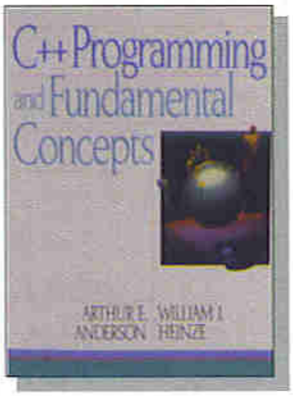
Order As WZ76H (Electr Prjts For PC) ***£3.95 NV***

C++ Programming and Fundamental Concepts

by Arthur E. Anderson and William J. Heinze

C++ is rapidly becoming a major force in software development, and this book is a comprehensive text on the language covering version 2.1 and its iostream library. Earlier versions and differences are also discussed in the text along with nested classes, multiple inheritance and other new features.

The book is designed to help the experienced professional C programmer and software engineers such as graphics, database, systems, network, application programmers as well as technical managers. Additionally, the book is suitable for courses in C++ being offered at colleges and universities.



The aim of the book is to provide C programmers with a description of the new features provided in the C++ programming language so they can incorporate these features in their C programming style. Initially, C programmers will probably incorporate non-object-orientated features such as code-lining, function prototyping, and function overloading into their programs. Programming will then incorporate data abstraction, operator overloading, and separation of interfaces, and then the feature of inheritance to create object-orientated programs.

Object-oriented programming promises to revolutionise programming in the 1990s much in the same way as structured programming revolutionised programming in the 1970s. Of all the object-orientated languages only C++ retains the simplicity and efficiency of the C language, and is set to become the major programming language of the 1990s.
1992. 503 pages. 233 x 177mm, illustrated. American book.

Order As WZ74R (C++ Programming) ***£28.95 NV***

IEE Wiring Regulations Regulations For Electrical Installations

16th Edition

This edition supersedes the fifteenth edition from the 1st January 1993, and is based on the plan agreed internationally for the agreement of safety rules for electrical installations. Also, the technical substance of the parts of the IEC Publications 364 so far published, and of the corresponding agreements reached in CENELEC, have been taken into account. The opportunity has also been taken to revise certain regulations for greater clarity or to take account of technical developments.

Considerable reference is made throughout the Regulations to publications of the British Standards Institute, both specifications and codes of practice. These publications are conveniently listed in Appendix 1 with their full titles, whereas throughout the Regulations they are referred to only by their numbers.

The book is divided into seven parts. Part one details the scope, object and fundamental requirements for safety; part two covers definitions; part three the assessment of general characteristics; part four covers protection for safety; part five details selection and erection of equipment; part six covers special installations or locations and part seven covers inspection and testing.
1991. 266 pages. 296 x 210mm, illustrated.

Order As WZ90X (IEE Wiring Regs) ***£35.00 NV***

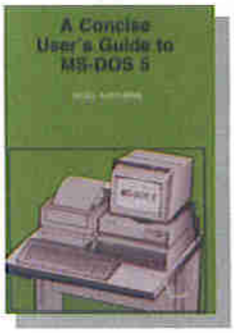
A Concise User's Guide to MS-DOS 5

by Noel Kantaris

Like many of the books in the 'Concise User's Guide' series, this informative guide is written for the beginner on a 'what you need to know first appears first' basis. The book is circular, which means that you don't have to start at the beginning and go through to the end. The more experienced user can start from any section as each section is self contained.The book is not intended to replace the documentation received with the MS-DOS operating system, but only to supplement and explain it. The book covers systems with both hard disk-based drives, and floppy disk-based drives as applicable to the PC and compatibles.

The book deals with the enhancements to be found in the MS-DOS version 5, over previous versions of the operating system. This is due to the refinement of the DOS shell, a menu-driven graphical interface, which first appeared in version 4.0.

Other topics dealt with in this informative guide include; how the DOS operating system is structured so that you can understand what happens when you first switch on your computer; directories and subdirectories and how they can be employed to structure your hard disk for maximum efficiency; how to manage disk files and how to use the MS-DOS Editor to fully configure your system by writing your own CONFIG.SYS and AUTOEXEC.BAT files; how to optimise your system by either increasing its conventional memory or increasing its speed; how to write batch files to automate the operation of your system.



At the same time, this handy little guide has been written in such a way as to also act as a reference guide, long after you have mastered most MS-DOS commands. To this end, a summary of the MS-DOS operating system commands are given in the penultimate section of the book. The commands are explained with relevant examples and, as such, the section can serve as a quick reference guide.
1992. 135 pages. 198 x 130mm, illustrated.

Order As WZ72P (Guide To MS-DOS 5) ***£4.95 NV***

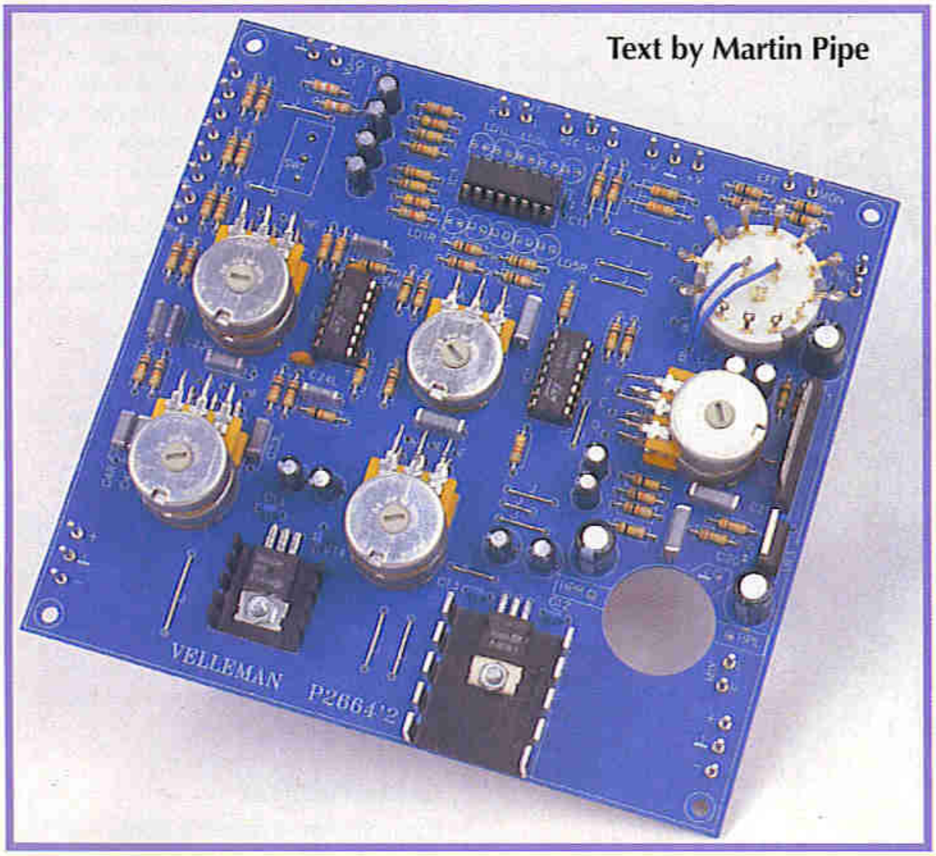
2 PROJECT RATING

MODULAR MIXING SYSTEM PART SIX

MASTER & HEADPHONE MODULE

The Master and Headphone Module is designed to be at the heart of a mixing system. It features a summing amplifier; each of the inputs can be fed in via a resistor, and there are no limits (save for practical ones!) with respect to the number of inputs that can be applied.

Text by Martin Pipe



The completed Master and Headphone Module (component-side).

There are three sets of stereo outputs – one set for a tape recorder, another for headphones, and the main (master) output. The master output features treble and bass tone controls, as well as a balance adjustment. The tape recorder output is exactly the same as the master output, except that the attenuator, mono/stereo switch, tone and balance controls have no effect on it. The headphone output can be used to monitor the pre-fade listen (PFL), effects send or monitor buses (if used), or the outputs – selection is by a 4-way rotary switch. Also included are two 5-LED VU meters, and split-rail voltage regulators for the module and other circuitry.

Circuit Description

1. Mixer/Tone Control

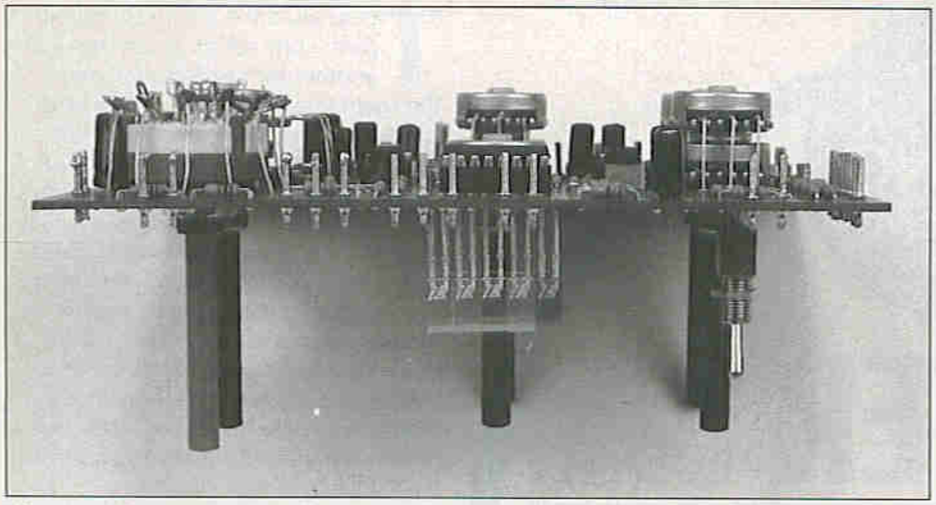
The circuit diagram of the Master and Headphone Module is shown in Figure 1. Amplifiers A1 and A2 are inverting input buffers, the output of which can be summed together (mixed to mono) by the stereo/mono switch SW1, and panned left to right (or vice versa) using the balance control RV1. If each signal to be mixed is fed into the input of A1 or A2, via a 10k resistor, the Op-Amp acts as a summing amplifier – the actual 'mixer' itself. Note that you will find these resistors on the mixer outputs of the other modules in the series; they have not been incorporated on the Master and Headphone Module since the exact number of channels will be dictated by the application in mind.
If building a mixer around this module, the values of the Op-Amp gain-setting resistors (R1L and R1R respectively) depend on the number of channels – 8k2 for an 8-channel

FEATURES

- ★ Headphone amplifier with selector and volume control
- ★ Three fixed output levels 0·775ØdBu, 1·55 and 2·5V RMS
- ★ Tape recorder output
- ★ 2 x 5 LED VU meter
- ★ Bass and treble controls

APPLICATIONS

- ★ Mixers
- ★ Preamplifiers



Side-view of the Master and Headphone Module, showing the arrangement of the potentiometers and switches.

mixer, and 3k9 for a 12-channel mixer. Should you require a different number of channels, a suitable value of R1L/R can be found by dividing 50k by the number of channels; the nearest practical value should then be chosen. For example, 2k should be chosen if 24 channels are anticipated.
If you are using this module in non-mixer applications (e.g., tone control, preamplifier), then input resistors (shown as Rx and Ry in Figure 1) must be added, so that the Op-Amps become inverting buffers. These resistors, and R1L/R, should be fixed at a value of 3k9.

