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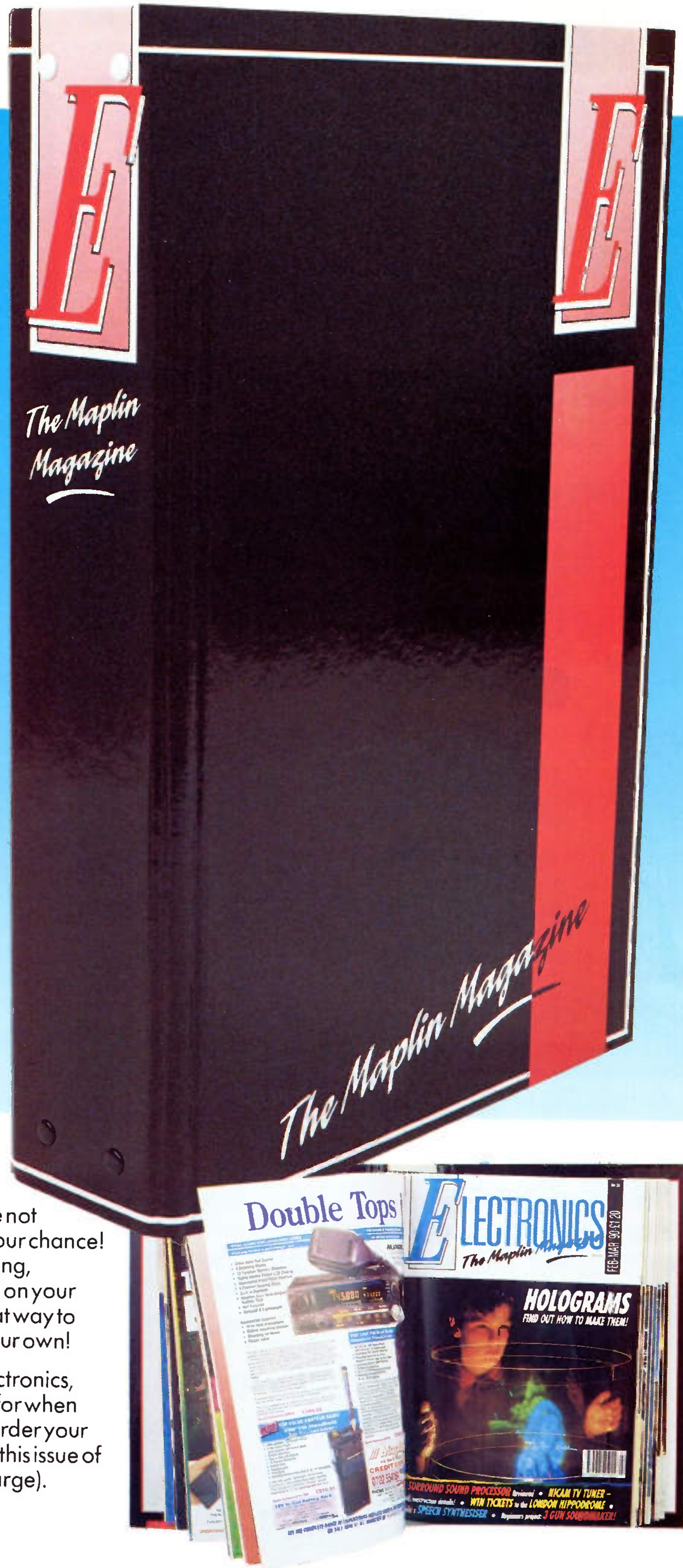

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NOVEMBER 1991 VOL.11 No.47

EDITORIAL

Hello again! and welcome to this month's issue of 'Electronics'. As ever, it's a really jam-packed issue full of projects for you to build and features for you to read. Instead of giving you the usual run-down of projects and features, I'll concentrate on one particularly fascinating project…

The cover picture shows the NPL Primary Frequency Standard Mk.II at the National Physical Laboratory, from where a caesium-based atomic clock is used to provide the highly stable signals required for the Rugby MSF time-code transmissions. The transmitter itself is located at Rugby in the Midlands. The Rugby Clock Receiver project presented in this issue allows these transmissions to be received and demodulated. The serial data stream from the receiver can be decoded using dedicated hardware or a computer running a decoding program. The data, once decoded, resolves the exact time, day of the week, day of the month, month of the year and the year. Certainly an excellent project for radio and electronics hobbyists, colleges and other educational establishments.

It has been a really tight fit trying to squeeze all of the projects, features and regulars into this issue – for this reason, Circuit Maker and Stray Signals have been held over until next month. So until then, all that remains for me to say, is that I hope you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

R D Ball

ABC 33,837

Editor Robert Ball
Project Development Chris Barlow, Gavin Cheeseman, Tony Bricknell, Alan Williamson.
Technical Author Mike Holmes.
Consultant Author Alan Simpson.
Technical Illustrators Paul Evans, Lesley Foster, Ross Nisbet.
Production Co-ordinator Alan Wraight.
Print Co-ordinator John Craddock.
Advertising Co-ordinator Kathy Peters.
Publications Manager Roy Smith.
Development Manager Dave Goodman.
Advertising Manager Vic Sutton.
Drawing Office Manager John Dudley.
Art Directors Peter Blackmore, Jim Bowler
Layout Artists Graham Smith, Jamie Bishop.
Typesetters Brian Lauezzari, Martin Needs.
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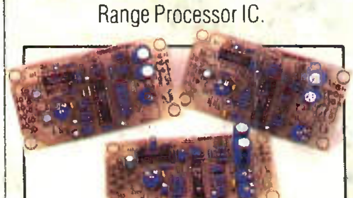
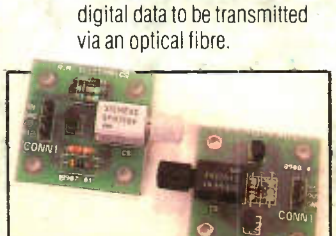
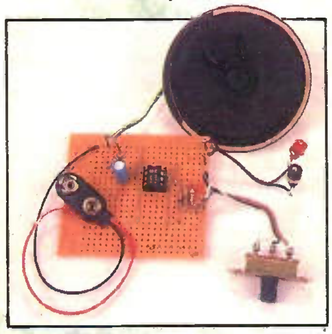
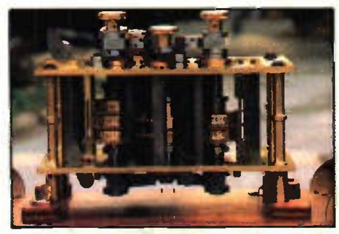
PROJECTS







FEATURES



REGULARS

CORRIGENDA

August to September 1991 Vol.10 No.45.
Microwave for Certain
Page 55, apologies to Jim Garrod author of 'Microwave for Certain' whose name was omitted.

October 1991 Vol. 10 No.46.
Microphones
Page 39, a sentence has been omitted before 'White noise…', which is 'Of course, you have to subtract the weighting curve (usually given in the sound level meter instruction book) from the measured response curve to get the actual microphone response.'

Prices shown in this issue include VAT at 17·5% (except items marked *NV* which are rated at 0%) and are valid between 4th October 1991 and 31st December 1991.

NEWS Report

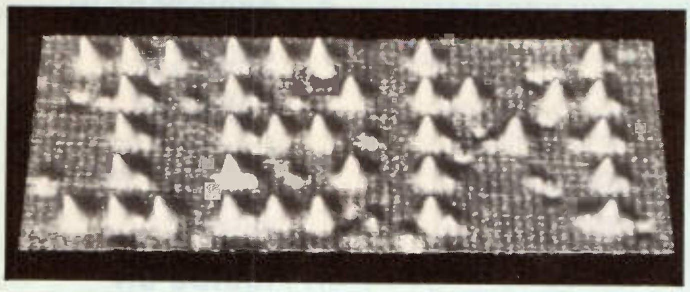
Delete Text

A chap living in New Jersey and less than happy with his home computer, decided to give it a lesson it would not forget in a hurry. Pulling out his .44 Magnum automatic, he pumped eight dum-dum bullets into the beast. He later told the police "I didn't think that there was any law about shooting your own computer in your own house".

Getting Ready For The Olympics

Sport and high technology will be lining up side-by-side at next year's Olympic Games. Sponsors of the Winter Olympics, which is being held in February at Albertville, France, include Kodak, IBM, Philips, Andersen Consulting and Alcatel. Alcatel will also be present in Barcelona next July, providing some 4000 journalists and correspondents from 50 countries covering the event with a special network. This highly ambitious networking project will link specially configured Toshiba portable laptop computers, fitted with modem and software, to a central database and messaging service based in Madrid. This will provide up-to-the-minute information on current proceedings together with historical input. With access through local public networks, journalists can, if they choose, report on the proceedings from their home base.

Meanwhile, The 1992 Olympic Game events are being seen as a worldwide launch pad for High-definition television broadcasts. Under the guidance of the European Commission, HDTV reception centres will be open to the public in all Member States; other reception centres will be used for private showings to demonstrate HDTV to the world's broadcasters, dealers and assorted VIPs. The Commission is planning over 800 HDTV receivers with the transmission facilities being provided by a consortium of broadcasters, producers and the manufacturing industry.



More Big Bang News

It was just ten years ago that IBM unveiled its PC – then seen as an 'invasion' of the home market. The IBM development team, which was given just 12 months to complete the project, were told to break the rules and go outside the traditional boundaries of product development. The IBM PC, as introduced to the world's press in New York, used Intel's 4·77MHz 8088 microprocessor – state-of-the-art for the time, but slow by today's standards. The diskette drives offered 160 kilobytes of storage in a 5¼in. format and the system memory went from 16Kb up to a maximum of 256Kb.

Today, systems are configured with the new 50MHz card benchmark, at over 57 times the performance of the original PC, offering over 1000 times the memory capacity (64Mb) and 10 *thousand* times the storage of the original PC, 1·6 gigabytes! The next decade of personal computing, says IBM, will bring even more rapid change and advancement than the last. In the next few years, voice recognition technology will enable users to speak into a microphone and tell the computer what to do. Using verbal commands as though entered from the keyboard, they will be able to 'type' documents by dictating into the microphone and the words will appear on the screen. Also in the coming decade, pen-based and wireless computing devices will bring computing to an entirely new class of user, mobile workers.

Spitting Sound

Love or loath the telephone answering machine, it is very much part of our lives. One major problem is recording the outgoing message, which tends to sound like it has been produced in Dr Who's 'phone box by a passing robot. Now help is at hand. That ever enterprising company, Spitting Image, are providing pre-recorded opening announcements to suit all occasions. These include such celebrities as the Queen Mother, Princess Di, Barry Norman and Sean Connery. Mind you, it will take a lot to beat that infamous message "You are through to intergalactic mission control. Unless you replace your receiver immediately, it will implode".

DTI Wish List

Having some obvious spare time in hand, the UK DTI has issued a 'wish list'. This includes car windscreens that can clean themselves and 'wall plugs' which are compatible with bone tissues for fixing broken bones. Other possible future products include an environmentally friendly wood preservative, and intelligent sensors in packaging which could indicate if food is past its sell-by date, or whether it has been tampered with. A further wish could be that the present unemployment levels will soon start to fall.

VCR Health Warning

Ever wanted to run your own TV station? Well this could be your chance. The Independent Television Commission is about to advertise the Channel 5 licence with a closing date for applications by March 1992. However, before you apply, give a thought to the related problems associated with Video Cassette Recorders. The chosen UHF TV frequencies will adversely affect VCRs. Interference problems will be evident primarily with those VCRs which are tuned to UHF output frequencies which are the same as those to be used for Channel 5 transmissions, ie channels 35 and 37. The government broadcasting acts require that the Channel 5 licence holder makes arrangements for the retuning or other modification of those VCRs affected by the interference between TV sets and UHF transmissions!

The ITC warn that, should every viewer who is able to receive Channel 5 opt to do so, then the number of VCRs which might need retuning totals 5·4 million. Even more problems, if you happen to live in an area of West London (extending out to Slough), where there may be difficulties in finding suitable channels for retuning. The Authority suggest that up to 50,000 VCRs in this area might not be able to be retuned satisfactorily. For more details, contact 071-584 7011.

BT Setting The Pace

BT's massive programme to modernise its telephone network has now reached the halfway stage in switching over its local exchanges from electro-mechanical to digital technology. To date, more than £15 billion has been spent on supporting, modernising and expanding mainstream services in the UK. As a result, BT report that 13 million customers can now receive the many benefits of modern communications technology which gives them clearer calls, fewer faults, faster call set-up times and call success rates. BT can now offer more than three quarters of their customers – some 20 million – itemised bills.

BT's network now has more than 1·5 million kilometres of optical fibre which means that voice, image, data and text can be transmitted across the network at high speed. The current technology employed allows more than 7,600 simultaneous phonecalls to be transmitted and received over a pair of fibres. In addition to converting more than 15 exchanges to digital operation each week (the equivalent of 6,500 new digital lines every working day), BT is continuing to extend its fibre network by more than 10,000 kilometres every single week.

BT has also been setting the pace in discouraging directory enquiry calls. As a policy this seems to be working. Thanks to the imposition of the 44·5 pence charge ('Electronics' tip: use a public call box – there is no charge for a directory enquiry call), overall calls to this service are down by more than 25%. The result, suggests 'Computergram', is that BT are 'letting go' substantially more operators than originally planned.

Canon Introduce the Egg-Shaped Stereo Speaker

OK, it may resemble an egg, but in reality, it is a new domestic loudspeaker system called 'Wide Imaging Stereo' from Canon. Unlike traditional loudspeakers which create a 'stereo hot spot' or optimum stereo area, found midway between the two speakers, the new system seeks to create an arc of sound emanating from each loudspeaker rather than unidirectional patterns set up by conventional speakers. Ideal, the company claims, for group or family listening. The speakers cost around £350. Details: Canon Audio Ltd 0483 756066.

Performance Guaranteed

No sooner had France Telecom announced that it would accept contractual liability for the performance of its larger customer's networks, than BT weighed in with a new customers Charter. The programme includes the payment to personal customers one month's exchange line rental for each day a BT engineer appointment is not kept or the exchange line repaired. For business customers, the BT penalty figure is £25 per day. This BT initiative rather took the wind out of the sails of UK Telecoms regulator, OFTEL, whose head, Sir Bryan Carsberg, had been criticising BT's incentive arrangements for users. Meanwhile, Carsberg has some serious explaining to do in respect of his somersault over equal access. As a result, new carrier entrants will not now have to pay an access charge to BT until a business has obtained a 10% market share, or until BT had lost 15% market share, whichever event came sooner.

Blasting Off

With security devices featuring strongly in the new Maplin 1992 Catalogue, a Frost & Sullivan report suggests that US residents will be spending some $6 billion a year on sophisticated security devices by 1995. The report indicates that major sales areas include presence and intrusion detectors. It seems that the computer world has now got the security message. One enterprising micro dealer, Bondwell Europe Ltd., is equipping its latest models with a Portable PC Alarm System which, apart from incorporating a software program to guard against unauthorised access to data, includes a motion detector alarm, which when triggered, activates a 90 decibel alarm if the machine is moved or lifted. How it would cope with a .44 Magnum automatic is not revealed.

Breaching The Barricades

At the best of times it is difficult to communicate with Moscow, but with the whole world wanting to watch, listen or get in touch during the recent abortive coup, global traffic jams formed. As 'Computerworld' reports, it took much ingenuity and technology to obtain connections between Russia and the outside world. Apparently Federation President Boris Yeltsin only managed to reach the outside world by borrowing a cellular phone from a visiting US executive, and dialling out by means of an international satellite network. However, during the crisis, one crucial message did get through on the academic network Usenet. 'Q: How many software engineers does it take to screw in a light bulb? A: It can't be done, it's a hardware problem.'

Computer Abuse and Misuse

It seems that consultancy house Hoskyns are getting all steamed up about such matters as transborder data flow and vehicle registration marks. The company believe that harmonisation of national data protection legislation is essential if The Council of Europe Convention is not to be circumvented. The council basically outlaws transborder flows of personal data, and Hoskyns believe that the sooner that all countries act on the Convention the better.

However, Hoskyns is perhaps on less firm ground when it comments on the fact that police are operating a form of computer misuse. Under the terms of the UK Data Protection Act, the police, and certain other categories, were justifiably exempt from the Act when accessing otherwise confidential data. Meanwhile, the DTI has launched a study on possible computer misuse. Presumably this won't include those moments when you swear at the screen or thump the processor.

New Video Tapes for Old

When Nokia took over ITT's consumer electronics division – in particular ITT's research laboratory in Germany – they took over the development of the Active Sideband Optimum (ASO). As a method of squeezing high quality pictures from VHS video cassette recorders, the technology looks set to replace the existing complex High Quality (HQ) picture enhancement systems. The new ASO system gives dramatically improved pictures from poor quality recordings, such as those on old or worn video tapes. The ASO circuit is the only system available that can simultaneously improve picture sharpness while reducing picture noise and vertical jitter.

Until the Nokia development, video recorder manufacturers have used the HQ system to overcome the problem of worn tapes. Unlike ASO, HQ makes use of four circuits which serve to enhance details and reduce noise. All video recorders record the picture as an FM signal, with symmetrical sidebands. Because of the problem of adequately recording high frequencies on slow moving tapes, amplifiers have to boost the high frequencies during playback. Although this improves the picture, it does also introduce unwanted noise. In turn therefore, the unwanted noise has to be suppressed.

The problem is tackled by *not* boosting the missing high frequencies and therefore eliminating the noise problem. Basically, the FM signal from the tape is passed through a filter which lets the high frequencies pass through 'untouched'. As Nokia says, "ASO is a single circuit which produces a better, clearer picture, even where the original tape is of poor quality."

To make sure that customers get the message, dealers of Nokia ASO models will run a demonstration tape. Currently Nokia is in discussion with a number of other manufacturers who are interested in licensing the ASO system. With video rental becoming as popular a pastime as watching real-time TV, plus the advent of NICAM stereo, the future for video recorders looks to be one of the few remaining growth areas in the market-place.

For details contact, Nokia Consumer Electronics, 071-436 4060.

Price Wars

The news that BT has brought down the cost of its main services has been greeted with joy by its business and residential customers. Even OFTEL gave grudging approval to the proposal to reduce unit charges for relatively heavy users of the telephone on standard tariffs, and the introduction of optional tariffs involving the payment of a higher fixed charge and a reduced usage charge.

As can be expected, Mercury was not slow to respond, reducing its basic call charges to all international destinations and holding present tariffs for UK long distance call charges.

What's On And Where

7-15 October. Telecom 91, Geneva. ITU, 010 41 22 5192-5969

8-11 October. Design Engineering Show, NEC, Birmingham. 081-948 9900

11-13 October. BBC Acorn User Show, London. 0737 814084.

17-27 October. Motorfair, Earls Court, London. 081-940 3431.

30-31 October. Mobile Standards, London. Commed, 071-274 8725.

30th Oct-2nd Nov. MAC User Show, Olympia, London. Emap, 081-404 4844.

5-7 November. Computer Graphics Exhibition, Alexandra Palace, London. 081-868 4466.

12-15 November. PC '91 Exhibition, London. Emap, 071-404 4844.

4-6 December. European Satellite Communications, QE11 Centre, London. 081-868 4466.

5-8 December. Computer Shopper Show, Wembley. UK, 081-868 4466.

October to End-November. Behind The Sofa – The World of Doctor Who, Museum of the Moving Image, London. 071-928 3535

Open until 19 January 1992. Michael Faraday 1791-1867, National Portrait Gallery, London. 071-306 0055

Please send details of events for the Diary Listings to The Diary Editor, 'Electronics'.

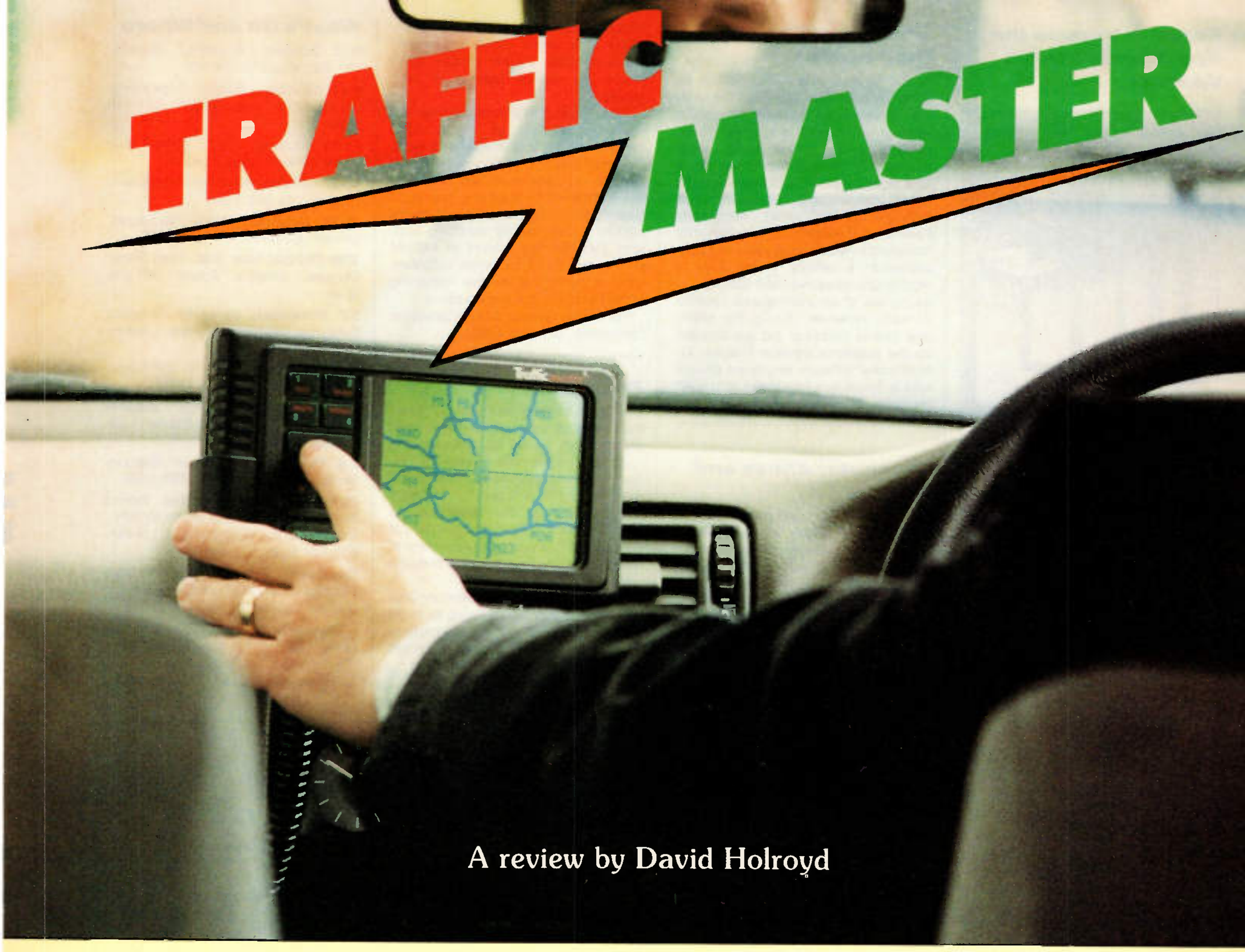
PICTURE CAPTION CHALLENGE

So just what is BT up to this month? Can it be:

- ★ A rehearsal for the annual BT vs Mercury tug-of-war;
- ★ BT auditioning for the next James Bond movie;
- ★ BT hoping to achieve an entry in the Guinness Book of Records for the world's longest cable run.

No. Apart from hoping for a transfer to the Local Area Network division, BT engineers at Cape Wrath on the North-West tip of Scotland are laying (with a certain amount of assistance from an helicopter) a new optical fibre telephone cable. The role of the helicopter was to airlift 40 drums of cable into pre-planned positions along the route. Apparently using an helicopter allowed the whole project to be completed in just five hours instead of 2 or 3 days using more conventional methods.

TRAFFIC MASTER



A review by David Holroyd

Introduction

Traffic and its management is one of those modern problems where electronics could play a bigger part. Without doubt the research cellars of both enthusiasts and companies are littered with excellent traffic management ideas and road clearing gadgets.

There is now an impetus to produce something marketable and lasting. The Road Traffic (Driver Licensing and Information Systems) Act of 1989 was the legislative 'green light' for the development of these opportunities.

Autoguide ('Electronics' December 1989 – January 1990 Issue 35) is an experimental navigation system still under development. But nothing involving information to deal with traffic delays, jams and the general frustration of our overcrowded roads seemed to be around.

That was until Trafficmaster, a new all British system which seems to be the first 'in-car jam-buster'.

The System

Trafficmaster works by using numerous infra-red sensor units strategically located around the road network, see Photo 1. Whilst driving around the M25 motorway these units may be clearly seen mounted on bridges. These units gather data, which is collated by a processor unit and then transmitted to a Control Centre via the Paknet data transmission system. After processing, traffic data is retransmitted via the Radio Paging network to the Trafficmaster units mounted on the dash board of subcribers vehicles, see Main Photo.

The starting point of the system is the infra-red sensor unit. More than two hundred of these are now located upon motorway bridges around the M25 London orbital motorway and across its main feeder motorways. Coverage will be extended to the entire Southern motorway network by early 1992, with full motorway coverage by the beginning 1993. Proposed and current coverage is indicated in Figure 1.

The remote station consists of a pair of bridge mounted sensor units and a

Photo 1. Infra-red sensors in use on the motorway network.

RECEIVER SPECIFICATION

Processor:	Z180 CMOS MPU
Support Logic:	74HC surface mount logic ICs
Receiver Frequency:	153·275MHz
Paging Sensitivity:	$10\mu V.m^{-1}$
Spurious Signal Rejection:	60dB
Selectivity:	>70dB at ±25kHz
Frequency Stability:	0·001% (−50 to + 50°C)
Data Modulation:	CSFK (Carrier Frequency Shift Keying)
Deviation	
Mark:	−4·5kHz (typ.)
Space:	+4·5kHz (typ.)
Data Format:	POCSAG coding NRZ
Data Bit Rate:	512 bps
Backlight:	Electroluminescent
Display Type:	High contrast supertwist LCD
Display Size:	101 × 82mm
Viewing Angle:	40°
Resolution:	160 × 128 pixels
Dimensions:	196 × 114 × 32mm (without holder)
Power Consumption	
Standby:	70mA
Backlit:	140mA

PAKNET TECHNICAL SPECIFICATION

RADIO LINK

Transmission	
Frequency Bands:	159/164MHz
Channel Allocation:	14 duplex channels, each of 12·5kHz bandwidth
Access Control System:	Slotted ALOHA
Error Correction:	100% error correction by a combination of Forward Error Correction by Golay Code plus CRC and automatic request for re-transmission
Protocols:	Asynchronous data to the following procedures. APACS 30/Standard 40. X.28 Subset V.25 bis Subset
Terminal Data Rate:	4800 Bits/second

HOST INTERFACE

Direct Access via fixed data link:	X.25
Data speeds:	up to 64kBits/second

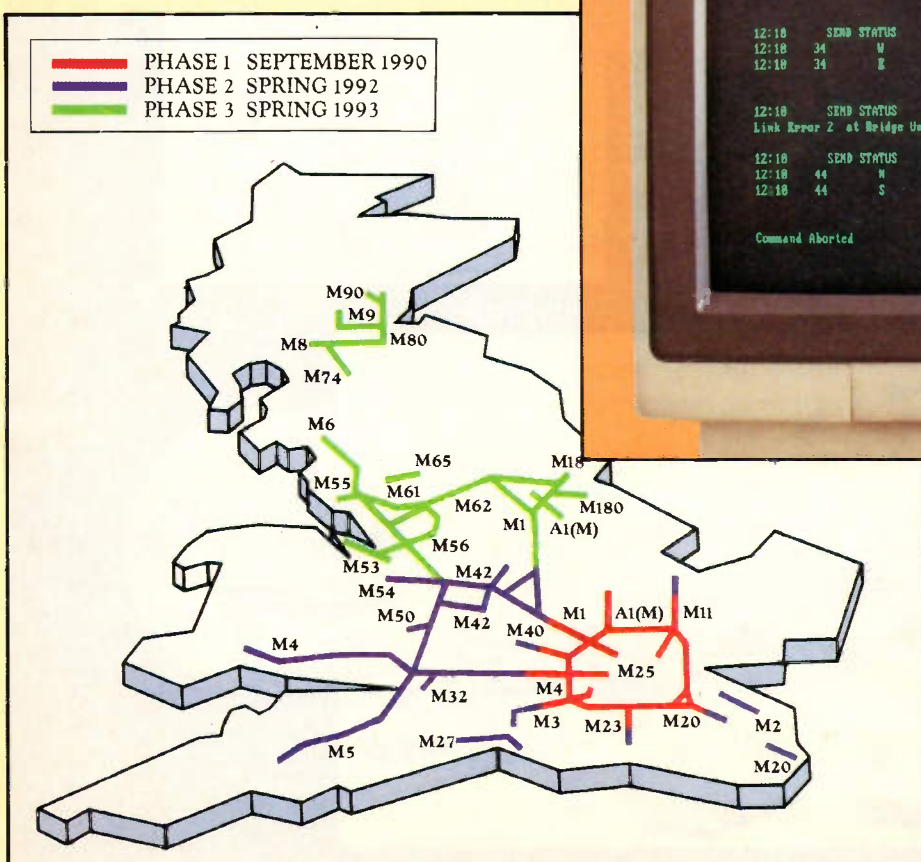


Figure 1. Trafficmaster motorway coverage, both current and proposed.

processor unit. The sensors monitor the outside lane of each carriage-way direction. The outside lane was chosen as it provides the best measure of average traffic speeds. The sensors cast twin beams onto the carriageway, the time taken for a vehicle to pass through both beams gives a precise measure of speed. The sensor units can be mounted at an angle of up to 15 degrees, allowing for a great variety of mounting configurations. The units are mounted at no greater than two mile intervals so an accurate picture of traffic flow can resolved. The sensors can be post mounted, but bridge mounting has been found to be less disruptive both for installation and ongoing maintenance.

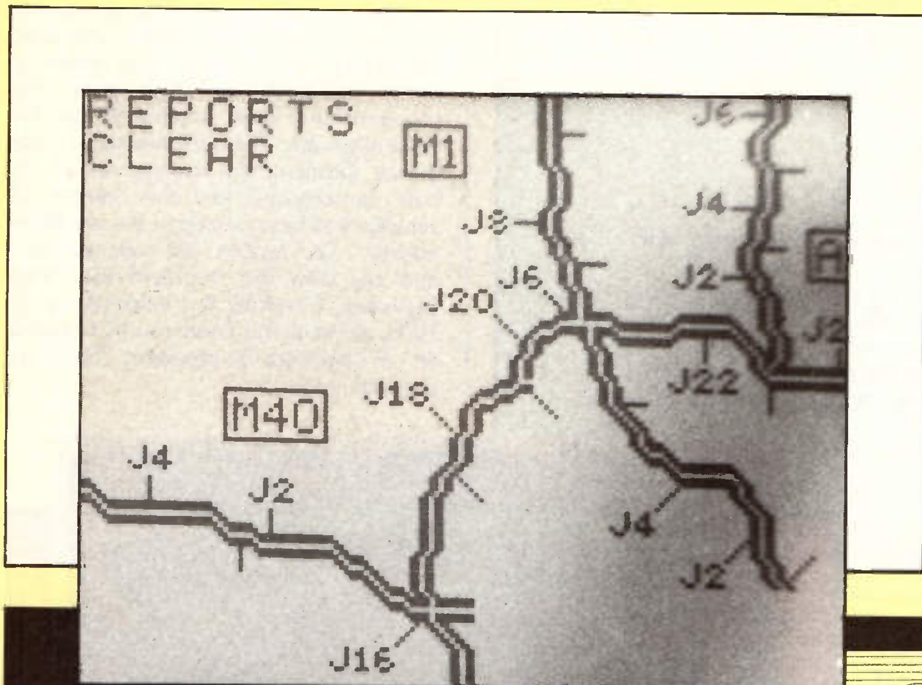
The bridge processors calculate the mean traffic speed over a three minute averaging period. The three minute period was found to give the best average measure of traffic speed. This activity will continue at each of the remote sites until the average traffic speed falls below a preset threshold, at which point the processor unit then 'reports in' to the Control Centre. The unit gives its ID code (hence location), the average speeds of both carriageways and the number of vehicles that have passed in the last three minutes. The reports will continue until one call after the threshold has been exceeded. Currently the threshold is 30 MPH, although this figure can be changed on a processor-by-processor basis as required.

Photo 2. An example of routine calls to a number of random processor units.

Each of the processor units are called up from the Control Centre at least once a day as a check of processor and sensor operation. In any case each processor unit has a number of diagnostic, error and failure routines written into the software. Photo 2 shows an example of routine calls to a number of random sites. The meaning of the information displayed is indicated at the top of the computer screen. Figure 2 shows an example of print-out of the information log which gives date and time of call, processor ID number, traffic speed averages in both directions, the preset

22/04/91	09:43	53	N	70	[30]	59
		53	S	30	[30]	67
22/04/91	09:43	79	E	10	[30]	61
		79	W	75	[30]	36
22/04/91	09:50	53	N	70	[30]	54
		53	S	35	[30]	81
22/04/91	09:51	4	E	25	[30]	61
		4	W	70	[30]	48
22/04/91	09:51	35	W	35	[30]	78
		35	E	75	[30]	42

Figure 2. Trafficmaster information log printout.



threshold and the vehicle count for the averaging period. Interestingly, the system will not log traffic speeds in excess of 75 MPH!

The system uses Paknet as the transmission medium. Paknet is primarily used by banking and financial systems, such as cash dispensers and EPOS equipment, however it is ideally suited to the requirements of Trafficmaster.

Figure 3 shows a pictorial diagram of how the system operates. The traffic information is received by the in car unit, a typical display is shown in Photo 3.

The Receiver

The receiver unit is itself very compact and attractively styled. The unit has a 160 × 128 pixel supertwist LCD (liquid crystal display) backlit with an electroluminescent panel. The large 101 × 82mm display has a viewing angle of 40° giving a clear crisp readout of information. Since the contrast of *all* LCDs is dependent on temperature, an automatic contrast control is provided. However, if required this may be manually overridden. The 'clever stuff' is carried out by a Zilog Z180 CMOS MPU IC. this device is supported by 74HC series logic ICs and a handful of other components. Photo 4 shows the inside of a development unit.•

Information is transmitted country-wide using the Air Call paging network using the POCSAG data format. The receiver display units have two 'cap codes' (addresses), one is a common to all units and is used to update the traffic information, the other is user unique. The unique code is used to commission or decommission units 'off-air' by coded transmission and provide a messaging service.

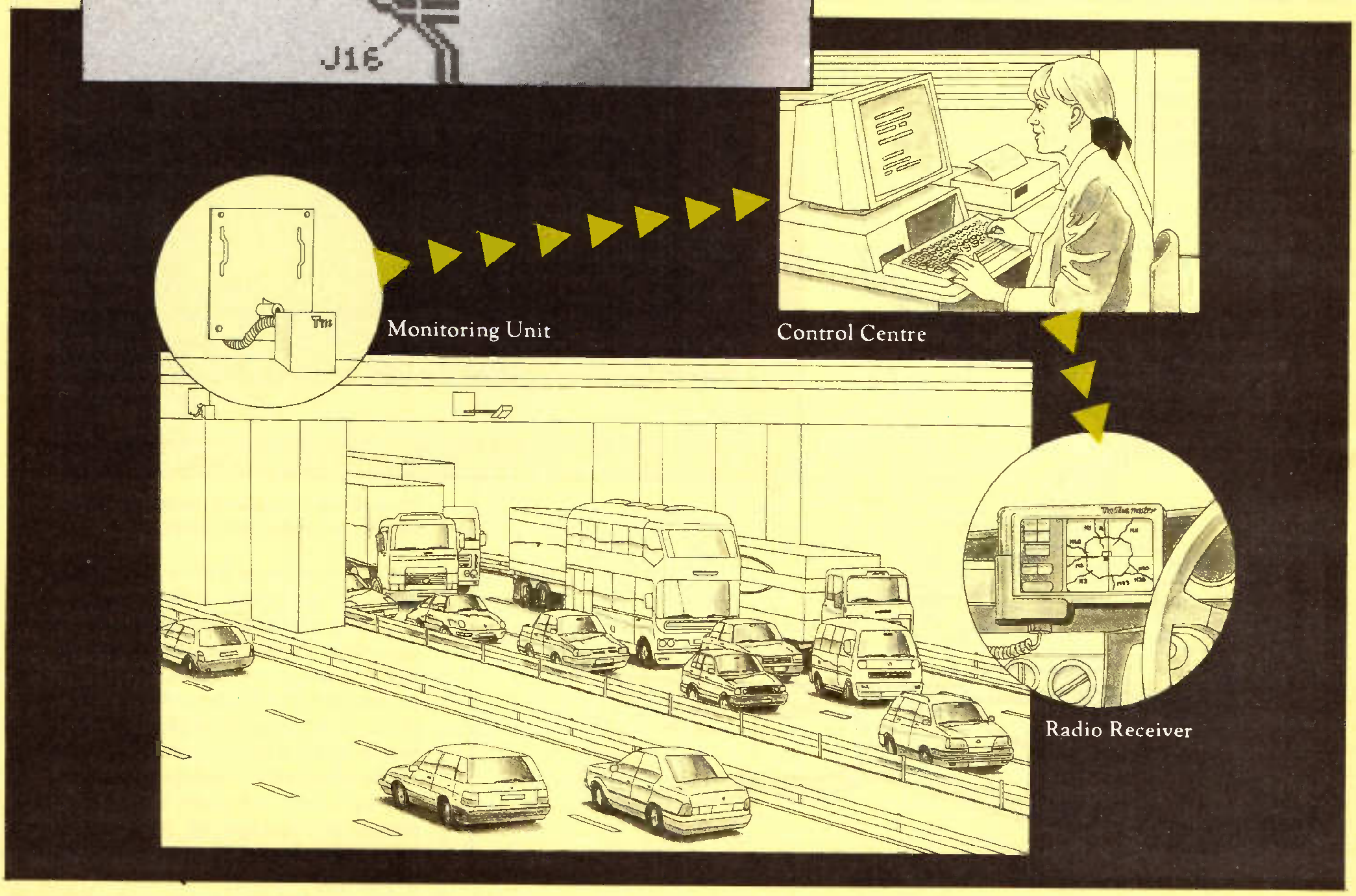


Figure 3. Pictorial diagram of system operation.

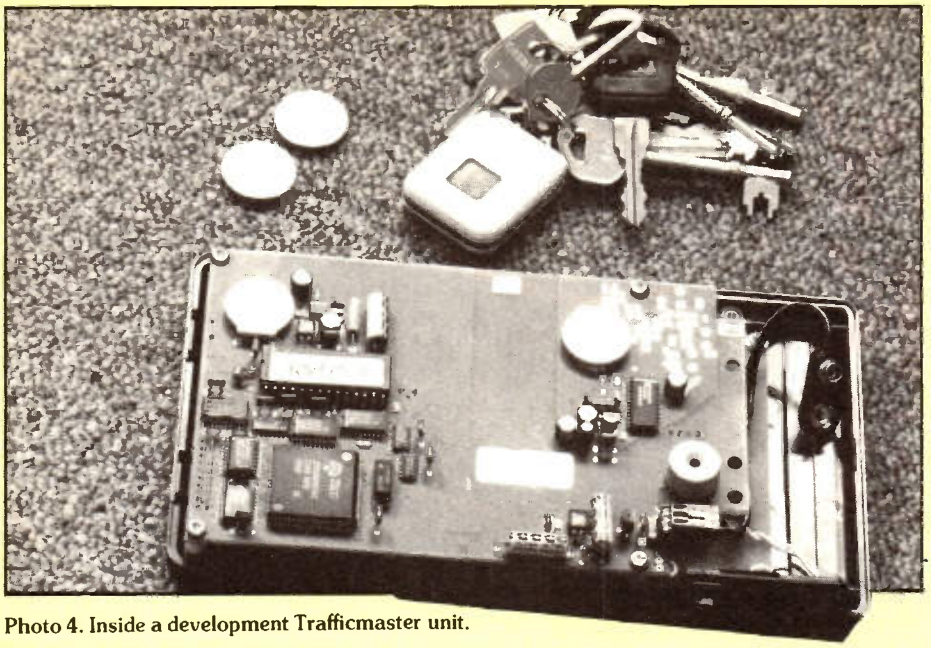


Photo 4. Inside a development Trafficmaster unit.

Power consumption when in standby is 70mA and 140mA when back-lit, which means that the unit can be left turned on for all but the longer absences. There is no external aerial required as the RF receiver is housed inside the car, along with the power supply and the display unit.

The siting and design of the units is subject to strict monitoring from the Transport and Traffic Research Laboratory and the Department of Transport. Design had to exclude cathode ray technology and had to provide audible indication of variations in display. The screen size had to be such that it was easily visible and did not conflict with the information from other driving instruments. Fitting is carried out only by specially trained installers.

The display currently offers several display options; overall and zone. The full display centres upon the M25 'hub', which can be subdivided into four quadrants. Each of the four quadrants can then be accessed from the key pad. The unit will not advise when a quadrant boundary has been crossed, however all that is required is a simple two key operation to change quadrants.

The traffic information display comes in two forms:

Trafficmaster will continuously updated information and will alternately indicate the average speed and direction at the relevant point when traffic speed falls below the preset threshold. This can be seen in Photos 5a and 5b, the average speed at Junction 5 is 10mph whilst at Junction 7 it is zero.

In addition the manned Control Centre can send text messages of up to 50 characters. This will usually be qualitative information, the accident icon, cause of hold up or such update as is available. Excellent links with police control rooms, AA Road Watch and their own maintenance vehicle fleet mean the control centre will qualify the information rapidly. The Control Centre is supervised during normal office hours, outside of these hours the system functions automatically. Thus information is available 24 hours a day, 365 days of the year.

The use of Air Call paging network also means that text based radio paging is available from the unit. Up to 50 messages can be held in the unit. Even if the message paging option is not required by the user it enables the service provider to disable the unit if it is stolen, or rentals have ceased.

A portable version with built-in power supply is imminent.

Photo 5a. Typical display (speed) of a traffic jam caused by an accident.

Photo 5b. Typical display (direction) of a traffic jam caused by an accident.

It is envisaged that as National Coverage of major trunk routes develops, the system will be zoned. Either local or widely used zones can be selected, or all zones, to give National Coverage. The degree of service required would then be reflected in the subscription fee. Trafficmaster is cheaper than Cellular Telephone systems (what isn't) and costs are controlled. For motorway users who need to plan journeys and where time is a direct and indirect cost, it is a boon. This is a larger group than might be thought. It includes all transport and haulage operators, the ubiquitous businessman, also coach operators, and the emergency and public utility services. Less obvious targets will include high security operations and regular drop and airline parcel operators. The list is extensive especially as the time people spend in traffic jams becomes more expensive, both to them and their employers.

There is no doubt that as the Nation's roads become more crowded better and more detailed information about traffic conditions will be required. Local Radio Stations will often give half hourly traffic details, but not knowing whether the broadcast is on the hour, half hour or quarter, or when they please can be a pain. The R.D.S. (Radio Data System) can help, but it is still in its infancy.

Trafficmaster is up and running and works. It offers major opportunities both to plan journeys effectively and to take avoiding action. It also relieves stress by providing confident information about the journey arrival time. It will need to be developed to include the major trunk routes, an option to enable alternative routes to be offered may be worth considering. This would link very well with the planned change to enable in-car unit locations to be advised. Shades of 'Big Brother' perhaps, but vital if the on board information is to relate to the journey actually taking place.

Trafficmaster is a great British development. It was conceived, designed, tested and is built in Britain. It is a British product to deal with a British problem. As we are all unlikely to relish restrictions upon our travelling freedom, having the best information musf be the way to improve our travelling efficiency.

Trafficmaster is the best piece of information efficiency we have found to date. It is far less inane than Local Radio and far cheaper than the premium Traffic Services through the conventional or Cellular Telephone System. It may be pricey but so were the first pocket calculators and digital wrist watches, and how far did that revolution take us?

Users, Costs and Future Developments

The current users of Trafficmaster are an impressive array of transport and other operators, they include, the Banks, Fire Service, the Automobile Association and courier companies.

The system is not cheap, units cost £295 to buy with a fixed £95 installation fee. Network rental is a further £18.50 per month. Personal Radio Paging adds a another £17.50 per month. It can also be rented for an inclusive cost of £38 per month again with the add on paging option.

Acknowledgement

Thanks to David Martell and all at General Logistics.

Further Information

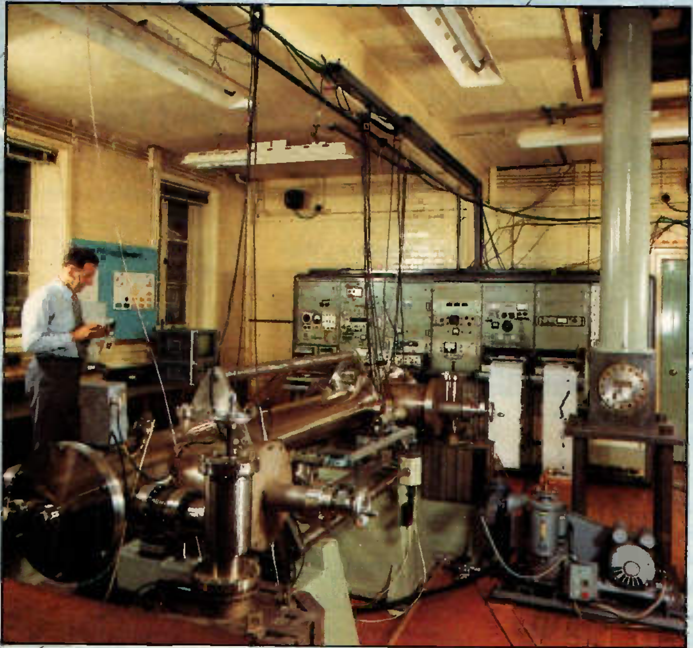
Further information on Trafficmaster may be obtained from:
General Logistics Plc.,
Luton International Airport,
Luton LU2 9LU.
Tel: 081-951-8787

Please do not contact Maplin for information on this product.

RUGBY CLOCK RECEIVER

Features

- ★ *Normal and Inverted Outputs*
- ★ *12V Operation*
- ★ *Fibreglass PCB*
- ★ *Visual Indication of Signal*
- ★ *Audible Indication of Signal*
- ★ *Selectable Filter Response*



Above: Caesium resonator equipment at the National Physical Laboratory.
Background photo: The Rugby MSF transmitter mast.

The Rugby Clock Receiver is a simple fixed frequency receiver intended for the reception of the MSF standard time service, transmitted from Rugby, in central England, at a frequency of 60kHz, see Figure 1. The Rugby MSF transmission is continuous, except for an interruption for monthly maintenance from 10:00hrs to 14:00hrs on the first Tuesday of each month. The MSF transmission includes time and date information, transmitted using both 'fast' and 'slow' codes, based on the Binary Coded Decimal (BCD) system. The receiver provides a normal and inverted digital output, corresponding to the transmitted information, together with an audible tone and a visual indication that the signal is being received.

Circuit Description

Figure 2 shows the circuit diagram of the receiver. The design is based on the Tuned Radio Frequency (TRF) principle in which all RF amplification takes place at the reception frequency. TRF designs have several disadvantages for high frequency reception, but are fairly well suited to very low frequency applications such as the Rugby Clock Receiver, where comparatively narrow bandwidths can be achieved using simple tuned circuits.

Unlike most conventional TRF receivers a phase locked loop (PLL) circuit is used for demodulation purposes. This effectively makes the receiver more selective and enables the transmitted information to be accurately demodulated. Because the PLL oscillator operates at the same frequency as the incoming signal it is important to prevent this signal from breaking through into the front end of the receiver, as this would make the PLL lock up permanently. For this reason the

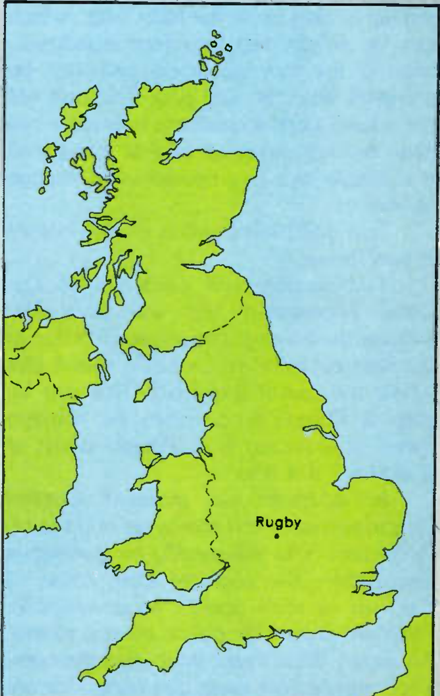
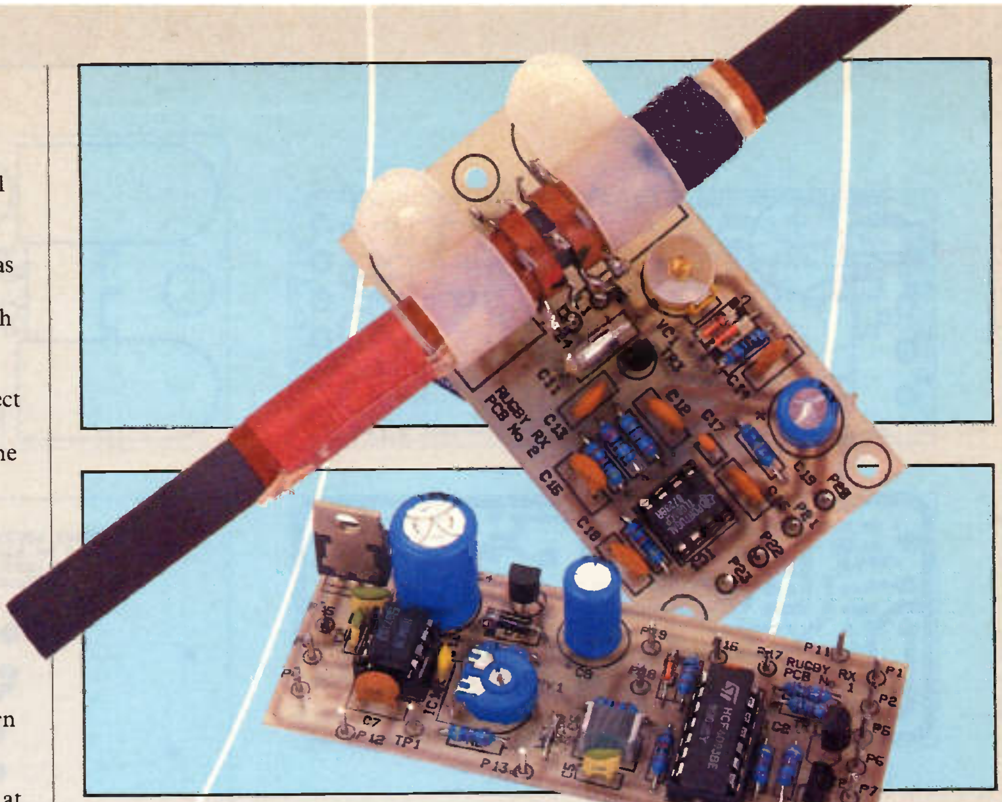


Figure 1. Location of the Rugby Transmitter.

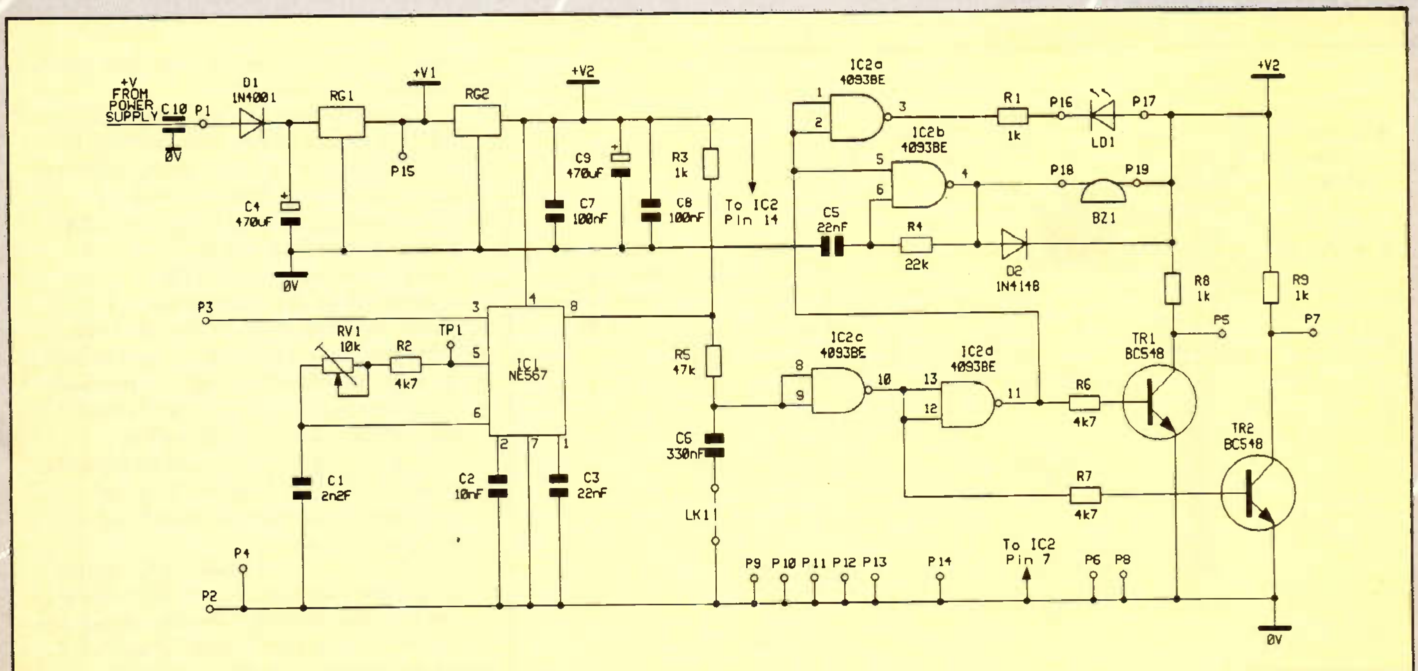
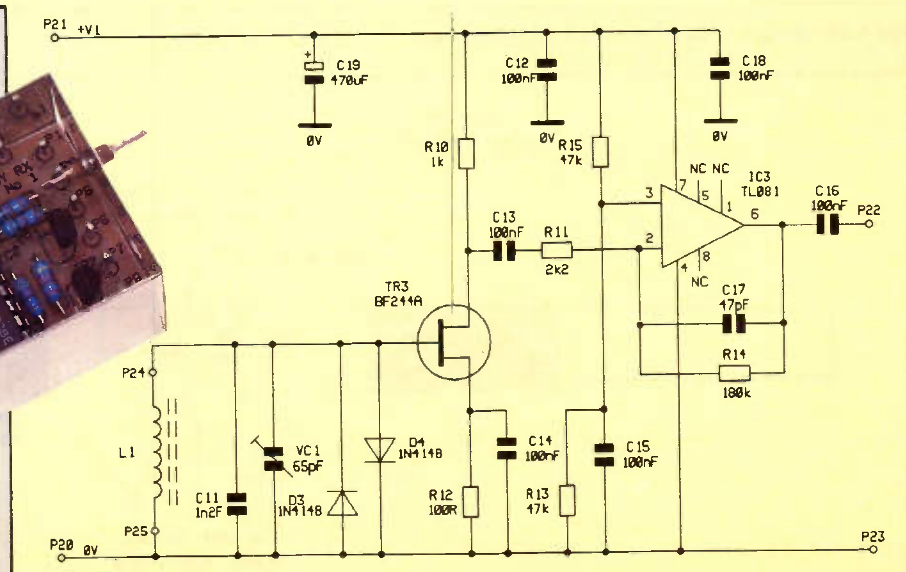
Rugby Clock Receiver uses two separate printed circuit boards (PCBs): PCB 1 is used for the PLL and digital part of the circuit, and the RF amplifier circuitry is on PCB 2. For screening purposes, PCB 1 is housed in a small metal box, which is located in a position remote from PCB 2.

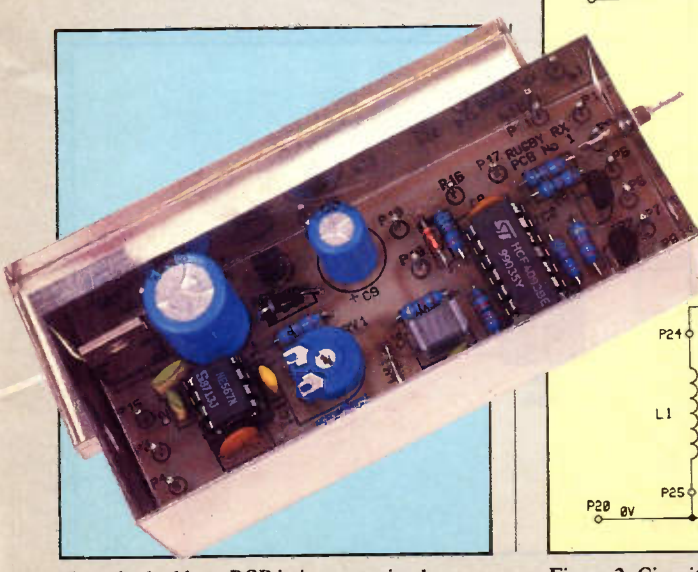
The basic operation of the circuit is as follows: Incoming signals at 60kHz are initially picked up by aerial coil L1, which is tuned to resonance by VC1 and C11. Diodes D3 and D4 provide a degree protection against overloading. Field effect transistor TR3 acts as a preamplifier, providing an initial stage of gain before the main amplifier stage. Capacitor, C13 provides interstage coupling, allowing AC signals to pass, whilst isolating DC voltages. Operational Amplifier IC3 provides additional RF amplification to bring the signal up to a level suitable to drive phase locked loop IC1.

Resistors RV1 and R2 together with capacitor C1 determine the frequency of the phase locked loop clock, which in turn determines the frequency at which the phase locked loop will respond. When a signal of the correct frequency is present at the input (IC1 pin 3), the phase locked loop responds with a logic low at the



Top photo: The assembled radio frequency PCB (PCB 2).
Above: The assembled phase locked loop PCB (PCB 1).



Phase locked loop PCB in its screening box.

Figure 2. Circuit Diagram of the Rugby Clock Receiver

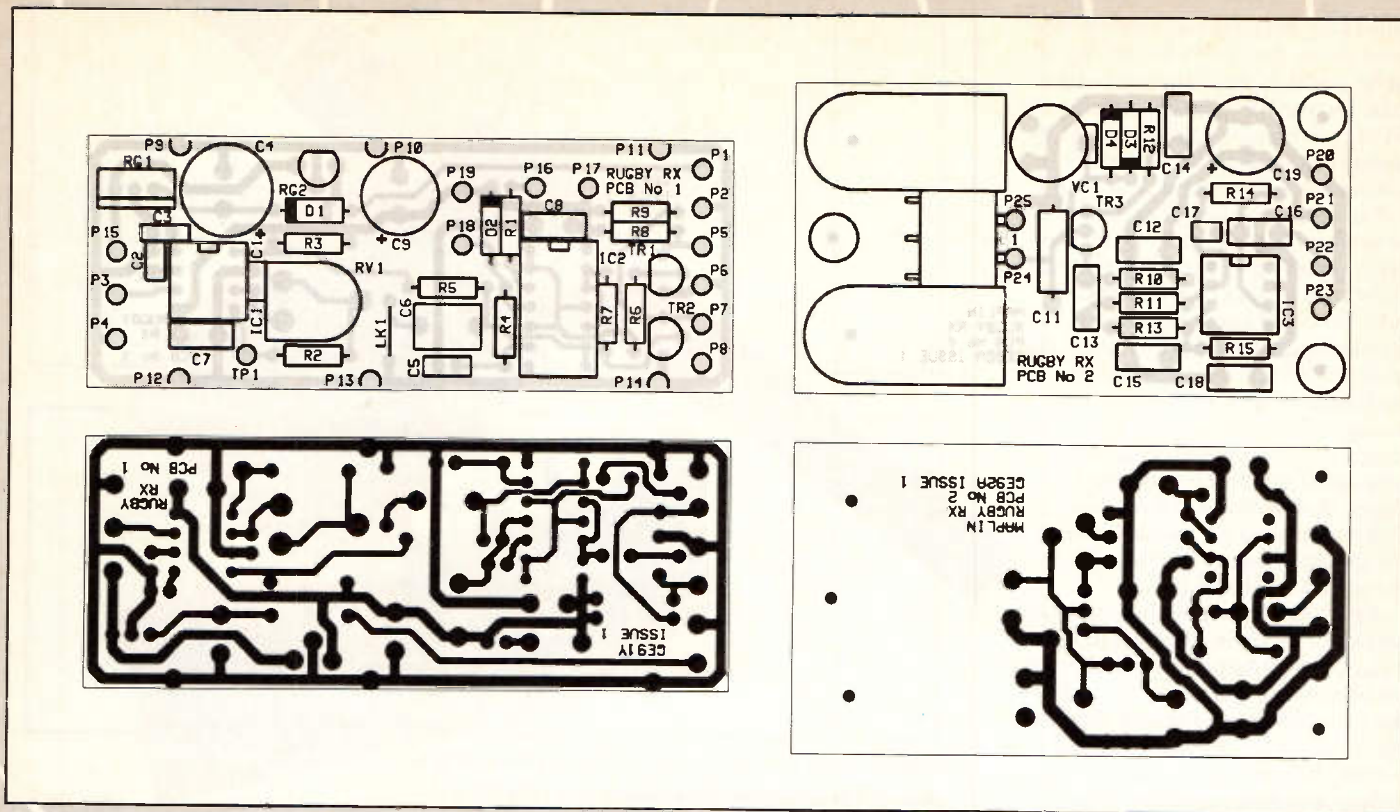


Figure 3. PCB legends and tracks.

