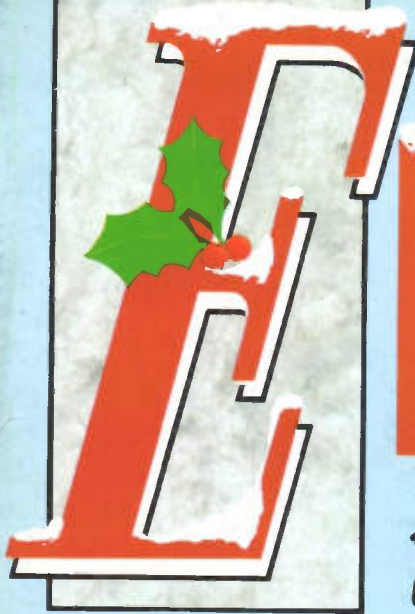


TEST EQUIPMENT • AUDIO • RADIO • COMMUNICATIONS

No. 61



ELECTRONICS

The Maplin Magazine

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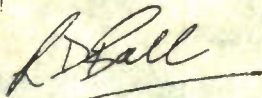
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EDITORIAL

■ Hello and welcome to this New Year's issue of 'Electronics'! Traditionally, the start of the New Year is a time for looking back at the year gone by, and looking forward to the year ahead. 1992 was certainly a year of firsts: the first full year of 'Electronics' being published monthly, the year when 'Electronics' changed over from 'cut and paste' to the high technology world of Desk Top Publishing, and the year when the Subscribers' Club with its Discount Scheme was launched. I am pleased to say that, despite the current economic circumstances, 'Electronics' is still Britain's Best Selling Electronics Magazine thanks to the support from you, the readers. In fact the number of people subscribing is increasing every month! I would also like to thank everyone who has written in over the past year, with a very wide range of comments and suggestions for improving the magazine. Based on your ideas, I have, together with a very capable team of editorial staff, engineers and authors, planned a very exciting year ahead for 'Electronics'. During 1993, there will be more projects and circuit ideas than ever appearing in each issue, after all what is an electronics magazine all about! These of course will be backed up by even better features, reports, serials and reviews! This month, it's welcome aboard for electronics engineer and journalist, Keith Brindley, as he joins the 'team' with 'Technology Watch', a monthly look at what is happening in the fast-moving world of consumer electronics. In next month's issue there's the start of a major new project, an expandable LED Moving Message Display, and a review of the new Philips/Fluke Scopemeter, plus lots of other exciting projects and features, see page 20 for details! So until next month, enjoy reading this issue and from the 'team' and myself, have a Very Happy and Prosperous New Year!



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 Editorial. The views of individual contributors/authors are not necessarily those of either the publisher or the editor.

PROJECTS

8 PROGRAMMABLE PULSE GENERATOR

■ This ingenious unit allows precision pulses to be generated over the range 1µs to 999ms.



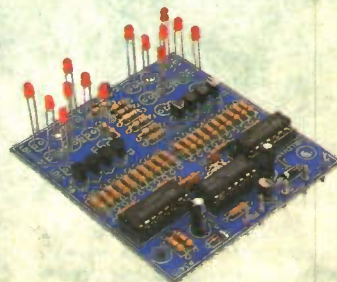
24 TELEPHONE RING SIMULATOR

■ This unit generates a telephone ringing signal, with either British or American timing, and is ideal for amateur dramatics or home video productions.



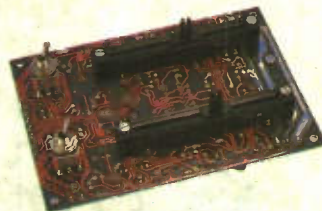
40 DUAL ELECTRONIC DICE

■ At last no more hunting for lost dice; this low cost project is a must for playing dice-based board games.



56 DUAL FADER

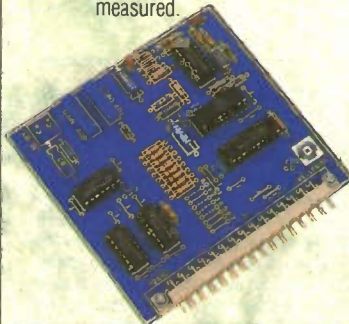
■ Part of a high quality Modular Mixing System,



this project allows signal levels to be adjusted.

65 ANALOGUE-TO-DIGITAL CONVERTER

■ Part of the Intelligent Motherboard project, allows analogue signals to be measured.



FEATURES

4 AUTOMATIC VEHICLE IDENTIFICATION SYSTEMS EXPLAINED

■ How the latest state-of-the-art technology is speeding up toll collection.

16 COLLECTING AND RESTORING VINTAGE RADIOS

■ This fascinating series continues with a look at the different categories of radio that can be collected.

32 FLUKE 10 SERIES DIGITAL MULTIMETER REVIEW

■ Modern, accurate, rugged test equipment is a must for everyone involved in electronics.

36 HOW TO USE PIEZO ELECTRIC FILM

■ This amazing material responds to sound, pressure, temperature and infra-red radiation.

50 WAVEFORM GENERATOR DESIGN

■ Ray Marston explains how to design 'special' types of generator circuits.

60 THE HISTORY OF AMATEUR RADIO

■ Ian Poole continues this fascinating story.

73 RADIO CONTROLLED MODEL CARS

■ Trevor Tennant returns with some hot tips on how to get the very best performance.

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CORRIGENDA

■ November 1992 Vol. 11 No. 59
 Soldering Iron Station Page 10.
 Figure 2, please note that the triac (T11) legend is incorrect: the device must be fitted with the tab closest to the edge of the PCB. This note applies to issue 1 PCBs only. This error has been corrected on issue 2 PCBs.
 Figure 4, the dimension for hole 'C' should be 16mm and not 11mm as shown.
 Parts List, CP64 Heatshrink sleeving (BF90X) was omitted from the Miscellaneous items.

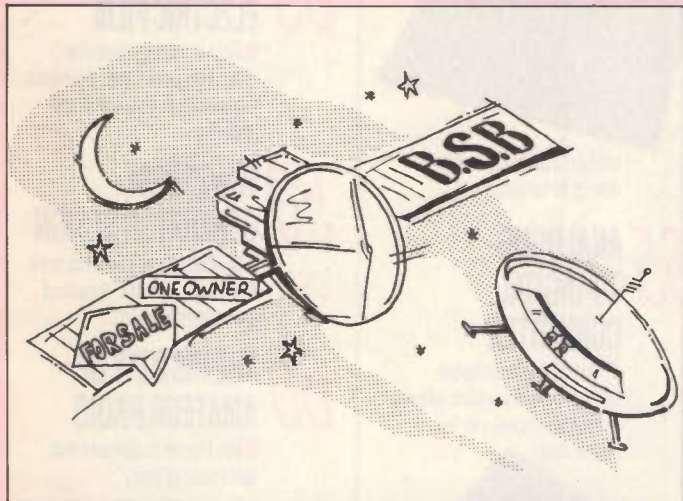
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Prices shown in this issue include VAT at 17.5% (except items marked *AV* which are rated at 0%) and are valid between 4th December 1992 and 28th February 1993.

NEWS

Report

The End of an Era



And now for BSKyB's New Year's greeting to all those who splashed out £400 plus for a BSB DMAC receiving system. On December 31st, the Marcopolo illumination of the five post-merger channels will cease – little more than three years after those first BSB test transmissions – in accordance with IBA (now ITC) regulations. The November 1990 'merger' – which took place less than a year after the BSB service was launched – breached the broadcaster's contract with the IBA.

BSB viewers have received some form of compensation from BSKyB – in the form of an obsolete ex-rental Amstrad SRX200, Videocrypt decoder, dish and installation. A far cry from the technical excellence of the BSB systems! Alternatively, if they already had an Astra system, they could opt for another choice – that preferred by BSKyB – namely a year's subscription to the broadcaster's pay-TV channels.

Ex-BSB viewers, as can be expected, did badly out of the merger. Apart from seeing BSB's British programmes replaced by Sky's cheap American ones, they were unable to receive transmissions from other Astra broadcasters (e.g., Lifestyle, MTV, etc.) unless, of course, they had already installed the appropriate receiving equipment; understandably, perhaps, the BSB fiasco may have put them off satellite television for good!

Interestingly, BSKyB's similarly short-lived Comedy Channel (now Sky Movies Gold) was not dual-illuminated from the Marcopolo satellite, despite the fact that a second Marcopolo satellite was in place (each has five transponders, plus back-ups). Although this second satellite has since been sold to a Swedish consortium (it has been co-located with Intelsat VA-F12 at 1°W), many ex-BSB viewers were angry since they were denied the channel. This was particularly ironic, as most of the British

programmes shown by the Comedy Channel during its first few months of operation were inherited from BSB as a result of the merger! Perhaps it was a cleverly-conceived plan to get ex-BSB viewers to Invest in an Astra system so that they would take up the cheaper (to them) subscription compensation offer – after all, most of those who chose BSB did so because of those classic BBC programmes! In any case, it all fell flat on its face when the BBC, under pressure from Equity, failed to renew its contract with the Comedy Channel – which then flopped unspectacularly due to dismal ratings, before being subsequently replaced by Sky Movies Gold.

Another reason why many BSB viewers felt 'stabbed in the back' was because they bought their systems between July and November 1990 – Sky Television had started secret merger discussions with BSB as far back as that July, although nothing had been fixed until mid-October.

This unhappy state of affairs has left over a hundred thousand BSB receiving systems installed at the time of the merger, those installed after the merger as a cheap alternative to Astra for watching Sky's channels, and many thousands gathering dust in manufacturers' and dealers' warehouses. Come December 31st, and they will all be useless.

As for the Marcopolo satellite? Earlier in 1992, the ITC invited bids from prospective broadcasters interested in using Britain's official DBS satellite. Unfortunately, none passed the ITC's 'quality' threshold (what is 'quality' television anyway?), and so Marcopolo seems destined for sale (an ever-decreasing possibility) – or failing that, a 'graveyard' orbit. BSKyB, of course, are delighted, as they have been released from their somewhat expensive obligation of operating the satellite.

Citizen's Charter Targeted at BT

OFTEL, the telecommunications watch-dog quango is calling for views on the performance standards that should be set for BT and Kingston Communications (Hull). Mercury does not apply as it has less than 25% of the voice telephony services within its licensed areas. Comments are being called for on such topics as directory services and public call boxes as well as levels of performance including those of speed of fault repairs. So now is your chance to influence telecomms standards!

Your views should be sent to OFTEL (Tel: (071) 634 8754).

The Voice of IBM

On the anniversary of the first IBM PC to be sold in the UK, IBM have stated that the PC can be called the most successful product in the world. In the space of a mere decade, the PC market has grown to be worth some \$90 billion dollars a year, and it is estimated that there are more than 120 million PC users around the world. The IBM PC transformed the working lives of millions – and put millions into the working lives of others. For instance Bill Gates, the founder of Microsoft – a small software company chosen by IBM in the early 80s to develop the PC's operating system – is now a multi-billionaire. Intel, the company responsible for the microprocessors at the heart of most PCs, is now a \$3.9 billion company. Other individuals and companies, say IBM, have made more modest fortunes.

Cheap Talk

November saw the launch of a low-cost voice recognition chip set from Sierra Semiconductor. Primarily speaker independent, the Aria Listener devices can be adopted to recognise a particular human voice.

The phonetic signatures of individual word structures are stored on support-

ing ROM – initial estimates indicate that 125 words will require 1MByte. Spoken words are then compared against the templates in memory and a match is made.

Targeted at consumer applications, manufacturers of entertainment equipment in California have already demonstrated products which incorporate the chip-set with PC cards expected to follow soon.

Priced at \$80, the overriding factor is expected to be memory requirements.

Dorset Lad Scoops Radio Award

The Young Radio Amateur of the Year Award for 1992 has gone to 17 year-old radio buff Martin Saunders (call sign G7JJCJ) of Broadstone, Dorset. Martin won £250 and a certificate signed by Michael Heseltine, the much-troubled President of the Board of Trade, who was presumably taking time off from closing down the nation's coal industry. Martin's main interest is in 'packet' radio, which involves transmitting computer data sequentially, a lump (or 'packet') at a time. He assembled his own equipment and has been granted a Notice of Variation to his Amateur Radio Licence to operate a mailbox, a computerised distribution agency that can be accessed by other radio amateurs wishing to receive a message.

Meanwhile, the Radiocommunications Agency has announced stiffer penalties for pirate radio stations (I thought that they couldn't get any stiffer, save of course for the reintroduction of the death sentence – Ed). According to DTI Minister Edward Leigh, 'pirate radio creates anarchy on the airwaves'. Fines have been increased for what is described as 'the theft of spectrum, threat to lives and 'mindless' disdain for ordinary listeners'. If you're prepared to throw money at the Treasury and Radio Authority in the form of a 'community' radio franchise application, that's different of course. Anyone want to buy a slice of the electromagnetic spectrum? Let's start the bidding at, say, £50,000 per annum. Going, going, gone.

Air Call Speeds the Traffic



Air Call has announced the UK's first portable traffic information service to deliver live national and regional coverage. The paging service will send live traffic information direct from the AA for display on pocket-sized four-line message pagers. Users receive traffic information relevant to the area they are travelling in. As they travel through

regions the traffic information received on their pagers will automatically change. To help with long distance journey planning, major national traffic incidents are sent to all subscribers. It does sound rather like the Traffic-master system, covered in some depth in issue 47 of 'Electronics'. For details, contact Air Call on (0707) 399003.

Special Report from J. M. Woodgate

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

Electrical and electronics engineers from all over the world travelled to Rotterdam, Holland for the 56th General Meeting of the International Electrotechnical Commission (IEC). Held at the World Trade Centre from 28th September to 10th October 1992, the General Meeting represents another step towards the goal of truly international standards for the specification, measurement, interfacing and performance of electrical and electronic equipment. The IEC has already published nearly 1,200 such standards, many of which are adopted word-for-word as British or European standards, as well as National Standards in many other countries. This is a valuable force in encouraging exports; indeed, the theme of the 56th General Meeting was 'international standards serving world trade'.

Thirty-two technical committees and sub-committees were involved in the General Meeting, as well as six policy level committees and numerous Working Groups, which implies an attendance of some 2,000 experts for some parts of the proceedings. The subjects discussed ranged from alkaline cells to video recording, and included connectors, lasers, electrical safety and luminaires (not 'luminaries', which are shining lights of a quite different sort!).

Your humble correspondent on this occasion was the Leader of the UK delegation (of one person!) to committee SC12A, which deals with radio and television receivers. The committee is deeply involved in standards for the measurement of satellite receiving equipment, MAC systems, NICAM, etc. and, in the sound broadcasting field, standards for the measurement of RDS receivers, and for Digital Sound Radio (DSR) receivers, already available in Germany, and for the future Digital Audio Broadcasting (DAB) receivers, which are planned to be available in Britain in 1995. At the same time, existing systems are not forgotten; the meeting discussed a revision of the standard for measurements on FM broadcast receivers (IEC315-4), and a Working Group meeting on this subject was held.

Apart from General Meetings, others go on throughout the year the world over.

Call for Urgent Information

A court in Manhattan last month found a 23-year old man guilty of leaving messages on thousands of radiopagers, asking users to call a telephone number for urgent information. What he neglected to indicate was that the line cost \$55 for connection. Having rigged up a computer and

modem to call over 4000 message pagers a day, the defendant was set to claim \$198,000 from New York Telephone - fortunately he was arrested before the telephone company passed his cash and now faces a five year jail sentence.

Now ET (and Squidgy) can Phone Home for Help

The RAC and Cellnet have combined forces to give motorists an in-car emergency telephone service. The Cellnet Lifetime cellular telephone

handset supplied by Motorola has been specially adapted to include free call, preprogrammed emergency buttons marked RAC and 999. Calls are routed direct to the RAC control centre and from there to a RAC or police patrol. The RAC ET (Emergency Telephone) unit costs RAC members £199 to buy including connection charges, with line rental being £15 a month.

The system competes with the AA Vodafone Callsafe service, and both the RAC and AA are targeting their female members as being potential users. But in both cases, ET and Squidgy will find the call costs high to offset the low rental charges.

Events Listings

To January 1993. The IRN-BRU Pop Video Exhibition. MOMI, South Bank, London. Tel: (071) 815 1339.

10 to 12 November. Image Processing '92. NEC Birmingham. Tel: (081) 742 2828.

19 to 22 November. Christmas Computer Shopper Show '92. Olympia, London. Tel: (081) 742 2828.

5 December. All-Formats Computer Fair. Birmingham Motorcycle Museum. Tel: (0608) 662212.

7 to 8 December. HDTV and Future Television. Cumberland Hotel, London. Tel: (071) 931

9985.

8 to 10 February '93. Microtech '93. Heathrow. Tel: (0344) 301491.

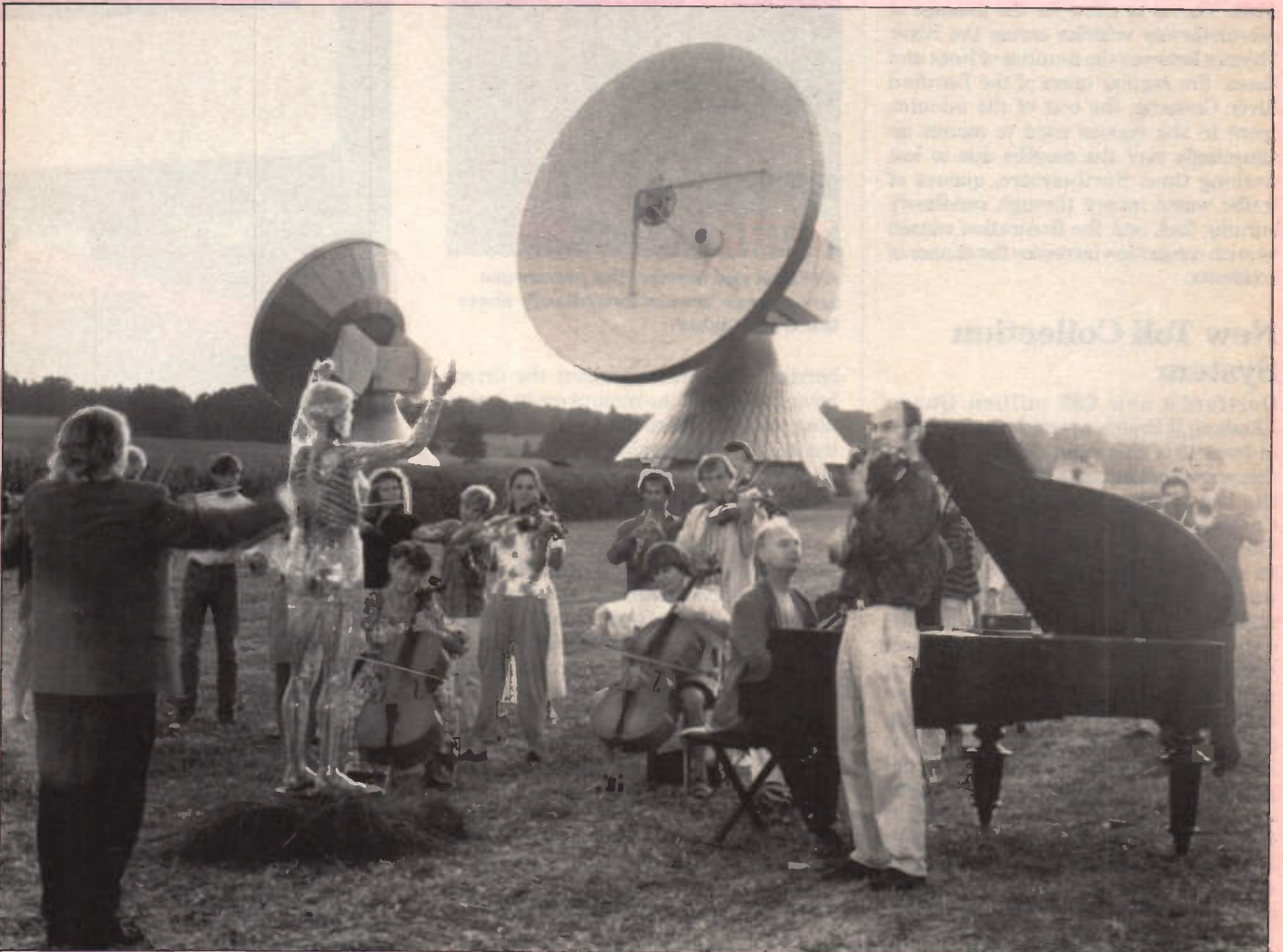
23 to 25 March. NEPCON. NEC Birmingham. Tel: (081) 948 9800. Don't forget to visit the Maplin Professional Supplies Stand!

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

24 April 1993. Marconi Birthday Exhibition. Wireless Museum, Puckpool Park, Seaview, I-o-W. Tel: (0983) 567665.

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

PICTURE CAPTION CHALLENGE



A musical interlude for this month's Caption Competition. No prizes (not even an audition with Andrew Lloyd Webber!). So what's up?

★ At last! Something for culture fans on Sky TV!

★ Alternative venue for music appreciation group after finding that the Royal Albert Hall is double-booked.

★ Welcoming committee for Nigel Kennedy, should he pass by.

★ Fieldwork taking place for the commissioning of a new Andrew Lloyd Webber musical.

Well, no! Actually it is a film using the symbolism of a symphony orchestra commissioned by Siemens. The film was on show at the recent EXPO '92 in Seville, Spain.

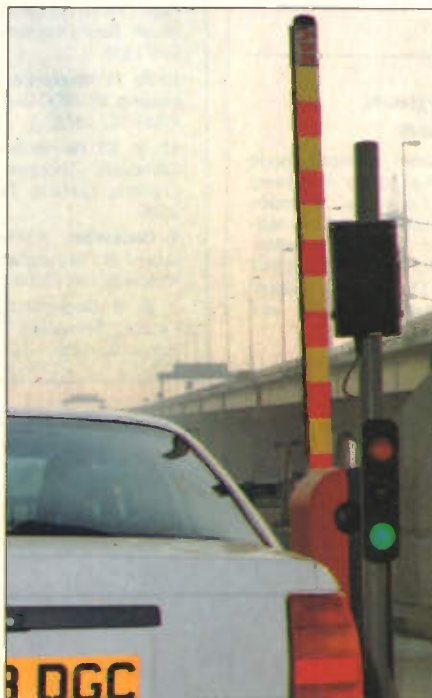
Taking Toll of Traffic Jams

by Stephen Waddington

The M25 is synonymous with traffic queues. Every rush hour, tailbacks stretching for miles are reported with vicarious glee by the motoring organisations and traffic journalists (not to mention public transport aficionados!) in the South East. One of the main areas of congestion used to be at Dartford, some forty kilometres east of the city of London. Here, the River Thames splits the M25 in two, and for a distance of eight kilometres the motorway becomes an 'A' road – the A282. This is to allow for the passage of non-motorway vehicles across the River Thames between the counties of Kent and Essex. For regular users of the Dartford River Crossing, the cost of the minutes spent in the queues used to mount up alarmingly over the months due to lost working time. Furthermore, queues of traffic waste money through needlessly burning fuel, and the frustration caused by such congestion increases the chance of accidents.

New Toll Collection System

Dartford's new £86 million Queen Elizabeth II Bridge, covered in some detail in Issue 49 of *'Electronics'*, has eliminated this once familiar congestion – at least for the time being. Now Dartford River Crossing Limited, part of the Trafalgar House Group, has invested an additional £2 million in a new toll collection system that will further reduce delays to the huge number of vehicles (100,000 a day and rising) that use the crossing, and will ensure that the possibilities of queues appearing in the future are reduced. Central to the system is Automatic Vehicle Identification (AVI), a facility which gives drivers the possibility of passing through the toll plazas without stopping. Drivers who open DART-Tag accounts with Dartford River Crossing Limited are supplied with a microwave transponder tag – known as a 'DART-Tag'. Once mounted on the windscreen of a vehicle, the DART-Tag is interrogated by an antenna whenever the vehicle arrives in a toll lane. The antenna, linked to a complex computer system, identifies the uniquely pre-programmed tag, and assuming the user's account is in credit, gives a green light and the lane

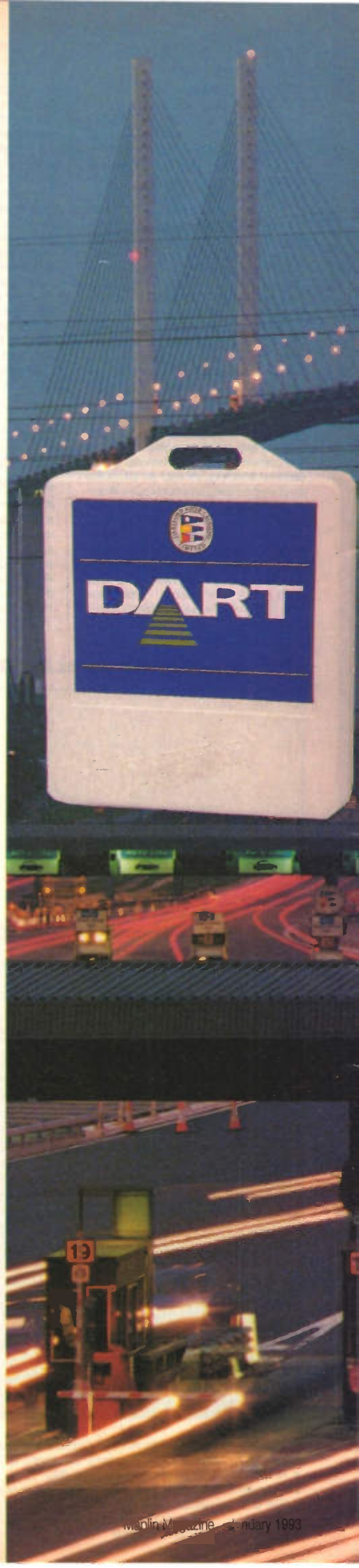


AVI Post and barrier. The microwave antenna can be seen immediately above the 'traffic lights'.

barrier rises almost without the driver having to stop. If the account credit is running low, an amber light shows. Should the tag be used illegally, or the user is out of credit, a red light shows and the lane barrier prevents passage through the toll plaza.

The AVI system links in with the newly-installed toll equipment. The eight existing vehicle classifications' toll charges have been maintained, although these will continue to rise with inflation as provided under the terms of the Dartford/Thurrock Crossing Act 1988. Customers are still able to pay by cash, although the facility to purchase multiple books of discounted tickets has been withdrawn. Instead customers are offered DART-Tags at a discount of 7½% below the usual toll rates, and with the added incentive of journeys free from delay.

The Dartford River Crossing system was designed, manufactured and installed by the French firm CSEE Peage. Responsible for the AVI aspect of the crossing, (the design of which is renowned throughout the world) were the Swedish company of SAAB Combitech. Having performed extensive trials on electronic



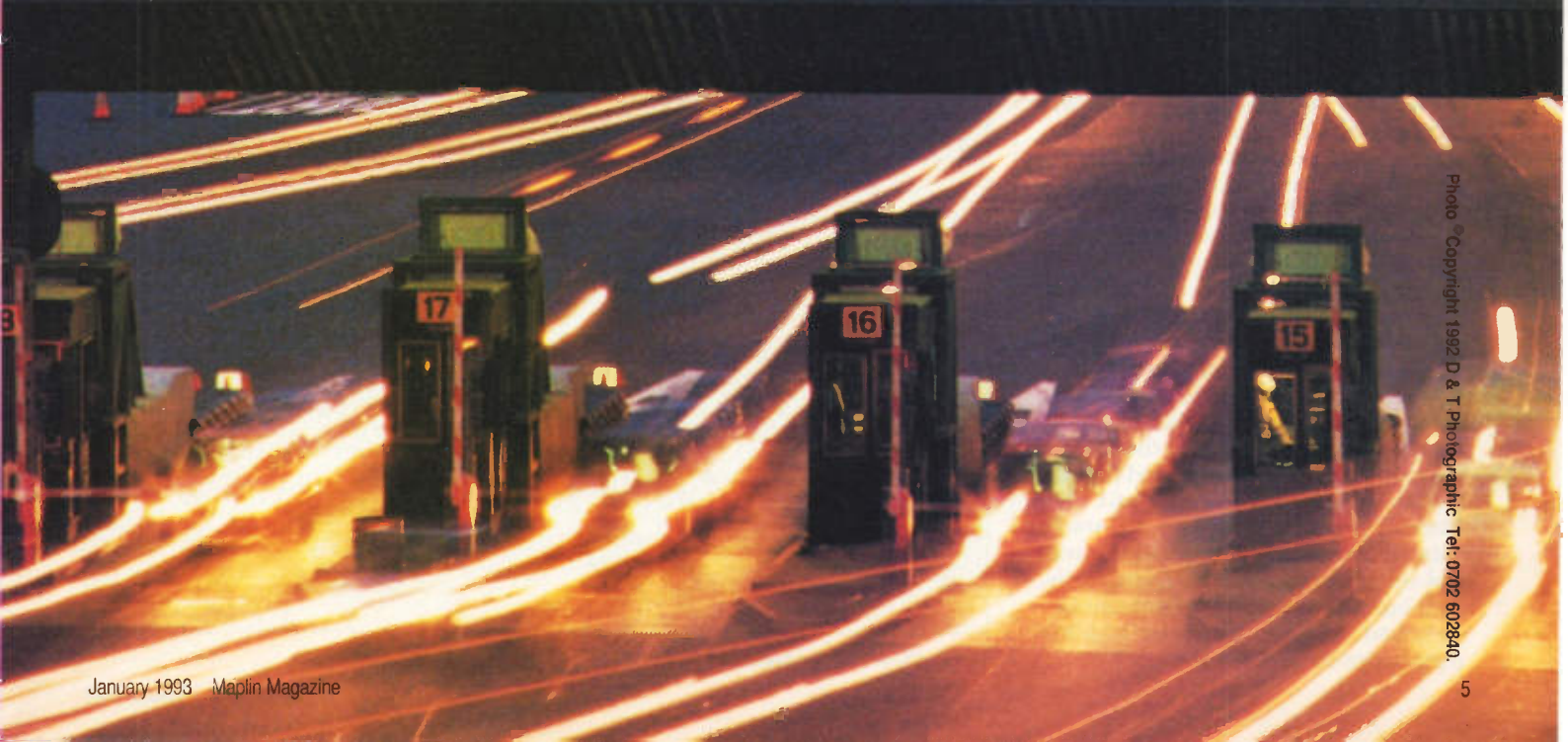


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toll collection systems, engineering consultants Mott MacDonald assisted Dartford River Crossing engineers in the supervision of all aspects of the project, from the preparation of the original contract to the final commissioning of the completed system.

Site Layout

When travelling south along the M25 and then the A282, drivers pass over the Queen Elizabeth II Bridge before facing the southbound toll plaza. Split into twelve lanes, many will accept any vehicle, several are dedicated for the passage of cars only, whilst one lane is reserved for DART-Tag cars only. Travelling north, drivers must pay their toll before progressing through either of the tunnels. Again, twelve lanes exist, with the northbound plaza laid out in a manner similar to its counterpart on the opposite carriageway. Geographically, the two plazas lie in front of the Dartford River Crossing offices, a few hundred metres apart.

Lane Computers

Each lane is equipped with a computer; three possibilities exist. A lane may feature either an Automatic Coin Machine (ACM), a Manual Toll Terminal (MTT) – or both, allowing Dartford River Crossing the flexibility to optimise traffic throughput. Drivers are forewarned of a lane's configuration by an overhead lane sign at the entrance to each lane. Figure 1 shows a lane equipped with both ACM and MTT.

A lane configured in ACM mode will allow the passage of cars only and payment is either by the correct cash value or DART-Tag. Drivers opting to pay cash, place – or more often, throw – the money into a large hopper at the front of the machine. Combining electromagnetic sensors, to identify coin thickness and metal content, with a sophisticated anti-jam device capable of eliminating foreign objects or rogue coins, the machines count the money presented. On recognition of the correct toll value, the lane barrier rises allowing the driver to continue their journey. Each ACM compiles and records all revenue and traffic data, returning details to a central computer when polled. Money collected is retained in vaults, in the depths of the machines, which are manually returned to a central cash office for processing on a regular basis.

Manual Toll Terminals differ intrinsically from ACMs in that any classification of vehicle can be processed. An operator is stationed in each lane, able to provide customers with change when they are unable to tender the exact toll value. The operator classifies vehicles as soon as they appear in the toll lane; AVI vehicles are then able to progress while cash-paying drivers are left to present the toll fare before continuing passage beyond the lane barrier. Again, as with Automatic Coin Machines, records of revenue and traffic data are retained and returned to a central computer on request. Additionally, each operator records details of transactions and provides figures for auditing purposes at the end of a shift.

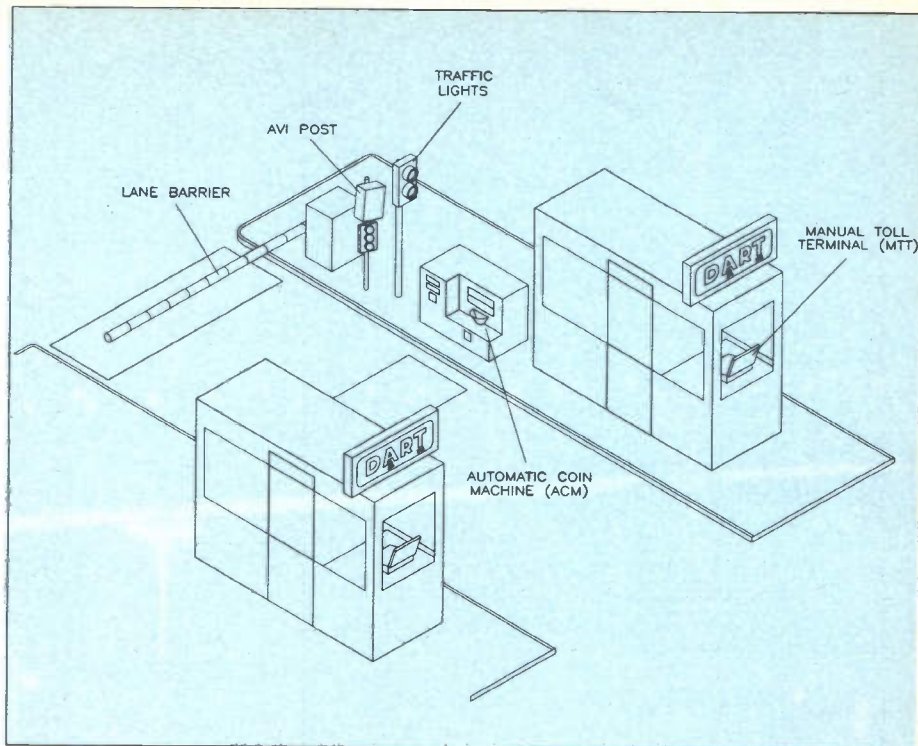


Figure 1. A Dartford River Crossing toll lane equipped with both ACM and MTT.

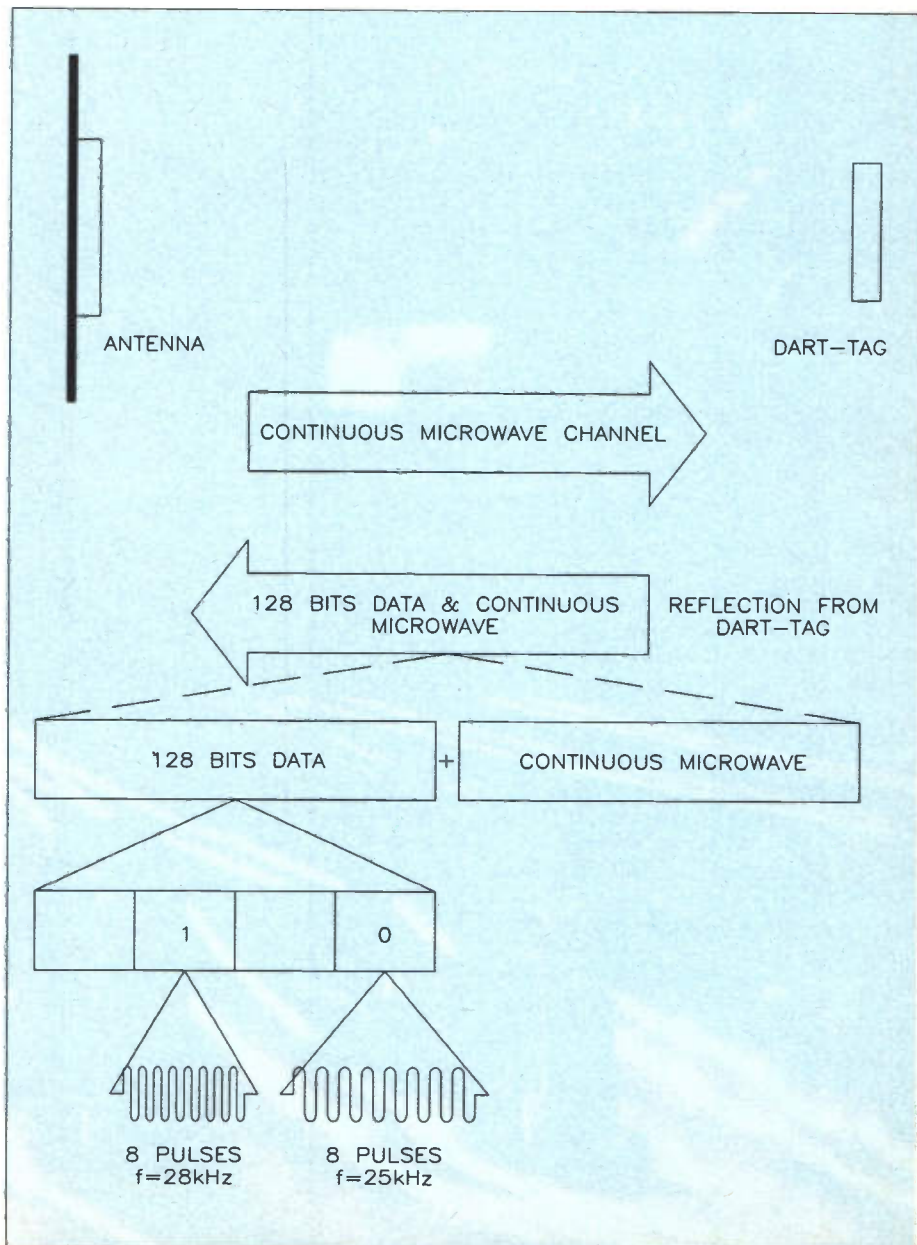


Figure 2. AVI transmission format.

Where both an ACM and MTT exist in a lane, either, but not both, may be active. When traffic flow is heavy, the MTT plays the predominant role allowing for the passage of any vehicle. During relaxed periods more emphasis is placed on the coin machines.

Central Computer

Crucial to the operation of each lane is the Central Computer; apart from interacting with each lane computer, it ties together numerous work-stations and associated peripheral devices. Terminals for the auditing and reconciliation of collected tolls provide an important contribution, as do management work-stations able to provide revenue and traffic reports. Statistical data can be viewed and considered with ease. Additional work-stations deal with AVI accounts, allowing the user to view statement details, open or close an account and, if necessary, black-list a lost or illegally used tag.

Innovative Vehicle Identification

The concept of automatic vehicle identification is not new; in modern production and distribution systems, there has been a fast-growing interest in such identification systems. Such schemes are varied and range between the identification of items passing along a supermarket conveyor belt to the military detection of objects – both friend and foe.

What is new and unique to systems such as that installed at Dartford is the automatic detection of objects, in this case vehicles, whilst they are in motion. Indeed the PREMID AVI system installed at Dartford River Crossing is capable of detection at speeds of 75km/h. Physical constraints including the length of a lane and physical layout of the Dartford River Crossing plazas prevent such speeds from being attained, although speeds in excess of 15km/h were reached during performance tests, increasing to 50km/h and beyond once the lane barrier was removed.

In any process, the initial step towards increased efficiency and automation is to eliminate all manual data entry operations. To achieve this a number of possible alternatives are available, including standard techniques such as optical and magnetic ink character recognition. Bar-coding and magnetic card technologies extend the list, though all are limited primarily to short and precise distance detection. To break beyond such a limited detection scale, other technologies which allow for remote identification, must be investigated. Systems based around camera, infra-red, and radio frequency (RF) technology are among those being considered.

Having realised possible methods of detection, further variables join the equation. The amount and form of data to be detected has to be examined. Camera systems rely on elaborate computer equipment and are not sophisticated enough to be considered on the electronic detection scale. Linked together, a camera and com-

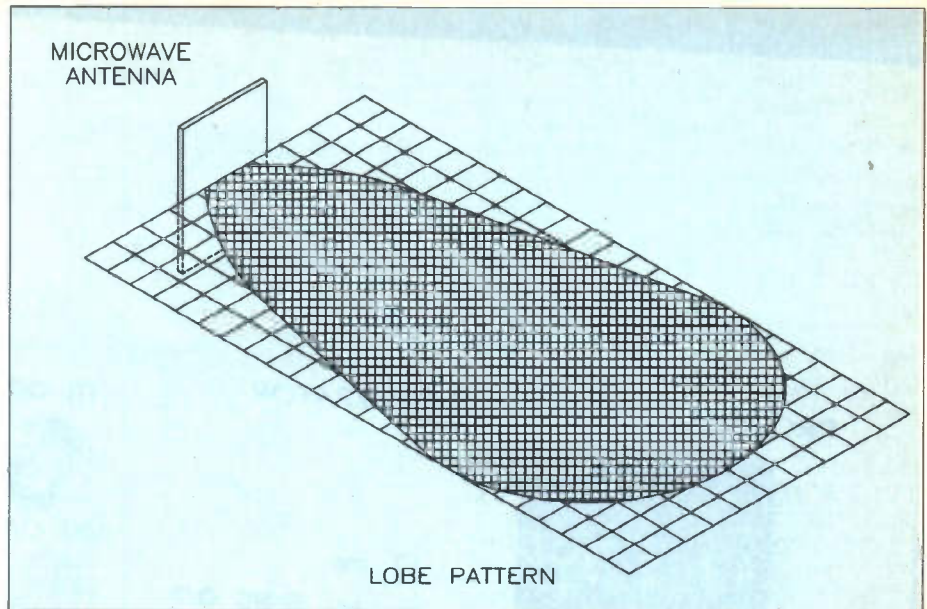


Figure 3. AVI antenna lobe pattern.



Inside the DART-Tag; the large circular object is the lithium battery.

puter can recognise pre-programmed objects, the limiting factor of such a system being the number of different objects that it may be called upon to detect. In this application, both infra-red and radio systems offer more practical alternatives, as data can be read from a moving carrier, and information processed, quickly and remotely – allowing transportation to continue without interruption. A radio system employing a particular band of the radio spectrum (in this case, microwave frequencies) can interrogate data from an information carrier at a considerable defined range. This latter system is the basis of the DART-Tag.

DART-Tag

At the Dartford River Crossing, the information carriers are known as 'Tags' or, to apply the marketed name, DART-Tags. An electronic memory device measuring 60mm x 70mm x 12mm, the DART-Tag is fixed on the inside of the vehicle's windscreen with the aid of a plastic wallet. Before reaching the customer, the Tag is programmed with a 20-digit number that relates to the customers' unique user and account numbers, and the type of vehicle for which it is intended. Once within a lane – the domain of the AVI's microwave antenna – the tag is interrogated within a mere 125ms.

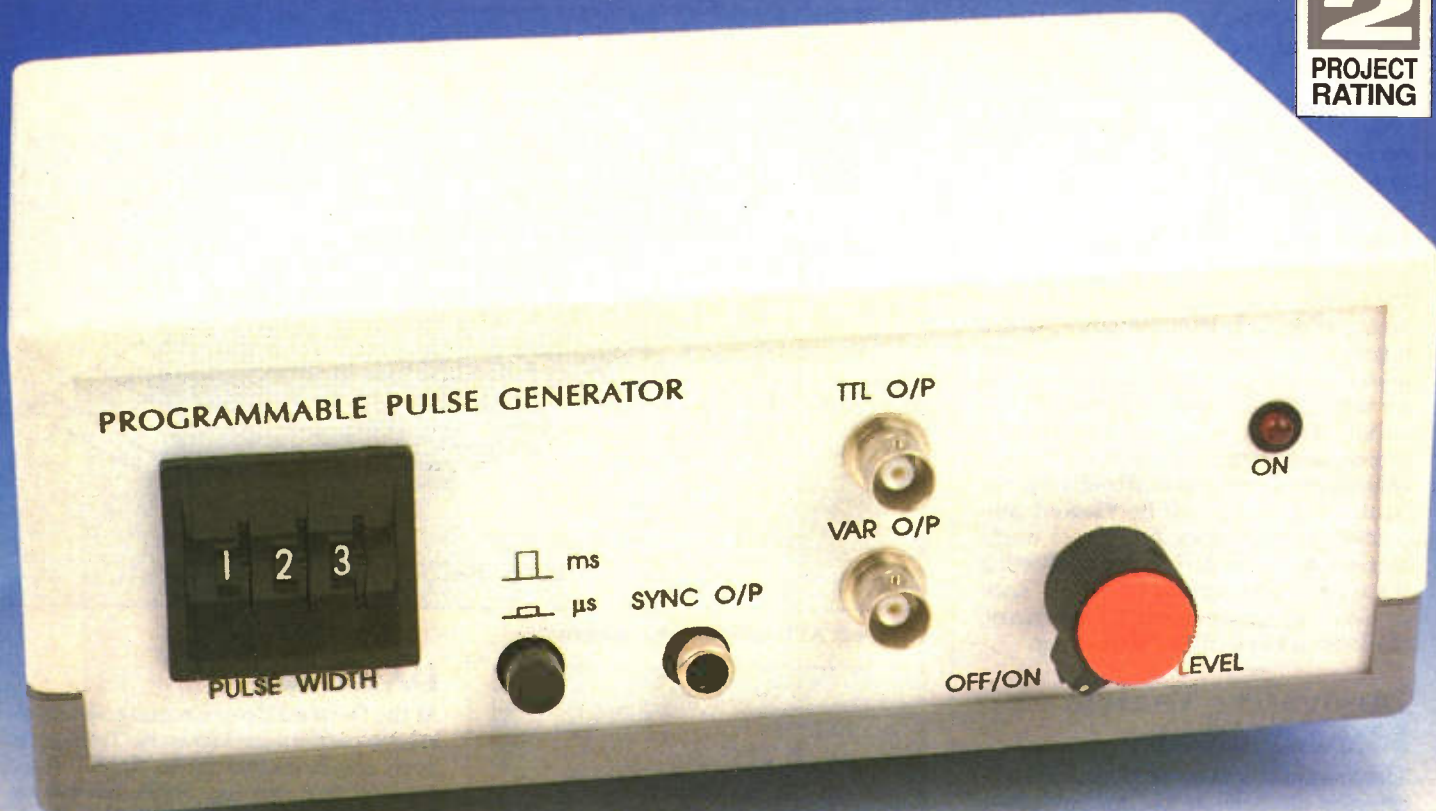
The dominant life-setting component of a DART-tag is its battery – essential for retaining the data in the memory of the tag; these are special lithium types that have been in production since 1976. On a SAAB PREMID installation in Alesund, Norway, tags have been in constant use since 1987. After two years of service a number were recalled for test. Subsequent measurements showed that there had been very little discharge. The fact that no RF energy is actually generated by the DART-Tag extends the expected lifetime, although Dartford River Crossing Limited expect to begin recalling Tags for replacement after five years.

The Antenna Unit

The device that is responsible for the generation of the microwaves and the reading of the DART-Tags is a microwave antenna unit – an intelligent device consisting of a printed circuit board array of sixteen dipoles. A Doppler module is included which emits a constant signal to the DART-Tag. Reflected data is demodulated and processed by the same unit.

Communication between the microwave antenna and the DART-Tag is across a single pulsed microwave channel. The 2.45GHz frequency employed is in the world-wide Industrial, Scientific and Medical (ISM) Band. Generation of the RF signal is performed solely by the lane antenna, which operates at a power

Continued on page 15.



Programmable Pulse Generator

by M. J. A. Turner

Modern pulse generators have a wide variety of applications, from the operation of relays or counters, to the calibration of oscilloscopes. The pulse width is usually set by means of a potentiometer, in conjunction with several switched ranges. If the exact frequency needs to be known, it is necessary to monitor the output with a digital frequency meter.

This programmable pulse generator (PPG) does not require monitoring, as the pulse width is set by using three programmable binary-coded decimal (BCD) switches, together with two non-overlapping ranges.

Circuit Description

As can be seen from the circuit diagram in Figure 1, the unit's power supply is based

FEATURES

- ★ High Accuracy
- ★ Microsecond and Millisecond Ranges
- ★ Easy Programming (BCD switches)
- ★ Variable and Fixed TTL Outputs

APPLICATIONS

- ★ Oscilloscope Calibration
- ★ Timing
- ★ Test Signals

around RG1, a 7805 5V regulator. Note that there are, due to the nature of this circuit design, three 'grounds', each at a different potential; 'PSU' ground (i.e. that of the connected power supply), 'PCB' ground, and a 'reference' ground (for RG1).

Power is supplied from a 9V DC PSU via SK1 and the power switch, which is part of the attenuator control (RV1). The PCB ground is held at approximately 0.6V above PSU ground by D2 so that TR2, half of the push-pull output stage, is biased correctly. The regulator's reference ground is held at 0.6V above PCB ground by D1 (in conjunction with the voltage drop across D2, this point is at 1.2V above PSU ground). As a result, the output of the voltage regulator is 5.6V with respect to PCB ground; this has the practical effect of decreasing the propagation delay of the counters (IC5,6,7). C1,

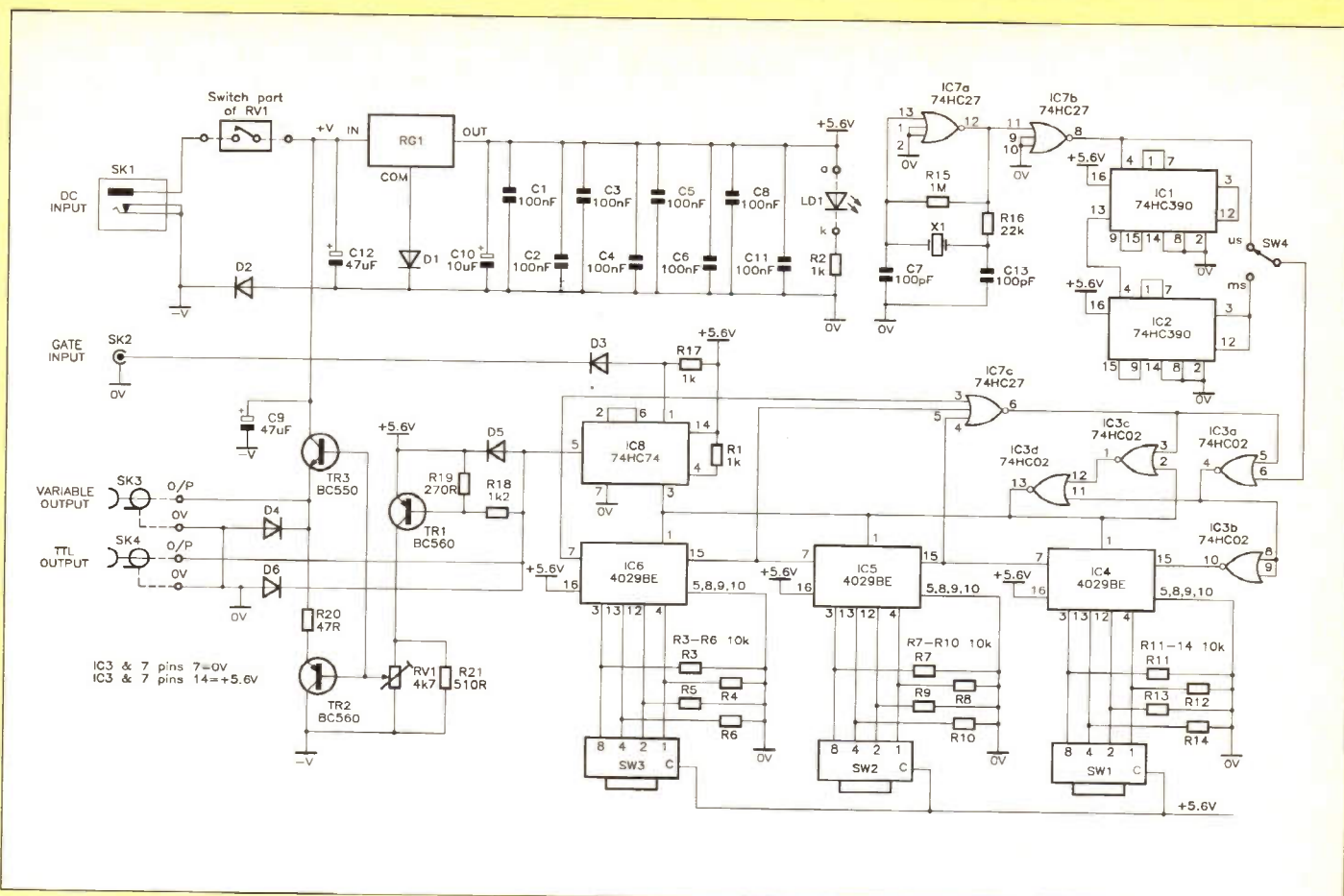
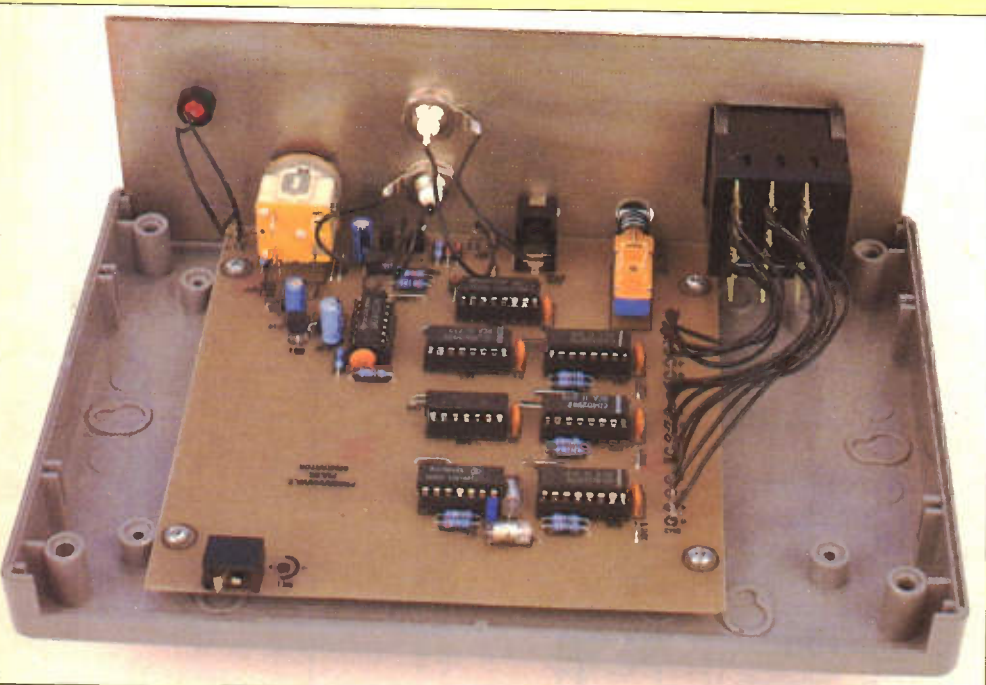


Figure 1. Programmable Pulse Generator circuit diagram.



Internal view of the pulse generator.

Specification

Power Supply:	9V DC @ 125mA (max.)
Standby Current:	25mA (approx.)
Pulse Width ('µs' range):	0 to 999µs
Pulse Width ('ms' range):	0 to 999ms
Rise Time:	20ns (approx.)
Accuracy:	±1% (max.)
Reference Oscillator Frequency:	1MHz
Output Voltage (variable output):	0 to 5V
Output Current (variable output):	100mA
Output Voltage (TTL output):	5V (Fixed)
Output Current (TTL output):	4mA (max.) into 1.5kΩ

C10 and C12 are used to decouple RG1, while C2 to C11 decouple the other ICs. LD1, the 'supply on' indicator, is powered from the output rail of RG1.

Two of the NOR gates in IC7, (a) and (b), form an oscillator. Its frequency is determined by R16, C7, C13 and X1 (a 1MHz ceramic resonator).

IC1 divides the signal by 100 to give 10kHz at pin 13, this is further divided by IC2 to give 1kHz at pins 3 and 12. The range switch, SW4, simply selects between the 10kHz output ('µs') and the 1kHz output ('ms').

The NOR gate, IC3(a), inhibits the signal from SW4 during the reset period, and prevents the decade counters, IC4 to 6, from counting through zero when all of the program switches have been set to zero. The reset condition effectively occurs when the output from the 'unanimous carry detector', discussed later, is low i.e. when the clock inputs of all three counters are high. The output of this gate is inverted by IC3(b) before being applied to pin 15 of IC4, which is the clock input of the units counter. Each counter is set to count down from the binary number set on its 'jam' inputs (pins 3, 13, 12 and 4). This number is set on the corresponding BCD switch (SW1, 2 or 3). R3 to R14 are used to pull down the jam inputs of the counters when they are not set to logic '1' by the programming switches.

