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OCTOBER 1983

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Project Electronics For Everyone

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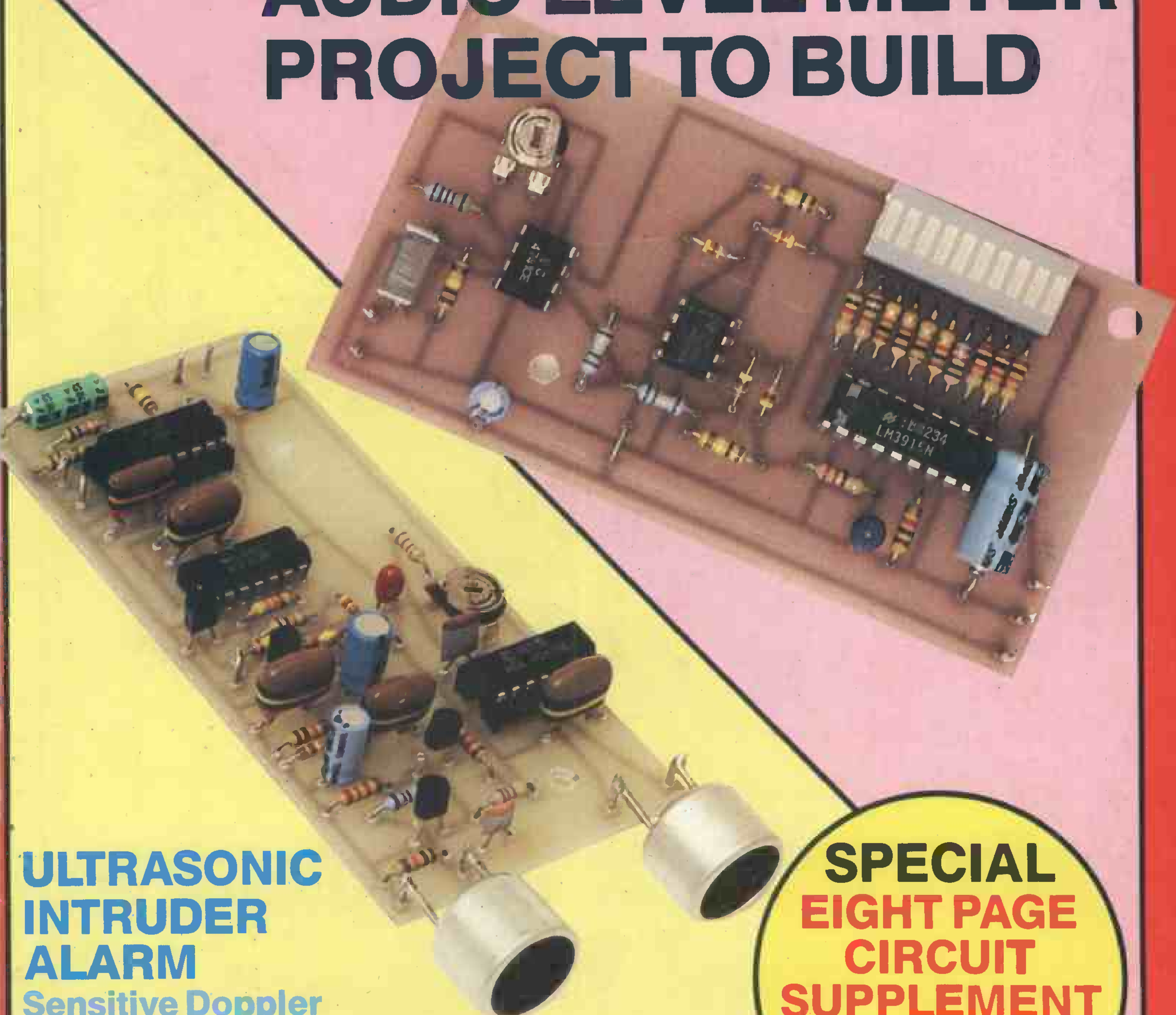

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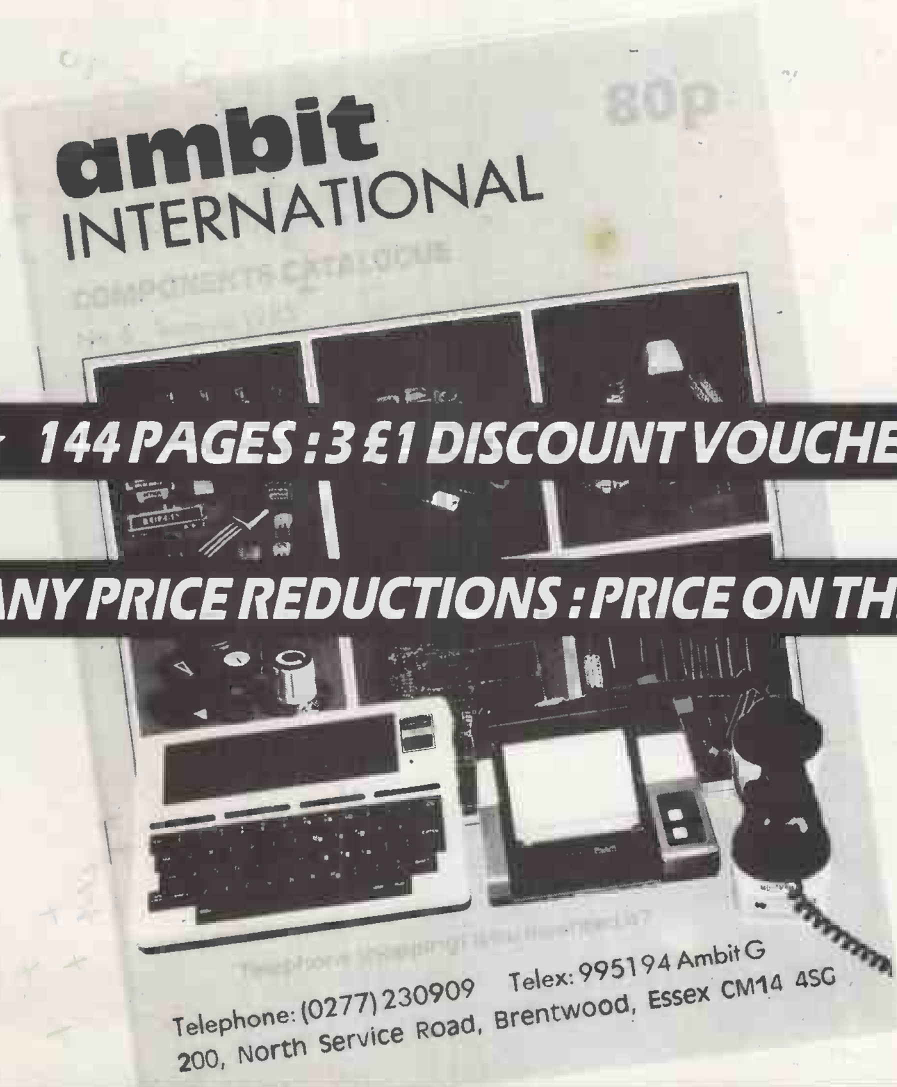

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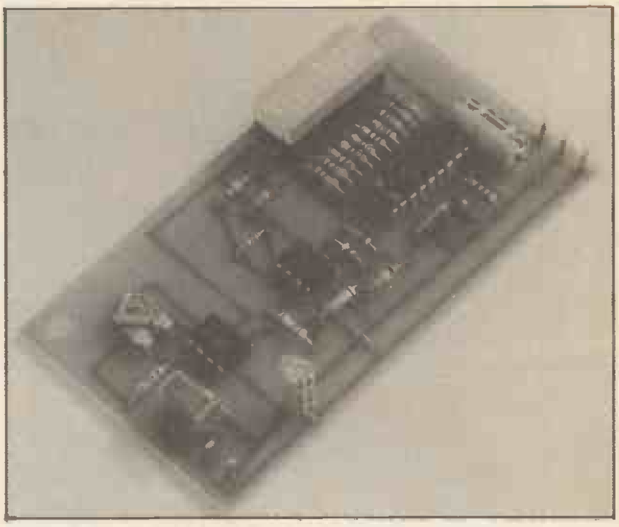
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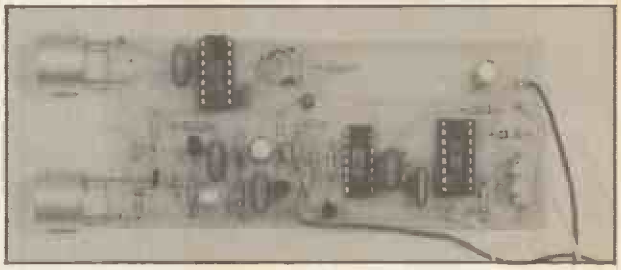
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● Three position changeover switch
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2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	150p
2SC2028	80p
2SC2029	200p
2SC2078	160p
2SC2335	200p
2SC2612	200p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	120p
40290	260p
40361/2	75p
40408	120p
40409	100p
40410	100p
40594	120p
40595	120p
40673	75p
40871/2	100p

DIODES

BY127	12p
BYX36300	20p
OA47	8p
OA90/91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	5p
1N4005	6p
1N4006/7	7p
1N5401/2	12p
1N5403/4	14p
1N5404/7	19p
S920	9p

BRIDGE RECTIFIERS

1A 50V	19p
1A 100V	20p
1A 400V	25p
1A 600V	30p
2A 50V	30p
2A 100V	35p
2A 400V	45p
3A 200V	60p
3A 600V	72p
4A 100V	95p
4A 400V	100p
6A 50V	80p
6A 100V	100p
6A 400V	120p
10A 400V	200p
25A 400V	380p

PCB MOUNTING RELAYS

6 or 12V DC Coil SPDT 2A 24DC	160p
6 or 12V DC Coil DPDT 5A 24V DC 240V AC	200p
6 or 12V DC Coil SPDT 10A 24V DC 240V AC	225p

OPTO ELECTRONICS

2N577	40p
OCP71	180p
ORP12	120p
DRP60	120p
ORP61	120p
TIL78	55p

OPTO ISOLATORS

ILD74	130p
MCT26	100p
MCS2400	190p
MOC3020	150p
ILQ74	240p
TIL11	70p
TIL12	70p
TIL13	70p
TIL116	70p

LEDs

0.125"	
TIL32	55p
TIL209 Red	9p
TIL211	12p
TIL212 Ye	14p
TIL216 Red	18p
0.2"	
TIL200 Red	10p
TIL222 Gr	12p
TIL228 Ye	14p
Rectangular LEDs (R,G,Y)	30p
NSB5881	570p
TIL311	600p
TIL312/3	110p
TIL321/2	130p
TIL330	140p
7750/60	200p

DISPLAYS

31015F	200p
DL704	140p
DL707 Red	140p
FND357	120p
FND500	90p
FND507	90p
MAN3640	175p
MAN4640	200p

DRIVERS

9368	250p
9370	300p
UDN6118	320p
UDN6184	320p

LOW PROFILE SOCKETS BY TI

8 pin	9p
14 pin	10p
16 pin	11p
18 pin	16p
20 pin	18p
22 pin	22p
24 pin	24p
28 pin	26p
40 pin	30p

WIRE WRAP SOCKETS BY TI

8pin	25p
14 pin	35p
16 pin	40p
18 pin	50p
20 pin	60p
22 pin	65p
24 pin	70p
28 pin	90p
40 pin	100p

VERO BOARDS

2.5" × 5"	95p
2.5" × 3.75"	85p
2.5" × 17"	330p
3.75" × 3.75"	95p
Vero Block	410p
3.75" × 5"	90p
3.75" × 17"	410p
4.75" × 7.9"	530p
2.5" × 1"	110p
Spot Face Cutter	130p

SWITCHES

TOGGLE SWITCHES
Subminiature
SPST £60p, SPDT 65p
DPDT 70p
Rotary Switches
1P12w, 2P6w, 3P4w, 4P3w 55p
DIGITAST SWITCHES 1xP
Push to make
(R,G,B)15p
Push to break (Black) 10p
Slide Switch DPDT 10p
Square PCB Switch 65p

RUGBY ATOMIC CLOCK

This Z80 micro controlled clock/calender receives coded time data from NPL Rugby. The clock never needs to be reset. The facilities include 8 independent alarms and for each alarm there is a choice of melody or alternatively these can be used for electrical switching. A separate timer allows recording of up to 240 lap times without interrupting the count. Expansion facilities provided.

Ready Built Unit . . . . £145 + £5.00 carr.
Reprint of ETI articles at £1.00 + s.a.e.

AS DESCRIBED IN JUNE/JULY/AUGUST ISSUE

MICROTRAINER

Complete Kit £64.00 + £1.00 p&p
8V 1.8A PSU £7.00 + 70p p&p
1802 Ref. £7.00

IDEAL for HOBBYISTS — learn and explore the workings of microprocessors and unravel the mystical field of computers.
INVALUABLE for training centres, schools and industries — gives effective insight into micros to engineers, electricians etc not directly involved in the computer field.
INEXPENSIVE — a truly low cost teaching aid — in fact a short step towards developing new ideas and systems.

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MICRO COMPUTER
OFFICIAL DEALER
Please phone for availability

BBC Model B £399
(incl VAT) Carr £8/unit
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upgrade kit £50
Fitting charge £15

Individual upgrades also available
WORD PROCESSOR 'VIEW'
16k ROM £52
TELETEXT ADAPTOR £195
WORLDWISE 8K ROM £39
TORCH Z80 DISC PACK £780
Business, Education and Fun
Software in stock
FLOPPY DISC INTERFACE
INC. 1.2.0.5. £95 and £20 installation

BBC FLOPPY DISC DRIVES

Single drive 5¼" 100K £230 + £6 carr.
Dual drive 5¼" 800K £699 + £8 carr.

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These drives are supplied in BBC matching colour cases.
SINGLE 100K £150 200K £215*
400K £265
SINGLE WITH PSU 100K £185 200K £260*
400K £330
DUAL WITH PSU 200K £355 400K £475*
800K £595
* These drives are supplied with a switch between 40 and 80 tracks.

Drive Cables: Single £8 Dual £12
Disc Manual & Formatting Diskette £17.50

MICRO TIMER

The programmable clock/timer is a 6502 based dedicated micro computer with memory and 4 digit 7 segment displays to form an extremely versatile timing device with following features:

- 24 hour 7 day timer
- 4 completely independent switch outputs
- 6 digit 7 segment display output to indicate real time turn-off times and reset times
- Individual outputs to day of week, switch and status LEDs
- Data entry through a simple matrix pad

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PSU .... £7.00 + 70p p & p
Construction details supplied

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Orders from Government Depts. & Colleges etc. welcome.
Detailed Price List on request.
Stock items are normally by return of post.

MONITOR

Flying Signals

Hawk Electronic Test Equipment of Maidstone have announced three pieces of equipment of interest, primarily, to small industrial users.

For the Apple micro, comes a 32 channel input/output card allowing external control and data feedback, with four 8 bit bi-directional I/O ports, four 16 bit interval timers, two serial to parallel, parallel to serial registers and handshake capability. The card costs £49.50 all-inclusive and comes with documentation and a sample program.

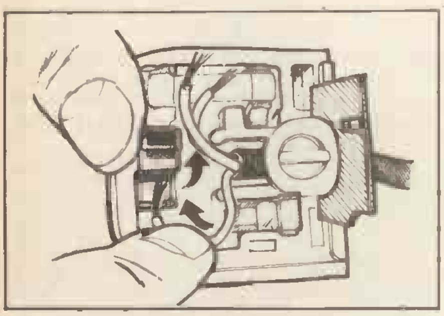
Anther card allows the Apple to function as an IEEE 4888 Controller for tests, measurements and control. This card can run up to fourteen separate controllable devices, with a transmission path of up to 20m. The on-board software interfaces directly with Basic and Applesoft strings. The GPIB Interface Card costs £189.00 inc. VAT and p&p.

Hawk have utilised advances in analogue to digitial flash converters to devise their Tele-Scope 200S digital scope, which uses an ordinary domestic TV set as a screen, via the UHF aerial input.

The Tele-Scope can digitise signals at the rate of one per 100ns and display them indefinitely, allowing for transient, single-shot capture up to 250kHz.

The Tele-Scope costs £89.00 for the kit, or £109.00 for a built and tested unit, with special parts available individually as necessary. The manual includes circuits and layouts, and is also available separately. Prices are exclusive of VAT and p&p.

Further information from Hawk **Electronic Test Equipment, Parkwood Industrial Estate, Bircholt Road, Maidstone, Kent ME15 9XT Tel: (0622) 686811.**



Electrician-Free Plug

At last, the perfect present for the electronics wizard who has everything. Particularly the boffins who raise their heads from their algebra only to be stymied by the necessity of putting an electric plug on their Fully Rotating Model Creation Of The Universe: the (almost) tool-free plug.

The TL-Handyplug, "A revolution in plug design", to quote its makers, actually does only require one small screwdriver (or screwdriver substitute) to wire it up to a standard appliance cable, although a bit more wire trimming would be needed for a cable with a flat-cut end. The side of the plug (which looks, otherwise, no different from an ordinary plug) incorporates a small blade in a channel, which can be used to strip the inner cores of the flex, automatically to the required length.

The base of the plug releases by operating one screw through 90 degrees, and the bare ends of the wires are secured by locking clips. All very simple, and reported by our technical department to work very well.

Its other accomplishments are claimed to be speed of wiring, childproof features, impact resistance, flame resistance, and the availability of an accessory to help disabled people use it. The Handyplug is available from retailers at around £1.25, but for further information you can contact **Toby Lec Marketing Ltd., Park Bridge Mill, Park Road, Blackburn, Lance. Tel: (0254) 679911.**

Heath Kits

The Heath Co. in the USA has appointed independent distributors in Europe for its well known Heathkits. The former Heath Electronics has changed its name to **Zenith Data Systems Ltd.**, and will in future be concentrating on its own microcomputers and Heath Assembled Robots. In the UK, the distributors for Heathkits will be our old friends **Maplin Electronics.**

The old showroom in Tottenham Court Rd., London has been closed down. Any technical or other enquiries about kits obtained either from Tottenham Court Rd. or from their Gloucester address should be addressed to: **Zenith Data Systems Ltd., Heathkit Division, 11B Bristol Road, Gloucester GL2 6EE,** in writing only; any kits needing servicing should be sent to that address.

Kits obtained through Maplin, on the other hand, will be dealt with by **Maplin** themselves, at **Maplin Electronic Supplies Ltd., P O Box 3, Rayleigh, Essex SS6 8LR. Tel: (0702) 554155.** A free Heathkit catalogue is available now from Maplin.

New Hobby Shop

Twyford Electronics has been set up with the aim of supplying components and accessories to hobbyists at competitive prices — this is what we like to hear. They are situated about 100 yards from Twyford Station, about six miles out of Reading in Berkshire, and believe they are the only components suppliers for a considerable distance. They will be doing mail order as well as over the counter sales. We don't have a price list or catalogue for them as yet but doubtless by the time you read this something will be available.

Phone, call or sent SAE to **Twyford Electronic Ltd., 22 Station Road, Twyford, near Reading, Berks. Tel: (0734) 340333.**

Exploring Jupiter

Jupiter Cantab have announced a 16K RAM pack and a 48K RAM pack, priced at £34.95 and £79.95 respectively, for the Jupiter ACE micro. As well as these, nine games tapes are now available, viz: Gobbledegook, Zombies and Potholes, and Othello for 19K memory; Greedy Gobbler, Blow Up The World, Missile Man, Spacefighter Pilot, Overtaker, Brands Hatch, Moo (!), Hangman, Fish ("swimming upstream to eat the floating detritus . . .") and Flutterer. The ninth tape is a Monitor tape (no relation) which enables the user to explore the inner workings of the computer and test programs.

Jupiter also have a new address, which is **Jupiter Cantab Ltd., Cheshunt Building, Bateman Street, Cambridge CB2 1LZ. Tel: (0233) 313479.** A glossy leaflet describing the ACE is also available.

Here Comes The Cavalry

You have obtained all the errata, tested all the components, checked all the dry joints, reversed all the electrolytics and changed the fuse. It still doesn't work. Do you despair? Do you give up electronics and take up flower arranging? No indeed! You contact **WEB Logic Systems Ltd.**, who will build, test and/or repair any unstarted or partially and completed projects (I quote).

Logic Systems quoted around £10-£20 as an average cost for the complete assembly of most projects, and expect normally to turn a project around within five days of receipt.

Anyone interested, contact WEB **Logic Systems Ltd., at Gainsborough House, 15 High Street, Harpenden, Herts. AL5 2RT. Tel: (05827) 62119.**

Organ Kits

As more people turn to home music making as a hobby, and the interest in home computers and electronics continues to grow, home-build electronic organs can give you two hobbies in one — the enjoyment of putting together your own instrument from a set of easy-to-assemble kits, and playing your completed organ afterwards. As an added bonus, you also save money when comparing the cost of kits against that of a comparable commercial instrument.

The kits in question are produced in Germany by the Dr. Bahn company; they were the originators of the electronic organ kit over thirty years ago, and the range is now available in this country from **Swankit Instruments**.

The latest computer techniques are employed in the design of these organs, not only to make the building easy, but to give the best tones and effects. The range begins with a small single keyboard portable organ, as a starter project. Even people with no experience of electronics at all can get involved. The instructions are designed to be easy to follow, with clear diagrams. If you should have any problems, expert advice is just a telephone call away. At the other end of the range there are several large three keyboard machines, with enough features to keep the experienced amateur or professional player happy for years. The proprietor of Swankit Instruments is Graham Watkins, who is himself a keen amateur organist.

For information contact **Swankit Instruments, Chantry Park, Henfield, W. Sussex BN5 9JE. Tel: (0273) 494238.**

Shorts

House of Instruments have announced the first group in a brand new range of oscilloscopes from **Trio**. CS-1010, CS-1012, CS-1020 and CS-1022 are 10MHz single and dual trace and 20MHz single and dual trace respectively. All the new range have large six inch rectangular CRTs with illuminated inner-face graticule and high accelerator potential. All have extremely high input sensitivity of 1mV/cm which is continuously variable to 5V/cm. 1mV/cm is particularly valuable in conjunction with the 20 nsec/cm to 0.5 sec/cm sweep speed for

These full feature oscilloscopes measure a neat and compact 260(W) x 160(H) x 400(D) mm and weigh from 8.1 kg. They have all the performance and reliability you could expect from a high quality, professional oscilloscope. Thehy are fully guaranteed for 00 years including free pick up, repair and return. Models with a tilt stand/carrying handle will be available. Please ask for free data sheets, prices or further information from **House Of Instruments, Clifton Chambers, 62**

High Street, Saffron Walden, Essex CB10 1EE. Tel: (0799) 24922.

The Electronic Organ Constructors Society is just that. They apparently have branch meetings in various parts of the country and publish a small magazine (A5, well printed, coloured card cover. The April issue has 40pp and I would guess it is published twice yearly). The emphasis in this issue is on traditional, theatre-style organs and *not* on rock music and synthesisers, just to put it in context, but the emphasis is genuinely on electronics nonetheless, with technical articles on a simple and advanced level, as well as area meeting reports and members' advertisements.

Contact the **Membership Secretary, Mr. W. Lewis, 8 St. John's Wood Rd., London NW8 8RE.**

Micro Peripherals have introduced the Juki 6100, a low cost 18CPS daisywheel printer designed for word processing use with personal and small business micros. The Juki 6100 is a full featured daisywheel emulating Diablo 630 protocol, fully compatible for use with Wordstar. Features include 18CPS bi-directional logic seeking; subscripts and superscripts; bold and shadow printing; character pitches 10, 12, 15 and proportional; graphics mode; 1/120 in min character spacing; 1/48 in line spacing; 2K buffer memory; 100 character Triumph Adler compatible 'drop in' daisywheel; 13 in platen with 11 in print line; linear motor for accurate positioning and low noise; IBM 82 compatible single/multistroke ribbons.

A centronics compatible interface is provided as standard with an RS232 serial and current loop interface as an option, and papers handling is either by friction feed or optional tractor feed. The price is £399.00 ex. VAT. Further details from: **Micro Peripherals Ltd., 69 The Street, Basing, Basingstoke, Hants. Tel: (0256) 3232.**

Elkan Electronics have just launched a new idea for Dragon 32 users (not forgetting Tandy TRS-80 Color Computer users). This is the "Dragon Supermarket". There's now no need to search through endless magazines or contact numerous different suppliers — the "Dragon Supermarket" is a phone call or a FREEPOST (no stamp required) away.

In addition, the "Dragon Supermarket" is distributed free every month with "Rainbow" and "Color Computer News", two magazines from the USA which are devoted entirely to Dragon 32 and Tandy color computers. Enquiries to **Elkan Electronics, 11 Bury New Rd., Prestwich, Manchester M25 8JZ. Tel: 061 798 7613.**

Ancom Ltd. write to say that they have just issued a four-page leaflet specifying their wide range of temperature and humidity measurement instrumentation. The ranges include digital thermometers, temperature indicators, controllers, annunciators, semi-intelligent devices and monitoring instruments, plus a psychrometer and a hydrometer. Ancom also do custom panels for non-standard requirements.

The leaflet we have at Hobby doesn't include prices, so specify, when writing, if you want a price list. Contact **Ancom Ltd., Devonshire St., Cheltenham GL50 3LT. Tel: (0242) 513861.**

Stotron's new main product catalogue has more than 160 pages and includes greatly enlarged ranges of Alarms, Connectors, Displays, LED Lamps, Mains Filters, Indicators, Switches, Relays, and many more products. A few of the suppliers that feature heavily are Arcolectric, Aries, Bulgin, C & K, Fabrilec, Hirose, ITW-Licon, Liton, National, Rafi, Roxburgh, Sifam, Star and Teka.

All product lines are held in stock sometimes more extensively than the suppliers! Prices are aimed generally at the one-off and small quantity order market and there is no minimum order charge. For your copy of the catalogue contact **Stotron Ltd., 72 Blackheath Rd., Greenwich, London SE10 8DA Tel: 01 691 2031.**

The first batch of **ORIC's** specially commissioned software is now available from dealers. The five titles in the series are: Oric Multigames (£7.95), a set of five family games comprising Bandit, Projectiles, Colour Match, Quest and Reversi; Oric Flight (£7.95), simulation of aircraft landing; Zodiac (£7.95), a sophisticated role playing adventure game; Oric Chess (£9.99), five levels of difficulty with superb graphics; Oric Base (£9.99 to include manual), a data management program which incorporates an easy to learn Query language. All cassettes are for the 48K model.

The Forth tape is also expected to be available very shortly and will cost £17.95, which includes the price of the manual.

MONITOR

Oric Printer

Oric Products' first peripheral for the Oric I — the specially designed four-colour plain paper printer — is now available from retail outlets, priced £169.95. The printer, which features the Alps mechanism and an internal power supply, comes complete with a connecting lead, no other accessories are required. The Oric Colour Printer (MCP40) is plugged directly into the Oric expansion port and can be used with both 48K and 16K models.

Four colours — black, blue, red and green — are provided by rolling ball point pen dispensers. The printer features full alphanumeric capability and graphics specification, and sample programs are included in the comprehensive manual.

The Oric Colour Printer measures 10.75x6.37x2.50in high (lowering to 1.25in at the front) and is identical in colour to the micro — grey with blue stripes. The printer runs on 220/240 volts and, with a minor adjustment, can be used in the USA on 110 volts. Spare pens and paper rolls will be available through retailers.

The Oric MCP40 has a standard centronic interface and can be used with any microcomputer having a centronics interface.

Oric Products will be mounting a summer promotion until mid-September, offering a start-up pack of software valued at £40 with every 48K machine sold. The software package will contain four tapes — Home Finance, Teach Yourself BASIC, Oric Flight and Multi Games. Although the titles are subject to change the proportions of one home business, one educational and two games programs will remain unchanged. Oric I 48K retails for £169.95.

The 16K Oric I — due in retail outlets from early July onwards — will also be sold with a software pack (valued at £30) containing adaptations of the programs produced for the 48K. Once again there will be one home business program, one educational one and two games tapes. The 16K plus software package will retail at £129.95.

Digital DMM

Keithley Instruments' Model 128 hand held DMM claims to be one of the lowest priced digital 'beeper' DMMs around. It offers 0.5% accuracy, 3½ digit resolution (1mV, OR1), 10A capability, resistance to 20MR and five functions.

The beeper indicates levels above the threshold when set to volts or amps, and below the threshold for ohms. The threshold is adjustable so that it can be set to the most useful point, from 10 to 300 digit, for the given situation. High imput impedance (10MR) when the beeper is activated makes the 128 useful for sensing CMOS and other logic levels. The beeper can be deactivated by a slider switch. The 128 has full overload protection, rotary switches and a colour coded faceplate. Battery life is 350 hours with alkaline batteries, and the price is £119 plus VAT and P&P.

Keithley have also recently introduced a range of four industrial standard digital thermometers, two models (865 for fahrenheit and 166 for centigrade) being thermistor thermometer and two, (the 868 and 869) with platinum resistance temperature detector sensors. These latter are the only four wire RTD hand-held thermometers on the market at present.

Futher information from **Keithley Instruments Ltd., 1 Bolton Rd., Reading, Berks RG2 0NL. Tel: (0734) 861287.**

Control Modules For Micros

Centec Electronic Systems are designers and suppliers of hardware and software primarily for education and industry. One of their specialities is a range of control modules with BASIC or machine code, with which your micro can be programmed to switch lights, measure voltages, control motors etc. Centec have actually worked on devising hardware for a Schools Council "Microelectronics In Control" course which is now taught in many schools, often as part of GCE 'O' level courses.

