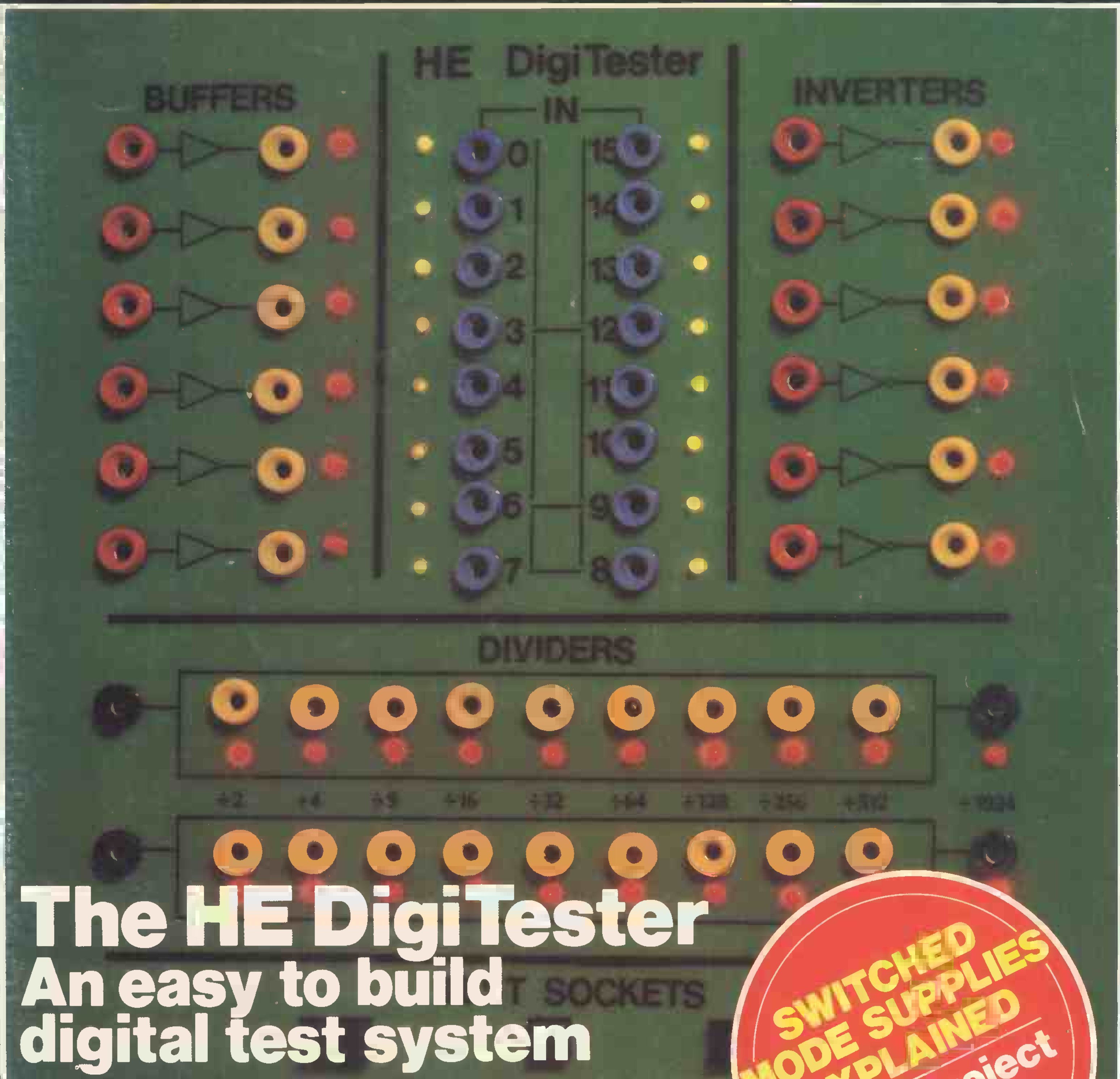
Hobby Electronics

JANUARY 1983

75p

Project Electronics For Everyone



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HE Cumulative Index, 1979-1982

Hobby Electronics

JANUARY 1983
Vol 5 No 1

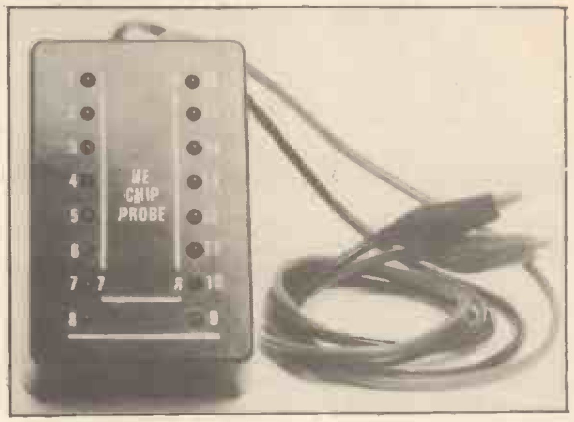
PROJECTS

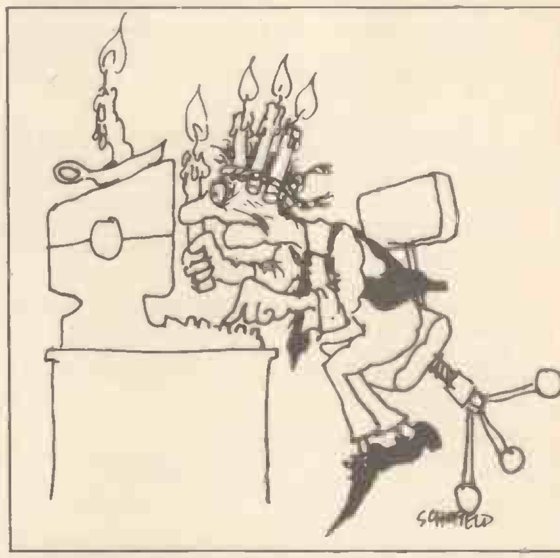
FEATURES

SPECIALS

REGULARS

Clever Dick *is on holiday (again) but he insists that he will return next month.*
Components For Computing Part 2, *dealing with Random Access Memory chips, will appear in the February 1983 issue.*





CUMULATIVE INDEX 1978-1982

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MONITOR

Making the Pulse

As an alternative to buying a digital pulse generator — build your own! **Global Specialities Corporation**, who already manufacture a popular pulser, are now doing it in kit form. Called, simply, DPK-1, the kit costs **£5.75** plus VAT and comes complete with all parts, instruction and operating manual.

This pulser can deliver single pulses or a train of pulses at 100 per second, indicating with a LED when the pulse is delivered. A voltage monitoring circuit ensures that a pulse of the right polarity and level is delivered.

You can order, or obtain further information, from **Global Specialities Corporation**, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ. Tel. 0799 21682.

Second Hand News

Amongst the strangest of papers to arrive on Monitor's desk in recent months has been the news sheet from **Barrett's of Croydon**. Barrett's are proud to be specialists in used vacuum equipment — all very well, but not likely to be of great interest to HE readers. Then a closer inspection of their Summer '82 Price Guide revealed a potential Aladdin's Cave; for there, just after the Vacuum Pumping Systems, Ovens and Cryogenics equipment, was quite a good range of second-hand electronic instrumentation.

The stock changes constantly, so if you're in the market for, say, a second-hand dual-trace oscilloscope for around £80 you'd have to be quick off the mark. It's always best to 'phone before dropping in, to see what is and isn't still available, and have a good look at anything you do want to buy and a talk to the staff, to make sure you don't end up buying something you can't, or wouldn't want to, handle — after all second-hand gear doesn't come with a maker's guarantee! That said, buying used equipment is a very good way of building up your workshop at a fraction of the price you would have to pay for new. Contact **Barrett's of Croydon**, 1 Mayo Road, Croydon CRO 2QP, Surrey. Tel (01) 684 9917 for lists and information.

From The OK Corral

A nice pair from **OK Machine and Tool (UK) Ltd.**, this month, in the form of OK's **PRB-1 digital logic probe** and **PLS-1** pulse **generator**, two pieces of equipment which are almost a necessity for anyone doing regular work with logic circuits. And, of course, OK recommend this probe and pulser as ideal partners.

The PRB-1 digital logic probe can detect pulses down to 10 ns, has a frequency response better then 50 MHz and automatic pulse stretching to 50 ns. It is compatible with RTL, DTL, HTL, TTL, MOS, CMOS and micro logic families. The in/output impedance is 120R and the normal supply voltage range is from 4 to 15 V, but an adaptor can be supplied for 15 to 25V. It also has power lead reversal, and over-voltage, protection up to 200V plus or minus. Price, **£33.24**.

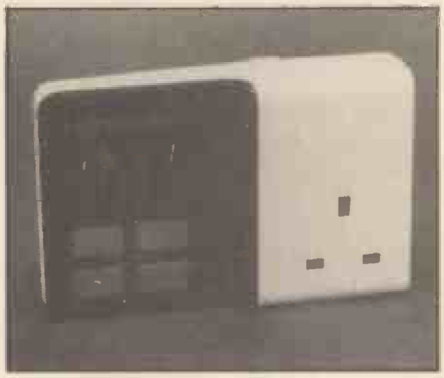
The PLS-1 "pocket-sized, multi-mode, high-current pulse generator" is designed to superimpose either a continuous train of pulses (20 pps) or a single 2 ns pulse onto the part of the logic circuit to be tested. Effectively it isolates that section from the rest of the circuit, without unsoldering or cutting tracks, for the duration of the test, and it is capable of forcing saturated output transistors into the oppsosite logic state: quite a powerful piece of equipment! The price of the PLS-1 is **£43.13**.

Also from OK comes the PCBH — 50 PCB holder which will take boards up to 10x12" (254x305 mm), incorporating a soldering iron holder and tip sponge. The left-hand end support slides to adjust for board width, and the board holders are spring-loaded so that the board can be removed and replaced without adjustment. The board can be rotated through 360° in the holders and locked at any angle, which should make it easy and comfortable to work on any part of the board.

You can get informaion on any OK products by contacting **OK Machine & Tool (UK) Ltd.**, Dutton Lane, Eastleigh, Hants SO5 4AA. Tel. 0703 610944.

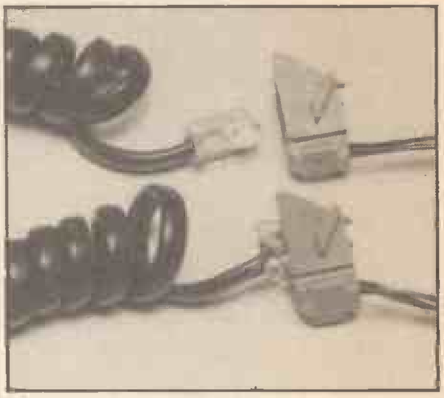
Microlog Errata

Last month's Microlog project (*Hobby Electronics* December '82, page 6, Figure 11) contained an error in the power supply circuit. The transformer output should be connected to the top corner of the bridge rectifier, BR1, not to the input of regulator IC3. The correct drawing is reproduced with this month's PCB Print-outs, on page 72.



Up-Market Timer

When it comes to the switch'em on and leave'em to it approach to electrical appliances, an automatic timer control must be the best alternative to an expensive micro or a highly-trained white rat. **Tek Marketing** have produced a fully electronic plug-in timer which is accurate to within a few seconds (unlike many mechanical timers) and can take loads of up to 3kW, so that it can be used to control heating appliances, as well as tape recorders, radios, house lighting, etc. Timetouch is push-button operated, and has a 24-hour LED display. There is a manual over-ride switch to turn on the appliance without disturbing the timing program. Timetouch costs **£25.00** from **Tek Marketing**, Burrel Rd., St. Ives, Huntingdon, Cambs PE17 4LE (Tel. St. Ives (0480) 62225).



Snap Out Of It

BFI Electronics is importing **Mars-Alcatel** Series 6010 miniature snap-in communications connectors, of a type which you might already have seen on some home telephones. Tiny plugs — the four-way version measures only 6.6x7.67x13.3mm — snap into a small socket which can be mounted anywhere. The plug is released by pinching a sprung release arm which is part of the plug. The plugs come in 2,4,8 or 16-way versions and the socket, which measures 10.2x20.7x 15.4mm (outside dimensions), offers a choice of wire terminations, length and colour. The plugs are made of transparent polycarbonate and the socket of moulded grey ABS.

This plug and socket system is in use in the French telephone network, and has phosphor-bronze contacts plated in nickel or gold, with a contact resistance of less than 30mR (very low for such a small plug) and a current handling of 1.5A (which is high). Insulation resistance between contacts is more than 10MR and the isolation voltage better than 1000V at 50Hz. The plug is very easy and quick to use and is ideal for connecting telephone hand-sets into communications equipment and the inter-connection of portable or mobile test and monitor equipment. For further information and prices contact Mick Savage, **BFI Electronics Ltd.**, 516 Walton Rd., West Molesey, Surrey KT8 0QF (Tel. (01) 941 4066).

Check This One Out

Mikro-Gen have produced an advanced chess program specifically for the 48k Sinclair Spectrum. One of the most powerful ZX chess programs available, the game, called 'Masterchess', has been designed to provide a more adventurous, less defensive game and makes use of high-resolution graphics.

'Masterchess' gives a choice of ten

levels of play, can change levels, or sides, during a game, provides a history of moves and a graphic display of the board which can be copied onto a printer at any stage to give a complete record of moves (useful for postal chess or just for mid-game arguments!). The board can be set to any configuration; player's and computer's moves can be displayed and the game can be saved at any stage. All legal chess moves can be played, and illegal moves are indicated. There is also a recommended move option with varying search depths according to the level of play, useful for the developing player. 'Masterchess' comes on cassette in a library case, and costs **£6.95** plus 40p p&p from the makers, **Mikro-Gen**, 24 Agar Crescent, Bracknell, Berks.

Stick That In Your Lug!

OK Machine and Tool are now producing DIP plugs for standard DIP sockets with 14, 16 and 24 pins. These have glass-filled thermoplastic bodies, and can be connected to any number of cable strands (up to a the limit of the pins, of course) by solder lugs which are in one piece with the plug-in legs. The leg/lug is in gold-plated phosphor-bronze for a good connection between one board and another, and the plugs come packed in pairs complete with slotted top-entry covers. Prices are **£1.80** (each, not per pair) for 14-pin plugs, **£1.98** for 16 pins and **£2.97** for 24 pins. Further information from **OK Machine and Tool (UK) Ltd.**, Dutton Lane, Eastleigh, Hants SO5 4AA (Tel. 0703 610944).

Multilingual Micro

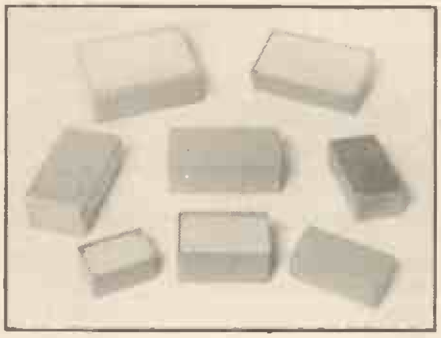
The new 48k Oric I micro will be available with FORTH as its second language (the first, of course, being BASIC). This will be available as a free cassette with every Oric I unit. In the New Year, **Oric Products** are also planning to offer 'Extended BASIC', which has the equivalent power to BBC BASIC but is claimed to be more sophisticated, giving a structural programming capacity. Pascal will be available soon afterwards. Full information from **Oric Products International**, Cowarth Park, London Rd., Ascot, Berks SL5 7SE (Tel. (0990) 27641.

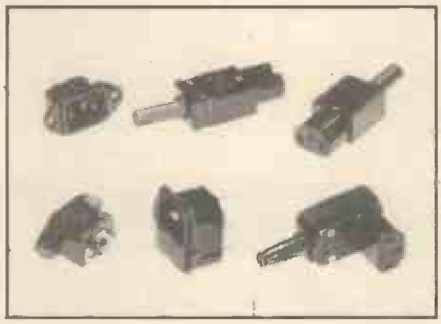
Getting The Games Bug

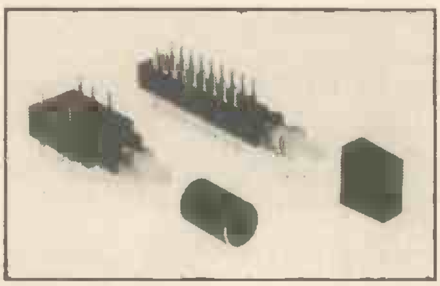
Micro software specialists **Bug-Byte** are expanding their range of micro games. For the VIC-20 (with 16k expansion) comes a chess package which boasts 1,000 levels of play (that should keep you off the street for a bit!) for **£7.00** plus VAT. For the BBC 32k Acorn micro, there will be an adventure game called Dragon Quest shortly. Bug-Byte plan more than 30 games by the end of 1982, all under a 12 month guarantee.

Entertainment of a rather different kind comes from their Aspect Assembler package, which enables the user to write programs in machine code. The program has a built-in error-detection system which Bug-Byte claim is foolproof — now there's a challenge! Price is **£9.00** plus VAT.

Orders can go to **Bug-Byte** at 100 The Albany, Old Hall Street, Liverpool, or from one of their dealers around the country.







Turn It On Again

Indefatigible suppliers of electronic hardware, **Stotron Ltd.**, have informed Monitor of three new products in their stock ranges.

From old favourites **Boss Industrial Mouldings** come new ranges of Bimbox construction boxes and small desk consoles. The Bimboxes are available in plastic, or plastic with metal lids or in aluminium in a full range of sizes, with 1.8mm PCB slots.

The Desk Consoles come in various sizes, including a Eurocard size, and all have grey ABS bases and 1mm-thick aluminium screw-down top panels. Some consoles have PCB slots, while some have ventilation slots in the base.

A series of good quality signal switches, both in momentary and alternate action types, come from **Nietzche.** With a choice of between two and eight poles, these switches will operate at 500mA/100VAC,, 200mA/25VAC and 1A/25VDC, with a breakdown voltage of 500V after one minute, operating temperatures of between −20 and +70°C and a very low contact resistance of less than 50mR after 20,000 cycles. A power switch, buttons and panel mounting brackets are available in the same range.

Bulgin have produced a range of useful chassis-mounted plugs and cable-end sockets. This includes a 6A/250V re-wireable AC chassis plug and free socket and an equivalent side-entry socket, a 10A free socket and chassis plug which meets BS4491 'Hot Condition' specifications, a mains-related moulded cord set with integral 13A plug and moulded connector with a 2.5mm cable and changeable fuse. There is also a flush mounting 6A 250V AC fused appliance coupler designed to extra-high safety standards.

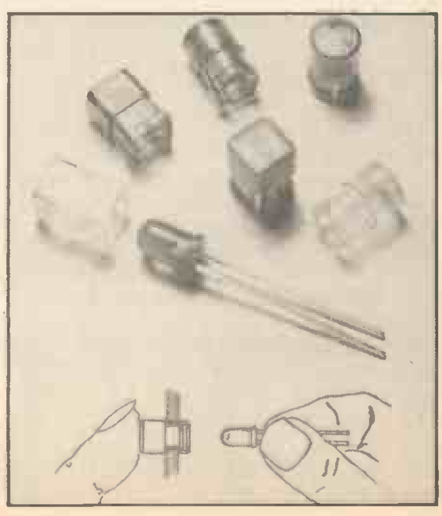
For prices and information on all of these, contact **Stotron Ltd.**, Haywood Way, Ivyhouse Lane, Hastings, E. Sussex TN35 4PL (Tel. Hastings (0424) 442160).

LED There Be More Light

Hidden deep inside many electronic hobbyists (and not always very deep, either — but we won't name any names!) is a frustrated light-show director whose greatest joy, if he can't have a few kilowatts of spotlights to play with, is to cover his front panels with lights, illuminated switches and LEDs of every description. If you are one of these, your life will probably be eased by **Boss Industrial Mouldings'** ingenious snap-in lenses for use with TI¾ (5mm) LEDs.

The lenses come in round and square shapes, making a nice variation on the normal LED profile, and are moulded in red, green, amber, clear or yellow cellulose acetate butyrate. The mouldings incorporate Fresnel rings and striated lines, which increase apparent brightness by up to 125% and give viewing angles of up to 180°.

The lenses are snapped into a 7.11 mm panel hole, and when the LED is inserted from the rear both are fixed firmly in place. The lenses will also protect other components from electrostatic discharges of up to 16kV. Contact **Boss Industrial Mouldings**, James Carter Road, Mildenhall, Suffolk IP28 7DE.



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400/800 SOFTWARE & PERIPHERALS

Don't buy a T.V. game! Buy an Atari 400 personal computer and a game cartridge and that's all you'll need. Later on you can buy the Basic Programming cartridge (£35) and try your hand at programming using the easy to learn BASIC language. Or if you are interested in business applications, you can buy the Atari 800 + Disk Drive + Printer together with a selection of business packages.

Silica Shop have put together a full catalogue and price list giving details of all the peripherals as well as the extensive range of software that is now available for the Atari 400/800. The Atari is now one of the best supported personal computers. Send NOW for Silica Shop's catalogue and price list as well as details on our users club.

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LIGHT AND POWER FROM DC SUPPLIES

Roger Harrison

Generating light and power from batteries is fraught with many unrealised difficulties. Whether you want DC back-up to operate equipment when the mains goes 'off the air' or a wholly independent 240 VAC supply, you should know the problems.

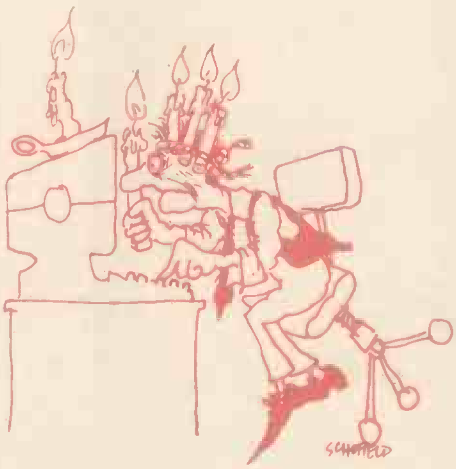
THAT'S THE TROUBLE with Electricity Boards – they've insidiously crept into our lives and made us quite dependent on them. For those occasions when we cannot avail ourselves of their 'services', we have to rely on other sources to provide light and power. The old paraffin pressure lamp has its advantages – and disadvantages – but how on earth do you keep a disk drive running when the AC mains 'browns out'? As storage batteries are easy to obtain, the 12V car battery in particular, it's natural that we turn to them to provide back-up and mains-independent supplies.

Back-up supplies

For equipment designed to be powered directly from a nominal 12V DC source or from either 12V DC or 230V AC, back-up supplies are employed to maintain continuity of supply; the battery is kept charged from the mains, but acts to maintain power supply to the equipment in the event of mains failure. This sort of system is commonly installed with burglar alarms and amateur radio repeaters, for example.

The 'power budget' of such systems is carefully considered to provide maximum service period from the battery supply when mains is unavailable. Hence a single 12V storage battery – generally a low maintenance type – is employed. Let's learn a bit about lead-acid batteries first.

The fully-charged, no-load terminal voltage of a lead-acid cell is between 2.3-2.4 volts. This drops under load to about 2.0-2.2 volts. When discharged, the cell voltage is typically 1.85 volts.



The amp-hour capacity is determined from a 10-hour discharge rate curve. The current required to discharge the battery to its end-point voltage of 1.85 V/cell is multiplied by this time; e.g: a 40Ah battery will provide four amps for 10 hours before requiring recharge. Note however that the amp-hour capacity varies with the discharge current. The same battery discharged at a rate of 10 amps will not last four hours; on the other hand if it is discharged at 1 amp it will last somewhat longer than 40 hours. The typical discharge characteristics of a (nominal) 12V battery are shown in **Figure 1**.

The ideal initial charging current for the fully discharged battery (cell voltage under 2.0V) should be about 20 amps per 100 amp-hours of capacity (i.e: 8 amps for a 40Ah battery). Once the electrolyte begins to gas rapidly, the terminal voltage will be around 13.8 volts and rising rapidly. At this point, the charging current should be reduced to somewhere between 4-8 amps per 100Ah until charging is complete.

At the end of charging, terminal voltage may rise to about 15.6 volts or more, but this decreases slowly after the charger is removed, the terminal voltage then usually reading around 14.0 to 14.4 volts (see **Figure 2**).

Back-up supplies are generally of the 'trickle-charge' type or the 'battery condition' sensing type. A good example is shown in **Figure 3**. This circuit trickle charges a 12V battery when the mains is on and provides automatic switchover when the power drops out. It's cheap and simple, but needs to be *used* for the batteries to stay in condition, so that they deliver their rated capacity when needed. Back-up supplies of this sort are only practical where the load on the supply is not too heavy – generally 20W or so.

To drive a heavier load, upwards of 50W for example, it's best to power the equipment from the battery all the time and have a charger which senses the battery terminal voltage, charging the battery when the terminal voltage falls to a preset level and turning off when the terminal voltage rises to the desired operating level again. There is a slight element of luck involved as to how charged the battery will be at any one time, but the lower limit is usually set so that the equipment will operate for a specified period. Such a battery can drive a 10 A load at the 10-hour discharge rate – which effectively means it's a good back-up supply for equipment with a power budget of up

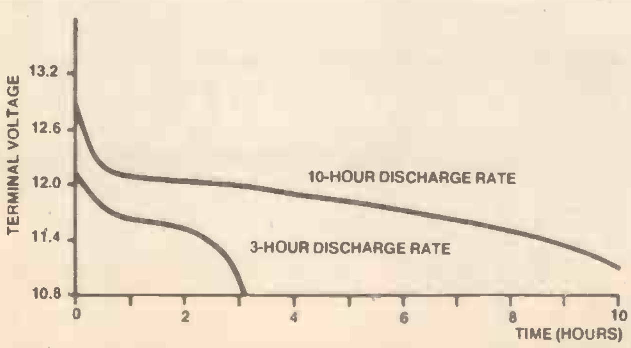


Figure 1. Discharge characteristics of a typical 12V (nominal) lead-acid battery.

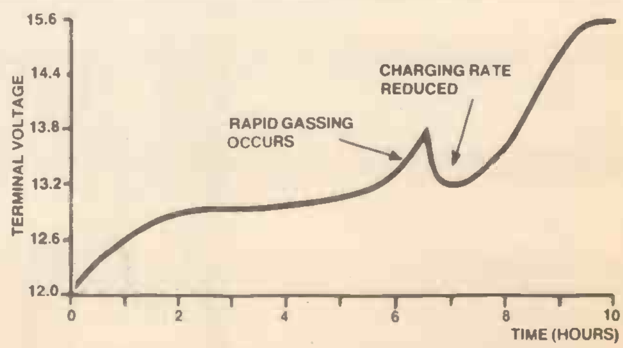


Figure 2. Charging characteristics of a lead-acid battery; the 'kink' in the curve near the six hour point is explained in the text.

to 120W mean consumption. This means that actual consumption can be greater than that from time to time, provided that consumption falls below the mean level for an equivalent period. An amateur VHF or UHF repeater is a good example. Whilst 'listening' only – no stations active on the input channel – consumption is quite low. When 'activated' by a station or stations, the repeater spends most of its time transmitting, and consumption can be four to ten times that during inactive periods, depending on the power output of the transmitter employed in the repeater.

As stated earlier, the major consideration with back-up supplies is the power budget of the equipment being supplied. If you anticipate the necessity of operating the equipment for periods exceeding, say, eight hours, then a battery of adequate ampere-hour capacity needs to be used. It is always prudent to choose a battery with 20-50% more capacity than strictly necessary.

DC-AC Inverters

Like storage batteries, 240V AC mains-operated equipment is quite common. The huge variety of products have been designed to be convenient, thus making themselves necessary. Or so it seems. Why on earth anyone would want to take an electric razor on a camping expedition and expect to power it from an ersatz 240V AC supply is beyond this writer – but then I haven't had a shave in more than 15 years except when my appendix was removed, and then they didn't shave my face!

There are common approaches to providing 50Hz AC power for mains operated appliances: provide square wave drive of the appropriate amplitude, or derive a sinewave (or pseudo sinewave) supply of appropriate amplitude. Both are fraught with hidden difficulties. If you want any substantial amount of power output – like 200W – you're in hot water – but probably unable to boil a kettle!

A square wave DC-AC inverter has the advantage of simplicity and efficiency – depending somewhat on the design. Inverters generally take two forms: 'self-excited', usually employing a feedback winding on the transformer, and 'driven', where an oscillator drives a switching circuit, generally with transformer output. Where the precise frequency of the AC output is unimportant, self-excited inverters are employed. Where a stable 50Hz output is required, a driven inverter is necessary.

Lighting is one area where self-excited DC-AC inverters find application. The common tungsten filament incandescent light globe is a poor choice for lighting where a DC supply is employed. They have an efficiency of less than a fifth of that of a fluorescent light of the same power rating – viz: around 12 lumens/watt for the tungsten filament lamp versus better than 60 lumens/watt for a fluorescent tube. A 20W fluorescent tube would provide as much light output as a 100W incandescent globe! Those figures are based on 50Hz AC supply. Fluorescent tubes actually improve in efficiency when driven from a higher frequency supply. **Figure 4** shows how the light output of a fluorescent tube increases with increasing supply frequency. Driving the tube from a supply frequency of 10kHz or more will result in a 20% increase in light output.

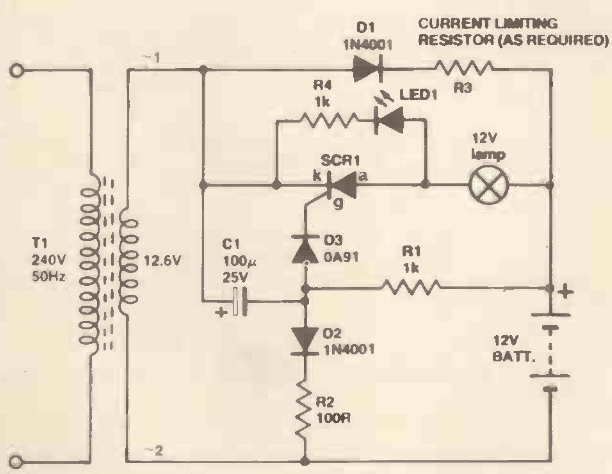


Figure 3. The circuit of a simple back-up supply. It maintains a trickle charge to the battery when the mains is on, and switches automatically when the power cuts out. It can also be used for purposes other than lighting, provided the power consumption is not too high.

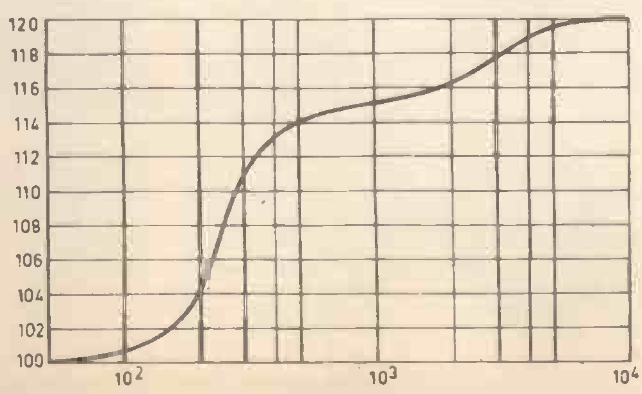


Figure 4. The light output of a fluorescent tube increases with frequency. This property is exploited by DC-AC inverter circuits to provide highly efficient lighting from DC supplies.

The circuit of a self-excited inverter driving a fluorescent tube is shown in **Figure 5**. It runs at around 2kHz and employs a ferrite-cored transformer; consumption is 2.5 amps. An incandescent globe to provide a similar light output would draw around 10 amps! Such inverters have one drawback – the transformer core 'sings', owing to the magnetostrictive forces on the core pieces (which generally come in two pieces). That can be solved in two ways – put the inverter in a 'soundproof' box or operate the inverter at a frequency above audibility. The first solution is inevitably only partially successful (though often acceptable).

When it comes to powering 240V AC equipment or appliances, a number of considerations have to be looked at. First, will the equipment operate from a square wave supply? Many appliances employing an AC or AC/DC motor will operate quite happily from a square wave supply. Such a supply, for example, can be used as a battery back-up for a computer's disk drives, supplying these with 240V, 50Hz square wave AC from a driven inverter. The general arrangement is shown in **Figure 6**. A 100Hz oscillator drives a flip-flop, which drives a pair of HEXFETs connected in push-pull across the secondary of a toroidal transformer. Battery supply was 24V. The transformer is operated 'back-to-front' here, where input is applied to the secondary and the load connected across the primary. Toroidal transformers perform much better in this application than conventional types, as core losses are lower and primary-to-secondary coupling is generally better. Some losses are involved, the saturation voltage of the HEXFETs generally being the greatest source. Hence the use of a 20-0-20 V winding and not a 24-0-24 V winding.

The saturation voltage loss in switching devices driving a transformer is an important consideration. One or two volts lost from a 24V supply represents only about 4% to 8% loss, but at 12V it's twice that! Any further losses only magnify the problem.

A square wave AC supply is inherently rich in harmonics. These can play havoc with audio and digital equipment and it's often difficult to suppress interference generated by the supply. Then again, some equipment – particularly anything containing a transformer and rectifier – will produce entirely different performance when it's operated from anything other than a sine wave supply. The problem arises because the peak and RMS values of a square wave are the same, whereas the peak/RMS ratio for a sinewave is 1.414. To deliver the same work value as a sine wave supply, the peak output voltage of a square wave DC-AC inverter is generally set at 240V. When driving a motor or resistive load, the square wave supply will deliver the same amount of power as a sine wave supply; i.e: the same amount of work will be done (all else being equal). But, where the load or equipment expects a peak voltage of 340V (as we have with the ordinary mains), then a square wave supply of a nominal 240V output will not 'deliver the goods', as its peak voltage is still only 240V.