After mixing (or buffering in the latter case), the two channels are then fed to a RV2L/R, a ganged attenuator ('volume control'). The output from each attenuator is fed to A5 (left channel) and A6 (right channel), each of which is a non-inverting Op-Amp set up for a gain of 20dB (x10). Each channel is then passed through a Baxandall tone control circuit, which is formed by A7 (left channel) and A8 (right channel) – together with associated components. The tone controls are designed to have 15dB of cut and boost at 40Hz (bass) and 8·5kHz (treble). The signal(s) can then be tapped off at the high, medium or low outputs; each tap is derived from a potential divider formed by R10L/R to R13L/R. Note that the tone control circuit is inverting; this 'negates' the inverting action of A1L/R, and consequently each channel is phase correct.

2. Selector Switch and Headphone Amplifier

4-way switch SW2L/R selects between the master output (from the tone control), or effects, monitor/return and PFL channels from other modules. In non-mixer applications this system could, no doubt, have other applications. Note that the PFL channel does not have an input resistor and that the effects send and return channels, being mono, are fed equally to both channels. The outputs from SW2L/R are then buffered by inverting Op-Amps A3 (left) and A4 (right). These Op-Amps have unity gain for the effects send and return channels, but the master channel is attenuated by a factor of 3. The outputs from A3 and A4 then feed IC4, via the headphone attenuator RV5L/R. Note that the VU meters can also be driven by A3 and A4. IC4 (LM2877) is the stereo integrated power amplifier used to drive the headphones. The output power from IC4 depends upon the impedance of the headphones used; 45mW will be delivered to a 400Ω pair (which will be more than loud enough!), 545mW into a 32Ω pair, and an ear-splitting 1·3W into an 8Ω pair – which is enough power to drive a pair of speakers to reasonable levels! Note that the outputs of IC4 are AC-coupled to prevent the headphones from being damaged by DC offsets.

3. VU Meter

IC3 (U2066B) is a purpose-designed dual 5-LED bargraph driver. Its associated components determine the attack and decay times, and the bandwidth over which indication will take place. Each of the two bargraph displays is made from three green, one orange and one red LED; the LEDs operate at approximately the following levels: red +3dB, orange 0dB, and green at −3, −6 & −12dB.

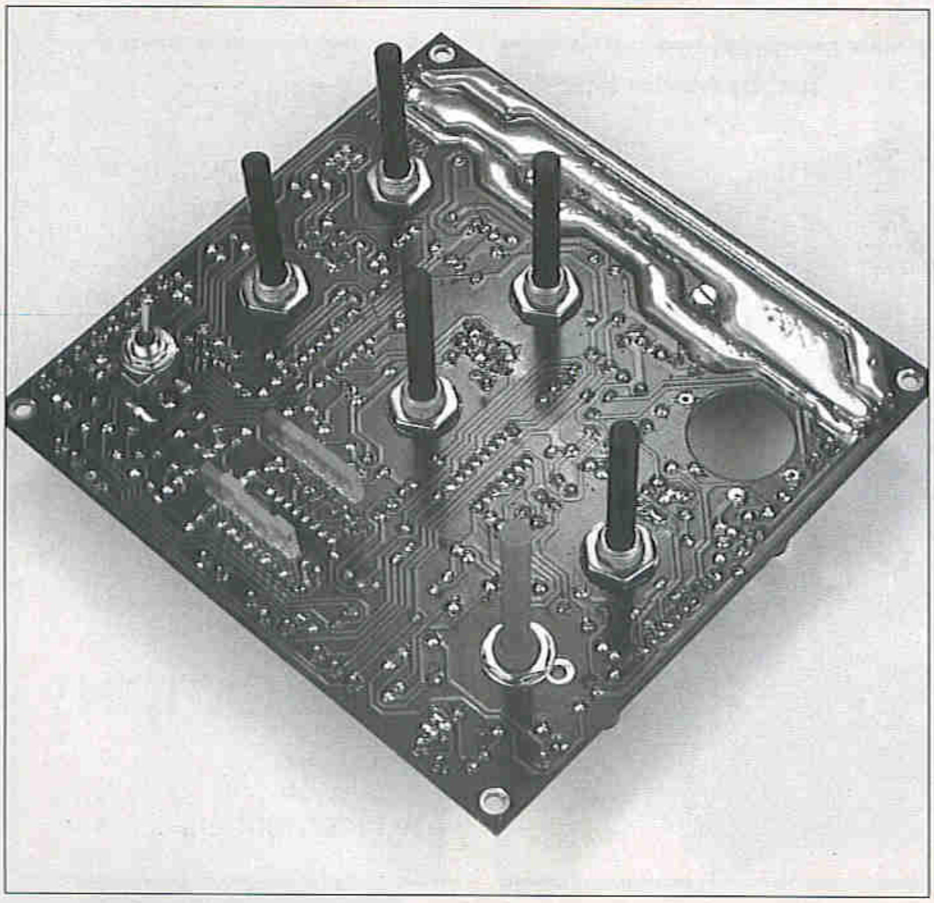
The input for the VU meter can be taken from the output of the tone control, or from the output of the select switch buffer. The latter option enables you to monitor all levels, and not just those of the master output. However, in those situations where the levels of the master output must be continually monitored (important recording sessions, radio stations) regardless of what's being heard 'through the cans', the former option may prove a better choice. Either option can be chosen when you build the unit.

4. Power Supply Provision

RG1 and RG2 are +15V and −15V voltage regulators respectively. Decoupled by C12 to C19, these two ICs supply all of the active components in the Master and Headphone Module, and any other circuits and modules – so long as the total load presented to each regulator does not exceed 1A. Of course, the unregulated supply rails feeding RG1 and RG2 must be capable of supplying such currents. Note that IC4, the headphone amplifier, has its own regulator (RG3).

Construction

If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful practical advice on how



The completed Master and Headphone Module (track-side).

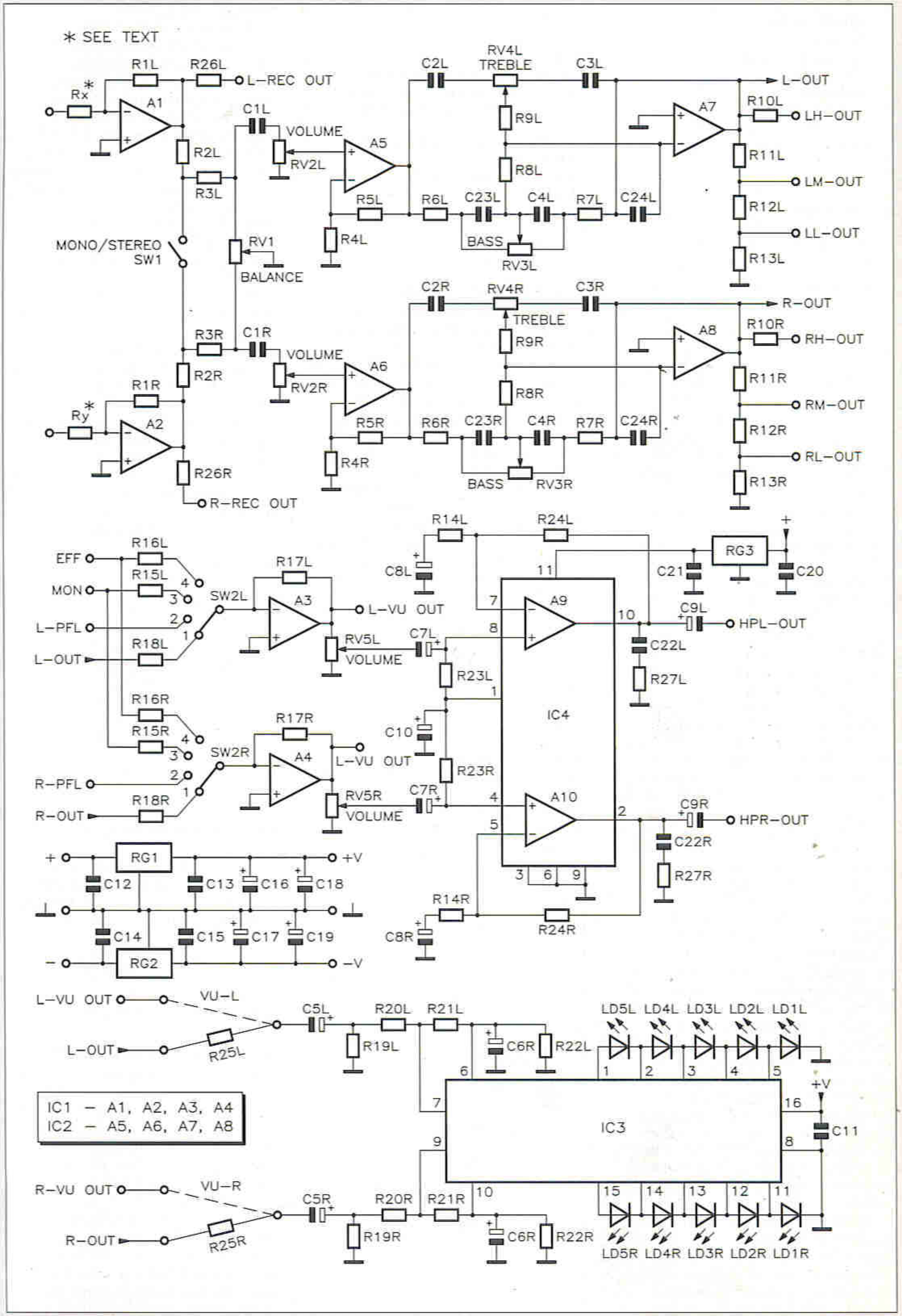


Figure 1. Master and Headphone Module circuit diagram.

Specification

Distortion:	0·05% (max.)
Signal-to-noise ratio:	>90dB
Bass control:	15dB boost and cut, centred at 40Hz
Treble control:	15dB boost and cut, centred at 8·5kHz
Output levels:	0·775V RMS (low); 1·55V RMS (medium); 2·5V RMS (high)
Headphone output:	45mW (400Ω load); 545mW (32Ω load); 1·3W (8Ω load)
VU meters:	green –12dB, –6dB, –3dB); orange (0dB); red (+3dB).
Current consumption (standby):	70mA
Current consumption (loaded):	500mA
Power supply voltage requirement:	±17·5V to 30V

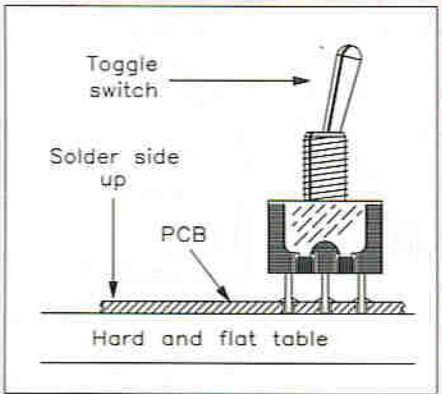


Figure 2. Fitting the mono/stereo switch SW1.

to solder, and identify components.