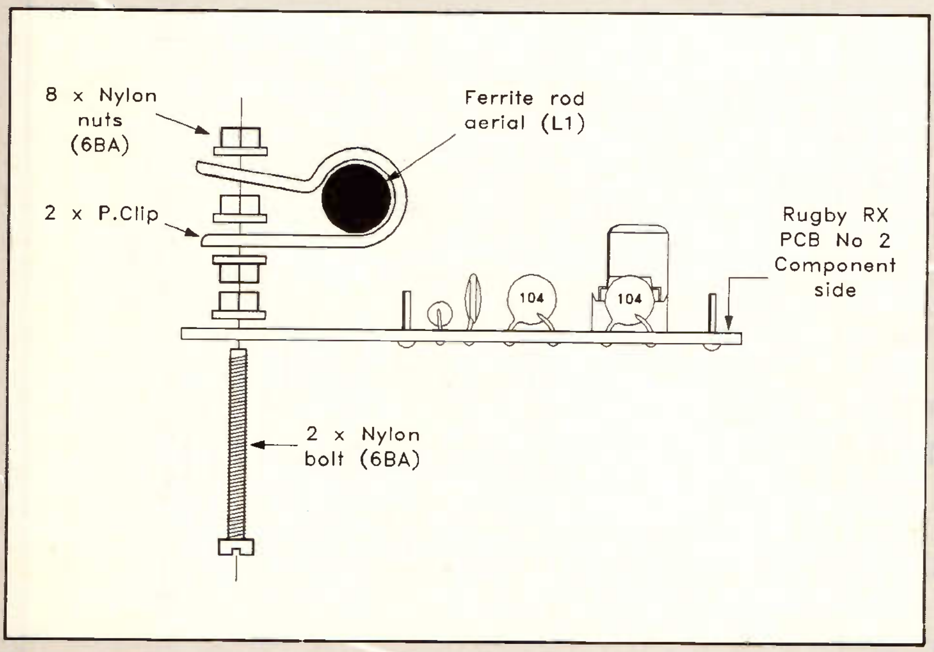


Figure 4. Mounting L1 using P-clips and nylon hardware.

output (IC1 pin 8); when there is no input, the output is logic high.

Outputs from IC1 are fed to IC2 which is a quad 2 input schmitt NAND gate; this device performs several different functions. IC2a is used to drive LD1 which provides a visual indication of the presence of a signal and IC2b acts as a gated oscillator, providing the corresponding audible indication. It should be noted that LD1 and BZ1 are operational when no signal is present and are switched off when a signal is received; when the receiver is receiving the MSF transmission, LD1 should flash at 1 second intervals accompanied by a pulsing tone from BZ1. IC2c and IC2d act as inverters providing both normal and inverted outputs.

Resistor R5 and capacitor C6 form a simple low pass filter when LK1 is fitted and this may be used to remove unwanted pulses. The outputs from IC2c and IC2d are fed to transistors TR1 and TR2 which

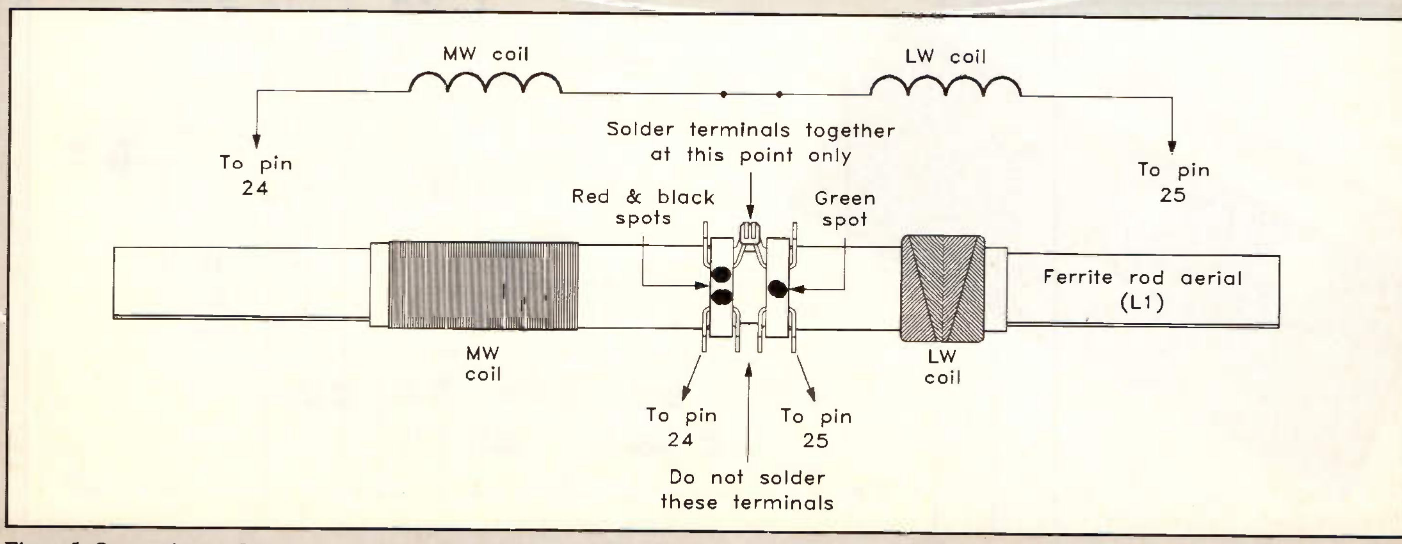


Figure 5. Connections to L1.

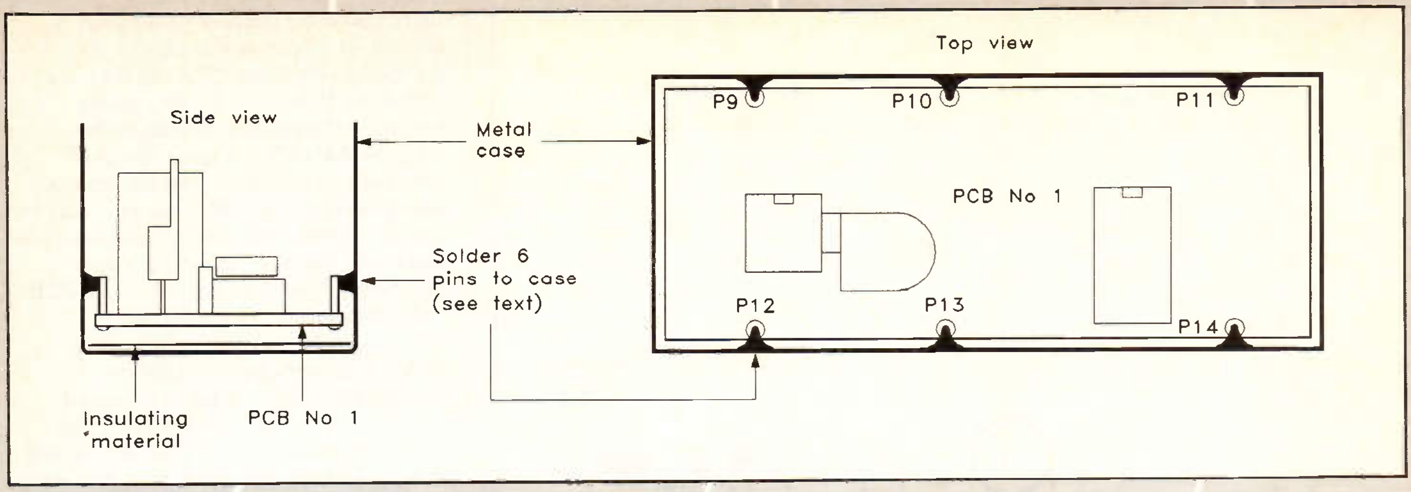


Figure 6. Installation of PCB 1 into its screening box.

are used to provide additional output drive capability.

Two different regulators are used in the circuit. RG1 is the main regulator, which provides a 9V supply to the RF part of the circuit and allows operation over a wide range of power supply voltages. RG2 is a 5V regulator and is used to power the PLL and logic part of the circuit providing a standard 5V output.

Construction

As previously mentioned, the circuit is in two parts and is constructed on two separate PCBs. The PCB legends are shown in Figure 3. It is recommended that PCB 1 is constructed first followed by PCB 2. Component designations start on PCB 1 and continue on PCB 2.

It is probably easiest to fit the resistors first as they can be awkward to fit at a later stage due to the height of surrounding components; this is also the case with the diodes. It is important to observe the polarity markings when fitting the diodes; the cathode (marked by a band at one end of the device) should be orientated toward the band indicated on the legend. Next fit the capacitors, ensuring that the negative lead of the electrolytic capacitors (marked by a

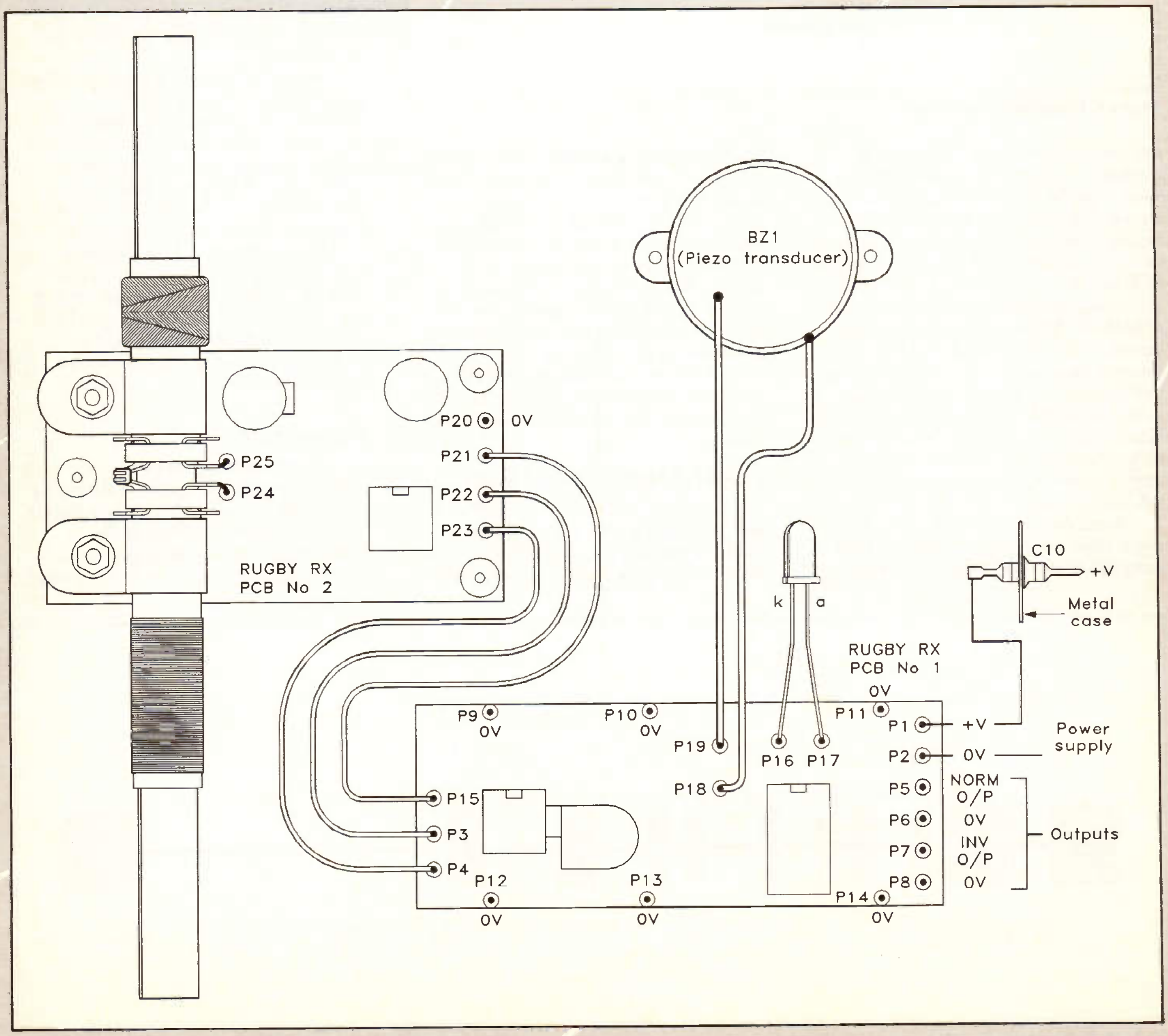


Figure 7. Wiring Diagram.

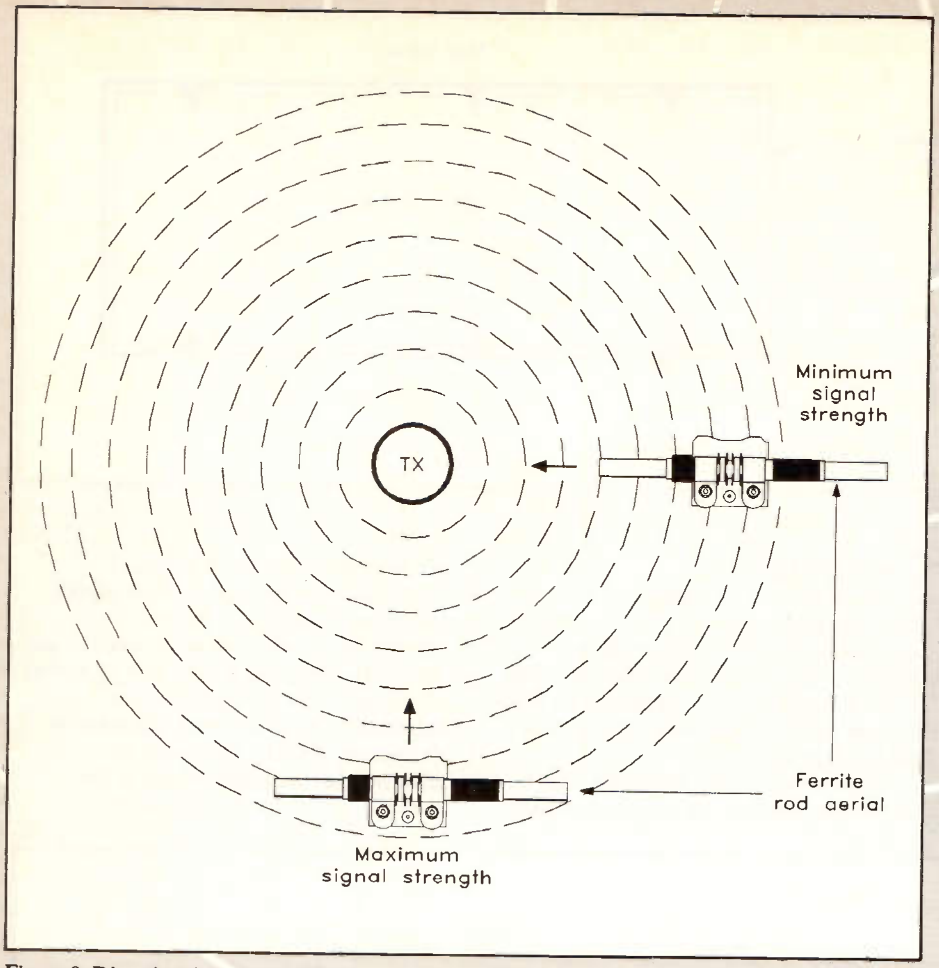


Figure 8. Directional response of L1.

negative (−) symbol on the side of the capacitor) is inserted in the hole furthest away from the positive (+) symbol on the legend. The regulators and transistors should be fitted so that the case of the device corresponds with the outline on the PCB legend. A hot soldering iron with a reasonably substantial bit will be required to fit the PCB pins. Insert the pins from the track side of the board, and heat the heads of the pins with a hot soldering iron until they are hot enough to press home, such that, each head is flush with the PCB. When each pin is heated in this way, very little pressure should be required for correct insertion. It is not necessary to fit LK1 at this stage.

Aerial coil, L1 is held in position by two P-clips, which are bolted to the PCB using nylon nuts and bolts, as shown in Figure 4. Before fixing the aerial in place, it is necessary to move the two coils to the centre of the ferrite rod and solder the tags, as show in in Figure 5, so that the coils are in series. Component leads may be used to make connections from the aerial to P24 and P25 on the PCB. All unused tags should be carefully bent back to prevent shorting; take care not to break any of the aerial connection wires.

For further information on soldering and constructional techniques, refer to the Constructors' Guide, which is included in the kit.

Final Assembly and Wiring

Figure 6 shows how to install PCB 1 into its screening box. Before installing PCB 1 in the box, it is suggested that you double-check your work, to make sure that there are no dry joints or solder short circuits. It is necessary to prevent the component leads and tracks on the track side of the PCB from shorting on the bottom of the metal enclosure, as this could be disastrous. A small square of insulating material (thick insulating tape, fibreglass board, plastic sheet, etc.) may be used for this purpose, but it is important to make sure that any component leads protruding from the track side of the PCB will not penetrate the insulation.

The PCB is actually held in place using six mounting pins which are provided close to the edge of the board (P9, P10, P11, P12, P13 and P14). The pins are soldered to the side of the box and in addition to providing support, also act as an additional ground connection. In some cases, for ease of soldering, it may be necessary to bend the mounting pins out slightly to allow contact with the box. Only the pins specified should be soldered to the case in this way.

PCB 2 may be used free-standing and does not require a box. Whatever kind of housing is used, it should be remembered that the performance of the receiver will be significantly modified by the presence of any metal in proximity to the ferrite rod aerial. It is, therefore, recommended that a plastic box is used for this purpose if, for example, the assembly is required to be weatherproof.

Wiring between PCB 1 and PCB 2 is made using 2-core screened cable (XR20W). 1m of cable is included in the kit, but the length may be extended to 5m without any significant degradation in performance. The type of wire used between PCB1 and any decoder is really dependent on which of the outputs are used but as a general guide, multiway screened cable is recommended. Many users may wish to disconnect BZ1 and/or LD1 after the unit is initially aligned and in this case, external wiring may be substantially reduced. Figure 7 shows wiring information.

Power Supply

The receiver requires a 12 to 16V power supply that is capable of supplying at least 50mA. A suitable supply is Maplin stock code XX09K. Although the smoothing capacitors and regulator circuitry allow operation, even when large

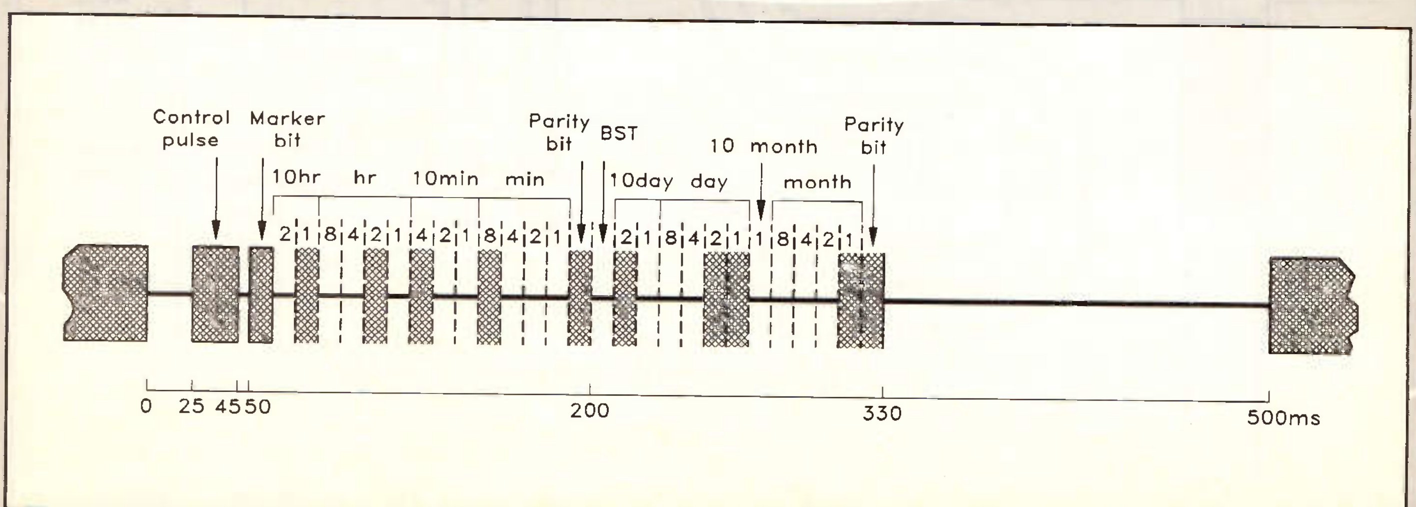


Figure 9. Format of 'fast' code.

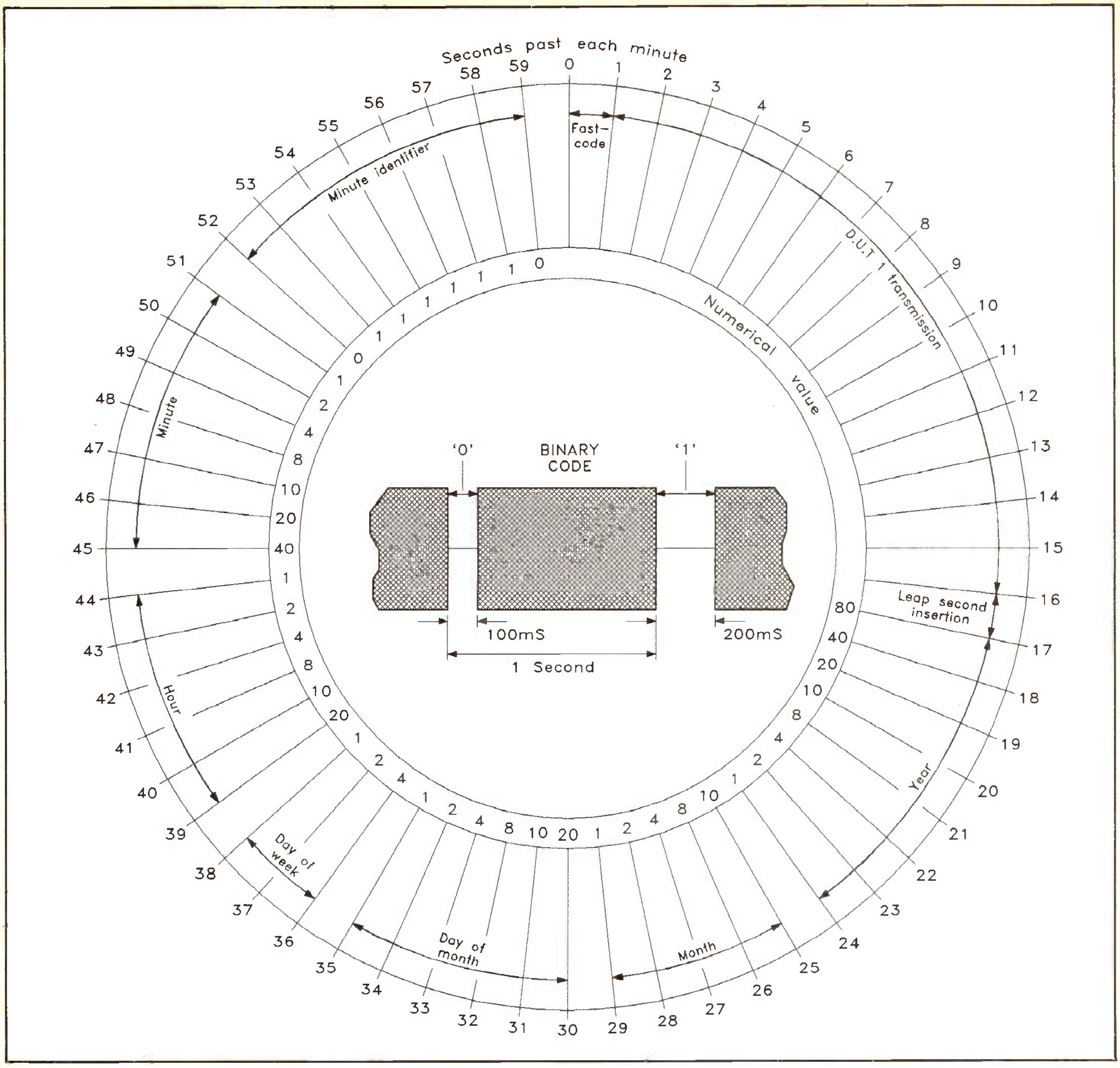


Figure 10. Format of 'slow' code.

amounts of ripple are present, it is recommended that a power supply with a relatively smooth output is used, as this will improve reliability of operation. Power supply connections are made to P1 (+V) and P2 (0V).

Testing and Alignment

Before the circuit is powered up for testing, it is recommended that you double-check your work to make sure that there are no dry joints or solder short circuits. There are basically two methods of alignment: with test equipment and by trial and error.

Alignment with test equipment requires some method of accurate frequency measurement, such as a frequency counter and a signal generator capable of generating a 60kHz signal of adjustable amplitude.

In many cases, the necessary test equipment is not available and it is possible to align the circuit without test equipment by trial and error; this can be a time consuming process, but achieves the same end result as alignment with test equipment.

Before any alignment is carried out it is advantageous to establish the direction of the MSF transmitter, from your location, so as to achieve the maximum signal strength possible. The ferrite rod aerial is directional and the approximate directions of maximum and minimum response are shown in Figure 8. When the ferrite rod is pointed in the direction of minimum response it will be found that there is a deep null and in many locations, the signal may be completely lost.

When power is first applied to the module, LD1 should light and BZ1 should emit an audible tone. To begin with, it is a good idea to position the ferrite rod such that the aerial coil (L1) is approximately central. Adjust RV1 until a break in the tone occurs. Move the ferrite rod in and out of L1 until a peak in the signal is achieved; only very fine movement is required as the tuning is quite sharp. Repeat this procedure until a satisfactory signal level is achieved. Any final fine tuning can then be made using VC1 and by further adjustment of RV1. Initial alignment should be made *without* LK1 fitted as this provides an *unfiltered* output. A satisfactory signal should produce a clear repetitive pulsing tone. In some locations, it may not be possible to achieve an interference free signal; if this presents a problem, LK1 may be fitted to provide extra filtering and to remove short duration pulses. It should be noted that when LK1 is fitted, much of the 'fast' code is filtered out, so for decoding purposes, the 'slow' code should be used. The 'slow' code filter (LK1 fitted) does modify the timing very slightly but in most applications this does not present a problem.

Using the Rugby Clock Receiver

To make use of the digital outputs from the Rugby Clock Receiver, it is necessary to use some form of decoder; this may either take the form of a dedicated decoder circuit or a computer

```
10 REM RUGBY SLOW CODE DATA DECODING PROGRAM
20 REM GW-BASIC FOR IBM PC AND COMPATIBLES
30 REM REQUIRES 24-LINE PC I/O CARD
40 REM (C) MAPLIN ELECTRONICS 1991
50 CLS
60 DIM TIM.DAT% (35)
70 FOR COUNTER% = 1 TO 35
80 READ TIM.DAT% (COUNTER%): REM READ BCD TIME AND DATE DATA
90 NEXT COUNTER%
100 BASEADD% = &H320
110 OUT BASEADD% + 3, &H9B: REM SET I/O PORT TO INPUT
120 DAT$ = ""
130 WHILE INKEY$ <> CHR$(13): REM ESCAPE FROM PROGRAM IF ENTER PRESSED
140 LAST.DAT% = DAT%
150 DAT% = INP (BASEADD%) AND 1: REM GET DATA FROM RUGBY RECEIVER
160 IF LAST.DAT% = 0 AND DAT% = 1 THEN TIM = TIMER
170 IF LAST.DAT% = 1 AND DAT% = 0 THEN TIM.HIGH = TIMER - TIM: GOSUB 200
180 WEND
190 END
200 BIN$ = "E"
210 IF TIM.HIGH < .05 THEN RETURN
220 IF TIM.HIGH >= .08 AND TIM.HIGH =< .12 THEN BIN$ = "0"
230 IF TIM.HIGH >= .18 AND TIM.HIGH <= .32 THEN BIN$ = "1"
240 PRINT BIN$;
250 DAT$ = DAT$ + BIN$
260 IF RIGHT$ (DAT$,8) = "01111110" THEN PRINT: GOSUB 280: DAT$ = "": REM DETECT
 MINUTE MARKER
270 RETURN
280 DAT$ = RIGHT$ (DAT$,43): REM STRIP VALID DATA
290 L.DAT% = LEN (DAT$)
300 IF L.DAT% < 43 THEN DAT$ = STRING$ (43 - L.DAT%,"E") + DAT$: REM PAD OUT IF
INCOMPLETE MINUTE RECEIVED
310 YEAR%=0: MONTH%=0: DAY.MONTH%=0: DAY.WEEK%=0: HOUR%=0: MINUTE%=0
320 FOR COUNTER% = 1 TO 8
330 IF MID$ (DAT$,COUNTER%,1) = "1" THEN YEAR% = YEAR% + TIM.DAT% (COUNTER%): RE
M CALCULATE YEAR
340 NEXT COUNTER%
350 FOR COUNTER% = 9 TO 13
360 IF MID$ (DAT$,COUNTER%,1) = "1"  THEN MONTH% = MONTH% + TIM.DAT% (COUNTER%):
 REM CALCULATE MONTH
370 NEXT COUNTER%
380 FOR COUNTER% = 14 TO 19
390 IF MID$ (DAT$,COUNTER%,1) = "1"  THEN DAY.MONTH% = DAY.MONTH% + TIM.DAT% (CO
UNTER%): REM CALCULATE DAY OF MONTH
400 NEXT COUNTER%
410 FOR COUNTER% = 20 TO 22
420 IF MID$ (DAT$,COUNTER%,1) = "1" THEN DAY.WEEK% = DAY.WEEK% + TIM.DAT% (COUNT
ER%): REM CALCULATE DAY OF WEEK
430 NEXT COUNTER%
440 FOR COUNTER% = 23 TO 28
450 IF MID$ (DAT$,COUNTER%,1) = "1" THEN HOUR% = HOUR% + TIM.DAT% (COUNTER%): RE
M CALCULATE HOUR
460 NEXT COUNTER%
470 FOR COUNTER% = 29 TO 35
480 IF MID$ (DAT$,COUNTER%,1) = "1"  THEN MINUTE% = MINUTE% + TIM.DAT% (COUNTER%
): REM CALCULATE MINUTE
490 NEXT COUNTER%
500 PRINT
510 IF INSTR (DAT$,"E") <> 0 THEN PRINT "ERROR IN DATA"
520 PRINT "YEAR          "; YEAR%
530 PRINT "MONTH         "; MONTH%
540 PRINT "DAY OF MONTH"; DAY.MONTH%
550 PRINT "DAY OF WEEK "; DAY.WEEK%
560 PRINT "HOUR          "; HOUR%
570 PRINT "MINUTE        "; MINUTE%
580 PRINT
590 RETURN
600 DATA 80,40,20,10,8,4,2,1: REM YEAR BCD DATA
610 DATA 10,8,4,2,1          : REM MONTH BCD DATA
620 DATA 20,10,8,4,2,1       : REM DAY OF MONTH BCD DATA
630 DATA 4,2,1               : REM DAY OF WEEK BCD DATA
640 DATA 20,10,8,4,2,1       : REM HOUR BCD DATA
650 DATA 40,20,10,8,4,2,1    : REM MINUTE BCD DATA
```

Listing 1. GW-BASIC 'Slow' Code decoding program for the IBM PC.

running the appropriate software.

Two different codes are transmitted by switching the carrier on and off. The 'Fast Code' is transmitted at the beginning of each minute within a 500ms window, using the format illustrated in Figure 9. 'Fast' code information includes time of day in Universal Time Co-ordinated (UTC) together with date information.

The 'Slow Code' is completely separate from the 'fast' code, and is sent over the period of 1 minute. Figure 10 illustrates the format of the 'slow' code. The carrier is interrupted once each second for a period of either 100ms or 200ms; 100ms corresponding to a binary '0' and 200ms corresponding to a binary '1'. 'Slow' code information includes time of day, day of week and date information.

Both codes use a 'Binary Coded Decimal' system and the 'slow' code is actually slow enough to be decoded by ear with some practice! Additional bits are used for error checking purposes and to indicate British Summer Time (BST). It should be noted that the 'slow' code is effectively inverted when compared to the 'fast' code.

Listing 1 gives a program written for the IBM-PC and compatibles in GW-BASIC to decode the 'slow code' transmission. To allow the digital code from the Rugby Clock Receiver to be read by the computer, a parallel input output/card must be used. The 24-line PIO card published in 'Electronics' April to May '91 is suitable for this purpose. The output from the Rugby Clock Receiver P7 (inverted output) and P8 (0V) should be connected to P19 (PA0) and P10 (0V) of the PIO Card. The address in line 100 will need to be set to whatever base address is being used by the PIO Card. Address &H320 was selected on the author's machine as this address was vacant, this may not be the case on other machines, so please check to avoid an input/output bus contention and possible damage to the computer and/or PIO Card.

It is possible to modify the program to run on other computers, however, it is outside the scope of this article to give exact details of how to do this.

In some locations, it may be possible to receive other standard time signals located in Europe but signal strengths vary from place to place, and results cannot be guaranteed. To receive such stations (which operate at different frequencies to MSF), it will be necessary to re-tune the receiver by adjustment of RV1 and VC1 and by sliding the ferrite rod in or out of the aerial coil (L1).

Finally, Table 1 shows the specification of the prototype receiver.

Table 1. Specification of Prototype	
Power Supply Voltage	12V to 16V
Average Power Supply Current (at 12V)	35mA
Operating Frequency	60kHz
Logic Output Level (Normal and Inverted)	5V

Table 1. Specification of prototype.

Acknowledgement

Photographs of the Rugby Transmitter Mast and Caesium Resonator ©1991 Crown copyright.

Maplin Electronics would like to thank the following people: Bryan Swabey and Peter Pearce, National Physical Laboratory, for their help, advice and technical information. The Staff at all of the regional Maplin Stores for assistance with field strength measurements at various locations in Britain.

References

Radio Data Reference Book, G. R. Jessop, RSGB. Wireless World, July 1978. BIPM report 1989. Standard Frequency and Time Transmissions in the UK, NPL.

Further information

Further information about the Rugby MSF transmissions, and other time-code and frequency standards may be obtained from:

Time and Frequency Section, Division of Electrical Science, National Physical Laboratory, Teddington, Middlesex TW11 0LW.

RUGBY CLOCK RECEIVER PARTS LIST

RESISTORS all 0·6W 1% Metal Film (Unless specified)			
R1,3,8,9,10	1k	5	(M1K)
R2,6,7	4k7	3	(M4K7)
R4	22k	1	(M22K)
R5,13,15	47k	4	(M47K)
R11	2k2	1	(M2K2)
R12	100Ω	1	(M100R)
R14	180k	1	(M180K)
RV1	Hor Encl Preset 10k	1	(UH03D)
CAPACITORS			
C1	2n2F Ceramic	1	(WX72P)
C2	10nF Ceramic	1	(WX77J)
C3,5	22nF Ceramic	2	(WX78K)
C4	PC Elect 470μF 35V	1	(FF16S)
C6	Poly Layer 330nF	1	(WW47B)
C7,8,12,13,14,15,16,18	Minidisc 100nF 16V	8	(YR75S)
C9,19	PC Elect 470μF 16V	2	(FF15R)
C10	Feed Through Capacitor	1	(BX16S)
C11	1% Polysty 1200pF	1	(BX57M)
C17	47pF Ceramic	1	(WX52G)
VC1	Trimmer 65pF	1	(WL72P)
SEMICONDUCTORS			
IC1	NE567	1	(QH69A)
IC2	4093BE	1	(QW53H)
IC3	TL081	1	(RA70M)
TR1,2	BC548	2	(QB73Q)
TR3	BF244A	1	(QF16S)
D1	1N4001	1	(QL73Q)
D2,3,4	1N4148	3	(QL80B)
RG1	μA78S09UC	1	(UJ55K)
RG2	μA78L05AWC	1	(QL26D)
LD1	LED Red 5mm 2mA	1	(UK48C)

MISCELLANEOUS			
L1	MW/LW Aerial	1	(LB12N)
BZ1	Min Piezo Sounder	1	(FM59P)
	Pins 2145	1 Pkt	(FL24B)
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 8-pin	2	(BL17T)
	Low-Z Mic Preamp Case	1	(FD20W)
	PCB 1	1	(GE91Y)
	PCB 2	1	(GE92A)
	Lapped Pair Cable	1m	(XR20W)
	Cable P-clip ⅜ inch	2	(LR04E)
	Nylon Bolt 6BA × 1in.	1 Pkt	(BF76H)
	Nylon Nut 6BA	1 Pkt	(BF80B)
	Instruction Leaflet	1	(XT01B)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	24-line PIO Card	1	(LP12N)
	37-way D-type Socket	1	(FV72P)

The Maplin 'Get-You-Working' Service is available for this project, see page 71 for details.

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

Order As (60kHz Rugby Rx) LP70M Price £16.95.

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 1992 Maplin Catalogue.

Rugby Rx PCB No. 1 **Order As GE91Y Price £2.45**

Rugby Rx PCB No. 2 **Order As GE92A Price £2.25**

A PC-based image processing work station (photo courtesy of Data Translation Ltd.).

Ima

The ability to convert a filing cabinet full of documentation on to a single 5¼ inch disk may seem fanciful. But such is the potential of Image Processing (IP) – a process says the Hoskyns consultancy, as revolutionary as the move from batch to online processing. In fact computer suppliers Wang suggest that IP will take its place as the 4th revolution following the advent of the mainframe in the 60's, word processing in the 70's and PCs in the 80's.

by Alan Simpson

For once all the experts – and an increasing number of actual users – are agreed: IP has an almost unlimited potential. "After several years gestation" says Charles Dawson of the PA Consulting Group, "IP is nearing a 'critical mass' in terms of products, sales and markets.

The industry has by no means fully matured yet, and there are many more opportunities now available for products". Certainly, with more than 95% of all documents still being stored as paper (whatever happened to that much promoted IT Paperless office?), that opportunity seems boundless.

Smart Money

Considerable levels of smart money are now going into Document Image Processing. As the NCC reports, when IP was first introduced, it was considered very much the domain of affluent organisations and more or less an up-market archive system. There are now estimated to be over 600 known systems in the UK, and probably many more stand-alone facilities that have gone unrecorded. More to the point, is the fact that IP is beginning to be more widely accepted as the salvation for paper congested companies in all walks of industry and commerce.

Equally revealing says the NCC is the broader applications base which is now moving well beyond the purely archival system and into the interactive and transaction processing needs of busy work groups. In a recent survey of 11,000 assorted businesses conducted by the NCC, 8% said they were already using IP either in pilot form, or in a fully commissioned system. Of the rest, over 20% reckoned to be using IP within the next two years, and a further 40% within 5 years. "With competitive awareness on the increase, and with the recognition that information management issues will influence performance, IP is likely to be the next technological wave to hit the office environment."

The R & D and pioneering phase is now over reports Paul Bradford of Andersen Consulting and the IP roll out is in fast-ahead mode. "It is a phenomenally huge market place for the 90's", says Carolyn Nimmy of Hoskyns, "We are talking about very big business."

Getting the Picture

But before we all get carried away with the latest technology, as Charles Dawson of PA points out, "just consider the old adage 'a picture paints a thousand words'." For much of our lives we use images in the form of drawings and pictures, relying on form, texture and coloration to provide us with information. These images include signs, photographs, X-rays, microfilm, television, adverts, packaging and more. Many of these images are incorporated into newspapers, magazines and books. Images apply to many fields of work. As a consequence computers have been applied for many years to store, reproduce and manipulate images, and to create new forms of previously unavailable images. Typical computerised image processing includes

★ Body scans – images of 'slices' of the interior of a body for medical diagnosis.

★ Computer aided design – architectural and manufacturing related drawings, and 3-D representations of the finished object.

★ Satellite imaging – weather formations, crop distributions, geographical feature analysis, military intelligence; all processed beyond the limits of normal photographs by computer image manipulation.

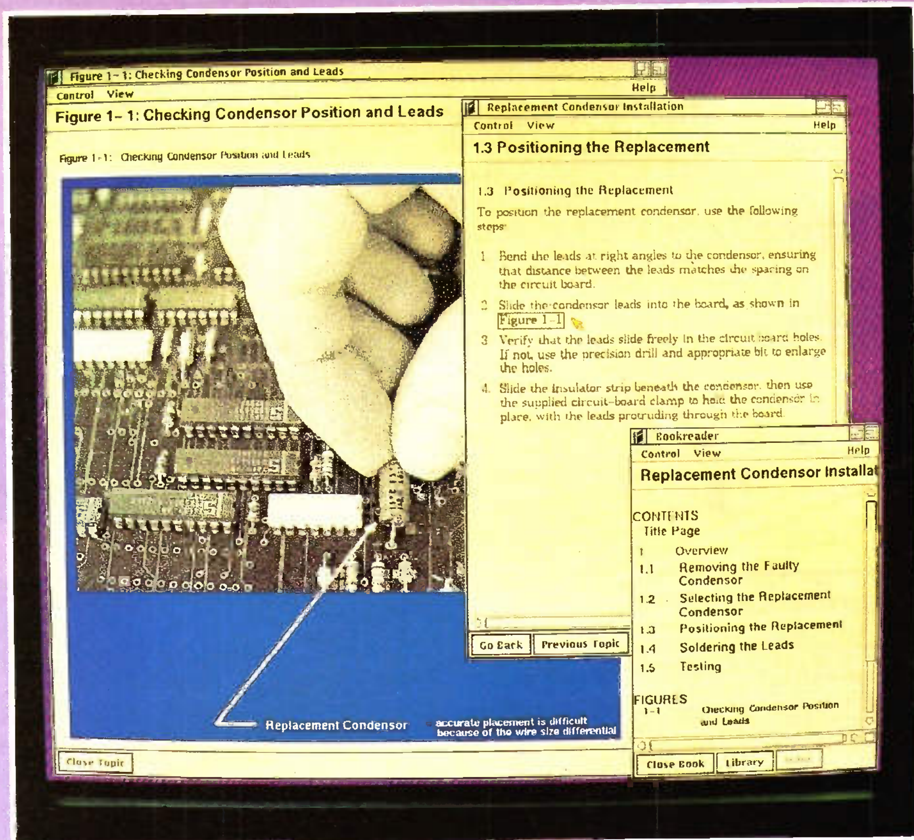
★ Police videofit – a computer graphics form of the identikit 'artist's impression' of suspects and missing persons. Also for fingerprint matching.

★ Image recognition – used on production lines for the placement of parts and recognition of defects, or to allow mobile machines to avoid obstacles.

★ Other image related applications include: sales and stock control – bar code recognition; flight simulators – creation of interactive visual displays; flight navigation; graphics design; publishing; television, film and video; archiving; Optical Character Recognition; and interior design.

But as Michael Naughton of ANR says, "What most people mean when they discuss imaging is electronic document processing. That is scanning paper documents and retrieving them onto a computer screen". This is not exactly a new technology – in fact it dates back to the 60's, but it was so expensive, that few could afford it. A more advanced analogue system emerged in the 70's which made use of magnetic disk tapes and drives. It was not until the early 80's when the second generation of document imaging emerged, based on optical disks. Nowadays, the availability of high powered PCs, has opened up the market-place both in price and technology.

Getting a better ge!



Screen display of a VAX station running DEC image software.

A VAX-based image processing work station (photo courtesy of Digital Equipment Corp.).

Defining DIP

Very basically, DIP is the taking of a paper document and converting it into electronic format for storage or manipulation. As the NCC state, in essence, the technology offers the business user an alternative to paper based information. The process involves scanning a document and saving the digitised result on a storage medium – usually an optical disk, from which it may subsequently be retrieved and viewed by many numbers of users simultaneously, and without losing the originally stored image.

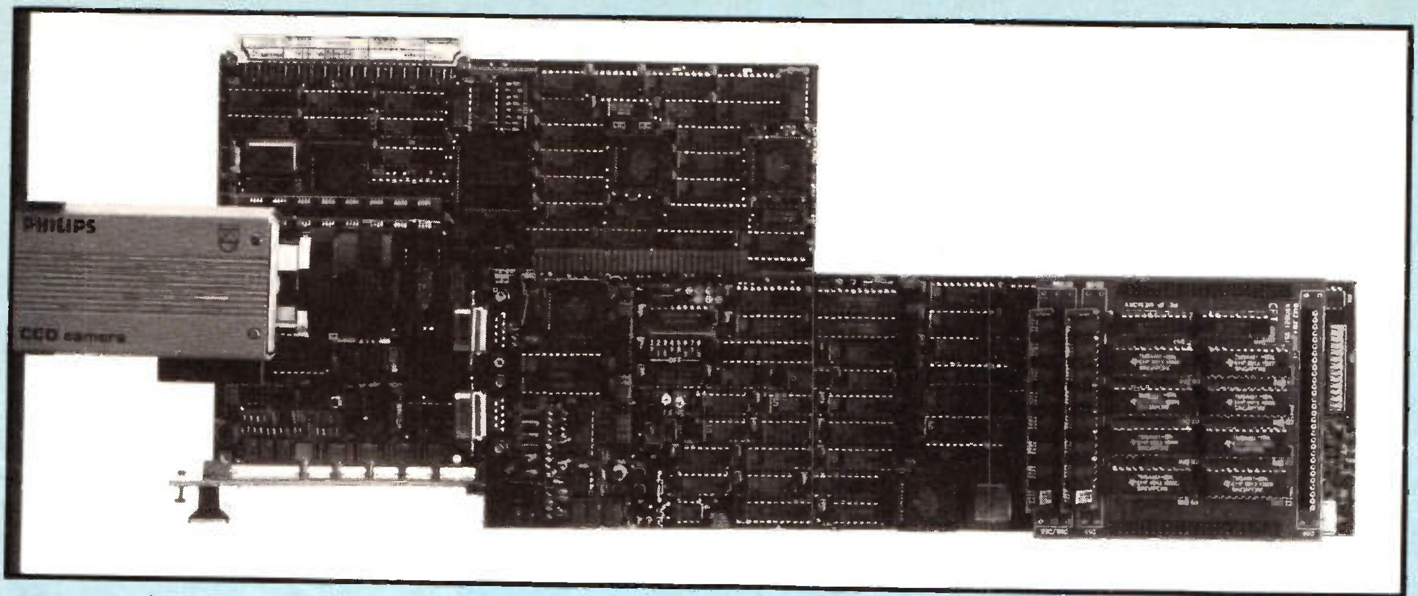
The complexity, says the NCC, arises once one begins to define what is meant by 'a document', also by what levels of sophistication one wishes to apply to the scanning process, and what the user wished to do with the result. A document can be regarded as a page of A4 text, pages from a book or journal, an engineering drawing, a microfilm or microfiche, a record card, a photograph, a line drawing or charts and graphics. More important than document types is the definition of a documents logical structure and layout, for this is how it presents the information it contains, and allows the user to identify parts of it for subsequent browsing and retrieval.

Similarly, report the NCC, the scanning process can be limited to a page image scan (simply a digitised equivalent of the paper version) – or fully coded text if one employs Optical Character Recognition (OCR) as part of the capture process. There are also differing levels of facility for those who need to handle compound documents – i.e. documents containing a mixture of text, graphics, photographs, drawings etc., which will support editing needs.

Distinguished Manipulation

DIP, believes PA, is distinguished from other image processing applications by its emphasis on storing rather than processing images. Paper documents are converted into an electronic format (by means of scanning), stored in computer-based archives and subsequently manipulated. The prime tasks of a DIP system are reading a document image, storing it, remembering where it is (by means of indexing), retrieving it, displaying it via a screen and printing copies. Indexing is the recording of information about the document (such as its age, location, author) and its content (subject matter, keywords) to assist in retrieval.

To help make the situation even clearer, PA's Charles Dawson says that DIP can be considered as a computer equivalent of microfilm document storage. "The advantage of DIP over microfilm is that documents can be retrieved more quickly and by more than one person at a time. The application of DIP is therefore more often geared to providing comprehensive and intelligent ways to locate



PC-based vision board from Philips.

documents. These facilities have much in common with text-retrieval systems used in wordprocessing and document management systems."

Image and Reality

When it comes to how image systems work, Michael Naughton of ANR fills in the picture. In hardware terms, it is normally composed of a combination of workstations, document scanners, servers, central processor (varies from the basic PC to a mainframe unit), storage media, display monitors, printers and a local area network. Software, the most important element of the system, includes a database management system for image indexing and software to drive the hardware components. In practice, users feed the document into the scanner, rather like you feed paper in the fax or photocopier machine. At this stage, the document is reduced to a binary series consisting of 1s for a dark portion of the document or 0s for a white portion of the document.

At this stage the image, as far as the processor is concerned, is an unintelligible mass of bits. Unlike a text-based file, the computer has no search reference point and specific index data has to be inputted – either manually or automatically. At this stage, data compression processes reduce the number of bits stored from a range of 15 to 1 to a more manageable 60 to 1.

As PA point out, optical disk storage media are usually used for storage due to their very high storage capacity in relation to their size and cost. Optical disks used in the computer industry are derived from the optical disks used in the audio industry in the form of compact disks. Thanks to the expanding market, the cost of optical disk technology is now competitive, information is stored on optical disks in digital format, with one exception of the the Philips Videodisk which uses analogue format. Error correction is standard within the decoding circuitry. Some of the main types of storage include:

CD – Audio industry optical disks which are a popular replacement for vinyl records. Available in 3½ inch singles and 5¼ inch album sizes.

CDV – Similar to CDs but used to record video images and sound and thus equivalent to video tape.

CD-ROM (Compact Disk, Read Only Memory) – Again very similar to CDs in format, but data is stored rather than music.

WORM (Write Once – Read Many) – Again similar to CDs but with a different physical surface which can be etched by a laser beam. As PA state, any part of the disk surface can only be written to (etched) once. Therefore data cannot be deleted, but it can be changed by writing it again to a 'free' part of the disk. In this way, an audit trail of data changes is built up.

Laservision Videodisk – This is the original optical disk produced by Philips in the 70's. It was never successful as a replacement for VHS video tapes but has been successfully used for data archives.

EMOD (Erasable magneto-optical disk) – Also known as CD-E (CD Erasable) and CD-R (CD Recordable) in the music industry; these disks are the latest addition to the optical disk family. In effect, says PA, they are erasable versions of the WORM disks using a magneto-optical coating upon which data is recorded.

Optical Juke-boxes

Optical disks reports PA can store very large quantities of data at a cost of about six pence per megabyte. Optical disk juke-boxes are devices similar to musical juke-boxes which contain several optical disks. These can store over 1 Terabyte (1362Gb), and can provide almost unlimited storage capacity. The disadvantage however of juke-boxes is the delay while the required disk is loaded and 'played' which is in the region of 10 seconds.

Meanwhile, consultancy Andersen warns the industry not to hold its breath over standards. Imaging brings together very many technologies – workstations, optics, user interfaces, networks, (LANs and WANs) which already have de facto standards. What is positive however is the size of the market-place. According to a Frost & Sullivan Report, imaging is bursting forth and headed up, up and away. In fact in Europe, the market could bring about a 14-fold leap in volume sales by 1993 valuing the market at some $100m.

Further confirmation, if such is needed, comes from a further US report. Image Processing is hot, with the market growing by some 50% annually. "There are a billion zillion dollars to be made in this area" says Nolan Norton & Co – a statement which must have had a zillion equipment suppliers reaching for their Porsche brochures. Yet a further authority believes that document image processing is the fastest growing segment of worldwide data processing.

Freeing the paper bottleneck

As Frost & Sullivan put it, "Say information systems, and automatically many people think 'computers' or 'computer networks'. In fact, close to 95% of all current business files are still paper based. Moreover, with paper records growing at the rate of 8% annually, the average organisation doubles its records volume every ten years – creating for many, a huge unmanageable storage problem."

Now thanks to image processing techniques, that paper dragon could be slayed, and at the same time, many forests saved. Certainly, Charles Dawson, principal consultant with PA, is excited about IP technology. "It makes the paperless office affordable and achievable – filing cabinet manufacturers should be concerned about their future."

Future Positive

Several different areas of technology advance are making their own contribution to the evolution of DIP and its wider acceptance says the NCC. These include processor speeds, network and communications technology, image compression performance, Optical Character and Intelligent Character Recognition (OCR/ICR), multi-media databases and more besides.

Hoskyns meanwhile, see the storage of voice alongside that of text, graphics and image as being a further development. Or as Andersen put it, in some ten years time, we will have moved from interfacing to integration. At which time, those filing cabinet suppliers really had better watch out while Porsche sales to IP suppliers can be expected to soar.

Contacts

Andersen Consulting: 071-438-5520
Applied Network Research: 081-947-2684
Hoskyns Group (Insight): 081-940-8070
NCC: 061-228-6333
PA Consulting Group: 071-730-9000

FRAME AND FERRITE ROD ANTENNAS

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

Words, Words . . .

'Antenna' or 'aerial'? For many years, I supported the British 'aerial' (until my arms got tired), but I am now convinced that the international standards authorities preference for the American usage of 'antenna', and the plural form 'antennas', is correct. The Oxford English Dictionaries are inconsistent in this latter respect. The Concise gives only the Latin form 'antennæ', while the Shorter explains fully that life forms have 'antennæ' while radio equipment has 'antennas'. So does this mean that miniature radio transmitters intended for secret surveillance, being 'bugs', have 'antennæ'?

A frame antenna is a coil of wire wound on a frame of insulating material, usually rectangular and with side dimensions between about 150mm and 2m (although much larger coils are sometimes installed, e.g. on the end-wall of a house).

The term 'rod antenna', unfortunately, is used both for a thin, vertical antenna (which we are not concerned with here) *and* for a coil of wire mounted on a rod of ferrite material. To distinguish them, we can say 'ferrite rod antenna'. In pocket radios, the rod may be no more than 75mm long, but some early transistor portables used 20mm diameter rods, 200mm long, to obtain as good a signal-to-noise ratio as possible.

Old Technology

Often there isn't much point in going back to look at the original designs of circuits for valves (or 'tubes'), because modern design methods, even when applied to valves (as currently in vogue for 'high quid-elity' [quid – get it?]), are generally better and simpler. But this is not always the case for passive-component circuitry. It isn't that modern methods may not be better, but because the circuit techniques have fallen out of favour for non-technical reasons (such as fashion), and modern methods have never been applied. Recently, while studying the EMC potential of audio frequency induction loop systems, my attention was directed to the articles listed in the Bibliography, and it seemed high time that the subject received a new airing.

Changes in Radio Broadcasting

Until quite recently the BBC, for social reasons, had been for many years wasting valuable spectrum space by duplicating the Radio 2, 3 and 4 programmes on AM (LF and MF) and FM (VHF). (LF – 'low frequency' – and MF – 'medium frequency' – replaced 'Long Wave' and 'Medium Wave' in techno-speak some time ago. Rather earlier, the opposite change, from 'VHF' to 'FM' had been made by the BBC!) This resulted in a 'chicken and egg' situation with regard to the spread of FM receivers. The public had no incentive to buy these while the programmes were available on AM, while the BBC considered that it could not stop the duplication until there were enough FM receivers in use! Finally, it was agreed that duplication should stop, but we still have, amongst other things, Radio 4 duplicated when there isn't a war on. In fact, the pre-emption of Radio 4 FM for continuous news on the Gulf War may well be a forerunner of more channel-splitting in future (hopefully not for war reports!). We also have the new programme Radio 5 on MF, although very few people are reported to be listening to it; Radio 3 is more popular by comparison. Also people would like to be able to listen to their local radio station even when away (not too far away) from its service area. The trend is clear; good reception of AM broadcasts will be increasingly in demand in the future.

LF and MF Reception Problems

There are four main problems that affect AM reception: inadequate and variable signal strength (the latter often accompanied by distortion of the modulation), interference from other stations and interference from electrical equipment. All of these problems can be reduced or even effectively eliminated by the use of a frame or rod antenna instead of the bit of damp string often supplied with hi-fi receivers and tuners with AM facilities, or a frame antenna with a receiver having a built-in rod antenna of mediocre performance. A properly installed, high external antenna is likely to be better still, particularly if used with matching transformers and a screened downlead, but too few are equipped to accommodate one these days.

Sensitivity and AGC

The sensitivity of the receiver may be inadequate, so that stations at medium distance are overly weak and noisy. The only remedy for this is to increase the effective signal strength presented to the receiver, and we shall describe an intriguing way of doing this a bit later. The Automatic Gain Control (AGC) may be inadequate, causing a loss of signal when fading due to multipath reception occurs. Nowadays multipath reception is mostly regarded as an FM and TV problem, but it occurs at LF and MF too, mostly during the night. What happens is that the 'sky wave', reflected from the ionosphere, and the 'ground wave' from the transmitter arrive at the receiver together. If they happen to be in phase coincidence, they add up, but if they are in phase-opposition, they subtract and tend to cancel out. Since the height of the ionosphere varies, the sky wave path length, and therefore the sky wave phase at the receiver, varies. This causes the signal strength to fluctuate, which is called 'fading'. Fading can also occur if two sky waves are received (this happens on short wave, 'HF' in new-speak, and at long distances from the transmitter), and the phase may depend so much on frequency that the carrier and sidebands of the signal are affected differently, thus leading to distortion in the received modulation. This is called 'selective fading'.

Increasing the average signal strength can allow an otherwise overstrained AGC circuit to reduce the audible effect of fading, and a non-vertical frame antenna may provide some discrimination against sky wave signals, but usually requires continual adjustment to be effective. Still, it's better than watching TV!

Interference from Other Stations

This is basically caused by inadequacies in the receiver (except where one of the, now few, stations not operating within the ITU Plan is concerned). The selectivity (sharpness of tuning) may be insufficient, allowing energy from transmissions on adjacent channels to cause interference in the form of whistles (due to beats between carrier frequencies) or 'monkey chatter' (frequency-inverted audio derived from adjacent channel sidebands). Alternatively, or additionally, the linearity of the receiver may be inadequate; strong unwanted stations may break through on the image frequency (wanted frequency plus twice the IF), or by cross-modulation, and/or will cause whistles. To some extent, superhet technology contributes to this problem, since it leads designers to provide nearly all the selectivity at the intermediate frequency (which is easy and cheap to do, particularly if a ceramic block filter is used) and to neglect front-end selectivity, which is indispensable in eliminating some forms of interference, particularly image. Even quite inexpensive receivers in the late 1930s included a tuned band-pass filter at the antenna input. Bring back the 3-gang tuning capacitor (or matched triplets of varicap diodes)!

A frame or rod antenna can help to overcome these problems, partly because it is directional. Figure 1 shows what may by now be a familiar shape: the directional response of a frame or rod antenna is the same as that of a velocity microphone and a hearing aid 'telecoil'. So a correctly-aimed antenna can greatly reduce the effective signal strength of potentially interfering stations which happen to lie in a direction approximately at right-angles to that of the wanted station. What may not be so obvious is that, provided a small loss of the *wanted* signal strength is accepted, the limitation of 'approximately at right-angles' can be relaxed to 'not within 60° of the wanted signal direction'. To take advantage of this, the procedure is to turn the frame or rod until the interference is weakest, not until the wanted signal is strongest.