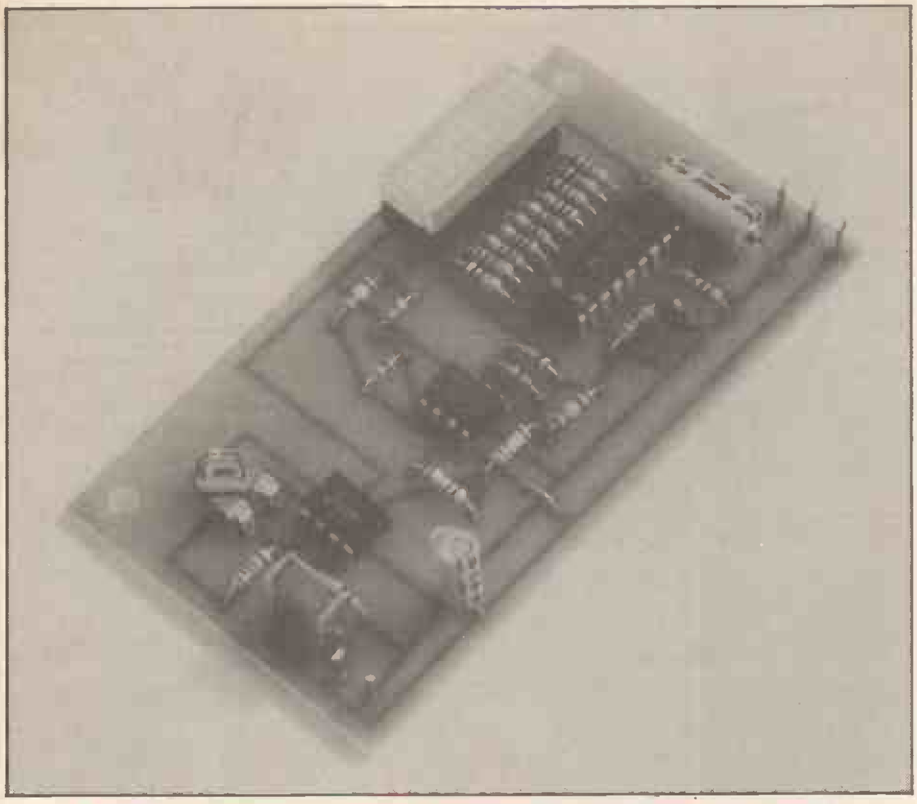
Their range includes a universal buffer module, A to D and D to A converters, DC motor and current buffer module, and a considerable list of other units both available now and under development. Compatible micros include the ZX81, Spectrum, Menta, 380Z, 480Z at present and others, including the BBC, to come.

Centec's 8-bit analogue to digital converter is designed to convert your computer system into an automatic data acquisition and analysis system, enabling you to automate the collection of any type of data for which the right transducer or sensor is available. It can monitor up to sixteen analogue channels and can be used by almost all BASIC and assembly language programs. The price is £42.95 one-off.

A range of mains switching units with one channel, two channels or four channels, features 5A per output socket (10A available optionally), LED monitors on socket outputs, 4mm sockets for connection to a computer, separate power supply and isolation from computer voltages. Units are priced £91.95, £29.95 and £49.95 respectively.

A separate power unit for the ZX81 features regulated DC output voltage, external voltage adjustments, short circuit protection, style to blend with the ZX81, among others. It is designed to power external hardware without overloading the micro, uses the micro's power supply and plugs straight in. The fixed 5 or 12V models are £6.95 each and the variable 5 to 12V model is £7.75. P&p is 45p per order.

Orders and enquiries to **Centec Electronic Systems, 47 Spur Rd., Orpington, Kent BR6 0QR. Tel: Orpington 35353.**



AUDIO LEVEL METER

R. A. Penfold

The golden secret of first-class sound reproduction is a reliable set of level meters. Our versatile log-driven peak-reading audio level meter can be built either with a 10-LED bargraph display, or ten separate LEDs, and cased either as part of another piece of equipment or separately, alone or as a pair . . . whatever you want.

ALTHOUGH not so long ago ordinary moving-coil meters were almost invariably used for audio level indication (the exceptions being the so called "magic eye" indicators), these days LED or liquid crystal displays seem to have largely taken over in this area. Superficially these look very similar to the old "magic eye" type indicators, but they are not just an expensive alternative to a high quality meter movement, and most types actually offer a higher level of performance than simple analogue VU meters. The latter are average reading, apart from some of those fitted to expensive items of equipment such as professional mixers. The drawback of the simple type is that many instruments, such as pianos, have a high peak-to-average signal level, so that the meter tends to under-read and severe distortion can result.

LED and liquid crystal level indicators are normally designed to be peak reading so that accurate and meaningful results are obtained regardless of the input waveform. Some give the option of average-reading so that someone who is familiar with the vagueness of this type of meter and prefers to use it can do so.

This audio level indicator is relatively simple and inexpensive, but nevertheless has a high level of performance. It uses a ten LED bargraph display, and the LED threshold levels are spaced at 3dB intervals. If, for example, the circuit is set up so that the highest LED switches on at +6dB, this would give LED threshold levels of −21, −18, − 15, − 12, − 9, − 6, − 3, 0, +3, and +6dB. However, the unit can be set up to have any threshold levels within reason, but the spacing between the thresholds will always be 3dB and it is not adjustable. The circuit has the professional standard attack and decay times of 2.5ms and 1s respectively, and it gives very accurate and reliable results. The unit will fit into most situations without difficulty as it has a full drive sensitivity which is adjustable from about 20 to 900 millivolts RMS.

System Operation

There are few stages in this unit, as can be seen from the block diagram of **Figure 1**.

The amplifier at the input is merely used to boost the gain of the circuit if necessary. Its voltage gain is adjustable from about 50 times to unity, and this gives the unit its adjustable sensitivity.

Two precision rectifiers are fed with the output of the amplifier, and their outputs are mixed together. The two rectifier stages are not the same, and the important difference is that one does not invert the input signal whereas the other does. They both provide a positive output signal. In effect, one rectifier provides an output while the input signal is positive and the other provides an output while it

The VU meter

THE VU METER, now somewhat long in the tooth, was developed to fulfill the need for a device to indicate the relative volume levels of programme material — speech and music — so that overloading of circuits could be avoided. Being calibrated somewhat arbitrarily, its background and use can be somewhat mysterious. Here, then, the mystery is explained.

The history of the development of the VU meter — more properly called a Standard Volume Indicator — can be traced back to 1921 when American engineers set out to broadcast the ceremony of the burial of The Unknown Soldier by means of telephone lines and public address amplifiers. In order to minimize distortion, the level at which overloading of the various line amplifiers occurred was determined by experiment, and this level was taken to be the reference level. A "volume indicator" was then developed consisting simply of a 2dB step attenuator, calibrated in decibels with respect to the reference level; a triode valve detector and a milliammeter. The method used was to adjust the attenuator so that the signal peaks reached the mid-scale point of the meter once in ten seconds, on average. The volume level was then read directly from the attenuator scale. This instrument provided an indication of the volume levels but exerted no control over these levels.

The next stage of advancement came in 1942, when it had become apparent that the large number of similar instruments by then existing was causing confusion. The American Standards Association published the results of a collaboration between engineers of the Columbia Broadcasting System, Bell Telephone Laboratories and the National Broadcasting Company, and in adopting the recommendations as a Standard, introduced the now universally accepted Standard Volume Indicator.

In the course of the work leading up to this Standard the effectiveness of both RMS and peak-reading meters was established as being virtually equal for systems extending over short distances. Group-delay effects (the term applied to the delay of different frequencies by differing amounts, which can be quite appreciable in long-haul links) however caused discrepancies in the peak-level meter readings, and therefore the RMS meter, happily of simpler design, was chosen for further development.

The final design consists of an RMS reading voltmeter, slightly underdampened to promote easier reading at peak level, calibrated in both Volume Units (hence the term VU) and in percentage of maximum permissable level. The scale has a buff-coloured background — said to reduce eye fatigue. In instruments designed for use with different systems, an attenuator is normally provided to suit the meter to the job in hand. More usually, the meter is permanently installed in one piece of equipment, and the OVU point will have been set at the level where overloading is just beginning to occur.

Its most important characteristic is that if offers freedom from cumbersome and unnecessary absolute RMS voltage measurements. An operator, faced with a number of meters, treats each in an identical fashion, rather than having to know how the appropriate voltage levels at each measurement pick-off point.

Most people will meet the VU indicator while adjusting tape recording levels. In this case, the indicator should be treated according to the type of programme material. The meter deflection should be observed for about one minute for music, and for five to ten seconds for speech. Opinions are divided, at this juncture, whether to accept the occasional deflection of unusual amplitude as being the peak reading or not. The highest possible recording level is desirable to maintain a good signal-to-noise ratio and wide dynamic range, but the danger of overload distortion is always present. With today's noise-reduction systems and companders, S/N ratio is not the problem it was, and so it is probably better to operate at a lower level. On the other hand, most equipment manufacturers will be erring on the side of caution in their calibrations, and absolute maximum peak levels of +1 or +2VU will, in all probability, do no harm. In the end, individual equipment characteristics and personal preferences will dictate the exact method of use.

Steve Roberts

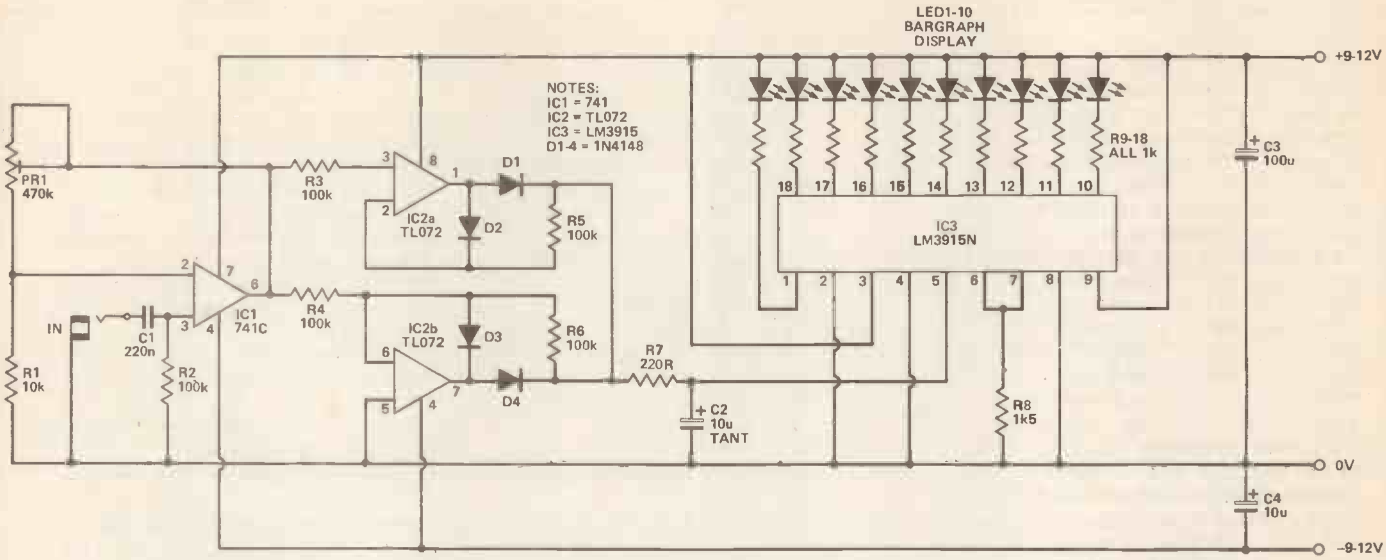


Figure 2. The circuit. Ten LEDs can be used instead of the bargraph unit.

is negative. This gives fullwave rectification so that the circuit responds to both negative and positive input half cycles, and this is an important feature since many signals encountered in practice, such as voice signals, are far from symmetrical. Halfwave rectification could result in over or under reading by 6dB or more!

The output of the rectifiers is smoothed by the next stage, and it is here that the required attack and decay time constants are set. The fast attack enables the circuit to respond properly to transients, and the slow decay time merely prevents continuous and very rapid changes in the display, which would make it practically unreadable.

The final stages are the bargraph driver and the bargraph itself. A normal (linear) drive is not ideal for this application as it would not quite cover a wide enough dynamic range, and in terms of dBs to LED thresholds would not be at convenient figures. The use of a logarithmic bargraph driver which is specifically intended for this sort of application solves both these problems.

The Circuit

Figure 2 shows the full circuit diagram of the Audio Level Meter. The input amplifier is based on IC1, and this employed in the standard operational amplifier non-inverting mode. PR1 provides an adjustable amount of negative feedback over IC1 and enables its voltage gain to be varied over the limits specified earlier.

The two rectifiers each use one section of IC2. IC2a is used in the non-inverting circuit while IC2b is utilised in the inverting rectifier. Each rectifier is effectively an operational amplifier working in the appropriate amplifying mode and followed by a diode (D1 or D4) which provides the rectification. The diodes introduce severe non-linearity since they require a forward voltage of about 0V6 before they begin to conduct readily; extra diodes are therefore used in the feedback path of each amplifier to introduce a non-linearity which counteracts the distortion in the rectifying diodes and gives overall good linearity. For this system to operate properly the output potential of each amplifier must be changed very rapidly, and it is essential to use a device that has a suitably high slew-rate. ICs such as the TL082, LF353, and CA3240E are all suitable alternatives to the TL072, but a slower type such as the LM1458 is not suited for this application.

C2 smooths the rectified signal, and the value of C2 together with the low output impedance of the rectifier circuit and the low value of R7 gives the circuit this required fast attack time. The decay time is largely determined by the value of C2 in conjunction with some of the resistors in the rectifier circuit, and due to the high value of the latter the circuit achieves a long decay time.

An LM3915 bargraph driver (IC3) is used; this device is probably not as well known as the popular LM3914 device. However, these two ICs are similar, and the LM3915 is merely the logarithmic version of the (linear) LM3914. IC3 is used in the bargraph mode as this gives the clearest display for this type of application, but this does give a fairly high maximum current consumption of about 75 to 80 milliamps from the positive supply rail. A much lower maximum current drain can be obtained, if preferred, by disconnecting pin 9 from the positive supply rail so that IC3 operates in the dot mode. Incidentally, the negative supply current is virtually constant at about 5 milliamps.

Construction

All the components including the display are mounted on the printed circuit board, as shown in the component layout diagram of **Figure 3**. Construction of the board is very straight forward, and none of the ICs are MOS types requiring any special handling precautions, but make sure that the diodes are fitted the right way round and the single link wire is not overlooked.

It is advisable to fit the display in a 20-pin DIL IC socket. This helps to raise the device above the other components so that the board can be mounted vertically behind the front panel of the case with the display behind a cutout. Of course, if preferred the display can be mounted off-board, and individual LEDs can be used instead of a proper bargraph

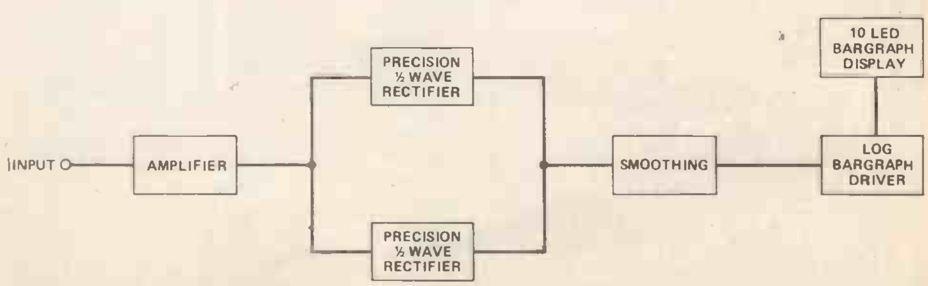


Figure 1. A block diagram of the Audio Level Meter.

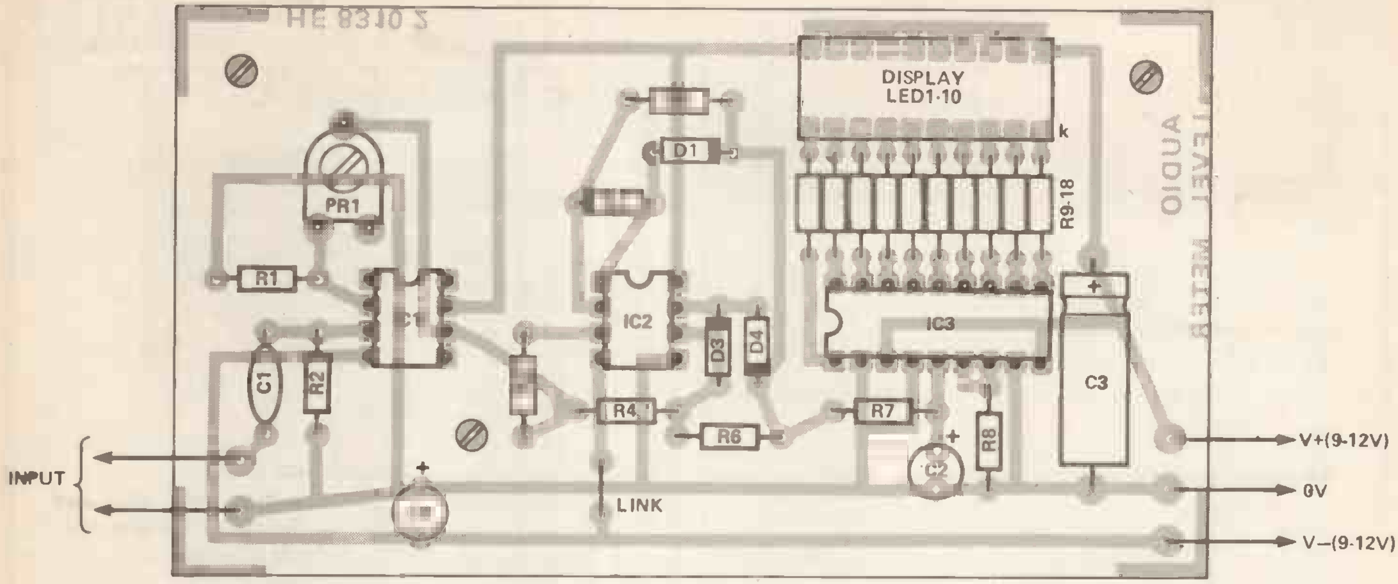


Figure 3. The components, with one wire link.

Parts List

RESISTORS
(All ¼W 5% carbon)
R1 .... 10k
R2, 3, 4, 5, 6 .... 100k
R7 .... 220R
R8 .... 1k5
R9 to R18 .... 1k

POTENTIOMETERS
PR1 .... 470k 0.1W horizontal preset

CAPACITORS
C1 .... 220n polycarbonate
C2 .... 10u 16V tantalum bead
C3 .... 100u 16V axial electro
C4 .... 10u 25V radial electro

SEMICONDUCTORS
IC1 .... 741C op-amp
IC2 .... TL072CP dial BIFET op-amp
IC3 .... LM3915N bargraph driver
D1, 2, 3, 4 .... 1N4148 signal diode
D5 to 14: 10 LED bargraph display any colour

MISCELLANEOUS
Printed circuit board; 20 pin DIL holder for bargraph display; Veropins; screened cable, wire, solder, etc.

BUYLINES .... page 32

display. An advantage of using individual LEDs is that LEDs of different colours can be used, and this can give a clearer and more attractive display, but it can be difficult to produce a really neat display. If you do use a proper bargraph display, make sure that it is connected the right way round. The normal method of identifying the polarity seems to be by having the device identification and other markings on the side of the device which has the anode pins. If the board is mounted horizontally (as shown in **Figure 3**) the display will read from left to right, like a conventional meter. Of course, it could be mounted vertically if it is felt that this would give a more easily interpreted display.

Mechanically construction must be varied to suit the way in which the unit will be used. It can be constructed as a self-contained unit powered from a couple of 9 volt batteries and housed in its own case, and a two pole on/off switch would then have to be included in the unit. Alternatively a mains power supply unit could be used as the power source. In some cases it might be possible to add the unit to an existing piece of equipment, or to build it into a piece of audio gear you are constructing.

If it is built as a separate unit the lead which connects it to the main item of equipment will have to be a screened type with the outer braiding connecting to the earths of the two pieces of equipment. This is not just a matter of preventing stray pick-up of hum and other noise from giving misleading readings from the unit, because without the use of a screened cable it is quite possible that noise could be fed into the main piece of equipment. It might also be necessary to use a screened lead if the unit is housed in the main item of equipment.

Of course, the signal take-off point will depend on what type of equipment the meter is used with. It could, for instance be used to monitor the output of a preamplifier or mixer, but it is obviously not possible here to give detailed instructions on how the unit can be connected to numerous items of audio gear. This is something that the constructor must determine for his or her self, but in most cases the correct method of connection will probably be fairly obvious.

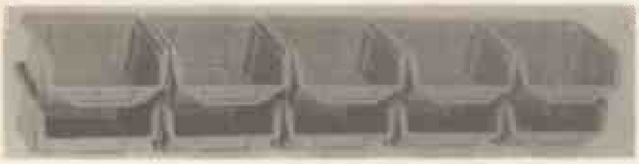
Adjustment

The finished unit only requires one adjustment, and this is to set PR1 for the correct sensitivity. In order to do this the main piece of equipment is fed with an audio signal that represents a level of 0dB (with controls on the main equipment being adjusted for the correct signal level as well, if necessary). PR1 is then adjusted just far enough in a clockwise direction to give a reading of 0dB from the display.

It is unlikely that the meter will prove to be over-sensitive even when set at minimum sensitivity, but if necessary a resistor of about 470k in value can be connected in series with the input to reduce the sensitivity to a satisfactory level.

If an average reading circuit is required it is merely necessary to raise the value of R7 to about 10k so that the attack time of the unit is lengthened and it responds less readily to transients. In the interest of obtaining an easily-read display it is advisable to retain the long decay time of the circuit. **HE**

MEON ELECTRONICS



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A Hobby Electronics hardware review

The FX-COMPUTER

The arrival of the Common, or Garden, microcomputer has made teach-yourself-computing one of the world's most popular pastimes. Now, using the same approach, we have teach-yourself-electronics — is it an advance? Read on . . .

Terry Westwood

The Japanese are said to value educational achievement more than any other nation, so it's hardly surprising when they come up with a self-training kit, for youngsters, in that apparently most essential of modern attainments, Knowing What To Do With A Microcomputer. The FX Computer is described as "A complete introduction to the How, Why and What of Computers and Electronics in the most practical way ever devised". It's certainly an attractive idea. The 'computer' is completely self-contained, not needing (and indeed prohibiting) any mains connection, while the actual components for experimentation are individually built in to plug-in plastic modules — an idea also used in industrial training kits, which removes the need for soldering and (more to the point) extensive desoldering, when experimenting with circuits.

The FX-Computer itself owes more in appearance to one of those fancy radio sets, covered in knobs, dials, loudspeakers and switches, than to a microcomputer. The casing is made of a reasonably tough plastic, but some of the joints give the impression of being rather flimsy. The 'peg-board' where the modules are plugged in to make up the circuit is so arranged that the modules plug in and stay put reasonably reliably — a matter of some importance, as the unit is designed to be used upright. The young (or not-so-young) experienced in the use of Lego bricks will not be satisfied if the modules start dropping out onto the tabletop! But so far this does not seem to be a problem; how the modules stand up to extensive wear and tear remains to be seen. For storage, the area containing the modules is covered by a clear plastic lid which hinges into place.

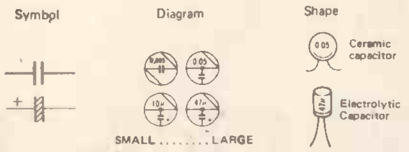
Pure And Simple

The power for all the circuits is taken from six HP7-type batteries. This can prove expensive to run. It's a distinct advantage, though, for young children, to have something which has no connection to the mains. Circuits are built up, simply by pugging the component modules into the 'peg-board' in the right configuration. The modules are made of transparent, green-tinted plastic, with a component symbol etched in white on the top, so it's easy to see what components are being used. The actual component is also easily visible through the plastic. Connection is made via flexible metal strips on the sides of the modules, like ordinary battery-holder contacts.

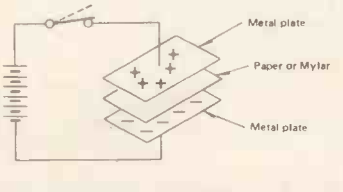
The peg-board matrix provides the power connections, and also connects to other 'modules' within the overall unit, for instance an amplifier with a volume control and loudspeaker, and a CdS cell which acts as a light-sensor for some of the experiments. Extra space is provided for future expansions such as a meter (and the FX's makers provide a number of kits which can be used to extend the FX's capabilities).

Two manuals are provided: one giving 65 electronics experiments, and the other with 100 computer programs. I can't recommend the manuals too highly. It's well known that a picture is worth a thousand words; this depends on the picture of course, but in this case the pictures are not only clear and illustrative, but pictures and text lead naturally on from one point to the next, making the whole thing supremely easy to follow, and I wish that a few other writers of self-instruction books would take a tip or two . . . For each project, the electronics manual gives clear instructions, circuit diagrams, outline identification and layout diagrams, with a simple and direct approach and with many ideas to aid the reader. This makes it much easier for the reader to associate these different aspects of project work. Being laid out step-by-step fashion, it will take a complete novice up to the point where he or she can build a series of simple circuits and understand basic electronics. Also provided are a pair of small cables for connection to external modules, provided with the kit.

• CAPACITOR



A capacitor stores direct current (charges up) by way of two metal plates positioned face-to-face.



The amount of electricity stored (the electrostatic capacity) depends upon the size of the metal plates. Larger plates — more capacity (F).

$$1\ \mathrm{F} = 1{,}000{,}000\ \mu\mathrm{F}$$
$$1\ \mu\mathrm{F} = 1{,}000{,}000\ \mathrm{pF}$$

When a capacitor is fully charged the current stops flowing. Alternating currents however (e.g. voice signals, dial tones) continue to flow. Alternating current changes its flow direction and a capacitor repeats charging and discharging.

A simple description of capacitors and capacitance.

Dubious Connections

Despite the obvious merits of the system so far I have some complaints. The first and most annoying, considering that the FX-Computer is not a cheap bit of equipment, is that some of the modules did not have accurately-machined connectors, resulting in irritating open-circuits. Not a lot of use when you are trying to learn about electronics without learning to solder! Also, some of the circuit symbols on the modules could be confusing to a novice. For instance, some components can be used simply as links, but this is not very well indicated. Maybe the use of an alternative colour for those modules would help? The explanations of the circuits, so far as they go, are fine, but they do not go into enough detail to build up the kind of understanding which could lead to building more complex circuits — for this reason, the electronics is kept at a very basic level indeed. Also, there are simply not enough components. For instance, there is only one transistor — so you cannot even build a bistable. And you can't bias that transistor accurately, as there are not enough resistors and capacitors (although there is a good selection) to produce a full E20 standard set.

Taking that complaint to its 'logical' conclusion (!) is my most serious grumble: that is there is *no logic* or IC tutoring whatever, a factor which seriously undermines the FX-Computer's claim to be a complete introduction to computers and electronics. The most essential link is omitted altogether! With the great increase in the use of digital as opposed to analogue electronics, this kind of thing is to be regarded as basic, not an 'extra'.

So let's look at the actual computer module. This plugs in in exactly the same way as the components, but is a great deal larger. Using the same connections, it provides the facility to learn about interface circuitry. The input is a hex key pad, which is also used as the tonic sol-fa for music programs. The outputs come in the form of a seven-LED strip, as single-figure seven segment display, and a loudspeaker, so that no television or monitor screen is needed.

The computing manual, as with the electronics manual, contains many good descriptions and clear diagrams. The flow charts describing the set exercises are easy to follow, and the manual takes you through an organized learning path, building up knowledge and confidence as you progress. Once again, we have a good idea, but with some serious drawbacks. The computer is designed to do teaching demonstrations, and that is all it can do. It can't be interfaced to any equipment not specifically designed to go with the FX-Computer system. The language used is a very low-level machine-code type, which does not bear a great deal of resemblance to the high-level languages normally used by microcomputer owners. And the manual, again, is excellent as far as it goes, but does not give enough detail for the bright enthusiast to progress further.

An Odd Couple

There is a case of trying to put a quart into a pint pot here: the FX does not have enough memory to provide a high-level language, yet tutition in a machine code gives the absolute novice no real introduction to practical computer programming, while those who *are* interested in code programming will find that the FX's level of electronics is laughable; even were each section of the FX's teaching scheme more extensive and ambitious, they would still be mismatched. I felt that there was a big jump in understanding between the electronics projects and the computing projects, and that the designers could have improved what linking there is between these two sections.

I feel that the FX-Computer is a good start in electronics for children beginning at about 10 to 14 (or adults with no previous experience), but I would not want to pay the price (£69.95) for the system as it stands for my son or daughter. What with low-cost micros available, and an increasing variety of self-teaching booklets, not to mention computers in school, there are too many good alternatives for anyone with determination. Perhaps I feel a confidence that parents not acquainted with computers would not feel, but as for the children — they have plenty of confidence, and will probably meet with plenty of opportunities to learn something about computers!

Electronics is another matter — and it's worth noting that the same companies (just for the record, the Denshi Block Mfg. Co. Ltd., and the Gakken Co. Ltd.) and their UK distributor, Electroni-Kit Ltd., also deal in a whole range of electronics self-teaching modules, in the same style as the FX system, but without the programming part. These are known as EX (sic) kits, and come in a variety of prices and sizes, and Electroni-Kit do a brochure describing the contents. Electroni-Kit, of course, do their own range of small self-teaching kits as well. You can write to them at **Electroni-Kit Ltd., 388 St. John Street, London EC1V 4NN.**

Mind you, the FX-Computer has been awarded a design prize by the Japanese Ministry and Science and Technology, so somebody obviously thinks it's going to work. I continue to feel that it's a very good idea which just isn't capable of giving full value within its adopted format. But, who knows — it may start some interesting trends. **HE**

TESTING FX-MELODY AND CLOCK
(where fitted)

1) Insert the batteries and press the Stop switch of the clock to test the clock unit.
2) Turn on the main switch to light the pilot lamp. A tune will play automatically; control the volume by turning Volume switch.
3) Press the key switch to light the Lamp.
4) If the above operations can be performed correctly the kit is functioning properly.

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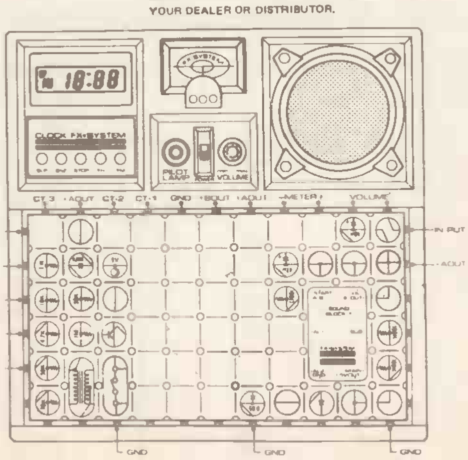


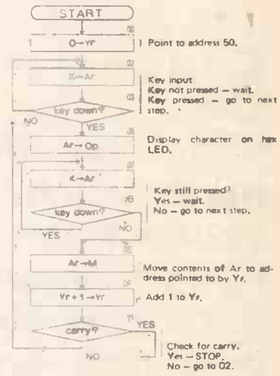
Each project is accompanied by an assembly diagram showing the component modules.