On reaching zero, IC4 (the 'units' counter) produces a 'carry' signal at pin 7. This is fed to the clock input of the 'tens' counter, IC5, which, in turn, clocks the 'hundreds' counter, IC6. The carry outputs from each IC are also taken to the 'unanimous carry detector', IC7(c), a triple-input NOR gate. When all three inputs to this gate are low, a '1' is generated at its output (pin 6). This sets the latch (IC3(c) and (d)), the out-

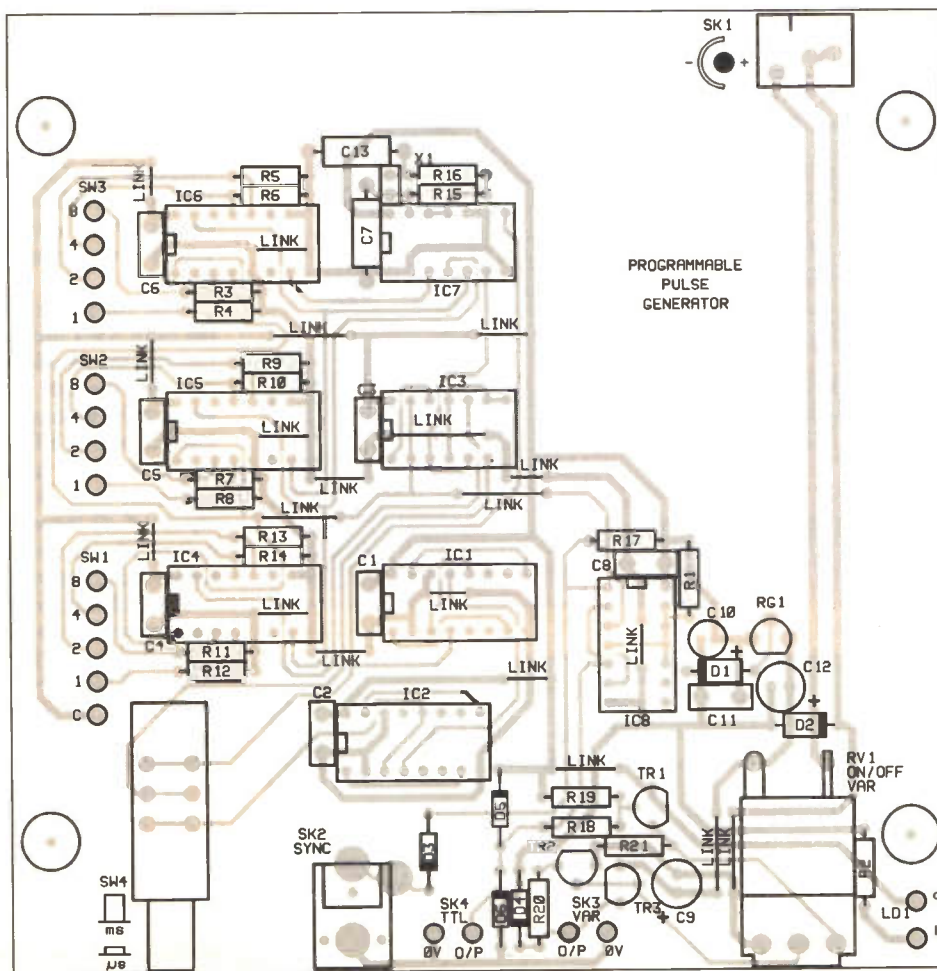
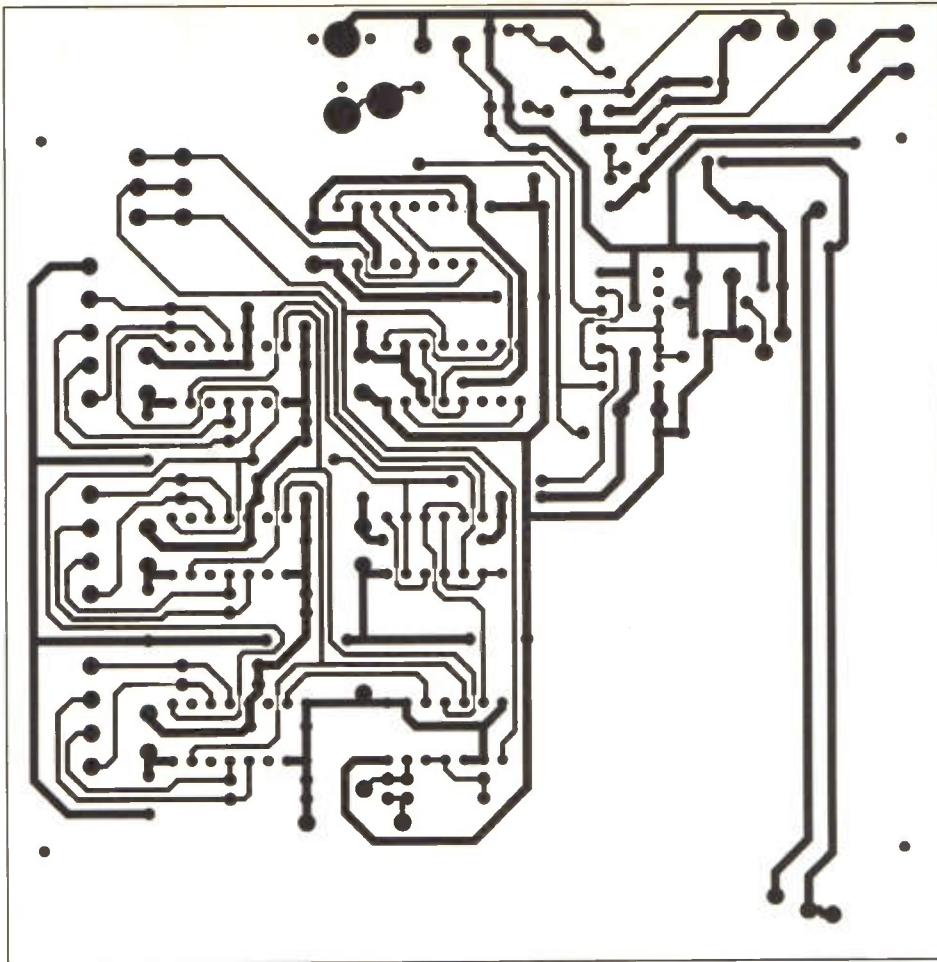


Figure 2. PCB legend and track.

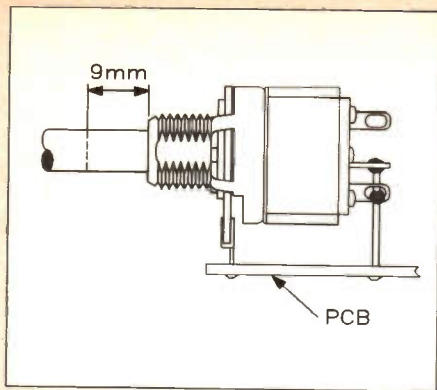


Figure 3. Trimming the shaft of RV1 to the correct length.

put of which forces all three counters back to the BCD number at the jam inputs. The latch is reset by the output of IC3(a) and the count-down begins again. The time lapse between any two counter resets is the desired pulse width; as a result, this signal is used to trigger the clock input of IC8 (a D-type flip flop), which is used to form the output pulse. Note that R1 is used to hold the preset input of IC8 high.

The 'Q' output of the flip-flop, at pin 5 of IC8, switches TR1 between ground and 6.2V. Via RV1, the level control, the output signal is fed to the bases of TR2 and TR3, which form a push-pull amplifier. SK3 provides the final square-wave output, which can be gated by applying a logic pulse to SK2. A 'low' input here prevents output pulses from occurring. D3 prevents damage to IC8 from excessive positive voltages. In addition to the variable output, a TTL output is available. This is derived from the output of IC8 itself.

Construction

Populating the PCB should pose no problems; the board itself is a good quality single-sided fibreglass component, and has a clear legend (reproduced, along with the track layout, in Figure 2) to aid you. The

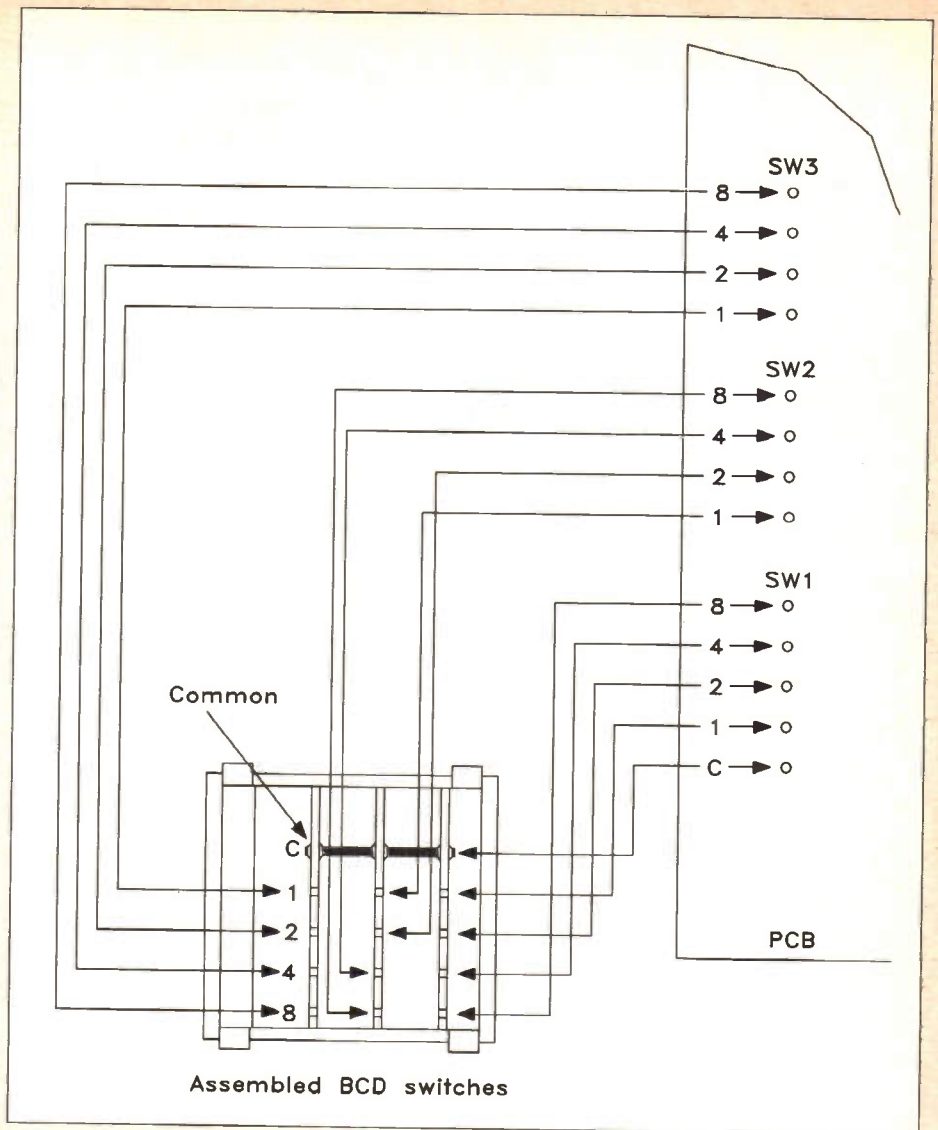


Figure 4. Wiring the BCD switches.

Constructors' Guide will help you if you are relatively new to electronic kit-building – and a quick perusal is recommended even to the more experienced amongst you.

Construction should proceed with the smaller items first, as the larger items may get in the way. Do not install RV1 at this stage, as its shaft requires preparation. The links

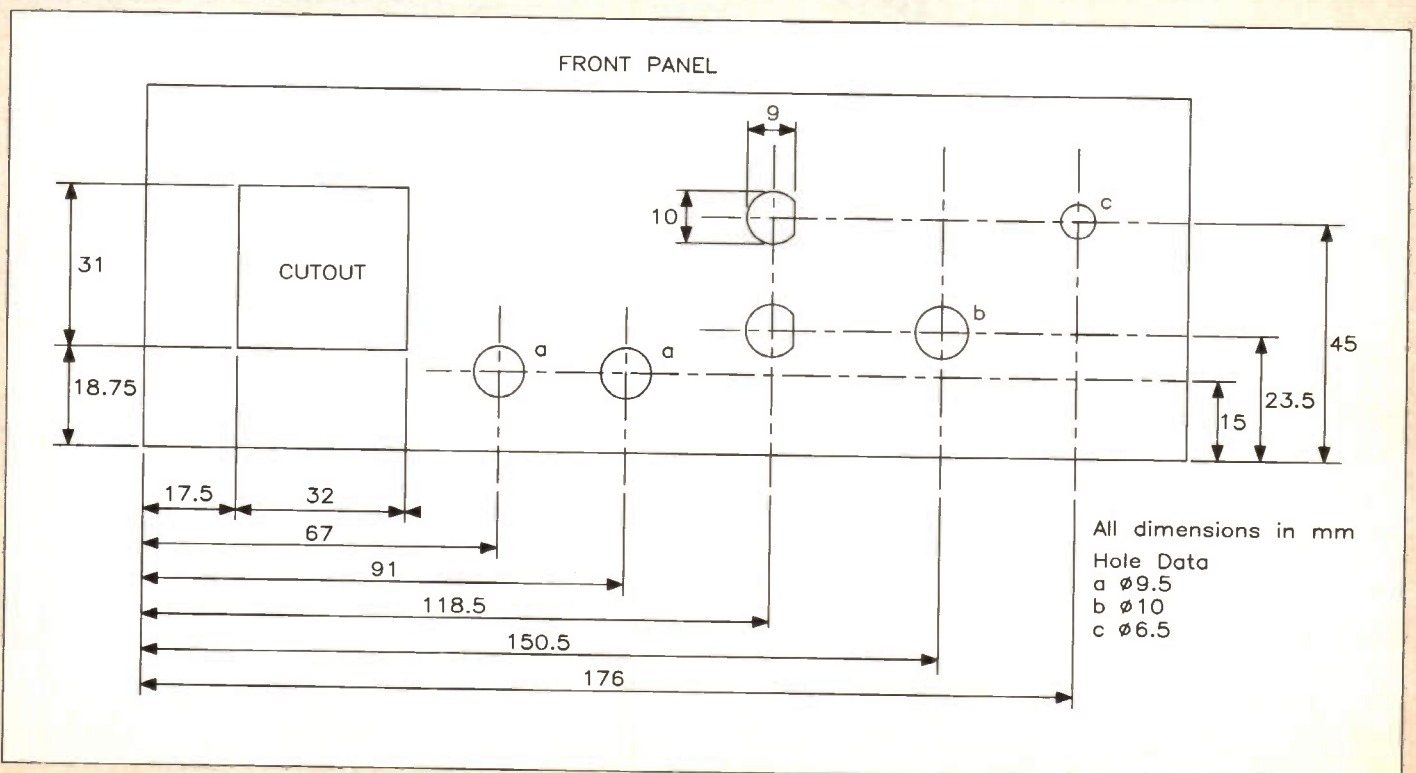
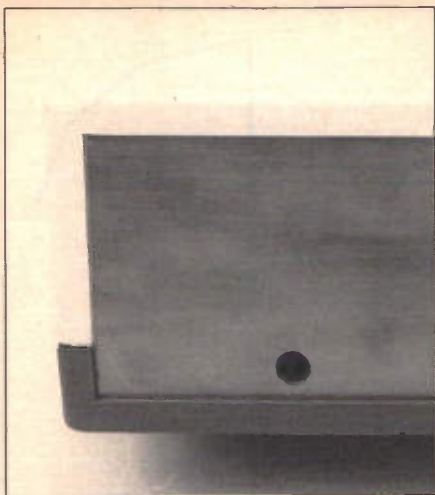


Figure 5. Front panel drilling details.



Rear panel power input connector.

should be fitted first, particularly as some reside under ICs! Transistors TR1 to TR3 should be fitted so that their outlines line up with those of the board legend. Note that TR1 and TR2 are BC560 (PNP) types, while TR3 is a BC550 (NPN) device. The electrolytic capacitors (C9 to 11) must also be correctly orientated; the '-' sign on the capacitors case must point away from the '+' sign of the relevant PCB symbol. The two sockets (SK1, SK2) and range switch (SW1) must be pushed fully home before being carefully soldered in position; any weak spots could result in one or more of the tracks lifting away from the PCB, and subsequently breaking, as switches are operated or leads plugged in and removed. If you wish to fit a

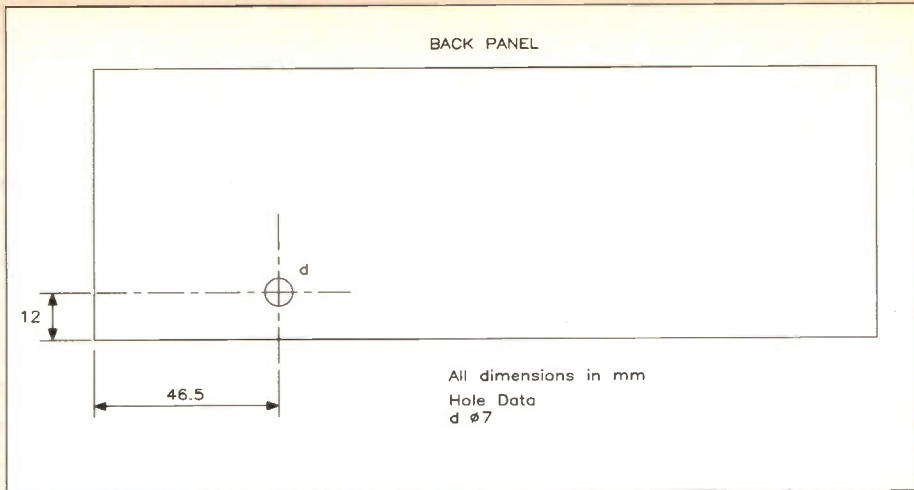


Figure 6. Rear panel drilling details.

panel-mounting BNC socket instead of the board-mounted SK2 phono socket (sync input), the interconnecting wires can be soldered to the relevant positions on the PCB. After the IC sockets have been soldered in position, leave them unpopulated – the ICs themselves will be fitted just prior to testing.

The shaft of RV1 requires trimming down to 9mm in length as shown in Figure 3. RV1 can then be fitted onto the PCB, along with the two wire links that connect the switch part of RV1 to the board.

The next stage is to clip the three BCD switches together and fit the end cheeks. A wire link can then be fitted through the common connection of all three switches, as shown in Figure 4.

Drilling the Case

A suitable case for this project is LL06G, drilling details for which are given in Figures 5 and 6. Drill and file out all the holes in the front and rear panels as shown, and then attach the self-adhesive label to the front panel – ensuring that it lines up with the holes before finally pressing it into place. Trim the label around the panel holes using a sharp knife.

Final Assembly

The BCD switch, BNC sockets and LED can then be installed into the front panel, as shown in Figure 7. Cut the supplied insulated wire into 10cm lengths, 19 are required – 13 for the BCD switches (only one common connection is required), two each for the BNC sockets and two for the LED. Note that the lead nearest the 'flat' side of the LED is its cathode connection; in addition, the LED leads need trimming down to 5mm. The front panel should then be mounted on the PCB, being loosely held in place by RV1's securing nut. The washer must be located behind the panel, as shown in Figure 7. The sockets, switch and LED can now be wired up to the PCB – refer once again to the BCD switch wiring details in Figure 4. At this stage it is probably worth pointing out that only one colour of wire is supplied in the kit; when you have completed the switch wiring, it is particularly important to check that no mistakes have been made.

The whole assembly can then be fitted into the box, and the PCB screwed down. Once RV1's nut has been tightened, the control knob and button can be positioned.

Testing

Before installing the ICs, connect up a DC power source capable of supplying 9V, at a current of at least 125mA, and switch on. If LD1 illuminates, approximately 5.6V should be measured between Pin 7 and Pin 14 of IC8, and 0.6V across D2. If all is OK at this stage, power can be removed from the unit and the ICs fitted in their sockets.

SW4 should be set to the 'ms' range, VR1 turned fully clockwise and the programming switches (SW1 to 3) set to read '500'. Next, a method of 'seeing' the pulse must be devised – an example is given in Figure 8. When the circuit is switched on, the LED should flash once a second.

If SW4 is set to its 'µs' range, and the

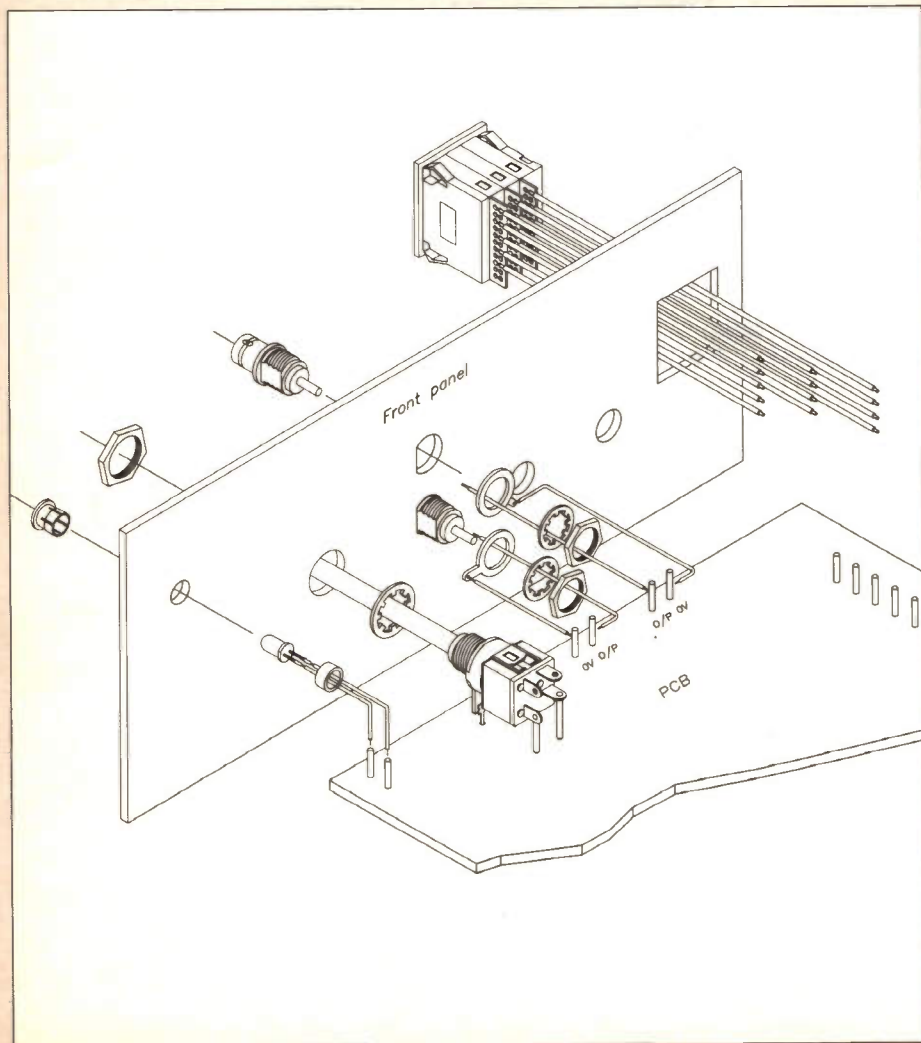


Figure 7. Front panel assembly.

LED replaced by a piezo sounder, a 1kHz tone should be heard. Feeding a slow TTL pulse into the gate socket (SK2), should 'chop up' the tone into a series of bleeps. The gating function can be quickly tested, by carefully shorting the centre pin to the outer ring of the phono socket, whereupon the 1kHz tone should cease.

Accuracy depends entirely on the 1MHz oscillator. As the rest of the circuit does not cause drift, any frequency meter able to read 1kHz accurately can be used. With the PPG still set at 500ms, a reading of 1kHz \pm 0.3% (\pm 3Hz) should be obtained.

Once tested, the lid of the box can be fitted, along with the feet.

Using the P.P.G.

The frequency range of the generator is from 0.5005Hz to 500kHz (pulse width of 1 μ s to 999ms). The relationship between pulse width and frequency is given by

$$f = \frac{0.5}{p}$$

or

$$f = \frac{1}{t_m + t_s}$$

where

f = frequency

p = pulse width (mark)

t_m = mark period

t_s = space period

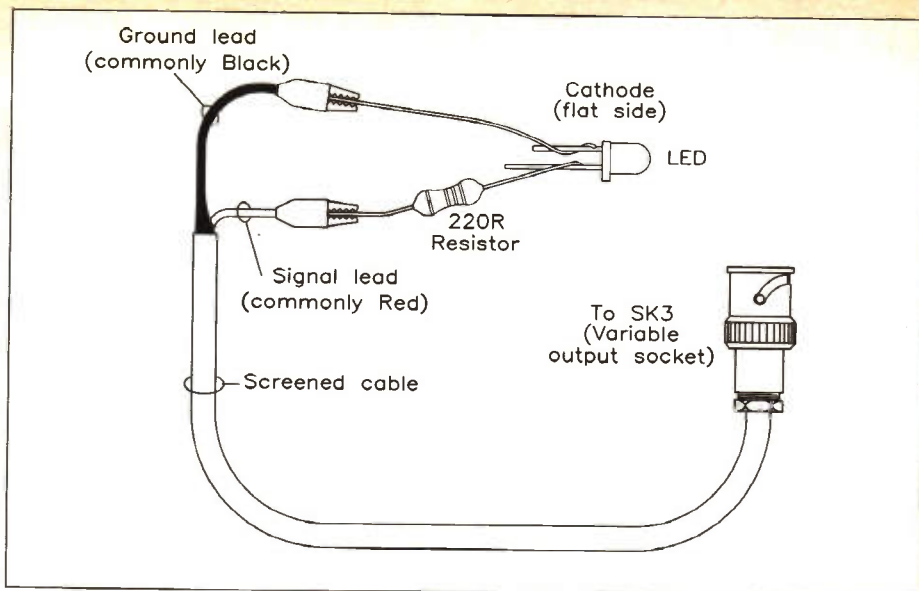


Figure 8. Test circuit.



Although the PCB 0V is 0.6V above ground, most things are relative and external equipment will 'see' it as being 0V.

Care should be taken to avoid shorting either output to ground. If the variable output, in particular, is shorted, possible damage to TR3 may occur. The minimum load impedance is 50 Ω - you have been warned! In addition, using the fixed and variable outputs simultaneously is not recommended.

PROGRAMMABLE PULSE GENERATOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless specified)

R1,2,17	1k	3	(M1K)
R3 - 14	10k	12	(M10K)
R15	1M	1	(M1M)
R16	22k	1	(M22K)
R18	1k2	1	(M1K2)
R19	270 Ω	1	(M270R)
R20	47 Ω	1	(M47R)
R21	510 Ω	1	(M510R)
RV1	4k7 Switch Potentiometer	1	(FW41U)

CAPACITORS

C1 - 6,8,11	100nF Ceramic Disc	8	(YR75S)
C7,13	100pF 1% Polystyrene	2	(BX46A)
C9,12	47 μ F 25V PC Elect	2	(FF08J)
C10	10 μ F 50V PC Elect	1	(FF04E)

SEMICONDUCTORS

D1,2	1N4001	2	(QL73Q)
D3 - 6	1N4148	4	(QL80B)
LD1	5mm LED Red	1	(WL27E)
TR1,2	BC560	2	(UL50E)
TR3	BC550	1	(UL49D)
RG1	μ A78L05AWC	1	(QL26D)
IC1,2	74HC390	2	(UB84F)
IC3	74HC02	1	(UB01B)
IC4,5,6	4029BE	3	(QW20W)
IC7	74HC27	1	(UB13P)
IC8	74HC74	1	(UB19V)

MISCELLANEOUS

X1	CSB1000J 1MHz Resonator	1	(CP91Y)
S1 - 3	Thumbwheel BCD Socket	3	(JK36P)
	End Cheeks	1 Pair	(JK37S)
S4	2-Pole Latch Switch	1	(FH67X)
SK1	PCB 2.5mm DC Power Socket	1	(FK06G)
SK2	PCB Phono Socket	1	(HF99H)
SK3,4	BNC Round Socket 50 Ω	2	(HH18U)
	14-pin DIL Socket	3	(BL18U)

16-pin DIL Socket	5	(BL19V)
7/0.2 Wire 10m Black	1 Pkt	(BL00A)
0.71mm 22swg TC Wire	1 Reel	(BL14Q)
PCB	1	(GH26D)
Pin 2145	1 Pkt	(FL24B)
5mm LED Clip	1	(YY40T)
Knob RN18 Red	1	(FD67X)
Small Latch Button Black	1	(KU75S)
Front Panel Label	1	(KP59P)
Instruction Leaflet	1	(XU04E)
Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

Verobox 202	1	(LL06G)
AC Adaptor Regulated	1	(YB23A)
Piezo Sounder	1	(FM59P)
5mm LED Red	1	(WL27E)
220 Ω Min Resistor	1	(M220R)
BNC Round Socket 50 Ω	2	(HH18U)

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

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

Order As LT20W (Programmable Pulse Generator)

Price £22.95

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

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

Prog Pulse Gen PCB Order As GH26D Price £4.25

PPG Front Panel Label Order As KP59P Price 98p

CSB1000J Order As CP91Y Price 48p

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QEII Bridge and northbound toll plaza at night.

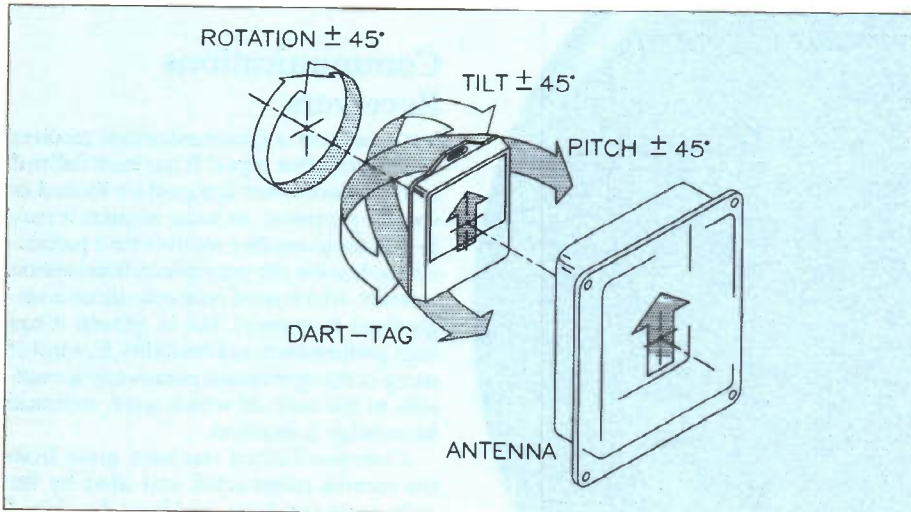


Figure 4. DART-Tag misalignment tolerance.

level in the order of 10^{-6} W/cm – a fraction of the regulatory limit set by the World Health Organisation, and about a millionth of the radiation level inside a microwave oven.

Reading of data from the DART-Tag is activated by pulses from the antenna. The electronic circuits within the tag are thus activated, and the stored number is transmitted in the form of different frequencies. The twenty-digit number corresponds to a 128-bit binary number, and is processed as a series of single data bits. A single bit is represented by a series of eight pulses; binary zero being on a 28kHz sideband, with binary one some three kilohertz lower at 25kHz. These frequencies are modulated onto the reflection from the DART-Tag, as illustrated in Figure 2.

Each lane throughout the Dartford River Crossing site is equipped with an AVI post as illustrated in Figure 1. A small set of lights provides account information to the customer, as discussed earlier, whilst the two antennas allow for the detection of both small vehicles (motor cycles and cars) and large vehicles (vans and heavy goods vehicles). In lanes dedicated for the passage of cars, only the lower antenna is used.

Lobe Pattern

Unlike other bands of the RF spectrum, microwaves can be controlled with ease, and usually have a readily described lobe

pattern. The directivity of a microwave antenna – similar to the light beam from a torch – can be designed to allow for either a wide or narrow beam. The ability to command the extent of the lobe is crucial since the geometry of the Dartford River Crossing toll plazas would allow a badly focused beam to overlap into an adjacent lane.

The antennas are positioned to provide a precise lobe in the area of the lane as illustrated in Figure 3. Detailed alignment tests performed by both Mott MacDonald and Dartford River Crossing engineers determined the optimum antenna position for each lane. Having maximised the plane of the lobe, the angle of orientation was considered; the antennae were positioned to ensure that DART-Tags are recognised as early as possible having entered the toll lane. In theory, a tag should be read anywhere within the communication lobe; however, the relative angle between the antenna and the tag is important. The ideal situation ensures that the antenna is parallel to the tag on the vehicle windscreen. However, a misalignment tolerance of 45 degrees, as illustrated in Figure 4, allows for a myriad of windscreen designs.

Once the tag is identified, and the unique 20-digit number recognised, the SAAB equipment is dismissed and the CSSE System takes over. In essence, the PREMID AVI system is an elaborate transducer which relays information to a

host computer in each lane. The lane computer, recognising the AVI transaction as an appropriate payment, compares the number against a list of black-listed tags. Having been verified as a valid tag, the computer records the customer details and raises the lane barrier.

Interest

The toll collection system at Dartford, and in particular the AVI System, has already aroused considerable interest. It is generally accepted that as more toll schemes are introduced, existing toll-collection systems must become obsolete. The disruption to traffic flow, caused by the need to stop at toll sites, will increase as the predicted rise in road traffic materialises. The use of a system such as DART-Tag prevents the need to queue, let alone stop; in turn, the reduced congestion at the site decreases journey times. Moreover, toll site operators may enjoy a possible increase in revenue, as other drivers are encouraged to use the facility once they recognize the benefits of reduced congestion. Further advantages, to the operator at least, include a steady reduction in staff costs as the number of automated lanes increases, whilst the scope for fraud and evasion is substantially reduced.

What is apparent from the number of visitors to the Dartford River Crossing is that the new toll system is a show-piece and is fast becoming the benchmark to which all others are compared. The most technologically advanced of its kind, the Dartford River Crossing Toll System is acknowledged as an experiment for private tolled motorways, or any eventual road pricing scheme in Europe.

For details of the DART-Tag scheme call (0322) 280222, or write to DART-Tag Administration, Dartford River Crossing Limited, South Orbital Way, Dartford, Kent, DA1 5PR.

Acknowledgments

I would like to thank the following individuals and organisations for providing information and assistance during the compilation of this article: Mr. R. D. Gillespie and Mr. R. L. Jones of Dartford River Crossing Limited; Mr. R. F. Holmes of Mott MacDonald Limited; and Mr. A. Pickford of SAAB Combitech.

THE FASCINATION OF VINTAGE RADIO



Part Two Widening Horizons

by Geoff Arnold

In last month's instalment, it was made clear exactly how popular vintage radio collecting has become. This month, we look at the various themes that your collection can take. Amateur or professional? Domestic or military? In the end, it's all down to what appeals to *you*. Were you in the Armed Forces during the Second World War, or a radio operator on board a merchant vessel? Your career could be the dominant influence. Even if your interest is triggered by nothing more than a love of bygone craftsmanship or the unmistakable character of the thermionic valve, the equipment of your desires can often be found if you look in the right places.

As I mentioned in the first part of this series, there are many different faces to the hobby that is loosely termed 'vintage radio'. Domestic radio – a collective term for the wireless and television sets of yesteryear – probably has the widest following. Some domestic collectors consider anything outside their particular sphere to be 'irrelevant rubbish', dismissing the whole lot as perhaps 'amateur radio' or 'professional gear'. Others have broader tastes, and are happy to have interests in different fields. As in many aspects of life, it is perhaps just as well that we do not all like the same thing!

This month's article looks at some of the non-domestic categories. Inevitably, there will be overlaps between them. Communications receivers, for example, are used in almost every radio service, amateurs use ex-military, aeronautical and maritime equipment, and so on.

Communications Receivers

Just what sets a communications receiver apart from other types? It has been defined as 'one which is not designed for limited or specific purposes'. In some respects it may be inferior to another receiver for a particular application (for example an interception receiver, which need only operate on a single fixed frequency), but in general it has high performance and flexibility. Control of many of the operational parameters is available to the user, of which some technical knowledge is required.

Communications receivers grew from the circuits constructed and used by the early radio amateurs, and have developed over the years into highly sophisticated sets for use by amateur, military and professional operators.

The 'Eddystone' range of receivers, produced for both professional and amateur markets by Stratton of Birmingham (now part of the GEC-Marconi group), is undoubtedly the best known from a UK manufacturer. Their valved sets ranged from the early-1940s Model 358 (with its plug-in coil packs), through many models and variants produced for radio amateurs, government and military users, to the Model 940. After that, the company entered the solid-state era, and moved firmly up-market.

From across the Atlantic, names like Hallicrafters, National, Hammarlund and Collins became well-known with UK amateurs – and with the military too. Large quantities of their receivers were in service with the British forces during World War II to help to fill the gap created by the enormous demands on our manufacturers.

The famous Marconi CR100, also known under its Royal Navy designation of B28, was one of our home-grown communications receivers produced at that time. Others were the Murphy B40 and B41. For the Royal Air Force, the legendary R.1155 and its companion T.1154 transmitter were produced by Ekco and several other manufacturers. All of these and many more have been avidly collected, used and modified over the past forty years or so by many enthusiasts.

For a collector wanting a working, living collection of communications receivers,

these sets from the 1940s and early '50s have their drawbacks in terms of frequency stability and sensitivity. Any which is used above 20MHz or so will benefit greatly from the addition of a low-noise aerial preamplifier. This is especially true of the VHF and UHF models, which are particularly 'deaf' by modern standards.

The stability problem was addressed in another world-famous receiver, the Racal RA17, which first saw the light of day in 1956. The RA17 employed an advanced method of frequency control called the Wadley Loop, in which any frequency drift in the first local oscillator was cancelled out by effectively mixing it a second time in a later stage of the receiver. The result was continuously variable tuning with frequency stability approaching that of a crystal oscillator.

Most of the valve communications receivers originally used in professional and military circles during the post-war era have now been replaced by the solid-state variety. It is rumoured, though, that valved front-ends are enjoying a revival in military receivers because of their ability to withstand the effects of lightning strike, electromagnetic pulse (nuclear explosion) and static fields associated with rain and sandstorms. The discarded receivers have flooded onto the enthusiast market at reasonable prices, and are attractive purchases for anyone with the space (and a strong enough table!) to accommodate one.

Like any professional radio equipment, many of the World War II era's ex-military sets adopted by amateur operators, have been heavily modified by them. After all, a receiver designed for operation from an aircraft's 28V DC supply via a whining 'Dynamotor' rotary converter is not immediately ideal for use in the home! When such sets pass from active use into collectors' hands, the aim is usually to restore them to their original state. For this reason, the less modified a set is, the more it appeals to the collector.

Amateur Radio

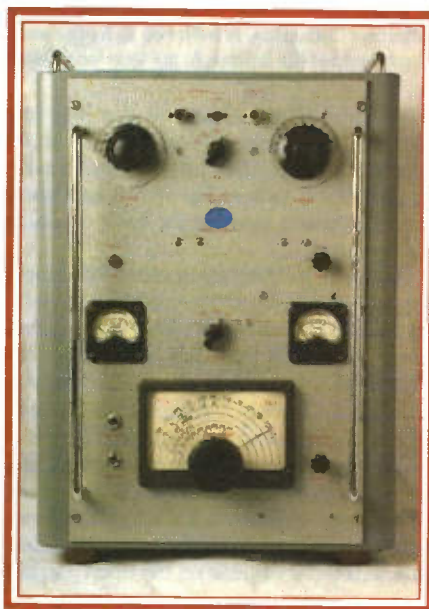
Originally, all radio or wireless equipment could be graded as 'amateur', for since it was only then being invented or discovered, there could have been no 'professional' wireless engineers or technicians at the time. In fact, much of the research that laid the foundation stones of today's radio and electronics miracle was performed by individuals who were not involved in any branch of engineering. This valuable contribution to research, carried out by private individuals in their own time and at their own expense, has continued to the present day.

The original amateur radio experiments were conducted with apparatus in which even the components had to be made by the constructor. Later, companies began to manufacture radio components which were offered individually or in kits, and the interest in construction and 'messing about with wireless' spread from the labs and workshops into individual homes.

Very little equipment intended for use by amateur radio operators was manufactured in the United Kingdom prior to World War II. A great deal of US-manufactured amateur equipment had been 'cross-



The Racal RA17, a 23-valve communications receiver, covering the range 1 to 30MHz, extending down to 500kHz with slightly degraded performance. The left-hand tuning knob selects the frequency range, while the right-hand one gives continuous tuning over that range. Read-out is on a film scale with an effective total length of approx. 145 feet.



The LG300 amateur transmitter, a 1950s product of Labgear, a company in the Pye group. It provides Morse Code communications in the 10, 15, 20, 40 and 80 metre bands.

ing the pond' since about 1937, to the extent that in 1938-39 the Radio Society of Great Britain, concerned by this trend, began to campaign for increased support of the home market.

When peace returned, enormous stocks of British Government 'war surplus' radio and radar equipment was sold off to dealers and enthusiasts under various schemes. Much of that equipment is still in use now by amateurs and short wave listeners, changing hands at radio rallies, swapmeets and through the small ads in radio magazines.

In the late 1940s, several British manufacturers began to produce sets for the amateur, but home construction (or modification of ex-military equipment) was still the most popular method of equipping a station, at least as far as the transmitting side was concerned. Commercially-built communications receivers covering the amateur bands were widely available, and were increasingly incorporated into otherwise 'home-brew' set-ups, beginning a trend which has unfortunately developed

into the largely 'black box' era of amateur radio today, dominated by the Japanese manufacturers.

From this potted history of amateur radio, you will see that a collection of amateur radio equipment prior to 1939 will be almost entirely home-constructed. Such equipment is of extremely variable quality, depending on the practical abilities of its constructor, and generally has little re-sale value among collectors. The exception is for particular items or complete stations built and used by one of the well-known 'pioneers' in carrying out their experiments, although such equipment tends to be donated to museums or established collections, rather than being sold on the open market.

From the immediate post-war years, very little UK-produced amateur radio equipment other than receivers is sought after, although some is still in use by old-timers. Some American equipment, such as that manufactured by Collins, attracts a considerable following.

Military Radio

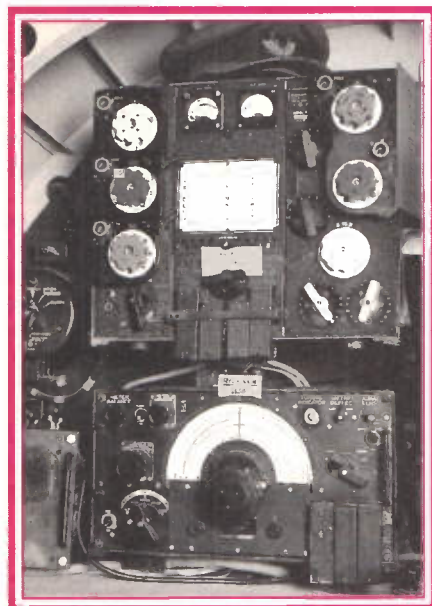
For the purposes of this article, the term 'military equipment' is used to cover that used by any of the fighting services. Their different operating and fighting environments greatly affect the equipment's design, and the practicality of collecting it.

Among naval equipment, radio-telephone transmitter-receivers like the British CNY (HF) or the American TBS (VHF) and Collins TCS (HF) from the 1940s and '50s, and their later replacements, are quite sizeable but at least they would sit on a tabletop. The same applies to the World War II receivers that have already been mentioned, although one of the Racal RA17 series, the last valved communications receivers to be used in the Royal Navy, weighed 44kg (getting on for a hundredweight) in its desk-top case! The average ship-board HF transmit-

ter, even one that might be found on a small warship or auxiliary, is likely to occupy at the minimum a rack or cabinet 6ft. tall and a couple of feet square. You would have to be a real enthusiast to consider preserving one of these in your home or even in a garden shed – and a shore-station transmitter would be even larger!

Army equipment is very different, although some large equipment was used at base stations and in the bigger wireless trucks, the cramped conditions in armoured vehicles and jeeps, and the requirement for mobile communications in man-pack and hand-held form, means that there is plenty of choice in transmitter-receivers for the collector with limited space. Perhaps the best-known from World War II are the 19 Set which was used in tanks, the W.S.18 man-pack, and the W.S.38/W.S.46 walkie-talkies. There are a considerable number of collectors of this sort of equipment – many of them, not surprisingly, having an ex-army background.

Equipment for use in aircraft needs to be as light and compact as possible, although the T.1154/R.1155 set-up used in Lancasters, and other RAF bombers of World War II, was pretty substantial. Ground station

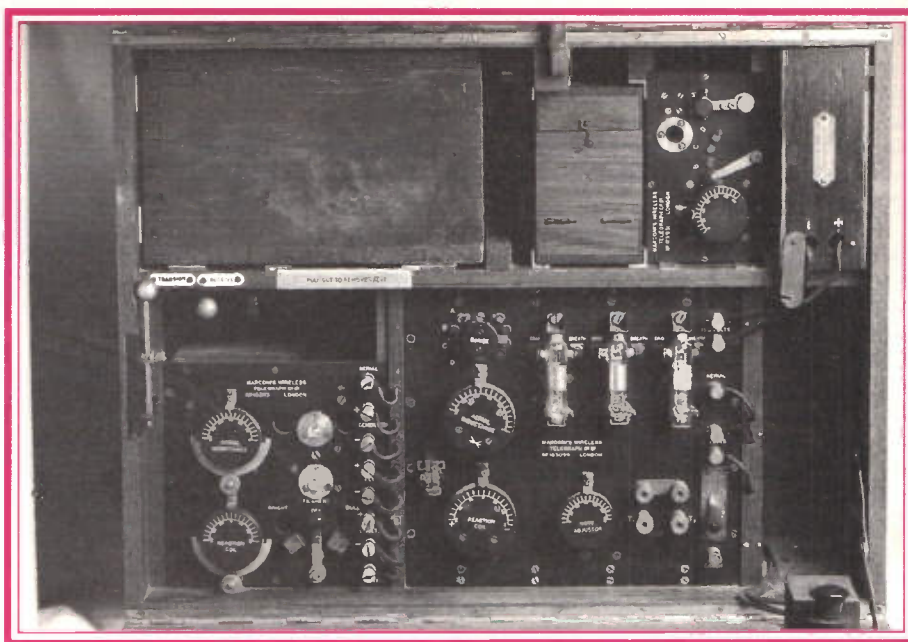


The famous T.1154/R.1155 aircraft transmitter-receiver combination from World War II, pictured here in a mock-up of an Avro Lancaster installation at the Chalk Pits Museum, Amberley, West Sussex.

equipment was much the same as that used in any other fixed station, ranging from desk-top units to floor-standing rack cabinets.

Of course, it wasn't just the UK and the USA that produced military radio equipment. Sets were also manufactured in Canada and Australia to help to meet the demand from the British forces. Germany, Italy and Japan made equipment for their various armed forces too, and there are enthusiasts in the UK and elsewhere who collect such pieces as and when they become available.

Military radio equipment from World War I is naturally somewhat rare and expensive, and most of that which remains is firmly in the hands of museums and established collectors. However, previously unseen bits and pieces do come to light



A World War I Marconi 50W CW Pack Set. This transmitter-receiver, from the Journeaux Historic Wireless Collection, is believed to be the only example remaining from a quantity of five, produced for the British Army between December 1918 and October 1919 at a cost of £283 each.

from time to time; within the last few months I have seen a World War I aircraft receiver on offer at an amateur radio rally, though it did look rather as if it had spent the intervening years at the back of a barn somewhere!

So far as military equipment from more recent times (the 1950s onwards) is concerned, there seem to be plenty of army sets, some navy, but very few aircraft radios. Technical information on military equipment, in the form of handbooks, etc., is subject to the 30-year rule on the release of official government documents. This has recently produced a strange situation; redundant equipment, for which the handbooks are still under a restricted classification, is freely available on the open market!

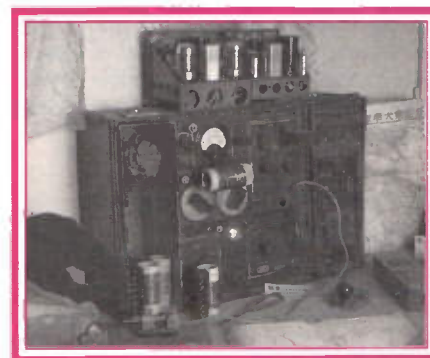
Clandestine Radio

The radio transmitters and receivers used by agents, spies and Resistance groups have a particular appeal to collectors because of their secret nature.

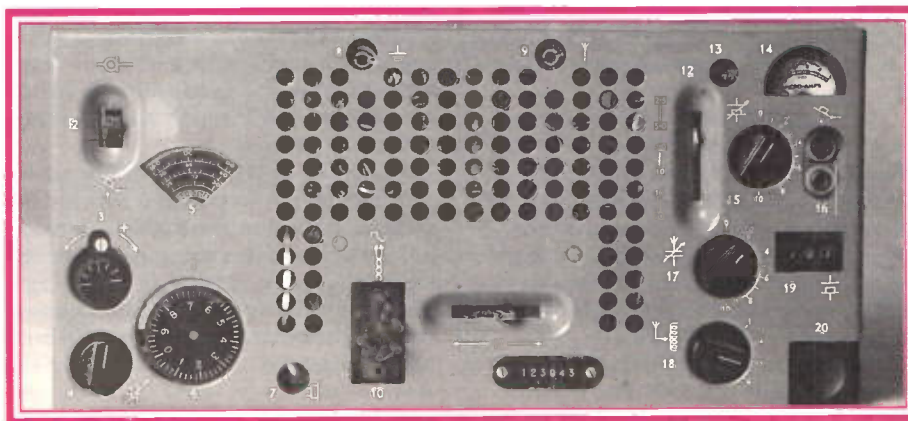
Of the sets used during World War II, undoubtedly the most famous is the suitcase transmitter-receiver Type 3 Mark II, better known as the B2, designed by John Brown G3EUR, but there were many others. A transmitter-receiver called 'Olga', subject of a recent article in 'Radio Bygones'

magazine, was designed and manufactured secretly in occupied Norway, being used for communications within the Norwegian Resistance. The OP3 pocket receiver, designed by Polish engineers working in Britain, was manufactured and distributed to Resistance groups in occupied Europe, allowing them to receive news and instructions from the BBC and other sources.

Moving to more recent times, the HF transceiver Mark 123, carried by raiding parties of Special Forces, has recently begun to find its way onto the surplus market, and



A collection of clandestine radio equipment from World War II pictured at the Chalk Pits Museum including, centre, the legendary B2 suitcase transmitter-receiver.



Transmitter-receiver Mark 123, used by Special Forces for telephone and telegraph communication in the frequency range 2.5 to 20MHz.



The Polish-designed OP3, a 4-valve receiver covering medium and short wave broadcast bands up to 12MHz. A second case of similar size housed the associated dry batteries.

represents a set which is not only collectible, but also still usable for communications by licensed radio amateurs.

Once again, similar sets were produced by other countries, both friend and foe.

Aeronautical Radio

Exactly what happens to redundant radio equipment from civil aircraft, large or small, is something of a mystery so far as I am concerned. More recent models which are suitable for fitting in small private planes are advertised from time to time in aviation journals, and some is in the hands of established collectors, but much more must have been disposed of over the past forty years or so. Perhaps it is 're-cycled', going on to provide further service in aircraft of the developing countries.

Maritime Radio

Communications receivers which have seen service on board merchant ships are popular with radio amateurs and short-wave listeners as working receivers, and they attract collectors too.

From Marconi Marine, the CR300 (a post-war development of the CR100), the 1950 'Mercury' and 'Electra' combination, and the 1954 'Atalanta' (the last model to use valves) still appear at amateur radio rallies and in the small ads. Sets of the same era produced by other UK marine wireless companies - Redifon and International Marine Radio, for example - have, for some reason, not enjoyed the same sort of popularity.

Occasionally, TRF receivers from the 1930s such as the Marconi Marine Types 352 and 730 appear on the market, but they are few and far between.

Several ex-seagoing radio officers, unable to tear themselves totally away from their former occupation, have begun to assemble, in a spare room at home, complete shipboard radio installations of a type dating back to their seagoing days. Although equipment removed from ships, as they are refitted or go to the breaker's yard, does come onto the market, a project of this magnitude is definitely not for the

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faint-hearted! The space required, the weight loading on tables and floors, and the perseverance needed to track down some of the ancillaries necessary to complete an authentic installation are all considerable. The same points apply, of course, to similar collections involving other forms of specialised radio equipment.

For anyone collecting the type of equipment of the size used in coast stations, accommodation would be even more of a problem. However, in many cases, such equipment is normally demolished to scrap on removal, to prevent resale. Exceptions to this rule have been made for equipment going to recognised museums. For example, the operating consoles recently removed from Niton Radio on the Isle of Wight have gone to the island's radio museum at Puckpool Park, while equipment from Land's End Radio forms part of a display in the theme park at Land's End.

Broadcasting Equipment

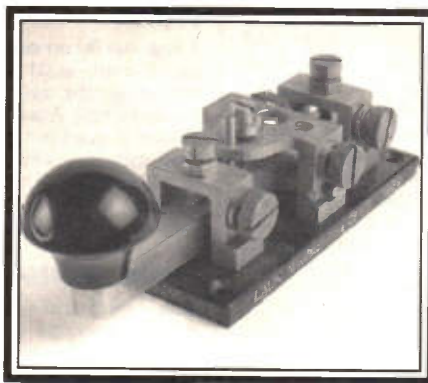
A limited amount of obsolete TV studio equipment finds its way onto the market, where it is eagerly snapped up by the aficionados, but studio and transmitter equipment are really rather more a suitable subject for a museum than for the average collector.

The Vintage Wireless Museum in Dulwich has several racks full of working TV video standards converters and associated equipment, and also a complete TV transmitter donated by the broadcasting authorities.

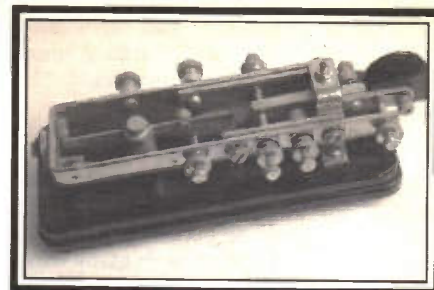
Telegraphy

In total contrast, the scope for collecting telegraph memorabilia is considerable. It might be thought that one Morse key is very much like any other, but nothing could be further from the truth. Morse keys of hundreds, if not thousands, of different types and patterns have been in use around the world for almost 150 years in land-line telegraphy, and for some 90 years in wireless telegraphy. They have the advantage, too, of requiring very little space to house quite a varied collection.

The term 'telegraphy' embraces all systems intended to produce a written or printed copy of a message at the receiving end. At its simplest, manual Morse Code, produced by a human operator with a manipulating key, is received aurally and



A conventional manual Morse key, the army Key W/T 8 Amp No.2. This particular example dates from 1939, but many variants of this design have been produced in large quantities by manufacturers in various countries from the late 1930s to the recent past.



A 1950s semi-automatic 'bug' key, made in Japan. The trembler arm (centre left) is mechanically damped between Morse characters by resting against the green plastic stop. The rate at which dots are generated can be changed by moving the weight along the trembler arm.

transcribed by another operator at the receiving end. However, that was not the way it began, for the fore-runner of Morse Code, as we know it today, was actually sent by a simple machine, being received by another machine which marked it on a paper tape.

Even when the hand-operated manipulating key was adopted for sending, reception was still by means of a machine tracing symbols on paper tape, from which an operator had to transcribe the message. Experienced operators soon found that they could 'read' the incoming signals directly from the distinctive click-clack sounds of the receiving machine, without having to look at the paper tape, and so the receiving 'sounder' was born. The idea of using buzzers or tone oscillators for reception came later.

Automation returned, at the beginning of this century, in the form of senders that produced Morse characters from perforated paper tapes previously prepared by an operator. At the receiving end, the signals operated another form of paper tape 'inker'. However, the dots and dashes of the Morse Code were not really suited to mechanical interpretation, and so more sophisticated direct-printing systems using codes of a totally different type were developed, such as electro-mechanical teleprinters and their modern electronic replacements.

The greatest nostalgia among telegraphy buffs is for hand Morse keys, relays, indicators and sounders. Keys take many forms. There are the traditional 'up-and-down' and 'side-swiper' keys, in which every dot, dash and space element is directly formed by the movements of the sending operator's hand and wrist. There are the semi-automatic or 'bug' keys, in which the dashes and most spaces are directly formed by the operator, but the dots and the spaces between strings of dots are formed by a weighted spring 'trembler' mechanism controlled by the operator. To use one of these successfully is quite an art!

A more modern development of the 'bug' is the electronic keyer, in which the mechanical trembler is replaced by gated oscillators that send dots, dashes and spaces of the correct lengths controlled by the side-to-side movements of a keying paddle by the operator.

Apart from the sending keys, other collectibles include the receiving devices - single-needle and double-needle visual indicators, sounders, buzzers - plus the relays, regenerators and repeaters necessary to overcome the signal distortion caused by

the natural inductance and capacitance of long telegraph lines stretching across continents, and beneath the oceans.

Audio Equipment

The ability of books, photographs and recordings to preserve images of the thoughts, events and achievements of the past has a great fascination. In many ways, sound remains the most evocative image, for most silent films and videos are but a pale reflection of the past.

Since Edison invented his cylinder phonograph in 1878, developments have been ceaseless. After the cylinder came discs, first single-sided, and then double-sided. Magnetic wire recording followed, before being replaced (in most applications) by magnetic tape. The original tape recorder, developed by a German named Stille, used steel tape carried on huge reels some 600mm in diameter. Later developments used magnetic oxide coatings on paper tape, and eventually plastic tape.

The inconvenience of having to lace up each new tape through the heads and transport mechanism of a reel-to-reel machine drove forward research for some form of 'drop-in' modular tape carrier. As a result, the Philips Compact Cassette and the Lear Jet 8-track cartridge were developed, more or less in parallel, in the early 1960s. The cartridge format, which used a continuous loop of tape, was intended mainly for use in in-car entertainment systems, but the design had a number of inherent drawbacks, and was soon abandoned in favour of the ubiquitous cassette.

Another unusual recording medium, which has been superseded by the tape cassette and mini-cassette, was developed for use in office dictating machines. This was a strange flexible plastic sleeve with a magnetic coating, perhaps best described as a 'floppy cylinder'!

To anyone wishing to start a collection of recording equipment, there is considerable scope. The clearing out of old homes, lofts and barns continues to yield a wide selection of machines, of all ages and in varying states of preservation. Even the



A 1922 Decca wind-up gramophone, a model reputed to have been developed from one used to entertain the troops in the trenches in World War I.

odd Edison Phonograph surfaces from time to time – I saw a somewhat worm-eaten example in a Wiltshire farmhouse clearance sale quite recently. A totally different theme for a collection would be those 8-track cartridge machines – why not grab some before they all migrate to the rubbish tips!

A working collection of vintage gramophones or recorders makes a much more attractive proposition than one that simply sits on shelves gathering dust. However, you will require suitable cylinders, discs, wires or tapes, preferably containing recorded material of the era; these are at present still fairly widely available. If acoustic gramophones are your particular interest, you also need supplies of the appropriate thorn or steel needles – not quite so common, but still advertised by several specialised stockists.

Another popular theme for an audio equipment collection is early Hi-Fi – for example the amplifiers, loudspeakers, tuners and control units made famous by companies such as Leak, Quad and Williamson. As with all valve equipment, it is vital to ensure availability of replacement valves if you want to keep it working. Most are available from one source or another, but some types can be very expensive.

You would find that a good-quality Hi-Fi system from the 1940s and '50s can still produce a wonderful sound; and because valve audio amplifiers are making a comeback in the 1990s, you could also consider yourself very 'with-it'.

Making Replicas

It is undeniable that the rarer a piece of equipment is, the more desirable (and expensive!) it becomes. Some items, by virtue of their style and design, lend themselves to the construction of replicas, and this is sometimes done by collectors who can find no other way of achieving their heart's desire. As in the art world, it is quite acceptable to produce a replica or copy of some item from a bygone era, providing that you do not try to pass it off as an original – it then becomes a fake!

In general, the older designs of radio equipment are the easiest to replicate satisfactorily, assuming that you can find or reproduce the components. Factories in those days did not have sophisticated machine tools and presses, and the manufacturing processes were sometimes not far removed from those available to a competent kitchen-table or garden-shed worker of today.

Later radio equipment does not lend itself so well to replication, apart from the sort of thing that was hand-made in very limited numbers under model-shop conditions. This is perhaps typified by the Norwegian 'Olga' clandestine transmitter-receiver already mentioned, which has been successfully replicated by a number of enthusiasts.



In next month's super issue of 'Electronics – The Maplin Magazine', there are some really great projects and features for you to get your teeth into! To whet your appetite, here's a taste of some of the goodies on offer:

PASSIVE COMPONENTS

A new series in which Ray Marston looks at the physical and electrical characteristics of passive components. In the first part, we look at resistors.

Many surprises lie in store; did you know that resistors are also inductors, as well as capacitors? All is revealed next month!

CAR PARKING RADAR SYSTEM

As parking (particularly that of the street variety) becomes more and more difficult, due to the ever-increasing number of cars appearing on the roads, a device of this type becomes a requirement rather than a luxury. For its operation, this inexpensive unit uses ultrasound to determine the distance between the car to which it is mounted, and any hard surfaces (other vehicles, walls, etc.) near it. If it's too close, a warning is sounded.

MONITOR AND EFFECTS MODULE

Ever had trouble with acoustic feedback? The most prominent feature of this module, which can either be installed into a mixer or used as a unit in its own right, is a tunable notch filter that will help considerably in

such situations. It also includes buffer amplifiers for the 'effects send' and 'effects return' loops in a mixing system.

SATELLITE TV SCRAMBLING SYSTEMS

A look into the mysterious and highly controversial world of programme encryption. The saga of popular (and widely-hacked) Astra movie channel Filmnet is described amongst others, along with the workings of a number of widely-used analogue and digital systems.

MOVING MESSAGE DISPLAY

This is the first of a three-part article that describes the design and construction of a moving LED message display of the type encountered in shops and on the London Underground, for example. Controlled by the Maplin P/O card, the Moving Message Display can be expanded from one display module (8 x 8 large LEDs) to 32. Just the thing to get the message across!