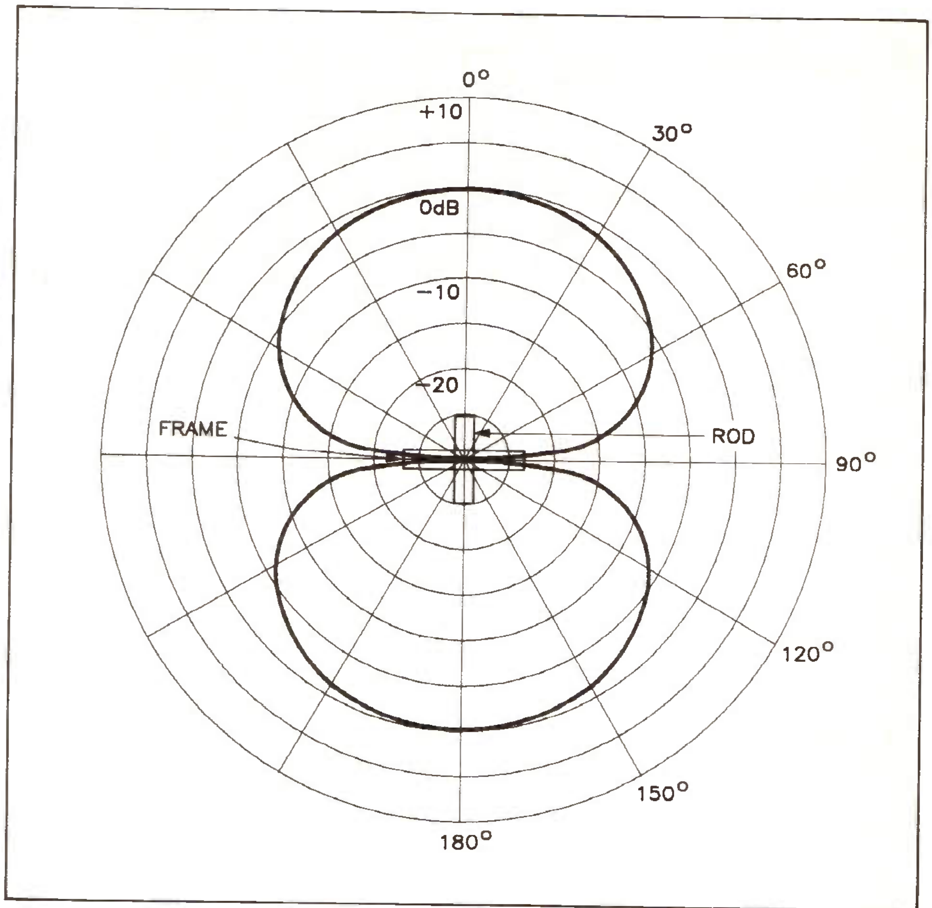


Figure 1. Directional response of a frame or ferrite rod antenna.

Interference from Electrical Equipment

Any piece of electrical equipment which includes switch contacts produces some radiated electrical noise, which may be from the body of the equipment and/or sent along the mains wiring, which can reradiate it at a distance. Electronic equipment which uses signals with fast transients (i.e. most digital equipment) also emits r.f. noise. These emissions can be reduced but complete elimination is not practicable.

At a far distant point from the source of noise, the electric and magnetic field strengths, E (volts per metre) and H (amps per metre) are related in value:

$$E/H = Z_0 = 377\Omega,$$

where Z_0 is called the impedance of free space. However, close to the source, while there still is a relation between the E and H values, it becomes very complex, and it is usually better to regard the magnetic and electric fields as independent. What does

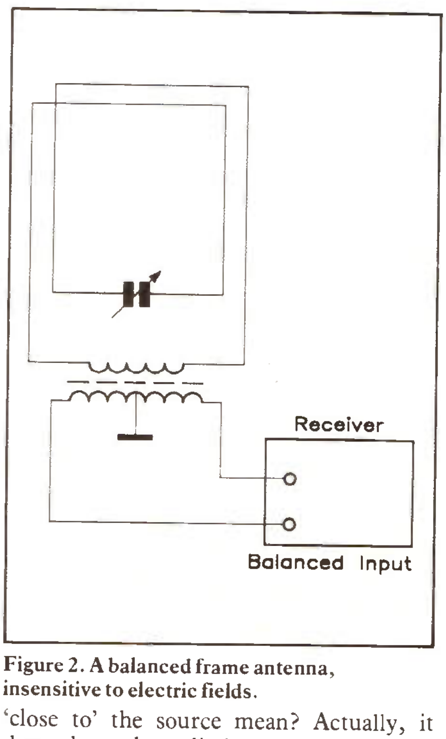


Figure 2. A balanced frame antenna, insensitive to electric fields.

'close to' the source mean? Actually, it depends on the radiating characteristics of the source, but is also related to the wavelength of the radiation as a 'scale factor', and may be taken as approximately limited by the 'critical distance' d_c metres:

$$d_c = \lambda/2\pi = c/2\pi f,$$

where λ is the wavelength in metres and f is the frequency of the radiation in hertz, c being the speed of light in metres per second. The critical distance is quite large at LF, being 241m at 1515kHz, the Radio 4 frequency.

Beyond the critical distance, the radiated field strength from most equipment is, luckily, too small to cause a serious problem. Within the critical distance, most equipment produces more electric noise than magnetic noise. (Audio frequency induction loop systems are a notable exception, in the rare cases of maladjustment when they produce any detectable noise at all!). Ordinary open-wire antennas are far more responsive to electric fields than to magnetic fields, whereas properly-designed frame and ferrite rod antennas are very unresponsive to electric fields. Hence they are much less sensitive to radiated noise from equipment than wire antennas are. Rod antennas are insensitive to electric fields because of the small linear dimensions of the coil: only a very small voltage appears across the coil. Frame antennas can be made insensitive to electric fields by using a balanced circuit configuration (Figure 2), where the electrical centre of the coil is earthed so that the voltages induced by the electric field in the vertical limbs of the coil are rejected as common-mode signals, and/or by screening the coil with a metal tube or a cage of wires (Faraday screen) so that the electric field strength close to the coil is much reduced, as shown in Figure 3.

Passive Amplifier

A frame antenna can help to overcome the inadequate sensitivity, AGC and

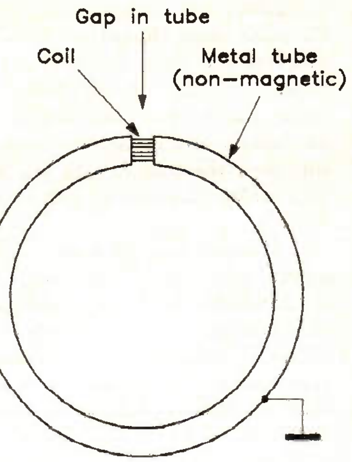


Figure 3a. A frame antenna screened with a metal tube.

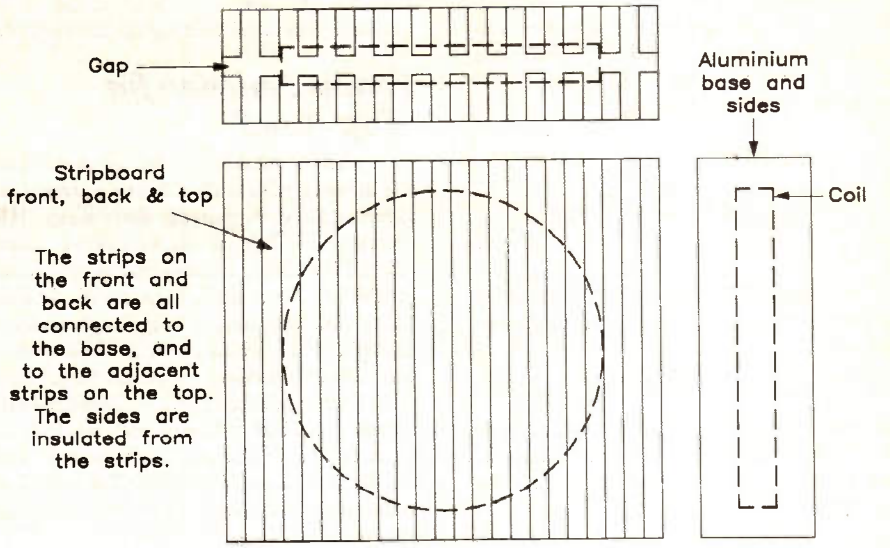


Figure 3b. A frame antenna screened with a cage of wires.

selectivity exhibited by a receiver fitted with a built-in ferrite rod antenna. No connection is needed between the antenna and the receiver, and the antenna needs no power supply. Since, nevertheless, it increases the signal strength presented to the receiver, it can reasonably be called a passive amplifier (with more justification than a 'pot in a box' is called a 'passive preamplifier' by hi-fi minimalists).

This remarkable device is easy to make. You need a frame made of insulating material (hardboard, perhaps), about 250mm square and up to 400mm deep (if you want to cover the LF band as well as the MF). Even a strong cardboard box will do for a try out. Wind about 32 turns of 16/0·2 hook-up wire (e.g. FA26D), or preferably 32/0·2 power connection wire (e.g.XR32K) close-wound around the box for MF, or 160 turns for LF. Connect the ends of the winding to an air-dielectric variable capacitor, preferably FF39N, if you are rich, or one cannibalised from an old radio if you are not (Figure 4). Because of the high self-capacitance of a frame antenna, low-value tuning capacitors, such as FT78K, can only be used if both sections are connected in parallel. Used in this way,

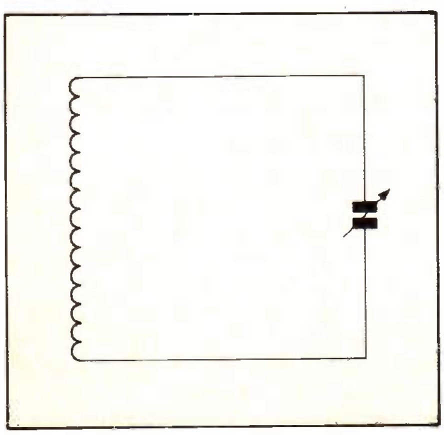


Figure 4. Circuit diagram of the passive amplifier.

FT78K gives a maximum capacitance of 200·8 pF, and needs more than 32 turns to tune to the low frequency end of the MF band. Really clever people will probably devise an electronically-synthesised capacitor, which would be cheaper than an air-spaced variable.

If you are prepared to accept a restricted tuning range on LF, i.e. you only want Radio 4 or one of the French pop-music stations, you can use 32 turns and connect a fixed capacitor (preferably polystyrene) in parallel with the variable one. You will need to adjust the value of the parallel capacitor, between approximately 1nF and 1·8nF, so that the wanted station comes within the tuning range. If you use 32/0·2 wire for the coil, you will also need to damp the circuit with a parallel resistor, 47 or 68kΩ, otherwise, as you will hear, the high-Q circuit will attenuate the sidebands too much and the sound will lack high frequencies (even more than usual).

To use the passive amplifier, tune the receiver to the wanted signal and turn it for maximum signal strength or minimum interference. Then line up the axis of the frame antenna with that of the ferrite rod in the receiver, and stand it about 15cm away. Now tune the antenna for maximum signal, and enjoy the music! If you put the frame too close to the receiver, it will detune the ferrite rod (not permanently!) and you will lose signal instead of gaining. You will find, if you tune to an apparently quiet place on the MF band during the day, that in fact there are several stations there which will become audible as you tune the frame antenna, and perhaps more if you turn the receiver and frame to point in a different direction.

The gain in signal strength produced inside the passive amplifier coil is approximately equal to the Q of the tuned circuit, which for a sample of the above design, wound on a low-loss Maplin cardboard box, measured 160 at 1MHz and 108 at 210kHz, using 1·5nF and 68kΩ across the tuning capacitor. It should be noted that these gains, 46dB and 41dB respectively, are somewhat higher than those produced at 150mm separation, by a factor that depends on the dimensions of the coil, and that even with 68kΩ damping, the bandwidth at 210/108 = 1·94kHz, which explains the sideband-cutting!

Designing a Frame Antenna

This could be a big subject, because there are many factors which might be included in the design criteria, and choices could be made as to which characteristics to optimise. It can be shown, for example, that in country districts where man-made interference is low, and especially during daylight hours in winter, the optimum size of a frame is 2 to 3 metres square, and it could be attached to a wall, either inside or outside the house, if you happen to have one facing in the right direction.

However, today we will keep to smaller frames. For a frame coil similar to that used in the passive amplifier, the required number of turns can be found as follows. The required inductance L is given by:

$$L = 1/\{4\pi^2 f^2 (C + C_s)\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1),$$

where f is the lowest frequency required to tune (531kHz for MF), C is the maximum value of the tuning capacitor (365pF for FF39N) and C_s is the self-capacitance of the frame coil, plus some stray capacitance.

The next step is to choose a convenient size for the frame. Assuming that the frame is a metre square, the value of C_s may be taken roughly as (60a + 20)pF, and the inductance is given by:

$$L = (\mu_0/\pi) \times 2an^2 \ln(2a/d),$$

where μ_0 is the permeability of space (0·4π μHm^{-1}), n is the number of turns and d is the depth of the single-layer winding (more or less independent of the thickness of the wire and the spacing of the turns). To save you the bother of looking up the natural logarithms (which are 2·3 times bigger than ordinary logarithms to base 10), here is a table of rounded values of ln(2a/d) for values of a/d from 1 to 10:

a/d	ln(2a/d)
1	0·7
2	1·4
4	2·1
10	3·0

We can simplify the equation a bit more by putting in the numerical value of $2\mu_o/\pi$, giving:

$$L = 1{\cdot}84an^2 \ln(2a/d)\ \text{MICROhenrys} \quad \ldots (2)$$

However, we need the number of turns n, which will give us the inductance L calculated from equation (1). So we rearrange (2) to give:

$$n = \sqrt{[L/\{1{\cdot}84a \ln(2a/d)\}]},$$

which is the number of turns we need.

It is possible to go further into what wire gauge to use, but this is rather complex. Using PVC insulated wire spaces the turns apart, which gives a higher Q factor, and the Qs obtained with 16/0·2 and 32/0·2 flexible wire are so high that there is no point in considering expensive Litz wire or even solid wire, which requires a very strong frame to withstand the winding tension.

Frame Antenna for a Hi-Fi (or not) Tuner

It is perfectly possible, and quite convenient, to use the passive amplifier as the frame antenna for a tuner. To do this, the tuner must have antenna and earth connectors, which may be in the form of a 2-contact socket similar to, but not the same as, the socket which goes with HH16S. What you do is to make a tapping on the frame coil at the exact centre (i.e. at the middle of turn 16 for a 32 turn coil), and taps at 2, 4, 6 and 8 turns from the centre (multiply by 5 for the 160-turn coil). The best way to do this is to use wire-strippers BR94C or BR95D, to cut only through the insulation of the wire, and to bare about 3mm, to which a piece of coaxial cable (up to about 3m long) can be soldered. Initially, solder the braid to the centre tap, and put an insulated croc-clip on the inner. To begin with, clip this onto the tap at 4 turns. At the other end, the braid goes to the earth terminal and the inner to the antenna terminal. You tune the tuner to the wanted station and then tune the antenna. Then you adjust the tap position up or down from 4 turns until you get the maximum (loudest) signal (or the maximum reading on the signal strength meter) without damping or detuning the antenna so much that interference or noise increases. You may have to retune the antenna when you move the tapping. If the tuner uses bottom-capacitance coupling for the antenna, instead of an input transformer, you might have to tap the coil at less than 2 turns for best results. The use of coaxial cable for the connection to the receiver prevents the cable acting as an antenna itself, and picking up interference.

Frame Antenna for 'Top-Band'

There is no reason why you should not get good results with a frame antenna for amateur radio or general short wave (HF) reception. While it is, of course, quite correct for Gavin Cheeseman to say, in his article in the previous issue on the Maplin 160m receiver, that a long, high outdoor antenna and a good earth are the best, a frame antenna could be much better than an indoor wire antenna and a doubtful earth connection. For this you will need rather more than half as many turns as you need for the MF band, but half the fun is finding out exactly how many, and where to tap the feeder in!

Low Impedance Frame Antenna

If you have a communications receiver with a 50 or 75Ω antenna input and, like me, you haven't built the Maplin ATU (LM06G) yet, you can experiment with a low impedance frame. I have been using the 500mm square single turn that I made for calibrating AFILS field strength meters (see Issue 43), without the series resistor, of course! This will tune up on my ancient RA17L receiver (not a Maplin code!), even at 27MHz, and seems to work quite well, although without an ATU I can't compare it with a long-wire antenna, of course.

Ferrite Rods

The earliest known magnets were lumps of rock, called 'lodestones', containing the mineral magnetite, which is an oxide of iron (Fe_3O_4) in which the iron atoms occupy two different positions in the crystal structure. But for the development of the petrol engine, this oxide would still be familiar as the bluish-grey 'smithy scale' which appears on hot horseshoes. Magnetite obviously has permanent magnet properties, and was magnetised by the Earth's magnetic field as it cooled from whatever high temperature it was subjected to in the depths of the Earth's crust. Different samples vary greatly in strength, and research has shown that this was due to the presence of other metals, replacing iron atoms at one of the two sites in the crystals. The chemical name for these compounds is 'ferrites', indeed magnetite is itself 'ferrous ferrite'($FeFe_2O_4$). It was eventually found that very good permanent magnets could be made by replacing some of the iron by the metal barium. This is done by strongly heating and compressing a mixture of the oxides. The result is the type of ferrite used so widely for loudspeaker magnets. It is far cheaper than the metal alloys, such as Alnico and Ticonal, which were formerly used.

The chemists also found that soft magnetic materials (i.e. materials that are magnetic but do not form permanent magnets, like soft iron) could be made by replacing part of the iron with other metals, such as manganese, and mixtures of manganese or nickel with zinc. These materials were found to have excellent properties at radio frequencies, with low losses and high permeability, and are cheaper to produce, mechanically stronger and less variable in their properties than the iron dust materials which had been used previously (from the mid 1930s to the late 1940s).

Manganese ferrites have 'square' hysteresis loops, and are used for pulse transformers and in components for switched-mode power supplies and CRT magnetic deflection. Manganese-zinc ferrites have the highest permeability (but far short of those of nickel-iron alloys such as Mumetal) and are used for pot cores for inductors. Nickel-zinc ferrites, which usually contain a proprietary mixture of other trace metals, are used at radio frequencies, up to about 200MHz. Ferrite rods (to get to the point) for antennas are usually made of these materials, which come in a variety of grades with different properties. Microwave ferrites are another subject, which we won't go into here.

Permeability

Permeability is a measure of how easy it is for a magnetic field to create magnetic flux in the material, and is the ratio of magnetic flux density B (expressed in tesla, symbol T) to magnetic field strength H (Am^{-1}). This is called 'absolute permeability', and we have already met the absolute permeability of space, $\mu_o = 0{\cdot}126\ \mu Hm^{-1}$. We are more often interested in how much easier it is for a material to be magnetised than for space. This is 'relative permeability', and we shall mostly be dealing with this.

A note on CGS Units

Some magnetic data is still given in units belonging to the centimetre-gram-second electromagnetic system. In this system the unit of magnetic field strength is the oersted (symbol Oe), and it is a big unit. 1 oersted is $1000/4\pi = 79{\cdot}6\ Am^{-1}$. On the contrary, the unit of magnetic flux density, the gauss (Gs), is very small. $1Gs = 100\ \mu T$. In this context, 'big' and 'small' relate to practical values, which, in electronics, are typically $1\ Am^{-1}$ and 10T.

Permeabilities of Ferrite Rings

Having decided to deal with relative permeabilities, we now find we have to consider another set of variations. If we have a ferrite material in the form of a ring (toroid, from 'torus', an anchor ring, not Taurus, the bull), and pass a current through a coil wound on it, magnetic flux is created in the ring, and its density can be measured. This can be done, for example, by using alternating current of a known frequency and measuring the voltage across the coil for a given current; this would allow us to calculate the impedance and inductance, but the magnetic flux density is easy to calculate from the voltage directly:

$B = V/(2\pi fAn)$,

where V is the voltage, f is the frequency, A is the area of cross-section of the ring and n is the number of turns in the coil. The magnetic field strength is:

$H = In/(2\pi r)$,

where I is the current and r is the average radius of the ring, so that:

$\mu_a = B/H = Vr/(fAn^2I)$

This gives the absolute permeability μ_a, and to get the relative permeability μ_r, we just divide by μ_o:

$\mu_r = Vr/(fAn^2I\mu^o)$

If we use a very small current, the value of μ_r that we measure is called the 'initial permeability' μ_i. As we increase the current, the permeability is found first to increase and then to decrease, eventually reaching 1, at which point the material is said to be 'fully saturated' with magnetic flux. The maximum measured value of permeability is naturally called 'maximum permeability', μ_{max}. Typical values for initial permeability, range from 20 for a ferrite suitable for use at 180MHz to 5000 for one usable up to 1MHz. The maximum permeability is typically 1·5 to 3 times the initial value. For ferrite rod receiving antennas, the current is so small that the initial permeability is the one that counts. This may well not apply to pot cores in miniature IF transformers, for example, where currents of the order of 100mA or more may flow in tuned coils.

Points to Watch Out For

There are a few points about ferrites that can catch you out if you do not know about them, and they are not too well known. First, some grades of 'soft' ferrite which are usable up to VHF can become permanently magnetised, which ruins them. Some other grades, which do not retain appreciable permanent magnetisation, nevertheless suffer permanent change if strongly magnetised. Since this information is often not published, ferrite rods should always be kept away from, for example, loudspeaker magnets. The third point is that some grades of ferrite conduct electricity quite well, while others are good insulators. You need to be particularly careful about ferrite beads, which may cause short-circuits if it is not realised that they are, or may be, conductors.

Permeabilities of Ferrite Rods

When we come to rods, we have to deal with yet two more varieties of permeability. Firstly, if we put the rod into a uniform magnetic field it concentrates the field within itself (Figure 5), and the amount of concentration is called 'rod permeability'. It depends on both the initial permeability

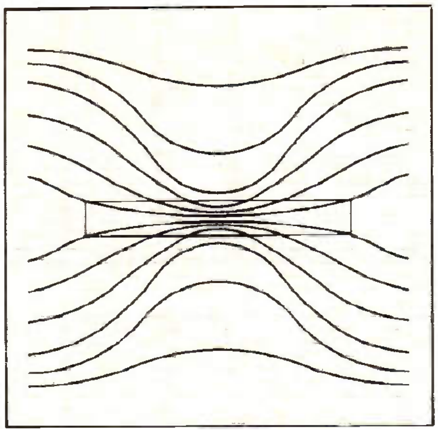


Figure 5. Concentration of the magnetic field by a ferrite rod.

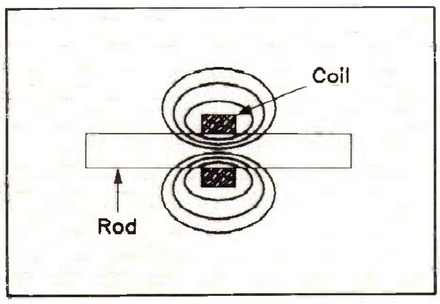


Figure 6. Flux paths round a coil on a ferrite rod.

and the ratio of the length to diameter of the rod. For the Maplin rods YG20W and YG22Y, the rod permeability is about 75, assuming that the initial permeability is about 200. This means that the flux density inside the rod is about 75 times stronger than it would be without the rod, so that the rod is equivalent to a frame of 75 times the area of cross-section of the rod, or approximately 0·013 m^2. Since quite a small frame (about 1 foot square) would have an area of 0·1 m^2, you can see that it will pick up about eight times as much signal as a rod (18dB more). Nevertheless, rods do pick up enough signal for everyday use.

The other sort of permeability we need to consider is that which is called 'apparent permeability', but is often more clearly termed 'coil permeability', and is a measure of how much the rod increases the inductance of a coil wound on it. Figure 6 shows the flux distribution round such a coil, and it can be seen that the coil permeability depends somewhat on the initial permeability, but most of the flux path is in air. The coil permeability is much less than the rod permeability. In fact, it depends mostly on the ratio of length to diameter of the coil, and the position of the coil on the rod. This is why the inductance of a rod antenna coil can be set by sliding it along the rod. Typically, the coil permeability is 10 to 14 for a coil on the centre of a rod, falling to 6 to 9 if the coil is at one end.

Coils for Ferrite Rod Antennas

By far the simplest construction is a single-layer coil wound on an insulating tube slightly larger than the rod diameter. The diameter affects the Q slightly, but not enough to matter. Traditionally, Litz wire has been used for LF and MF coils, resulting in a very high Q, too high to preserve the sidebands due to high modulation frequencies ('high' in this context being 4kHz, remembering that most transmissions are limited to 4·5kHz modulation frequency to avoid adjacent-channel interference). Solid wire is therefore usable, and 24 to 34 SWG can give useful values of Q. Enamel-covered wire does not give the highest Q if close-wound, so a spaced winding may be preferable. Winding a coil for LF is beyond most home-constructors who do not have a coil-winder (too many turns), but for the MF and HF bands, it is not too difficult.

Ferrite Rods at VHF

This has always been one of those developments that never quite seems to have 'made it'. The broadcast receiver industry was offered suitable ferrites in the early 1960s, but no simple way of using them was found. In 1977, the BBC Research Department produced a design, but again there was no take-up. One of the problems is that the ferrite rod antenna may be distinctly less sensitive than a dipole, or even the usual telescopic rod fitted to FM broadcast receivers. Another is (again!) that three tuned circuits are needed, and 3-gang variable capacitors are very expensive 'specials', while the use of varicap diodes really implies *four* tuned circuits (because of the lower Q offered by the diodes), which adds even more cost to the feature. However, the use of a ferrite rod antenna for portable VHF equipment, instead of the popular 'duck', might well be worth looking at if suitable VHF-grade ferrite rods can be obtained. At least the coils are easy to wind! It should be noted that for horizontally-polarised transmissions, the axis of the rod should be vertical, and it then, of course, is omnidirectional in the horizontal plane.

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A lot more detailed information (some of it perhaps too detailed!) may be found in the following:

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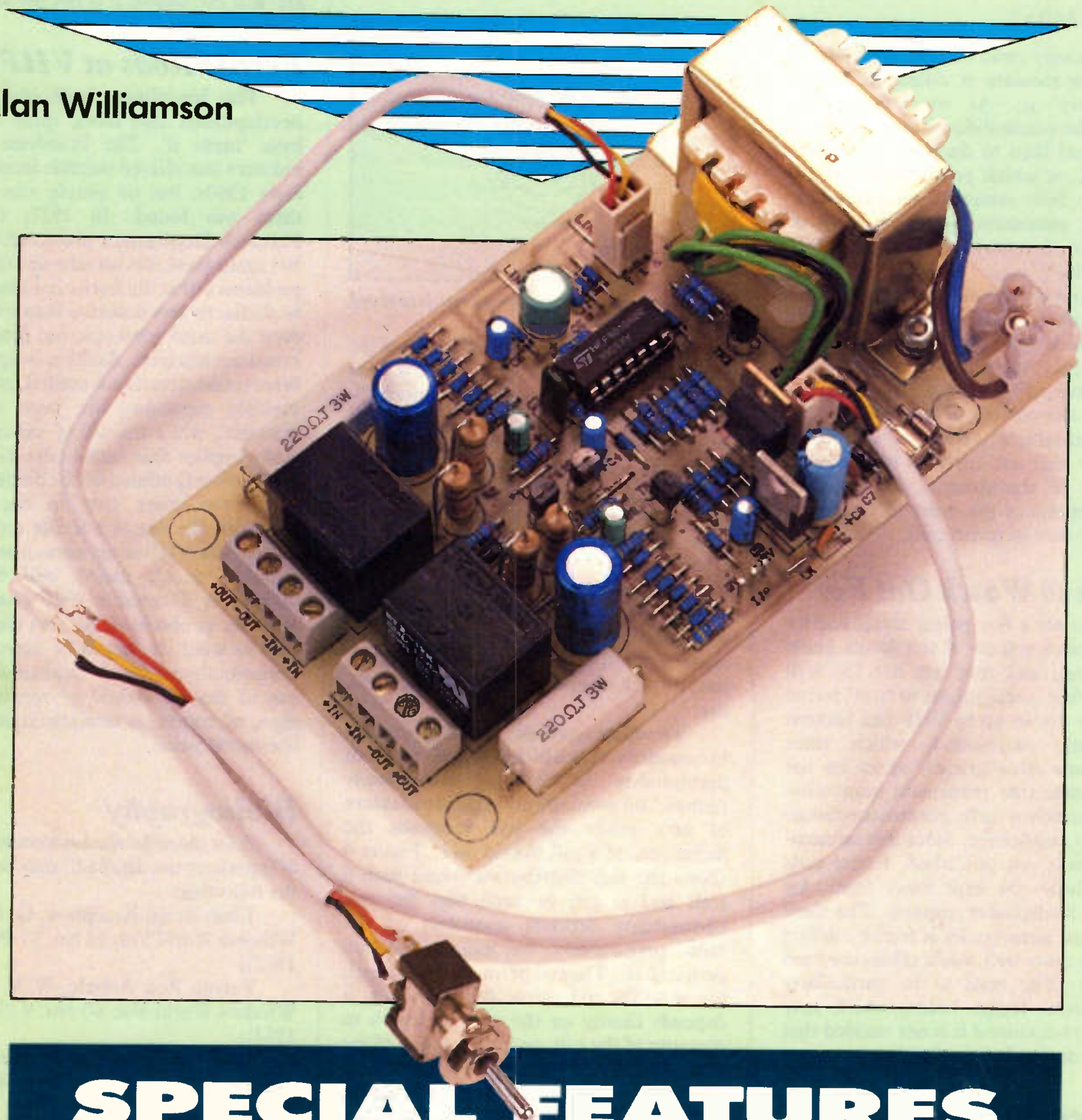
A Band II Ferrite Aerial Unit for Portable Receivers, R.D.C. Thoday, BBC Research Report RD1977/11.

AMPLIFIER MONITOR

by Alan Williamson



SPECIAL FEATURES

- ★ Prevents switch-on and switch off transients
- ★ Protects loudspeakers against amplifier and power supply faults
- ★ Self resetting or manual reset modes of operation
- ★ Can be used with mono or stereo amplifiers

Prototype Specification

Mains power supply:	240V AC 50Hz
Supply current:	34mA max.
Monitor input voltage:	±50V max.
Monitor input trip voltage:	±3V min.
Signal requirements to trip	
Input frequency	
C1 and C101 = 10μF:	<8Hz
C1 and C101 = 33μF:	<2·5Hz
Pulse width at 4Vpk	
C1 and C101 = 10μF	>70ms
C1 and C101 = 33μF	>200ms
Output current from −12V:	75mA max.

Introduction

The Amplifier Monitor described here provides loudspeaker protection against such 'nasties' as d.c. offsets. This can (and does!) occur when amplifiers and their associated power supplies go faulty. The circuit is, however, not intended to protect loudspeakers from being over-driven, we'll leave this up to your ears to decide if this occurs.

The circuit is intended to protect d.c. coupled loudspeakers — such as bass and mid-range units. Generally tweeters do not require this type of protection as the majority of these are a.c. coupled by a capacitor in the crossover unit.

The Amplifier Monitor also provides a time delay at switch-on, during which the loudspeakers are 'disconnected' from the amplifier by means of relays, this allows the power supply to stabilise and allows the amplifier output capacitor(s) (if fitted) to charge. At switch-off, the relays immediately 'drop-outs'. Thus the Amplifier Monitor prevents those nasty 'bangs, pops and thuds' at switch-on and switch-off, which otherwise might damage your delicate and expensive loudspeakers.

The Amplifier Monitor is suitable for use with amplifiers having symmetrical or asymmetrical power supplies up to ±50V or +100V, see note*. The Amplifier Monitor also has the facility for adding an external trigger circuit, e.g. a temperature monitor circuit, giving complete protection for both amplifier and loudspeakers. Such a circuit will be published in the next monthly issue of 'Electronics'.

If you wish to use this Amplifier Monitor for PA use, you may find that the monitor will promptly drop out when a 'miked-up' drum kit is struck, to overcome this, replace the 10μF capacitors with 33μF capacitors of the same type (stock code JH33L), enough room has been allowed on the PCB.

Circuit Description

The circuit described below is based around a hex schmitt-trigger inverter package.

Some components have been duplicated to allow the Amplifier Monitor to be used with a stereo amplifier, these components are numbered 1XX (e.g. R101). The

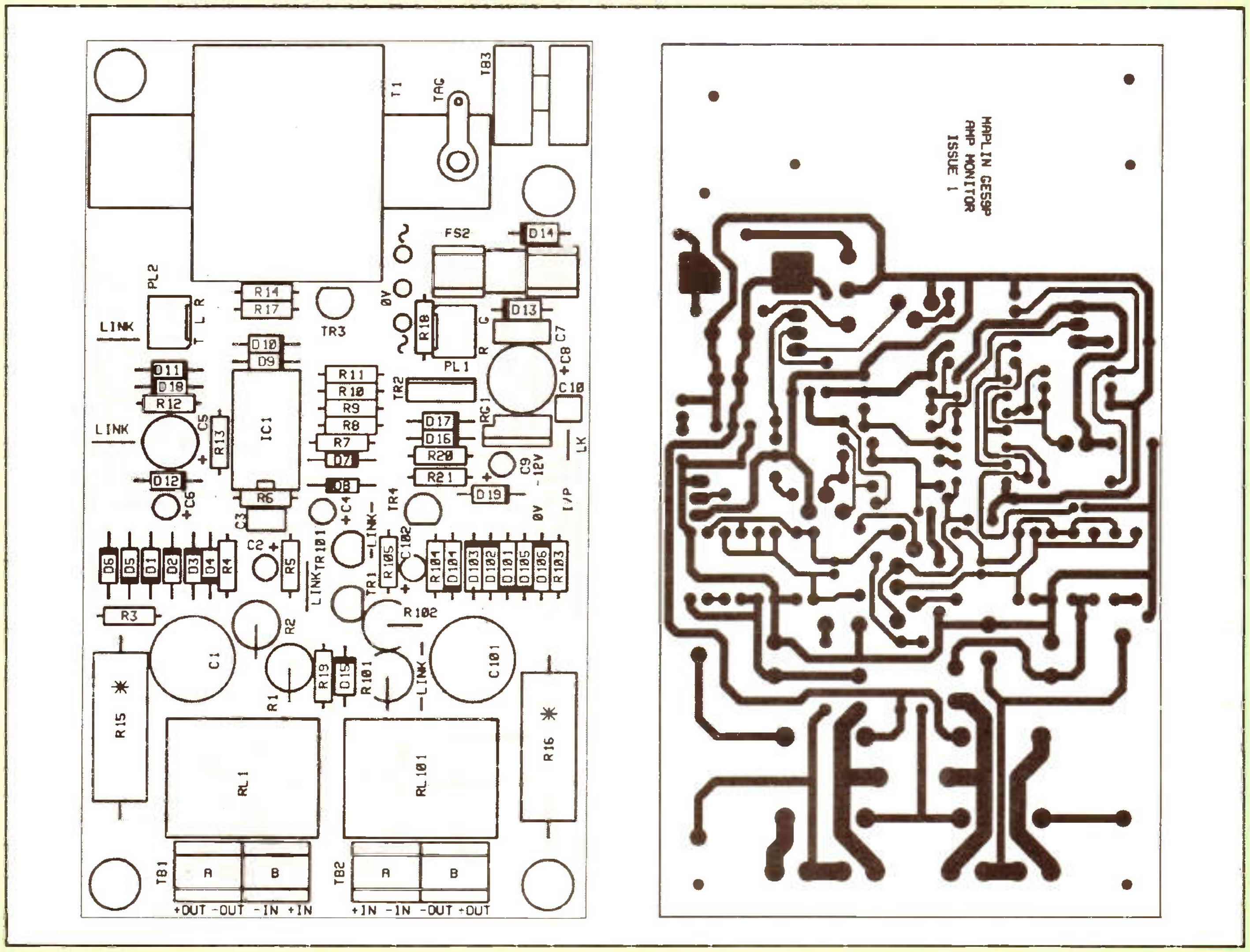


Figure 1. PCB legend and track.

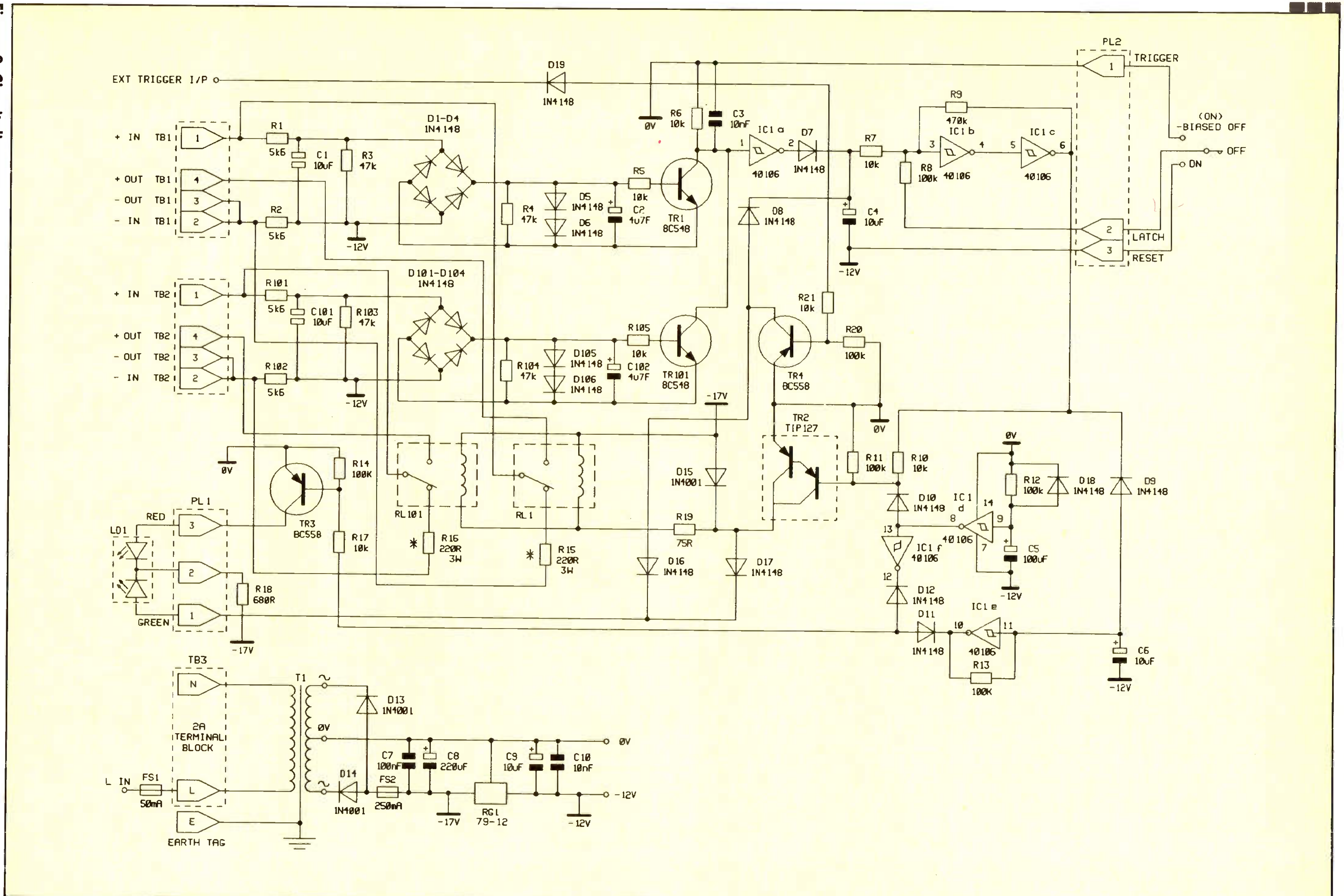


Figure 2. Circuit diagram.

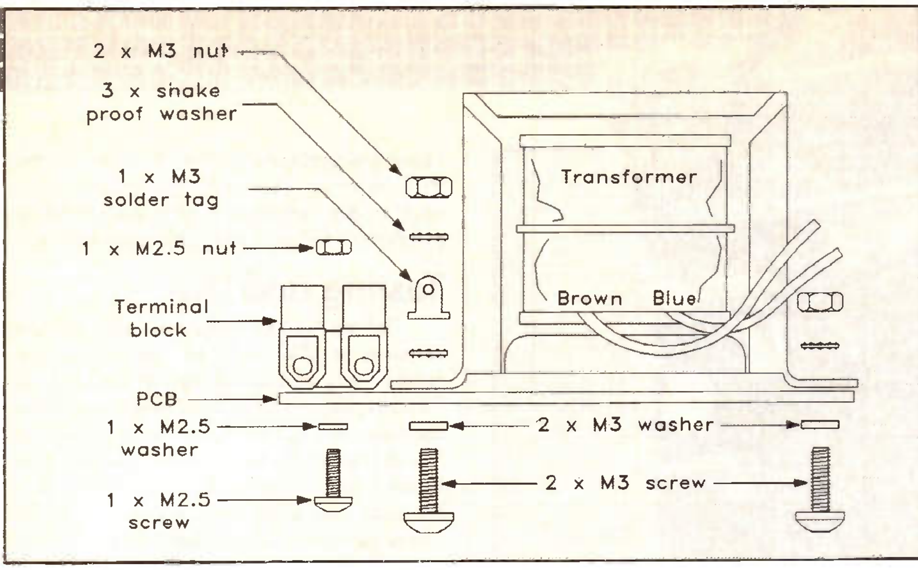


Figure 3. Transformer and terminal block mounting details.

use of two input stages prevents any possible interaction between the two channels being monitored.

Referring to Figure 2, the signal from the amplifier is monitored by filtering out any a.c. component above 10Hz, and rectifying the remainder. R1-R3 and C1 are the filtering components, diodes D1-D4 form the rectifier. Diodes D5 and D6 limit the offset voltage across R5 to a maximum of 0·6V (1·2V −0·6V = 0·6V), there is also 1·2V dropped across D1-D4, the rest of the voltage is dropped across R1 and R2.

Capacitor C2 provides the required smoothing for TR1, which is used as a voltage level shifter, making the circuit much more sensitive to d.c. offsets. Capacitor C3, ensures that the circuit starts with the correct logic state at the input of IC1a by generating a reset pulse when power is applied to the circuit. Diode D7 prevents IC1a from resetting the latch circuit once triggered, the latch is formed by IC1b and IC1c.

Switch S1, connected to the input of the latch circuit has three positions ON, OFF, (ON). Assuming that the latch has been triggered (relays de-energised and loudspeakers 'disconnected'); with S1 in the ON position, the switch will reset the latch; with S1 in the OFF position, the switch will not reset the latch, i.e. it remains latched; and with S1 in the (ON) position, the latch is triggered and the loudspeakers disconnected.

IC1d is used as a timer which feeds a jamming voltage to the base of TR2, thus preventing the relays from being energised at switch-on and providing the time delay of approximately 10 seconds. While IC1d is 'timing out', TR3 is turned on via IC1f, D12 and R17, illuminating the red half of LD1. IC1e is used as an oscillator, diode D9 and IC1c disable the oscillator when the latch is in the logic low state, when the latch is in the logic high state, diode D9 is reverse biased and the oscillator is then allowed to run causing the red half of LD1 to flash; this indicates a fault condition. The green half of LD1 illuminates continuously only when the relays have operated.

Construction

The kit contains all the components required to build the project. A Constructors' Guide is also provided in the kit for those of you who are beginners, the Guide contains some useful information on component identification and constructional techniques.

To assist construction a high quality glass-fibre PCB, which has solder resist on the track side and a silk screened legend on the component side, is supplied.

Note:* If your amplifier has an asymmetrical power supply (+V and 0V only), it will also have an output capacitor; resistors R15 and R16 should therefore be fitted, but if your amplifier has a symmetrical supply (+V, 0V and −V) then R15 and R16 should NOT be fitted.

Begin construction by giving each

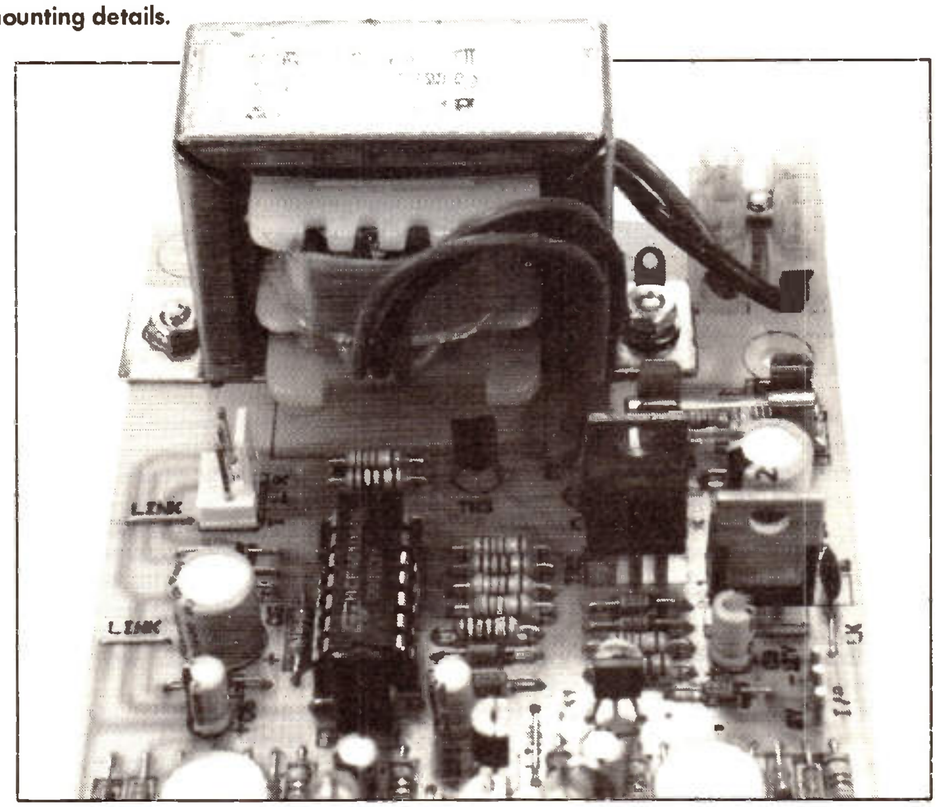
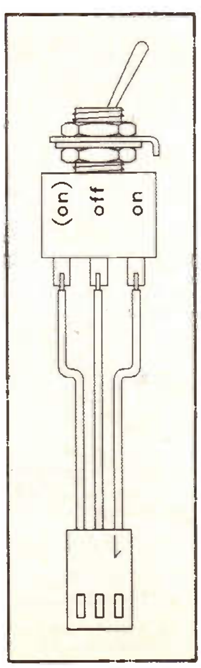
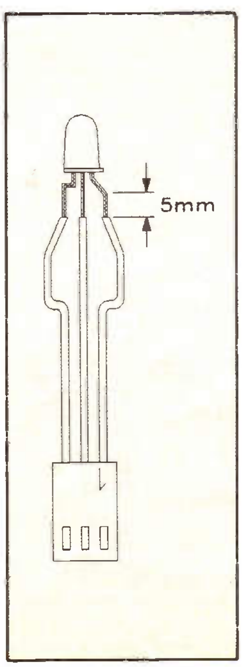


Photo 2. Close-up of transformer wiring.





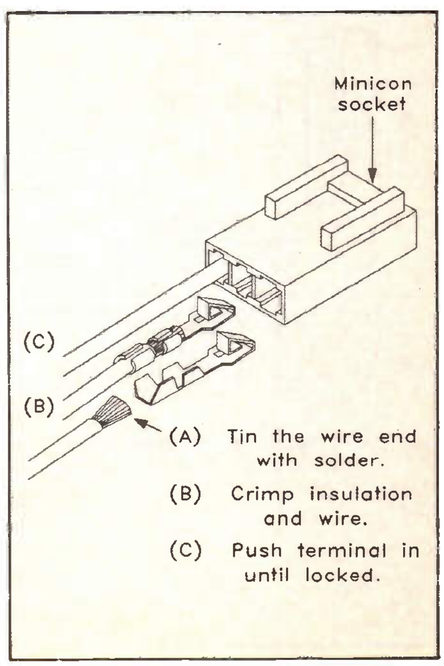
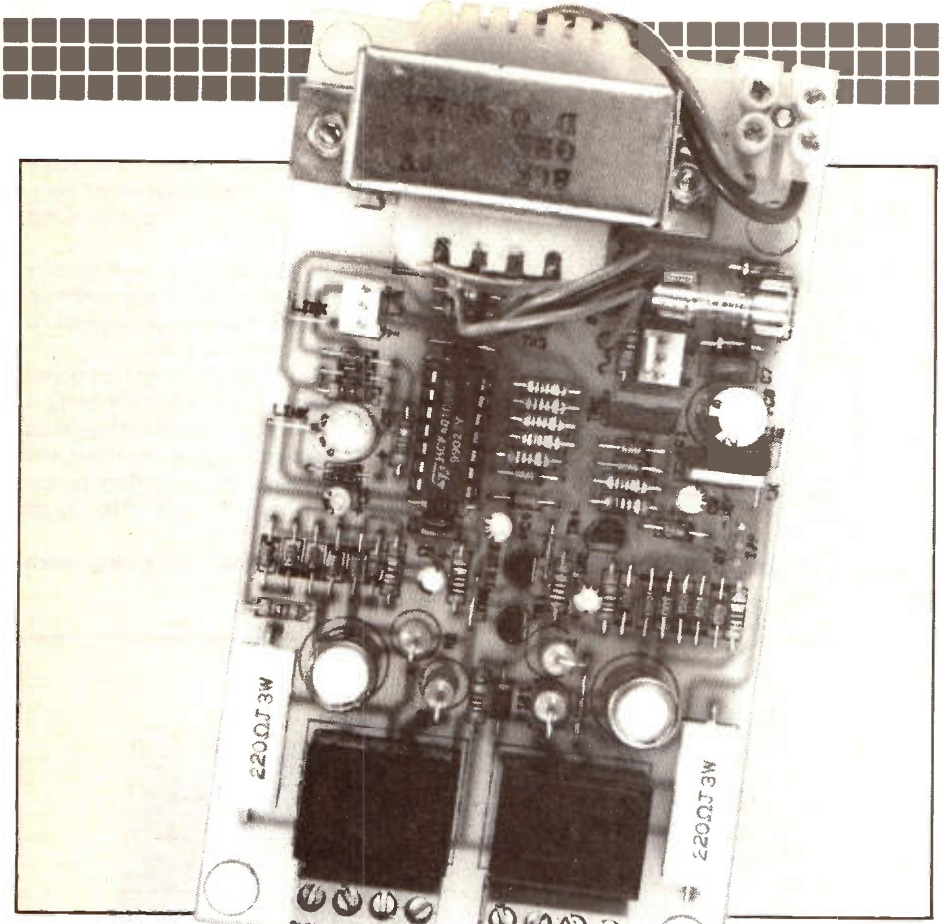


Figure 4. Switch wiring. Figure 5. LED wiring. Figure 6. Minicon assembly.



Complete PCB.

component lead a thorough clean, removing all traces of tarnish. Start by fitting the smallest components first, working up in size to the largest, use the component lead offcuts for the links. Avoid over-heating the semiconductors, the electrolytic capacitors and diodes (except C1 and C101 which are nonpolarised devices) must be correctly orientated for proper operation of the circuit, check and re-check that each component is correctly fitted before soldering — there are a lot of diodes in this kit and it's all too easy to make a mistake. The PCB pins are fitted from the track side, you may wish to fit the optional minicon connector instead.

Figure 3 shows the transformer and terminal block mounting details. Figures 4, 5 and 6 show the switch, the LED and the minicon connector wiring respectively.

There are two tracks on the PCB which are free of solder resist, these areas should be 'built-up' by heavily tinning with solder; this is to increase the current rating of the tracks.

After completing the PCB, clean off all traces of flux residue using a suitable solvent (PCB cleaner YJ45Y or Ultraclene LH03D). Having now cleaned-off all the flux from the PCB, re-check the soldering for dry joints and solder whiskers which could cause premature failure or reliability problems.

Testing and Use

Before testing can begin, the module requires a 240 volt AC mains supply, temporarily connect a mains lead with a 13 amp plug (fitted with a 2 amp fuse) to the module, connect the fuse holder with insulating boot in the live line (not forgetting to fit the fuse into the holder). The wiring must be safe, please be very careful! Double-check for your own health's sake that you cannot touch any part of the mains wiring accidentally or otherwise, before plugging into a 13 amp socket.

For testing purposes you will need a wire link and a >3V supply — a PP3 battery would suffice.

Apply power to the module, the tri-colour LED will immediately illuminate continuous red, this shows that the module is 'timing out'. After a short period, approximately 10 seconds, the LED will change from red to continuous green, at the same time a click will be heard indicating that the relays have operated.

The first test is to check that the switch is operating correctly, move the switch toggle into the biased-off (ON) position and hold for two seconds; the relays will de-energise and the LED will flash red. Let the switch toggle return to the centre OFF position, there should be no change. Now move the switch to the ON (latching) position, the module will then reset after two seconds re-energising the relays and illuminating the LED green, leave the switch in the ON position for the rest of the tests.

Second test, apply your battery to the speaker input terminals, the relays will de-energise and the LED will flash red. Remove the battery, allow the module to

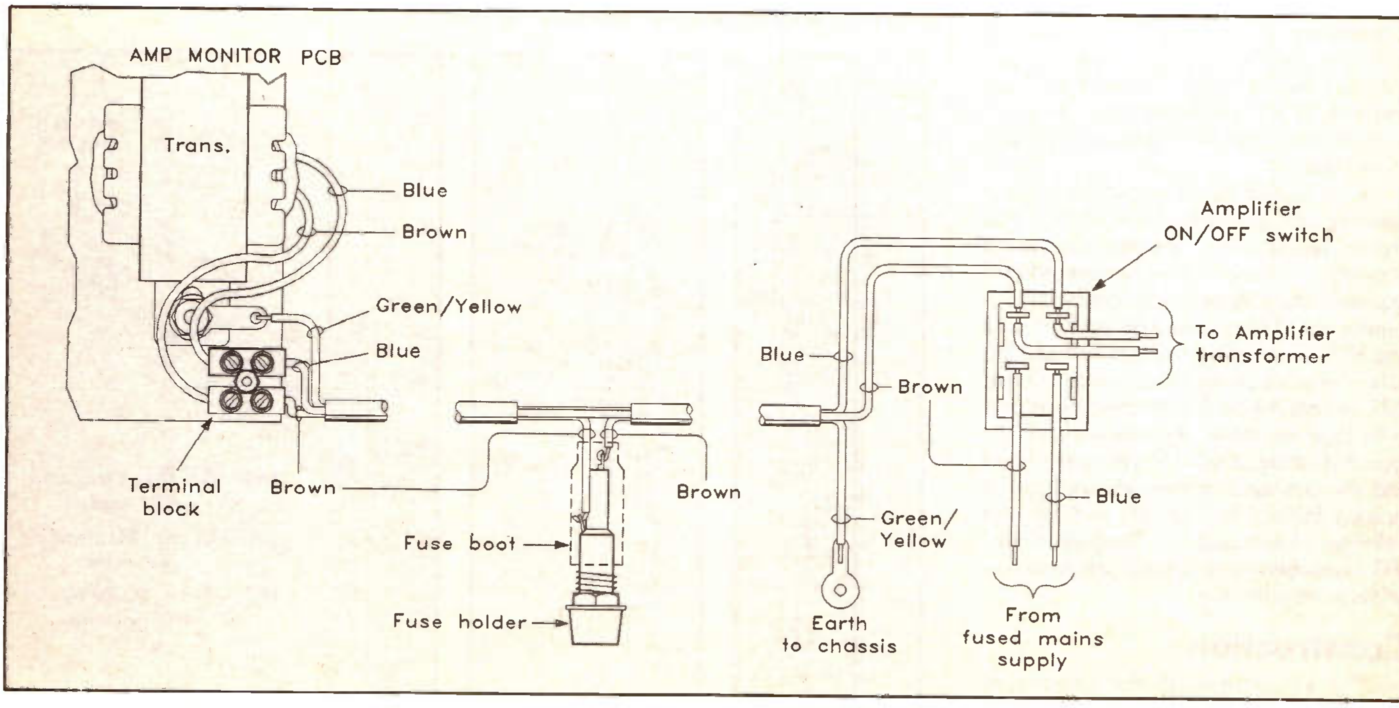


Figure 7. Mains wiring.

reset, reconnect the battery with the opposite polarity, this will test all the diodes in the bridge (D1-D4 and D101-D104).

Third test, connect a wire link between the external trigger input and −12V, the relays will de-energise once again and the LED will flash red/green, remove the wire link. Please note that if the switch is in the centre OFF position, and the wire link is removed the LED will change from flashing red/green to flashing red showing that there was a fault condition.

Last test, allow the module to reset (continuous green LED), use a multimeter set on the lowest resistance/continuity range and check that there is a connection between +IN and +OUT on each relay.

If your module fails to do any of the above, check that you have not fitted a BC548 in place of a BC558 or vice versa, or inserted a diode/electrolytic capacitor the wrong way round.

When the module has been tested and found to be operating correctly; it can be fitted into your amplifier, see Figure 7 for the mains wiring details and Figure 8 for the speaker wiring.

You may also wish to solder the speaker leads directly to the PCB track to minimise the number of connections, Figure 8 shows an alternative speaker wiring for minimum signal degradation.

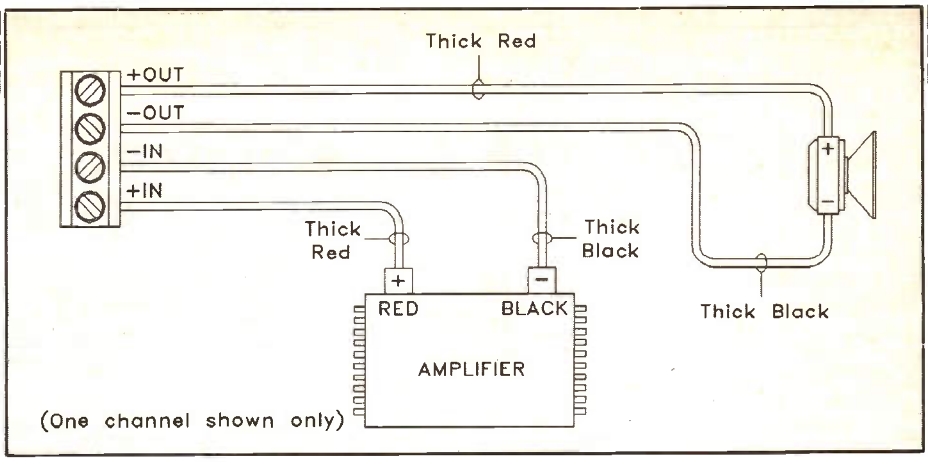


Figure 8. Speaker wiring.

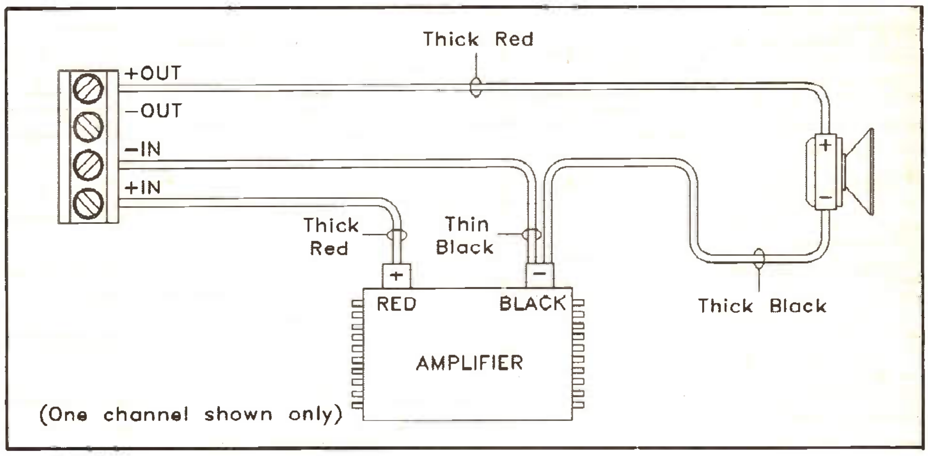


Figure 9. Alternative speaker wiring.