No.22 Use of TIY, AIY and AM to store date in memory

• PROGRAM

address	command	machine code
00	TIY	A
01	⟨0⟩	0
02	KA	0
03	JUMP	F
04	⟨0⟩	0
05	⟨2⟩	2
06	AO	1
07	KA	0
08	JUMP	F
09	⟨0⟩	0
0A	⟨E⟩	E
0B	JUMP	F
0C	⟨0⟩	0
0D	⟨7⟩	7
0E	AM	4
0F	AIY	B
10	⟨1⟩	1
11	JUMP	F
12	⟨1⟩	1
13	⟨1⟩	1
14	JUMP	F
15	⟨0⟩	0
16	⟨2⟩	2

FLOWCHART



This program is another example of two KA commands being used in different ways. At the first KA, the program waits if a key has not been pressed; at the second it waits if a key has not been released.
Program ends when data has been stored at all 16 addresses 50-5F.

Part of a programing instruction, showing a listing and flow diagram.

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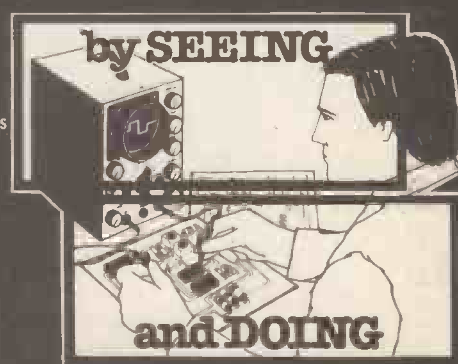

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CAREERS IN ELECTRONICS '83

Expertise in computer electronics does not only lead to the lab. It can lead to a career as a Customer Engineer, and further. This month we look at a special training course, and some other career routes in digital hardware

A Customer Service Engineer in any business needs a combination of technical and management skills which puts him not so much with a foot in each camp, as with both feet in both camps — unlikely as this may sound. This is doubly true of customer engineers in companies dealing in computer systems, where very expensive and specialised equipment is being sold, often in quantity, to non-specialist customers, many of whom (at the present) are dabbling in computer systems for the first time.

Customer Service Engineers are responsible for installing computer systems on the customer's site, and also maintaining equipment and solving any problems which arise, also on site. This calls for a fairly high level of technical skill, coupled with the ability to handle a possibly irate or anxious customer tactfully and maintain his confidence in engineer, company and system!

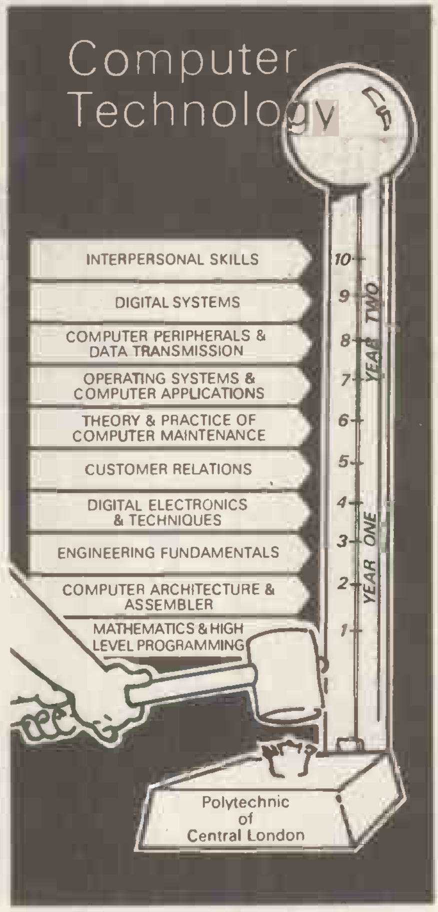
The Customer Engineer is very much his company's direct ambassador. (The vast majority of computer engineers are still men. This is due to lack of women applicants — as one college department said when asked why they had only taken in one woman engineer in a year: "We accepted all the applicant we had".)

He may also have the role of salesman for his company to established customers, consulting them on their future needs and advising them which equipment to install. Taking into account the competition from ever-hungry rivals, this can be a very responsible job indeed.

All-Rounders Needed

It's not surprising that computer systems companies have had some difficulty getting enough engineers of the calibre they want, even from among college leavers (or school leavers) with the right technical background. This is the reason why five major computer systems companies have banded together with a technical college of good repute, the Polytechnic of Central London (PCL) to devise a full-time, two-year course in computer technology which not only leads to a TEC (Technical Education Council) Higher Diploma, but is tailored specifically to the needs of the kind of company involved, and is more

Helen Armstrong



broadly-based than most technical courses.

The five companies involved are Data General, who specialise in broad, compatible product lines from microprocessors to multi-processor systems, plus peripherals; Data Logic, who deal in hardware, consultancy and customer service; the Digital Equipment Corporation, who invented the minicomputer, Harris Communication and Information Processing, who produce advanced equipment for information technology, and Hewlett Packard, a major computer and instrumentation manufacturer.

Hewlett Packard is one of the world's biggest electronics companies, and their Computer Systems side, which they developed comparatively recently, is their fastest-growing and principal market area now, with 56% computer products.

World sales in 1982 well exceeded four billion dollars, (£169 million pounds in the UK) and there are 1300 Sales and Service employees in the UK, out of more than 67,000 employees worldwide. They are well known in their fields for measuring instruments, and medical electronics, but their computer products belong in the mainframe and minicomputer class, with desktop and realtime technical computers, business computers, and factory automation systems, word processing and a personal computer aimed at businessmen. Their pride and joy is the desktop-sized HP9000, which has the capacity of a 32 bit mainframe and is based on their custom NMOS III microprocessor.

Difficult Choice

While we're on the subject of careers in electronics, Hewlett Packard was formed in California in 1939 by Bill Hewlett and Dave Packard — in Packard Sr.'s garage — with a new form of audio oscillator designed by the partners. Great oaks from little acorns — but that's another story.

Mike Faithfull, an electronics engineer of long experience both outside and inside Hewlett Packard, spoke to Hobby Electronics both about the PCL course, and generally about entry into the many fields of electronics embraced by a large engineering concern.

As well as being an electronics man, Mike is also responsible for interviewing candidates for the PCL course on behalf of Hewlett Packard — one of a panel of assessors representing the five companies involved.

"The main problem in selecting people has been the combination of skills needed. Even the initial screening can be tricky, because PCL are used to selecting people by their academic achievements. That, and the fact that most applicants are very young. Youngsters change a lot in two years. You have to be able to spot a Customer Engineer in his unfledged state!"

There are, of course, minimum academic qualifications required. Candidates should have obtained (or expect to obtain) four GCE passes, including one at A level, in a mathematical or physical science subject, and an O level in English. Equivalent qualifications from TEC, CGLI, OND or ONC are also considered. Once the applications have been screened, applicants are interviewed by the selection panel. Each successful applicant will be sponsored specifically by one of the sponsoring companies.

Students on the course, as well as their local authority grant, get a bursary of over £600 from their sponsor, as well as employment by the sponsoring firm during the long vacation at around £350 a month (which is tax free for anyone with normal student status), giving a real taste of practical working experience. It's also an opportunity for the trainee to work in different departments of the sponsoring company and see how the whole show runs.

Success Rate

Employment is not actually guaranteed at the end of the course, but Mike made it sound as if the trainees have to try quite hard in order to fail. "We have a better than 90% success rate" he says. "I'm astounded, when you look at the difficulty in selecting raw recruits." Nor do the sponsors have a cast of thousands to choose from: although they advertise in the press and approach local careers offices, they only just made their quota of students this year. This is less because the students they are looking for are rare creatures (although they are) than because conventional academic selection is geared more to qualifications and less to the right mix of technical aptitude and personality.

However, where a likely applicant doesn't have the required qualifications, Hewlett Packard is sometimes prepared to offer in-house training for two years, along with day release to take a TEC course, before the trainee goes out into the field. This is not commonplace in computer engineering, although it's not uncommon in other fields of electronics. As Mike explained, "Computers are just too big." Other types of equipment can be brought back and serviced in the company workshops, allowing an even workflow and time enough to allow day release. Computers need to be serviced on site — and immediately, or sooner — so that the service force needs to be constantly on call.

But Hewlett Packard's swift expansion on the computer side has led them to regard good customer engineers as an investment. Before the PCL course was devised, there was no standard training for customer engineers, and companies relied on attracting experienced engineers from their rivals — or poaching, as it is known in the trade! But this 'free exchange of talent' can no longer keep up with demand.

Casting an eye down the course's subject list is instructive: Mathematics and High Level Programming, Computer Architecture and Assembler, Engineering Fundamentals and Digital Electronics and Techniques are followed by Customer Relations; Theory and Practice of Computer Maintenance, Operating Systems and Computer Applications, Computer Peripherals and Data Transmission, and Digital Systems are followed by Interpersonal Skills. Definitely, the candidates' ability, or potential ability, to present themselves positively, and communicate well is an important factor in selection. Mike Faithfull adds that interpersonal skills are highly rated by computer companies, but, in his opinion, not highly rated enough: he would place their importance at 30% to 70% with engineering skills.

Students at the Polytechnic of Central London: computer engineering calls for the ability to unravel the mysteries of the computer both through its own language and through the hardware itself.

Teamwork

Because the role of the customer engineer involves not only being able to install, maintain, repair, extend and trouble shoot computer systems, but also being able to do so under the nose of the customer, the course emphasises teamwork and the combination of individual and collective efforts from the start.

"There is not the emphasis on individual marks that you expect on a normal academic course" Mike explains. "Obviously individual study is essential, but within the college the work is structured as it would be in a business context. There is both group pressure, and group help. Everyone is on first name terms and has to work together on projects and presentations."

The sponsoring companies don't remain aloof from the process; senior staff from the Managing Director downwards hold lectures and seminars for their students and pass on the benefit of their first-hand experience in the business — a style of motivating management commonplace in the USA and still uncommon in the UK. Hewlett Packard have found that, given the chance to contribute ideas, use their initiative and take responsibility, employees are more involved in their work, and happier (not to say more productive) for it.

Says Mike "We're looking for leaders rather than followers" — but he has no rigid way of defining the right applicant. Attention to detail — a businesslike style of dress, the ability to pay attention to and show an interest in the panel's questions, and express himself well in return, being firm without being aggressive and polite without being timid — are some of the bald character traits which a successful candidate might show, but Mike admits that it is 'gut reaction' which decides the final choice. This is the more important as successful students could well graduate from customer engineering to management or more specialised engineering, and the selection panel has this prospect in mind.

So much for the 'personality' aspects of customer engineering; what about the engineering? The academic qualifications are fairly basic, less than would be needed for, say, a university course in engineering, and a comprehensive education in computer engineering is given at the Polytechnic. So what divides one candidate from another at selection stage? "They need a feel for practical things" says Mike. "We're looking for people who have a strong amateur interest in practical things: electronics, car mechanics, house wiring, amateur radio, — people who can make things work. Some people think we must be looking for people who have ZX81s and know a bit of BASIC — but this has very little relevance to hardware."

Mike has reason to appreciate practical ability with electronics. Starting from a hobby interest in electronics, Mike took the decision to work at something he enjoyed, and worked his way up from mechanical assembly ("I knew how to solder") via prototype wiring and R&D at British Aerospace (he worked on Concorde and is proud of the fact that his 'bits' are still part of the design) to Hewlett Packard while still under thirty. He reckons that five years' practical experience in industry — for the person who is attentive and watches out for opportunity — is as effective as five years' study but "The piece of paper is always worth having if possible."

No Time Like The Present

Mike believes that the present is a very good time for anyone wishing to work in computer engineering to get into the Customer Engineer side. The industry is expanding very fast, and a good supply of skilled people is needed to get the machinery up and running. In a few years, with servicing techniques more automated and standardised, the demand for skilled troubleshooters will have shrunk considerably, and the field will be carved up among technicians out on the road servicing and replacing modules, and a smaller backup force of highly skilled customer engineers for the real problems. Today's customer engineers are looking forward to a future where their versatility will open doors into management, Research and Development and higher-level computer engineering.

Hewlett Packard also take in graduates from the 'Milk Round', their representatives visiting nineteen universities in 1982 and, again, look for personal as well as academic qualifications. Once accepted, the graduate will be both sponsored out on training courses — IEE classes, for instance — and is encouraged to extend his or her own knowledge and put ideas forward in their field. There are also apprenticeships on the bench electronics side. They seek for, and take in, people from all kinds of sources — local advertising, YTS schemes, Job Centres, schools and colleges, and also employ a fair number of sandwich course students who are not destined for future employment with the company.

One important tribute to their motivational style of management is that engineers who have completed the training course successfully nearly always accept employment with the company, although not compelled to do so, where some big corporations find themselves losing their trainees after the minimum time contracted, as they go in search of greener pastures or a more congenial atmosphere. And before we leave Hewlett Packard to look at a couple of other companies who employ Customer Engineers, some advice from Mike Faithfull for anyone who has ever applied for a course or a post — or several — and has been unlucky. "Keep trying" he says. "Don't take disappointment personally. If you keep applying, you will find the right place eventually. A lot of failures are simply bad luck; but it does pay to check that your approach has been right."

Other Companies

Another large company which sponsors students in a course which is specifically linked to industry needs is Ferranti Computer Systems. The course which they sponsor at the University College of South Wales at Bangor, along with GEC Marconi Electronics, aims to combine undergraduate study with industrial experience in an integrated four-year course, with a full ten weeks of industrial training during the long vacation — a rather different deal from doing a general arts or science degree!

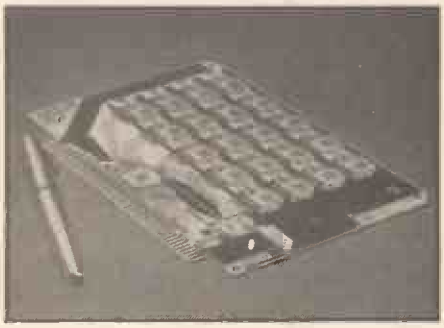
Sponsored students receive a bursary while on the course, and a salary while working in industry. The course is divided into Engineering Science, Mathematics and Physics for Engineers, and Support Technology; the latter including Production, Commerce and Industry, Quality and Reliability and the appropriately-named 'Human Component' course! The whole training, while very comprehensive, is far more specifically aimed at practical requirements than the purely academic, theoretical education offered by normal university courses. Application to this and similar courses is through UCCA in the usual way for a University.

Basic entry requirements for the course are A levels (Grade C or above) in Maths and Physics, plus O levels in English Language and two other subjects, or an ONC, OND, or TEC equivalent.

Ferranti also operate a Graduate Training Scheme of between one and two years for graduate engineers and programmers at their technical training centre in Bracknell — fields fall roughly into Engineering, Programming and Technical Documentation. Training is a combination of on-the-job, and coursework at the centre.

Computer giants IBM recruit both experienced Customer Engineers — often ex-BBC or British Telecom — and untrained applicants with A levels in Maths and Physics or equivalent qualifications. Training takes at least four years, and is a combination of on-the-job and classes; again, as the Customer Engineer is effectively a representative for the company, emphasis is placed on a businesslike approach and ability to communicate, as well as technical skills.

Apart from Customer Engineering, IBM have an intake of Higher TEC students for jobs in product testing, test engineering and quality control; much of IBM's equipment is designed by them in-house, including microprocessors, so there are computer-related jobs in



Above: the memory board from the HP9000 desktop computer, compared in size to an ordinary fountain pen. Below: Generating graphics on the HP9000 itself.

production engineering and production management as well. Graduates are recruited on the 'Milk Round' for design and R&D careers, and at the other end of the scale there are jobs in testing and assembly on the manufacturing side — all under the umbrella of one large company.

Allied Business Systems have also switched from recruiting, primarily, experienced customer engineers with GCE or OND/HNC qualifications, to taking on trained but inexperienced engineers, often from TOPS courses. These trainees are given a ten week initial training course in the company's products, and another four weeks later. In other fields — R&D, workshop and production engineering, ABS recruit mostly experienced engineers, through electronics employment agencies. Such agencies are also a source of experienced customer engineers — good customer engineers are still sufficiently scarce for a company like ABS to feel that it is not worth their while advertising through the press; agency recruitment, while it is expensive, can get the right people for the job, quickly. And as always at the business end of industry, people are in demand who have specific skills and, even more important, the know-how in using their skills to get results.

The message is, that if you want to work with computer hardware, it pays to consider training with a specific bias in that direction. This can mean seeking either a sponsored course, or a trainee position in a computer systems company. Sources of information are the usual ones: schools and local authority careers offices, advertising in local, national and specialist press, TOPS for older students, and speculative applications to firms in the field. Discerning use of directories and the periodicals rack in your nearest central library is called for. Training for a specific career is hard work and calls for dedication, but the rewards can be considerably more discernable than those beyond a purely academic university or polytechnic course.

One of Hewlett Packard's several R&D and manufacturing sites.

Many thanks to Mike Faithfull and Hewlett Packard for talking to us about the Polytechnic of Central London's Computer Technology course; thanks also to ABS, Ferranti and IBM for supplying further information.

HE

*see next page

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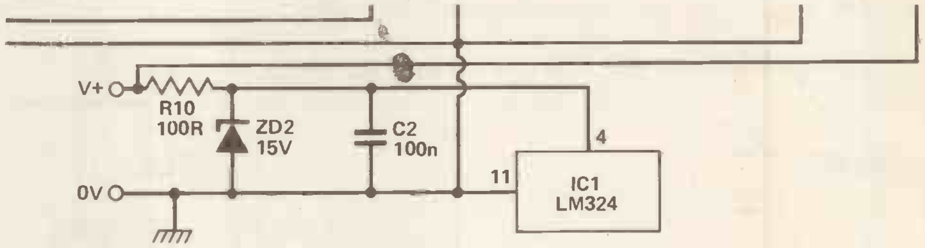
FORWARD BIAS

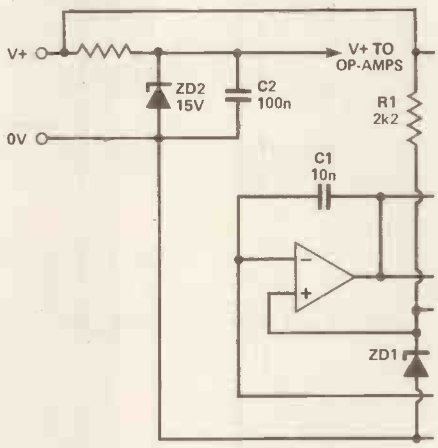
Questions, answers and errata from readers and writers.

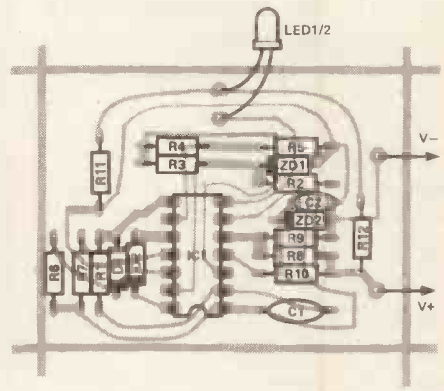
The Bat Light
(HE June '83)

There were three errors in the Bat Light diagrams: R12 was omitted from the Component Overlay although it was quite clear in the photograph of the assembled Bat Light board; in **Figure 1**, R10 etc. should be connected direct to V+ and not via C2 and ZD2; in **Figure 2**, R1 etc. should be connected direct to V+, not via C2 and ZD2, while the positive rail should go to the op-amps.

However, if the project is constructed according to **Figure 3**, with R12 added as shown here, the project should work with no problems.







The diagrams show the correct details from Figure 1 (above) and Figure 2 (below left), and the whole of Figure 3, the component overlay, with R12 added.

Did You Notice Our Sneak Preview?

The sharp-eyed among you will have noticed that the **Sound Pressure Level Meter**, as featured on page 17 of the September issue, had two probes which were not described in the project.

Were they for inserting into the listener's ears? Or for investigating the sub-plughole noise generated by draining bathwater? No. In fact, they belong to the Hi-Voltage Meter, as featured on page 28 of this issue. You weren't going mad. We were.

Tremoleko

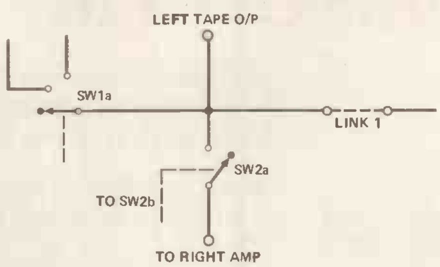
Switch Two (SW2) was inadvertently omitted from the PCB overlay drawing of this project. It should connect between the two spare pads (because we left the switch out!) situated between R2 and PR1.

COLLECTED BOOBS

Continuing excerpts from the Hobby Electronics Errata Box.

Tantrum Amplifier
(HE October '79)

Figure 1: SW2 is incorrectly drawn; the correction is shown here. The PCB is correct.



Parts List: The push button switches are obtainable from RS Components (via your local components stockist). You need four 2-pole changeover switches, four buttons, and a four-way mounting bracket C2, 102 can be PCB mounting electrolytic tapes.

The **text** running from p.11 over to p14 has been scrambled — however, it is all there and the meaning will be clear to anyone reading it through.

Balance Control: Disconnect the ends from C13 and C113 and take them to the sliders of RV3a and RV3b respectively.

Multi Option Siren
(HE October '79)

Circuit Diagram: Many people have wondered what happened to RV4. Look carefully at the photograph, and you'll see that lack of space meant that it had to go on the back of the box.

Figure 3: The wire coming from the junction of R12, R3 should be marked SK1 *not* SW1.

HEBOT I
(HE November '79)

The original HEBOT is now totally extinct, as the chassis and motor are no longer available.

Digi-Die *(HE January '80)*

Figure 5: The labels IC2 and IC3 on the Overlay should be swapped over. The link from IC2 pin 16 and IC3 pin 14 to the positive supply has gone missing — just wire in a link from these pins to the pad that goes to the battery positive (junction of R1 and R2).

Short Circuits: Noise Gate
(HE January '80)

Circuit Diagram: Q1 is a P-channel FET as shown, and not N-channel as stated in the text.

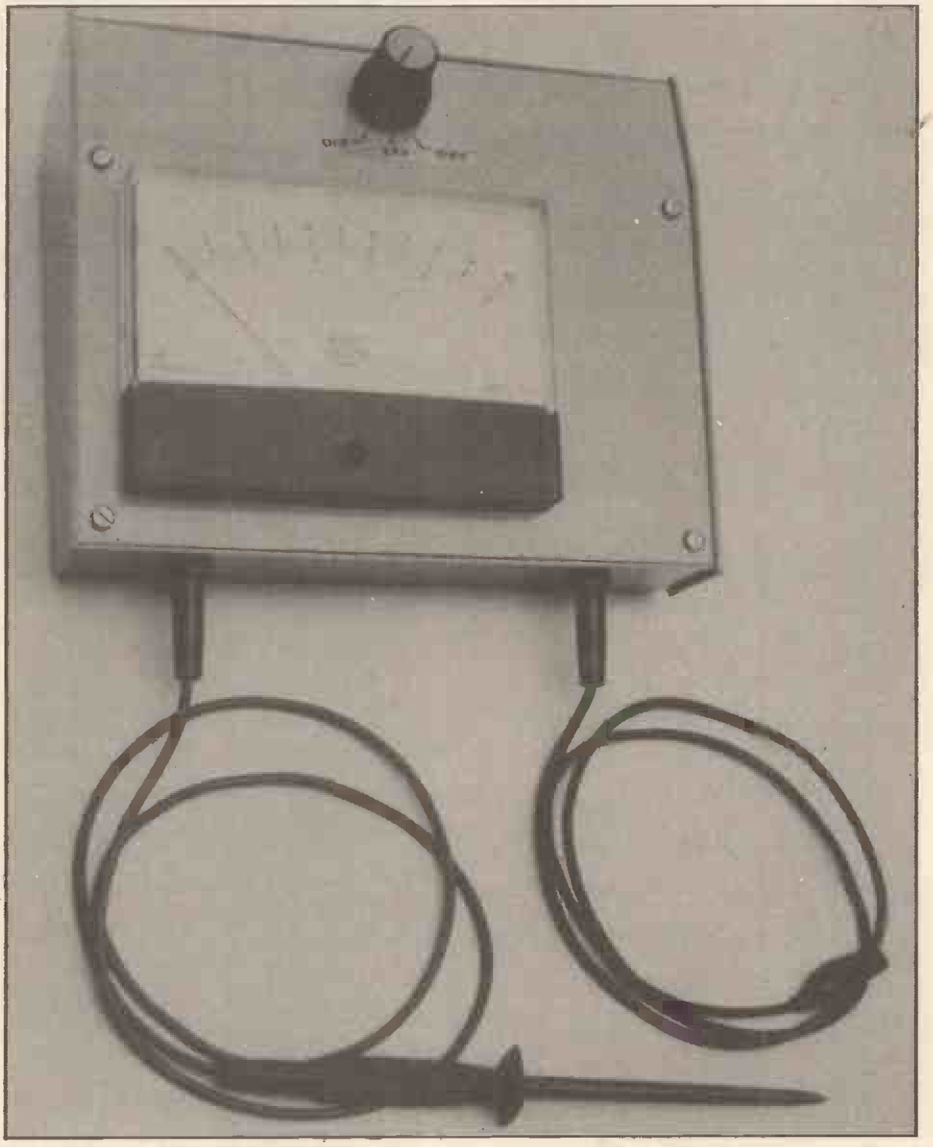
HE

Hi-Voltage Meter

Lightning from a clear sky? Check it out with the HE Hi-Volt Meter.

James E. Aman

DANGER 10,000 VOLTS!! But now this meter tames the kilovolts and brings high voltage measurement easily into the range of the experimenter's pocketbook. If you've been left "holding the probe", and getting nowhere because of the 1kV limit on your ordinary voltmeter, then this is the logical expansion to your compliment of bench test gear. And at around £15, one really can't afford not to build this project, if only to "save the bacon" of your digitally delicate devices.



High Voltage Circuit

The meter uses (now) readily available ultra-high value thick film resistors to make up the bulk of a resistor chain forming voltage divider. The measuring device is a MOSFET input op-amp which sports the facility of being able to sense voltages below the negative supply rail, making dual supplies unnecessary. Thus with the extremely high input resistance of 1000MR coupled to the FET op-amp we realize a circuit capable of monitoring up to 10 kilovolts without significantly affecting the circuit under test. When metering 10kV, an input impedance of 500 megohms draws 20uA which suggests that a resistor of a quarter watt is a bit "near the knuckle". Increasing the input impedance to 1000 meg ohms and using 0.4 watt resistors was more acceptable. Resistors 1-10 reduce the voltage across R11 to a manageable level, which is then sensed by IC1, and produced at its output to drive the current meter. IC1 is connected as a voltage follower, which presents the same voltage at the output as it sees across R11 (its input). It therefore is acting as an impedance transformer and supplies current to the 100uA

Parts List

RESISTORS
(All ¼ watt 5% unless noted)
R1-10 .... 100M 0.4W
R11 .... 100k 1%
R12 .... 4k7
R13 .... 2k2

POTENTIOMETERS
RV1 .... 10k 1in
PR1 .... 10k horiz preset
PR2 .... 5k horiz preset

CAPACITORS
C1 .... 100n disc ceramic
C2 .... 1000u 16V radial electro

SEMICONDUCTORS
IC1 .... CA3140 MOSFET op-amp
ZD1, 2 .... BCY88C3V3

MISCELLANEOUS
M1 .... panel meter 100uA
SW1 .... 2-pole 6-way rotary
PCB; case (see Buylines); HV probe and leads (see text); PP3 battery and clip; knob, wire, nuts and bolts etc.

BUYLINES .... **page 32**

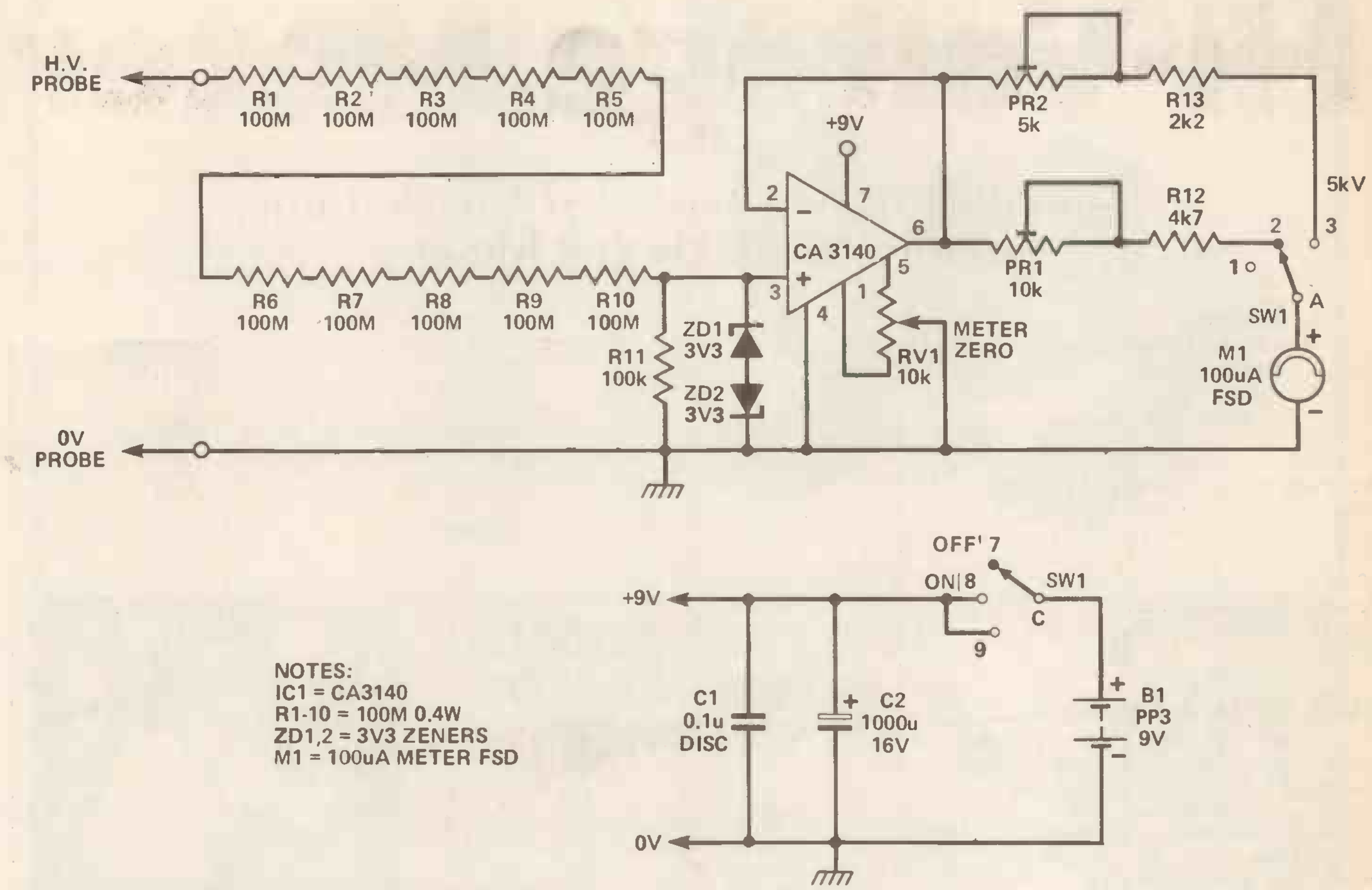


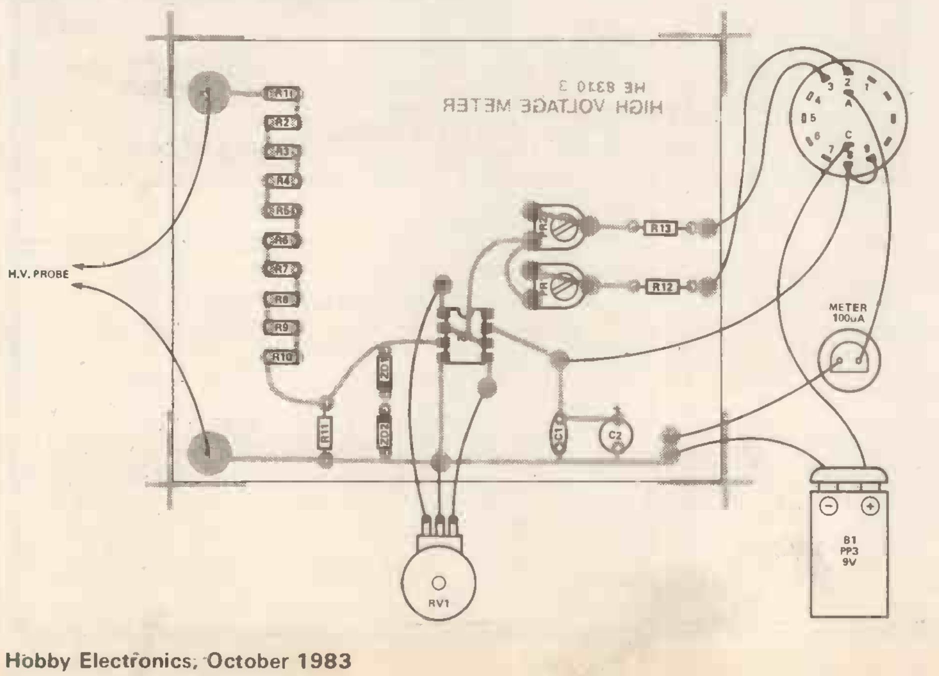
Figure 1. The circuit, in two parts.

meter. This is connected with a series resistor (adjustable for calibration) making it into a voltage meter, reading in kilovolts.