The first component fitted must be the toggle switch SW1. This is mounted on the solder side of the PCB. Place the PCB, solder side up, on a hard flat surface, as shown in Figure 2. Fit the switch squarely into position and solder the centre leg only. Viewing from the sides of the PCB, check that the switch is still 'nice and square' – if so, solder the other two legs into position. If not, melt the solder and try again.

The wire links marked 'J', and the PCB pins (inserted from the component side), are fitted next, followed by the resistors – except R25L/R. If you want the bargraph display to monitor the master output, fit R25L/R; if you wish to use the bargraph display to monitor the output from the select switch, however, fit the wire links in the positions marked with a dashed line, next to R25L/R. In addition, note that the value of R1L/R depends on the number of inputs – 8k2 for a 6-channel mixer, and 3k9 for a 12-channel mixer. If a different number of channels are required, the value for R1L/R as determined in the 'Circuit Description' section should be used. The capacitors can now be installed – watch out for the electrolytics (C5L/R to C9L/R, C10, C16 to C19), which are polarised devices and must be correctly orientated. Before fitting to the PCB, the leads of all electrolytic capacitors must be preformed. Fit the IC sockets next, aligning the notch on the socket with that printed on the legend.

Mount voltage regulators RG1 and RG2, together with their heatsinks (RG1 has the larger one) onto the PCB, using the 10mm M3 hardware supplied, as shown in Figure 3. In order to fit properly, the regulator leads should be bent through 90°, at a distance of 5mm from the package. The use of thermally-conductive paste (not supplied), applied between the tab of each IC and its heatsink, may improve long-term reliability – particularly if the Master and Headphone Module's regulators are used to power ancillary items. Do not get the two regulators mixed up – the 7815 (+15V) is RG1, while the 7915 (–15V) is RG2. Once bolted down, they can be soldered in place. Note that the screws are fitted from the track side of the PCB. The final regulator, RG3 (7815), can be inserted along with the headphone amplifier, IC4 – the regulator tab faces inwards towards the rest of the PCB. When fitting IC4, the stripe (and cut corner on the heatsink tab) on IC4 corresponds to pin 1.

Install the potentiometers from the component side of the PCB, as shown in Figure 4. Make sure that each potentiometer goes in the correct position – in particular, do not confuse linear ('lin') and logarithmic ('log') potentiometers of the same value (for example RV3L/R and RV5L/R), as these have somewhat different characteristics! When you are satisfied that all of the potentiometers have been installed correctly, use the bandoliered wire links to connect their pins to the relevant positions on the PCB. The last component to be fitted is the switch SW2 – also fitted

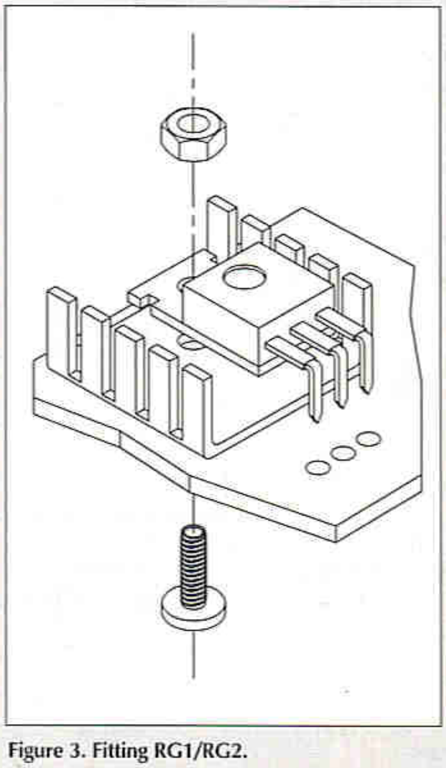


Figure 3. Fitting RG1/RG2.

from the component side.

If the effects send and return inputs are not required, the switch can be modified into a 2-way one. Turn the switch shaft fully anti-clockwise and remove the nut, spring washer and tab washer. Refit the tab washer in the hole identified on the body as '2'. After reassembling the control, fit it to the PCB and align it so that the numbers embossed on it line up with those printed on the PCB legend. Using some of the remaining bandoliered wire links (or component lead offcuts), wire up pins 1 to 8 of the switch to the relevant positions of the PCB. The final connections to SW2, pins 'A' and 'B', which are located in the centre of the switch, must be connected to the PCB using insulated wire (not supplied in the kit).

The LEDs are fitted from the track side of the PCB so that their tips are 23mm above the base of the PCB. The shorter (cathode) lead of each LED is aligned with the flat side of the LED shown on the board legend; note that LD1L/R are the red LEDs, LD2L/R are the orange and LD3 to 5L/R are the green. Solder only one lead from each LED; the second leg should not be soldered until all LEDs have been positioned at the correct height and are squarely aligned.

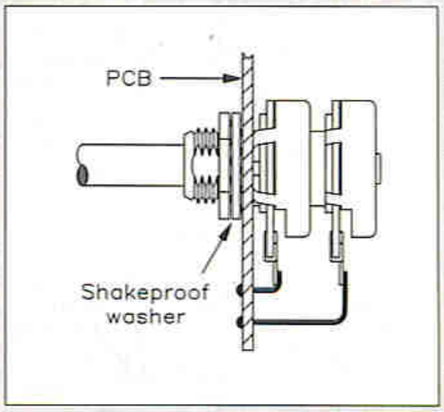


Figure 4. Installing the potentiometers.

Finally, coat the power supply tracks, which are the wide tracks free of solder resist, with more solder. After completing assembly, it is prudent to check your work – finding any incorrectly placed components could save considerable time and expense later on. Other gremlins to watch out for include solder bridges/whiskers and poor joints.

Testing and Installation

The best form of testing is to use the Master and Headphone Module in its intended application. Ensure that the power supply can provide the required currents. The module should be installed away from any strong mains fields (power transformers and the like), in a screened case. If the completed board is to form part of a modular mixing system, it should be built into a decent metal case anyway! Screened cable (such as XR15R) should be used for all audio connections, to reduce the possibility of hum pick-up. Once the installation has been inspected, the ICs can be inserted and the system powered up.

MASTER AND HEADPHONE MODULE PARTS LIST

RESISTORS

R1(L/R)	3k9 or 8k2 (see text)	2 of each
R2, 3, 4, 10, 26(L/R)	1k	10
R5 to 8, 14 to 17(L/R)	10k	16
R9(L/R)	3k3	2
R11, 19(L/R)	1k8	4
R12, 13(L/R)	1k5	4
R18(L/R)	33k	2
R20(L/R)	150k	2
R21(L/R)	120k	2
R22(L/R)	47k	2
R23, 24(L/R)	100k	4
R27(L/R)	2Ω7	
R25(L/R) (not necessarily fitted – see text)	3k9	2
RV1	10k Lin	1
RV2, 5(L/R)	100k Dual Log	2
RV3, 4(L/R)	100k Dual Lin	2

CAPACITORS

C1, 22(L/R)	100nF Poly Layer	4
C2, 3(L/R)	4n7F Poly Layer	4
C4, 23(L/R)	47nF Poly Layer	4
C5, 6(L/R)	4µ7F 50V Electrolytic	4
C7, 8(L/R)	1µF 100V Electrolytic	4
C9(L/R), C10	220µF 35V Electrolytic	3
C11 to 15, 20, 21	100nF Resin-dipped Ceramic	5
C16 to 19	10µF 50V Electrolytic	4
C24(L/R)	15pF Ceramic	2

SEMICONDUCTORS

LD1(L/R)	Rectangular Red LED	2
LD2(L/R)	Rectangular Orange LED	2
LD3 to 5(L/R)	Rectangular Green LED	6
IC1, 2	TL074	2
IC3	U2066B	1
IC4	LM2877	1
RG1, 3	µA7815	2
RG2	µA7915	1

MISCELLANEOUS

SW1	SPDT Toggle Switch	1
SW2	3-pole 4-way Rotary switch	1
	14-Pin DIL Socket	2
	16-Pin DIL Socket	1
	Large Heatsink (for RG1)	
	Small Heatsink (for RG2)	
	PCB Pins	3 pkts.
	PCB	1
	Screw M3 x 10mm	2
	Nut M3	2
	Bandoliered Wire Links	18
	Construction Leaflet	1

OPTIONAL (Not in Kit)

Alternative value of R1L/R – see text		
Constructor's Guide	1	(XH79L)
Screened Cable	As required	(XR15R)
Heat Transfer Compound	1 syringe	(HQ00A)

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 VE33L (Master and Effects Module) Price £44.95.
Please Note: Some parts, which are specific to this project (e.g., PCB, IC4) are not available separately.

Stray Signals

by Point Contact

One of the advantages (or disadvantages, depending upon one's point of view) of writing a column such as this is receiving the occasional letter, that a reader feels compelled to write. Sometimes a reader writes to say how much he agrees with something I said – which is very gratifying – and often goes on to illustrate the point from his own experience. More frequently, a reader writes to say how strongly he *disagrees* with something I said, which in a way is equally welcome, since it reassures PC that at least some people out there do actually read Stray Signals! The Editor forwarded two such letters recently, one from J.V.H. of Fareham, not a million miles away from PC's South Hants abode.

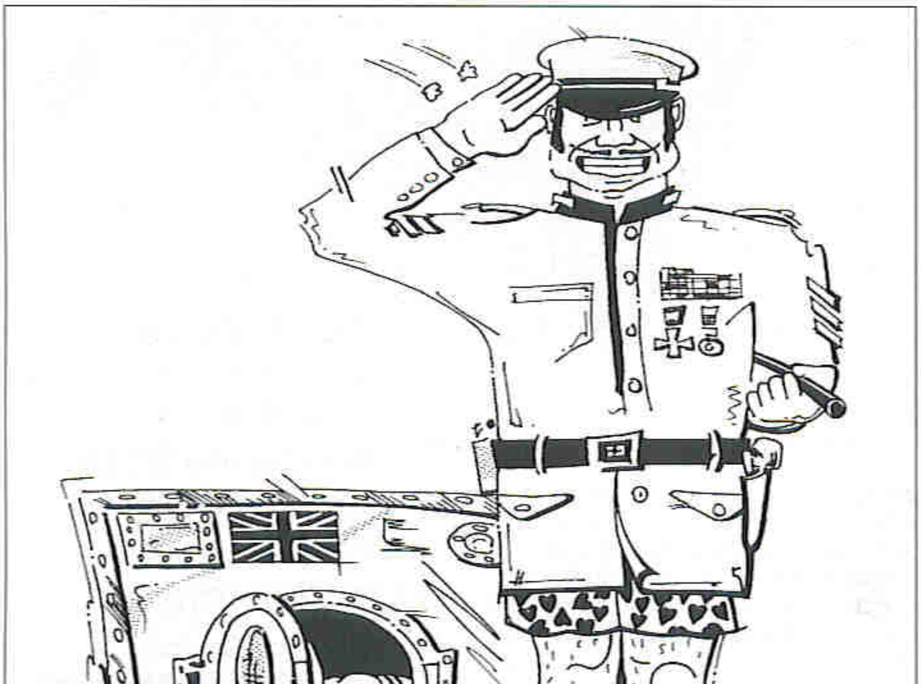
Taking me to task for my (undeserved, he maintains) strictures in Electronics Issue 59 on the quality of the design and manufacture of British goods, he cites the case of a Kenwood dishwasher which he pensioned off recently after 20 years service, not due to any operational failure, but due to the plastic inner coating having finally worn through, resulting in rusting. A new model from an EEC country, which he purchased recently, has, by contrast, failed within a fortnight, and its *replacement* has failed twice already!