So much for that; let's look at sinewave DC-AC inverters. At this stage, you might like to take a look at the letter from Mr. Channer in this month's Points Of View.

Requests of a similar nature arrive quite commonly, though this one is a little unusual, compared to most we receive! Many readers ask for a 1kW or similarly rated inverter to run from a 12V battery. The latter is impractical, for the following reasons.

Consider this: a sinewave DC-AC inverter needs to be of the driven type. Hence it generally consists of an oscillator driving a class B power amplifier – usually a push-pull type. The theoretical maximum efficiency obtainable with a class B power amplifier is 78%. With losses and power consumption of drive circuitry taken into account, the DC power input to AC power output efficiency of an inverter of this type is generally around 65-70%. Thus a 1kW DC-AC inverter to run from a 12V battery would draw in excess of 120 amps at full load! Few batteries would supply that sort of current for long! With currents of that magnitude, special arrangements have to be made for primary circuit conductors. A resistance of 5 milliohms (0.005 ohms) will result in a power loss of more than 70 watts. Then again, special consideration has to be given to heat dissipation in the power output stage. The devices used would dissipate something over 400W at peak load. No load dissipation would probably be in the vicinity of 40-50W, which is no mean amount to get rid of.

Apart from the weight of a heatsink, consider the weight of a 1kVA (or 1000W) transformer (assuming a single transformer is used). We'll leave the expense to your imagination.

The problems are reduced somewhat when a much higher DC supply voltage is available. However, in the latter case other techniques of DC to AC conversion present themselves – but that should be the subject of another article as it's a whole new ballgame.

Where a 12V battery supply only is available, there is a practical limit to the maximum power of a DC-AC inverter, and that's probably around 300W output. At typical efficiencies, the DC input power is around 450W, or close to 35-40 amps current from the battery.

As you would already appreciate, this brings its own special problems. A battery to supply that sort of power for any appreciable or worthwhile period would need to have a considerable ampere-hour capacity. Your typical 40-60Ah car battery would barely deliver an hour's worth of power. If the inverter is installed within the vehicle, or close by, and you are willing to keep the engine running during operation, then the battery will deliver the goods for quite a period, provided you can 'set' the throttle to suit so that battery charge is maintained. At this stage, I might point out that an alternator coupled to the motor would provide a more efficient energy conversion!

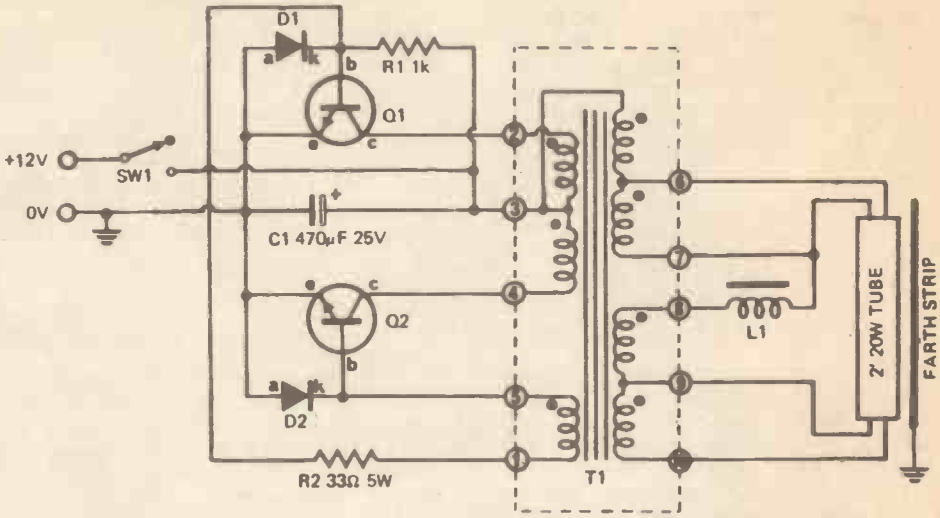


Figure 5. A circuit for a self-excited square wave inverter operating at 2kHz and suitable for driving a 20W fluorescent tube.

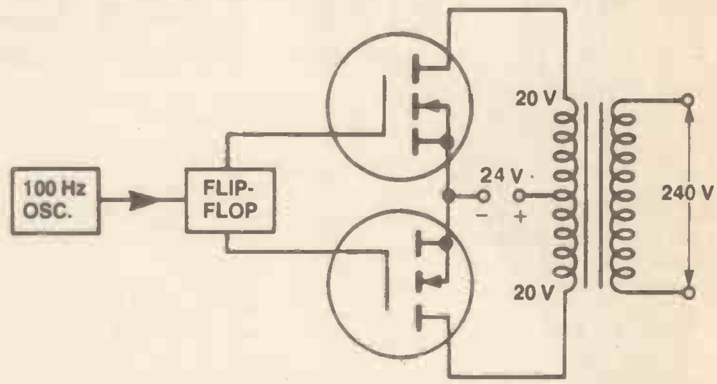


Figure 6. Outline of a 'driven' DC-AC square wave inverter with a nominal 240VAC output.

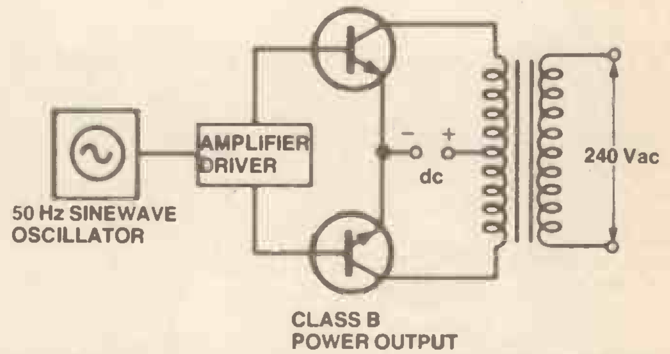


Figure 7. A Class B driven sine wave inverter for providing 240VAC from a DC supply.

To gain, say, four to six hours of operation for a 300W inverter, you would need a battery system of more than 200Ah capacity.

A more practicable power level for a sinewave DC-AC inverter would be around 120W. Such an inverter would pull 12 to 15 amps from the battery, a much more manageable figure.

Having seen the primary side of the problem, let's consider the secondary side – the load. How many appliances do you have rated at less than 300 watts? Very few. The humble electric kettle is rated from 1kW to 2.4kW. Monochrome TV sets, particularly portables, may only consume 100W, but a colour TV may draw three times that or more. A 'low power' (say, 30W/ch.) domestic hi-fi will draw around 100W, depending on how much equipment is in use and how loud you like it. Anything more ambitious has a proportionately larger consumption. A 300W DC-AC inverter is best considered where the full output is only required intermittently.

Conclusion

As can be seen, many factors have to be taken into account when considering obtaining light and power from a battery supply – whether it be in a back-up application, for lighting or 240V AC substitution. The ubiquitous 12V battery is not up to the job in some instances – in which case higher voltage DC systems are better considered. **HE**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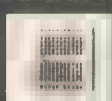
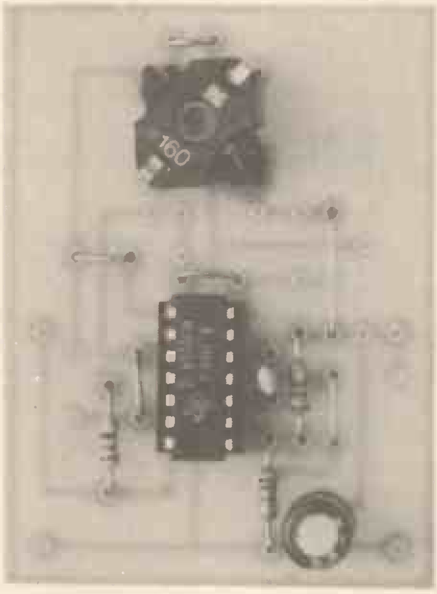


Switched Mode Supply

Paul Kelly

DC supplies for all occasions.



THE APPLICATION of integrated circuit technology to modern electronics has produced a dramatic increase in the performance and sophistication of many electronic systems, yet it has also brought with it much more stringent demands on power supply performances. Fortunately, semiconductor manufacturers provide a wide range of integrated circuit 'regulators' which satisfy these requirements.

A 'regulator', in this context, is a device which provides a stable high performance voltage supply from a low performance or 'unregulated' DC supply of a higher voltage. Although internally complex, these devices are easy to use and low in cost, to the extent that they are employed in virtually every IC-based circuit around today.

The method of voltage regulation employed by almost all of these devices, known as 'series pass' regulation, suffers from one major disadvantage — it is very inefficient. An efficiency of less than 50% is not uncommon in these regulators, and thus a substantial amount of power is dissipated within the device itself. We are more concerned though, not by the 'scandalous' wastage of energy but by the necessity for bulky heatsinks, preventing the device from being destroyed by excess heat, and by the inevitably high running temperature.

Switch-mode regulation offers a high-efficiency alternative to series pass regulation for any applications where small physical size and low running temperatures are a premium. This type of voltage regulator is generally more complex but this is largely offset by the current availability of IC switching regulators.

Series Passed

A conventional series pass regulator is illustrated in **Figure 1a**. In this circuit, QI attempts to maintain the output voltage (Vout) constant with respect to a reference voltage (Vref) against variations in the input voltage (Vin) and the load current. In so doing, a voltage drop appears across the collector-emitter terminals of QI which increases with Vin. For the regulating action of QI to be effective, the input to output voltage difference must be a volt or so, at minimum, and in practice several volts would be used to accommodate the worst case drop of Vin. However, it is precisely this voltage drop that is responsible for the high internal power dissipation, which is equal to the product of the voltage drop and the load current passed by QI.

There are also two modes of operation of the circuit, which are not usually relevant to series pass regulation, in which the device power dissipation is close to zero; in one case, Vout is almost as high as Vin (irrespective of current load) and hence QI is switched 'fully on'; in the other, the output draws no load current and so QI is switched off. Curiously enough, it is these states that enable switching regulators to operate with minimal power losses.

Switching Modes

A simple switched mode regulator is depicted in **Figure 1b**. The ganged switches SW1a and b represent an active switch capable of connecting the point 'P' to either Vin or to ground (OV). Suppose that we periodically switch between the two alternatives (1a on, 1b off; and 1b on, 1a off) so that the voltage at point 'P' is a periodic square wave with a given mark to space ratio (that is, the ratio between the time spent at a high voltage to the duration at a low voltage). We know that the switches dissipate no power, if ideal, and in practice dissipate very little power even when a load resistance is connected between P and ground. Now the time-averaged voltage at 'P' varies between the extremes of 0% and 100% of Vin as the mark to space ratio of the waveform varies from zero to infinity. The implication is that if a method can be found of averaging this waveform to a steady DC level, then we have the means of generating any DC voltage (lower than Vin) as a function of the mark to space ratio of the switch.

To express this another way, a waveform could be generated consisting of a DC component on which is superimposed an AC (square wave) component (if the DC component is removed the waveform remaining would be symmetrical about the zero volt axis). And if the AC component could somehow be removed or 'filtered out', then a DC voltage will remain — extracted without significant power loss.

As shown in **Figure 1b**, this is achieved with a simple LC filter. An LC filter (series inductance, parallel capacitance) is the simplest low pass filter that is lossless; its inclusion results in no additional power losses to those of a simple capacitor (which is really an RC filter): at all frequencies at and above the switching frequency, L presents a high impedance and C a low impedance, thus the potential divider action considerably attenuates the AC component of the waveform whilst allowing the DC component to pass.

The circuit as described is able to provide a stepped down DC voltage, with minimal power loss, with the ratio determined by the switch duty cycle (the mark-space ratio). However with a constant switching duty cycle, the output voltage is highly dependent on Vin, and to produce a regulating action a control circuit must be added to correct changes in the output by making corresponding shifts in the switch mark to space ratio. The basis for such a circuit is shown in **Figure 2**.

The main switching element of the regulator is QI equivalent to switch SW1a in the circuit of **Figure 1b**. Diode DI is known as a 'commutating diode', because it enables current flow in inductor L to be sustained while QI is

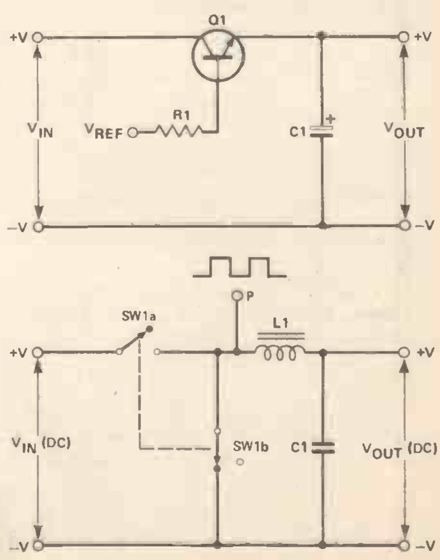


Figure 1a (above). A conventional series-pass regulator; (1b below) the basis of switched-mode regulation.

switched off; functionally, it is equivalent to switch SW1b.

Marking Spaces

The control circuit of the regulator consists of a variable duty cycle, fixing frequency oscillator, with a single voltage controlled input and, additionally, a difference amplifier. Basically, the amplifier compares a stable reference voltage with a feed-back portion of the output voltage (taken from the junction of R1/R2) and generates a difference or error signal to control the oscillator, which directly switches QI. If, for example, Vout exceeds (Vref X (R1 + R2)/R2) to any extent, the error amplifier will provide a positive voltage to the oscillator which will have the effect of reducing the duty cycle of the switch, hence reducing the output voltage Vout. The converse applies, of course, if Vout falls.

This description is of a pure feed-back system which will regulate the output voltage against any tendency to change. We will not attempt to describe the internal operation of the control elements of the variable oscillator because they are, in general, very complicated indeedl Anyway, the control circuit is usually contained within an IC and therefore there is no real need to understand it in detail.

Figure 3 reveals some of the waveforms to be found in the circuit of **Figure 2**, and analyses the operation of the filter components. The important points to notice are that the current flow in the inductor is essentially constant, with a gentle rise and decay as the voltage across L switches between two extremes, and, further, that the capacitor is being charged by this current at the same time as it is being discharged by the load current, and therefore shows a very small ripple voltage.

A crucial aspect of the design of switched power supplies is the choice of values for L and C, and the switching frequency. Ideally, to minimise the ripple on the output voltage, all three should have numerical values as high as possible. In practice, the frequency will be chosen somewhere in the range of 5KHz to 50KHz; much lower than this, the inductor and capacitor will have unreasonably high values; much higher and the circuit becomes progressively less efficient, because the switching transistor is unable to operate properly at that speed. Another point to consider, in the selection of an inductor, is its saturation current. The material on which the inductor is wound is able to store only a limited level of magnetic energy (½LI^2), after which the core is said to 'saturate'; when this happens, the filter becomes 'lossy' and the circuit will not operate efficiently. At frequencies of several kHz, a ferrite core material is usually used and this does allow a reasonable power to be handled with a fairly small coil.

Variations

In **Figure 4** there are illustrations of two novel variations of the switching circuit. With these curious re-arrangements of the transistor, diode and filter components, one can generate a step up of voltage (a) or an inversion (b).

Looking at **Figure 4**a first of all, transistor QI connects L1 across the input voltage supply as it is switched on. The current in the inductor builds up in this time to a maximum level, but lower than the saturation current. When QI turns off current continues to flow in L1, charging the output capacitor through the diode (the diode here is known as a 'blocking diode', as it prevents current flowing out of the capacitor during switch-on periods). By the time the current in L1 has decayed to zero (or much sooner) QI again switches on, re-energising the inductor to its maximum level of current. Thus in

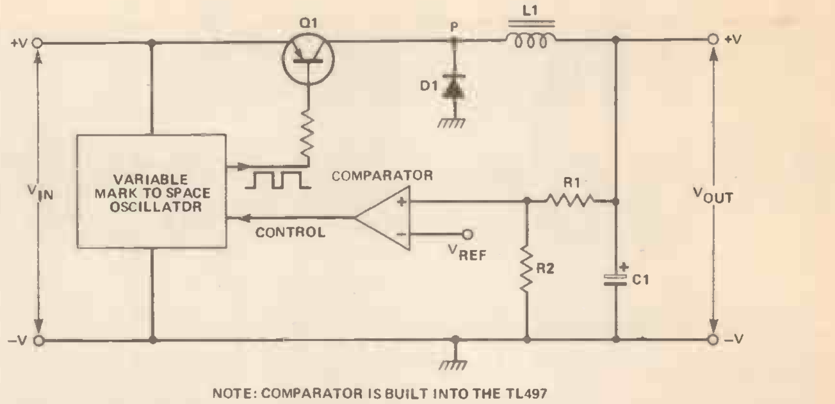


Figure 2. Block schematic of a switched-mode regulator; most of the elements can be found in the TL497 chip (compare with Figure 5, below).

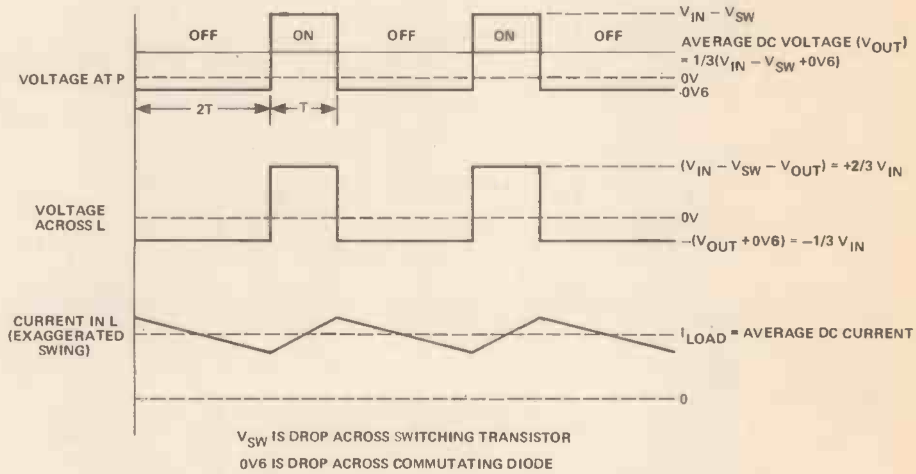


Figure 3. Some of the waveforms produced by the circuit of Figure 2.

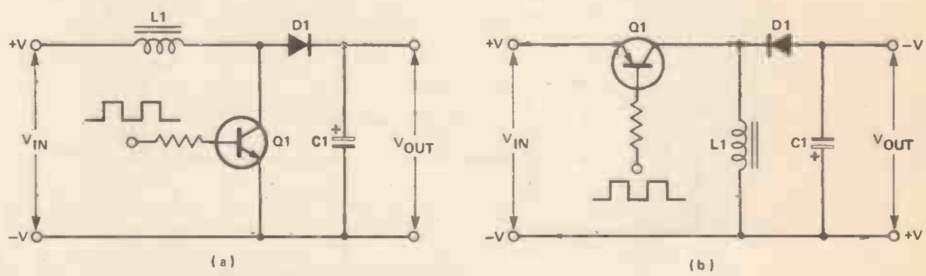


Figure 4. Switching arrangements; (a) shows the configuration for step-up while (b) shows the step-down circuit.

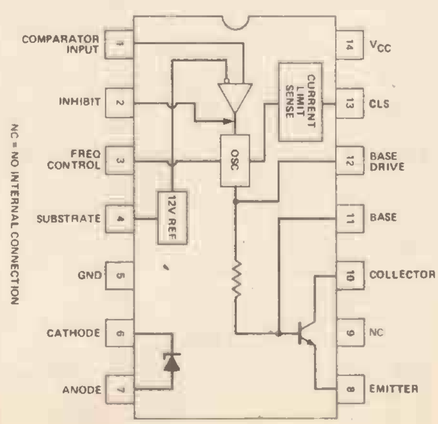


Figure 5. Pin-outs and logic diagram of the TL497.

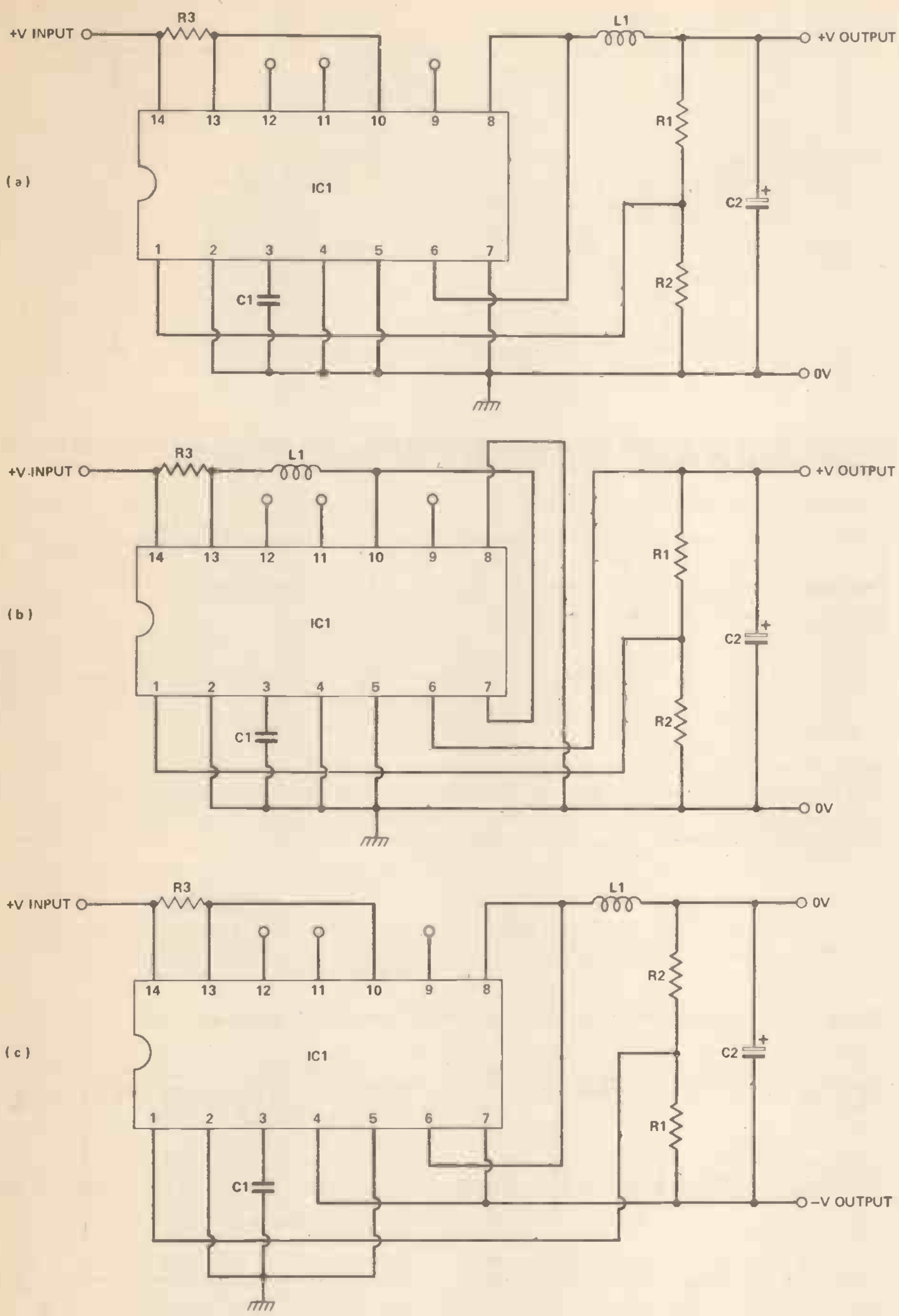


Figure 6. Three practical circuits showing (a) Mode A (step-down); (b) Mode B (step-up) and (c) Mode C (invert). The differences are subtle, but significant.

successive on-periods, charge is pumped into the output capacitor at an average rate that should match the load current.

The circuit of **Figure 4b** operates on very much the same principal except that the connection of the components allows a negative voltage (with respect to ground) to build up on the capacitor.

With both these circuits the output voltage is highly dependent on load current, making a feedback control circuit quite necessary. In fact under zero load conditions, these circuits are theoretically infinite voltage generators, in that they will continue to 'pump' their output capacitor with equal amounts of energy per switch period until something 'gives' – or a control circuit judiciously intervenes!

So far the switch-mode principle has been described in its role as a regulator but it has a second, essentially similar, application as a so-called 'transformerless power supply'. This is especially useful as a mains convertor, as it eliminates the bulk of a transformer and large smoothing capacitor whilst increasing overall conversion efficiency. The basic principle is that the mains voltage is first rectified with a bridge rectifier and smoothing capacitor, providing some 330VDC. Being a high voltage supply, it is required to supply a correspondingly small current for a given power requirement, and thus the smoothing capacitor may be small.

A switching regulator circuit, employing a high voltage transistor and diode, is able to produce a high current low voltage supply with a high conversion efficiency. There is however one obvious disadvantage of this scheme, namely that there is no mains isolation. It is possible to provide this isolation by using a high frequency transformer in place of the inductor and, furthermore, by feeding back the error signal through opto-isolators; in this way the advantages of efficiency and small size are retained – but the cost of such a system may be considerable!

A Practical Circuit

The heart of the circuit is the TL497A IC by Texas Instruments Ltd, which contains all the active elements of a switching regulator, including the switching transistor, the commutating diode and the control circuit, as illustrated in **Figure 5**.

The transistor's collector and emitter connections and the diode are brought out on separate pins so that the three modes of step-up, step-down and inversion are possible, depending on the external wiring. The transistor is an NPN type but may be used with all three configurations, provided that the TL497 is operated from the same supply as that being switched. The three circuits are shown in **Figure 6** and comparison may be drawn with the circuits presented earlier.

The TL497 differs from most switching regulators in that the oscillator has a fixed on-time but variable frequency output, resulting in a simplification of the internal circuitry and a reduction of the number of external components. The switch on-time is controlled by a single capacitor, connected from pin 3 to ground.

The device also has an on-chip reference voltage, which is a highly accurate band-gap reference of IV2. The output of the regulator, therefore, must be divided down by RI, R2 to 1V2 to be compared in the 'comparator'.

The sequence of operations in this device are explained as follows: the transistor has just completed its on-period and the output capacitor has charged to a shade above the average DC output voltage. The comparator recognises that the voltage at the junction of R1 and R2 is slightly higher than the reference voltage, and therefore holds the oscillator off. As soon as the output voltage decays below its nominal level, due to the effect of the load current on the output capacitor, the comparator signals to the oscillator to switch on. The transistor thus conducts and will recharge the output capacitor to a higher level again. This is perhaps the simplest of control systems yet devised for switching regulators, but readers should be aware that it has its limitations – particularly in respect of ripple voltage performance.

Getting It Together

Following on from the discussion, we present a simple project for the evaluation of switching regulators. The unit is

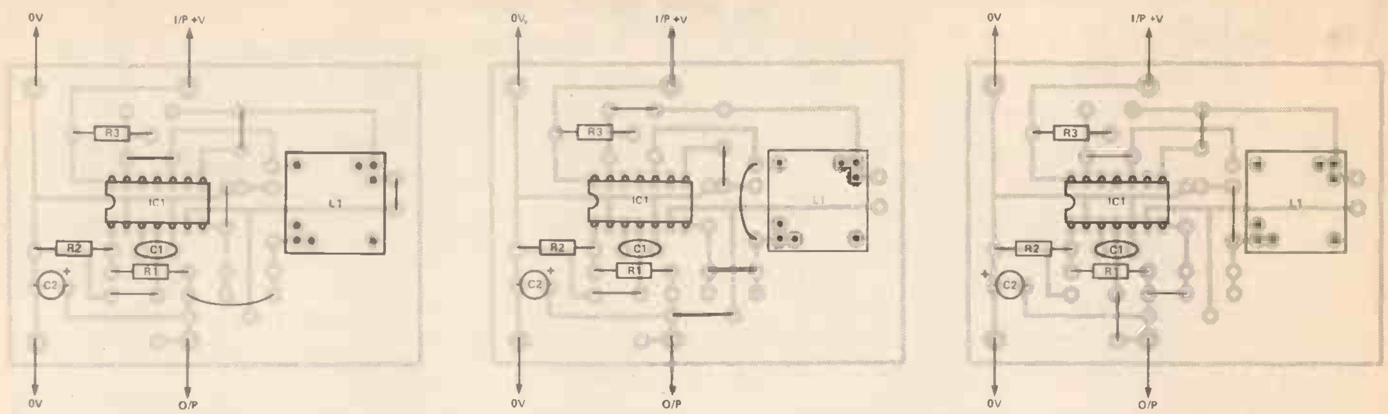


Figure 7. The PCB overlays for each of the circuits of Figure 5; (left) Mode A, (middle) Mode C and (right) Mode C.

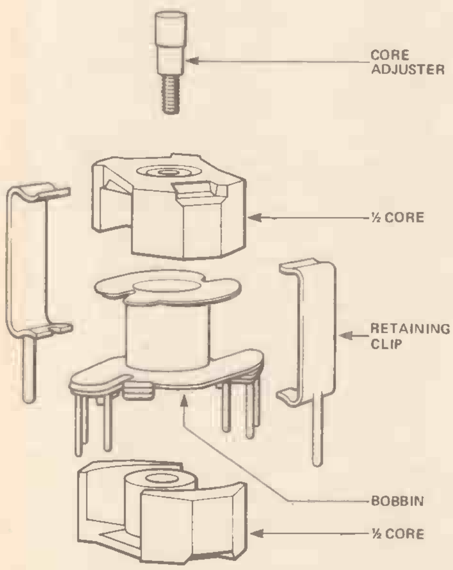


Figure 7. Exploded drawing of the RM6 pot core. Some types appear to have only two connecting pins per side, but will nevertheless fit the PCB holes.

Parts List

RESISTORS
(All ¼ watt carbon film, 5% E24 Series)
R1,2 . . . . see Table 1
R3 . . . . 1R0

CAPACITORS
C1 . . . . see Table 1
radial electrolytic*
C2 . . . . 100p
min ceramic
*Working voltage must be greater than the required output voltage.

SEMICONDUCTORS
IC1 . . . . TL749
switched mode regulator

MISCELLANEOUS
L1 . . . . see Table 1
Ferrite core former . . . . . type RM6
PCB, wire etc.

BUYLINES 34

MODE	I/P	O/P	ImA	C1	L1	TURNS	SWG	R1	R2
A	5V	3V	250	50u	50uH	18	22	1k8	1k2
A	12V	5V	250	100u	150u	30	25	3k9	1k2
B	5V	25V	50	200u	100u	25	24	12k	1k2
B	5V	12V	100	100u	100u	25	24	11k	1k2
C	12V	−12V	100	100u	250u	40	25	1k2	11k

Table 1: Mode A is step down; Mode B is step up; Mode C is invert. In general, the circuits will tolerate a small spread of input voltages (eg, in Mode B, between 5 and 12V in will still give 12V out, though with reduced current capacity), but for precision, the value of R1 should be changed, as explained in the text.

capable of producing a wide range of fixed voltage supplies, however, and should be relevant to many practical applications.

The circuit is based on the TL497 IC switching regulator, which can operate in step-up, step-down or inverted modes, these being selected as required by a system of wire links on the PCB.

In step-down mode, the unit is particularly useful for the generation of 3V for TTL-based projects in, for example, a car or caravan, where only a 12V battery is available.

The step-up mode of operation will produce high voltages for applications requiring battery supplies, but eliminates the need to connect many batteries in series.

Sometimes there is a need to build an EPROM programmer into an existing microcomputer that has only +5V available. Here again, a step-up switching regulator can generate the necessary 25V programming voltage directly from the 5V.

Many MOS devices, in particular dynamic rams, require a negative bias which may be conveniently provided by an inverting switch mode regulator. In general the inverting regulator can convert a single-ended supply to a double ended supply which is often required by op-amp circuitry.

Table 1 gives a set of component values for various voltage requirements in each of the three operating modes. If a supply is required that does not appear on the table, first select the example that is closest from the point of view of the input voltage (when working with modes B and C) or input-output differential (Mode A); to modify the output voltage required, recalculate R1 (R2 for mode C) according to the expression:

$$(V_{out} - 1.2)kR$$

The limitations, for the TL749, are 5V to 12V (15 amps absolute maximum) on the input, and −25V to +30V on the output.

Assemble the PCB according to the appropriate component overlay (Modes A, B, C) paying particular attention to the position of the wire links and the polarity of C2. The former, type RM6, is supplied as a kit; insulated copper wire should be wound, according to the specifications of **Table 1**, on the plastic former, and having scraped the insulation back ⅛" on each end, the ends should be soldered to one of the three pins at each side of the former, taking care that your soldering does not prevent the pins from being inserted in the PCB. The two ferrite halves should then be enclosed around the former, and the retaining lugs clipped over. These two lugs also fit through the PCB and are soldered in, to securely retain the core former. In case you're wondering why two sets of three pins are fitted, this is to allow the winding of more complicated transformers on the same former.

A number of applications for a switched mode regulator have already been mentioned — but having got this far, we're confident that you'll come up with many more. It's just a variation on Parkin son's Law — applications readily come to mind when the circuit is available! **HE**

Rapid Electronics

MAIL ORDERS:
Unit 2, Hill Farm Industrial Estate,
Boxted, Colchester, Essex CO4 5RD.
TELEPHONE ORDERS:
Colchester. (0206) 36412.