AMPLIFIER MONITOR PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless specified)			
R1,2,101,102	5k6 1W Carbon Film	4	(C5K6)
R3,4,103,104	47k	4	(M47K)
R5,6,7,10,17,21,105	10k	7	(M10K)
R8,11,12,13,14,20	100k	6	(M100K)
R9	470k	1	(M470K)
R15,16	W/W Min 220Ω	2	(W220R)
R18	680Ω	1	(M680R)
R19	75Ω	1	(M75R)
CAPACITORS			
C1,101	10μF Reversolytic	2	(JH31J)
C2,102	4μ7F Minelect	2	(YY33L)
C3	10nF Mylar Film	1	(WW18U)
C4,6,9	10μF Minelect	3	(YY34M)
C5	100μF Minelect	1	(RA55K)
C7	100nF Ceramic	1	(BX03D)
C8	220μF 35V PC Elect	1	(JL22Y)
C10	10nF Ceramic	1	(BX00A)
SEMICONDUCTORS			
D1-12, 16-19, 101-106	1N4148	22	(QL80B)
D13,14,15	1N4001	3	(QL73Q)
LD1	Tri-colour LED	1	(YH75S)
TR1,101	BC548	2	(QB73Q)
TR2	TIP127	1	(WQ74R)
TR3,4	BC558	2	(QQ17T)
IC1	40106	1	(QW64U)
RG1	μA79M12UC	1	(WQ89W)
MISCELLANEOUS			
TB1a,1b,2a,2b	PCB Screw T/Block 2Way	4	(FT38R)
PL1,2	3 Way Minicon Plug	2	(BX96E)
RL1,2	12V/10A Min Relay SPST	2	(JM67X)
T1	Sub-Min Tr 15-0-15 (250mA)	1	(YN17T)
FS1	A/S 100mA Fuse 1¼in	1	(UK58N)
FS2	A/S 250mA Fuse	1	(RA06G)
S1	Sub-Min Toggle C	1	(FH02C)
	Fuse Clip	2	(WH49D)
	DIL Socket 14-Pin	1	(BL18U)

PCB Ltch Hsng 3-Way	2	(BX97F)
Minicon Terminals	1	(YW25C)
Terminal Block 2A	1	(FE78K)
Pins 2145	1 Pkt	(FL24B)
Isobolt M3 × 6mm	1 Pkt	(BF51F)
Isobolt M2·5 × 12mm	1 Pkt	(BF55K)
Steel Nut M3	1 Pkt	(JD61R)
Isoshake M3	1 Pkt	(BF44X)
Steel Washer M3	1 Pkt	(JD76H)
Steel Nut M2·5	1 Pkt	(JD62S)
Steel Washer M2·5	1 Pkt	(JD77J)
Isotag M3	1 Pkt	(LR64U)
4-Wire Burglar Cable	1 Mtr	(XR89W)
1¼in Clickcatch F/H	1	(FA39N)
Fuseholder Boot	1	(FT35Q)
PCB	1	(GE59P)
Constructors' Guide	1	(XH79L)
Instruction Leaflet	1	(XK41U)
OPTIONAL (Not in kit)		
M3 × 10mm Insulated Spacer	1 Pkt	(FS36P)
3 Way Minicon Plug	1	(BX96E)
3 Way Minicon Hsng.	1	(BX97F)
Min Mains Black	As Req	(XR01B)

The Maplin Get-You-Working Service is available for this project, see page 71 for details.
The above items are available as a kit (excluding Optional), which offers a saving over buying the parts separately.
Order As LP32K (Amplifier Monitor) Price £17.95
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 item (which is included in the kit) is also available separately, but is not shown in our 1992 Catalogue.
Amp Monitor PCB **Order As GE59P Price £3.95**

RESISTORS *in* SERIES *and* PARALLEL

by R. T. Irish

A method of obtaining that 'difficult to come by' resistor value.

Introduction

Nowadays, modern resistors are high-quality components and, providing they are correctly used, are both reliable and accurate. Unfortunately, it is this very accuracy which can turn out to be an embarrassment if a particularly unusual value of resistance is required in some critical part of a circuit. The following approach will enable any value of resistance to be achieved with a high degree of accuracy (certainly within 1%) from a maximum of three preferred-value components.

Method

1) Select the preferred value resistor which is the closest to the desired resistance. A table of preferred values, taken from the Maplin range of 0·6W Metal Film resistors is given in Table 1 to illustrate some of the points made and to provide a basis for a couple of typical examples. If the desired resistance is *higher* than the preferred value, then proceed to 2 below; if it is *lower*, then go to 3.

Preferred Values in Ω

1	10	100	1k0	10k	100k	1M
	11	110	1k1	11k	110k	
1·2	12	120	1k2	12k	120k	1M2
	13	130	1k3	13k	130k	
1·5	15	150	1k5	15k	150k	1M5
	16	160	1k6	16k	160k	
1·8	18	180	1k8	18k	180k	1M8
	20	200	2k0	20k	220k	
2·2	22	220	2k2	22k	220k	2M2
	24	240	2k4	24k	240k	
2·7	27	270	2k7	27k	270k	2M7
	30	300	3k0	30k	300k	
3·3	33	330	3k3	33k	330k	3M3
	36	360	3k6	36k	360k	
3·9	39	390	3k9	39k	390k	3M9
	43	430	4k3	43k	430k	
4·7	47	470	4k7	47k	470k	4M7
	51	510	5k1	51k	510k	
5·6	56	560	5k6	56k	560k	5M6
	62	620	6k2	62k	620k	
6·8	68	680	6k8	68k	680k	6M8
	75	750	7k5	75k	750k	
8·2	82	820	8k2	82k	820k	8M2
	91	910	9k1	91k	910k	
						10M

Table 1. 0·6W 1% Metal Film range.

2) Now select a resistance value from the preferred list which when connected in *series* will *just* take the total value *above* the desired value. For example, if it desired to make up a resistor of value 3425Ω, first select the nearest preferred value. This, from the table below, is 3300Ω. A preferred value resistor of 150Ω, connected in series will increase the total resistance to 3450Ω – just above the wanted 3425Ω, see Figure 1.

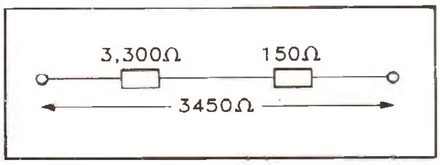


Figure 1

Now select the nearest preferred value of resistance, which when connected in *parallel* with the two resistors will reduce it to the wanted 3425Ω:

$(1 \div R_T) = (1 \div R_1) + (1 \div R_2)$

therefore:

$R_1 = (R_2 \times R_T) \div (R_2 - R_T)$

with $R_2 = 3450\Omega$ and $R_T = 3425\Omega$

$R_1 = 472{\cdot}6k\Omega$ (nearest preferred value 470kΩ)

A value of 470kΩ is therefore selected, see Figure 2.

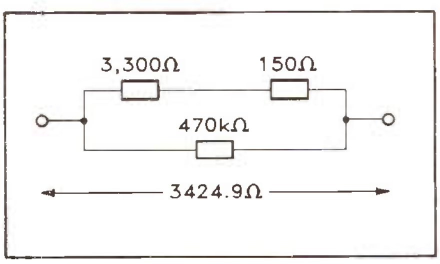


Figure 2

The result is an equivalent resistance of 3424·9Ω which should be near enough to the wanted value of 3425Ω for all conceivable practical purposes.

3) Now select a resistor from the preferred list which will, when it is connected in *parallel*, will just take the total value *below* the desired value. For example, if it is desired to make up a resistor of value 2633Ω, the nearest (higher) preferred value is 2700Ω. To reduce this to 2633Ω would require a *parallel* resistor of 106·1kΩ. The nearest, lower, preferred value is 100kΩ and the combination would then have a resistance of 2629Ω, see Figure 3.

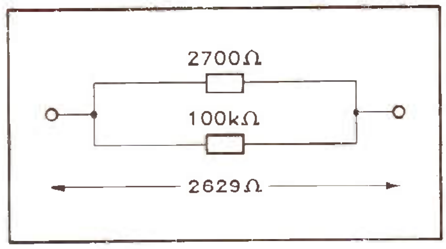


Figure 3

The series connection of 3·9Ω would bring this up to 2632·9Ω which is probably near enough to the desired 2633Ω, see Figure 4.

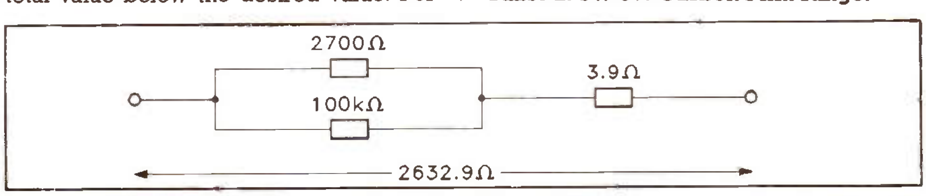


Figure 4

Note that the scope of the resistors shown below is quite wide and encompasses most of the values that would normally be needed in practice. However, other resistor types – perhaps of higher wattage – may not be available in such a range of values and this technique would then come into its own more frequently – the carbon film, 1W range of values is given in Table 2 to illustrate this point.

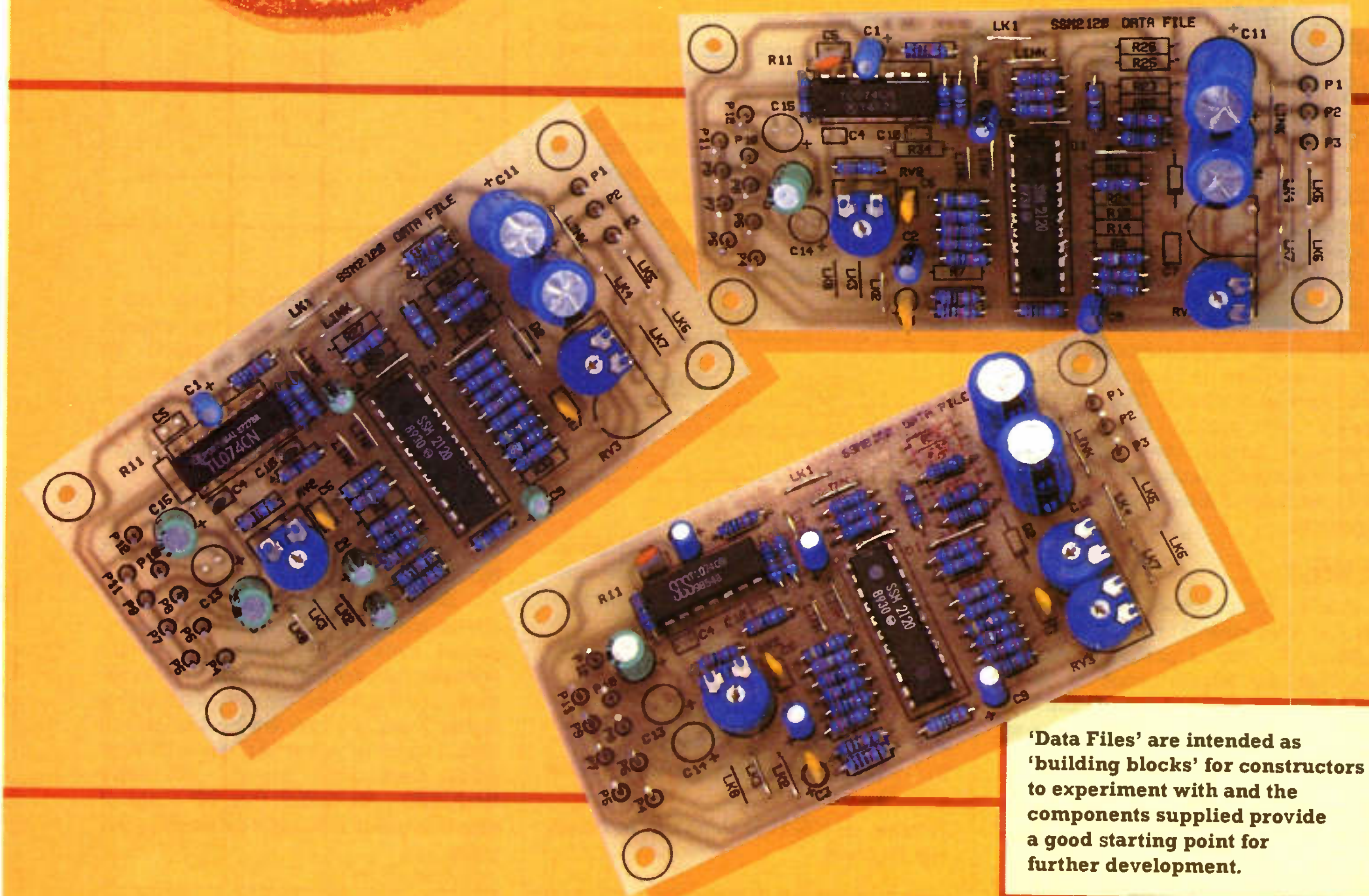
Preferred Values in Ω

10	100	1k0	10k	100k	1M	10M
12	120	1k2	12k	120k	1M2	
15	150	1k5	15k	150k	1M5	
18	180	1k8	18k	180k	1M8	
22	220	2k2	22k	220k	2M2	
27	270	2k7	27k	270k	2M7	
33	330	3k3	33k	330k	3M3	
39	390	3k9	39k	390k	3M9	
47	470	4k7	47k	470k	4M7	
56	560	5k6	56k	560k	5M6	
68	680	6k8	68k	680k	6M8	
82	820	8k2	82k	820k	8M2	

Table 2. 1W 5% Carbon Film range.

DATA FILE

SSM2120 DYNAMIC RANGE PROCESSOR



'Data Files' are intended as 'building blocks' for constructors to experiment with and the components supplied provide a good starting point for further development.

FEATURES

★ Wide supply voltage range ★ Low distortion ★ Low external parts count ★ Large VCA dynamic range ★ Kit available

APPLICATIONS

★ Compressors ★ Expanders ★ Limiters ★ AGC circuits ★ Voltage-controlled filters ★ Noise reduction systems ★ Stereo noise gates

Introduction to SSM2120

The SSM2120 is a versatile IC designed for the purpose of processing dynamic signals in various analogue systems including audio. This 'dynamic range processor' consists of two VCAs and two level detectors. These circuit blocks allow the user to logarithmically control the gain or attenuation of the signals presented to the level detectors depending on their magnitudes. This allows the compression, expansion or limiting of AC signals which are some of the primary applications for the SSM2120. The device will operate over a wide range of power supply voltages between ±5V and ±18V. Figure 1 shows the IC pin-out and Table 1 shows some typical electrical characteristics for the device. Figure 2 shows the IC block diagram.

Parameter	Conditions	Min.	Typ.	Max.
Supply voltage range				
Dual supply:		±3V	±15V	±18V
Single supply:		+6V	+30V	+36V
Supply current				
Positive:			8mA	10mA
Negative:			6mA	8mA
Level Detectors				
Dynamic range:		100dB	110dB	
Input current range:		30nA$_{P-P}$		3mA$_{P-P}$
Output offset voltage:			±0·5mV	±2mV
Frequency response				
I_{IN} = 1mA$_{P-P}$:			1MHz	
I_{IN} = 10μA$_{P-P}$:			50kHz	
I_{IN} = 1μA$_{P-P}$:			7·5kHz	
VCAs				
Frequency response:	Unity-gain or less			250kHz
Control feedthrough (trimmed):	R_{IN} = R_{OUT} = 36kΩ, A_V 0dB to −30dB		750μV	
Gain control range:	Unity-gain	−100dB		+40dB
THD (unity-gain):	+10dBV IN/OUT		0·005%	0·02%
Noise (20kHz bandwidth):	Ref: 0dBV		−80dB	

Table 1. Typical electrical characteristics.

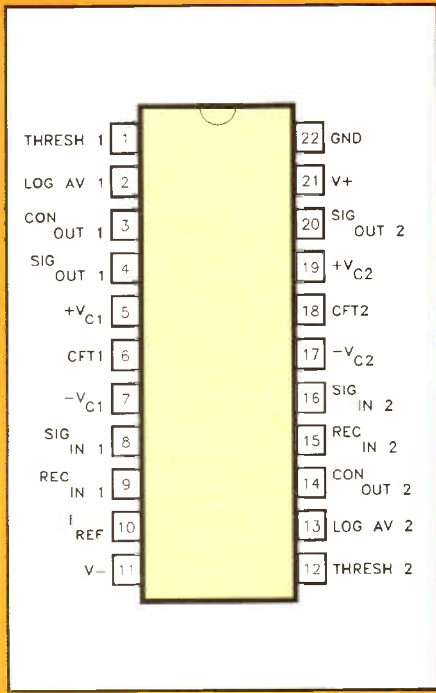


Figure 1. IC pinout.

IC Description

The SSM2120 effectively contains two duplicate parts; each with a level detector and a VCA.

Level Detector Circuit

Two independent level detection circuits are provided, each containing a wide dynamic range full-wave rectifier, logging circuit and a unipolar drive amplifier. These circuits will accurately detect the input signal level over a 100dB range from 30nA to 3mA peak-to-peak.

Level Detector Theory of Operation

Referring to the level detector block diagram of Figure 3, the REC_{IN} input is an AC virtual ground. The next block implements the full-wave rectification of the input current. This current is then fed into a logging transistor (TR1) whose pair transistor (TR2) has a fixed collector current of I_{REF}. With the use of the LOG AV capacitor, the output is then the log of the average of the absolute value of I_{IN}.

When applying signals to REC_{IN}, a blocking capacitor should be followed by an input series resistor since REC_{IN} has a DC offset of approximately 2·1V above ground. Choose R_{IN} for a ±1·5mA peak signal; for ±15V operation, this corresponds to a value of 10kΩ.

A 1·5MΩ value of R_{REF} from LOG AV to −15V will establish a 10μA reference current in the logging transistor, biasing the transistor in the middle of the detector's dynamic current range in dB to optimise dynamic range and accuracy. The LOG AV outputs are buffered and amplified by unipolar drive op-amps.

The attenuator from CON_{OUT} to the appropriate VCA control port establishes the control sensitivity. Use a 180Ω attenuator resistor to ground and choose R_{CON} for the desired sensitivity.

Voltage-Controlled Amplifiers

The two voltage-controlled amplifiers are full Class A current in/out devices with complementary dB/V gain control ports. The control sensitivities are +6mV/dB and

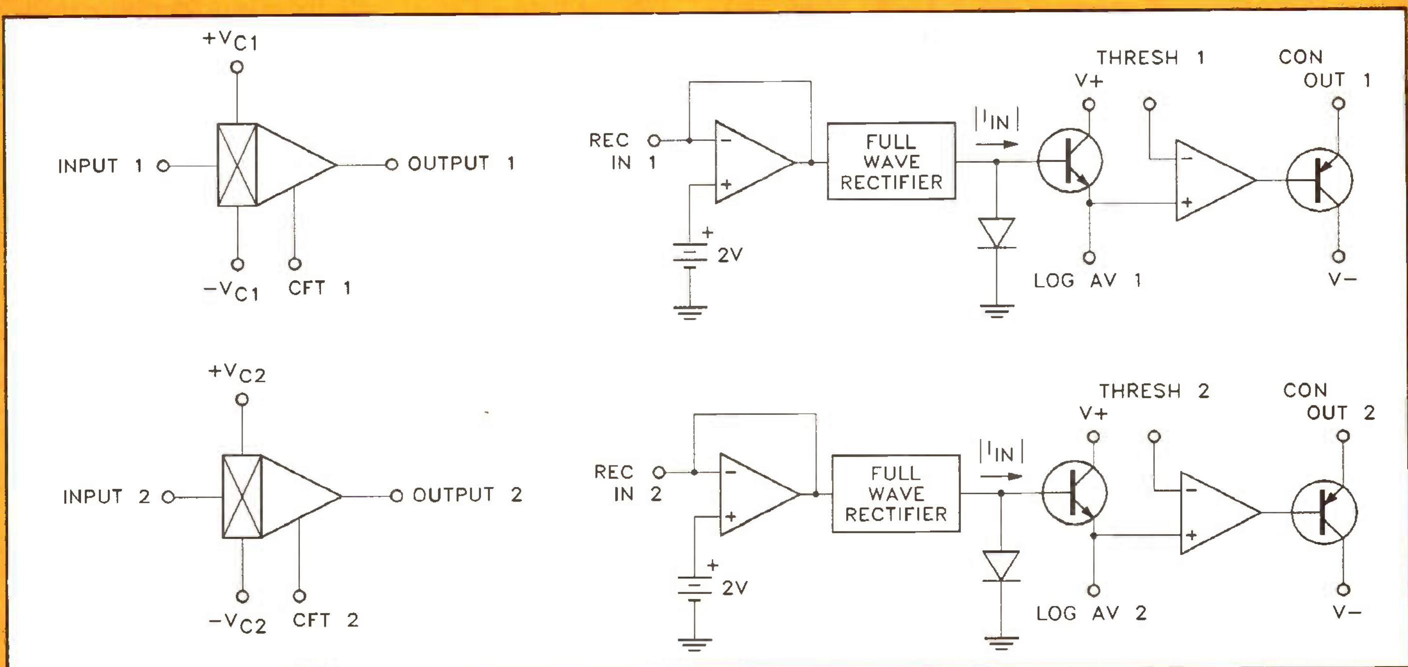


Figure 2. SSM2120 block diagram.

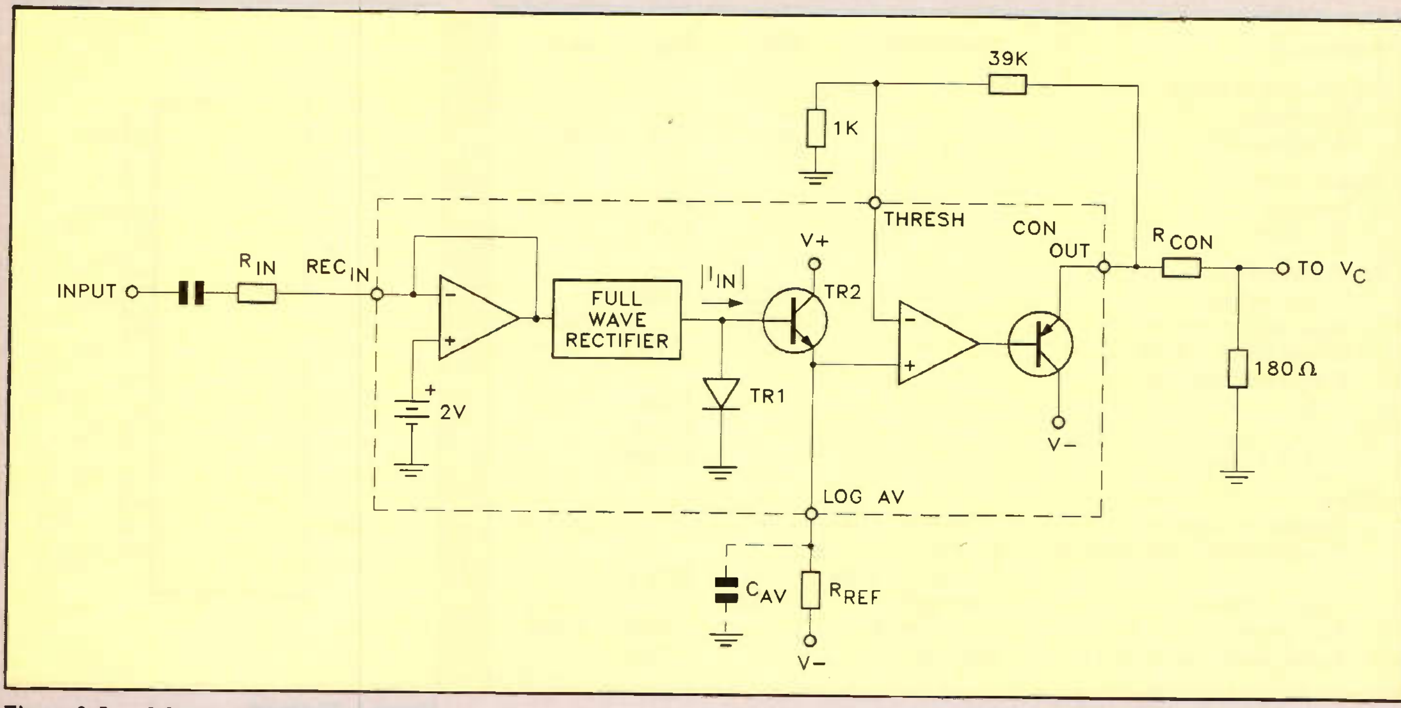


Figure 3. Level detector block diagram.

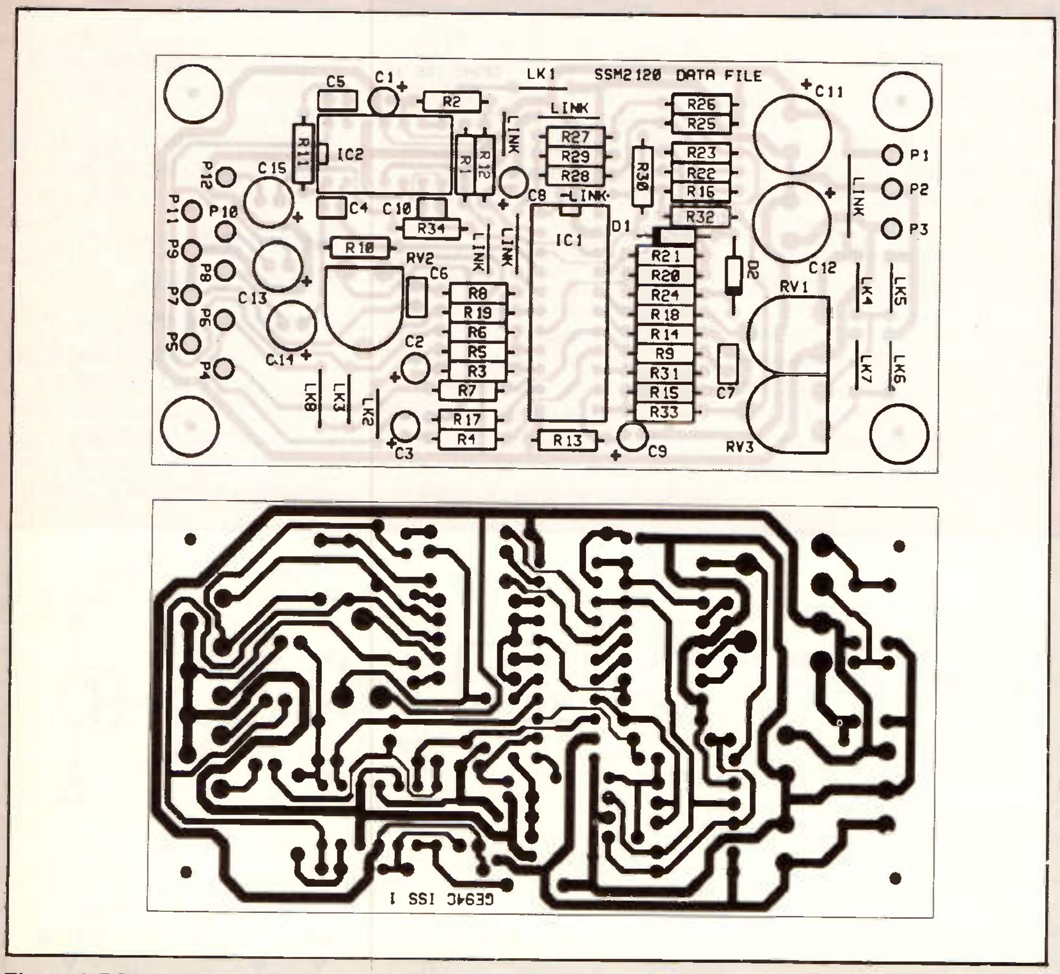


Figure 4. PCB legend and track.

−6mV/dB. A resistor divider is used to adapt the sensitivity of an external control voltage to the range of the control port.

The signal inputs behave as virtual grounds. The input current compliance range is determined by the current into the reference current pin. This current is set by connecting a resistor to V+. The current consumption of the VCAs is directly proportional to I_{REF}, which is nominally 200μA, giving input and output clip points of ±400μA. The device will operate at lower current levels, but with a reduced effective dynamic range.

The VCA outputs are designed to interface directly with the virtual ground inputs of external operational amplifiers configured as current-to-voltage converters. The power supplies and selected compliance range determines the values of input and output resistors required. Note that the signal path through the VCA, including the output current-to-voltage converter, is non-inverting.

Trimming the VCAs

The control feedthrough (CFT) pins are optional control feedthrough null points. CFT nulling is required in applications such as noise gating and downward expansion. Applications such as compressors/limiters typically do not require CFT trimming because the VCA operates at unity-gain, unless the signal is large enough to initiate gain reduction, in which case the signal masks control feedthrough. This trim is ineffective for voltage-controlled filter applications. If trimming is not used, leave the CFT pins open.

Kit Available

A kit of parts is available to build several application circuits using the SSM2120. The kit includes a high-quality fibreglass PCB with a screened printed legend to aid construction, see Figure 4. Figure 5 shows the circuit diagram used to produce this PCB. Note that, because the module may be used in many different applications, some of the component values supplied

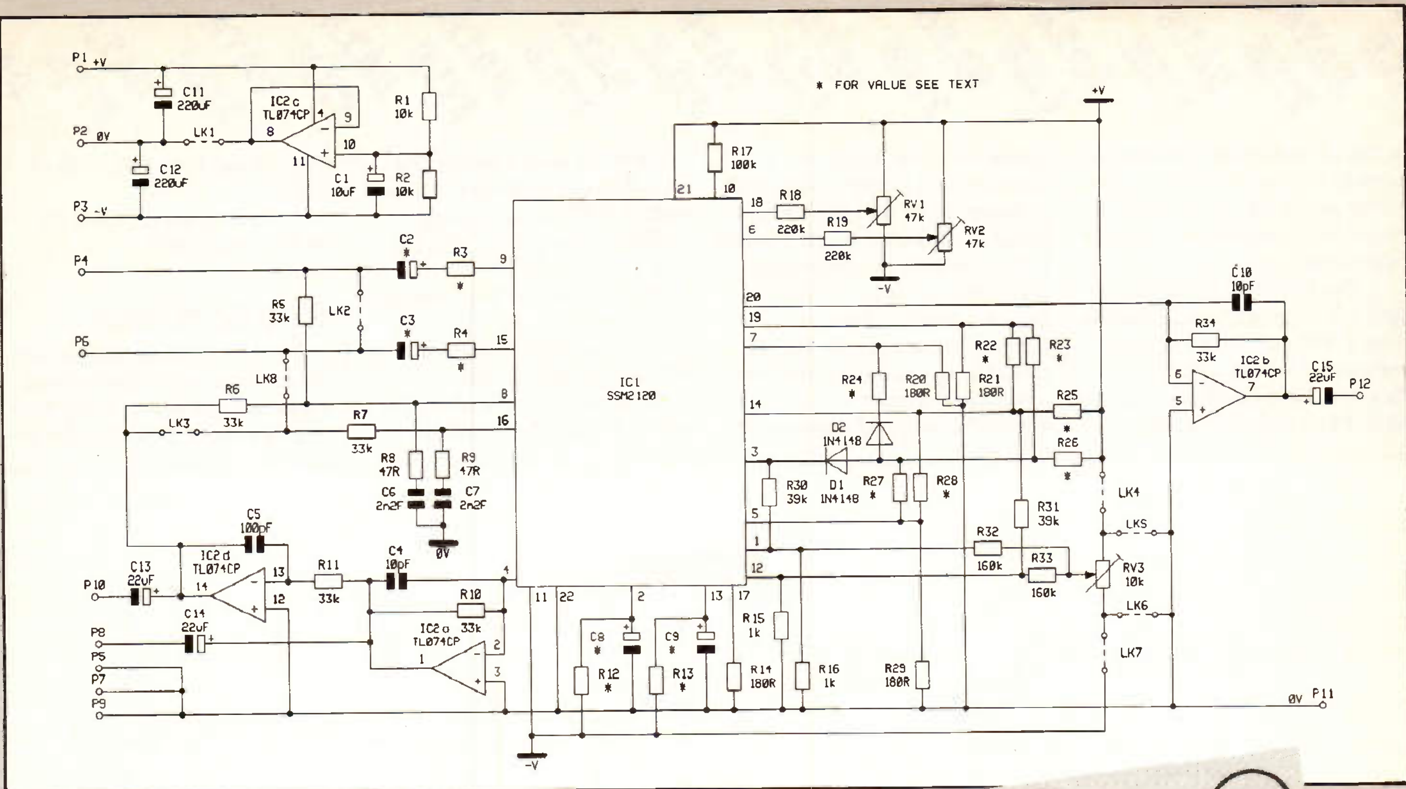


Figure 5. Circuit to which the PCB is designed.

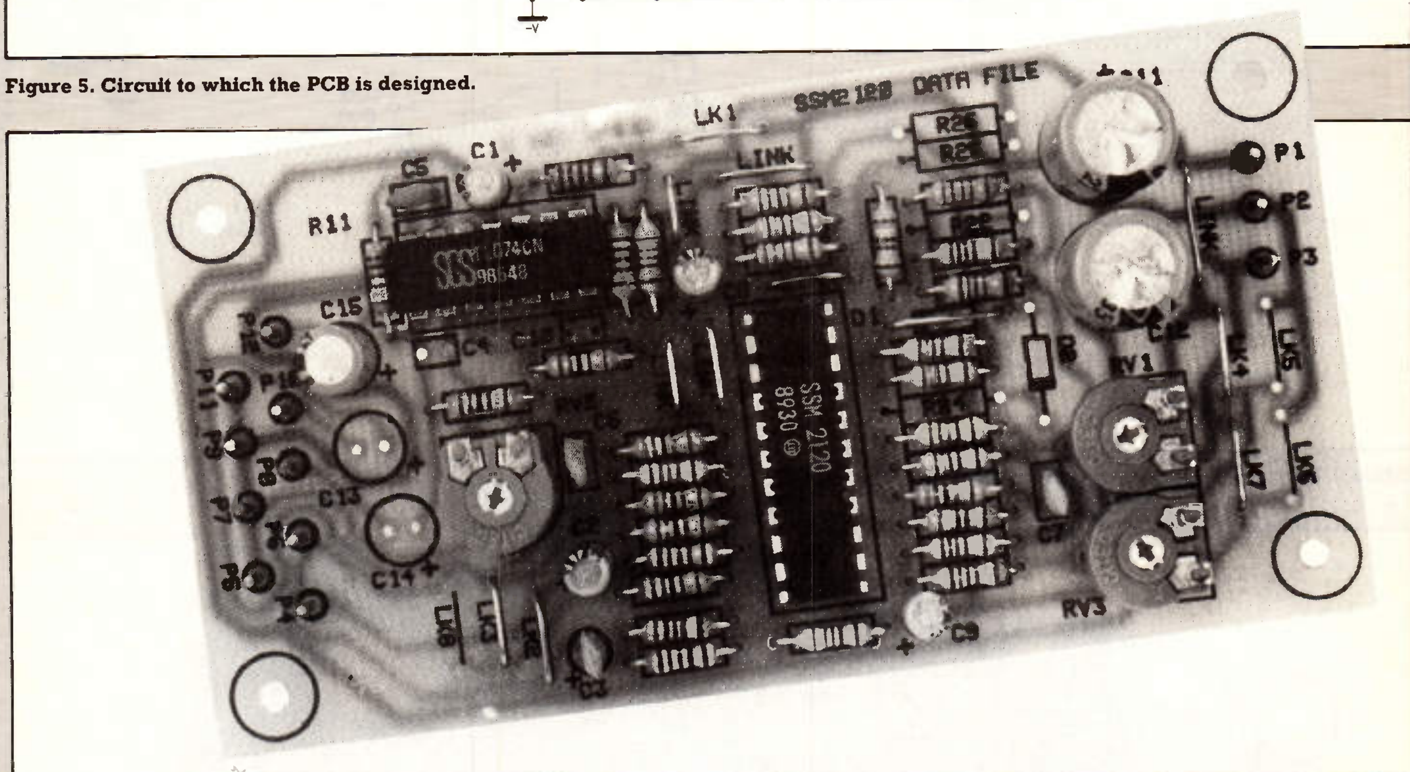


Photo 1. Assembled dynamic filter with downward expander.

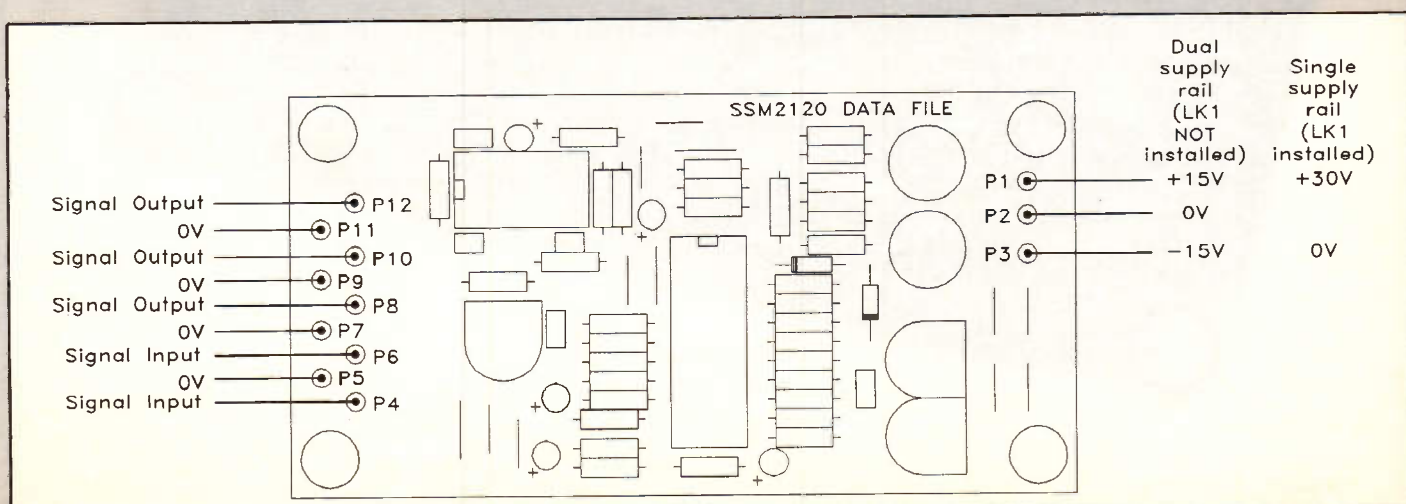


Figure 6. Basic wiring diagram.

in the kit have been assigned an arbitrary value. For this reason minor modifications may be necessary to adapt the circuit to individual purposes.

The SSM2120 requires a split-rail supply and will operate over a wide range of voltages between ±3V and ±18V. However, additional components have been included in the design to allow the circuit to operate from a single rail supply of between 6V and 36V, by installing link LK1. It is important that the supply is adequately decoupled in order to prevent the introduction of mains derived noise onto the supply rails. For optimum performance a regulated power supply should be used. All application circuits contained within this Data File are optimised for use with a ±15V power supply (+30V power supply with LK1 fitted).

The current into the reference pin determines the input and output compliance range of the VCAs. This current has a nominal value of 200μA, and is set by R7; for ±15V operation this corresponds to a value of 100kΩ.

Figure 6 shows the basic wiring information.

Applications

Figure 7 shows the control circuit for a typical downward expander, providing a negative unipolar control output. This is

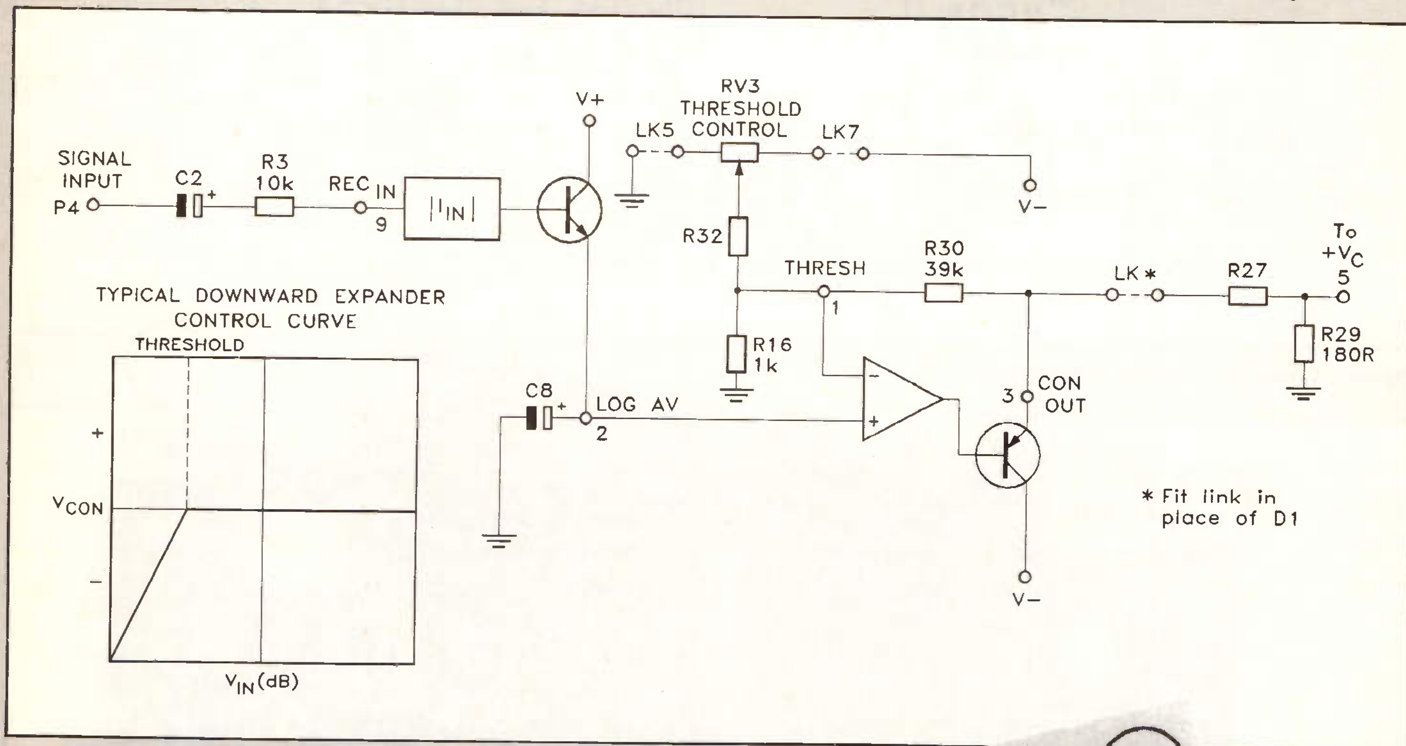


Figure 7. Downward expander control circuit.

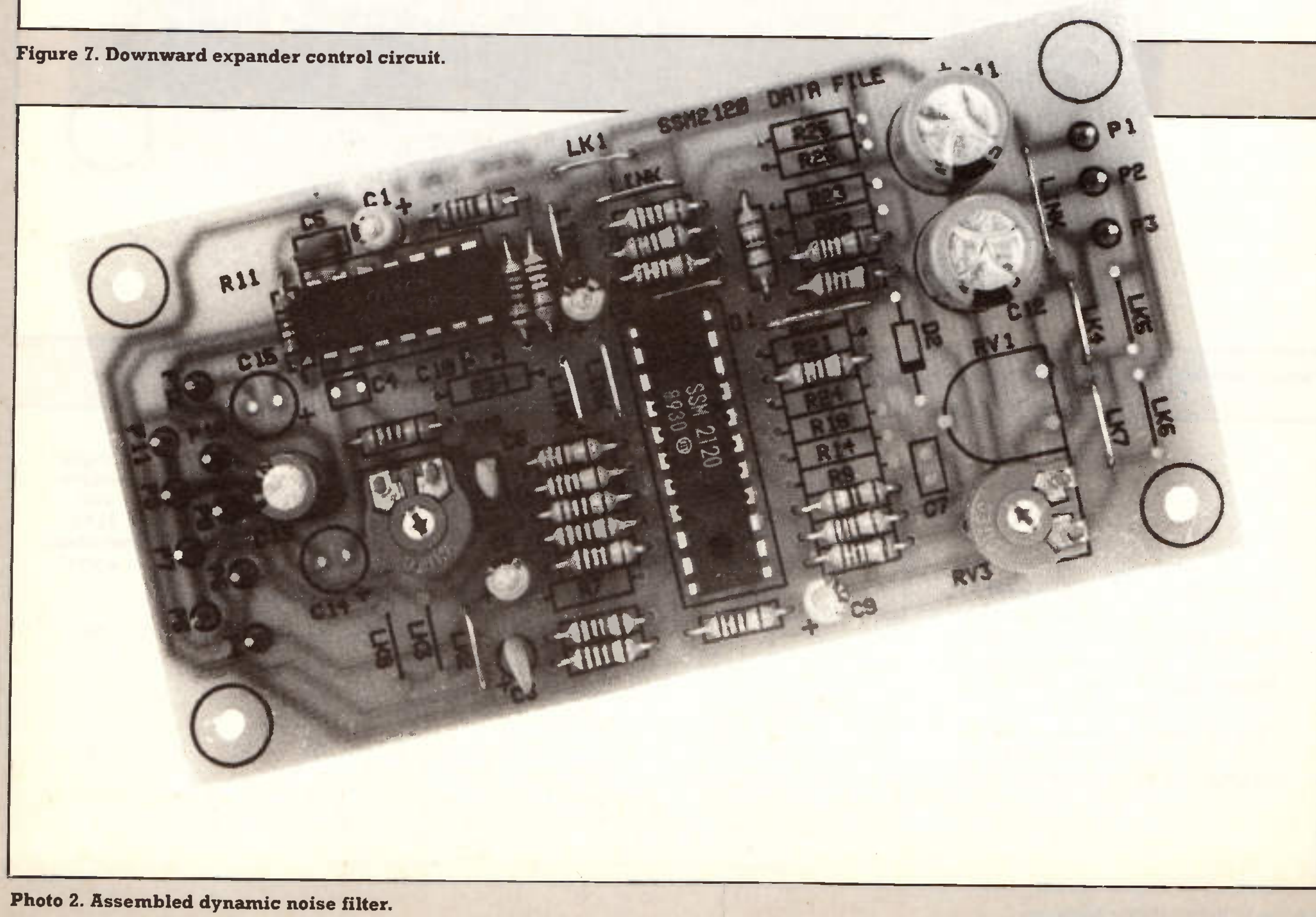


Photo 2. Assembled dynamic noise filter.

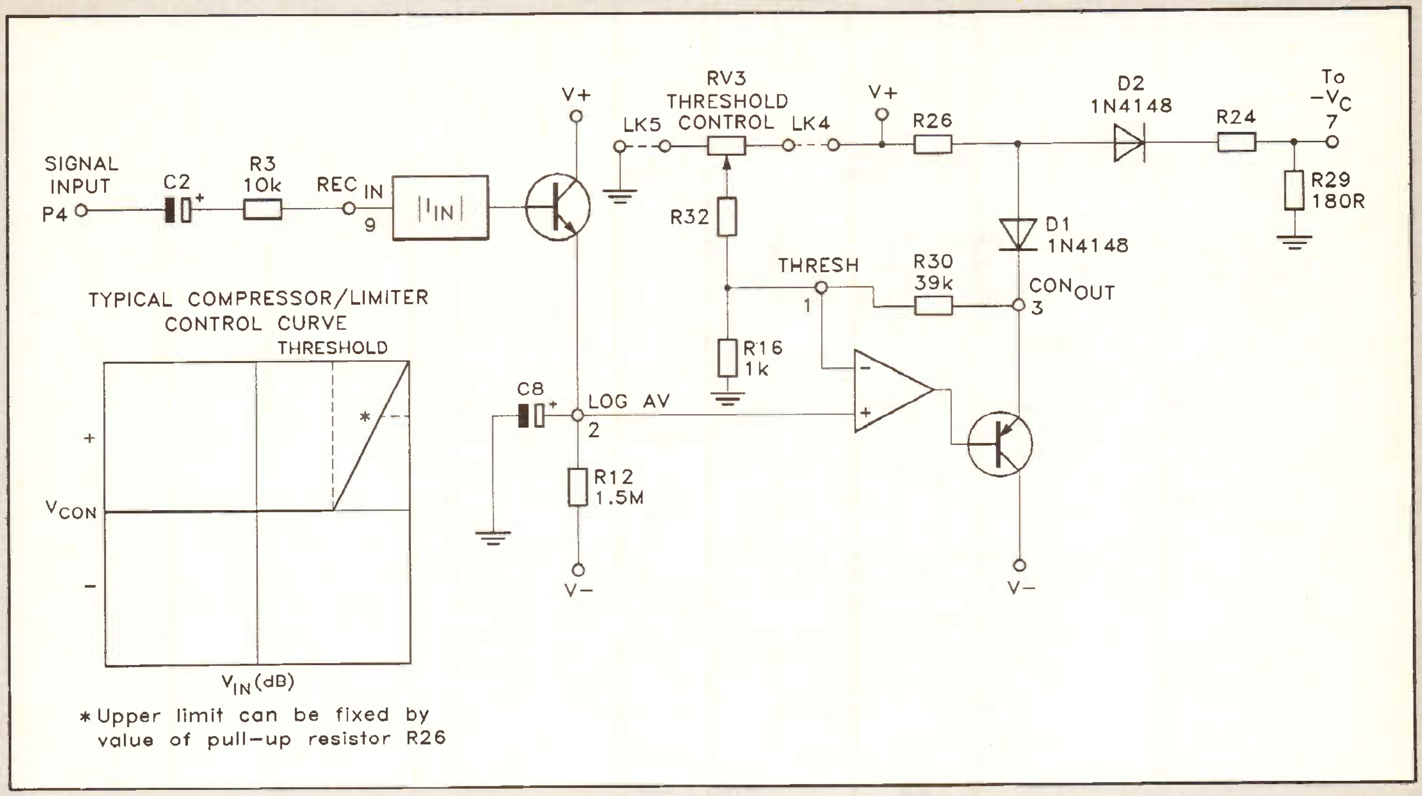


Figure 8. Compressor/limiter control circuit.

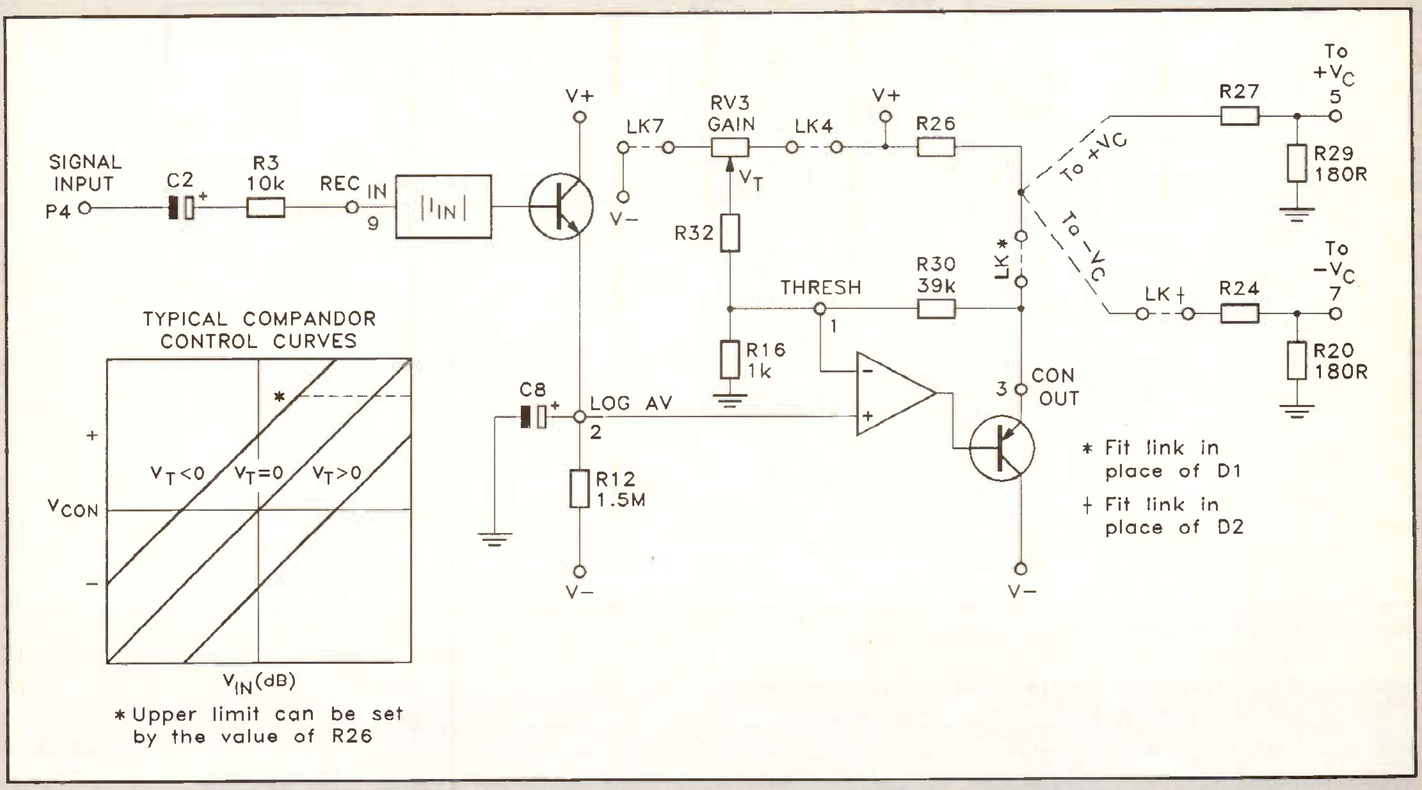


Figure 9. Typical Compander control circuit.

typically used in downward expander, noise gate and dynamic filter applications. Here, the threshold control RV3 sets the signal level versus control voltage characteristics. The sensitivity of the control action depends on the value of R32.

For a positive unipolar control output add two diodes, see Figure 8. This is useful in compressor/limiter applications.

Bipolar outputs can be achieved by connecting a resistor (R26) from the op-amp output to V+. This is useful in compander circuits as shown in Figure 9. The value of resistor R26 will determine the maximum output from the control amplifier.

An attenuator resistor (R24/R27) from CON_{OUT} to the appropriate VCA control port establishes the control sensitivity.

As mentioned previously, in applications such as noise gating and downward expansion the VCA's require trimming as follows:

Apply a 100Hz sinewave to the control point attenuator (D1 side of R27 for VCA1, R31 side of R22 for VCA2). The signal peaks should correspond to control voltages which induce the VCAs maximum intended gain and at least 30dB of attenuation. Adjust RV1/RV2 for minimum feedthrough.

In all other applications, leave the CFT pins open by not fitting resistors R18 and R19.

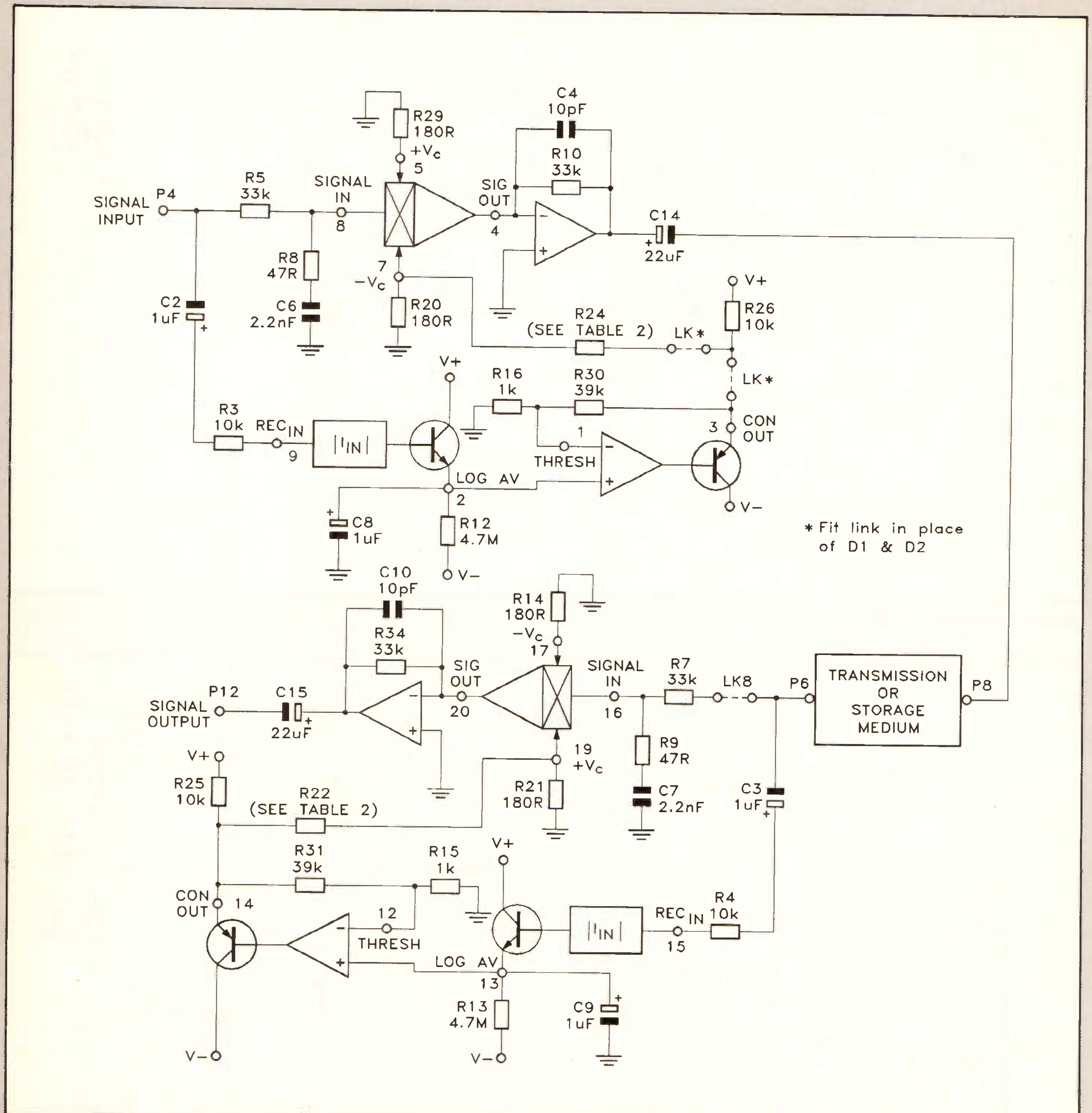


Figure 10. Companding noise reduction system.

Compression/ expansion/ ratio	R22/24 (kΩ)	Gain (reduction or increase) (dB)	Compressor only output signal increase (dB)	Expander only output signal increase (dB)
1·5:1	11·800	6·67	13·33	22·67
2:1	7·800	10·00	10·00	30·00
3:1	5·800	13·33	6·67	33·33
4:1	5·133	15·00	5·00	35·00
5:1	4·800	16·00	4·00	36·00
7·5:1	4·415	17·33	2·67	37·33
10:1	4·244	18·00	2·00	38·00
AGC*/limiter	3·800	20·00	0	40·00

Note: *AGC for compression only

Table 2. Compression/Expansion ratios.

Companding Noise Reduction System

A complete companding noise reduction system is shown in Figure 10. Normally, to obtain an overall gain of unity, the value of R24 (compression) is equal to R22 (expansion). As shown in Table 2, the values of R22/24 will determine the compression/ expansion ratio. Note that signal compression increases gain for low level signals and reduces gain for high levels while

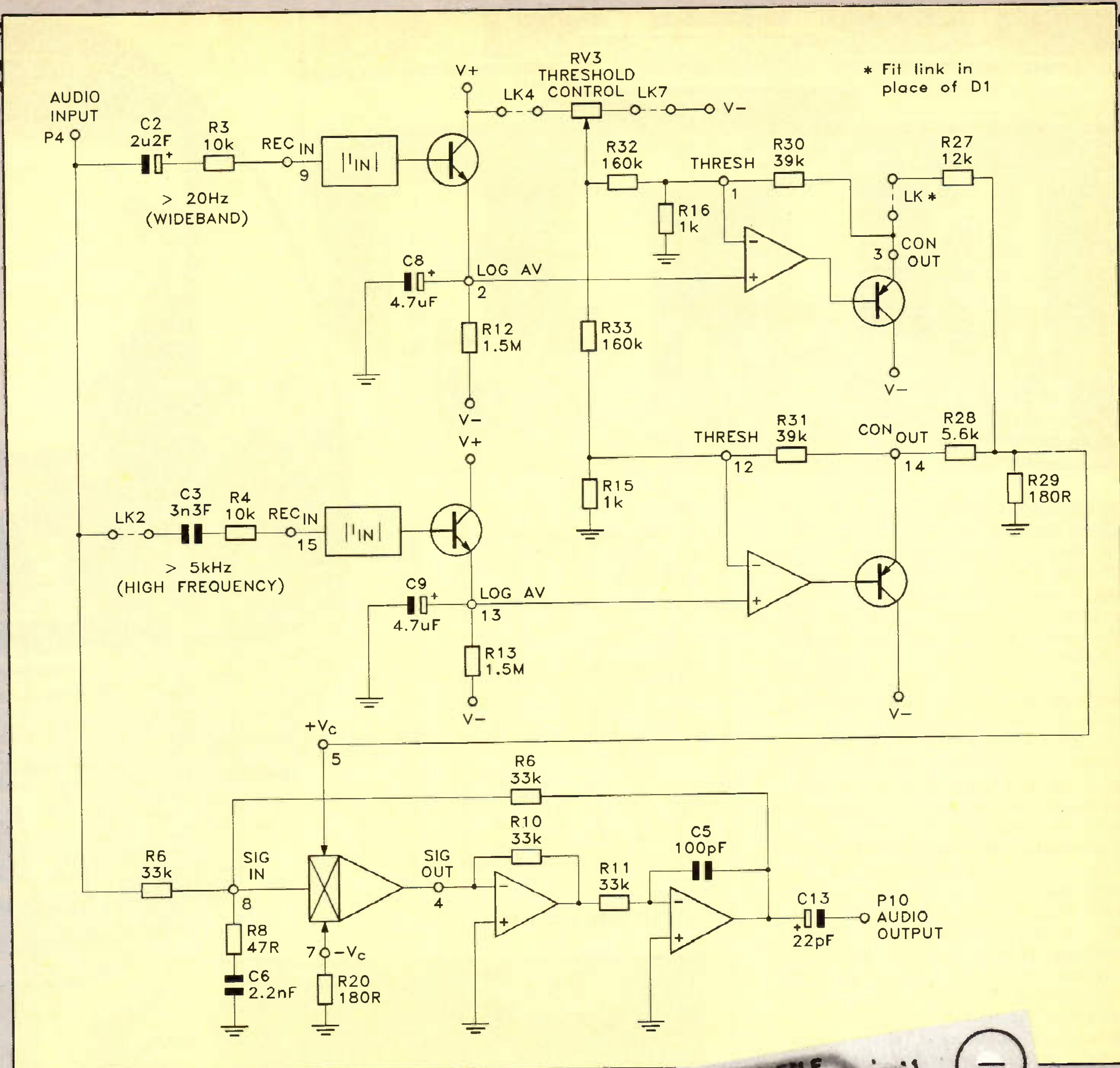


Figure 11. Dynamic noise filter circuit.