Now I must admit that I was *referring* to the unfortunate experiences with household goods in the PC home recently: in the past things were very different. In the days of the Raj, the whole world (or at least that part of it that we thought mattered, being coloured pink in the atlas) rode a British bicycle, and, coming up just a little nearer to modern times, in the mid sixties Mrs PC bought a Kenwood Chef food mixer with all the attachments. This was built like a battleship, has never gone wrong and (touch wood) seems set fair to outlast Mrs PC, her spouse, and possibly their children as well. Nowadays, goods seem to be designed for the absolute minimum cost of production to maximise a firm's short term profits – perhaps this is because manufacturing firms are now run by accountants rather than engineers.

The other interesting letter was from G.L.M. of Edgware, and this reproached me for recommending brass bayonet lampholders as safer and more reliable than plastic ones. Pointing out that some (he says the majority) of houses do not have an ECC – Earth Continuity Conductor – in the lighting circuit, he says that the danger of the lampholder becoming live nullifies any advantage over the plastic variety. Now your modern brass lampholder has a terminal on the metalwork for connecting to the ECC, and the current IEE Wiring Regulations (16th Edition) stress the importance of fitting an ECC in lighting circuits, as indeed did the previous 15th Edition. After all, so many houses and flats have a fluorescent light in the kitchen, and the extensive metalwork of such a fitting *definitely* needs earthing. If your lighting circuit does not incorporate an ECC, you should seriously contemplate rewiring. Perhaps PC has just been unusually unlucky, but in his experience, the shade retaining ring on a plastic lampholder *always* seems to seize up after a few years.

On a totally different subject, PC was experimenting recently with one of the 'new' current feedback op amps. In fact, they have been around for some years now, but the particular one I was playing with has only recently been announced. It is billed by the manufacturer as having a 100MHz bandwidth and a 100mA output drive capability, both claims being entirely true – individually. With a 1kΩ load you get the 100MHz bandwidth; however, if you opt to load the op amp with such a low impedance that the 100mA output drive capability is used to the full, then the bandwidth is only some 50 to 80MHz, depending upon the demanded gain and whether the circuit is inverting or non-inverting. So, like the Boy Scouts, *be prepared;* 'American spec-writing' still flourishes.

Popping out to post a letter recently, it being a fine Saturday afternoon, on arriving at the post box, PC was more than a little surprised when seeing the time of the next collection. There, as plain as plain in the 'next collection' holder at the top of the door of the pillar box, was the usual sort of little metal plate, clearly showing that the next delivery was 'NOW'! Surprised at the PO's psychic divination, that PC had an urgent letter to post, he looked around, half expecting a post-van to pop up from nowhere. Eventually PC (who is getting on a bit, poor chap) realised that, he had missed the last Saturday post, and the next collection was really 'MON', but the metal plate was upside down!



Yours sincerely

Point Contact

RS232

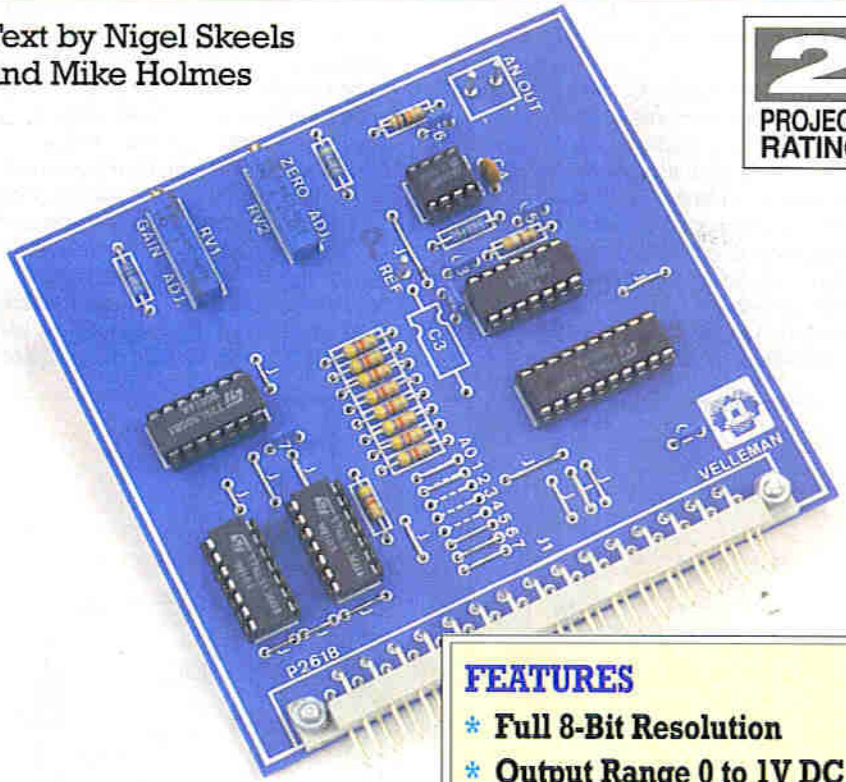
SERIAL PORT EXPANSION SYSTEM

PART SIX

Digital to Analogue Converter Card

Text by Nigel Skeels and Mike Holmes

2 PROJECT RATING



The Digital to Analogue Converter Card is intended for use with the Intelligent Motherboard for the RS232 Serial Port Extension System, as described in Issue 59 of 'Electronics – The Maplin Magazine', and is an addition to the other plug-in cards in this range. The D-to-A (Digital to Analogue) Converter transforms a binary number, presented to it via the system data bus from the Intelligent Motherboard, into an analogue voltage output. The 8-bit binary input offers up to 256 possible steps, each step producing an analogue DC output of 4mV. With a binary input of 0000 0000 (decimal 0 or hex 00), the minimum output from the D-to-A converter is 0V, but with an input of 1111 1111 (decimal 255, hex FF) an output of 1·02V is obtained.

This output from the D-to-A Converter Card could then be used to control analogue equipment – for example the volume of an automated mixing desk or the control of lighting, even motors and actuators, etc. The possibilities are endless, and only limited by your imagination.

Circuit Description

As with all of the other plug-in cards for use with the extension system, a connection is made between the D-to-A Converter Card and the computer via the Intelligent Motherboard and its Extension Card, which buffers the data signals, generates the necessary auxiliary signals and provides the power supply for the interface plug-in cards.

The circuit of the card, which is shown in Figure 1, is quite simple and mainly consists of an octal latch presenting 8-bit data to the D-to-A converter, IC2. Since up to four cards can be installed in the motherboard extension card at the same time (and possibly more on further extension cards), each is required to be uniquely addressed to prevent addressing contention between the cards. This is achieved through the fitting of links at the positions 'A0' to 'A7' on the PCB. IC3 and IC4 between them provide eight 2-input, exclusive-OR gates, which together form an 8-bit logic comparator. An 8-bit address bus from the mother-board is presented to A0 to A7 in Figure 1 (J1-13 to J1-J25), while wire links may or may not be fitted between R1 to R8 and ground at 'A0' to 'A7'.

Each gate has an open-collector non-inverting output, and in each case, the exclusive-OR action requires that the two inputs must be at different logic levels to achieve an active high (output off) at the output. If both inputs are at the same level, either '0' or '1', the output is always '0' (output low, or on). Wherever a wire link is fitted at 'A0' to 'A7', there MUST be a logic '1' bit from the address bus corresponding to the same position, A0 to A7; similarly, where a link is omitted, the corresponding address bit must be '0'. Such a condition allows all the gates to release the common output line pulled up by R9, and thus this card is properly selected.

IC5 provides two inverters which also have open-collector outputs. Once the eight exclusive-OR gates, properly addressed, are all off, it only remains for the I/O request control line $\overline{IORQ}$ and the write enable line $\overline{WR}$ to both go low to completely release the common output line, producing a positive going pulse at IC1 pin 11.

IC1 is an octal, D-type, positive edge triggered flip-flop, meaning that on each occurrence of the clock pulse input, pin 11, going high, the data bits on D0 to D7 are transferred to the outputs and latched by the flip-flops.

The $\overline{OE}$ (Output Enable) function of IC1 (it has tri-state outputs) is permanently enabled by pin 1 being tied to ground, so that the D-to-A converter, IC2, continuously receives

FEATURES

* Full 8-Bit Resolution
* Output Range 0 to 1V DC in 255, 4mV Steps
* Non-Linearity of ±0·5 LSB
* Programmable from BASIC

APPLICATIONS

* Analogue Control of Motor Speed, Attenuators, Frequency Generators, etc.
* Automated Varying Voltage Generation
* General Purpose Analogue Signal Generation