ACCESS AND BARCLAYCARD WELCOME

CAPACITORS

Polyester, radial leads. 250v. C280 type: 0.01, 0.015, 0.022, 0.033 - 6p; 0.047, 0.068, 0.1 - 7p; 0.15, 0.22 - 9p; 0.33, 0.47 - 13p; 0.68 - 20p; 1u - 23p.
Electrolytic, radial or axial leads: 0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V - 7p; 22/25V, 47/25V - 8p; 100/25V - 9p; 220/25V - 14p; 470/25V - 22p; 1000/25V - 30p; 2200/25V - 50p.
Tag end power supply electrolytics: 2200/40V - 110p; 4700/40V - 160p 2200/63V - 140p; 4700/63V - 230p
Polyester, miniature Siemens PCB: 1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, 7p; 22n, 33n, 47n, 68n, 8p; 100n, 9p; 150n, 11p; 220n, 13p; 330n, 20p; 470n 26p; 680n, 29p; 1u 33p; 2u2, 50p.
Tantalum bead: 0.1, 0.22, 0.33, 0.47, 1.0 @ 35V - 12p. 2.2, 4.7, 10 @ 25V - 20p; 15/16V - 30p; 22/16V - 27p; 33/16V - 45p; 47/6V - 27p; 47/16V - 70p; 68/6V - 40p; 100/10V - 90p.
Cer. disc. 22p-0.01u 50V, 3p each.
Mullard miniature ceramic plate: 1.8pF to 100pF 6p each.
Polystyrene, 5% tol: 10p-1000p, 6p; 1500-4700, 8p; 6800 0.012u, 10p.
Trimmers. Mullard 808 series: 2-10 pF, 22p; 2-22pF, 30p; 5.5-65pF, 35p

RESISTORS

¼W 5% Carbon film E12 series 4.7 ohm - 1M . . . . 1p each.
½W 5% Carbon film E12 series 4.7 ohm to 4M7 . . . . 2p each.
¼W 1% metal film E24 series 10 ohm - 1M . . . . 6p each.

SOCKETS

SOCKETS	Low profile	Wire wrap
8 pin	6p	25p
14 pin	8p	35p
16 pin	9p	42p
18 pin	12p	52p
20 pin	13p	60p
22 pin	16p	70p
24 pin	18p	70p
28 pin	2[illegible]	80p
40 pin	25p	98p

Soldercon pins 60P 100

POTENTIOMETERS

Rotary. Carbon track Log or Lin 1K - 2M2. Single 32p. Stereo 85p. Single switched 80p. Slide 60mm travel single Log or Lin 5K - 500K 63p each.
Preset submin. hor. 100 ohms -1M 7p each.
Cermet precision multiturn, 0.75W ¾" 100 ohms to 100K - 88p each.

REGULATORS

78L05	30	79L05	65
78L12	30	79L12	65
78L15	30	79L15	65
7805	35	7905	40
7812	35	7912	40
7815	35	7915	40
LM309K	130	LM723	35
LM317K	270	LM338K	475
LM317T	120	78H05 5A	
LM323K	350	▶5V	550

SOLDERING IRONS

Antex CS 17W Soldering iron	460
2.3 and 4.7mm bits to suit	65
CS 17W iron: 450, element:	210
Antex XS 25W	480
3.3 and 4.7mm bits to suit	65
Solder pump desoldering tool	480
Spare nozzle for above	70
10 metres 22swg solder	100

PCB MATERIALS

Alfac transfer sheets — please state type (e.g. DIL pads etc.)	45
Dalo etch resist pen	100
Fibre glass board 3.75"x8"	80
Ferric chloride 250ml bottle	100

TOOLS

Small trimming tool	22
Small pocket screwdriver	16
Large pocket screwdriver	13
6 piece precision screwdriver set in plastic case	170
Low cost side cutters	160
High quality side cutters	650
Low cost pliers	160
High quality pliers	650
Wire strippers	120
Expo reliant drill	695
Expo Titan drill	1025
Drill stand	1200
Reduced shank drill bits for above 0.8mm, 1mm, 1.4mm	60

OPTO

▶3mm red	7	▶5mm red	7
▶3mm green	10	▶5mm green	10
▶3mm yellow	10	▶5mm yellow	10

Clips to suit - 3p each.

Rectangular		TIL32	40
▶red	12	TIL78	40
green	17	▶TIL111	60
yellow	17	ORP12	85
▶TIL38	40	TIL100	90
2N5777	45	Dual colour	60

Seven segment displays:

Com cathode		Com anode	
DL704 0.3"	95	DL707 0.3"	95
▶FND500 0.5"	100	FND507 0.5"	100
TIL313 0.3"	115	TIL312 0.3"	115
TIL322 0.5"	115	TIL321 0.5"	115

LCD: 3½ digit 580p. 4 digit 620p.

TRIACS

400V 4A	50	400V 8A	65
		400V 16A	95
		BR100	25

COMPONENT KITS

An ideal opportunity for the beginner or the experienced constructor to obtain a wide range of components at greatly reduced prices. ¼W 5% Resistor kit. Contains 10 of each value from 4.7 ohms to 1M (total of 650 resistors) . . . 480
Ceramic Cap. kit. 5 of each value - 22p to 0.01u (135 caps) . . . 370
Polyester Cap. kit. 5 of each value from 0.01 to 1uF (65 caps) . . . 575
Preset kit. Contains 5 of each value from 100 ohms to 1M (total 65 presets . . . 425
Nut and Bolt kit (total 300 items): 180p

25 6BA ¼" bolts	50 6BA washers	50 6BA nuts
25 6BA ½" bolts	25 4BA ¼" bolts	50 6BA washers
50 6BA nuts	25 6BA ½" bolts.	

LINEAR

555CMOS	80	ICL7106	790
556CMOS	150	ICL7611	95
709	25	ICL7621	180
▶741	14	ICL7622	180
748	35	ICL8038	295
9400CJ	350	ICL8211A	200
AY-3-1270	720	ICM7224	785
AY-3-8910	370	ICM7555	80
AY-3-8912	540	▶LF351	45
CA3046	60	LF353	85
▶CA3080	65	LF356	90
CA3089	190	LM10	350
CA3090AQ	375	LM301A	25
CA3130E	85	LM311	70
▶CA3140E	36	LM318	120
CA3161E	100	LM324	40
CA3189	290	LM334Z	100
▶CA3240E	110	LM335Z	125

LM339	45	LM3911	120	NE566	140	TL064	96
LM348	60	LM3914	175	▶NE567	100	TL071	30
LM358	50	LM3915	195	▶NE570	370	TL072	50
LM377	170	LM13600	105	NE571	370	TL074	95
▶LM380	65	MC1496	68	▶RC4136	55	▶TL081	25
▶LM381	120	MC3340	135	▶RC4558	60	TL082	45
LM382	120	▶MF10CN	350	SL480	170	TL084	95
LM384	130	ML922	400	SL4[illegible]	250	TL170	50
LM386	65	ML924	195	SL7[illegible]	50	UA2240	120
LM387	120	ML925	210	▶SN[illegible]	[illegible]	ULN2003	85
LM393	100	ML926	140	SP[illegible]	[illegible]	ULN2004	90
LM709	25	ML927	140	TBA[illegible]20S	70	XR2206	290
LM711	60	ML928	140	TBA800	75	[illegible]14	100
LM725	350	ML929	140	TBA81[illegible]	[illegible]	ZN[illegible]23	135
LM733	75	MM5387A	460	TBA[illegible]	[illegible]	ZN424	135
LM741	14	NE529	225	[illegible]	[illegible]	ZN425E	350
LM747	60	NE531	160	[illegible]1008	[illegible]	ZN426E	330
LM1458	40	NE544	205	▶TDA1022	[illegible]	ZN427E	650
LM2917	200	▶NE5[illegible]	[illegible]	TDA1[illegible]	125	ZN428E	480
LM3900	45	▶NE[illegible]	[illegible]	TL06[illegible]	40	ZN459	285
▶LM3909	70	NE[illegible]	140	TL062	60	ZN1034E	200

TRANSISTORS

AC125	35	BC149	9	BC517	40
AC126	25	BC157	8	BC547	7
AC127	25	BC158	10	BC548	10
▶AC128	20	BC159	8	BC549	10
AC176	25	BC160	45	BC558	10
AC187	22	BC168C	10	BCY70	18
AC188	22	BC169C	10	BCY71	18
AD142	120	BC170	8	BCY72	[illegible]
AD149	80	BC171	10	BD115	[illegible]
AD161	40	BC172	8	BD131	35
AD162	40	BC177	18	BD132	[illegible]
AF124	60	BC178	18	BD1[illegible]	[illegible]
AF126	50	BC179	18	BD1[illegible]	40
AF139	40	BC182	1[illegible]	[illegible]	30
AF186	70	▶BC182L	[illegible]	[illegible]	30
AF239	75	BC183	[illegible]	[illegible]	30
BC107	10	BC183L	10	[illegible]	35
BC107B	12	BC184	10	[illegible]	[illegible]
▶BC108	9	BC184L	[illegible]	[illegible]	[illegible]
BC108B	12	BC212	[illegible]	[illegible]	[illegible]
BC108C	12	BC212L	10	[illegible]	[illegible]
BC109	9	BC213	10	[illegible]	[illegible]
BC109C	12	BC213L	10	[illegible]	[illegible]
BC114	1[illegible]	BC214	10	[illegible]	[illegible]
BC115	[illegible]	BC214L	8	BF196	12
BC117	[illegible]	BC2[illegible]	8	BF197	12
BC119	[illegible]	[illegible]	14	BF198	10
BC137	40	[illegible]	12	BF199	18
BC1[illegible]	40	[illegible]	14	BF200	30
[illegible]	28	[illegible]	14	▶BF244B	22
[illegible]141	30	BC337	14	BF245	30
[illegible]142	25	BC338	14	BF256B	45
[illegible]143	25	BC477	30	BF257	32
BC147	8	BC478	30	BF258	25
BC14[illegible]	8	BC479	30	BF259	35

BF337	40	MPSU56	60	ZTX108	8	2N3055	50
BF[illegible]	33	TIP29A	[illegible]	ZTX109	12	2N3442	120
BF[illegible]	23	TIP[illegible]	[illegible]	ZTX300	14	▶2N3702	8
BF[illegible]81	20	TIP29C	37	ZTX301	16	▶2N3704	8
BFX29	25	TIP30A	35	ZTX302	15	2N3703	9
BFX84	25	TIP30B	35	ZTX304	17	2N3705	9
BFX85	25	TIP30C	37	ZTX341	30	2N3706	9
BFX86	28	TIP31A	35	ZTX500	15	2N3707	10
BFX87	25	TIP31C	37	ZTX501	15	2N3708	10
BFX88	25	TIP32A	35	ZTX502	15	2N3709	10
BFY50	23	TIP32C	37	ZTX503	18	2N3772	170
BFY51	20	TIP33A	50	ZTX504	25	▶2N3773	195
BFY5[illegible]	[illegible]	TIP33C	75	2N697	20	▶2N3819	18
BFY[illegible]	32	TIP34A	60	2N698	40	2N3820	40
[illegible]	32	TIP34C	85	2N706A	20	2N3823	65
[illegible]	32	TIP35A	105	2N708	20	2N3866	90
BRY39	40	TIP35C	120	2N918	35	2N3903	10
[illegible]X20	20	TIP36A	125	2N1132	22	2N3904	10
[illegible]X29	35	TIP36C	135	2N1613	30	2N3905	6
[illegible]Y95A	25	TIP41A	45	2N2218A	45	2N3906	10
BU205	160	TIP42A	45	2N2219A	25	2N4037	45
BU206	180	TIP120	90	2N2221A	25	2N4058	10
BU208	170	TIP121	90	2N2222A	20	2N4060	10
MJ2955	99	TIP122	90	2N2368	25	2N4061	10
MJE340	50	TIP141	98	2N2369	16	2N4062	10
MJE520	65	TIP142	98	2N2484	25	2N5457	38
MJE521	95	TIP147	110	2N2646	45	2N5468	36
MJE3055	70	TIP2955	60	2N2904	20	2N5459	30
MPF102	40	TIP3055	55	2N2904A	20	2N5485	36
MPF104	40	TIS43	40	2N2905	22	2N5777	45
MPSA05	22	TIS44	45	2N2905A	22	2N6027	30
MPSA06	25	TIS90	30	2N2906	25	40360	40
MPSA12	30	TIS91	30	2N2906A	25	40361	50
MPSA55	30	VN10KM	45	2N2907	25	40362	50
MPSA56	30	VN46AF	75	2N2907A	25	40408	70
MPSU05	55	VN66AF	85	2N2926	9		
MPSU06	55	VN88AF	95	▶2N3053	23		
MPSU55	60	ZTX107	8	2N3054	55		

MICRO

BEST PRICES ANYWHERE!

2114L-2	75	Z80A CPU	290	81LS96	85
2716	205	Z80A P10	260	81LS97	85
2532	340	Z80A CTC	260	1488	55
2732	340	Z80A S10	900	1489	55
4116 P20	70	Z80A BMA	1150	Epson Printers and D	
6116-P3 150nS	365	Z80A DART	500	Connectors now available at low low prices.	
4164	440	81LS95	85		

SPECIAL OFFERS

TIC206D [illegible]0V
Triac
TL084
3mm [illegible]
7805 10
[illegible] 3

CMOS

		4016	20	4034	140	4054	78	4081	12	40193	[illegible]	4528	[illegible]
		4017	30	4036	249	4055	80	4082	12	4502	[illegible]	4529	150
		4018	45	4039	280	4059	430	4085	48	4503	[illegible]	4532	60
4000	10	4019	25	4040	40	4060	42	4086	50	4507	35	[illegible]	400
4001	10	4020	42	4041	40	4063	80	4089	125	4508	110	[illegible]	60
4002	12	4021	40	4042	38	4066	22	4093	[illegible]	4510	45	4543	50
4006	50	4022	45	4043	40	4067	225	4094	[illegible]	4511	[illegible]	4549	360
4007	14	4023	16	4044	40	4068	14	4095	[illegible]	4512	[illegible]	4553	215
4008	36	4024	33	4046	40	4069	13	4097	290	4514	[illegible]	4555	35
4009	24	4025	12	4047	35	4070	13	4098	70	4515	115	4556	35
4010	24	4026	75	4048	38	4071	13	4099	70	4516	55	4559	390
4011	10	4027	20	4049	21	4072	13	40106	40	4518	40	4560	140
4012	15	4028	40	4050	21	4073	13	40108	110	4520	50	4584	35
4013	20	4029	45	4051	42	4075	13	40163	60	4521	130	4585	60
4014	45	4030	14	4052	48	4076	[illegible]	40173	100	4526	60	4724	140
4015	40	4031	125	4053	48	4077	14	[illegible]	75	4527	50		

LS TTL

		LS20	12	LS75	20	LS123	[illegible]	LS160	35	LS197	45	LS353	60
		LS21	12	LS76	17	LS125	[illegible]	LS161	35	LS221	50	LS365	28
		LS22	12	LS78	17	LS126	26	LS162	35	LS240	60	LS366	28
LS00	11	LS26	14	LS83	35	LS132	35	LS163	35	LS241	55	LS367	28
LS01	11	LS27	12	LS85	48	LS136	26	LS164	[illegible]	LS242	55	LS368	29
LS02	11	LS30	12	LS86	15	LS138	30	LS165	[illegible]	LS243	55	LS373	58
LS03	12	LS32	13	LS90	24	LS139	30	LS166	[illegible]	LS244	55	LS374	60
LS04	12	LS37	14	LS92	25	LS145	70	LS170	75	LS245	70	LS375	43
LS05	12	LS38	15	LS93	24	LS147	[illegible]	LS173	60	LS247	48	LS377	60
LS08	12	LS40	13	LS95	38	LS148	[illegible]	LS174	45	LS251	28	LS378	57
LS09	12	LS42	28	LS96	[illegible]	LS151	38	LS175	45	LS257	32	LS390	45
LS10	12	LS47	35	LS107	40	LS153	38	LS190	35	LS258	32	LS393	40
LS11	12	LS48	45	LS109	21	LS154	75	LS191	35	LS259	50	LS399	156
LS12	12	LS51	14	LS112	21	LS155	28	LS192	35	LS266	20	LS541	78
LS13	19	LS55	14	LS113	21	LS156	36	LS193	36	LS273	58	LS670	135
LS14	30	LS73	18	LS114	22	LS157	26	LS195	32	LS279	30		
LS15	12	LS74	17	LS122	35	LS158	29	LS196	45	LS283	38		

TTL

		7413	[illegible]	7444	85	7483	30	74122	38	74161	46	74190	40
		7414	23	7446	58	7485	60	74123	38	74162	46	74191	40
		7416	[illegible]	7447	36	7486	19	74125	33	74163	46	74192	40
7400	11	7417	[illegible]	7448	[illegible]	7489	180	74126	33	74164	46	74193	40
7401	11	742[illegible]	14	7450	[illegible]	7490	19	74132	30	74165	46	74194	40
7402	11	742[illegible]	19	745[illegible]	14	7491	34	74141	54	74167	150	74195	40
7403	12	74[illegible]	19	745[illegible]	14	7492	24	74145	48	74170	115	74196	40
7404	12	74[illegible]	18	745[illegible]	14	7493	24	74147	75	74173	58	74197	40
7405	14	74[illegible]	25	746[illegible]	14	7494	33	74148	60	74174	53	74198	80
7406	19	7430	13	7470	22	7495	33	74150	48	74175	45	74199	80
7407	19	7432	20	7472	[illegible]	7496	38	74151	38	74176	35		
7408	13	7433	20	7474	19	7497	86	74154	47	74177	42		
7409	13	7437	23	7475	26	74100	78	74155	36	74179	75		
7410	13	7438	24	7476	24	74107	22	74156	36	74180	38		
7411	15	7440	14	7480	45	74109	24	74157	28	74181	100		
7412	17	7442	30	7482	65	74121	24	74160	55	74182	55		

SWITCHES

Submin toggle:
SPST [illegible], SPDT 60p. DPDT 65p.
Miniature toggle:
SPDT 80p. SPDT centre off 90p.
DPDT 90p. DPDT centre off 100p.
Standard toggle:
SPST 35p. DPDT48p
Miniature DPDT slide 12p.
Push to make 12p.
Push to break 22p.
Rotary type adjustable stop.
1P12W, 2P6W, 3P4W all 55p each.
DIL switches:
4SPST 80p 6 SPST 80p. 8SPST 100p.

TRANSFORMERS

Please add carriage charges to our normal post charges.

Miniature mains:
606V, 909V, 12012V all @ 100mA 100p each.
PCB mounting. Miniature:
3VA 0-6, 0-6 @ 0.25A; 0-9, 0-9 @ 0.15A; 0-12, 0-12 @ 0.12A 200p each.
6VA 0-6, 0-6 @ 0.5A; 0 9, 0-9 @ 0.3A; 0-12, 0.12 @ 0.25A 270p each.
High quality. Split bobbin construction.
6VA 0-6, 0 6 @ 0.5A; 0-9, 0-9 @ 0.4A; 0-12, 0-12V @ 0.3A 220p each.
12VA 0-6, 0-6 @ 1A; 0-9, 0-9 @ 0.8A, 0-12, 0-12 @ 0.5A; 0-15, 0-15 @ 0.4A 295p (plus 40p carriage).
25VA 0-6, 0-6 @ 1.5A; 0-9, 0-9 @ 1.2A; 0-12, 0-12 @ 1A; 0 15, 0-15 @ 0.8A 330p each (plus 60p carriage)
50VA 0-12, 0-12 @ 2A, 0-15, 0-15 @ 1.5A. 440p each (plus 75p carriage)

VERO

VEROBLOC◀	350
Size 0.1 matrix:	
2.5 x 1	22
2.5 x 3.75	75
2.5 x 5	85
3.75 x 5	95
VQ board	160
Veropins per 100:	
Single sided	50
Double sided	60
Spot face cutter	105
Pin insertion tool	162
Wiring pen and spool	310
Spare spool 75p Combs	6

HARDWARE

PP3 battery clips	6
Red or black crocodile clips	6
Black pointer control knob	15
Pr Ultrasonic transducers	350
▶6V Electronic buzzer	60
▶12V Electronic buzzer	65
▶PB2720 Piezo transducer	75
▶64mm 64 ohm speaker	70
▶64mm 8 ohm speaker	70
20mm panel fuseholder	25

CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12p	10p	3.5mm	9p	9p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	12p	13p	4mm	18p	17p

UHF (CB) Connectors:
PL259 Plug 40p. Reducer 14p.
SO239 square chassis skt 38p.
SO239S round chassis skt 40p.
IEC 3 pin 250V/6A.
Plug chassis mounting . . 38p
Socket free hanging . . 60p
Socket with 2m lead . . 120p

BOXES

Plastic with lid + screws		Aluminium	
		3x2x1"	70
		4x3x1½"	85
3x2x1"	55	4x3x2"	100
4½x3x1½"	88	6x4x2"	120
7x4x2	160	6x4x3"	150

SCRs

▶C106D	30
400V 8A	70
400V 12A	95

DIODES

BY127	12	▶1N4001	3
OA47	10	1N4002	5
OA90	8	1N4006	7
OA91	7	1N4007	7
OA200	8	1N5401	12
OA202	8	1N5404	16
1N914	4	1N5406	17
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Charles Wheatstone

Ian Sinclair

A multi-talented Victorian scientist and inventor.

One of the curious facts about the way we remember Charles Wheatstone is that the measuring system that bears his name, the Wheatstone Bridge, was not, in fact, his invention, nor did he ever lay any claim to it!

Charles Wheatsone was born in 1802 at Gloucester, and seems to have been educated at rather undistinguished schools, because we have no record of his progress in these days. There seems to have been little about his early life to connect him to electrical engineering, and the first impression he made on the world was in 1829, when he invented, of all things, the concertina, that miniature accordian which became the traditional accompaniment of singing sailors in the Victorian era. His interest was at that time intensely devoted to sound waves, and he is credited with the discovery that sound travels faster in glass or metal rods than in air.

In 1834, his research efforts were rewarded by his appointment as Professor of Experimental Philosophy at Kings College, and he continued his researches into sound. It was at this time, incidentally, that he coined a new word: "microphone" — though he didn't invent the device. His most important achievement, however, was the measurement of the speed of electric current along cables.

Not many details of the experiment survive, but from the hints that remain, we can reconstruct the method.

Two spark gaps were connected in series, one at the start of a very long length of cable, and the other at the end of the cable. The idea was that when a high voltage (he seems to have used a capacitor charged from a Wimshurst Generator) is applied to one end of the cable, sparks will be produced across both gaps — but the spark at the far end of the cable will occur slightly later than the one at the start.

A Space in Time

The time difference is not large, however. If we assume, as we know now, that the speed of the current wave in the cable is around 200 million metres per second, or 200 m per microsecond, then it takes a 200 m length of cable to cause a delay of only one microsecond. That's not a lot even by todays standards, and it was unimaginably small in those days. Wheatstone used a method which had already been used to measure the speed of light — a revolving mirror.

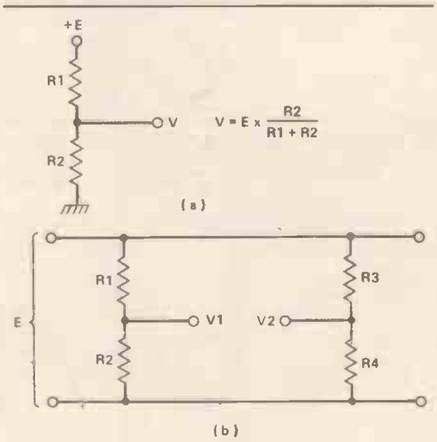
The mirror was small, and turned at a very high, steady, measurable speed. The light from the first spark would reflect from the mirror, and so would the light from the second spark — but in the short interval between these sparks the mirror would have turned, so that the reflected images, which would coincide if the mirror had not turned, seemed to separate. The faster the mirror was rotated, the greater was the separation. From the separation of these images, Wheatstone could work out the angle through which the mirror had turned and, knowing the rotating speed, he could also find the time it had taken to cover this angle. This was the time between the two sparks, and from this he could find the speed of the current in the cable.

The method worked (using several kilometres of cable) and Wheatstone was able to announce a value for the speed of electric current in a cable.

This work on the speed of current, however, led Wheatstone to become interested in sending signals through cables, the work which was to occupy him for the rest of his life. He was elected a Fellow of the Royal Society in 1836, at a time when he was working with William Fothergill Cooke on a telegraph system which was to be standard on railways all over the world for more than a century.

Getting the Needle

Wheatstone's aim was to produce a telegraph signalling system which could be used by relatively unskilled operators, but which could handle a lot of information. His first efforts used a 6-wire system which operated three needles (using electromagnets), but this was quickly superseded by a 6-wire, 5-needle system.



$$V1 = E\frac{R2}{R1+R2} \qquad V2 = E\frac{R4}{R3+R4}$$

$$V1 = V2 \text{ if } E\frac{R2}{R1+R2} = E\frac{R4}{R3+R4}$$

$$\text{WHICH IS TRUE IF } \frac{R1}{R2} = \frac{R3}{R4}$$

Figure 1. The 'Wheatstone Bridge'; (a) a simple potential divider; (b) Two dividers connected in a bridge formation.

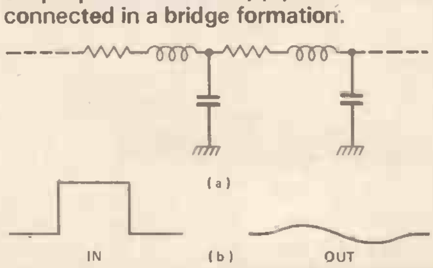


Figure 2. Cable capers; (a) a long cable can be represented as a set of inductors, capacitors and resistors; (b) their effect is to smooth out pulse waveforms, and this limits the speed of transmission of information.

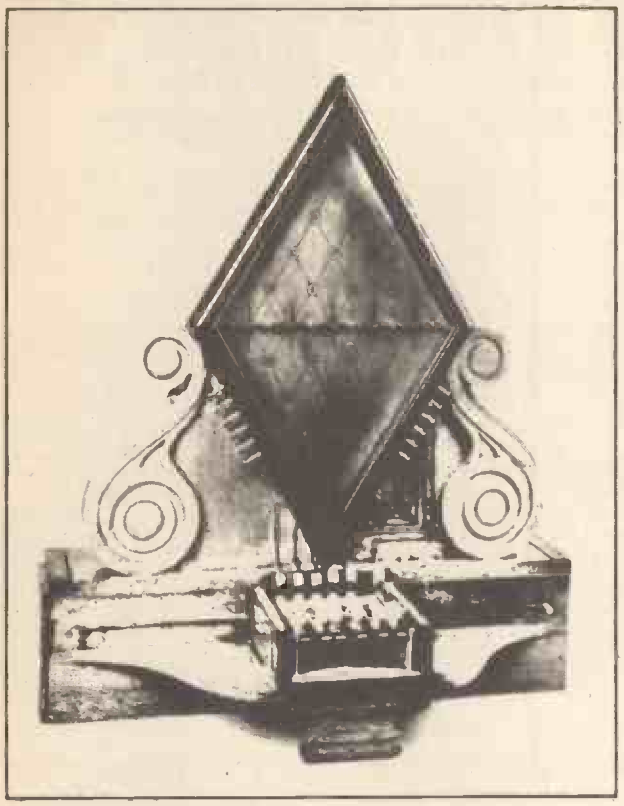
Each of the five needles was operated by an electromagnet which was connected between one of the five signal wires and the sixth (earth return) wire. Current in one direction would turn the needle clockwise, current in the opposite direction would turn the needle anticlockwise; the needles were spring-loaded to ensure that they returned to the central position when the magnets were not energised, and also that the angle of deflection was proportional to the current passing through in the electromagnet. The principle was that a digit could be selected by pointing a needle at it, and a letter could be selected by pointing two needles so that they intersected. It may look slow and clumsy, but remember that it only needed looking at to receive the message and Morse code, which in any case needs a trained operator, was still a thing of the future.

Wheatstone and Cooke's telegraph system was eagerly adopted by railways all over the world as the railway boom of the 1840-1860 period got under way and, in this country at least, the name of Wheatstone became almost synonymous with telegraphy. Wheatstone then became deeply immersed in submarine telegraphy — the use of underwater cables — and this involved the measurement of large resistance values. The solution that he adopted actually was an invention by Samual Christie to be known as the "Wheatstone Bridge".

The principle, like that of so many good inventions, was simple. If we connect two resistors in series, the voltage across one resistor depends on the ratio of its resistance to the total resistance of the pair. If we use *two* pairs of resistors, then the voltages at their junctions (**Figure 1**) are equal when the ratios of the resistances are equal. Since this equality, which determines that no current will flow between the points, is easy to detect, and can be detected using very sensitive instruments, it forms a much better system for measuring high-value resistors than the use of Ohm's law. The delightful point about the bridge system is that no *measuring* instrument is needed. All we need is a sensitive galvanometer (which need not be calibrated) to read zero when the voltages are equal, and some resistors of known value.

From cables to TV

Wheatstone's use of the bridge circuit was another step forward in telegraph technology and led to the first successful transatlantic cable being laid in 1866.



The original Cooke and Wheatstone five-needle telegraph, first used alongside the Euston-Camden railway.

This was a remarkable event, not simply because it linked the telegraph systems of two major continents, but because of the other advances which it sparked off. During his work on high resistance measurements, Wheatstone had used the element selenium as a resistor material, and found that its resistance value altered according to the brightness of the light striking it. This discovery set off the research on image transmission that led to TV. In addition, the integration effect of capacitance, inductance and resistance in a long cable (**Figure 2**) led to the analysis, by Oliver Heaviside (HE September '81), of the effect of capacitance and inductance on signals and particularly on pulses, in cables — work which was later to be of inestimable value in radar engineering.

Wheatstone was knighted in 1868, a just recognition of his pioneering efforts which covered a huge range of activities not mentioned here. One of these was the stereoscope, which allowed the viewer to see three-dimensional pictures. Another was the use of electromagnets as field magnets in dynamos, a development which changed the dynamo from laboratory device to engineering plant, and led to the large-scale use of electricity (a power source regarded at the time with as much superstitious dread as nuclear power is now).

Wheatstone also amused himself with ciphers, cryptographs and his first love, music. He died in Paris in 1875, too soon to see some of the most exciting results of his work, but with the satisfaction of knowing that he had made a lasting contribution to many fields. **HE**

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The HE DigiTester...

Andi Elam Paul Kelly

The HE DigiTester, as shown on this month's cover, is a modular system that can be built up a piece at a time to provide a device whose "whole is greater than the sum of its parts"!

Part I: Chip Probe

THE DIGITESTER, which will be revealed over the next half dozen issues of *Hobby Electronics*, is a complete digital test and breadboarding system built-up from simple, inexpensive components — yet providing a facility equal (in terms of use if not of 'class') to many highly priced commercial systems.

At this stage, the DigiTester has been planned to incorporate the following features (though of course since it is a modular system, there is no limit on the types of modules that can be added)...

1. Chip Probe — the basic module; a simple plug-in logic probe that can also be constructed as a stand-alone unit.
2. Power Supply — providing a number of useful power and logic voltage levels.
3. The Divider block provides two stages of 'divide by 1024' — permitting clock frequencies of greater than 4MHz to be resolved visually.
4. Variable Frequency Clock — this module provides two-phase outputs at frequencies between 2 and 4 MHz, continuously variable.
5. A general purpose monitoring module, which will consist of six inverters, six buffers, four NAND gates and four NOR gates.
6. A set of four pulse generators, providing positive and negative edge triggered pulses with fixed timings of 1ms and 1s; four de-bounced switches, positive and negative edge, can be used to trigger the pulse generators or used directly with circuits under development.
7. Two 8-bit latches, which can monitor up to 16 bits simultaneously, providing pulse-coincidence detection at a glance. The latch-enable can be either manual, clocked, re-triggered or one-shot.
8. IC test sockets for 8, 14 and 16 pin ICs — these can be used, together with the other facilities of the DigiTester, to check out most common logic and even special purpose ICs.

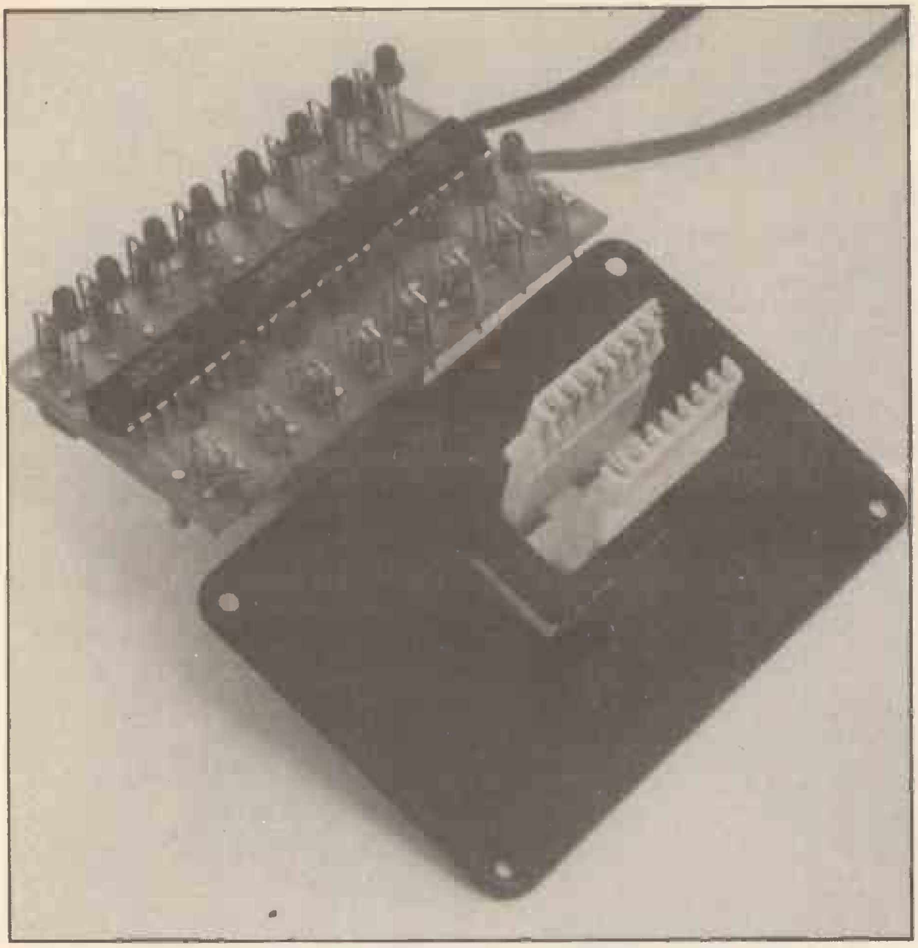
The entire system is built around a central core of sixteen 4mm 'banana' sockets; each module, as planned, is a separate device with its own input and output sockets, and LED monitors. The various modules are simply patched into the equipment under test — or the circuit being developed — using an IC test clip, connected to the DigiTester by a length of 16-way ribbon cable.