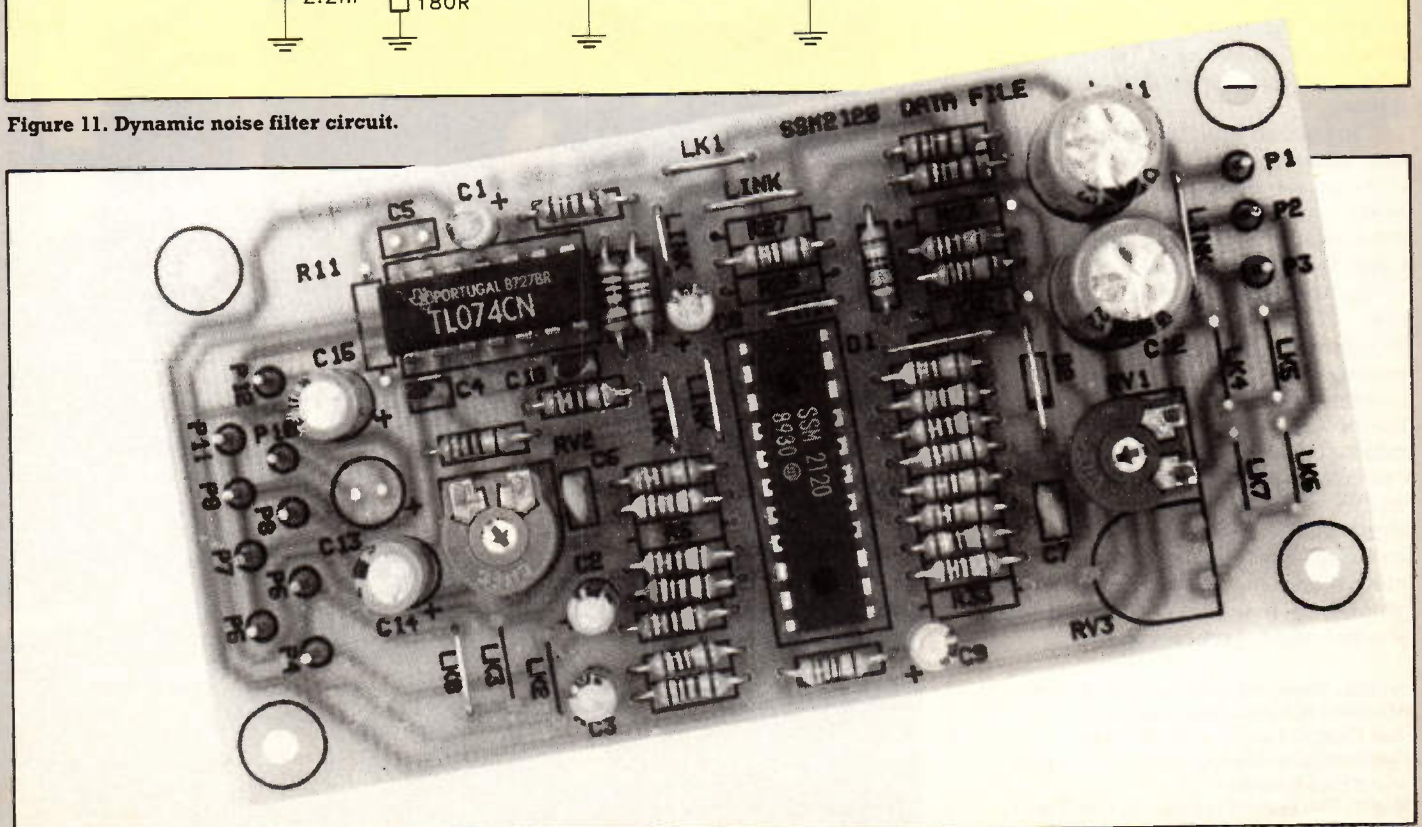


Photo 3. Assembled companding noise reduction system.

Continued on page 50.

Hands-On High Tech in London

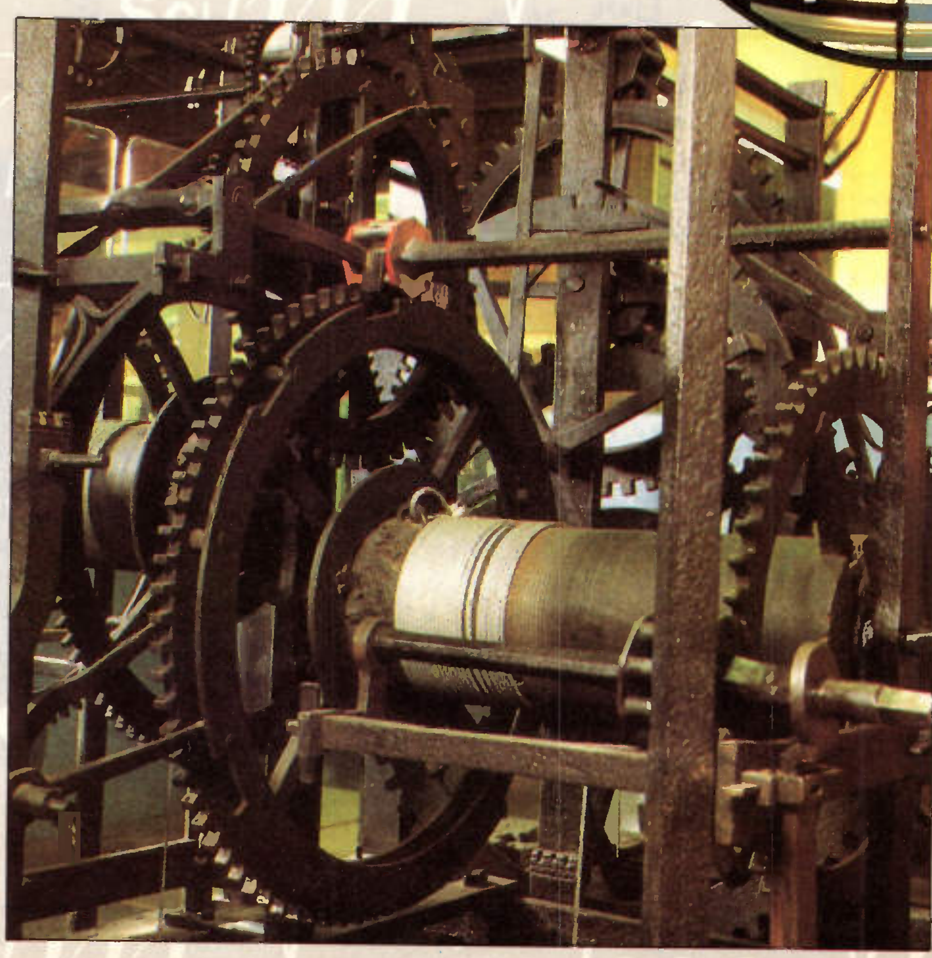
by Alan Simpson

HAPPY BIRTHDAY! In case you didn't know, this year is the bicentenary of the birth of both Charles Babbage and Michael Faraday, respectively, 'the fathers of computers and electricity'. Not only has the Bank of England issued a new and smaller £20 note, which features Faraday; there are many exhibitions and events to mark the occasion being staged throughout the UK.

But without doubt, the most ambitious – and the one which got your intrepid 'Out and About' reporter to hasten on his bike (no spare £20 note for editorial expenses being available) to downtown South Kensington. Here at the Science Museum they are having a particularly busy year. Apart from special exhibitions on Michael Faraday and Charles Babbage (where there will be a real-live working Babbage Machine, never built before), Japanese robots are also on show together with 'Flight Lab', an interactive exhibition about flight, which complements the Aeronautics gallery.

In fact, so much is happening that you should book your place in the daily queue now, purchase a season ticket – or better still, enter our competition and try to win a family season ticket to The Science Museum. With renowned collections made up of more than 200,000 objects, the Science Museum is the world's pre-eminent museum devoted to the history and contemporary practice of science, technology and medicine. As the catalogue says, "the museum features exhibits of actual equipment, instruments and machinery which tell the story of the history of science and industry, from the first steam locomotive and the beginnings of photography, to man's first flight in space and computer technology."

Above: The front facade of The Science Museum in South Kensington.
Top Centre: Lenses from a Devon lighthouse, made to a pattern by French scientist Augustin Fresnel.
Right: The second oldest clock in Britain, built in 1392 for Wells Cathedral, now tolls the hours in the Time Measurement gallery.



OUT AND ABOUT

Only at the Science Museum will you come face-to-face with the original 'Puffing Billy' steam locomotive and the Apollo 10 command module spacecraft; a Scottish tramcar, a 1929 Austin 7 and the latest Ford Lotus; replica telecomms cabins of 1910 and 1990, and The Vickers Vimy, the first aircraft to fly the Atlantic non-stop.

The origins of the Science Museum dates back to 1857, when Queen Victoria opened the South Kensington Museum. Out of this emerged the Science and Victoria and Albert Museums at the end of the last century. More recently, the museum has been totally redeveloped, with new galleries being opened by Her Majesty the Queen. The museum, points out Caroline Nolan who runs the press office, "is both a child of the industrial revolution and a record of it, and presents some fascinating and awesome objects of the era." As our national museum of industry, in the country which 'invented' industrialisation, it is well endowed with the first-hand evidence of what happened in one of history's major turning-points.

Spaced Out

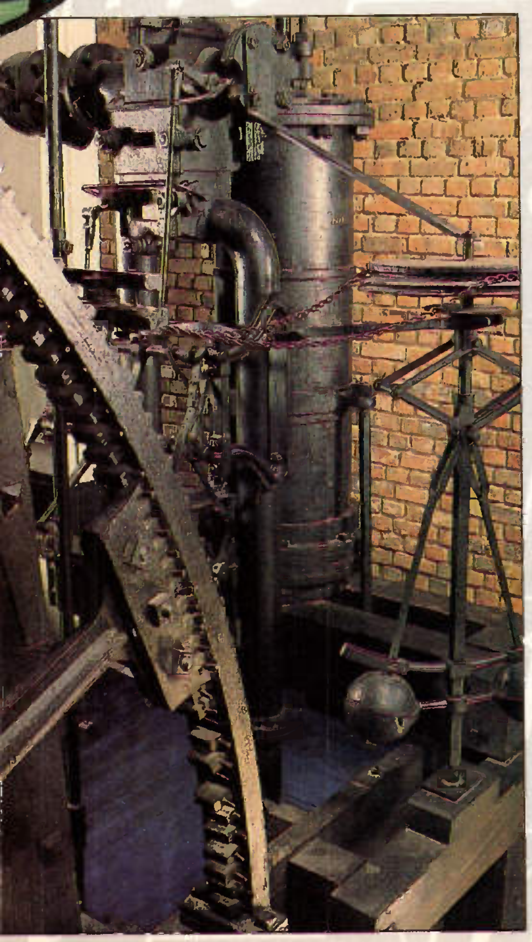
Time has not stood still at the Science Museum, one of the top ten London museum attractions, which attracts nearly 1m visitors annually, is the innovative 'Launch Pad', an exciting hands-on area of the museum; where you can discover what technology is, how it works and what it can do. Billed as an interactive gallery for children of all ages, Launch Pad allows visitors to experience close encounters of a scientific kind by building bridges, being a human battery, operating a model grainpit and carrying out a range of challenging experiments. Meanwhile, 'Food for Thought – The Sainsbury Gallery' features many computer driven exhibits and replica sets, including a 1926 Lyons Corner House and, not surprisingly, an early Sainsbury store.

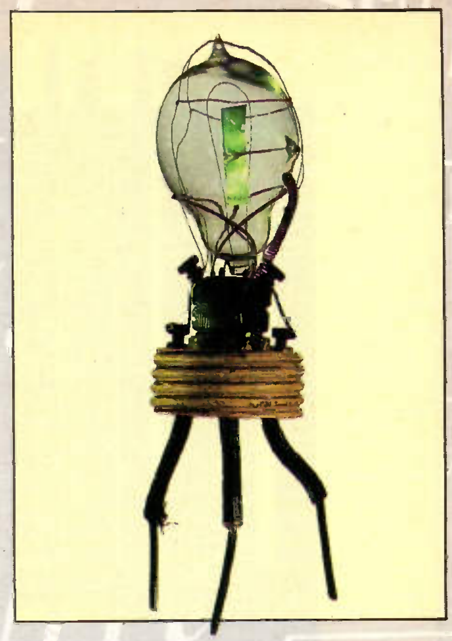
But for most 'Electronics' readers, the key galleries include 'Exploration of Space', 'Aeronautics', 'Land Transport', and 'The Chemical Industry'. More space and related topics are on show in the lecture theatre every day where programmes from the TV series 'Spaceship Earth' for example, are screened.

Not only does the museum incorporate high level audio visual and computer driven exhibits, but the organisers have brought history back to life with teams of actors and interpreters representing such colourful characters as Amy Johnson, of aviation fame. Although not quite in the space launching class, you can ride in a high tech glass lift, designed to reveal the technology of hydraulics.

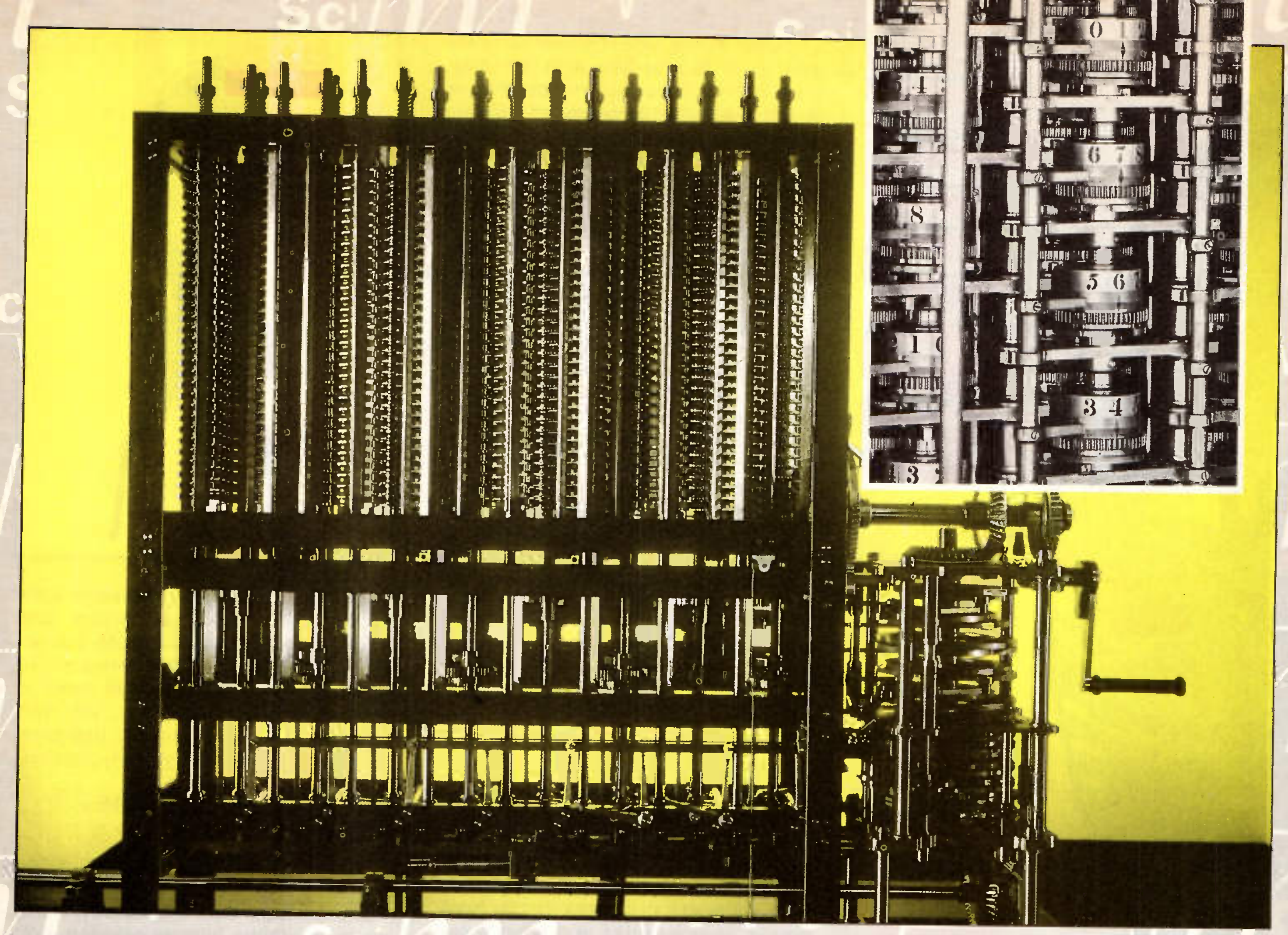
Robotic Feet on the Ground

Even more down to earth is the current exhibition – until 31st October – of Japanese robot technology. Here, sword wielding, portrait painting, golf putting and wall climbing are just some of the activities that state-of-the-art Japanese robots are performing. Japanese robots are widely used



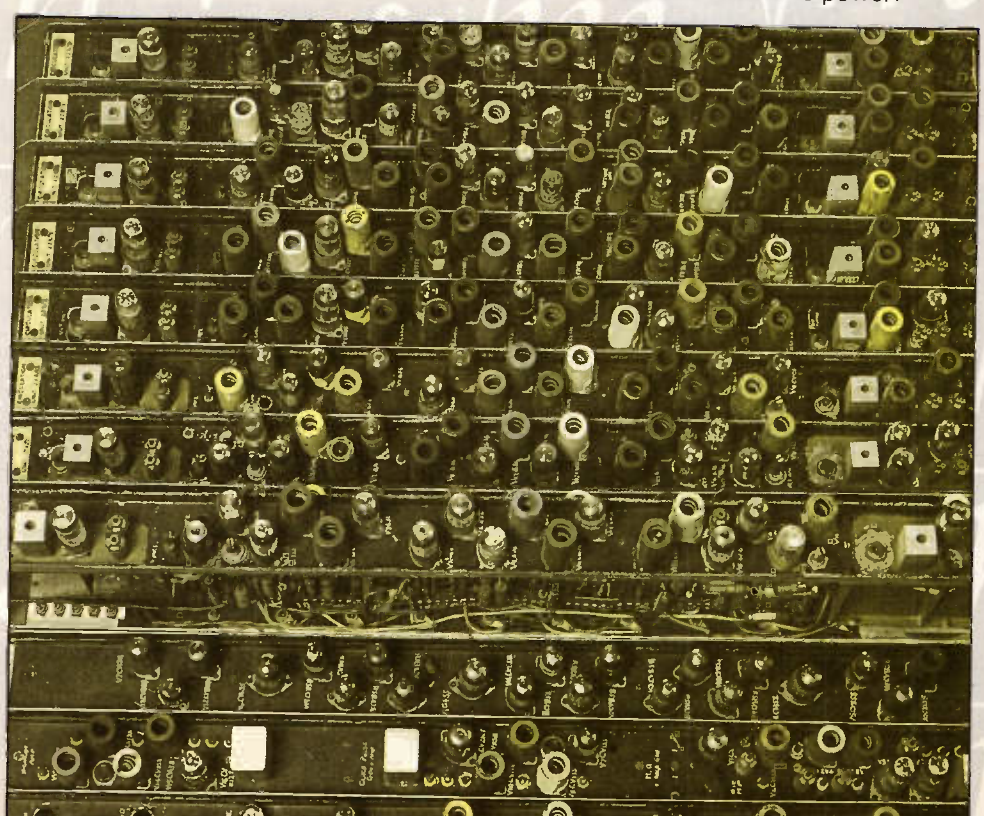


Top right: A light bulb converted into one of the first radio valves by Ambrose Fleming.
Left: Built by Matthew Boulton and James Watt in 1788, this steam engine was capable of driving up to 43 separate machines in a factory. The steam engine began the liberation of mankind from toil, and today machines which handle energy, and the industries that provide their fuel, have become crucially important to society. Without them, everything else grinds to a halt.
Right: One of the first 'serious' microscopes, intended for real research rather than as a plaything, made in 1675.



throughout the industrial world, and this highly visual exhibition features no less than twenty of them. If you still believe that robots are designed on the lines of the first generation Maplin 'HERO', then a visit will be most enlightening. Here you can see two synchronised robots, working with amazing precision, balancing spinning tops on the edge of a Samurai sword; a sitter being scanned by a video camera with the information being transferred to a robot which produces a portrait; flowers being selected by their colour and so on. In real life, this last robot works on high-tension power lines which are coloured coded. there is a robotic exercising machine (you will have to find out for yourself if the unit is wearing a leotard), and different coloured golf balls being accurately putted by a voice activated robot.

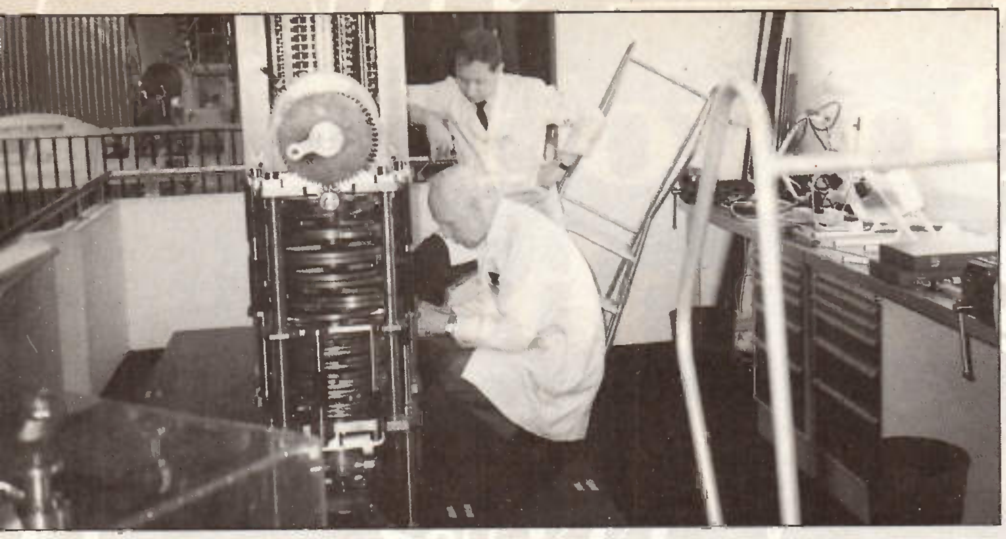
The Science Museum already has a comprehensive selection of calculators and computers, all the way from the basic abacus to what is often claimed as the world's first real computer, the Pilot Ace, developed from electronic code-breaking machines and featuring some eight hundred radio valves. But the museum has also taken delivery of a Cray 1A supercomputer which, until recently, was in active service at Aldermaston AWE. The scientists there must have been somewhat relieved to be rid of their five ton, six foot diameter and six foot high, freon-cooled machine which incorporated some 50 miles of wiring and consumed 200kW of electric power!



Above: Babbage's second difference engine, itself designed by Babbage and built by the Science Museum. It would seem that it was Babbage's own test pieces which kept failing – the design was sound, but Victorian metallurgy wasn't up to it.

Inset: A close-up of just one of the shafts of numbered cog-wheels in the difference engine.

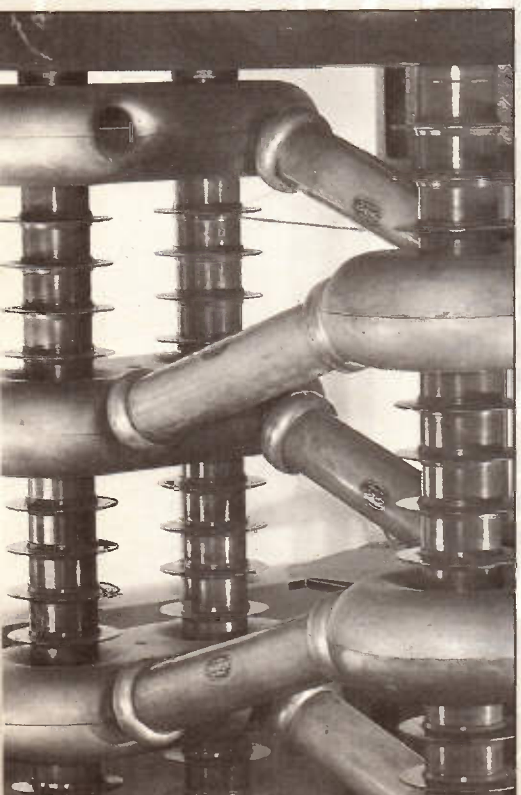
Right: A few of the 800 valves (many wearing coloured screening cans) which made up 'Pilot Ace', one of the first real computers and finished in 1950. It evolved thanks to British experience in building code-breaking machines during the Second World War.



The Babbage Heritage

It was the English mathematician Charles Babbage who was the true inventor of computers. He designed a machine which had many of the attributes of modern electronic computers, but which would not become reality for nearly another century, including the use of punched cards. In fact Babbage's plans were too advanced for the technology of the time, and he died a dissatisfied and unhappy man two hundred years ago this year.

Recognition is now being given to the extraordinary talents of Babbage by the Science Museum, who are constructing, in public view, a full-size working example of the 'Difference Engine No. 2', directly from Babbage's original designs, but making use of modern machining processes. The engine consists of 4,000 parts, weighs 3 tons and measures 10 feet long, 6 feet high and 1·5 feet deep – a 'footprint' which is not exactly lap-top size!



Babbage tried to stretch Victorian cog-wheel technology up to and beyond its limits. "It is widely believed that Babbage failed because of the limitations in nineteenth-century machine tool technology," says Doron Swade, Curator of Computing at the museum, and responsible for the construction project. "By building a Babbage engine to original designs, we have set out to prove that these machines could have worked in Babbage's day. We have a unique opportunity to redeem this great man, in time for the 200th anniversary of his birth and rewrite history in the process." On completion of its construction, the machine will remain on show until the end of January 1992.

HP Gets into the Babbage Act

Hewlett-Packard will be lending a Vectra 486/25 PC to the museum in order to demonstrate the principles and workings of Babbage's Difference Engine No 2 by means of a 3D animation and soundtrack. The software has been commissioned by HP with UCM Ltd, a company specialising in multi-media technologies – the integration of text, graphics, 2D and 3D animation and high quality sound on a standard desktop PC.

Bright Sparks

1991 also sees the Science Museum celebrating the bicentenary of the birth of Michael Faraday, one of the great figures in the history of science. The exhibition, organised in association with the Royal Institution and sponsored by London Electricity, runs to the end of the year. It features some of Faraday's original apparatus and reconstructions of his principal experiments. Not only will the event explain what Faraday did, it will also show how such things as electric motors, generators, and even radios and microwave ovens have been developed from his work.

Above: Museum staff laboriously assembling Charles Babbage's complete 'Difference Engine No. 2'.
Left: The million volt cascade generator, as part of a particle accelerator built at Cambridge university, which helped research into nuclear physics during 1937. The generator was powerful enough to imitate lightning, though that wasn't its real function.

At least, Messrs Babbage and Faraday did not arrive home after a long and hard day in the laboratory to find the message on their computer screens, "What time do you call this – your dinner is in the microwave."

For details contact The Science Museum, London SW7, telephone 071 938 8000. Fees are: adults, £3.50; OAPs, £2; children/students, £1.75. Disabled persons are free.

However, as a Maplin reader you have the chance to avoid those queues – and at the same time save your family some cash – by entering our contest. The Science Museum is making available to 'Electronics' four sets of season tickets. Each of the season tickets, which normally cost £15, is available for a year, and allows two adults and four children unlimited visits. All you have to do to win one is to correctly answer the four questions below. All entries will be put into the dark recesses of the editor's famous hat and will be drawn on 29th of November 1991.

Please note that multiple entries will be excluded from the draw. Please post your entry to: The Science Museum Contest, The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR. Go to it!

Sci√m COMPETITION

All the questions have been sourced from 'Launch Pad', published by The Science Museum.

1. In Britain a typical family's energy bills (gas, electricity, petrol, etc. add up in one year to:
(a) less than £350.
(b) £350 to £700.
(c) more than £700.

2. Gear wheels were invented:
(a) about 100 years ago.
(b) about 500 years ago.
(c) about 2000 years ago.

3. The world's largest telescope mirror is:
(a) about three metres across.
(b) about six metres across.
(c) about nine metres across.

4. If all the TV programmes seen by an average person in Britain in one year were put end to end, how long would they last?
(a) less than one week.
(b) between one week and one month.
(c) more than one month.

Do you remember your first time?

Of course you do, and like all the best things in life, it's improved with age!

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The 10th ANNIVERSARY ISSUE of 'Electronics – The Maplin Magazine', is on sale from 1st November 1991, for only £1.60. Available from all branches of **WH SMITH,** Maplin Regional Stores, your local newsagent, or by subscription.

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COMPETITION WINNERS REACH FOR THE SKY

"Winning the star SKY prize made my day – and year". For Mary Kaup of Norbury, South West London, winning the 'Electronics' prize award – a complete SKY TV Satellite Receiver System could not have happened at a better time. "I was about to get married and move into a new house. Funds were more than short and I was resigned to having to visit my parents to watch any special satellite programmes. Now I can enjoy the variety of programmes – particularly tennis and music, available on the SKY TV channels. I didn't believe it when Maplin phoned to say I had won the star prize and it was not until the installation men arrived that I knew it was for real. Thank you Maplin, thank you SKY".

First runner up, Dave Hilton of Macclesfield, Cheshire won the visit to the SKY TV centre and studios prize. Dave, an electronics engineer, together with his niece Hannah Blyth were met at the centre by Greg Hayman, SKY TV News press officer. "We were shown round the studios where the technical controllers tried valiantly to explain in simple terms the wall to wall TV monitor screens facing them, above an equally impressive console filled with banks of switches, levers and buttons. The highlight was watching the 3pm news going out live where despite the contents being up-dated, re-written and re-timed during the actual broadcast, the transmission still finished spot on time. Our thanks to Maplin and SKY TV for making this a thoroughly enjoyable visit. We also appreciated the 'Olde English' Cream Tea to finish with".

It might have been the second runner-up prize, but for Mark Khan, winning the prize of a visit to the Music TV studio in Central London was an event not to be missed. Mark who happens to be one half of the 'The Boys (with no name)' pop group, the visit was both fascinating and timely. "Making a close encounter of the pop music kind in what is the world's premier music TV station was certainly an eye-opener. It beats anything I had imagined. Who knows, before long the station might even feature our forthcoming video. In the meantime, thank you Maplin and of course MTV for a great experience".

For another great competition for you to enter, turn to page 43!

SKY TV Satellite Receiver System prize winner, Mary Kaup – "Thank you Maplin, thank you SKY".

First runner-up, Dave Hilton and his neice, Hannah Blyth, in the SKY News Studio.

Second runner-up, Mark Khan from 'The Boys (with no name)', at MTV.

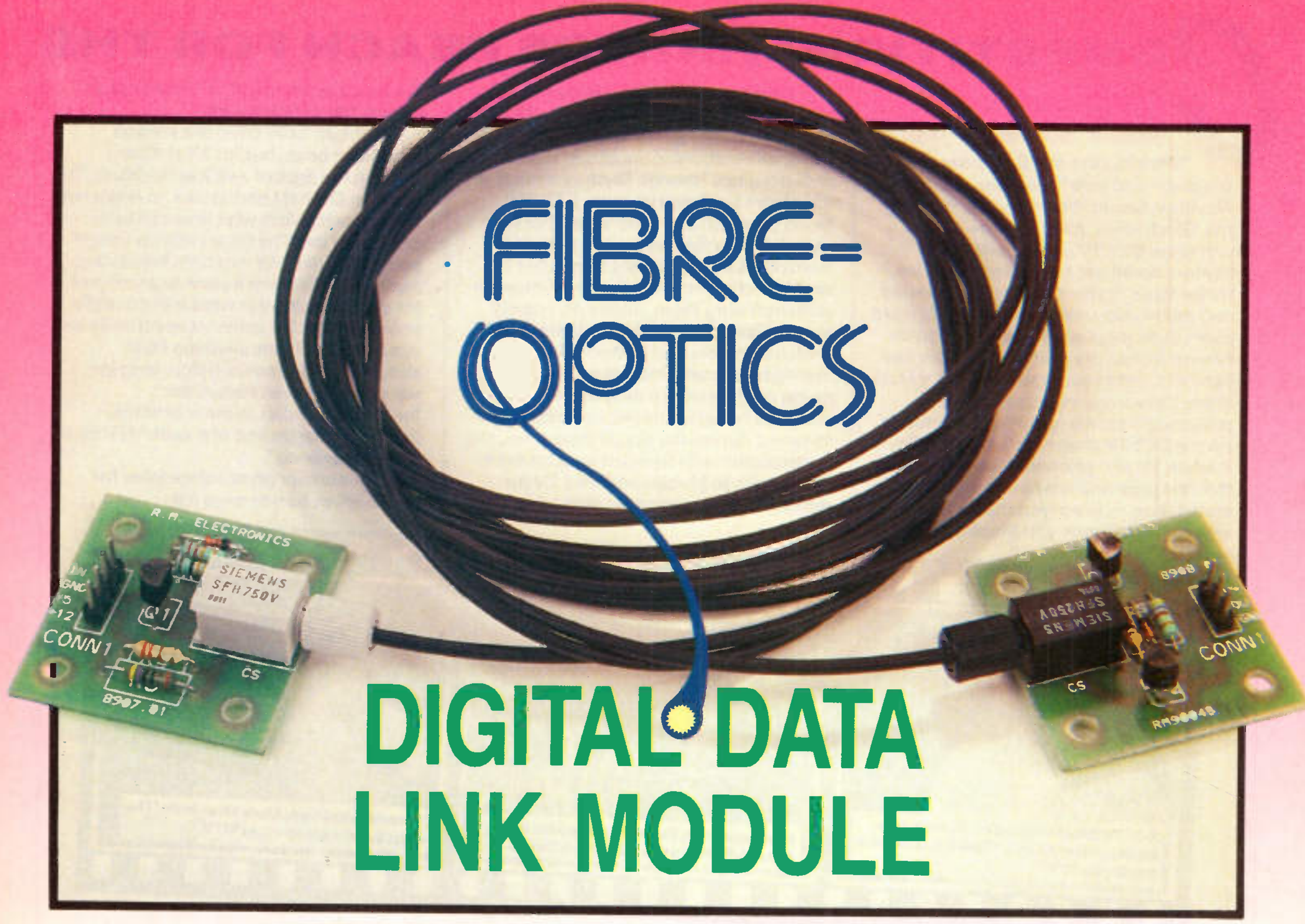
MAPLIN'S TOP TWENTY KITS

POSITION			DESCRIPTION OF KIT	ORDER AS	PRICE	DETAILS IN		
1.	(7)	◆	1/300 Timer	LP30H	£ 4.95	Magazine	38	(XA38R)
2.	(1)	◆	Live Wire Detector	LK63T	£ 4.25	Projects	14	(XA14Q)
3.	(-)	RE-ENTRY	MOSFET Amplifier	LW51F	£20.35	Magazine	41	(XA41U)
4.	(2)	◆	TDA7052 Kit	LP16S	£ 4.45	Magazine	37	(XA37S)
5.	(6)	◆	Mini Metal Detector	LM35Q	£ 4.95	Magazine	25	(XA25C)
6.	(3)	◆	PWM Motor Driver	LK54J	£ 9.95	Best of Book	3	(XC03D)
7.	(5)	◆	Car Battery Monitor	LK42V	£ 7.95	Magazine	37	(XA37S)
8.	(4)	◆	Digital Watch	FS18U	£ 2.45	Catalogue	'92	(CA09K)
9.	(-)	NEW ENTRY	Low Cost Alarm	LP72P	£12.95	Magazine	45	(XA45Y)
10.	(-)	NEW ENTRY	Vehicle Intruder Alarm	LP65V	£ 9.95	Magazine	46	(XA46A)
11.	(12)	◆	Siren Sound Generator	LM42V	£ 4.25	Magazine	26	(XA26D)
12.	(13)	◆	LM386 Amplifier	LM76H	£ 3.75	Magazine	29	(XA29G)
13.	(9)	◆	TDA2822 Amplifier	LP03D	£ 6.95	Magazine	34	(XA34M)
14.	(11)	◆	I/R Prox. Detector	LM13P	£ 9.95	Projects	20	(XA20W)
15.	(-)	NEW ENTRY	Courtesy Light Extender	LP66W	£ 2.75	Magazine	44	(XA44X)
16.	(10)	◆	Partylite	LW93B	£10.25	Catalogue	'92	(CA09K)
17.	(-)	NEW ENTRY	Video Preamp	LP60Q	£11.95	Magazine	44	(XA44W)
18.	(16)	◆	Watt Watcher	LM57M	£ 5.45	Magazine	27	(XA27E)
19.	(14)	◆	U/Sonic Car Alarm	LK75S	£17.95	Projects	15	(XA15R)
20.	(20)	◆◆	TDA1514 Power Amplifier	LP43W	£16.45	Magazine	40	(XA40T)

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.

FIBRE-OPTICS DIGITAL DATA LINK MODULE



REVIEWED BY TONY BRICKNELL

FEATURES

- ★ 100% galvanic isolation
- ★ Superb EMI, RFI and crosstalk immunity
- ★ Transmitter compatible with TTL/CMOS and RS232C signals
- ★ Receiver output LS TTL/CMOS compatible
- ★ Maximum communication speed: 20kbit/sec
- ★ Wide operating voltage: 5 to 12V DC
- ★ Immune to ambient light
- ★ Extremely high isolation voltage

Historical Perspective

The phenomenon of total internal reflection at the interface between two dielectric media has been known for some considerable time. In 1870, Tyndall demonstrated that, as a result, light could be guided within a water jet. However, although some theoretical studies were carried out in the early years of the present century, it was not until the mid-1960s that the idea, of a communication system based on the propagation of light within circular dielectric waveguides, was considered seriously.

Wire Communications

Wire communications inherently have problems due to the conductive metallic path of the interconnecting wires:

Radio frequency interference (RFI) from radio, TV stations, computers etc. can cause errors in data communications, where the wire cable is acting as an antenna picking up RF signals.

Electromagnetic interference (EMI) in wire systems can be caused by inductive pick-up of power line current or interference due to industrial machinery. Traditional methods of solving these problems have been to use expensive balanced lines with differential drivers and receivers or heavy twisted shielded cables.

Also, the data driving the wire cable can be radiated with the interconnecting wire cable, acting as a transmitting antenna, causing interference to neighbouring circuits. Every time a logic level changes in a wire, there is an *overshoot* or *undershoot*, followed by *ringing*. Although the switching frequency may be only a few kilohertz, the ringing frequency depends on the resonance of the wiring and may cover a bandwidth of several megahertz.

Whenever data is transmitted over any distance, ground loops can cause a problem. A ground loop is caused by using 'ground' as a reference on both the

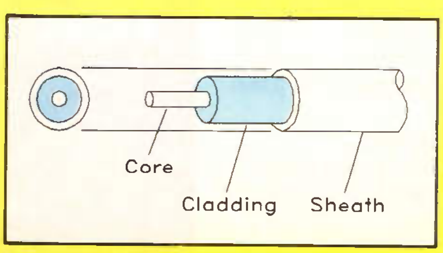


Figure 1. Optical fibre construction.

APPLICATIONS

- ★ Data links between electronic equipment requiring galvanic isolation with excellent noise and interference immunity
- ★ Remote connections of switches, tacho's, pulse devices and detectors which demand reliable operation in hostile environmental conditions
- ★ Replacement of shielded cables in digital applications

transmitter and receiver side of a wire cable when the two 'grounds' are not at the same potential. The ground loop manifests itself as a current flowing through the shield (or ground wire) of the connecting cable. Tying the 'ground' of each unit to a common point or using very heavy grounding wires, as sometimes done in computer installations, can occasionally solve this problem.

Capacitance between wire cables can cause coupling between data lines and if the interference is great enough, the data will be corrupted.

The Fibre-Optic Solution

The advantages of using fibre-optics over wire, lies in the non-metallic, totally dielectric fibre-optical cable. Information is transmitted in the optical waveguide by packets of photons, which have no charge and are not affected by radio frequencies or other electromagnetic interference.

Data can be transmitted with complete isolation between points of vastly different potential, eliminating any ground loop or common mode voltage problems.

A dielectric medium with no current flowing also has beneficial safety considerations. If the fibre is cut, there is no possibility of sparks or short circuits. Hazardous areas such as those with flammable chemicals can use fibre-optics for control and gathering data.

As can be seen from Figure 1, a fibre-optic cable consists of three distinct regions: a core, the cladding, and a sheath. The core has a constant or smoothly varying index of refraction, and the cladding region a different constant index of refraction. A light source radiates at many angles relative to the centre of the fibre. In Figure 2, it can be seen that these light rays propagate in a zig-zag fashion down the core of the fibre until they reach the other end. They do this because light waves bend or change direction when they pass from one medium to another – as the speed of propagation of light in each medium is different – a phenomenon called refraction.

The Module

The Fibre-Optic Digital Data Link Module is one of a series of products distributed by Maplin Electronics. Sold as 'ready-to-use' modules (without housing) and supplied with a comprehensive instructions leaflet.

The fibre-optic digital data link consists of two 35mm square PCBs (1 x transmitter, 1 x receiver) and a 3 metre length of fibre-optic waveguide. See Figure 3 for circuit diagrams of both PCBs.

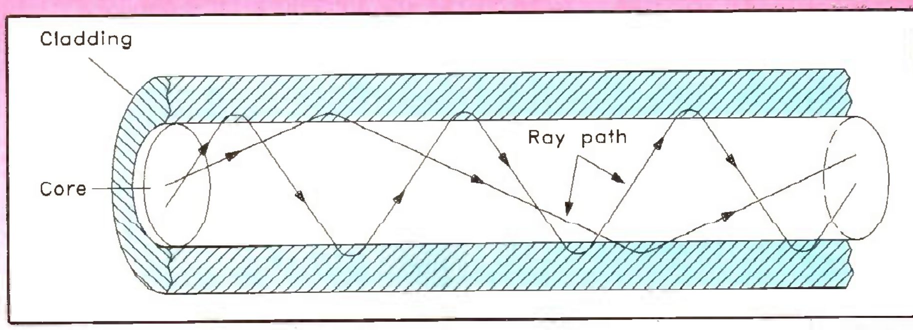


Figure 2. Light ray path in a waveguide.

The transmitter requires a DC power supply of 5V *or* 12V at 20mA (max.), and accepts digital input signals of between ±5V and ±15V, allowing it to be connected directly to a TTL, CMOS or even RS232C output.

A 5V to 12V DC supply is required for the receiver; however, note that the receiver's output signal is nearly equal to its supply voltage so, if working with 5V logic, the receiver must also be supplied with 5V.

Connection to the fibre-optic cable is achieved by couplers on the Tx and Rx PCB, see Figure 4. These packages maximise the electro-optical conversion efficiency by maintaining the axial optical alignment of the emitter and detector with the mating fibre. *Continued on page 52.*

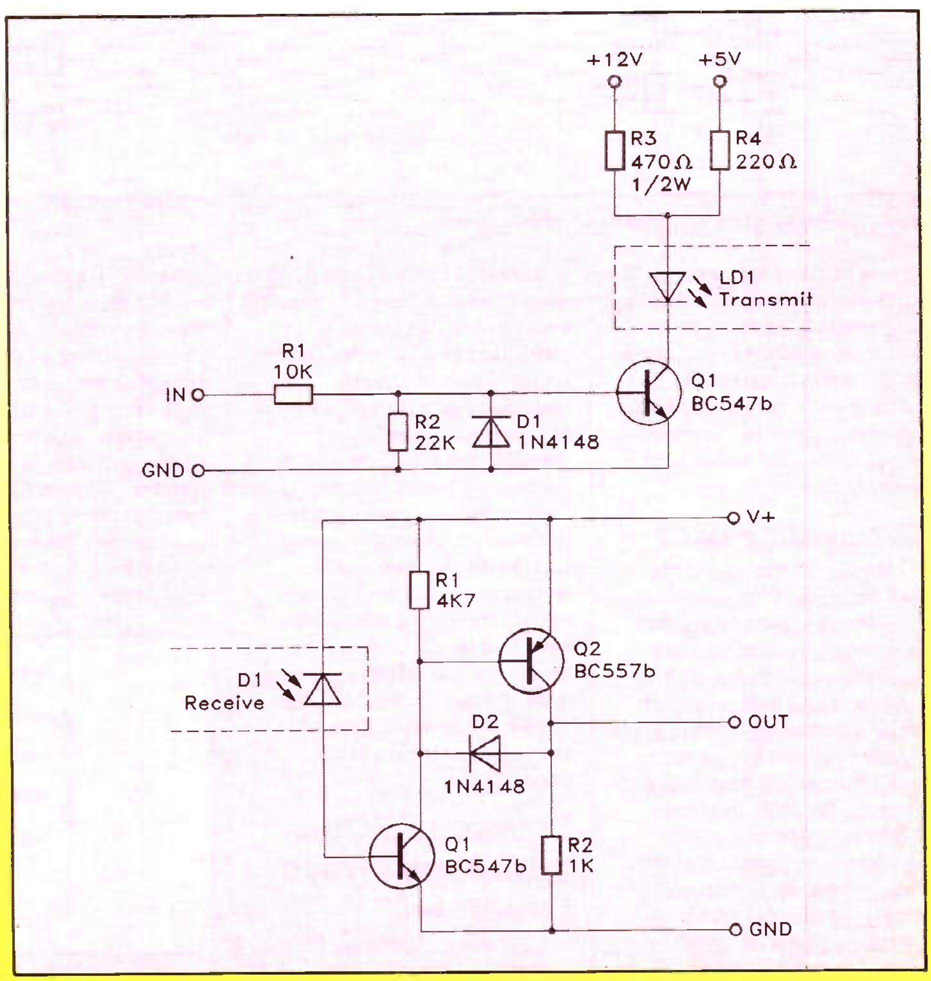


Figure 3. Circuit diagrams.

Data File: SSM2120 continued from page 39.

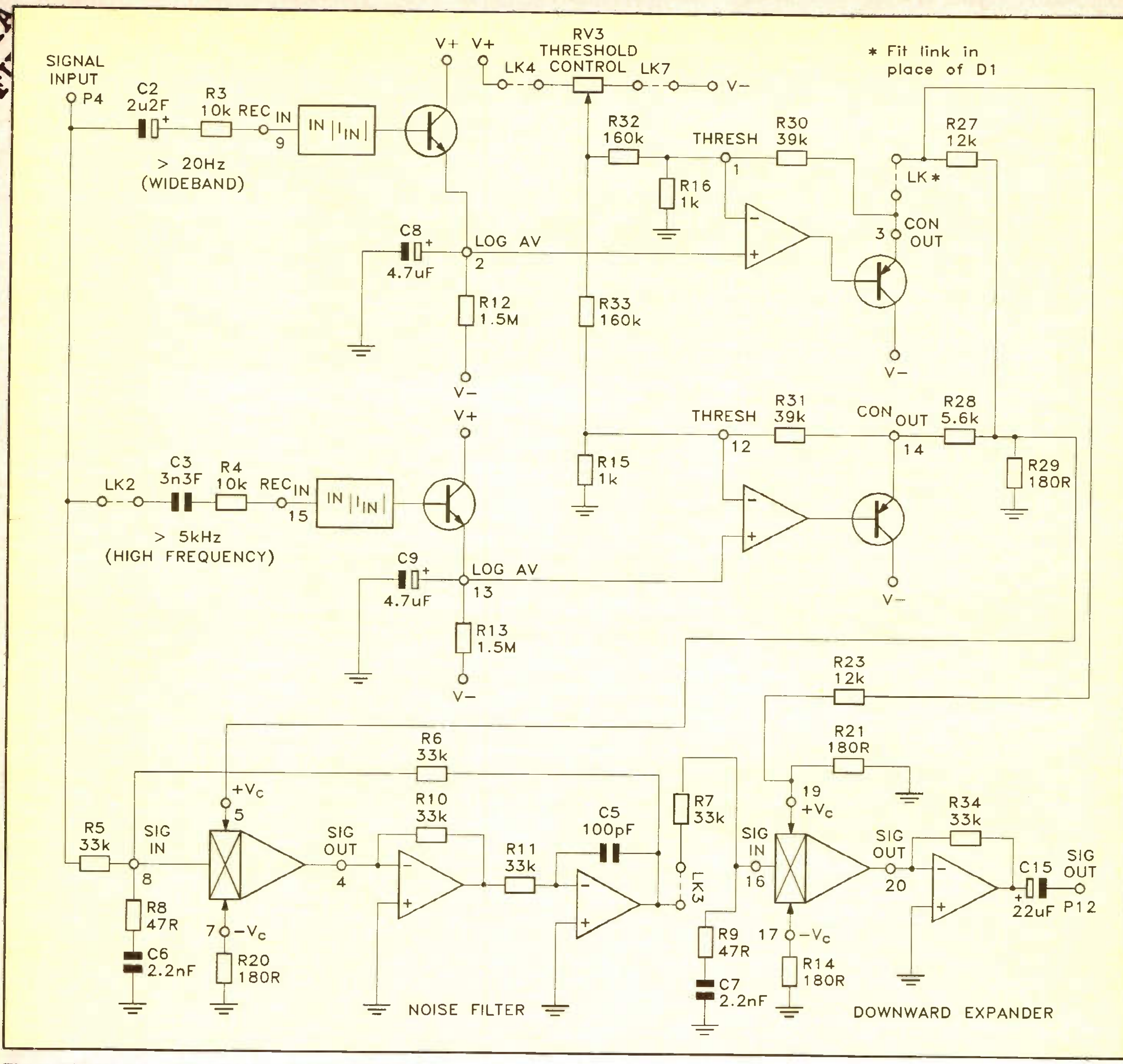


Figure 12. Dynamic filter with downward expander.

expansion does the reverse. The exact compression/expansion ratio needed depends on the recording medium being used. For example, a household cassette deck would require a higher compression/expansion ratio than a professional tape recorder.

Dynamic Filter

Figure 11 shows a dynamic filter capable of single ended (non-encode/decode) noise reduction. Dynamic filtering limits the signal bandwidth to less than 1kHz unless enough 'highs' are detected in the signal to cover the noise floor, when the filter opens to pass more of the audio band. Such circuits usually suffer from a loss of high-frequency content at low signal levels because their control circuits detect the absolute amount of highs present in the signal. This circuit, however, measures wideband level as well as high-frequency band level to produce a composite control signal combined in a 1:2 ratio. The upper detector senses wideband signals with a cut-off of 20Hz, while the lower detector has a 5kHz cut-off to sense only high-frequency band signals. Unfortunately, even in this system, a certain amount of mid- and high-frequency components will be lost, especially during transients at very low signal levels. The threshold control, RV3, sets the filter characteristics for 50dB (V+) to 90dB (V−) dynamic range programme source material.

Dynamic Filter with Downward Expander

As shown in Figure 12, the output from the wideband detector can also be connected to the +V$_C$ control port of the second VCA which is connected in series with the sliding filter. This will act as a downward expander with a threshold that tracks that of the filter. Downward expansion uses a VCA controlled by the level detector. This section maintains dynamic range integrity for all levels above the threshold level (set by RV3) but, as the input level decreases below the threshold, gain reduction occurs at an increasing rate, as shown in Figure 13. This technique reduces audible noise in fade-outs or low level signal passages by keeping the standing noise floor well below the programme material. Using this system, up to 30dB of noise reduction can be realised while preserving the crisp highs with a minimum of transient side effects.

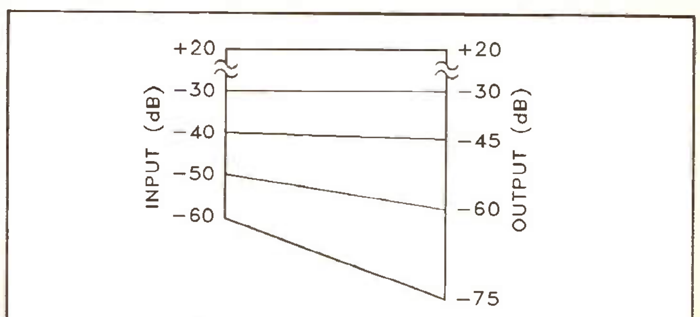


Figure 13. Typical downward expander I/O characteristics at −30dB threshold level (1:1·5 ratio).

COMPANDING NOISE REDUCTION SYSTEM PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless specified)

R1,2,3,4,25,26	10k	6
R5,7,10,34	33k	4
R8,9	47Ω	2
R12,13	4M7	2
R14,20,21,29	180Ω	4
R15,16	1k	2
R17	100k	1
R18,19	220k	2
R22,24	*See Table 2**	2
R30,31	39k	2
RV1,2	47k Horizontal Encl. Preset	2

CAPACITORS

C1	10µF 16V Minelect	1
C2,3,8,9	1µF 63V Minelect	4
C4,10	10pF Ceramic	2
C6,7	2n2F Ceramic	2
C11,12	220µF 35V PC Electrolytic	2
C14,15	22µF 35V Minelect	2

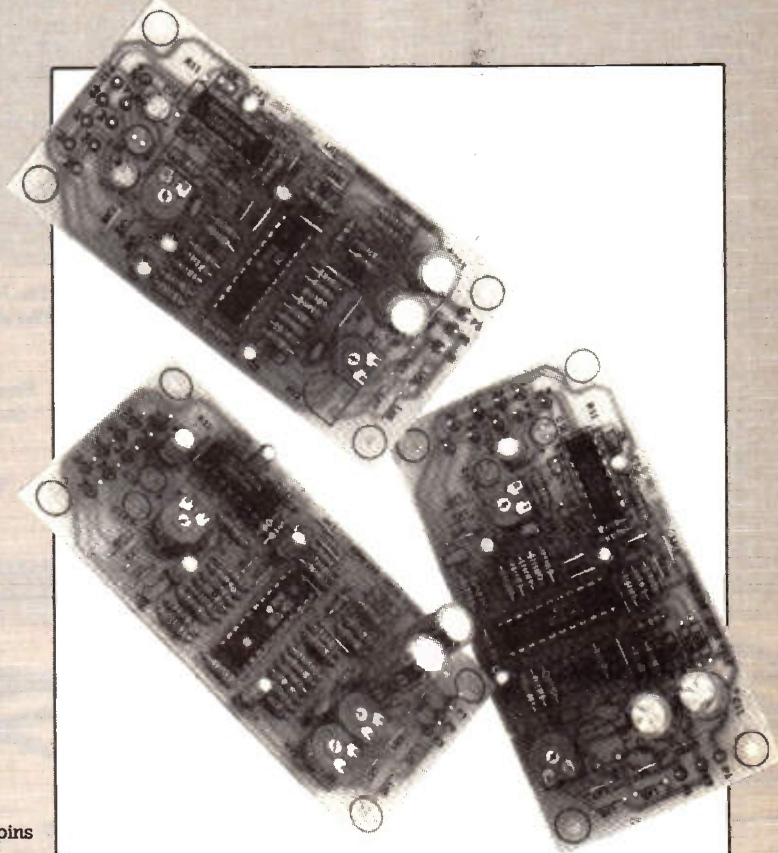
SEMICONDUCTORS

D1,2	Fit Link	2
IC1	SSM2120	1
IC2	TL074CN	1

MISCELLANEOUS

P1-12	Pins 2145	12 pins
LK8	Fit Link	1

*Note R22 and R24 are supplied as 7k5 in the kit.



DYNAMIC NOISE FILTER WITH DOWNWARD EXPANDER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless specified)

R1,2,3,4	10k	4
R5,6,7,10,11,34	33k	6
R8,9	47Ω	2
R12,13	1M5	2
R14,20,21,29	180Ω	4
R15,16	1k	2
R17	100k	1
R18,19	220k	2
R23,27	12k	2
R28	5k6	1
R30,31	39k	2
R32,33	160k	2
RV1,2	47k Horizontal Encl. Preset	2
RV3	10k Horizontal Encl. Preset	1

CAPACITORS

C1	10µF 16V Minelect	1
C2	2µ2F 63V Minelect	1
C3	3n3F Ceramic	1
C5	100pF Ceramic	1
C6,7	2n2F Ceramic	2
C8,9	4µ7F 35V Minelect	2
C11,12	220µF 35V PC Electrolytic	2
C15	22µF 35V Minelect	1

SEMICONDUCTORS

D1	Fit Link	1
IC1	SSM2120	1
IC2	TL074CN	1

MISCELLANEOUS

P1-12	Pins 2145	12 pins
LK2,3,4,7	Fit Link	4

DYNAMIC NOISE FILTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless specified)

R1,2,3,4	10k	4
R5,6,7,10,11	33k	4
R8	47Ω	1
R12,13	1M5	2
R20,29	180Ω	2
R15,16	1k	2
R17	100k	1
R19	220k	1
R27	12k	1
R28	5k6	1
R30,31	39k	2
R32,33	160k	2
RV2	47k Horizontal Encl. Preset	1
RV3	10k Horizontal Encl. Preset	1

CAPACITORS

C1	10µF 16V Minelect	1
C2	2µ2F 63V Minelect	1
C3	3n3F Ceramic	1
C5	100pF Ceramic	1
C6	2n2F Ceramic	1
C8,9	4µ7F 35V Minelect	2
C11,12	220µF 35V PC Electrolytic	2
C13	22µF 35V Minelect	1

SEMICONDUCTORS

D1	Fit Link	1
IC1	SSM2120	1
IC2	TL074CN	1

MISCELLANEOUS

P1-12	Pins 2145	12 pins
LK2,4,7	Fit Link	3

Magazine Version

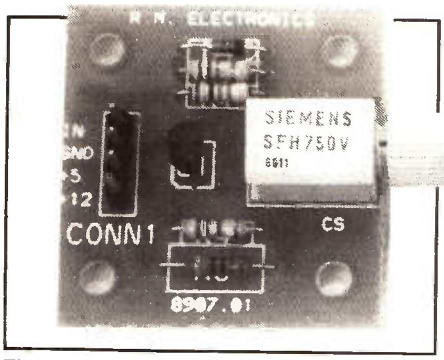
SSM2120 PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless specified)			
R1,2,3,4,25,26	10k	6	(M10K)
R5,6,7,10,11,34	33k	6	(M33K)
R8,9	47Ω	2	(M47R)
R12,13	4M7	2	(M4M7)
R12,13	1M5	2	(M1M5)
R14,20,21,29	180Ω	4	(M180R)
R15,16	1k	2	(M1K)
R17	100k	1	(M100K)
R18,19	220k	2	(M220K)
R22,24	*See Table 2* (nominally 7k5)	2	(M7K5)
R23,27	12k	2	(M12K)
R28	5k6	1	(M5K6)
R30,31	39k	2	(M39K)
R32,33	160k	2	(M160K)
RV1,2	47k Horizontal Encl. Preset	2	(UH05F)
RV3	10k Horizontal Encl. Preset	1	(UH03D)
CAPACITORS			
C1	10μF 16V Minelect	1	(YY34M)
C2,3,8,9	1μF 63V Minelect	4	(YY31J)
C2	2μ2F 63V Minelect	1	(YY32K)
C3	3n3F Ceramic	1	(WX74R)
C4,10	10pF Ceramic	2	(WX44X)
C5	100pF Ceramic	1	(WX56L)
C6,7	2n2F Ceramic	2	(WX72P)
C8,9	4μ7F 35V Minelect	2	(YY33L)
C11,12	220μF 35V PC Electrolytic	2	(JL22Y)
C13,14,15	22μF 35V Minelect	3	(RA54J)
SEMICONDUCTORS			
D1,2	1N4148	2	(QL80B)
IC1	SSM2120	1	(UL78K)
IC2	TL074CN	1	(RA69A)
MISCELLANEOUS			
P1-12	Pins 2145	1 Pkt	(FL24B)
	PCB	1	(GE94C)
	Instruction Leaflet	1	(XT18U)
	Constructors Guide	1	(XH79L)

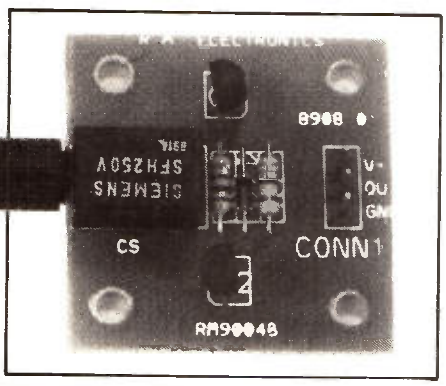
The Maplin 'Get-You-Working' service is not available for this project.
The above items are available as a kit, which offers a saving over buying the parts separately.
Order As LP79L (SSM2120 Data File) Price £10.95
Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately.
SSM2120 D. File PCB **Order As GE94C Price £3.45**

Fibre-Optic Digital Link Module continued from page 49.