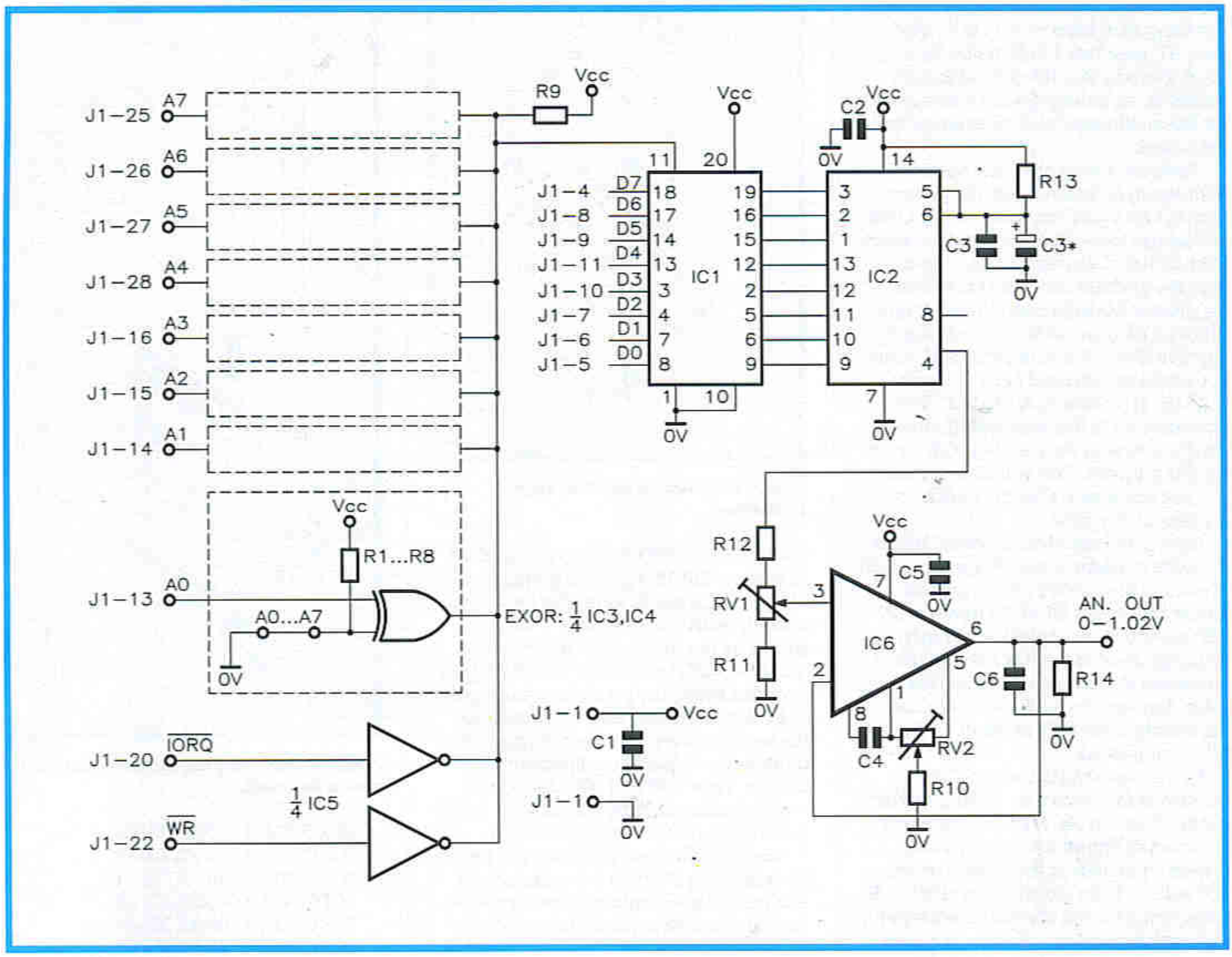


Figure 1. Circuit diagram.

the latched 8-bit data from IC1. IC2, a ZN426, is an 8-bit D-to-A converter containing a 2·5V precision reference source and produces binary weighted voltages (i.e., the output voltage doubles for each multiple of 2 in the binary data) at its output, pin 4. The ZN426 is one of the easiest D-to-A converter ICs to use and is ideal for general purpose applications, and is suitable here.

The precision reference voltage from pin 6 is biased into action by R13, and decoupled to ground via C3, before connecting to the reference input of IC2. It is possible that this reference source (output current 3mA) can be used to bias a further 1 or more ZN426 D-to-A chips on other cards, and this will enable all of them to 'track' together accurately with reference to the same source. It is only necessary if absolute accuracy between the different cards is essential; normally it is not important. However, should the precision reference be used in this way, a 2·2μF, 16V electrolytic should be added in parallel to C3 (marked as C3* in Figure 1), and space is provided on the PCB for it (but the component is not included in the kit).

The DC reference is necessary so that the D-to-A part of the ZN426 IC can relate its DC output to some sort of constant, interpreted as the centre of the total range available. Hence, 2·5V equates to the centre of a total swing of 0 to 5V DC out at pin 4, but whatever its value it will also correspond to an input of 128 (80 hex, 1000 0000 in binary). It is possible for the reference to be at some other level (provided externally), to shift the centre point, but given the supply limitations the IC will run out of 'headroom' somewhere near the high or low extreme of the input binary value.

Moreover, the IC interprets values of 128 and above as 'negative' (where the Most Significant Bit is logic '1'). These upper values are stored in 'twos complement', i.e., as soon as the input rolls over from '0111 1111' (127) to '1000 0000' (128), it actually becomes '1111 1111' (-1). As long as the MSB is '1', the other bits will be inverted to produce the real value. The reason for this is that the supply current drawn depends, to a degree, on the various logic states in the internal gates, and if the value changes from '0111 1111' to '1000 0000' there may be sufficient disturbance in the supply current to affect the accuracy of the conversion. Using 'twos complement', the actual bit values stored will follow a smooth transition from '0000 0000', through '1111 1111' to '1000 0000' over the whole range of inputs 0 to 255. This activity is, of course, entirely internal to the IC and is not something you need concern yourself with while actually using the card.

The final stage comprises IC6 by way of buffering, which is a CA3130 MOSFET input, CMOS output Op-amp, chosen for its ability to swing its output all the way to either supply rail level. The stage has unity gain, but is provided with adjustable input attenuator R12, RV1 and R11 to set the precise maximum output level. RV2 is used to cancel the ICs DC offset error. Both of these presets are multi-turn types.

Construction

Construction is quite straightforward and is dealt with in greater detail in the leaflet supplied with the kit. However, the following notes are also beneficial.

As a recommended sequence of events, firstly mount the wire links between the PCB holes marked 'j'. After fitting these the card's address must be chosen, and this is according to what other addresses you will be using for other cards, i.e. if this is the first card on the extension board then it can be given the address '1', which would be set by installing wire links at 'A0', 'A5', 'A6' and 'A7' (see Part 1 in Issue 59 for a table showing the different addresses available, including special addresses for the multiplexer and an external real-time clock).

However, be warned that once the addressing links are fitted, the pattern may not be easily modified without risk of damage to the PCB. One recommendation is that, if you want to be able to alter the address settings at any time for greater flexibility and to better mix different plug-in cards, to be inserted at any position in the extension card, then you could use an octal SPST DIL switch (XX27E) at positions 'A0' to 'A7'. The hole spacing in this area is deliberately compatible with the standard DIL layout for this purpose. This will allow you to quickly and easily alter the card's address at any time.

Next fit the resistors, followed by the IC sockets, taking care to align the notch of each to the marker on the legend. Fit the capacitors C1 to C6 (there is no C3* provided, as explained earlier). Although most of the ICs are not CMOS types and should not be at risk from static damage, do not insert them into their sockets yet until all other work has been completed.

Fit the right-angled male PCB connector to the card by bolting in place using M3 hardware BEFORE soldering, as shown in Figure 2. Similarly fit the female connector to the motherboard, and solder. Then attach the upright PCB edge guides to the motherboard with the self-tapping screws as shown in Figure 3.

Insert the two PCB pins from the component side of the PCB at positions 'AN OUT', last of all, insert all the ICs, making sure to align the notch on each package with the notch on the sockets. Note that IC6 is a MOS device and, although it is a protected device, some care in handling is still advised.

Testing and Setting Up

The unit requires setting up before use. Firstly this involves setting the address, and secondly the calibration of the output stage by adjusting RV1 and RV2.

A unique address is required to be set by fitting wire links or a DIL switch bank on the PCB in the positions A0 to A7, as described above. This will enable the motherboard to recognise the board as an individual device, and data can then be transferred only to the card with the correct address.

Calibration of the unit should be completed using a multimeter (preferably a digital one for accuracy), with the range set to 2V DC and in conjunction with the following program :

001 EPEX XX XX XX
002 OPDA 3 001

Note the address has been set to card no. 3.

Connect the multimeter to the output of the card ('AN OUT'), and adjust the

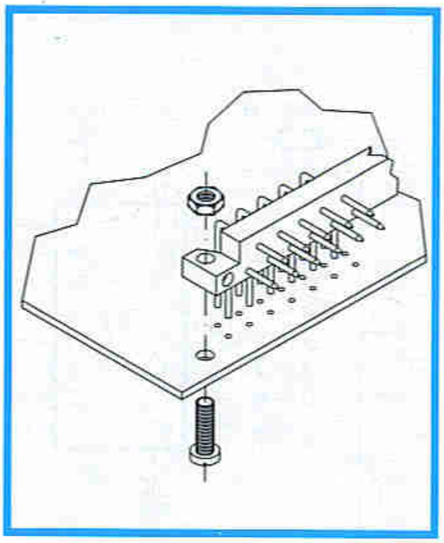


Figure 2. Mounting the card edge connector.

preset RV2 ('ZERO ADJ.') to obtain 4mV. Now type 'OPDA 3 250' (don't forget to hit the return key to enter the new line), and adjust RV1 until exactly 1·000V is shown on the multimeter. Because the 'ZERO ADJUST' affects the 'GAIN ADJUST' and visa versa, the procedure will need to be repeated several times until both the required readings are obtained. To double-check that the adjustments are correct, type 'OPDA 3 000', for a multimeter reading of 0·000V, then type 'OPDA 3 255' for a meter reading of 1·02V.

The following test program will begin by outputting 0V, then for each second that passes the output voltage increases, until on the 10th second the maximum output voltage of 1·02V will be achieved. On the 11th second the program will repeat again, outputting 0V.