The description of the DigiTester system starts with the most useful element — a simple logic tester or Chip Probe, which displays the logic state of any IC pin by lighting a LED whenever there is a logic '1' present on an input.

The Chip Probe Circuit

The circuit of the Chip Probe is based on CMOS technology, so that it can operate on a wide range of supply voltages — from 5-15V — as the chips under test may be operating within the same range. Two flying leads from the unit must be connected to the same supply as the circuit under test, and these connect to the power lines of the Chip Probe's own circuitry.

There are three ICs within the Chip Probe, each a type CD4049. These devices contain six inverting buffers, so that there are a total of 18 buffers in the probe, though only 16 are used. Each of the 16 contacts of the IC test clip is connected to one of the buffers, which are therefore able to sense the logic state of each pin of the chip under test. It is important to note that, because the 4049 devices are supplied from the same voltage source as the chip under test, the defined logic levels (voltage representing logic 'O' and logic '1') are the same for all devices, whether the chip is TTL or CMOS. The inverting ▶



The component side of the PCB; the resistors are mounted vertically to minimise the size of the board.

buffers have outputs at logic '1' for a logic 'O' input, and outputs at logic 'O' for a logic '1' input. Between each output and the positive supply is a LED in series with a resistor; when the output is a logic '1', ie close to V+, there is insufficient voltage across the LED to turn it on and therefore it is unilluminated.

However, when the output is at logic 'O', ie close to OV, almost the full supply voltage appears across the LED and its resistor, which therefore conducts and illuminates. The series resistor limits the current in the LED at max supply voltage to 20mA. Thus the LED lights if the input of the corresponding buffer is logic '1' or high and extinguishes when the input is at logic 'O'.

The 47k resistor placed across each input and ground is to hold the inputs low when the probe is 'floating' (unconnected) so that all the LEDs are off

It Stands Alone

As mentioned earlier, the Chip Probe can be used either as part of the DigiTester system or as a stand-alone logic probe. Most of the constructional details, this month, apply to when the device is to be used alone; instructions for fitting the DigiTester as part of the overall system will have to wait until a bit more of the system has been outlined in these pages!

The PCB layout (see **Figure 2** and the PCB Printout page) has been kept very tight, to reduce the size of the unit to the smallest possible dimensions. This is primarily for convenience when using it as a logic probe, where small size is absolutely necessary. In part, this has been achieved by placing the pull-down resistors (across the inputs) on the track-side of the board as shown in **Figure 2b**. (Once more, this is not recommended practice, but is tolerated here for reasons of compactness — Ed.)

Other than that, assembly of the PCB should not cause any trouble — just be careful to observe the correct polarity for the LEDs and, even if using 'static protected' ICs, it always pays to be careful when handling CMOS chips!

The tricky bits start when the PCB is to be fixed into its box. However, we've made things easier by drawing up **Figure 3**, a template which can be used to accurately drill the holes for the LEDs. After that, simply push the PCB down into the box so that the LEDs poke through the holes. It's a little fiddly (you may need to enlarge the holes with a miniature file, and be careful not to bend the leads of the LEDs), but patience will be rewarded, in the end.

At this point, you can attach the two power leads to the appropriate PCB points; it's a good idea to tie a knot in the leads before soldering them in place, to provide a measure of strain relief, as shown in the internal photograph.

Now comes the *really* tricky bit — modifying the IC test clip. One of these

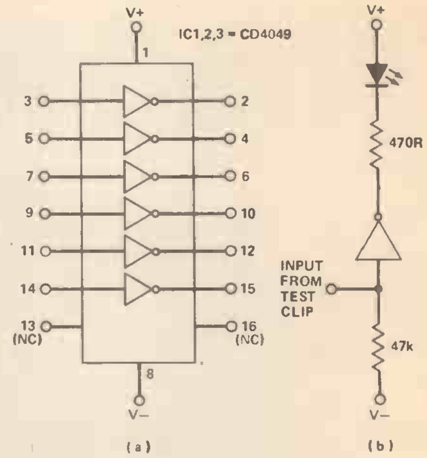


Figure 1. The circuit consists of sixteen hex-inverters, each connected as shown on the right (on the PCB, the positions of the LED and current limiting resistor are transposed).

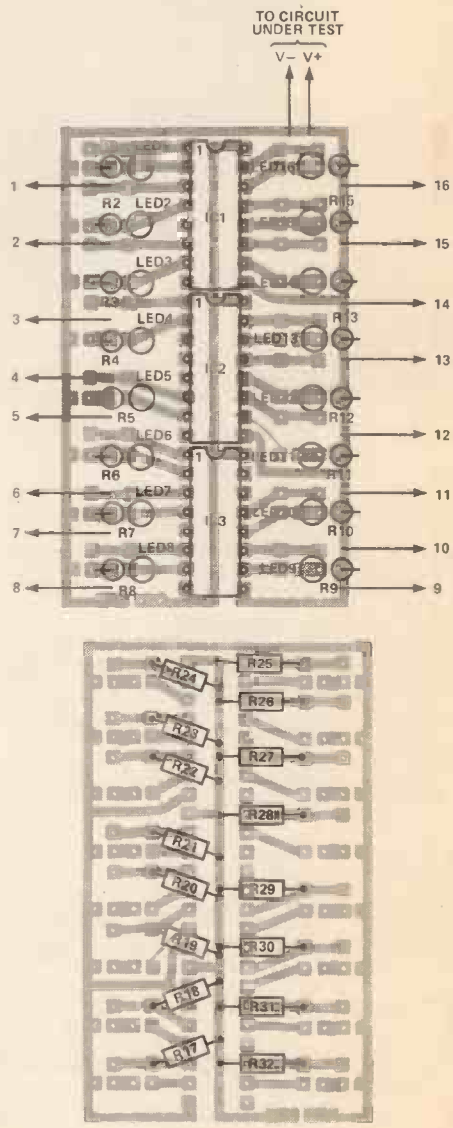


Figure 2. Above: The PCB overlay, viewed from the component side. Below: The track-side of the PCB, showing the positions of the pull-down resistors.

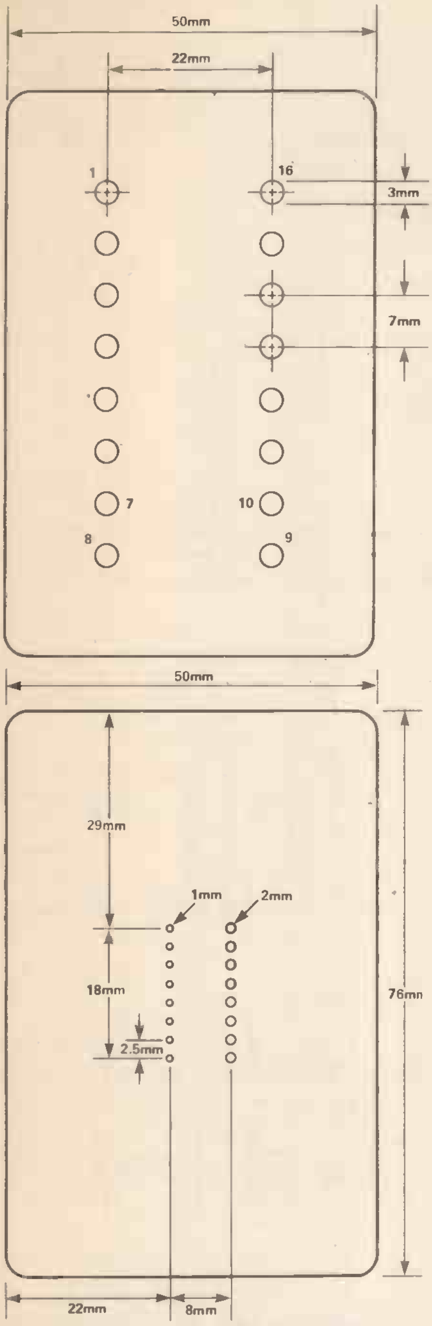


Figure 3. Above: A drilling template for the LED display.
Below: The gold pins of the IC test clip fit through these holes.

Parts List

RESISTORS

(All ¼ watt 5% carbon)
R1-16 .... 470R
R17-32 .... 47k

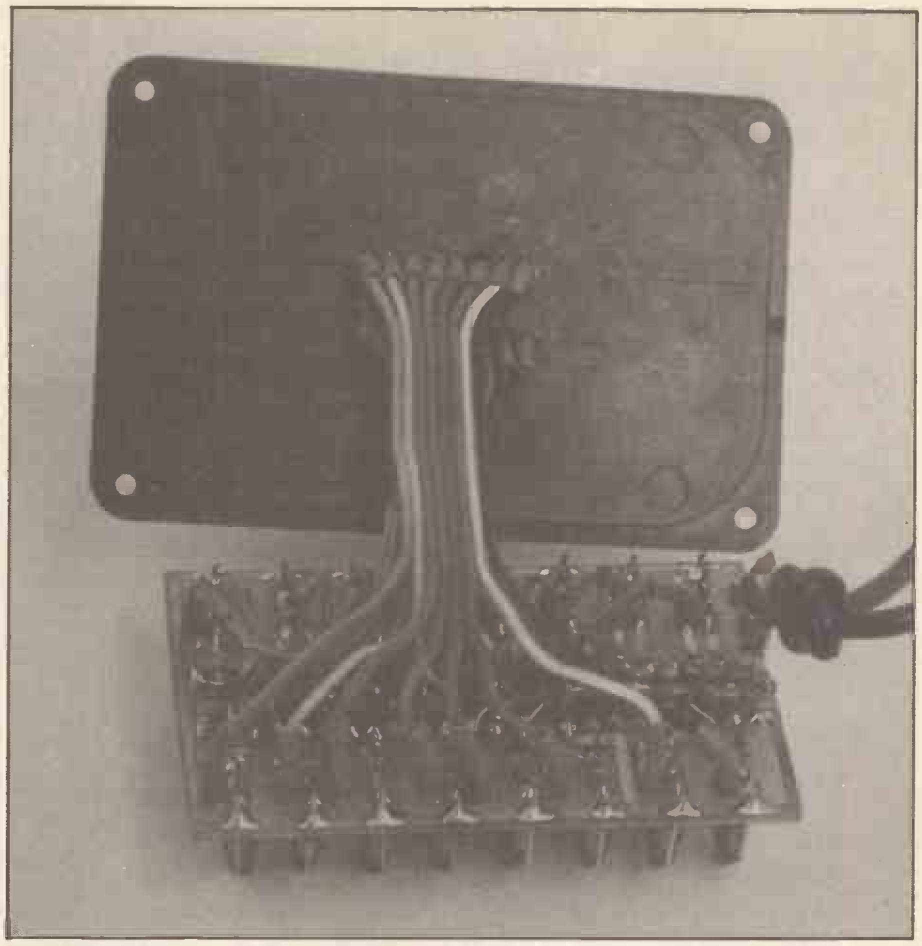
SEMICONDUCTORS

IC1,2,3, ... CD4048B
CMOS hex inverters
LED 1-16 .... red LEDs
standard 0,2″ types

MISCELLANEOUS

Small black box, approx 3″ x 2″ x 1″ deep; IC test clip; ribbon cable (see text); PCB; wire, solder etc.

BUYLINES .... page 34



The underside of the PCB; solder the pull-down resistors across the tracks before connecting the ribbon cable!

readily available gadgets is quite handy when fault-finding on any circuit which uses DIL ICs. It clips over the IC so that of number of gold-plated pins make firm contact with the pins of the IC. The test-clip pins are lead up through the plastic housing to protrude through the top, making the IC pins readily accessible. The modification is required to allow a test-clip to be fitted to the box but sill pivot in the desired fashion.

First, take a small screwdriver or strong pin and push the black hinge pin so that it sticks out through one end. With a small pair of pliers, remove the hinge pin while holding the sides together (this ensures the clip does not suddenly spring apart all over the workroom) and place it carefully to one side. Then pull off the black 'pressure grip' and put it with the hinge pin.

Select either side of the clip and carefully remove the gold pins by pulling them out from the top with a pair of pliers; put aside the half with the pins still in it (be careful not to lose the spring). Next remove about 1mm of plastic from the top of the half-clip; grip it firmly in a vice, if possible, and use a small, fine file to remove the plastic — be very careful not to remove too much, as this will weaken the hinge.

Now smooth the burred edges of the plastic and, carefully, push the pins back into the clip from the top; they should finish up level with the bottom edge of the clip (use the other half as a guide). Reassemble the test clip, fitting the halves together, replacing the pressure grip' and inserting the hinge pin.

The final stage (almost) is to drill the top of the box so that the modified test clip can be fitted and wired in. Once more, a template (**Figure 5**) makes this task easier. Once in place, connect short lengths of 8-way ribbon cable from each test-clip pin to the input of an inverting buffer — but be careful to keep a one-to-one correspondence between the test pins and the inputs, or you won't know "which way is up", when trying to use the device.

The only remaining task is to screw the lid on the box; the pressure of the bunched-up ribbon cable ensures that the PCB will not move about.

Part of the System

If the Chip Probe is to be used as part of the DigiTester system, the complicated procedure for modifying and mounting the test clip becomes unnecessary; the Chip Probe will be mounted with the other modules of the system and connected to the circuit under test by a *long* length of 16-way ribbon cable, which terminates in a perfectly standard, unmodified test clip. However, limitations in time and space (take a bow, Mr. Einstein) prevent us from describing it in detail, this month.

HE

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3.3	40	11p
3.3	63	12p
4.7	16	8p
4.7	25	9p
4.7	40	11p
4.7	63	12p
4.7	100	14p
4.7	350	30p
10	40	12p
10	63	14p
10	100	16p
22	25	11p
22	40	14p
22	63	16p
22	100	21p
47	25	14p
47	40	17p
47	63	26p
47	100	28p
68	25	17p
68	63	25p
100	16	14p
100	25	16p
100	40	22p
100	63	25p
100	100	30p
220	10	16p
220	16	17p
220	25	22p
220	40	25p
220	63	30p
220	100	40p
330	16	19p
330	25	25p
330	63	38p
470	16	22p
470	25	28p
470	40	30p
470	63	43p
470	100	60p
1000	16	30p
1000	25	38p
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BF246B 53p
BF247A 54p
BF247B 56p
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BF255 35p
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BF256B 45p
BF256C 62p
BF257 30p
BF258 32p
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MPSA14 40p
MPSA16 30p
MPSA18 50p
MPSA20 48p
MPSA42 49p
MPSA43 49p
MPSA55 28p
MPSA56 30p
MPSA65 40p
MPSA66 47p
MPSA70 45p
MPSA92 39p
MPSA93 39p
MPSL01 42p
MPSL51 48p
MPSU01 84p
MPSU04 1.32
MPSU05 56p
MPSU06 56p
MPSU07 75p
MPSU51 88p
MPSU55 58p
MPSU56 59p
MPSU57 1.00
OC20 2.30
OC22 2.00
OC23 2.00
OC25 2.00
OC28 1.70
OC29 2.35
OC35 2.35
OC41 80p
OC43 80p
OC44 82p
OC70 50p
OC71 50p
OC72 50p
OC81 50p
OC82D 70p
OC83 75p
TIP29A 32p
TIP29C 36p
TIP30A 38p
TIP30C 38p
TIP31A 38p
TIP31C 38p
TIP32A 42p
TIP32C 45p
TIP33A 65p
TIP33C 78p
TIP34A 88p
TIP34C 1.00
TIP35A 1.08
TIP35C 1.28
TIP36A 1.28
TIP36C 1.39
TIP41A 49p
TIP41C 55p
TIP42A 55p
TIP42C 60p
TIP49 1.20
TIP50 1.40
TIP53 1.57
TIP54 1.58
TIP110 74p
TIP112 90p
TIP115 81p
TIP117 96p
TIP120 69p
TIP122 73p
TIP125 1.20
TIP127 1.27
TIP130 1.50
TIP132 1.60
TIP135 1.60
TIP137 1.00
TIP140 1.04
TIP142 1.04
TIP145 1.18
TIP147 1.18
TIP162 4.08
TIP2955 77p
TIP3055 70p
TIS43 60p
TIS45 86p
TIS46 86p
TIS47 49p
TIS88A 62p
VN10KM 68p

VN46AF 84p
VN66AF 85p
ZTX107 10p
ZTX108 10p
ZTX109 10p
ZTX300 13p
ZTX301 15p
ZTX302 15p
ZTX303 23p
ZTX304 15p
ZTX310 35p
ZTX311 32p
ZTX312 35p
ZTX313 36p
ZTX314 24p
ZTX320 35p
ZTX330 35p
ZTX341 35p
ZTX500 14p
ZTX501 14p
ZTX502 14p
ZTX503 17p
ZTX504 24p
ZTX510 34p
ZTX530 24p
ZTX531 25p
ZTX650 48p

DIODES
1N34A 30p
1N821 70p
1N823 92p
1N914 08p
1N916 10p
1N1190 1.47
1N4001 4p
1N4002 4p
1N4003 5p
1N4004 5p
1N4005 6p
1N4006 6p
1N4007 7p
1N4009 20p
1N4148 6p
1N4150 18p
1N4448 22p
1N4517 22p
1N5172 30p
1N5176 94p
1N5400 12p
1N5401 13p
1N5402 14p
1N5403 15p
1N5404 16p
1N5405 16p
1N5406 16p
1N5407 19p
1N5408 19p
1N5024 52p
1N5625 60p
1N5626 62p
1N5627 68p
1S44 10p
BA102 25p
BA115 25p
BA133 40p
BA138 30p
BA142 20p
BA144 18p
BA155 15p
BA156 38p
BA157 30p
BA158 30p
BA159 32p
BA182 40p
BA201 18p
BA202 28p
BA316 25p
BA317 25p
BA318 30p
BAV10 14p
BAV19 15p
BAV20 15p
BAV49 15p
BAX13 10p
BAX16 11p
BY126 20p
BY127 22p
BY134 52p
BY182 1.26
BY188A 65p
BY206 38p
BY207 36p
BY223 1.56
BY297 48p
BY299 56p
MZ2361 1.60
CA10 70p
OA47 20p
OA90 10p
OA91 10p
OA95 20p
OA200 20p
OA202 20p

DIACS
BR100 40p
ST2 28p

BRIDGE RECTIFIERS /PIV shown in brackets)
1½ amp type
W01 (100) 20p
W02 (200) 28p
W04 (400) 28p
W06 (800) 40p

2 amp type Square with hole
S01 (100) 37p
S02 (200) 40p
S04 (400) 40p
S08 (800) 56p

6 amp type Square with hole
PW01 (100) 50p
PW02 (200) 78p
PW04 (400) 85p
PW06 (600) 89p

25 amp type Metal clad with hole
K01 (100) 2.20
K02 (200) 2.30
K04 (400) 2.88
K06 (600) 3.48

Proprietary Bridges
B40C1500 1.20
B80C3700 1.80
BY164 55p
BY179 80p

ZENER DIODES
400-500mW E24 Series 2.4-47V 8p
1.3 Watt E24 Series 3.3-82V 15p
2.5 Watt E24 Series 7.5-75V 1.10

NEW OPTO DEVICES
New LEDs Now in stock
R = red
G = green
Y = yellow
Large diffused 1+ 50+
R5D 9p 7p
G5D 15p 12p
Y5D 15p 12p
Small diffused
R2D 8p 6p
G2D 12p 10p
Y2D 12p 10p
Micro 0.1"
R1D 25p 22p
G1D 27p 25p
Y1D 27p 25p
Large clear
R5C 12p 10p
G5C 17p 13p
Y5C 17p 13p
Super bright Large (100 times brighter)
R5U 38p 29p
G5U 42p 34p
Y5U 42p 34p
Tri-colour flat
RGY9 83p 79p

THYRISTORS
4, 8 & 12 Amps Texas TO220
Suffix: A = 100V
B = 200V
C = 300V
D = 400V
M = 600V
4A
TIC106A 48p
TIC106B 47p
TIC106C 48p
TIC106D 59p
TIC106M 63p
8A
TIC116A 68p
TIC116B 68p
TIC116C 71p
TIC116D 73p
TIC116M 80p
12A
TIC126A 72p
TIC126B 72p
TIC126C 73p
TIC126D 77p
TIC126M 96p

TRIACS
Texas 400V TO220 Case
TIC206D(4A) 65p
TIC225D(6A) 74p
TIC226D(8A) 80p
TIC236D(12A) 1.16
TIC246D(16A) 1.22
TIC253D(20A) 1.80
TIC263D(25A) 2.11

LM1871 4.38
LM1872 4.08
LM1886 7.64
LM1889 3.77
LM2907N 2.75
LM2907N8 2.60
LM2917N 1.58
LM2917N 1.88
NE531N 1.38
NE543N 2.60
NE544N 1.80
NE555 18p
NE556 65p
NE558 1.88
NE560 3.20
NE562 4.08
NE565 1.18
NE5661.49
NE567 1.37
NE570 3.76
NE571 3.75
NE5534A 1.25
PLL02A 4.88
PLL03A 12.75
RC4136 58p
TBA500 2.87
TBA500Q 3.11
TBA510 2.96
TBA510Q 3.06
TBA520 2.87
TBA520Q 2.75
TBA530 2.56
TBA530Q 2.76
TBA540 2.72
TBA540Q 2.74
TBA550 3.28
TBA550Q 3.37
TBA560C 2.87
TBA570 2.37
TBA570Q 2.44
TCA910 2.19
TCA940 1.88
TDA1002 3.38
TDA1003 3.84
TDA1004 2.87
TDA1005 3.39
TDA1010A 2.25
TDA1022 4.85
TDA1024 1.19
TDA2610 3.90
TDA2611A 2.50
UAA170 1.69
UAA180 1.69
ULN2003 85p
UPC575C2 2.85
UPC1156 2.75
XR2206 2.82
ZN414 79p
ZN419 2.25
ZN1034 1.98
ZN1040 6.69
ZTK22 89p
ZTK33 89p

CPUs
1802 7.00
2650A 11.98
6502 3.24
6800 2.74
6802 2.89
6809 8.50
8035 3.49
8060 10.90
8080A 2.78
8085A 3.49
8900 57.75
9980 21.00
SCMP1 17.98
Z80A 2.98

LOGIC ICs including COMPUTER SUPPORT
ADC0800 22.50
ADC0816 14.80
ADC0817 10.08
AY5-2376 6.90
ICM7556 80p
INS1671 20.00
INS1771 20.00
RO2513LC 6.90
RO2513UC 7.00
SAA5000 3.00
SAA5010 7.10
SAA5012 7.10
SAA5020 6.50
SAA5030 9.00
SAA5040 15.00
SAA5041 15.00
SAA5050 8.50
SAA5052 8.50
TMS6011 3.38
8T26 1.38
8T28 1.35
8T95 1.35
8T97 1.35
81LS95 90p
81LS96 1.20
81LS97 90p
81LS98 1.20
6522 3.19
6532 6.95
8154 9.42
8155 3.60
Z80ACTC 2.58
Z80ADART 8.00
Z80ADMA 10.00
Z80APIO 2.88
ZN425E8 3.38

LINEAR ICs
AN103 2.20
AY1-0212 6.80
AY3-0215 7.95
AY1-1320 2.20
AY1-5050 98p
AY1-1270 7.28
AY3-8910 6.25
AY3-8912 5.59
CA3048 2.99
CA3049 3.21
CA3059 2.80
CA3060 4.00
CA3090AQ 3.70
CA3130E 87p
CA3130T 1.20
CA3140E 46p
CA3140T 86p
HA1366W 2.19
HA1388 2.20
LC7120 3.20
LC7130 3.20
LF351 47p
LF353 92p
LF355 83p
LF356 92p
LF357 1.00
LM348N 82p
LM349N 1.20
LM350K 4.00
LM379S 4.79
LM380N14 75p
LM380N8 1.50
LM381AN 2.28
LM381N 1.40
LM382N 1.12
LM383T 3.40
LM384N 1.40
LM386N1 88p
LM386N4 1.20
LM388N 2.43
LM391N60 1.70
LM391N80 1.93
LM723CH 1.00
LM723CN 40p
LM725CH 3.40
LM725CN 3.18
LM733 69p
LM741CH 96p
LM741CN 15p
LM741CN14 80p
LM747CN 55p
LM748CH 1.08
LM748CN 35p
LM1303N 1.00
LM1304N 2.58
LM1305N 3.10
LM1307N 2.78
LM1310N 1.70
LM1330N 2.28

VOLTAGE REGULATORS
– Positive – 100mA
78L05A 30p
78L12A 30p
78L15A 30p
78L24A 30p
1 Amp TO220
7805T 39p
7812T 39p
7815T 39p
7824T 39p
– Negative – 100mA TO92
79L05 59p
79L12 65p
79L15 59p
1 Amp TO220
7905T 44p
7912T 44p
7915T 44p
7924T 44p

ZERO INSERTION DIL SOCKETS
24 pin 4.80
40 pin 5.30

40 CMOS
4000 10p
4001 10p
4002 11p
4006 48p
4007 15p
4008 32p
4009 24p
4010 24p
4011 10p
4012 15p
4013 20p
4014 39p
4015 39p
4016 20p
4017 32p
4018 44p
4019 25p
4020 44p
4021 39p
4022 39p
4023 12p
4024 32p
4025 12p
4026 77p
4027 20p
4028 37p
4029 43p
4030 14p
4031 1.19
4032 80p
4033 1.20
4034 1.29
4035 59p
4036 2.49
4037 1.30
4038 99p
4040 40p
4041 40p
4042 39p
4043 46p
4044 41p
4045 99p
4046 44p
4047 39p
4048 39p
4049 22p
4050 23p
4051 44p
4052 44p
4053 49p
4054 83p
4055 89p
4056 89p
4059 4.36
4060 42p
4063 79p
4066 22p
4067 2.22
4068 14p
4069 13p
4070 13p
4071 13p
4072 13p
4073 13p
4075 13p
4076 44p
4077 13p
4078 13p
4081 12p
4082 13p
4085 49p
4086 53p
4089 1.20
4093 20p
4094 69p
4095 75p
4096 70p
4097 2.88
4098 74p
4099 90p
For higher numbers in 40 Series, substitute 74C for 40 prefix, eg 40107 = 74C107

45 CMOS
4502 50p
4503 29p
4507 33p
4508 1.19
4510 45p
4511 48p
4512 39p
4514 1.10
4515 1.10
4516 50p
4518 39p
4519 29p
4520 48p
4521 90p
4526 54p
4527 55p
4528 46p
4532 60p
4534 4.29
4536 2.59
4538 65p
4539 59p
4543 65p
4553 2.38
4555 36p
4556 36p
4560 1.90
4566 1.90
4569 1.58
4584 45p
4585 90p

MEMORIES
2101 4.00
2102AL2 1.36
2111-1 3.00
2114 (200ns) 180p
2532 3.60
2564 11.95
2708 2.25
2716 (5V) 2.11
2764 9.75
4027 3.00
4044 7.00
4060 9.60
4116 (200ns) 75p
4118-3 3.25
4164 4.80
5204 7.50
6116 4.80
6514 3.30
6810 1.16
7489 4.20
74LS189 4.00
74LS188 3.28
74LS289 3.28
74LS287 2.28
74LS288 2.28

TTL
7400 10p
7401 11p
7402 11p
7403 12p
7404 12p
7405 15p
7406 16p
7407 16p
7408 14p
7409 14p
7410 14p
7411 15p
7412 16p
7413 16p
7414 17p
7416 17p
7417 17p
7420 15p
7421 20p
7422 20p
7423 20p
7425 18p
7426 16p
7427 18p
7428 18p
7430 17p
7432 21p
7433 19p
7437 19p
7438 19p
7440 15p
7441 65p
7442 27p
7443 65p
7444 65p
7445 48p
7446 45p
7447 40p
7448 40p
7450 15p
7451 15p
7453 15p
7454 16p
7460 15p
7470 25p
7472 25p
7473 25p
7474 18p
7475 22p
7476 24p
7480 40p
7481 1.19
7482 65p
7483 38p
7484 60p
7485 65p
7486 18p
7489 1.70
7490 20p
7491 35p
7492 25p
7493 28p
7494 35p
7495 35p
7496 36p
7497 85p
74100 80p
74104 65p
74105 60p
74107 25p
74109 30p
74110 29p
74111 40p
74116 55p
74118 57p
74119 60p
74120 60p
74121 35p
74122 30p
74123 30p
74125 32p
74126 29p
74128 29p
74132 29p
74136 40p
74141 40p
74142 1.75
74143 1.95
74144 1.95
74145 55p
74147 80p
74148 55p
74150 55p
74151 40p
74153 40p
74154 55p
74155 40p
74156 45p
74157 40p
74159 65p
74160 40p
74161 40p
74162 40p
74163 40p
74164 45p
74165 48p
74166 55p
74167 1.17
74170 1.17
74172 2.50
74173 48p
74174 54p
74175 48p
74176 35p
74177 45p
74178 88p
74180 1.15
74181 1.15
74182 55p
74184 90p
74185 90p
74186 4.89
74188 2.50
74190 45p
74191 45p
74192 45p
74193 45p
74194 45p
74195 45p
74196 45p
74197 45p
74198 77p
74199 77p
74221 65p

74H TTL
74H00 1.45
74H01 1.45
74H04 1.55
74H05 1.55
74H10 1.45
74H11 1.45
74H20 1.45
74H21 1.46
74H30 1.45
74H40 1.56
74H51 1.76
74H53 1.65
74H54 1.46

74LS TTL
74LS00 11p
74LS01 11p
74LS02 11p
74LS03 12p
74LS04 12p
74LS05 12p
74LS08 12p
74LS10 12p
74LS11 12p
74LS12 12p
74LS13 19p
74LS14 22p
74LS15 14p
74LS20 12p
74LS21 12p
74LS22 12p
74LS27 12p
74LS28 14p
74LS30 12p
74LS32 13p
74LS33 14p
74LS37 14p
74LS38 14p
74LS40 12p
74LS42 28p
74LS47 35p
74LS51 14p
74LS54 14p
74LS55 14p
74LS73 18p
74LS74 18p
74LS75 18p
74LS76 18p
74LS78 18p
74LS80 1.20
74LS83 33p
74LS85 39p
74LS86 18p
74LS90 22p
74LS92 25p
74LS93 24p
74LS95 30p
74LS96 50p
74LS107 20p
74LS109 23p
74LS112 20p
74LS113 22p
74LS114 22p
74LS122 25p
74LS123 34p
74LS124 28p
74LS125 24p
74LS126 25p
74LS132 33p
74LS136 24p
74LS138 24p
74LS139 27p
74LS145 70p
74LS147 99p
74LS148 69p
74LS151 30p
74LS153 30p
74LS154 79p
74LS155 29p
74LS156 36p
74LS157 27p
74LS158 28p
74LS160 32p
74LS161 35p
74LS162 35p
74LS163 35p
74LS164 40p
74LS165 50p
74LS166 80p
74LS169 65p
74LS170 70p
74LS173 55p
74LS174 35p
74LS175 35p
74LS181 88p
74LS183 1.20
74LS190 36p
74LS191 36p
74LS192 36p
74LS193 37p
74LS194 32p
74LS195 32p
74LS196 45p
74LS197 48p
74LS221 58p
74LS240 55p
74LS241 56p
74LS242 56p
74LS243 55p
74LS244 55p
74LS245 70p
74LS247 55p
74LS248 55p
74LS249 55p
74LS251 30p
74LS253 30p
74LS257 33p
74LS258 33p
74LS259 56p
74LS261 56p
74LS266 18p
74LS273 53p
74LS275 1.25
74LS279 30p
74LS280 95p
74LS283 40p
74LS289 4.70
74LS290 38p
74LS293 40p
74LS295 75p
74LS298 79p
74LS299 1.56
74LS323 1.56
74LS324 1.46
74LS325 2.96
74LS326 2.30
74LS327 2.30
74LS347 95p
74LS348 88p
74LS352 79p
74LS353 79p
74LS362 7.25
74LS365 29p
74LS366 29p
74LS367 29p
74LS368 29p
74LS373 58p
74LS378 59p
74LS386 1.04
74LS390 45p
74LS393 42p
74LS395 80p
74LS398 2.70
74LS399 1.58
74LS445 1.80
74LS490 2.20
74LS540 1.80
74LS541 1.80
74LS640 1.80
74LS641 1.80

ECC82 etc. VALVES
DY86/87/802 1.32
ECC82 1.22
ECC83 1.22
ECC84 1.22
EF86 1.80
EL34 2.89
EL84 2.50
KT66 10.75
KT88 12.50
PC900 1.76
PCC84 3.00
PCC85 3.40
PCC89 1.89
PCF86 2.30
PCF201 3.00
PCF801 2.57
PCF802 2.11
PCL82 1.80
PCL85 2.20
PCL86 2.10
PCL805 2.20
PD510 4.95
PFL200 2.99
PL504 2.11
PL508 2.95
PL509 4.75
PL802 4.17
PY88 1.82
PY500A 2.63
6L6 2.69

POINTS OF VIEW

Technical Enquiries

First off, our sincere apologies to all those people who send us technical enquiries and SAEs — we really are going to reply as soon as we can. But due to the remorseless burden of toil and tears involved in getting out your Ten Project Xmas Special (flowers, messages of sympathy and money will be acceptable...) and the fact that your editor has been running things single-handed for a while, we have got a bit behind with the enquiries.