The transmitter module.



The receiver module.

Preparation of the Light Guide

Both couplers are designed to be used with 1000 micron (1mm) core plastic fibre. A 3m length is supplied with the module. Greater lengths can be ordered under stock code XR56L; however, note that the module can only drive up to 20 metres. When cutting the light guide, great care should be taken to avoid scoring the fibre core. Try to make a single, straight cut thus keeping the end as smooth as possible, this being important for maximum light transfer to the couplers. Use a *very* sharp knife for this. Very fine emery paper, or the striking edge of a matchbox (but not glass-paper types!) can be gently rubbed squarely across the cut fibre end to polish the surface. Liquid metal polish also helps to develop a smooth finish and could also be used to finish off.

Alternatively, the cut fibre end can be placed close to a naked flame for a few seconds until the end begins to round off. Excessive heat should be avoided as it will melt the fibre completely. This method has the advantage of producing a near perfect finish and develops a 'lens' in the fibre – ideal for good light transfer. Whichever method is employed, aim for a mirror-like finish on the fibre end if maximum range is required.

Push the prepared end of the light guide, through the fluted cap and into the coupler. Tighten the cap with your fingers only - do not use any tools to do this! Repeat the procedure on the opposite end so that both transmitter and receiver modules are secured to the light guide. It must be emphasised that careful preparation of the light guide endings is of vital importance if maximum range is required.

When installing the light guide in a permanent position, be careful with bends. With reference to Figure 5, the absolute minimum radius of any bend in the fibre should not be less than 20mm. Exceeding the limit could result in cracking of the fibre, which will completely refract light and result in zero throughput. If using clips to hold the guide in position, be careful not to pinch or damage the outer sheath in any way. Light will escape and/or enter from pierced sheathing giving poor results.

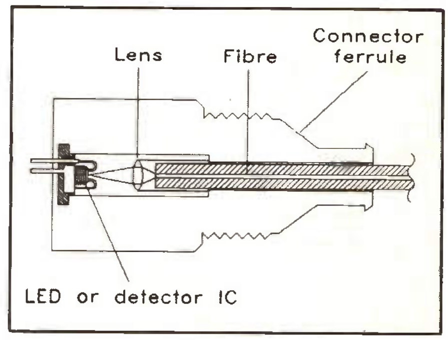


Figure 4. Fibre-optic coupler.

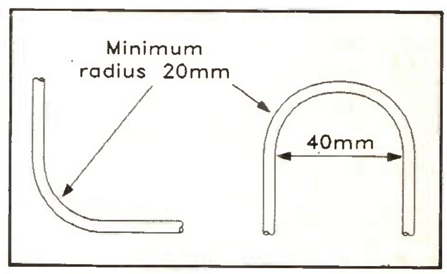


Figure 5. Bending the light guide.

Excessive heat and some chemical solvents will also damage the guide and should be avoided.

Availability

The Fibre-Optic Digital Data Link Module is obtainable from Maplin Electronics by mail-order or through their numerous regional stores. The Order Code is LP81C and the price just £22.95 inclusive of VAT.

Reference

Finally, for additional information on fibre-optic techniques, reference is made to 'Opto-Electronic Line Transmission' by R.L. Tricker (Order Code WS74R).

PREDICTING WAVESHAPES USING A COMPUTER

PART THREE
The Resistor – Inductor Circuit

by Philip Lawton

Introduction

The previous two parts of this series dealt with predicting and drawing the frequency response of C/R circuits. This time it is the turn of Resistor-Inductor combination. How to predict some of the transient and steady state waveshapes that are associated with inductors will be explained.

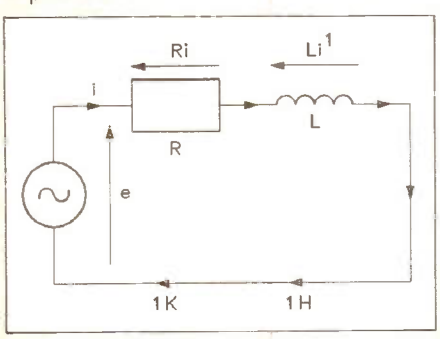


Figure 7. Resistor-Inductor series circuit.

The Resistor-Inductor series circuit, as shown in Figure 7, is used to illustrate how to apply the fundamental laws in order to obtain a very useful 'rate' equation. This is followed by a description of a computer program used to evaluate the 'rate' equation for any applied input emf and to plot the predicted waveshapes. Program listings are given in both GW BASIC, as used on the IBM PC and compatibles; and BBC BASIC, as used on the Acorn BBC micro. To adapt them for use on different machines, only the statements which plot the waveshapes onto the screen need to be altered.

The input to the circuit is assumed to be a constant. Other inputs are a ramp and a sinewave. Finally, the predictions are related to the time-constant.

Fundamental Laws

A useful law for the inductor relates the induced emf (emf) to the product of the inductance (L), with the 'rate of change' with respect to time of the current (si).

The law is:

$$emf = L \times si$$

which is derived from:

$$emf = N \times d0 \div dt$$

and

$$L = N \times d0 \div di$$

This law predicts the fact that, when a rate of change of current (magnetic flux) occurs, an emf is induced in the coil of the inductor. Note that magnetic materials are associated with the B-H loop. The magnitude of the change of magnetic flux does depend on the instantaneous value of the current and its direction. If the core saturates then the induced emf is very low, and an 'inrush' of current can occur which is only limited by the resistance of the inductor.

Equations

An equation for modelling the RL circuit can be derived using Kirchhoff's voltage law, Ohm's law and the above law. Note that the waveshape of the applied input signal is represented by the symbol e (volts), and that the results are a current i (amps), and an induced emf (emf).

This equation is:

$$e = (R \times i) + (L \times si)$$

where:

e is the value of the applied emf,
R is the value of the resistor,
i is the value of the current,
L is the value of the inductor,
si is the rate of change of the inductor current (di ÷ dt).

From this equation, another equation to predict the rate of change of inductor current, with respect to time (si), can be obtained:

$$si = (e \times 1 \div (R - i)) \div (L \div R)$$

This is the rate of change equation, and is used to evaluate the rate of change with respect to time of the inductor current (si). The rate of change is equal to the difference between the input to the RL circuit (e), multiplied by the gain (1 ÷ R), and the actual current (i) divided by the value of the time constant (L ÷ R).

Program

This 'rate of change' equation can be evaluated for any input emf (e) using a computer and a suitable language. Note that the evaluation can be for *any* input waveshape, and that this is a good reason for considering this program.

The program is shown in Listing 5 in GW BASIC, and Listing 6 as BBC Acorn BASIC. It predicts, at successive time

```
10 REM RL Listing 5 PC version Philip Lawton
20 REM Resistor-Inductor circuit
30 REM Evaluate inductor current
40 SCREEN 2 : CLS    : REM for graphs
50 LET R=1000        : REM Time Constant
60 LET L=1           : REM L/R is .001 s
70 LET I=0           : REM At switch time
80 LET H=.00004      : REM time step
90 FOR T=0 TO .00628 STEP H : X=T*100000
100 LET E=1 : REM LET E=1-1*T/.00314
110 PSET(X,100)                : REM zero
120 PSET(X,100-E*50)           : REM volts
130 PSET(X,100-I*50000)        : REM amps
140 LET SI=(E*1/R-I)/(L/R)     : REM rate
150 REM PSET(X,100-SI*50)      : REM i/s
160 REM At time T+H secs : -
170 LET I=I+SI*H               : REM amps
180 NEXT T : REM E=1*SIN(1000*T+45/57.3)
```

Listing 5. The Resistor-Inductor prediction program in PC GW BASIC.

```
10 REM RL Listing 6 BBC Acorn version Philip Lawton
20 REM Resistor-Inductor circuit
30 REM Evaluate inductor current
40 MODE 4            : REM for graphs
50 LET R=1000        : REM Time Constant
60 LET L=1           : REM L/R is .001 s
70 LET I=0           : REM At switch time
80 LET H=.04E-3      : REM time step
90 FOR T=0 TO 6.28E-3 STEP H : X = T*1E5
100 LET E=1 : REM LET E=1-1*T/3.14E-3
110 PLOT69,X,200                   : REM zero
120 PLOT69,X,e*200+200             : REM volts
130 PLOT69,X,i*2E5+200             : REM amps
140 LET SI=(E*1/R-I)/(L/R)         : REM rate
150 REM PLOT69,T*1E5,SI*200+200    : REM i/s
160 REM At time T+H secs : -
170 LET I=I+SI*H                   : REM amps
180 NEXT T : REM E=1*SIN(1E3*T+45/57.3)
```

Listing 6. The Resistor-Inductor prediction program in BBC Acorn BASIC.

steps, the inductor current i (amps) when the applied emf e (volts) is a constant. The predicted waveshapes are described in the next section. This program is based on a FOR STEP NEXT loop, and contains several very interesting statements. In line 90 time is stepped from 0 up to 6·28ms in intervals of h ms, in order to evaluate the equations (h has to be relatively 'small', at present h = 0·04ms).

In line 100, the applied emf is specified as a constant of 1 volt (e = 1). Alternatively, by changing line 100 a sine wave could be specified, angular frequency, ω, of 1000 radians per second (159·15Hz), periodic time of 6·28ms:

100 LET E=1*SIN(1E3*T+45/57.3)

In line 140 the rate of change equation is evaluated as amps per second (alternatively amps per time constant).

Line 170 contains a method of predicting the changing current. It can be stated as LET the new value of i become the old value of i plus an increment, where the increment is the product of the rate of change and a step in time. Provided the step in time, h, is relatively 'small', then the predictions will be useful (compare h with the time constant L ÷ R = 1ms).

Waveshapes

Figure 8 shows the predicted waveshape for a constant applied emf.

The horizontal axis represents time from 0 to 6·28ms (note that the time constant is 1ms, hence the time axis is equivalent to 6·28 time constants). The vertical axis represents the constant applied emf of 1 volt, and the resultant cur-

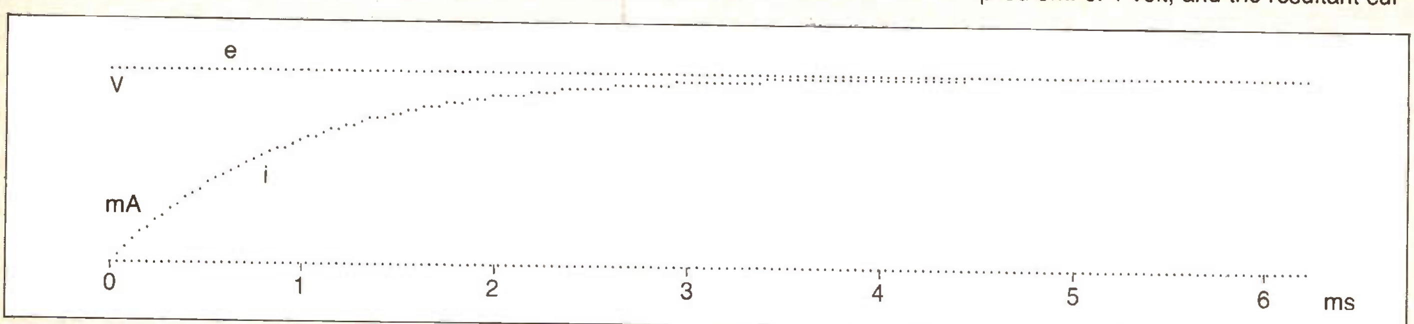


Figure 8. Predicted current for constant emf. Compare this with I=e*1÷R ×(1−EXP(−1÷1E−3)).

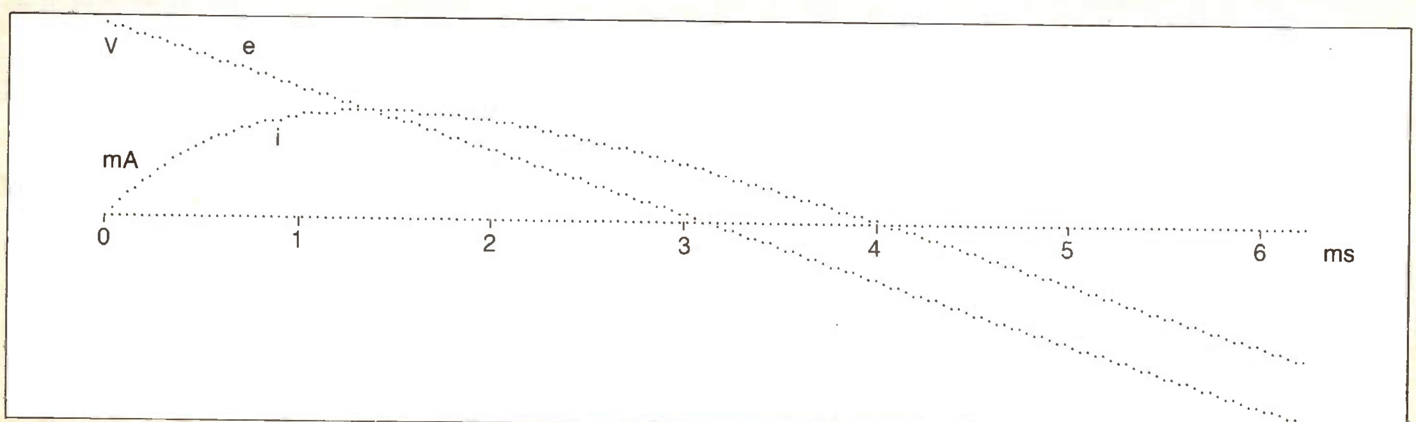


Figure 9. Predicted current for ramp waveform.

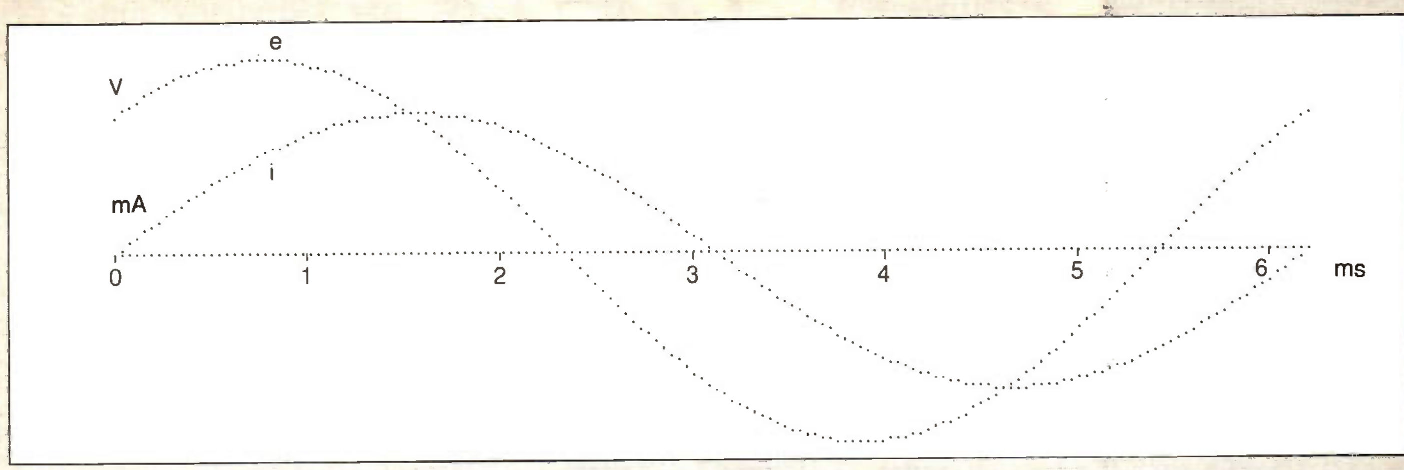


Figure 10. Predicted current for a sine wave – immediate steady state due to switching angle.

rent whose final value is a constant of 1mA. The current increases from 0 to a final value of 1mA (e ÷ R) in approximately 3ms. This period is equal to 3 time constants.

Figure 9 shows the predicted waveshape for a ramp waveform, and is very interesting, especially the transient. The applied emf changes from +1 to −1 at a rate of −1 ÷ 3·14E−3 v/s. At first the applied emf is decreasing whilst the current is increasing, then the emf is negative whilst the current is positive, and finally the current has a constant rate of change. The current is always less than e ÷ R, where e is the instantaneous value of the applied emf.

A useful way of considering this type of response is to suggest that, at any moment in time, the current has a value and is associated with a final value determined by the applied emf considered as a constant. For example, at time equal to zero the current is zero, and the final value is one milliamp (e ÷ R, e = 1), the rate of change of current is a maximum (+1mA/ms).

Later, at a time equal to the time-constant (1ms), the current is 0·5mA and the final value is 0·7mA (e ÷ R, e = 0·7), the rate of change of current is lower (+0·2mA/ms)

Figure 10 shows the response to a sine wave at a frequency of 1000r/s. The current lags the applied emf by a time equal to 1/8th of the periodic time (6·28 ÷ 8 ms). This is equivalent to −45 degrees. Note that the value of the applied emf at the instant of switching on ensures that the current immediately enters the steady state waveshape.

Things to Do

One interesting thing to do is to reduce the applied emf to zero:

```
100 LET E=1 : IF T >= 3.14E−3 THEN
E=0
```

It is left to the reader to predict the waveshapes for various sinusoidal inputs, construct the phasor diagrams, and to measure the actual responses using an oscilloscope. Useful frequencies are ω = ωb, ωb × 10, ωb ÷ 10, where ωb represents the break frequency of 1000 radians per second. (These are frequency 'decades', alternatively use 'octaves'.)

The problem of 'inrush' current can be predicted using a frequency of ωb × 100 (display the transient on a time axis of time-constant ÷ 10). The value of the first peak current can be twice the value of the steady state current. This problem can be minimised by switching on the applied emf at its maximum.

Note that the break frequency is the reciprocal of the time constant of the circuit (ωb = 1 ÷ (L ÷ R), or ωb equals 1 ÷ τ (one over tau), where τ is the time constant). The break frequency is a useful number in relation to the frequency response (Bode) diagram, and relates to some interesting arithmetic involving equal numbers and 1 ÷ 1·414 (0·707).

Finally

The Resistor-Inductor series circuit and a computer program have been used to explain how to predict the waveshapes for the response of the RL circuit.

An exponential response has been predicted for a constant input using the equation si = (e × 1 ÷ (R − i)) ÷ (L ÷ R), and the statement 'LET I=I+SI∗H' and the responses to a ramp and to a sine wave have been predicted.

The program can be amended to illustrate the reality of the B-H loop which is associated with magnetic materials. All in all this is a very powerful method for predicting the dynamic responses of complicated systems using existing simulation programs. In Part 4 mutual inductance of transformers will be examined.

Square One

A First Course in the Theory and Practice of Electronics

Part 11 by Graham Dixey C.Eng., M.I.E.E.

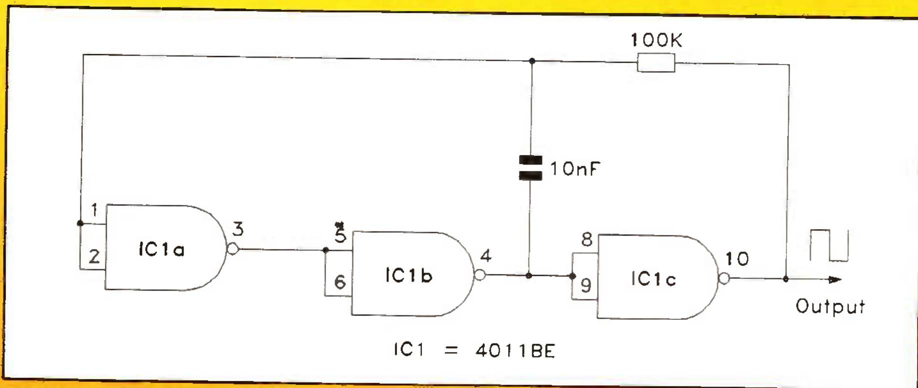


Figure 1. The 'ring-of-three' astable clock oscillator.

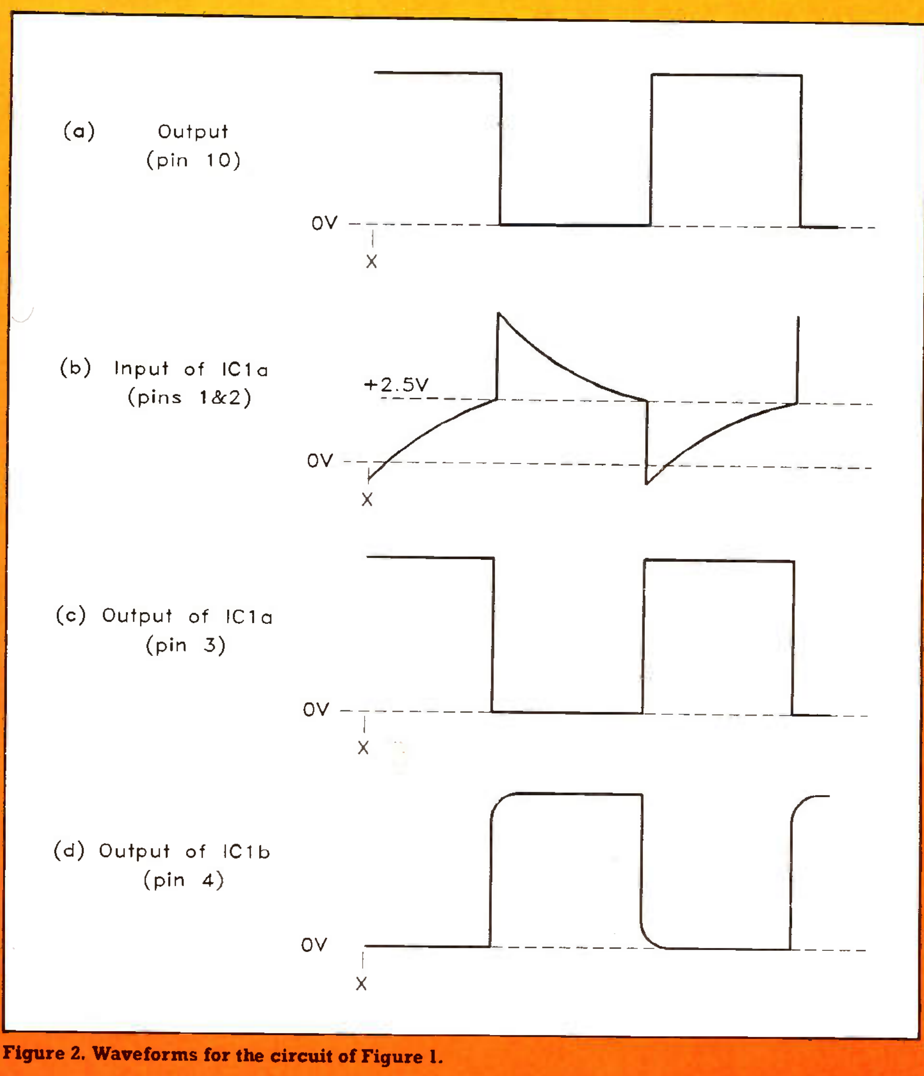


Figure 2. Waveforms for the circuit of Figure 1.

Introduction

A newcomer to electronics, reading this series, may well conclude that there is a considerable variety of circuits that can be used for generating various waveforms. This is the fourth consecutive part (but also the last!) in this series that deals with this specific topic, before we move on. Even then, we shall not have exhausted the subject by any means. To round up our survey we are going to look at a few more circuits that are useful in digital electronics. The first of these is another relaxation oscillator (remember the basic principle from the previous issue?), one that may be found in digital circuits, especially those which are microprocessor based, performing the function of a 'clock' oscillator.

The Clock Oscillator

The sequence of operations carried out by a microprocessor (the program) needs to be carefully timed. This timing is performed by an oscillator which generates a square-wave at a specific, often carefully regulated, frequency. The value of the clock frequency varies between different types/makes of microcomputer, being rarely less than 1MHz and often considerably higher, 8–20MHz for example. The rise and fall times (see last issue) of the leading and trailing edges of the clock waveform are often important. Nonetheless, the circuit itself is usually very simple, with a low component count. One possible circuit is shown in Figure 1, from which it can be seen that only three gates, one resistor and one capacitor are required. The operation is quite straightforward and can be understood very easily by reference to the waveforms, taken at various points in the circuit, shown in Figure 2.

This type of oscillator is termed a 'ring of three' circuit, since a closed loop or ring is formed by connecting the output of the final gate to the input of the first. The gates, in this instance, are simply inverters. Either TTL or CMOS ICs can be used, though the latter are most commonly employed. There is no need to use inverter packages as such. A NAND or NOR gate will perform the function of an inverter if all of its inputs are strapped together. In CMOS terms, the choice usually falls on the 4001BE (quad 2-input NOR) or the 4011BE (quad 2-input NAND). These ICs have the merits of being economical on both one's pocket and on power supply current! The only other components required are the timing resistor and capacitor, so called because they determine the speed at which the circuit operates, in other words the 'frequency' of the output waveform.

Now for the manner in which the circuit works. It is safe and convenient to assume that, at switch on, the capacitor C is uncharged. We can then assume that both the output of IC1b and the input of IC1a are low. This would line up with the statement just made, that the capacitor is uncharged — for example, both plates at 0V. From this starting point, the other potentials can be deduced. Thus, if the input of IC1a is low then, by inversion, the output of this stage must be high; this is the input of IC1b, of course. Similarly, since the output of IC1b is low, the output of IC1c must be high, by the inverting action of this stage. The resistor R is connected to the latter point, and it is towards this potential that the capacitor will attempt to charge, via this resistor. This potential is often referred to as the 'aiming point', because as the capacitor voltage rises, it effectively 'aims' at this potential. At this instant in time, the voltage across the resistor is equal to the supply voltage V_{DD}, giving rise to a current flowing in the resistor to charge the capacitor. This is the point in time 'X' on the waveforms of Figure 2.

Now consider what happens as the capacitor charges towards this point. The junction of R and C rises exponentially; this is the input of IC1a, which, therefore, also rises exponentially from its initial potential of zero volts. When the capacitor voltage reaches a threshold value, about +2·5V in this case, the output of IC1a switches from high to low. By inversion the output of IC1b goes high and, by a further inversion, the output of IC1c goes low. What has happened to the potential at the input of IC1a (pin 1)? The waveform diagram of Figure 2b shows that, at this instant, it has suddenly gone high. How do we explain this behaviour? It is due to a fundamental fact concerning capacitors, namely that they cannot change their state of charge instantly. Thus, whenever one plate of a capacitor is moved suddenly from one potential to another, the potential of the other plate moves by the same amount. That is exactly what has happened here. When pin 4 (lower plate of C) suddenly went high, this change was immediately communicated to the upper plate of C, which is connected to pin 1 of the IC, forcing the latter point high as well.

As a result, there is now a voltage across R once more (and, hence, a current flowing in this resistor), but the polarity has now reversed. The current flowing through R is, therefore, a 'discharging' current from C. Thus, in Figure 2b we can see that there is now a falling exponential voltage at pin 1. When this voltage reaches the same threshold voltage as before (+2·5V), all the voltage levels change state once more and a new cycle commences. The end result is that there is an excellent square-wave output at pin 10 of the IC, and also a slightly inferior anti-phase version at pin 4.

The values of R and C given in the circuit of Figure 1 should produce an output frequency of about 800Hz. Obviously, there is an infinite range of values of R and C that can be used, though it is better to keep the value of R moderately high (greater than 10kΩ), otherwise the output waveform deteriorates.

The pin-out diagram for the 4011BE IC used in the previous circuit is given in Figure 3.

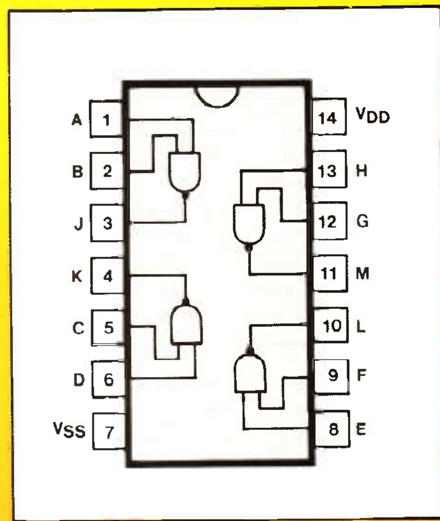


Figure 3. Pin-out diagram for the 4011BE CMOS IC.

A Crystal Controlled Clock Oscillator

The Need for Frequency Stability

A frequently desirable feature of oscillator circuits is frequency stability, that is the ability of the circuit to remain as close as possible to the frequency to which it is initially tuned. It is not difficult to see why this is important in any form of communication system, since any tendency for the tuning to drift would result in partial or total loss in communication between transmitter and receiver. The latter item of equipment normally needs to be designed to accept only a fairly narrow band of frequencies about the nominal reception frequency (known as the carrier frequency), to avoid picking up interfering signals from transmitters on adjacent frequencies. Care in design of the oscillator circuit can often bring about the necessary degree of stability but, where very high precision is needed, use of crystal control may be necessary. The main disadvantage of this method, as far as communication systems is concerned, is that the frequency cannot then be continuously variable; spot frequencies only are possible, and one crystal must be provided for each frequency in use. In computers it is common to use only a single clock frequency, requiring just one crystal, though some machines offer the choice of two switchable clock frequencies. Thus, the stability of crystal control can be conferred conveniently and cheaply.

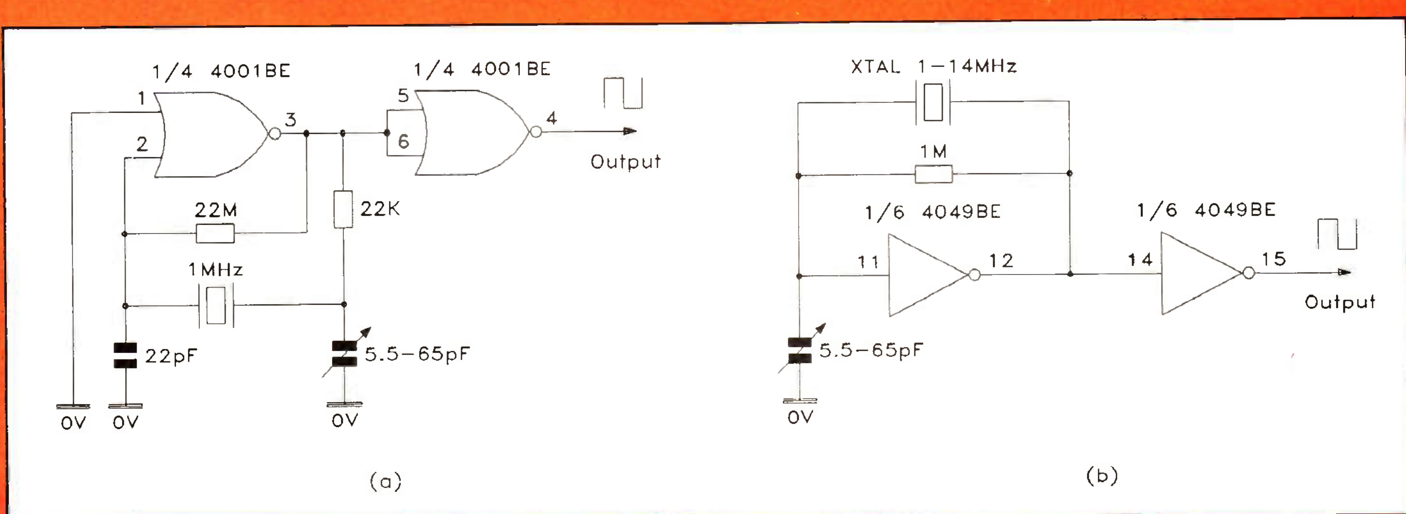


Figure 4. Two examples of crystal controlled clock oscillators.

Crystals and the Piezo-electric Effect

So what does a crystal do, and what sort of crystal can be used?

The type of crystal that is used in oscillators is a 'quartz' crystal though the same effect, known as the piezo-electric effect is also found and employed in crystals of Rochelle-salt. However, the latter were only used in crystal pick-ups and microphones for audio work.

The piezo-electric effect is a two-way phenomenon:

(i) If a slice of quartz crystal is subject to stress, for example by squeezing, twisting or bending, it develops a voltage proportional to the applied stress across an opposite pair of its faces.

(ii) Conversely, if a voltage at the resonant frequency of the crystal is applied across it, it vibrates mechanically at this frequency. This frequency of vibration is very stable in value.

It is possible to include a crystal in an oscillator circuit so as to maintain the oscillations at the desired frequency, namely that of resonance of the crystal. Since the frequency of crystals is commonly of the order of MHz, it follows that the physical dimensions of the crystal must be quite small. In fact, it is more a matter of the thickness of the crystal slice that determines the frequency. They can be ground in thickness so precisely that the frequency may be specified to at least eight decimal places!

The circuit of Figure 4a shows a clock oscillator, using two NOR gates from the 4001BE IC, that will oscillate at 1MHz. Apart from the IC and the crystal, the only other components are two resistors and two capacitors, one of the latter being a small preset for adjustment of the oscillator. Thus, apart from the expense of the crystal, around £5.00 currently, the circuit is cheap and simple. However, the circuit of Figure 4b is even simpler. It is also a CMOS type, but using two inverters and fewer components. The crystal frequency can lie in the range 1-14MHz, the variable capacitor having sufficient 'spread' to cope with this.

The Monostable Circuit

As the name implies, this circuit has only one stable state, in which it rests until a trigger input is applied. Immediately upon being triggered it changes state, the new state being termed the 'quasi-stable' state. This state is purely temporary and its duration depends upon the time constant of an RC combination. At the end of this timed period the circuit reverts to its original stable state, awaiting further trigger inputs.

This circuit is, then, a 'one-shot' pulse or square-wave generator, giving out a single pulse for each trigger input. That may not seem to offer much of an exchange until it is appreciated that:

(i) The output pulse can be of any precisely defined length, which may even be made variable, if desired.

(ii) The output waveform may be of better shape than the input trigger waveform that produced it, thus offering the possibility of regenerating waveforms.

One thing that won't change is the frequency; an output pulse will only appear when the input is triggered. From this it would be logical to deduce that we need to wait for the quasi-stable time to end before re-triggering the circuit. This is generally true, though there are monostables that permit re-triggering during the quasi-stable time.

Discrete or IC?

While as a general policy, I do not usually include discrete circuits where they have been effectively superseded by integrated versions, there is sometimes a case for doing so. Thus Figure 5 shows a very simple but effective monostable designed around two transistors and a handful of other components. The waveforms for this circuit appear in Figure 6. This circuit nicely demonstrates the monostable action. It works as follows:

Stable Time

Transistor TR1 is biased ON by the 12kΩ resistor R3 between its base and the positive supply; its collector potential (the output of the circuit) is, therefore,

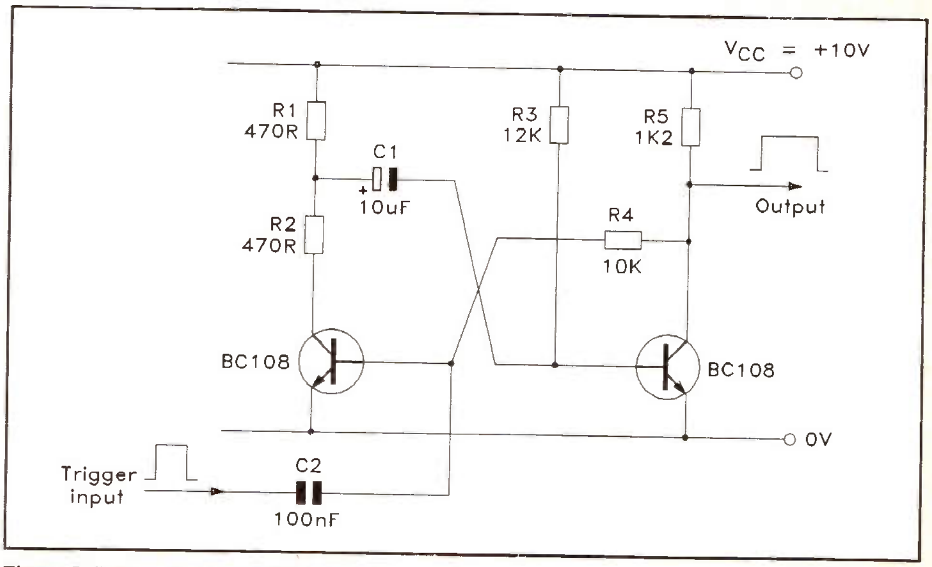


Figure 5. A discrete monostable circuit.

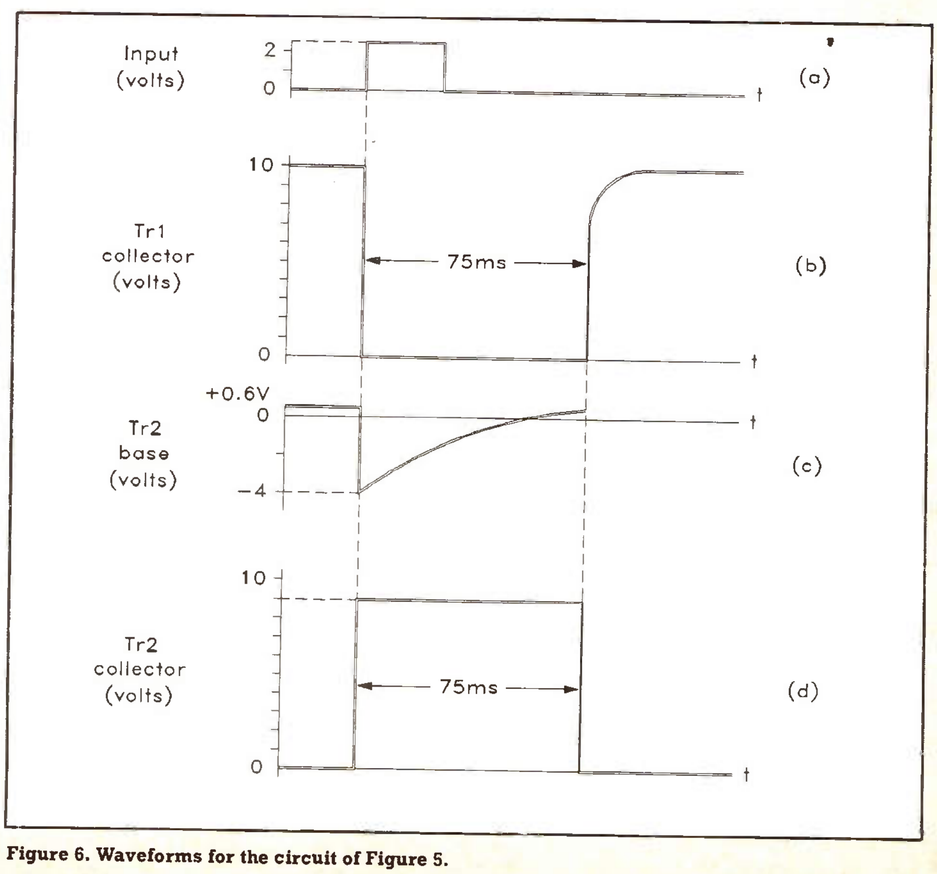


Figure 6. Waveforms for the circuit of Figure 5.

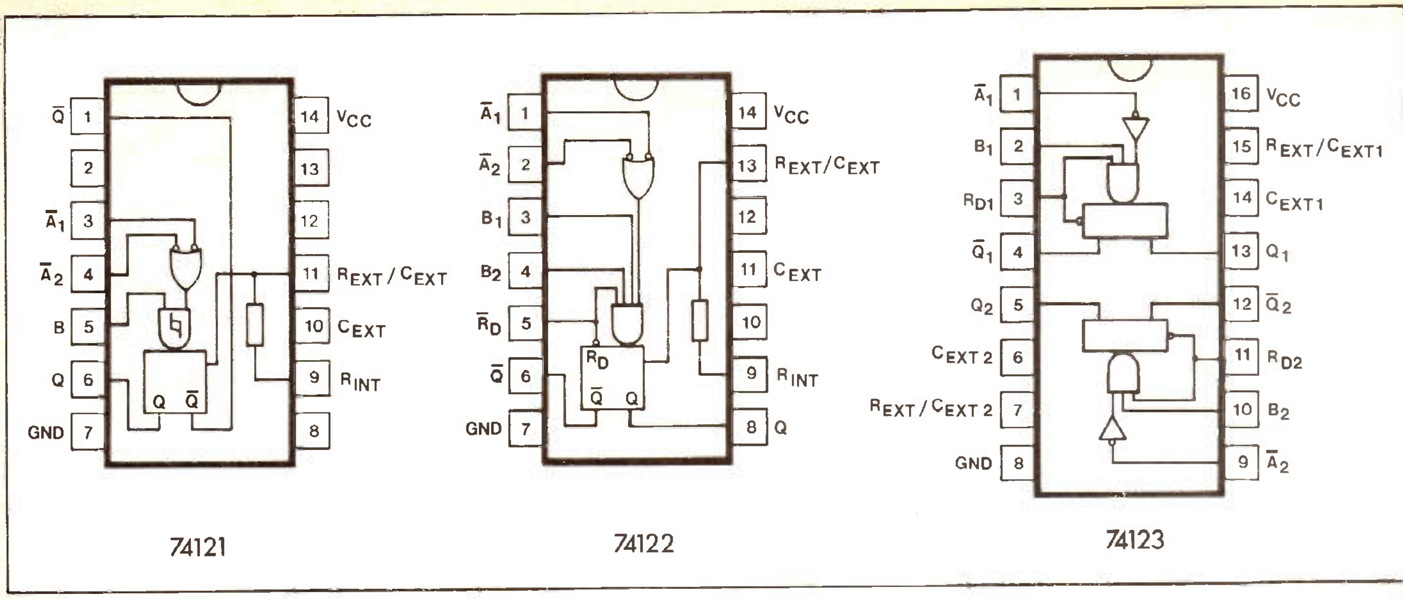


Figure 7. Pin-outs for some TTL monostables.

low — virtually 0V. The bias for the base of TR1 is derived from this point via R4, which means that there is no forward bias available for this transistor, which is, therefore, cut-off. As a consequence, its collector potential is high. These levels are shown in Figures 6b and 6d, while the base voltage of TR2 is given in Figure 6c. Now consider the voltage across C1 at this time.

The left-hand plate of C1 is at +10V since TR1 is not drawing current and, hence, there is no volt drop across R1. The right-hand plate of C1 is at a potential of +0·6V because this is the normal forward bias voltage across the base-emitter junction of a conducting transistor and, as we can see, this plate of C1 connects to the base of TR2. From this we deduce that the net voltage across C1 is the difference between these two voltages, namely 10 − 0·6 = 9·4V. The polarity of this voltage is such that the left-hand plate is positive with respect to the right-hand one.

Now we apply a positive step or square-wave to trigger the circuit into the alternative state. This is shown in Figure 6a.

Quasi-stable Time

The trigger input is capacitively coupled to the base of TR1 by C2. This transistor is, we remember, cut-off at this time. Therefore, at the moment of triggering, its base is forced to rise sharply in potential and, if the trigger input has sufficient amplitude, TR1 will into conduction. Once it is drawing current its collector potential, and that at the junction of R1 and R2, will fall; the latter falls, in fact, by about 4·6V. Since the left-hand plate of C1 is connected to this point, this also falls by the same amount. The crucial question is, "what happens to the potential on the right-hand plate of C1?" The short answer is that it also falls by 4·6V! This phenomenon was explained previously when discussing the clock oscillator.

Since the right-hand plate of C1 is connected to TR2 base, the latter falls by 4·6V from its original value of +0·6V to a new value of −4V. See Figure 6c. Transistor TR2 is now well and truly cut-off by this negative base bias. Therefore, its collector voltage will now be high, in practice about +9V. This marks the start of the output pulse. This voltage also provides a forward bias to the base of TR1 via R4, holding this transistor in the on state into which it has just been driven by the trigger pulse. If the trigger terminates now TR1 will stay on; the circuit is in the quasi-stable state.

The explanation given above does nothing much more than describe the situation that maintains at the instant of triggering and the sequence of events and resulting conditions that force a change from stable to quasi-stable states. From this instant onwards the circuit begins its return to the stable state.

Return to the Stable State

Consider resistor R3. The upper end is at +10V, the lower end at −4V; the voltage across it is, therefore, 14V. Under these conditions, the current flowing in R4 is 14 ÷ 12mA = 1·17mA. This current must flow somewhere and since it can't flow into the reverse biased base of TR2, it can only be flowing in the path that includes C1, R2 and the collector-emitter region (a virtual short-circuit) to the 0V line. Since this current is flowing in the opposite direction from the current that charged it up in the first place, the inference is that C1 is discharging. The voltage across it is, therefore, reducing. Because the left-hand plate of C1 is tied to a fixed potential, this must mean that the potential at the right-hand plate is rising. We can see by looking at Figure 6c that it is, in fact, rising exponentially from −4V towards the supply voltage. When it eventually rises above the 0V level, TR2 will begin to conduct. At this point a regenerative switching action will occur that will return the circuit to the stable state. This is explained as follows:

As TR2 starts to draw current its collector potential falls; this fall is directly coupled to TR1 base by R4. Therefore, TR1 takes less current; its collector potential rises. A proportion of this rise at the R1/R2 junction is then coupled through C1 to TR2 base, so reinforcing the exponentially rising voltage at this point. This makes TR2 conduct even harder, its collector potential falls even more, reducing further the voltage at TR1 base . . . in no time at all the circuit is back in the stable state. The collector of TR2 returns to 0V (nearly); this marks the end of the output pulse.

The Timing Components

It should be obvious now that the length of time that the circuit spent in the quasi-stable state was equal to the time that it took for the base voltage of TR2 to rise from −4V to just above 0V. The rate at which this rise occurs depends upon the value of C1 and the series resistance through which it charges. The latter is principally R3 since R2 is small in value by comparison. To change the length of the output pulse it would seem that we could alter the value of either C1 or R3. In practice it is better to leave R3 alone and use different values of C1. This is because R3 has another role, supplying base current to TR2 to hold it in the stable state. Make R3 too large and TR2 may not conduct sufficiently.

The Trigger Input

A fairly sharp trigger input is required, of about 2V amplitude. A square-wave of this peak-to-peak value will trigger the circuit satisfactorily. For the value of C1 given here, an input frequency of about 5Hz will work well. By reducing the value of C1, a higher trigger frequency can be used.

IC Monostables

TTL Monostables

As mentioned earlier, there is nowadays no real need to build a monostable circuit discretely, except to satisfy one's curiosity. Several IC versions exist and, in the TTL range, one can cite the 74121, 74122 and 74123 ICs as examples. These chips, whose pin-outs appear in Figure 7, are differentiated as follows.

74121: Single, non-retriggerable.

74122: Single, retriggerable.

74123: Dual, retriggerable.

In this context, the terms single and

dual refer to the number of individual monostables contained in the IC package. The terms non-retriggerable and retriggerable require further explanation.

Non-retriggerable and Retriggerable Monostables

In the case of some monostable circuits, it is essential to allow the triggered circuit to recover fully before attempting to trigger it again. The 74121 is an example of such a circuit. On the other hand, there are circuits that respond to a new trigger pulse, occurring during the recovery time, by commencing a complete new cycle from the re-trigger point. With such circuits, if they are constantly triggered by a train of pulses of frequency f, with a periodic time τ somewhat less than the timing period of the monostable, they will stay permanently in the quasi-stable state. This leads to an application known as a 'missing pulse detector', in which the absence of a pulse allows the output level to return momentarily to the stable value, long enough perhaps to trip a latch to indicate the absence of a pulse. The 74122 and 74123 are both retriggerable.

The behaviour of both types of monostables is illustrated by the waveforms of Figure 8.

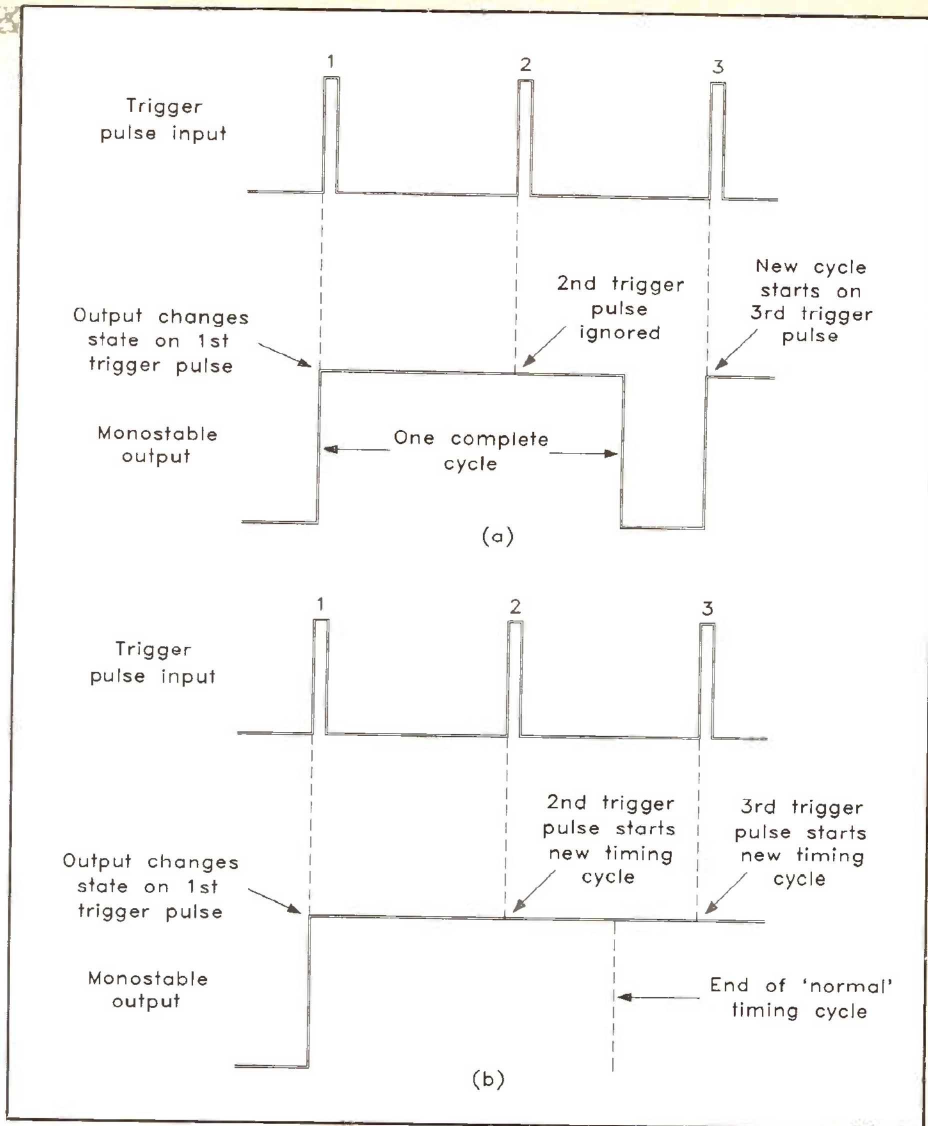


Figure 8. (a) Waveforms for non-retriggerable and (b) retriggerable monostables.

Application Circuits for TTL Monostables

Figure 9 shows the three TTL ICs mentioned, from which it can be seen that the only external components required are the timing components consisting of a single resistor and a single capacitor. The 74123, of course, requires a pair of such components for each of its dual sections. Each of these monostables requires a negative going pulse input with the connections as shown. However, as seen later, the trigger requirements can be configured according to the user's needs.

Values of the Timing Components

As just stated, for each of the TTL monostables only a single RC time constant is required. Obviously, there are many RC products that will give any one particular output pulse duration. However, there is a restriction on the value of resistor employed. For the 74121 it should lie in the range 2-40kΩ, while for both the 74122 and 74123 its value should be between 5-25kΩ. The capacitance value can be from 10pF upwards. In practice, it is usual to use these TTL monostables for very short duration pulses, in the region of tens of nanoseconds to several microseconds, although as Figure 10 shows, pulse lengths up to 10ms are possible using a 1μF capacitor, while keeping within the limits for R.

The graph of Figure 10 is a convenient way of determining the values of these two components. In use, all one has to do is project a horizontal line from the vertical axis of pulse widths to

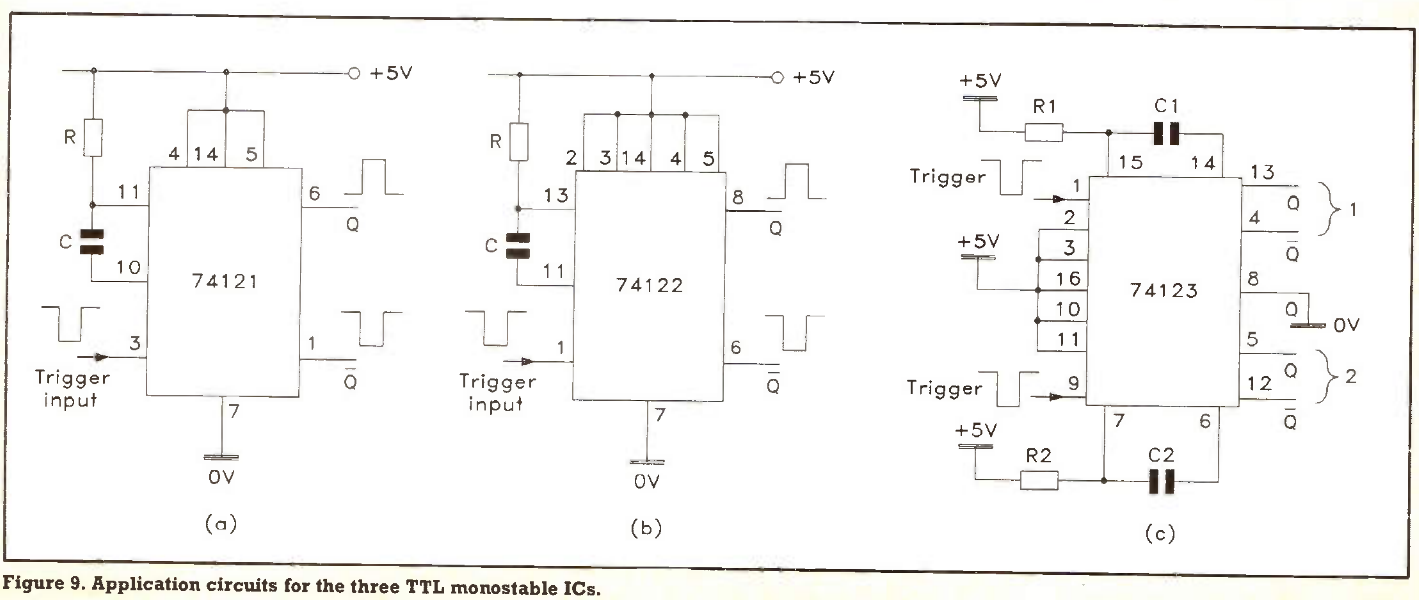


Figure 9. Application circuits for the three TTL monostable ICs.

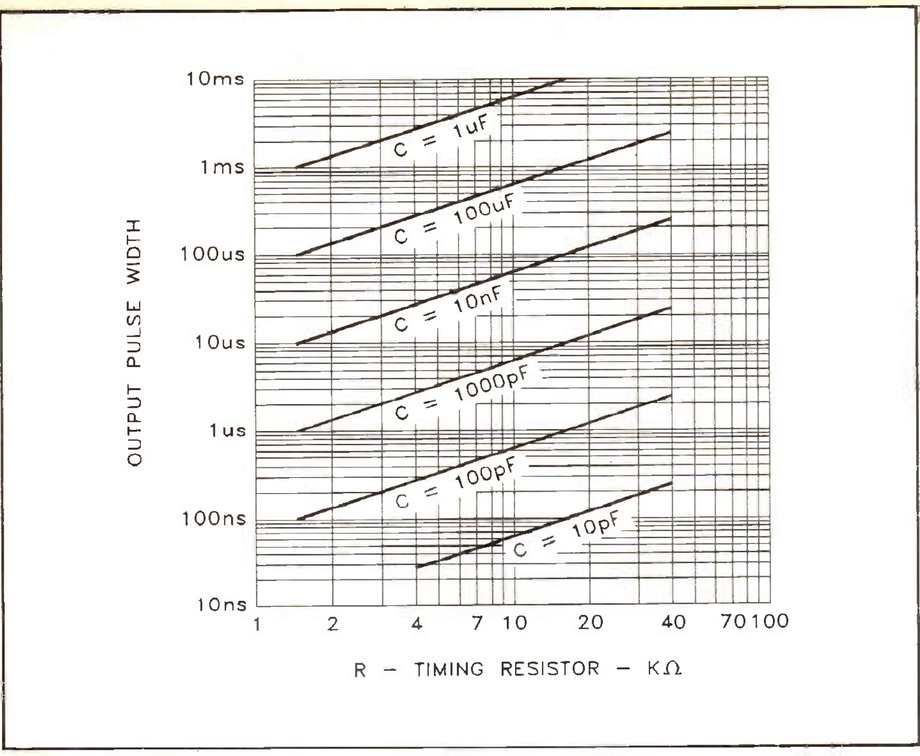


Figure 10. Graph for calculating RC timing components for TTL monostables.

intercept one of the 'lines of constant capacitance'. Projection downwards from this interception point, onto the horizontal axis, gives the resistor value. For example, if the pulse length is to be 100μs, then the value of C is 10nF and the value of R is about 16kΩ.

Trigger Requirements

The three TTL monostables in question, each have several trigger inputs, which offer various modes of triggering, or even of inhibiting the trigger operation, according to how they are utilised. For the three ICs, these facilities are described as follows.

74121: trigger inputs are $\overline{A1}$, $\overline{A2}$ and B.

(i) $\overline{A1}$ = $\overline{A2}$ = 0V; B is taken high to trigger circuit. This method has a very positive action known as a Schmitt trigger action.

(ii) $\overline{A1}$ = B = high; $\overline{A2}$ is taken from high to low to trigger circuit.

(iii) $\overline{A2}$ = B = high; $\overline{A1}$ is taken from high to low to trigger circuit.

74122: trigger inputs are $\overline{A1}$, $\overline{A2}$, B1 and B2; CLEAR $\overline{RD}$ input must be high, otherwise triggering is inhibited.

(i) $\overline{A1}$ = $\overline{A2}$ = B2 = high; B1 is taken from low to high to trigger the circuit.

(ii) $\overline{A1}$ = B1 = B2 = high; $\overline{A2}$ is taken from high to low to trigger the circuit.

(iii) $\overline{A2}$ = B1 = B2 = high; $\overline{A1}$ is taken from high to low to trigger the circuit.

74123: Each section has two trigger inputs, $\overline{A}$ and B. As with the 74122, the CLEAR $\overline{RD}$ input must be high for triggering to be allowed.

(i) $\overline{A}$ = 0V; taking B from low to high triggers the circuit.

(ii) B = high; taking $\overline{A}$ from high to low triggers the circuit.

One advantage of these TTL monostables is that there are two complementary outputs. The 'normal' output at Q is a positive pulse during the quasi-stable time; that at the $\overline{Q}$ output is a negative pulse, coincident in time.

The 555 as a Monostable

The 555 timer IC, which we have already used as an astable, that is a free-running pulse generator, can be easily adapted as a one-shot circuit (as the monostable is often known). Furthermore, it can be set up as either a non-retriggerable or retriggerable type merely by changing one pin connection. The circuits for both types are shown in Figure 11.

The quasi-stable time period, t_Q, is determined by the values of R and C and is given by the formula:

$t_Q = 1{\cdot}1 \times R \times C$.

For the values given in Figure 11, the quasi-stable time works out to 1·1ms. Obviously such a simple formula makes it a straightforward matter to calculate the components required for any given pulse length.

Example: Calculate the component values for a timed positive output pulse of duration (i) 50μs and (ii) 250ms.

Since it is required to calculate the values required for *two* components and there is only *one* formula, we play the usual trick of making a sensible (we hope!) guess at one of them, usually the capacitor. It helps that we already know the values that give a pulse length of 1·1ms, since we can then scale these accordingly to get a rough estimate and then calculate the more precise values afterwards.

(i) Suppose we say that the time is roughly 1ms and R = 10kΩ; C = 100nF. Then, since 50μs is 1/20 of 1ms, we could scale the capacitor value down in the same ratio, to 100/20 = 5nF. The nearest preferred value to this is 4·7nF and this is what we choose to use. What we now do is to substitute this value into the formula together with the value for the required time and calculate the required value of R. First we must transpose the formula for R, as follows.

$R = t_Q \div (1{\cdot}1 \times C)$.

$= (50 \times 10^{-6} \div (1{\cdot}1 \times 4{\cdot}7 \times 10^{-9})$.

$= 9671\Omega$.