001 EPEX XX XX XX
002 OPDA 3 000 XX XX X0
003 OPDA 3 005 XX XX X1

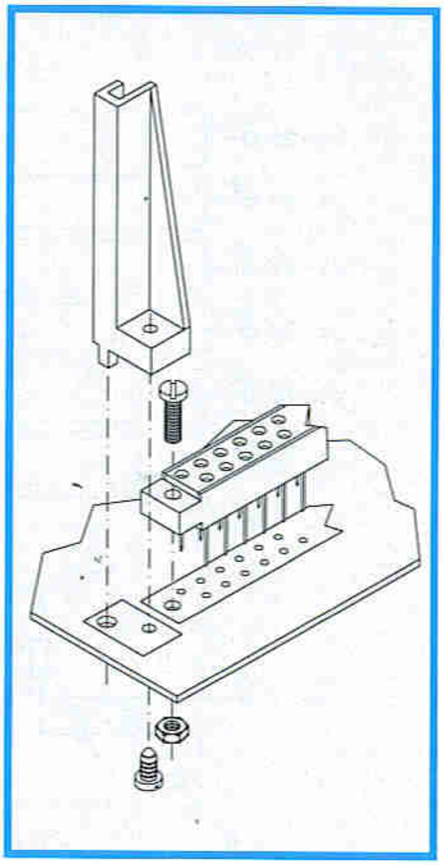
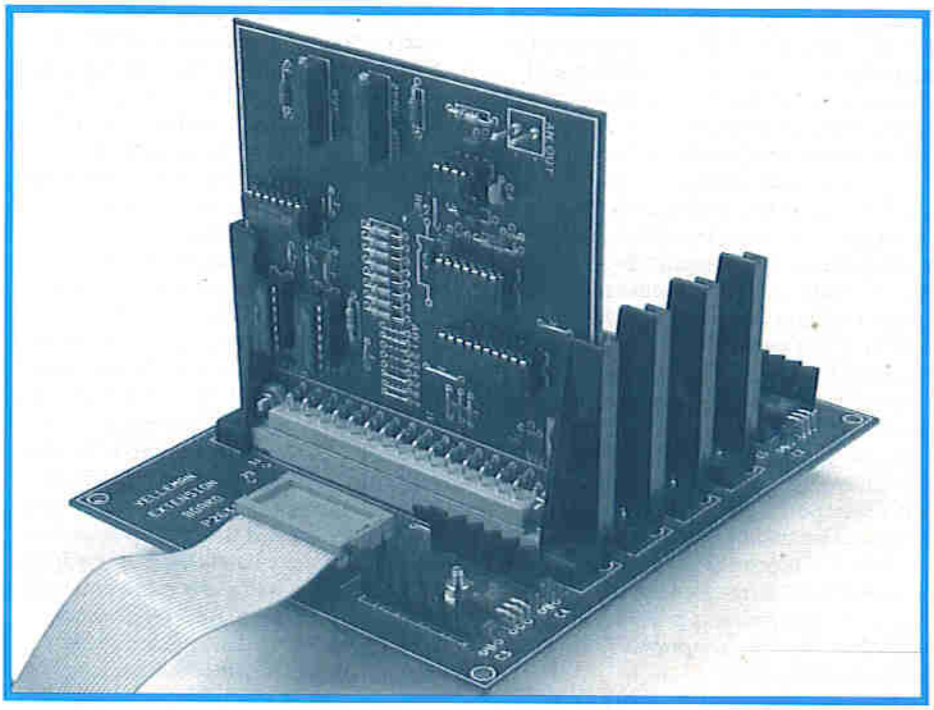


Figure 3. Mounting the motherboard PCB socket and card.

004 OPDA 3 010 XX XX X2
005 OPDA 3 020 XX XX X3
006 OPDA 3 040 XX XX X4
007 OPDA 3 070 XX XX X5
008 OPDA 3 100 XX XX X6
009 OPDA 3 180 XX XX X7
010 OPDA 3 200 XX XX X8
011 OPDA 3 255 XX XX X9

Note that program lines are only included for convenience and should not be included when entering the program.



The Opto-Coupler Input Card installed in the expansion unit.

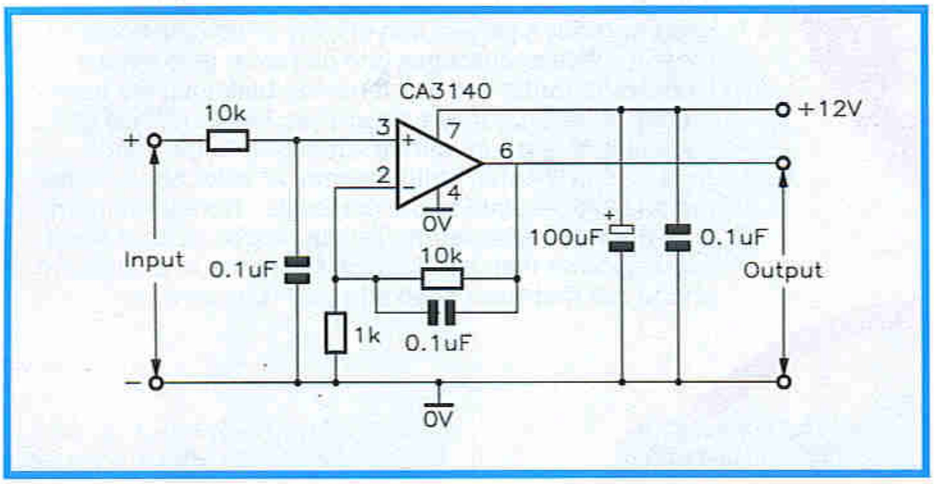


Figure 4. x **10 voltage amplifier circuit.**

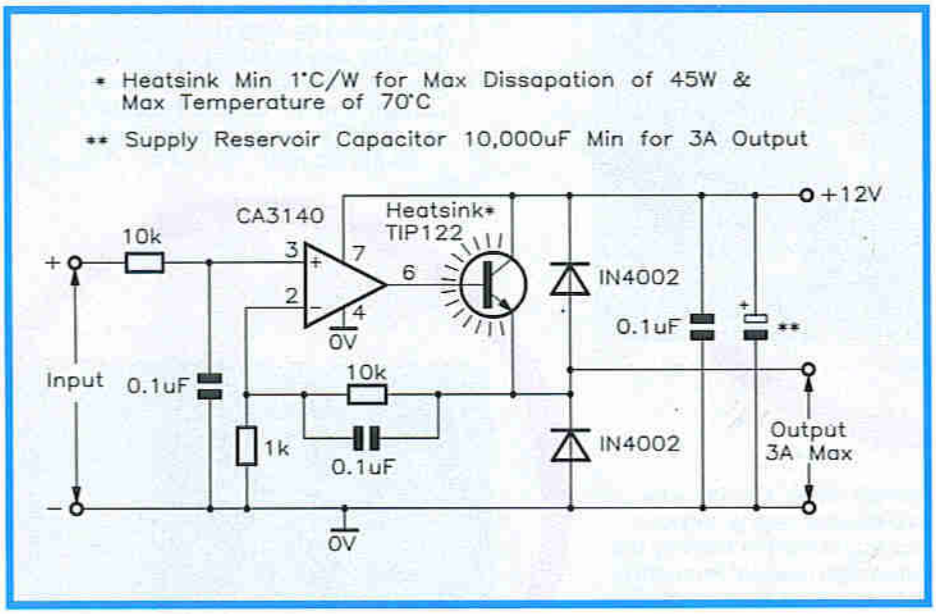


Figure 5. x **10 voltage amplifier with current buffer circuit.**

In Use

When using the device it is obviously limited by the maximum voltage it can output (1·02V), but with the minimum of additional circuitry it is possible to amplify the output signal to a more acceptable level. The circuit shown in Figure 4 does just this using a CA3140 Op-amp. This circuit will amplify the voltage by a factor of 10, but is still not capable of supplying enough current for applications such as the control of lighting, motors, etc. For these, a current buffer is required; and this can be achieved by adding a TIP122 power transistor, with diode protection, to the circuit of Figure 4, as shown in Figure 5. PLEASE NOTE that the TIP122 will become hot in use and should be fitted to a heatsink that is appropriate for the amount of current being drawn.

The heatsink size can be calculated using the following formula. First calculate the power dissipation in the output transistor:

Maximum supply voltage – minimum output voltage x maximum output current = Watts

Secondly, to find the maximum permissible heatsink temperature:

Max H/sink Temp – Room Temp = Max temp rise

Heatsink size = Max temp rise / Power dissipation = °C/W

Thermal resistance has not been taken into account, therefore you can multiply the answer by 0·9, this effectively increases the heatsink size by 10%. Also note that if you are driving a motor from the current buffer, then the motor must be fully suppressed.

D TO A CONVERTER CARD PARTS LIST

RESISTORS: All 5% Metal Film (Unless specified)		
R1-10	4k7	10
R11,12	15k	2
R13	390Ω	1
R14	10k	1
RV1,2	10k Multi-Turn Preset	2
CAPACITORS		
C1-3,5-7	100nF Monolithic Ceramic	6
C4	56pF Ceramic Disc	1
SEMICONDUCTORS		
IC1	74LS374	1
IC2	ZN426	1
IC3,4	74LS136	1
IC5	74LS05	1
IC6	CA3130	1
MISCELLANEOUS		
	8-Pin DIL Socket	1
	14-Pin DIL Socket	2
	20-Pin DIL Socket	1
	PCB Pins	2
	31-Way PCB Plug	1
	31-Way PCB Socket	1
	PCB Guides	2
	Screw M3 x 4mm	4
	Nut M3	4
	Self-Tapping Screw	2
	Instruction Leaflet	1

OPTIONAL (Not in Kit)			
C3*	2µ2F 100V Axial Electrolytic	1	(FB15R)
	10k Min Res	2	(M10K)
	1k Min Res	1	(M1K)
	100nF Monores	3	(RA49D)
	100µF 25V PC Elect	1	(FF11M)
	CA3140E	1	(QH29G)
	TIP122	1	(WQ73Q)
	IN4002	2	(QL74R)

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

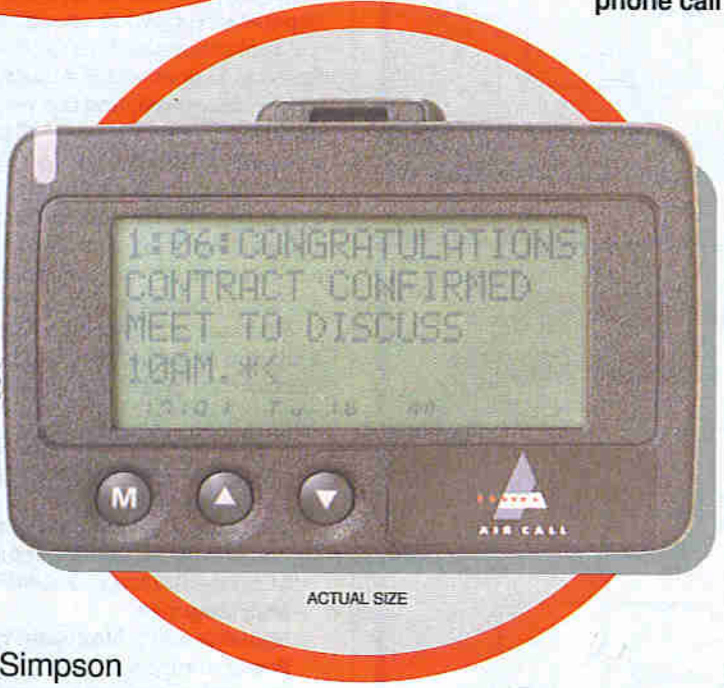
The above items (excluding Optional) are available in kit form only.

Order As VE95D (D-to-A Converter Card) Price £32.95

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

PAGING ON THE MOVE

Radio paging is a method of sending a signal to a small radio receiver (the pager) which is carried by the user of the service. The 'message' can be as basic as a 'bleep' or a full-blown 200-character message displayed on a small screen. Today's pagers can display telephone numbers, receive full text messages and can even give regular news, road traffic and stock-market bulletins. Far from merely bleeping, today's pagers are highly refined with the ability to flash or vibrate according to the user's (and environmental) requirements. At least one is better prepared to respond to the message, "Honey I've burnt your dinner – delay return", when displayed on a small screen, rather than learning the bad news in a follow-up phone call that was triggered by a bleep service.



ACTUAL SIZE

by Alan Simpson

There are two main types of paging services in use – bleeps and messaging apart. On-site paging systems, as featured in most of the television hospital series, operate in and around buildings such as factories, farms and building sites. Then there is the wide area networked paging system which operates nation-wide. Whether it is the ability to contact quickly the local doctor, plumber, members of the sales team or even the boss on a golf course, keeping in touch by a pager is acknowledged as being an essential component of business and social activities.