STATIC ELECTRICITY

Stephen Waddington finds out about static electricity – what it is, how it can be detected, its benefits and pitfalls – and lists some preventative measures to stop it from damaging electronic components.

RDS

RDS (Radio Data System) is one of the most important developments in domestic VHF FM broadcasting since the introduction of stereo – particularly for car radio applications. The most significant RDS features are the ability to stop a cassette or CD so that a traffic report can be heard, or to retune the radio to the station's strongest repeater in that area. In this special feature, Ian Poole looks at how it works, and at the latest developments.

Plus, of course, there's all the usual features for you to enjoy! 'ELECTRONICS – THE MAPLIN MAGAZINE', BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE.

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Stray Signals

by Point Contact

The industrial chemists are folk worth keeping an eye on, as they are always getting up to useful things. Take synthetic polymers, for example: these long molecules stringing together hundreds of identical molecules of the precursor monomer and have been used as insulators in electrical equipment since the turn of the century. In the 1970s, polymers with usefully high levels of conductivity first appeared in research laboratories. Imagine how useful it would be to be able to produce injection moulded piece parts with conductivity like a metal casting. However, these early attempts were unstable as, for example, newly prepared doped polyacetylene has a conductivity at room temperature rivalling that of copper but suffers an irreversible loss of conductivity when exposed to the atmosphere. This is due to reactions with oxygen and water vapour. The newer polymers are more stable and offer great promise in a range of applications from batteries to medical applications to mention but a few. The interesting thing is that charge conduction in these materials is due to spinless charge carriers called polarons and bipolarons, unlike the electrons which are responsible for conduction in metals and which do have spin. In the case of the electron, it's true that physicists don't understand what 'spin' is, but the upshot is that the conductivity of such polymers depends exponentially on temperature, rather like a semiconductor.

The drive is now on to develop traction batteries for electric vehicles. The science of conducting polymers is one of the few technologies theoretically capable of the required power and energy density with low weight necessary for this application. Solar cell research is also proceeding with one manufacturer claiming such cells will be cheaper than silicon types. Additionally, the generated electricity would cost half that of the best conventional power stations, for those areas of the world where there is sufficient insolation (to you, sunlight) at the times when the electricity is needed.

Talking of electricity supply, it looks as though wireless communications are set to take a growing part in the industry. A little transmitter in your meter could transmit the readings to the supply company without the need for a meter reader of the human variety. The scheme has been in operation for over four years in the USA – interference between installations is avoided by using very low power transmissions. A van drives along the street waking up each meter in turn with a coded signal to its receiver, and the meter then transmits its data back to the van. Clearly this two-way system is expensive and a one way system of communicating to meters (though not for taking readings) has been in operation in the UK for some years.

Phase modulation of the carrier of the BBC's longwave transmitter is used to control off-peak electricity loads in one

and a half million UK homes, providing the electricity supply industry with a means of staggering the loads and minimising peak loading. Two way signalling could do this and provide meter reading and other facilities as well, and various schemes using signalling via the mains, phone lines and radio have been or are currently undergoing trials. The driving force is 1st April 1998, as from then on you will be able to buy your electricity from the cheapest supplier, rather than being forced to get it from your public electricity supplier (area board). Consumers with a maximum demand in excess of 1MW can do this already, and over a thousand have opted to do so, despite the extra cost of special metering facilities. From 1st April 1994 consumers with a maximum demand of greater than 100kW will likewise be able to shop around, with our turn, thee and me, in 1998 – if they have managed to crack the metering and billing problems by then.

It appears from the history of engineering that due to an irreverent streak in their make-up, engineers have always been pranksters. Electrical and electronic engineers are no exception, especially those in a research environment. I wish I could tell you about some of the pranks that folk at Central Research Labs got up to when I was there as a student assistant in the '50s. About the electrolytic mortar, the macroplast or about the incredible exploits of Dr. K. (PhDs were thick on the ground there) with liquid air; but the Editor tells me that for legal reasons this is verboten. However, as this article started off talking about chemical engineering, surely he won't mind PC telling you about the element SMP which was 'discovered' there. Not often included in the Periodic Table, it appears all over the tiled surfaces of fume cupboards as a greyish-white powdery deposit called Scradge, which no-one will own up to. It also appears in a flask as a dirty liquid deposit (Minge) whenever no-one knows who used it last, whilst Punge – the unmistakable vapour phase – can be smelt in almost any lab at any time. To those of you with a background in physics or chemistry, who say that it cannot exist in all these forms at the same time, PC can only reply that it is the only known element with a triple point at room temperature and atmospheric pressure.

Yours sincerely

Point Contact



AUTORING

by Max Horsey



2
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RATING

PROHIBITED from direct or indirect connection to public telecommunication systems. Action may be taken against anyone so connecting this apparatus.

The completed AutoRing.

One of the most difficult sounds to simulate in plays and films is a telephone which must ring on cue, and stop ringing when picked up. Finding a 'mock' telephone that rings with the exact timing cycle of a conventional BT-style telephone is even more difficult. The project is designed to simplify matters and, when operated, will cause a connected BT telephone to ring correctly. Note, however, that AutoRing will not work with bell-type telephones as the ringing current required by such telephones exceeds that produced by the unit. An optional internal bleeper can be added for 'off stage' effects, and the design includes an LED to indicate the correct ringing effect. The current required by AutoRing is very low and the total consumption of the circuit when connected to a typical phone is less than 100mA. AutoRing must on **NO CIRCUMSTANCES** be plugged into a BT socket - don't be

fooled into thinking that you can start the entire telephone network ringing!

Operation

Figure 1 shows the standard telephone ringing cycles. There are two short rings of 0.4 seconds separated by a gap of 0.2 seconds (the American system dispenses with this gap). This sequence repeats after a gap of 2 seconds. A 16-way mechanical switch could produce the correct effect, but the switch used in the AutoRing is an all-electronic 4067B 16-channel multiplexer, shown in Figure 2. The advantage of this system is there are no moving parts to wear out, and so reliability is assured.

Circuit Description

Figure 3, the block diagram, shows how the 4067B 16-channel CMOS multiplexer (IC3) is controlled so that it 'rotates' at the correct speed. A clock pulse is provided

Features

- * American or UK Ringing Sounds
- * Adjustable Timing
- * Ringing Pattern Customisable
- * Can be Used with Most BT-Compatible Plug-in Telephones

Applications

- * Theatre or Radio Plays
- * Amateur Film Production
- * General Sound Effects
- * Telephone Testing
- * Fooling Friends!

by an astable multivibrator based around two of the NOR gates in IC1, a CMOS 4001B device (the other two gates are not used); refer to the circuit diagram of Figure 4. The clock period, typically 0.2 seconds, is determined by C1 and RV1/R1. Note that RV1 provides quite a large range of adjustment. The output of the astable is fed into the clock input of a 4029B counter, IC2, which is configured to provide a 4-bit binary count ranging from 0000 (0) to 1111 (15). The four outputs are present at pins 6 (Most Significant Bit - MSB), 11, 14 and 2 (Least Significant Bit - LSB). Each time a clock pulse is received at its input, the binary count is advanced by 1 - see Table 1. The counter outputs are used to determine the switch position; IC3 requires 4 control bits (from the counter) at pins 10 (MSB), 11, 14 and 13 (LSB). The decimal value of the 4-bit binary input (see Table 1) corresponds to the switch position selected (0001, position 1; 0010, posi-

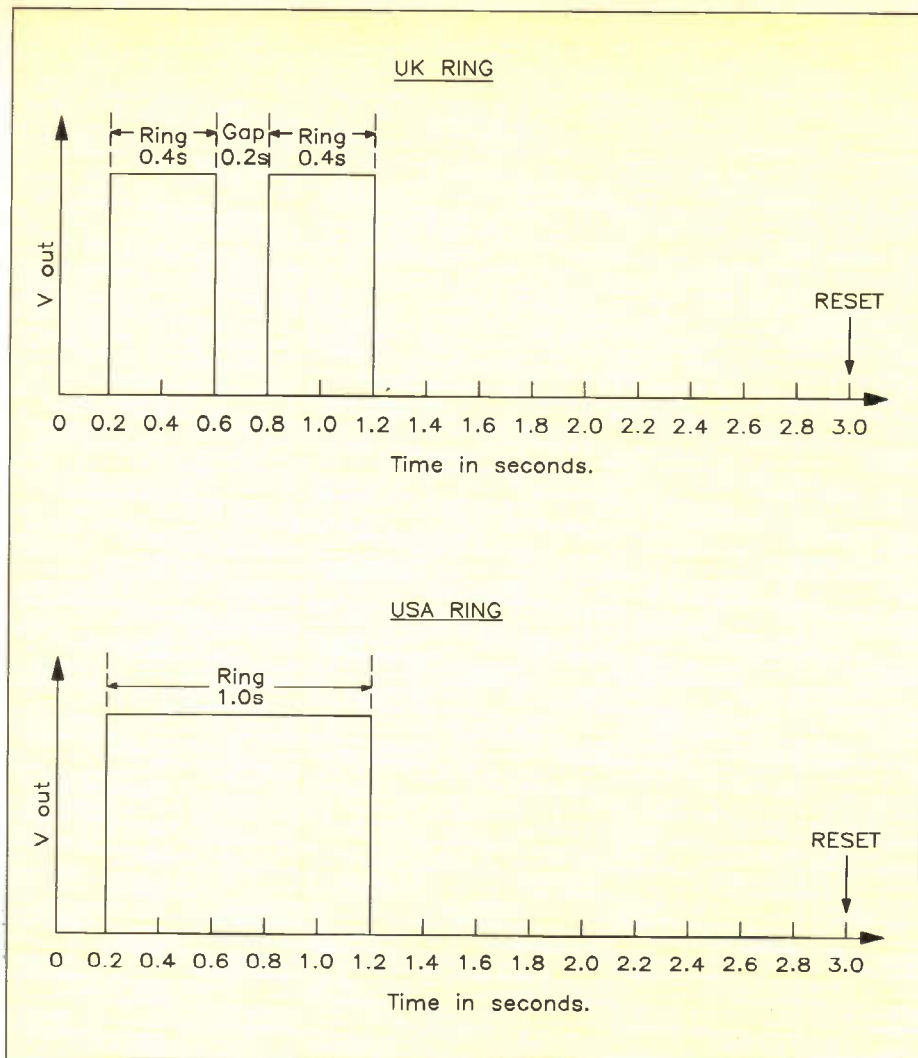
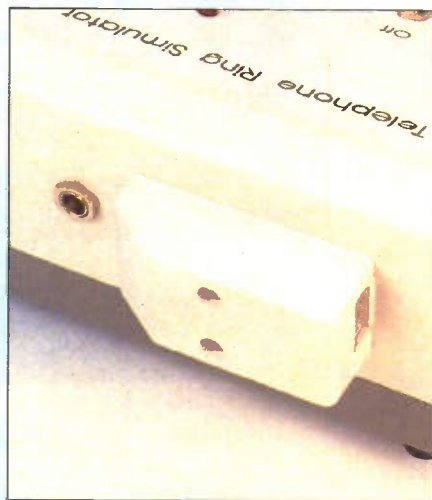


Figure 1. Standard UK and US telephone ringing cycles.

tion 2; 1110, position 14 and so on).

The common pole of IC3 is connected, via pin 1, to the power supply. As each of the switch positions is selected in turn, at 0.2 second intervals, the voltage will be present at the output pin corresponding to that switch position. Position 15 (corresponding to a binary control input of 1111) is used to reset IC2. A 10k resistor (R2) is used to hold the reset input low when it is not required. Positions 1, 2, 4 and 5 determine the length and timing of the ringing sequence. In addition, position 3 is switched in by S3 when an American-style ring is desired. All of these switch poles are summed together onto a single control line so that the ringing circuit operates whenever there is a voltage present at one of the relevant pins. There is no reason why you cannot 'invent' your own tele-



BT line socket fitted to rear of case.

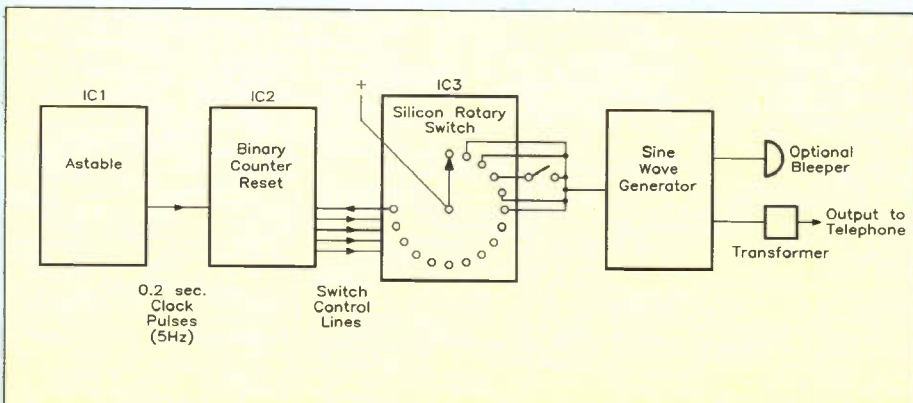


Figure 3. AutoRing block diagram.

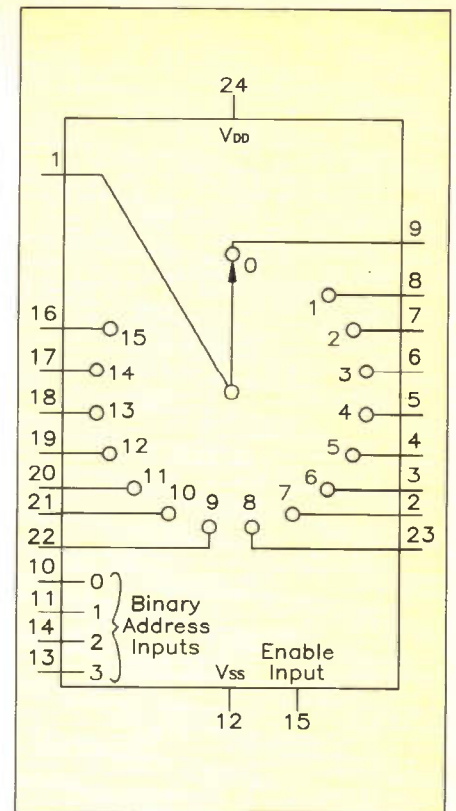


Figure 2. 4067B 16-channel multiplexer.

phone ringing sound – just connect the required switch poles onto the control line! Note, however, that the PCB does not cater for this.

Visual indication of the ringing sequence is provided by LD1, which derives its power from the control line via its series resistor R3. The control line is held at 0V by resistor R4 when no voltage from IC3 is present. D1 holds the base of TR1 at nearly 0V, preventing the sine wave generator from functioning. Each time the control line goes positive, D1 is reverse-biased, allowing the sine wave generator to operate. The network of resistors and capacitors around TR1 produces a pure enough sine wave to operate the transformer T1 quite effectively. T1, out of interest, is a mains transformer used 'in reverse' as a step-up transformer; in other words the oscillator input is applied across the designated 'secondary' winding – used here as the primary – while the output is obtained from across the 'primary', which effectively acts as the secondary. In conjunction with a push-pull driver stage (based around TR2 and TR3), T1 increases the output voltage to around 60V, so that it is compatible with the normal ringing voltage of the telephone. C6 is used to prevent a flow of DC through the input of T1. Switch S2 is used to select between T1 and the optional bleeder. S2 has a centre-off position, so that the 'ringing' can be monitored with the LED before letting it be heard. Capacitors C7 and C8 decouple the supply, and D2 ensures that no damage will result if the PSU is connected with the wrong polarity.

PCB Construction

It is important to begin construction by mounting the switches S1 to S3 first. These are mounted on the solder side of the board so that they can be mounted onto the front panel. To mount the switches, first

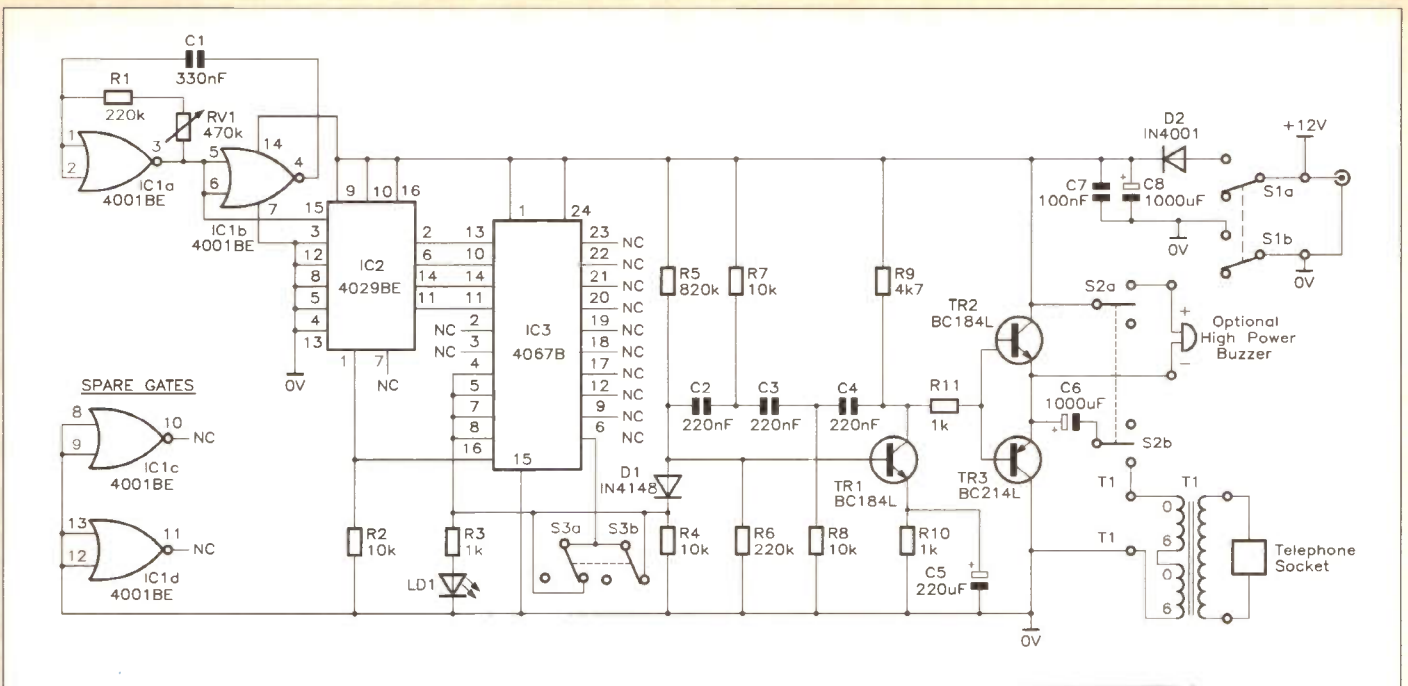


Figure 4. AutoRing circuit diagram.

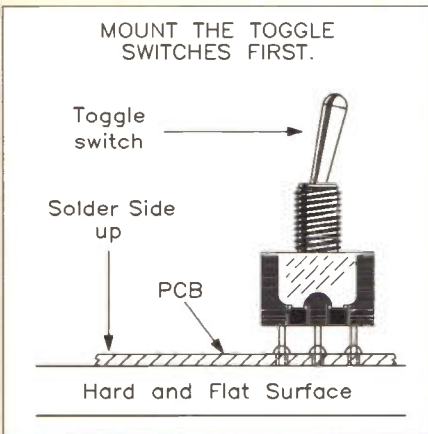
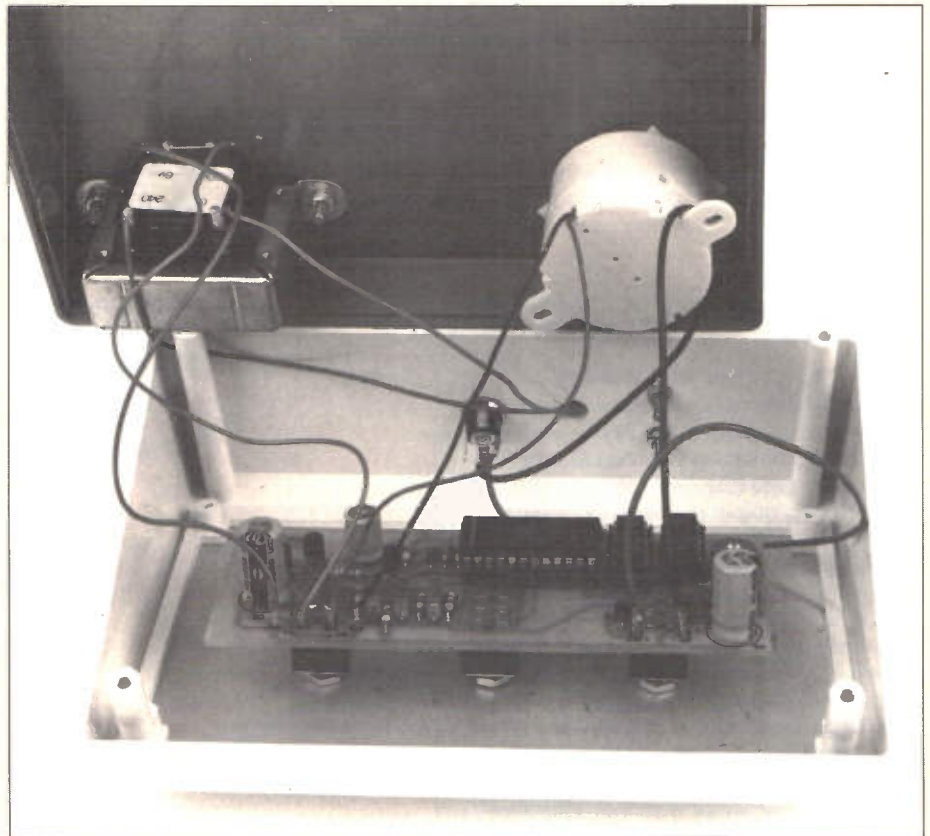


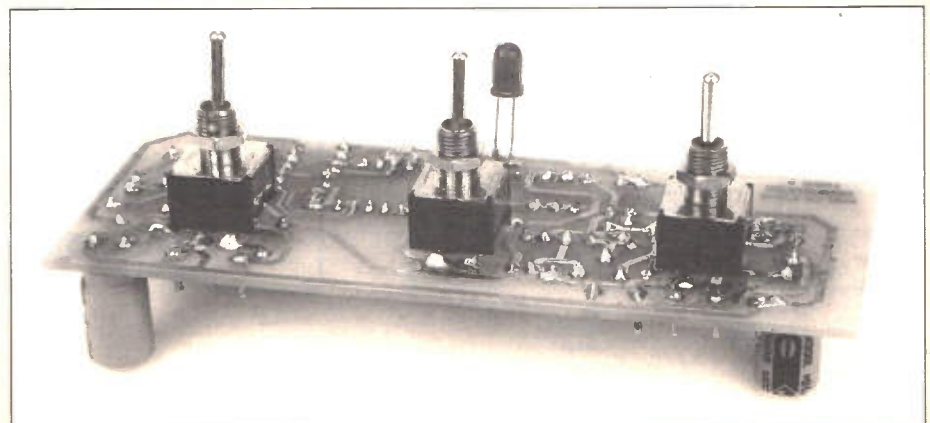
Figure 5. Fitting the toggle switches (S1 to S3).

lay the PCB (legend side down) on a flat surface such as a table – see Figure 5. To avoid marking your best dining table, it is advisable that you place a flat piece of wood between it and the PCB. Stand the switches in position, taking care to select the correct switch as S2 is the only one with a centre-off position. It is imperative that you get it 'right first time'; removing a switch without damaging the PCB is exceedingly difficult once it has been soldered in! The PCB legend and layouts are reproduced in Figure 6. Once in position, solder the base of the leg of each switch to the pad. When doing so, be careful not to melt the plastic body of the switch.

Once the switches have been fitted, the rest of the construction is fairly straightforward. Newcomers to electronic project-building should refer to the Constructors' Guide supplied with the kit for helpful and practical advice. Even the more experienced kit builder may benefit from looking through its pages. Generally, it is best to fit the smallest components first, while there is 'room to manoeuvre'; for this reason the larger components are normally left until last. Note that the ICs are fitted in sockets; these should be soldered in place so that the notch or recess lines up with that of the PCB legend. The ICs will be



Internal view of completed AutoRing, showing mounting of PCB, optional buzzer and TR1.



The assembled PCB (track side) showing LED and switches.

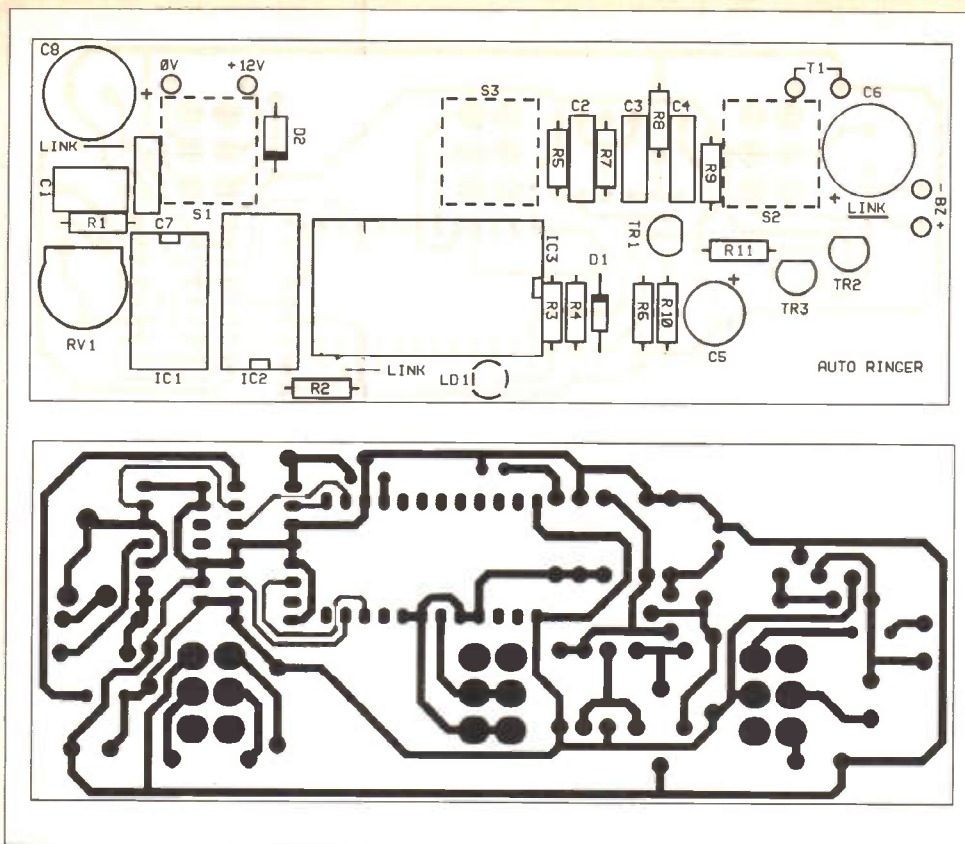
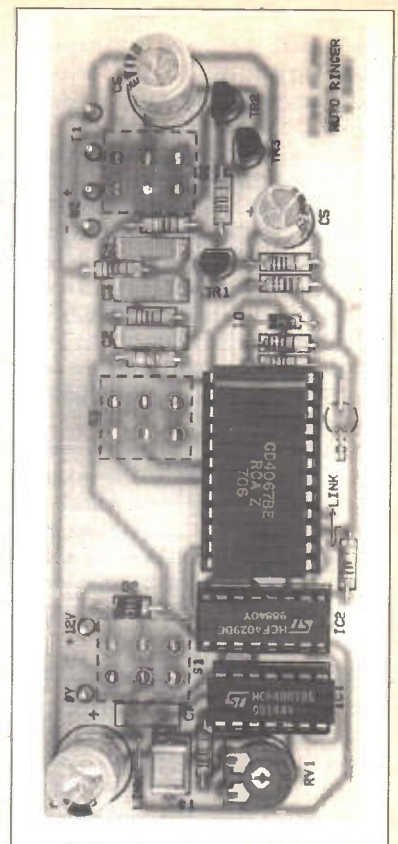


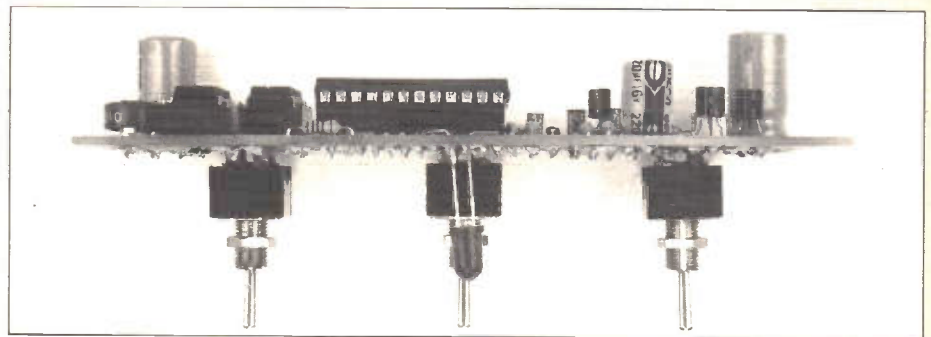
Figure 6. PCB legend and track.



The assembled PCB (component side).

inserted just before testing – these are static-sensitive CMOS devices and should be treated with care.

It should also be noted that TR1 and TR2 are BC184L (NPN) devices, while TR3 is a BC214L (PNP) transistor. Get any of them mixed up, and the circuit will not function. The electrolytic capacitors are polarised components, and should be fitted so that the negative sign embossed on the capacitor's case appears furthest from the positive sign shown on the corresponding PCB markings. D1 and D2 must also be fitted the correct way round; the band on each



Side view of completed PCB, showing switches and LED mounted on track side.

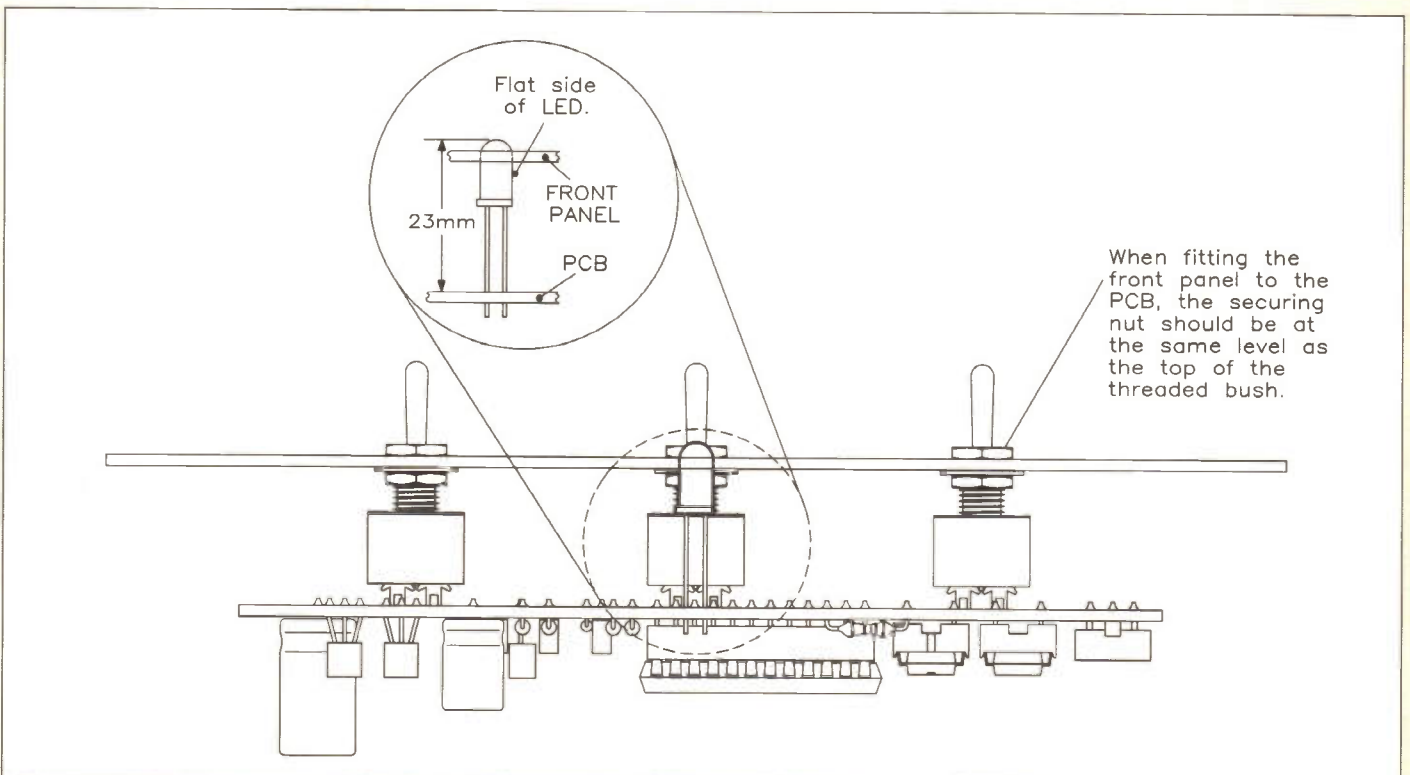


Figure 7. Correctly positioning the LED.

indicates the diode's cathode and should line up with that of the PCB legend. A hot soldering iron can be used to push the six PCB pins into position if any reluctance is noted.

Finally, the LED needs to be positioned at the correct height – on the track side of the PCB – before soldering, as it will eventually protrude from the control panel. Referring to Figure 7, it can be seen that the distance between the PCB and the top of the LED needs to be 23mm. The LED must be fitted the correct way round; the legend on the component side of the PCB indicates the flat side (cathode) of the device.

Once you have completed assembly of the PCB, check for errors such as misplaced components and solder bridges. This stage is as important as assembly itself – any such mistakes that are allowed to remain could cause premature death to the circuit when it is powered up!

Testing and Alignment

The PCB should be wired up to a 12V DC supply and BT telephone. T1 should be wired up as shown in Figure 8, with a telephone connected to its output winding via a BT socket. Note that a link is fitted between two of the transformer's input terminals. Alternatively, if the internal bleeper is fitted, set S2 so that it sounds when the unit is powered up. Hopefully, the desired ringing tone will be heard, with the LED flashing in sequence. If it is not, then check your work – or try another telephone. If no obvious solution can be found, refer to the 'Fault Finding' section.

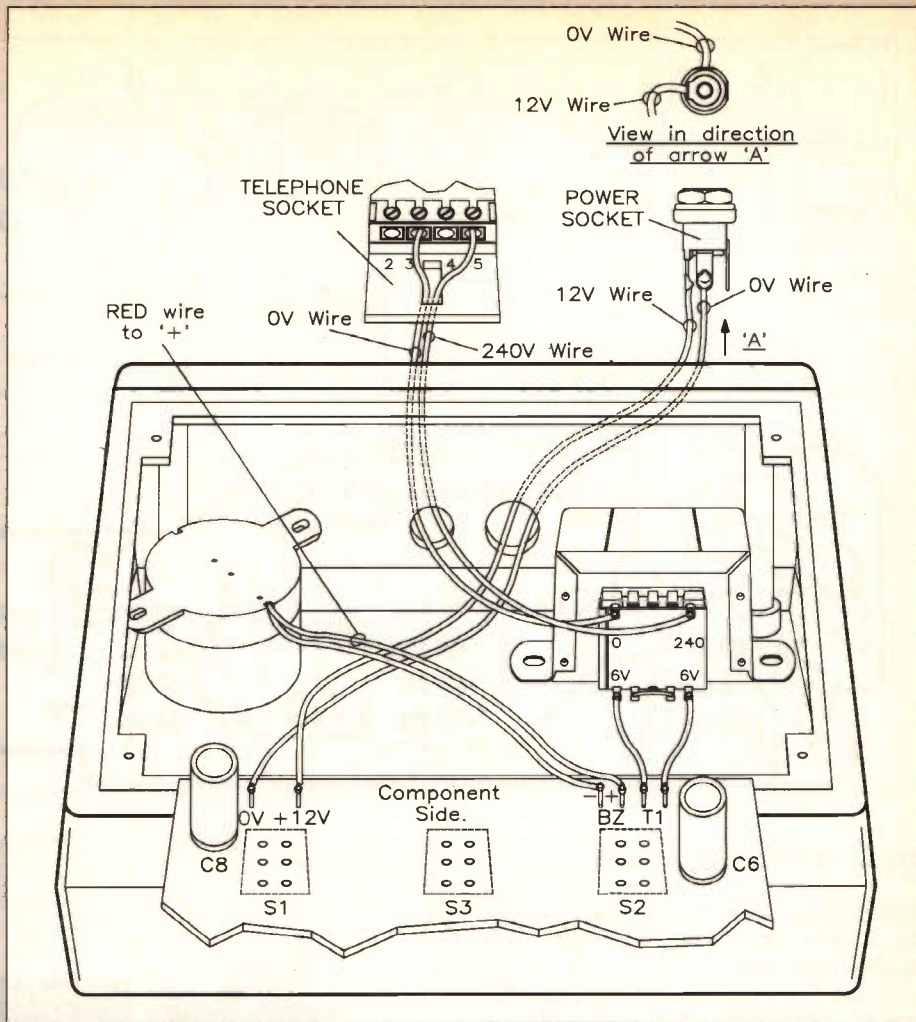


Figure 8. Wiring diagram.

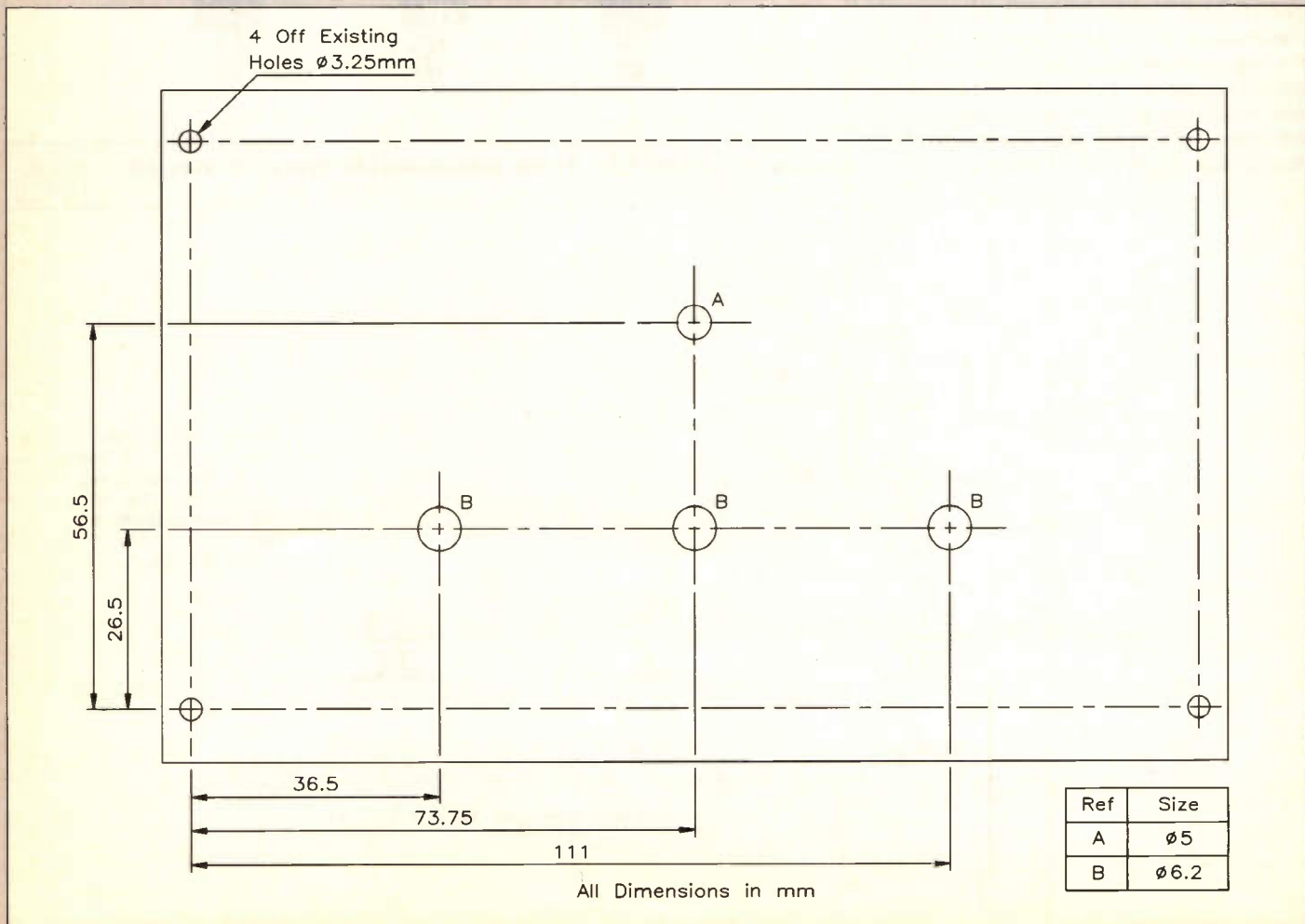


Figure 9. Front panel drilling details.

Rear of Top Half of Verobox 217

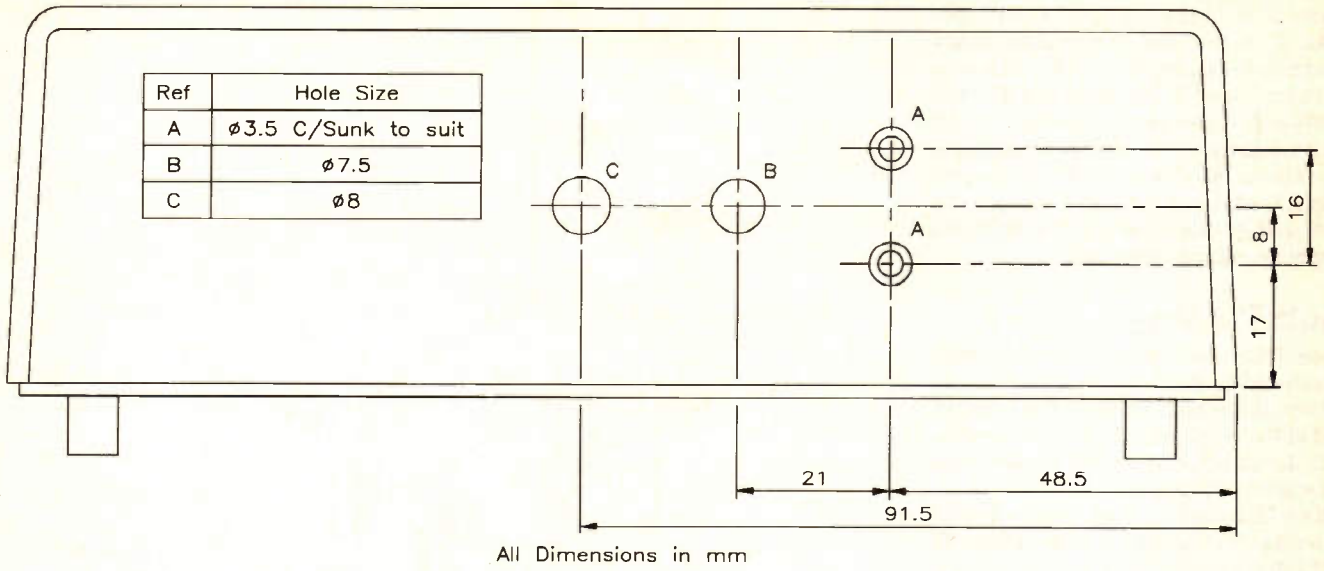


Figure 10. Rear drilling details.

Front

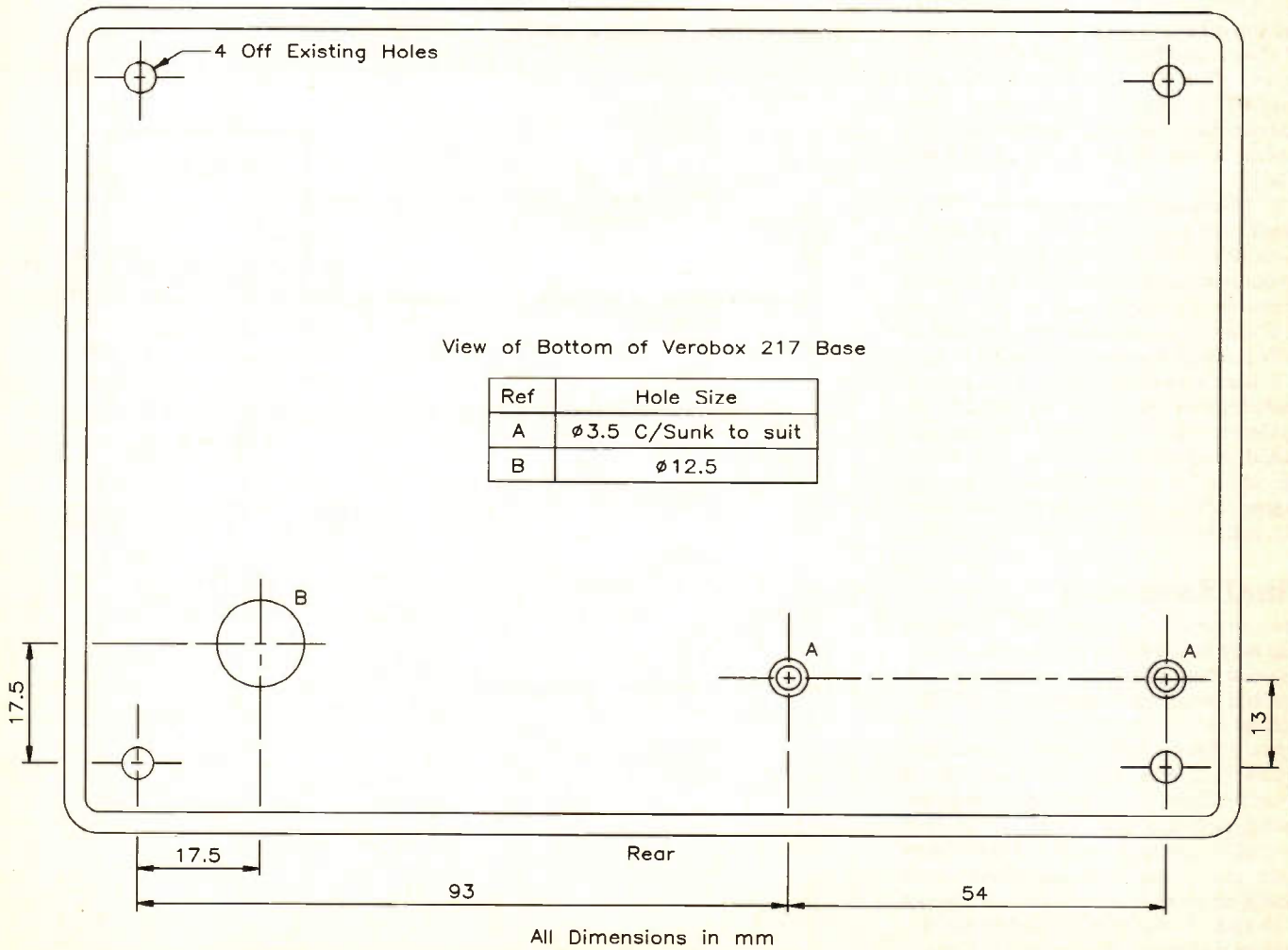


Figure 11. Base drilling details.

If all is well, RV1 can be set to obtain the correct ringing speed. Normally, this will be at the centre of the preset's travel. Ask a friend to ring your telephone number, then set RV1 so that the LED flashes in step. Alternatively, set RV1 so that the LED flashes occur at a rate of 1 pair every 3 seconds. If an oscilloscope or frequency counter is available, RV1 can be set so that the clock speed is 5Hz. Note that RV1 has a wide adjustment range; the clock speed can be decreased to simulate, in conjunction with the operation of SW3, the ringing of an American telephone. It can also be increased, so that the sound of a European telephone can be emulated.

Fault Finding

A few voltmeter (or oscilloscope) readings should establish the section of the circuit which is at fault. Connect the 'ground' lead of the oscilloscope (or voltmeter) to 0V in the circuit, and use the positive voltmeter lead as a probe.

If the LED does not flash, check whether the lead at the top of R3 is pulsing from 0V to 12V during the ringing sequence. If it is, the LED is probably connected the wrong way round. If it is not, check the following:

1. **Astable Multivibrator (IC1).** Check that pin 14 of IC1 is at about 12V, and pin 7 is at 0V. The astable may be checked by monitoring pin 3 of IC1 with an oscilloscope. The voltage should pulse up and down.

2. **Binary Counter (IC2).** Check (preferably with a CMOS logic probe) that pins 9, 10 and 16 of IC2 are at about 12V, and that pins 3, 4, 5, 8, 12, 13, and 1 are at 0V. Check that the pulse from IC1 is reaching pin 15 of IC2. Checking the outputs from IC2 is difficult without a logic analyser, but an oscilloscope will indicate, to some extent, if pins 6, 11, 14, & 2 are pulsing.

3. **16-channel multiplexer (IC3).** Check that pins 1 and 24 of IC3 are at about 12V, and pin 15 is at 0V. Check that the counter outputs from IC2 are present on the control inputs (pins 10, 11, 13 and 14 of IC3). Check whether pin 4 produces a 12V reading in step with a 'ringing tone'.

4. **Sine wave oscillator (TR1, etc).** If diode D1 is removed (or the supply voltage fed to the cathode of D1), the astable should produce a continuous sine wave. This could be checked with an oscilloscope probe connected to the collector of TR1, and then the emitters of TR2 and TR3.

Final Assembly

Once tested and aligned, the AutoRing PCB may be mounted in the case or console that best suits your requirements. A suitable housing, however, is LM11M. Drilling details for this case are given in Figure 9 (front panel), Figure 10 (rear) and Figure 11 (base). If the piezo sounder is not to be fitted, then the large hole in the base (labelled as 'B' in Figure 11) need not be drilled. Once the required holes have been made, the PCB and other items should be assembled as shown in Figures 7, 12 and 13. The PCB is fitted to the aluminium control panel, as shown in Figures 7 and 12. The shakeproof washers should be installed between the height-setting nuts and the panel so that, when tightened,

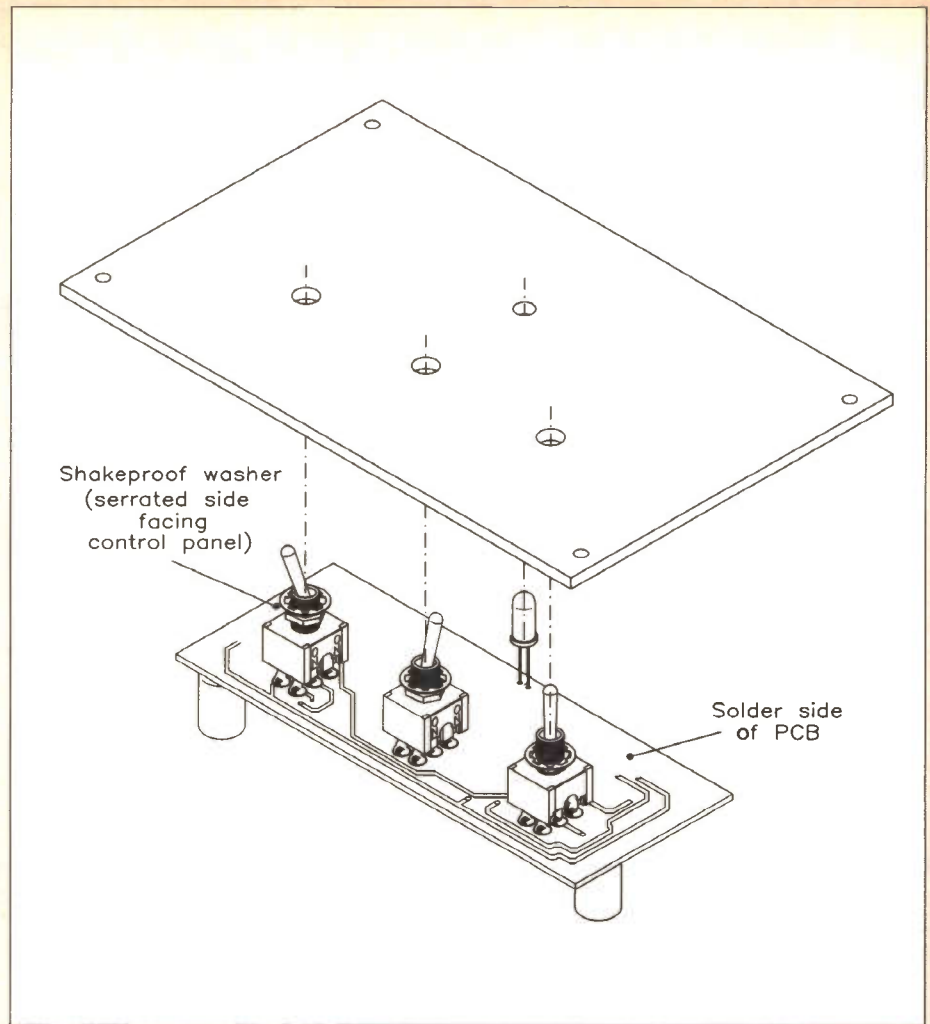


Figure 12. Fitting front panel to PCB.

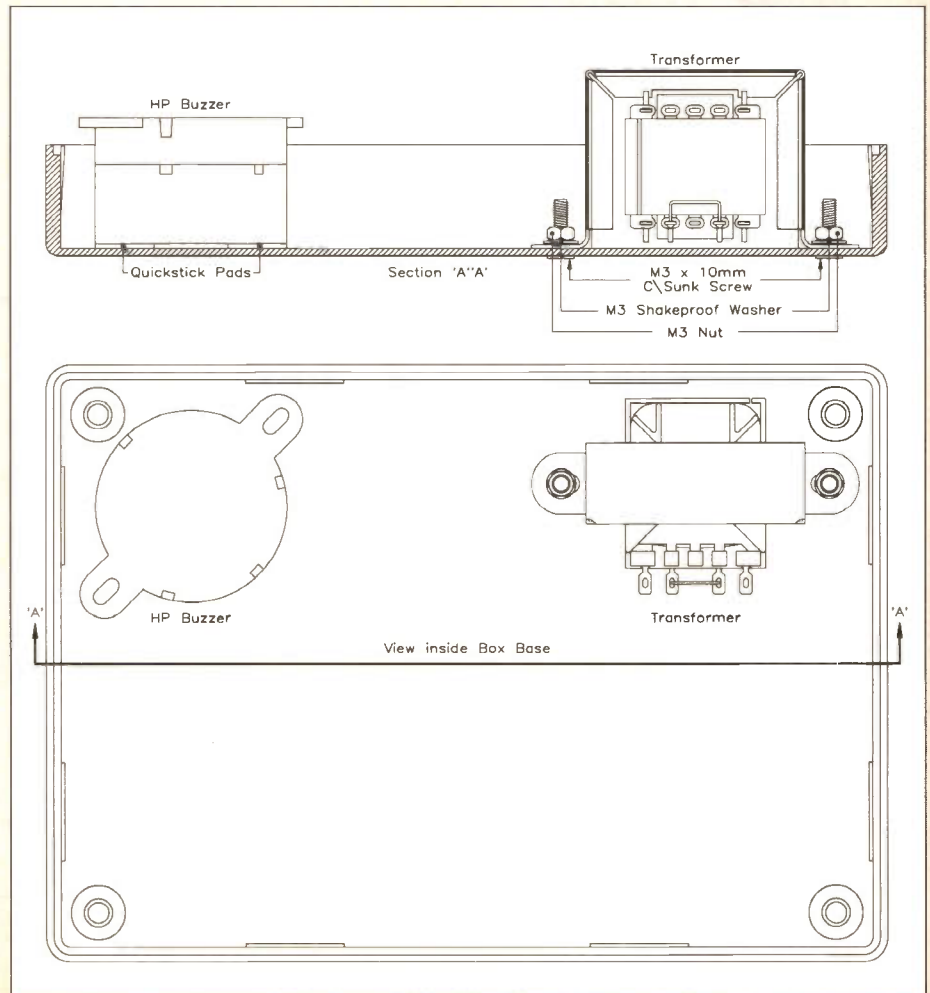


Figure 13. Positioning the transformer and optional piezo sounder.

the switches (which effectively hold the PCB in position) are unlikely to work loose. Obviously, the serrated side of the washer should be on the panel side of the switch bush. Note that the top of each switch-securing nut should be at the same level as the top of the threaded bush; this will contribute to a neat-looking finished project.

The transformer is installed on the bottom section of the case with M3 mounting hardware, as shown in Figure 13. From this diagram, it can also be seen that each side of the piezo sounder (if used) is attached with half of a 'quickstick' pad. Note that it must line up with the hole drilled in the base. Once the mechanical assembly has been completed, the interconnections should be made as shown in Figure 8. The inset drawing shows how the power socket is wired up. As the telephone socket mounts on the side of the case, the two wires connecting it to the transformer must be fed through the relevant hole first. It can then be fitted to the case with 30mm M3 screws as shown in Figure 14, covering up the hole and thus maintaining a tidy appearance.

Using AutoRing

Firstly, the desired telephone and a suitable regulated 12V DC supply should be obtained. Note that the power supply should have a standard 2.5mm power connector, with the barrel negative and the inner conductor at 12V. A suitable choice is YB23A.

S1 is the power switch; in its lower position, AutoRing is switched on.

S2 selects between the piezo sounder (upper position), if fitted, and the external telephone (lower position). It also has a central 'standby' position, which enables the ringing to be monitored by means of the LED before the phone is required to ring. A normal BT phone will stop ringing when picked up - at this point the circuit operator must remember to return S2 to its 'standby' position, otherwise the phone will start ringing again as soon as the receiver is replaced!

The centre switch, S3, is used to change the ringing sequence (refer to Figure 1); in the upper position a British phone is simulated, while in the lower position the unit will generate an American-style ring.

A Designer Ring

As discussed in the Circuit Description section, AutoRing can be used to generate the ringing sound of your choice. By linking together the desired multiplexer switch positions onto the control line, you can 'design' your own ringing sound. The presently unused switch positions are 0, and 6 to 14 inclusive (pins 9, 2, and 16 to 23). The pins corresponding to the desired switch positions can be connected to those already present on the control line (pins 4 to 8 inclusive), using insulated wire bridges. Refer to Table 1, which correlates timing information with the switch position and pin number. If any of the present switch positions are not required, IC3 can be removed, and the relevant pins bent back so that, when re-inserted, no contact is made with the corresponding socket contact.

Continued on page 35.