This is quite close to the value of 10kΩ used originally; our approximations didn't take us too far from the truth after all! Whether we can use 10kΩ will depend upon the degree of accuracy required. Suppose that the pulse length is to be within 10% of the specified value, i.e. between 45 and 55μs. We should probably be alright, depending upon the tolerance of the capacitor. It would be

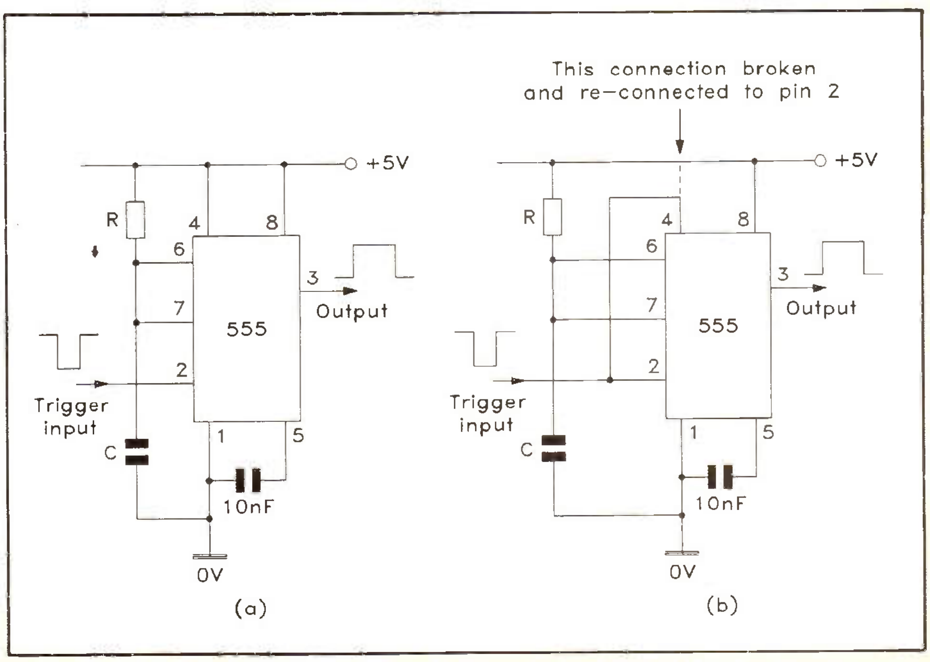


Figure 11. The 555 IC as a monostable: (a) non-retriggerable and (b) retriggerable modes.

quite easy to carry out some calculations, using the value of 10kΩ and the lower and upper limits of the capacitor value, based on its nominal value and percentage tolerance. However, I won't take up space with that here.

(ii) In the second example, a very much longer time is required, almost 250 times greater than in the original case (1·1ms). We could try simply scaling up either R or C by 250 times, or both by a suitable proportion for each.

For example, scaling R by 250 gives 250 × 10kΩ = 2·MΩ; scaling C by the same factor instead gives 250 × 100nF = 25µF. While both of these values are possible, it is often better to aim for 'middle of the road' values.

Instead, we could scale the resistor 10 times (= 100kΩ) and the capacitor 25 times (= 2·5µF); or we could scale the resistor 25 times (= 250) and the capacitor 10 times (= 1µF), both of which are viable choices, except that we shall need to modify C to be either 2·2µF instead of 2·5µF or R to be 220kΩ instead of 250kΩ, if we intend to use preferred values (as opposed to making up values by combinations).

As an example, suppose we choose the former possibility, with C = 2·2µF, we can calculate what the actual value of R should be to give the required time exactly.

$R = t_Q \div (1{\cdot}1 \times C)$.

$= (250 \times 10^3) \div (1{\cdot}1 \times 2{\cdot}2 \times 10^{-6})$.

$= 103k\Omega$.

If we use 100kΩ instead, this will almost certainly be satisfactory. In this case, as in any other, if the time period needs to be set very closely to some specified value, it will be necessary to include a preset potentiometer as part of the total resistance value. This variable part should be only a small percentage of the total, otherwise adjustment will be too coarse. For example, if the nominal value of R is 100kΩ, then a 91kΩ resistor with a 22kΩ preset in series should allow accurate setting to be achieved.

The 555 timer IC represents a useful device in one-shot applications, being inexpensive and easy to set up. Its one shortcoming, when compared with the TTL chips discussed previously, is its lack of a complementary output. However, this can easily be provided by using the normal 555 positive output at pin 3 to drive a TTL inverter as shown in Figure 12.

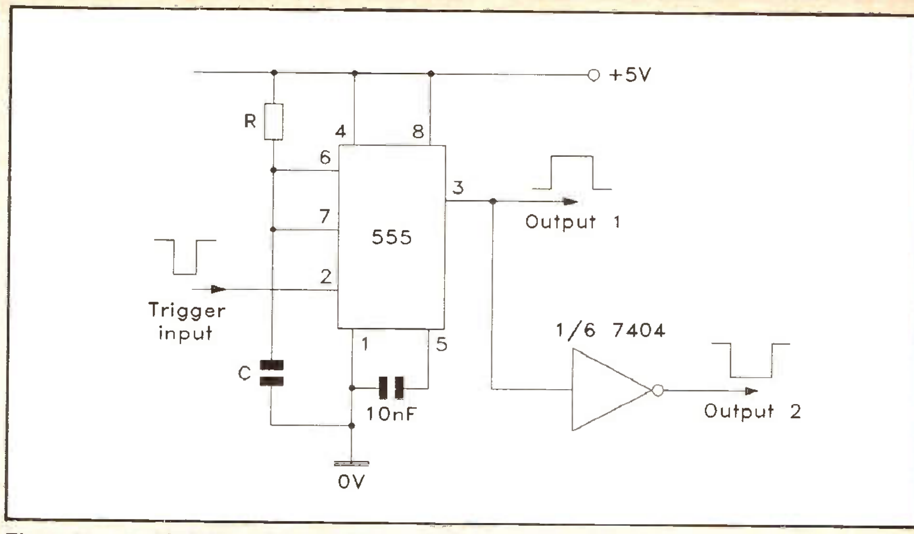


Figure 12. Circuit of Figure 11a modified to provide complementary outputs.

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A readers forum for your views and comments. If you want to contribute, write to:

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

AIR YOUR VIEWS

Dear Editor

Chop their Bandoliers off!

Dear Sir,
I frequently use the Maplin Catalogue and your Components Service, and have only one major complaint. This is, the habit of your staff tearing resistors and diodes off their tape bandoliers instead of cutting them off. I know that they are working under pressure, but the result is that these components arrive with the leads twisted and bent. Apart from the annoyance of receiving components in this mangled state and having to straighten the leads before use, it is possible that a small proportion are actually damaged: for example, one is not supposed to bend the leads of diodes within a millimetre or two of the seals. The force needed to tear the tape on a bandolier is quite considerable, and much of it gets applied to the component in the process. Sometimes the enamel on a resistor is cracked at the point where the wire emerges. Twice before, over the years, I have written direct to Maplin to complain about this, and once I asked for some resistors to be replaced (which they were without any fuss). Components still arrive bent, and yet it would be easy enough to cut components off with scissors or side-cutters.
Dr. J. R. Baker, Bath.

Dave Foreman from the Q.C. Department Replies:
Thank you for drawing the matter of resistors and diodes being 'torn off' the bandoliers, to my attention.
I accept that some staff have been in the habit of doing this in the past, but this problem has now been addressed and it is now standard practice to cut components from their bandoliers.
I am monitoring this situation closely to ensure that the correct procedure is being carried out and that old habits have in fact 'died'.

'Allo 'Allo?

Dear Sir,
June/July issue of 'Electronics', page 2, Picture Caption Challenge – I think it's: That English idiot Constable Crabtree, somewhere in France, masquerading as Arthur Bostrum, masquerading as a bird fancier, saying "Owl-o Owl-o".
J. Rodgers, Sheffield.

Turn to page 3 for another equally stupid picture caption challenge to solve!

Remote Chance

Dear Sir,
Your publication of Mr A. Williamson's article on the I/R tester is rather coincidental! A friend of mine has several TV remote controllers that are not functioning properly.
A. Chetwood, Shrewsbury.

It's nice to know that our projects are appreciated.

S·T·A·R L·E·T·T·E·R

This month, D. Greespan from Middlesex receives the Star Letter Award of a £5 Maplin Gift Token for his letter on re-using discarded IC carriers.

When the Chips have Gone...

Dear Sir,
In these days of environmental awareness, we should try to recycle as much as possible or at least make better use of the things we have. Many ICs come delivered inside plastic capsules with conductive bases. For some time, these have been cluttering up my workbench, with no obvious use. However, if you use a two-part epoxy resin adhesive, you'll find the plastic part of the capsule is perfect for mixing them in. Remove the backing from the capsule. Squeeze some adhesive into one end of the plastic part, and the same amount of the hardener into the other end. Now, using a small screwdriver, mix the two together. There is no wastage as you can scrape out every last drop of the stuff, and there is no mess as you can throw the capsule out (like you were going to in the first place). I have found quick-setting epoxy resin very useful for encapsulating small circuits. It makes them virtually indestructible, and because it goes opaque when set, all the little secrets inside are safely kept.
D. Greespan, Middlesex.

What an ingenious idea!

Hard Nut

Dear Sir,
A year ago I bought a Maplin Hobby Multimeter. This instrument has been dropped a number of times on to a tiled brick floor. There is no sign of a crack in the case, no pivot stick balance, 'spot-on' accuracy 2% at FSD. I am sure you will agree that this is a remarkable achievement for an instrument, after receiving such rough treatment.
E. Vaughan.

It certainly is! However, we would not recommend that multimeters or other items of test equipment are deliberately mistreated. Accuracy can be seriously affected by both physical and electrical mistreatment; care should be exercised when making measurements. For example, ensure that a multimeter is not switched to a current or resistance range when attempting to measure mains voltage! It may sound obvious but this is probably the commonest way of 'killing' a meter. A good practice to adopt is to switch the meter to 'off' when the meter is not in use. However, some meters do not have an 'off' position and in this case the meter is best switched to a high (say 1000V) voltage range. Meters, such as the well respected AVO 8, often damp the meter movement when switched off so as to afford further protection against vibration and physical shock.

More Video Please

Dear Sir,
Firstly congratulations on yet another interesting edition of the magazine. It's always worth reading and informative. I'm sure that many readers already have or have hopes (like me!) of acquiring a video camera. I have already used several different models (courtesy of various friends), and this just helps to emphasise that one must be very careful in choosing just the right model. I am very interested in editing, titling etc. so I was pleased to see the video amplifier article in the June-July magazine as this could prove to be very useful in the not too distant future. Most of the equipment currently available for editing, adding video effects and titles is extremely expensive. I'm sure this is because of the relatively small number of people prepared to pay the level of price demanded. I'm quite sure that there must be many video camera owners who would welcome the chance to construct a unit (or several!) which would enable them to add effects and titles to their 'masterpieces'. This could perhaps be offered in several modules varying in use and complexity, audio modules in one series and video in another, so that those who like me have a fairly comprehensive audio set-up already, do not have to buy these unnecessarily.
Dr M. I. Jackman, Chale, IoW.

Thank you for your suggestions, which, in time honoured tradition, have been passed onto the lab for their perusal. (Psst. I'm not supposed to mention this but there is another video project in the pipeline . . . just don't tell anyone that I said so!)

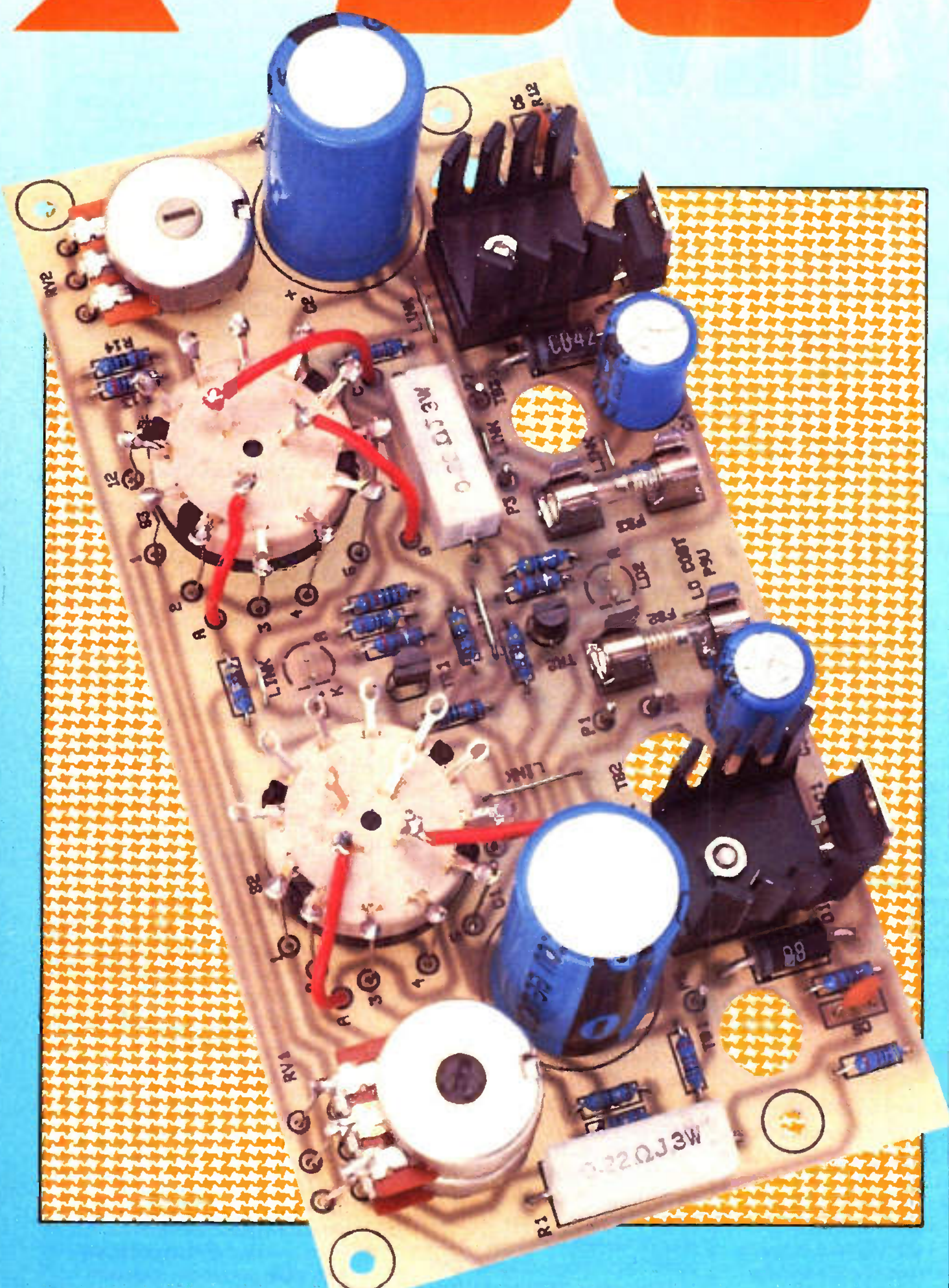
Lonely Hobbyist

Dear Sir,
I have been very interested in electronics for a number of years and have built numerous projects from the pages of 'Electronics'. Most of which worked first time, and those that didn't were usually due to my own mistakes. However, far from being discouraged (as so many hobbyists these days seem to be) when the projects didn't work first time, I set about finding out why they didn't work. The overall result was that I learnt a lot more about how and why circuits work. This really brings me on to the main point of my letter; often I want to talk to other hobbyists about electronics, exchange ideas and tips and things like that. Unfortunately none of my friends are interested in electronics, is there any kind of club or society that could put me in touch with other hobbyists?
P. Hewitt, Caernafon, Wales.

The club that springs to mind is the British Amateur Electronics Club, the club is very well established (it was formed some 25 years ago) and has members all over the UK and abroad as well. The club publishes a regular newsletter, containing all manner of useful information and has contributions from club members. For further information contact: Mr H. F. Howard, 41 Thingwall Park, Fishponds, Bristol BS16 2AJ.

LOW COST PSU

by Gavin Cheeseman



FEATURES

- ★ Variable and Fixed Outputs
- ★ Current up to 1A
- ★ Stable Regulated Supply
- ★ Single or Split Rail Outputs
- ★ LED Status Indicators

Introduction

The Low Cost Power Supply is a relatively simple design that provides reliable performance and is ideal as a power supply for the home constructor. The supply makes available a variety of voltage combinations which include variable split supply, variable single supply, a fixed 5V and a fixed 12V supply. A three position, switchable current limit is also provided and the unit is capable of supplying current levels up to 1A.

Circuit Description

Figure 3 shows the circuit diagram of the power supply. The supply is based around the L200C regulator, which is capable of handling input voltages up to a maximum of 40V and output voltages up to 30V with programmable current limit. The circuit effectively uses two individual single power supplies i.e. a transformer with two separate secondary windings and two regulators.

A 2A transformer is used in the design to allow plenty of headroom when the power supply is being used at a current level of 1A. It is important that the transformer secondary voltage is not allowed to drop below the minimum input voltage for full voltage output from the regulator, as regulation would be lost.

Mains voltage is applied to transformer T1 via primary fuse FS1 and mains on/off switch S1. A mains voltage of 240V RMS on the primary of the transformer, corresponds to a secondary voltage of approximately 20V RMS. The low voltage AC is fed to two separate bridge rectifiers (BR1 and BR2) via fuses FS1 and FS2. The output from the rectifiers is smoothed by electrolytic capacitors C1 and C2. Two completely separate unregulated DC supplies are produced which are then individually fed to the input of regulators IC1 and IC2. The output voltage of each regulator is determined separately by a network of resistors, switched by S3. A similar set of resistors (switched by S2) are used for current limiting purposes. S3 is also used to select single or split supply operation. Transistors TR1 and TR2 are used to drive two LEDs which indicate the status of the power supply outputs (single or split). Diodes, D1 and D2 are used to prevent voltage spikes or residual voltages from external equipment connected to the output of the supply from damaging the regulators. Fast recovery diodes are used in this application because of their fast switching characteristics. Resistors R7 and R15 ensure that the diodes are maintained in a conducting state even at very low output current levels. Capacitors C3 and C4 decouple the regulators, attenuate noise and prevent instability.

Construction

Insert and solder the components onto the PCB referring to Figure 2 and the Parts List. It is a good idea to start with the resistors, as these are relatively low profile components, and may be awkward to fit at a later stage. Next, using the resistor lead off-cuts, fit the eight links on the PCB, these are marked 'LINK' on the legend. The fuse clips (used to hold FS1 and FS2) should then be fitted; these must be kept flush with the PCB when soldering as illustrated in Figure 1. Next insert and solder the capacitors. It is important that the electrolytic capacitors are fitted with the correct polarity; the negative lead of the capacitor, marked by a negative (−) symbol on the component body, is

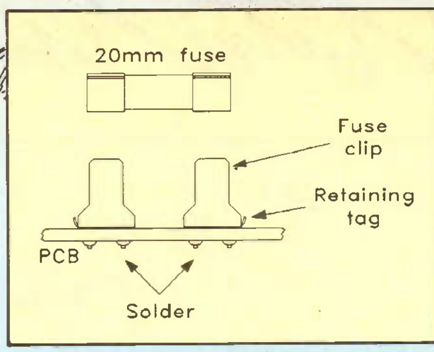


Figure 1. Mounting the fuse clips.

inserted into the hole furthest from the positive (+) symbol on the legend. Transistors TR1 and TR2 are fitted such that the case of the component corresponds with the outline on the PCB legend. Regulators RG1 and RG2 are fitted in a similar manner with the heatsink tags perpendicular to the PCB; the tags are bolted down to the bottom of the case, using insulating bushes and washers, when the PCB is finally installed. Bridge rectifiers, BR1 and BR2 are inserted and soldered such that the symbols on the corners of the device correspond with those on the PCB legend. The bridge rectifiers each use a small heatsink and these are held in place by a nut and bolt through the PCB. Position the heatsink such that it is clear of any surrounding components. Potentiometers RV1 and

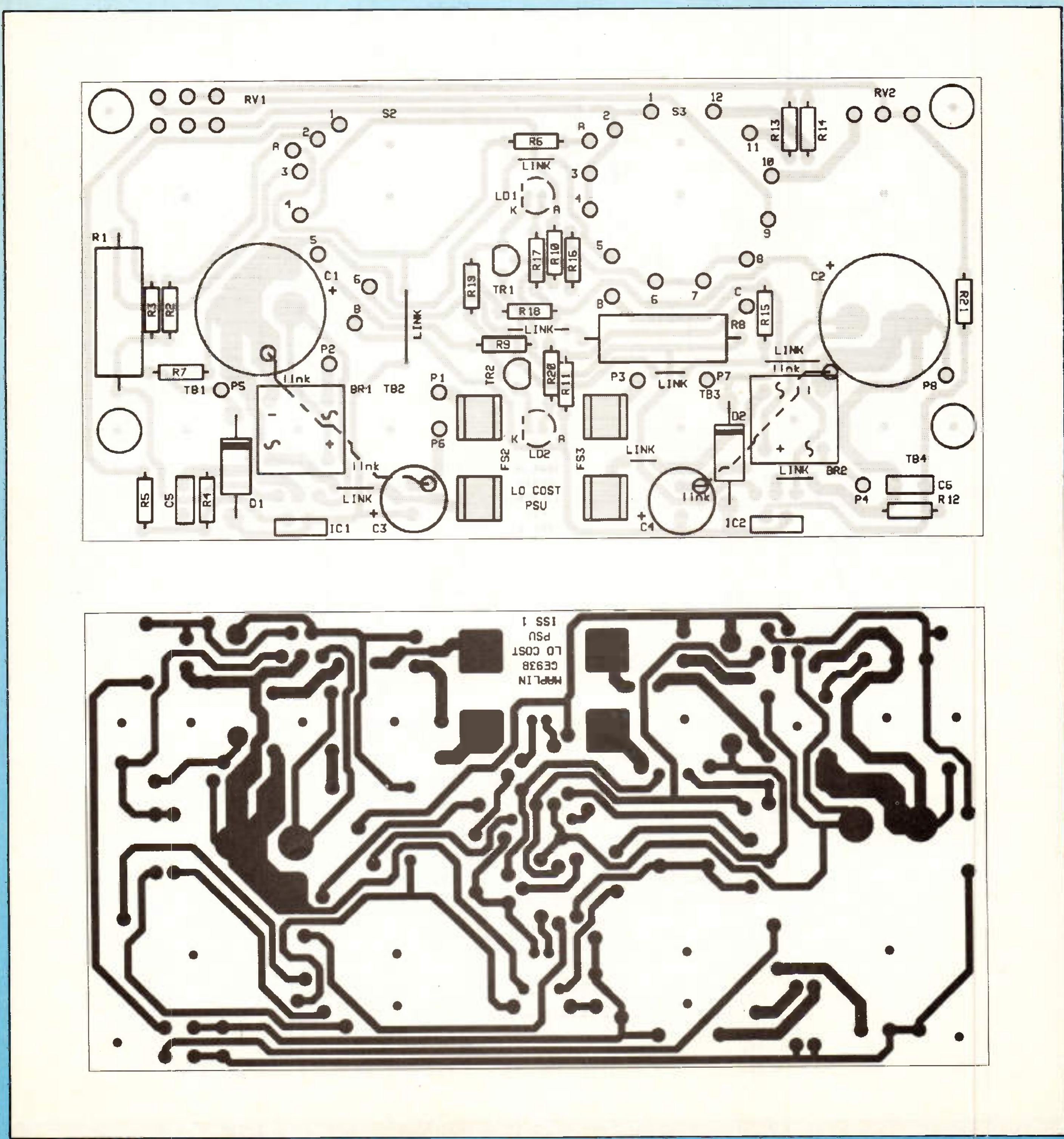


Figure 2. PCB legend and track.

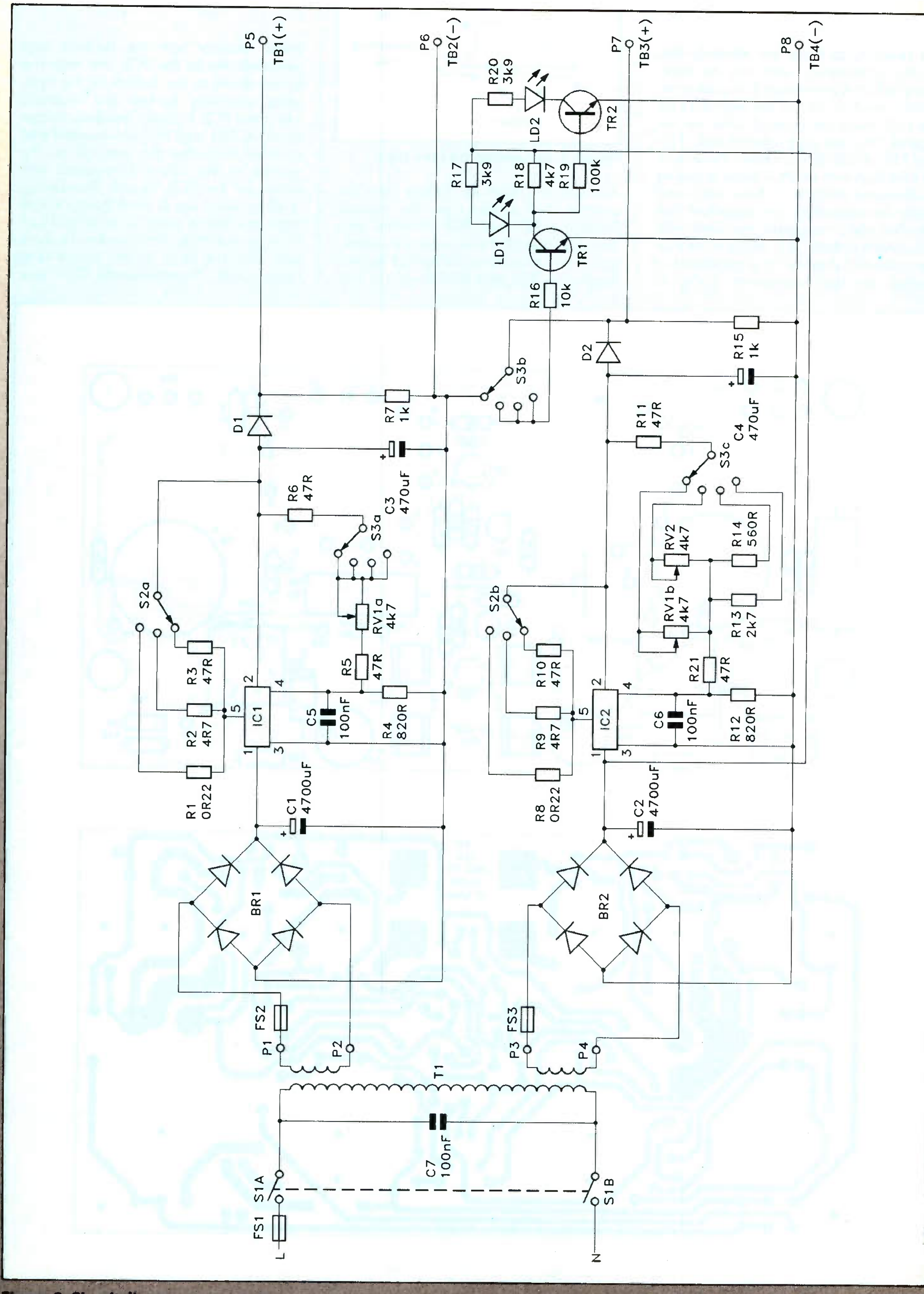


Figure 3. Circuit diagram.

RV2 are mounted on the component side of the PCB as shown in Figures 4a and 4b. Switches S2 and S3 are mounted in a similar manner to RV1 and RV2 and are connected to the PCB using insulated hook-up wire as shown in Figure 5. Fit the two LEDs on the track-side of the PCB, ensuring correct orientation, this is indicated by the dotted legend on the component-side of the PCB. Finally fit the two track-side links using insulated hook-up wire. The location of each, is indicated on the component-side of the PCB by a dotted line; a circle at each end of the dotted lines indicates the position where the wire ends should be soldered to the track. Please note, to prevent instability these links must be fitted exactly where indicated by the legend and not at any other point.

For further information on soldering and construction techniques, reference should be made to the constructors' guide included in the kit.

Enclosure and Wiring

Before the supply can be powered up, the transformer, PCB and associated components MUST be housed in a suitable metal case. The recommended case is Steel Case 1608 (stock code XJ28F) and the drilling details, for those wishing to use this case, are shown in Figure 6. PCB mounting information is shown in Figure 7.

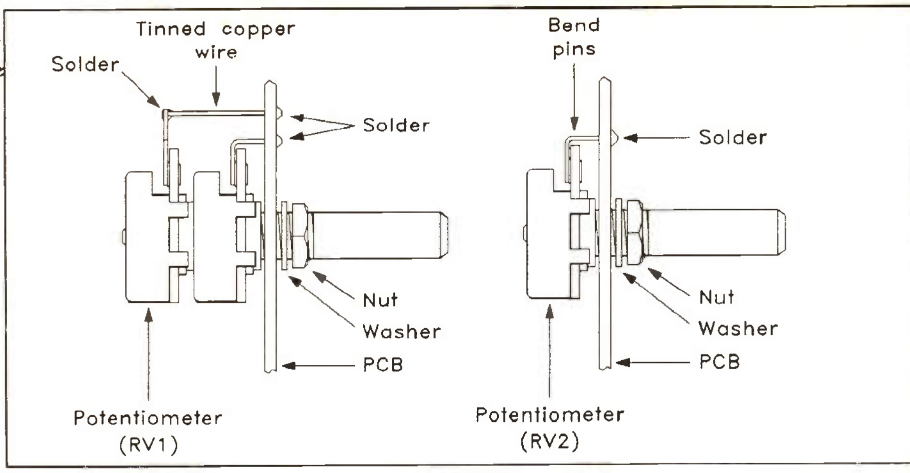


Figure 4. a) Mounting RV1, b) mounting RV2.

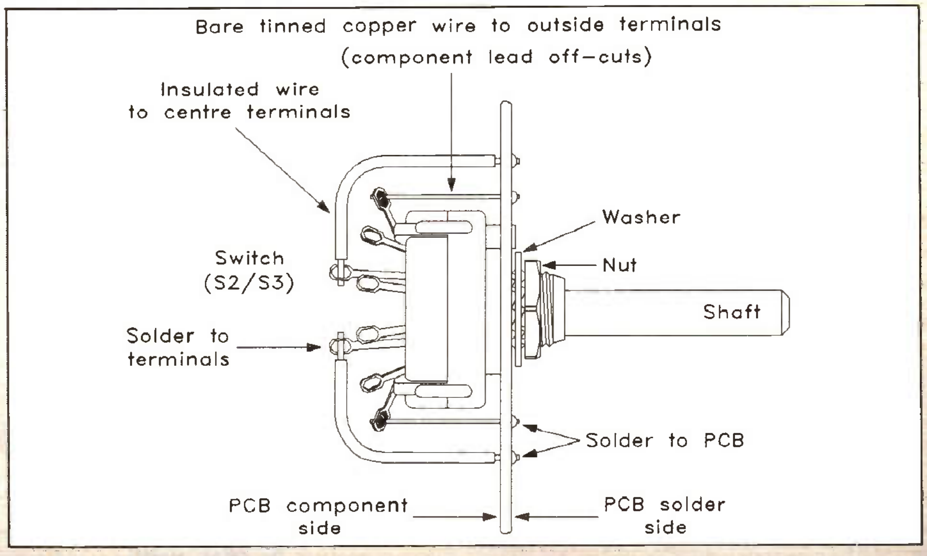


Figure 5. Mounting S2 and S3.

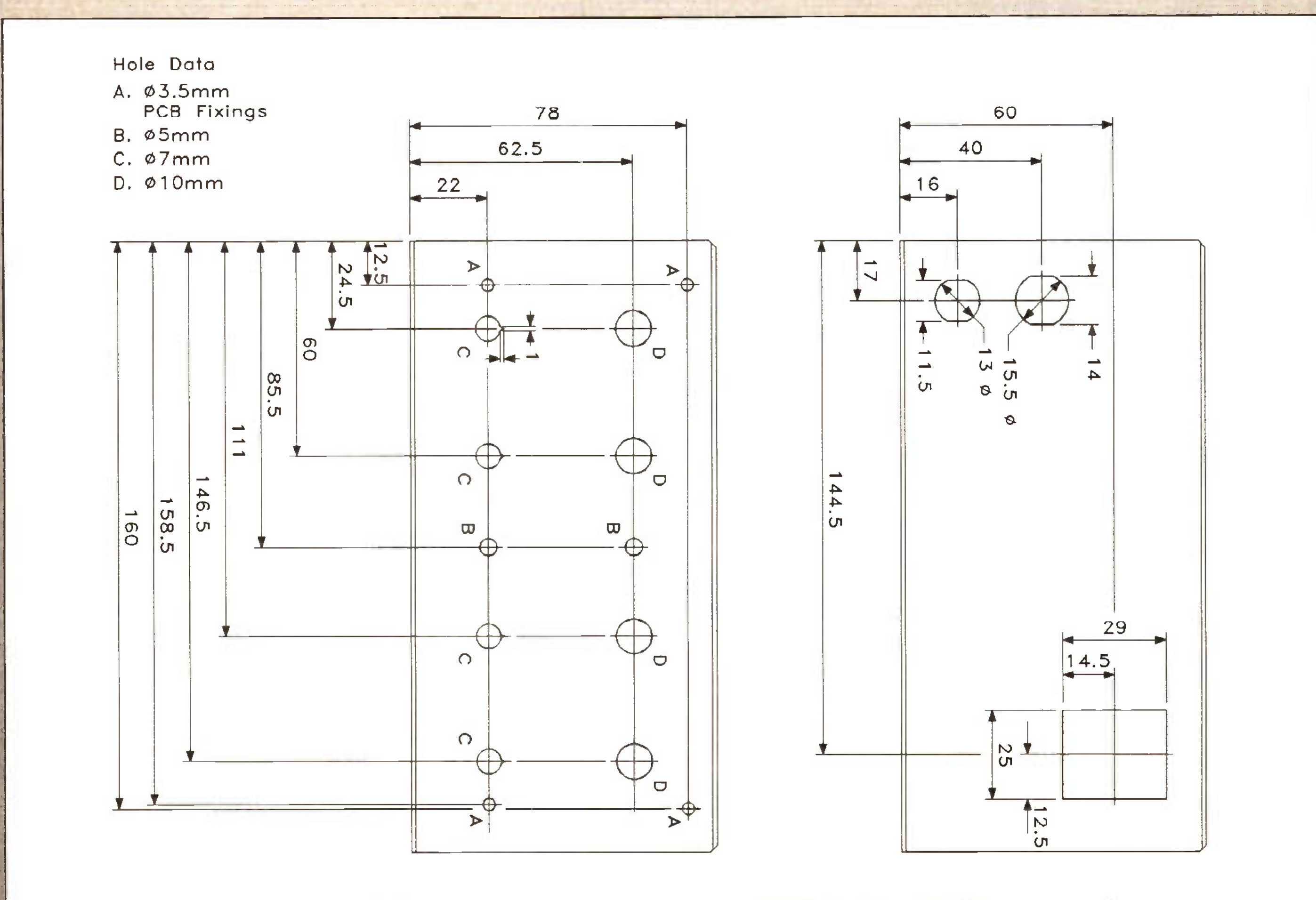


Figure 6. Drilling details for suggested case.

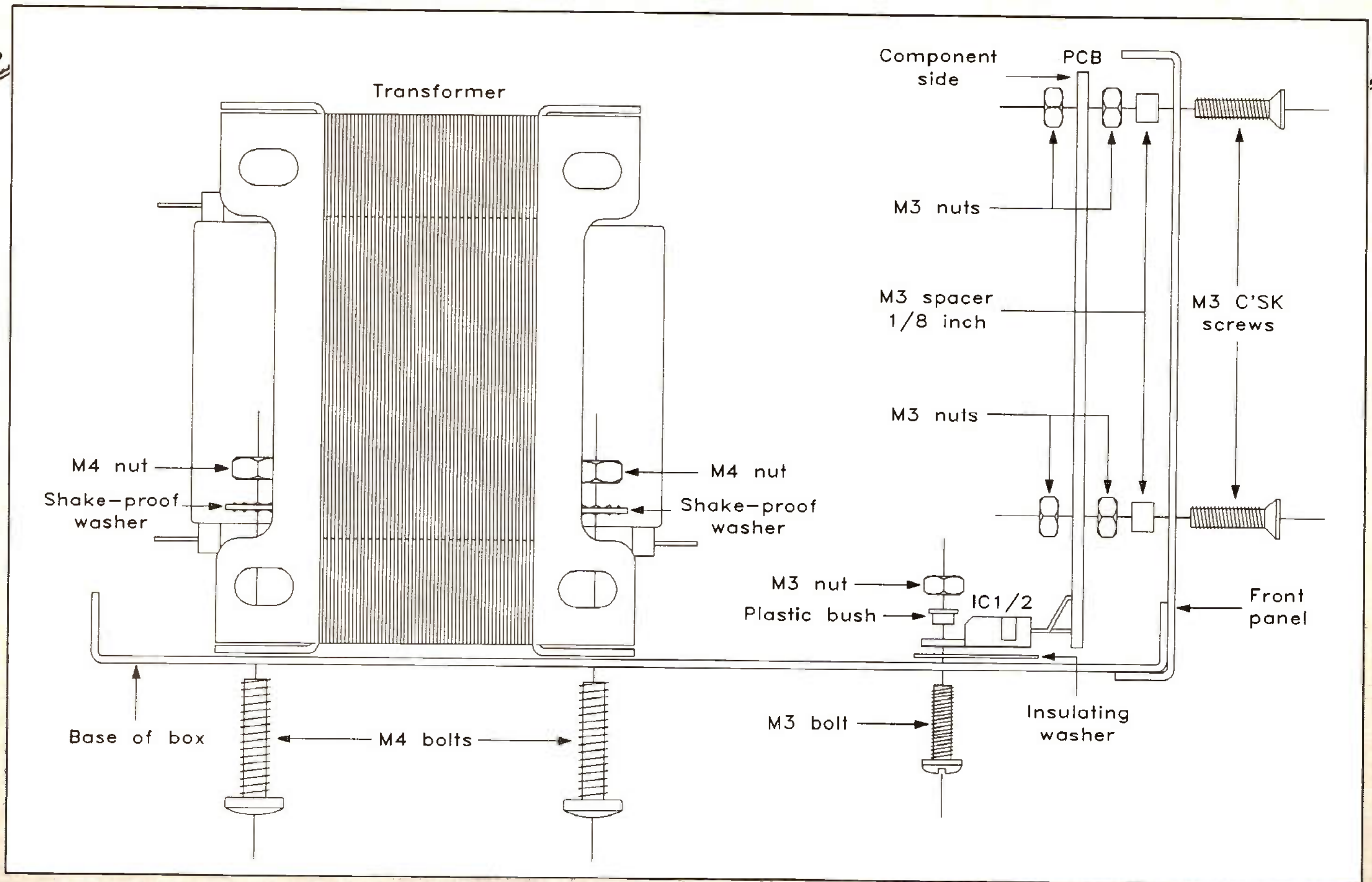


Figure 7. Mounting the PCB and the transformer.

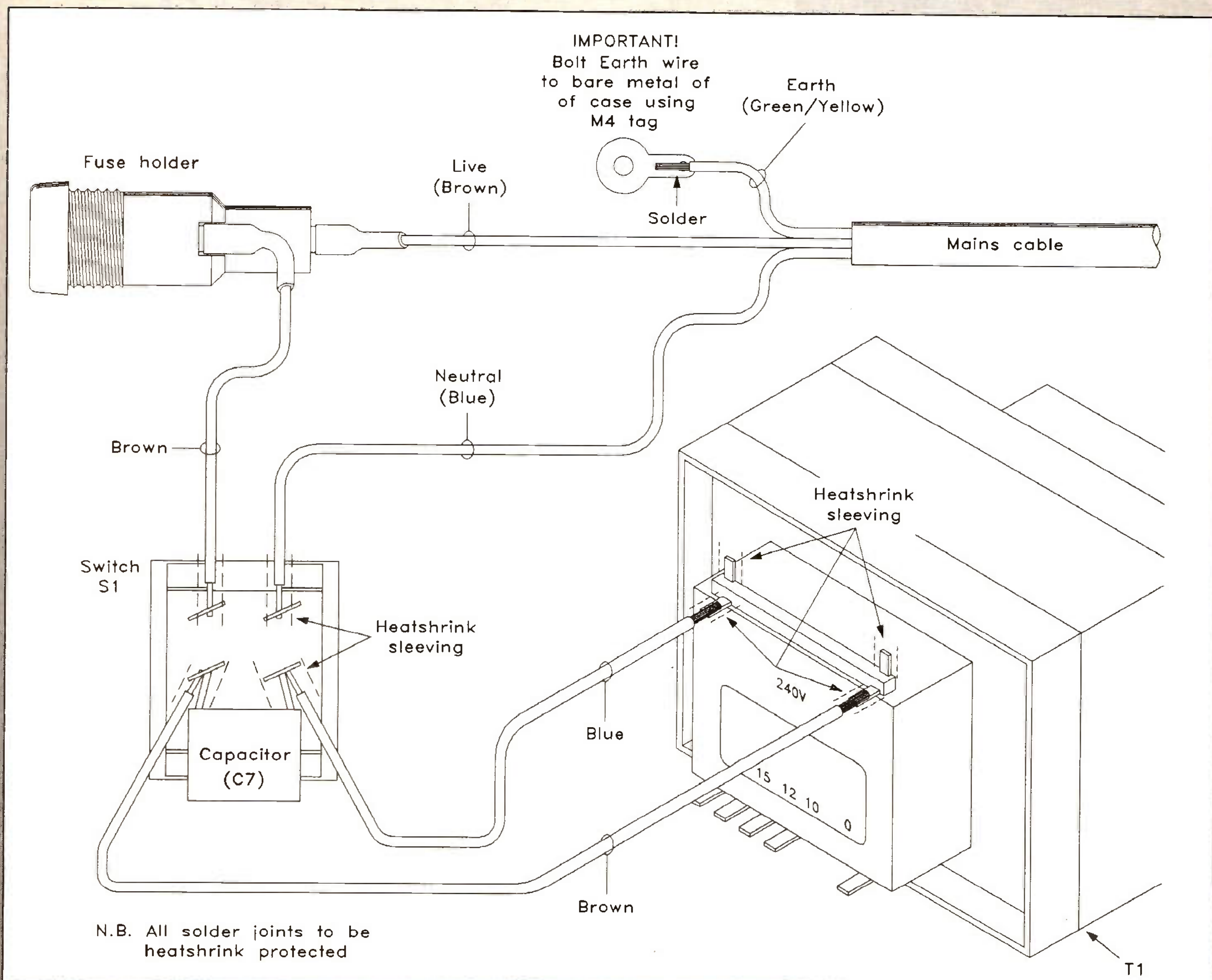


Figure 8. Mains connections showing wiring to fuse holder (FS1), S1 and T1.

For ease of assembly, it is recommended that the wiring to the PCB is made before fitting into the case, and that the PCB is fitted before the transformer. With the recommended case, it may be found advantageous to remove the rear panel when installing the PCB and transformer.

It is important that the case used has no large holes as live mains is present inside, on the primary side of the transformer, and it is important that the risk of electric shock due to touching any of these parts is eliminated. Figure 8 shows connections to the mains fuse holder (FS1), on/off switch, suppression capacitor and transformer (T1) primary.

Transformer secondary (low voltage) wiring is shown in Figure 9. All mains leads should be shrouded using heatshrink sleeving. The wiring should be double checked to make sure that there are no errors. Connection of the earth lead is an essential safety precaution; make sure that the earth lead (colour coded green/yellow) is securely connected to the tag provided, and that the tag is bolted securely to the chassis, so as to make a good electrical connection.

The front panel layout is basically determined by the position of the front panel components, but the actual front panel legend is down to the user. A suggested front panel layout is shown in Figure 10; the illustration also shows the different switch positions and approximate voltage settings for the variable voltage controls (RV1 and RV2).

Terminal posts TB1 (+), TB2 (−), TB3 (+) and TB4 (−) are mounted on the front panel of the case and pass through four large holes in the PCB. The tags are connected to PCB pins P5 (TB1), P6 (TB2), P7 (TB3) and P8 (TB4) as shown in Figure 11.

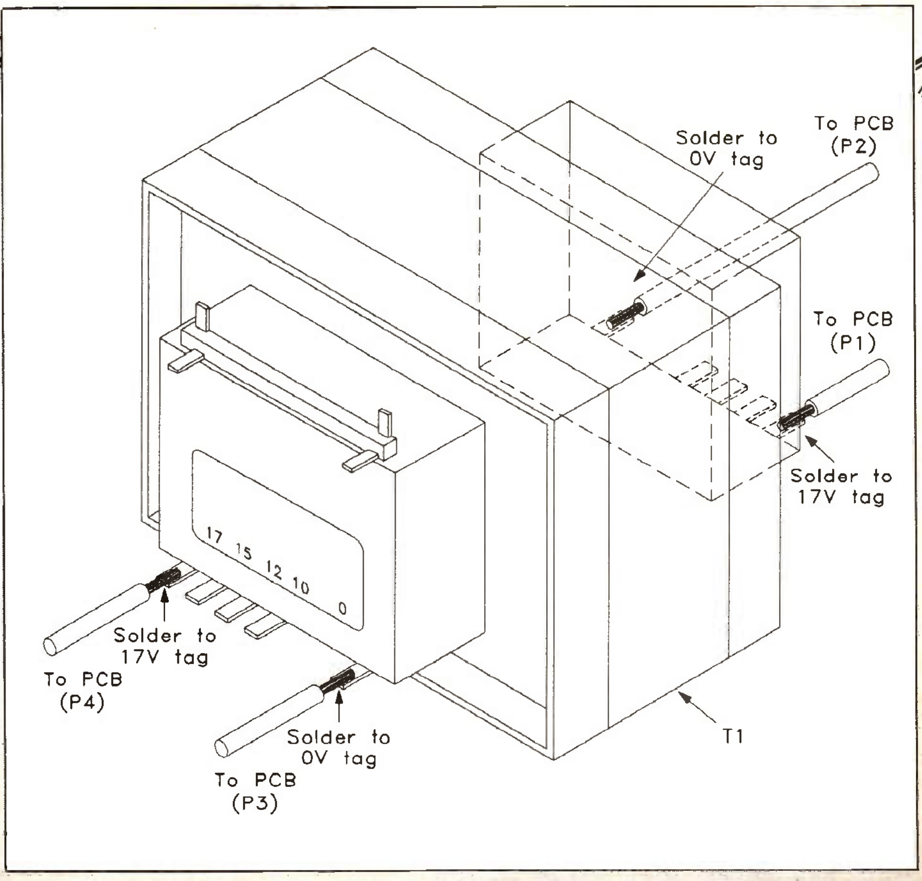


Figure 9. Transformer secondary connections.

It is important that RG1 and RG2 are suitably heatsinked. The metal case suggested will provide sufficient heatsinking under normal conditions. However, if a different case is used, it may be necessary to provide additional heatsinks. Failure to provide the rated current level due to the regulators 'shutting down' suggests additional heatsinking is necessary.

Because the bottom of the case is used as a heatsink, it is important that the case is slightly raised to allow air to flow freely under the case-bottom. Four rubber feet (one at each corner) can be used for this purpose.

Testing

Before the circuit is powered up it is essential that the transformer, PCB and associated circuitry is installed in an earthed metal case, and the cover or lid is firmly in place; this eliminates the risk of electric shock by accidentally touching live parts. IMPORTANT: ANY WORK ON THE CIRCUIT SHOULD BE CARRIED OUT WITH THE MAINS SUPPLY DISCONNECTED, and the supply should NEVER be powered up with the cover (lid) of the case removed. Remember, MAINS VOLTAGE CAN KILL.

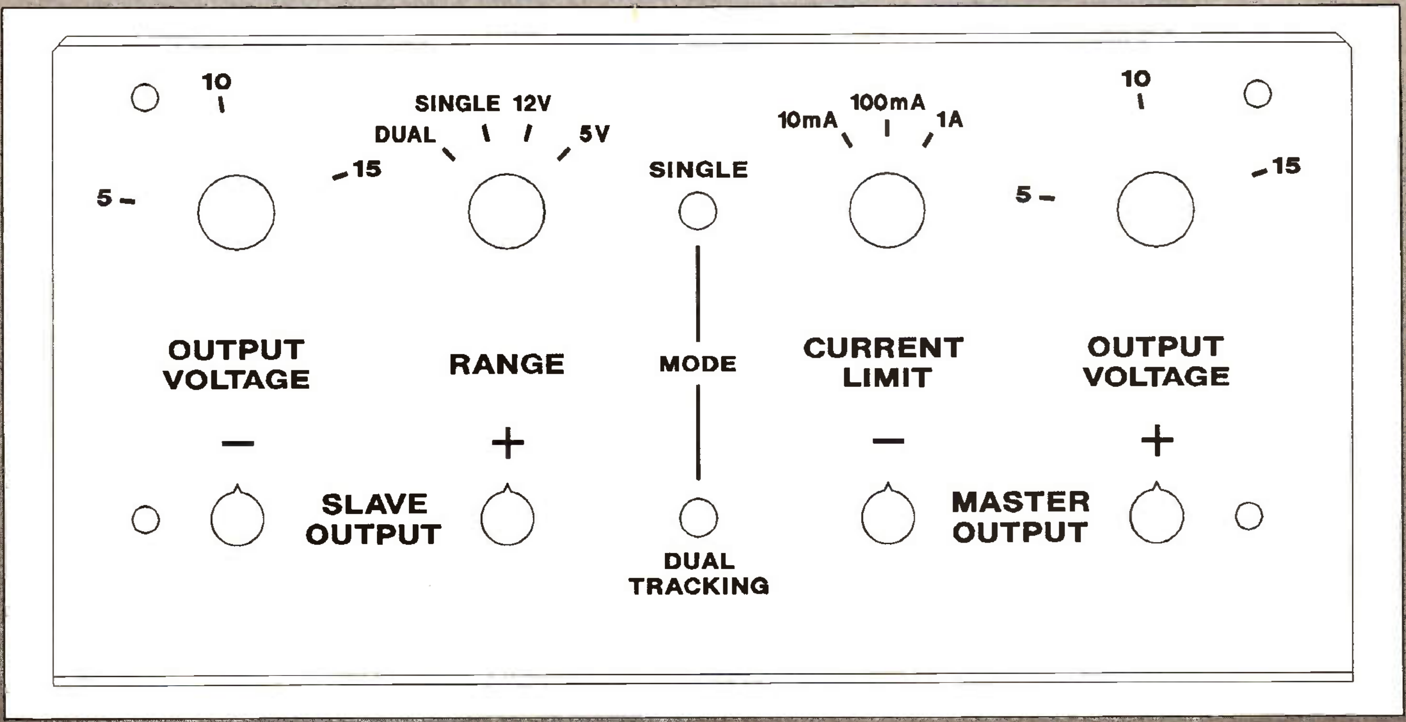


Figure 10. Front panel layout showing switch positions and approximate voltage settings.

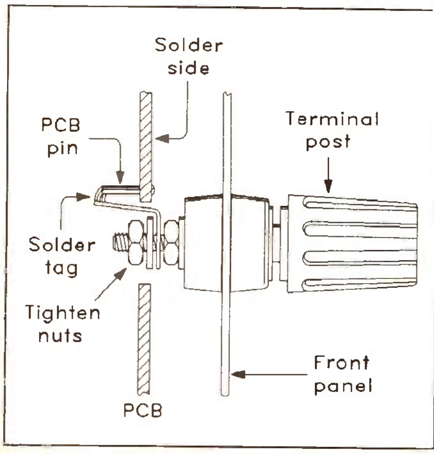
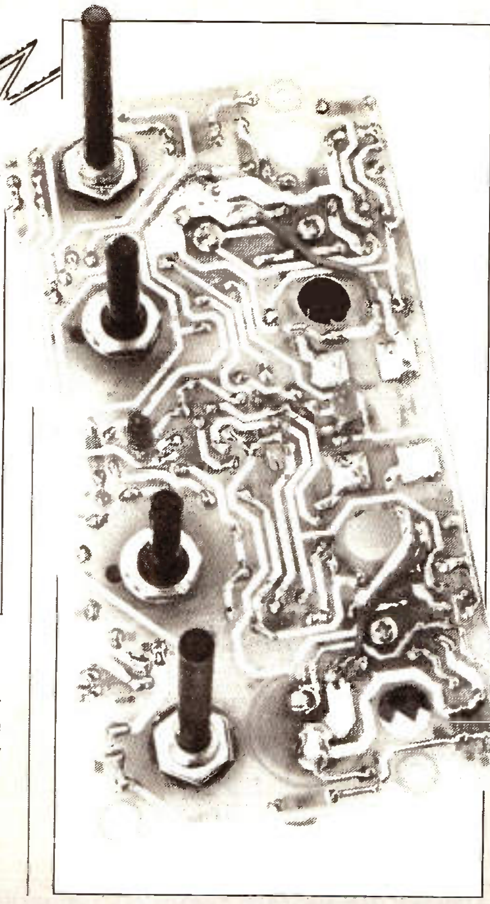


Figure 11. Terminal post connection.

It is recommended that you double-check your work before powering up the supply, to make sure that there are no dry joints or solder short circuits, and to ensure that all off-board wiring is correct.

Insert the fuses into the fuse holders; the 1¼ inch fuse (FS1) is inserted into the chassis fuse holder, which should be mounted on the rear panel, and the two 20mm fuses (FS2 and FS3) are fitted into the appropriate fuse clips on the PCB.

The circuit requires no alignment and once construction is complete, the supply should be ready for use. A multimeter is required to test the supply properly. Initially, rotate RV1 and RV2 fully anti-clockwise. Set current limit switch S2 to the 1A position and voltage range switch S3 to the tracking position (position 1). With S3 in this position, the supplies are coupled together, and an output voltage of approximately 3V should be present between each set of outputs (TB1 and TB2, and TB3 and TB4); the voltage between TB1 and TB4 should be around 6V. In the tracking mode, LD2 should light. As RV1 is rotated clockwise the voltage should increase to at least 15V, between each set of outputs, and approximately double this between TB1 and TB4. The voltages stated may vary somewhat due to component tolerances. Set S3 to the variable single position (position 2). Similar results should be obtained, but this time RV1 controls the voltage between TB1 and TB2, and RV2 controls the voltage between TB3 and TB4. The voltage between TB1 and TB4 should be 0V on this range, as the supplies are separate and are not directly coupled together. In all modes except the tracking mode, LD1 should light indicating single supply operation. With S3 in the 12V position (position 3), a fixed 12V supply is available between TB3 and TB4, and a variable supply between TB1 and TB2. With S3 in the 5V position (position 4), a fixed 5V supply is available between TB3 and TB4, with a variable supply between TB1 and TB2. Table 1 summarises the different output voltage combinations available and Table 2 shows the three different current limit settings. The voltage range and current limit threshold figures shown are only approximate, and these may vary considerably. Switch S2 sets the current limit for both sets of outputs. The actual current limit thresholds may be measured by connecting a multimeter, set to measure current, between TB1 and TB2 or TB3 and TB4, such that the supply is temporarily short-circuited. This procedure should be repeated on each of the three current ranges. To prevent stress on the components, it is recommended that the power supply is not left in a short circuit condition for more than 1 minute, although under normal conditions the supply should be capable of operating into a short circuit for considerably longer.



S3 Position	TB1 and TB2	TB3 and TB4
1	Variable Tracking Master (RV1), 3V to 15V	Variable Tracking Slave (RV1), 3V to 15V
2	Variable Single (RV1) 3V to 15V	Variable Single (RV2) 3V to 15V
3	Variable Single (RV1) 3V to 15V	12V Fixed (RV2)
4	Variable Single (RV1) 3V to 15V	5V Fixed (RV2)

Table 1. Output voltage ranges.

S2 Position	Approximate Current Limit Threshold
1	10mA
2	100mA
3	1A

Table 2. Approximate current limit thresholds.

Using the Power Supply

The power supply is suitable for general-purpose use and should provide a relatively smooth regulated output, if the guidelines set out in this article are adhered to. Table 3 gives specifications of the prototype power supply. The outputs are protected against unwanted positive transients and the supply features full overload protection.

The supply outputs should exhibit very few unwanted switching transients; however, to prevent any possible damage it is recommended that the power supply is initially switched on BEFORE any loads are connected.

To prevent overheating, the supply should not be located where the free-flow of air is inhibited as this will impede heat dissipation.

In the dual tracking mode (S3 in position 1) TB2 is connected to TB3 internally and an external link is not required for this purpose. In this mode TB1 is the +V output, TB2 or TB3 are 0V connections and TB4 is the −V output. In all other modes two completely separate supplies are provided; one set of outputs is available from TB1 (+V) and TB2 (−V) and a separate set is available at TB3(+V) and TB4(−V).

Input Voltage to Transformer (T1)	240V AC Mains
Input Voltage to Power Supply PCB (Off Load)	23V RMS
Power Supply Output Voltage	See Table 1
Maximum Output Current	See Table 2
Output Ripple Voltage (500mA Output Current)	5mV

Table 3. Specification of prototype.

LOW COST POWER SUPPLY PARTS LIST

RESISTORS All 0·6W 1% Metal Film (Unless specified)			
R1,8	0Ω22 W/W Min	2	(W0R22)
R2,9	4Ω7	2	(M4R7)
R3,5,6,10,11,21	47Ω	6	(M47R)
R4,12	820Ω	2	(M820R)
R7,15	1k	2	(M1K)
R13	2k7	1	(M2K7)
R14	560Ω	1	(M560R)
R16	10k	1	(M10K)
R17,20	3k9	2	(M3K9)
R18	4k7	1	(M4K7)
R19	100k	1	(M100K)
RV1	Dual Pot Lin 4k7	1	(FW84F)
RV2	Pot Lin 4k7	1	(FW01B)
CAPACITORS			
C1,2	PC Elect 4700μF 35V	2	(JL30H)
C3,4	PC Elect 470μF 35V	2	(FF16S)
C5,6	Disc 100nF 50V	2	(BX03D)
C7	IS Cap 100nF	1	(JR34M)
SEMICONDUCTORS			
IC1,2	L200	2	(YY74R)
TR1,2	BC548	2	(QB73Q)
D1,2	BYW98-150	2	(UK65V)
LD1	LED Red 5mm 2mA	1	(UK48C)
LD2	LED Green 5mm 2mA	1	(UK49D)
BR1,2	S04	2	(QL10L)
MISCELLANEOUS			
T1	Tr 34V HP	1	(WB22Y)
S1	DPST Rocker	1	(YR69A)
S2	Rotary SW3B	1	(FF76H)
S3	Rotary SW4	1	(FH44X)
	1¼in. Clickcatch F/Holder	1	(FA39N)
	SR Grommet 5R2	1	(LR48C)
	Pins 2141	1 Pkt	(FL21X)
	Large Terminal Post Black	2	(HF02C)
	Large Terminal Post Red	2	(HF07H)
	Fuse Clip	4	(WH49D)
	PCB	1	(GE93B)
FS1	A/S 160mA Fuse 1¼in.	1	(UJ99H)
FS2,3	A/S 2A Fuse	2	(WR20W)
	Heat Shrink CP32	1	(BF88V)
	Vaned Heatsink Plas Pwr	2	(FL58N)
	Insulator TO220	2	(QY45Y)
	Plastic Bush TO66 Short	2	(JR78K)
	Wire 16/0·2mm 10m Red	1 Pk	(FA33L)
	Isobolt M4 x 12mm	1 Pkt	(BF49D)
	Isonut M4	1 Pkt	(BF57M)
	Isotag M4	1 Pkt	(LR63T)
	Isobolt M3 x 16mm	1 Pkt	(JD16S)
	Isonut M3	1 Pkt	(BF58N)
	Instruction Leaflet	1	(XT05F)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in kit)			
	Steel Case 1608	1	(XJ28F)
	Min Mains Black	As Req	(XR01B)
	Isobolt M4 x 12mm	1 Pkt	(BF49D)
	Isonut M4	1 Pkt	(BF57M)
	Knob K7A	2	(YX01B)
	Knob K7B	2	(YX02C)
	Isoshake M4	1 Pkt	(BF43W)
	Isonut M3	1 Pkt	(BF58N)
	Isoshake M3	1 Pkt	(BF44X)
	Spacer M3 x ⅛in.	1 Pkt	(FG32K)
	Poziscrew M3 x 16mm	1 Pkt	(JC70M)

The Maplin 'Get-You-Working' Service is available for this project, see below for details.

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

Order As (Lo Cost PSU) LP74R Price £34.95 C

Please Note: where 'package' quantities are stated in the parts list (e.g. Packet, Strip, Reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately, but is not shown in the 1992 Maplin Catalogue.

Lo Cost PSU PCB **Order As GE93B Price £4.25**

Now it's easier than ever to get our back-up...

HOW? When you buy a Maplin Kit and if you run into difficulties constructing it, we *are* here to help you.

Sometimes you may have the disappointment of putting time, effort and money into a project, only to find that on completion it doesn't work. When you buy a Maplin Kit you will have the reassurance that, if in the unlikely event your completed project doesn't work, you know that we *will* 'Get-You-Working'.