Certain authorities – and it is not too difficult to guess who – have tagged paging as being yesterdays technology. However, far from crumbling in the face of cellular or emerging mobile communication technologies, the world of paging is as energetic as ever. Some twelve years or so ago, pagers were mainly used by the emergency services – particularly for fire, ambulance and hospital operations. Now the pager is used by doctors, managers and engineers, lift and car park attendants as well as your local DIY store employees. As for status, even that business consultant, and TV guru, Sir John Harvey-Jones has admitted being a fan of the pager. "Why make a phone call when a pager will do the trick?", he asks.

Paging Pedigree

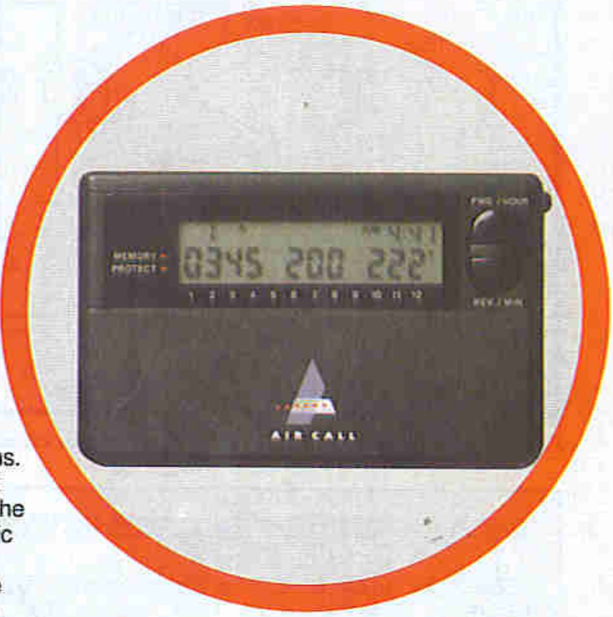
On-site paging first saw action back in 1956 at St Thomas's hospital in London, and was supplied by BT's predecessor the Post Office. The first wide area network paging service was established in 1968 by the Cambridge Medical Answering Services, about the time Air Call – now one of the world's leading paging operators – started operations. In 1975, Air Call developed the first 'Tone and Voice Paging' system in the UK followed by the first alphanumeric paging service in 1983. More recently, Air Call have developed 'PageSign', an electronic moving message display system.

What is a Pager

A pager, says Air Call Communications, is a small, lightweight receiver that can receive audible alerts, telephone numbers or full text messages. Your pager can 'bleep' to provide an alert to call a pre-determined number such as the office or home; will display the telephone number of people trying to contact you; or will display full text messages such as "Meet you at the Arizona Wine Bar at 6pm."

In the UK, unlike the US, where numeric paging dominates, tone paging still commands the majority of the market. The pocket-size Air Call Tone Pager comes with one alert tone plus three optional extra tones, each with a different sound. This allows the user to allocate a unique telephone number to selected contacts – your office, home or girlfriend. To reach you, the caller just dials the number and within 60 seconds a flashing light, and the relevant, tone will make it easy to identify who has called. As with all pagers, the audible alert can be put into silent mode, leaving the light and/or vibrator to get the message across. Numeric Pagers however, display numbers on a small LCD screen on the pager. A telephone number to be called back can be displayed or a mutually agreed coding system can be used. It is possible to transmit directly a sequence of numbers to the pager from any DTMF (tone dialling) telephone.

At the top of the Air Call range is the Premier Message Pager. To reach you, callers dial a number that is exclusive to your pager, and pass their message to one of the Air Call bureau operators. The message is repeated back to the caller before being transmitted to the pager. Within seconds, a flashing light and distinct escalating tone will alert you as the message is displayed. The pager has a four line screen and can show up to 80 characters at a time. Messages can be up to 200 characters long, and as the unit has an in-built memory, it can store up to 40 messages (5,500 characters maximum). These messages can be protected or deleted as required. Message pagers are now the most popular choice in the UK, displaying not only personal messages but such information services as share and commodity prices, exchange rates, news, weather and traffic reports. Not only is it possible to incorporate a small printer into the system, but data can be fed directly into a computer or organiser interface.



Left: Two types of Pager that are available. Above: Air Call operators answering calls, and a Pager displaying a typical message.

Below left: An Air Call Tone Pager

Getting the Message

The latest generation of pagers feature an extra wide screen, with automatic back-lighting, which is triggered by a built-in sensor. Also, the pagers can store in a separate area of memory, approximately ten confidential messages, such as PIN numbers or your partners birthday. Other fringe benefits include an alarm clock and a facility to time stamp incoming messages.

Certain pagers sound an alarm if a message is not retrieved within a specified time period. Colour is another feature being introduced, with a range of pagers available in green, pink, ivory, yellow and orange.

By 1995, commentators agree that today's 700,000+ UK users of paging services will have expanded to over two million. In Europe, the number of subscribers to paging services is expected to reach twelve million by the year 2000. Even so, Europe has a long way to go to catch up with the US where, according to a Frost & Sullivan survey, about 23 million Americans will be hooked on radio pagers by 1996.

To help meet the demand, Air Call alone have 400 transmitters located throughout the UK, covering over 96% of the population. In case you have not noticed them, the radio transmitter masts are usually sited on top of high buildings such as the Barbican, The Hilton Hotel and Alexander Palace. "We also make use of isolated farm buildings – anywhere in fact where there is a network requirement backed by a suitable location", says Keith Ferguson, Air Call Communications Network Engineering Manager.

So how do pagers work? A pager, according to 'Communications News', is a VHF or UHF radio receiver permanently tuned to a single 'station'. When it is manufactured, it is given a unique code number (called the radio identification code or RIC) which is built into the pager. It is this code which is transmitted by the paging system transmitters when a call is sent to the pager. While it is switched on, the pager is patiently listening for its RIC among the thousands of other codes being transmitted, and when it recognises its code, it triggers the actions it is programmed to perform. When the paging bureau is involved, Air Call messages are received by the centre with the caller normally dialling the subscribers individual number, rather than dialling the bureau and quoting a number. The call is inter-cepted by an operator who keys in the message on a computer terminal, using a preselected code for standard or routine messages. When ready for sending, the formatted message is sent by Air Call's own national communication network to the transmitters. So by means of computers, multiplexers, modems, telephone links and transmitters, the message is directly 'inputted' into the correct pager.

The Network Centre

At the very heart of Air Call is a very modern operations centre. Open for business 24 hours a day, 365 days a year, the centre handles over 30,000 calls a day – or a staggering eleven million calls a year. The company employs over 130 operators – each operator has undertaken programme tests in telephone answering, typing and spelling. An Automatic Call Distribution system routes the calls to the operators, and a battery of computers. Even before the operators hear a bleep in their headphones, the screen terminal is displaying the name of the user being called. The operator greets the caller with the name of the Air Call Customer that has been dialled – "Good Morning this is Fred Smith's answering service" – the operator then inputs the message, repeats it to the caller and, if all is well, releases it into the transmitter network.

The average response time of the operator is between zero and five seconds, with the message being received by the Air Call subscriber within 40 seconds. At the same time, the computer database is logging the call, allowing real-time network monitoring to take place by the in-house team of engineers. Just to remove any doubt whether or not the network is fully functional, test paging messages are sent to each network outstation every minute monitoring the status of all equipment. The system will automatically flag any problem in any zone and re-route messages and, at the same time, send e-mail paging messages to local engineers. Before transmission from the centre, all calls are batched and signalled in order to make efficient use of radio channels. The traffic is fanned out to ten area zones by means of 64Kbits/sec links, a service which allows users to buy as much or as little coverage as they require. From the zones, the messages are transmitted to intelligent local nodes. A call from London to a subscriber in Aberdeen would go from the Air Call Centre in Welwyn Garden City, Hertfordshire, and having been batched and coded, to the local node, where it will be instantaneously transmitted in Scotland. However, if the user has opted for an all zone service, then the call will be routed to all ten area zones. Service users, such as fire brigades, can be issued with a dedicated direct input circuit.

Acting as back-up to the wide area network links, is an ISDN UK-wide loop allowing traffic to be re-routed to the main transmitters by smart nodes. The analogue call, as received by the operator, is stored on disc before being transmitted as a digital string. Individual pagers then decode and display the message on the screen.

Messages are synchronised to within 10ms in order to avoid any conflict between transmitters. "Digital Paging", says Keith Ferguson, "makes the messages very difficult to decode, anyone can buy a scanner and listen to the traffic, but with all messages being transmitted in digital mode, they are near impossible to decode". Also there is no fear that lack of power at the control centre will put a halt to proceedings. As Keith explains, "Our 200kW uninterruptible power supply (UPS), can keep the system going for approximately twenty minutes. This is more than adequate to get the on-site half megawatt generator up and running. The whole centre is fully air-conditioned with fire protection and smoke detector alarms in every office". In case you are wondering, one pager battery will last between six to eight weeks with normal usage. Keith describes normal usage as having the unit switched on and receiving messages daily.

Pagers Matter

As Keith comments, "Air Call have only just emerged from a major equipment enhancement, costing well over four million pounds (including software). Any fortunate visitor to the Air Call operations centre will be impressed by the number of multiplexers, modems, controllers and screens all engaged in routing messages from caller to subscribers in half a trice. Also, recently installed are three 'front-end client server message entry systems', each of which can handle traffic volumes for up to 80 operators without degradation.

A Growth Market

Any doubts that radio paging is finding it tough going in the face of cellular is discounted by recent surveys. In the past six months, some 15,000 new subscribers have joined the pager club. At present, it seems that more and more people are using a combination system of pager and mobile phone with initial contact being made through the pager, with the cellular phone being used for the reply. This saves not only cellular phone batteries, but time taken up by poor cellular lines and reception. It also enables the receiver to decide whether or not the reply is urgently required.

Sending the Message

So just who is using radio pagers? According to Graeme Oxby, Air Call's Marketing Manager, there is practically no situation where a pager cannot assist in improving efficiency, communications and the environment – a golf course manager exchanges players cellular phones for less distracting pagers! "It is not necessary to be out and about or on the move to get the benefits of paging", says Graeme. "Car park attendants and cinema management are prime user examples. In fact Air Call have at least one pager in every market sector."

Among the many Air Call network services, AA Roadwatch is the first time that live national travel information is made accessible other than through radio or television. This is a constant flow of traffic information day and night, providing information on a regionalised basis. Meanwhile the IRN NewsDesk allows paging users to be kept up to date with all major national and international news. Headlines direct from IRN's computerised newsroom are transmitted in concise news bulletins throughout the day. Because IRN NewsDesk is a live information service, subscribers will have access to news information before it is transmitted on radio and television. Other innovative Air Call services include Hotel Watch and Crime Watch where other local traders can be warned of suspicious incidents. Air Call also operate telephone answering services, Answerline and Serviceline, as well as Babybuzz, which will alert midwife and husband. Other value-added services provide a mobile gateway to voice-processing, electronic mail and computerised messaging systems.