Calibration

The calibration procedure is sweet and simple. First zero the meter on the 5kV range, with the probes shorted together, via R16 on the front panel. On the 10kV range simply connect 1V DC across R11 (negative to earth) and adjust PR1 to a full scale reading of 10kV. Then, on the 5kV range connect 0V5 DC across R11 and adjust PR2 for a full scale reading of 5kV. The meter face should be scaled 0-10kV in 1kV steps across the top of the meter and 0-5kV in 1kV steps across the bottom of these same gradations.

Figure 2. The simple component layout.



Construction

Construction of this project should pose no real problems. The high impedance resistor chain should be soldered and trimmed, leaving no sharp points on the leads. The meter-zero pot should be mounted on the front panel and the meter should be wired between the wiper (pin A) of SW1 and earth, as shown in the circuit diagram. Care should be used when installing IC1, as it is static sensitive.

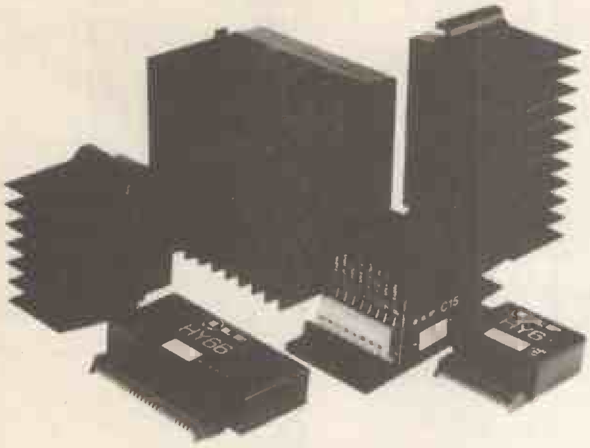
Probe connections can be made through the case either by means of 4mm banana plugs and sockets or by (in the interest of safety) feeding the probe wires directly through matching holes in the case. In the latter case the leads should be knotted on the inside of the case, as a strain relief, and held in place with Superglue.

A HV probe with a rubber-booted crocodile clip may be used instead. The experimenter may prefer to test the HV source by first clipping the meter to the points under test and then switching on, but make sure power is *off* before approaching high voltage points! This method, used with sensible caution, can prove to be a safer and a less nerve racking procedure, since the probe isn't at hand during "power on" testing.

HE

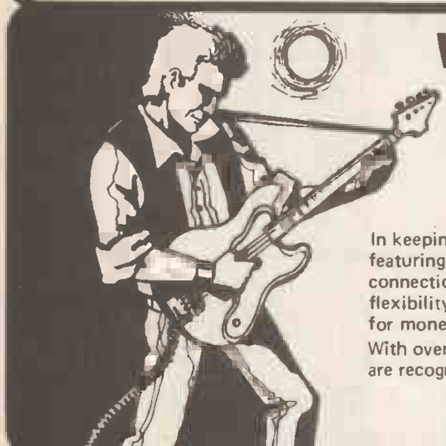
AMPLIFIERS

ILP



Over the last few years we have received feedback via the general public and industry that our products are from Taiwan, Singapore, Japan, etc... ILP are one of the few 'All British' electronics Companies manufacturing their own products in the United Kingdom. We have proved that we can compete in the world market during the past 12 years and currently export in excess of 60% of our production to over twenty different countries — including USA, Australia and Hong Kong. At the same time we are able to invest in research and development for the future, assuring security for the personnel, directly and indirectly, employed within the UK. We feel very proud of all this and hope you can reap some of our success.

I.L.Potts — Chairman



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.D. 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 15K Ω 3V rms into 8 Ω
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.

BUYLINES

Audio Level Meter

An all-purpose audio level meter that will find a home in many hifi systems and in semi-professional recording studios, where constant attention to the recording level is always required!

Most of the components are readily available, with only the TL072 and the 10-segment LED array likely to prove difficult. The TL072 is stocked by **Rapid Electronics**, for instance, as well as several other suppliers, but the LED array may have to be ordered — quote the Radio Spares part number 586-706 (for a red display) or 588-033 (if you'd prefer green), and your favourite supplier should be able to get it for you. Alternatively suitable types (again in red or green) are stocked by **Technomatic.**

Polycarbonate capacitors can be somewhat hard to come by, and are a little expensive for the average hobbyist: polyester types are an adequate substitute, and although the PCB is laid out for an axial capacitor, a C280 or equivalent polyester can be 'made to fit'.

Because of the many different potential applications of the Audio Level Meter, a case has not been spedified. However the cost, excluding case and PCB, should be in the region of £6.50.

Ultrasonic Alarm

The first thing to note is that a case or other enclosure has not been specified for this project. Although the author suggests standard metal or plastic boxes, a favourite trick is to disguise an alarm system such as this as an otherwise ordinary piece of household equipment — a bookshelf loudspeaker unit, for example. So, all things considered, we decided to leave the final choice to the individual.

The dimensions of the project can easily be judged from the PCB foil pattern reproduced on page 72, allowing virtually any shape of enclosure to be designed around it.

The components are almost all standard and can be obtained from one of the larger mail order companies, such as **Maplin Electronics.** Several of the transistors specified may not be available, but substitutes such as the BC184 or BC209 for the BC239; or BC182, BC237 for the BC171, are quite acceptable. Similarly $\frac{1}{3}$ watt resistors, which may be supplied in some instances, can be used instead of the specified $\frac{1}{4}$ watt types.

The estimated cost of the Ultrasonic Alarm, excluding PCB and case, is around £10.00.

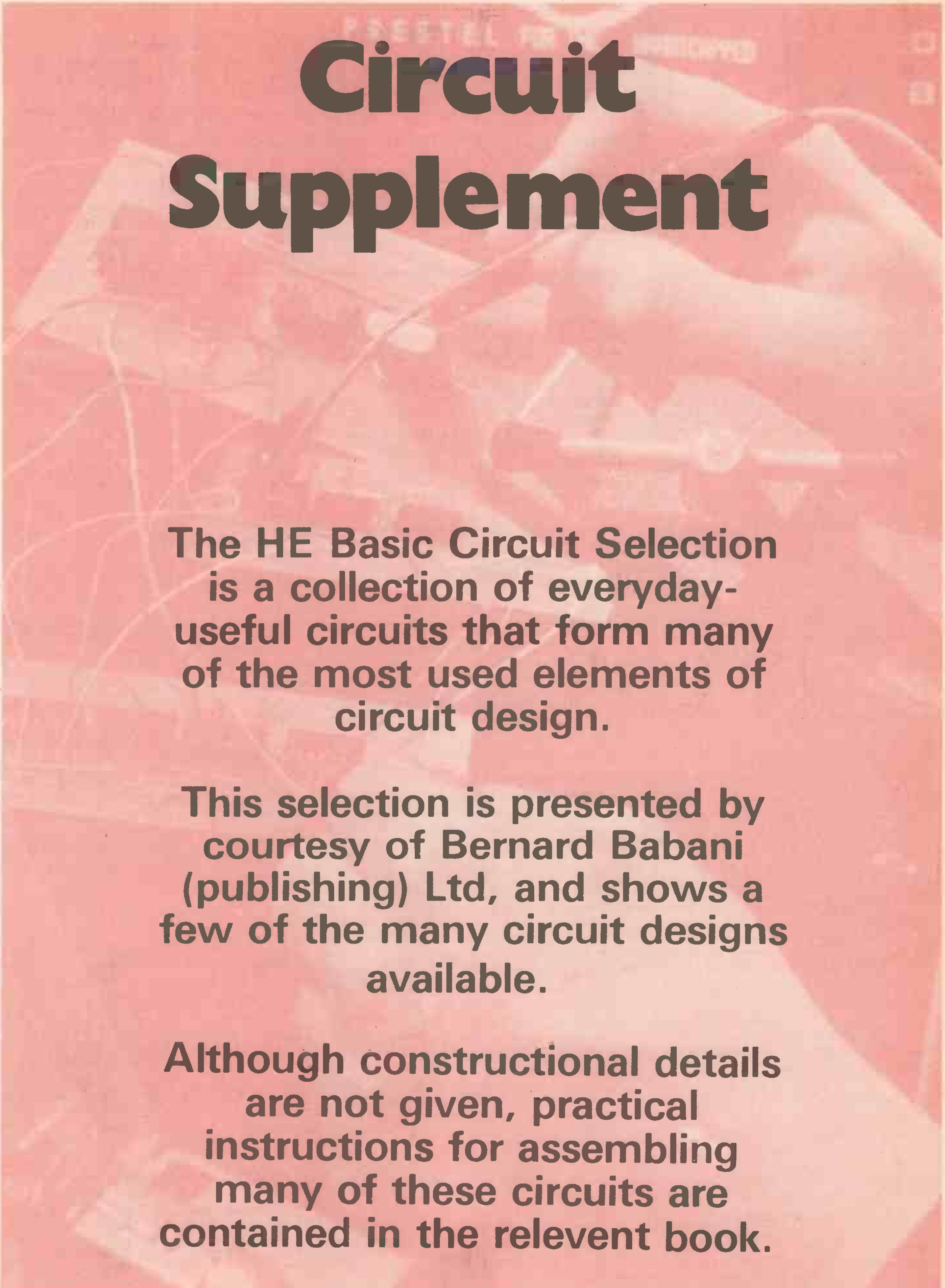
Hi-Volt Meter

Astute readers may have noticed the "special preview" of this project on page 17 of the last issue. Yes, that's right — we made a mix of the pix. However as you'll see by comparing the pictures in the September issue the two projects use virtually identical meters and are housed in a box that looks . . . well, they're very similar aren't they?

That being so, we again called upon **Greenweld Electronics,** who once more came to the rescue with an offer to supply all the components for just £21.95, including case, meter and high voltage probes. This price, as usual, excludes the cost of the PCB from our very own PCB service.

Trump Card

The Trump Card PCBs and 23-way-Ace edge connector are being supplied by **Innovonics,** 147 Upland Road, East Dulwich, London SE22 for £5.95 including VAT, p&p.



Circuit Supplement

The HE Basic Circuit Selection is a collection of everyday-useful circuits that form many of the most used elements of circuit design.

This selection is presented by courtesy of Bernard Babani (publishing) Ltd, and shows a few of the many circuit designs available.

Although constructional details are not given, practical instructions for assembling many of these circuits are contained in the relevent book.

555 Oscillators

The 555 timer integrated circuit has been featured in a great many projects for the electronics constructor, and this is not surprising when one considers the low cost and versatility of this device. It is well worthwhile being familiar with the capabilities of this device, and it will be considered in some detail in this section.

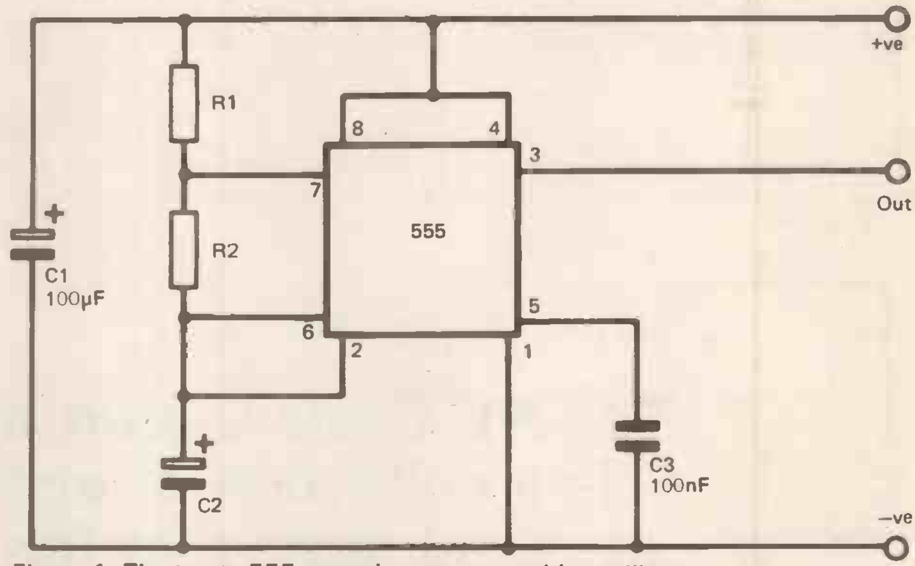


Figure 1. The trusty 555 geared up as an astable oscillator.

The standard 555 astable configuration shown will probably be familiar to most readers. It is really a form of relaxation oscillator with C2 first charging to two thirds of the supply voltage though R1 and R2, and then discharging through R2 to one third of the supply voltage. The operating frequency is therefore set by the values given to R1, R2 and C3, and is given by the formula:

Frequency = 1.44/(R1 + 2R2) C2 Hz

The reason for adding the value of R1 to double the value of R2 (rather than simply adding the two values together) is that R2 is both the charge and discharge paths of C2 and therefore has double the effect of R1. Rather than calculating the operating frequency with the resistance in ohms and the timing capacitance in farads it is better to use Megohms and microfarads. This avoids having very low figures for the capacitance and very large figures for the resistance.

Typical values for the timing components would be 4k7 for R1 and R2 plus 100nF for C2 giving an operating frequency of just over 1kHz.

There are, of course, certain limitations on the circuit values, and it is advisable to keep the combined resistance of R1 and R2 to no more than about 10MR. A resistance substantially higher than this could gi e rather unpredictable results or might result in the circuit failing to oscillate at all. This is due to the very low currents that would be present in the timing circuit, and consequent effects tiny input currents drawn by the 555 or leakage through C2 might have.

There is also a limit on the minimum value R1 should have, and this can be calculated by dividing the supply voltage by 0.2. This would, for example, give a figure of 45R with a 9V supply. In practice it is often necessary to use a value very much higher than this absolute minimum figure, and one reason for this is simply to keep the dissipation in the 555 down to a reasonable level. It should also be remembered that an internal transistor of the device places a virtual short circuit from pin 7 of the 555 to the negative supply rail during the discharge period of C2, and apart from any effects on the 555 itself, a low value component in the R1 position will give a high dissipation in this resistor and a very high current consumption during the discharge period. A minimum resistance of about one kilohm is therefore more realistic.

Pin 3 is the output of the 555, and this terminal goes high while C2 is charging and low when it is discharging. This gives a rectangular waveform at the output of the device, but it is not a squarewave having a one-to-one-mark-space ratio. This is simply because C2 charges through both R1 and R2, but it discharges thorugh R2 alone (plus the insignificant impedance of the discharge transistor within the 555).

The output of the 555 gives a peak to peak voltage almost equal to the supply voltage used, and it is at a low impedance. The device has a form of class B output stage, and it can source or sink up to 200mA. However, with high output currents the output is pulled well away from its normal (no load) level, and a combination of large output voltage and high current cannot be supplied directly by the device.

An output signal can be taken from across C2, but this is only permissible if a very low output current is taken since any loading here obviously has an effect on the charging and discharging of C2. The higher the values of R1 and R2, the less cutput current that is available. The waveform across C2 is roughly triangular, but C2 charges and discharges exponentially and so this is obviously not a linear triangular waveform. Also, like the output at pin 3, the mark-space ratio of the signal is not one-to-one.

A slight shortcoming of the 555 is that once per output cycle the supply is "crowbarred" and a negative voltage spike is introduced onto the supply lines. C1 is included to decouple this noise.

C3 is also a decoupling capacitor, and this removes any stray pick-up at pin 5 of the 555.

Any electronic circuit will only operate between certain supply voltage limits, and this is something which must always be borne in mind. For the 555 device the minimum and maximum supply potentials are 5V and 15V. The 555 actually has a maximum permissible supply voltage of 16V, but with any figure of this type it is advisable to leave a small safety margin and 15V is therefore the maximum nominal supply voltage. The maximum operating frequency of the device is at least 500kHz, and there is no properly defined lower limit to the operating frequency. The lower limit is determined by the quality of the timing capacitor C2 which for very low frequencies must be a polarised type such as a tantalum or electrolytic type. Although in theory it is perfectly alright to use a capacitor of (say) 100uF with a total timing resistance of several megohms, in practice this is unlikely to work. The

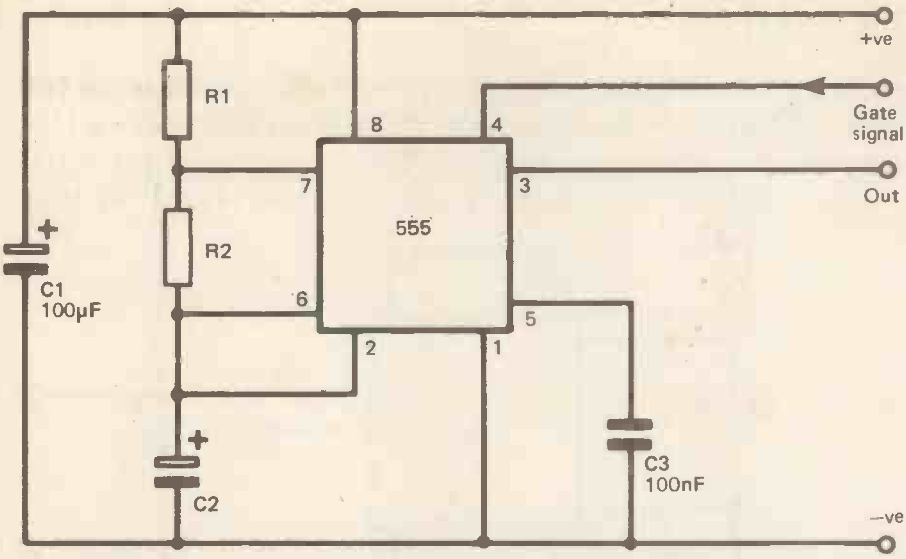


Figure 2. The gated astable can be used for producing tone-bursts or a gated clock signal.

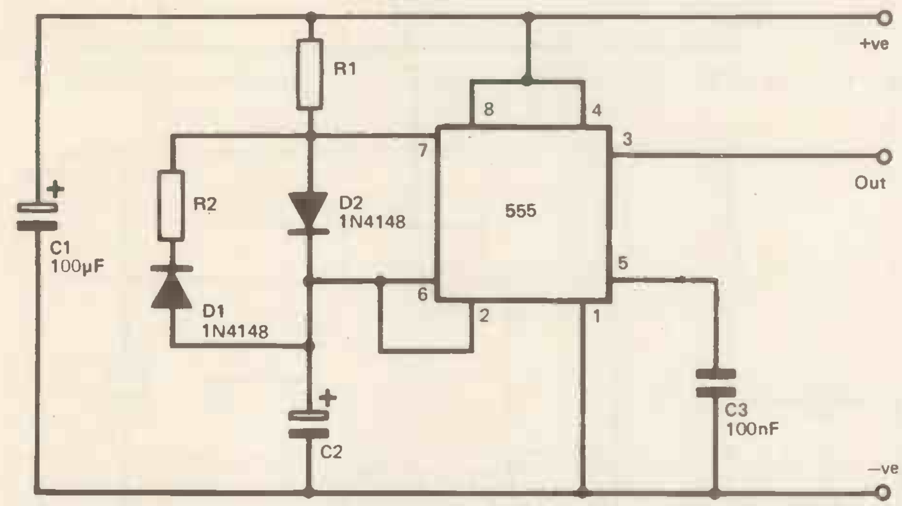


Figure 3. The mark-space ration can be varied continuously if R1, R2 are replaced by variable resistors.

leakage resistance of the capacitor may well be only a few hundred kilohms, and this would limit the charge voltage to a level which would not permit correct operation of the circuit. Tantalum types are generally much better in this respect than electrolytic capacitors, and such a combination of timing component values might work well using a tantalum capacitor.

A point that is sometimes of importance, especially when the 555 is used in very low frequency applications, is that the first half of the initial cycle is longer than that obtained on subsequent cycles. This is simply due to C2 starting with zero charge on the first cycle, whereas it starts with a charge equal to one third of the supply voltage on subsequent cycles. This is not unique to the 555 by any means: in fact most simple C-R oscillators produce a longer initial cycle.

Gated Oscillator

The 555 can be used as a gated oscillator, as shown. This circuit is basically the same as the one shown above but instead of pin 4 of the 555 being taken to the positive supply rail it is fed with the gating signal. Pin 4 must be taken below about 0V5 in order to switch off the oscillator, and the output goes to the low state when the circuit is gated off. The input current to pin 4 is only about 100uA. If pin 4 is left floating it is normal for the oscillator to operate, incidentally.

The current consumption of the 555 varies from about 3mA with a 5V supply to about 10mA with a 15V supply (it is about 7 to 8mA with a 9V supply).

Adjustable Duty Cycle

As mentioned earlier, it is possible to produce a 555 astable circuit that can give any desired mark-space ratio, and a circuit of this type is shown. This has steering diodes D1 and D2 which direct the charge current through R1 and the discharge current through R2. Thus a 1 : 1 mark space ratio can be obtained by simply making R1 and R2 the same value. If R1 is made larger in value than R2 the charge (high) time is made proportionately longer than the discharge (low) time. Similarly, making R2 higher in value than R1 makes the discharge (low) time proportionately longer than the charge (high) time.

The formulas for calculating the operating frequency and high output time are slightly different since R2 is not in circuit while C2 is charging. Thus in the frequency calculation the timing resistance is simply R1 plus R2 rather than R1 plus double R2. Similarly, the timing resistance when calculating the high output time is simply R2 and not R1 plus R2. The two diodes have a marginal effect on the frequency, charge, and discharge times, but this will not normally be large enough to be of significance.

Frequency Modulation

As mentioned earlier, the operating frequency of a 555 astable can be modulated by a control voltage. This differs from the normal 555 astable configuration in that the decoupling capacitor at pin 5 of the device has to be removed and the control voltage is applied to this pin instead.

Pin 5 of the device connects to the internal potential divider circuit which sets the two thirds of the supply voltage threshold level at which the 555 triggers from the charge mode to the discharge one. By taking pin 5 above two thirds of the supply voltage the operating frequency is decreased since C2 has to charge to and discharge from a greater potential, and therefore takes longer to do so. Taking pin 5 below two thirds of the supply voltage reduces the voltage to which C2 has to charge and discharge so that both processes take less time and the operating frequency is increased. The output waveform at pin 3 remains unchanged, but there is a slight change in the waveshape and the amplitude of the signal across C2.

Pin 5 of the 555 does not connect directly to the internal potential divider of the device, and the threshold voltage at which the device triggers from the charge state to the discharge one is not equal to the voltage fed to pin 5. This limits the degree of control that can be obtained using a control voltage fed to pin 5, and the frequency is reduced by a little more than 50% if the control input is taken to the positive supply voltage. The output frequency is slightly more than doubled if the control terminal is taken to one third of the supply voltage, and it can be boosted a little further if it is taken slightly lower in voltage. However, if it is taken too low in voltage a malfunction occurs and the output frequency reduces considerably. It is therefore advisable to keep the control voltage between one third of the supply voltage and the full supply potential.

The control range is not very great but it is useful for applications such as modulated tone generators.

This circuit and description are taken from "Practical Electronic Building Blocks, Book 1", *BP117, by R. A. Penfold, published by Bernard Babani (publishing) Ltd.*

Basic 555 Monostable

The 555 timer IC can be used as a monostable multivibrator, and is often the most cost effective choice when a circuit of this type is required.

The basic 555 monostable configuration is shown in Figure 1.

Normally the input of the circuit is held at more than one third of the supply voltage, and under stand-by conditions the internal discharge transistor of the 555 hold C1 in uncharged state and the output at pin 3 is low. If the trigger input is taken below about one third of the supply potential the circuit is triggered, pin 3 of the 555 goes high, and the intenal discharge transistor switches off so that C1 can charge by way of R1. This continues until the charge potential on C1 reaches two thirds of the supply voltage, and the circuit then reverts to its original state. At least, it returns to its original state provided the trigger input has been taken back above one third of the supply voltage.

The output pulse has a duration of 1.1CR seconds, and the minimum pulse length is about one microsecond, and the maximum pulse duration is limited only by the maximum practical timing capacitance (as for the astable mode).

Manual Triggering

An improved method of manual triggering is shown. Here R3 normally holds the trigger input at virtually the full positive supply voltage, but a brief negative pulse will be produced at the input when BP1 is operated due to C2 charging via R3. This gives the brief trigger pulse, and no matter how long PB1 is depressed, it is the time constant of R3 and C2 that sets the length of the trigger pulse. R2 rapidly discharges C2 when PB1 is released so that the circuit is almost instantly ready for another operation of PB1.

The trigger pulse applied to IC1 is only a few microseconds in duration, and the circuit will obviously work properly with output pulse lengths of around 10us or more. For shorter pulse lengths of only about 1us or so it would be necessary to decrease C2 in value, although triggering might become unreliable if this component is made much lower in value.

Reset Facility

In the monostable mode pin 4 of the 555 device is the reset terminal, and this should normally be in the high state. Taking this pin low during the output pulse can cause the pulse to be immediately brought to an end. The circuit shows how to add both manual and electronic reset facilities to a 555 monostable.

This circuit and description are taken from "Practical Electronic Building Blocks Book 1", BP117 by R. A. Penfold, published by Bernard Babani (publishing) Ltd.

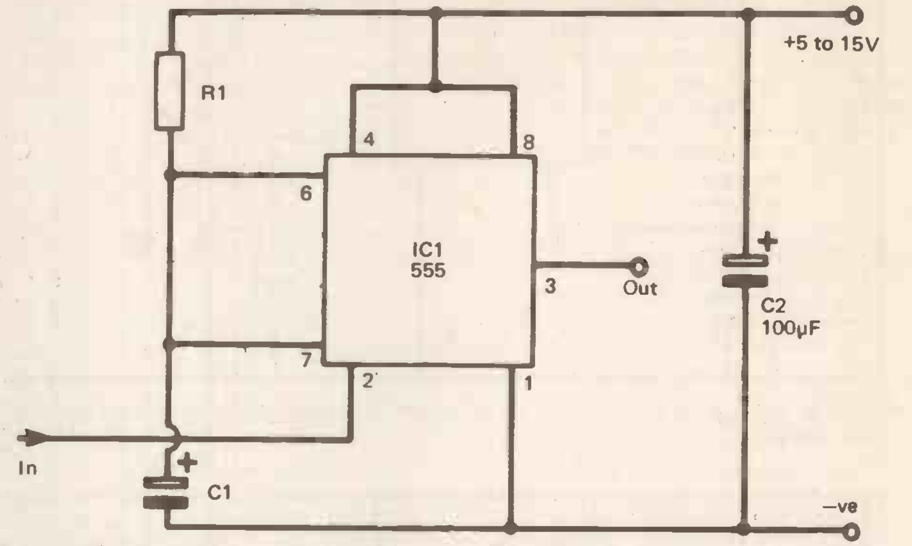


Figure 4. Basic 555 monostable. It is triggered by briefly taking pin 2 below ⅓ V+.

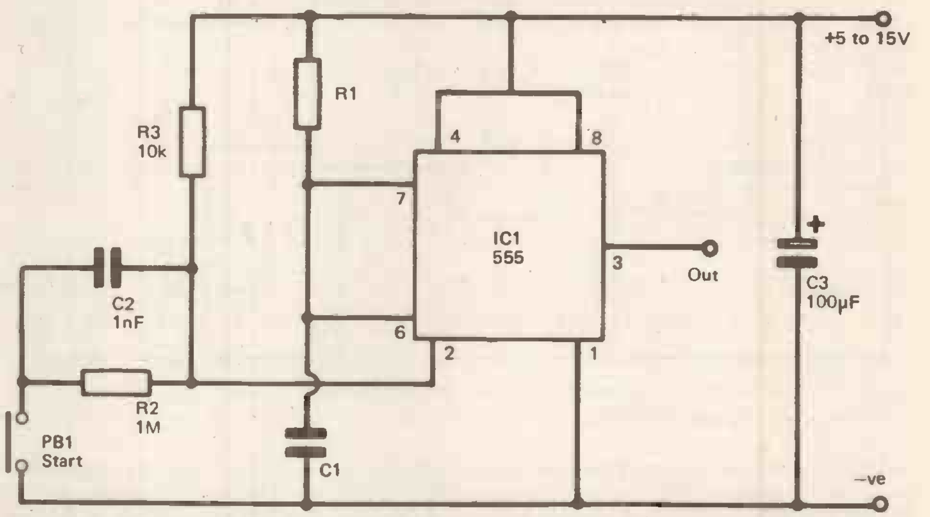


Figure 5. The length of the trigger pulse can be controlled by an RC network around the trigger switch.