However, now that your editor has a brand new assistant to help him out, rest assured that all letters will be answered as quickly as possible. Won't they?

Oh dear. The pile of letters seem to have fallen on the editor! Never mind. I'm sure you'll find something to keep you occupied in the following priceless gems of advice.

Electronic Pop Groups

Dear Sir,
I have been looking through a few back issues of HE (November and December 1980) and I am interested in building the Mini-Synth but I would like a few more details.

Will the price from Magenta Electronics still be the same at £28.50? I see that the kit includes the PCBs and IC holder, but are the wires included?

Is it possible for the synth to give some of the sounds produced by the "electronic pop groups" or is it like an electric organ? I wish to obtain the sort of sounds that modern pop groups produce. I know that for £30 it cannot compare with the expensive synths but I hope that it can mimic some of the sounds.
Ian Meadows,
Wimborne,
Dorset.

Before answering this one we had to work out what an "electronic pop group" was (any suggestions?). Anyway, the *Memory Bank Mini-Synth* produces a wide range of sounds covering basic sythesiser tones *and* electronic organ notes. In fact, the best way of discovering the capabilities of the thing is to build one, and then experiment, which is what pop groups always claim to do. Sorry we can't be more explicit, but describing the way a musical instrument sounds is quite difficult. Perhaps we can arrange a demonstration at this year's Breadboard exhibition. As for the cost of the kit, looking through the advertisements we found that it's gone *down* by 10p — one in the eye for inflation! And yes, Magenta say their kits include all the hardware needed.

Audio Break Down

Dear Sir,
For the past few months I have desperately been searching for information on how to construct a particular electronics project — which simply consists of a small LED sound analyser! What I was looking for was a circuit which would receive information (audio) from a hi-fi system, break it down into three or four predetermined frequencies and then output the individual frequencies on a corresponding row of square LEDs, to get the effect of three or four rows of ten LEDs oscillating in accordance with the sound from the cassette or record.

My friends tell me the circuit I have in mind is one used for ordinary VU meters. Are they correct?

You will probably have gathered that my search was in vain. As a result I thought I would consult the experts — perhaps you have published such a circuit in one of your past editions of HE. If this is the case then I would be extremely grateful if you would be kind enough to send me a copy of the circuit. If this is not possible please point out the edition in question and where I may obtain it.

I would of course be willing to pay for any charges for postage etc.
M. Nanra,
Greenford,
Middlesex.

A VU meter circuit provides a measure of the signal level over the entire radio bandwidth, so it would not provide the kind of display you want. What you are describing is a simple two or three band sound-to-light unit, using a LED display panel. The last time we published a similar circuit was in September '79, but our *Audio Spectrum Analyser* (August and September issues, 1982) can suit the purpose. You could use different coloured LEDs to provide a more visually attractive display (watch the current consumption, though), and you might wish to use fewer than the full ten bands, which will reduce the cost.

It's Been Done Before

Dear Editor,
You will be pleased to hear that the project for the two watt amplifier has served me well for several months now, and I have no complaints so far, but I am hoping to expand a little. As you will already know, the two watt amplifier is only monophonic, because of the (LM380N) IC, and I am wondering if you have thought of designing a stereophonic amplifier using the LM381, which is a low noise dual audio pre-amplifier capable of magnetic cartridge and metal tape and other inputs, and also offers tone control facilities. Supply voltage is roughly 9 to 40V.

That is just an idea for the readers, but what I am really looking for is a small versatile stereo amp which offers bias, treble and balance control facilities and I would be most grateful if you could publish in HE a circuit diagram and parts list. If you think this is too expensive and impractical to publish in HE could you please send me a diagram and parts list.
P.G. Jones,
Stockton on Tees,
Cleveland.

The compliments seem to keep rolling in! What should interest Mr Jones is that we published (almost exactly) a project using the LM381 in a stereo amplifier design. This appeared in the October '79 issue, and by all accounts was quite popular. All those interested should contact our back numbers department forthwith.

Electric Currents

Does the idea of a waterwheel-driven electricity supply conjure up visions of flickering light bulbs and Bakolite wireless sets? Not a of bit it:

Dear Editor,
I am a new recruit to electronics and have recently started to take HE.

My house runs completely on 12VDC from a waterwheel, and I am having difficulty in locating a supplier of inverters to give 240VAC for use with fluorescent lights, video, telephone answering machines, etc. Alternatively, how about an article on building such an inverter?

I also need a 12VDC oscilloscope, if you know of a supplier — I've already tried several of the names from the Directory in HE October '82.
Gordon Channer,
Relubbus,
Cornwall.

Just in time — see this month's feature on switched mode supplies and the accompanying project! The 12VDC oscilloscope is another matter altogether — can any of our readers advise? If so, please contact us here and we'll print the reply.

Incidentally, this waterwheel business does remind me of the bloke who went into his local suppliers and asked for a couple of rechargeable batteries to fit the drain pipe he was carrying, but that's another story...

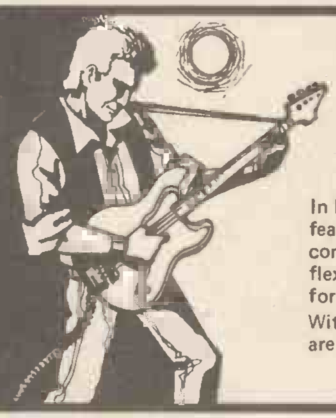
HE

GET BIG POWER

ILP Modular Amplifiers

the third generation

Due to continous improvements in components and design ILP now launch the largest and most advanced generation of modules ever.



WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.O. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/μs. Risetime: 5μs. S/N ratio: 100db.
Frequency response (−3dB) 15Hz – 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω. Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards

For ease of construction we recommend the B6 for modules HY6–HY13 £1.05 (inc. VAT) and the B66 for modules HY66–HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
Frequency response (−3dB): 15Hz – 100KHz. Input sensitivity: 500mV rms
Input impedance: 100K Ω. Damping factor: 100Hz > 400.

'NEW to ILP' In Car Entertainments

C15

Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction. **£9.14 (inc. VAT)**

Mounts anywhere in car.

Automatic switch on.

Output power maximum 22w peak into 4Ω.
Frequency response (−3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω.
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω.
Size 95 x 48 x 50mm. Weight 256 gms.

C1515

Stereo version of C15. **£17.19 (inc. VAT)**

Size 95 x 40 x 80. Weight 410 gms.

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "O" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

WITH A LOT OF HELP FROM ILP ELECTRONICS LTD

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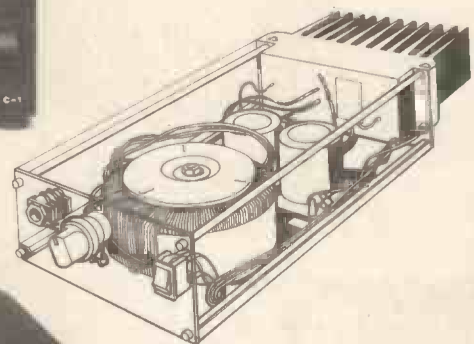

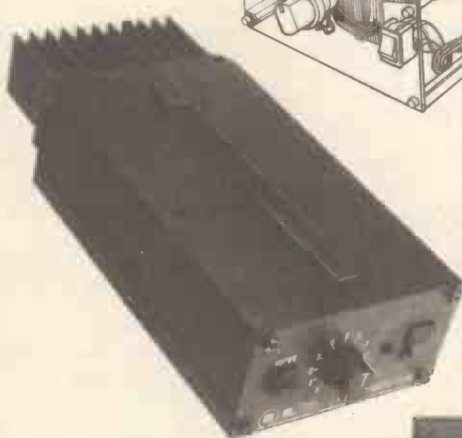

Unicase

Over the years ILP has been aware of the need for a complete packaging system for it's products, it has now developed a unique system which meets all the requirements for ease of assembly, adaptability, ruggedness, modern styling and above all price.

Each Unicase kit contains all the hardware required down to the last nut and bolt to build a complete unit without the need for any special tools.

Because of ILP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.

Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

POWER AMPS: The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

UNICASES

HIFI Separates					Price Inc. VAT
UC1	Preamp				£29.95
UP1X	30 + 30W/4–8Ω	Bipolar	Stereo	HiFi	£54.95
UP2X	60W/4Ω	Bipolar	Mono	HiFi	£54.95
UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4–8Ω	MOS	Mono	HiFi	£84.95
Power Slaves					
US1X	60W/4Ω	Bipolar	Power	Slave	£59.95
US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4–8Ω	MOS	Power	Slave	£69.96
US4X	120W/4–8Ω	MOS	Power	Slave	£89.95

Please note X in part number denotes mains voltage. Please insert 'O' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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POP AMPS

Owen Bishop

Simple measuring circuits based on operational amplifiers.

No. 3: Millivoltmeter

THE MILLIVOLTMETER is a circuit with a high input impedance, to allow you to measure potentials from just under 1 volt down to tenths of a millivolt.

In the diagram (**Figure 1**) the amplifier (represented by a triangle) has two inputs (+ve and −ve) and one output. It needs a balanced power supply (V+ and V−) provided by two PP3 batteries (+9V, −9V). A mains power supply of +18V can be used with the potential divider network of **Figure 2**, but better operation is obtained by using a regulator IC to provide a balanced supply from a single-rail such as the circuit described in the October issue of *Hobby Electronics*. All voltages are measured with respect to the common 0V battery rail.

The 741 has two offest null terminals (pins 1 and 8) with which we can adjust the output voltage to exactly 0 V when both inputs are at equal voltage. The input terminals are temporarily connected together and RV1 is adjusted until the output at pin 6 is 0 V.

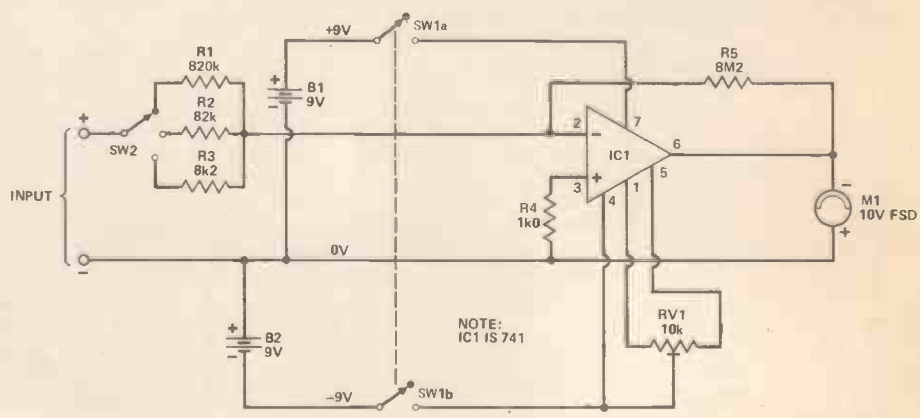
Voltage Amplifier

Like all op-amps, the 741 is an amplifier with the capability of very high gain. Without the feed-back resistor its gain (the open-loop gain) is as high as 200,000 or more. There is, of course, the limit that the output voltage cannot exceed the supply voltage in either direction. In practice, the output does not quite reach either supply voltage; the swing is approximately ±8V. Within this range, a small input voltage is amplified so that it becomes large enough to be read on a low-cost multimeter.

The non-inverting (+ve) input is tied to the 0 V rail through R4. The op-amp will have zero output voltage when its inverting (−ve) input (at pin 2) is also at 0V; in this state, no current flows through R5. When a voltage is applied to the positive input terminal, a current will flow through one of the resistors R1-R3. Suppose the voltage here is 0V5 and SW2 is in the position shown. With pin 2 at 0V, the resulting current through R1 is 0.6uA. The potential at pin 2 now begins to rise and the output of the op-amp swings negative. It continues to swing negative, pulling the entire current flowing through R1 and through R5 to the output terminal, thus maintaining a 'virtual earth' at the inverting input. To make a current of 0.6uA flow through R1 and through a 8M2 resistor requires a voltage of 5 volts, so, for an input of 0V5, the output must swing to −5V. This means that there is tenfold voltage amplification — but note that the output voltage is *negative*. However, the meter is connected to display this as a positive voltage.

With a feedback resistor in the circuit, the gain of the amplifier is precisely determined by the ratio of the feedback resistance to the input resistance. In the example above, R5/R1 = 10, which gives ten-fold gain. If SW1 is switched, the gain becomes 100 or 1000, respectively. If 5% tolerance resistors were to be used, one resistor might be up to 5% larger than its nominal value and the other might be 5% smaller. The ratio, and hence the calculator gain, could therefore be up to 10% in error, in either direction, so to obtain reasonable accuracy, it is important to use 1% or 2% resistors.

The input impedance of this circuit is the value of the input resistor that is switched into circuit. With R1 in circuit, the maximum output voltage that can be read is about 8V, equivalent to 0V8 input. Thus the input impedance is just over 8M2 in parallel with 2M (the input impedance of IC1), which gives 1M6, or 2M0 per volt FSD, which is considerably higher than that of a low-cost multimeter; the same figure applies in the other ranges, so we have the twin benefits of greater sensitivity and high impedance. The advantage of high impedance is discussed in connection with Pop-Amp No. 4.



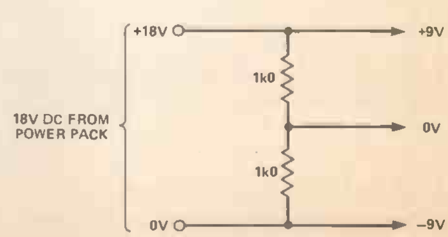


Figure 1. Top, the Millivoltmeter circuit; RV1 is used to adjust the offset to zero; left, how to power any Pop Amp circuit from a +18V single rail supply.

Parts List

RESISTORS
(0.4 watt 1% metal film, except as noted)
R1 . . . . 820k
R2 . . . . 82k
R3 . . . . 8k2
R4 . . . . 1k
0.25 watt 5% carbon

POTENTIOMETERS
RV1 . . . . 10k
min. horiz. preset

SEMICONDUCTORS
IC1 741
op-amp

MISCELLANEOUS
M1 . . . . 10 V FSD meter
SW1 . . . . DPST
toggle or slide switch
SW2 . . . . 3-way rotary switch
Stripboard, 63 x 25 mm (24 hole x 10 strips); 2 x PP3 battery clips; 4 x 4 mm sockets; 9 x 1 mm terminal pins; wire, solder, etc.

BUYLINES . . . . page 34

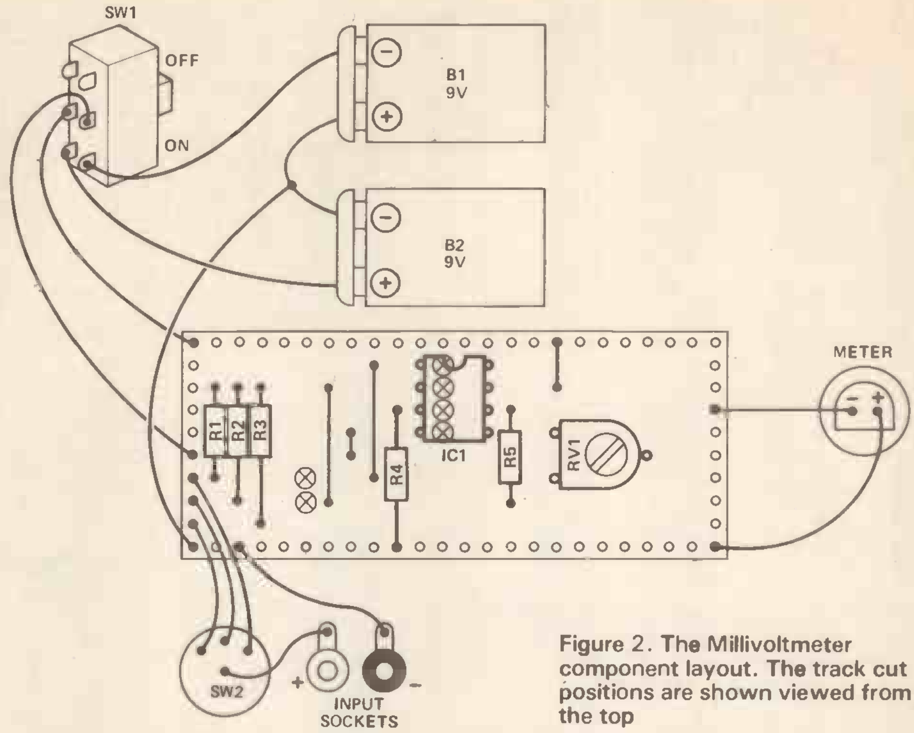


Figure 2. The Millivoltmeter component layout. The track cut positions are shown viewed from the top

Using The Circuit

Connect the circuit to the multimeter, switched to 10 V or 15 V DC range. Connect the power supply to the circuit. If you have not already done so previously, adjust RV1 for zero output with pins 2 and 3 shorted together. Switch SW2 to the position shown. The meter now covers the range 0-0V8. Read the meter and divide the reading by 10 to obtain the value of the input voltage. If the reading is low, switch to the second (0-0V88) or third position (0-0V008). If batteries are used as the power supply, remember to switch off or disconnect them when the circuit is not being used!

HE

Hobby Electronics

Components Order Form

Use this convenient form to order components from suppliers advertising in Hobby Electronics!

PART	CODE	UNITS	PRICE	COST

POSTAGE AND PACKAGING	
LESS CREDIT VOUCHERS ETC.	
TOTAL	
VAT (15% if applicable)	
TOTAL INC. VAT	

Hobby Electronics Component Order Form

N.B. Hobby Electronics is not a supplier of electronic components

Name ______________________________

Address ______________________________

____

Signature ____________________ **Tel.** __________

**Delete as necessary*

Debit my *Access/*Barclaycard

My Cheque*/Postal Order*/International Money Order* for £ ____________ is enclosed.

BUYLINES

Switched Mode Supply

Not many components required for this project — though most are a little out of the ordinary. First there is the single IC, a TL497, made by Texas Instruments. Depite its obvious usefulness, it doesn't seem to be in demand. Still, it appears in the Verospeed catalogue, and can be ordered from most retail suppliers as well; Ace Mailtronix or Greenweld will let you have one if you ask them nicely.

Lastly, the coil L1. This requires a pot-core type RM6, with an inductance factor (AL) of 160. A suitable type is listed in Electrovalue's catalogue, but the AL value must be specified in your order.

CHECK LIST

RESISTORS
(All ¼ watt 5% carbon, E24 range).
1 x 1R0; R1,2 selected from Table 1.
CAPACITORS
1 x 100p ceramic; C1 selected from Table 1.
SEMICONDUCTORS
1 x TL497.
MISCELLANEOUS
RM6 pot-core; PCB etc.

Chip Probe

All the parts are readily available except, perhaps, for the IC test clip. Our prototype was from the RS catalogue, stock number 423-627, however we are reliably informed that an identical type is stocked by Watford Electronics; their price — £2.00.

The case should be just large enough to fit the PCB, or the Chip Probe becomes too top-heavy to use easily. The prototype was built in a box from Verospeed. Their part numbers are 75-1413E or 75-14692 for black or white respectively.

CHECK LIST

RESISTORS (All ¼ watt 5% carbon)
16 x 470R; 16 x 47k.
SEMICONDUCTORS
3 x CD4049B; 16 x 0.2" red LEDs.
MISCELLANEOUS
Box, test clip (see above); PCB etc.

CB Selective Caller

The difficult component in this project is the relay. The prototype uses a hard-to-find variety, labelled "Hi-C d'Italia" which has a 320R coil. The nearest we can find is from the Brian J. Reed catalogue; it has equivalent lead-outs but is a 675R type operating from 12-24VDC. Alternatively, a standard relay may be used though the tracks will have to be modified.

The NE567 chips are readily available from, for example, Rapid Electronics, Technomatic or Hemmings Electronics. All other components are standard.

CHECK LIST

TRANSMITTER:
RESISTORS (All ¼watt 5% carbon)
2 x 820k; 6 x 10k; 1 x 56k; 1 x 390k; 1 x 470k; 2 x 100k.
NB: R12,13 (both 100k) have been omitted from the Parts List.
POTENTIOMETERS
(All sub min PCB mounting presets)
3 x 100k.
CAPACITORS
3 x 10n ceramic; 2 x 1n tantalum; 1 x 2u2 tantalum.
SEMICONDUCTORS
2 x CD4011; 1 x 741.
RECEIVER
RESISTORS (All ¼watt 5% carbon).
6 x 10k; 2 x 18k; 1 x 330R; 2 x 4k7; 1 x 100R ½watt.
POTENTIOMETERS
1 x 1M
CAPACITORS
(All ceramic unless noted)
3 x 10n; 3 x 1u, 2 x 2u2 tantalum; 1 x 100n; 1 x 68n; 1 x 22n; 1 x 10u electrolytic.
SEMICONDUCTORS
1 x BC109; 1 x 741; 2 x NE567; 1 x CD4001; 1 x 1N914; 1 x BZY88C7V5.
MISCELLANEOUS
1 x 2-pole 4-way rotary switch; 1 x 12V 2-pole changeover relay (see above); PCB etc.

CUMULATIVE INDEX 1978-1982

See What You've Been Missing In The Last Four Years.

FEATURES

PROJECTS

READER'S SURVEY

Once again the January issue rolls around and it's time to ask Hobby readers what they think of our efforts over the past year. Not only does this give us the chance to collect lots of stamps, but it means we can try to please more of our readership more of the time by giving *you* what you want — as far as possible, that is.

By filling in the questionnaire overleaf you'll be helping us to plan Hobby in the months to come. If you feel moved to take up pen and postage stamp, then remember we appreciate honest comments. Philately will get you nowhere.

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So that we don't have to cope with staples, Sellotape or sealing wax, we've made things easier by designing this form to fold up quite neatly. Simply fold along the dotted lines and tuck the small bit into the bigger bit. You don't need an envelope, either!

Reader Survey

1. Please rate the following articles on a scale of 1 (awful) to 10 (brilliant). If you didn't read the article, please score a 0, and we've left space for you to write down any other projects or features that you found interesting. Don't forget to tick off any project that you built in the past year!

Title	Read	Scanned	Built	Score
Intelligent Nicad Charger (Jan)				
Scaling the Hi-Fi Heights (Series)				
Into Electronic Components (Series)				
Making Tracks (Feb)				
TV Masthead Amplifier (Feb)				
Bike Siren (Mar)				
Dual Engine Driver (Apr)				
Inside Colour TV (Apr)				
Digital Capacitance Meter (Apr)				
Radio Rules (Series)				
Digital Thermometer (May)				
HE Echo-Reverb (May)				
Telephone Timer (Jun)				
Auto Greenhouse Sprinkler (Jun)				
HE MicroTrainer (Jun)				
Solar Cells (Jul)				
Equalisation — It's Easy (Jul)				
Tanover (Jul)				
Beginner's Guide to Construction (Aug)				
ZX Interfaces Explained (Aug)				
HE 'Junior' Slot-Car Controller (Sep)				
ZX Interface (Sep)				
CB Squelch Unit (Oct)				
Directory of Electronic Supplies (Oct)				
Fault-Finding Made Easy (Oct)				
HEBOT II (Nov)				
Pedometer/Odometer (Nov)				
Electronic Housekeeping (Nov)				
Microlog (Dec)				
Phase Four (Dec)				
Components for Computing (Dec)				

10. Do you read the advertisements in the magazine?

Always ☐ Frequently ☐ Hardly ever ☐ Never ☐

11. Do you find the advertisement useful when purchasing goods or components?

Very useful ☐ Moderately useful ☐ Don't bother ☐

12. Do you often purchase goods or components from suppliers advertising in Hobby Electronics?

Usually ☐ Sometimes ☐ Hardly ever ☐ Never ☐

12a. Do you normally purchase components by mail order or over the counter?

Mail order ☐ Over the counter ☐

13 What is the most important consideration when you are buying goods or components?

Service ☐ Convenience ☐ Price ☐ Product range ☐

Other (please specify) . . . .

. . . .

14. About how many suppliers do you regularly buy from?

one ☐ two ☐ three ☐ four ☐ more ☐

15. Please write down the name of your favourite component supplier.

. . . .

16. Approximately how much have you spent on electronic components and hardware in the past year? £ . . . . . .

And about how much do you think you will spend during 1983? £ . . . . . .

17. The field of electronics is very wide, ranging from amateur radio to computers and covering a lot of ground in between! What would you say is your main interest in electronics? (Please number in order of importance).

Amateur Radio ☐ General Interest ☐

Hifi ☐ CB Radio ☐

Musical Applications ☐ Modelling/Control ☐

Digital/Computers ☐ Other (please specify below)

. . . .

. . . .

17a. Are you a member of a radio/electronics club or activity group?

Yes ☐ No ☐

18. Is there a stereo system in your home?

Yes ☐ No ☐

2. How long have you been reading Hobby Electronics? (Please tick the appropriate box).

6 months ☐ 1 year ☐ 2 years ☐ longer☐

How many isues have you bought during 1982, then . . . .

3. If you have been a reader for longer than a year, how do you think Hobby compares now with last year's issues?

much better ☐ slightly better ☐ no difference ☐ slightly worse ☐ much worse ☐

4. How long do you keep your copies of the magazine?

1 month ☐ 3 months☐ 6 months ☐ 1 year longer ☐

5. How did you become a reader of Hobby Electronics?

Saw a friend's copy ☐
Impulse buy in a newsagent ☐
Saw an advertisement ☐
Other reason (please specify) . . . .

. . . .

5a. How do you normally obtain your copies of Hobby Electronics?

Purchase from local newsagent ☐
Purchase from travel point ☐
Purchase from High St. newsagent (W.H. Smith, Menzies etc) ☐
Copy delivered to home ☐
By subscription ☐

5b. Do you have difficulty purchasing copies of the magazine? Yes ☐ No ☐

6. How many people read your copy of HE?

one ☐ two ☐ three ☐ four ☐ more ☐

7. In general, when building a project, would you rather . . .

Buy a complete kit of parts? ☐
Assemble the components yourself? ☐

8. If a project is designed around a printed circuit board, do you generally . . .

Etch your own PCB? ☐
Send off for a ready made PCB? ☐
Transfer the design to a different medium (eg Stripboard)? ☐
Forget it? ☐

9. Are there any goods or services that you would like to see on offer in Hobby Electronics? (Please specify).

. . . .

. . . .

19. Do you think a good sound system is worth having or are you content with a portable cassette/radio?

Essential ☐ Desirable ☐ Not important ☐

20. Is there a video system in your home? Yes ☐ No ☐

If not, do you or your family intend to rent or buy a video system in 1983?
Yes ☐ No ☐

21. Do you either own, or have the use of, a home computer or microprocessor system?

Own ☐ Have use ☐ Have use but not interested ☐

22. Are you likely to buy, or to gain access to a computer or microprocessor system during 1983?

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23. If you are a computer user, please indicate the type of system.

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26. If you are a computer owner, is it likely that you will be adding to your system during 1983?

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32. What was your approximate income during 1982? £......

33. What is your job title?
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41. Please indicate which of these magazines or papers you read (use the extra space provided to enter any titles we've missed that you also read regularly).

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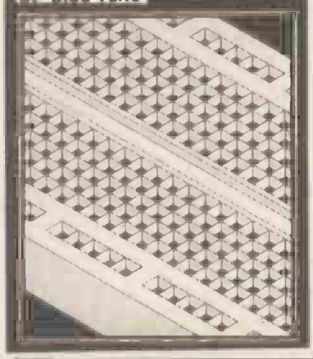

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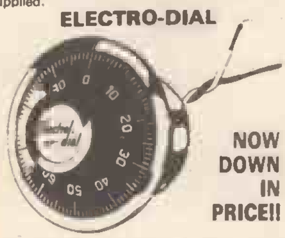

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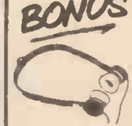

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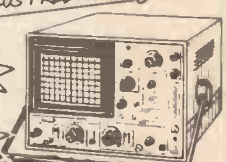

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A M Receivers

Before we start to look at AM receivers, which are still the most frequently-used type of receivers, we'd better be clear about what modulation, and particularly Amplitude Modulation (AM), is. Modulation means making a carrier wave, which is a high frequency radio wave, carry a signal. This means that the low frequency signal, or modulating signal (usually Audio Frequency, or AF), has to be able to change some feature of the carrier signal. Amplitude modulation means that the amplitude of the carrier is controlled by the instantaneous voltage of the audio frequency signal.

Look at an example. **Figure 1**a represents a carrier wave, with a constant value of peak amplitude. This is an unmodulated wave. When an audio wave with a much lower frequency (**Figure 1b**) is used to modulate this carrier, the peak amplitude of the carrier rises and falls so that its size is proportional to the amplitude of the audio signal at each instant (**Figure 1c**). The carrier wave was symmetrical around the zero-volt line before modulation, meaning that the positive peak height was equal to the negative peak height, and it is also symmetrical after modulation, so that the outline of the modulated carrier signal is shaped like the audio wave on both positive and negative sections of the wave.

A Band on the Side

A perfect sinewave has just one single frequency, with no harmonics, and a good carrier wave should answer to this description. When we modulate a carrier wave, however, we change its shape — the waves of the carrier are no longer identical because each one has a slightly different peak amplitude, due to the modulation. A modulated carrier therefore consists of more than one frequency, and when we analyse it we find that there is a range of frequencies that we call sidebands, some at frequencies higher than the carrier frequency and so called upper sidebands, and some at frequencies lower than the carrier, called lower sidebands.

The sideband frequencies very much depend on what audio wave has been used to modulate the carrier. If, for example, we modulate a 1000 kHz (which is 1 MHz) carrier with a 1 kHz sinewave, we find that the upper sideband is a single frequency of 1001 kHz (1.001 MHz) and the lower sideband is a single frequency of 999 kHz (0.999 MHz). The upper sideband frequency is the sum of the carrier frequency plus the audio frequency, and the lower sideband is the carrier frequency minus the audio frequency. When the audio signal is not a sinewave but a mixture of frequencies, like speech or music, then there will be a range of sideband frequencies. Figure 2 shows what these sidebands look like on the screen of a spectrum analyser, which gives a cathode-ray tube display of peak wave amplitude plotted against frequency.

Normal amplitude modulation creates two sets of identically shaped (as seen on the spectrum analyser) sidebands. We have already seen that we can reduce the amount of power wasted in transmission by using one sideband only, but for this part we shall be dealing with the double sideband system only. Note that the fact that there are two sidebands has nothing to do with the shape of the modulated wave as seen on an oscilloscope screen, with its two sets of modulation shapes. A wave with only one sideband looks pretty much the same on a 'scope, and the difference is apparent only when a spectrum analyser is used.

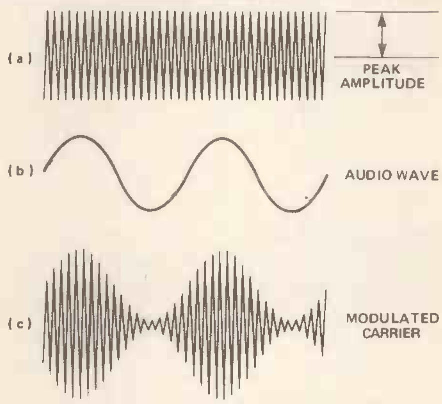

Figure 1. Amplitude modulation. (a) An unmodulated carrier wave. (b) The audio signal. (c) Amplitude-modulated carrier — note that the maximum amplitude of the modulated wave can be greater than the amplitude of the carrier.

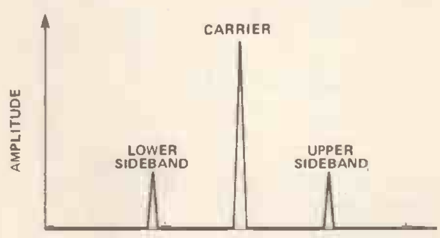

Figure 2. Sidebands, as seen on a spectrum analyser. This is how the sidebands of a carrier modulated by a single sinewave look.

Receiver Principles

Long ago, all receivers were tuned radio frequency (TRF). This involved picking up the modulated carrier on the aerial, amplifying it through several stages of tuned amplifier circuits all tuned to the carrier frequency, demodulating (reversing the effect of modulation), and feeding the resulting audio wave to an amplifier (**Figure 3**). It's simple and obvious, but the principle is not used now except for a few cheap (and not always cheap!) and thoroughly unsatisfactory pocket receivers. There are many factors that make the TRF principle unsatisfactory for modern times, among them the problems of tuning several stages at once; selectivity; sensitivity; and feedback. With the small carrier separation that has to be used in today's crowded radio wavebands, a receiver must be able to select one carrier from neighbouring ones only a few kHz different. This calls for good selectivity, requiring a lot of tuned circuits. At the same time, to be able to pick up weak signals requires many stages of amplification. The snag is that if you amplify a radio frequency very much it becomes difficult to prevent some of the amplified signal from finding its way back to the aerial input, creating feedback, which at some frequency or other will be positive and cause oscillation. The problem, which first became serious in the early '30s, was solved by Edwin Armstrong's invention of the superhet receiver.