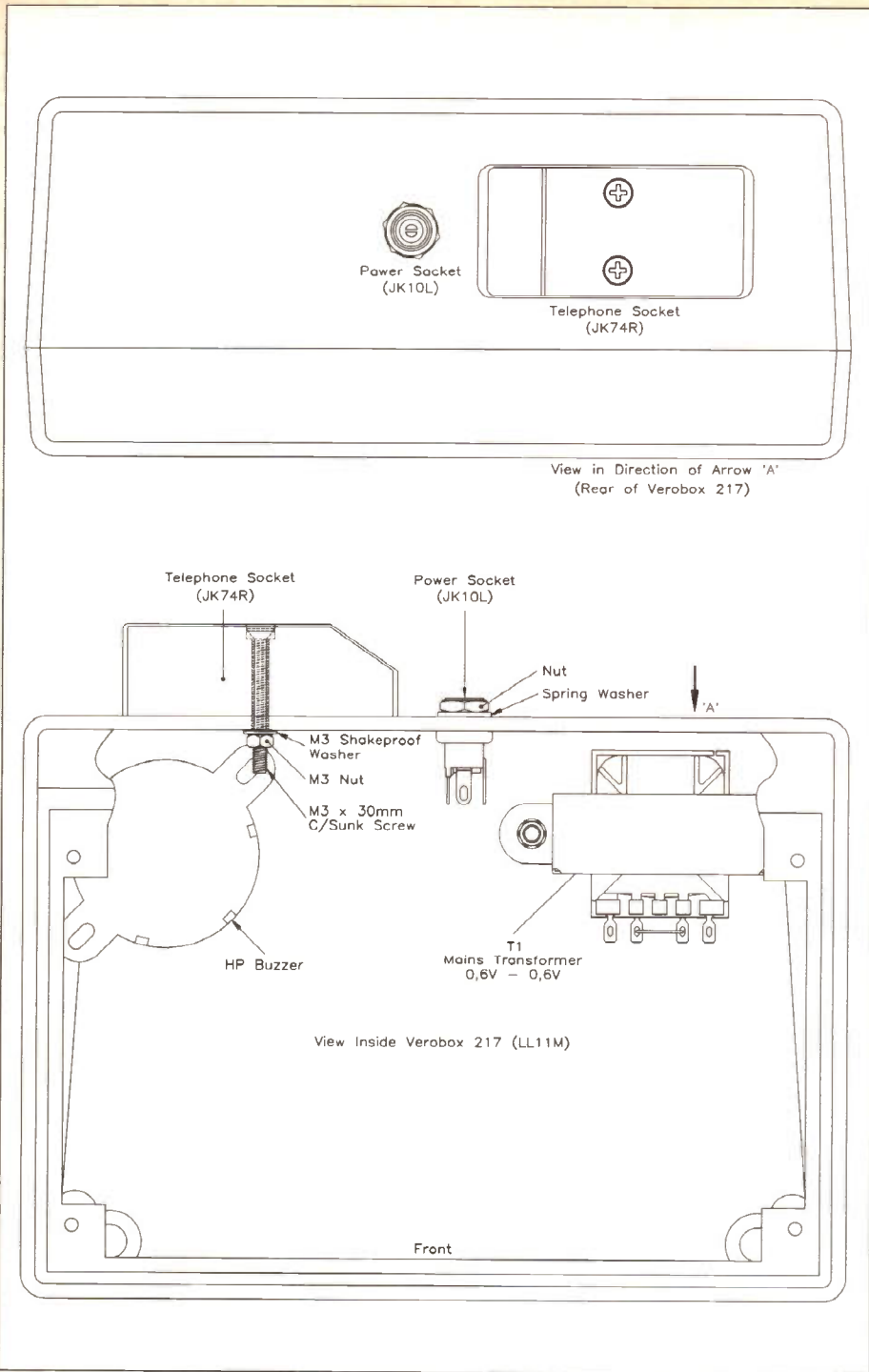


Figure 14. Mounting the telephone and power sockets on the rear of the case.

Count MSB	Count LSB	Switch Position	Switch Pin No.	Arbitrary Time (Sec) *	Action of unmodified Unit
0	0	0	0	0	-
0	0	0	1	0.2	} Ring
0	0	1	0	0.4	
0	0	1	1	0.6	} Gap (UK) Ring (US)
0	1	0	0	0.8	
0	1	0	1	1.0	} Ring
0	1	1	0	1.2	
0	1	1	1	1.4	-
1	0	0	0	1.6	-
1	0	0	1	1.8	-
1	0	1	0	2.0	-
1	0	1	1	2.2	-
1	1	0	0	2.4	-
1	1	0	1	2.6	-
1	1	1	0	2.8	-
1	1	1	1	3.0	Reset Counter

* exact timing will depend on the setting of RV1

Table 1. Counter/switch operation.

A New Approach to DMMs

by Pierrot Maaten



The basic low-cost DMM is one of the most essential instruments for frontline service personnel. Its main advantage over any other single instrument is that it can quickly help identify the great majority of common first line faults in a wide variety of equipment ranging from electrical systems to industrial control and computer systems.

Until recently, the multimeter user has, unfortunately, generally been faced with a difficult compromise between cost and quality. The expression 'You get what you pay for', has been as true of DMMs as it has of any other product.

However, field servicing requirements are changing, driven by the needs of customers for faster repairs and reduced equipment downtime. In turn, this is causing users to demand higher quality and more reliable test instruments which are better suited to their needs but which cost no more than traditional low-priced DMMs.

One of the first companies to recognise and respond to these changes is Fluke, who have introduced the new generation Series 10 low-cost DMMs. The range is aimed at giving the more price-sensitive user the level of quality, ruggedness and safety normally only expected in much more expensive models. Traditionally, the multimeter market has generally been split into two quite distinct categories.

Quality versus Cost

The lower end of the market has been dominated by low-cost basic DMMs. These meters have suffered from a general lack of ruggedness and reliability – just dropping this type of meter from as little as one metre can be enough to render it useless. For this reason, the low-cost DMM has usually tended to be regarded as a throw-away item – when it goes wrong the user simply buys another one. They have therefore appealed to the user for whom price rather than quality is the main attraction. As a result, low-cost DMM manufacturers have relied on aggressive pricing to sell their meters to price sensitive users. However, today's users are becoming much more demanding in terms of quality and reliability.

At the other end of the market is the professional quality DMM offering much greater ruggedness plus more advanced safety and operating features. This market is largely driven by quality and features rather than price alone. Users expect a very high degree of robustness and a wider choice of more advanced features such as MIN/MAX recording, fast continuity, full auto and manual – ranging and comprehensive safety protection.

Trends in Frontline Servicing

One of the most significant trends identified by Fluke is a move towards a simplified level of frontline servicing. More and more, the emphasis is on getting equipment up and running with the least possible downtime. This usually means quickly identifying common faults

in power supplies, relays, sensors, switches, connectors and so on. Once a faulty board or module is found it will often be swapped for a new one – the faulty board is then returned to the depot for more extensive fault diagnosis and repair.

As a result, frontline servicing often involves conducting more different types of measurement, instead of less. This in turn is increasing the demand for low-cost test instruments, with an improved set of basic measurement functions and features.

At the same time, users are demanding a higher level of professional quality in their test instruments. The throw-away approach associated with the traditional low-cost meter is no longer acceptable.

Another important aspect of the quality issue is safety. DMM users frequently work in hazardous environments with dangerous voltages and currents. Both employees and employers are becoming increasingly aware of safety issues and regulations and this in turn is making the safety features of a DMM increasingly important.

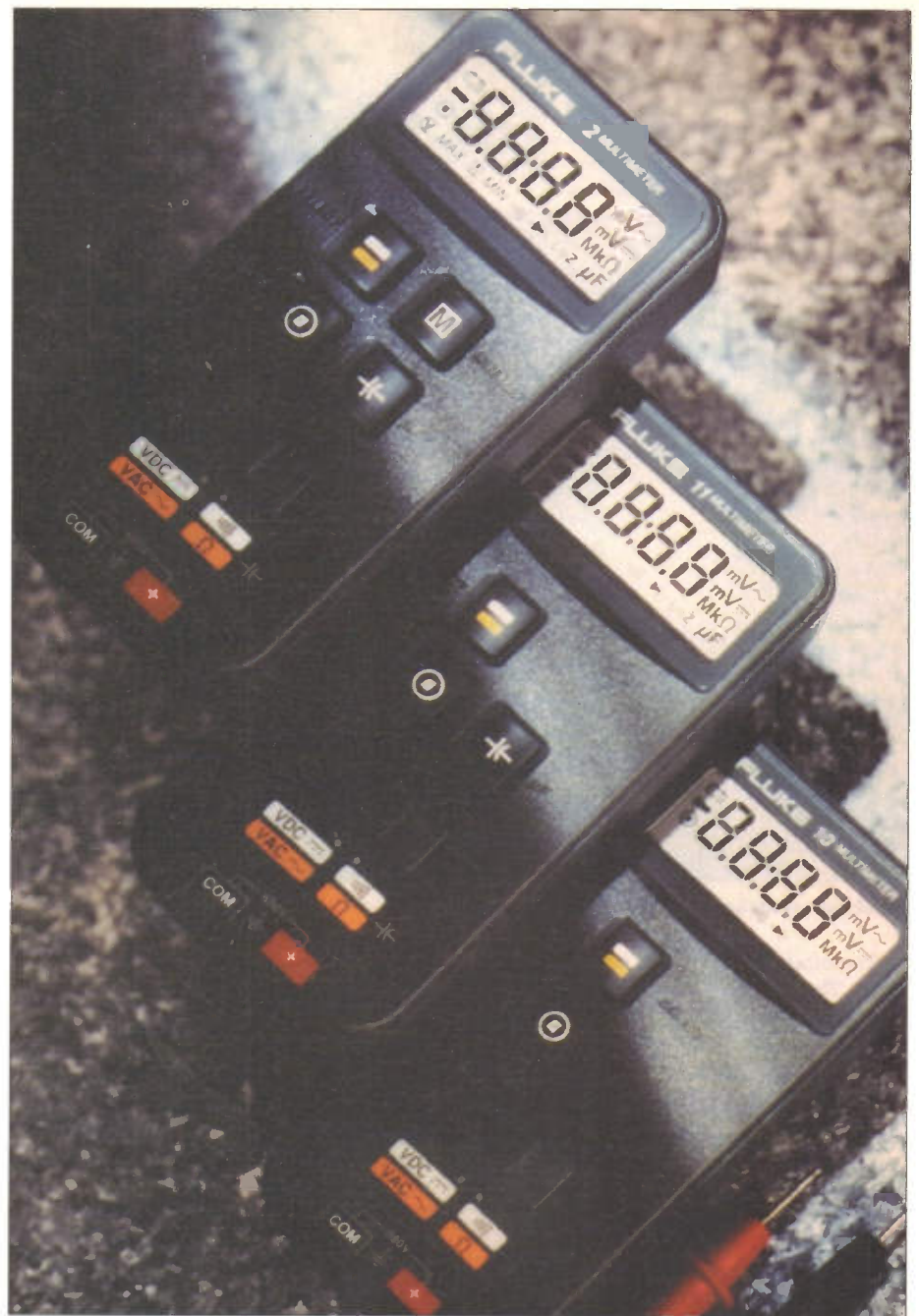
The New Generation of DMMs

As a result of its experience in the manufacture of quality DMMs, Fluke was able to bring a different approach to low-cost DMMs.

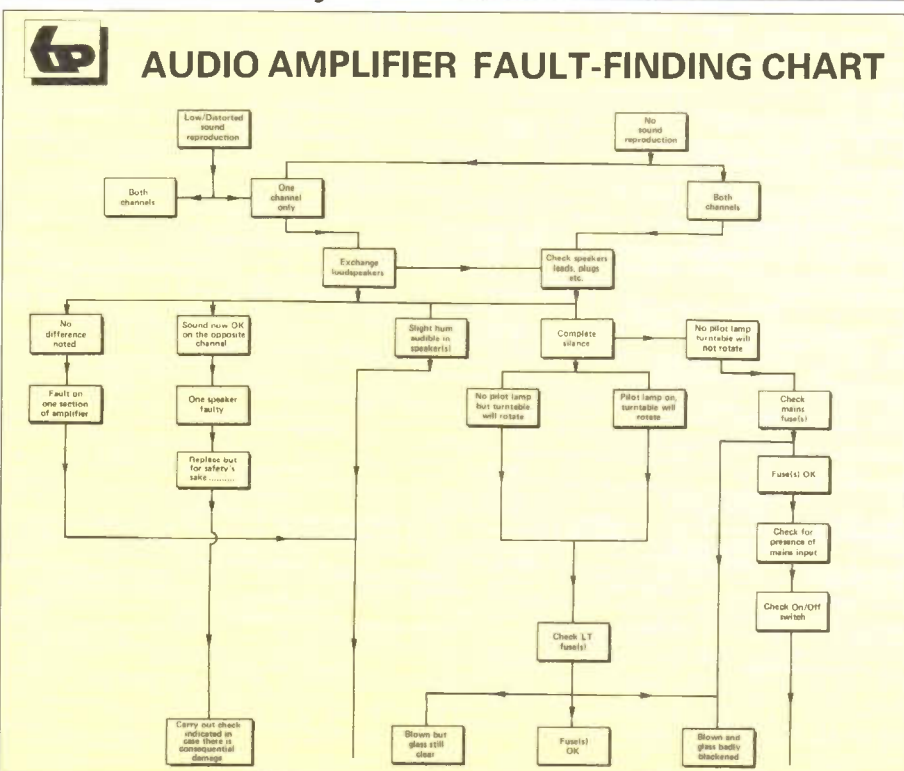
Instead of trading off quality for price, the company decided to meet both requirements head-on.

Such an approach required both a high degree of innovation, and a 'leveraged' approach to making the best use of existing design and production experience.

To meet the market need for a basic



Below: Part of Babani's Flow Chart. An excellent aid for fault-finding.

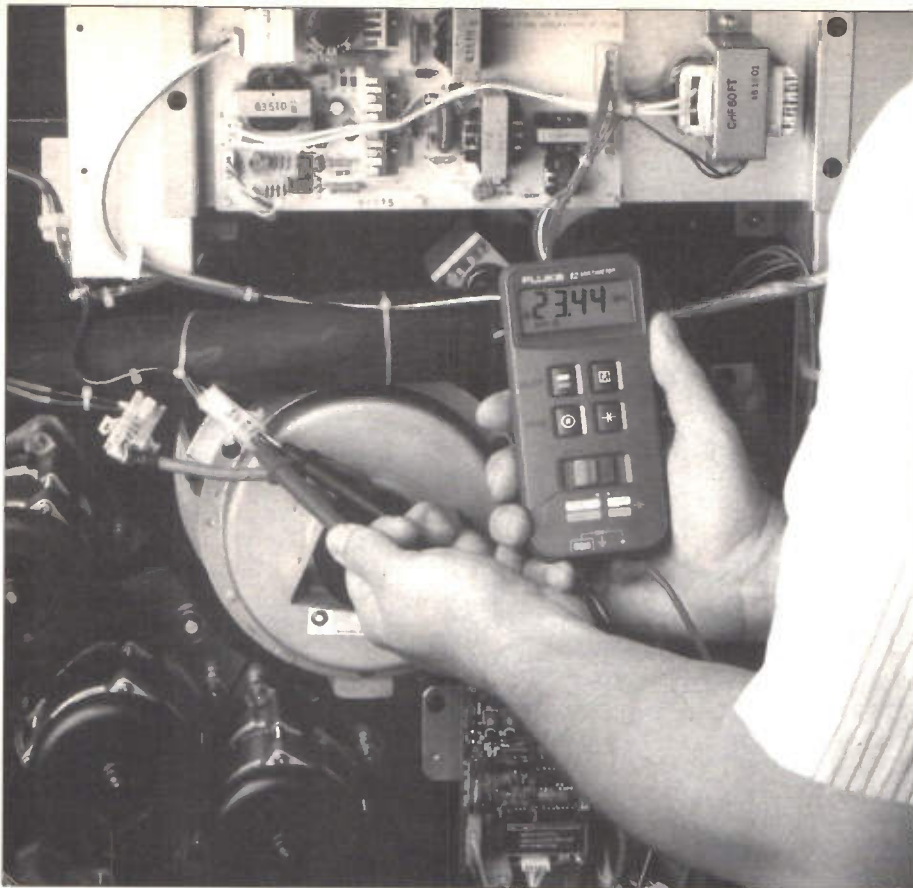


Above: The Fluke Series 10 DMMs, high-quality meters, with a good range of features at a reasonable price.

DMM, the Series 10 was designed around a core set of the most needed measurements to allow the user to locate the vast majority of hard faults, and to carry out first line checks quickly and easily. These included AC and DC volts, ohms, continuity check, diode test and a 4,000 count auto-ranging display with manual override.

From the start, the Series 10 was designed to provide all the ruggedness and durability of its larger cousins – the Fluke 70 and 80 Series professional DMMs – which means they can withstand even very harsh treatment such as a 10 metre drop.

In addition to the core features, safety was very much a design goal, since many of these meters will be used in potentially lethal applications. A measure of Fluke's commitment to safety is that nearly 15% of all the internal components are there merely to provide protection from overload or accidental misuse. It is also fully double insulated to IEC and UL safety standards to further protect the user.



Good design makes the Fluke Series 10 easy to use.

The other major design goal was price. The Series 10 starts at £56.95 for the basic model, rising to £74.95 for the top of the range model 12.

Typical Applications for the New Generation of DMMs

The traditional DMM measurement capabilities of AC or DC volts, ohms and diode test need little introduction.

The basic model in the range offers a core set of the most common functions required for servicing – AC and DC volts, ohms, fast continuity detection with audible bleeper plus diode test. All the models in the range feature a high resolution 4,000 count autoranging display with a manual range override facility. This is especially useful for making repetitive measurements or when using matched accessories such as thermocouple modules scaled to m/degree for example. Another useful feature not normally found on low-cost DMMs is a sleep mode. This conserves battery life by automatically powering down the DMM, if it has been left unused for 45 minutes, thus alleviating the problem of flat batteries if the user forgets to switch the meter off.

These basic facilities are augmented by more advanced features on the Fluke 11 and 12 models – these include an exclusive V-Chek™ dual continuity/voltage function, capacitance, MIN/MAX recording with unique elapsed time stamping, input change alert, and a high speed 'continuity capture' mode. This last feature is useful for finding faults such as intermittent problems on wiring harness and long cable runs.

Simultaneous Continuity/Voltage Mode

This is a new function on DMMs and is unique to Fluke. It will find many applications in front line servicing for fast checking and for making measurements easier and safer.

Called V-Chek™, this innovative facility operates in continuity mode automatically and safely switching to voltage mode, either AC or DC, whenever a voltage greater than 4.5V is present. This allows the user to apply the probes to say a power supply rail, for example, and simultaneously check for shorts, opens or voltage levels without having to change function switches or test probe connections. This is much quicker than checking first for voltage, and then manually changing over to continuity. It also avoids the danger of damage to the DMM by inadvertently connecting to a live voltage, such as 220V AC, when in continuity mode – a common cause of failure with conventional DMMs.

Low Impedance Mode for Checking Phantom Voltages in Power Systems

A frequent requirement in installing and commissioning power systems is to check installations for any hard voltages which may be backfed from another connection. Unfortunately a conventional DMM's high input impedance makes it extremely difficult to distinguish whether the voltage is 'real' or just a 'phantom'

voltage resulting from leakage or capacitive coupling.

A special feature of the V-Chek™ mode is a low input impedance of only 2kΩ which effectively drains the phantom voltage allowing real and possibly dangerous voltages to be detected more easily and quickly. When V-Chek™ switches from continuity to AC or DC volts, the instrument gives an audible bleep and a 'lowZ' indication appears on the display.

Another application for the low impedance V-Chek™ facility is in telecommunications testing where phantom voltages can appear on very long wire pairs due to noise pickup. The low 2kΩ impedance of V-Chek™ easily distinguishes if the voltage is 'hard' or merely noise.

Min/Max Recording – with Elapsed Time Stamping

Some of the most difficult types of fault to detect are intermittent or time related, problems such as power supply variations or other high or low voltage problems including those caused by fluctuation or poor connections. In these circumstances, a simple handheld DMM with a MIN/ MAX recording facility can be very useful. This allows both the highest and lowest readings to be automatically and continuously recorded over long periods of up to 100 hours without having to look at the meter. It even allows unattended monitoring, for example overnight, to enable intermittent or rare event faults to be detected. A bleep warns the user whenever a new high or low reading is recorded.

What makes the Fluke Model 12 even more useful is a unique built-in elapsed time clock which time stamps each high and low reading, so the user knows not only what happened but also when. Knowing when an event happened can be very important in troubleshooting difficult time related faults.

The MIN/MAX recording and time stamp facility also operates in the ohms continuity mode. This can be used, for example, to save time when carrying out continuity checks on cables or wire pairs over long distances where it is impossible to observe the DMM when making the test. The user makes the test and can check the results stored in the DMM at his convenience.

Capacitance Testing Applications

Service personnel increasingly require the ability to carry out capacitance measurement without having to carry a separate capacitance tester.

For example, large motor start capacitors usually require regular checking in order to maintain motor performance and efficiency. Similarly, the capacitors in power supplies can be frequent causes of problems.

These everyday problems are easily addressed using the capacitance

measuring capability of the Fluke Models 11 and 12 DMMs which cover the range from 0.001 μ F to 9999 μ F.

Fast Continuity Testing Catches Elusive Faults

Another of the useful DMM functions available on modern DMMs is fast continuity indication. By combining high-speed continuity capture with an audible bleep, the Fluke 10 Series allows the user to test for continuity problems very quickly and easily. Typical problems include opens, shorts and wrong connections in wiring harnesses, backplanes, connectors and so on.

High-speed continuity detection catches glitches (opens or shorts) as short as 250 μ s, so that intermittent continuity faults can be detected. By combining fast continuity detection with the MIN/MAX recording facility of the Fluke Model 12, the user doesn't even have to watch the meter to identify intermittent shorts or opens. For example, the user can twist or flex a wiring harness or printed cable to find an intermittent open or short without looking at the display - the DMM captures the event and gives a visual indication on the display.

Conclusion

Frontline servicing is demanding higher quality test instruments in order to cope with increasing demands for faster, more effective troubleshooting. The latest generation of DMMs, are designed



The top-of-the-range Fluke 12 DMM.

to bring professional levels of quality and features at a price which will provide a severe challenge to existing low-cost multimeters. The Fluke 10 Series is available from Maplin along with a matching holster and carry case. The Fluke 10 (ZF42V) £56.95^A, the Fluke 11 (ZF43W) £64.95^A and the top of the

range Fluke 12 (ZF44X) £74.95^A. The matching holster (ZF45Y) £11.95 and the handy soft vinyl carrying case (ZF46A) £11.95. The holster and carrying case are suitable for all meters in the Fluke 10 series range. The Babani fault finding chart is also available from Maplin (WP83E) 95p.

AutoRing continued from page 31.

AUTORING PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless specified)

R1,6	220k	2	(M220K)
R2,4,7,8	10k	4	(M10K)
R3,10,11	1k	3	(M1K)
R5	820k	1	(M820K)
R9	4k7	1	(M4K7)
RV1	470k Min Vertical Preset	1	(UH21X)

CAPACITORS

C1	330nF Polyester	1	(WW47B)
C2,3,4	220nF Polyester	3	(WW45Y)
C5	220 μ F 16V PC Electrolytic	1	(FF13P)
C6,8	1000 μ F 16V PC Electrolytic	2	(FF17T)
C7	100nF Ceramic	1	(YR75S)

SEMICONDUCTORS

D1	1N4148	1	(QL80B)
D2	1N4001	1	(QL73Q)
TR1,2	BC184L	2	(QB57M)
TR3	BC214L	1	(QB62S)
IC1	4001BE	1	(QX01B)
IC2	4029BE	1	(QW20W)
IC3	4067BE	1	(QW42V)
LD1	Red 5mm LED	1	(WL27E)

MISCELLANEOUS

T1	Min Transformer 6V	1	(WB06G)
S1,3	Sub-Min Toggle E	1	(FH04E)
S2	Sub-Min Toggle F	1	(FH05F)
	Compact Line Jack	1	(JK74R)
	7/0.2 Wire 10m Black	1 Pkt	(BL00A)
	14-pin DIL Socket	1	(BL18U)
	16-pin DIL Socket	1	(BL19V)

24-pin DIL Socket	1	(BL20W)
Pin 2145	1 Pkt	(FL24B)
PCB	1	(GH27E)
Instruction Leaflet	1	(XU03D)
Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

BZ1	HP Piezo Sounder	1	(FK84F)
	Pan Mnt Pwr Skt 2-5	1	(JK10L)
	Verobox 217	1	(LL11M)
	AC Adaptor Regulated	1	(YB23A)
	Quickstick Pad	1 Strip	(HB22Y)
	Poziscrew M3 x 10mm	1 Pkt	(LR57M)
	Shakeproof Washer M3	1 Pkt	(BF44X)
	Steel Nut M3	1 Pkt	(JD61R)
	C/sk Poziscrew M3 x 30mm	1 Pkt	(JC72P)

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

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

Order As LT19V (AutoRing) Price £14.95

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 item (which is included in the kit) is also available separately, but is not shown in the 1993 Maplin Catalogue.

AutoRing PCB Order As GH27E Price £2.45

PIEZOELECTRIC TECHNOLOGY

by Douglas Clarkson

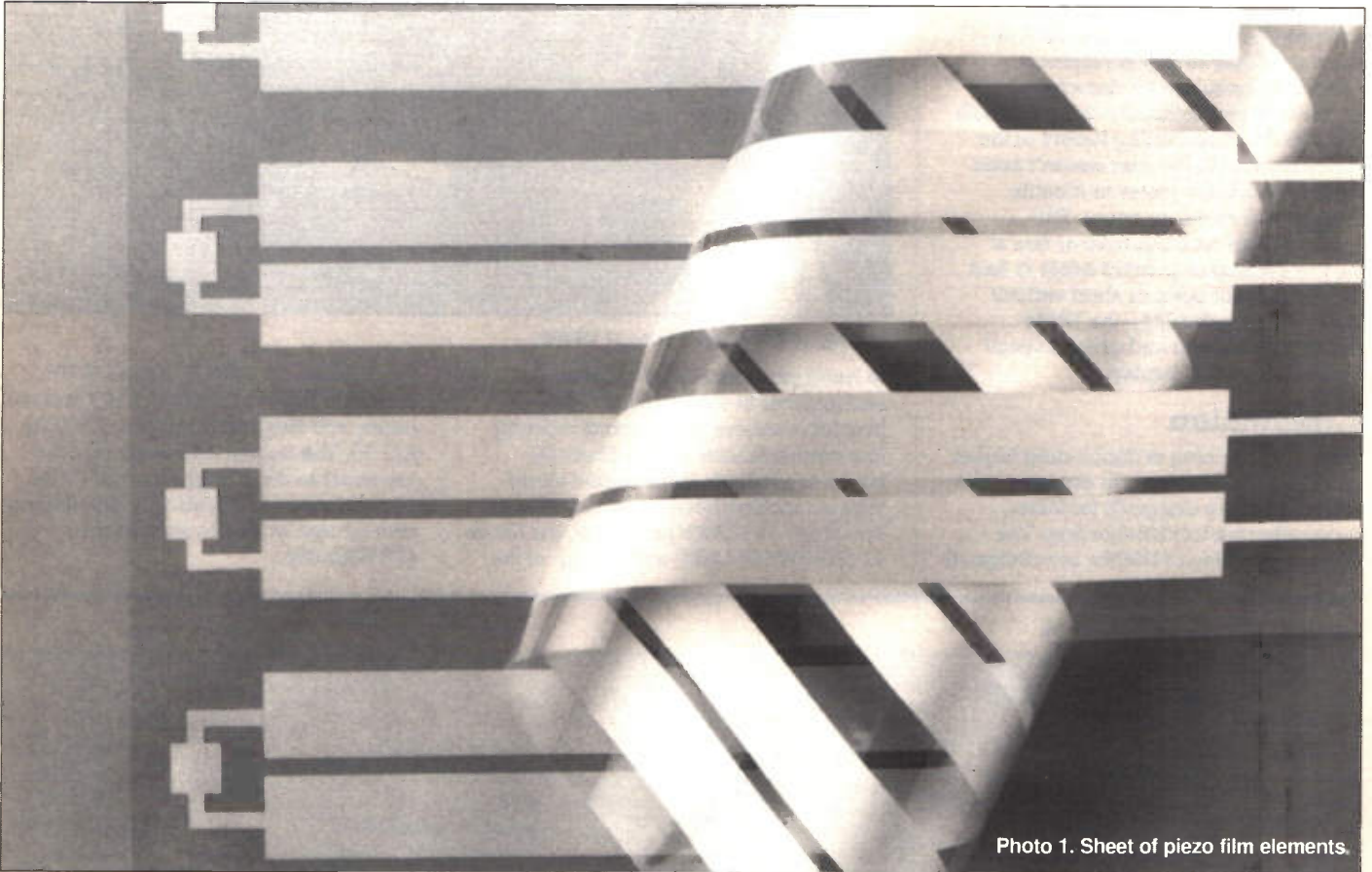


Photo 1. Sheet of piezo film elements.

The piezoelectric effect can be demonstrated in a wide range of materials and today is used extensively in a broad range of measurement techniques. The phenomenon of piezoelectricity was initially demonstrated by Pierre and Paul-Jacques Curie in 1880, by means of the properties of natural crystals such as quartz, tourmaline and Rochelle salt. Piezoelectricity, meaning 'force-electricity', relates to the ability of mechanical deformation (in the form of compression, tension, bending or twisting) to produce a potential difference across the surfaces of the deformed element, and conversely the ability of an applied voltage signal to yield a corresponding mechanical effect.

While piezoelectricity is identified with equipment measurement technology, it is becoming apparent that biological systems utilise significant piezoelectric effects. Bone, for example, demonstrates piezoelectric properties which influence sites of growth of new bony tissues.

Extensive development of piezoelectric transducers came with World War I and the need to defeat the U-boat menace. It was not until the closing stages of the

war in 1918, however, that work initiated by the French scientist Paul Langevin, while working with British (and later American) scientists, produced an echo detection system.

During World War II the Allies maintained a significant advantage over Germany in terms of underwater sonar detection, which was vital for the war effort. Much work has been subsequently undertaken since 1945 in developing SONAR. Developments in piezoelectric technology have, in particular, passed from military applications through to diverse industrial and medical uses.

The main disadvantage of natural crystals (such as quartz) was that they could only be produced in a limited number of configurations. In addition, their power handling properties were limited. The search to produce more useful piezoelectric materials led to the creation of Barium Titanate ceramic material. This substance was formed from a mix of chemical compounds which, when heated sufficiently, melted and could be poured into a mould to produce discs, rings, slabs or cylinders of material when cooled. During the cooling process, a high-voltage 'poling' field was established to 'lock' in the

piezoelectric properties of the compound. This process allowed much greater flexibility in the design of such piezoelectric elements. Configurations, however, of Barium Titanate usually required high levels of DC bias voltages.

A more recent generation of so-called PZT (Lead, Zirconium, Titanate) ceramics has been developed which, despite being produced using the same general procedures, offers a higher performance – both as a sensing element and an active vibrating element – with frequencies ranging from kHz to tens of MHz. In addition, ceramics made from this material may be operated without any bias field.

PZT ceramic elements are widely used in a broad range of disciplines. In the medical ultrasound field, transducer technology, using these elements, has been extensively developed to produce systems capable of mapping anatomical structures in great detail. More recently, such systems have been used for the mapping direction of blood flow in the heart using Doppler techniques. PZT ceramics are also used in ultrasonic cleaning baths since they can cope with being driven at high power levels.

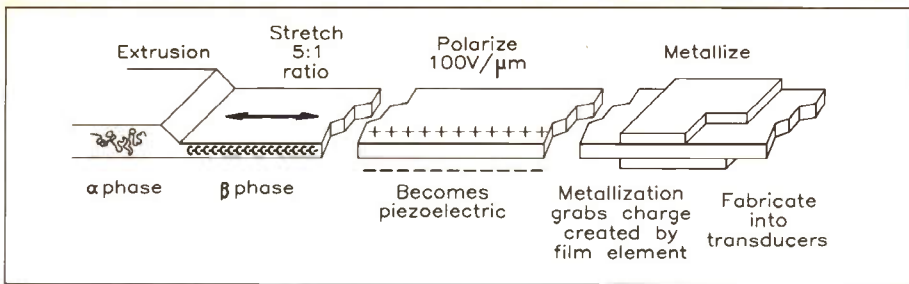


Figure 1. Manufacturing process of piezo film.

Piezo Film Technology

While PZT ceramics brought about a diverse range of transducer elements, the range of applications was often limited by the fragile nature and relatively high cost of the ceramic elements. The introduction of thin plastic films demonstrating piezoelectric properties has extended significantly the application of piezoelectric elements in sensor technology. Like so many ideas in this field, the original impetus for their development came from research into improving the efficiency of military sonar systems, particularly those used for submarine detection.

One piezoelectric polymer film, which has gained widespread use in a range of applications, is PVDF (polyvinylidene fluoride). This polymer is made up of the monomeric unit $\text{CH}_2\text{-CF}_2$. The compound has the advantage of being chemically inert – so it can be used in a range of hostile environmental conditions.

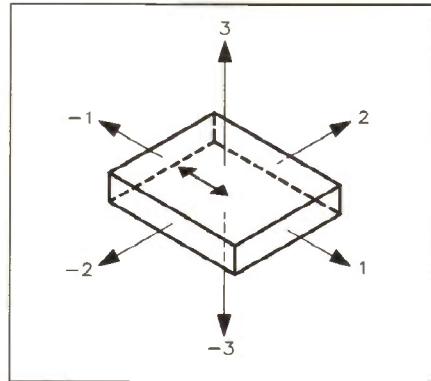


Figure 2. Orientation of axes of piezo film.

manufacture is outlined in Figure 1.

In describing the properties of piezoelectric materials, parameters are usually quoted in relation to specific direction axes. Figure 2 shows how these are defined for PVDF films. The electrodes are applied on the flat

Thickness	9, 28, 52, 110 & 500 μm
Piezoelectric Strain Constant (d31)	$23 \times 10^{-12}\text{CN}^{-1}$
Piezoelectric Strain Constant (d33)	$-33 \times 10^{-6}\text{CN}^{-1}$
Piezoelectric Stress Constant (g31)	$216 \times 10^{-3}\text{VmN}^{-1}$
Piezoelectric Stress Constant (g33)	$-339 \times 10^{-3}\text{VmN}^{-1}$
Pyroelectric Coefficient (p)	$-25 \times 10^{-6}\text{Cm}^{-2}\text{K}$
Temperature Range	-40°C to 80°C
Maximum Operating Voltage	$30\text{V}\mu\text{m}^{-1}$
Capacitance	380pFcm^{-2} for $28\mu\text{m}$ film
Frequency Response	DC to GHz

Table 1. Summary of properties of Kynar piezo film.

The process of PVDF film manufacture initially involves the stretching of films to around 500% of initial size at a temperature of 50°C . This encourages the formation of the 'beta phase' of the polymer. Then, maintaining the temperature, a poling field is applied across the material, typically of about 100V per micron thickness. Electrodes can then be deposited on selected areas of the film by the vacuum deposition of aluminium.

The PVDF film contains highly covalent bonds between carbon atoms and fluorine atoms, and the electric field tends to deform the alignments of atoms. The field is maintained as the temperature of the film is reduced, so that the deformation of charge centres is preserved within the final structure. While ceramics can withstand temperatures of up to around 300°C , the piezoelectric properties of PVDF films are lost when their temperature is raised to over 100°C . This upper limit of temperature, above which the piezoelectric properties of the material are lost, is termed the Curie temperature. The process of piezo film

'3' axis. Table 1 outlines the values of typical piezo film parameters. The value of the piezoelectric stress constant g_{33} relates to the sensed voltage across the '3' direction, for an applied force across the '3' direction. The value of g_{31} relates to the sensed voltage across the '3' direction for an applied force in the '1' direction. It makes no sense in this configuration to quote values of g_{21} etc. since there are no electrodes to pick up voltages across the '2' direction. Stress across the '1' direction will generate voltages of up to 10 times the amount of that across the '2' direction.

The strain constants relate to the change in thickness following application of a driving voltage signal. While the stress constants are similar for the 31 and 33 directions, the strain constant of the 31 direction is significantly smaller than that of the 33 direction.

Photo 1 shows an array of manufactured PVDF piezo film elements. The clear material is the PVDF sheet with uniform piezoelectric properties, while the patterns on the film are the metallised electrodes. The active piezo film element can be considered as the circuit shown in Figure 3, where the transducer is a voltage source V , with capacitance C in series with a load resistance R . The relative values of C and R determine the frequency response of the sensor. Figure 4 shows the equivalent high-pass filter characteristic of the basic piezo film circuit with a load resistance of $10\text{M}\Omega$. Where low frequency signals are required to be detected, this requires that high values of load resistance are used. In the example shown, a specific sensor has a capacitance of 2.4nF and is interfaced to a FET with a $10\text{M}\Omega$ resistor; the -3dB frequency is 6.6Hz .

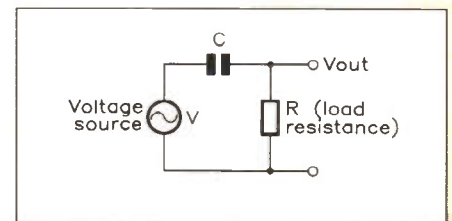


Figure 3. Equivalent circuit of piezo film element loaded with resistance R .

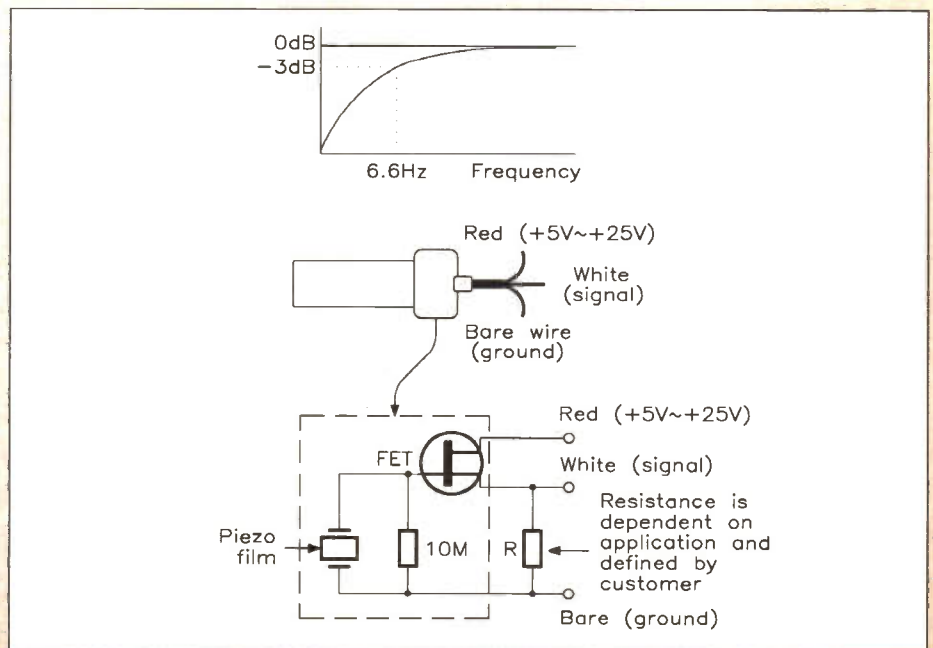


Figure 4. Typical frequency response of piezo film element with a $10\text{M}\Omega$ load resistance.

Where a very high load impedance is indicated, special high impedance buffer circuit elements are required. Some devices successfully used include JFET 4117, LMC660, LF353 (National Semiconductor), OP80 (PMI) and 2201 (Texas Instruments).

It may be necessary in some situations to reduce the sensitivity of the input stage. This is often the case with impact sensing circuits where the initial voltage may be hundreds of volts in amplitude. Figure 5 shows some circuits used to reduce input voltage to the sensing circuit.

Response of Film to Stimuli

The typical response of piezo film to a force stimulus is shown in Figure 6. When a force is applied, the piezo film immediately responds with a corresponding voltage. This begins to decay as charge leaks through the series RC circuit. When the force is removed, a voltage of opposite sign is added to the remaining voltage signal. The resulting net negative voltage decays towards zero as indicated. The transducer element is therefore not acting like a conventional strain gauge transducer where the signal remains for only as long as the stimulus is present.

The sensitivity of the film is exceedingly high. Even tapping an element of piezo film with your finger will generate a signal of several volts. The key to this use of such sensor technology is that it is 'self-exciting'.

Applications

The range of applications of piezo film is already considerable and is expanding rapidly. Some of the more important areas will be considered.

Electronic switches. The main advantage of the use of piezo film in switch technology is that the voltage produced by the switch is self-generating. Thus it is possible, for example, to trigger the high-impedance inputs of CMOS circuits directly. In the design of the piezo film switch, care has to be taken that a steady slow build-up of pressure will still activate the switch mechanism correctly. This is achieved by designing the switch with a specific mechanical action that will deform a piezo element in a consistent time interval and so give rise to a signal of the necessary amplitude.

One type of piezo switch is designed like a diving board, which deforms when objects are dropped onto it. The switch produces a voltage signal which indicates the magnitude of the event and also the direction of impact. This information can be used, for example, in an industrial environment for the size-sorting of objects from a production line, and also for the counting of items for packing.

Such switches can be used to trigger on an acoustic event. They have even been designed in microwave ovens which monitor the 'popping' of popcorn to implement an automatic timing feature. Specialised PVDF switches have been developed for rehabilitation engineering projects where disabled individuals are capable of only very limited body movements. PVDF films, taped to the foreheads of Multiple Sclerosis sufferers, have been successfully used, for example, as inputs to computers acting as communication aids.

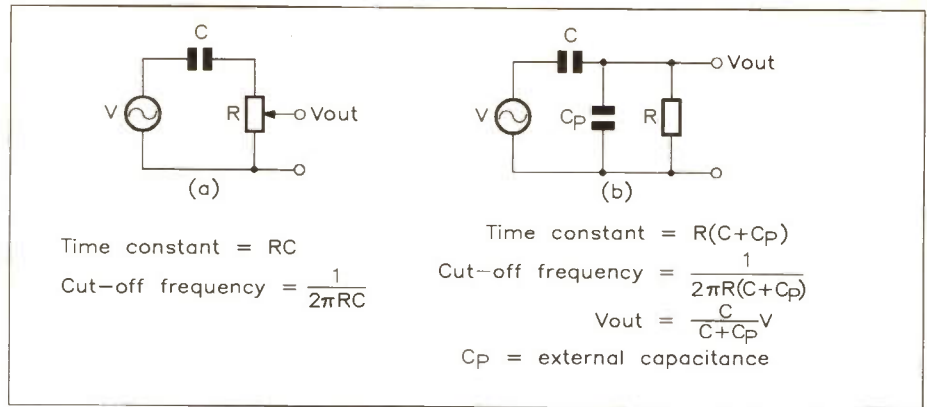


Figure 5. Circuits to reduce sensitivity of the element.

Impact Sensors

The range of so-called impact sensors relates to the need to both detect impact events and estimate the magnitude of the event. In terms of the resolution of the sensor array, manufacturing procedures allow 50 micron (0.050mm) resolution in the size of finite sensing elements. This allows impacts of extremely small objects to be measured quantitatively. Also, the nature of the piezo film allows a great variation of dynamic range of input force stimulus. A range from 10^{-12} gram force to 10^6 psi is possible.

These components have been developed as traffic sensors, where the signal is proportional to the weight-in-motion. Such a design has the advantage of being solid-state, with none of the problems associated with the mechanical contacts of conventional switches failing, due to continual use in heavy traffic conditions.

Use has been made of PVDF sensors for detecting the 'signature' of coins inserted into vending machines. Such films have also been used in the automotive industries, during research programmes, to record patterns of impact pressure on the facial features of dummies in car crash simulations. They have also been used to record pressure distributions, on the soles of the feet, of individuals with walking difficulties.

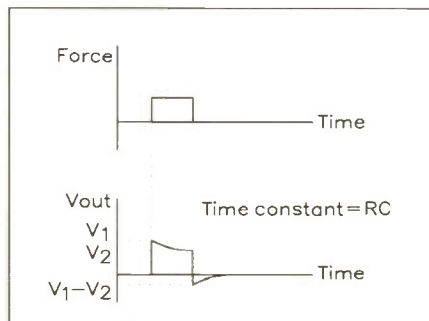


Figure 6. Typical voltage/time response associated with the application of a force to the piezo film element.

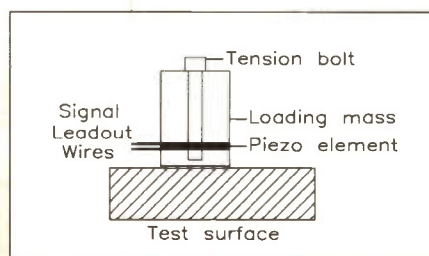


Figure 7. Design of accelerometer incorporating a piezo film element.

It is important to realise, however, that it is often difficult to isolate various types of mechanical deformation, and also temperature effects. If a film experiences pure compression, then one type of effect will be experienced, via the g_{33} stress coefficient. If the film is pulled, another effect (via the g_{31} stress coefficient) will be noticed. If the film is bent upwards, it will generate a separate signal. In addition, if the film's temperature is changed, it will develop a separate pyro-electric related signal.

It is important, therefore, that the way in which a PVDF sensor is mounted is clearly identified, in order to select which mode of signal is required to be detected.

As charge builds on the system due to piezoelectric effect, it also leaks away again as current leaks across the PVDF film and amplifier system. During an interval of time dt , when the voltage present is V across the load resistor R , the charge lost will be:

$$\frac{V \cdot dt}{R}$$

This will be equivalent to a fall in voltage of:

$$\frac{V \cdot dt}{RC}$$

where C is the equivalent capacitance of the sensor system.

The total 'lost' voltage can be calculated by summing the value of the expression $(V \cdot dt / RC)$ over all the time intervals of the measurement period. In analogue circuitry, this can be implemented using some form of integration circuit. Where data is sampled using an A-to-D converter, computer software can readily reconstruct the true pressure trace.

For systems where the impacts are occurring in times appreciably shorter than the time constant RC of the sensor system, the maximum uncorrected signal is a useful indication of the peak pressure across the sensor. The system then requires essentially a peak-hold circuit. For arrays of sensor elements, where each element is measuring a localised parameter, calibration parameters have usually to be determined separately for each element.

One novel 'impact' application in which PVDF films played a major role was the observation of comet debris in Halley's Comet (shown in Photo 2), as part of the European Space Agency's Giotto probe when it intercepted the comet back in 1986. When the comet's orbit takes it closer to our Sun, it gets warmer and emits streams of particles 'ahead of it' (the head or coma) and 'behind it' - the tail.

The Giotto spacecraft flew across the head of the comet, and areas of PVDF film recorded the impact of dust particles on its

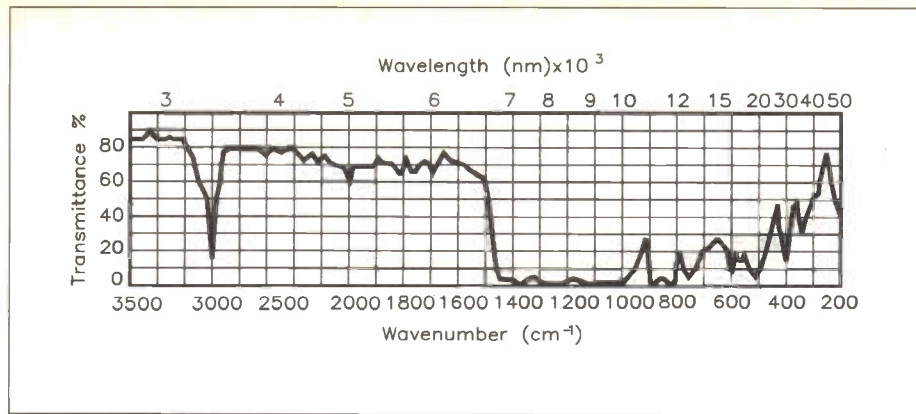


Figure 8. Infra-red absorption spectrum of piezo film.

body. Thus scientists on Earth could not only determine how many impacts were being detected, but also relate this to the size of particle – information based on the amplitude of the signal. Had the space probe passed directly through the tail of the comet, then it would have probably suffered greater damage than it did in fact experience. The probe was able to reveal the existence of ultra-fine dust particles in the head of the comet.

Accelerometer Components

Figure 7 indicates the typical design of an accelerometer unit. When the main mass, M, of the accelerometer moves up and down, the piezo sensing element in the unit experiences a force corresponding to the acceleration of the mass. On conventional accelerometer units, the piezo element is in fact a ceramic type. Increasingly, however, the piezoelectric element is a PVDF device. The lower cost of the piezo film option allows such devices to be produced at lower cost.

The typical bandwidth of such units is from 0.001Hz to 75kHz. Linearity is approximately 0.01%. Often, the dynamic range is important for vibration monitoring applications. Piezo film accelerometers typically have a very great dynamic range, extending from tens of nano g's to thousands of g's where 1g is the unit of acceleration in the earth's gravitational field.

Pyroelectric Sensitivity: Passive Infra-Red Sensors

The listed pyroelectric properties of piezo film will, for a typical sensor, typically produce a 1.5V output (open circuit) for a change in temperature of 1°C. This temperature change can result from thermal contact with an object, or from absorbed energy such as infra-red radiation. This is why it is important to separate force-initiated responses from ones related to temperature change.

Figure 8 shows the infra-red absorption spectrum of piezo film sensors. The visible spectrum is considered to end at 700nm wavelength. Infra-red radiation from objects in a given field of view can be focused onto the surface of a piezo film element and detected due to the voltage produced by the resulting change in temperature. This is the principle used extensively in intruder alarms.

One refinement, however, which piezo film fabrication technology allows, is for the sensitive piezo film surface to be produced

with a number of separate sensitive zones which are activated by radiation focused by a special lens structure. One such design can scan a field of view of greater than 180° into 24 individual zones. Such systems are therefore not only capable of detecting an intruder, but are also helpful in locating where the alarm has been triggered.

Vibration Sensors

Accelerometers tend to be used where their mechanical loading does not affect the vibrations they are trying to detect (this state of affairs could develop when the device is, for example, attached to a bridge or building). Piezo film elements can be attached to surfaces directly, picking up vibrations where their loading does not interfere with the vibrating structure they are monitoring. In this application mode, the frequency response is typically in the range 0.001Hz to 100MHz. The maximum sensitivity of such units is typically 30mV per micron of strain. Piezo film elements are able to cope with values of deformation as high as 4% strain in any axis direction.

An individual piezo film element can, for example, be attached to the surface of a guitar using double-sided adhesive tape, to transform the mechanical vibrations faithfully into a voltage signal. Often, however, considerable care is required in coupling vibrational energy into piezo vibration sensors. In the case of the guitar pick-up, various locations of attachment will have specific vibration responses. A simple microphone can be constructed by attaching a piezo film element, using double-sided adhesive tape, to a plastic cup. As the cup vibrates to sound, the resultant mechanical energy will be coupled to the piezo film – which transforms it into a voltage signal.

This experiment also highlights the problem of coupling vibrations effectively into the piezo film.

'Singing' Technology

In addition to their role as vibration sensors, piezo film devices can also be used 'in reverse' as vibration sensors and transducers, transforming voltage signals into vibrational energy using the technique of so-called 'singing technology'. There are many structures which have specific resonant frequencies of mechanical vibration. Simple examples would be that of a metal bar, or a membrane, under tension.

Singing technology typically uses one transducer to generate mechanical vibrations, and another to sense the level of mechanical vibration established in the structure. Where, for example, the driving signal is a frequency sweep, the frequency response of the structure can be identified. Systems where this technology has been used successfully include estimating the immersion depth of a structure in liquid, and the weight loading of various systems.

Summary

Piezo film technology allows access to a rapidly-expanding area of transducer/sensor technology. The scope of application is already considerable, and new applications of the basic film technology are constantly being developed. This area is also one which can be investigated at low cost by the interested electronics enthusiast.

Suppliers of PVDF Films

In the UK, Atochem Sensors Ltd. are the principal supplier of piezo film products. Individual sensors are available at relatively low cost and in addition, a sample of piezo film can be supplied so that the basic properties of the PVDF material can be investigated. A range of development kits are also available, to investigate further various aspects of the sensor material:

- Basic Design Kit
- Switch Kit
- Vibration Sensor and Accelerometer Kit
- Piezo Cable Kit
- IR (Infra red) Sensor Kit

Please note that these are *not* available from Maplin.

ATOCHEM can be contacted in Europe at: ATOCHEM Sensors Ltd., 22 Ridge Way, Hillend Industrial Park, Dunfermline, Fife, Scotland KY11 5JN. Tel.: (0383) 825063 Fax.: (0383) 825070.



Photo 2. Photograph of Halley's Comet, obtained in 1986.

Most board games involve a random element (chance), which is normally obtained cheaply and easily using wooden or plastic dice. Most of the dice commonly used in board games have six sides, although role-playing games, such as 'Dungeons and Dragons' so beloved by pure science students, frequently make use of dice of 18 (or more!) sides. However, a humble six-sided die – or this up-to-date electronic version (which, incidentally, contains two such dice) – may suffice if a multiple throw system is used. With this modern equivalent, a button is simply pressed and then released, the result being indicated by a pattern of 5mm red LEDs mimicking the standard die's number patterns. To conserve battery power the Electronic Dice has a 'time-out' function that blanks the display 30 seconds after the dice have been 'thrown'. One or two dice may be used; each may be selected by means of an optional switch – or the desired mode of operation may be obtained by permanently hard wiring the unit.

As the unit's internal oscillator operates in the region of 2.5kHz, it is too fast for the player to be able to predict when to release the button. It is possible to cheat, but you would need *extremely* fast reflexes!

Circuit Description

As can be seen from Figure 1, the circuit of the Dual Electronic Dice is a fairly simple design. Each oscillator is based around one of the Schmitt NAND gates in

DUAL ELECTRONIC D.I.C.E

Text by Martin Pipe and Nigel Skeels



FEATURES

- * Two independent dice; may be used in 'single die' mode if required
- * Displays are switched off after approx. 30 seconds to conserve battery power

* Bright LED Display

* Powered by a PP3 Battery

APPLICATION

Ideal for playing dice-based games in limited spaces, or on the move! (No more hunting for dice under the table!)

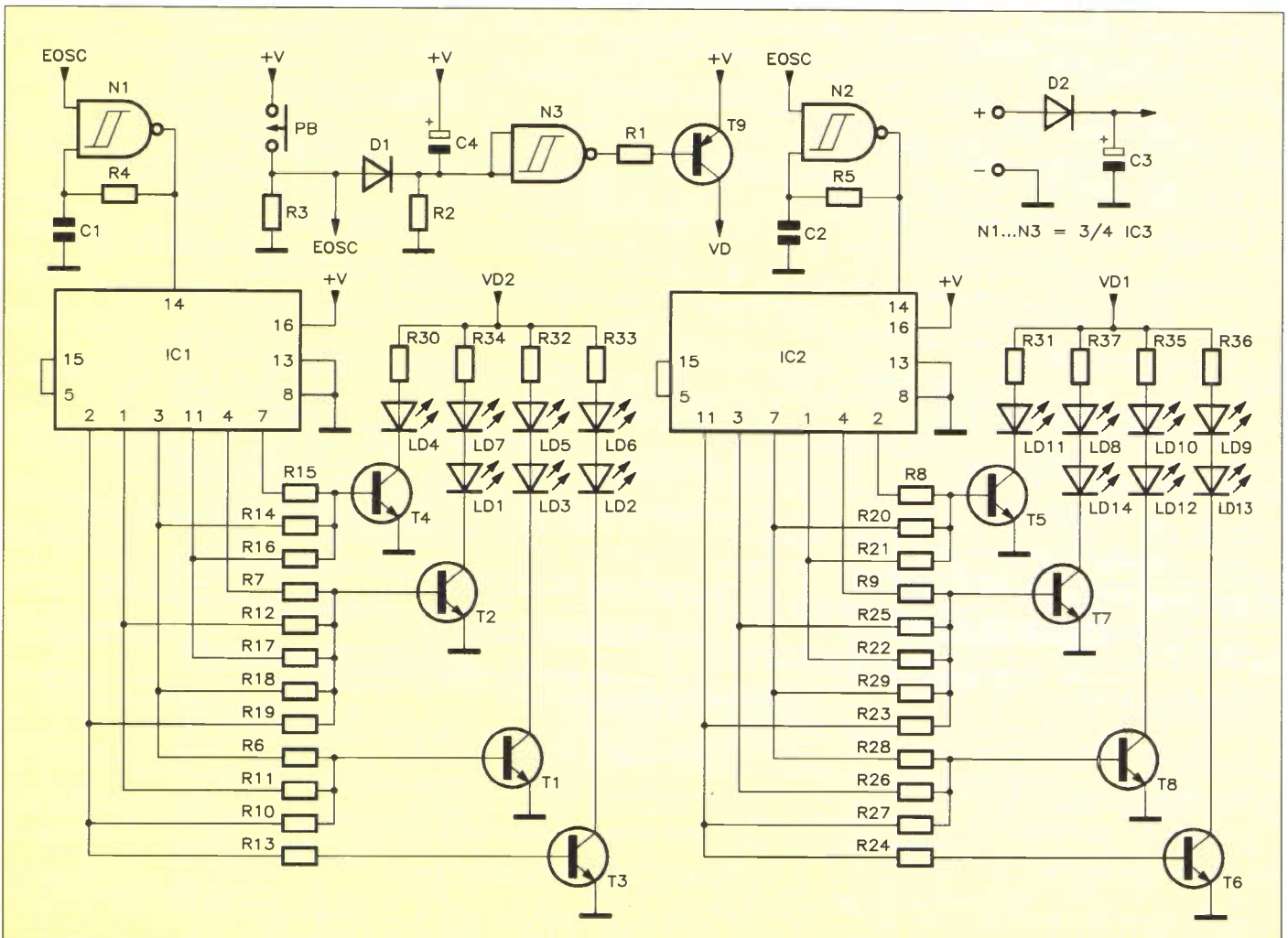
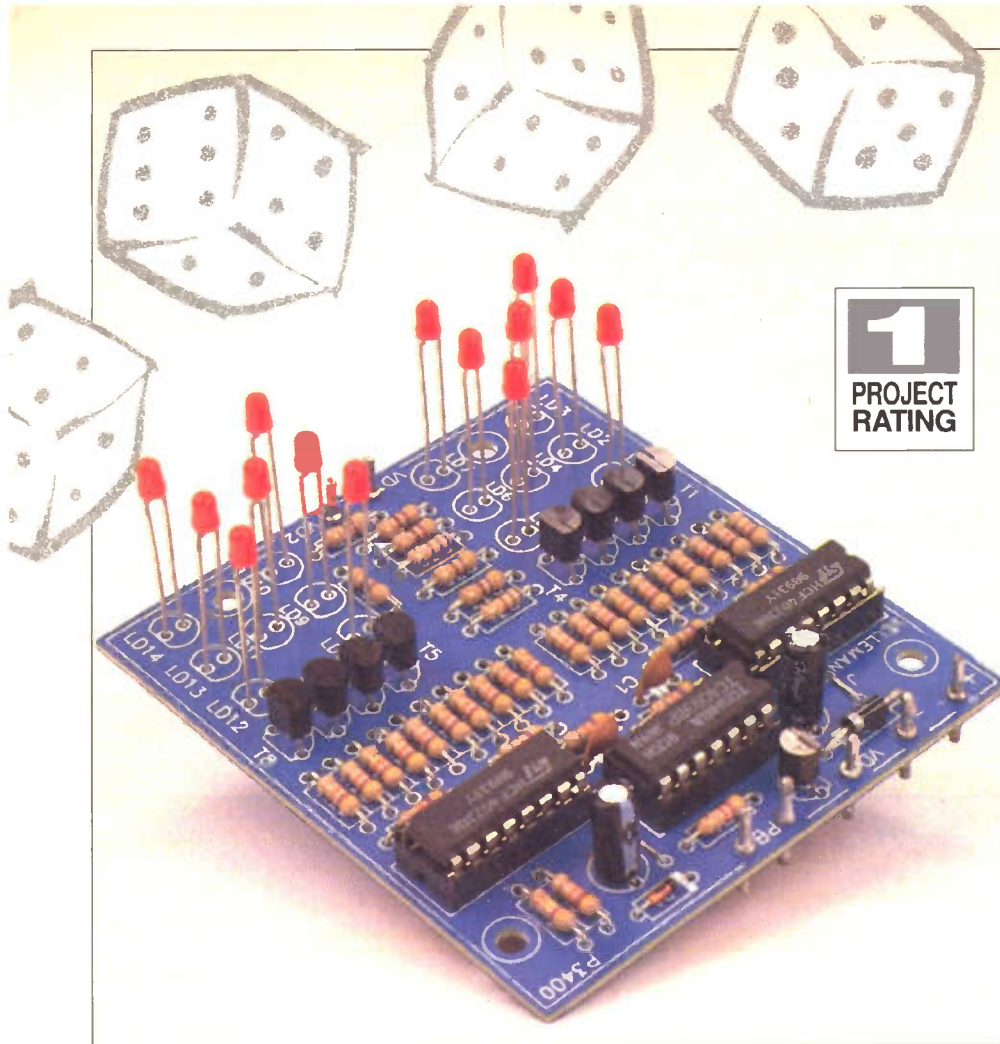


Figure 1. Circuit diagram of the Dual Electronic Dice.