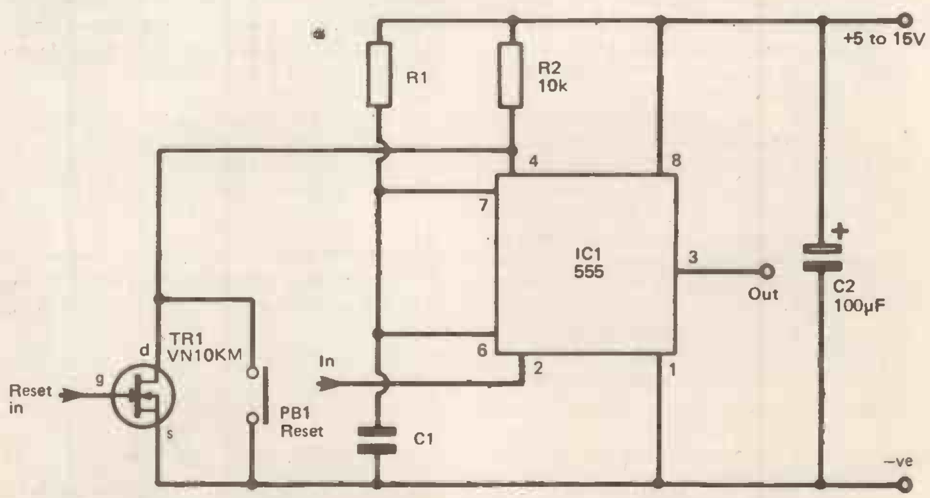


Figure 6. The monostable can be reset by taking pin 4 low, either manually with a switch or by taking the gate of TR1 a few volts positive.

Emitter Follower

Losses due to loading can be substantially reduced using a buffer amplifier.

Loading of one stage on another, or loading of a circuit of some kind on a transducer such as a microphone, can produce a large reduction in signal level.

An emitter follower has 100% negative feedback and therefore only unity voltage gain, but the full current gain of the transistor is realised so that only a small input current is needed to give a comparatively large output current, and the required high to low impedance conversion is thus obtained. It should perhaps be pointed out that an emitter follower stage does not actually give unity voltage gain, but in actual fact gives marginally less than unity gain (about 0.96 being the typical voltage gain obtained). This very small drop in signal level is not usually of any practical significance though.

The input impedance of the circuit is equal to the parallel impedances of R1, R2 and the input impedance of Tr1. These give an input impedance of roughly 100k using the specified values. The output impedance of the circuit is 2k2, but this does not take into account the effect of the source impedance of the input signal. This lowers the output impedance of the circuit to a figure which can be calculated by dividing the source impedance by the current gain of Tr1 (which is about 520 at the collector current used here). In fact the basic 2k2 output impedance of the amplifier is in parallel with the impedance obtained from the calculation detailed above, but in practice the output impedance of the circuit will normally be so low that this 2k2 is of no consequence.

Although the output impedance of the circuit is likely to be only about 100R or less in a practical situation, and normal loading of the output will not significantly reduce the output signal level of the unit, it is important to bear in mind that the maximum output current of the circuit is equal to the emitter current of Tr1, or about 2mA using the values specified. In other words, trying to provide an output signal of a few volts peak into a load impedance of only about a hundred ohms will not give satisfactory results since the output current capability of the circuit will be inadequate on signal peaks, and clipping will occur. The purpose of a circuit of this type is to match a source impedance of (say) about 10 or 20k to a comparatively low input impedance of (say) about 1 or 2k without producing the massive loss of signal level that would occur using direct connection of the two pieces of equipment.

The circuit is not intended to be a powerful amplifier and will not work as one.

The circuit will work reasonably well on any supply potential of between 3V and 18V. The current consumption from a 9V supply is about 2mA, and this changes roughly in proportion to alterations in the supply voltage.

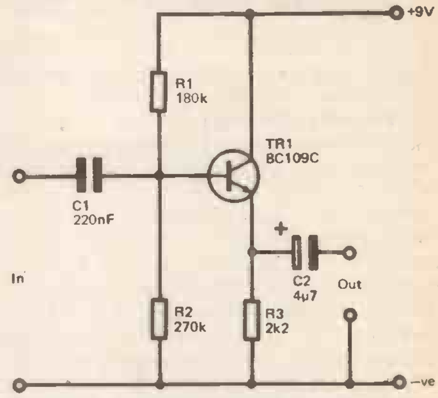


Figure 7. A simple emitter follower circuit is often used to reduce loading effects.

Due to the large amount of negative feedback employed in the circuit the noise and distortion levels are both extremely low.

This circuit and description are taken from "Practical Electronic Building Blocks, Book 2", BP118, by R. A. Penfold, published by Bernard Babani (Publishing) Ltdd

General Purpose Amplifier

This unit can feed any speaker having an impedance of 8 ohms or more and will produce a maximum output of about 1 watt into an 8 ohm load when used with a fresh battery

This simple design is intended for general purpose use, and it is an extremely useful piece of equipment to have around. It is surprising the number of occasions on which an amplifier of this type can be put to good use. The circuit diagram of the unit is shown.

The circuit is based on the popular LM380N IC which has the advantage over most other ICs of requiring very few discrete components to complete a practical amplifier. A practical amplifier can be constructed using this IC and just three discrete components. These are an output DC blocking capacitor (C5) an input DC blocking capacitor (C4), and a supply decoupling capacitor (C1).

There are two drawbacks to using just a basic circuit of this type in the present application, and these are the inadequate voltage gain and input impedance of the circuit. The LM380N has typical input impedance and voltage gain figures of 150k and 50 respectively. Ideally for this application these should be about ten times higher in each case, so that the amplifier could operate from high impedance low level loads, such as a crystal microphone.

Therefore, in order to boost the input impedance and voltage gain of the basic circuit a FET common source preamplifier stage has been added. This utilizes Tr1. VR1 is the volume control, and this doubles as the gate bias resistor for Tr1. C2 provides DC blocking at the input. S1 is the on/off switch, and this can be ganged with VR1 if desired. C1 is the only supply decoupling capacitor that is required for the entire amplifier circuit.

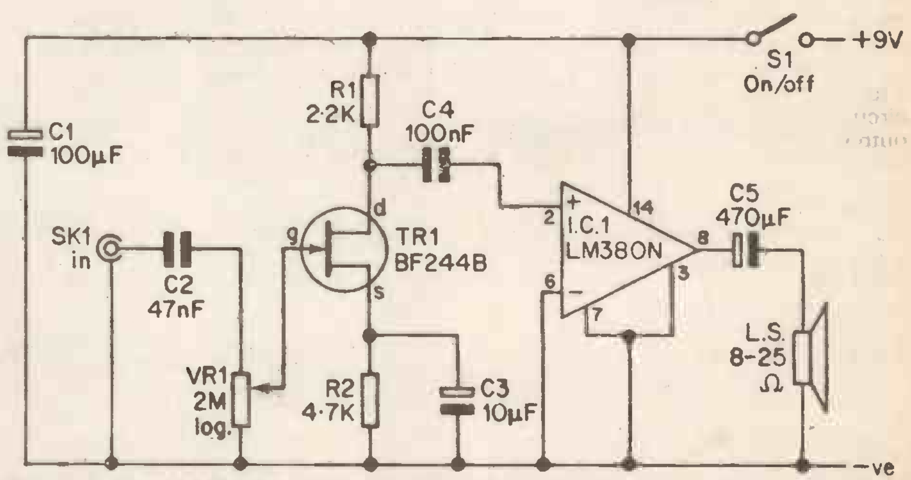


Figure 8. The LM380N has built-in thermal and short circuit protection, making it the ideal device for test and breadboard situations.

This circuit and description are taken from "Popular Electronic Projects", BP49 by R. A. Penfold, published by Bernard Babani (publishing) Ltd.

Filters

Filters are required in many applications, and are often implemented by passive capacitor and inductive networks. Inductors are, however, bulky, expensive and somewhat difficult to obtain. The use of operational amplifiers with frequency selective feedback allows filters to be designed using only resistors and capacitors.

Low Pass Filters

Simple Low Pass Filter

The simplest possible low pass filter is shown. The capacitor C has infinite impedance at DC, and the low frequency gain is determined by R1 and R2 as described below. As the frequency rises the impedance of C decreases causing the gain to fall.

The roll off frequency is given by:

$$f = \frac{1}{2\pi CR2}$$

Classical Low Pass Filter

The classical operational amplifier low pass filter is shown. This has unity gain at low frequencies. To simplify calculations, R1 and R2 should be equal, and C1 should be twice the value of C2.

The cut off frequency is then given by:

$$f = \frac{\sqrt{2}}{4\pi RC}$$

If R1 = R2 = R, C2 = C and C1 = 2C.

With the relationships above the filter is said to be critically damped and the cut off is far sharper than the simple filter. If C1 is not twice C2 the cutoff frequency is given by:

$$f = \frac{1}{2\pi R\sqrt{C1.C2}}$$

if R1 = R2 = R.

Dependent on C1 and C2 the response can be made gentle or peaky as shown.

Similar low pass filters are the basis of audio scratch filters.

High Pass Filters

Simple High Pass Filters

The simplest high pass filter is shown. At high frequencies the gain will be determined by R1 and R2 (and the amplifier itself). At low frequencies C will have significant impedance reducing the gain. The cutoff frequency is given by:

$$f = \frac{1}{2\pi CR1}$$

Note that the high frequency gain will be reduced by the limited bandwidth of the amplifier itself.

Classical High Pass Filter

The circuit is identical to the low pass filter with the capacitors and resistors interchanged. Ideally the components should be chosen such that C1 and C2 are equal and R2 is twice the value of R1. The cutoff frequency is then given by:

$$f = \frac{\sqrt{2}}{4\pi RC}$$

where C1 = C2 = C, R1 = R and R2 = 2R.

The general equation with C1 = C2 = C is:

$$f = \frac{1}{2\pi C\sqrt{(R1.R2)}}$$

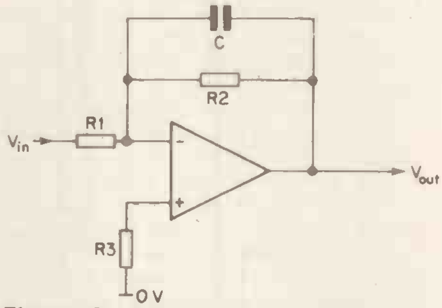


Figure 9. Simple op-amp low pass filter.

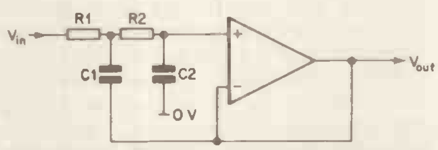


Figure 10. The classical filter gives a sharper cutoff.

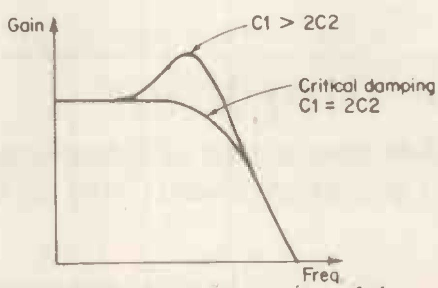


Figure 11. Response curves of the classical filter circuit.

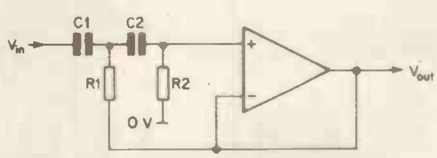


Figure 12. The classical high pass filter.

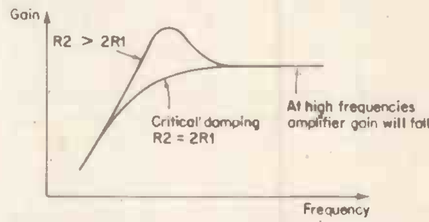


Figure 13. High pass filter response curves.

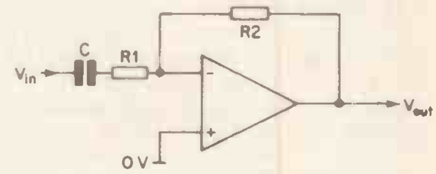


Figure 14. The simplest high pass filter circuit.

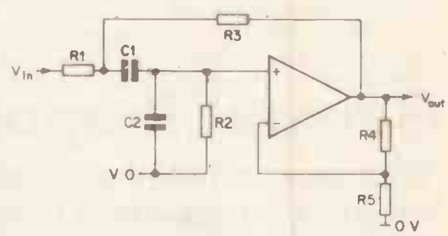


Figure 15. A single-amplifier band pass filter.

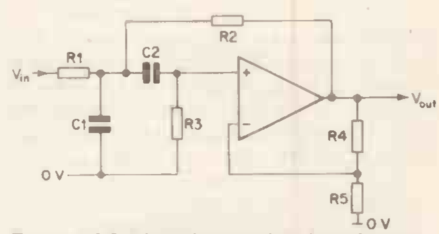


Figure 16. An alternative band pass circuit.

with the ratio of R1 to R2 determining the response at cutoff.

The high pass filter is widely used as a rumble filter in audio circuits.

Bandpass Filter

Introduction

A bandpass filter will, as its name implies, pass a specific band of frequencies and reject frequencies higher or lower than the specified band. A bandpass filter is specified simply by two parameters; the centre frequency and the ratio of the centre frequency to the −3dB bandwidth (denoted by Q). The higher the value of Q, the sharper the shape of the curve shown.

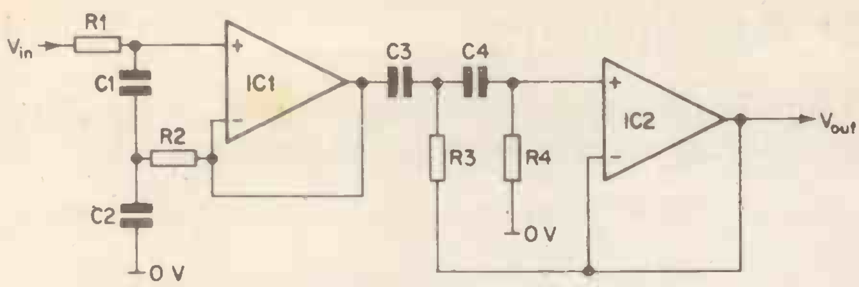


Figure 17. A two stage bandpass filter.

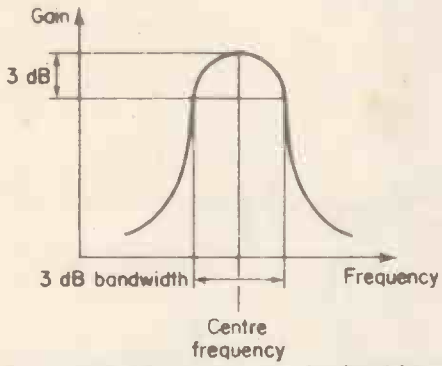


Figure 18. The response obtained by a bandpass filter.

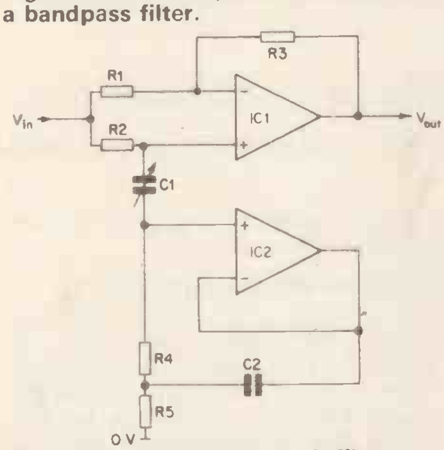


Figure 19. A turnable notch filter.

Single Amplifier Bandpass Filter

The circuit is widely used as a bandpass filter. To simplify calculation R1, R2, R3 should be equal (denoted by R) and C1 and C2 should be equal (denoted by C). The centre frequency, fo, is then given by:

$$fo = \frac{\sqrt{2}}{2\pi RC}$$

The Q of the circuit is determined by R4 and R5 with:

$$Q = \frac{R5\sqrt{2}}{4R5 - R4}$$

An alternative single amplifier circuit is shown. The components should be chosen such that R1 and R2 should be equal (denoted by R) and R3 should be chosen to be 2R. C1 and C2 should be made equal (denoted by C). The equations are somewhat simpler, with:

$$fo = \frac{1}{2\pi RC}$$

$$\text{and } Q = \frac{R5}{2R5 - R4}$$

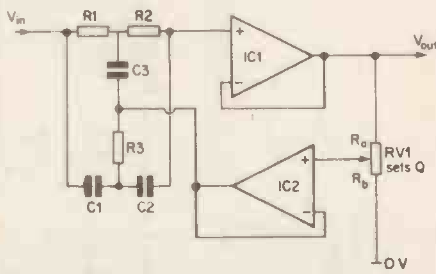


Figure 20. This notch filter has adjustable Q.

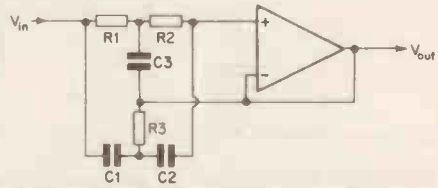


Figure 21. The high Q notch filter.

Two Stage Bandpass Filter

The circuit is easier to comprehend than those of the previous section, although it uses two amplifiers. IC1 is a low pass filter, and IC2 a high pass filter. The centre frequency is determined by:

$$fo = \frac{1}{2\pi RC}$$

if R1 = R2 = R3 = R4 = R and C1 = C2 = C3 = C4 = C.

The bandwidth is determined by the cutoff frequencies. If the above equalities do not hold, the upper and lower frequency cutoff can be determined separately.

Notch Filters

Introduction

A notch filter is the opposite of a bandpass filter in that it rejects a band of frequencies. Commonly the notch filter is used to reject 50Hz mains hum (60Hz outside Great Britain) in sensitive audio circuits and measuring instruments. The centre frequency and Q of a notch filter are defined in a similar manner to those of a bandpass filter.

Single Amplifier Notch Filter

The circuit gives a notch filter of very high Q. To simplify the design, the values should be chosen such that:

R1 = R2 = R
R3 = R/2
C1 = C2 = C
C3 = 2C

If the above conditions are met, the centre frequency is given by:

$$fo = \frac{1}{2\pi RC}$$

Two Amplifier Tunable Notch Filter

The circuit can be tuned by a single variable capacitor, C1. Normally C1 will be a few hundred picafarads and the C2 several microfarads. As usual, the design is simplified by the resistor equalities below:

R = R2 = R3 = R
R4 = R5 = R/2

The centre frequency is then given by:

$$for = \frac{1}{\pi R\sqrt{C1C2}}$$

Adjustable Q Notch Filter

The circuit allows the Q of a notch filter to be varied by a single potentiometer without varying the centre frequency. The potentiometer can be any reasonable value, the Q of the circuit being determined by the ratio R_a/R_b. As usual, some equalities must be observed:

R1 = R2 = R
R3 = R/2
C1 = C2 = C
C3 = 2C

The centre frequency is given by:

$$fo = \frac{1}{2\pi RC}$$

The adjustable Q notch filter is very useful in low level measuring instruments.

Practical Observations

The obvious is sometimes overlooked, but it should be noted that in all the above equations resistors must be in OHM and capacitors in FARADS giving results in Hz (cycles per second for older readers!)

Where equalities are given, precision resistors (at worst 1% tolerance) should be used and close tolerance capacitors. Multiples and division by two is often needed in the equations, and this is best achieved by one value of resistor and capacitor throughout, and using parallel or series combinations to produce the multiples required.

It will often be found that none of the preferred value resistors or capacitors give the required frequency. Series combinations of resistors should be used in preference to variable resistors. This is inelegant, but one of the sad facts of life in filter design. Alternatively precision wire wound or thin film resistors can be ordered to specific values. Although prohibitively expensive for home "one-offs" this approach is economically viable for production runs. The inherent inductance of wire wound resistors limits their use to low frequency circuits.

This circuit and description are taken from "How To Use Op-Amps", BP88, by E. A. Parr, published by Bernard Babani (publishing) Ltd.

Audio Operational Amplifiers

Some operational amplifiers are primarily designed for use in audio frequency amplifiers despite the fact that these devices were originally designed for use as DC amplifiers.

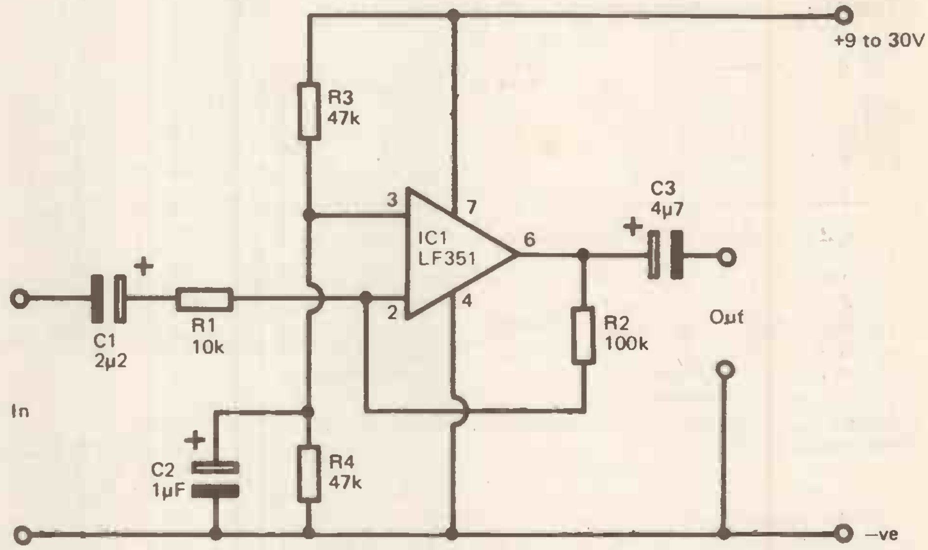


Figure 22. The circuit for an inverting amplifier using the LF351 op-amp, biased from a single supply rail.

Operational amplifiers can be used in two basic modes of amplification; the inverting mode and the non-inverting one. This circuit is for an inverting amplifier (we will consider a non-inverting amplifier shortly).

R3 and R4 are used to bias the non-inverting input (and also the output) to approximately half the supply voltage. C2 filters out any hum or other noise which might otherwise be coupled to the non-inverting input of IC1 from the supply lines via the bias circuit. This also removes any stray feedback from the output of the amplifier to the non-inverting input and thus reduces the risk of instability.

R1 and R2 are a negative feedback circuit which determine the input impedance and voltage gain of the circuit. By giving these two components the appropriate values it is possible to set both these parameters with a high degree of accuracy, and this makes operational amplifier based circuits (or discrete circuits using similar techniques) ideal for use where it is essential to be able to set the gain and input impedance reliably and consistently.

The input impedance is equal to the value given to R1, and the voltage gain is equal to R2 divided by R1, or ten times using the specified values for these components. C1 and C3 are merely DC blocking capacitors.

Obviously R1 and R2 can be given values to set almost any desired input impedance and voltage gain. However, there are definite limitations on the voltage gain that can be obtained, and to a lesser extent on the input impedance than can be achieved in practice.

If we take the voltage gain first, it must be borne in mind that the gain-bandwidth product of the LF351 device is 4MHz. In other words, the maximum frequency the amplifier must handle multiplied by the voltage gain of the amplifier must be no more than 4MHz. For an amplifier that must cover the full audio band (which extends from about 20Hz to 20kHz) the maximum voltage gain that can be used is clearly 200 times (20kHz multiplied by 200 equals 4MHz). In most cases the LF351 will be able to provide sufficient voltage gain using a single stage of amplification, but two stages connected in series can be used where additional voltage gain is needed.

In theory there is no limit on the input impedance that can be achieved using a circuit of this type, but in practice there is the problem of obtaining resistors of sufficiently high value, especially in cases where a combination of high voltage gain and high input impedance of 10 Megohms and a voltage gain of 100 times would require R1 to have a value of 10M, and R2 to have a value of 1000M. This is clearly not a practical proposition, and in cases of this type it is better to use a low gain buffer stage to give the high input impedance, and a separate high gain stage to step-up the voltage gain to the desired figure.

Problems can arise with this type of due to the input capacitance of the operational amplifier effectively making the negative feedback, to a degree, frequency selective, so that unwanted peaks or dips in the frequency response are produced. This is only really likely to be a problem in circuits that are used to provide low voltage gain and a high input impedance, and the result is normally a roughly doubling in gain at a frequency of few tens of kilohertz with the response falling away at frequencies above the peak. Where low gain and high input and impedance are needed it is better to use a non-inverting amplifier since a low impedance feedback network can then be used, and the input capacitance of the operational amplifier becomes insignificant.

Bearing in mind the limitations mentioned above, the appropriate values for R1 and R2 are easily calculated. R1 is simply given the nearest preferred value to the the required input impedance, and then this figure is multiplied by the required voltage gain to give the value of R2 (and again the nearest preferred value must be chosen).

Non-Inverting Amplifier

The circuit of an operational amplifier used in the non-inverting mode is shown. R3 and R4 bias the non-inverting input to IC1 to about half the supply voltage with R5 being used to couple this bias voltage to IC1. C2 decodes any hum or other electrical noise on the supply lines so that it is not fed to the input of the amplifier. The value of R5 is equal to the required input impedance of the amplifier, and C2 provides DC blocking at the input (and should have its value chosen to suit the input impedance of the circuit).

R1 and R2 are the negative feedback network, and the voltage gain of the circuit can be calculated by first adding the values of R1 and R2, and then dividing this figure by the value of R1. The specified values given to R1 and R2 can be any two that have the correct ratio to give the desired voltage gain, but in practice it is not a good idea to have low values that will heavily load the output of the operational amplifier, or to have high values that would result in a far from flat frequency response due to the input capacitance of IC1. In practice it is therefore advisable to have the total value through R1 and R2 at something in the region of 25 to 100k.

In order to choose suitable values for R1 and R2 first decide on a value for R2, and any value of a few tens of kilohms should do. Then divide this by one less than the required voltage gain to find the correct value for R1. The nearest

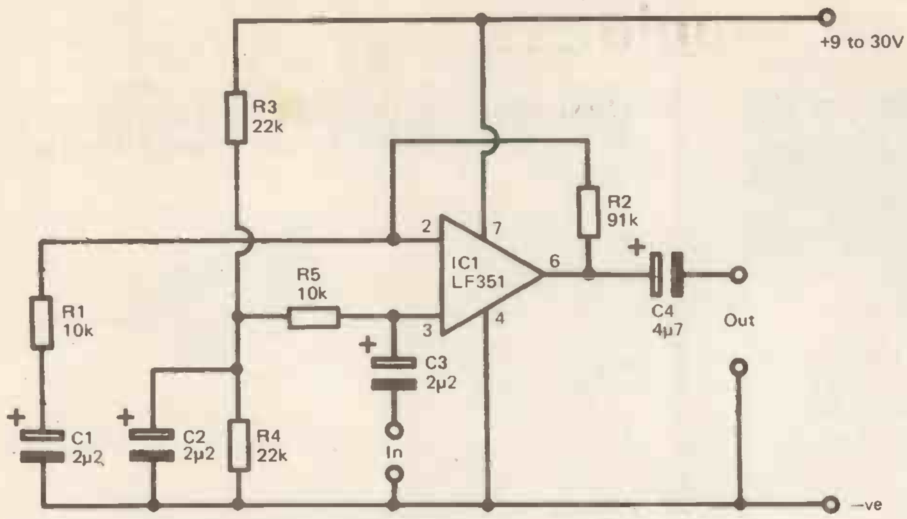


Figure 23. The LF351 in non-inverting mode.

preferred value to the calculated figure is the used. C1 is a DC blocking capacitor which gives the circuit 100% negative feedback and unity voltage gain at DC so that the circuit is biased properly. At audio frequencies it must not add significantly to the impedance provided by R1, and the correct value is calculated in the same way as the value of the input and output coupling capacitor values are obtained.

The distortion performance of the LF351 is extremely good with the distortion level being only about 0.02% provided the output is not heavily loaded, the circuit is not driven into clipping and the amplifier is not used at very high gain levels. If used at fairly high voltage gains the distortion performance does reduce at high audio frequencies, although the distortion level is still likely to be less than 0.1%.

The noise performance of the LF351 is also extremely good with an output noise level of only about 500uV even if the amplifier is used at a high voltage gain of one hundred times.

One point that must be emphasized is that although in theory it is perfectly satisfactorily to have a non-inverting amplifier with an impedance of (say) 5M and a voltage gain of one or two hundred times, and the LF351 is quite capable of achieving these performance figures, in a practical situation it is highly unlikely that such a circuit could be made to operate satisfactorily. The problem is simply that there would inevitably be a certain amount of stray feedback from the output of the amplifier to the input, and as these two points are in-phase it is almost certain that instability would occur with the circuit breaking into oscillation. It is therefore better to use two stages of amplification with the first giving the high input impedance and the second providing the voltage gain.

This enables better separation to be obtained between the input and the output so that stray feedback can be reduced to an insignificant level. It is also a good idea to have the second stage of amplification of the inverting type so that the input and output of the amplifier as a whole are then out-of-phase, and any stray feedback will therefore be of the negative variety. This will not cause instability, but will simply result in a small reduction in the high frequency gain of the amplifier.

This circuit and description are taken from "Practical Electronic Building Blocks, Book 2", BP118 by R. A. Penfold, published by Bernard Babani (publishing) Ltd.

Supply Splitter

Many op-amp circuits require dual balanced power supplies of up to 12 volts each and, while a special power supply circuit can be built, a simple supply splitter is more convenient if a single-cell supply is already available.

A method of obtaining dual balanced supplies is to use a supply splitter that gives a low impedance centre-tap on a single supply, rather than generating two equal supplies and connecting them in series. A supply splitter such as the one shown in the circuit diagram is intended for use with an existing bench power supply, and is not an independent unit. This particular circuit will work well with supply voltages of between 15V and 30V, and each of the output rails has a potential equal to half the input voltage (thus 30V is needed at the input to give dual 15V outputs for example). The unit will readily handle currents of up to 100mA, and it should not be necessary to fit Tr3 and Tr4 with heatsinks.