Het and Superhet

Superhet stands for supersonic heterodyne, and the principle is a very ingenious one. A signal received from the aerial is changed to a lower frequency, one which will not radiate so easily, called the intermediate frequency. When this frequency changing operation is carried out,

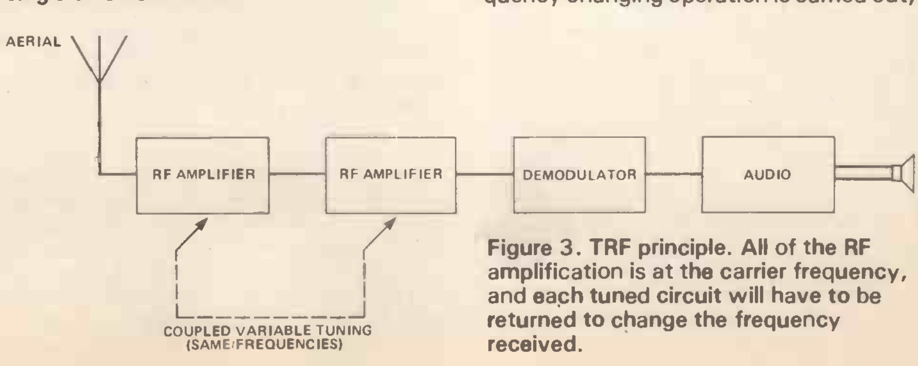

Figure 3. TRF principle. All of the RF amplification is at the carrier frequency, and each tuned circuit will have to be returned to change the frequency received.

the modulation of the new Intermediate Frequency (IF) signal is the same as the modulation of the carrier that was received from the aerial, because the shape of the modulation is not affected by the frequency-changing operation. The IF is now amplified and selected, because this is a fixed frequency which can use preset tuning, with no variable capacitors to be adjusted. Because of this, the IF stages can be shielded to prevent feedback, with no holes in the shielding for variable capacitors. In any case, if there *is* any feedback to the aerial, it is less likely to cause oscillation, because the aerial circuits are tuned to the frequency of the incoming carrier, and the IF is at a different, lower frequency. The scheme is shown in Figure 4, and we can analyse what is happening by considering each block separately.

Mix it a bit

The mixer stage is the key to the action of the superhet, because it is in this stage that the signals from the aerial, selected by a tuned circuit, are converted to the intermediate frequency. This is done, as the name suggests, by mixing the signal with a sinewave which has a different frequency. Now when we pass signals at two different frequencies into a linear amplifier, we get the same two frequencies out, and that's all.

If, however, we put two different frequencies into an amplifier which is *not* linear (meaning that a graph of output plotted against input is not a straight line), then we get at the output two additional signals. One is at the different frequency, equal to the higher frequency minus the lower one, and the other is at the sum frequency, the higher frequency plus the lower one. This is a mixing action, and if it sounds rather like modulation that's not surprising, because the effects are pretty much the same. Mixing, like modulation, requires a device that can be made to work in a non-linear way. A transistor will do this when one of the signals into it is large, and a FET will do it very well indeed for almost any amplitude of signal. The classic transistor mixer (**Figure 5**) uses the base as the input for the signal from the aerial (which may have been amplified by a "preselector" stage), and the emitter as the input terminal for a sinewave signal of greater amplitude, the local oscillator signal, with which it is mixed.

The conventional method is to use an oscillator signal whose frequency is above the frequency of the input signal from the aerial, and to use as the IF the difference signal from the mixer. This difference signal will normally be at a much lower frequency than either of the inputs, and can easily be separated from them, even with a simple low-pass filter. There is very little gain in the mixer stage, because the signal that is used at the output is created from the non-linearity of the mixer rather than from its normal amplifying action. The important point, though, is that the difference frequency, which is the IF, will carry any modulation that appeared on the input waves. If the local oscillator waveform is a pure sinewave, then the IF will carry only the modulation of the original signal from the aerial. If the local oscillator waveform is

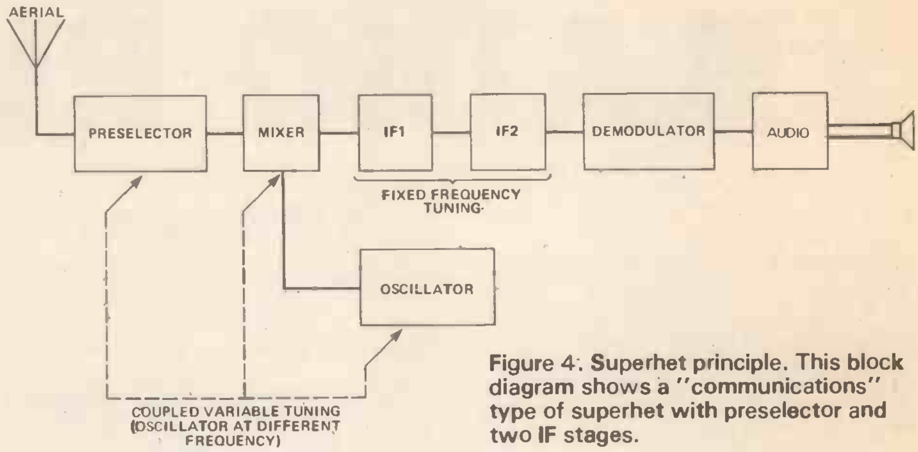

Figure 4. Superhet principle. This block diagram shows a "communications" type of superhet with preselector and two IF stages.

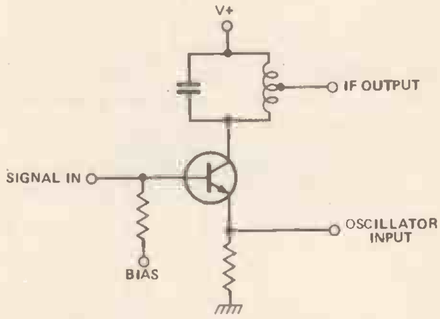

Figure 5. A transistor mixer, using a modulated signal into the base, and oscillator frequency into the emitter.

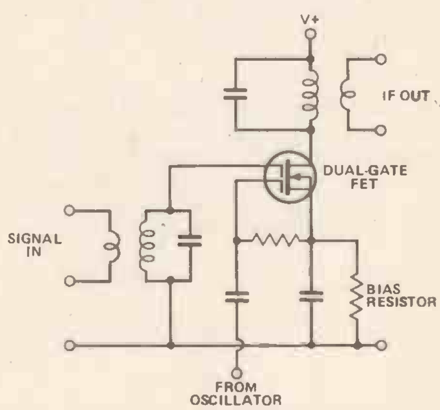

Figure 6. A double-gate FET used as a mixer — a feature of high-grade receivers.

not a perfect sinewave — it might, for example, be modulated by mains hum — then the IF will carry both of these modulating signals.

Mixers in high-grade receivers (communications receivers) make use of separate oscillator circuits, which can be any of the conventional RF sinewave oscillators, or can be crystal controlled. One favourite technique for high-grade receivers is to use a double-gate FET as the mixer (**Figure 6**). Both gates affect the electron stream in the channel (assuming the use of N-channel), and the aerial signal can be applied to one gate, with the local oscillator signal applied to the other and the IF output obtained from the drain circuit. This type of mixer ensures excellent separation between the aerial signal and the local oscillator — a very desirable feature when the frequencies are not very different, because a local oscillator can be "pulled", ie made to synchronise its frequency to the incoming signal, if there is much signal passed from the aerial input to the oscillator. This type of design is used in many VHF tuners.

A much less expensive option, with a much lower performance, is the self-oscillating mixer used in most medium-wave receivers. This uses a transistor whose collector and emitter circuits are arranged as an oscillator (**Figure 7**), so that signals coming in at the base will be mixed with signals present at the emitter. The use of a transistor for the two actions is possible, because the oscillator frequency is considerably different from the signal input frequency and IF. This means that tuned circuits for the oscillator have very little impedance at either of the other frequencies, so that the actions of the circuits are almost independent. A typical circuit is shown in **Figure 7**.

To put some figures to these ideas, imagine a medium-wave signal input at 1 MHz. For a 1 MHz signal from the aerial, we can run the oscillator at a frequency of 1.455 MHz, so that the IF is 455 kHz, the difference between these two. There's a lot of difference between these frequencies, so they are easy to separate at the output of the mixer, and a self-oscillating mixer gives an acceptable performance because its frequency is so different from that of the signals. Things look rather different if the input signal is on one of the amateur bands, around 28 MHz. The oscillator frequency would then have to be 28.455 MHz to get the IF of 455 kHz, and this oscillator frequency is very close to the frequency of the input signal. What really counts is the percentage difference, which is:

$$\frac{\text{oscillator frequency-input frequency,}}{\text{input frequency}}$$

which is equal to:

$$\frac{\text{intermediate frequency}}{\text{input frequency}}$$

and put into percentage terms by multiplying by 100. In these terms, the percentage difference for the 1 MHz signal is 50%, but for the 28 MHz signal it's only 1.67%, a lot less. With this small difference, the self-oscillating mixer is not a good proposition.

When we look at the VHF bands, we find that the only way of keeping a reasonable percentage difference between oscillator frequency and input frequency is by using a higher IF. A 90 MHz signal on the VHF broadcast bands, for example, uses a 10.7 MHz IF, so that the percentage difference is around 12%, which makes separation rather easier and avoids pulling the oscillator frequency.

A very common way of getting around these difficulties is to use double conversion. A double conversion receiver (**Figure 8**) uses two IFs, converting the VHF input signals to some higher IF, and then converting again to a lower value — communications receivers used to use 1.6 MHz and 455 kHz as their IFs, but higher first IF values are needed for the VHF bands.

The main problem that is involved at the mixer stage of a superhet is that of tracking. The oscillator frequency must always be the correct amount above the input frequency, whatever the frequency of the input happens to be, and this implies that the tuning of the local oscillator and the input circuits must be linked. The problem is that these two are working over different frequency ranges, so that if they produce an IF, of, say, 455 kHz at the middle of the tuning range, there is no guarantee that they will still be 455 kHz apart at the extremes of tuning. This is traditionally dealt with by using trimmers and padders (see **Figure 9**). Trimmers are small preset capacitors added to the main tuning capacitor of the oscillator in parallel, to increase its minimum capacitance, and padders are presets added in series to reduce the maximum capacitance. By careful adjustment, it is possible to ensure that the correct IF is generated at both extremes of the tuning range, and we can hope for the best in the middle. High-grade receivers can make use of coupled capacitors in which the vanes of the oscillator section are shaped to ensure that the two keep in track, and modern electronic tuning methods can make use of ICs which will control the frequency of the oscillator so that the IF is always correct.

The IF Factor

Once converted to IF, the modulated signal can be amplified, using transistors with parallel resonant circuits as loads. A more recent development is to use crystal filters or surface acoustic wave filters (SAWs) in place of parallel resonant circuits, because a very much higher Q value can be achieved with these devices. Using one filter of this type can often achieve all the selectivity we need for telephony, so that an IC can be used for amplification in place of separate transistors.

The IF stage (**Figure 10**), which may in fact be several stages all working at the same frequency, is very important, however, because it is here that all the selectivity and sensitivity of the receiver will be achieved. High quality receivers devote a lot of attention to good design of the IF stage, incorporating switched filtering for a variety of uses because, for example, the bandwidth that will be needed for FM, even narrowband FM, is much greater than will be needed for AM, which in turn is greater than will be needed for single sideband, which is in turn greater than will be needed for Morse (CW). Since it's important for the purpose of avoiding interference to trim the bandwidth of the IF to the needs of the signals being received, a switch selection of bandwidth is a very valuable feature.

Demodulation and AGC

At the end of the IF stage, the signal is still a modulated high frequency signal. This will have no effect on earphones or on a loudspeaker because it is at too high a frequency, and even if it could affect these devices we still could hear nothing. What we have to do is to recover the low frequency audio signal from the varying-amplitude wave, and this is the task of the demodulator.

Dozens of demodulator circuits have been devised over the years, but receivers generally stick to the old-fashioned diode and reservoir capacitor method. This works in a similar way to the power supply circuit, but the time constant of the capacitor and the load (usually a volume control resistor) is critical. The time constant should be long compared to the time of one IF cycle, but short compared to one cycle of the highest frequency of AF that is to be demodulated. What happens is that the diode passes only the positive peaks of the modulated wave, allowing the capacitor to charge up to the positive peak voltage of each wave (**Figure 11**). Because the time constant is long compared to the cycle of IF, the voltage across the capacitor does not follow the AC wave voltage downwards, but keeps the diode cut off, losing only a small amount of voltage, until the next peak causes it to conduct again. The capacitor voltage therefore follows the peaks of the carrier signal, and since this involves tracing out the waveshape of the audio wave, the

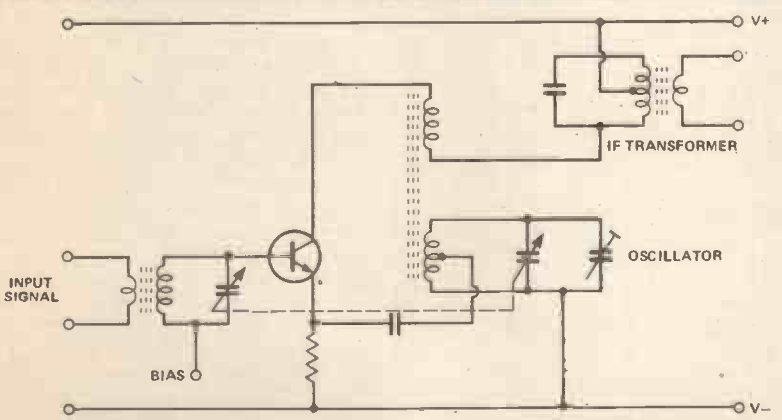

Figure 7. A typical self-oscillating mixer as used on domestic receivers.

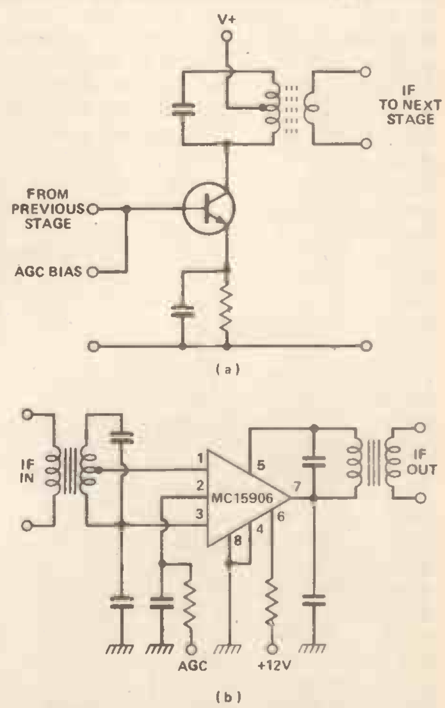

Figure 10. IF stages (a) a simple transistor IF, (b) an IC IF. Solid-state resonators, such as transfilters or SAW filters can now be used in place of conventional IF transformers, with considerable gain in performance.

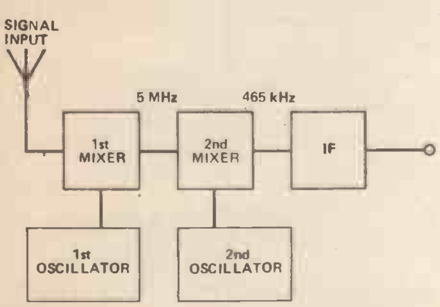

Figure 8. The double-conversion principle which is often used for VHF receivers of the communications type.

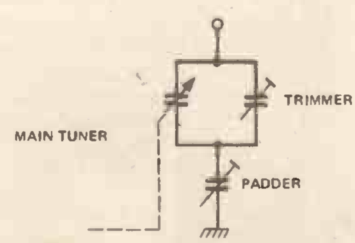

Figure 9. Using a trimmer and a padder to keep the oscillator frequency aligned.

waveform across the capacitor is the audio waveform.

It's not a perfect audio wave, because it's made out of zig-zag pieces of IF wave, but with a little more smoothing it can be very close to the shape of the original audio wave — perhaps 5% distortion or so. This is good enough for most purposes, certainly good enough for speech, so there's little reason to look for demodulators with better performance. Hi-Fi uses FM, with very different types of demodulators in any case, and Terry Wogan sounds much the same with 0.5% distortion as he does with 10%.

In addition to the audio modulation across the capacitor of the demodulator, there will be a DC component present. The size of the audio signal depends on how much modulation is present, but the size of the DC component depends on what the peak amplitude of the IF is, and this in turn depends on the peak amplitude of the carrier at the input. If the carrier fades because of reflections in the ionosphere, then the DC component of the output at the demodulator will also drop, even if the modulation is unchanged, and if the carrier strength rises, so the DC voltage will rise, again unaffected by the modulation.

This effect is used in automatic gain control (AGC) circuits (see Figure 12) to control the gain of the IF and also for any amplifying stages that are used before the mixer (the mixer itself has enough to do without adding DC control signals!). By using this DC signal, filtered free from any traces of AF and IF and amplified if necessary, we can ensure that the output to the demodulator from the IF has an almost-constant amplitude, despite carrier fading and boosting, so that reception of signals over long distances is greatly improved. AGC greatly improves reception, but it can't work miracles, and if the carrier fades out completely, then you receive nothing but the noise of a receiver working at full gain. Similarly, if the amplitude of the carrier becomes so great that it overloads the first stage of the receiver (mixer or preselector) then the resulting distortion just has to be suffered.

All this, of course, assumes that we are listening to an AF signal. If the signal is being received in CW, then the audio output consists of a set of clicks which are not easy to think of as Morse. To get around this, we can use another oscillator feeding into the demodulator. If we have a 455 kHz IF, and we make this other oscillator operate at 455 kHz, then the demodulator, being non-linear, will have a mixing action, and will cause the frequency with 1 kHz difference to be generated whenever the presence of a carrier causes an IF to be received. This 1 kHz can be amplified and passed to the loudspeaker to give a note that is much easier on the ear. The oscillator that is used for this purpose is called a beat-frequency oscillator (BFO) and is essential if you plan to listen to CW to any extent. Beating is an old term for signal mixing, and the 'beat frequency' in this example is the 1 kHz that we get by mixing 455 kHz with 456 kHz.

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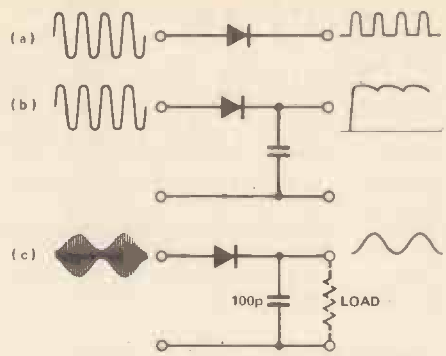


Figure 11. Demodulation. A diode by itself (a) will remove half of a carrier wave, but adding a capacitor (b) will give a voltage which follows the peaks of the carrier. With a correctly chosen time constant (c), this can be used for demodulation.

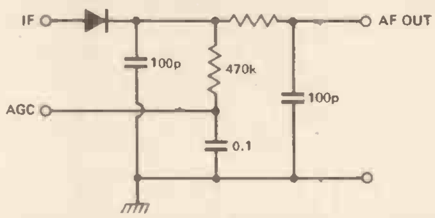


Figure 12. Taking an AGC supply from the demodulator. A large capacitor/resistor time constant is used to remove any trace of AF, leaving a DC signal whose size is proportional to the carrier amplitude.

THE ELECTRONIC REVOLUTION: WIRELESS GOES TO WAR

John Biggins

Although radio did not play a highly significant role in the First World War, it was the new equipment and techniques invented during the years 1914-1918, under the pressure of war, which provided the springboard for the great communications breakthrough that was to follow.

DURING the 19th Century electricity advanced, from being a minor and useless scientific curiosity, to revolutionise communications more thoroughly than anything since the invention of printing. In 1800, apart from a few expensive and unreliable government-operated semaphore relays, communication had only been as fast as a horse could gallop or a pigeon could fly or a despatch vessel could sail. By 1902 however, when the trans-Pacific telegraph cable was finally linked up, it had become possible to send a message right around the world in a matter of seconds, provided that the automatic relays were all working properly. The telegraph, the steam printing-press and the railways together created the newspaper as we know it today, fostering mass semi-literacy and making it possible for the world at the turn of the century to be blessed with press-barons like Lord Northcliffe and Randolph Hearst. And, in a less spectacular way, the telephone was changing business and social life in the last few years of the 19th Century. One by one, the uniformed messenger-boys (in fact sour-tempered and unreliable old men) employed by the Ministries in Whitehall were pensioned off, as it became possible for civil servant to speak directly to civil servant.

But the electronic revolution in communications was still only a partial one. Communication was virtually instant, whatever the distance involved, but it was still individual-to-individual until the information carried over the wires was printed in the newspapers and distributed to the public. More important, from the naval and military point-of-view, instant communication was still firmly tied up with copper wire. As armies and fleets grew in size from the mid-19th Century onwards, the generals and admirals, for all their instinctive dislike of anything new, began to hanker after some reliable means of controlling them from minute to minute in the field and at sea. It had been alright at Waterloo where Wellington could see most of his army from where he stood, but after the example of the American Civil War, with its mass-armies fighting on fronts miles across, it was becoming clear that couriers on horseback were getting to be less than adequate as a way of controlling them. Likewise at sea flag-signals might have been sufficient to manage fleets of wooden men-of-war under sail but they were dangerously out-of-date in the era of squadrons of ironclads steaming towards one another at a combined speed of 30 knots in a haze of coal-smoke! The electric telegraph had been put to military use ever since the Crimean War, when a cable had been laid across the Black Sea to keep the Allied headquarters in touch with London and Paris — to the immense disgust of the commanders in the field, who threatened on several occasions to resign if their governments didn't stop bothering them with orders and damnfool questions.

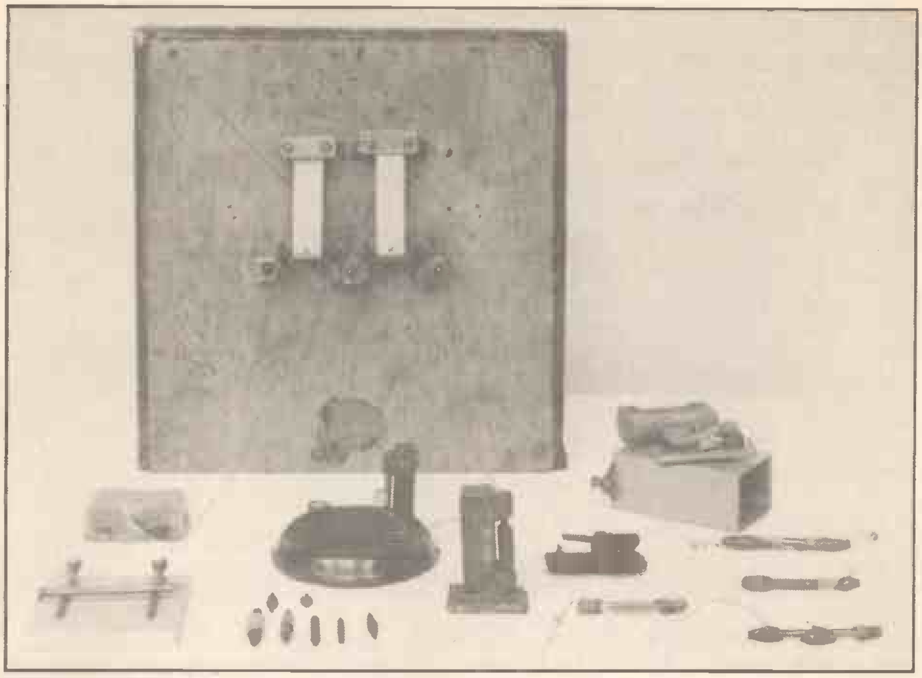
All at Sea

But the telegraph's use was still strategic rather than tactical. During the American Civil War, the Union armies had experimented with field telegraph units, reeling out wire behind horse-drawn wagons to try and give commanders some control over the troops actually doing the fighting. The results seem to have been disappointing, though. The system worked well enough at sieges, where the armies weren't moving, but once they began to advance or retreat it became very difficult for the telegraph wires to keep up with them. At sea things were even worse, and right up to the end of the century a ship was on its own once it got out of sight of the nearest telegraph station: a state of affairs which was increasingly annoying to governments but far from unwelcome to ship's captains, who generally hated being told what to do by some clerk several thousand miles away!

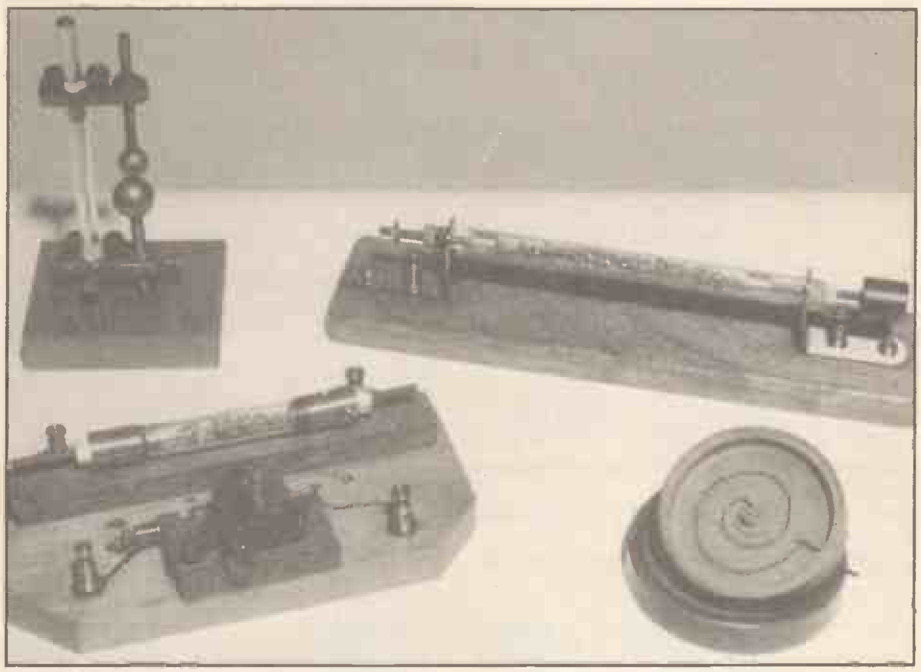
By the early 1880s though even the most encrusted naval officers could see that there was a need for some form of all-weather ship-to-ship communication, even if it was only over line-of-sight distances. So, as various experiments in various countries groped their way hesitantly towards wireless telegraphy, it was almost always the navy departments and the merchant shipowners and insurers who took most interest in what they were doing.

The idea of transmitting electric signals without wires was certainly not a new one. In 1842 Morse's experimental telegraph cable beneath New York harbour had been cut by an anchor, but still went on passing weak signals: an accident which prompted Morse to experiment later with copper plates dipped into the sea. Water relays were occasionally used when commercial telegraph wires beneath the sea were damaged, including one six-mile link between the Isle of Wight and the mainland in 1882. Air-induction was also tried by a number of early experimenters like Preece, who succeeded in passing signals over 3 miles between parallel telegraph wires, and Edison, who developed a fairly successful system of inducing currents in lineside wires by means of a 500-foot coil running the length of a moving train. The induced currents were weak, though, and the wires extremely cumbersome, so this path of enquiry was not followed up. It was not until the early 1890s that researchers began to look at the theoretical calculations of James Clerk-Maxwell, dating from the 1860s, and the experimental work of Hertz, twenty years later, on radiation of electro-magnetic waves from an oscillating circuit. Various observers as far back as the 1840s had noticed that one spark in a circuit could cause a secondary spark some distance away — on one occasion when a pencil was held near a brass doorknob. During 1879-80 Hughes, in the UK, had come frustratingly close to discovering radio after noticing that sparks could cause crackling in a nearby telephone earpiece. He actually got as far as listening into these noises over a distance of 500 feet in a London street, until the scepticism of the learned physicists of the day caused him to give up — but not before he had unwittingly made later progress possible by inventing the first sensitive radio-wave detector, that crazily ingenious little device, the coherer. This was a glass tube with contacts at each end, and filled with metal filings which stuck together under the influence of electro-magnetic waves, thus allowing a current through the tube; the metal filings were then shaken apart by a clockwork-operated arm tapping the glass.

By the mid-1890s, a number of experimenters were hot on the trail of wireless telegraphy: Popoff in Russia, Righi in Italy, Ducretet in France, Slaby in Germany and Captain Jackson working for the Admiralty in Britain. It will never be known for sure who was the first to transmit an intelligible message, but for what it is worth, it seems that Popoff may have transmitted a signal over four miles from the Imperial Observatory in St.Petersburg early in 1895. But Popoff was working for the Russian navy and thus bound by official secrecy, so it was left to Righi's young neighbour, Marconi, to pick up the ball and run with it.



Hughes 1880 Wireless apparatus. (British Crown Copyright. Science Museum, London)



Lodge's Coherer, dating from about 1897. (Lent to the Science Museum by Sir Oliver Lodge, DSC, FRS)

On the Ball

And run he did! Though he had never had a job in his life, being the amateur-scientist son of a wealthy Italian landowner, Marconi had a shrewd business head on his shoulders and soon realised that, with its huge navy and merchant fleet, Britain was the place to be as far as the development of wireless telegraphy was concerned. The choice turned out to be a good one when Marconi arrived in London in 1896. Maxwell's equations had predicted, and Hertz's experiments seem to have confirmed, that radio waves behaved like light and therefore could reach no further than the eye could see. Marconi seems to have had intuitive doubts about this even in 1896, but as far as the GPO was concerned the opinion of the world's leading physicists was good enough: wireless telegraphy could never compete with the wire-telegraph so there was no need to oppose the new invention tooth-and-nail, as it had fought the telephone back in the 1880s. As luck would have it, the old wireless telegraphy experimenter Preece was now Chief Engineer to the Post Office, so he naturally gave every encouragement to the young Italian. Even the Admiralty, which normally resisted every technological development, was mildly helpful: perhaps because it realised dimly that radio would make life easier for the great battle-fleets while the other new gadgets of the late 1890s (like submarines) could only threaten them. At any rate, Marconi was able to obtain his world-wide patents in 1897, thus making the Marconi Company the object of envy throughout the wireless industry for the next quarter-century! And in the same year, during experiments for the Italian Navy, he was also able to prove what he had suspected for some time: that whatever the scientists might say, radio-waves *did* propagate over the hump of the Earth's surface. The way was clear for him to perform his most dramatic *tour de force* on 12 December 1901 when he sent a signal from Poldhu in Cornwall to a receiver on the coast of Newfoundland. Wireless now had the potential to rival the telegraph.

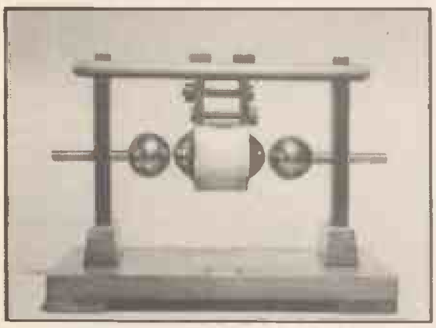
Tuning In

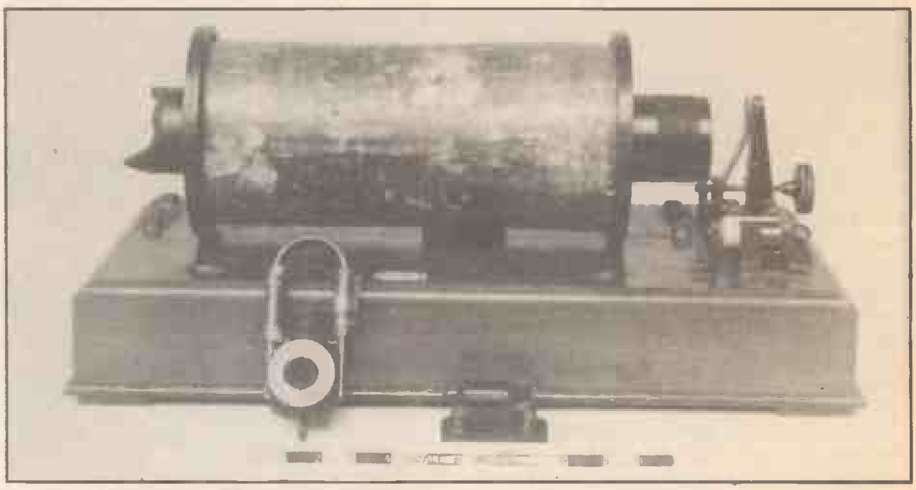
There was certainly a great deal of development work to be done at the turn of the century, though, before wireless could rival the telegraph in efficiency. The early plain-aerial spark transmitters made a raucous crackling which was often so coarse that individual morse dots were lost in the grain, as it were. Worse still, the bandwidth was so great that one signal either blotted out every other signal within range or merely merged with them into an unintelligible rasping. Operators frequently got their message through by the simple expedient of placing a brick on the morse-key until everyone else gave up and went off the air! The most urgent need was for separate tunable frequencies, and from 1901 onwards Marconi and the British Lodge-Muirhead firm started putting a variable capacitor and transformer into their aerial circuits to refine the oscillations; the method allowed switching between at first two and later eight separate "tunes". From the mid-1900s onwards the quality of radio transmissions increasingly improved, with inventions like Fessenden's toothed-wheel rotary spark-gap and the Poulsen arc, coupled with Alexanderson's 100,000 cycle per second alternator, narrower bandwidths, more regular waves and higher frequencies.'