Help is at hand!

For Technical Queries*:

Write to: 'Customer Technical Services', Maplin Electronics, P.O. Box 3, Rayleigh, Essex, SS6 8LR.

We will do our utmost to speedily answer your technical enquiry; or Fax: (0702) 553935; or 'Phone: (0702) 556001, 2pm to 4pm, Monday to Friday, except public holidays.

And if you get completely stuck with your project, get *our* back-up and we'll get you back up and running!

The 'Get-You-Working' Service:

We will undertake to get working any of the Maplin Kits** published in 'Electronics – The Maplin Magazine'. Please return the completed kit

to us at the following address: 'Service Department', Maplin Electronics, P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order for approximately 10% of the cost of the kit being returned (subject to a minimum of £15.00). If the fault is due to faulty components, incorrect instructions or any error on our part which could have led to the fault, we will repair the project free of charge and return it to you carriage paid with a refund of your postage to us.

If the fault is due to an error or errors that you have made, we will charge you at the competitive rate of £15.00 per hour, or part thereof, and for the cost of any parts replaced. If this is less than the amount you sent, we will refund the difference, after deducting the cost of postage to you. If the cost including return postage is more than the amount you sent, we will ask you to pay the difference before the goods are returned.

We will 'Get-You-Working' as fast as possible, but please allow up to four weeks. We will acknowledge receipt of your returned kit by return of post.

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* We can only answer technical queries related to Maplin projects and products.

** The 'Get-You-Working' Service is available for all Maplin Kits and Maplin Projects with the exception of: 'Data Files'; projects not built on our ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' type circuits.

NEW BOOKS

Interfacing Standards for Computers

An IEEIE Monograph

by A.C. Maine

This monograph serves as an introduction to the interfacing techniques and standards used by computers. Both computer standard buses and local area networks have been deliberately excluded from the text as due to their breadth, complexity and importance, each deserves a monograph in their own right.

With communication being such a vital concept in computing systems, the basics of interfacing never hurt from restating. The opening chapter defines the need to have devices which have to be physically connected and which must recognise a common data format.

The book then goes on to discuss RS-232C Serial Interface Standard, the IEEE-488 General Purpose parallel interface bus, the HP-IL Serial Interface Standard and Parallel Interfaces in general. A note upon Character Code Standards and Appendices giving a data transmission Glossary and a Summary of the CCITT recommendations complete the work.

The quest for better, error free, quick communications in computer systems has never been greater. Interfacing still remains the most common way of helping computers to communicate.

This book will ensure that linking is both good practice, good engineering and has regard to the International standards and protocols.

1987. 209 x 147mm. 62 pages, several line diagrams and useful tables.

Order As WT60Q (If Standards Comps) ***Price £3.90 NV***

A Beginners Guide to Modern Electronic Components

by R.A. Penfold

The wide range of components available for use in modern electronics tends to baffle both newcomers and more seasoned users alike.

This book tries to make life a little easier. The book describes the basic functions of components but is not an electronics text book. Instead it deals with the practical aspects such as colour codes, deciphering code numbers and the suitability of components for given applications.

Some of the components covered include Resistors (including Potentiometers), various types of capacitors, inductors, diodes (including Zeners and Varicaps). Transistors both silicon and germanium, opto electronic devices, operational amplifiers, logic integrated circuits, loudspeakers and microphones and meters. The book cleverly divides the components into Passive, semiconductors integrated circuits and The Rest which includes connectors, switches and multiway components. A useful index has to be used in conjunction with the contents pages, but does enable much of the detail about components to be tracked down.

A range of useful line drawings and diagrams further enhance a very useful and readable book. An unusual trait in what is almost a reference book.

The Penfold/Babani Partnership has advanced the understanding of electronics both to enthusiasts and the less committed. This book carries on that tradition and will be an essential addition to any bookshelf.

1990. 178 x 110mm. Many useful diagrams, charts and line drawings.

Order As WT61R (Guide to Elec Comps) ***Price £3.95 NV***

The Home Electrical Appliance Manual

A Haynes Manual

by Graham Dixon

Each year sees an increase in the number and variety of small electrical appliances. Some are for convenience, some are luxuries and some are labour saving. Both indoor and outdoor electrical appliances of various shapes and sizes are to be found in every home. From the humble electric kettle to the immensely sophisticated video recorder, from the electric drill to the lawn strimmer, they all have one thing in common – at sometime they will fail to function correctly, at which point you fully realise how indispensible this object is. But often lack of maintenance is responsible for the failure of both new and old equipment. Although mass production and large volume sales have made many of these items very low cost, it may still be a practical proposition to effect a repair, even though the lack of spares outlets for these items makes it difficult. Gone are the many small ironmongers shops who would be able to supply a new knob for your kettle lid or a handle for your broom and so on, and who also would be willing to repair the smaller electrical items at a reasonable cost. The larger surviving repair businesses now have such high overheads, that it is they who make such repairs uneconomical.

Throwing away a complete item which has a relatively minor fault can have far-reaching effects – it may be made from non-renewable materials and some of its constituent parts may even be hazardous in disposal.

Maintenance and repair could save money by not buying a new one, conserves resources and is kinder to the environment. Above all you have the satisfaction of making a successful repair. The book also helps you understand how many of our household items work, and from this you can understand how and why faults occur and how to prevent them.

1991. 182 pages. 276 x 212mm hardcover, illustrated.

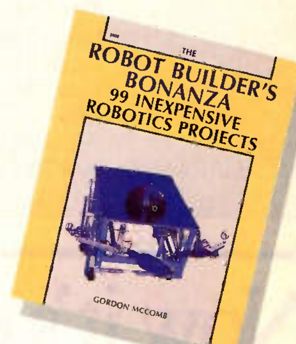
Order As WT79L (Appliance Manual) ***Price £12.95 NV***

The Robot Builder's Bonanza

99 Inexpensive Robotics Projects

by Gordon McComb

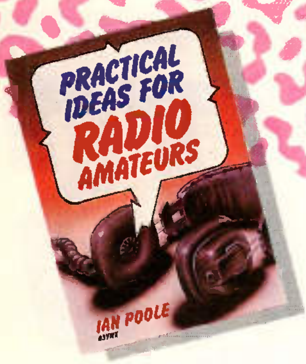
Express your robotic creativity with this fascinating guide. It offers you a complete and unique collection of tested and proven project modules that you can mix and match to create an almost endless variety of highly intelligent and workable robots. By using the modular approach there is plenty of leeway for your imagination. 99 different experiments are provided which, in different combinations, enable you to create robots of all shapes and sizes and abilities. There are rolling robots, walking robots, talking robots, robots which can vacuum the floor, serve drinks, teach the kids, protect the family against fire and intruders, in fact anything is possible using these modules and a little ingenuity.



None of the projects are very expensive and the majority of the ICs required can be budget priced surplus parts. The book is aimed at both the novice and intermediate robotics enthusiast; the projects include all the necessary information you need to construct the essential building blocks that go into the typical personal robot: the body and frame; power and locomotion; appendages; eyes, ears and mouth; navigation; and electronic control. How you put them together is up to you. Suggested alternative approaches and component sources are provided. In addition to the abundance of illustrations, schematics, diagrams and parts lists, there is also a listing of tools and equipment required, an IC matching chart, a drill bit and bolt sizes chart, and computer programs for supplying your creation with more than switches for control.

1987. 335 pages. 234 x 187mm, illustrated.

Order As WT77J (Robot Bonanza) ***Price £14.45 NV***



Practical Ideas for Radio Amateurs

by Ian Poole G3YWX

This book is designed to take the new Amateur Radio enthusiast a little further. It offers a wealth of hints, tips and general practical advice for transmitting amateurs and short wave listeners.

The book is divided into chapters, based around a particular aspect of amateur radio, such as the 'shack', aerials, constructional techniques, components, circuits and testing techniques. The Circuit ideas chapter goes beyond offering a range of circuit designs. Instead it aims to be a source of useful ideas. Some of which may be incorporated into other circuits to improve them or add facilities. Others may save time and money, or just help to get over a problem. The chapters are complemented by appendices which offer a wide range of useful information.

All in all a invaluable book that well worth having.

1988. 210 x 150mm. 125 pages, illustrated, b&w photographs.

Order As WT67X (Prct Ideas Radio Amt) ***Price £6.50 NV***

Build Your Own Laser, Phaser, Ion Ray Gun

and Other Working Space-Age Projects

by Robert E. Lannini

Build a hand-held, battery operated, visible laser light source capable of illuminating low level clouds, special effects, light shows, long range sighting, holography, amid other exciting space-age experiments! You can put together your own magnetic field distortion detector that lets you listen to, measure and record solar activity; aircraft, UFOs and other objects by sensing the slightest change in the Earth's magnetic field. Just two of the unique and exciting projects to be found in this fascinating book – real space-age stuff that you can put to work for both practical and fun purposes. The book provides detailed building instructions reinforced with plenty of excellent illustrations and parts lists, complete to the last detail. Also there are listings of names and addresses (note, United States only) of likely suppliers.

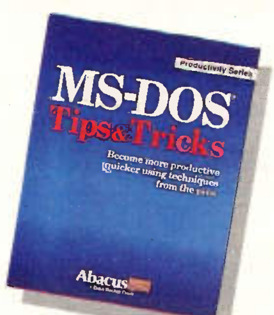
You can build several different kinds of workable lasers, ultrasonic devices including those for pest and insect control, telsa coils, ultra-high frequency power supplies, ion producing devices, and some highly practical security units such as an infra-red and a voice operated wireless 'phone transmitter. 24 projects in total, all designed, built and thoroughly tested by the author, an expert in his field.

1983. 400 pages. 234 × 198mm, illustrated. American book.

Order As WT81C (Ray Gun Book) ***Price £15.95 NV***

MS-DOS Tips and Tricks

by M. Tornsdorf and H. Tornsdorf



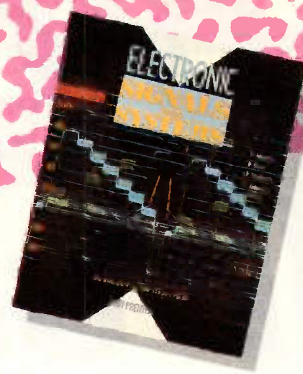
At last a collection of those useful tips so easily either missed or mislaid.

This book draws upon the experience of professionals using MS-DOS, and sets down some of their secrets. The techniques set out include: finding any file on a hard disk, copying data from BACKUP without the lottery of RESTORE, protecting data from unauthorised access and booting up from a batch file. The book lays out the tips as groups covering file management, user and data protection, printer tips, screen and keyboard routines, and updating and modifying DOS. There is also a large section of quick tips, which includes details on how to make better use of files such as AUTOEXEC.BAT and CONFIG.SYS.

A well referenced, easily understood companion to the MS-DOS manual.

230 x 175mm. 220 pages, listings.

Order As WT64U (MS-DOS Tips & Tricks) ***Price £16.45 NV***



Electronic Signals and Systems

Television, Stereo, Satellite TV, Automotive

by Stan Prentiss

Understanding electronic signals is much more than just simply illustrating waveforms from selective sources and describing them. To fully define signal characteristics, you must also have a working knowledge of the equipment producing the signals.

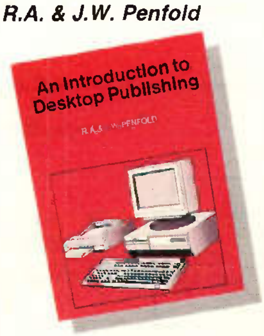
This book presents a detailed study of signal analysis as it applies to the operation and signal generating capabilities of today's most advanced electronic devices, including: spectrum analysers, digital storage 'scopes, logic analysers, high-end multimeters, frequency counters; transmission coax. cable, fibreoptics, AM and FM modulation, stereo multiplexing, vectors, television antennas; satellite earth terminals, data traffic, transponder waveforms; mono and stereo audio, harmonic distortion, stereo separation; and multiple and satellite master antenna systems. Also covered are conventional distributors, fuel injection and turbo and super-chargers. The book provides a fresh insight into both the commercial and consumer aspects of electronics that you won't find in any other volume.

1991. 325 pages. 235 × 188mm, illustrated. American book.

Order As WT80B (Signals & Systems) ***Price £15.95 NV***

An Introduction to Desktop Publishing

by R.A. & J.W. Penfold



Desktop publishing is one of the most exciting developments in computing. It puts all the facilities of document design and typesetting at the disposal of anyone with a suitable micro-computer. This opens up the field of written communication as never before.

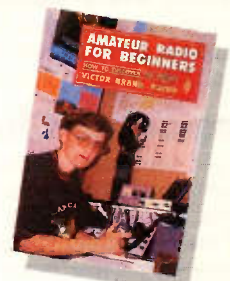
The book introduces the software and hardware required for 'DTP', and shows that it does not necessarily require very expensive equipment, though this may be desirable for best results. It shows how a start can be made with modest computers and printers. You will learn how to create and lay out documents, how to use fonts and typography, and how to add illustrations, both drawn and scanned graphics. Also included is an extensive glossary of DTP, computing and printing terms.

1991. 94 pages. 263 x 194mm, illustrated.

Order As WT78K (Intro Desktop Pub) ***Price £5.95 NV***

Amateur Radio for Beginners – How to Discover the Hobby

by Victor Brand G3JNB



Amateur Radio is a hobby which is enjoyed by over one and a half million people. These people are on air from their homes, clubs and schools worldwide.

Designed for the absolute beginner, this book could easily be enjoyed by another million. As well as extolling the virtues of 'Ham' radio, the book goes on to explain how to make your first receiver and progress through to the acquisition of a licence. The grades of Novice (class A or B) licence are described, as is the help provided by R.S.G.B. to obtain the licence. The support and benefits derived from being in a club are described. Hopefully, this will go some way to shattering the common fallacy that 'Ham' radio is some kind of lonely attic hobby.

For many people the discovery of amateur radio has been the beginning of an entirely new and unique hobby. They have derived much from its pursuit and have gained knowledge of electronics in the process.

Whatever the age, or reason this book will ensure the absolute beginner has all the information needed to join the worldwide Amateur radio family.

1991. 210 x 145mm. 65 pages, illustrated and b&w photographs.

Order As WT69A (Amtr Radio Beginners) ***Price £3.50 NV***

Bob's MINI-CIRCUITS

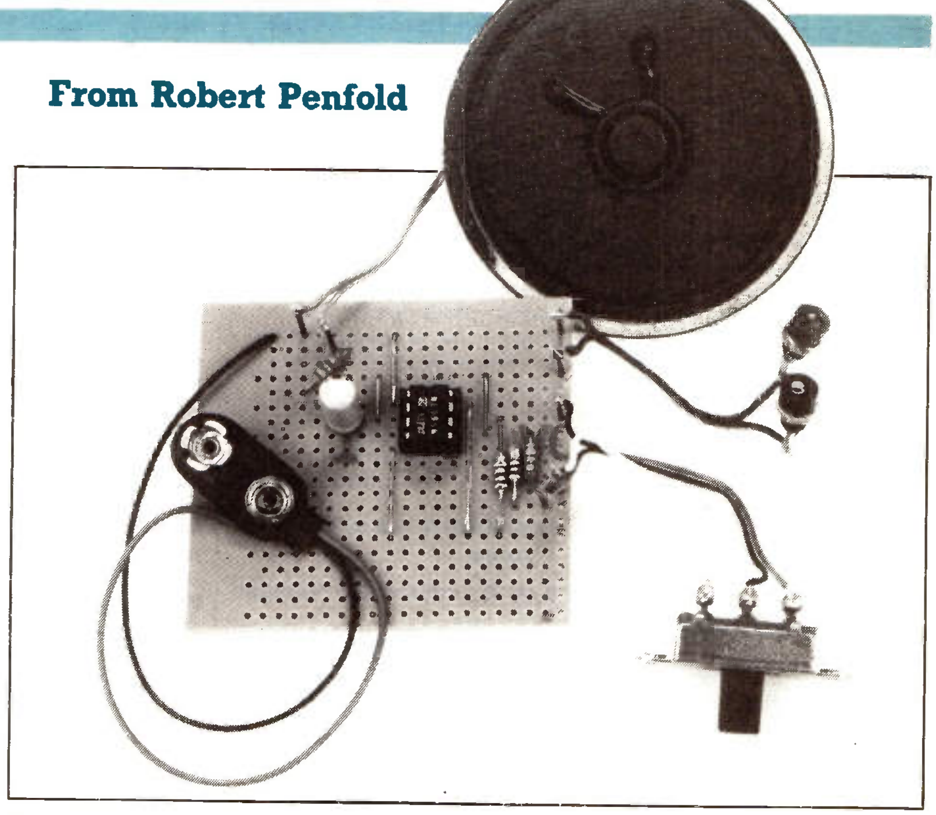
From Robert Penfold

Introduction

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

Capacitor Checker

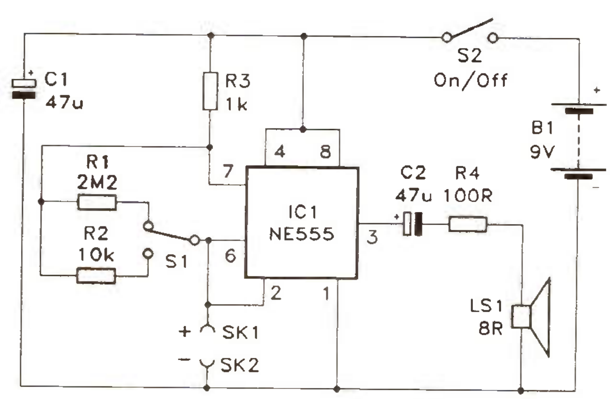
A commonly asked question by constructors who are having difficulty in getting a project to work is "How do you test the capacitors?". Some multimeters do now have capacitance ranges, but this feature is far from being a standard one. In the absence of a suitably equipped multimeter, ideally a capacitance meter would be used, but these can be quite expensive. The lowest cost option is a simple tester of the type featured here. This will not tell you the values of the suspect components, but it will give a rough idea of their values, and will sort out the complete duds from those that are basically serviceable.



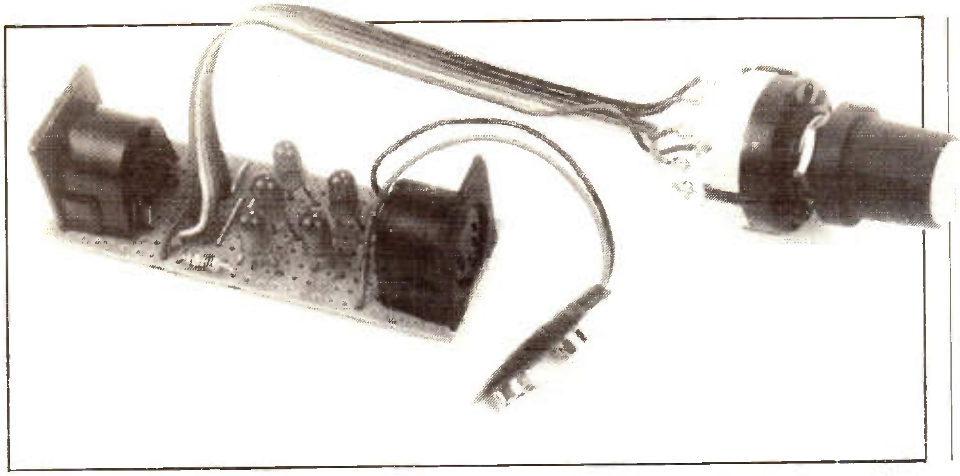
The Capacitor Checker.

This tester is basically just a C/R oscillator, with the test capacitor forming the capacitive element in the timing circuit. The unit relies on the fact that a faulty capacitor is unlikely to have a value that is slightly removed from the correct one. These components usually function properly, or are totally inoperative, with no half measures. One common fault is a damaged dielectric, which results in a short circuit between the two plates. This can actually be detected quite easily using a multimeter set to a low resistance range, or using a continuity tester. With this unit it shows up quite clearly as it results in zero output. The other common type of fault is where a connection to one of the plates breaks away, or possibly a plate might become damaged, with only part of it being connected to the lead out wire. This results in the component having an extremely low capacitance. In fact the capacitance is no more than a few picofarads in most cases. This results in the output frequency of the checker being far higher than it should be.

The circuit is basically just a 555 astable circuit with SK1 and SK2 connected in place of the timing capacitor. Note that electrolytic and other polarised capacitors must be connected to SK1 and



The Capacitor Checker circuit.



The MIDI Lead Checker.

SK2 with the polarity indicated in the circuit diagram. The output of IC1 drives a miniature loudspeaker via R4. The latter reduces the volume to a level which is appropriate for this application, and it also prevents excessive loading on IC1's output. In order to permit a wide capacitance range to be accommodated there are two switched timing resistors. R1 is used for low value capacitors of up to about 10nF or so, while R2 is used for higher value components.

Before using the unit in earnest it is a good idea to try it out with capacitors covering a wide range of values so that you know what to expect when functioning components are checked. With very high value capacitors an audio tone will not be produced, but instead there will be a series of 'clicks' from the loudspeaker. The higher the value, the greater the time between 'clicks'. If a faulty capacitor is connected to the unit, either no audio tone will be produced, or the pitch will be substantially wrong (probably in the high frequency direction).

Very low value components are notoriously difficult to test, and are beyond the capabilities of many capacitance meters. With this unit there will be a very high pitched output when R1 is selected and no test component is connected. The self capacitance of IC1 effectively provides the timing capacitance. With a low value capacitor connected across SK1 and SK2 there will be a small drop in the pitch of the output signal. However, with capacitors of a few picofarads in value the change in pitch may well not be noticeable, and such low value capacitors can not be tested reliably using this unit. As with any capacitance tester or meter, always make sure that test components are discharged before testing them.

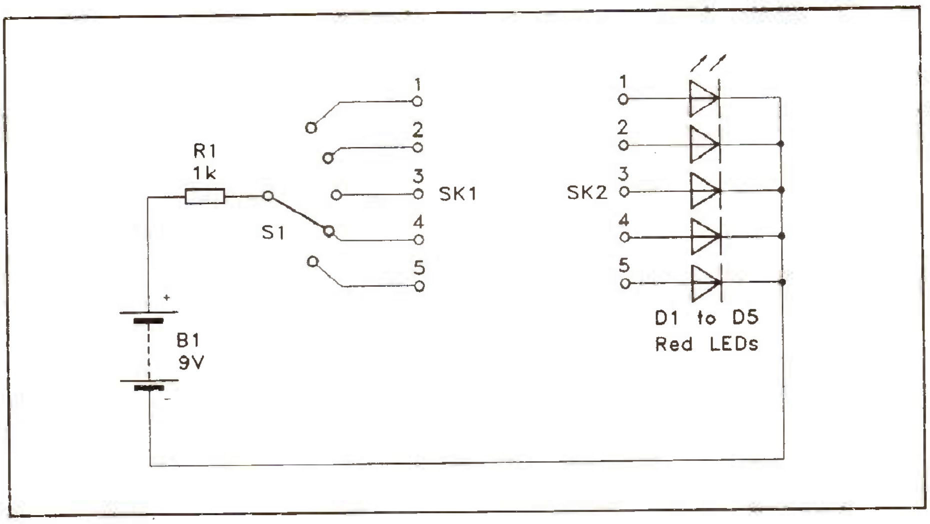
MIDI Lead Checker

Anyone who is involved with a MIDI system is likely to encounter problems before too long, with a unit in the system not responding to the signals sent to it. There are several possible causes for the lack of activity. The two most common ones are something in the system not being set up correctly, and a damaged MIDI lead. Checking for a broken lead is probably the best place to start, especially if several units in a 'chained' system fail to operate. The likely cause of the problem is then a damaged lead feeding into the first unit in the 'chain' which is failing to respond properly. The simplest of continuity testers are good enough for lead checking purposes, but investigating leads fitted with DIN plugs tends to be a very fiddley task.

MIDI lead testers are now available as ready-made products, but these are rather expensive. A simple do-it-yourself MIDI lead tester can be produced at quite low cost though, and is a more practical proposition for amateur MIDI users. Assuming the tester featured here is housed in a low cost box, or simply left as an open unit, it can be built for just a few pounds. It will indicate a lack of continuity between pairs of pins that should be interconnected, as well as showing up any short circuits between pins of a plug.

Basically all the unit has to do is feed a DC signal down each conductor in turn, with some form of indicator showing whether or not the signal is reaching the far end of the cable. In this circuit a five way switch is used to enable the signal to be manually connected to each conductor, one at a time. R1 provides current limiting for the five LED indicators at the opposite end of the cable. If there is continuity between the selected pin and a pin at the opposite end of the cable, then the appropriate LED will switch on. If there is a short circuit between the selected pin and another pin or pins, then two or more LEDs will switch on. If a pin on one plug connects to the wrong pin on the other plug, then this will be shown by the wrong LED lighting up. Of course, with a lack of continuity through a connector, no LEDs will be activated.

With a normal MIDI cable there is a connection from pin 1 to pin 1, pin 2 to pin 2, and pin 3 to pin 3. Pins 4 and 5, which are the ones at the ends of the arc of pins, should not be connected. In reality it is not uncommon for these pins to be linked, but this should not prevent the lead from operating. These pins are simply not connected on pieces of MIDI equipment. Presumably a lot of MIDI leads are actually audio types and not leads made specifically for MIDI use. Some 5-way DIN audio leads have pins 1 to 5 connected to pins 5 to 1 respectively. These cross-connected leads are not suitable for MIDI use. The Atari ST computers have a non-standard THRU/OUT socket using all the pins of the 5-way DIN socket. With an ST THRU/OUT lead pins 4 and 5 on the main plug connect to pins 1 and 3 on the THRU plug. Note that a lack of connection between pin 2 on one plug and pin 2 on the other should not result in a MIDI lead failing to work. It does mean that its shielding is faulty though, and in use it might radiate electrical interference.

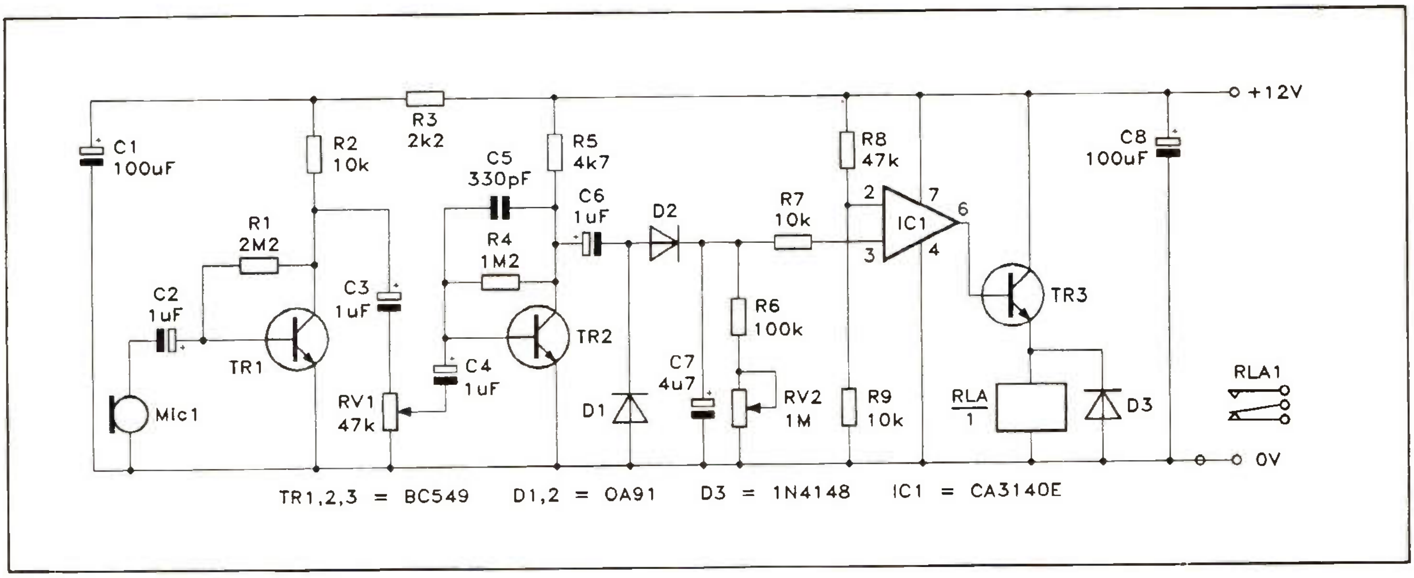


The MIDI Lead Checker circuit.

Construction should present few difficulties. The prototype is constructed on stripboard using printed circuit mounting sockets, but obviously the unit can be built using panel mounted sockets and LEDs, with everything hard-wired if preferred.

Sound Switch

Sound switches are used in applications such as burglar alarms, automatic tape recording systems, and VOX sys-



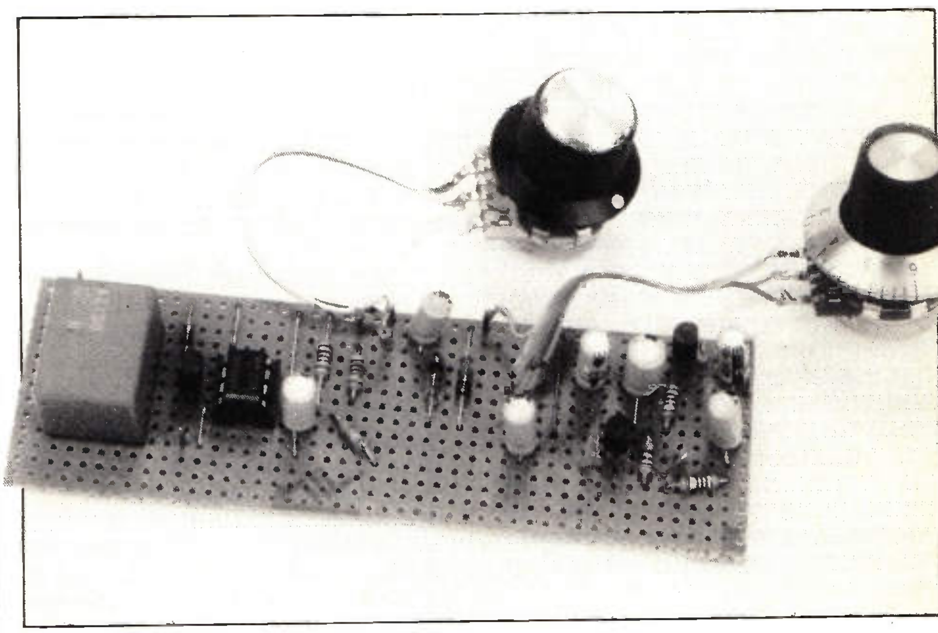
The Sound Switch circuit.

tems in radio transceivers. Ideally where a unit of this type is used to operate something like a tape recorder or a transceiver, the audio signal to the main equipment should be fed through a delay line. This compensates for the fact that the tape recorder (or whatever) will not switch on instantly. Also, although the sound switch is fast in operation, it is inevitably something less than instant. In practice the delay line is usually omitted as it greatly increases the cost and complexity of the unit. Remarkably, its absence usually does little to compromise results, but obviously in critical applications a simple sound switch of the type described here will only operate satisfactorily if it is used in conjunction with a suitable audio delay-line circuit.

TR1 acts as a high gain preamplifier stage using the common emitter mode. This will work reasonably well with practically any normal type of microphone, but sensitivity will be better with higher impedance types than with something like a 200Ω or 600Ω impedance dynamic microphone. RV1 is the sensitivity control, and this is an important feature. The sensitivity must be set high enough for reliable operation, but it should not be set so high that background noises cause frequent spurious operations of the unit. TR2 operates as a second high gain common emitter stage, giving the unit an overall voltage gain in excess of 80dB (10000 times).

The output from TR2 is rectified by D1 and D2, and then smoothed by C7, R6, and VR2. The latter controls the decay time of the smoothing circuit, and enables this to be set at anything from about half a second to around five seconds. In general it is best not to use a very short decay time, as this can result in the unit switching off during the brief pauses that occur during normal speech. On the other hand, a very long cut-off time can make the unit inefficient in some applications. RV2 therefore has to be adjusted for the best compromise for the prevailing circumstances.

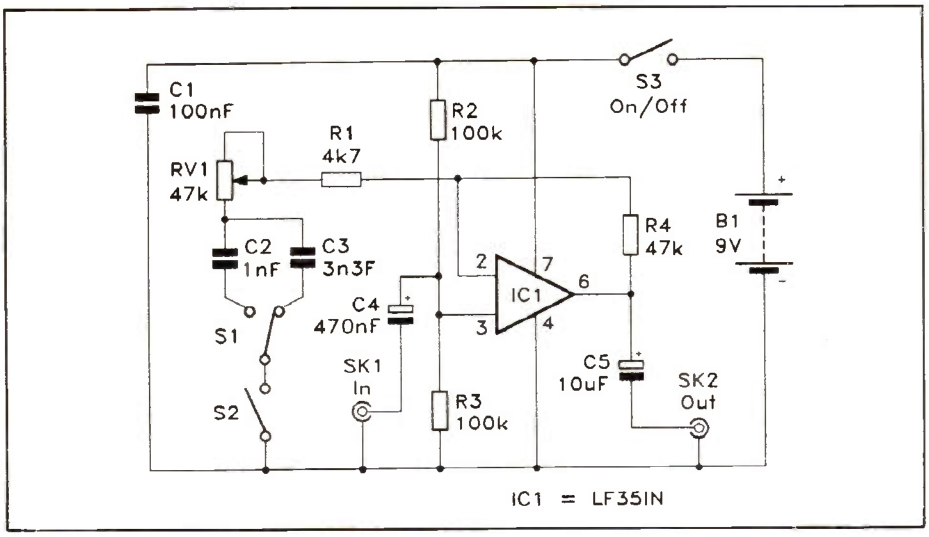
IC1 is an operational amplifier which operates here as a simple voltage comparator. R8 and R9 provide a bias of about 1·5 volts to the inverting input of IC1, while the output from the smoothing circuit is fed to the non-inverting input. The output of IC1 drives the relay coil via emitter follower buffer stage TR3. Under standby conditions the output from TR2 is negligible, and the voltage produced by the smoothing circuit is very low. The output of IC1 therefore goes low, and the relay is not activated. When the unit is activated by a suitably loud sound, the output voltage from the smoothing circuit goes above 1·5 volts, the output of IC1 goes high, and the relay is switched on. D3 protects the circuit against the high reverse voltage spike that can be produced when the relay switches off.



The Sound Switch.

When building the unit bear in mind that its voltage gain is quite high, and that the component layout must be designed to avoid stray feed-back that could encourage instability. The high frequency roll-off provided by C5 prevents the circuit from being hypercritical in this respect, but the component layout still needs to be designed with reasonable care. Unless the lead to the microphone is extremely short, it must be a screened type. It is advisable not to have the microphone mounted in the case, together with the relay. This would encourage audio feed-back from the relay to the microphone, which would almost certainly result in the circuit going into low frequency oscillation. D1 and D2 are germanium diodes which are vulnerable to heat damage. Take due care when soldering them into circuit.

The operating voltage for the relay coil is only about 9 volts, but virtually all 12 volt relays are guaranteed to operate reliably on this potential. A 9 volt supply can be used, but the relay must then be a 6 volt type. The coil resistance should be about 200Ω or more for 9 volt operation, or 300Ω or more with a 12 volt supply. Be sure to choose a relay which has adequate contact ratings for the load being controlled. The standby current consumption of the circuit is only about 4

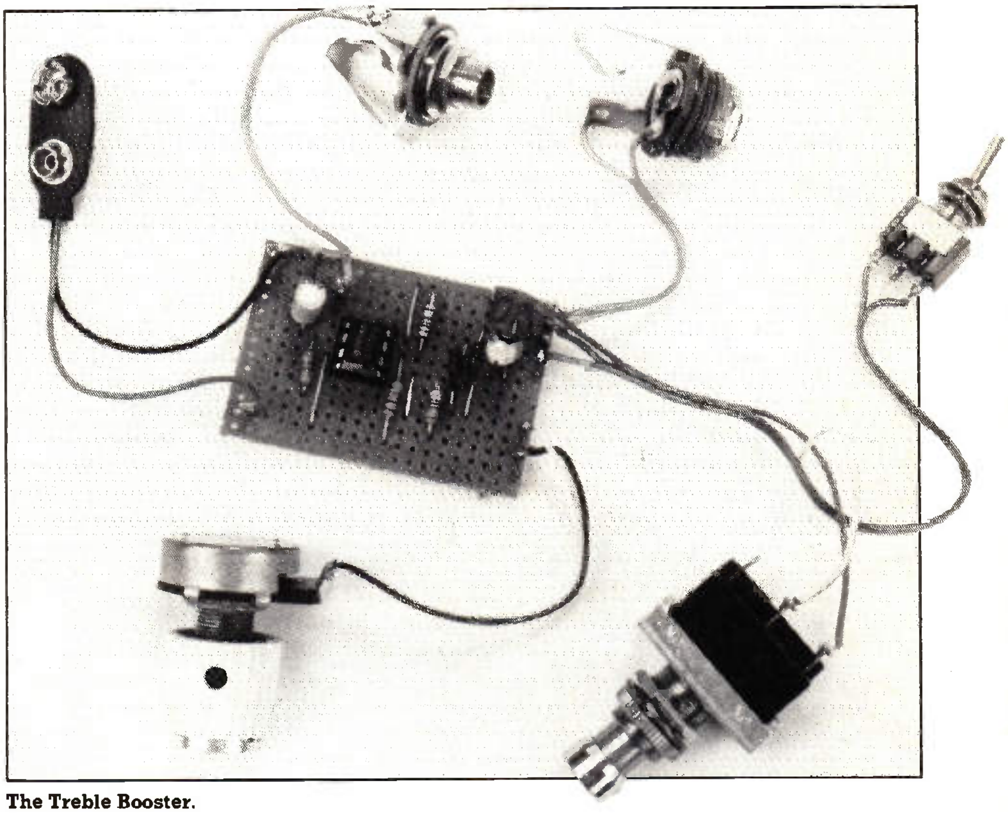


The Treble Booster circuit.

milliamps, but the consumption rises to over 30 milliamps when the relay is activated.

Treble Booster

Treble boost is one of the most simple of guitar effects, and as its name implies, it merely provides some high frequency boost to the processed signal. This gives a 'brighter' sound, but without the distortion produced when a 'fuzz' type unit is used. It is perfectly safe to play chords when using a treble booster! On the face of it you could get much the same effect by simply advancing the treble control on the amplifier. In practice this might result in treble boost being applied to other instruments as well, depending on the precise set up used. Anyway, the degree of treble boost available from an effects unit is substantially more than that which can be obtained with full treble boost on most amplifiers. It is perhaps worth pointing out that a unit of this type is reliant on there being some high frequency signals to boost. It can not 'make a silk purse out of a sow's ear', and if used with a really 'muddy' pick-up it is unlikely to have much effect on the sound.



The Treble Booster.

The circuit is basically just an operational amplifier used as a non-inverting amplifier. At low frequencies the circuit has approximately unity voltage gain due to the feed-back through R4. At higher frequencies some of this feed-back is decoupled by R1, RV1, and C2 or C3. The low values of the capacitors results in the gain of the circuit rising steadily at 6dB per octave through the treble range. The higher value of C3 results in it starting to apply the boost at a lower frequency than C2, thus giving a stronger effect with some middle frequencies being boosted significantly. The strength of the effect can also be controlled using RV1, which limits the maximum amount of boost applied. It gives a boost range from a minimum of about 6dB at maximum resistance, up to a little over 20dB at minimum resistance. A higher maximum boost can be obtained by reducing the value of R1. Bear in mind though, that using high levels of treble boost might give problems with feedback or excessive noise. S2 enables the effect to be switched in and out.

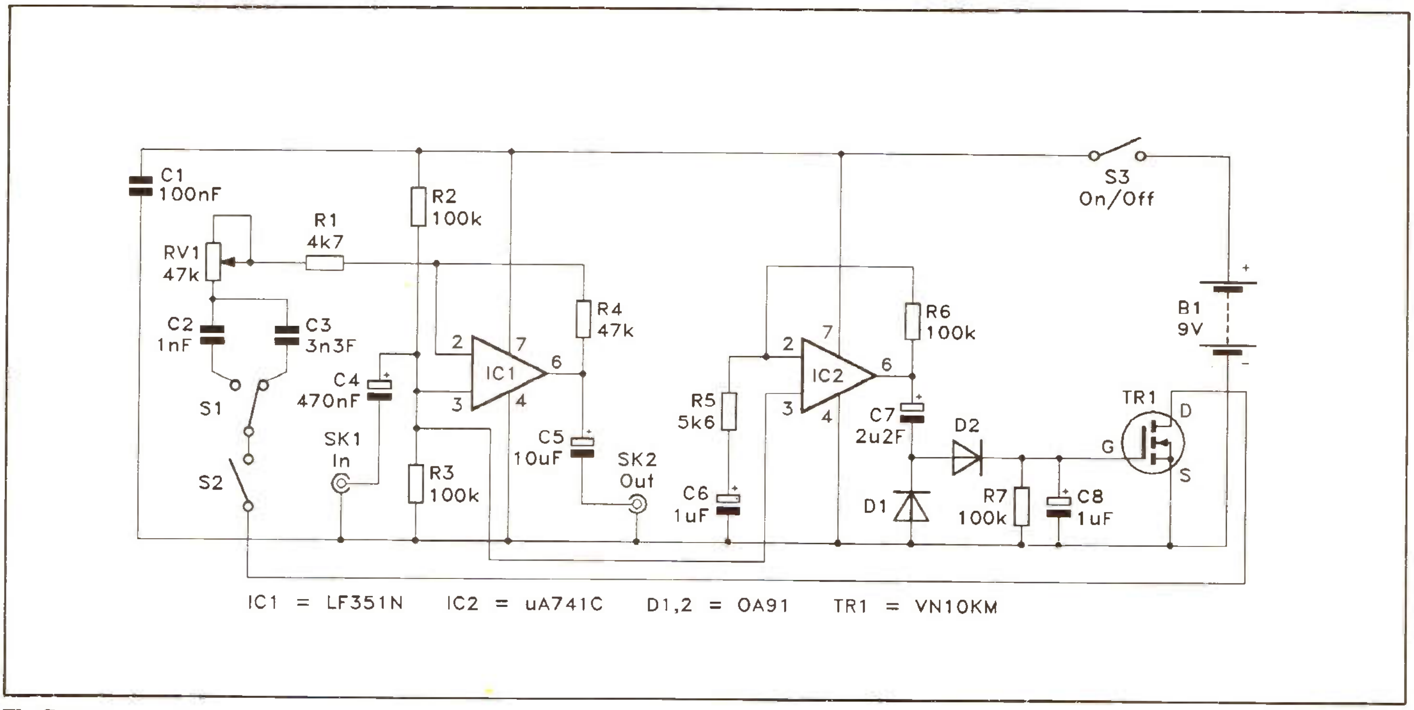
Construction of this simple project is mostly straightforward. However, bear in mind that when used with some guitar pick-ups it will be handling fairly low signal levels, and that the wiring must be kept quite short so that significant pick up of stray signals is avoided. A metal case earthed to the negative supply rail will provide screening and further assist in avoiding unwanted pick up. It is advisable to use a strong case as S2 should be a heavy duty push-button switch mounted on the top panel of the unit so that it can be operated by foot. The most convenient type of switch to use is the successive operation type. With this type of switch, operating it once switches the effect in, operating it again switches out the effect, a further operation switches it back in again, and so on. This avoids having to keep your foot on the switch for the duration that the effect is required. On the other hand, a simple push-to-make non-locking switch is best if you will need to repeatedly switch the effect in and out with precise timing.

The current consumption of the circuit is only about 2 milliamps, and a PP3 size battery is therefore more than adequate as the power source. Some modern high output guitar pick-ups have surprisingly high output levels, and for operation with these the treble booster might be lacking in 'headroom'. Any problems with overloading can be overcome by powering the unit from two 9 volt batteries wired in series so as to give an 18 volt supply.

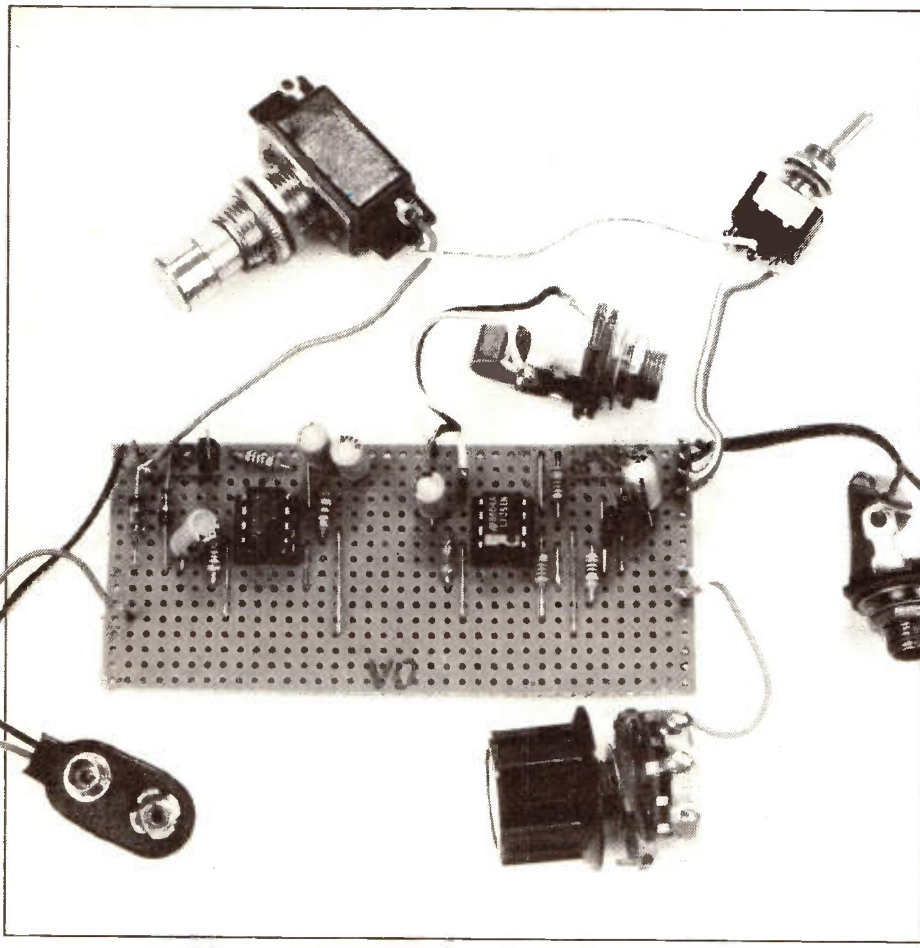
Dynamic Treble Booster

Most treble boost effects units, like the one featured elsewhere in this feature, provide a preset amount of treble boost continuously. There is a potential problem with such units in that the treble boost can result in problems with feed-back and noise, due to the greatly increased gain at some frequencies. The feed-back can be combatted by being careful with the positioning of loudspeakers relative to the instruments, and using the other normal methods of counteracting this problem.

The noise problem can be overcome by using a noise gate which can be a separate unit, or built into the effects unit, as in this dynamic treble booster. The noise will still be there when a reasonably



The Dynamic Treble Booster.



The Dynamic Treble Booster circuit.

strong signal level is present, but it will be masked by the main signal. When the signal decays to a low level, the signal path is cut and the noise is removed. In this case the unit does not provide a true noise gate action, and at low signal levels the signal path is maintained. However, the treble boost is removed on low level signals, which should reduce the noise to an acceptable level. This more subtle approach is not normally apparent, which is not always the case with a true noise gate action.

The basic treble booster circuit is exactly the same as the one featured elsewhere in this feature. However, the drain to source resistance of TR1 has been added in series with S1, S2, etc., and the treble booster action is only obtained if TR1 is switched on. This is a VMOS transistor, and accordingly it is normally switched off and requires a forward bias to bring it into conduction. Its control signal is produced by first amplifying the input signal using IC2, and then rectifying and smoothing the amplified signal using D1 and D2 in a conventional rectifier and smoothing circuit. This gives a control signal that is roughly proportional to the input signal level. This circuit has a fast attack time, plus a slower (but still reasonably fast) decay time, so that the DC output signal accurately tracks the input level. With no input signal or only a very low input level, the bias fed to TR1's gate is too small to switch it on, and no treble boost is obtained. At more than quite a modest input level the bias on TR1's gate is high enough to bias this device hard into conduction so that the full treble boost is obtained.

The notes on constructing the treble booster unit apply equally to this circuit. Additionally, note that D1 and D2 are germanium diodes, and that they are more vulnerable to heat damage than are the more familiar silicon types. Consequently, extra care should be taken when soldering these components into circuit. TR1 is a MOS device, but it has a built-in anti-static protection circuit.

In use it might be found that the value of R6 has to be altered in order to give a suitable threshold level at which the treble boost is introduced. If the treble boost is held on by the background noise level, then R6 must be made lower in value. If the treble boost is introduced only on volume peaks (which is unlikely), then the value of R6 must be increased. The current consumption of the circuit is only about 3 milliamps, and a PP3 size battery is adequate to power the unit. Like the basic treble boost unit, it might be necessary to use two 9 volt batteries in series to give an 18 volt supply if the unit is used with a high output guitar pick-up.

CAPACITANCE CHECKER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

R1	2M2	1	(M2M2)
R2	10k	1	(M10K)
R3	1k	1	(M1K)
R4	100Ω	1	(M100R)

CAPACITORS

C1,2	47µF 25V PC Electrolytic	2	(FF08J)

SEMICONDUCTOR

IC1	NE555	1	(QH66W)

MISCELLANEOUS

S1	SPDT Slide Switch	1	(FF77J)
S2	SPST Sub-min Toggle	1	(FH97F)
LS1	50mm dia. 8Ω Loudspeaker	1	(WB08J)
SK1	1mm Socket Red	1	(WL60Q)
SK2	1mm Socket Black	1	(WL59P)
B1	9 volt (PP3 size) Battery	1	(FK62S)
	Battery connector	1	(HF28F)
	8 pin DIL IC socket	1	(BL17T)

MIDI LEAD CHECKER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

R1	1k	1	(M1K)

SEMICONDUCTORS

D1,2,3,4,5	Red LED	5	(WL27E)

MISCELLANEOUS

SK1,2	5-way 180 degree DIN	2	(YX91Y)
S1	12-way 1 pole rotary	1	(FF73Q)
B1	9 volt (PP3 size) Battery	1	(FK62S)
	Battery connector	1	(HF28F)

SOUND SWITCH PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless stated)

R1	2M2	1	(M2M2)
R2,7,9	10k	3	(M10K)
R3	2k2	1	(M2K2)
R4	1M2	1	(M1M2)
R5	4k7	1	(M4K7)
R6	100k	1	(M100K)
R8	47k	1	(M47K)
RV1	47k log. Potentiometer	1	(FW24B)
RV1	1M lin. Potentiometer	1	(FW48C)

CAPACITORS

C1,8	100µF 25V PC Electrolytic	2	(FF11M)
C2,3,4,6	1µF 100V PC Electrolytic	4	(FF01B)
C5	330pF Ceramic	1	(WX62S)
C7	4µ7F 63V PC Electrolytic	1	(FF03D)

SEMICONDUCTORS

IC1	CA3140E	1	(QH29G)
TR1,2,3	BC549	3	(QQ15R)
D1,2	OA91	2	(QH72P)
D3	1N4148	1	(QL80B)

MISCELLANEOUS

RLA1	10A mains relay (or similar)	1	(YX97F)
Mic1	See text	1	
	8 pin DIL socket	1	(BL17T)

TREBLE BOOSTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless stated)

R1	4k7	1	(M4K7)
R2,3	100k	2	(M100K)
R4	47k	1	(M47K)
RV1	47k lin. Potentiometer	1	(FW04E)

CAPACITORS

C1	100nF Ceramic	1	(BX03D)
C2	1nF Polyester	1	(WW22Y)
C3	3n3F Polyester	1	(WW25C)
C4	470nF 100V PC Electrolytic	1	(FF00A)
C5	10µF 50V PC Electrolytic	1	(FF04E)

SEMICONDUCTOR

IC1	LF351N	1	(WQ30H)

MISCELLANEOUS

S1	SPDT ultra-min toggle	1	(FH98G)
S2	Foot switch	1	(FH92A)
S3	SPST ultra-min toggle	1	(FH97F)
B1	9 volt (PP3 size) Battery	1	(FK62S)
SK1,2	Standard jack	2	(HF93B)
	Battery connector	1	(HF28F)
	8 pin DIL socket	1	(BL17T)

DYNAMIC TREBLE BOOSTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless stated)

R1	4k7	1	(M4K7)
R2,3,5,6	100k	4	(M100K)
R4	47k	1	(M47K)
R5	5k6	1	(M5K6)
RV1	47k lin. Potentiometer	1	(FW04E)

CAPACITORS

C1	100nF Ceramic	1	(BX03D)
C2	1nF Polyester	1	(WW22Y)
C3	3n3F Polyester	1	(WW25C)
C4	470nF 100V PC Electrolytic	1	(FF00A)
C5	10µF 50V PC Electrolytic	1	(FF04E)
C6,8	1µF 100V PC Electrolytic	2	(FF01B)
C7	2µ2F 100V PC Electrolytic	1	(FF02C)

SEMICONDUCTORS

IC1	LF351N	1	(WQ30H)
IC2	µA741C	1	(QL22Y)
D1,2	OA91	2	(QH72P)
TR1	VN10KM	1	(QQ27E)

MISCELLANEOUS

S1	SPDT ultra-min toggle	1	(FH98G)
S2	Foot switch	1	(FH92A)
S3	SPST ultra-min toggle	1	(FH97F)
B1	9 volt (PP3 size) Battery	1	(FK62S)
SK1,2	Standard jack	2	(HF91Y)
	Battery connector	1	(HF28F)
	8 pin DIL socket	2	(BL17T)

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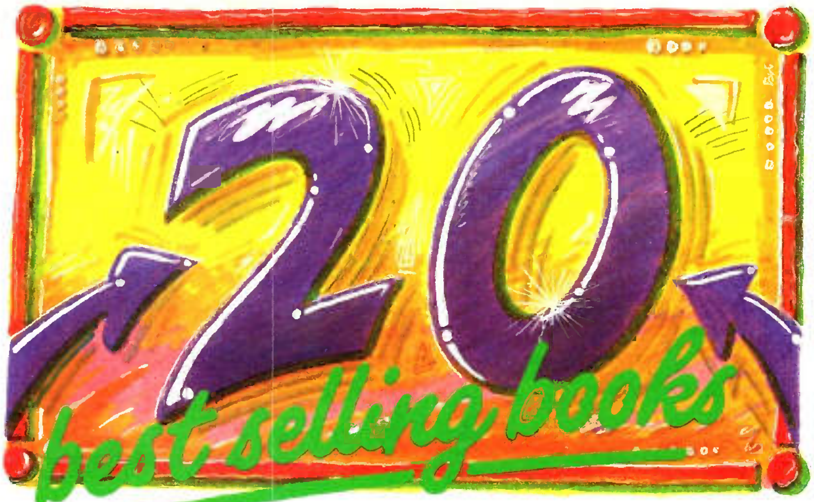

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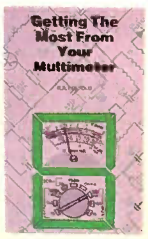

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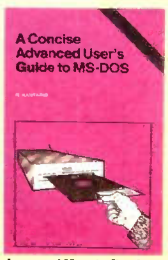

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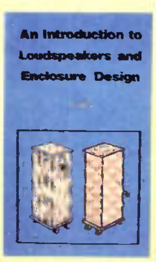

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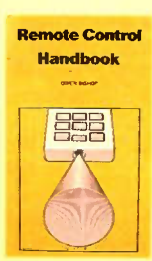

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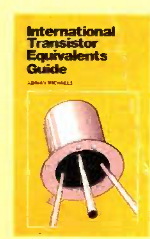

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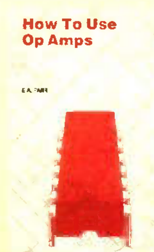

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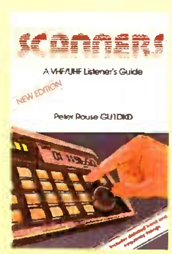

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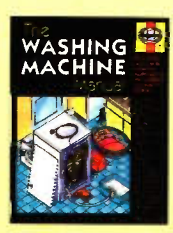

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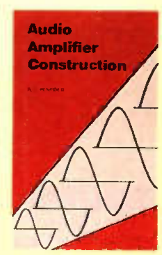

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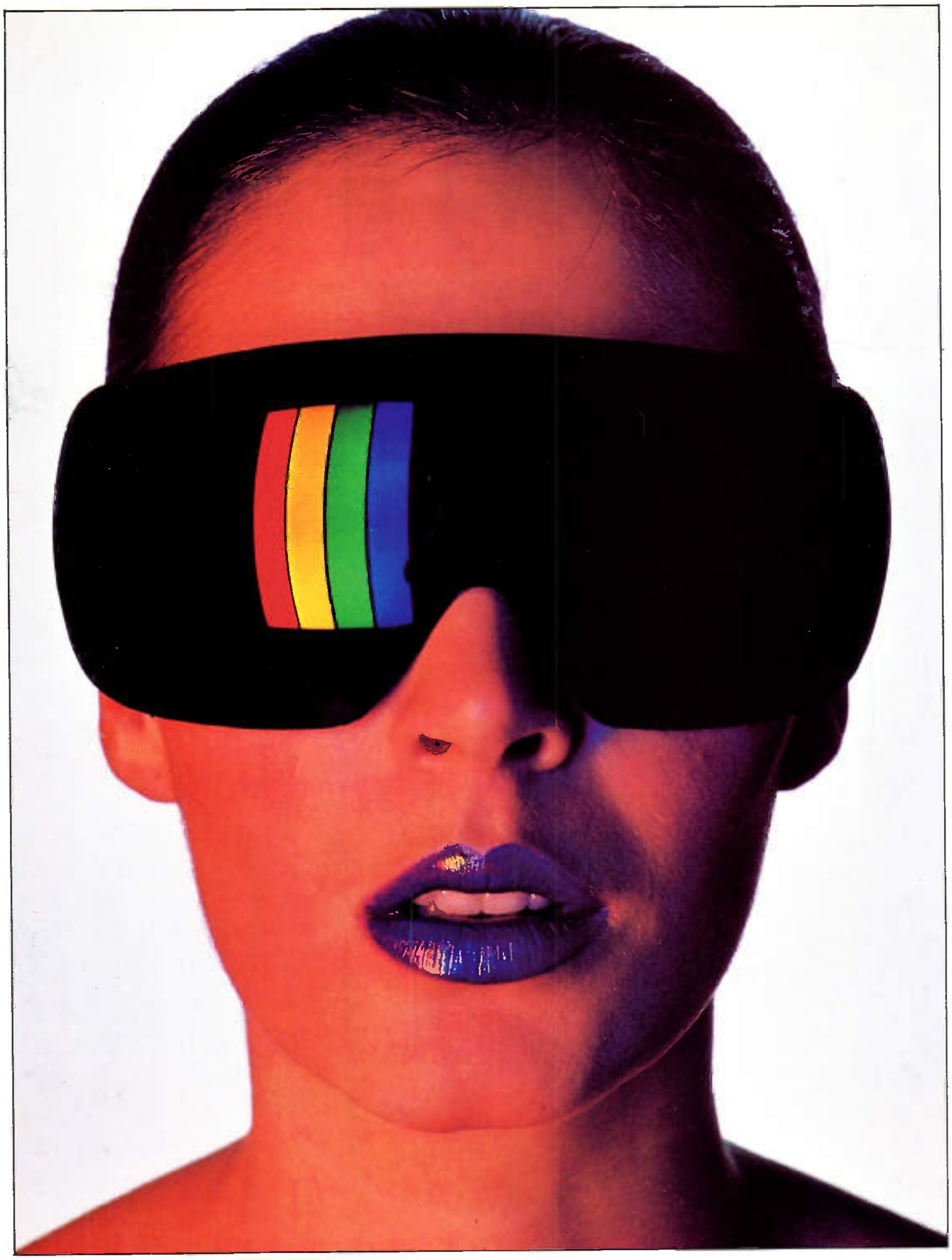

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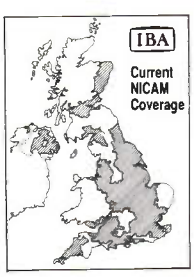

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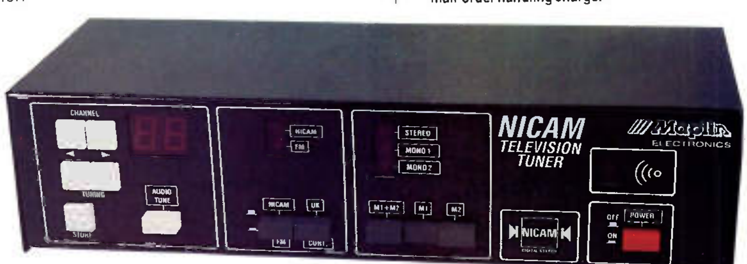

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