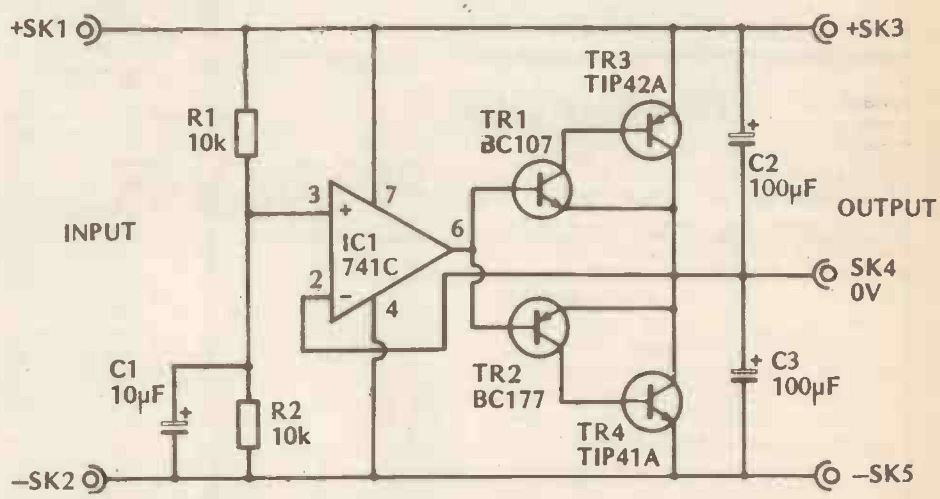


Figure 24. This supply splitter will prove its usefulness to the experimenter.

The circuit is really just an unity gain amplifier having a high imput impedance and a low output impedance class B output stage. A class B output stage is used as this gives the unit a low quiescent current consumption (only about 2mA). Trl and Tr3 are common emitter amplifiers, but as there is 100% negative feedback from Tr3's collector to Tr1's emitter these give only unit gain. Tr2 and Tr4 form a complementary output pair for Tr1 and Tr3. There is 100% negative feedback from the output of the unit (Tr3 — Tr4 collectors) to the inverting input of IC1, and this gives unit voltage gain from the non-inverting input of IC1 to the output. R1 and R2 bias the non-inverting input of IC1 to half the supply potential, giving the same voltage at the output, but at a very low impedance. The three capacitors are needed to maintain stability.

This circuit and description are taken from, "Popular Electronic Circuits Book 2", B98, by R. A. Penfold, published by Bernard Babani (publishing) Ltd.

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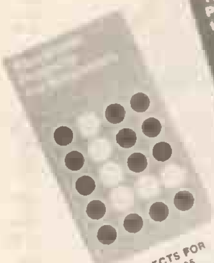

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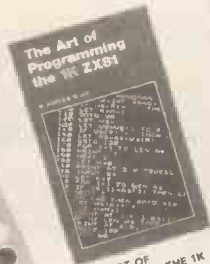

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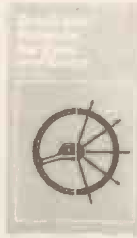

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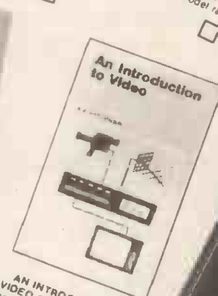

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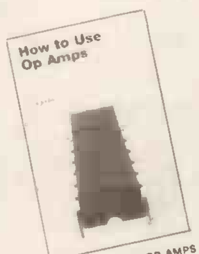

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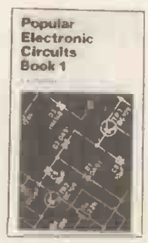

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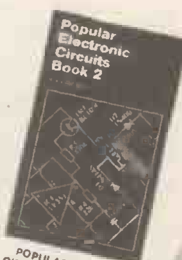

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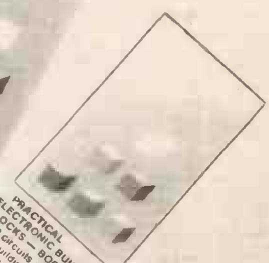

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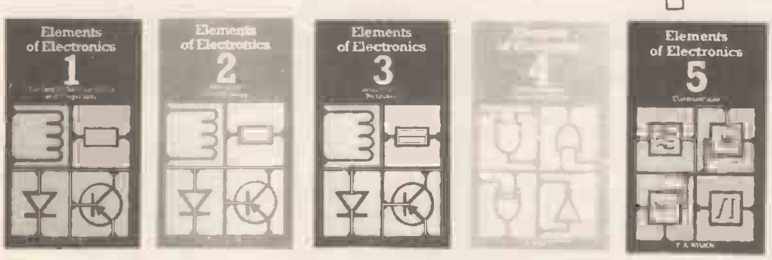

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POINTS OF VIEW

Feel like sounding off? Then write to the Editor stating your Point of View!

Facing The Interface

I write to you in desperation. I have been an interested and happy reader of your brilliant mag since it first hit the newsagents' shelves – an 'Everyday Electronics' convert I be!

Since then I've built many projects, short circuits, etc. which have always eventually worked. Recently I purchased a ZX Spectrum, having read your "Spotlight on the Spectrum". I soon started on the I/O interface board (HE September '82). This time I cannot seem to get it to work! Hours have been spent with circuit diagram, manual and multimeter, but no result!

I beg of you – understanding that your are busy people – please take a look at the notes I have enclosed tabulating my results and in comparison with what you know to be happening inside the chips try to suggest reasons for my dilemma.

Testing Results:

Construction believed to be of good standard. Using PCB. Connection to Spectrum using ribbon cable rather than "piggy back" method. Using a 23 x 23 way connector. Polarising key position 3.

1) Components all correctly fitted in accordance with mag article, all solder joints sound. PCB tracks appear OK.

2) Computer functions correctly in normal mode.

3) Everything appears OK – things don't get warm!

4) The first PRINT IN 65503 gives correct 255, thereafter all input commands give result 56.

5) Outputs don't seem to change at all. Usually at OV4 (using 20kR/V meter).

6) Ribbon cable connections all seem OK and correct.

7) QUERY: the fact that pin 11B on the connector is not A15 on Spectrum but 1ORQGE – is this supposed to be so?

Thank you most sincerely,
A.D. Fraser,
Gosport,
Hants.

It's difficult for us to tell, at the wrong end of a letter, whether the problem with a non-working project is because there is a fault in the design/printed circuit or whether there is a constructional error.

Some project errors do become apparent very quickly, while others turn up only after numerous queries from readers.

In the case of the relatively 'old' project such as this one, when no errors or mistakes have already been brought to light, the most likely cause is a construction error.

In this case a clue is given by your query in para 7 of the testing results: pin 11B on the connector is not Spectrum address bit A15 — nor is it supposed to be the Spectrum 1ORQE line. It is, in fact, the ZX81's A15 line!

When using the I/O board with a Spectrum, this connection is non-operational since, as specified with Notes to the Circuit, the output of IC3c is NOT linked to IC3d.

It appears that you are confusing the alternative link-wires intended to adapt the boards for use EITHER with a Spectrum OR with a ZX81.

If you make sure that the links are wired in as per note "For IO Mapped Version (For Use With The Spectrum)", you should find that the project performs exactly as required.

Thank you by the way for an exemplary enquiry. If all our distressed enquirers made it quite so plain exactly what they had done with which project, we would have a much better chance of sorting their problems out for them. Also, going through your test procedures point by point often reveals oversights which help to sort out a problem straight away.

Note: you are nearly always closer than you think. Mr. Frazer had produced nine-tenths of his own solution and would only have needed a small flash of extra information to produce what we now hope is a final answer.

Personal Project

Dear Sir,

I'm a regular reader of your magazine, ever since I picked up your November '82 issue at the local newsagent. Your magazine is very interesting, especially your page.

I haven't built any of your projects so far because I haven't found any that suit my requirements. I'm particularly interested in the personal stereo cassette recorder and I'm looking forward to building one. I hope my idea will be considered. It will be different to play a machine you made by yourself.

Yours sincerely,
Wing Lee.

Certainly no shortage of ambition here! What can I say to this determined gent, who not only reads his Hobby even when he isn't building a project, but plans to build his own personal stereo? I positively quail to admit that we are not very likely to do a personal stereo project, because the commercial companies have got it down to such a fine art that no magazine could possibly compete with them—not a hope! By the time all the parts which are too complicated to make at home have been provided (including the case) there would be little left to do but the assembly, and it would still be more expensive and less reliable than the ones you can buy in the shops. So it's not feasible as a magazine project. Sorry!

. . . And You Thought *You* Had Power Supply Problems

Dear Sirs,

Thank you for your January article. Suppled by overhead 220/380V lines in a rural area, power failures are commonplace here during frequent summer evening electrical storms. The failures last for plus/minus hours, but up to nine hours. Cooking is by gas stove from a cylinder. The refrigerator can cope. Dinner can be by candle light but it would be pleasant to have the use of the gramophone or TV for an hour or so. Using a clamp meter, the hifi averages less than the load of a 100W bulb, but can peak for brief intervals up to TV levels or higher momentarily in extreme cases. The TV has a high load switch on.

I use a car battery as a burglar alarm, fed by an SCR controlled variable charger. The battery is a standby for a vehicle, and is my basic power supply for electronics. It is coming to the end of its life after four years.

It seems that a 300W DC/AC inverter as suggested by you is the answer. However I am not sure if a sine wave is necessary. Fuses should not blow at peaks or switch on. Such a project would be welcome.

On a related subject, so many circuits for AM radio, but what about a pure FM circuit from 12VDC supply, concentrating on purest sound with maximum simplicity, merely tuning and volume, assuming correct tone in the first place?

Yours faithfully,
E. Strang,
Krugersdorp,
South Africa.

Fascinating to see how the other half of the world manages! Your project suggestions have been noted with thanks. On a general note, don't forget that if any reader has developed a circuit or is inspired to do so by someone else's suggestion, we are always happy to have a look at them (the circuits, not the readers . . .) with possible publication in mind. Think of the glory! (It'll keep your mind off the money.)

Howling Error

Dear Sir,
Mr. Biggins' history brought back so many happy memories that it may seem a bit churlish to point out a mistake (The Electronic Revolution, HE '83):

The accumulator was used for the filament (cathode) not the anode (or "plate") which required a 100-volt dry battery the size of a brick.

The instability causing "howling" was due to feedback from the anode to the aerial circuit giving "reaction", and was a characteristic of the "superregenerative circuit", not the superheterodyne which came later.

Amateur radio construction before the war received its greatest setback when the highly efficient super heterodyne came into being in the early 30s, as they needed professional assistance to tune or "trim" the intermediate frequency transformer.

My first licence was a "provisional" dated October 1923.
Yours faithfully,
A.H. Jenkins,
Dringhouses,
York.

Thanks for these additions and corrections to "The Birth of Broadcasting" (HE February '83). Yes, the arrival of equipment with "non-user-servicable parts" does tend to discourage enthusiasts accustomed to being able to do everything themselves. But time usually brings a new crop of enthusiasts with some different approaches, or new ways of using the old ones, as we're seeing with amateur radio. We're told that general electronics is taking a knocking from home computing just at the moment, but I'd like to think that the new generation of computer wizards won't be content to sail on into the twenty-first century entirely ignorant of what goes on inside the micro, far from it. They'll probably all be reading "Hobby Chip Manufacture Today" or some such rag!

Recharging NiCads

Dear Sir,
I am interested in a NiCad charger working off my car battery.

The NiCad is seven amp hours' capacity, 12V nominal - so charging could be constant current OA2 to OA5 at 15V5.

What is the simple way of doing this? I did read in Power Supply Projects *(see HE Bookshelf) about the DC step-up, ie IC1, TDA2030. This one is however OA1 to 9V. The car battery is, say, 14 to 11v.*

Your advice will be greatly appreciated.
R. W. Kakebeeke,
Johannesburg,
South Africa.

Charging NiCad batteries from a car battery requires special circuitry — but don't worry. We're working on it for HE in the future.

Transmitter Needed

Dear Sir,
I have for some time now been reading your articles in Hobby Electronics. I am a student reading Vocational Education which includes Electronics. I read and carry out some simple projects.
Your article that really spurred me to write to you is that in HE October '82, 'Radio Rules'. Transmitters were the main theme. I was so excited and I thought by the time I am through, my dream of making my own transmitter would have materialised. But alas the whole text was just theories. I felt really disappointed I must say.

Please can you give me a transmitter circuit because I have not been able to lay hands on any. (I mean a functional circuit, a circuit with the component values inserted). I can make do with a low-powered transistor circuit or one using valves or both. Maximum power should be kept within the amateur range of 150W, because I hold an amateur licence.

Thank you.
Fleming Udofiah,
Abak,
Nigeria.

If you're going to build your own radio gear, you should look at a few possibilities. We and our radio-orientated relations here do not have a design which would obviously fulfil your needs without involving you in a lot of trouble and expense as well, and also we're not entirely clear what you are looking for — do you need a receiver as well, for instance, or do you already have one?

I suggest you contact the Radio Society of Great Britain, if there are no similar societies which can help you out in Nigeria, and tell them what you want. The will probably be able to advise you. The **RSGB** are now at **Alma House, Cranbourne Rd., Potters Bar, Herts EN6 3JW.**

The Tesla Controversy

Dear Sir,
I have just read your January issue (sea mail takes time to reach us here) and found the "Wireless Goes To War" article most interesting. However, surely there should be mention of Nikola Tesla, who transmitted signals by wireless before Marconi, and whose patents were upheld against Marconi?

On page 56 the caption to the lower right photograph says that the purpose of the "fan" is not known. I'm sure that the Science Museum must know that the "fan" is a wind driven generator, used to power the wireless equipment. Battery power supplies with engine driven generators were not in use in 1914-1918!
Yours truly,
Martin Berner 9Y4TAM,
Trinidad,
The West Indies.

Tesla, it seems, was a genius whom the highest pinnacles of fame were doomed to elude. Consulting HE December '78 for its article "The Tesla Controversy", we find that Tesla seems to have discovered the Light Sword, for which credit subsequently went to Obi-wan Kenobi, and also invented the Tesla coil which, adds the article, is known as the Ruhmkorff coil.

More seriously, Tesla was the kind of genius whose greatest ideas were so far ahead of his time that they never achieved much in the way of commercial exploitation. This, of course, makes them difficult to fit neatly into any brief history of modern technology. But who knows where his theories will appear again in the future?

As for the now-famous fan, when you receive your March *Hobby Electronics* in May (by which time we shall be preparing the issue for August) you will find some pertinent comments from our resident balls of fuzz, and your mind will be at rest by the time you receive your October issue just in time for Christmas.

Don't Switch The Switch

Dear Sir,
I intend building the Touch Switch (HE October '81) and would like to install it in my car, running off 12 volts.

I would be very grateful if you could advise me of any modifications necessary and suggest a suitable relay to operate accessories such as fog lights, etc.
Yours faithfully,
G. Chamberlain,
Ebbw Vale,
Gwent.

There shouldn't be any problems with a 12V supply — just connect the switch directly. Check the current drawn by the lights you intend to use and make sure you have the right contacts. We're not auto-electric experts here, but suggest that around 10A would be suitable. The relay must be a 12V one, of course. **HE**

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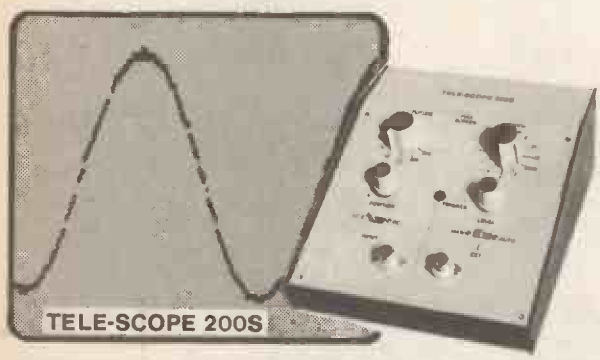

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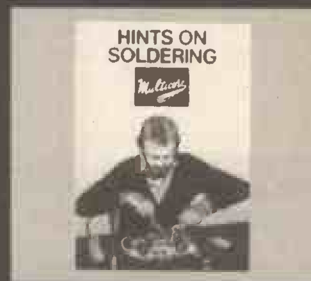

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Keith Brindley

TECHNICALLY SPEAKING, a semiconductor is an element which belongs to a particular group within the Periodic Table! Those readers who have studied Physics or Chemistry to any depth will know that the Periodic Table is simply a method of collating all known elements in tabular form. **Figure 1** shows the Periodic Table and the elements in the shaded box: C (carbon); Si (silicon) and Ge (germanium) form the group we know as semiconductors. Although officially, carbon *is* a semiconductor, it is not used in the manufacture of electronic semiconductor components for technical reasons. All semiconductors are made with germanium, and particularly silicon.

Electronically speaking, the term *semiconductor* has been applied to the many electronic components which are constructed with the use of semiconductor materials. Electronic components belonging to the semiconductor family include: transistors, integrated circuits (ICs), diodes, thyristors, and triacs.

So that we can understand the operation of these semiconductor components, we must first look at the materials which are used in their construction — the elements of semiconductor materials themselves. **Figure 2** represents a minute section of such an element — so minute that each circle in the figure is an atom of the element. Each atom is linked (bonded) to an adjacent atom by a covalent bond. A semiconductor atom has four electrons in its outside 'orbit' of electrons — and a covalent bond consists of one electron from one atom and one electron from the adjacent atom. So, a covalent bond is literally a shared pair of electrons.

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	← TRANSITION ELEMENTS →										13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57* La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89† Ac															

*LANTHANONS	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
†ACTINONS	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Figure 1. The Periodic Table of Elements. Those three elements in the shaded area, C (carbon), Si (silicon), Ge (germanium) form the group known as semiconductors.

Breaking The Bonds

An individual covalent bond is not a strong one and it is quite simple to remove an electron and use the electron as a charge carrier through the material, in the same way that electrons carry charge through any other conductor. The force required to break the bond and remove the electron is greater than the force needed with a good conductor say, copper, and so the semiconductor displays a certain amount of resistance to current flow. As we saw last month, of course, carbon (semiconductor) is actually used to make certain types of resistors.

But resistors are purely passive devices: if we apply a voltage across a resistor, a current will flow through it according to Ohm's Law and to the formula:

$$I = \frac{V}{R}$$

Remember?

It doesn't matter which way round the resistor or voltage is in the circuit, the effect will be the same. A resistor is passive and is acted upon by applied voltages and currents — the effect is dependent only on the size of the voltages and currents. The actual electronic components which have been given the name semiconductors (and remember this doesn't include carbon resistors!) are very much cleverer and more useful than this. Such semiconductor component are active: they can be used to act upon and control the applied voltages and currents.

We form these active components by combining slightly different types of semiconductor elements. These different semiconductor types are made by adding small quantities of impurities to change their electrical characteristics. Adding impurities to a semiconductor to change its electrical

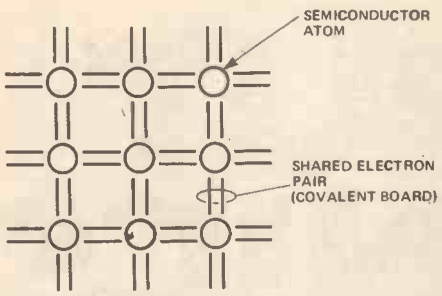

Figure 2. A minute section of semiconductor material showing atoms and covalent bonds.

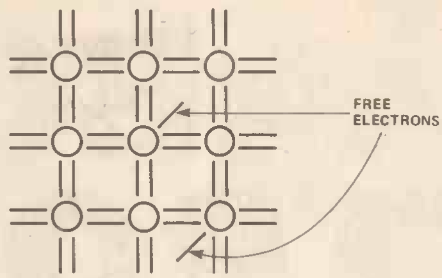

Figure 3. N-type semiconductor. Pure semiconductor material is doped with atoms which have five electrons in outer orbit. Four electrons pair with electrons of adjacent atoms leaving one free electron.

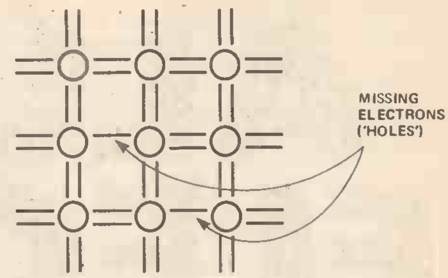

Figure 4. P-type semiconductor formed by doping pure semiconductor material with atoms having only three electrons in outer orbit. This leaves a hole for a missing electron.

characteristics is known as *doping*. Doping is done in two ways to make two separate types of semiconductor material:

- N-type — formed by adding atoms of elements with five electrons in their outside 'orbit'. Four of the electrons form covalent bonds with electrons from adjacent semiconductor atoms, leaving one electron unattached. These free electrons are used as charge carriers (**Figure 3**).

- P-type — formed by doping the semiconductor with atoms of elements with only three outer electrons as in **Figure 4**. These three electrons form covalent bonds with three adjacent atoms but what should be the fourth covalent bond has a missing electron — we call it a hole. Doped semiconductor holes can be thought of as charge carriers in exactly the same way that electrons can be thought of as charge carriers in type semiconductor materials. The holes are, of course, positively charged though (the missing negatively charged electron creates a positively charged hole, get it?).

The first active semiconductor device we shall look at is a diode. Diodes are the simplest of semiconductor devices: we call them two-terminal devices and they are formed by combining one layer each of n-type and p-type semiconductor as shown in **Figure 5**. At the junction between the two layers is a region known as the depletion region. The depletion region is an area where no charge carriers (either electrons or holes) exist because they are repelled by electrostatic charges.

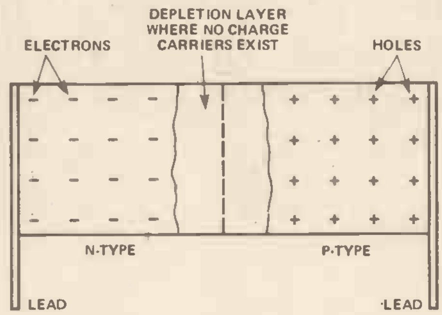

Figure 5. A diode, formed by a combination of P-type and N-type semiconductor material. No voltage is yet applied across the diode.

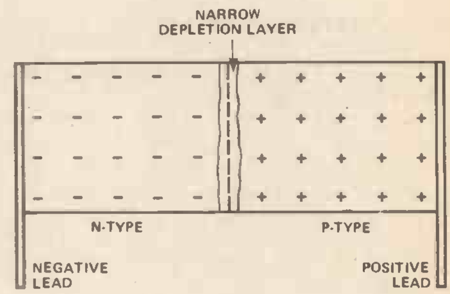

Figure 6. A diode with a positive potential applied to the P-type semiconductor layer. Above 0V7 (for a silicon diode) current flows.

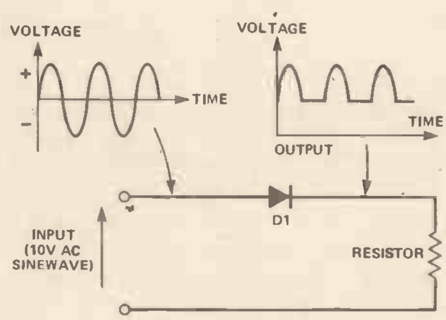

Figure 7. Application of an AC voltage to a diode gives a halfwave rectified output.

Figure 8. Output voltage of a cell is a very smooth DC.

Stop The Current

When a positive voltage is applied to the p-type layer (as in **Figure 6**) the effect of the electrostatic charges are lessened and the depletion region is narrowed until finally at a certain voltage (about 0V2 for germanium diodes, 0V7 for silicon diodes) it disappears and charge carriers can cross the junction and current flows. With a voltage applied the other way round ie, negative to the p-type layer, holes are attracted towards the negative lead. A sort of electronic 'vacuum' is formed at the junction, the depletion region widens and no charge carriers cross the junction ie, no current can flow.

We have made a device which will allow current to flow in one direction but not in the other.

Now, how can we use such a device? A quick look at the circuit in **Figure 7** shows one way. The AC input (alternating between positive and negative) after being applied to the diode has all of its negative half cycles removed. Incidentally, you should be able to see how the circuit symbol of a diode in **Figure 7** displays quite graphically how current passes in the direction of the arrow head but when voltage is reversed current cannot flow against the bar.

The output voltage of the circuit in **Figure 7** is not AC because there are no negative cycles so it must be DC. Because only half a cycle of the total input waveform appears at the output we say the output is half-wave rectified DC. Admittedly its not a very smooth DC voltage. The voltage from a DC cell for example is perfectly smooth (**Figure 8**). But don't worry we'll see how we can improve the smoothness of the rectified DC waveform later.

By combining four diodes (**Figure 9**)

we form what is known as a bridge rectifier. This gives a full-wave rectified DC voltage output from an AC voltage input. Operation of the bridge rectifier can be explained with reference to **Figure 10a and b.**

Diodes In Pairs

Figure 10a shows how the circuit works when the AC voltage input is in a positive half cycle — point A is positive with respect to point B. Diodes D1 and D3 both conduct but diodes D2 and D4 do not. So current passes through diode D1 through the load resistor R1, and finally through diode D3. During the negative half cycle (**Figure 10b**) diodes D2 and D4 conduct, but diodes D1 and D3 do not. Now current passes through (from terminal B this time) diode D2, through the load resistor (*in the same direction as in the positive half cycle*) and finally through diode D4.

Any type of diode has a set of parameters (or limits) which define what the diode can be used for. For example, an application in which diodes are often used occurs in a meter when we wish to measure AC voltages and current. If you remember from the August issue of HE, the meters discussed were only used to measure DC voltages and currents. They simply would not work for AC! A meter can be used however, to measure AC voltages and currents if the AC voltage or current is rectified first (**Figure 11**). Now, the parameters of the diodes used in the bridge rectifier of **Figure 11** must be great enough to ensure that any voltage or current measured will not damage the diodes. Say, for example that currents up to 1A and voltages up to 1000V ratings must be used. Other applications might call for higher ratings.

It's time now to consider how to improve the rectified DC voltages which diode rectifiers give and make them as smooth as possible. We do it with the addition of a single electronic component — and we have met the component already: the capacitor. **Figure 12** shows a capacitor used to smooth the rectified DC output of a bridge rectifier. Use is made of the charge-holding capability of the capacitor to maintain the voltage at the peak of the full-wave rectified waveform during the trough till the next peak. When a capacitor is used in such a way it is called a smoothing (or more correctly speaking, a reservoir) capacitor, for obvious reasons.

Of course, simple addition of a capacitor to a rectifier circuit cannot completely remove all the peaks and troughs which occur, but they can be reduced to acceptable limits. There will always be, for example, a small variation in voltage — which is known as ripple — but as long as this is held within, say ±100mV, of the desired DC voltage then it is acceptable for most purposes. If we need a more accurate DC voltage then there are other component and complex circuits which can reduce ripple even further but we don't need to know about such methods yet. More about those another month.

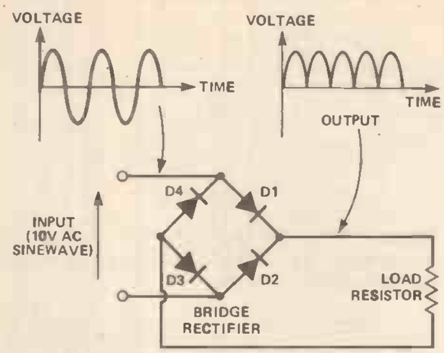

Figure 9. A bridge rectifier, consisting of four diodes, giving a full-wave rectified DC output from an AC sinewave input.

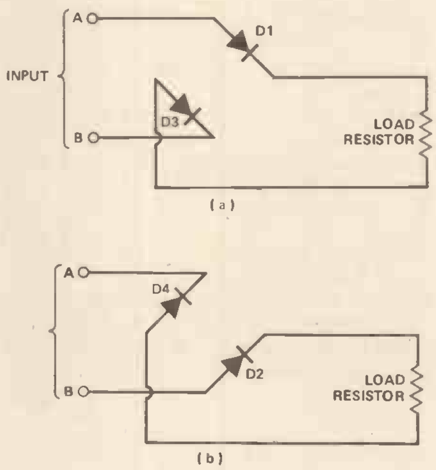

Figure 10: a) what occurs during the positive half cycle of input sinewave b) what occurs during the negative half cycle.

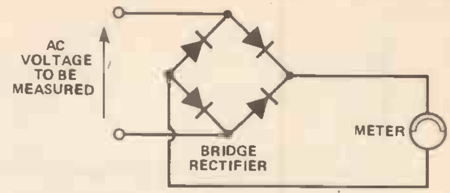

Figure 11. Measuring an AC voltage with a DC meter.

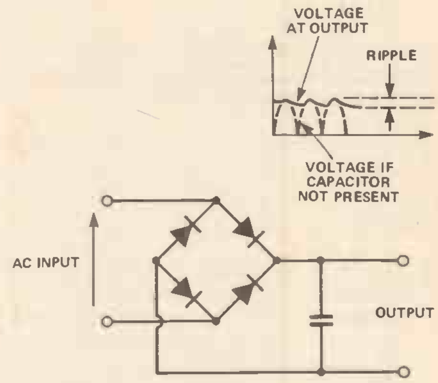

Figure 12. A reservoir capacitor used to smooth the full-wave rectified DC output of the bridge rectifier to an acceptable ripple.

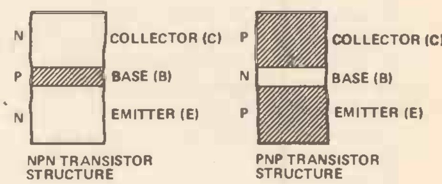

Figure 13. NPN and PNP transistor constructions.

Introducing Transistors

The diode is the simplest of active semiconductor devices — as we have already seen, it is a two-terminal device. The next type of semiconductor is a three-terminal one and its common name is a transistor. Within the family of transistors there are a number of different types. This month we shall look only at the variety known as bipolar transistors. In later months we shall look at other varieties such as field effect transistors (FETs) and also consider four-terminal semiconductors.

Bipolar transistors are made by combining three layers of doped semiconductor material so that two PN junctions (ie, combinations of p-type and n-type semiconductor) are very close together. There are two different ways this can be done of course:

- with the central layer of semiconductor being p-type and the outside layers n-type (forming what we know as an NPN transistor)
- with the central layer n-type and the outside p-type (forming a PNP transistor).