1
PROJECT
RATING

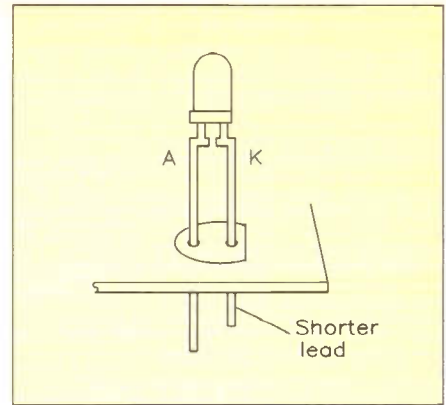


Figure 2. Installing the LEDs

practical advice on how to solder, component identification and the like. Order of construction is not important. The two wire links can be made from component lead off-cuts.

Be sure to insert the polarised components (LEDs, diodes, transistors) the correct way round; in addition, note that most component leads will need pre-forming before they can fit neatly to the board prior to soldering. When fitting the transistors, note that T9 is an PNP transistor (BC557 or equivalent) and must not get interchanged with one of the others (all the rest are BC547 NPN devices)! All transistors should be fitted so that their outlines match those depicted on the PCB legends. Care must be exercised when fitting each LED; the cathode wire, which is the shorter of the two, must

The completed Dual Electronic Dice.

IC3, a CMOS 4093 device. The operating frequency of the first die is determined by the values of R4 and C1 (R5 and C2 for the second die); with the supplied components this frequency is around 2.5kHz. The outputs of each oscillator are fed to pin 14 of IC1 (1st die) and IC2 (2nd die). These two ICs are 4022BE divide-by-8 counters. In the counter circuits of both dice, pin 15 (reset) is linked to pin 5, which goes 'high' as soon as the counter has reached 6; this has the effect of starting the counter again. Consequently, the result will never exceed six i.e. the number of faces on the non-electronic (very solid-state?) die. The outputs of IC1 and IC2 are decoded by a series of resistors that act as discrete OR gates and, along with transistors T1 to T4 (1st die) and T5 to T8 (2nd die), drive the LEDs.

When the 'throw' button PB1 is pressed, its contacts close, C4 discharges and the oscillators run. If PB1 is then released, the oscillator (and thus the counter) will stop, displaying the outcome of the 'throw'. Whilst in this state, C2 charges through R2. Approximately 30 seconds later, determined by the time constant of C4 and R2, the output of the Schmitt NAND gate (another of those in IC3) will drop to 0V, thus allowing T9 to switch off and blank the display.

Construction

Construction is fairly straightforward, and full details are given in the leaflet supplied with the kit. If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful

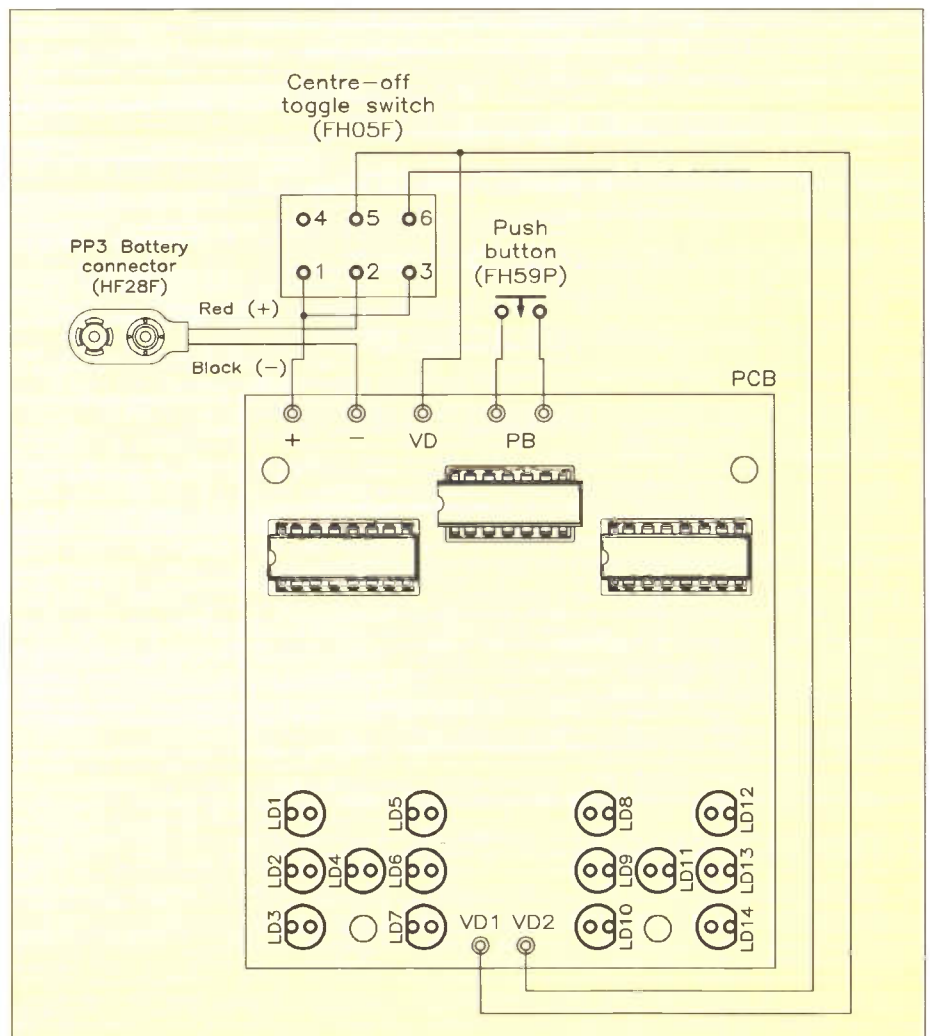


Figure 3. Wiring diagram.

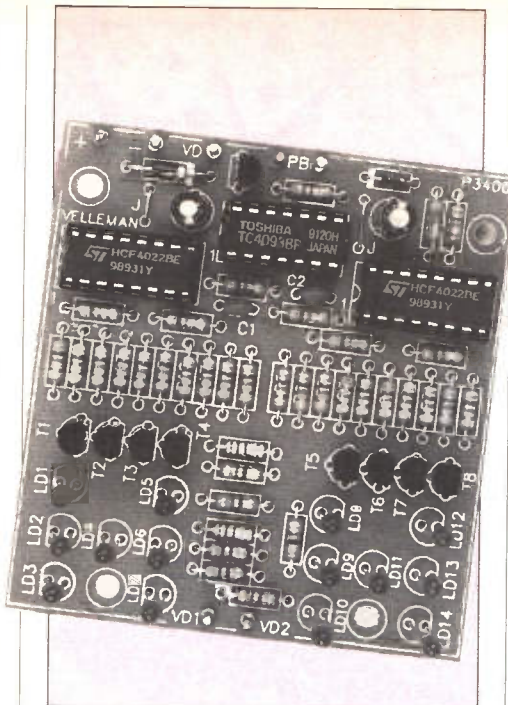


correspond with the 'flat' side of the LED symbol printed on the PCB overlay; see Figure 2. In addition, the orientation of the ICs are also critical; note that these three components are fitted in IC sockets. The sockets, rather than the ICs themselves, should be soldered in place – the ICs should be inserted just before testing.

When fitting the seven PCB pins, note that they are also fitted from the component side. After completing assembly, it is prudent to check your work – finding any incorrectly-placed components could save considerable time and expense later on. Other gremlins to watch out for include solder bridges/whiskers and poor joints.

Testing and Use

Terminal VD should be connected to VD1, VD2, or both VD1 and VD2; a 2-pole changeover switch could be used, so that the relevant number of dice can easily be



selected for different games (see Figure 3) and also conserving battery power. A DPDT switch with a centre 'off' position (such as FH05F) is recommended in this application. A push-to-make switch (FH59P) should be connected across the two PB terminals, as shown in Figure 3. A press of this button throws the dice.

A power supply (8 to 12V DC) also needs to be added – bearing in mind the use of the Dual Electronic Dice, a 9V PP3 battery is ideal in this application; it should be connected to the '+' and '-' terminals of the PCB; refer once more to Figure 3.

The Dual Electronic Dice can be housed to suit your particular requirements; a complete range of cases may be found in the boxes section of the current Maplin catalogue. As a low cost alternative, the transparent box in which the kit was supplied could also be used – no drilling required for the LEDs!

DUAL ELECTRONIC DICE PARTS LIST

RESISTORS: (All 0.25W 5% Metal Film)

R1	4k7	1
R2	470k	1
R3 to 29	47k	27
R30,31	680Ω	2
R32	470Ω	5

CAPACITORS

C1	390pF Ceramic	1
C2	470pF Ceramic	1
C3,4	100μF 16V Electrolytic	2

SEMICONDUCTORS

D1	1N4148 or equiv.	1
D2	1N4000 or equiv.	1
LD1 to 14	Red LED 5mm	14
TR1 to 8	BC548 or equiv.	8
TR9	BC558 or equiv.	1
IC1,2	4022BE	2
IC3	4093	1

MISCELLANEOUS

14-Pin DIL Socket	1
16-Pin DIL Socket	2
PCB Pins	7

PCB	1
Construction Leaflet	1
Tinned Copper Wire	1 Length

OPTIONAL (Not in Kit)

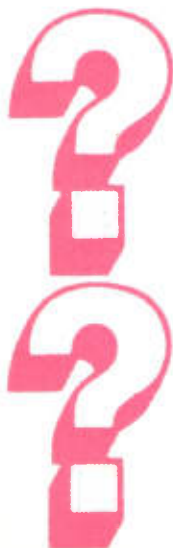
Constructor's Guide	1	(XH79L)
Centre-Off DPDT Toggle	1	(FH05F)
Push-to-Make Switch	1	(FH59P)
Alkaline PP3	1	(FK67X)
PP3 Battery Clip	1	(HF28F)

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

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

Order As VE07H (Dual Electronic Dice) Price £11.95.

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



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The First Picture Show



A Telewriter, as used in 1912.

It is a century and a half since the Highland clockmaker Alexander Bain proposed "...a kind of forerunner of the 'wire-picture' apparatus of today". Bain was already known for this application of magnetism to the clock pendulum, and as the inventor of the inked ribbon for typewriters – an essential part of his chemical telegraph of 1841. As far as his patent and proposal of the following year was concerned though, he was ahead of his time and its technology.

The further advance of his ideas had to wait for Fredrick Bakewell's 'cylinder-and-screw' arrangement, on which the optical carriage drive of many subsequent systems would rely, and some form of device to convert sunlight into electricity.

By 1875, the American electrical

~ by Greg Grant ~

A History of Facsimile Transmission

engineer G. R. Carey had developed a crude selenium device capable of converting light into electricity. Although this pointed the way to the photoelectric cell, selenium was very inefficient "turning less than 1% of the energy of sunlight into electricity". Carey attempted to improve this result by arranging his devices in cells, but it required hundreds of his devices, lamps and wires to handle even the mediocre quality of a newspaper photograph.

Three years later one of the earliest forms of facsimile equipment appeared. The Telewriter (or Teleautograph) was, as its name implied, specially created for handwriting. Designed by E. A. Cooper, the device consisted of a pencil connected to the arms of a pantograph that regulated the currents transmitted

as the pencil moved across the writing desk. At the receiving terminal, the line currents controlled another set of pantograph arms carrying a recording pen.

When the transmit pen was lifted from the writing surface, the receive pen faithfully followed. Like the present-day computer mouse which remains effective only on its mat, the telewriter pen remained communicative only within the parallel lines of the writing desk. Although transmission speed was slow, the equipment was widely used for short distance point-to-point links, mostly by the Post Office.

In 1904, the German physicist Arthur Korn developed a photoelectric cell especially for wire transmission. Two years later he transmitted a picture of the German Crown Prince over a distance of 1800 kilometres.

His equipment was based on an invention of the Italian physicist Luigi Cerebotani that enabled a photograph to be taken a small portion at a time. From each 'take', an electric current was produced that corresponded to the portion's shades of grey.

In 1907 the first newspaper photograph – one of King Edward the 7th – was transmitted from the Paris office of 'L'Illustration' to the London office of the 'Daily Mail'.

In the following year, a photograph dispatched from Paris to London enabled Scotland Yard to apprehend a criminal; some 18 months before Doctor Crippen would do more to publicise the new technology of radio than even Marconi had managed!

The First World War inhibited facsimile development somewhat, but by the early 1920s the big names in the rapidly evolving radio industry on both sides of the Atlantic were getting distinctly interested. In 1924, two Bell Laboratories engineers, Frank Grey and Herbert Ives, used equipment they had developed to transmit a photograph from the Cleveland and Chicago presidential conventions to New York, using the public telephone network.

The Radio Corporation of America (RCA) also became actively involved in facsimile development, as well. One of RCA's engineers, R. H. Ranger, designed a system synchronised at both transmitter



This 1935 photograph, shows the drum, containing the original picture, being loaded into the sending machine.

and receiver by tuning fork oscillators. It was with this equipment that the first radio transmissions of still pictures were conducted between the United States and the United Kingdom.

In the following year, Grey and Ives transmitted a photograph of US Secretary of Commerce Herbert Hoover, using a combination of landline and radio, from Washington D.C. to New York – a distance of some 200 miles.

In 1929, the Marconi Company entered the field with equipment designed by G. M. Wright, later to be the company's Chief Engineer. After a demonstration to the press, the equipment was used on a transatlantic trial between Somerton, Somerset and Rocky Point, New York. Here at last was "...true facsimile; documents and Press material of all kinds including photographs could be transmitted across the Atlantic at high speed – three minutes was an average time for a photograph"³. Five years later, facsimile was sufficiently established for Cable and Wireless Ltd., to begin a service between Britain and Australia using the Wright-Marconi equipment. In 1935 Zworykin, Morton and Malter of RCA developed the photo-multiplier tube which improved the facsimile image quality considerably.

Transmission

Figure 1 shows the general arrangement of an original 'wirephoto' or facsimile transmitter. The photograph was wrapped around the drum and kept in place by clips. The drum was then rotated about its axis while being driven along this axis under a fixed light spot. The area being scanned reflected the light in varying degrees, and these reflections were then focused onto a photoelectric cell, which produced an output voltage directly proportional to the reflected light incident upon it.

Long since obsolete, the chopper disc was a method of converting the signal into a modulated waveform, the frequency of the carrier being determined by the disc speed. Later systems used photomultipliers and solid-state oscillators to achieve the same end.

In the original equipment, the spot was formed by a small aperture mask.

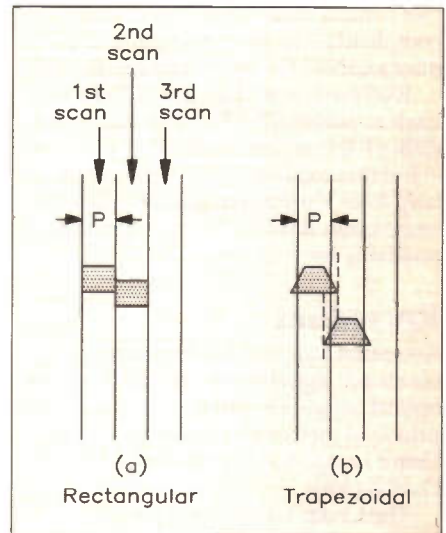


Figure 2. The two major shapes of scanning spot in a phototelegraphy system.

A more modern method was to focus a much smaller spot of light onto the photograph, thus obviating the need for both aperture and mask. Nevertheless, the former method was often preferred, as the distortion caused by the drum's mechanical irregularities was less noticeable.

The output signal's waveshape was determined by the shape of the scanning spot. As Figure 2 shows, the most effective spot shape was rectangular. Occasionally a trapezoidal spot was used such that the average length of the top and bottom sides equalled the scanning width or pitch, P; although the corners of the spot overlap on successive scans, the average area-of-overlap illumination was the same as that over the remainder of the spot area.

Modern facsimile machines do not use a drum; instead, the image of the document to be scanned is focused onto a solid-state image sensor (e.g., CCD or photodiode array), a fine line (not a line of text!) at a time. Such electronic machines have been replacing the bulky drum-based 'analogue' machines since the mid-1970s – although some argue that the older systems produced a better

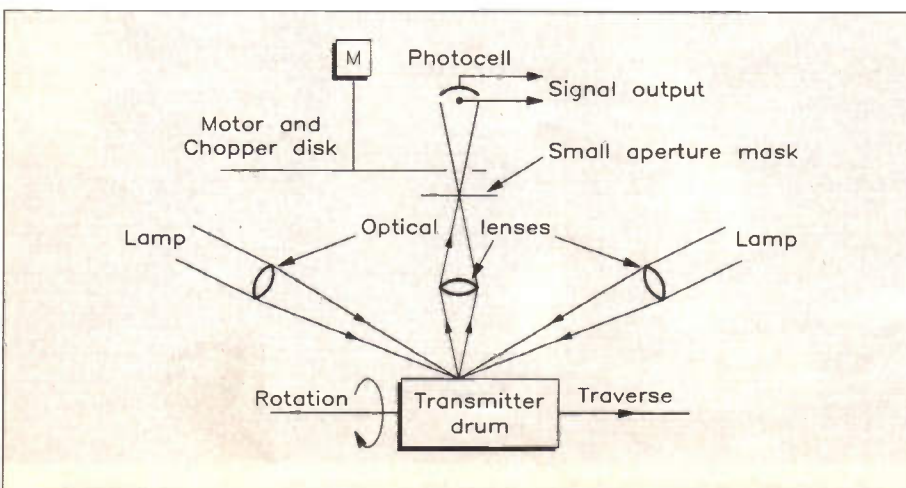


Figure 1. System layout of an early facsimile transmitter.

image quality. This, for most applications, did not matter. The main advantage with the first 'all-electronic' machines was that transmission time, with the then new concept of 'data compression', could be greatly reduced. As time went by, however, clever electronic design offered many features that could never be built into the older systems – such as automatic dialling and document storage memories.

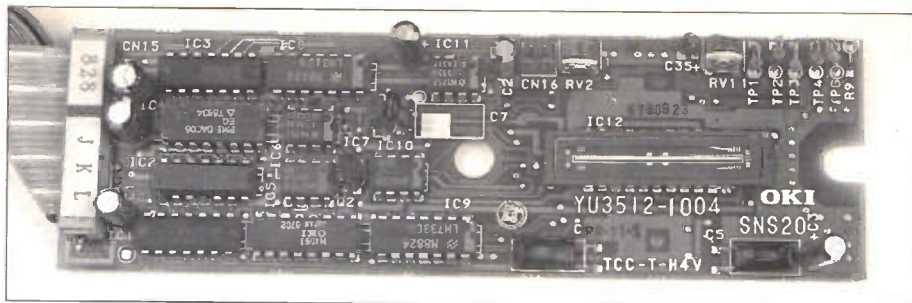
The light source used depends on the characteristics of the imager used, but is typically a fluorescent tube with a high 'green' output. Modern machines are much more reliable; the numbers of moving parts have been considerably reduced. Generally, the document is passed through the mechanism in a linear fashion whilst being scanned from top left to bottom right. Theoretically, the only moving part is the feed-roller, which is belt-driven by a stepper motor. Although the mechanics (in most cases) have been simplified, the electronics that control them are of formidable complexity – as the photograph of a disassembled Group 3 machine shows!

Electronic assembly (on PCBs) lends itself to automation far more easily (less difficult?) than the mechanics, however – and this explains why, with a little help from Far-Eastern mass-production techniques, modern fax machines are relatively inexpensive.

Reception

Reception required the incoming electronic signal to be converted into an optical image. Originally, there were two principal methods of doing this – the Crater Lamp, and the Duddell Mirror Oscillograph.

The Crater Lamp was a glow-discharge tube containing argon, helium or neon. It could be used as a point source of light, the intensity of which was broadly proportional to the voltage



The image sensor board of a modern fax machine, the sensor itself can clearly be seen to the right of the photo.

across it. A signal voltage applied to the lamp produced a light that mimicked this voltage. The light was then focused onto the photographic paper fixed to the receiver drum.

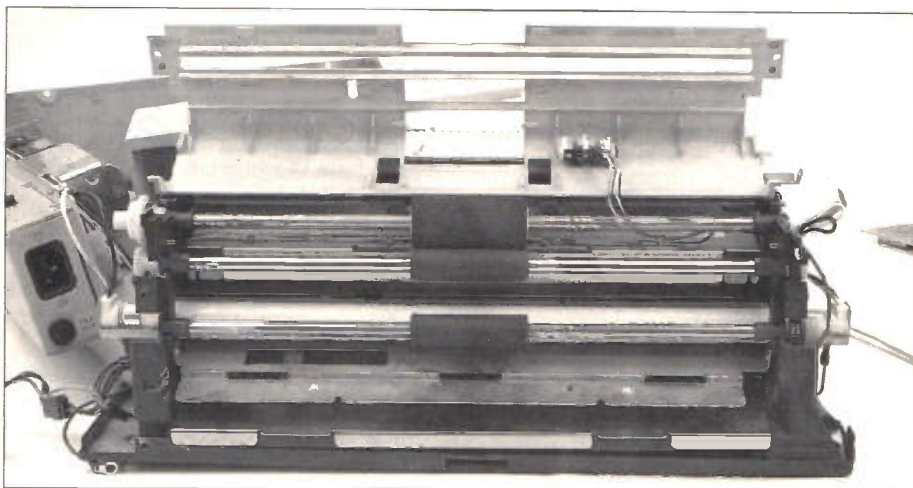
Unfortunately the Crater Lamp system could not handle the maximum black-to-white range of some photographs, which in certain cases can amount to 30dB (a voltage ratio of some 32:1). Nevertheless, with a range of around 16dB, the system could handle the majority of pictures.

The Duddell Mirror Oscillograph, invented by the British physicist W. D.

Duddell in the early years of this century, is shown in Figure 3.

The device consisted of a tiny mirror, about 0.2 x 0.5 centimetres in size, mounted on a small coil of fine wire. When the whole assembly was placed in a magnetic field, and the received signal passed through the coil, it would deflect in proportion to the signal current.

The beam from a light source was focused onto the coil-mounted mirror, from where it was directed onto the paper (or film) on the receiver drum via a series of apertures, lenses and mirrors.



The paper feed mechanism of a modern fax machine. The fluorescent light tube can also be seen.



In 1930, the Post Office opened a 'Picture Telegraphy' service initially to Berlin. Using Siemens-Karolus equipment, the sending and receiving machines are either side of the control panel on the right.

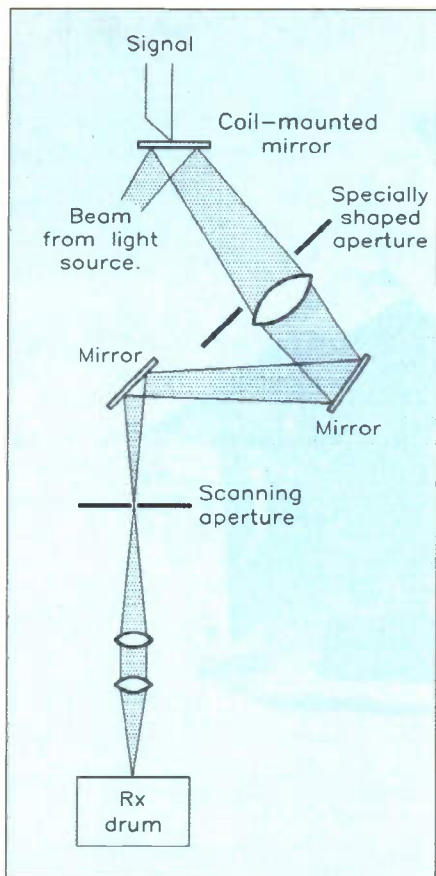


Figure 3. The Duddell Mirror Oscillograph in a phototelegraphy receiver.

The maximum deflection of the mirror could be made to equate to maximum light if photographic paper was being used to give positives, or a minimum deflection could be arranged if negatives were required. Since they can be processed faster, positives were usually the chosen method, since the meeting of publishing deadlines was (and still is!) paramount!

Negatives, however, have some singular attractions. To begin with, many copies can be made from the original – and secondly they can be retouched, thus ‘improving’ the final picture quality. The latter may also have been of benefit to certain unscrupulous newspaper editors!

Photographs aside, documents were also transmitted – particularly after the introduction of tuning fork oscillators and synchronous motors made synchronisation thoroughly reliable.

The receptive material used in the early document receivers was as varied as both the equipment and the manufacturers. Alexander Bain’s earliest efforts involved paper impregnated with starch-potassium-iodide solution. When the received current passed through this paper it left a black-brown image.

More recently, a similar technique was employed in the American Hogan Facs-News system and the British Mufax equipment, produced by Muirhead and Company. Naturally, the paper and impregnation solutions had improved since Bain’s day.

Muirhead, for example, used a resin-bonded sulphite pulp paper, the characteristics of which were great

absorbency and high wet strength, the latter limiting ‘spreading’. As the paper passed between the recording electrodes or a helix and writing edge, the received current “...caused the dissociation of the electrolyte, and one of the dissociation products reacted with the stylus to form a metallic salt. This in turn reacted with the colour-forming substances to colour the paper”, the colour depending on the metal used.

There were three essential criteria that influenced communication using the original facsimile system – namely correct phasing, synchronisation and index of co-operation, or IOC. Synchronisation ensured that the received signal was the exact copy of that transmitted. This was achieved by a signal, set by international agreement at 1020Hz. The transmitter drum speed was directly related to this tone and the receiver drum speed was stroboscopically adjusted to the relationship, giving an accuracy of one part in 100,000 or – put

another way – if the transmitter was sending at 60 rpm, then the receiver drum would stay within ± 0.0006 rpm of this speed.

Phasing performed one specific function in picture transmission – ensuring that the picture-retaining clips did not impinge on the transmitted copy.

The receiver operator adjusted the drum speed to the correct setting using the synchronisation tone, and located the drum on the ‘start’ position. The transmitter then sent a pulsed ‘start’ signal which tripped the switch, latching the receiver drum and message reception began, synchronised and in phase.

The ratio of picture height to width is termed the Index of Co-operation (IOC), a ratio which depends upon the scanning pitch and the diameters of the receiver and transmitter drums. What can happen when a facsimile system’s speed and phase are incorrect, or there are differences in transmit or receive IOCs, is illustrated in Figure 4.

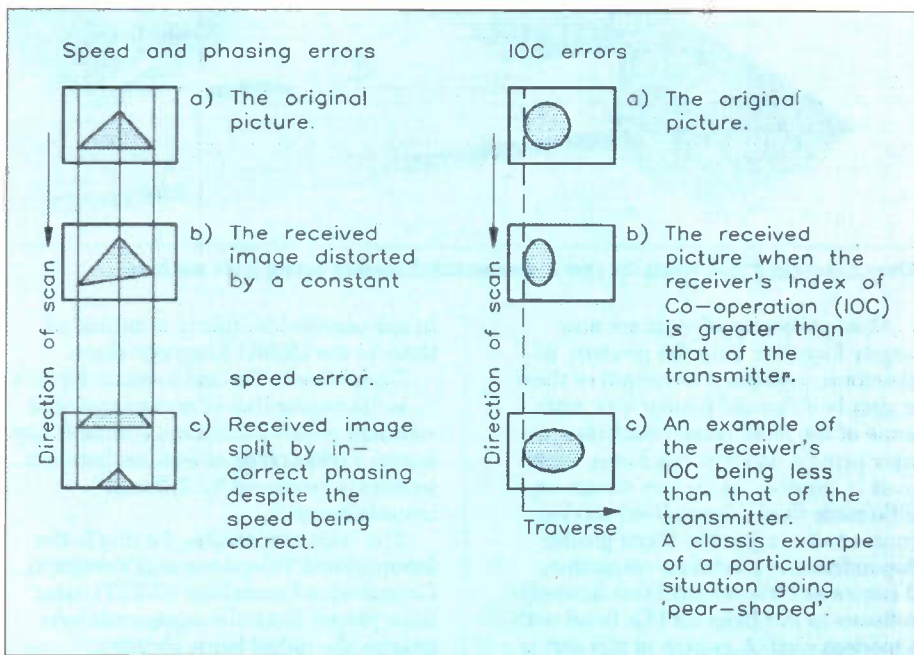
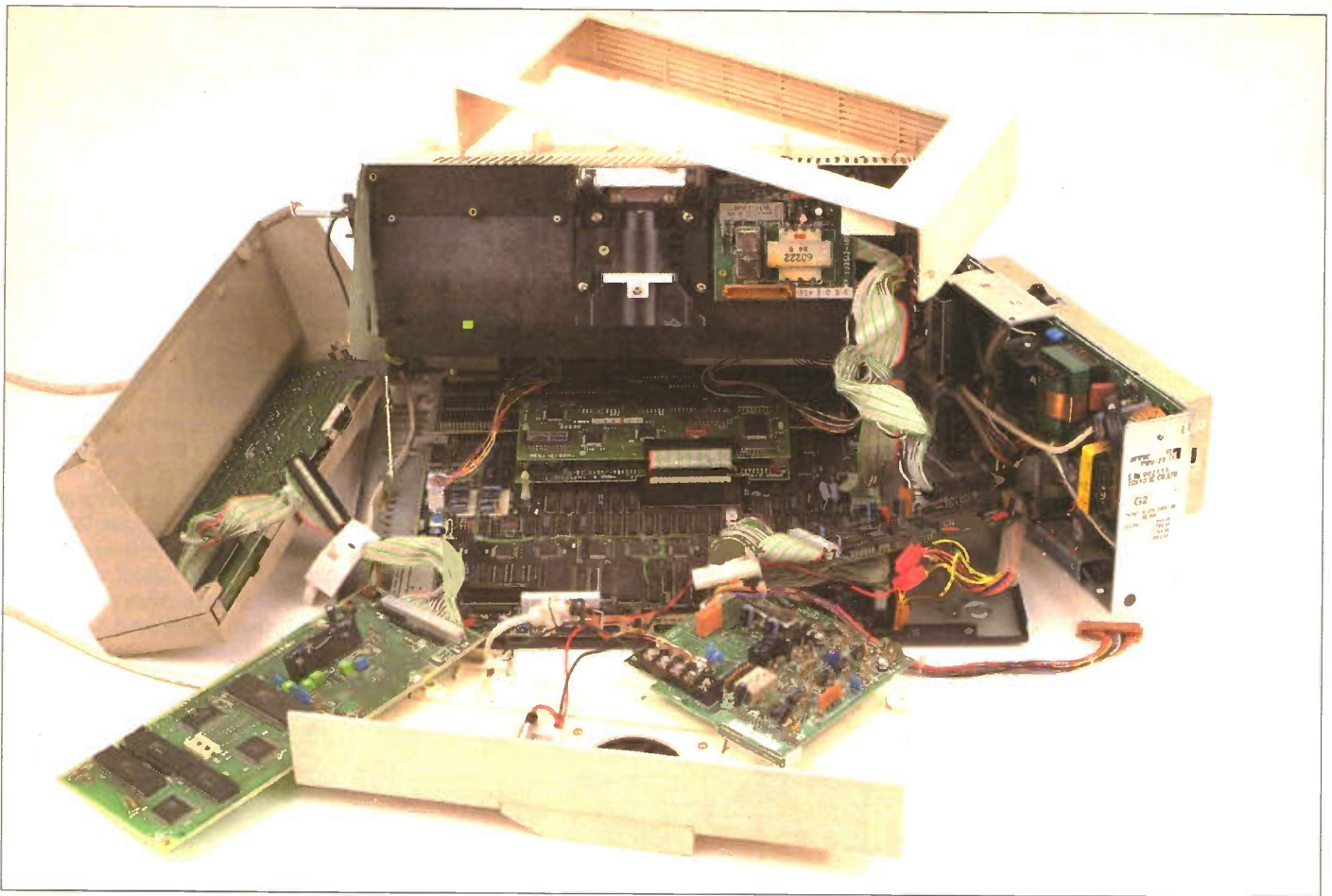


Figure 4. Problems with early facsimile transmission.



The 1951 Muirhead ‘Mufax’ equipment in use, showing the control panel.



There's more to it than meets the eye! A disassembled modern Group 3 fax machine.

Most of these problems are now largely forgotten with the modern, all-electronic systems. The output of these is simply a thermal printer – or, with some of the more recent machines, a laser printer. Modern machines, when used in 'receive' mode, are effectively little more than a specialised modem connected to a printer. Since greater dependence is placed on computers, it comes as little surprise that facsimile software is available for PCs fitted with a modem card. A system of this sort is in use at the 'Electronics' editorial office.

Economy of Bandwidth

To transmit a short message – for example, a telegram – in a reasonable time over a facsimile system requires a bandwidth akin to that of a good quality telephone line, about 2kHz. A teleprinter, on the other hand, would only use some 120Hz. For short distances (up to 40 miles) this did not matter, but beyond this it was far more economical to use channelling equipment and have a number of teleprinter channels transmitting over one telephone circuit.

Thus, as recently as the 1970s, facsimile was still "...largely employed for transmitting press photographs... weather maps and allied information".

More on the Modern

Since the 1970s, however, facsimile growth has been spectacular. Figures available at the time of writing reveal that there are over 20 million transceivers

in use worldwide, nearly 2 million of them in the United Kingdom alone.

Undoubtedly the main reason for this "...is the availability of an international standard which guarantees compatibility across a wide range of features between terminals produced by different manufacturers".

The body responsible for this is the International Telephone and Telegraph Consultative Committee (CCITT), who have placed facsimile equipment into groups, the oldest being Group 1, standardised in 1968. The latest groups are 3 and 4 which were standardised in 1980 and 1984 respectively.

Group 3, which is in widespread use today, could be termed the first 'modern' facsimile system. Its data signalling rate is 4800 baud (bits per second) giving a 1 minute transmission time for the average A4 document which, as has been revealed, is scanned from top left to bottom right. Across the page, every line is subdivided into 1728 picture elements, or pixels. Vertically, the page is scanned at 3.85 lines per millimetre, giving some 1145 lines per page.

This gives a total of some 2 million bits per page. If the information had been transmitted as 1 bit per pixel at 4800 baud, the transmission time would

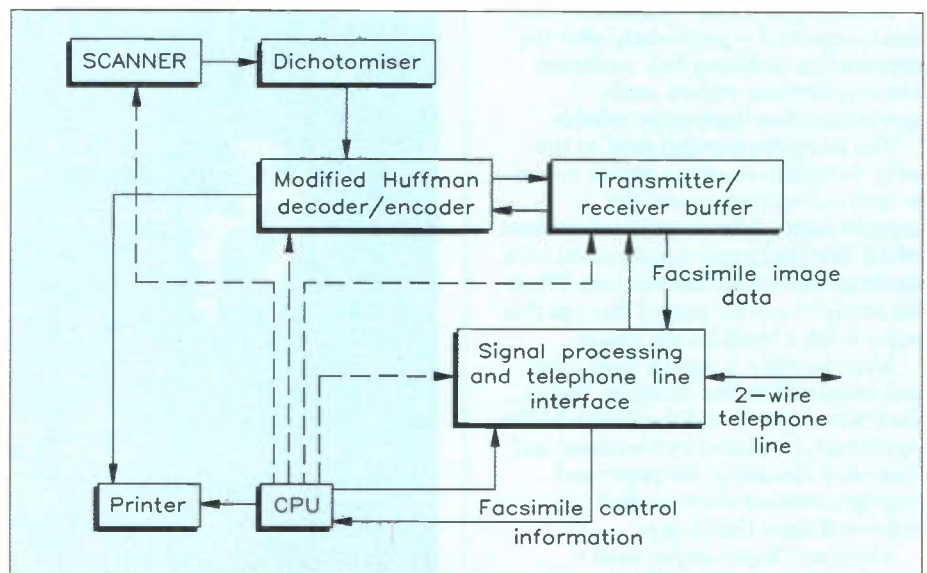


Figure 5. Block diagram of a typical digital facsimile transceiver.

have totalled nearly 7 minutes. This problem is overcome by a technique known as 'redundancy coding', where the shortest codeword is allocated to the most commonly occurring event. The system was developed in the early 1950s by David Huffman, an expert in information theory at the Massachusetts Institute of Technology. The version used by the CCITT is known as modified Huffman, or the MH system.

Figure 5 illustrates a typical digital facsimile transceiver. The document to be transmitted is scanned a line at a time, each line consisting of many pixels which are dichotomised into ones and zeros before being temporarily stored. The picture data is then passed to the line via a modulator.

Figure 6 shows the procedure by which a single page of A4 text is transmitted. The set-up activity consists of the exchange of control information at 300 baud, followed by a 9600 baud line quality test.

This is followed by another exchange of control information where the receiver can request a lower transmission rate if the performance and quality at 9600 baud is unacceptable. When a suitable data rate has been decided upon, the document is transmitted. The final 300 baud information exchange clears the call.

It was as much "...a large customer demand from Japan" as international standards, or low-cost equipment, that brought facsimile in from the margins.

The Japanese language consists of two syllabic writing systems: the Hiragana, employed in newspapers and general literature; and the Katakana, used for foreign or foreign-derived words. Both systems are expressed in almost 2,000 different Kanji characters, themselves of Chinese origin.

Where the simplicity of the Latin alphabet made teleprinting desirable, the complexity of the Japanese written word made facsimile essential. Where the Japanese have led, the rest of the world has followed and in its 150th year facsimile, powerfully aided by modern technology, has achieved a ubiquity once the prerogative of telegraphy. There can be little doubt that, as the 21st century approaches, it will supplant teleprinting as the leading form of document communication.

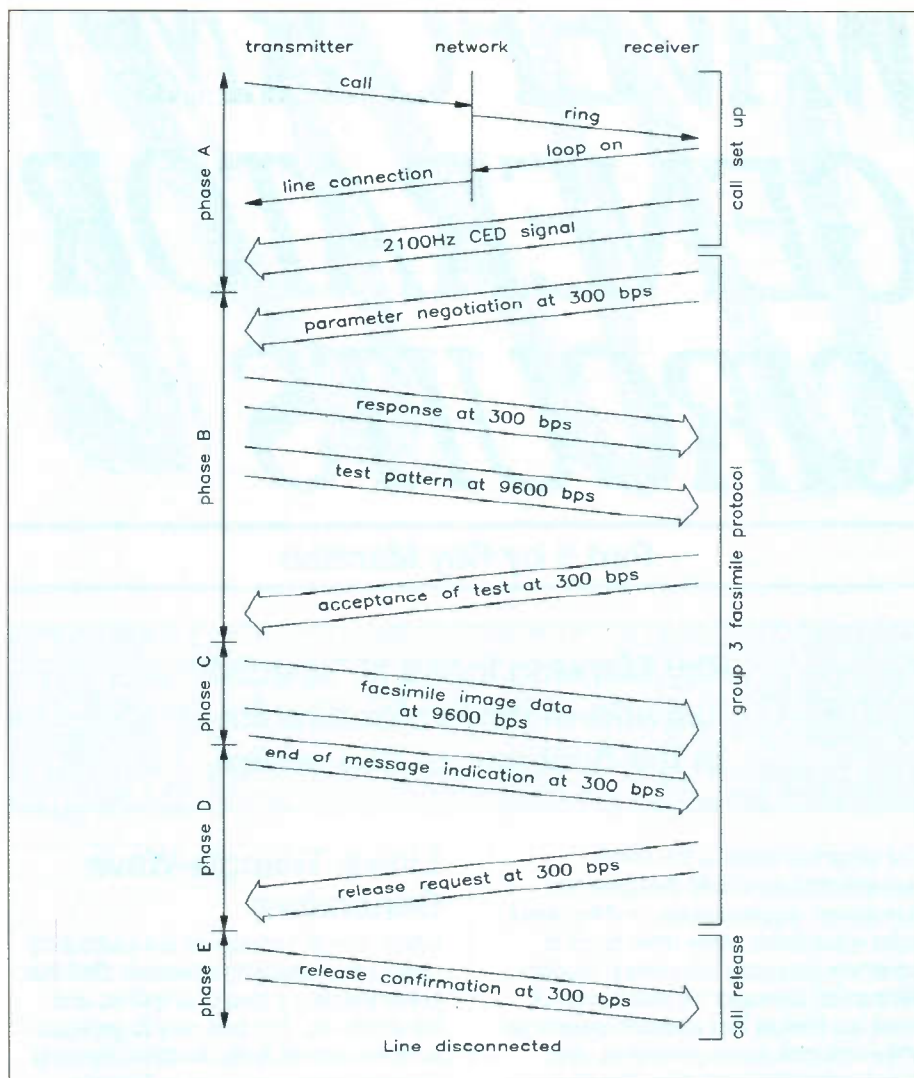


Figure 6. The transmission sequence for the facsimile transmission of an A4 page of text.

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WAVEFORM GENERATOR CIRCUITS

Part 5 by Ray Marston

Ray Marston looks at 'special' waveform generator circuits in the final part of this series.

The other four parts of this series concentrated on circuits that generate sine-waves, square-waves, and triggered pulse waveforms. Many other types of waveform generator are used in modern electronics; amongst the best known of these are triangle and sawtooth generators, white- and pink-noise generators, and crystal-controlled oscillators. Practical waveform generator circuits of all these types are described in this final part.

Linear Triangle-Wave Generators

Linear triangle waveforms are particularly useful when checking crossover distortion in low-frequency (audio) amplifiers and Op-amps, etc. The best way to generate such waveforms is via the basic Op-amp 'function generator' circuit of Figure 1, which also generates a useful square-wave output waveform. Here, IC1 is wired

as an integrator, driven from the output of IC2. IC2 is wired as a differential voltage comparator, itself driven from the output of IC1 via potential divider R2-R3. The square-wave output of IC2 switches alternately between positive and negative saturation. The circuit functions as follows:

Suppose initially that IC1's output is positive and IC2's output has just switched to positive saturation. The inverting input of IC1 is a virtual earth point, so a current, i of $+V_{sat}/R1$ flows into R1, causing IC1's output to start swinging down linearly at a rate of $i/C1$ volts per second. This output is fed, via the R2-R3 divider, to IC2's non-inverting input, which has its inverting terminal referenced directly to ground.

Consequently, the output of IC1 swings linearly to a negative value until the R2-R3 junction voltage falls to zero, at which point IC2 enters a regenerative switching phase in which its output abruptly switches to negative saturation. This reverses the inputs of IC1 and IC2, and so the output of IC1 starts to rise linearly, until it reaches a positive value at which the R2-R3 junction voltage reaches the zero volts reference value, initiating another switching action. The whole process then repeats ad infinitum.

Important points to note about this circuit are that the peak-to-peak amplitude of the linear triangle waveform is controlled by the R2-R3 ratio, and that the operating frequency can be altered by changing either the ratios of R2-R3, the values of R1 or C1, or by feeding R1 from a potential divider connected to the output of IC2 (rather than directly from IC2). Figure 2 shows a practical variable-frequency triangle/square generator using the latter technique.

In Figure 2, the input current to C1 (obtained from RV2-R2) can be varied over a 10:1 range via RV1, enabling the frequency to be varied from 100Hz to 1kHz; RV2 enables the full-scale frequency to be set to precisely 1kHz. The amplitude of the linear triangle output waveform is fully variable via RV3, and that of the square-wave output via RV4. The square-wave output gives typical rise and fall times of less than 1µs.

The circuit of Figure 2 generates symmetrical output waveforms, since C1 alternately charges and discharges at equal current values (set by RV2-R2, etc.). Figure 3 shows the circuit modified to make a variable-symmetry ramp and square-wave generator, in which the slope of the ramp and the mark/space ratio of the square-wave is variable via RV2. C1 alternately charges via R2-D1 and the upper half of RV2, and discharges via R2-D2 and the lower half of RV2.

A UJT Linear Sawtooth Generator

Linear sawtooth waveforms are widely used as timebases for oscilloscopes and wobblers, for example. One of the easiest ways to make a linear sawtooth generator is to use a unijunction (UJT) in the configuration shown in Figure 4. Here, TR1 (plus R1, D1, R2, RV1, and R3) are wired as a constant-current generator, with current variable from 35µA to 390µA via RV1. In each operating

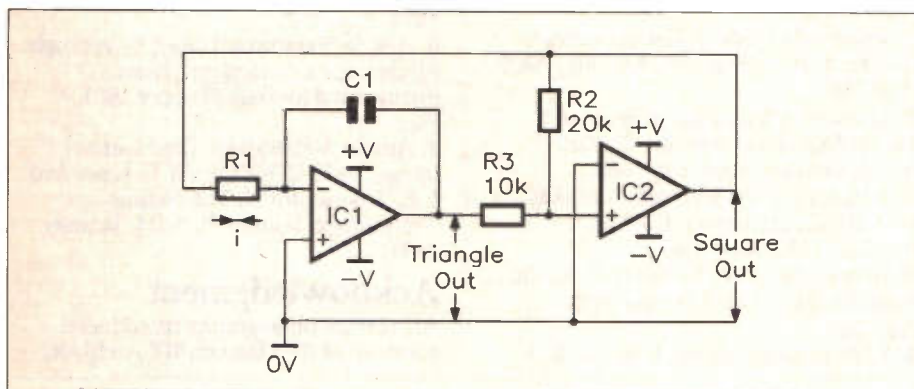


Figure 1. Basic linear triangle-wave generator.

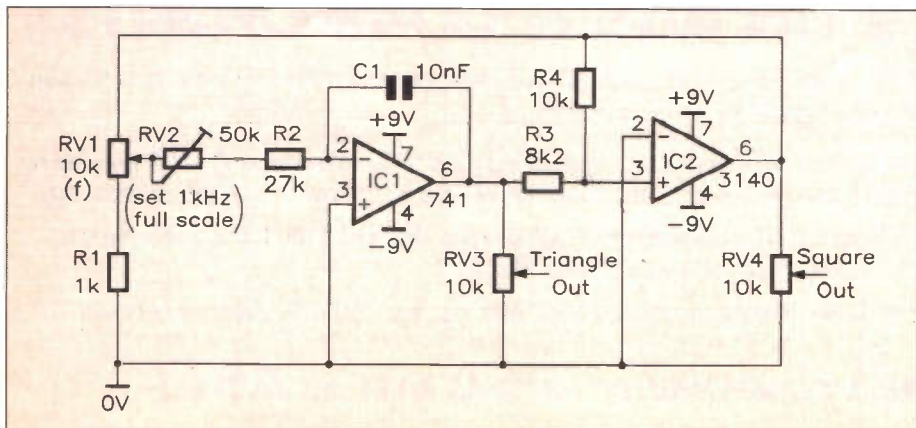


Figure 2. 100Hz to 1kHz triangle/square generator.

cycle, this constant-current generator charges C1 linearly until its charge voltage reaches the 'peak point' or firing voltage of TR2, the UJT. At this point TR2 turns on and rapidly discharges C1 until its discharge current falls to the UJT's 'valley point' or unlatching value, at which point the UJT turns off and C1 starts to recharge again, and the sequence repeats ad infinitum.

Thus, a free-running linear sawtooth is generated across C1, and can be fed to external circuits via buffer transistors TR3-TR4 and RV2. With the C1 value shown, the frequency is variable from 60Hz to 700Hz via RV1; it can be varied from below 0.1Hz to above 100kHz by using alternative C1 values.

The Figure 4 circuit can be used as a simple free-running timebase generator for an oscilloscope. In this application, the sawtooth output should be fed to the oscilloscope's EXTERNAL TIMEBASE socket, and the positive 'flyback' pulses from R5 can be taken via a high-voltage blocking capacitor and used for beam blanking. The sawtooth can be synchronised to an external signal that is fed to TR2 via C2; this signal (which must have a peak amplitude of between 200mV and 1V) modulates the triggering points of TR2, and thus synchronises the oscillator and input signals. Note that C2 must have an impedance less than 470Ω at the sync signal frequency; if the sync signal is rectangular, with short rise and fall times, C2 can simply be given a value of 470pF.

555 Linear Sawtooth Generators

A 555 timer IC can be used as a triggered linear sawtooth generator by wiring it as a modified monostable multivibrator or pulse generator, with its timing capacitor charged via a constant-current generator, as shown in Figure 5. Here, TR1 acts as the constant-current generator, and the output waveform is taken from across timing capacitor C4 via TR2 and RV2.

When a capacitor is charged via a constant current generator, its voltage rises linearly at a rate of I/C volts per second, where I is the charge current in amps and C is the capacitance in farads. Using more practical quantities, the rate of voltage rise can also be expressed as $I(\text{mA})/C(\mu\text{F})$ volts per ms. Note that the rise rate can be increased by either increasing the charge current, or by decreasing the capacitance value.

In Figure 5, the charging current can be varied from about $100\mu\text{A}$ to 1.1mA via RV1, giving rise rates variable from 10V/ms to 110V/ms using the 10nF timing capacitor. Now, each monostable cycle of the 555 ends at the point where the C4 voltage reaches $\frac{2}{3}$ of V_{CC} so, assuming that a 9V supply is used (giving an 'end' value of 6V), it can be seen that the circuit's sawtooth cycles have periods variable from $600\mu\text{s}$ ($= 6/10\text{ms}$) to $55\mu\text{s}$ ($= 6/110\text{ms}$) respectively. Periods can be increased beyond these values by increasing the C4 value, or decreased vice versa. The circuit's supply rail voltage must be regulated, to give stable timing.

Figure 6 shows how the above circuit can be modified for use as a triggered

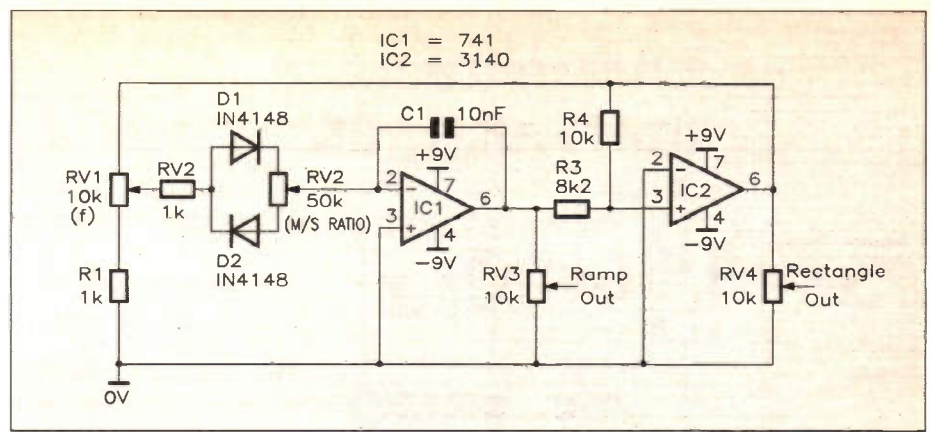


Figure 3. 100Hz to 1kHz ramp/rectangle generator with variable slope and mark-space ratio.

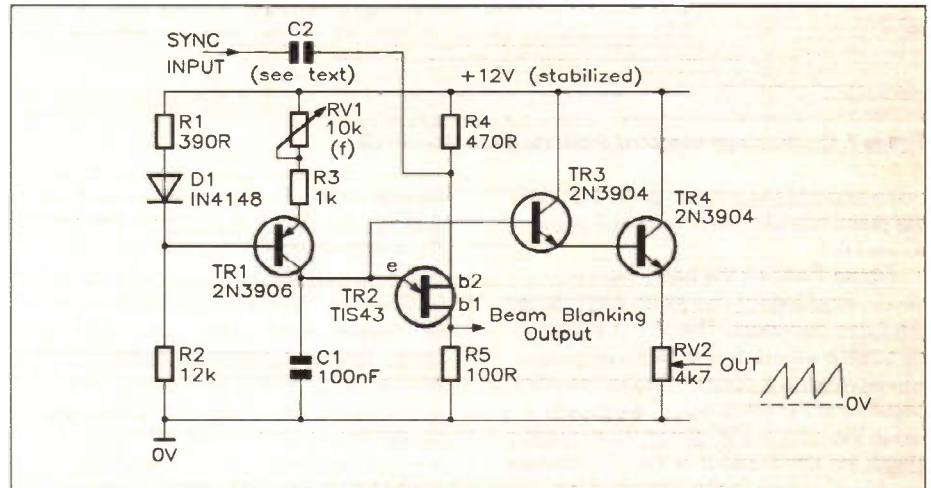


Figure 4. UJT-based oscilloscope timebase generator.

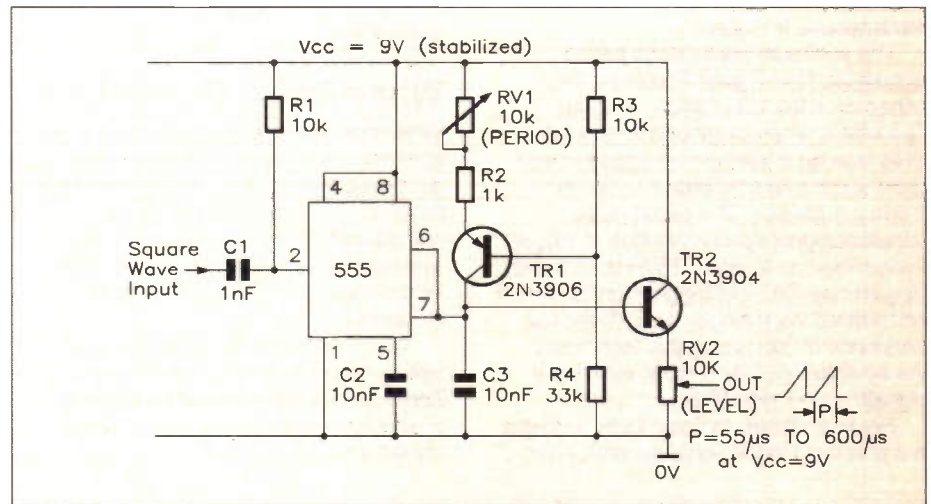


Figure 5. Triggered linear sawtooth generator.

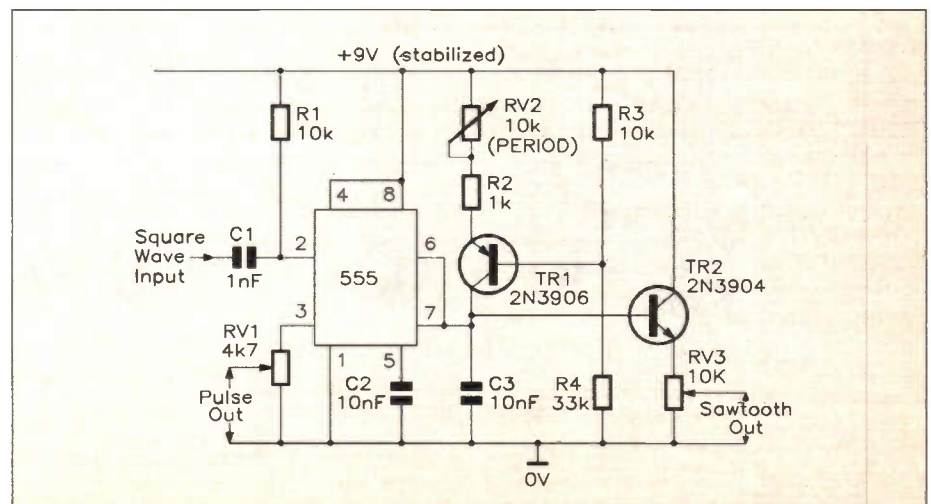


Figure 6. Triggered pulse and sawtooth generator, with range of $55\mu\text{s}$ to $600\mu\text{s}$.

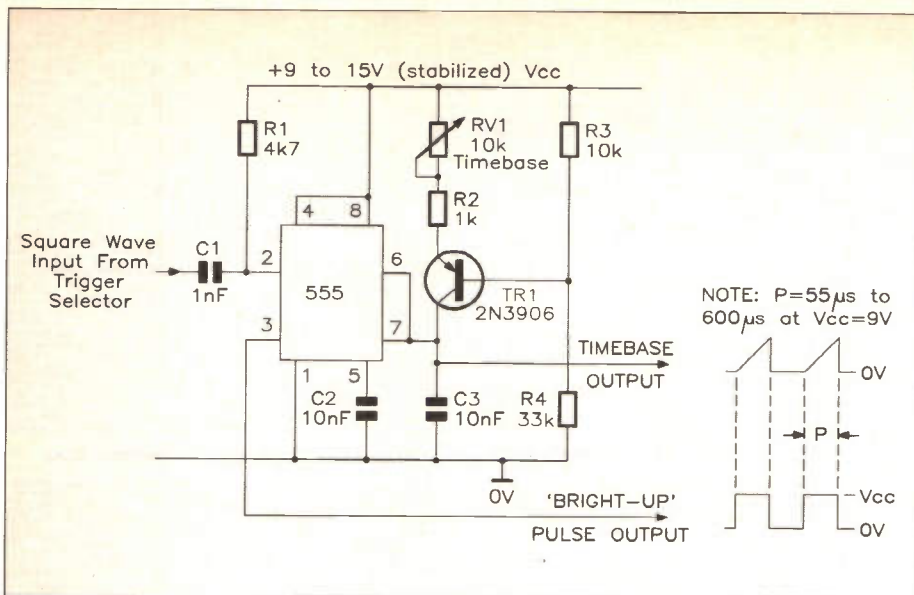


Figure 7. Oscilloscope-triggered timebase generator circuit.

pulse and linear-sawtooth generator, with the pulse output taken from pin 3 of the IC via RV1.

Figure 7 shows the basic Figure 5 circuit, modified for use as an oscilloscope timebase generator. The 555 is triggered by square-waves derived from external waveforms via a suitable 'trigger' selector circuit, and the ramp output waveform is fed to the 'scope's 'X' plates via a suitable stage; the pin-3 output of the 555 provides 'bright-up' pulses to the 'Z' axis of the 'scope tube during the ramp period, ensuring that the tube is blanked when the timebase is inactive.

The minimum useful ramp period obtainable from Figure 7 (using a 1nF capacitor in the C3 position) is about 5µs which, when expanded to give full deflection on a ten-division 'scope screen, gives a maximum timebase speed of 0.5µs per division. The circuit gives excellent signal synchronisation at trigger frequencies up to about 150kHz; at higher frequencies the input trigger signals should be reduced via a single- or multi-decade frequency divider; using this technique, the timebase can be used to view input signals up to many MHz.

Figure 8 shows, in basic form, a simple but effective trigger signal generator that

can be used with the Figure 7 circuit. SW1 enables the trigger signal to be derived INTERNally via the 'scope's 'Y' amplifier, or EXTERNally via a suitable terminal; SW2 enables the selected signal to be AC or DC coupled to the input of the TR1-TR2 phase-splitting differential amplifier. SW3 enables either in-phase of anti-phase ('+' or '-') outputs to be taken from the phase-splitter and fed to the Schmitt trigger, and RV1 allows the Schmitt to 'switch' at any desired point on the selected waveform; the Schmitt's output couples directly to the C1 input of the Figure 7 time-base generator.

White-Noise Generators

White-noise can be described as a signal containing a full spectrum of randomly generated frequencies, all with randomly determined amplitudes, but which gave equal power per bandwidth unit when averaged over a reasonable unit of time. White-noise is of value in testing AF and RF amplifiers, for example.

White-noise can be generated using either analogue or digital techniques. Zener diodes act as excellent sources of analogue white-noise, and Figure 9 shows a simple but useful circuit that uses

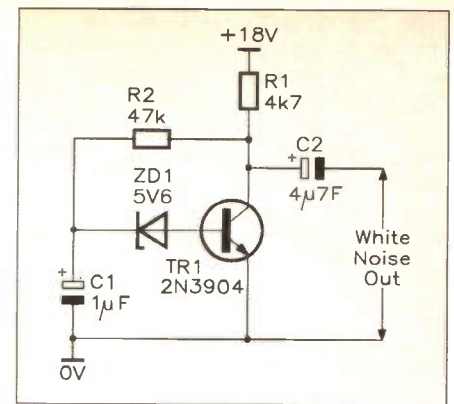


Figure 9. White-noise generator.