At the receiver end, the coherer fell out of use as a detector and was replaced by Marconi's patent magnetised-wire sensor. In 1908 the Japanese researcher Torikata discovered that the resistance of zincite and bornite crystals in contact varied in the presence of radio-waves, and in this way the legendary crystal detector — ancestor of the modern transistor — was born. During the years 1902-04, Fessenden and Latour in the United States discovered that a signal's output could be greatly strengthened by superimposing it on a base-signal in the receiver, and in this way heterodyne reception came into being. Then in 1906 the most far-reaching discovery of all was made when DeForest stumbled on the thermionic valve. Progress in the theory and practice of radio was rapid in these years, but it was abruptly choked off in August 1914 when Europe went to war. Over the next four years, development was to be geared exclusively to military needs, and while this speeded up research in some areas it certainly slowed it down in others (like development of valves) which were of no particular interest to the warring nations.

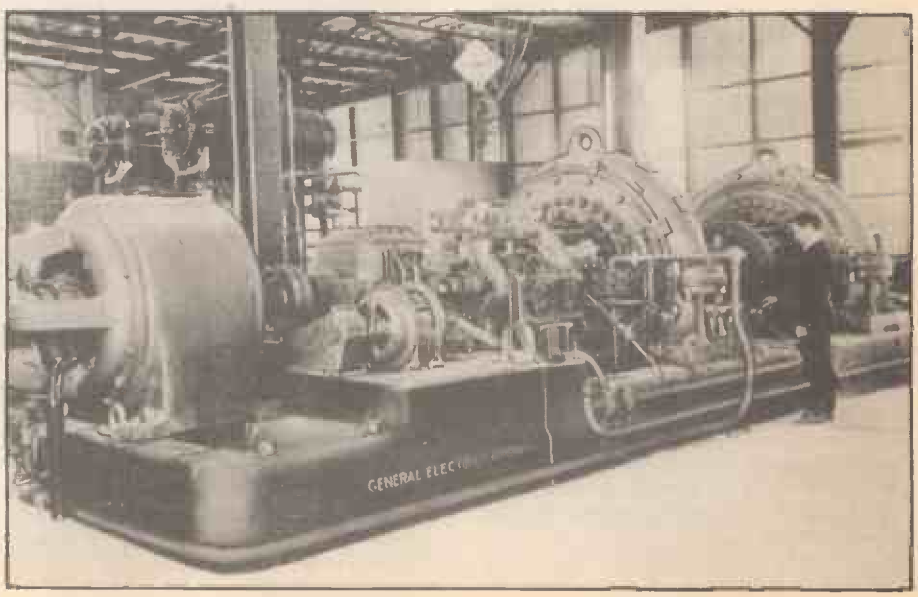
Wireless at War

When the Great War broke out it was the world's navies which took up wireless telegraphy with the most enthusiasm. Back in the early 1900s, ship's captains had generally made little secret of their distaste for being ordered around by radio, and had often shut their W/T operator away, alone and ignored in his wireless shack, to carry out whatever daft experiments he pleased while the ship went about its business. But the tactical value of radio was made obvious to even the most traditionally-minded naval officers during the war between Russia and Japan in 1904-05. Although





Above: Marconi's spark-gap generator, from about 1895.
Right: Marconi Trans-Atlantic Receiver, first used in 1901.
(both lent to the Science Museum by the Marconi Wireless Telegraph Co. Ltd.)



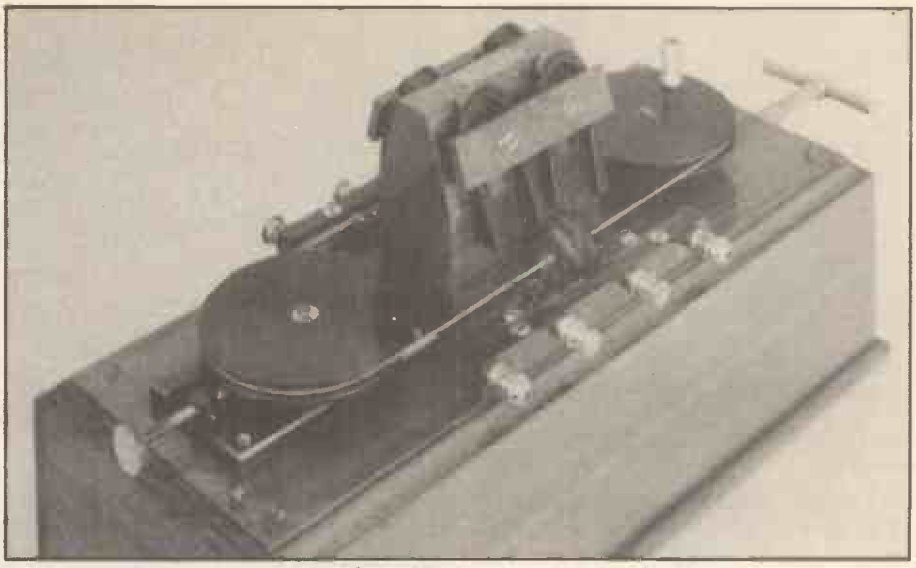
Above: Operating the Poulsen Arc Generator in 1909.
Right: Alexanderson's 200kW alternator.
(both photos, Science Museum, London)

equipped with more primitive sets than the Russians, the Japanese had used them with great skill throughout the war, in particular when they located and destroyed the Russian 2nd Pacific Squadron at the end of its fateful journey halfway round the world to the Straits of Tsushima, in May 1905. This highly impressive demonstration led to all the major navies working up their use of wireless into an exact drill over the next nine years, with strict rules of procedure and increasingly sophisticated codes to overcome the small problem that anyone within range could pick up a wireless signal.

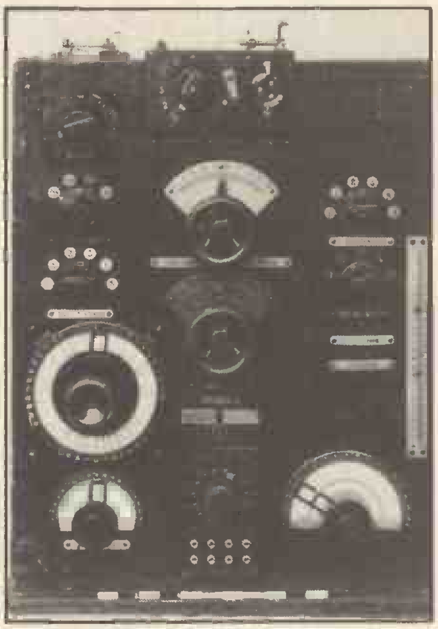
It was this last inconvenience which was to do most to defeat the German Imperial Navy during the years 1914-18. The Germans knew perfectly well that their long-wave station at Nauen, near Berlin, could be listed to by the British and so they took good care to use it only for the most essential traffic and under elaborate ciphers. What they didn't realise though was that the medium-wave signals which they used for passing signals between ships anchored at Wilhelmshaven and Keil, and out in the Heligoland Bight, could also be picked up on the East Coast of England. The experts had told them that it was impossible so that was the end of the matter. They used code of course, just in case, but the value of this precaution was reduced more than a little late in 1914, when the Russians sank a German cruiser in the Baltic and picked up a brand-new code-book, which they very decently passed on to London. This book and the monitoring station set up at Hunstanton on the Norfolk Coast formed the basis of the Admiralty's famous Room 40 wireless cryptographic section which, throughout the entire war, kept the Royal Navy as well-informed as the Germans themselves about the intentions and movements of the High Seas Fleet. Every time the German fleet put to sea, the British battleships left Scapa to meet it, and by mid-1916 the Germans had begun to suspect that something was not quite right.

They first suspected highly-placed traitors in Germany, and British intelligence was only too willing to provide scraps of information to add weight to this idea. The German Navy eventually set up its own monitoring station at Neumünster, but by then it was too late: having seen how easily security could be penetrated, the Royal Navy took good care to keep radio traffic to an absolute minimum right up until the end of the War. The end came dramatically on the afternoon of 29 October 1918, as Room 40 listened to the fleet flagship at Wilhelmshaven giving orders to raise steam for a last Wagnerian suicide-raid on the Thames Estuary. Suddenly the air was filled with mostly unprintable signals in clear: the High Seas Fleet had mutinied and the war at sea was over.

On land, radio didn't do nearly as well as it did at sea during the years 1914-18. The British Army had experimented with field radio as early as the Boer War in 1900, when three Marconi sets had gone to South Africa and proved total failures in the hilly, dusty, static-laden terrain. By 1914, all the world's major armies were using radio for communication, at least to Divisional HQ level, and in August 1914 the Russian armies invading East Prussia brought disaster on themselves by their charming but incorrect belief that since wireless messages were invisible, there was no need to put them into code! At the front, though, (and partly, no doubt, because of this lack of privacy) the armies relied on the more traditional methods of signalling, supplemented by the field telephone. Much of the hideous, blundering carnage of the next four years on the Western Front can be put down to the fact that these methods were simply not up to the task of controlling the vast armies involved: huge, lumbering bodies with wretchedly inadequate nervous sytems. On that brilliant summer's morning of 1st July 1916 many of the tens of thousands of British infantrymen who clambered out of their trenches north of the River Somme, and trudged forward to their rendezvous with a machine-gun bullet, were carrying the Boy-Scoutish signal equipment of the day among the 80-odd pounds of kit on their backs: pigeon-baskets, flares, semaphore flags, reels of white tape to lay out markers for spotter-aircraft and coils of telephone wire which was not only liable to be cut by every shell which landed nearby, but was also far from being as secure as the generals imagined. In at least one place, that morning, the Germans had been given two hours advance warning of the attack as a result of having managed to bury two copper grids near British trench-telephone wires, and as for the rest of the attacker's signalling arrangements that day, the results had been seen many times before and were to be seen many times again: units losing contact as soon as they had disappeared into the murk (at least one company was never seen again), artillery shelling its own men, wave after wave going forward to festoon the uncut wire because their commanders had no idea what was happening up-front, and those few units which managed to penetrate the German line being wiped out by counter-attacks, unsupported because nobody knew they had got that far.

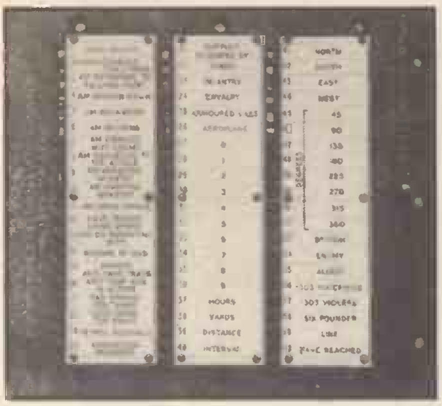


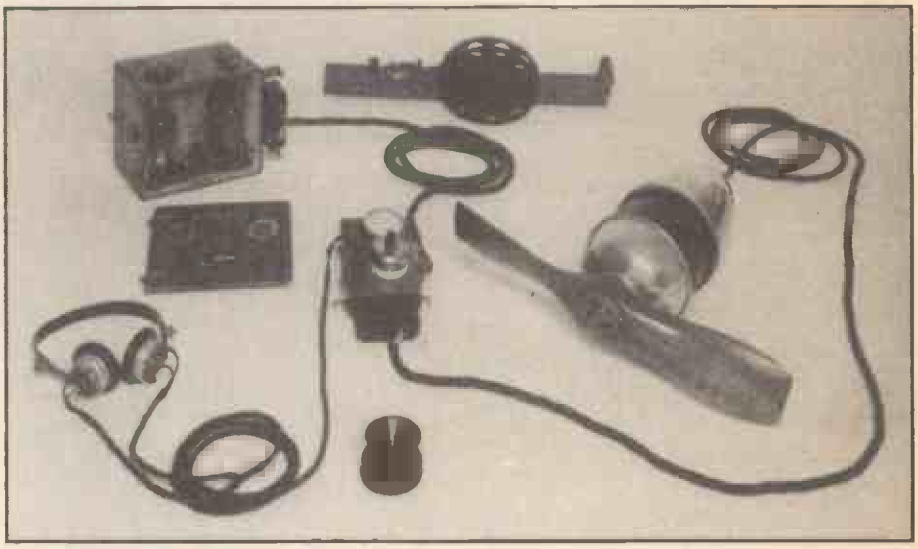
Marconi's Magnetic Detector, from about 1904.
(Lent to the Science Museum by Kings College, Strand, WC2)



Crystal Receiver from a German Battleship, 1912.
(Lent to the Science Museum by the Institute of Electrical Engineers)

British Army "Front Transmitter", used in the trenches in 1917.
(British Crown Copyright. Science Museum, London).





Above: RAF pre-set signal board for aircraft.

Above right: A Mark III British aircraft receiver, dating from 1918.

Right: A 1918 RAF aircraft voice transmitter; the purpose of the fan (propellor?) is not known!
(All British Crown Copyright. Science Museum, London)

There had to be a better way but, during the Great War at least, no one was able to find it. Attempts were made to develop an effective man-portable radio set, but the technology of the day was not up to the task. Small transmitter/receiver sets were produced for use in the front line, but somehow they were never popular. Sticking an aerial up out of a trench merely invited a hail of grenades and mortar-bombs, while the arc-transmitter, though practically noiseless during the day, gave out an alarmingly noisy hiss in the silence of No Mans Land at night. Spark, arc and valve-equipment alike was simply too delicate to stand up for long to the mud and wet of the trenches and the concussion from shell-bursts, not to speak of ill-treatment at the hands of the soldiery. Neither side developed tactical ground radio very much and when the Germans broke through in France, in the spring of 1918, they relied on a bewildering array of multi-coloured rockets and flares which the British christened a 'Brock's Benefit.' It wasn't much good, but it was still the best means of communication going for a rapidly advancing army.

So ground radio made little progress during the war years, while at sea the navies merely worked at up-grading their pre-war spark and arc transmitters. Radio's real advance during the Great War — though it wasn't recognised as such at the time, was in voice-telephony, which was developed to serve the needs of the air forces. Experiments had been made with wireless sets in aircraft as early as 1908, and during the war, the German Navy unquestionably got excellent value from the Siemens transmitters fitted in its Zeppelins patrolling the North Sea. The static artillery-battles in France meant that, from about mid-1915 onwards, wireless sets were fitted into spotter-aircraft as a regular practice. This was morse-key wireless telegraphy and as such it had serious drawbacks. The most obvious was that each aeroplane had to carry an observer to work the radio, since even the generals had to admit that it was expecting rather a lot of the pilot to tap out messages with one hand while flying the plane with the other in a sky full of enemy fighters. There was also the matter of the 200-foot aerial wire which had to be trailed behind (often to wrap itself around the tailplane) and winched in sharpish if the Red Baron appeared. Also, it was soon found that the wire-gauze screens fitted around the engine and magneto, to cut down interference, had the unexpected side-effect of weakening the plug spark to the point where the engine cut out: inconvenient at any time but especially so at 12,000 feet without a parachute! The answer had to be valve-transmitted radio telephony using a microphone, damped down to cut out background noise, and by the summer of 1918 the RAF was fitting its aircraft with such sets, giving a range of about 30 miles air-to-ground and about 5 miles between aircraft. It came too late to have much influence on the course of the war, but radio-telephony was unquestionably the most momentous piece of radio development work done between 1914 and 1918, since it made broadcasting possible.

Military electronics advanced rapidly in the years between the Wars. On the one hand small, powerful shortwave voice radio sets made the Panzers of 1940 a possibility by allowing tanks to keep in touch with each other and with supporting infantry, and also call up dive-bombers as a sort of flying artillery. On the other, the radar systems developed in the early 1930s made it possible for Britain to survive in the summer of 1940 and beat the U-boats three years later. Enigma was to repeat Britain's radio intelligence achievements of the Great War — but on a much larger scale — while the needs of the European resistance movements led to intensive research into powerful beamed shortwave radio transmissions. As a minor but pregnant footnote, it seems that it was the requirements of service personnel selection during the 2nd World War which pushed forward the development of digital computers.

But the First World War really marks radio's coming-of-age. Original development work was slight and the influence of wireless on events was not great away from the North Sea. However, the fire was lit beneath the boiler in a number of ways and in the years after 1918, the great engine of mass-communication began to move.

The first installment of this series appeared in the May 1982 issue of Hobby Electronics. The remaining installments have been held up until now because of difficulties in obtaining suitable illustrations. Part 3, next month, is "The Broadcasting Revolution".

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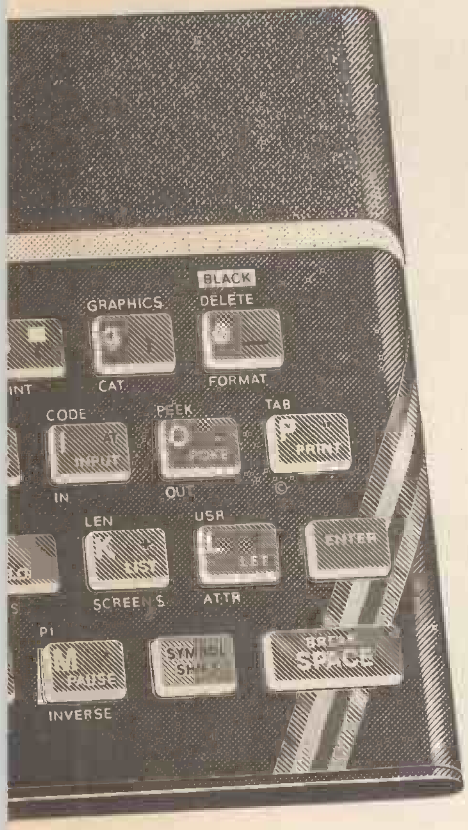

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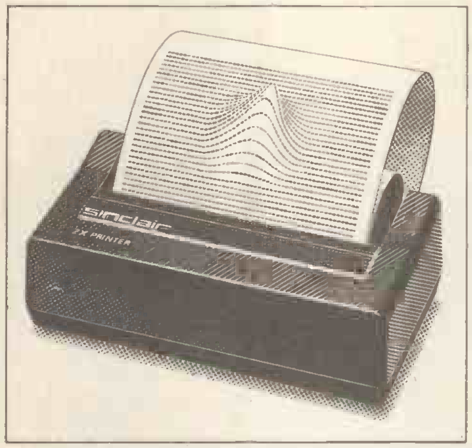

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CB SELECTIVE CALLER

Graham Brant

An easily built add-on for a CB rig

THERE HAS been a profusion of CB selective call Units described by various sources recently. Most of these provide a large number of different codes in a complex digital format. For a large user this is very useful but for the average small operator the provision of 2000 plus codes is rather an overkill. The system described provides only threecodes, but for an average operator and a few friends, it is quite adequate. Total cost is about £8-£9 for each Receiver/Transmitter pair so this unit is considerably cheaper than using a custom chip.

First, though, what is a Selective Caller? Selective Call is an electronic system, usually consisting of an encoder and decoder, that generates a series of tones or pulses picked up on a specially adapted CB receiver. When the adapted CB receiver is left in the 'standby' mode, it will only respond when the correct tones or pulses are picked up. It shouldn't respond to any other signals or transmissions on the nominated channel — it's a little like a telephone; the bell won't ring unless the correct number is dialled.

In order to use selective calling certain conditions must be fulfilled:

1. The receiver must be left switched on.
2. The receiver and transmitter must be on the same channel.
3. Called stations must be within range of the transmitter.
4. The receiver/decoder must be set to respond to the correct combination.

In the Marketplace

Commercial selective call encoders and decoders come in three basic varieties. The simplest, and most common, are the separate add-on units consisting of a hand-held bleeper and plug-in decoder which plugs into the rig's external speaker socket.

The second type is the purpose-built unit that plugs into the back of specially modified rigs. This device usually has both the encoder and decoder built into the one box. A specially designed interface plug is fitted to the back of the rig during manufacture.

The third and last type of Sel-Call is built into the CB rig during manufacture. None are available in the UK at the moment.

All selective callers depend on an audible signal being transmitted and received. To this end a number of different systems have evolved over the past few years. One of the most common is the two-tone system. Two tones are simultaneously generated and transmitted and, providing the receiver and encoder are on the correct channel and calling frequency, the call will get through.

Providing even more flexibility is another kind of system using a five tone signal, allowing literally thousands of different combinations. The third system, which utilises digital pulse transmission, is the most sophisticated of all.

Our selective caller project, however, is much simpler — and less expensive! It is a selective caller of the second type — ie, it must be interfaced with the rig — and uses a simple system of single tones, used either alone or in combination. At the start of a transmission, the transmitter unit sends one or two tones of approximately one second duration. By selecting either one or both tones, three diferent codes can be generated. A disadvantage of this system is that the decoder can be activated by a loud whistle on the channel; however, this is a small price to pay for the simplicity and low cost of our unit. The code transmitter is reset every time the Push-to-Talk (PTT) button is pressed, and therefore the tones are sent at the beginning of each and every transmission.

The receiver unit detects these tones and decides whether the correct code has been received. If this is the case, the audio line is connected by means of a relay which latches on and is only reset when the PTT button is operated. An open-code position is also provided to enable the receiver to operate with rigs not equipped with the code transmitter. The open position could also be used after the call has been established; however, since the tone transmission is only one second long, nothing much is gained by this additional procedure. In fact, the transmission of the code every time the PTT button is operated ensures that third parties are effectively cut out of your conversation (though they can still listen in, of course).

The Transmitter Unit

The tones are each generated by a pair of NAND gates, ICs 1a, 1b and 2a, 2b, connected as astable multivibrators. An Enable input to one gate of each astable allows the circuits to operate only when there is a logic '1' (V+) present. This Enable signal is generated by a timer circuit consisting of two

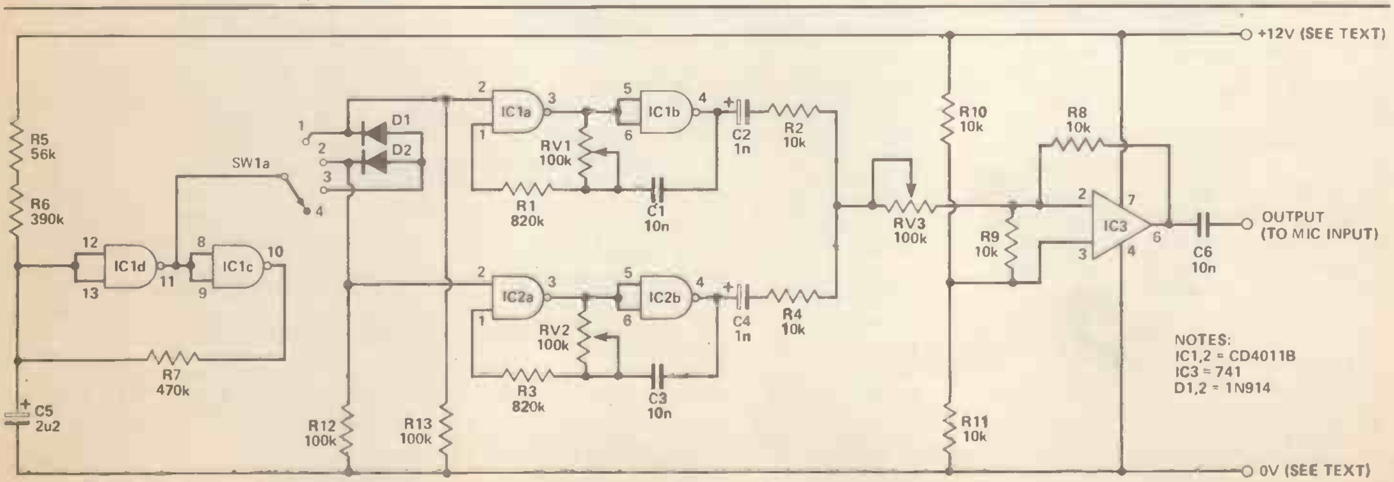


Figure 1. The Transmit board circuit.

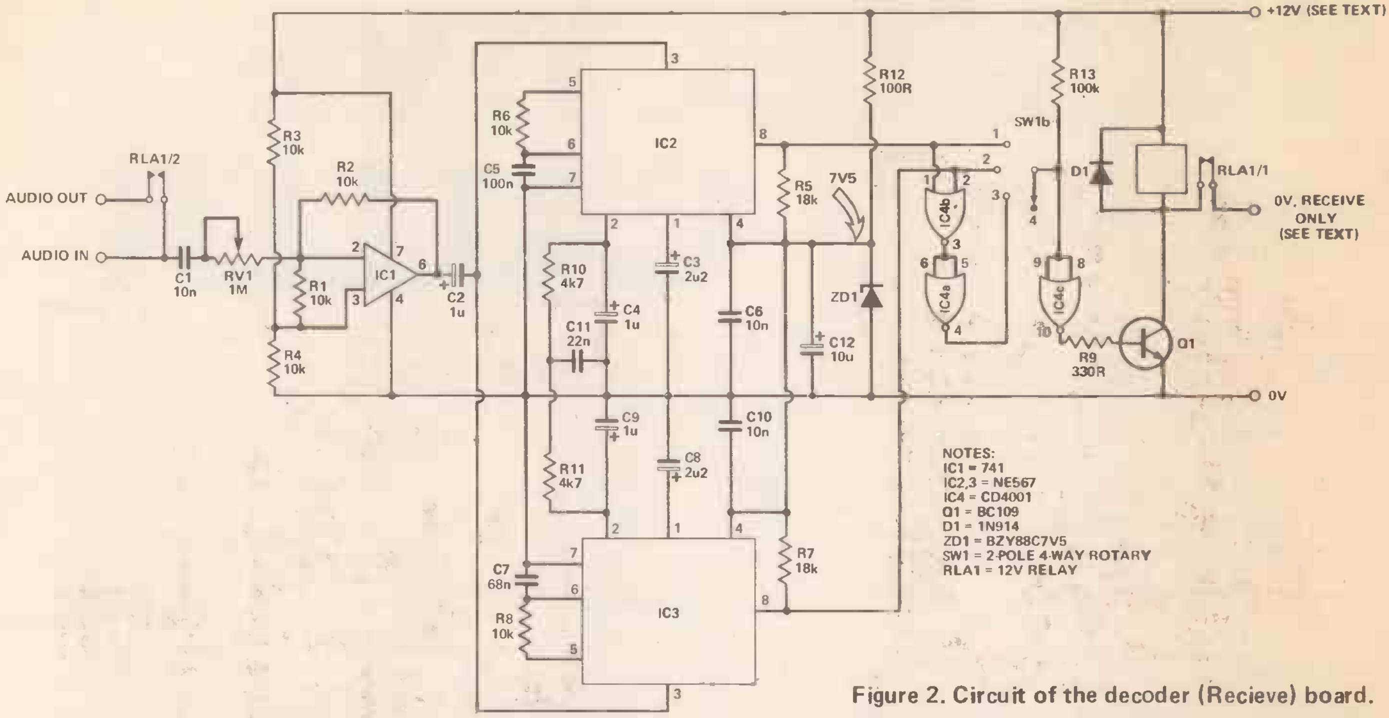


Figure 2. Circuit of the decoder (Recieve) board.

more NAND gates, ICs 1c and 1d, connected as a monostable. The period of the monostable is set by R5, R6 and C5; the values shown give a tone-transmit time of about one second. The frequency of the transmitted tones is adjusted by means of a trim pot in each astable circuit. Finally, a 741 op-amp is used as a buffer, with another trim pot to the output level to be adjusted so as not to produce distortion.

The V+ line for the transmit unit must be obtained from the rig itself; it must be taken from a point which has voltage present only when the rig is in transmit. When V+ is applied to the unit, one or both of the astables begin to operate, provided the appropriate Enable line is high. After about one second, though, the output from the timer circuit goes low and the oscillators will be inhibited. They can be reset only by removing V+ and re-applying it, ie by starting another transmission.

The Receive Unit

The Receive circuitry consists of an input amplifier, two tone decoder chips, a relay driver and the code select circuitry.

The input amplifier is identical to the Transmit unit output amplifier, and needs no further description. The tone decoders are based on the NE 567 IC and will produce a logic 'O' output whenever the correct tone is present. The centre-frequencies of the tone decoders are set by R6, C5 and R8, C7 respectively; these frequencies can be altered, as will be described later.The bandwidth, or range of frequencies over which the decoders will still detect an input signal, is set by the values of C4 and C9 respectively.

The audio input to the Receive unit is taken from the rig, just before the volume control. Power must also be supplied from the rig, but in this case V+ can be taken directly from the rig's power line.

When the correct tone is present, one or the other of the decoder outputs will go low; this information is itself decoded by IC4 and SW2, and the resultant signal is used to operate RLA1 via Q1 if the correct code is received. A second contact on the relay is used to latch it on, by connecting the point which is at 0V in receive only (though it can be at any voltage, or open circuit, when the rig is not receiving), thus ensuring that the audio line remains connected. When the PTT button is operated, however, the relay will un-latch, thus resetting the decoder. Selection of the 'open' switch position allows the receiver to be used in the normal way.

Construction

The two PCBs have been designed to be as small as possible, to allow them to be used in very cramped conditions. Ideally, they could be built into the rig itself, though this might involve some difficulty, particularly in installing the tone-select switch. The simplest method might be to fit them inside a small diecast box which can attach to the rig. In any case, take particular care when making connections to the rig!

Other points to watch are the links underneath the PCBs (not usually recommended, but acceptable in this case because of the need to keep things small), and the usual handling precautions (anti-static measures) must be taken with the CMOS ICs.

Interfacing

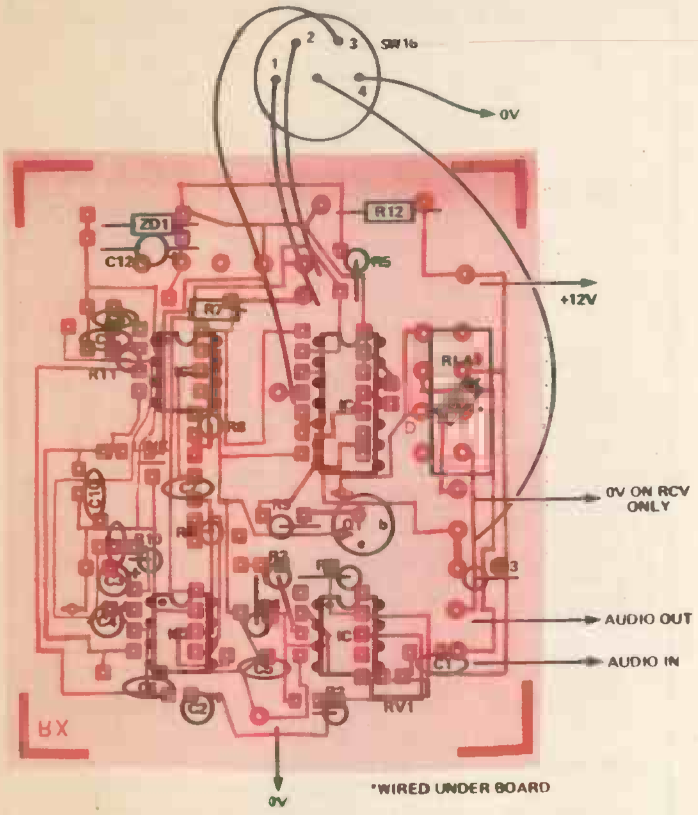
Similarly because of the great variety of CB rigs, we cannot give too specific instructions regarding intefacing the Selective Call unit with any particular rig. In general, though, the following signal and power lines are needed:

1. The Transmit unit V+ line must come from a point where voltage is present *only* when transmitting; this can usually be taken from the transmitter section supply line.
2. The output from the Transmit unit connects the microphone input.
3. The OV line for both the Transmit and Receive units can be taken from the main OV line.
4. The Receive unit V+ line also comes from the rig's power rail.
5. The Receive unit's audio input is obtained by breaking the rig's audio line just before the volume control (this is usually fairly easy to get at, as is the mic input terminal); the audio out of the Receive unit connects back to the volume control.
6. The relay latch OV line must come from a point which is switched to ground *only when the rig is in receive;* look around the mic input, where a OV line is often switched by the PTT button, or around the aerial changeover circuitry.

That makes a total of seven lines between the Selective Caller and the rig; if you have more or less, something is wrong somewhere!

Setting Up

Connect the Transmit and Receive units directly, connect the relay latch input to OV and apply power to both boards. Now temporarily enable both tone generators by connecting the Enable inputs to V+ and set the Transmit output level to about 100mV using RV3. The next step is to adjust the tone generator frequencies so that the decoders give a logic 'O' output; select the appropriate switch position and then adjust the trim pots RV1 and 2 until the relay operates. If a 'scope or



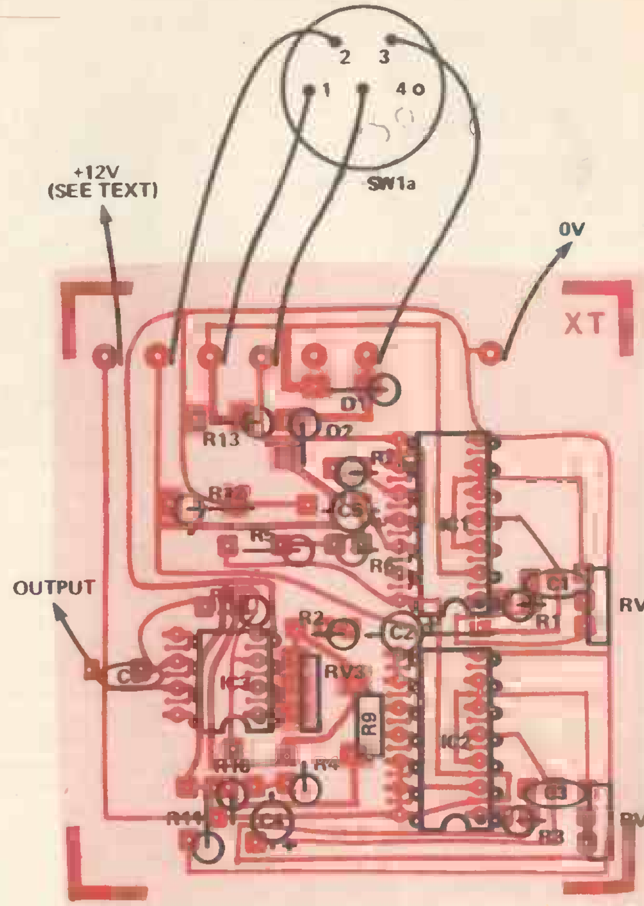


Figure 3. Above, the Receiver board component overlay; below, the overlay for the Transmit PCB.

audio frequency meter is handy, you should find that IC2 will respond to a tone around 1kHz and IC3 should react to a 1k5Hz tone.