The central layer is always called the *base* and the outside layers are the *emitter* and the *collector*. **Figure 13** shows both the NPN and PNP transistor constructions. Although the emitter and collector are made of the same type of material, there are ususally constructional differences within the transistor which mean that their roles in a circuit cannot be reversed.

Circuit symbols for NPN and PNP transistors are shown in **Figure 14**. The arrowhead on the emitter of both types shows the general direction of current through the transistor when the emitter-base junction is forward biased (ie, the base is more positive than the emitter in an NPN transistor or the emitter is more positive than the base in a PNP transistor).

In the following discussion about transistor operation I am going to describe only the NPN transistor, but PNP operation is similar — only the

Figure 14. Circuit symbols for NPN and PNP transistors.

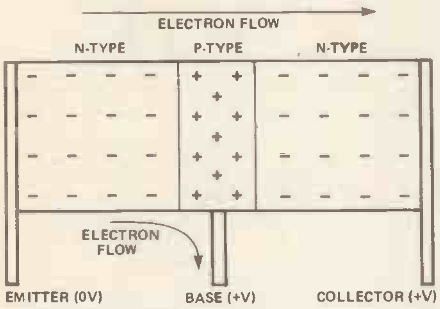

Figure 15. Basic format and applied potentials to an NPN transistor.

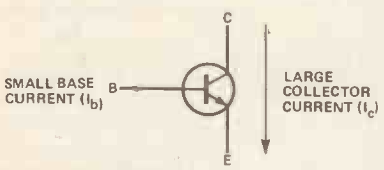

Figure 16. Summarised action of an NPN transistor.

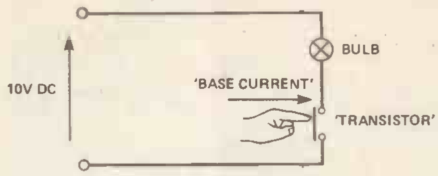

Figure 17. Likening the action of a transistor to that of a mechancial push-button switch.

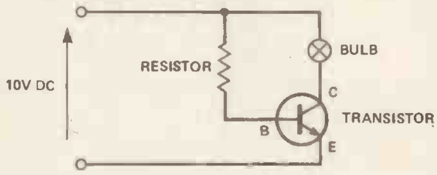

Figure 18. The circuit of Figure 17 — using a transistor.

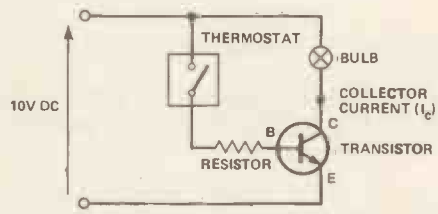

Figure 19. Automatically switching a transistor using a thermostat.

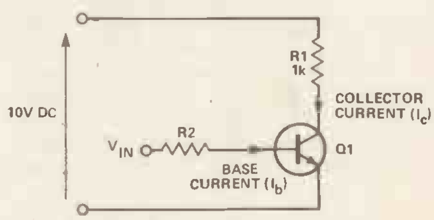

Figure 20. Studying currents within a transistor circuit.

polarities of all applied voltages and currents should be reversed. I shall also assume use of silicon transistors, so a base-emitter voltage of 0V7 is used in all calculations. **Figure 15** shows the basic format of an NPN transistor. The collector of the transistor is held at a positive potential to the emitter. The PN junction between base and emitter acts as a diode. So with no voltage applied to the base no current flows from base to emitter. However, if a positive voltage (greater than 07V) is applied to the base, the diode is forward biased and electrons flow from emitter to base (ie, current flows from base to emitter).

If the base is made thin, some of the electrons moving from emitter to base will carry on and move into the collector (because they are attracted to the positive potential of the collector). If the base is thin enough and the transistor construction is good a high percentage of the electrons entering the emitter (say 95%) will pass to the collector. Thus a larger current will flow from collector to emitter than that from base to emitter.

If we remove the positive voltage from the base the collector-to-emitter current (known as the collector current, Ic) stops. What we have made is a simple machine — in which a small current (created by the application of a potential difference to the base) causes a large output current. This is summarised in **Figure 16**.

The ratio of the collector current, Ic, to the current from base to emitter (the base current, Ib) is:

$$\frac{Ic}{Ib}$$

$$= \beta \text{ (the Greek letter, beta)}$$

and depends primarily on the type of transmitter used. For example a common transistor, the BC109, has a β of about 200, ie for a base current of 0mA1 a collector current of about 20mA will occur.

Application of base current (Ib) effectively switches the transistor from being an insulator to a conductor. When the transistor has no voltage connected to its base the collector to emitter resistance is very high (about 20M). We say the transistor is 'off'. When a voltage is applied to the transistor base the resistance from collector to emitter is low (about 10R) and we say the transistor is on.

In a nutshell, that's all the transistor — any transistor — is really: a device, the resistance of which can be varied electronically (by the voltage to its base): a *trans*ferrable res*istor* — *TRANSISTOR* — get it?

Switching Circuits

When the resistance of a transistor is varied from high to low by the application of a voltage to its base, the transistor is acting as an electronic switch, and another way of looking at the operation of a transistor is shown in **Figure 17.** The 'transistor' is shown graphically as a push-button switch, and the 'base current' is shown as a finger about to operate the switch. As the finger (base current) operates the switch (transistor) the resistance of the switch goes from high (when it is open-circuit) to low (when it is closed-circuit) and the current passes through the bulb, lighting it.

Figure 18 shows the same circuit but replaces the switch and the finger with a transistor. Circuit operation, however, is identical: apply a base current and the bulb lights. The base current can, in fact, be supplied from the positive voltage supply to the bulb as in **Figure 18.** Note the resistor in series with the base, to limit the base current to a maximum level — too large base currents will cause high power dissipation which will irreparably damage the transistor.

Base current could be provided by say, a thermostat (which is simply a temperature controlled switch) as in **Figure 19,** so that when temperature falls below a certain minimum, the thermostat closes providing base current and automatically turning on the bulb. Of course, it might not be a bulb: it could be a heating pump, or a boiler etc.

It really doesn't matter what provides the base current to the transistor — it could be temperature (as in the thermostat example above), a magnetically operated reed-switch, another transistor, a computer, or whatever — the fact is that in this type of circuit the transistor is operating as an automatic electronic switch with only two states: on and off. When base current flows, the transistor is on; when no base current flows, the transistor is on; when no base current flows, the transistor is off.

Let's look further into this transistor switch circuit. **Figure 20** shows a transistor with a 1k collector resistance, (ie, the resistor between the transistor collector and the positive supply rail, R1). This could be a bulb as in **Figure 18,** or a relay which will turn almost anything on and off! Resistor R2 is the transistor base resistor.

Calculating The Current

First we will consider the collector current. I said earlier on that the collector current, Ic, was a function of β and the base current, Ib:

$$Ic = \beta \times Ib$$

Well, Ic is also a function of the collector resistor, R1. Take for example the case when the transistor is on; its resistance is low (about 10R) and can be neglected compared with R1 (1k). So the collector current is defined primarily by the collector resistor and the power supply voltage by the formula (which, of course, we all know!):

$$Ic = \frac{V}{R}$$

$$= \frac{10}{1000} = 10mA$$

Now we can calculate the required base current to turn on the collector current — we know that the transistor $\beta = 100$ so for a collector current of 10mA, the base current needs to be:

$$Ib = \frac{Ic}{\beta} = \frac{10 \times 10^{-3}}{100} = 100uA$$

(Not a lot!) The base resistor, R2 can now be calculated as being:

$$R2 = \frac{VR2}{Ib}$$

where VR2 is the voltage across R2. This voltage depends on two things; the voltage at the base, and the voltage at the input V_{in}. The voltage at the base is easily worked out because it is the voltage at the emitter (0V) plus the base-emitter voltage 0V7 — the base-emitter junction is a diode — remember?. Let's say the voltage V_{in} is to be 5V, then the voltage across R2:

$$VR2 = 5 - 0V7 = 4V3$$

Therefore

$$R2 = \frac{4V3}{100 \times 10^{-6}} = 43000R = 39k \text{ (NPV)}$$

So, with a base current of 100uA, 10mA of a collector current flows and, with no base current, no collector current flows. This is exactly what we wanted from our transistor switch.

In an electronic switch mode, transistors are either fully on (known as saturation) or fully off. But what happens in between these two limits? Let's look at the circuit of **Figure 20** again but apply an input voltage of V_{in} of say 2V65. This sounds inconvenient but when we calculate the voltage across the base resistor, R2:

$$2V65 - 0V7 = 1V95$$

and calculate the base current:

$$Ib = \frac{VR2}{R2} = \frac{1.95}{39 \times 10} = 50uA!$$

then we see that the collector current:

$$Ic = \beta \times Ib = 5mA$$

ie, half the collector current of the previous calculation. In other words the transistor is half on. This illustrates another type of transistor operation — *linear mode operation.*

A transistor operating in its linear range can be likened to a control valve in a water system. If no base current flows the 'control valve' is closed and no collector current flows. But when the 'control valve' is half open, or a quarter open, or an eighth open; half the full collector current, a quarter, or an eighth the full collector current flows. We thus have linear mode transistor operation, the most important point of which is that the large collector current is controlled by a small base current. We have developed a very simple current amplifier generating a large current from a small current the gain of which is the transistor's β over the linear range, ie:

$$\text{amplifier gain} = \beta = \frac{Ic}{Ib}$$

The amplifier circuit of **Figure 20** is effectively a DC circuit only — it will not operate with AC voltages and currents **Figure 21** shows why not. The input to point A, ie, the input voltage, V_{in} to the transistor is a sinewave, varying from +5V to 0V to −5V. During the positive half cycles the transistor is operational in its linear range and its resistance varies from maximum (about 20M) to minimum (about 10R) as the sinewave varies. The lower the resistance of the transistor, the lower the voltage point β because the effective resistance of the transistor in series with the collector resistance R1 forms a voltage divider. So the output voltage (over the positive half cycle of the input sinewave) is the inverse of the input voltage!

I Say, AC, I See!

But what happens as the input voltage varies over the negative half cycle? Well, the transistor is off (and can't go any more off) so the output voltage stays at maximum. Thus the output voltage waveform is an inverse half-wave rectified version of the input voltage waveform. An AC current cannot therefore be amplified by this simple circuit. So, do we amplify an AC current?

If a fixed direct current (which permanently turns the transistor half on) is applied to the base, at the same time as the sinewave output is applied then the collector current will vary up and down with the base current and all parts of the AC input waveform will be amplified. **Figure 22** shows one way of supplying this fixed DC input. Because the collector resistor, R1, and the power supply voltage (10V) are the same as in **Figure 20** we know that a collector current of 5mA means the transistor is half on. And with a β of 100 we know that the required current is 50mA to turn the transistor half on. Thus the voltage across the resistor, R3 is:

$$10 - 0V7 = 9V3$$

So the required resistor value:

$$R3 = \frac{VR3}{Ib} = \frac{9V3}{50 \times 10^{-6}} = 186000$$

$$= 180K \text{ (NPV)}$$

The current to turn the transistor half on is known as the bias current, resistor R3 is the bias resistor, and the standing collector current is known as quiescent current.

We have now designed a very simple AC current amplifier from a transistor, with a gain β, which is also a voltage invertor.

That's about all for this month — we've covered a lot of ground and learnt some new ideas about electronic semiconductor components. In the next few months you'll see other semiconductor circuits and other semiconductor components, particularly those in the large family of integrated circuits (ICs), but the basis of semiconductors (ie, this month's topic) is applicable to them all.

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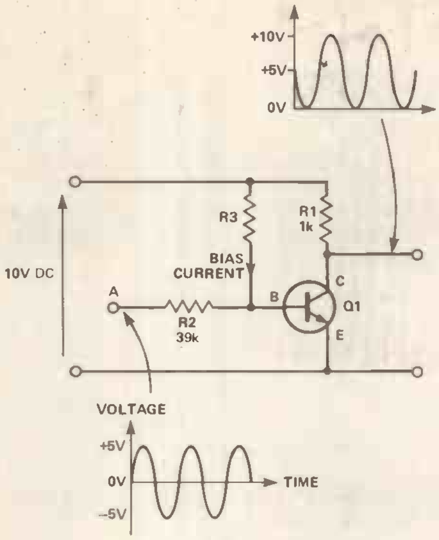


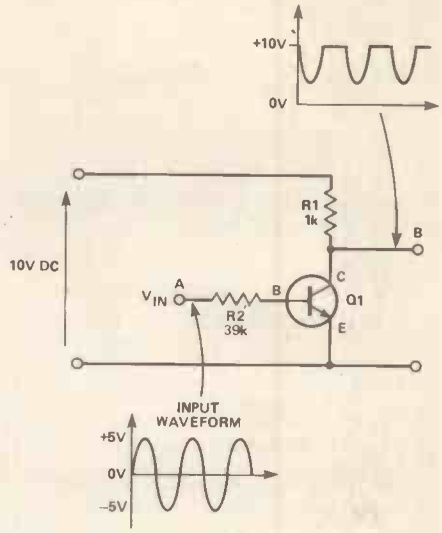


Figure 21. Attempting to use the circuit of Figure 20 to amplify a AC sinewave.

Figure 22. Turning the transistor half on, by applying a fixed bias current to the base, allows the transistor to be used with AC input.

This is the Great Hobby Electronics Computer-Controlled Model Railway COMPETITION

Sponsored by Oric Products International Ltd., Beatties of London Limited and ASP Software (a division of Argus Specialist Publications Ltd.).

WHEN it was proposed that there should be a Grand Computer Controlled Model Railway Competition for the 1983 Breadboard exhibition, we rapidly became bogged down with seemingly endless complications. We spent most of the time during discussions simply explaining jargon: what, to a computer hardware man, is a "dead frog"? Something unpleasant by the roadside, was the popular answer! On the other hand our modelling consultant was somewhat bemused by the many acronyms that punctuate conversations between computer buffs: who, or what is a PIA? Bits of what? What is a multiplexer, and so on, and on, and on . . . !

In the end we were all quite bewildered — but this confusion ultimately gave us the clue to our Computer Controlled Model Rail Competition: no one, it seems, truly knows how best to marry a computer to a complex model rail layout or what it should do and, particularly, how it should be done.

We decided, finally, that the simplest and best approach would be to throw the thing wide open, with only a few essential restrictions. The only rule of the competition, then, is that the winning entry will be that which demonstrates the most ingenuity, usefulness and practicality in adapting a modern home computer to control a model railway layout — the what, how and why we quite happily leave to our readers!

The essential limitation we felt obliged to impose is that the layout should measure no more than 6ft by 2ft — in other words, something that can be transported to the Breadboard exhibition in Hammersmith in late November this year.

We anticipate that most of the entries will be from constructors who have an existing computer interfaced layout, but the competition is open to all comers so anyone who wants to "have a go" will be welcome in the lists. For the benefit of those who fancy their chances at the Grand Prize, here are a few ideas that resulted from the meeting of the minds in Hobby's editorial offices (we won't mention the ideas that evolved later, down at the Royal George!).

- A fairly simple software application would be to write a program for storing and modifying timetables and operating schedules; an extension of this idea would be an interface to position sensing circuits so that an operator would know not only when the next train was due to leave, but also when it was safe to start down the track.

- One of the most obvious ideas proposed was to program a mimic board which could show not only the track layout but the condition of signal lights and with 'train in section' indication: colour would be necessary for user-friendliness!

- Ways to adapt microprocessor technology to model train control: one option that might be easily constructed would be to computer-control sections of track rather than individual trains. However completely automatic running is not the goal of most railway modellers, so any system should allow lots of room for the operator to control the layout himself.

And that is about the limit of the ideas we came up with before brain fog set in. We'll leave it to the inventiveness and competitive spirit of our readers to stun the judges with brilliant projects we should have thought of . . . but didn't!

1

FIRST PRIZE

Hot off the production line, an Oric 48K colour computer, donated by Oric Products International Ltd.

2

SECOND PRIZE

Gift vouchers to the value of £50, redeemable on model rail products at any Beatties of London shop.

3

THIRD PRIZE

£25 worth of games and utility program tapes from ASP Software.

Entry forms, together with an entrance fee of £1.00 (cheque or money orders only, please) should be sent to:
The Exhibition Manager, BB83, ASP Exhibitions, 145 Charing Cross Road, London WC2H 0EE.

Closing date is 31st October 1983. Judging will take place at Breadboard '83, Cunard Hotel, Hammersmith, London W6, on either Wednesday 23rd or Thursday 24th November 1983. Entrants will be informed of the day on which they will be required to present their layouts at the exhibition. Finalists will be asked to demonstrate their layouts at some time(s) during the open days of Breadboard '83 (25, 26, 27th November) and layouts will be available for collection between 1600 and 1800 hours on Sunday 27th November. **The judges decision will be final and no correspondence will be entered into.**

Entry Form

PLEASE USE BLOCK CAPS

NAME: ....

ADDRESS: ....

....

TEL NO: .... AGE ON 30TH NOV. 1983: ....

BRIEF DESCRIPTION OF LAYOUT AND FUNCTIONS: ....

....

....

....

SCALE: .... SIZE OF LAYOUT: (MAX 6FT X 2FT): ....

COMPUTER USED: ....

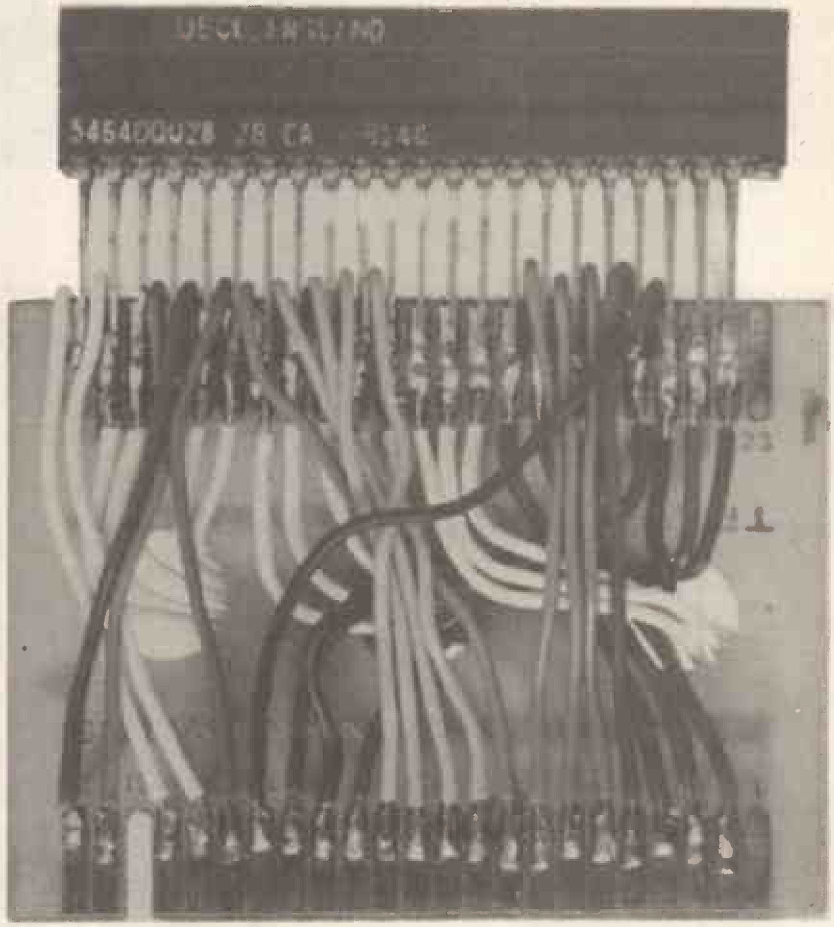
COMMERCIAL PERIPHERALS USED: ....

....

TRUMP CARD

With the Trump Card, hardware designed for the Sinclair Spectrum or ZX81 can be used with the Jupiter ACE (with very few exceptions). Simple to make, it will add enormously to the ACE's versatility as a controller.

Colin Freestone



TRUMPCARD is a simple but very effective project for owners of the ever more popular Jupiter Ace computer. At present the Ace, even with the recent release of 16K and 48K RAM packs, still does not yet enjoy large scale hardware support, such as that available for the ZX81 or Sinclair Spectrum, that would allow the Ace user to extend the range of his computer activities.

The Ace, a versatile and useful computer, is becoming particularly popular for control applications. In time, a wide range of hardware accessories will no doubt become available for it (*such as the RAM I/O board and the Joystick Controller in last month's issue of Hobby Electronics!*) but in the short term, users who might like to experiment with speech synthesizers and similiar devices are bound to be somewhat frustrated.

The solution, though, is quite simple. The Ace and the ZX81 are very similar in may ways, and so it has proved simple enough to design an interface board that will allow most ZX81 add-ons to be used with the Ace.

Trumpcard is simply a small dual-sided PCB edge connector that can be wired to re-route the ZX81 signal lines to correspond with the corresponding Ace signals. The only limitation is since the Ace does not produce the control signals ROMCS and RAMCS (ROM and RAM Chip Select), Trumpcard cannot be guaranteed to operate reliably with an ZX add-on that makes use of these signals.

Construction

The connections between the two sets of edge connectors are made with short lengths of coloured wire — single stranded 'bell wire' is best. Coloured wire makes it easier to keep track of the links as they are made and also to fault-find, if this is later necessary. The colour scheme is optional, but that outlined in **Table 1** is logical and consistent.

The first step in assembling the Trumpcard is to modify the edge connector socket so that it can be wired onto the PCB. The socket is a 23+23 way (double sided) type with the keyway at one end and must have wire-wrap length pins.

Take a pair of long-nosed pliers and insert one jaw between the rows of pins; grasp one row firmly between the jaws and bend the pins outward by about 30° (you may need two bites at this, carrying out the operation from either end if the jaws are not long enough). Then bend the opposite row outwards by the same amount.

When this has been done, the next step is to bend the pins back inwards, but this time from the base so that the ends of all the pins all lie parallel and just far enough apart for the PCB to slip between the rows.

To achieve uniform bending in the second operation, hold the body of the connector against the edge of a table with the bottom row lying flat on the table surface; then push down, gently but firmly, bending the pins inward. Repeat for the other row and continue to bend both rows until the PCB just fits between the rows.

Now with the polarising key on the right and the ZX key-slot at your top left, align the socket with the Ace edge connectors on the PCB, making sure that they all line up accurately. Push the pins onto the tracks, but leave about 5mm of free copper for soldering on the link wires. If the pins have been bent correctly, they will all lie neatly against the copper pads,

TABLE 1A							
ACE PIN	TRUMPCARD NUMBER (ACE EDGE)	SIGNAL	2K PIN NUMBER	TRUMPCARD NUMBER (ZX EDGE)	COLOUR	LENGTH (INCHES)	ROUTE
1A	23A	OV	4B	20B	WHITE	2¼	EDGE
2A	22A	OV	5B	19B	WHITE	2¼	EDGE
3A	21A	+9V	2B	22B	GREY	2¼	EDGE
4A	20A	+5V	1B	23B	GREY	2¼	EDGE
5A	19A	CLK	6B	18B	PINK	2¼	EDGE
6A	18A	A11	15B	9B	ORANGE	2¼	EDGE
7A	17A	A12	14B	10B	YELLOW	2¼	EDGE
8A	16A	A13	13B	11B	YELLOW	2¼	EDGE
9A	15A	A14	12B	12B	YELLOW	2¼	EDGE
10A	14A	A15	11B	13B	YELLOW	2¼	EDGE
11A	13A	D4	10A	10A	YELLOW	1¼	DIRECT
12A	12A	D3	9A	9A	ORANGE	1½	DIRECT
13A	11A	D5	8A	8A	GREEN	1½	DIRECT
14A	10A	A2	9B	15B	BROWN	2	HOLE 2
15A	9A	A10	16B	8B	ORANGE	2¼	EDGE
16A	8A	A9	17B	7B	ORANGE	2¼	EDGE
17A	7A	A8	18B	6B	ORANGE	2¼	EDGE
18A	6A	A7	19B	5A	RED	2¼	EDGE
19A	5A	A0	7B	17B	BROWN	2¼	EDGE
20A	4A	D1	5A	5A	BROWN	2¼	DIRECT
21A	3A	D6	7A	7A	BLUE	2¼	DIRECT
22A	2A	WE	NC	NC	—	—	—
23A	1A	(SLOT)	—	—	—	—	—

TABLE 1B							
ACE PIN	TRUMPCARD NUMBER (ACE EDGE)	SIGNAL	ZX PIN NUMBER	TRUMPCARD NUMBER (ZX EDGE)	COLOUR	LENGTH (INCHES)	ROUTE
1B	1B	NL	—	—	—	—	—
2B	2B	INT	11A	11A	PINK	2	HOLE 1
3B	3B	NMI	12A	12A	PINK	2	HOLE 1
4B	4B	HLT	13A	13A	PINK	2	HOLE 1
5B	5B	MREQ	14A	14A	PINK	2	HOLE 1
6B	6B	IORQ	15A	15A	PINK	2	HOLE 1
7B	7B	RD	16A	16A	PINK	2	HOLE 1
8B	8B	WR	17A	17A	PINK	2	HOLE 1
9B	9B	BUSAK	18A	18A	PINK	2	HOLE 2
10B	10B	WAIT	19A	19A	PINK	2	HOLE 2
11B	11B	BUSRQ	20A	20A	PINK	2	HOLE 2
12B	12B	RESET	21A	21A	PINK	2	HOLE 3
13B	13B	M1	22A	22A	PINK	2	HOLE 3
14B	14B	RFSH	23A	23A	PINK	2	HOLE 3
15B	15B	A6	20B	4B	RED	1¾	DIRECT
16B	16B	A5	21B	3B	RED	1¾	DIRECT
17B	17B	A4	10B	2B	RED	1¾	DIRECT
18B	18B	A3	10B	14B	BROWN	2	DIRECT
19B	19B	A1	8B	16B	BROWN	2	DIRECT
20B	20B	D0	4A	4A	BLACK	2¾	HOLE 3
21B	21B	D2	6A	6A	RED	2¾	HOLE 3
22B	22B	D7	1A	1A	PURPLE	2¾	HOLE 3
23B	23B	(SLOT)	—	—	—	—	—

Table 1. Wiring chart for the Trumpcard. Each TRUMPCARD NUMBER connects to the opposite EDGE via a length of coloured wire. The non-standard Trumpcard numbering is related to the conventional ACE and ZX81 numbering system, and the middle column shows the signal on each pin.

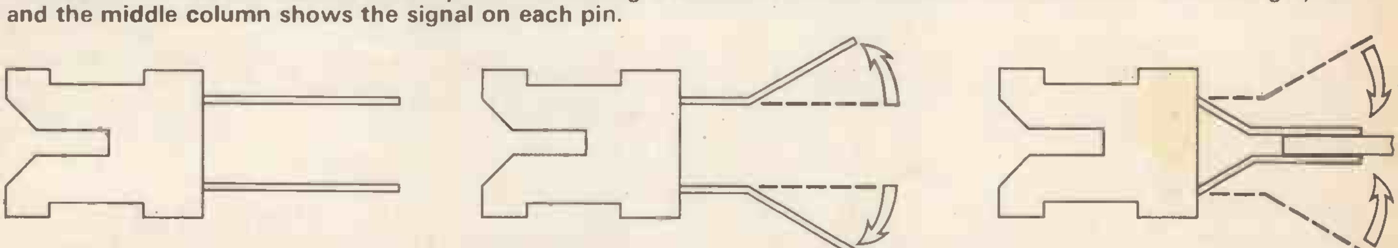


Figure 1. How to bend the pins on the edge-connector socket for soldering to the PCB.

ready for soldering.

Make sure the socket is running parallel with the edge of the PCB and quickly solder the outside pins to hold it in place. Then you can proceed to solder the remaining pins; for best results use a good hot iron and touch the tip to both the pin and the track. Don't use too much solder, to avoid bridges between track pins, and don't overheat, as this can result in a dry joint.

At this stage the link wires should be prepared to the lengths recommended in Table 1. Pare off about 3mm insulation from each end and when all have been trimmed, the wiring can commence.

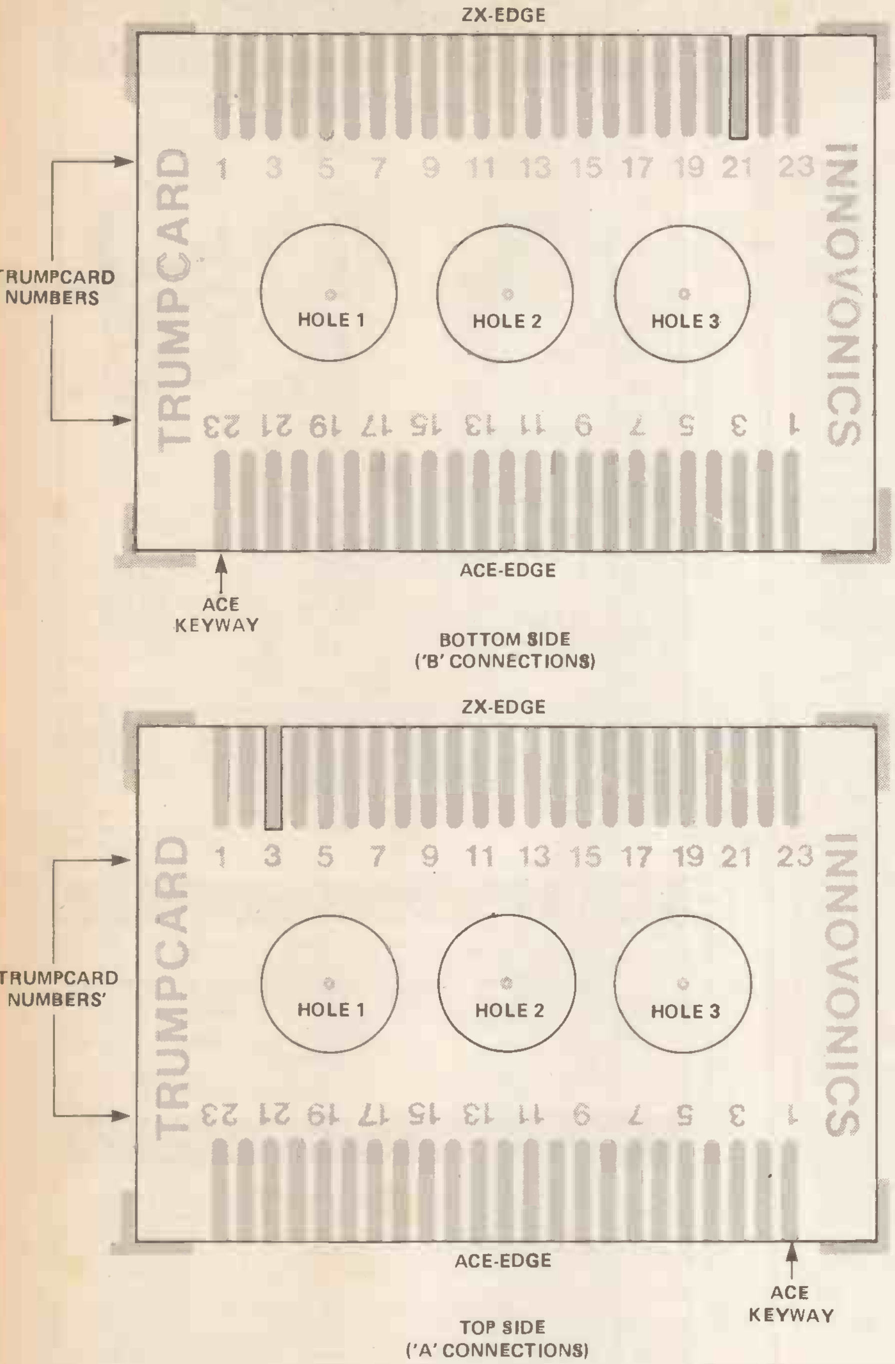


Figure 2. Wires are routed either via the HOLES in the PCB, DIRECT from edge to edge, or between the pins of the EDGE connector as seen in the photograph.