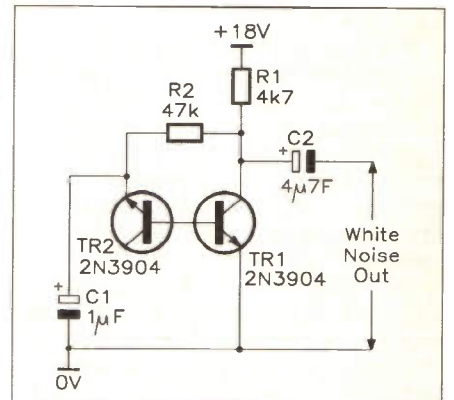


Figure 10. Alternative white-noise generator.

one of these as its basic noise source. Here, R1 and the zener diode form a DC negative feedback loop between the collector and base of common-emitter amplifier TR1 and thus stabilise its DC working levels, but the loop is AC decoupled via C1, so that the zener acts as a noise source and is in series with the base of TR1. Note that the zener can be any 5-6V type. TR1 simply amplifies its noise and provides a useful (typically about 1V peak-to-peak) white-noise output at its collector.

The base-emitter junction of an ordinary NPN transistor acts as a zener diode when reverse-biased, and can thus be used as an inexpensive white-noise source; the 2N3904 typically zeners at about 5-6V, and Figure 10 shows how it can be used as a noise-generating zener in the Figure 9 circuit.

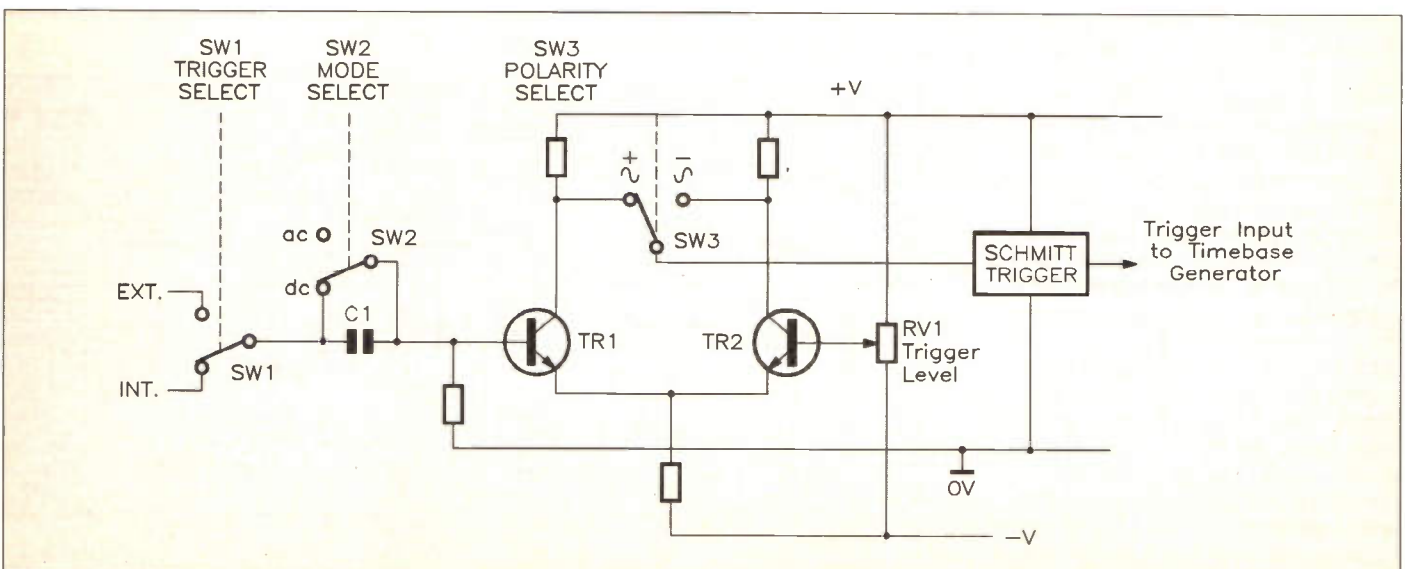


Figure 8. Basic dual-polarity timebase signal generator.

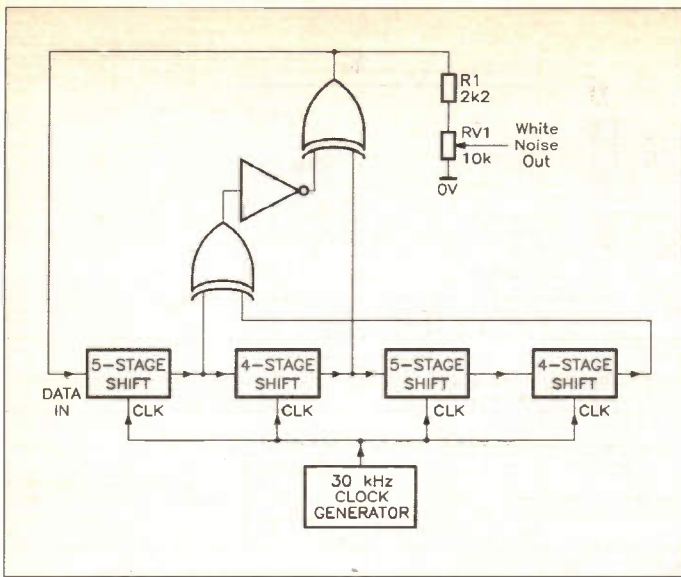


Figure 11. Block diagram of digital white-noise generator.

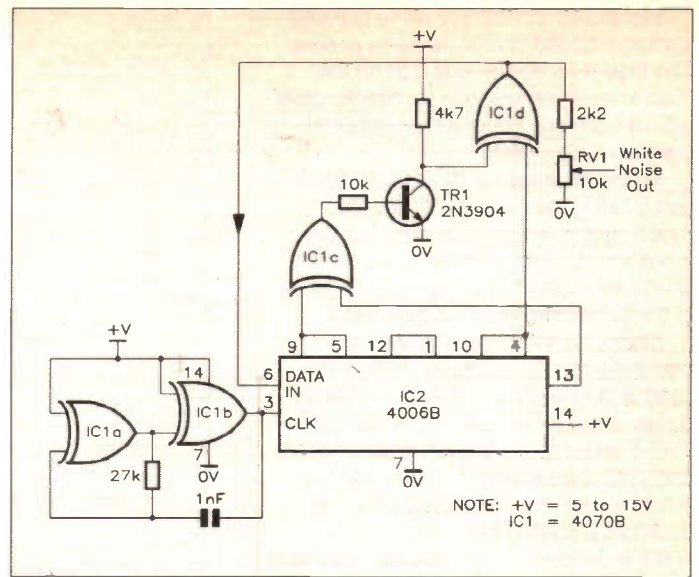


Figure 12. Practical digital white-noise generator.

Simulated white-noise can be generated digitally via a maximum length pseudo-random sequence generator; Figure 11 illustrates the basic principle. Here, an 18-stage shift register is clocked at 30kHz, and wired so that its 'data' is fed forward one step on the arrival of each clock pulse. The 'data' circulating through the shift register is derived by EX-ORing the outputs of stages 5, 9 and 18 so that a pseudo-random, or jumbled, output sequence is generated; this apparently random sequence repeats every few seconds in fact, but (because its digital output is very rich in harmonics) otherwise acts like perfect white-noise.

Figure 12 shows a practical CMOS

version of the digital white noise generator. Here, the 18 shift register stages are obtained from IC2, and the 30kHz clock generator is formed via IC1a-IC1b, which are wired as an astable multivibrator, and EX-ORing is obtained via IC1c, IC1d and TR1. The white-noise output signal amplitude is variable via RV1.

Pink-noise

White-noise is a signal with a power (energy) content that is constant at all units of bandwidth. Thus, the energy of a 100Hz bandwidth white-noise signal is the same at 1kHz as it is at 10kHz: but 100Hz bandwidths are 10 times more common at

10kHz than they are at 1kHz, and it can thus be seen that (by definition) the output level of a white-noise generator rises at rate of 3dB per octave. Thus, if one listens to (or measures) white-noise signals, it will be noticed that high-frequency 'hiss' is predominant.

A far more useful noise signal is one in which the output level is flat over the whole frequency band, so that (for example) the frequency responses of an amplifier, filter, or graphic equaliser can be quickly checked by feeding this 'noise' signal to its input and measuring the frequency levels at its output. Noise with this specific characteristic is known as 'pink' noise, and is normally generated by feeding ordinary white-noise through an R-C filter that is configured to give a first-order slope of -3dB/octave. Figure 13 shows an 'add-on' filter that is designed for this purpose and gives (when used with any of the above white-noise generators) a pink-noise characteristic that is within ¼dB of this value, over the entire 10Hz to 40kHz frequency range.

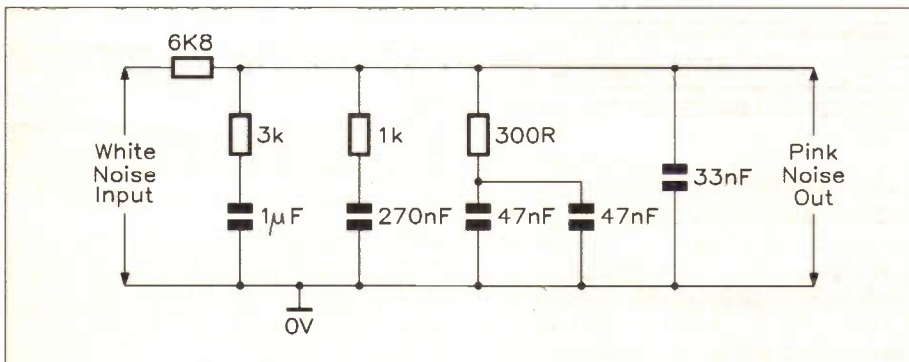


Figure 13. 'Add-on' white-noise to pink-noise converter.

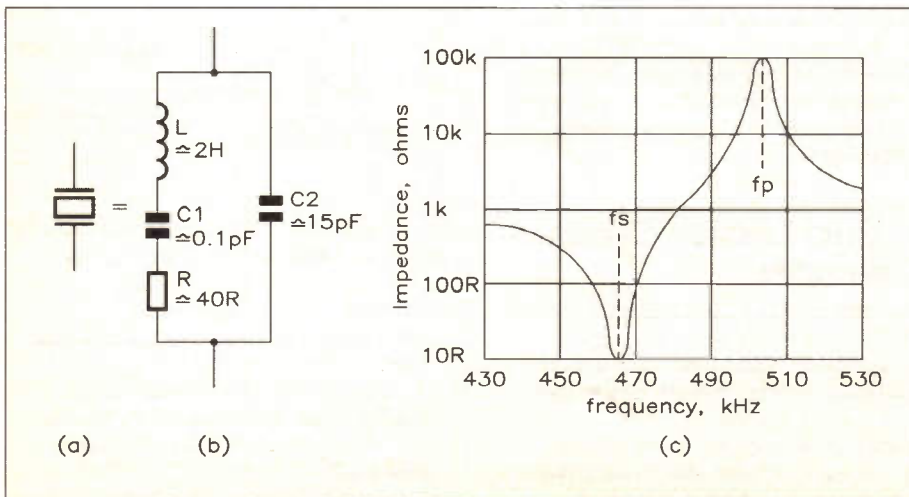


Figure 14. Quartz crystal symbol, typical equivalent circuit, and typical response curve of a 465kHz series-resonant crystal.

Crystal Oscillators

Crystal oscillators generate waveforms with great frequency precision. They use piezo-electric quartz crystals as electro-mechanical resonators or tuned circuits with typical effective Q factors of about 100,000; these crystals provide roughly 1000 times greater frequency stability than a conventional LC tank circuit. The crystal's resonant frequency (which may vary from a few kHz to 100MHz) is determined by its mechanical dimensions. All quartz crystals have both series and parallel natural-resonance modes, and are cut to provide calibrated resonance in only one of these modes; series-mode devices present a low impedance at resonance, while parallel-mode devices present a high impedance at resonance.

Figure 14 shows the symbol and typical equivalent electrical circuit of a quartz crystal; it also shows the typical frequency/impedance response curve of a crystal that is cut to give series resonance at 465kHz; note that this particular crystal also has an uncalibrated parallel resonant mode at 505kHz.

Figures 15 to 18 show some practical transistor-based crystal oscillator circuits. The Figure 15 design is based on the Pierce oscillator, and can be directly used with virtually any good 100kHz to 5MHz parallel-mode crystal.

Figure 16 shows a 100kHz oscillator that is designed for use with a series-mode crystal. In this case, the circuit is wired as a Colpitts oscillator, and the L1-C1-C2 tank circuit is designed to resonate at the same frequency as the crystal.

Figure 17 shows an outstandingly useful 2-transistor oscillator that can be used with virtually any 50kHz to 10MHz series-resonant crystal. In this design, TR1 is wired as a common-base amplifier and TR2 is an emitter follower, and the output signal (from TR2 emitter) is fed back to the input (TR1 emitter) via C2 and the series-resonant crystal. This really is an excellent circuit, and will oscillate with almost any crystal that shows the slightest sign of life.

Finally, Figure 18 shows a popular variation of the Colpitts oscillator, in which TR1 is wired as a voltage follower and the crystal acts as the resonant circuit. Note in this circuit (and that of Figure 17) that a small 'trimmer' capacitor (C3) is wired in series with the crystal and enables its frequency to be varied over a narrow range.

Some simple TTL or CMOS digital gates and buffers can be made to act as crystal oscillators by first biasing them into the linear amplifier mode, and then connecting the crystal into a positive

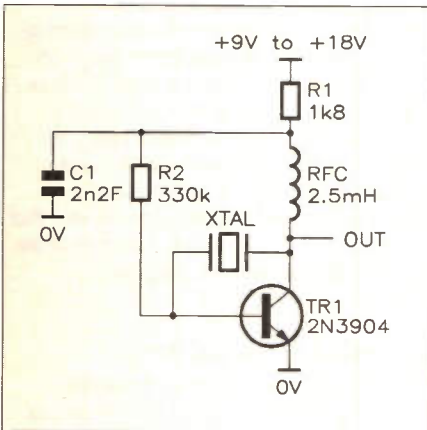


Figure 15. Wide-range Pierce oscillator with parallel-mode crystal.

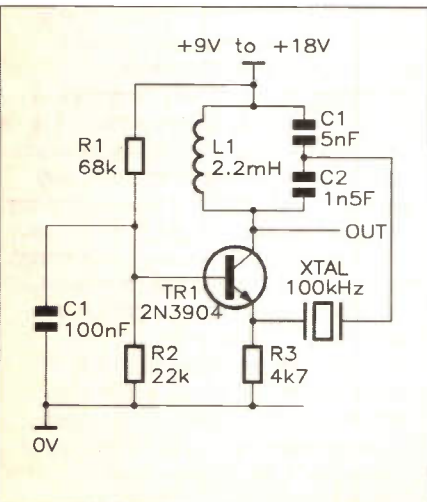


Figure 16. 100kHz Colpitts oscillator using series-mode crystal.

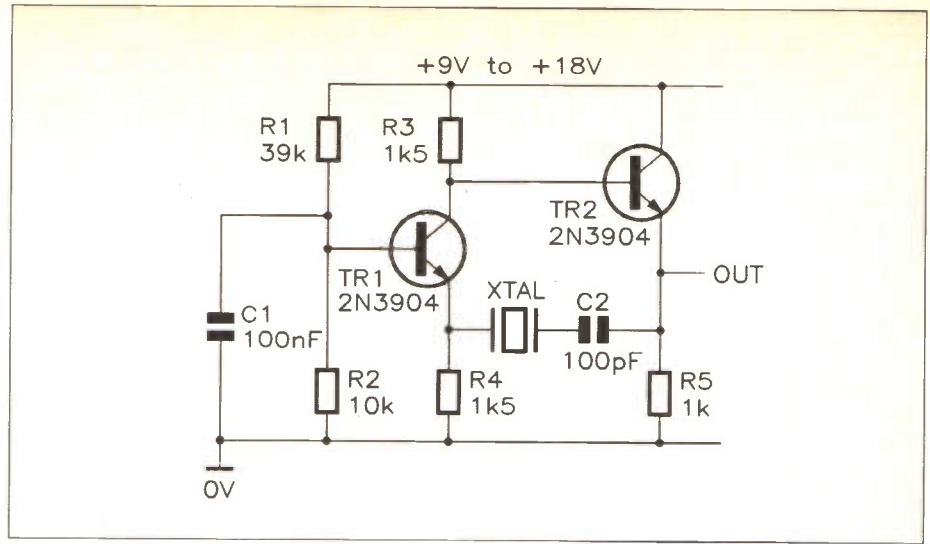


Figure 17. Wide-range (50kHz to 10MHz) oscillator can be used with almost any series-mode crystal.

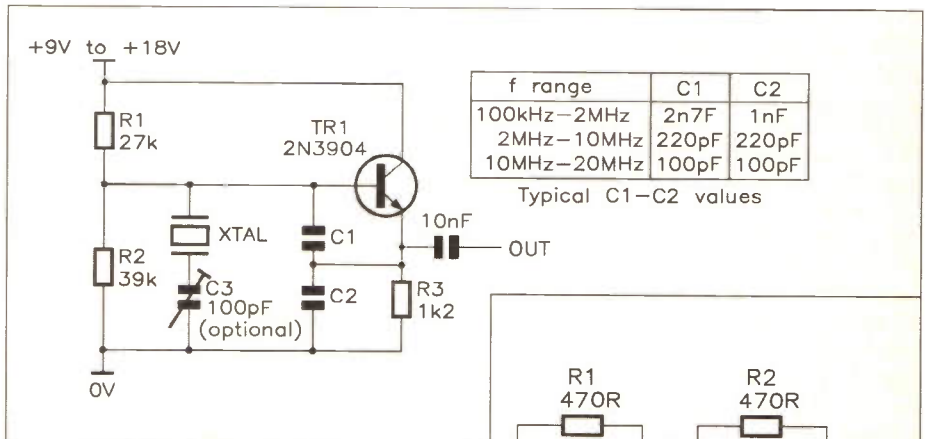


Figure 18. Untuned Colpitts oscillator using series resonant crystal.

feedback path between the amplifier's output and input. Figures 19 and 20 show examples of such circuits. The Figure 19 TTL design uses two 74LS04 hex-inverter stages, which are each biased into the linear mode via 470Ω output-to-input feedback resistors, and are AC coupled in series via C1, to give zero overall phase shift. The circuit is then made to oscillate by wiring the crystal (which must be a series-resonant type) between the output and input. This circuit can operate from a few hundred kHz to above 10MHz.

The CMOS circuit in Figure 20 is based on a pair of 4049B unbuffered hex-inverter stages; the first stage is used as a crystal oscillator by wiring it into the linear amplifier mode via R1, and feeding the output back to the input via the parallel-resonant crystal; the second stage is used as a simple output buffer.

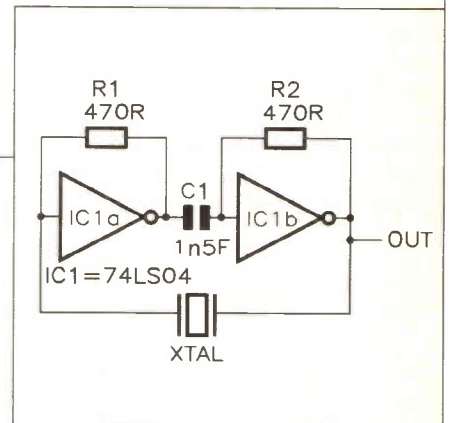


Figure 19. TTL-based crystal oscillator.

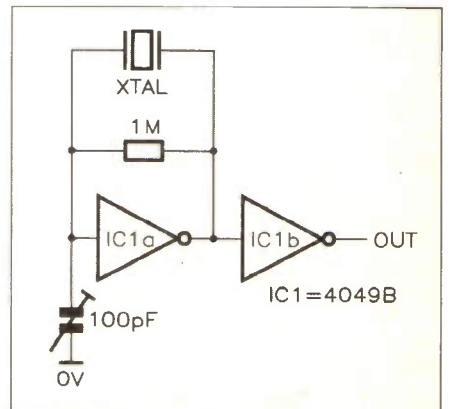


Figure 20. CMOS-based crystal oscillator.

A Multi-Decade Crystal Calibrator

A crystal oscillator can be used to provide precision sub-multiples of the crystal frequency by feeding its output through a suitable number of digital divider stages. One popular application of this technique is in the multi-decade 'crystal calibrator'. In this circuit, a basic 1MHz precision signal is divided down, via a set of cascaded decade dividers, to (commonly) generate standard frequency (period)

outputs of 100kHz (10μs), 10kHz (100μs), 1kHz (1ms), etc. To conclude this series, Figure 21 shows an example of a practical TTL-based 6-decade calibrator of this type; the circuit is configured to provide symmetrical square-wave outputs on all ranges, which extend down to 1Hz (1s). The circuit typically consumes 60mA from its 5V supply.

Continued on page 79.

TECHNOLOGY WATCH!

with Keith Brindley

Just what is all the hype about? With pictures, photographs, televisions and computers I mean. First off, Philips introduces CD-I – interactive compact disc. Initially this seemed just like a good – and logical – upgrade from its earlier development of CD-ROMs. Most readers will have heard of the latter, if not used them at the local library, school, college or university to access information digitally stored on a compact disc. With a computer and a CD-ROM player, you can have complete personal data banks of information at your fingertips.

In turn, CD-ROM is just a natural progression from the basic compact disc which most of us have grown to love as a medium of storing high-quality audio. Well, actually, it's debatable whether the principle of audio CD did come before that of CD-ROM. It's a sort of chicken-and-frog situation. Or is that egg-and-toad; or even toad-in-the-hole? Who cares. The question of which came first is largely irrelevant – a CD can be used to store huge quantities of audio, visual, or digital information in varying manners.

The fact is, CD-I is just another variation on the same basic medium. However, it allows you to access the data selectively, presenting it on your television screen in a manner over which you have direct control. If you haven't seen CD-I players set up in the electrical departments of the larger stores and the like, displaying what's available, you must be somewhat short-sighted. Philips own press and magazine advertisements, showing a television tom in half with the byline 'without CD-I you're only using half of it' gives you the idea it lets you control the TV. In fact, all you're doing is selectively controlling access to the information on whichever CD-ROM is playing in the machine. Now, while the dog's out chasing cats, the kids are doing their homework and the wife is washing the dishes (I'm not sexist, but I do hate cats!), you can be having a

glorious time in the living-room pressing buttons and rolling trackballs through Dungeons and Dragons, or whatever else turns you on.

Next, Kodak (yes, the photographic film people!) announce Photo-CD. Now you can take your undeveloped film along to Boots or wherever, and ask to have the shots digitally recorded onto a CD instead of printed onto paper, whereupon you take it back home, stick it in a Photo-CD player and view the results on your TV screen. You can even take piccies of the dog eating the neighbours cat, the kids asleep in bed, and the kitchen (to show your wife where the sink is) to remind you of how good life is with this modern electronic technology.

As you can guess, Photo-CD is yet another progression from the plain old ordinary audio compact disc. But it's not a forward progression from CD-I. While you can play Photo-CDs on a CD-I player, you can't play a CD-I disc on a Photo-CD player. Kodak's answer to this is to market Photo-CD players considerably cheaper than a CD-I player.

Yet CD-I (in its current state) is still not the pinnacle of CD technology. Soon, full motion video (FMV) pictures will be available from a CD-I disc. Current players, of course, won't be able to use those discs, although there may be an upgrade route for certain players. I've got two points to make with all this surge of electronic technology in the living-room. First, you're tied to a television in order to use it. Can you imagine getting out your holiday snaps to bore the neighbours with, and putting them on a TV screen? How does Grandpa take his pictures of his grandchildren along to the over-60's club? Secondly, do we always have to be force-fed with what manufacturers want to sell us? Is anybody apart from devoted gadget-lovers (myself included) going to want a Photo-CD or CD-I player?

Without any doubt, there is a market for CD-ROM and its variants in professional fields. Photographers, television programme makers, publishers

and the like are simply demanding the availability of a decent standardised digital storage method for pictures. Being able to easily (and cheaply!) place a picture onto a computer screen during page make-up, for example, would be a real boon to a magazine such as 'Electronics'. There's been a lot of work recently on the extended architecture of CDs (CD-XA) which will allow computer CD-ROM players to fully utilise CD-I, Photo-CD and the like within the framework of the computer application.

But is the man in the street the least bit bothered? While Philips does battle portraying its CD-ROM format as the medium of the future, on another front at least, Philips is about to do battle against a new disc format. Sony's MiniDisc (MD) is a digital record and play audio medium which is likely to dramatically lower sales of Philips own digital compact cassette (DCC). Both systems, on sale for Christmas, do largely the same things, but Sony's is disc-based, while Philips is tape-based. Philips' DCC cassettes are the same size as conventional audio cassettes (also invented by Philips) with which, incidentally, DCC players are designed to be downwards-compatible. This, I feel, gives DCC the edge over MD. In a funny sort of way this is a shame. If we're going to rely on discs for home entertainment purposes, courtesy of CD, CD-ROM, CD-I and Photo-CD, won't a tape-based medium seem a little out of place?

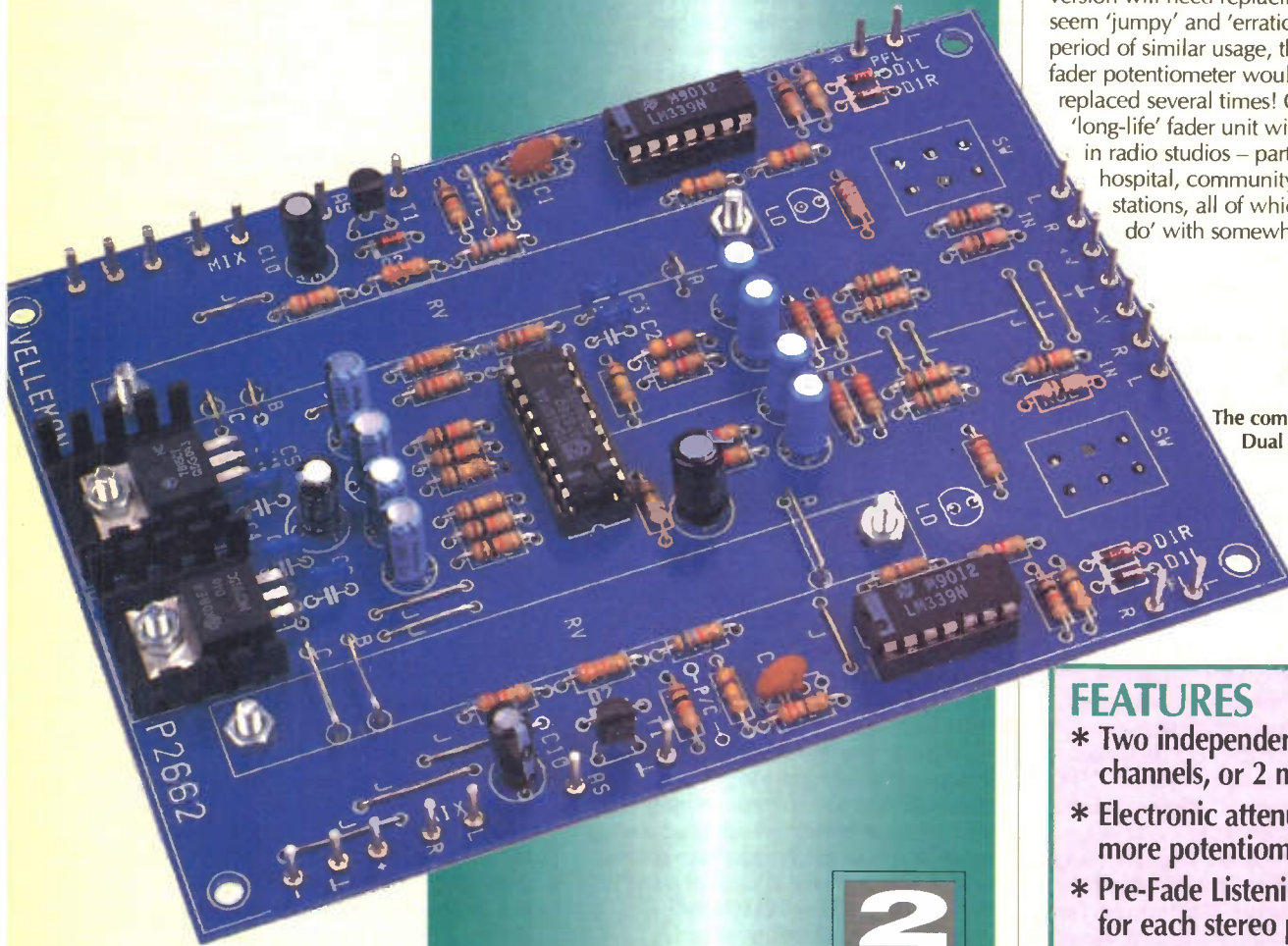
It's all largely a matter of personal choice, of course, but I can't help getting the feeling that all this technology is leading us up the garden path. All these things cost money, and people have learnt to become a bit shy of expensive electronic gadgetry – courtesy of home computers that became obsolete virtually overnight, BSB satellite systems and, of course, the videocassette wars between Sony's Betamax format, JVC's VHS and Philips' V2000. After all, who wants to spend £500 or so to find that the product is not supported a few years later?



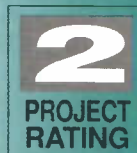


DUAL STEREO FADER MODULE

Text by Martin Pipe



The completed Dual Stereo Fader



Specification

Number of channels:	2 stereo (4 in all)
Distortion:	0.05% (max.)
Signal-to-noise ratio:	>90dB
Fader start/stop rating:	24V @ 50mA
Attenuation (slider at min.):	90dB
Peak LED indication:	3dB

This 'building block' unit is a voltage-controlled dual stereo fader module, complete with +3dB overload LED indicators, pre-fade listen (PFL) switches and turntable start/stop facility – ideal for the DJs amongst you. This unit scores over the faders in most mixers because the fader potentiometer does not carry audio signals directly – but a control voltage. Little difference will be noted between the two designs when both are new. When they have been in use for some time, however, crackling noises will begin to plague the conventional fader as the slider is moved up and down – indicating that the potentiometer requires maintenance in the form of a clean and a squirt of contact cleaner (a short-lived cure, as my past experience with college campus radio testifies!), or replacement. Eventually, the potentiometer in this voltage-controlled version will need replacing (the fade will seem 'jumpy' and 'erratic') – but during a period of similar usage, the conventional fader potentiometer would have been replaced several times! Consequently, this 'long-life' fader unit will be ideal for use in radio studios – particularly those of hospital, community and student radio stations, all of which have to 'make do' with somewhat limited budgets!

FEATURES

- * Two independent stereo channels, or 2 mono pairs
- * Electronic attenuators – no more potentiometer crackles!
- * Pre-Fade Listening (PFL) for each stereo pair
- * Fader-controlled start/stop facility for turntables, tape machines or CD players
- * On-board voltage regulators
- * LED peak detector
- * Long Fader Life

APPLICATIONS

- * Mixing Systems (particularly those of radio stations and disco consoles)
- * Upgrading Existing Equipment
- * DC Control of Volume

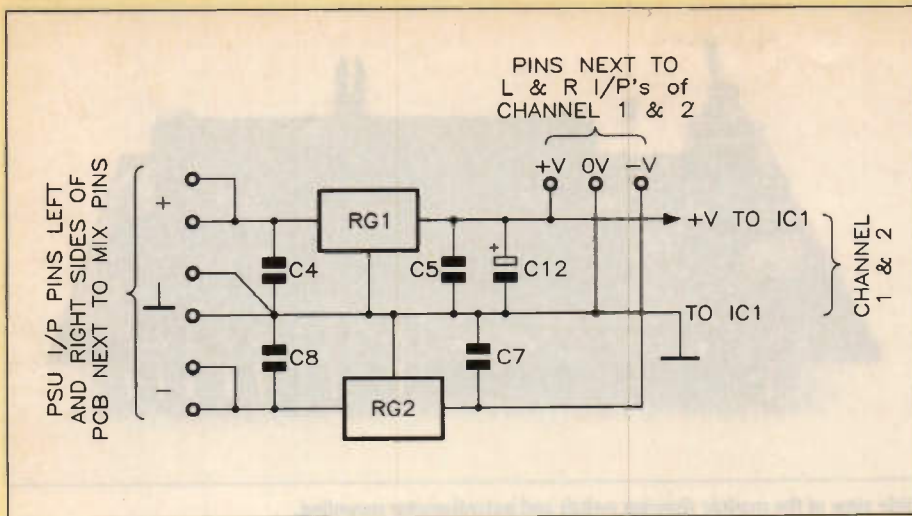


Figure 1. Dual Stereo Fader power supply circuit diagram.

Two stereo channels are catered for, each with their own independent fader. Each stereo channel could be substituted by a mono pair – but attenuation would affect both independent channels simultaneously.

In a complete mixing system, the PFL function (as the name suggests) allows the signal to be monitored before rendering it audible on the final mix. The PFL outputs of each stereo channel are normally brought to a 'PFL bus', whereby the DJ or recording engineer can monitor the desired signals

with a pair of headphones (or 'cans' in trendy talk!). The module is provided with toggle switches that determine if the relevant channel is sent to the PFL bus.

For turntables equipped with auto-start inputs (such as purpose-designed studio components), this module incorporates an open-collector output that is triggered when the fader is pushed up. 'Pulse' and 'continuous' turntables can be used. Note that some professional CD players also incorporate an auto-start facility.

For radio stations, the switch output of the fader used for the microphone channel could be employed to operate a tape machine, so that only the worldly-wise observations of the DJ (and not the music) can be recorded whenever the fader is up – and later checked for profanity without having to scan through an entire 2-hour show! For obvious reasons, this tape machine (which need only be an inexpensive cassette recorder) is commonly known in amateur broadcasting as a 'wally box'! At this stage, it is worth pointing out that if the Dual Stereo Fader is to be used with microphone inputs, a suitable preamplifier must precede it.

Circuit Description

Note that this section refers to Figures 1 and 2.

1. PSU. The whole circuit is powered from a single +15V supply (based around a 7815 regulator IC), although a 7915 (–15V) regulator has been included on the PCB to supply other modules that require a split (symmetrical) supply. C4, C5, C7, C8 and C12 are the associated decoupling capacitors.

2. Level control. IC2, a Philips TDA 1074A, contains four 'electronic potentiometers' configured as two pairs, both of which require a common control

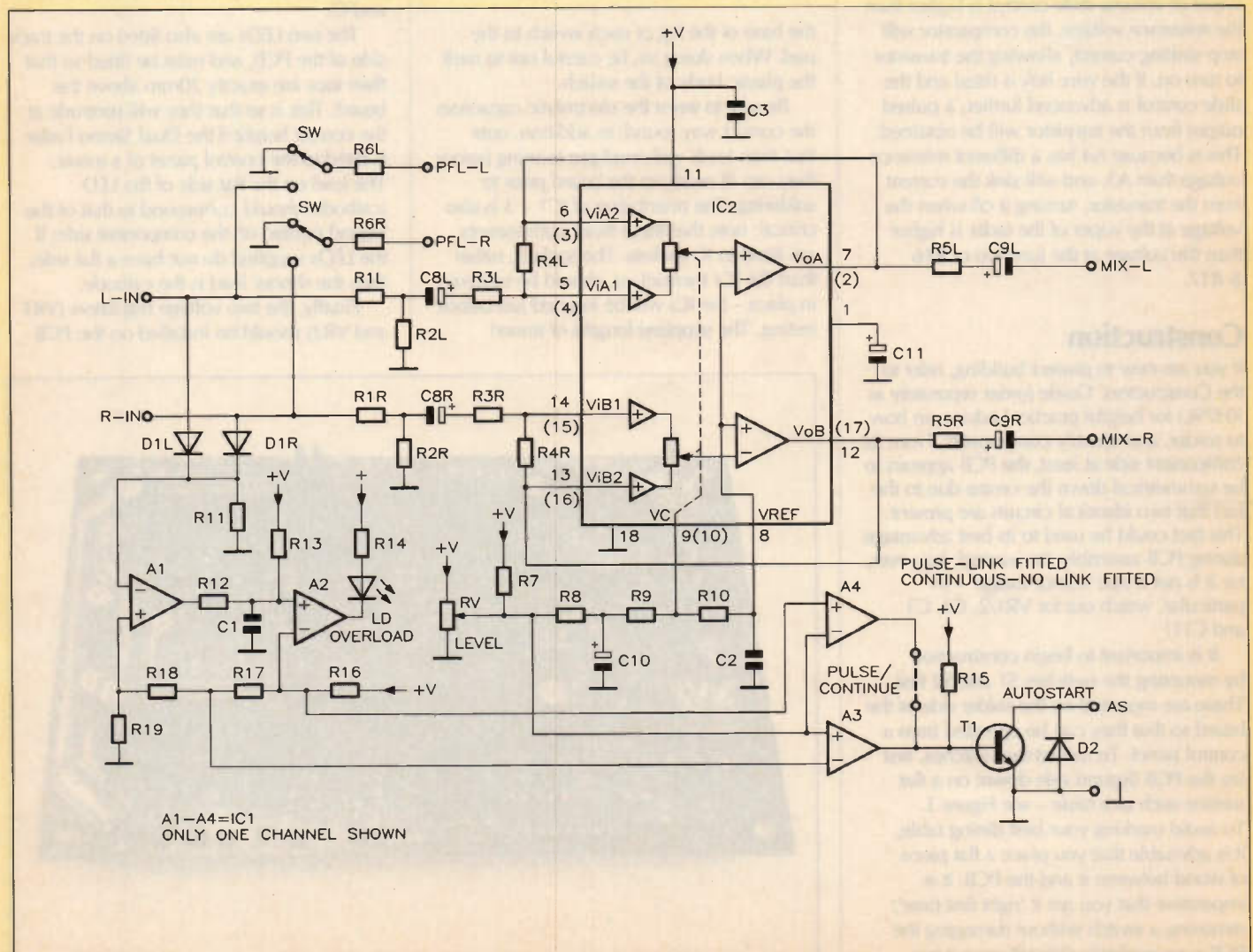


Figure 2. Circuit diagram of the Dual Stereo Fader. Note that this project consists of two identical circuits on the same PCB.

voltage. For stereo channel 1, the control voltage is applied to Pin 9; for stereo channel 2, pin 10. Each electronic potentiometer is used as a VCA (Voltage Controlled Attenuator), and can attenuate input signals by up to -90dB . The inputs and outputs of the VCA are AC-coupled, because they are at half the potential of the positive supply rail.

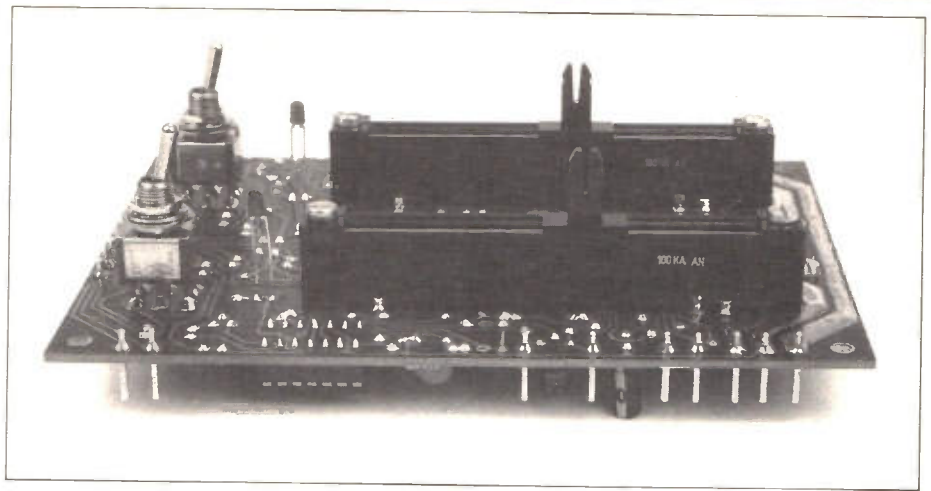
3. Overload indicator. The overload indicator monitors the left and right input signals of each stereo pair, and will illuminate the LED if the positive peak input is over $+3\text{dB}$. The circuit is based around two comparators – A1 and A2. A1's reference voltage is derived from a potential divider based around R16 to R19. If the signal input to A1 is higher than the reference voltage, the output of A1 will swing low. R12 and C1 form a low-pass filter, while R13 and C1 provide a delay. The filter removes high frequency glitches, preventing false overload indication, while the delay ensures that the LED will be illuminated long enough to be noticed. Note that A2 is used only as a current sink for the LED.

4. Auto turntable start/stop. This facility allows a turntable, CD player or tape recorder to be started and stopped from the fader's slide control. A3 obtains a reference voltage from the potential divider chain (R16 to R19). When the potential on the wiper of volume slide control is higher than the reference voltage, the comparator will stop sinking current, allowing the transistor to turn on. If the wire link is fitted and the slide control is advanced further, a pulsed output from the transistor will be obtained. This is because A4 has a different reference voltage than A3, and will sink the current from the transistor, turning it off when the voltage at the wiper of the fader is higher than the voltage at the junction of R16 & R17.

Construction

If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful practical advice on how to solder, and identify components. From its component side at least, the PCB appears to be symmetrical down the centre due to the fact that two identical circuits are present. This fact could be used to its best advantage during PCB assembly; be warned, however, for it is not a true 'mirror image' – in particular, watch out for VR1/2, C2, C3 and C11!

It is important to begin construction by mounting the switches S1 and S2 first. These are mounted on the solder side of the board so that they can be operated from a control panel. To mount the switches, first lay the PCB (legend side down) on a flat surface such as a table – see Figure 3. To avoid marking your best dining table, it is advisable that you place a flat piece of wood between it and the PCB. It is imperative that you get it 'right first time'; removing a switch without damaging the PCB is exceedingly difficult once it has been soldered in! Once in position, solder



Side view of the module showing switch and potentiometer mounting.

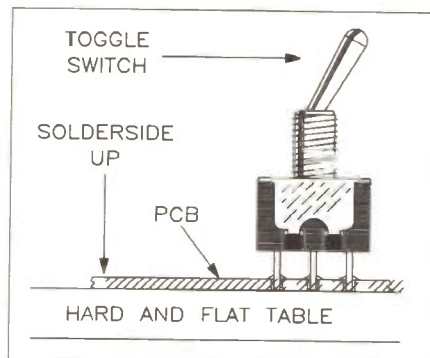


Figure 3. Fitting the PFL switches.

the base of the leg of each switch to the pad. When doing so, be careful not to melt the plastic body of the switch.

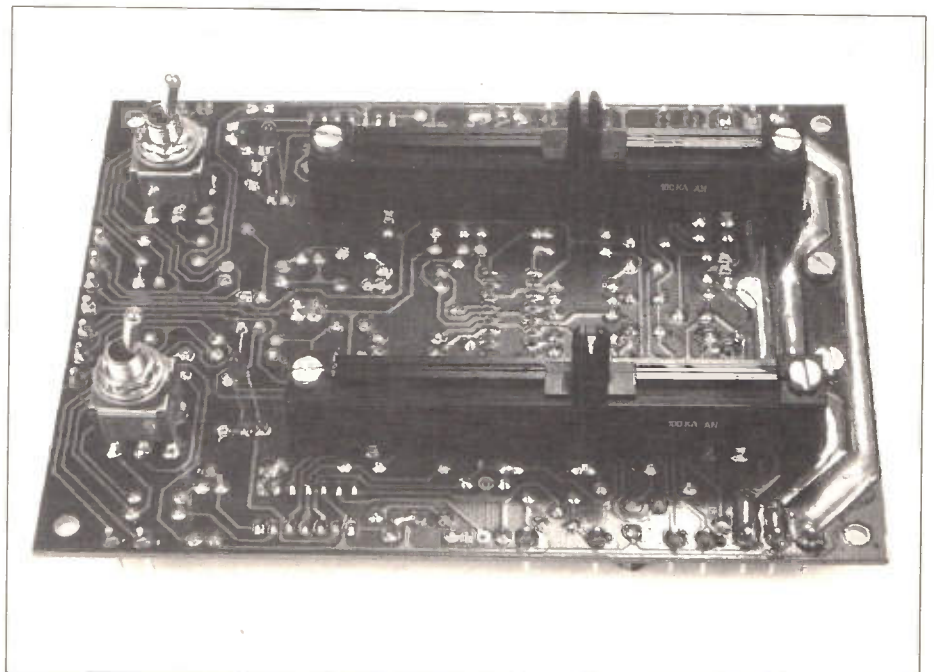
Be sure to insert the electrolytic capacitors the correct way round; in addition, note that their leads will need pre-forming before they can fit neatly to the board prior to soldering. The orientation of IC1 – 3 is also critical; note that these three components are fitted in IC sockets. The sockets, rather than the ICs themselves, should be soldered in place – the ICs will be inserted just before testing. The supplied lengths of tinned

copper wire (or alternatively the component lead off-cuts) are used for the PCB's 19 links.

Each slider potentiometer is bolted to the track side of the PCB with 25mm M3 screws at either end, as shown in Figure 4. Before it can be installed, the potentiometers' holes must be very carefully enlarged with a 3mm drill. Figure 4 also shows how links are made between the control's terminals (which should be protruding on the component side of the board) and the corresponding PCB connections, referred to for each potentiometer as points A, B and C.

The two LEDs are also fitted on the track side of the PCB, and must be fitted so that their tops are exactly 20mm above the board. This is so that they will protrude at the correct height if the Dual Stereo Fader is fitted to the control panel of a mixer. The lead on the flat side of the LED (cathode) should correspond to that of the legend printed on the component side; if the LEDs supplied do not have a flat side, then the shorter lead is the cathode.

Finally, the two voltage regulators (VR1 and VR2) should be installed on the PCB



The complete Dual Stereo Fader.

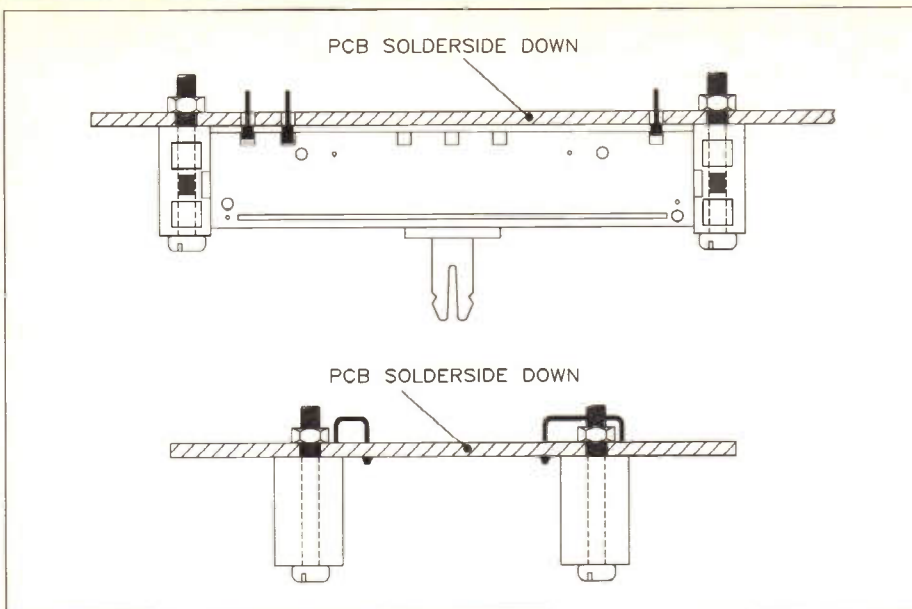
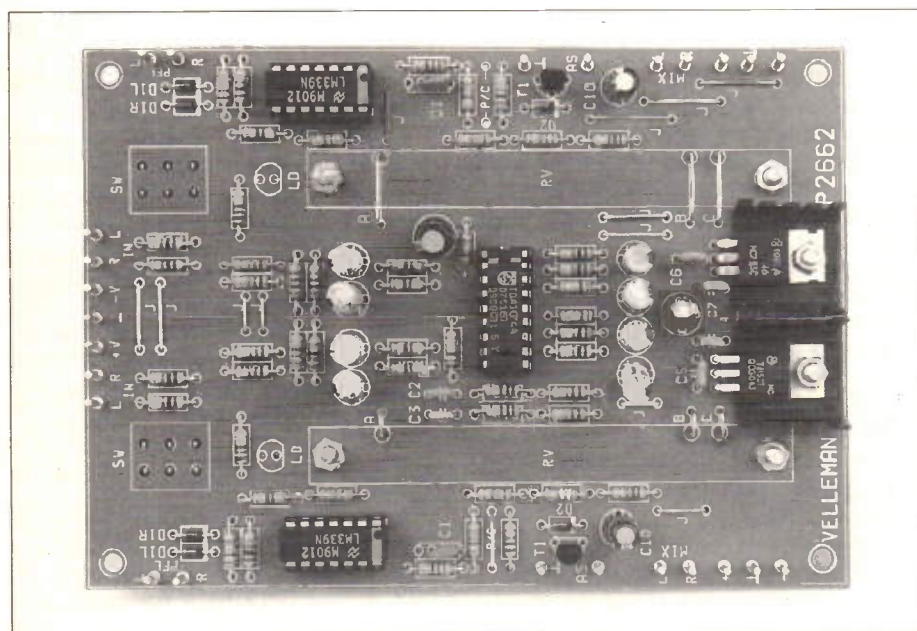


Figure 4. Fitting the slider potentiometers (RV).



View of component side.

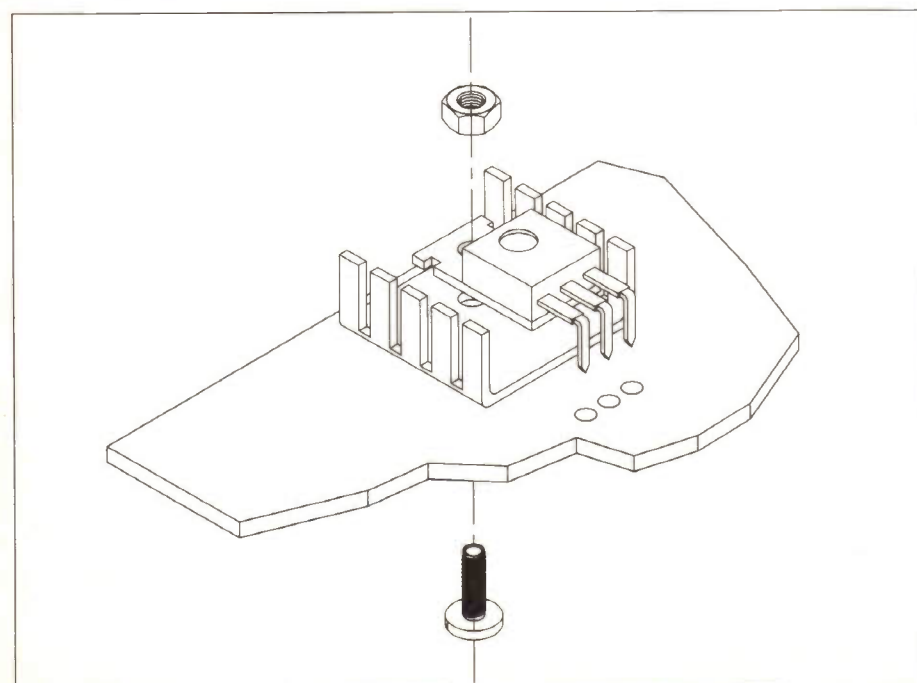


Figure 5. Fitting the voltage regulators (RV1, RV2).

as shown in Figure 5, using the 10mm M3 bolts. It must be ensured that the two heat-sinks do not touch each other, otherwise the input of the negative regulator will be shorted to ground. The use of thermally-conductive paste (not supplied), applied between the tab of each IC and its heat-sink, may improve long-term reliability – particularly if the Dual Stereo Fader's regulators are used to power ancillary items. Do not get the two regulators mixed up – the 7815 (+15V) is VR1, while the 7915 (-15V) is VR2. Once bolted down, they can be soldered in place; at this stage it may be a good idea to tin the wide power tracks with extra solder.

After completing assembly, it is prudent to check your work – finding any incorrectly placed components could save considerable time and expense later on. Other gremlins to watch out for include solder bridges/whiskers and poor joints.

Testing and Installation

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

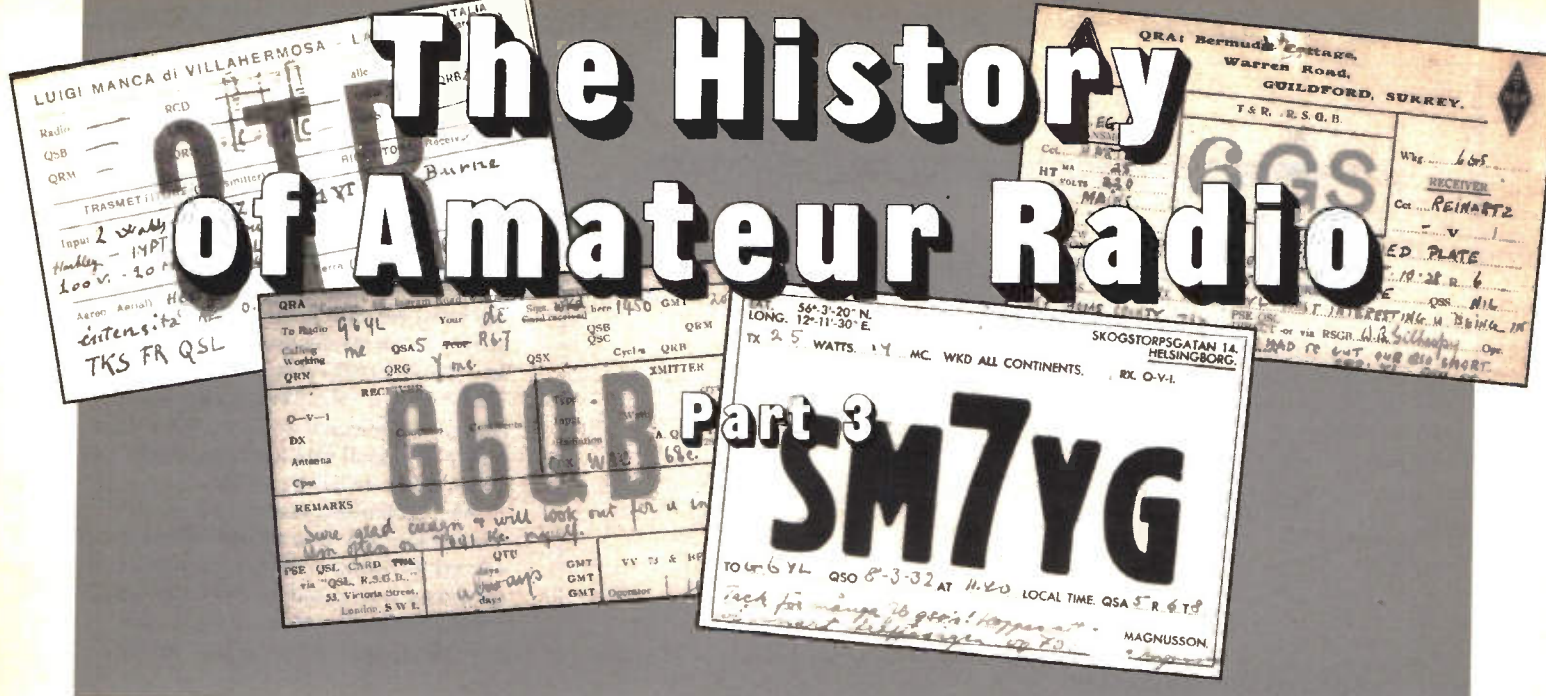
The open-collector turntable stop/start will work with any piece of equipment with the appropriate connection, provided that the voltage presented to the collector of T1 does not exceed 24V. As D2 is present, a relay (coil voltage less than or equal to 24V) could be connected directly to the output terminals, with an appropriate DC voltage applied to the transistor's collector. This would be essential with the 'wally box' mentioned earlier, so that a cheap cassette-tape recorder with a 'remote' jack could be used. A relay will also help in situations where the current to be switched exceeds 50mA – the maximum load that can safely be switched – or where the voltage to be handled exceeds 24V.

More on the Wally Box

The tape recorder input is normally connected to the effects or monitor output of the microphone channel (in the case of the Modular Mixing System, refer to the 'Dual Stereo Tone Control in last month's 'Electronics'). A suitable signal will also be available between the microphone preamp and the Dual Stereo Fader. A buffer will be required here to prevent loading of the preamp's output – as in some cases, a simple attenuator network (a potential divider) will be required to prevent overloading of the tape recorder's input circuitry – this is particularly important if the machine to be used only has a microphone input.

Continued on page 64.

The History of Amateur Radio



Part 3

SM7YG

by Ian Poole (G3YWX)

The 1920s and 1930s brought great strides forward in radio, and amateurs were at the forefront of many of these developments. Despite many restrictions on their operation, this period had seen a rapid growth in interest, but this was not to last. Germany was flexing the might of her armed forces and all too soon conflict was upon the world again.

As far as licensed amateurs were concerned, in the U.K. they were advised that in the event of war all stations would have to be closed down and equipment would be impounded.

As time progressed diplomacy failed and war became imminent. As a result on 31st August 1939 all full and artificial aerial licences were suspended. A few days later on Sunday 3rd September 1939 Britain was at war with Germany.

War Years

To enable the war effort to be successful a large variety of skills were needed, not least in the field of radio communications. Radio amateurs were in an important

position, having valuable experience of radio techniques from transmitters and receivers through to aerials and operating techniques. Many amateurs joined up, some even before the outbreak of war, and they made vital contributions to the war effort.

For those who did not join the forces themselves, there were still opportunities of making valuable contributions. The Radio Security Service needed people to act as voluntary interceptors (VIs). Their job was to monitor the airwaves and listen for transmissions of importance. In fact, their main job was to help detect any German spies who could be on the British Mainland.

Not all amateur activity stopped with the outbreak of war in Europe. Although German stations were closed down on the 1st September, three were allowed to stay on the air. As the war progressed this number rose steadily until it reached around a hundred. American stations were not unduly affected by the hostilities, although after their entry into the war they were not allowed to contact any

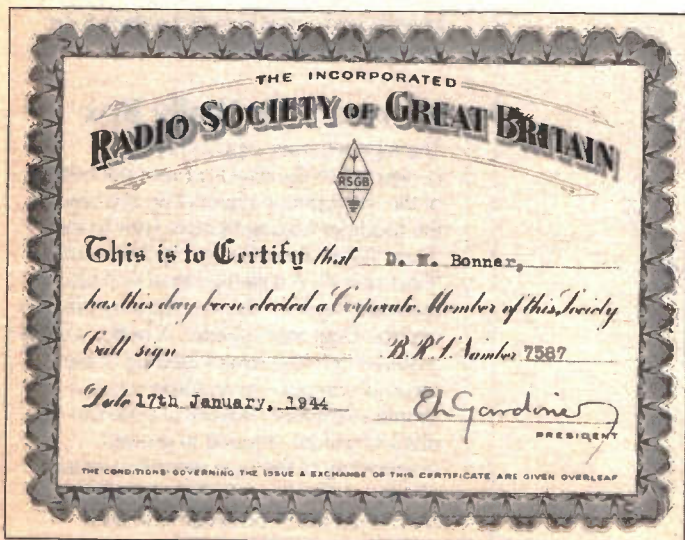
stations in the war zone. Also Japanese stations ceased operation at this time.