When both circuits are operating correctly, dismantle the temporary set-up, install the boards in the required location and make the interface connections as described above. The transmitter unit audio output must now be adjusted to about 70mV; if a meter is not available, monitor your transmission on another rig and adjust RV3 so that the tone signal is not distorted. Finally, adjust the audio input level to the Receive unit so that with the tones present, the output from IC1 is about 100-200mV; if the level is too high, the decoders will lose sensitivity.

Parts List

TRANSMITTER UNIT

RESISTORS
(All ¼ Watt 5% Carbon)
R1,3 . . . . 820k
R2,4,8,9,10,11 . . . . 10k
R5 . . . . 56k
R6 . . . . 390k
R7 . . . . 470k

POTENTIOMETERS
(All sub min pcb mounting presets)
RV1,2,3 . . . . 100k

CAPACITORS
C1,3,6 . . . . 10n ceramic
C2,4 . . . . 1nf tant bead
C5 . . . . 2u2 tant bead

SEMICONDUCTORS
IC1,2 . . . . CD4011
IC3 741

RECEIVER UNIT

RESISTORS
(All ¼ Watt 5% carbon)
R1,2,3,4,6,8 . . . . 10k
R5,7 . . . . 18k
R9 . . . . 330R
R10,11 . . . . 4k7
R12 . . . . 100 ½W 5%

POTENTIOMETERS
RV1 . . . . 1M

CAPACITORS
(All ceramic unless noted)
C1,6,10 . . . . 10n
C2,4,8 . . . . 1u tant bead
C3,8 . . . . 2u2 tant bead
C5 . . . . 100n
C11 . . . . 22n
C12 . . . . 10u electrolytic

SEMICONDUCTORS
T1 . . . . BC109
IC1 741
IC2,3 . . . . NE567
IC4 . . . . CD4001
D1 . . . . 1N914
D2 . . . . BZY88C7V5

MISCELLANEOUS
SW1 . . . . 2 pole 4-way rotary
RLA1 . . . . 12V relay
2-pole changeover . . PCB mounting
PCBs, wire, etc.

BUYLINES . . . . page XX

Variations

As set up, the ast decoders respond to frequencies of 1kHz and 1k5Hz respectively, but this means that anyone who builds this unit and operates in your neighbourhood will be on your 'party line'! However, the decoder centre-frequencies are easily changed, *but the two tones must not be harmonically related* (do not use 1kHz and 2kHz, for example). The decoder centre frequencies are set by R6, C5 and R8, C7 to a frequency equal to 1/1.1 RC; with this information, itis a simple matter to set up the receive unit to personal calling frequencies. As given, the tone generation circuits can be adjusted between 100Hz and around 3-4kHz using the trim pots. Changing the values of C1 and/or C3 will give a different range of frequencies, should this be neccessary.

Part of this article appeared in the April 1982 issue of Citizen's Band Magazine as "Selective Call Explained". HE

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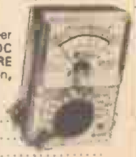

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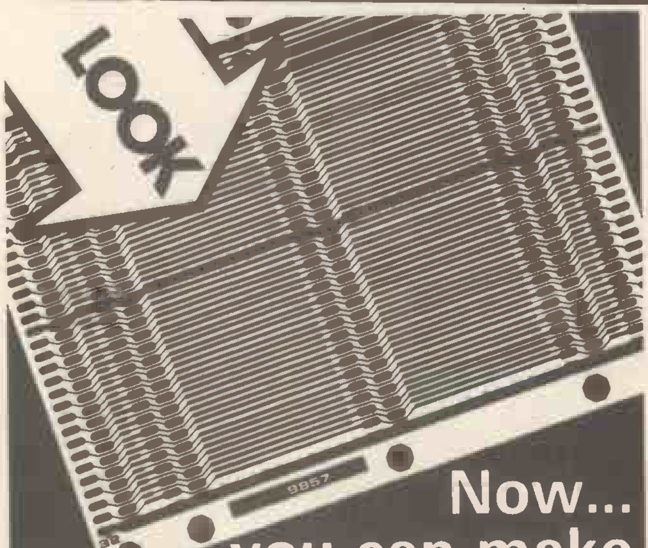

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THE HE BOOK REVIEWS

HE's literary tasters test the flavour of three books on the ZX81, and an introduction to the art of electronics.

The Explorers Guide to the ZX81
by Mike Lord.
published by Timedata Ltd, 57 Swallowdale, Basildon, Essex
Reviewed by **Tim Hartnell**

This carefully-written book will be a boon to ZX81 users who already know the rudiments of programming in BASIC, but are not yet ready to tackle the intricacies of machine code. As well as information on how to write, improve and adapt programs, the book also has a useful hardware section.

I'll go through the chapters one by one, to give you an idea of their contents, and an impression of the value of each section.

Programming aids: The 1K RAM supplied on the standard ZX81 makes great demands on programming ingenuity. This section contains a number of tricks to get the most out of your 1024 bytes. Mike Lord points out that both the display file and numeric constants eat up memory at an alarming rate, and gives some useful hints on how to minimise memory use when handling these. Among other things, he points out that, in certain circumstances, you can use a character array, rather than a numeric one, to save space.

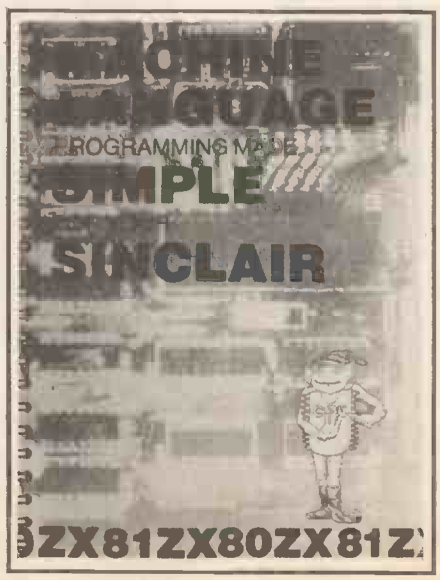
Other BASICs: This section lists the main differences between ZX81 BASIC and the dialects used by other popular machines, pointing out ways of getting around the lack of READ, DATA and RESTORE in ZX BASIC, as well as ways of emulating such things as DEF FN and LEFT, MID, and RIGHT.

Some games, and other novelties: This chapter is the lightest one of the book, both in intention and execution. There is a fair share of predictable programs—Weekday, Dynamite (NIM), Sums Tester and Copycat (Simon) – but as well there are programs with considerable more merit, including "ZX Sofft Shoppes", a simulation game in which you act as a software salesman; "Decimal Peeker", to list the contents of any 22 consecutive memory locations and "Variable Peeker", to investigate the variables area of RAM. A RAMtest and ROMtest program completes this section of the book.

Applications: This chapter discusses the possible uses of the ZX81, other than for playing games, and then gives a number of programs, including one to calculate the standard deviation of a series of items of data entered by the user, a "ladder analysis" programme which "calculates the gain (or loss), input impedance and output impedance over any range of frequencies for a passive ladder network of up to 10 series or parallel (shunt) branches" to illustrate how the ZX81 can be useful in the engineering field, and' 'G.P.G.P.", a general purpose graph plotter to produce bar charts. A useful personal bank account program completes this section.

Machine language: While not pretending to be an extensive introduction to the use of machine code on the ZX81, this chapter covers a lot of ground in a small space and — for those unacquainted with the mysteries of USR and hexadecimal notation — it will repay careful reading. Written simply (considering the subject!) and well, this chapter covers the following: binary and hexadecimal representation of numbers; floating point binary; using USR (a discussion on the Z80 processor, machine language, where to put your code); and four programs, "All Change", "Birds", "Alien Attack" and "Renumber".

Discovering the ROM: The fifth chapter of this book lists the starting addresses of a number of ROM routines which machine code programmers can use, as well as start addresses for several tables in the ROM, including the keyboard table (from 01FA) and the graphics table (00F3 to 0110). The way the display is generated is discussed at some length, complete with a diagram of the major circuit elements involved. The ROM routines which control the display are also listed and discussed.



Hardware: There is a shortage of useful information available on the hardware of the ZX81, and this chapter does much to remedy the problem. A number of ideas are given to improve the power supply, operation and display of the ZX81, along with a circuit to build your own add-on memory board. A circuit is also given that will allow you to run your ZX81 from a 12 volt car battery, along with circuits and diagrams showing how to connect up an external keyboard, add a reset button, and connect up a display monitor.

All in all, this is a worthwhile book, giving a lot of information in a clearly-written, careful manner. It is well-bound and printed, and appears free of other than a few trivial errors (at one point, for example LET is spelt LAT). The hardware section, especially, makes the book a worthwhile purchase. If it is time you started exploring beyond BASIC, this book will be a useful guide!

Machine Language Programming Made Simple for Your Sinclair
Published by Melbourne House, (1981), 160 pages, £8.95.
Reviewed by **Roy N Green**

The problem with writing a machine code programming book for the Sinclair ZX80 and ZX81 is that it is essentially a BASIC machine; there are no provisions for writing or running machine language programs. So, the author of this book is actually attempting a much more complicated task than is initially apparent (mysterious references in this review to 'the author' are no accident; the book is published anonymously, although various references in it suggest it was actually written by one of the 'little people'.)

The book attempts to simplify what is actually a very technical and intricate subject by using very simple English, and tries to liven it up by the use of a cartoon character. Although I liked the character, a friendly leprechaun-CPU chip, I thought the language tended toward the childish, without really making things any easier to understand. For example,

"The CPU is no big mystery. I like to think of the CPU as a lonely little fellow, sitting in the middle of your Sinclair, being asked to do things all the time."

And,

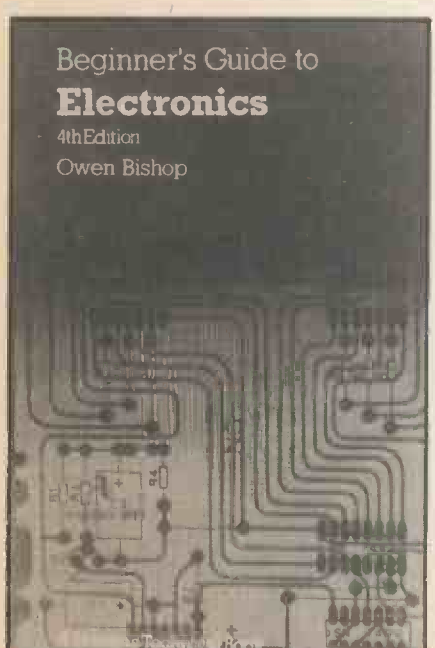
"The CPU's hands and feet are called REGISTERS."

OK, so lots of seven year olds do use the ZX80/1 — but bedtime stories about the CPU...!?

If you can put up with the style you will be taken through the range of instruction that the CPU can execute, what they are and what they do. There are listings of three useful little programs, one to display 100 bytes in HEX, a machine code editor and one to load code from rem line to array, but there is only one example of any size of an actual machine code program — a draughts program. This, however, is very well documented.

I'm not sure who this book would suit, because I find it difficult to imagine someone who would want to deal with such advanced topics in this make-believe style. There is the danger that anybody who *does* rely on it may later find it a little difficult to hold a sensible conversation about machine code! Although all the important jargon is eventually introduced as the book progresses, it is possible to pick up some rather odd extra ideas, and even some idiosyncratic buzz words that are really nothing to do with machine code programming. All this in rather unfortunate, because I have the impression that, hidden inside this unsatisfactory volume, there is actually a very good explanation of ZX80/81 machine code programming struggling to get out.

'Understanding your ZX81 ROM'' by Dr Ian Logan.
Published by Melbourne House, (1981), 162 pages, £8.95.
Reviewed by **Roy N Green**



A rather misleading title this. The ZX81 ROM is a long machine code program that many people would be interested in. In this book, however, Dr Logan attempts to teach machine code programming using the ZX81 ROM as a source of examples. Perhaps a more appropriate title would have been along the lines of "Learn to Program the Z80 via your ZX81 ROM". However his aim, to impart the ability to write short machine code programmes so that the reader can produce programmes of greater complexity that run faster, is a worthwhile one.

The first part of the book discusses the Z80 microprocessor and its instruction code: Chapter One is a short introduction to the book; Chapter Two examines the Z80 microprocessor, giving details of its data and address buses, its registers etc; Chapter Three introduces binary and 2's complement arithmetic and hexadecimal coding, and chapter Four details the Z80 machine code intsruction set. The second part of the book deals with actual machine code programs: Chapter Five presents 26 simple BASIC programmes which illustate the use of machine code instructions; Chapter Six examines the 8K monitor program (extracts from which are given throughout the book and also in Appendix 1) and includes the BASIC command routine addresses; and Chapter Seven goes through the process of producing machine code routines, giving some well worked through examples.

In spite of all the detailed explanation, however, I still came away with the impression that Dr Logan's book would not enable readers, with only a knowledge of BASIC, to graduate to writing machine code. This is not so much a criticism of the book itself, however, as a recognition of the fact that machine code programming is very difficult to learn from books alone. You really have to try it out, and have someone you can turn to when you get stuck. As mentioned above, readers who already know how to program the Z80 may be misled by the title, and hence disappointed not to find a complete listing of the monitor ROM in one place. It is true that many addresses of useful machine code routines are given, but I did not come away with the feeling that I'd "understood" my ZX81 ROM. I am, however, pleased to be able to report that Dr Logan has recently made good these shortcomings with the publication of two new titles, on ZX81 ROM disassembly.

Beginner's Guide to Electronics
by Owen Bishop.
Published by Newnes Technical Books, 237 pages.
Reviewed by **Paul Coster**

When starting out on a new venture it is always a problem finding the right source of information. What's required is an introduction that is sufficiently detailed, but retains the readers' interest by keeping theory to a bare minimum. This is especially true of electronics; the book to be reviewed seems to have attained quite a good balance between theory and interest.

"Beginner's Guide to Electronics" presents a thorough (in parts too thorough!) introduction to the field of electronics — with special bias toward the constructor. It also provides a valuable insight into several application areas including medicine, recording and communication. Most of the 240 pages are illustrated with diagrams, some with component values for practical circuit designs.

The book contains 13 chapters; the first three educate the reader in the fundamentals of electromics theory. This includes a wide range of topics and, although extremely comprehensive, does tend to assume a certain prior knowledge — the section developing atomic structure needed fairly concentrated study. However, this is not a major drawback since throughout the book, topics are restated and explained from a different viewpoint. Learning is therefore accomplished through a process similar to assembling a jig-saw puzzle — fit all the pieces and the picture becomes clear.

The next three chapters investigate a range of circuits, and include the practical application of those components already introduced. All of the material in this section is highly readable and well written, meeting the needs of beginner and experienced constructor alike — indeed the book is well worth buying for this part alone!

The remaining chapters are allocated to specific application areas, one chapter for each. These differed in approach, but were all worth reading more than once (a sign of good writing?). The chapter on test instruments was very easy to understand, but the introduction into computer electronics suffered slightly from over-zealous presentation. Particularly absorbing was the description of basic principles of magnetic recording — including some very up-to-date video developments.

In conclusion, Owen Bishop's book is packed full of essential subjects. It is written in a lively and conscientious style with plenty of illustrative examples.

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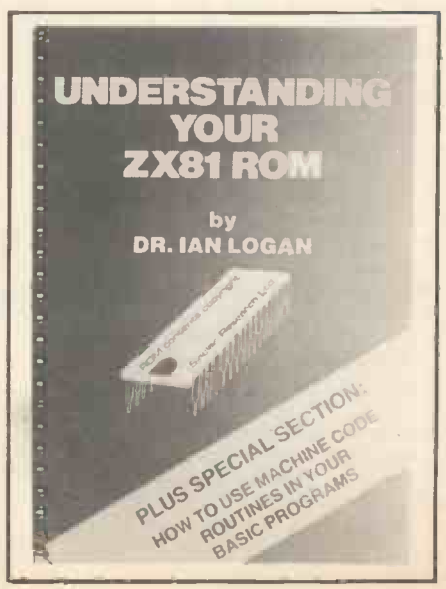

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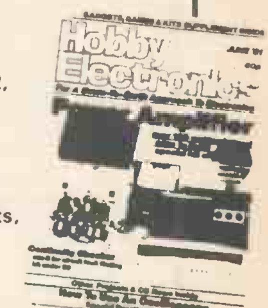

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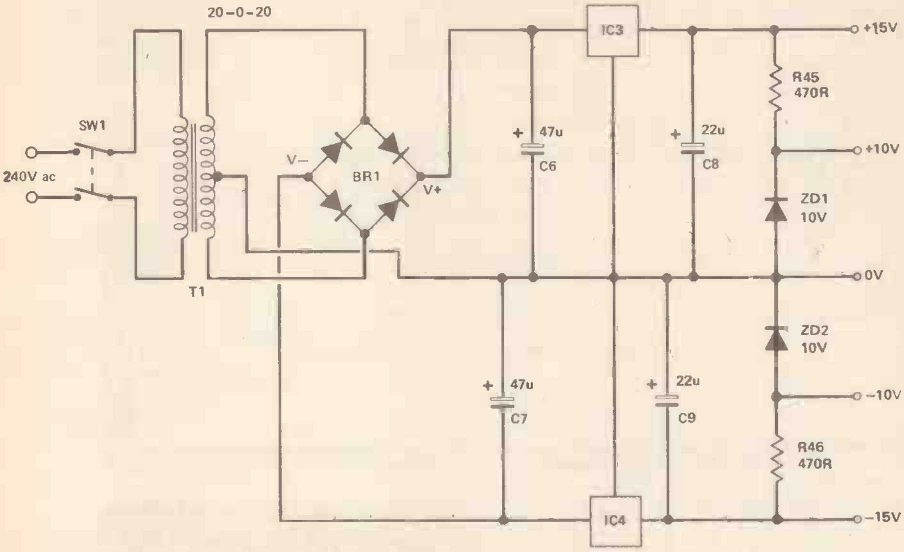

Above; the corrected Microlog power supply circuit.

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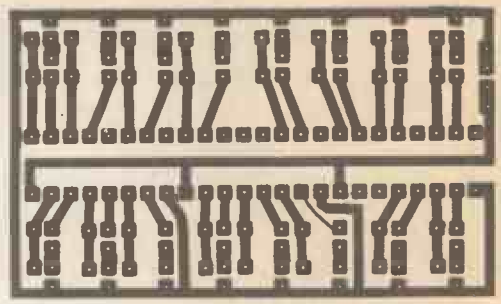
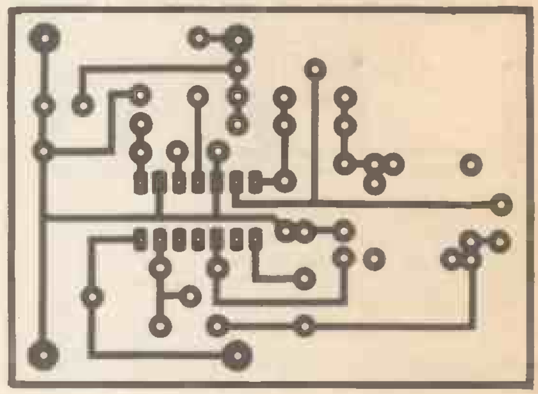


Top; the foil pattern for the Chip Probe. Below; the Switched Mode Supply board. This PCB is used for all three circuits.



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ADVERTISERS INDEX

MULLARD SPEAKER KITS

Purposefully designed 40 watt R.M.S. and 30 watt R.M.S. 8 ohm speaker systems recently developed by MULLARD'S specialist team in Belgium. Kits comprise Mullard woofer (8" or 5") with foam surround and aluminium voice coil. Mullard 3" high power domed tweeter. B.K.E. built and tested crossover based on Mullard circuit, combining low loss components, glass fibre board and recessed loudspeaker terminals. SUPERB SOUNDS AT LOW COST. Kits supplied in polystyrene packs complete with instructions.

8" 40W system — recommended cabinet size 240 × 216 × 445mm
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1000 MONO DISCO MIXER

A superb fully built and tested mixer/pre-amp with integral power supply. 4 inputs 2 turntables (ceramic cartridge). Aux. for tape deck etc., plus Mic. with override switch, all with individual level controls. Two sets of active tone controls (bass and treble) for Mic. and main inputs. Master volume control. Monitor output with select switch and volune control.

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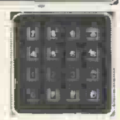
KEYBOARDS

MEMBRANE KEYBOARDS manufactured from a tough polycarbonate film mounted on 1mm glass fibre printed circuit board assembly incorporating silver plated contacts.



16 way numeric keyboard Standard keyboard providing 0-9 and A-F functions.
Size: 100mm × 100mm × 2mm. Price: £5.99 + 35p p&p

Alpha Numeric Keyboard Full size 55 key non encoded keyboard with the commonly required functions in a Qwerty array. Matrix output via a 16 pin DIL socket.
Size: 350mm × 100mm × 2mm. Price: £13.99 + 50p p&p

STEREO CASSETTE TAPE DECK MODULE.

6 piano type keys

Comprising of a top panel and tape mechanism coupled to a record/play back printed board assembly. Supplied as one complete unit for horizontal installation into cabinet or console of own choice. These units are brand new, ready built and tested.

Features: Three digit tape counter. **Autostop. Six** piano type keys, record, rewind, fast forward, play, stop and eject. Automatic record level control. Main inputs plus secondary inputs for stereo microphones. **Input Sensitivity:** 100mV to 2V. **Input Impedance:** 68K. **Output level:** 400mV to both left and right hand channels. **Output Impedance:** 10K. **Signal to noise ratio:** 45dB. **Wow and flutter:** 0.1%. **Power Supply requirements:** 18V DC at 300mA. **Connections:** The left and right hand stereo inputs and outputs are via individual screened leads, all terminated with phono plugs (phono sockets provided). **Dimensions:** Top panel 5¾in × 11¾in. Clearance required under top panel 2¼in. Supplied complete with circuit diagram and connecting diagram. Attractive black and silver finish.

Price £26.70 + £2.50 postage and packing.

Supplementary parts for 18V D.C. power supply (transformer, bridge rectifier and smoothing capacitor) **£3.50.**

BSR P256 TURNTABLE

P256 turntable chassis ● S shaped tone arm ● Belt driven ● Aluminium platter ● Precision calibrated counter balance ● Anti-skate (bias device) ● Damped cueing lever ● 240 volt AC operation (Hz) ● Cut-out template supplied ● Completely manual arm. This deck has a completely manual arm and is designed primarily for disco and studio use where all the advantages of a manual arm are required.

Price: £28.50 + £2.50 P&P

NEW RANGE QUALITY POWER LOUDSPEAKERS (15", 12" and 8")

These loudspeakers are ideal for both hi-fi and disco applications. Both the 12" and 15" units have heavy duty die-cast chassis and aluminium centre domes. All three units have white speaker cones and are fitted with attractive cast aluminium (ground finish) fixing escutcheons. Specification and Price.

15" 100 watt R.M.S. Impedance 8ohm 59 oz. magnet. 2" aluminium voice coil. Resonant Frequency 20Hz. Frequency Response to 2.5KHz Sensitivity 97dB. **Price £32 each £3.00 Packing and Carriage each.**

12" 100 watt R.M.S. Impedance 8 ohm. 50 oz magnet. 2" aluminium voice coil. Resonant Frequency 25Hz. Frequency Response to 4KHz. Sensitivity 95dB. **Price £23.70 each. £3.00 Packing and Carriage each.**

8" 50 watt R.M.S. Impedance 8 ohms. 20 oz. 1½" aluminium voice coil. Resonant Frequency 40Hz. Frequency Response to 6KHz. Sensitivity 92dB. Also available with black cone fitted with black metal protective grill. **Price: White cone £8.90 each. Black cone/grill £9.50 each.** P & P £1.25 each.

OMP POWER AMPLIFIER MODULES

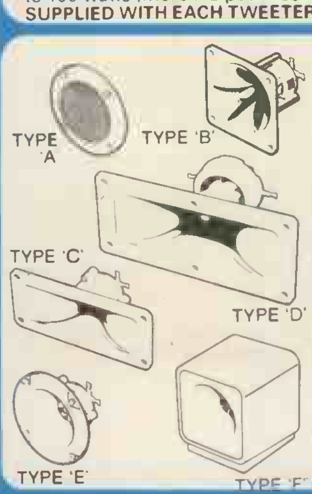
100 WATT R.M.S. AND 300 WATT R.M.S. MODULES

Power Amplifier Modules with integral toroidal transformer power supply, and heat sink. Supplied as one complete built and tested unit. Can be fitted in minutes. An LED Vu meter is available as an optional extra.

SPECIFICATION:
Max Output Power: 110 watts R.M.S. (OMP 100)
310 watts R.M.S. (OMP 300)
Loads: Open and short circuit proof. 4-16 ohms.
Frequency Response: 20Hz — 25KHz ±3dB.
Sensitivity for Max. Output:
500mV at 10K (OMP 100) 1V at 10K (OMP 300)
T.H.D.: Less than 0.1%
Supply: 240V 50Hz
Sizes: OMP 100 360 × 115 × 72mm
OMP 300 460 × 153 × 66mm
Prices: OMP 100 £31.50 each + £2.00 P&P
OMP 300 £89.00 each + £3.00 P&P
Vu Meter £6.50 each + 50p P&P

PIEZO ELECTRIC TWEETERS MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. **Price £3.45 each.**

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TYPE 'F' (KSN1057A) Cased version of type 'E'. Free standing satellite tweeter. Perfect add on tweeter for conventional loudspeaker systems. **Price £10.75 each.**

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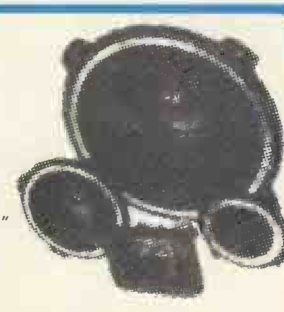
Matching 3-way loudspeakers and crossover



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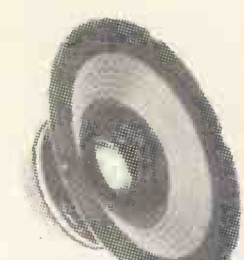
Build a quality 60 watt R.M.S. system.

★ 10" Woofer 35Hz-4.5KHz
★ 3" Tweeter 2.5KHz-19KHz
★ 5" Mid Range 600Hz-8KHz
★ 3-way crossover 6dB/oct 1.3 and 6KHz
Recommended Cab-size 26" × 13" × 13"

Fitted with attractive cast aluminium fixing escutcheons and mesh protective grills which are removable enabling a unique choice of cabinet styling. Can be mounted directly on to baffle with or without conventional speaker fabrics. All three units have aluminium centre domes and rolled foam surround. Crossover combines spring loaded loudspeaker terminals and recessed mounting panel.

Price £22.00 per kit + £2.50 postage and packing. Available separately, prices on request.



12" 80 watt R.M.S. loudspeaker.
A superb general purpose **twin cone** loudspeaker 50 oz. magnet. 2" aluminium voice coil. Rolled surround. Resonant frequency 25Hz. Frequency response to 13KHz. Sensitivity 95dB. Impedance 8ohm. **Attractive blue cone with aluminium centre dome.**
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4014	50p
4015	45p
4016	25p
4017	40p
4019	35p
4020	48p
4021	46p
4022	55p
4023	13p
4024	42p
4025	13p
4027	26p
4028	40p
4029	60p
4030	13p
4035	66p
4040	50p
4042	40p
4044	46p
4047	50p
4049	20p
4050	20p
4051	50p
4052	60p
4053	50p
4066	28p
4067	447p
4069	13p
4070	13p
4071	13p
4076	50p
4081	13p
4086	45p
4093	30p
4098	70p
4503	42p
4510	52p
4511	45p
4512	50p
4516	60p
4518	40p
4520	60p
4528	64p
4539	64p
4555	45p
4556	45p
40014	50p
40085	70p
40097	60p
40098	60p
40161	55p
40163	55p
40175	60p
40193	60p

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7400	13p
7401	13p
7402	13p
7403	13p
7404	13p
7405	14p
7406	20p
7407	24p
7408	14p
7409	14p
7410	14p
7411	14p
7412	18p
7413	22p
7414	26p
7416	18p
7417	22p
7420	15p
7421	20p
7425	20p
7426	27p
7427	15p
7430	15p
7432	18p
7437	18p
7438	18p
7439	24p
7440	16p
7442	24p
7445	50p
7446	68p
7447	55p
7448	55p
7450	15p
7451	15p
7453	15p
7454	15p
7470	30p
7472	25p
7473	25p
7474	22p
7475	23p
7476	22p
7483	47p
7485	60p
7486	25p
7490	26p
7491	45p
7492	38p
7493	28p
7495	50p
7496	45p
74107	25p
74121	20p
74122	35p
74123	40p
74125	38p
74126	38p
74132	30p
74145	50p
74150	90p
74151	40p
74153	45p
74154	75p
74155	45p
74157	35p
74158	30p
74161	45p
74163	45p
74164	60p
74165	65p
74166	70p
74167	120p
74170	120p

TTL contd.

74173	60p
74174	50p
74175	50p
74180	50p
74190	60p
74191	60p
74192	70p
74193	60p
74194	60p
74195	46p
74196	46p
74197	50p
74221	75p
74279	40p
74290	60p
74298	60p

TTL LS

74LS00	14p
74LS01	14p
74LS02	14p
74LS03	14p
74LS04	14p
74LS05	14p
74LS08	14p
74LS09	14p
74LS10	14p
74LS11	14p
74LS13	21p
74LS14	21p
74LS15	14p
74LS20	14p
74LS21	14p
74LS26	14p
74LS27	14p
74LS28	22p
74LS30	14p
74LS32	14p
74LS33	14p
74LS37	19p
74LS38	14p
74LS40	19p
74LS42	40p
74LS47	44p
74LS48	44p
74LS51	14p
74LS54	14p
74LS74	18p
74LS83	42p
74LS86	14p
74LS90	30p
74LS92	30p
74LS93	30p
74LS95	40p
74LS109	40p
74LS112	30p
74LS113	30p
74LS125	28p
74LS126	28p
74LS132	40p
74LS133	25p
74LS136	20p
74LS138	30p
74LS139	30p
74LS151	40p
74LS153	40p
74LS155	45p
74LS156	45p
74LS157	30p
74LS158	30p
74LS160	35p
74LS161	35p

TTL LS contd.

74LS162	35p
74LS163	35p
74LS164	45p
74LS165	50p
74LS168	60p
74LS169	60p
74LS170	70p
74LS173	40p
74LS174	45p
74LS175	45p
74LS181	110p
74LS190	45p
74LS191	45p
74LS192	45p
74LS193	45p
74LS194	50p
74LS196	35p
74LS197	50p
74LS240	70p
74LS241	70p
74LS244	70p
74LS245	80p
74LS247	60p
74LS249	40p
74LS251	40p
74LS253	35p
74LS256	55p
74LS257	40p
74LS258	40p
74LS259	65p
74LS260	30p
74LS266	22p
74LS273	60p
74LS279	40p
74LS283	40p
74LS290	34p
74LS293	34p
74LS295	52p
74LS299	83p
74LS322	90p
74LS323	130p
74LS347	55p
74LS352	60p
74LS353	60p
74LS365	30p
74LS366	35p
74LS367	30p
74LS368	30p
74LS373	75p
74LS374	75p
74LS375	40p
74LS377	70p
74LS378	60p
74LS379	60p
74LS390	50p
74LS393	50p
74LS395	48p
74LS447	45p
74LS490	64p
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BZY88C6V8	8p
BZY88C8V2	8p
BZY88C12	8p
BZY88C15	8p
BC107	11p
BC107A/B	11p
BC108A/B/C	11p
BC109A/B/C	12p
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BC183	9p
BC184	9p
BC212	9p
BCY70	17p
BCY71	18p
BCY72	18p
BFY50	28p
BFY51	28p
BFY52	28p
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TIP30/A	35p
TIP31/A	45p
TIP32/A	45p
TIP/41A	50p
TIP42/A	50p
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2N918	26p
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2N2219/A	28p
2N2221/A	24p
2N2222/A	28p
2N2904/A	29p
2N2905A	28p
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.22uf	11p	10uf	18p
.47uf	11p	15uf	30p
1.0uf	11p	22uf	35p
2.2uf	14p	33uf	48p
3.3uf	14p	47uf	80p
4.7uf	18p	68uf	110p

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.15uf	13p	1.5uf	15p
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.33uf	13p	3.3uf	17p
.47uf	13p	4.7uf	20p
.68uf	13p	6.8uf	20p
		10.0uf	27p

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