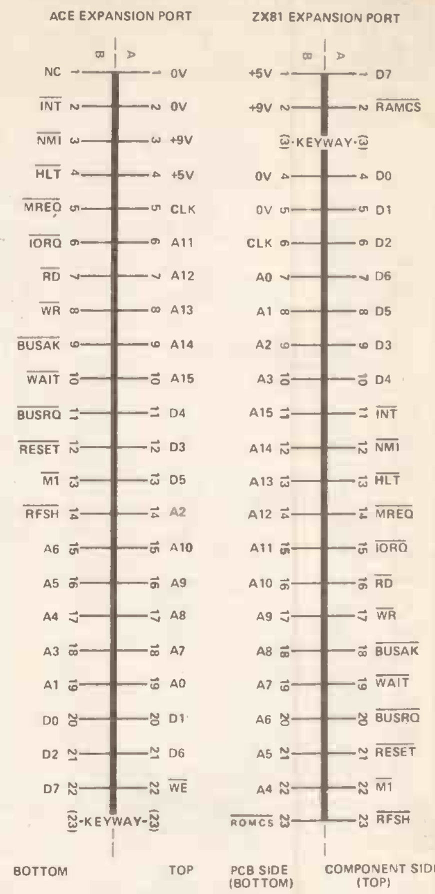


Figure 3. The ACE pins have been renumbered according to the convention used for the ZX81.

Start with the underside, at the Ace edge, and work from pin 2B across to the other end. The wires go by three different routes; either directly from edge to edge, via one of the three holes or, when you come to the other side, between the pins of the Ace edge connector ('Edge' route in **Table 1**). When attaching the wires to the ZX-edge be sure to leave at least 4mm of track free to accept the ZX add-on socket!

When the underside is complete, turn the PCB over and wire up the top side; this time most of the links go via the 'Edge' route, with a few direct connections and one link via Hole 2.

Testing

When the wiring is complete, test all the connections thoroughly, then plug onto the Ace and attach the ZX add-on of your choice (the RAM pack is best for testing purposes).

Power up, and you should get a normal screen; a white-out or loss of synchronisation (rolling screen) means that something is wrong, somewhere.

Assuming that all is well and that a RAM pack is attached, type

15384 @

This is the Ace's RAM TOP system variable, and with 16K RAM attached it should return 32768. If the value returned is 16384 then the pack is not connecting properly and the seating of the pins should be checked.

If you do not have a RAM pack available, test the TRUMPCARD with some other add-on with which you are completely familiar, to assure yourself that it is working properly. Then, when you have successfully completed the project, you have added a formidable accessory to your Ace computer.

In the absence of any fixed convention for numbering the Ace pins in chart form, we have taken the liberty of re-arranging the author's system, for the sake of consistency, to conform with the well established standard for the Sinclair ZX81/Spectrum computers. Thus the 'Ace pin number' in Table 1, follows our convention (see also Figure 3), while the 'Trumpcard Number' is that etched onto the Trumpcard PCB (see Figure 2). Later issues of the PCB will follow the new numbering system.

HE

Parts List

Trumpcard PCB; 23+23-way edge connector socket, keyway at position 23; 46 lengths coloured wire (see text), solder etc.

BUYLINES .... page 32

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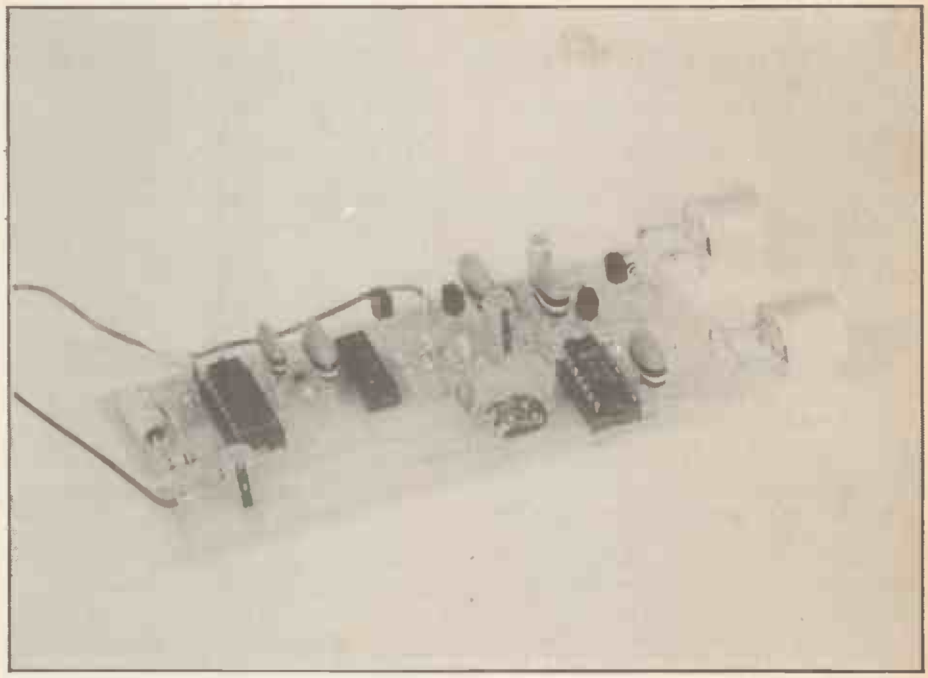
R. A. Penfold

IDEALLY, every property would be protected by a comprehensive burglar alarm system but the cost, plus the difficulty of installation, makes it an impractical proposition in many cases. However, a fairly simple and self-contained system can be built at low cost, installed with minimal difficulty, and offer a worthwhile improvement in security. It is a unit of this type that is described in this article.

The system is of the ultrasonic Doppler-Shift type and when used, in even quite a large room, it will detect movement virtually anywhere in the room and sound the alarm. The alarm generated is a frequency modulated tone of quite high pitch and fairly high volume, which should alert the occupants of the building and (hopefully) scare away the intruder — who is unlikely to wait around to see if anyone responds to the alarm!

The circuit includes a switch-on delay which enables the user to activate the alarm and move away without triggering it. A delay to prevent the alarm from sounding until a few seconds after it has been triggered could also be included, so that the user has an opportunity to switch off the unit before the alarm sounds. However with this particular type of alarm, such a delay could make the unit less effective and more vulnerable, and with a small alarm for internal use having the alarm generator operate briefly each time it is switched off is not a major drawback. A switch-off delay has, therefore, been omitted from the unit.



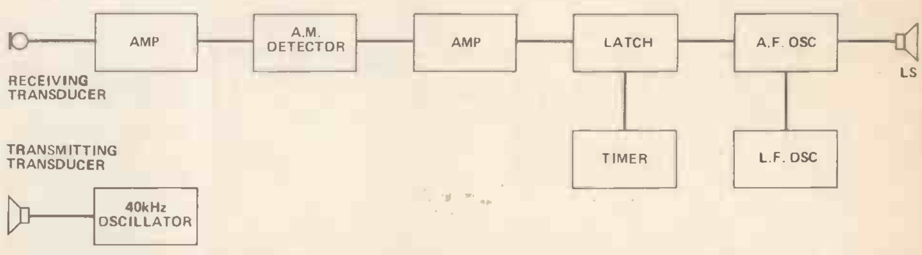


Figure 1. The block diagram, showing the transmitting and receiving stages.

System Operation

Figure 1 shows the various stages of the unit in block diagram form; there are two separate sections — the transmitter and the receiver.

The transmitter is by far the simpler; this is just an oscillator operating at a nominal frequency of 40kHz and feeding into a special transducer. A frequency of 40kHz is used because this is where the transducer is most efficient and it is an ultrasonic frequency so that the sound waves produced by the transducer are too high in pitch to be heard by human ears. An intruder could not be alerted to the presence of the alarm by hearing the output of the transmitter.

A second ultrasonic transducer is used at the input of the receiver; this picks up sound waves from the transmitting transducer and converts them to small electrical signals. The two transducers are mounted side-by-side and some of the pick-up is due simply to sound waves which travel *direct* from one transducer to the other. This accounts for only part of the received signal though, and a large part of it is received indirectly due to reflections from the walls, furnishings, or any other objects in the room (including people).

Signals received via the stationary objects will be at the transmitted frequency but, due to the well known

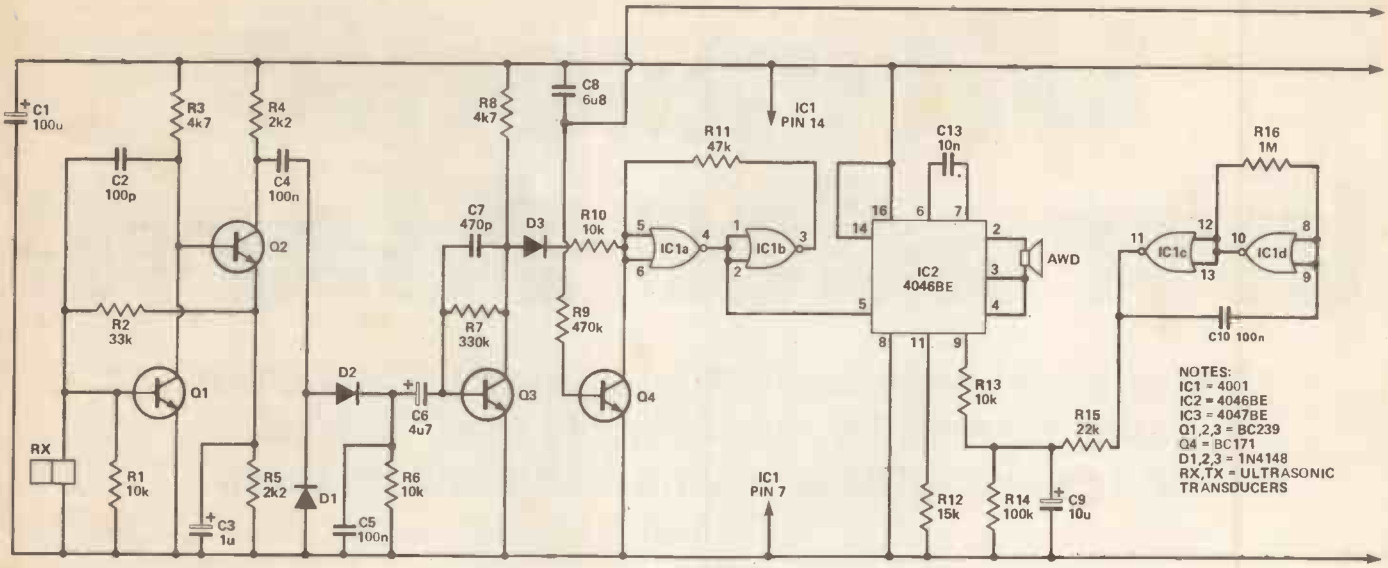


Figure 2. The circuit.

Doppler Shift effect, sounds received by way of any object which is moving towards the transducers will be raised in frequency, while any picked up via an object that is moving away from the transducers will be reduced in frequency. The frequency shift depends on the speed at which the object moves, but for someone walking around a room, it would be a low audio frequency of between a few tens of Hertz and a few hundred Hertz.

The frequency shifted signals mix with the non-shifted ones, but because of the varying phase of the two signals they first add together to give a strong signal and then tend to have a cancelling effect on each other, so that a much weaker signal is produced. Thus the strength of the received signal varies at the shift frequency, and an output at this frequency can be obtained using an ordinary AM demodulator (ie, a rectifier and smoothing circuit). Of course, with no Doppler Shift there is no audio output from the detector, since the received signal will be of constant strength. The output from the receiving transducer is unlikely to be very large, and would typically be well under one millivolt RMS. A high gain amplifier must therefore be used ahead of the detector to give a usable signal level.

Further amplifiction is needed in order to bring the output of the detector to a sufficient strength to drive the next circuit, which is a latch (bistable) circuit. This permanently switches on an audio oscillator when an input signal, no matter how brief is received. This is an essential feature, as the alarm would otherwise only sound while someone was actually *moving* around the room. A timer circuit disables the latch for a few seconds after switch-on so that the switch-on delay is produced. A low frequency oscillator is used to frequency-modulate the audio oscillator so that a more effective and penetrating alarm is produced.

The Circuit

The full circuit diagram of the Ultrasonic Intruder Alarm is shown in **Figure 2**; the transmitter is built around IC3. This is a CMOS 4047BE device which can be used in a variety of monostable and astable modes but in this circuit is employed as a straight-forward free running astable. RV1 is adjusted for the output frequency that give optimum efficiency from the circuit. The 4047BE has anti-phase outputs at pins 10 and 11, and by connecting the

Parts List

RESISTORS
(All 0.25W 5% carbon)
- R1, 6, 10, 13 .... 10k
- R2 .... 33k
- R3, 6 .... 4k7
- R4, 5 .... 2k2
- R7 .... 330k
- R9 .... 470k
- R11 .... 47k
- R12 .... 15k
- R14 .... 100k
- R15 .... 22k
- R16 .... 1M
- R17 .... 8k2

POTENTIOMETER
- RV1 .... 22k 0.1W hor preset

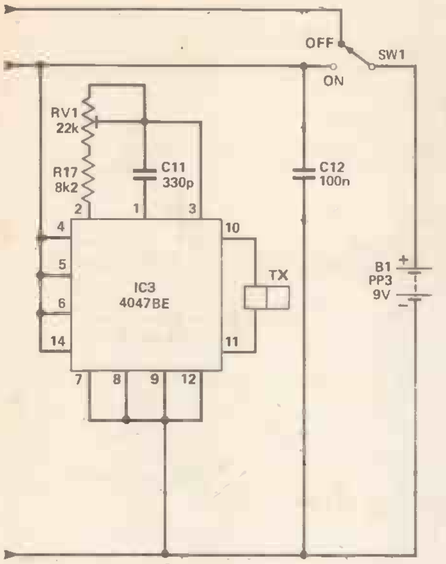
CAPACITORS
- C1 .... 100u 10V radial electro
- C2 .... 100p ceramic plate
- C3 .... 1u 50V radial electro
- C4, 5, 10, 12 .... 100n polyester
- C6 .... 4u7 50V radial electro
- C7 .... 470p ceramic plate
- C8 .... 6u8 tantalum
- C9 .... 10u 25V axial electro
- C11 .... 330p ceramic plate
- C13 .... 10n polyester

SEMICONDUCTORS
- Q1, 2, 3 .... BC239 high gain NPN
- Q4 .... BC171 NPN
- IC1 .... 4001BE or 4001UBE quad 2-input NOR
- IC2 .... 4046BE phase locked loop
- IC3 .... 4047BE astable/monostable
- D1, 2, 3 .... 1N4148 signal diodes

MISCELLANEOUS
- SW1 .... SPDT min. toggle or keyswitch
- RX .... Ultrasonic transducer type R40-16
- AWD .... Ceramic resonator type PB2720
- TX .... Ultrasonic transducer type T40-16
- B1 .... 9 Volt battery preferably NiCad

Battery connector; printed circuit board; IC sockets; wire etc.

BUYLINES .... **page 32**



transmitting transducer across these (rather than from one output to earth) the voltage fed to the transducer is virtually doubled. This gives a useful boost to the performance of the equipment. The output impedance of the 4047BE is not very low, but the transducers are piezo types with an impedance of a few hundred ohms, typically, so a low drive impedance is not essential.

A two-stage, direct-coupled common emitter amplifier is used at the imput of the receiver section. This is probably the most cost effective way of obtaining the required high gain at the signal frequency of 40kHz. As the receiving transducer is also a piezo type it can be direct coupled to the input of the amplifier. C2 rolls-off the response of the amplifier at radio frequencies which help to avoid problems with breakthrough of radio signals, as well as reducing the risk of instability.

The AM demodulator is a standard configuration, with D1 and D2 providing the rectification while R6 and C5 smooth the rectified signal. The audio ouput from the demodulator is coupled by C6 to the input of a single stage, high gain, common emitter amplifier based on Q.

R10, R11, and two CMOS NOR gates (connected here as inverters) form a simple latch circuit, and this has in input fed from the output of Q3 via D3. Under stand-by conditions R7 biases Q3 so that it has a low collector voltage, and the input of the latch is not taken high. However, if there is a suitable output from the detector, the collector of Q3 will swing positive and negative of its quiescent level, and on the first positive half cycle the latch will be triggered to the high state. D3 ensures that the latch cannot be taken back to the low state on negatative excursions of Q3's collector.

At switch-on C8 will charge through R9 and the base-emitter junction of Q4. This switches on Q4 which consequently holds the input of the latch in the low state. This provides the switch-on delay and also ensures the latch is initially set to the correct state. After about 15 seconds the charge current for C8 becomes too low to hold Q4 in the on state, and the circuit is then able to function normally. SW1 is the on/off switch, also used to discharge C8 when the unit is switched off so that a fresh switch-on delay is produced when it is turned on again.

The audio oscillator uses a 4046BE CMOS phase locked loop, but it is primarily the voltage controlled oscillator (VCO) section that is used here. One of the phase comparators is used as an inverter which gives anti-phase outputs to drive the loudspeaker, the latter being a ceramic resonator which is well matched to the high drive voltage and low current available from IC2.

IC2 is frequency-modulated by a low frequency oscillator formed using the remaining two gates of IC1. This provides a roughly squarewave output, but filtering by R15 and C9 converts this to an almost triangular waveform which sweeps the VCO smoothly up and down in frequency at a rate of a few Hertz. The VCO operates at frequencies of around 2 to 4kHz where the AWD (Audible Warning Device) has optimum efficiency and despite the low power at which it operates, provides a high volume.

A mains power supply unit capable of giving a well smoothed 9V output could be used to power the unit, but NiCad batteries represent a good alternative; six AA cells in a plastic battery holder are suitable. The unit could be powered from ordinary (non-rechargeable) batteries, but with a quiescent current consumption of about 10 milliamps and the unit likely to be used for prolonged periods this would probably be an uneconomic way of doing things!

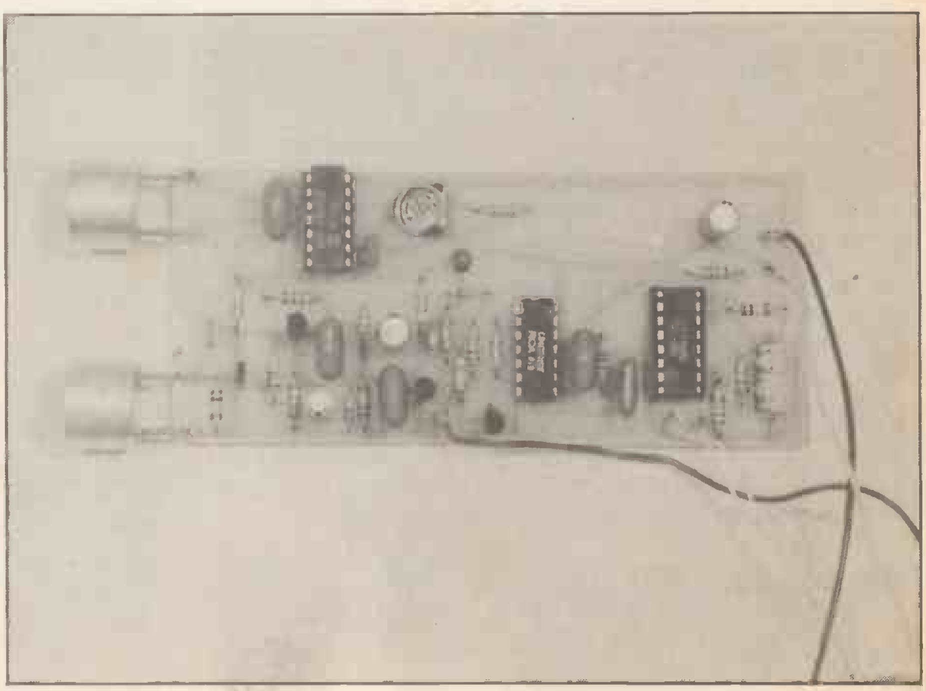
Construction

Details of the printed circuit board are shown in **Figure 3**. All three integrated circuits are CMOS types and the appropriate handling precuations should therefore be taken. It is advisable to fit IC2 and IC3 in DIL IC sockets, but as IC1 is a very inexpensive type it could reasonably be deemed not worthwhile to use a socket for this device.

The ultrasonic transducers can be mounted direct on the board, either vertically or horizontally if they are soldered onto pins. They have very narrow separation, and it might be possible to obtain improved performance by mounting them off-board and using greater separation. However, the prototype gives excellent results with the tranducers mounted on-board, and it is probably not worthwhile experimenting with greater separation. The circuit should work properly using any normal 40kHz ultrasonic transducers and it is not essential to use the specified types (but obviously alternatives might give reduced performance).

C8 must have a low leakage level or the switch-on delay could be greatly extended, possibly not ending at all! A tantalum bead component is therefore preferable to an electrolytic type.

Mechanical construction of the unit must be varied to suit your particular requirements. Alarms of this general type are often disguised as some ordinary household object such as a book or a small bookshelf



In the prototype, the transducers are mounted directly on the board.

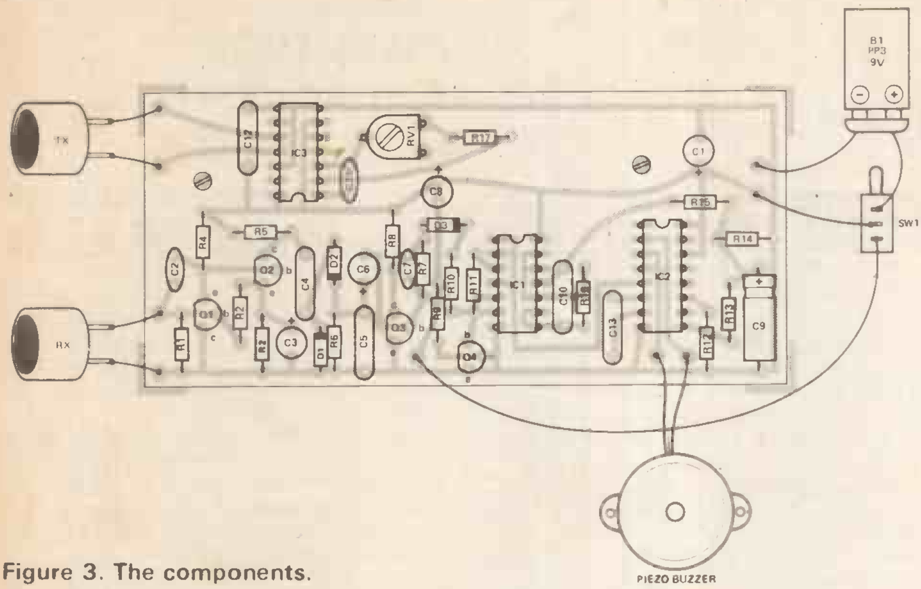


Figure 3. The components.

loudspeaker. However, the unit is almost certain to be triggered before any intruder realises what it is and can simply be built as a normal project fitted to a standard plastic or metal box. It should not be possible for an intruder to easily switch off the unit, so SW1 should be concealed in some way. The AWD is mounted on the exterior of the case, and the two ultrasonic transducers are fitted behind cutouts which enable the sound waves to flow freely to and from the transducers.

Adjustment

There is only one adjustment to make before the unit is ready for use, and this is to set RV1 for optimum results. This can be done simply by trial and error, but there is a much quicker way if a multimeter is available. The multimeter is used to monitor the voltage across C5, and RV1 is adjusted for the highest obtainable voltage reading. The two ultrasonic transducers should be aimed into a reasonably empty space while this adjustment is made. There may be two peaks at slightly different settings of RV1 and in this case the more pronounced of the two settings should be used.

If the switch-delay is considered to be too short it can be extended somewhat by increasing R9 to about 1 megohm, or using a higher value component for C8.

To a certain extent the performance of the unit will depend on where in the room it is located and where it is aimed. With a little experimentation a suitable position for the unit should soon be found. With this type of detector there are normally a few "dead" spots in the room where the unit is insensitive, but it should be possible to obtain good sensivity over the majority of even quite large rooms. Remember that the unit responds to movement, not just to the presence of an object. Also bear in mind that false alarms can be produced by such things as curtains blowing in the wind, pets moving within the protected area and even turbulence in the air caused by a heater. Obviously the unit should be positioned where false alarms of this type are not likely to occur. **HE**

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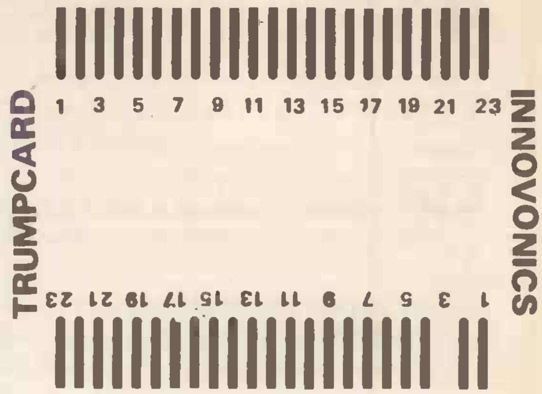

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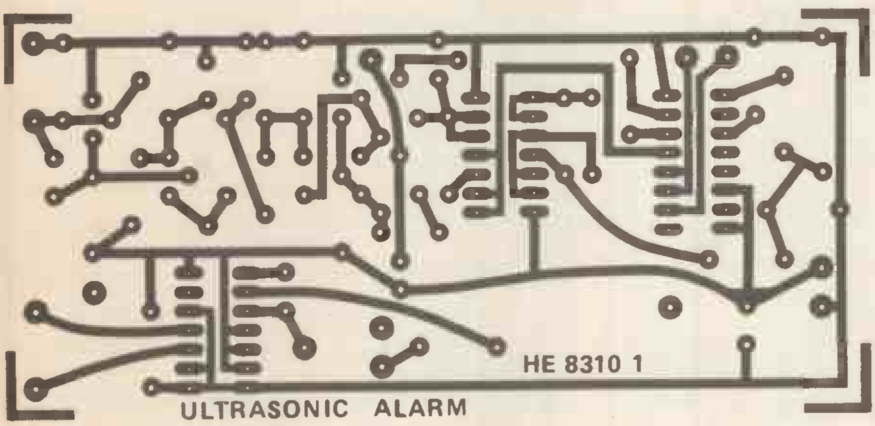
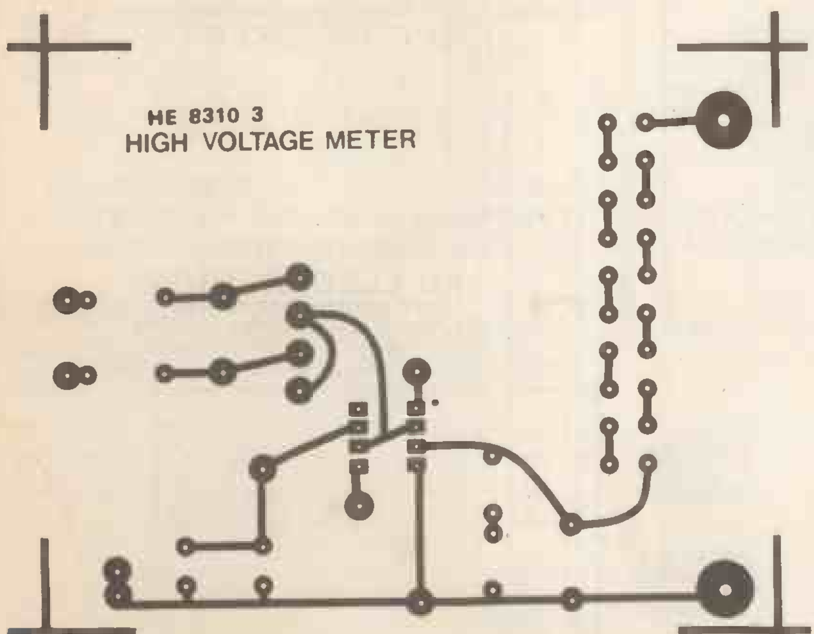
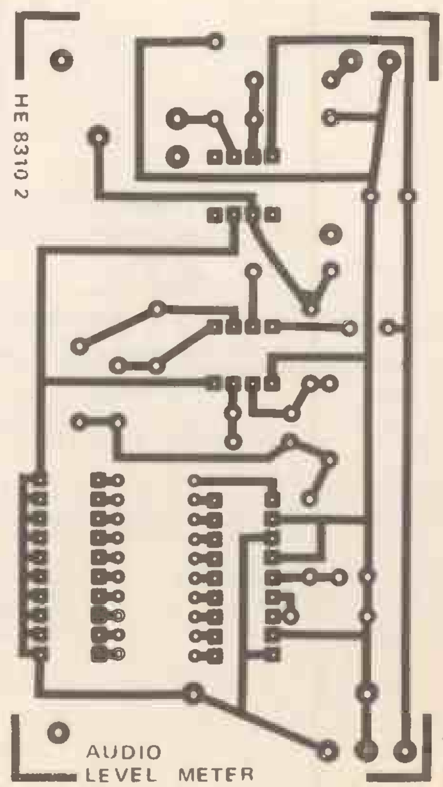


Left: The Ultrasonic Intruder Alarm PCB layout.

Below Left: The Hi-Volt Meter PCB layout.

Below: The Audio Level Meter PCB is laid out for a 10-LED module, but ten separate LEDs can be used instead.





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