Paying the Price

Radio Paging, according to Air Call, is essentially a fixed price service with no extra charges for usage. For callers to the network, there is a single rate from wherever they call. Paging costs are dependent on the type of pager unit – the basic Air Call tariff starts at just £10.50 per month for a basic tone pager, in one area, to £47.60 for a Premier Message Pager that gives national coverage across all ten regional zones. In addition to monthly rental fees, (users seldom purchase their pagers), there is a connection charge of £19.50.

In fact the fixed monthly costs are among the leading benefits of radio paging, alongside those of mobility, reliability and quality of service.

Standards Matter

As with all matters concerning communications, European and indeed international standards do matter. All developed countries have their individual paging systems, and all individually incompatible with one another! This is because of the choice of radio channel on which the service operates. Because pagers are single-channel receivers, it is not possible for the user to 'tune' them to foreign channels. Also, the system used by one pager company to communicate with a pager is often different to that used by another pager company. To overcome these differences, the world radio standards organisation (CCIR) has approved a standard protocol for pagers known as POCSAG.

On the European front, four countries, France, Germany, Italy and the UK, have created the service 'Euromessage' which provides a paging service in the capital cities and surrounding areas. However, this could be a prelude to the EEC's initiative ERMES with the objective of relaying messages throughout Europe over the international telephone system. As a result, pagers will have to incorporate new technologies, including the ability to scan 16 channels, to look for a signal which it recognises as having been allocated for the exclusive use of ERMES, throughout the EEC. Also, allowance has to be made for up to ten times the number of pagers able to work on a single channel. Satellites can also be expected to play an increasing role in paging systems.

Paging the Future

Wide-area paging is a very powerful and economical service for both mobile and non-mobile users. Manufacturers have already introduced paging units the size of fountain pens and units that can replicate more than a page of text. With the introduction of wrist-watch radio, the beeper looks set not just to expand its users base (in the States, US teenagers arrange their social life by means of a pager) but offer a positive communications service for the future.

Well now, "Electronics – The Maplin Magazine" has the power to let you sample hands-on, all-tariffs paid, radio paging. Yes, the winner of this month's contest will win three months subscription-free use of the top of the range Air Call Premier Pager. (Normal rental costs over this period are £170.55 including connection charge and insurance.)

There are two runners-up prizes of three months subscription-free use of the Air Call Tone Pager (value over £50). Also all three winners, together with a partner, will be able to visit the exciting operations centre of Air Call – all expenses paid.

All you need to do to enter the contest is to correctly answer all four questions and send your answers on a postcard or back of a sealed-down envelope to: Air Call Pager Contest, The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR. Your answers must be received by 30th April 1993. Good messaging.

Please note that employees of Maplin Electronics and family members are not eligible to enter. In addition multiple entries will be disqualified.

AIR CALL PAGER *Competition*

1. What is Babybuzz?

(a) An Air Call package which could save a baby's life;

(b) The name given to a German buzz bomb in the Second World War;

(c) A type of champagne served in night clubs.

2. To use a mobile pager, users must be

(a) In transit;

(b) In a place with an unrestricted view of the horizon;

(c) Virtually any place, anywhere.

3. Pagers alert users by which means?

(a) By activating a clapperboard;

(b) By flashing and bleeping;

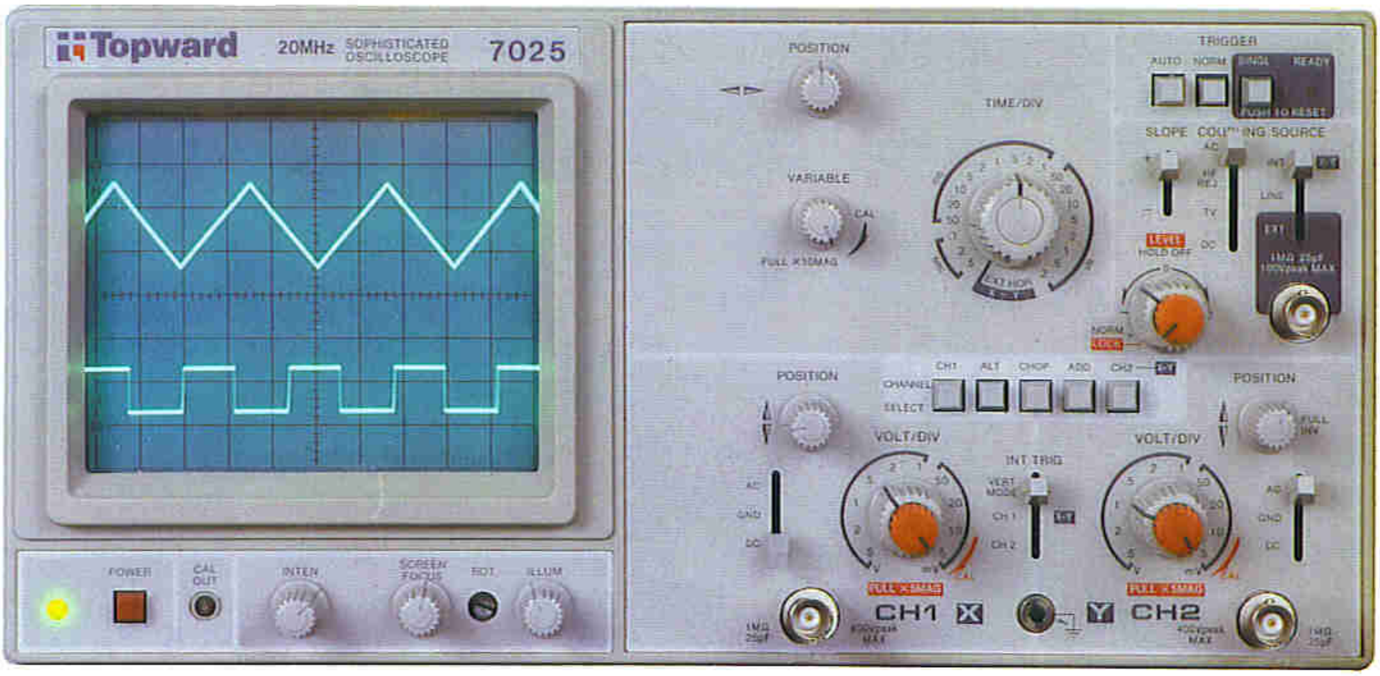
(c) By a voice message.

4. Pagers are so called because they represent:

(a) A page of a book;

(b) A medieval page who brought the news;

(c) A method of channelling information.



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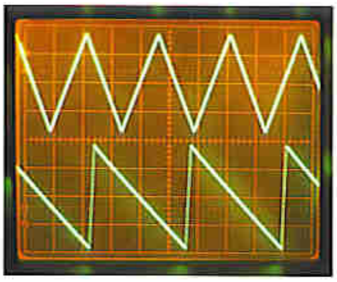

**** Please note: MONEY SAVING BARGAINS SHOWN ON THIS PAGE are applicable to purchases made in MAPLIN STORES ONLY and are not available at these prices through Mail Order.***

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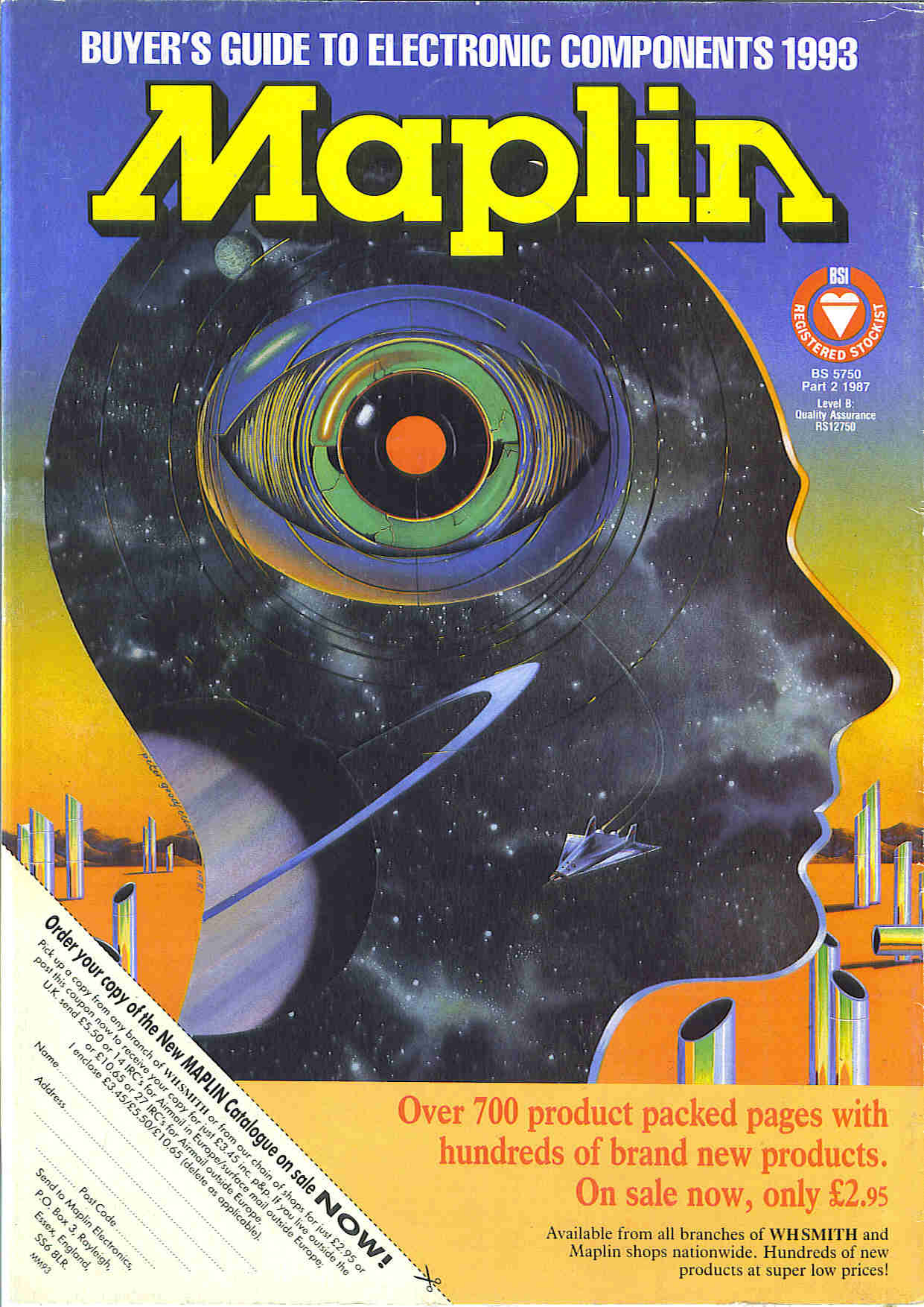

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