Despite the war, amateur operation continued to rise in Europe, even though it was on a small scale. In 1942 a few licences were issued for people to operate in Hungary and Czechoslovakia. In addition to this some German stations were able to use their calls in a number of the occupied countries including France, Norway and North Africa. Apart from these operations amateur activity was very definitely curtailed.

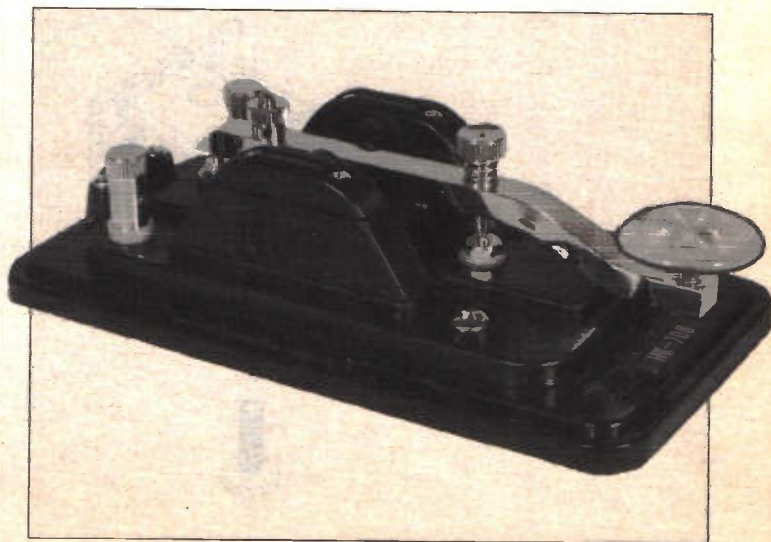
New Licences

The war in Europe officially ended on Tuesday 8th May 1945, but the war with Japan continued until their surrender on 14th August. In only a few weeks the amateur bands were alive with activity from around the war zones where permission had been mistakenly granted by local officials.

This operation caused much annoyance in Britain where no activity was permitted. This was despite the fact that



A temporary certificate issued by the RSGB towards the end of World War II.



A typical Morse keyer as used by many amateur enthusiasts. This particular one is available from Maplin.

the Post Office had released a notice to inform holders of pre-war licences that they should apply for post war ones if they wanted to.

Preparation for the new licence took some time and it was not until December that the format was made public. It was totally new. Unlike the pre-war experimental licences this one was a true amateur one. No longer did stations have to detail experiments to be undertaken, and there was an end to restrictions on the length and size of aerials and operating periods.

To qualify for a new licence, new applicants would have to pass a theory examination called the Radio Amateurs' Examination, as well as a Morse Test. This required the applicant to send and receive 12 words a minute. However, those people who could prove they held equivalent qualifications did not need to take the examination.

Finally, in January 1946 the first licences were issued. Those who held pre-war licences received their old call signs of G2, G3, G4, G5, G6, and G8 plus two letters. Those who held artificial aerial licences received call signs in the series G2 plus three letters corresponding to their old call numbers with a G prefix. New licences were issued in the series G3 plus three letters.

Initially, operation was only allowed on the part of the 10 metre band from 28 to 29MHz and the old 5 metre band between 58.5 and 60MHz. Three months later 'Top Band' stretching from 1.8 to 2.0MHz was released. However DX (long distance) enthusiasts had to wait until 1st July 1946, then sections of 40 metres from 7.15 to 7.3MHz and 20 metres from 14.1 to 14.3MHz were released.

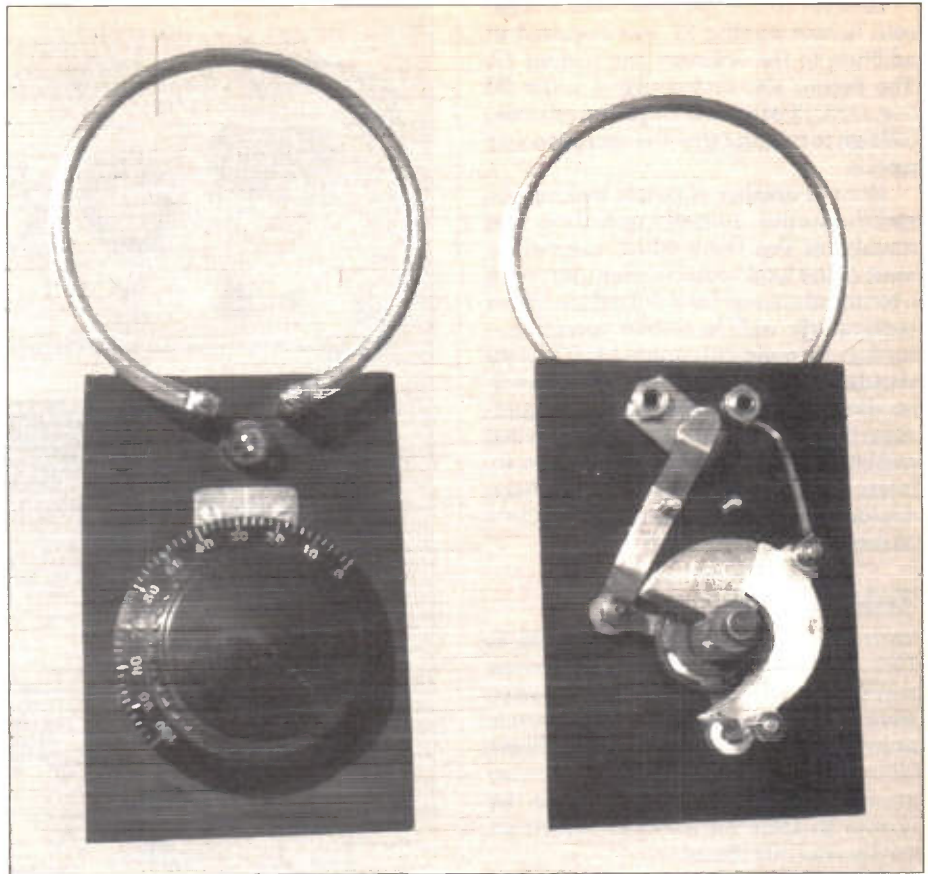
For the radio amateur of the day, equipment was plentiful as the government surplus business boomed. Receivers, transmitters, and all sorts of ancillary equipment were available at very good prices. As a result amateurs became very adept at converting and modifying this surplus equipment to suit their requirements.

Surplus equipment continued to be available for many years after the war, although by the 1960s it had become much less plentiful. However, sets like the 19 set, AR88, 1152, 1155, HRO and the like will be remembered for many years to come.

Atlantic City

It soon became clear that radio communications around the world had changed to a large degree since before the war and re-allocation of a number of frequency bands was urgently needed. To achieve this a World Administrative Radio Conference was organized and was held at Atlantic City in 1947. This was to be a crucial time for radio amateurs because there was a lot of pressure on the short wave bands from many interested parties including broadcasters. Amateurs were aware that they would have to fight hard if their allocations were not to be reduced significantly.

In broad terms amateurs fared well, in Europe they managed to retain the band



In the early days, the amateur had to make most of his own equipment. This simple wavemeter was made by G. Jessop G6JP and D. Walters G5CV.

between 1715 and 2000kHz. The 80 metre band stretching from 3.5 to 3.8MHz was also held and in America it extended up to 4.0MHz. However, the 40 metre band was a disappointment, with the allocation for European stations being reduced so that it only covered 7.0 to 7.15MHz. Even then the top 50kHz was shared with the broadcasting services. Similarly 20 metres was reduced, but by only 50kHz, to give a band 14.0 to 14.35MHz. The 10 metre also suffered slightly as the allocation became 28.0 to 29.7MHz.

Not everything was bad news. A new band was given to amateurs and it stretched from 21.0 to 21.45MHz. Initially there was some scepticism about its usefulness, but initial concern soon gave way as its full potential was quickly realized when long distance contacts started to be made.

In addition to the extra HF bands there was some good news for the VHF enthusiast. Some new bands in the VHF and UHF sections of the spectrum were also allocated. There was one between 144 and 146MHz (144-148MHz in America) and another between 420 and 460MHz as well as some much higher in frequency.

Further changes to these bands were made in 1953, then Top Band was reduced by 85kHz to give a band just 200kHz wide between 1.8 and 2.0MHz. Also in 1958 the shared section of the 40 metre band was lost completely to the broadcasters.

To the Rescue!

Late in the night of 31st January 1953 devastating floods struck the East Coast

of England. Many people died and there was a vast amount of destruction. Normal communications were cut and the emergency services found it very difficult to operate. Ignoring the terms of their licences and looking to help wherever possible, radio amateurs linked up with the emergency services to provide valuable communications. Amateurs were uniquely placed to help. Much of their equipment was capable of being used under portable conditions and in addition to this they had the experience to improvise and use their equipment as best they could.

Not only did amateurs help the services who were rescuing people along the flooded shoreline, they also helped those services at sea. The floods had silenced a vital ship to shore radio station and realising this many amateurs monitored the shipping frequencies, taking and relaying information about a number of distress calls.

As a result of this operation the value of amateurs under disaster conditions was realized and a clause was later written into the licence allowing them to use their stations to help the emergency services when disaster struck.

Mobile

When licences were issued after the war, operation from cars was not allowed. Although many other countries allowed it, the Post Office had repeatedly refused to give way, saying that it would be dangerous. However, matters finally changed in 1954 when a new licence schedule was issued allowing mobile operation.

In order to operate from a car a separate licence costing £1 was required in addition to the ordinary one costing £2. The licence also stated that a suffix /M (e.g. G2XXX/M) had to be placed after the callsign to indicate that the operation was mobile.

Quite a number of people took up the mobile licence. Initially operation was mainly on Top Band which catered for most of the local contacts. However, from a technical standpoint it did not lend itself particularly well to mobile operation – having a wavelength around 160 metres resulted in large aerials. The much smaller aerials required for mobile operation had to be heavily inductively loaded and as such they were inefficient. Even so, many designs appeared in the radio magazines to make these aerials as efficient as possible.

Television

With the televising of the Coronation in 1953, television was starting to become part of everyday life. Although televisions were still very expensive, many people were experimenting with their own home built ones. Amateur interest was also growing and with the revision of the licence in 1954 an amateur television licence was introduced.

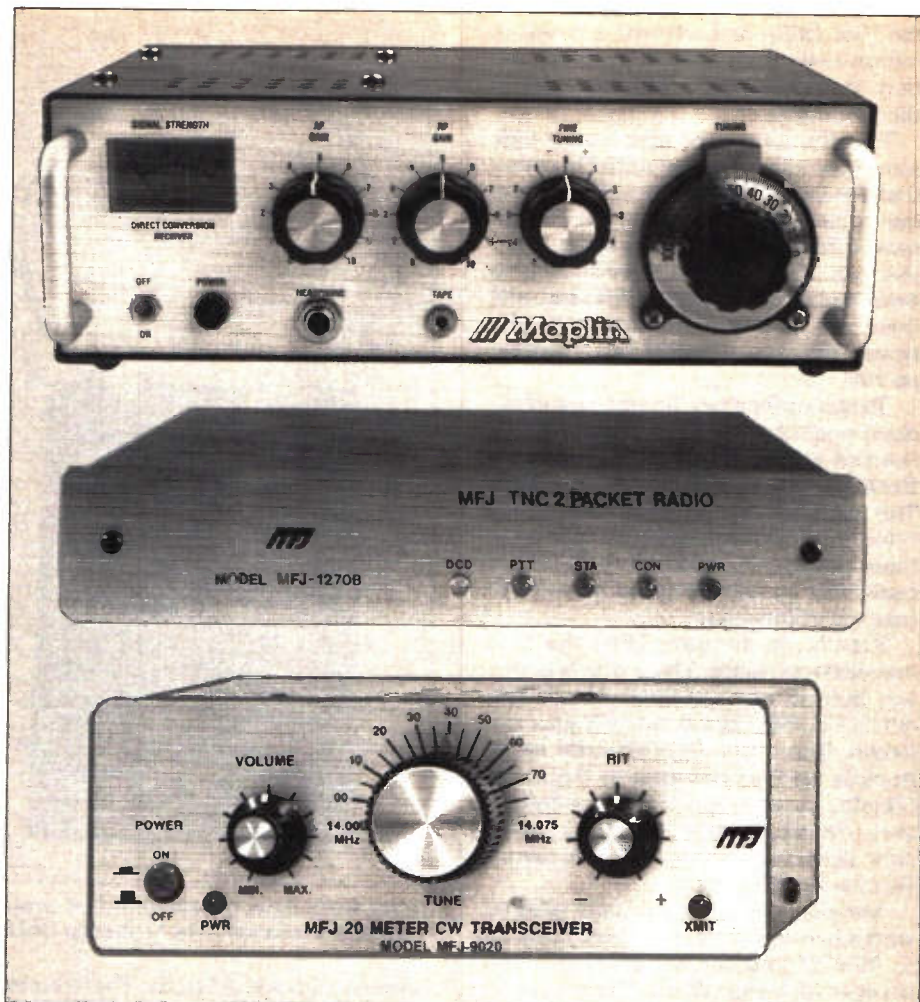
Transmissions were only allowed on frequencies above 420MHz, and to obtain a licence it was only necessary to have passed the Radio Amateurs' Examination; no Morse test was necessary. However, it was not a short cut to obtaining an ordinary sound licence as it was only possible to send vision signals. To send any accompanying sound an ordinary sound licence was needed.

Initially, callsigns in the G3 plus three letter series were issued but with a /T to indicate it was a television licence. Those who already held a licence just added the /T to their callsign when transmitting television signals. Later it was felt necessary to issue calls in a new series for television licences. Accordingly in 1964 calls in the G6 plus three letters were issued. Again a /T was used to indicate the call was used for television transmissions.

VHF Licence

The basic concept and terms of the amateur licence had remained more or less unchanged since 1945 when it was first proposed. In 1964, a new type called the class B licence was launched. To obtain this licence the applicant only needed to pass the Radio Amateurs' Examination. There was no need to pass the Morse. However, it limited operation to speech or 'phone' (no morse was allowed) and to frequencies above 420MHz.

The initial response to the licence was fairly slow and the rate at which licences were taken up was much less than for the standard class A licence – it was fairly difficult to set a station up on these bands. Very little commercially made equipment was available and the technology of the time meant that home construction was not at all easy, particularly where high power transmitters were concerned.



A range of modern amateur radio equipment. These items are part of a wide range available from Maplin.

Fortunately this new licence did stimulate more use of the UHF bands which were not widely used at the time.

The licence remained unchanged for about four years, but then in 1968 the terms were changed so that the use of the 2 metre band was allowed. This proved to be a tremendous success. The number of class B licences being issued rose dramatically, even outstripping the number of class A licences being issued at times. The reason for this was that it was much easier to obtain or build equipment for 2 metres. Many people used ex-PMR (private mobile radio) equipment which they had converted. However, about this time equipment specifically for the amateur started to become available for this band at affordable prices.

Repeaters

With the increase in the number of stations using 2 metres, and the availability of equipment, there came a marked rise in the amount of mobile activity on the band. It was far more convenient than Top Band, which had previously carried most of the mobile contacts, because wavelengths were shorter and aerials more efficient and easier to make.

Along with the increase in mobile activity came the demand for repeaters. These stations would be situated in a good location and would pick up signals on one channel and re-radiate them on another.

This would enable weak mobile stations to transmit into the repeater, and by using its coverage they would be able to make many more contacts.

The first repeater was activated on 14th September 1972 with the callsign GB3PI. It was located in Cambridge at the Pye Telecom, although six months later it was moved to Barkham in Hertfordshire.

Soon after this other repeaters were set up, and now most places in the U.K. are within the range of a repeater on 2 metres and 70 centimetres.

Licence Update

With the two basic types of licence which were available as well as the mobile and television ones, it was becoming difficult for the authorities to administer the licences so in 1977 they were rationalized. The separate mobile and television licences were abolished, and provision was made in the basic licences for mobile and television use without any further licence or paperwork. This simplification gave amateurs more freedom in the way they wanted to pursue their hobbies and it cut back on costly government administration.

Changes to the Hobby

With the progression of time the nature of amateur radio as a hobby had naturally changed. In the very early days amateurs

were true experimenters and although this attitude persisted, the emphasis on home construction decreased. In the 1950s and 1960s more commercially made equipment became available with names like Minimitter, Labgear and KW became commonplace in the U.K. In fact the KW2000 transceivers initially launched in the 1960s are still in use in many stations today.

Towards the end of the 1960s, equipment from Japan started to arrive in ever increasing quantities. Names like Trio/Kenwood, Yaesu, and Icom began to dominate the market, and more people bought equipment designed and made specifically for the amateur market. In many ways this was inevitable because the complexity of the equipment was increasing - this meant that the time and skill required to build a set was too much for many amateurs.

The advent of this equipment opened up the hobby to a lot more people, with many people using the hobby as a relaxing and enjoyable pastime. People enjoyed a wide range of interests in the hobby, which included chatting to friends, DXing (contacting long distance stations), experimenting and construction.

Many famous people took up the hobby as well. One of the most well known was King Hussein of Jordan who operated with the callsign JY1. Others included Barry Goldwater, an American Senator and Presidential candidate, Rajiv Gandhi, and from the film industry there was Marlon Brando.

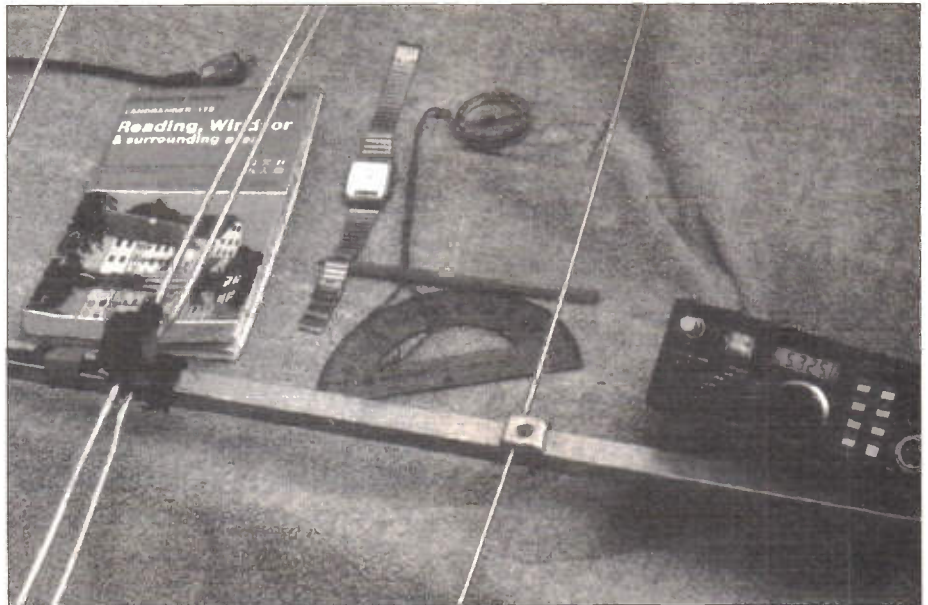
New Bands

In 1979 a World Administrative Conference was held, prior to which, a lot of preparatory work was undertaken by many of the national radio societies, including the RSGB. This paid dividends because despite pressure from broadcasters wanting more space, amateurs won a number of victories. In the first instance many of the broadcasters who had been creeping into the 40 metre amateur band were removed. In addition to this three new bands were gained: 10.100 to 10.150, 18.068 to 18.168 and 24.89 to 24.99MHz. These bands were released on a gradual basis over the following years.

When the old 405 line television services finished broadcasting in the U.K. large amounts of the radio spectrum were left unused. Plans were made to use them for various forms of mobile communication. However, amateurs also made petitions to see if they could regain a band in the region of 50MHz. Initially 40 permits were allocated in 1983 for use in the band during restricted hours. Later additional permits were allowed, but a number of restrictions remained so that interference was not caused to any continental television services. Gradually the restrictions were lifted and all licences were able to use the band which covered 50 to 52MHz.

Space Operation

With the advent of the American Space Shuttle, space flight became a comparatively normal event. Launches did not hit



For those who like to be out and about, an amateur radio direction finding contest should appeal to their nature - equipment shown is for a 2m 'Fox-hunt', as these events are popularly known!

the headlines and were placed well into news bulletins if they were mentioned at all. The experiments performed by these missions took many forms, with amateur radio being allowed onto a number. In the first amateur operation from space, WOORE took a Motorola handheld set on board, and using a special aerial fixed to the window of the Shuttle he was able to have a radio 'bird's eye' view of a very large area. As a consequence, the main problem was interference from the large number of stations calling him. Only short periods of time could be allocated to radio operation as this experiment was in addition to his normal operational duties. However, the experiment was hailed as a success.

Further missions took other radio amateurs into space. One with an all German crew in 1985 operated with the callsign DPOSL. However the loss of a Shuttle put an end to amateur radio operation in space for some time.

The most recent operation took place when the first British astronaut Helen Sharman when up with a Russian MIR space mission in May 1991. Using the callsign GB1MIR she contacted a number of stations including many specially set up in schools around the United Kingdom.

Novice Licence

It had long been felt that the examination, which needed to be passed to obtain a licence, presented a very significant hurdle which some people could not overcome. The young were a particular group who would find it difficult to obtain licences. With this in mind a number of people campaigned over many years to have a novice licence introduced. This would be much easier to obtain than the ordinary licences but would obviously not offer the same facilities.

The RSGB started negotiating with the Department of Trade and Industry who



This TV picture was sent to RSGB Headquarters by astronaut Tony England, who was the amateur radio callsign WOORE, while he was on board the Space Shuttle.

administer amateur licences. The idea was agreed and a draft of the licence was issued in April 1990. The licence was then launched at the beginning of 1991, and to qualify for a licence, applicants needed to take part in a course organised by the RSGB and then sit a simple examination based on the course. Having passed this exam a class B novice licence could be issued for use on the allocations above 30MHz. However, if the applicant wanted to operate on the HF bands a Morse test of 5 words per minute had to be passed. The first seven licences were presented on the 25th July 1991 by the Corporate Affairs Minister of the Department of Trade and Industry.

Once the first novices came on the air, numbers started to rise. Not only was the licence a success from the point of numbers, but as most of the applicants were young it seemed to be achieving its aim of encouraging younger people into the hobby.

The Future

Today amateur radio is a thriving hobby. Many millions of people world wide enjoy it in all its aspects. Whilst many changes have taken place since it first started, most of them have been very beneficial. People now enjoy it as a relaxing pastime. However, many amateurs are still at the forefront of technology with the new developments in data communications. Packet radio is a particular example because commercial systems have been



Amateur radio rallies are held throughout the country. This one was at the G-Mex Centre in Manchester.

developed, assisted by the experience of amateurs. In addition to this, amateurs are still contributing to the scientific understanding of a number of different modes of propagation.

Amateur radio is set for a bright future, since most governments realise its potential in opening up the idea of a technical career to young people, and for the backup which amateurs can bring during a disaster. Amateurs will no doubt continue to help in advancing technologies associated with radio as they have done in the past. To do this the licence needs to be as flexible as possible to ensure that no undue

restraints are placed on them as they have been in the past.

Acknowledgment

Acknowledgments are due to the Radio Society of Great Britain for the loan of valuable archive material and the use of photographs, some of which are reproduced here. The photographs in question are taken from the RSGB publications 'Amateur Radio for Beginners' by Victor Brand, 'The Bright Sparks of Wireless' by G.R. Jessop, and the RSGB magazine 'Radio Communication'.

Dual Stereo Fader continued from page 59.

DUAL STEREO TONE CONTROL PARTS LIST

Components marked with a * are duplicated for the second stereo channel.

RESISTORS: All 0.25W Carbon Film (Unless specified)			
R1(L/R) *	15k	4	
R2(L/R) *	3k3	4	
R3(L/R) *	4k7	4	
R4(L/R) *	100k	4	
R5(L/R), R6(L/R) *	10k	8	
R7 *	33k	2	
R8 *	27k	2	
R9 *	12k	2	
R10 *	1k	2	
R11 *	100k	2	
R12 *	220Ω	2	
R13 *	470k	2	
R14 *	1k2	2	
R15 *	10k	2	
R16 *	68k	2	
R17 *	47k	2	
R18 *	4k7	2	
R19 *	10k	2	
RV1 *	100k Log Slider	2	
CAPACITORS			
C1 *	22nF Ceramic	2	
C2 to C7	100nF Ceramic	6	
C8(L/R) *	2μF 50V PCB Electrolytic	4	
C9(L/R) *	1μF 100V PCB Electrolytic	4	
C10 *	10μF 50V PCB Electrolytic	2	
C11	100μF 50V PCB Electrolytic	1	
C12	47μF 25V PCB Electrolytic	1	
SEMICONDUCTORS			
D1(L/R), D2 *	1N4148	6	
LD1 *	Red 3mm LED	2	
T1 *	BC547 or equivalent	2	
IC1 *	LM339 Quad Op amp	2	
IC2	TDA1074A	1	
VR1	μA7815	1	
VR2	μA7915	1	
MISCELLANEOUS			
	DPDT Toggle Switch *	2	
	14-Pin DIL Socket	2	
	18-Pin DIL Socket	1	
	PCB Pins	25	
	PCB	1	
	25mm M3 Screw	4	
	10mm M3 Screw	2	
	M3 Nut	6	
	Wire Links	20	
	Construction Leaflet	1	
OPTIONAL (Not in Kit)			
	Constructor's Guide	1	XH79L
	Screened Cable	As Req.	XR15R
	Heat Transfer Compound	1syringe	HQ00A

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

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

Order As VE31J (Dual Stereo Fader) Price £32.95.

Please Note: Some parts, which are specific to this project (e.g., PCB, IC2) are not available separately.

This Analogue to Digital Converter Card can be used to connect the RS232 Serial Port Expansion System, described in Part 1 of this series, to the analogue outside world. This means that, via the A-to-D converter, the Intelligent Motherboard can receive information from any devices that can output a DC voltage of up to 5·1V. It can, for example, be used to sample information from various sensors, such as light dependent resistors (light sensors), potentiometers (position sensors), thermistors (temperature sensors), and pressure sensors.

Circuit Description

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

The circuit of the card is shown in Figure 1, and is based around a successive approximation A-to-D converter chip, IC6. Whenever the clock pulse input (pin 11) of IC1 (an octal D-type flip-flop) goes high, eight data bits from IC6 will be transferred into IC1 and latched. The outputs of IC1 are put onto the system data bus when pin 1 of IC1 goes low.

Address Decoder

Since several of these cards can be installed in the motherboard extension card at the same time, each is required to be uniquely addressed to prevent addressing contention between the cards. This is achieved through the fitting of links at the positions 'A0' to 'A7' on the PCB. Between them, IC2 and IC3 provide eight 2-input, exclusive-OR gates, which together form an 8-bit logic comparator. An 8-bit address bus from the motherboard is presented to A0 to A7 as shown in Figure 1.

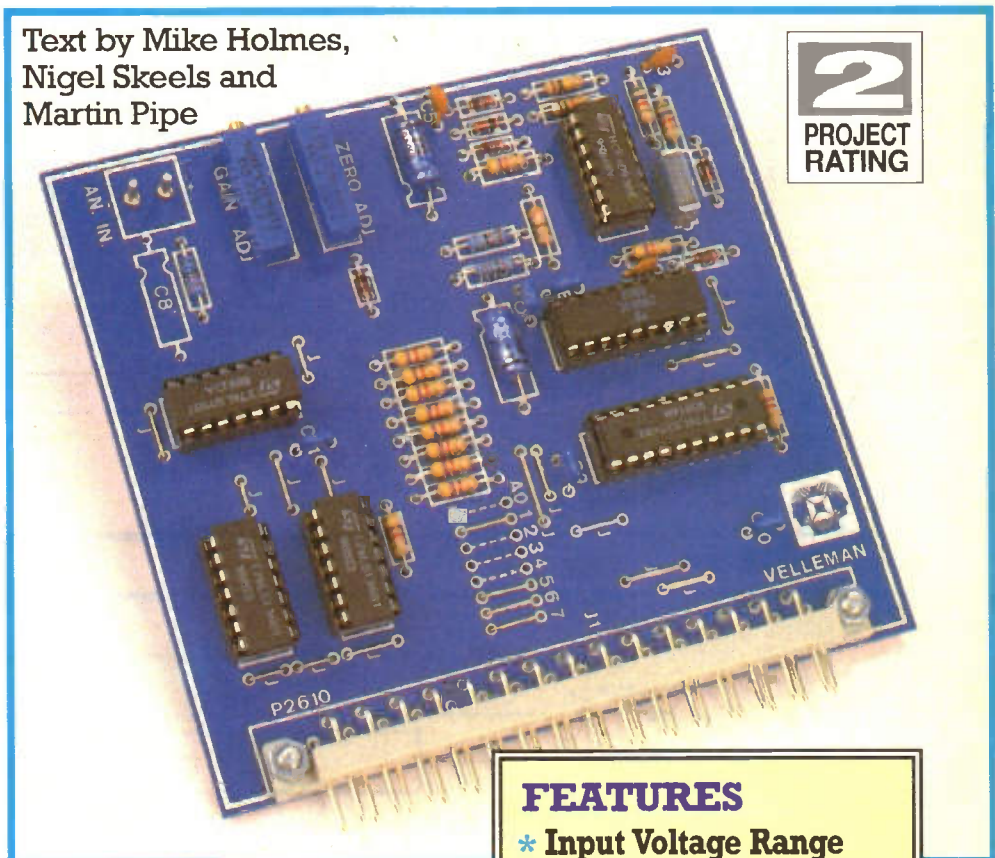
Each gate has an open-collector non-inverting output, and in each case, the exclusive-OR action requires that the two inputs must be at different logic levels to achieve an active high (output off) at the output. If both inputs are at the same level, either '0' or '1', the output is always '0' (output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

IC4 provides two inverters, which also have open-collector outputs, for the system IORQ and WR lines. Once the eight exclusive-OR gates, properly addressed, are all off, it only remains for the I/O request control line IORQ and the write enable line WR to both go low to completely release the common output line, producing a positive going pulse at the junction of R9. This is inverted by another part of IC4 to

RS232 SERIAL PORT EXPANSION SYSTEM PART THREE Analogue to Digital Converter Card

Text by Mike Holmes,
Nigel Skeels and
Martin Pipe

2
PROJECT
RATING



The completed Analogue to Digital Converter Card.

Specification

Input Sensitivity:	5·1V (full scale)
Conversion Type:	8-bit successive approximation
Number of Steps:	256
Step Resolution:	20mV
Linearity Error:	± 1 LSB
Power Supply:	5V at 95mV (from Intelligent Motherboard)
Dimensions:	106mm x 106mm x 15mm

FEATURES

- * Input Voltage Range 0 to 5·1V
- * 0·02V Resolution

APPLICATIONS

- * Variable Voltage Input
- * Analogue Information Gathering
- * Digital Conversion
- * Computer-based Measurement/Monitoring

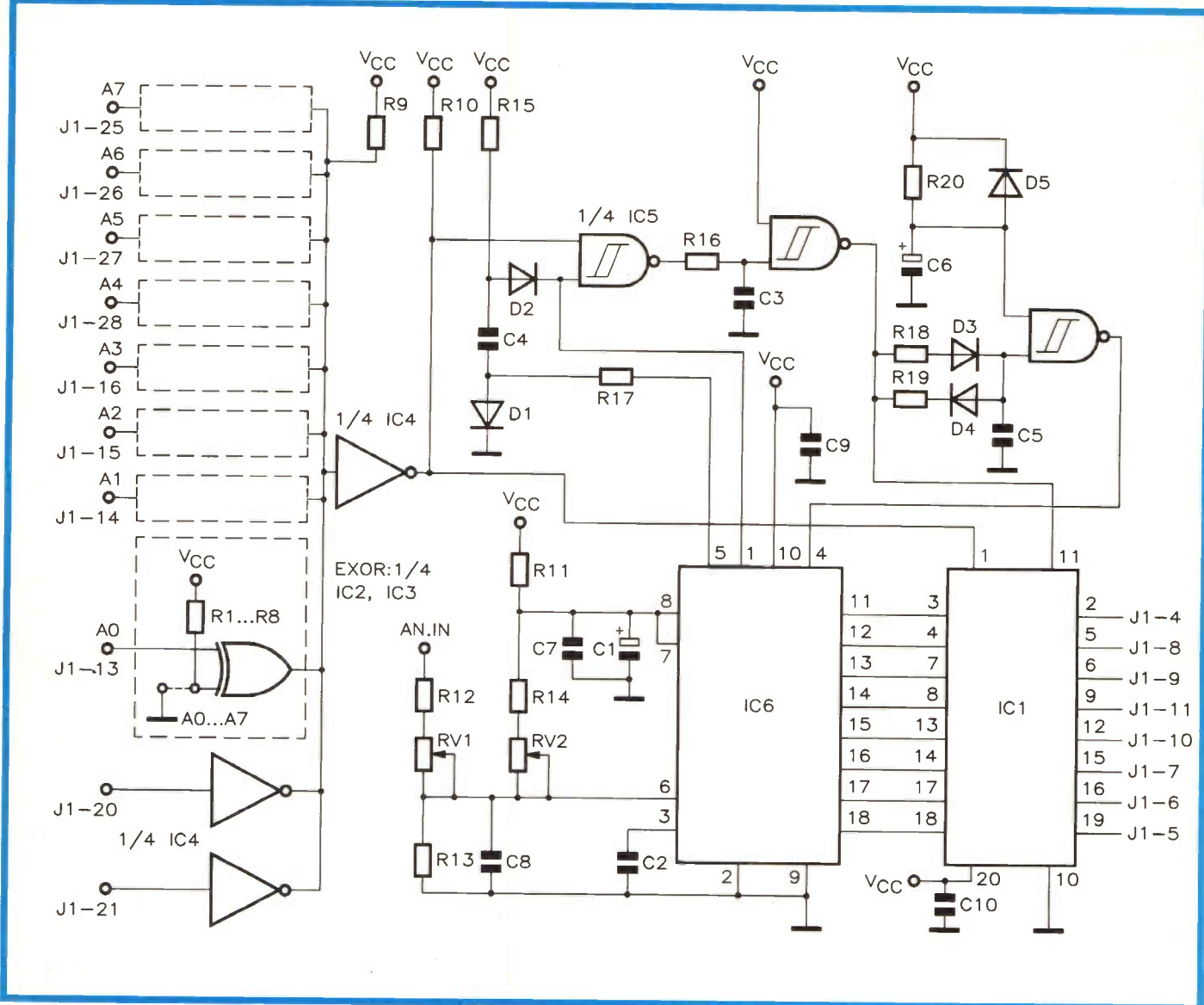


Figure 1. Circuit diagram.

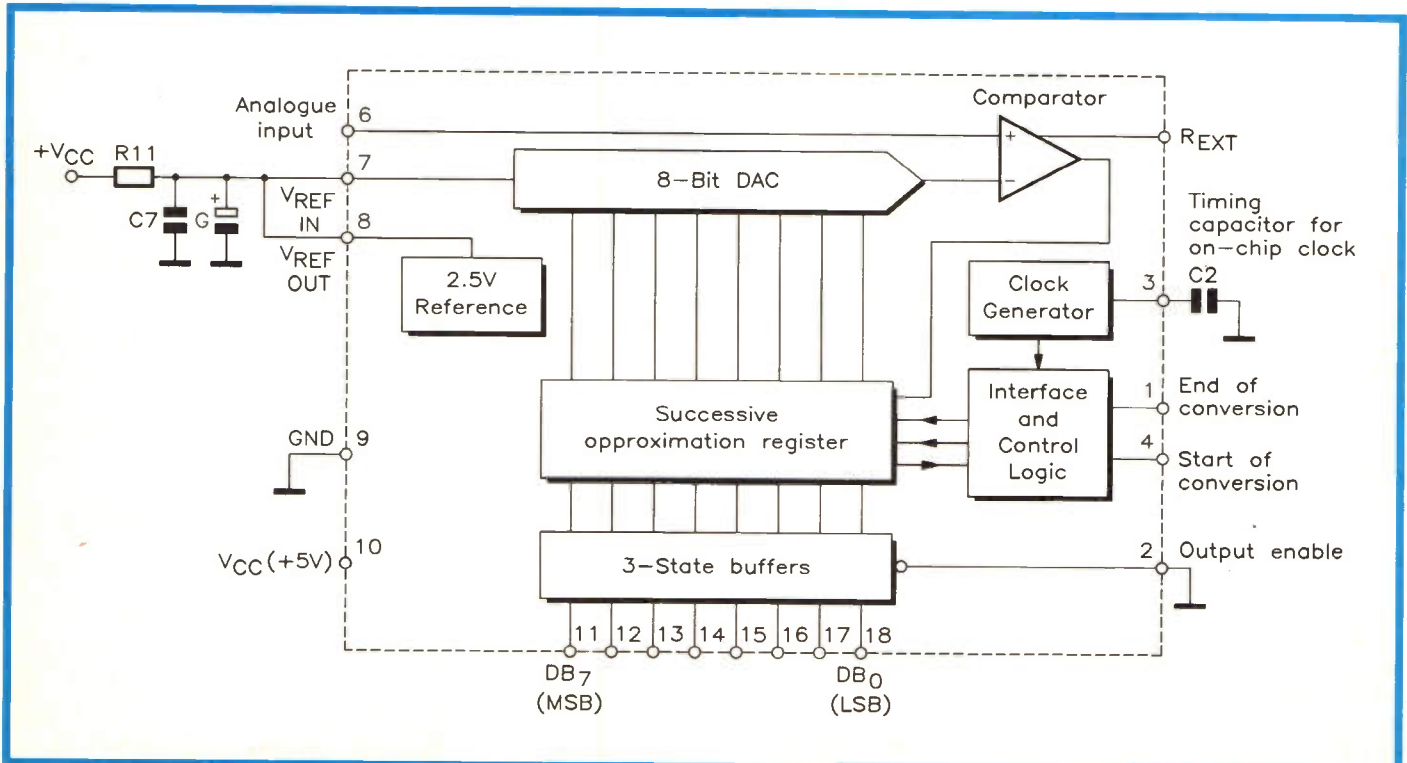
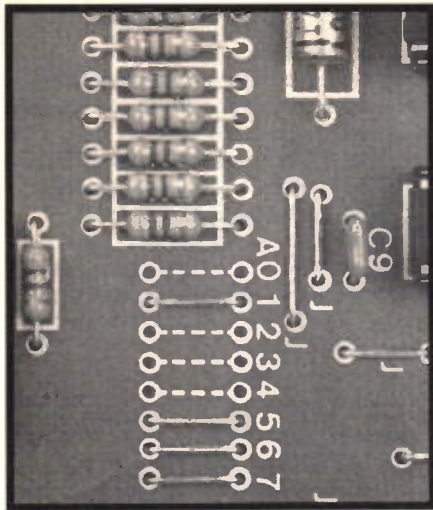


Figure 2. Block diagram of ZN449 successive approximation A-to-D converter (IC6).



Close-up of address-setting links.

provide an active low 'Output Enable' signal for pin 1 of IC1, whose data then appears on the system data bus.

The ZN449

The remainder of the circuit concerns controlling the actual process of A-to-D conversion. The converter itself is built around IC6, a ZN449 successive approximation converter, shown in Figure 2.

In a successive approximation A-to-D, an internal D-to-A initially produces an analogue voltage equal to half of the internally-generated reference voltage (2.5V) – corresponding to a binary number of 1000000. This is compared to the input voltage which, in the case of the ZN449, is applied to pin 6. If the input exceeds half the reference voltage, the MSB is left at 1, if it is less, the MSB is changed to 0. This is controlled by the IC's 'successive approximation register'.

If the MSB is now low, the next most significant bit is then changed to 1, but this time is compared to a voltage a quarter of the supply voltage, again generated by the IC's internal D-to-A.

If the MSB is high, however, the internal D-to-A generates a voltage equal to half the reference voltage added to a quarter of the reference voltage (i.e. three quarters of the reference voltage). This is compared to the input.

In both cases, this 'next most significant' bit is changed according to the output of the comparator. This process is then repeated for each of the other, successively less significant, bits. It can thus be seen that in this type of A-to-D, the input voltage is constantly compared with an incrementally changing internally-generated reference until a match (a close as the resolution of the A-to-D allows) is found. At this stage, the eight bits of the successive approximation register will contain the converted form of the analogue input voltage. The ZN449's outputs are buffered, and are present on pins 11 (MSB) to 18 (LSB) of IC6. The conversion time is a function of the chip's internal clock, the frequency of which is set by C2.

The ADC Support Circuitry

At power up, IC4 is charged via R15, so that pin 1 of IC6, the A-to-D converter, is initially low and represents an 'end conversion' control signal to IC6 (acting as a reset). Similarly, R20 and C6, inverted by one of the Schmitt NAND gates of IC5, pull the 'start conversion' control line (pin 4) high, delaying the start of a conversion cycle.

After this, pin 4 is taken low, causing IC6 to begin a conversion cycle. The analogue input is read and converted into an 8-bit binary value, and then the IC stops and waits. The 3-state outputs are permanently enabled by pin 2, being tied to ground, and go straight to IC1.

When the interface system addresses and reads the card, the data is fetched from IC1 as previously described, and the active low addressing pulse, at R10 and IC1 pin 1, is also passed via part of IC5 to a simple time delay network, comprised of R16 and C3. A delayed active low transition from the following NAND gate, wired here as a Schmitt inverter, operates the 'load' control (clock input – pin 11) of IC1, causing the current data from IC6 to be loaded into the flip-flops. This does not, however, affect the outputs from IC1, which retain the previous value.

This same line is taken through a further stage of time delay (R18, R19, D3, D4, C5) to present a final active low pulse to pin 4 of IC6, causing it to re-convert another byte of data.

Construction

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

As a recommended sequence of events, firstly mount the wire links between the PCB holes marked 'J'. After fitting these the card's address must be chosen; this is according to what other addresses you will be using for other cards, i.e. if this is the first card on the extension board then it can be given the address '1', which would be set by

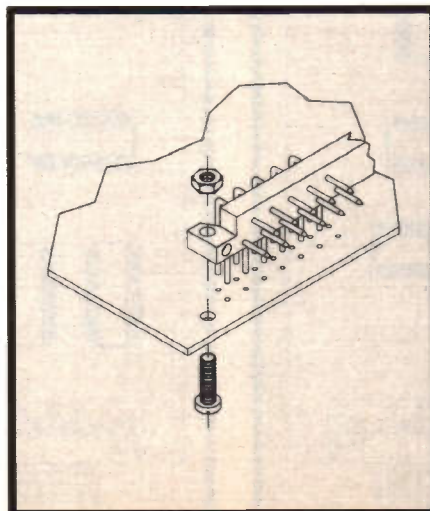


Figure 3. Mounting the card edge connector.

installing wire links at 'A0', 'A5', 'A6' and 'A7' (see Part 1 for a table showing the different addresses available, including special addresses for the multiplexer and an external real time clock).

However, be warned that once the addressing links are fitted, the pattern may not be easily modified without risk of damage to the PCB. For this reason, an octal SPST DIL switch (XX27E) can be fitted at positions 'A0' to 'A7'. The hole spacing in this area is deliberately compatible with the standard DIL layout for this reason. The fitting of such a switch will allow you to quickly and easily alter the card's address at any time – useful in situations where you want greater flexibility and the ability to freely mix different plug-in cards on the extension card.

Bolt the right-angled male PCB connector to the card using two M3 screws and nuts BEFORE soldering, as shown in Figure 3. The female connector should be installed to the motherboard in a similar way. The upright PCB edge guides can then be attached to the motherboard with the self-tapping screws as shown in Figure 4.

The PCB pins can be inserted next, using a soldering iron to heat each pin while applying light pressure to it; this should stop the track on the PCB from lifting.

The rest of the components can then be fitted – ensure that polarised components (diodes, IC sockets, electrolytic capacitors) are orientated correctly – or the circuit will not function properly.

After giving your work a thorough final inspection, insert the ICs into their

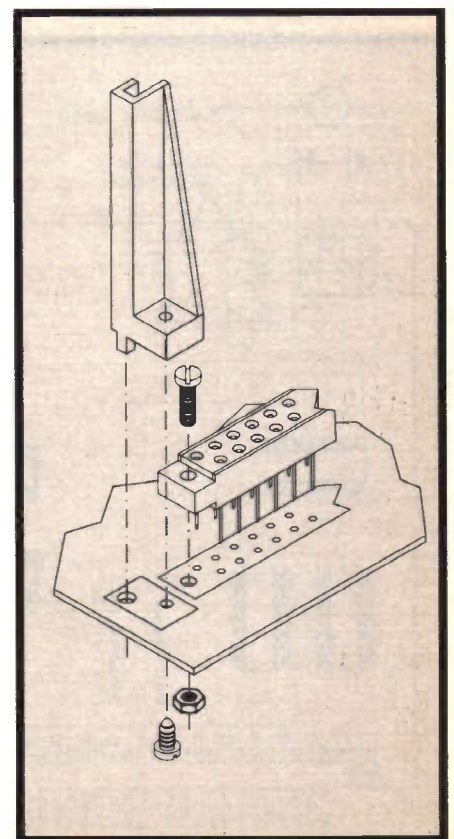
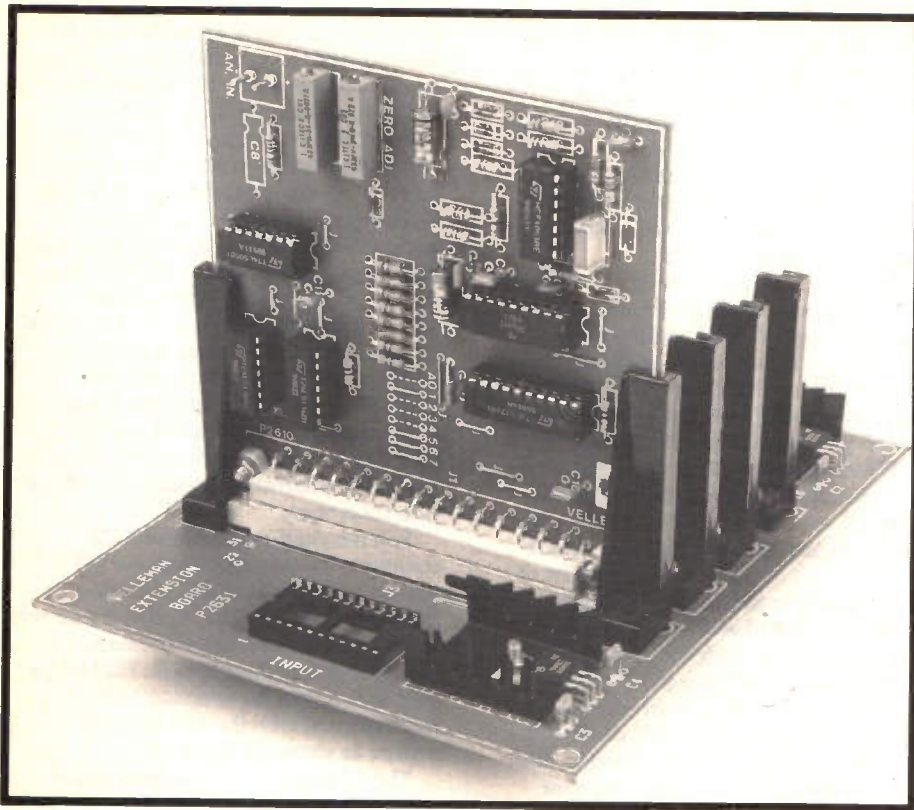


Figure 4. Mounting the motherboard PCB socket and card PCB guides.



The Analogue to Digital Converter Card installed in the expansion unit.

respective sockets, again making sure of correct polarity.

Testing and Setting Up

The unit requires setting up before use. Firstly this involves setting the address, as described above, and secondly the calibration of the input by adjusting RV1

and RV2, which control the input level and the reference voltage for the A-to-D converter respectively. The address needs to be set so that the motherboard will recognise the card as an individual device, and will not confuse it with instructions that are meant for another board. The address is set by inserting a

link to produce a logic 1, or leaving the position vacant for logic 0. A list of possible addresses is supplied with the instructions, which also shows the special addresses that are reserved for the Multiplexer Card and the External Real-Time Clock (to follow in future issues).

Calibration of the unit should be completed using a multimeter, a power supply, and the following program (for the Intelligent Motherboard, refer to the Programmer's Guide supplied with the Motherboard Kit):

```
001 EPEX XX XX XX
002 EPTX XX XX XX
003 EATX XX XX XX
004 EINT XX XX XX
005 RDDA 2 XX XX XX
```

When run, this program will print out the input status every second, enabling adjustment of RV1 and RV2 to be carried out. To begin with, the 'Zero Adjust' preset, RV2, should be adjusted so that your computer's display shows 'zero'; note that no input voltage is being carried out. Next, a stable 5.1V DC supply should be applied to the AN.IN pins as shown in Figure 5. RV1, the input attenuator, can now be adjusted so that the display reads 255 - the maximum conversion possible with an 8-bit A-to-D.

Use

The important thing to remember when using the device is that the accuracy of the reading will depend on how well the unit is calibrated and how stable the power supply (from which the A-to-D's reference is derived) is. With this in

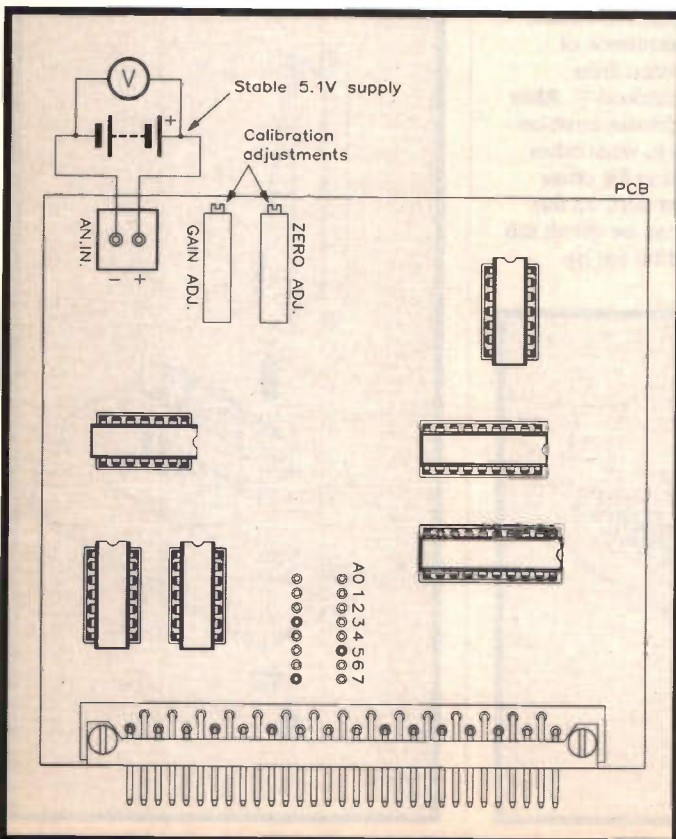


Figure 5. Setting up circuit for calibration.

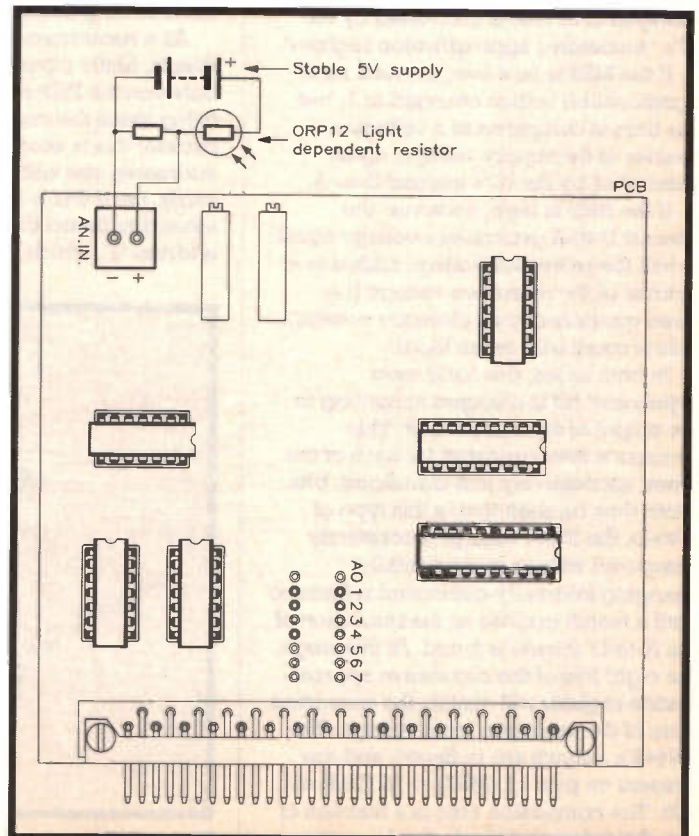
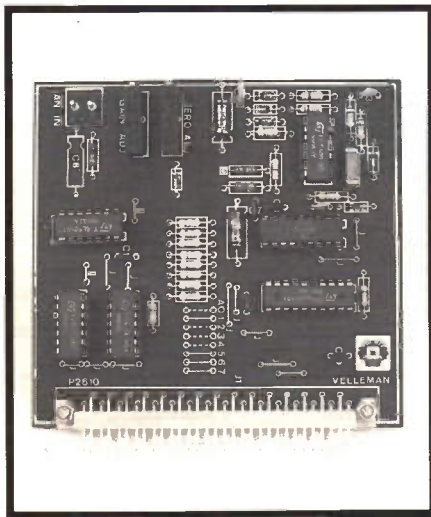


Figure 6. Connection for sensors showing LDR as an example.

mind, it is possible to obtain measurements ranging between 0V to 5.1V, in steps of 0.02V. If linearity errors of lower than 1 LSB are required, the ZN448 (Maplin order code UF43W, not included) may be used to halve linearity errors to 0.5 LSB. Inputs can be provided by sensors, for example the light sensor shown in Figure 6. Current can also be read with the additional circuit shown in Figure 7.

An ideal use for the system is to monitor an input voltage and, when it reaches a preset level, the Motherboard will display an alarm message. This can be done with an 'alarm-on' bit command. Alternatively, alarms can be set to operate if a bit changes, or the value goes above or below a certain point.



The completed A-to-D Converter Card.

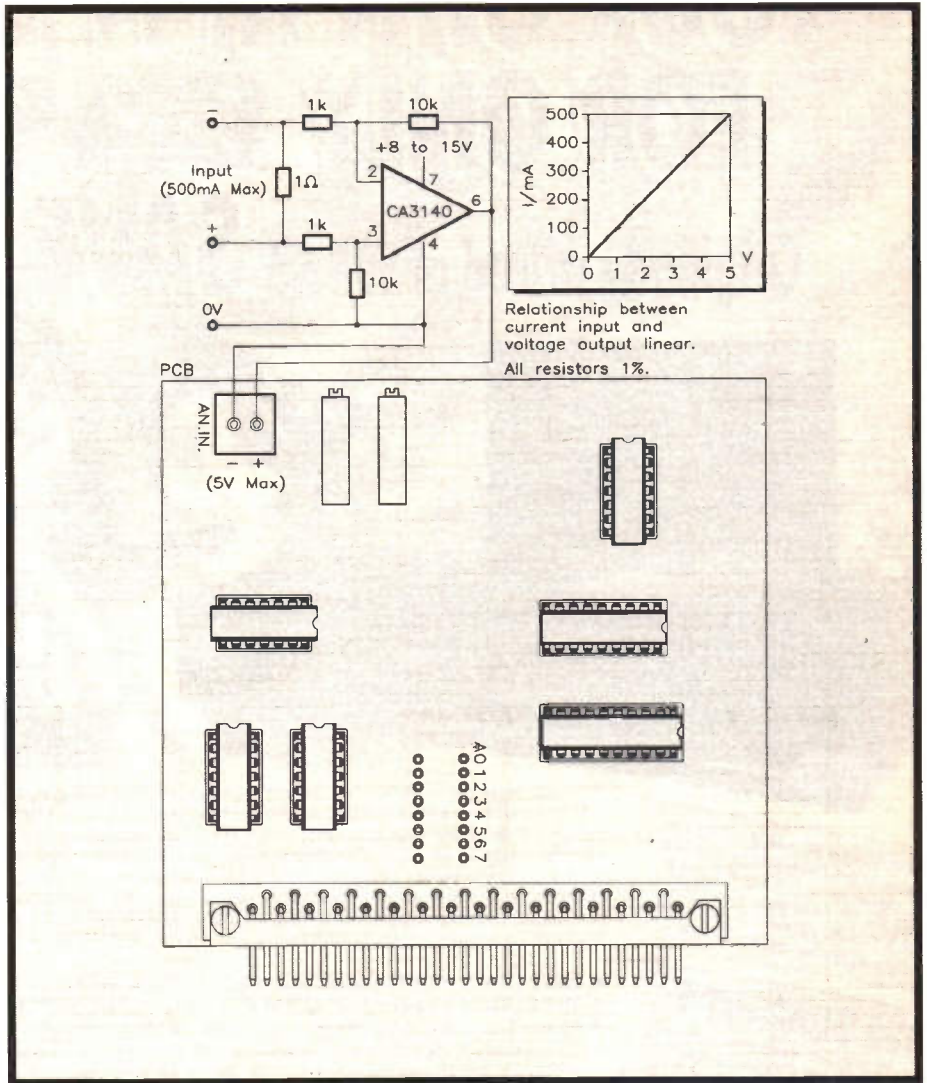


Figure 7. Current to voltage converter.

A-to-D CONVERTER CARD PARTS LIST

RESISTORS: All 5% Metal Film Unless Specified

R1-10	4k7	10
R11	390Ω	1
R12,15,16	5k6	3
R13	8k2	1
R17,20	47k	2
R18	100k	1
R19	15k	1
R14	680k	1
RV1	5k Multi-Turn Preset	1
RV2	1M Multi-Turn Preset	1

CAPACITORS

C1	4μ7F Electrolytic	1
C2,3	470pF	1
C4	47nF	1
C5	220pF	1
C6	2μ2F Electrolytic	1
C7	100nF Epoxy	3

SEMICONDUCTORS

D1-6	1N914 or 1N4148	6
IC1	74LS374	1
IC2,3	74LS136	2
IC4	74LS05	1
IC5	CD4093	1
IC6	ZN449	1

MISCELLANEOUS

Wire links	
14-pin DIL Socket	4
18-pin DIL Socket	1
20-pin DIL Socket	1
PCB Pins	2
31-way PCB Plug	1
31-way PCB Socket	1
PCB Guides	2
M3 x 10mm Screw	4
M3 Nut	4
Self Tap Screw	2
PCB	1
Instruction Booklet	1
OPTIONAL	
ZN448E ADC	1 (UF43W)

The Maplin 'Get-You-Working Service' is available for this project. See Constructors' Guide or current Maplin catalogue for details.

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

Order As VE93B (A/D Converter Kit) Price £34.95

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

**Answer to a
Houseplant's Prayers**

Dear Sir,
I hope you will find interest in the following. About two months ago, in an idle moment, I made up a Plant Water Tester for my wife, following the circuit of the Funtronics Project No.3 ('Electronics' February 92). However, I put it into a box and fitted rigid probes. It was so successful that I have since had to make 5 more for friends and relations!
The probes are made from a double-ended steel knitting needle, which is cut in half (cut half-way and then break – they're hard), and the two probes are held in a two-channel section of rigid connection block fixed to the bottom of the box by a counter-sunk screw and nut. The circuit can be assembled on stripboard and tested out of the box if all leads are about 10cm long and then put into the box, PROBES FIRST. The circuit and battery are, of course, held in place by quickstick pads.
G. R. Andrews, Grimsby.

Thanks for the hint – your plants will love you for the rest of their (extended) lives!

Your Flexible Friend

Dear Sir,
I thought I might add a little humour to the pages of 'Electronics', if that is allowed. I was most pleased to receive my 5% Discount Card as I am a loyal subscriber, so I read the terms and conditions as instructed. As I read on, I came across what I should do in the event of loss of the card. It instructed me to phone or write to the address and telephone number on the back of the card which I and my family found slightly amusing. I hope you don't mind me laughing at the expense of your magazine, please keep up the good work – it's a great magazine to read.
David Higgins, Bishop Sutton.

We are pleased that the 5% Discount Card will be of use to you – indeed, judging by the number of times that they have been used, the scheme has been a tremendous success. However, the point being made is that YOU note down the address/telephone information, and for that matter your card number, somewhere safe! The reason for including this information on the card, rather than the terms and conditions leaflet, is that the card, being durable and wallet-sized, can be used as a handy reference by those who wish to contact Maplin.

Component Vexation

Dear Sir,
May I make a suggestion regarding your magazine. If a contribution shows a circuit diagram using components you do not stock yourself, it would be helpful if he would state where these can be purchased. The sine square generator on page 36 of your September issue, for instance, shows a LF356 being used as the main component, as the basic oscillator, but this is not available from Maplin. A brief note in the text stating where this can be obtained would obviously be of great value.
P. E. Baker, Potters Bar.

For the convenience of the reader we ensure, wherever possible, that any circuits published in 'Electronics' use components available from Maplin – including educational and experimental circuits published in articles such as the 'Waveform Generator Circuits' series to which you refer. However, on this occasion we slipped up – whoops! In the article, Ray Marston specifies the LF356 in the high-frequency (up to 150kHz) Wien-bridge oscillator described, because its high slew rate is less detrimental to operation at such high frequencies. According to our data books, the LF356 offers a slew rate of 12V/μs with a ±12V supply rail (it will be slightly degraded at the ±9V suggested in the article). A similar FET input type, such as the superb LF441 (which, in fact, has a slew rate quoted as 15V/μs at ±12V) should do the job just as well – and it's available from Maplin.

Dear Editor

AIR YOUR VIEWS

STAR LETTER

This issue, D. Lee from Birkenhead, receives the Star Letter Award of a £5 Maplin Gift Token for his interesting suggestions.



Suggestions Galore

Yet more suggestions on articles/projects you might consider for the Maplin Magazine: Could you do a full product preview of the Message Display System (YJ49D). Seems like an interesting product!
How about a project based on the large Dot Matrix LED Display (FT62R). Make your own simple display board similar (smaller) to the above but project based, link it to the output of a micro, LED patterns designed/tested before being loaded onto EPROM. Then use as stand-alone display.
Article/project on your Transformer Kits; how to wind your own transformers – power and HF ferite types – and applications.
You recently did an article on 'How to use the Oscilloscope'; I found this very interesting; can the 'scope be used for further advanced applications – any unusual applications e.g., digital storage etc.
Could you write an article on safety and mains voltage; electrocution, earthing, testing, fault-finding and the dangers involved. How do you wire up a workshop; safety devices, switch ELCB etc.?
In the next issue of the Maplin Magazine, you are doing an article on Amateur Radio. Is this going to include a beginner's guide to CB, how to wire up equipment and use it, then move onto Amateur Radio communication systems? Also a practical guide on how to use Maplin radio communication equipment, including licence details.
Recently I managed to get hold of some 1970s copies of 'Television' and it showed past projects; 'Build your own BLACK/WHITE TV', then a 'COLOUR TV' project. Have you considered this; 'Build your own MAPLIN COLOUR TV'. Then you might say it's cheaper to buy one. But there are lots of school-leavers and electronics students wanting to go into the TV/electronic servicing trade (and lots of TV engineers desperate to get out of this trade)! It would be a good educational project. Small-size MONITOR style, modular panels, use it for computer, TV DXing, video monitor, general use. Begin with a basic Black/White TV then convert/upgrade it to colour TV.

various add-on panels to up-grade it, remote control, stereo sound, lots of sockets (RGB, A/V in/out etc.). Simple switchable faults could be built-in – ideal for training purposes! Maybe a series on TV servicing?
What about 'Build your own VHS Video Recorder'; publish it in the April '93 issue. I am also interested in Telephone systems, how about an article? How advanced are they? Is the BT System X (X as in don't know) the joke of the future? It is advanced now, but BT were using 1930s Strowger technology in 1991/2! When are you going to publish an INDEX for your magazine. Maybe you could put it on floppy disk!
Over the years I have sent quite a few letters with suggestions for your magazine and I noticed a lot of my suggestions have been taken up. Thanks very much, but is there any chance you could publish a line, 'an idea suggested by xxx', so that the person who thought of the idea can get some credit for it! By the way what does it take to get the star letter prize of a £5 voucher. If I bribe the editor with a crisp £5 note will I get the star letter award?
**WHEN ARE YOU GOING TO OPEN A STORE IN LIVERPOOL?
D. Lee, Birkenhead.**

*Well, well, well – are you a mind-reader or what! Many of the features that you have suggested are currently being looked at or are in an advanced state of preparation. We will be publishing details of a 'Moving Message Display' – yes, like the ones you see in shops only better (and cheaper), starting in Issue 62 (February 1993). This one will be controlled by a host computer, but a subsequent project may be a 'stand alone' design.
The first part of a new series on Transformer Design, by John Woodgate, will be forthcoming in Issue 64 of 'Electronics' (April 1993). Covering both theory and practice, it is well worth waiting for!
In recent issues our regular amateur radio correspondent Ian Poole has written on a wide variety of topics related to the subject. Although many 'hams' may (perhaps*

*understandably) scoff at citizens' band radio ('CB') being mentioned in the same breath as amateur radio, many recent amateurs have 'cut their teeth' on CB. Anyway, getting back to the point, Ian will be contributing features on CB – and the Novice Licence (the next stage?) – in future issues.
Unfortunately, a DIY TV project would not be practical. Apart from the fact that dangerous voltages are involved (25kV commonly found in the EHT sections of colour TVs), many TV component manufacturers will only supply OEMs (original equipment manufacturers) – and only then in the large quantities (many thousands) expected from a lengthy production run. One of the projects that we are currently looking at, however, is an add-on that converts a normal oscilloscope into a digital storage 'scope (DSO). Scheduled for publication, meanwhile, in Issue 62 (February 1993) is a review of a very novel DSO – the Philips Scopemeter – we're sure you'll find it interesting! As we said in the reply to D. A. Oram's letter last month, we are considering publishing an annual index – but not in computer format!
Many of our projects and articles are influenced not by one person, but by many (this is where writing in helps – there is nothing like public opinion!). A list of the names of all those who suggested an idea would often take up more space than the text of the article itself! As a result, we cannot do this (much as we would like to) for practical reasons!
You, along with countless other Merseyside customers, will no doubt be pleased to know that Maplin hopes to open a store in Liverpool sometime!
And to your final point. No, you don't need to bribe the Editor with a £5 note to get a gift token or, for that matter, your letter published (although you could try!) – you just have to write a good letter (as you have proven!).*

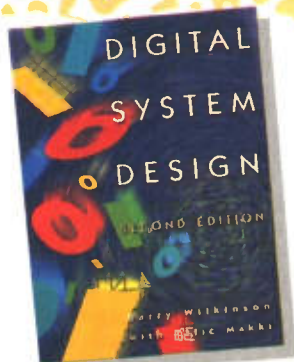
★★★★★★★★

Savouring the TL170C Hall-Effect Switch

Dear Sir,
Here is a useful tip for readers. The exceedingly useful TL170C magnetically operated zero-bounce Hall-Effect Switch appears on page 471 of the 1993 Maplin Catalogue. When purchasing, the relevant data sheet will be provided with it – if you remember to request it when ordering. I have used the TL170C for a number of purposes, but Texas Instruments told me recently that this handy device is now out of production and discontinued. Its linear (hysteresis-free) companion the TL172C has already disappeared from the catalogue. Therefore be warned, do not design the TL170C into any new product that you may be 'developing'. On the other hand, if you are planning to use one in a 'one-off' at sometime in the future, now is the time to get in and buy one, better still, buy and keep one in stock as a spare, just in case!
Ben Sullivan, Waterlooville.

A quick phone call to our Buying Office confirms that this item will shortly no longer be available. Maplin have tried to source it from another manufacturer, but Motorola (the only other company known to produce it) has also dropped it from its product range. Perhaps we can persuade them to change their minds – it certainly looks like a useful device. In fact, one of the Editorial team used one as an auto-stop on a home-brew turntable – a magnet was mounted on the underside of the tone-arm; as the record finished (i.e. tended towards the middle), it came in close proximity to a TL170C which activated a solenoid and relay via some simple interface circuitry. The solenoid activated a damped arm lift, while the relay shut off the power to the motor. Maplin do have some stocks left, but please only buy one if you're sure you'll need it, as some customers will require them to complete projects or repair equipment, and direct replacements will become increasingly harder to come by.

NEW BOOKS



Digital System Design – 2nd Edition

by Barry Wilkinson with Rafic Makki

This book introduces the fundamental topics of digital system design, and can be used as a text for undergraduate electrical engineering, computer engineering, and computer science courses in logic design and microprocessor systems. The book is divided into three parts. The first part deals with logic design, while part two is devoted to the components of a microprocessor system. The last part contains further aspects of digital system design, and extends topics introduced in the other two parts. The overall aim of the book is to provide a comprehensive coverage in concise chapters.

In this expanded second edition, the treatment of logic design has been expanded, and the text on microprocessors has been up-dated. A major new chapter on VLSI systems design and testing has been included.

Part one is covered in the first five chapters and covers the basic topic of binary numbers and codes, with a new section on ANSI/IEEE floating point numbers, Boolean variables, expressions and simplification methods including both the Karnaugh map method and the Quine-McCluskey method, logic circuits and devices, flip-flop logic circuits and counters. Part one concludes with electronic circuit details of logic devices.

Part two outlines the basic stored program concept embodied in computer and microprocessor systems. Various possible instruction formats are described and the concept of a reduced instruction set computer (RISC) is introduced, with potential advantages. A new chapter discusses the instructions found in microprocessors with examples drawn from 32-bit microprocessors, including the Intel 80x86 family, the Motorola 680x0 family and the Motorola 88100 RISC processor. Other topics include memory devices, memory

management systems and input/output devices, and operation.

The final part deals with sequential circuit design, and includes both synchronous and asynchronous sequential circuit designs, programmable logic devices (PLDs), central processor design, microprogramming, VLSI logic design and reliability of digital systems.

This book has been thoroughly revised and updated to provide a comprehensive treatment of modern logic design.

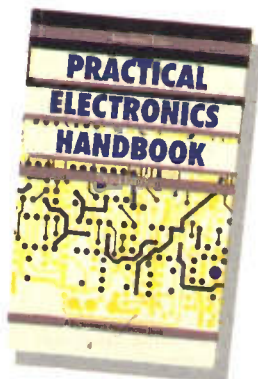
1992. 558 pages. 235 x 174mm, illustrated. American book.

Order As WZ65V
(Digital Syst Design) £19.99 NV

Practical Electronics Handbook

Third Edition
by Ian Sinclair

Databooks often tend to be simply collections of information, with little or nothing in the way of explanation, and in many cases with so much information that the user has difficulty in selecting what he needs. This book has been designed to include, within a reasonable space, most of the information which is useful in electronics together with brief explanations which are intended to serve as reminders rather than instruction. The book is not, of course,



intended as a form of beginner's guide to the whole of electronics, but the beginner will find here much of interest, as well as a compact reminder of electronic principles and circuits. The constructor of electronics circuits and the service engineer should both find the data in this book of considerable assistance, and the professional design engineer will also find that the items collected here are of frequent use, and would normally only be available in collected form in much larger volumes.

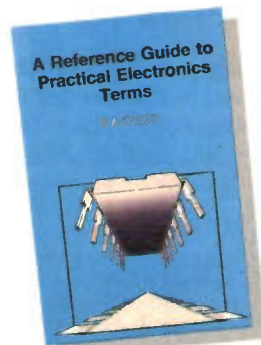
This completely updated and revised book covers many areas not available

elsewhere in such a handy volume, and this new edition has ten chapters on topics covering passive components, active discrete components, discrete component circuits, linear ICs, digital ICs, microprocessors and microprocessor systems, transferring digital data, digital-analogue conversion, computer aids in electronics, hardware components and practical work. Included in the appendix is a standard metric wire table, the hex scale and a bibliography, which suggests very useful books for further reading.

This profusely illustrated book will be a useful companion to anyone with an interest in electronics.

1992. 340 pages. 216 x 138mm, illustrated.

Order As WZ60Q (Pract Elect Handbook) £14.95 NV



A Reference Guide to Practical Electronics Terms

by F. A. Wilson

Electronics is passing through a period of relentless expansion, resulting in electronic devices surrounding us on all sides and their numbers are increasing without mercy! For the electronics engineer and enthusiast, the problem is one of keeping up with this relentless expansion.

Unfortunately it is not possible to know it all, and most of us do not wish to afford the cost of large reference books which explain many concepts in fair detail. This inexpensive reference guide explains briefly and succinctly, many of the underlying electronics features of practical devices, most of which to a certain extent control our lives.

This book is in effect more than just a dictionary of practical electronics terms, it goes a stage further in also getting down to fundamentals. Accordingly the number of terms may be limited but the explanations of the many which are included are designed to leave the reader more competent and satisfied. Complicated mathematics has been avoided as this can be confusing on first reading.

The entries are in alphabetical order, and where necessary, entries have references for further reading. The references are no more than enlightened suggestions, and the reader can choose which, if any, should be explored further.

Modern equipment is often little more than a cluster of unfathomable integrated circuits so we learn better from circuits of discrete components. Accordingly these are frequently used for illustration even though in the practical world integrated circuits have taken over.

This practical reference guide is ideal for everybody concerned with electronics.

1992. 442 pages. 198 x 130mm, illustrated.

Order As WZ59P
(Guide Electr Terms) £5.95 NV

An Introduction to Scanners and Scanning

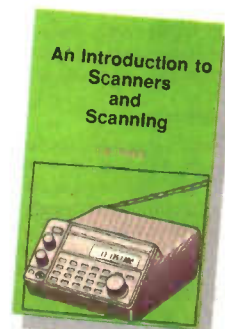
by I. D. Poole

Over the past few years a new type of radio has hit the market – the scanner. Its arrival has given a new dimension to general coverage radio receivers. Previously the only general coverage receivers which could be bought were the short wave types, which usually only covered frequencies up to about 30MHz. There was nothing for the listener who wanted to explore any bands which were any higher in frequency. Now this has all changed. Radio scanners are rapidly increasing in popularity, opening a whole new realm to short wave listening.

Employing the latest in today's silicon technology they are far more than just short wave receivers with extended frequency coverage. They offer a host of new features which revolutionise listening and enable the listener to pick up signals which could not be heard before. This book aims to cater for the new breed of scanner listener.

Topics covered in the book include: radio wave propagation; types of transmission which can be heard, how a scanner operates, aerials, the radio frequency spectrum (including a frequency list), operating procedures, broadcast bands, amateur radio, and citizen's band. In addition to this there is an appendix which includes a glossary of essential terminology and callsign prefix lists.

Scanners are specifically designed for modern listening. They can be programmed to tune or scan over a number of preset frequencies and stop when they find a signal. By using this facility the receiver can be made to monitor several frequencies of interest.



This book will provide a useful reference to scanner listeners, those who own World Band Radios and anyone with an interest in short wave listening of any description.

1992. 152 pages. 179 x 111mm, illustrated.
Order As WZ62S
(Intro To Scanners) £4.95 NV

Radio Controlled Model Cars

by Trevor Tennant
Advanced Techniques

The most important aspects of going racing using the new Traxxas Bullet car as the basic vehicle, were covered previously. The Bullet has been raced with some success considering that the driver was a complete novice! A few alterations have been made to improve the car. Owing to a freak accident the body shell was damaged, but a visit to the local buggy shop found a suitable body and a separate wing. The result is a lighter and sleeker-looking car. The radio switch position had to be changed to enable the new body to sit on the chassis properly.

The motor was changed for the Maplin HP-230GS2 (Order Code KU39N) which gave a pleasing brisk performance when geared with a 12-tooth motor pinion. The standard battery will last the five minute race duration – provided there are not too many crashes! The XL-1 speed controller (Order Code ZF33L) is very effective and ran very cool in spite of the novice driver's off-circuit excursions. Replacing the mechanical speed controller (supplied in the kit) with an electronic one has increased the running duration of the car to a marked degree. This improved performance can be attributed to the fact that there is no wasted power operating a servo or heating up a resistor.

The Radicator, shown in Photo 3, has received some critical attention. Although slightly less expensive than the Bullet, in some ways it is a better car. The Radicator has the currently fashionable 'in-line' battery location of the Bullet, and an all-enclosed plastic tub chassis (see Photo 2). Thanks to the latter, the Radicator tends to keep quite clean, and not let the weather into the works.

Spare Part Surgery

What is an interesting exercise is to substitute some of the parts with their equivalents from the other vehicles. As a typical example, the ballrace set for the Blue Eagle will also fit both the Radicator and the Bullet. The benefit brought about by such a change will be the more precise location of all shafts and axles. The car will have a tighter feel as it is rolled along. The biggest improvement will be the dramatic reduction in friction. The

oilite bearings are quite effective but, because adequate clearance is required for them to function, play in the shafts and axles will be greater than that of a ballraced car. While fitting ballraces, it is a sound exercise to completely strip the car down; time is well spent making certain that everything is correctly adjusted, so that there is no binding of the various linkages and gearbox shafts.

The plastic dampers on the Radicator can be replaced with the Bullet's alloy fixtures as can be seen in Photos 1 and 3. Be sure to use the nylon upper damper mount bushes; alloy parts will not wear well against other alloy parts.

The Radicator's wheels are a worthwhile modification to the Bullet. They are lighter because of the single-piece construction. The wheels have a different arrangement for the rear driving centres; the metal 'hexagon' adaptor is not required with the Radicator wheels when used on a Bullet. The Radicator wing mounting can be used on the Bullet, if you change the body like we had to.

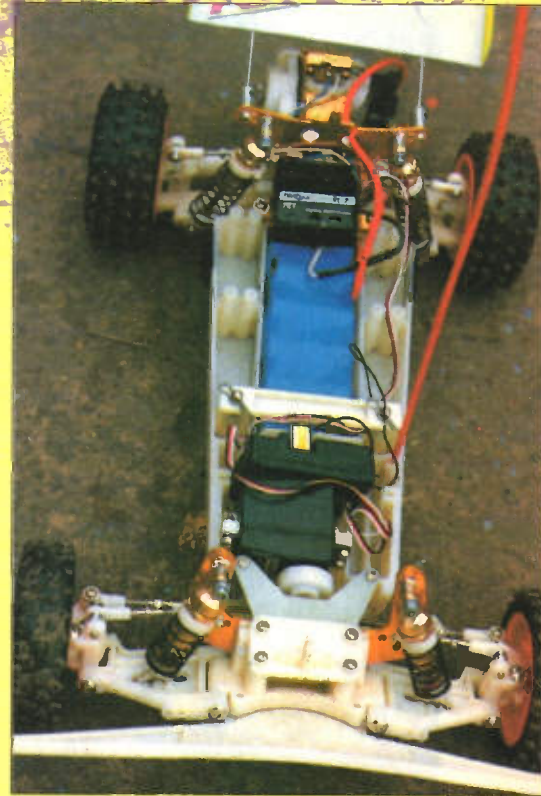


Photo 1. Radicator, with body shell removed. Note the XL-2 speed controller, and home-constructed battery pack.

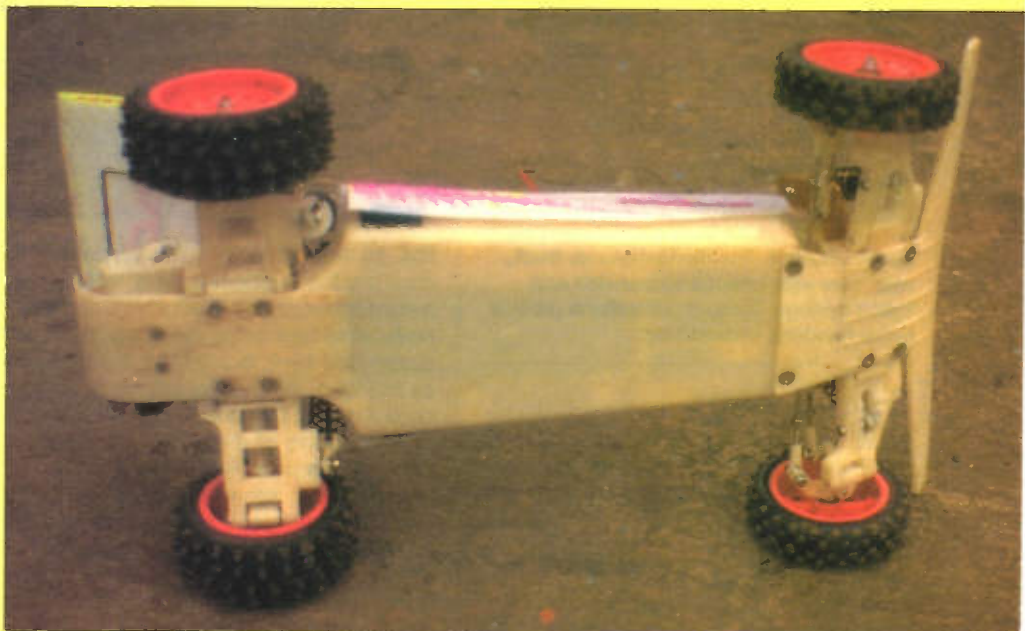
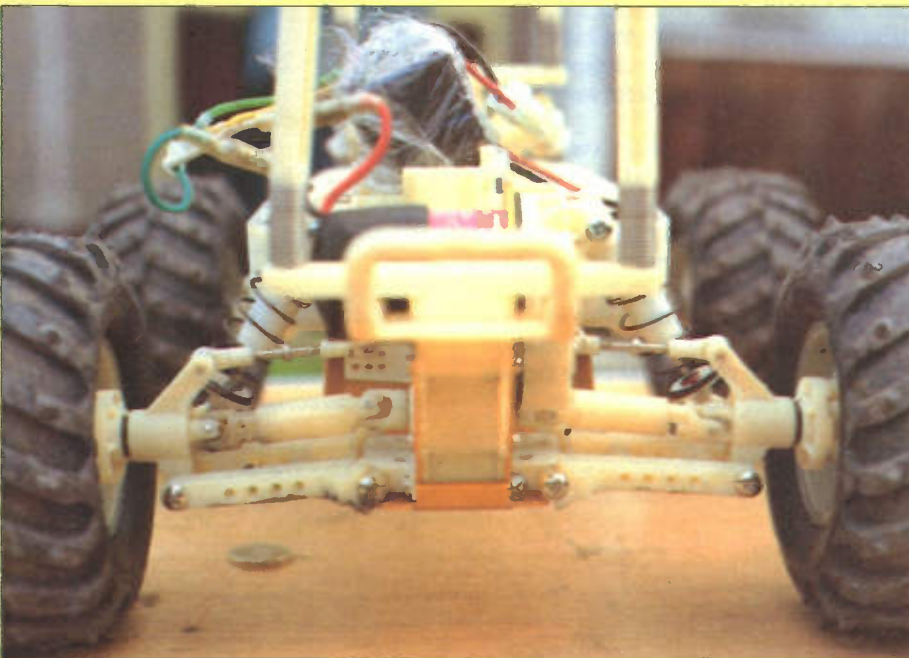


Photo 2. Underside of Radicator, showing plastic tub chassis construction.



Photo 3. A race-ready Radicator, paintwork courtesy of Brett Nixon. Note the alloy shocks.



Above: Photo 4. The Sledgehammer truck, seen here with lowered suspension and lighter springs. These modifications provide better handling when racing.

Trucks

So far, we have only discussed the cars of the Traxxas range. In addition to these, there are two excellent two truck racers available.

The Sledgehammer

The first of these, the Sledgehammer, is a monster truck vehicle and as such is designed for stunt and 'car-crushing' activi-

ties, as well as racing. The suspension is such that the vehicle rides very high, and as a consequence, the Sledgehammer is not really at its best being raced against lower suspended pure racing-bred trucks. Used as intended, the Sledgehammer is tremendous fun, and will give kids (and adults!), of all ages, hours of enjoyment. As shown in Photo 4, it is possible to lower the truck by the simple process of removing one of the shock absorber pairs from each corner, and using a softer spring on the remaining rear damper units. With these simple modifications, along with a ten tooth pinion on the motor, this truck will handle better around corners, and will pull wheelies up to 100 feet

long! The chassis tub is very tough, and the suspension is strong enough to accept the most ham-fisted abuse with little (or no) damage.

The Blue Eagle

Shown in Photos 5, 6 and 7, the Blue Eagle is the flagship of the Traxxas cars. This particular vehicle is, in my opinion, the best ready-to-run car I have seen; it has a performance potential of the highest order, having all the current state-of-the-art features that are expected on the top racing machines of the 1990s.

The Eagle will be an extremely suitable and economical vehicle for The British Radio Car Association 1/10th scale Stadium Truck racing class. With the addition of suitable ancillary equipment, this car will give the careful and competent driver a chance of 'mixing with the best' at club level competition. At its first race meeting the car, as used by me, was a revelation – it was easily the fastest off-road car that I had ever driven! It took three races to come to terms with its handling sharpness; this, I might add, was no fault of the car! During the final race, a different approach to the driving of the car saw it disappear into the distance, lapping the rest of the field easily. The win was to be denied, however, because a freak collision with a Bullet being raced at the same time caused the alloy screws, which hold the rear suspension in place, to shear off. The truck was hit in mid-air, and the Bullet's front bumper somehow got tangled in the truck's transmission. The alloy screws sheared clean off, losing the drive completely. This freak accident is most unlikely to occur again, but as a precaution I have replaced the alloy screws with steel ones. Otherwise the car performed very well indeed.

Equipment used in the Blue Eagle was as follows:

1. HP-230GS2 Motor (Order Code KU39N).

Note that the motor mounting plate, supplied with the Blue Eagle, will not allow the most powerful motors of the Maplin range to be fitted. However, a simple spacer, as shown in Figure 1, was made up so that they could then be used. It appears that the very latest generation of buggy motors use a smaller diameter bearing housing at the output shaft end. The motor, fitted with the larger driven gear, gave really good acceleration. Because the fully ballraced drive train is so free and efficient, motor choice is very wide; it is only really governed by the quality of the drive batteries. Incidentally, the Blue Eagle's gear-box is shown in Figure 2. Note the fine pitch gears and ballraces used – no skimping on quality here!

And now a note on motor noise suppression. If this is not done, electrical noise produced by the motor may interfere with the radio control gear or, even worse in a competition, an automatic lap-counting system (such as the AMB Auto Count). Therefore, it is wise to install a noise suppression network from the start. This consists of two 100nF disc ceramic capacitors (Order Code BX03D), which are soldered to the motor, see Figure 3.

2. Traxxas XL-3 Speed Controller (Order Code ZF35Q).

This superb forward-only unit will easily work with any available motor. It requires that you fit your own motor and battery connectors – which is quite easy. A word here regarding connectors; The Tamiya-type connector fitted to most battery packs is not ideal; they are fine for average motors, but are a bit lacking when it comes to serious use with hot motors and batteries. A better bet is the range of Powerpole connectors stocked in good model shops. A faulty Tamiya connector caused me to return a slope charger to its maker – the charger was faultless; it was the connector that was intermittent!

Be warned with any electronic speed controller – READ THE INSTRUCTIONS! More controllers are wrecked by stupid mistakes than by any form of racing! The correct way to wire up an electronic speed controller is shown in Figure 4. This diagram also shows the aforementioned motor suppression network. The XL-3 was set up according to the information sheet, and worked very well indeed. The instructions regarding interference suppression must be obeyed, or all manner of strange effects can occur. A useful tip is to keep all connecting leads as short as possible. Solder the controller's output leads to the motor's terminals – do not rely on plugs and sockets here! The use of multi-strand silicone-sheathed wire is justifiably highly recommended.

The author experienced problems using a pulse code modulation (PCM) radio system. It seems that the PCM system interacts with the XL-3 speed controller, preventing it from working properly. Changing to a normal receiver solved the problem.

With a switching capacity twice that of the XL-1 (and roughly half that of the XL-3) the XL-2 (Order Code ZF34M), which also has an excellent performance, fits neatly in the middle of the Traxxas range. One of these controllers, suitable for use with medium-

powered motors, can be seen fitted to a Radicator in Photo 3.

3. Maplin High-capacity 7.2V Racing Pack (Order Code YP92A).

These battery packs give more speed, and can withstand a more punishing charging regime, than the standard Maplin batteries. They are quite adequate for initial racing use. However, it has to be realised that as experience is gained, batteries capable of providing greater performance will be required. This topic will be looked at later.

Getting it all Together

The Eagle's instruction manual is extremely comprehensive. The tuning guide on its own is worth the money you pay for the complete car! I learnt several interesting points studying it.

Apart from fitting a suitable motor and the radio equipment, there is little work required to have the car ready for the track.

Before you run the car, the ball differential and the slipping clutch will need to be correctly set up. The ball differential, as you can see from Figure 5, is a complex item. The method of locking the transmission, so that the pressure on the ball differential can be quickly adjusted, is cunning. You adjust the tension by locking the transmission with an allen wrench, and then turning the offside rear wheel either way. It is a question of experimentation when deciding how tight to set the differential. If it is too loose it will not drive properly; if it is too tight, differential action will be lost and the car will not steer correctly. The slipping clutch will be a new feature to most people so a few words of comment may be useful.

The slipping clutch, shown in Figure 6, is a device which can be adjusted so that the amount of power transmitted to the rear



Above: Photo 5. Blue Eagle with body shell removed.

Below: Photo 6. The Blue Eagle – a most formidable club racing machine.

wheels by the motor can be varied. A side benefit is that when the truck lands after taking a jump, the transmission will not be damaged because the clutch will slip, absorbing the motor's excess energy until the truck gets moving again. The correct adjustment of the clutch will depend on three factors:

1. Amount of traction available from the track surface.
2. Skill of the driver. A smooth driver will not need as much clutch slippage as a rough jerky-action driver.
3. Amount of power from motor.



The clutch is adjusted by pre-loading the clutch by turning a 4mm 'nyloc' nut on the end of the clutch shaft. A car with a powerful motor, being used on a very dusty track, will require quite a lot of clutch slip. The reverse will apply with a 'grippy' track and a modest motor. The idea is to allow the clutch to slip as the throttle is snapped open, so that the wheels will only just spin. As the car begins to come up to top speed, though, there is no slippage. Like most things, both the ball differential and the slipper clutch will 'bed in' as they settle, and they will require adjustment for the first two or so races. After that, adjustment should not be required for long periods.

The extent to which the slipping clutch smoothes out the running of the Eagle is quite surprising, and you may wonder why it has not been used before.

Gear Ratios

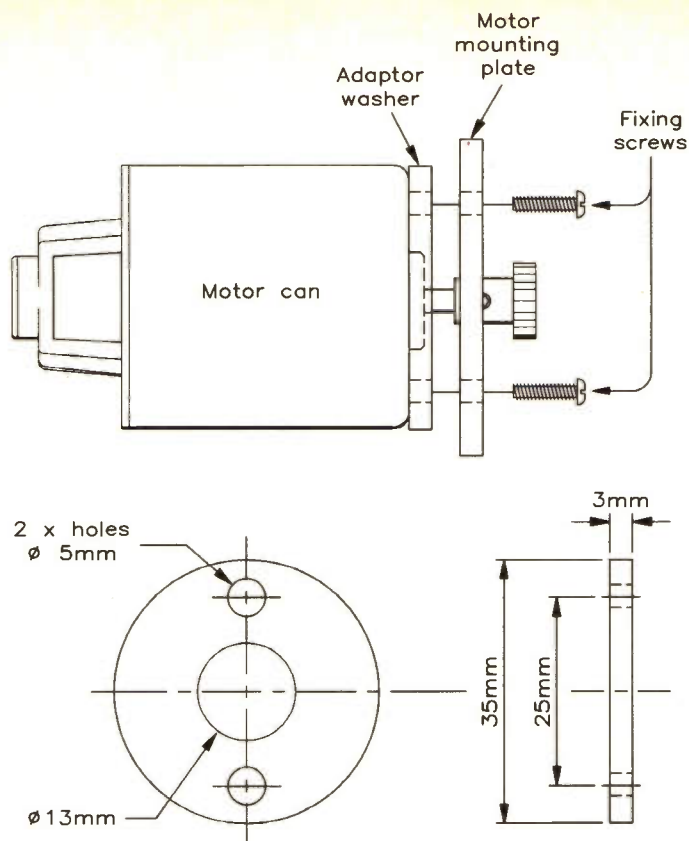
The single most important factor affecting speed and duration on any radio controlled car is the gear ratio. This is why different-sized motor pinions and driven gears are available.

It will be appreciated that the overall gear ratio is the critical factor. The overall ratio is calculated by dividing the number of teeth on the motor pinion (for example, 15 teeth)

Right: Figure 1. Fitting Maplin's high-powered motors to the Blue Eagle. Note that these items have a tall bearing housing, and so an adaptor washer must be used.

Below: Figure 2. Internal details of the Blue Eagle's high efficiency gearbox. Fine pitch gears and ballraces are fitted as standard.

Below right: Figure 3. Fitting the motor noise suppression capacitors.

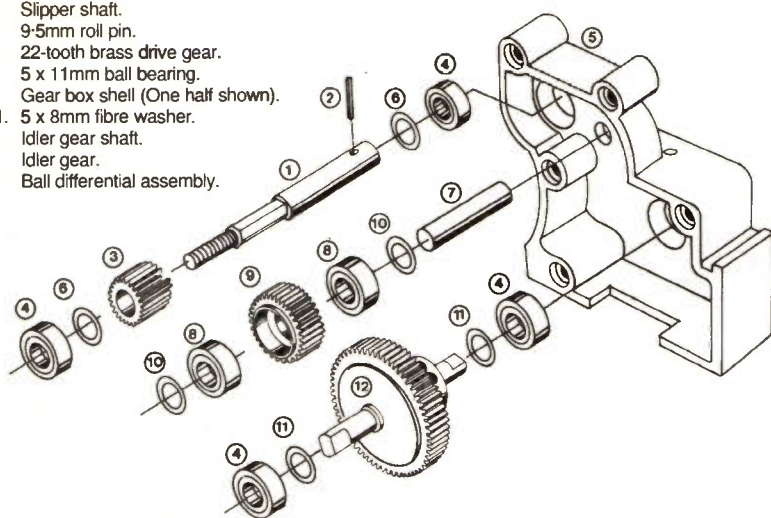


Adaptor washer is fitted so that motors with a tall bearing housing can be used with the Blue Eagle.

Make from aluminium alloy.

To use, the washer is inserted over the motor output bearing boss. The motor screws are then threaded through the motor mount, the washer then being held tightly between the motor body and the mounting plate.

1. Slipper shaft.
2. 9.5mm roll pin.
3. 22-tooth brass drive gear.
- 4,8. 5 x 11mm ball bearing.
5. Gear box shell (One half shown).
- 6,10,11. 5 x 8mm fibre washer.
7. Idler gear shaft.
9. Idler gear.
12. Ball differential assembly.

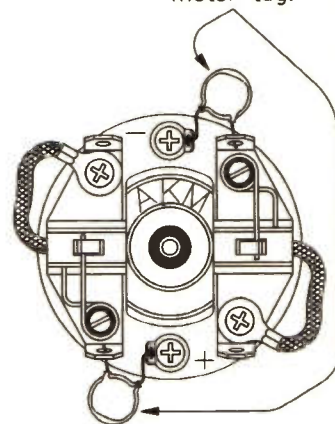


by that of the driven spur gear (say, 90 teeth) to give a primary ratio (which, in this case, will be 6:1). Next we consider the internal gear box ratio, which is fixed at 2.72:1. The overall ratio, in this case, will be 16.32:1, i.e. the motor will have to rotate 16.32 times for the rear wheel to rotate once. The pinion supplied with the Eagle is a 25-tooth item and so, with the largest spur gear (which has 84 teeth), the overall ratio will be 9.14:1. This ratio will be suitable for motors with windings in the order of 27 turns per pole. Most stock motors are to this specification.

A more powerful ('hot') motor will require a much higher ratio; something in the region of 19.84, or 12.02:1 overall, will be more suitable. The reason for this difference is that to give more power, the hot motor will need to rev higher than a stock motor.

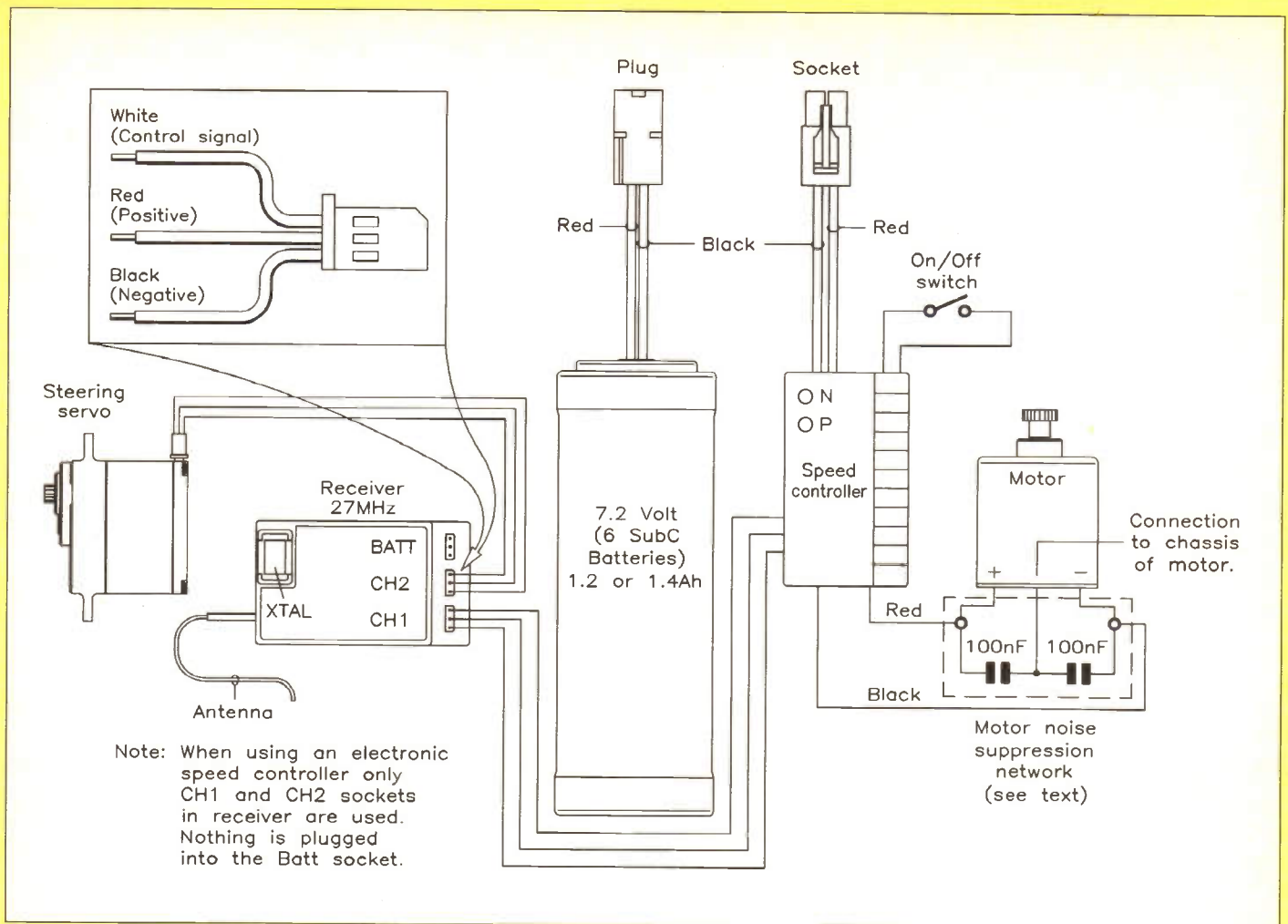
If you try running a really hot motor on a ratio which is too low, there will be big problems. Firstly, the motor will run very hot indeed and may be damaged. The speed controller will also get hot and bothered, because it is having to pass an awful lot of current. Worst of all, the battery pack will

100nF disc ceramic capacitor soldered to tag on can and motor tag.



End view of AKM motor showing brush gear and essential motor suppression for AMB Auto Count System

get so hot that it may, at the very least, melt its shrink sealing cover. In some cases, the heat can be so bad that it can melt its way into any nearby plastic. If you have this problem, or are faced with a situation where the battery terminals have effectively been shorted together by a fault in the car's electrical system, DO NOT PANIC! Firstly, clear



an area, the battery pack has to be removed from the car, and bearing in mind its temperature, it may burn the bare hands. Using gloves or a cloth, etc., remove the battery clamp retainer. Cut the wires from the battery to the speed controller. Do not waste time trying to undo plugs or you may get burnt. Remove the battery pack and either dump it into a bucket of water, or put it under cold running water until it has cooled down. Even under normal circumstances (i.e. after a race) it is worth cooling the batteries down, albeit somewhat less dramatically; sandwich

Above: Figure 4. Wiring diagram for electronic speed controller.

Below: Figure 5. The ball differential transmission, as used in the Blue Eagle.

it between two sealed ice packs (of the type used by picnickers and travellers for keeping food cool) until the pack cools down. In an emergency, though, keep cool yourself – and don't just leave your battery pack to cook. If at a meeting yell for help!

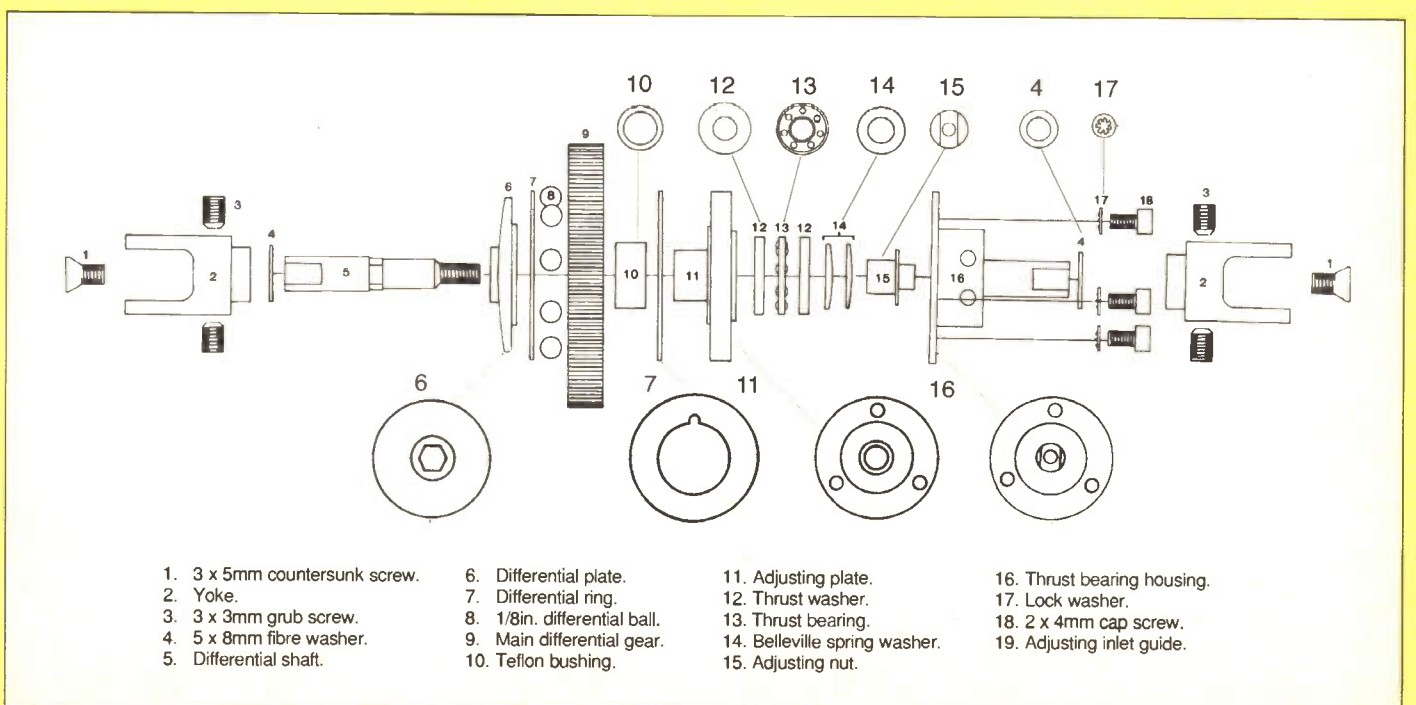
When you have the correct gear ratio, the truck will run for the five minutes at full-speed

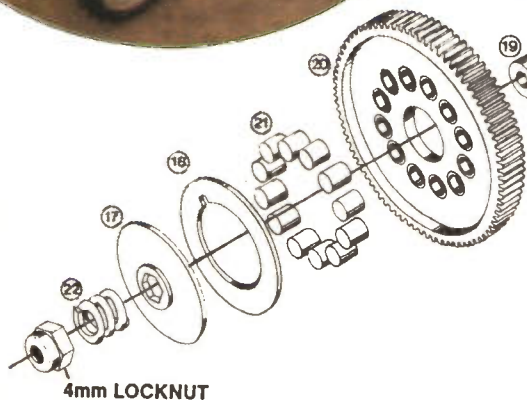
without the motor or cells overheating. Both will get warm, but not to the extent that you feel pain when touching them with your finger after the race.

Batteries and Charging

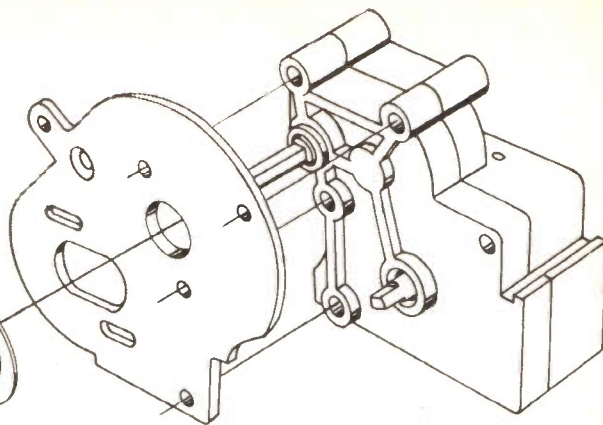
In the first part, I mentioned that you should keep to a simple routine regarding batteries and charging, thereby concentrating on the driving. When you can drive reasonably well, it will be time to uprate your equipment.

On the battery scene, developments





4mm LOCKNUT



- 17. Slipper pressure plate.
- 18. Notched slipper ring.
- 19. Spur gear bushing.
- 20. Spur gear.
- 21. Friction pegs.
- 22. Coiled tension spring.

Above: Figure 6. The Blue Eagle's slipping clutch arrangement.

have been quite hectic in the last year. The giant Japanese Sanyo and Panasonic concerns are at the forefront of Ni-Cd battery development. In the world of National and International class off-road racing, the preferred choices tend to be the Sanyo SCE 1700/SCR 1400, or the Panasonic 1700 SCR.

The individual cells of each pack will, without exception, be computer selected and then very accurately matched to each other. Each company doing the cell matching will process thousands of cells to obtain a small number of the very highest quality; these will be issued to works-sponsored drivers. Any set of batteries bought from these outlets will have a good performance, but remember that the best of the crop will always be kept for the favoured few. And now for some recommendations regarding batteries. Firstly, I cannot recommend Sanyo SCE type batteries for normal (club-level) racing. These batteries are very fragile, in that they will not accept the abuse that normal club running will give them. They should only be used once a week to get the best life out of them, and even within that restriction they are only good for approximately fifty charges at peak performance. In addition, you would need a very good charger to carefully charge them at no more than 4 amps. A better choice would be the Sanyo SCR 1400 battery. These can be charged at quite high currents, and have a very good life. Meanwhile in the USA, Panasonic 1700 SCR batteries seem to be the 'in thing', with the Cleveland 4-cell circuit Racing Nationals of last year seeing them completely sweep the first 30 places. They are of a stronger construction than the Sanyo SCE, but are nowhere near as bullet-proof as the Sanyo SCR 1400s.

Charging batteries is a very complex subject, with very many different methods and makes of charger in use.

One thing is for certain to win at racing the batteries have to be as near fully charged as possible. The way in which a Ni-Cd battery charges is interesting; the voltage across it increases as it charges. The difference between the cell voltage and the charge voltage gets smaller as a result, and so the charge current decreases. The charger should therefore be able to supply a lot of current initially; towards the end of the charging cycle the current consumption will obviously decrease. The main types of Ni-Cd charger are:

1. **PEAK CHARGING.** A peak charger senses the point at which the voltage of the battery pack under charge ceases to rise and starts to fall – at this point (normally a drop of 0.02V), the charger cuts off. The battery pack's state of charge will have reached 95% of its full capacity. In today's highly competitive racing climate, this is simply not good enough!

2. **THERMAL CHARGING.** A thermal charger, with the aid of a temperature sensitive probe, senses the temperature of the battery pack and stops charging once a user-defined limit has been reached. Settings in the order of 40 to 50 degrees Celsius are normal. Under ideal conditions, maximum capacity of the battery pack can be obtained. There are, however, some problems with this technique. Forget to insert the probe into the battery pack and there is nothing to regulate the charger; severe damage to the battery is likely. The ambient temperature is also an important factor; charging in very hot weather can 'confuse' the charger, resulting in very undercharged batteries! Similarly, in winter months the possibility of overcharging cannot be ruled out. Thermal charging is a very good method of charging the SCR type of battery. However, it would be unwise to charge SCE-type batteries using this technique.

3. **SLOPE CHARGING.** Although slope charging is a relatively recent technique, it

is quite straightforward to understand. A slope charger monitors the voltage of a battery pack under charge. Once the battery has 'peaked' and the voltage has started to fall, the charger records the voltage and shuts down at a user-defined voltage drop (i.e. slope setting). This setting will be different, depending upon the manufacturer and type of cell; in the event of uncertainty, the battery manufacturer will advise the correct slope setting. Unlike the more robust cells, certain delicate types of high capacity Ni-Cd battery will not tolerate high slope settings.

Slope charging has many advantages, namely:

- (a) The charger has no external temperature probe to worry about.
- (b) The technique is not affected by changes in ambient temperature.
- (c) High accuracy monitoring ensures that consistent charges will be maintained throughout a day's racing.
- (d) A battery will never vent gas or electrolyte when slope charged as the temperature, and thus the internal gas pressure, can never rise enough to give problems.
- (e) Because the battery is never overcharged, its working life will be extended.
- (f) You can determine the absolute optimum charge for your batteries safely and accurately – no more hit and miss.

Most of the above factors, however, depend upon the correct slope setting for good results. Once properly set up for your battery packs, they deliver superb results – and this is why I have been using a slope charger for the last 2 years or so!

Performance and Maintenance Tips.

After some months of racing it will be apparent that the suspension settings of your car may not be completely correct for your track conditions.

It may be found that the dampers are either too soft or too hard in action. Trying some thinner, or maybe slightly thicker, grade damper oil is certainly worth a try. Only use oil designed for model applications. Several of the damping oils used on full-size vehicles can damage the seals in model dampers. After some time the oil will become contaminated with dirt and moisture, and will impair their performance. The Traxxas manuals will show you how to dismantle the dampers without damage.

If you need to remove the damper shaft seals, it is recommended that you remove the C Clips inside a clear polythene bag, so that you can find them when they fly off.

Washing the car down after a muddy meeting should be done as soon as possible after the meeting finishes. When the car has dried out, the suspension pins should be checked for free movement. If stiffness develops, remove the pins and clean any rust off them with very fine 'wet or dry' paper. A thin film of oil can be applied to the pin before it is refitted.

Eventually, the treads on your tyres will lose their sharp edges, and the traction obtained will therefore be reduced.

The original equipment items are available as spares, but it's a good idea to try some other makes of rubber that will fit the wheels and compare the results. I have found that in the case of the Eagle, the standard tyres wear and grip very well indeed. A word of warning here regarding tyres – continued running on tarmac-type surfaces will wear the tyres out extremely quickly.

The motor should be checked after every



Above: Photo 7. The Blue Eagle, being raced at Bedworth Off-road Circuit.

meeting for signs of wear on the motor brushes. These can wear out quite quickly towards the end of their lives; this is because the spring tension will slacken as the brush shortens – leading the way for excessive sparking. A commutator skim should be considered after (approximately) an hour's running if it shows signs of burning. Whenever you have the motors commutator machined, fit new brushes as a matter of course. Seek

advice on the correct brush material for the type of motor in use.

Another activity really worth your while would be to visit some major race meetings and see how the top-line drivers perform. It will be a real education to see how fast their cars perform!

Acknowledgments

Acknowledgments are due to Traxxas Europe, for granting us permission to use copyright material.

Waveform Generators continued from page 54.

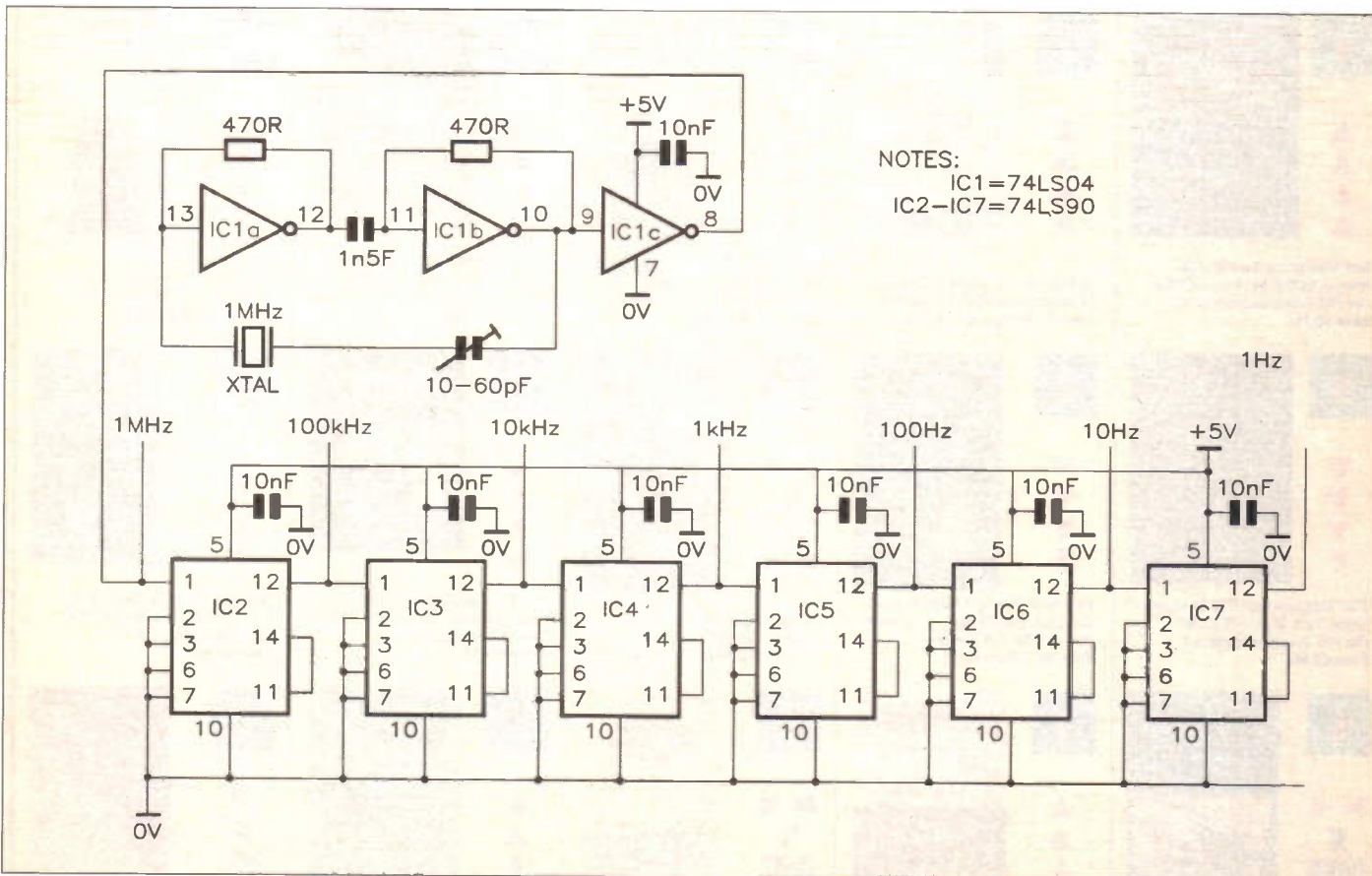
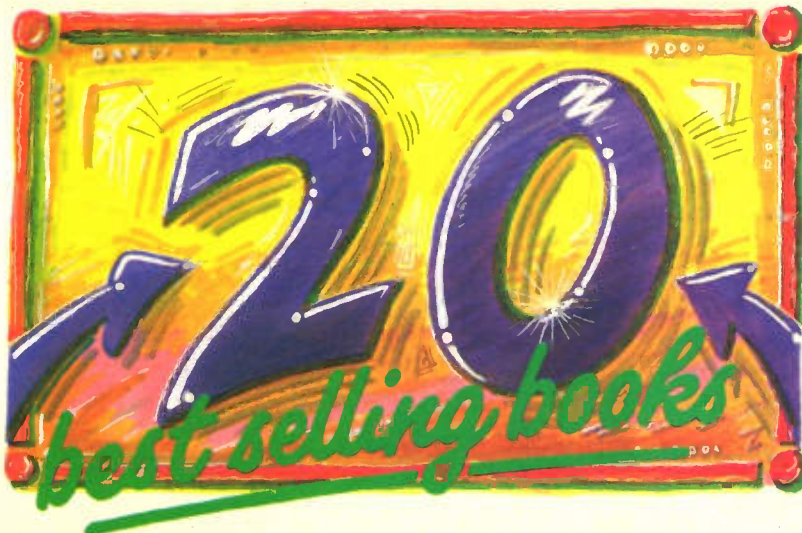


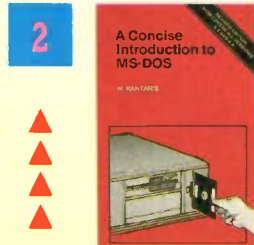
Figure 21. TTL-based 6-decade crystal calibrator.

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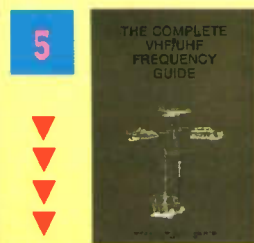
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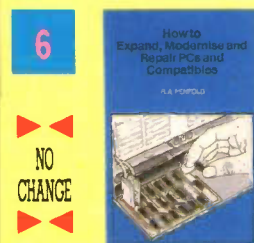
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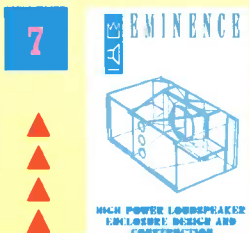


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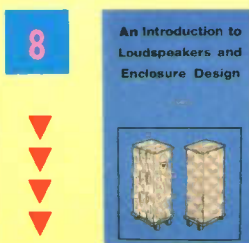
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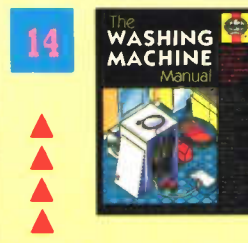
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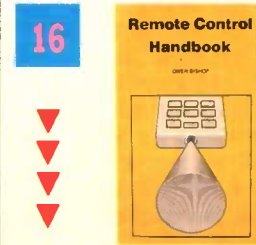
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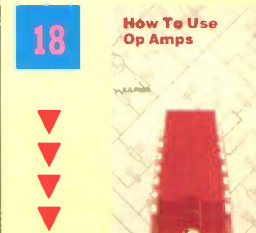
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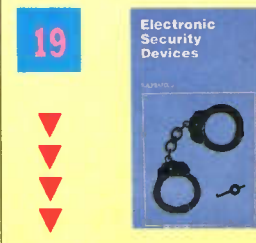
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